

The Illusion of Quality: Controlling Subjective Inspection

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Abstract

An inspection process that depends on subjective evaluation may give a misleading image of product quality. An experiment was conducted at an electronics company to measure the accuracy of inspectors' judgements on the acceptability/rejectability of electrical connections. Using a statistical measure of agreement, it was found that inspectors were accepting a high proportion of electrical connections that should have been rejected. After identifying management deficiencies, recommendations are given for improving the accuracy of the inspection process.

Introduction

Almost every manufacturing organization in the U.S. today is facing a number of critical challenges precipitated by increased global competition and technological change (Peters and Waterman, 1982). Organizations are struggling to lower product cost while at the same time attempting to increase the overall quality of their products (Harrington, 1987). While some might argue that it is a rather straightforward process to diagnose and analyze the problems of how to reduce costs and increase efficiency, the problem of improving the quality of manufactured goods is a more complicated and all encompassing task (Iacocca, 1984).

Organizations are spending millions of dollars and man-hours attempting to implement "quality improvement processes" that generally combine "quality" training for the workforce, improved product standards, quality circles and worker involvement programs, zero-defect philosophies, statistical process controls, and enlightened approaches to management (Crosby, 1979; Walton, 1986). Traditionally, product quality was the primary responsibility of the quality control department. Now the traditional role of the quality control department is being changed by the philosophy that "quality should be everyone's primary concern" (Crosby, 1984).

This view has caused organizations to rethink the traditional role of the quality control department. In the past quality control departments were used primarily for purposes of "after-the-fact" inspection, i.e., searching for product defects. Today, quality control managers and departments are generally responsible for coordinating

a full gamut of activities that affect product quality in addition to their traditional role of "inspection." These activities can generally be classified into one of three broad categories: 1) quality education; 2) worker force involvement; and 3) quality improvement (Feigenbaum, 1983).

The primary goal of these activities is to focus on improving quality and eliminating manufacturing defects prior to and during the manufacturing process itself. Yet, no matter how proficient these efforts and activities are during the manufacturing process itself, stringent quality standards generally dictate that the quality control department enact its traditional role of product inspection (Harrington, 1987). The key person in the quality inspection process is the quality control inspector who is responsible for some form of subjective (personal) and/or objective (scientific) appraisal to determine if a product meets some predetermined level of quality (Feigenbaum, 1983).

While many factors will affect decisions on when, where, and how to inspect a product two outcomes are clear. The inspection process of any manufactured product affects both the final quality and cost of that product - the very issues that U.S. manufacturing organizations are currently struggling with (Meagher and Scazzero, 1985). Inspection also represents the organization's last attempt to ensure product quality (Juran and Gryna, 1980).

A product that passes inspection is assumed to meet

required quality standards while a product that fails inspection is subject to either rework or scrap. Two types of errors can be made however during the inspection process. If a product that should be rejected passes inspection the organization's overall efforts to ensure quality and guarantee customer satisfaction have failed. If a product meets the organization's quality standards and is mistakenly rejected the overall costs of goods will rise. Thus, a great deal is riding on the overall quality of the quality inspectors' decision-making process. This is true whether a manufacturing organization has implemented a comprehensive quality assurance program or is simply using the traditional after-the-fact approach.

In many circumstances, the inspection process involves difficult subjective evaluations which often lead to conflicts between the production departments and quality inspectors. Thus a critical question arises, "How does an organization determine if its inspectors are making effective and correct decisions?" Since the outcome of the inspector's decision affects product quality and product cost, the answer to this question is very important to any manufacturing organization's long-term success.

While there is a great deal has been written on how quality inspectors should do their jobs, very little research exists on evaluating the quality of the inspector's decision-making processes. In this paper we will discuss the efforts of a Fortune 100 electronics manufacturing organization to determine if inspectors were accurate in their subjective assessment of product quality. This research was undertaken when production managers felt that quality inspectors were overly critical in the inspection process. Production management believed that overly critical subjective evaluation resulted in increased costs, delays, and scheduling problems which created hostility and tension between the production and quality departments. To resolve this dilemma, a study was conducted to determine if quality inspectors in this organization were accurate in their appraisals of manufactured electronic components. In addition, insight is offered into what steps organizations can take to enhance the performance of quality inspectors to insure accuracy and consistency in their subjective inspection decisions.

Method

Design

In an attempt to determine the accuracy of an inspection process that involved subjective evaluations, a controlled experiment was performed involving all 33

inspectors in an electronics division of the organization involved in this study. The inspectors were tested on their ability to perform their inspection duties on electrical connections regularly manufactured in this division. The average age of the participants was 47 years with an average of 12 years of inspection experience with the organization.

After union cooperation was obtained, a meeting was held with the inspectors involved. The inspectors were informed that an experiment was being conducted to evaluate the company's training program. They were told that they would evaluate two electrical chassis according to Workmanship Standards (these standards covered not only electrical connections but also such items as wiring, solder, and cleanliness). These electrical chassis were commonly seen by inspectors and were part of the company's regular product line. These chassis, however, had sustained some external damage that made them unsuitable for customer delivery but suitable for the experiment. In order to minimize bias, the inspectors were not told that the primary interest of the experiment was their evaluation of electrical connections. In addition, certain other types of defects were inserted into the chassis to prevent special attention to the electrical connections by inspectors.

To ensure that each inspector's evaluation was recorded accurately and performed under regular working conditions and recorded accurately the following steps were taken:

- 1 Both electrical chassis were carried to an inspector at his/her work station. Verbal and written instructions, reviewing the purpose of the experiment and pledging confidentiality, were given to the inspector.
- 2 The inspector was asked to place a red dot on any item that he/she felt were rejectable according to Workmanship Standards. Although no time limit was set, each inspector was asked to take approximately the same amount of time that he/she would under normal circumstances.
- 3 After both chassis were inspected, a Quality Engineer brought the units to a private area and recorded the inspector's evaluations of each electrical connection.
- 4 After recording an inspector's evaluations, the red dots were removed and the chassis were brought to another inspector. Each inspector agreed not to ask for help or discuss their results with any other inspector.
- 5 The process was repeated until all 33 inspectors had

completed evaluating the same two electrical chassis on an independent basis.

Analysis

After the experiment, the evaluations of each inspector were compared to those made by a Committee of "Experts" which determined the true acceptability/rejectability of each electrical connection. Out of a total of 153 connections in both chassis, 111 were acceptable and 42 were rejectable according to the Committee of Experts. Since each inspector also classified each electrical connection as either acceptable or rejectable, a 2 x 2 table was constructed for each inspector. This 2 x 2 table was used to compute Cohen's Kappa, a statistical measure that assesses the degree of agreement between the Committee and an inspector (Bishop et al., 1975). The resulting Kappa value was then used to assess the accuracy of each inspector's judgment of product quality.

Cohen's Kappa, K, is a measure with desirable properties. Like a correlation coefficient, K = 1 indicates complete agreement between the Committee and the inspector. If the observed agreement is greater than or equal to that expected by chance then $K \geq 0$. Similarly, if the observed agreement is less than or equal to chance then $K \leq 0$. The minimum value of K falls between 0 and -1. A key feature of Cohen's Kappa is that it incorporates a correction for chance-expected agreement.

To illustrate how to compute Cohen's Kappa, consider Table 1 for one inspector in the experiment.

Then,

$$K = \frac{\% \text{ agreement} - \% \text{ agreement due to chance}}{100\% - \% \text{ agreement due to chance}}$$

$$K = \frac{(105+17)/153 - [(111)(130)+(42)(23)]/(153)^2}{1 - [(111)(130)+(42)(23)]/(153)^2} = .41$$

In order to interpret different Kappa values, Landis and Koch (1977) suggested the following guidelines: $.61 \leq K \leq 1.00$ - excellent; $.41 \leq K \leq .60$ - moderate; and $K \leq .40$ - poor. Thus, the above Kappa value of .41 indicates a moderate degree of agreement between the inspector's evaluation of the electrical connections and the actual quality of the electrical connections based on the judgment of the Committee.

When the individual Kappa values for the 33 inspectors were categorized using Table 1, the results in Table 2 were obtained:

Table 2 shows that almost all the inspectors had poor agreement with the Committee of "Experts" on the acceptability/rejectability of electrical connections. Further analysis showed that the poor agreement was largely due to the inspectors' inaccurate evaluations of the rejectable electrical connections, i.e., the inspectors were accepting a large proportion of electrical connections that should have been rejected.

Production management were especially surprised by these results since they had originally accused the inspectors of being too critical in their evaluations. But the reverse was actually true - the inspectors were too lenient.

Discussion

The initial impetus for this experiment was a belief on the part of the production management team at this organization that quality inspectors were being too critical in their evaluation of electronic connections. This group was especially surprised by the results of this experiment which clearly demonstrated that the reverse was actually true - the inspectors were too lenient in their subjective evaluations. As a result of the inspectors' poor performance in this experiment, management realized that their perception of high product quality for these types of connections might actually be inaccurate. Management erroneously assumed that because a quality inspection process was in place, product quality would be carefully monitored and controlled. By accepting quality inspection reports without question, on a process that required subjective evaluation, management was operating under the "illusion" of high quality. That is to say, they believed that quality was assured by the inspector's activity when in fact inspectors were accepting poor quality and were not requiring needed rework.

A follow-up investigation was then conducted to determine the cause of the inspectors' poor performance in the experiment. A number of critical deficiencies emerged based upon interviews with both the quality inspectors and their supervisors. First, inspector training was found to be deficient in a number of areas. Inspectors were taught about the acceptability/ rejectability of electrical connections off-the-job by being shown pictures of connections that had varying degrees of quality. They did not, however, actually see these different types of connections in person. The only connections that they saw in person were extreme cases,

Table 1. 2 x 2 Table Comparing the Evaluations of the Committee with An Inspector

		Inspector		Totals
		Acceptable	Rejectable	
Committee	Acceptable	105	6	111
	Rejectable	25	17	42
	Totals	130	23	153

Table 2. Summary Results of Inspectors' Evaluations

<u>Degree of Agreement Beyond Chance</u>	<u>Number of Inspectors</u>	<u>%</u>
Excellent	0	0
Moderate	2	6
Poor	<u>31</u>	<u>94</u>
	33	100

i.e., the very good or the very bad. As a result, the inspectors had a poor basis for judging marginal connections, which comprised a substantial portion of all connections. Thus an inspector's initial training focused on identifying extreme cases, was passive in nature, and lacked experiential learning which provided an incomplete knowledge base for new inspectors.

In addition, when new inspectors did receive on-the-job training it was from an inspector who had gone through the exact same training program so the coaching they received was from a potentially unreliable source. If an inspector was not sure about the acceptability/rejectability of a connection, he/she would ask another inspector. Since most inspectors did not know the true standards, the response obtained would vary from inspector to inspector and connection to connection. In summary, this organization provided its inspectors with training that was incomplete and lacked sufficient rigor to reduce the subjectivity of the evaluative process. As a result, the door was opened for ineffective quality inspection (Crosby, 1984; Harrington, 1987).

Secondly, quality standards had changed over a period of years and no refresher or follow-up training had taken place to upgrade the inspectors' skills and knowledge levels to effectively respond to these changes. Management assumed that inspectors would simply adjust to the new standards by themselves. Research continues to show that workers must be trained and conditioned to respond to changes in quality standards at all levels (Deming, 1989).

Thirdly, quality inspectors received little if any feedback on their performance. They were left on their own to do their jobs with a minimum amount of interaction and input from their immediate supervisors. Thus, no steps were taken on a daily basis to ensure that inspectors were doing their jobs effectively and the absence of specific performance feedback resulted in inspectors operating "in the dark" in terms of their overall performance. Without effective feedback inspectors can become demotivated and develop bad habits that can reduce the overall effectiveness of the inspection process (Stitt, 1989; Walton, 1986).

Ultimately, the reasons for the poor performance of the inspectors can be directly attributed to management. Management virtually ensured the poor performance of a group of workers who were interested in doing a good job

by not providing quality training, upgrading the skills of their inspectors as quality standards changed, and providing regular performance feedback. This situation illustrates the position of both Deming (1989) and Juran and Gryna (1980) who clearly state that the bulk of quality problems are due to an inability of management to provide effective support and leadership to their workers.

When management was presented with these results, they decided to put all the inspectors through a new more intensive training program. This program emphasized visual assessment of a wide variety of electrical connections, experiential learning, and on-the-job coaching. As a result of the new training, the inspectors felt more confident in their ability to evaluate electrical connections. They also received more regular feedback from their superiors in terms of their performance against new quality standards. Workers were more satisfied and had higher self-esteem than before the experiment which was partially due to the fact that they could perform their jobs more effectively and that management took an interest in helping them do a better job.

It has been said the quality does not just happen it requires hard work and effort (Crosby, 1984). Nowhere is this more true than in the quality inspection process of a manufacturing organization that is counting on its inspectors to safeguard against defects and customer disappointments. Quality inspection does not guarantee quality unless those doing the inspection are properly trained, motivated, and managed especially when subjective inspection is involved. One thing is clear from this study: accurate quality inspection requires both leadership and support from management.

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