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Principal Consultant

Quality Costs

Central **O**hio **Q**uality **A**ssurance **A**ssociation

January 21, 2010

Before We Begin!

- Top management understands the language of money
- Tracking quality costs does not solve quality problems
- Costs of inefficient processes and other forms of waste must be accounted for.

Quality Professionals vs. Top Management

Quality Professionals Are Busy Calculating	*Top Management Understands*
σ, Cpk, Cp, Ppk, Pp, %on-time, DPMO, GRR, Error Rate, RPN, PPM, Quality Level, Defective Rate	

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Software Quality Facts

- Labor-Intensive Technologies
- Intellectual product (as opposed to physical product in manufacturing)
- Specifications / Requirements are always changing
- Most defects result from human misunderstanding / mistakes
- The cost of the manufacturing (production) phase of software is insignificant compared to the development phase
- Statistics for quality cannot be applied to replication as is the case in manufacturing
- Cost of Quality can be an attractive model for measurement in software technologies but has been difficult to implement

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Key Dimensions in Software Quality

- Degree of Customer Satisfaction (how measured?)
- Product Value for Stakeholders
- Key Attributes such as:
  - Reliability
  - Maintainability
  - Portability
- Defect Level Experienced by Target Users
- Process Quality

Breakdown of Quality Costs

- Costs of Conformance:
  - Prevention Costs
  - Appraisal Costs
- Costs of Non-Conformance (Failure)
  - Internal Failure Costs
  - External Failure Costs

Prevention Costs

- Costs associated with activities to prevent poor quality in products and services
- Examples include (but not limited to):
  - Quality Planning
  - Process Control (including SPC)
  - Design Verification / Validation
  - QMS Development / Maintenance
  - Training / Workforce Development
  - Preventive Maintenance
  - QMS Audits
  - Supplier Capability Monitoring
- Specific to Software Quality:
  - Defining Acceptance Criteria for Release

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Appraisal Costs

- Costs associated with measuring, evaluating, or auditing products / services to ensure conformance to established standards
- Examples include (but not limited to):
  - Incoming Product Inspection
  - Lab-Acceptance Testing
  - In Process Inspection
  - Insurance Policy Review
  - Setup for Inspection
  - Calibration Costs
  - Product Final Audits
  - Field Testing (prior to release)
- Specific to Software Quality:
  - Go / No Go Decisions for Release
  - Software QA Testing
  - Code Regular Reviews

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Internal Failure Costs

- Costs associated with product or service not conforming to requirements prior to its delivery
- Examples include (but not limited to):
  - Scrap
  - Rework
  - Unplanned Downtime
  - Supplier-Caused Losses
  - Extra Production Operations
  - Troubleshooting / Corrective Action
  - Re-inspection
  - Preparing Wrong Order
- Specific to Software Quality:
  - Pre-release defect management
  - Re-testing
  - Re-reviews

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External Failure Costs

- Costs associated with product or service not conforming to requirements after its delivery
- Examples include (but not limited to):
  - Returns
  - Complaint Processing
  - Replacement
  - Customer Downtime
  - Troubleshooting
  - Product Recall
  - Liability
  - Warranty Charges
- Specific to Software Quality:
  - Complaint Investigation
  - Customer Support on Quality Issue
  - Defect Notification
  - Remedial Upgrade

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Types of Errors and Results

The Decision of your Internal Quality Assurance is:	Your Product is actually: Good	Your Product is actually: No Good
Accept	Correct Decision (No Waste)	Incorrect Decision (Type II Error) (Result: External Failure Costs)
Reject	Incorrect Decision (Type I error) Appraisal System Error	Correct Decision (Result: Internal Failure Costs)

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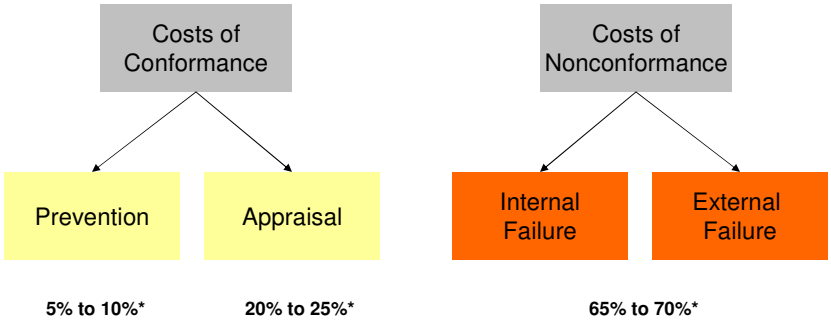
Conformance vs. Nonconformance Costs



*Breakdown of Quality Costs according to Feigenbaum

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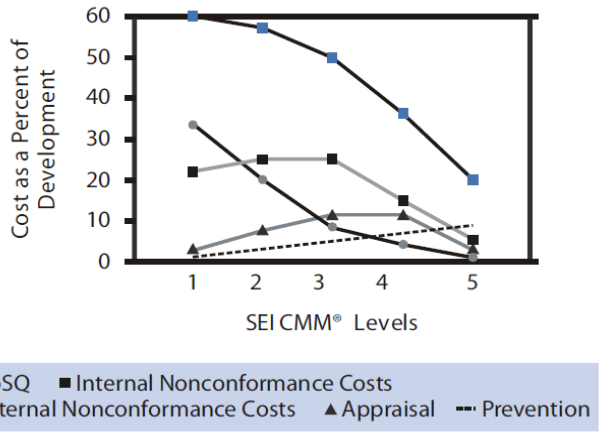
Costs of Quality vs. CMM Levels



Knox Theoretical model showing relationship between CoSQ and SEI CMM® levels (1)

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Knox's Software CoQ

- Total Cost of Quality is 60% of Development Cost for CMM Level 1
- He used manufacturing for CMM level 5 assuming that excellent organizations can cut CoQ by 67%
- Other levels are determined accordingly. For example, he predicts that an organization at CMM Level 3 would be at 50% CoQ with a conformance to nonconformance ratio of 0.5
- Knox model is considered a good predictor for Total Cost of Quality but not necessarily the details

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Another Definition for Quality Costs

Quality Costs = Actual Cost of Providing Product or Service - Cost of Only Value-Added Activities

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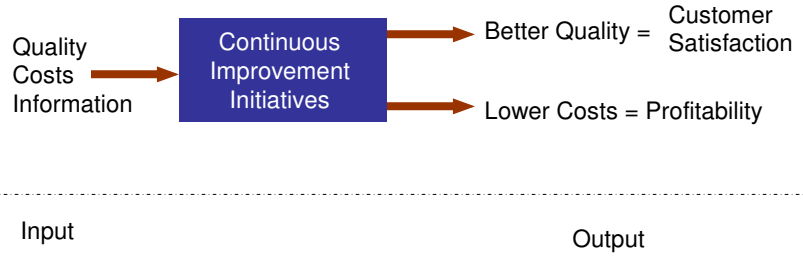
Quality Costs as Input



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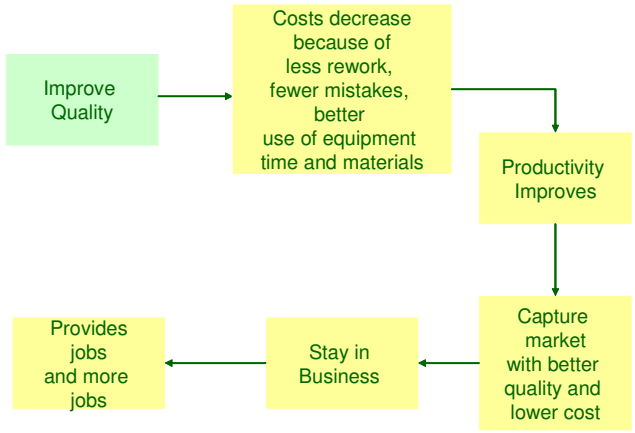
Deming's Chain Reaction Model

Deming
1900-1993



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Juran on Quality Costs

- "In the US, about one-third (33%) of what we do consists of redoing work previously done!"
- Examples
  - Manufacturing: scrap, rework, additional inspection
  - Service: Rewriting insurance policy, Losing luggage, wrong prescription, wrong order returned, re-installing software

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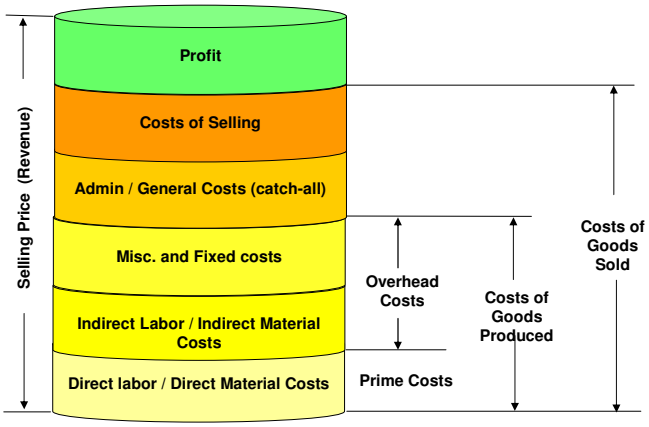
Juran on Quality Costs - Cont'd

- Quality-related costs are estimated to be between 20% and 40% of sales
- Quality costs extend beyond manufacturing to support and logistics
- The bulk of quality costs are related to poor quality (Failure Costs)

Traditional Cost Structures

Category	Examples
Direct Material	Plastic product: resin; Hamburger: bun
Direct Labor	Production Operator, Packaging Associate; Cook
Indirect Materials	Costs consumed in the operation but not a part of the end product or service. Examples: perishable tools, shipping materials.
Indirect Labor	Supervisors, Maintenance personnel, Material handler
Fixed & Misc. Expenses	Depreciation, Taxes, Rent, Utilities, Design Engineering (for Mfg), Scheduling, Customer Service
Cost of Selling	Marketing, Sales, Advertising, Invoicing, Warehousing, Shipping
Admin / General Costs	This is a catch-all category. Examples include Public Relations, Legal, Financial, etc.

Traditional Cost / Revenue Structure



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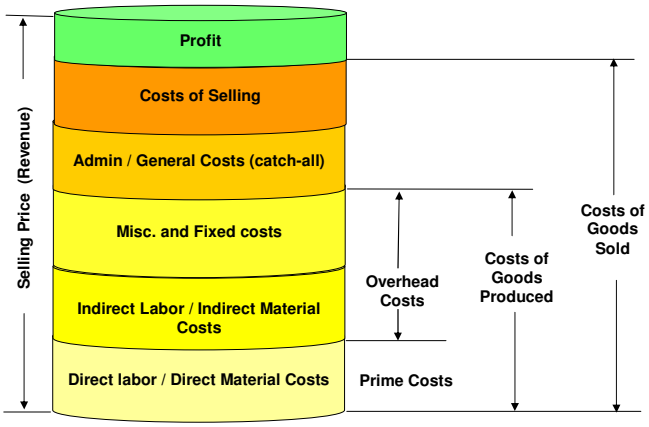
Increasing Costs of Quality



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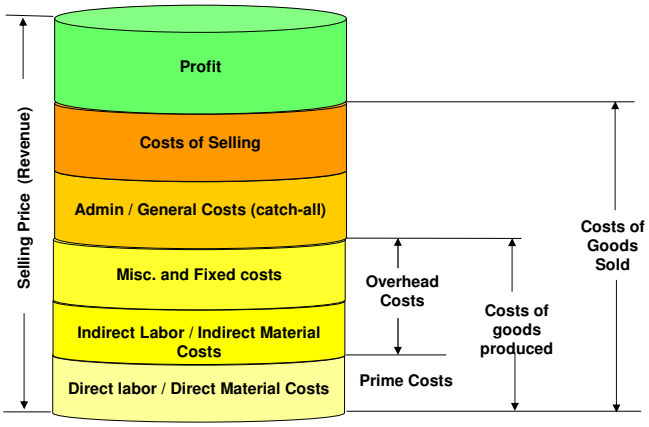
Decreasing Costs of Quality



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Capturing Quality Costs

- Hidden quality costs are like variation within a process.
- If you do not understand their sources, then you accept them as common causes
- If you design the system to catch them, you'll be able to isolate and remove their root causes

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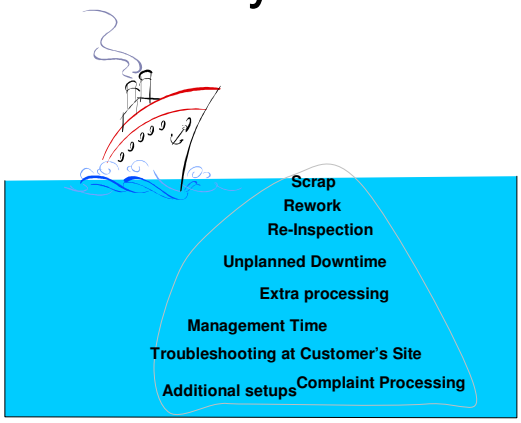
Hidden Costs of Quality

- Only few quality costs are obvious (tip of the iceberg)
- Westinghouse Electric reported a multiplier effect of 3 to 4 due to hidden costs of failure costs



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More Examples of Hidden Costs of Quality

- Extra Inventory
- Premium freight
- Unexpected overtime
- Lost machine capacity
- Re-scheduling production
- Emergency material purchases (small lots)
- Extra wear / tear on equipment
- Overtime for troubleshooting

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Hidden Costs of Quality

- Most quality costs that are related to failure are hidden because the typical accounting system classifies them by the type of cost, not by their cause
- Historical records of quality costs suggest that for every $1 of scrap / rework, there is $6 to $7 in hidden costs

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High Quality Costs Impact

- Increased quality costs inflate production cost which may result in:
  - Utilizing inferior material / service to compensate
  - Increasing the selling price of the product or service
- Increased quality costs results in image problems due to:
  - Defective product
  - Dissatisfaction of customers

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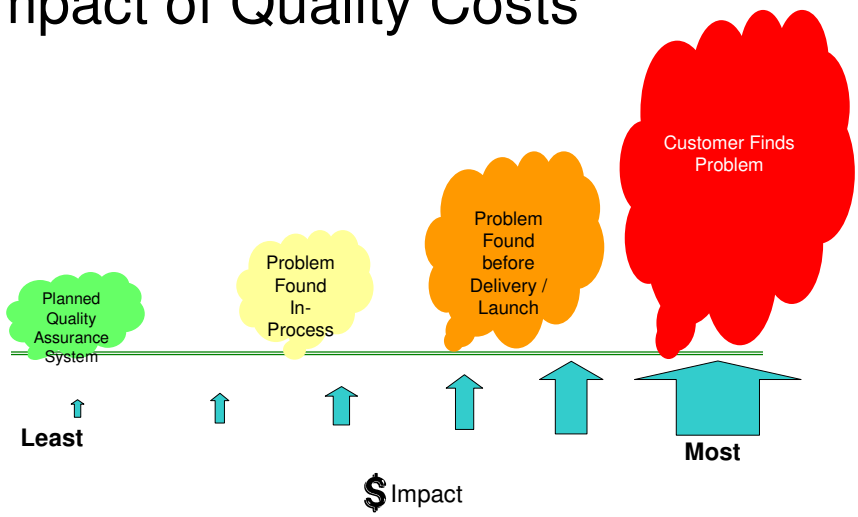
Impact of Quality Costs



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Typical Manufacturing vs. Software Cost of Quality

- Manufacturing
  - Quality Related Costs are 20% to 40% of sales
  - CoQ for good performing companies are between 2% and 5%, most of which should be preventive
- Software
  - Range between 10% to 70% of Development Cost
  - Knox's Model is sometimes used with surveys to determine contribution by each step in the development cycle

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CoQ Data Collection

- Best Case
  - Departmental Accounting
  - Schedules
  - Time Reports
  - Defect Reports
  - Outsourcing / Purchasing Records
- Worst case
  - Interviews to determine estimates

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Reporting Cost of Quality Information

- To compare over time, between divisions or between projects, it is best to report CoQ information in terms of ratios:
  - Total CoQ/Sales
  - Total CoQ/CoGP
  - Total NC-CoQ/CoGP
  - Internal Failure Cost/ CoGP
  - External Failure Cost/ CoGP
  - Appraisal Cost / CoGP
  - Prevention Cost / CoGP
- In Software, you can substitute “Development Cost” for “CoGP”

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Taguchi Quality Loss Function

- The Taguchi philosophy:
  - Cost cannot be reduced without affecting quality
  - Quality can be improved without increasing cost (also Crosby's "Quality is Free")
  - Cost can be reduced by improving quality
  - Improving quality can be achieved by reducing variation

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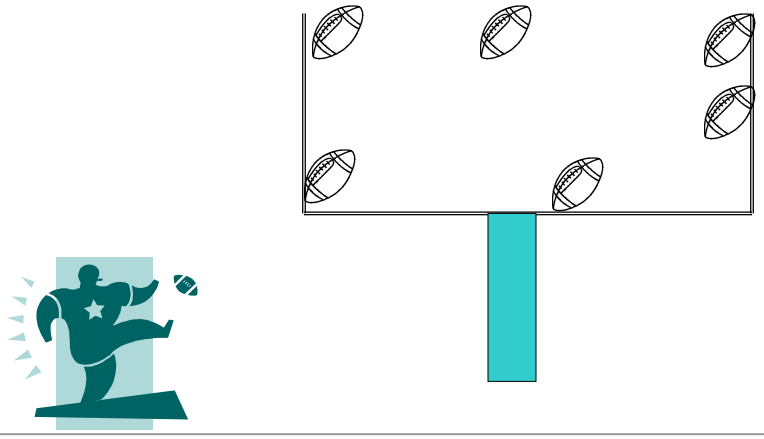
Taguchi Quality Loss Function - Cont'd



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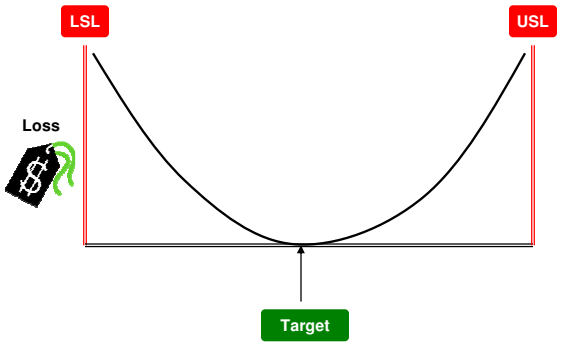
Taguchi Quality Loss Function - Cont'd



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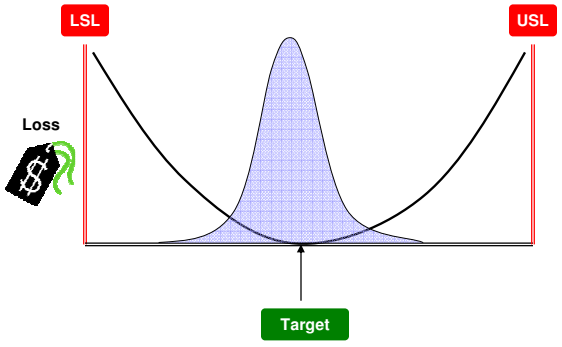
Taguchi Quality Loss Function - Cont'd



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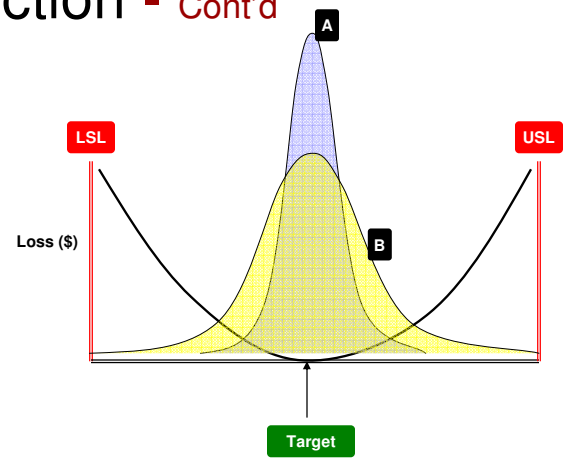
Taguchi Quality Loss Function - Cont'd



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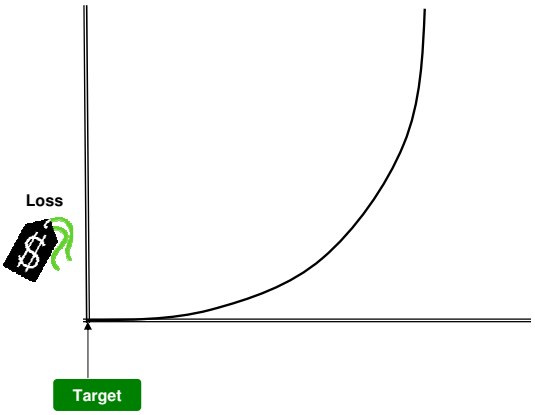
Taguchi Quality Loss Function – Lower Is Better- Cont'd



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Case Study: Results & Analysis

- Cont'd

Quality Cost Item	January				February				March				
	% of Salary	Hours	$	Total $	% of Salary	Hours	$	Total $	% of Salary	Hours	$	Total $	
Outside Calibration Service			$500	$500			$500	$500			$500	$500	A
Ongoing Incoming Inspection		25		$500		20		$400		20		$400	A
Third Party Audits -by a Registrar-				$0				$0			$1,500	$1,500	A
Process Audits	10%			$500	10%			$500	10%			$500	A
Regular In-process Inspection		20		$400		20		$400		20		$400	A
Processing Customer Complaints	8%			$400	10%			$500	10%			$500	EF
Sorting and Replacing Due to Customer Returns		50		$1,000		40		$800		35		$700	EF
Downgrading Differential (Found by customer)			$2,000	$2,000			$1,500	$1,500			$1,500	$1,500	EF
Travel Expenses to Customer Site for Sorting			$1,500	$1,500			$1,000	$1,000			$1,500	$1,500	EF
Premium Freight Due to Customer Complaint			$2,500	$2,500			$2,000	$2,000			$1,500	$1,500	EF
Re-inspecting after Machine Alarm		40		$800		40		$800		50		$1,000	IF
Troubleshooting process failure		15		$300	10%			$500	8%			$400	IF
incoming Inspection for a Problem	5%			$250	10%			$500	5%			$250	IF
Scrap Differential (found in-house)			$7,500	$7,500			$2,500	$2,500			$3,000	$3,000	IF
Unplanned Machine Downtime			$2,000	$2,000			$2,500	$2,500			$2,000	$2,000	IF
Overtime Resulting from Process Failure		60		$1,200		30		$600			$40	$40	IF
Lost capacity due to internal process failure			$3,000	$3,000			$2,000	$2,000				$0	IF
Quality Planning	10%			$500	10%			$500	10%			$500	P
Poka Yoke Device			$1,500	$1,500				$0				$0	P
Scheduled Preventive Maintenance			$1,500	$1,500			$1,500	$1,500			$1,500	$1,500	P
Supplier Development Expense			$1,200	$1,200			$200	$200			$200	$200	P
Quality Education				$0				$0				$0	P
Marketing research	10%			$500	10%			$500	10%			$500	P
Statistical Analysis and Preventive Action	10%			$500	15%			$750	15%			$750	P
Total				$30,050				$20,450				$19,140	

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Case Study: Results & Analysis

- Cont'd

	Jan	Feb	Mar	Total
Prevention	$5,700	$3,450	$3,450	$12,600
Appraisal	$1,900	$1,800	$3,300	$7,000
Internal Failure	$15,050	$9,400	$6,690	$31,140
External Failure	$7,400	$5,800	$5,700	$18,900
Total Costs of Quality	$30,050	$20,450	$19,140	**$69,640**
Cost of Goods Produced	**$110,000**	**$110,000**	**$110,000**	**$330,000**
Sales	**$200,000**	**$200,000**	**$200,000**	**$600,000**

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Case Study: Results & Analysis

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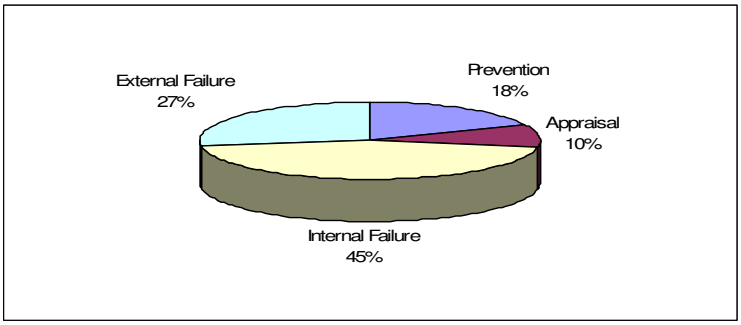

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Case Study: Results & Analysis

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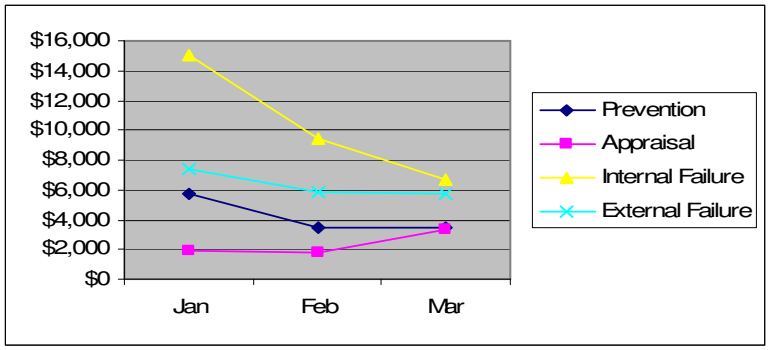

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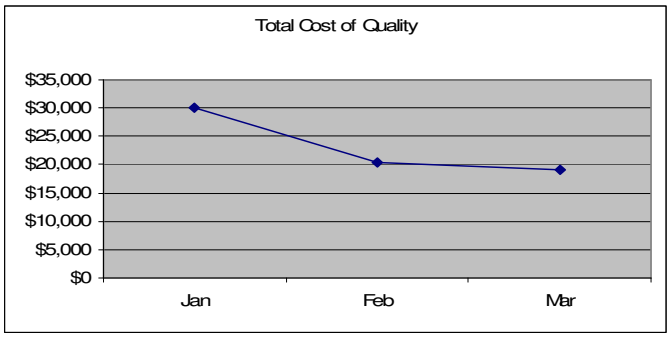

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Case Study: Results & Analysis

- Cont'd

Summary of Quality Costs

	Jan	Feb	Mar	Total	Annual Projection
Prevention	$5,700	$3,450	$3,450	$12,600	$50,400
Appraisal	$1,900	$1,800	$3,300	$7,000	$28,000
Internal Failure	$15,050	$9,400	$6,690	$31,140	$124,560
External Failure	$7,400	$5,800	$5,700	$18,900	$75,600
Total Costs of Quality	$30,050	$20,450	$19,140	**$69,640**	**$278,560**
Cost of Goods Produced	**$110,000**	**$110,000**	**$110,000**	**$330,000**	$1,320,000
Sales	**$200,000**	**$200,000**	**$200,000**	**$600,000**	$2,400,000
Total Costs of Quality / Sales	**0.15**	**0.10**	**0.10**	**0.12**	**0.12**
Costs of NC / Costs of Goods Produced	**0.20**	**0.14**	**0.11**	**0.15**	**0.15**
Internal Failure Costs / COGP.	**0.14**	**0.09**	**0.06**	**0.09**	**0.09**
External Failure Costs / COGP.	**0.07**	**0.05**	**0.05**	**0.06**	**0.06**
Prevention Costs / COGP.	**0.05**	**0.03**	**0.03**	**0.04**	**0.04**
Appraisal Costs / COGP.	**0.02**	**0.02**	**0.03**	**0.02**	**0.02**

If well-performing companies keep their total cost of quality – to – sales ratio within 5 % (mostly in prevention costs), how do you rate this company?

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