Design and Implementation of a Quality Assurance Process for Hydraulic Elevator Installations

by

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B.S. Civil Engineering, U.S. Military Academy, 1990

Submitted to the Sloan School of Management
and to the Department of Civil and Environmental Engineering in partial fulfillment for the degrees of

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Abstract

Otis Elevator Company measures product quality primarily by monitoring all breakdowns, or callbacks, at a central office. Elevators tend to have the highest callback rate during the first several months of operation. This problem is further compounded because this coincides with the customer's formative impressions regarding the caliber of the elevator purchased.

A large portion of the newly installed elevator callbacks can be directly categorized as installation-specific. Otis employees install several different types of elevators in a variety of construction environments. Employees also vary widely in training and skill levels. Contributing to the nonstandard milieu is the unwavering pressure to reduce the total number of installation man-hours in efforts to trim costs. This frequently results in a rushed installation.

Otis inspects all installations prior to presenting the product to the customer. This is known as a Handover Inspection. Besides ensuring a high quality elevator installation, the inspection also serves to transfer, or "handover" of responsibility from the installers to other Otis employees who will be servicing the unit. Research indicates that employees place little value on the handover inspection for a variety of reasons, and that the policy is not firmly enforced. Improper handover inspections do little to prevent installation-related callbacks, which costs Otis hundreds of thousands of dollars annually.

The essence of the problem is to understand the intent of the Handover Policy. Because the handover serves to ensure quality by preventing callbacks, then one must research the problem areas within a particular product, and tailor the handover inspection to target these areas. The existing handover inspection questions are inadequate in addressing the parts that frequently fail due to improper installation.

The issue is further exacerbated by introducing a new handover system to a culture which is cynical of change. A greatly improved process will mean little if it is not enforced or the employees do not perform a thorough inspection.

This thesis analyzes these issues and shows the following proposed solutions:

- Research callbacks of newly installed elevators. Uncover those that are installation-specific. Develop an inspection process that focuses on the high callback areas.

- Design quality checks that occur **during** the installation process, rather than at the end. This can substantially reduce rework costs.

- Incorporate a higher level of ownership among elevator installers.

- Standardize the installation of a laborious part by the introduction of a new tool.

- Write an improved Handover policy that is easily understood, incorporates a higher level of managerial involvement, and ensures an "on-site" Handover inspection.

- Implement the new Handover policy and quality checks nationally, with minimal resistance from field employees.

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My advisors, Don Rosenfield and Charles Helliwell, thanks for their inputs, direction, and interest in this project.

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1. Thesis Overview

The purpose of this overview is to provide background information pertaining to the thesis research, discuss the thesis goals, preview data collection methods, and lastly, provide a summary of the remaining chapters.

1.1. Background

Most of the thesis research occurred during my six month internship with Otis Elevator Company in Bloomington, Indiana. I was a peripheral member of a team that was dedicated to reducing reliability problems associated with certain types of elevators. My project was one that was of moderate importance to the team, but had never been a high priority to justify committing scarce personnel resources.

1.2. Thesis Goals

By writing this paper, I hope to accomplish several personal goals:

- Demonstrate to Otis how I arrived at my solutions, and to also further illustrate that a heightened awareness of elevator installation quality can significantly contribute to the profitability of the company.
- Explore a real world problem in depth, apply the tools that I have learned at MIT, and offer an optimal, viable solution.
- Develop a logical methodology of quality assurance that can be easily understood and transferred to other functional areas within a company. Quality has become the focus

of many companies. Enacting new policies and metrics to monitor this qualitative and abstract term is difficult to do. Perhaps this thesis can provide a basic framework for others to approach solving quality related problems.

1.3. Data Collection

Research took many forms for this paper. A comprehensive combination of retrieving numerical data and interviewing dozens of Otis employees provided most of the information. Global benchmarking against other methods of elevator inspections, as well as researching many books devoted to the subject of quality initiatives also contributed to the inputs.

1.4. Overview of the Remaining Chapters

Chapter 2 provides background on the elevator industry. The following is discussed: the role of elevators in the new construction industry, the cyclical trends in yearly elevator sales, and elevator life cycle costs. The industry is profitable, but tied largely to the strength of the construction sector. The remainder of the chapter is dedicated to the explanation of the company's organizational structure and to the defining of the problem.

Chapter 3 details the initial research method used in order determine the scope of the problem. It primarily involves database sifting and sorting.

Chapter 4 begins by outlining the current means by which the company's elevators are inspected. This chapter is primarily devoted to explaining the research from interviews, best practices, benchmarking, current academic literature, and the newest quality programs in other industries.

Chapter 5 discusses the root cause analysis of the installation-related quality problems. It includes a comprehensive systems diagram that shows the interrelationships that lead to these types of callbacks. Also, the constraints placed upon any implementable solutions are explained in this chapter.

Chapter 6 outlines the proposed solutions that I recommend based upon all of the prior inputs. The bulk of the solution lies in policy change that will change the fundamental way that the elevators will be inspected, and how the system will be monitored. However, one solution to a reliability problem is presented in the form of a new tool that will assist mechanics with a part that is difficult to install properly. This tool is pending patent.

Chapter 7 discusses the issues encountered with implementing major policy change. Pilot sites were used and modifications to the original plan are discussed. Also, the importance of networking and lobbying the decision makers in order to ensure the proposed changes will be allowed is explored.

Chapter 8 reviews the conclusions drawn from the research.

2. Elevator Industry and Problem Definition

"Give me a lever long enough and I can move the world."

-Archimedes

History records Archimedes as inventor and builder of an elevator similar in principle to those developed in the early 1900's.[1] Modern high-rise elevators still mechanically function based upon his quote. Also true is that the elevator, a modern "lever," does move the world. Roughly calculated, all of the elevators currently in service move the equivalent of the world's population every few days.

Early versions of the elevator were simple levers that Egyptians used to lift blocks in Pyramid construction. Later this concept evolved to a block and tackle system for such applications as constructing fortresses and lifting guillotines. Then, in 1853, Elisha Graves Otis changed the role of elevators to public conveyance when he successfully (and dramatically) demonstrated his safety elevator. This quickly shattered conventional building height limits and transformed the way cities were built.[2]

---

[1] F.A. Annett, Elevators: Electric and Electrohydraulic Elevators, Escalators, Moving Sidewalks, and Ramps (York, PA: The Maple Press Co., 1963) 1.
[2] Jean Gavois, Going Up (Hartford, CT: Otis Elevator Co., 1983) 10-11, 50.

2.1. The Role of Elevators in the Construction Industry

Elevators quickly became an integral part of the construction industry. Even at the advent of the twenty-first century, city skylines continue to grow to record heights as building and elevator technologies progress.

With the passage of the American Disabilities Act in 1988, elevators were further integrated into the construction industry. Simply put, all buildings over one story in height must have handicap access. This is predominantly accomplished via elevators.

2.1.1. Spending in the construction industry

The construction business is extremely cyclical in nature, generally following the overall strength of the economy. It is primarily anchored to the Federal Reserve's prime lending rate. The lower the cost of borrowing money, the more readily builders and prospective owners can obtain loans. Conversely, high interest rates can quickly make all major construction activities cost prohibitive. Figure 1 below represents the value of new

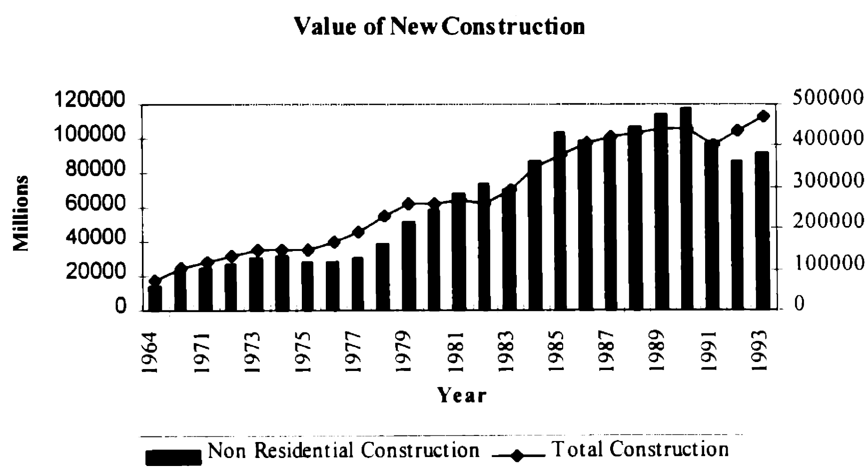

Figure 1

construction put in place in the United States during each year.[3] As elevators are primarily installed in nonresidential buildings, this closely links the elevator industry to the construction industry. Figure 2 shows the total elevator sales for the same approximate time era.[4] The chart is very similar to the nonresidential construction spending in Figure 1.

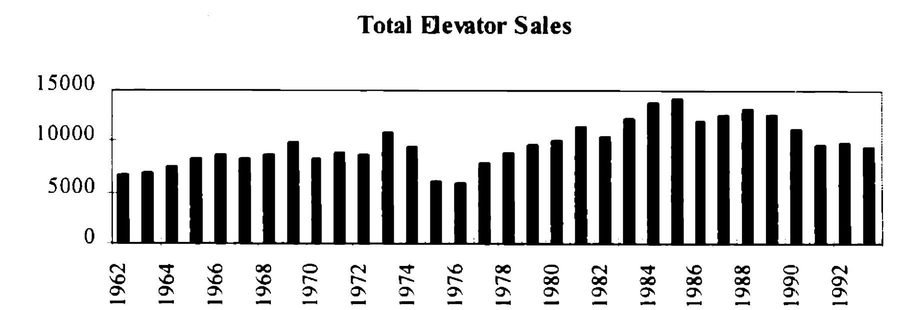

Figure 2

2.1.1.1.Elevator Industry unit sales in U.S. 1962-1993

Figure 3 on page 14 shows the history of the major elevator product lines for the past 30 years.[5] Hydraulic elevators typically serve buildings from 2-6 stops. Geared elevators serve mid-rise buildings and Gearless elevators suit skyscrapers. Though somewhat busy, the chart shows the shift in the types of buildings constructed over the years, and thus the types of elevators purchased by the builders.

[3] Bureau of the Census, Statistical Abstract of the United States, 1994 (Washington, D.C.: 1994) 726.
[4] "New Booked Sales Annual Summary," Elevator World, Oct. 1994: 8.
[5] Ibid.

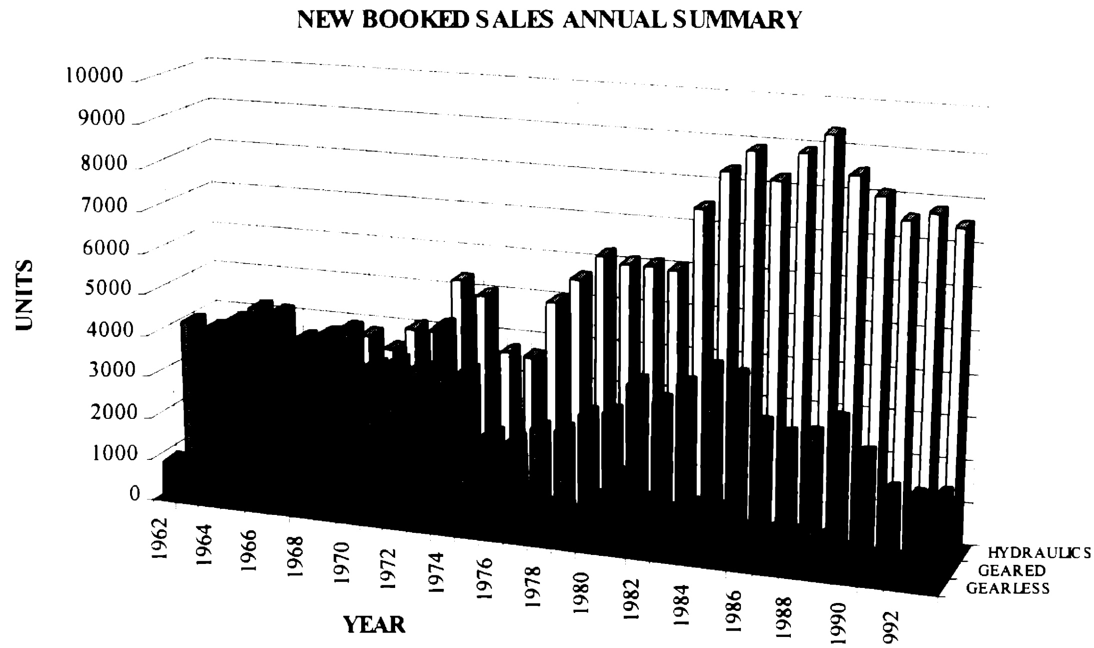

Figure 3

As the graph shows, while the Gearless market has virtually disappeared in the United States, the hydraulic elevator market has grown considerably.

2.1.2. Elevator cost as a percentage of total building cost

Elevators significantly contribute to the overall cost of a structure. Although costs vary based upon the building design and the type of elevator, architects and estimators refer to Means Building Construction Cost Data to obtain rough estimates. The following examples are considered "rules of thumb" in determining initial elevator costs.[6]

- For multi-story buildings and housing projects, elevators cost 2.5% to 4% of the total building cost.

[6] R.S. Means Company, Means Building Construction Cost Data (Kingston, MA: 1993) 302.

- For office buildings elevators cost 2.5% to 10% of the total building cost.

2.1.3. Life Cycle Cost

A life cycle cost analysis of elevators with various rises provides an interesting economic perspective. The average elevator has a design life of 20 years, but can last much longer. Industry experts often see elevators that function for 70 to 100 years before replacement.[7] Table 1 provides the principle elevator costs that confront building owners over the course of 40 years.[8] All of the cost categories vary widely, based upon several parameters which are discussed after the table.

AVERAGE LIFE CYCLE COSTS						
Elevator Type	**Purchase Price**	**Maintenance Contract**	**Power**	**Billable Repair**	**Moderniza-tion**	**Total Cost**
3 Stop Hydraulic	25,000 - 33,000	100 - 250 per month	100-250 per month	400 - 1000 per year	20,000 during life of elevator	101,000 - 193,000
15 Stop Geared	80,000 - 120,000	220 - 500 per month	100-250 per month	750 - 2000 per year	70,000 during life of elevator	241,800 - 410,000
30 Stop Gearless	200,000 - 350,000	600 - 1100 per month	100-250 per month	2000 - 2750 per year	100,000 during life of elevator	508,000 - 829,000

Table 1

[7] Telephone interview with Dennis White, Manager, Hydraulic Products, Otis Elevator Company, 10 Oct. 1994.

[8] Telephone interviews with Dennis White, Mic Maurer, Rick Pulling, Otis Elevator Company, 11, 28 Oct. 1994.

2.1.3.1.Purchase price

Purchase price includes the installation. Salesman typically use an elevator pricing system based upon the following variables:[9]

- New or renovation project
- Location of building
- Number of elevators
- Use of elevator
- Capacity of elevators
- Car speed
- Controls and operation of elevators
- Type of motor
- Total travel of elevator in feet
- Number of stops and openings
- Single or double entrance car
- Location and size of elevator machinery room or penthouse
- Kind of current available
- Size of hatch or platform
- Design of cab, doors, and frames
- Federal, state, local, and ANSI codes

2.1.3.2.Maintenance Contract

Salesmen also often utilize a computerized estimating system to determine maintenance contract pricing. Contract costs vary based upon type of service desired. A full maintenance contract can guarantee repairmen respond to an elevator breakdown within one hour, in addition to performing preventative maintenance regularly. An example of a less expensive maintenance contract could be one that only arranges for the repairmen to replace broken parts.

2.1.3.3.Power

Generally, elevators capture 2 to 4% of the building's power consumption. The primary variable is elevator usage, which varies upon building function. For example, office

[9] Frank R. Walker Company, Walker's Building Estimator's Reference Book: 24th Edition. (Lisle, IL, 1992) 14.1.

buildings are occupied approximately 12 hours per day, and hospitals operate 24 hours per day. The power costs will be considerably different.

2.1.3.4. Billable Repair

This category consists of vandalism to elevators, and any elevator repairs caused by construction crews. These repairs are considered separate from the maintenance contract. These costs are typically 15% of the maintenance contract price.

2.1.3.5. Modernization/Upgrade

Elevator modernization typically occurs once in the product life cycle. This upgrade could be as simple as interior cab renovation or as complex as changing from relay-based logic to solid-state. Costs vary based upon current building codes, which change over time. Also, a good maintenance program can substantially reduce modernization costs, or even prevent them altogether.

2.1.3.6. Total cost

The Total Cost column shows the wide range of elevator costs throughout a design life cycle. It also emphasizes the continuous capital investment required to retain operability. One last point of interest is that the Total Cost column is for one elevator only. Nearly every mid to high-rise building requires several, which means higher costs to the building owner throughout the product life cycle.

2.2. The Elevator Industry

The elevator industry is characterized by five to six major competitors dominating approximately 65% of the global market share. The remainder of the market is comprised of many smaller companies throughout the world that compete regionally.

Elevator companies serve all countries, but the relative low volume of the product only requires manufacturing facilities in few locations. The pie chart below depicts the estimated 1993 global market share in the elevator industry.

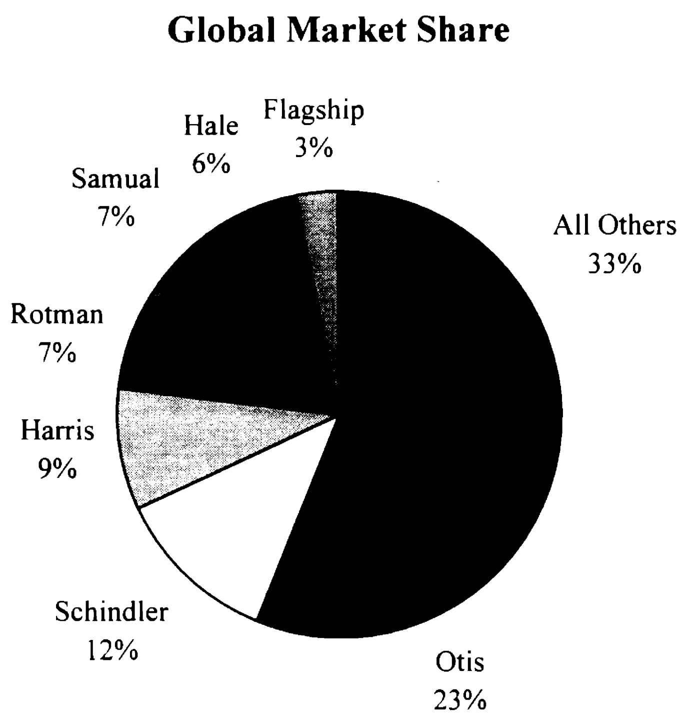

Figure 4

2.2.1. Market Shifts

Economically, elevator companies have migrated from "high rise = high margin" to "low rise = low margin." Figure 3 on page 14 demonstrates the transition that began in the late 1960's. Although the profit losses are somewhat offset by higher volume in the hydraulic products, technology in the hydraulic elevator has not changed substantially in the past 50 years. The "hydro" has become a fairly standardized, low margin product. The true profit margins of these elevators lie within the maintenance contracts, which will be discussed later.

2.3. Otis Elevator Company

I performed my research with Otis Elevator Company; the world's oldest, largest, and most respected company in the elevator industry. One interesting characteristic of this company is the decentralized organizational structure. The four divisions in Figure 5 below effectively delineate global responsibility, and each operates autonomously from the other.

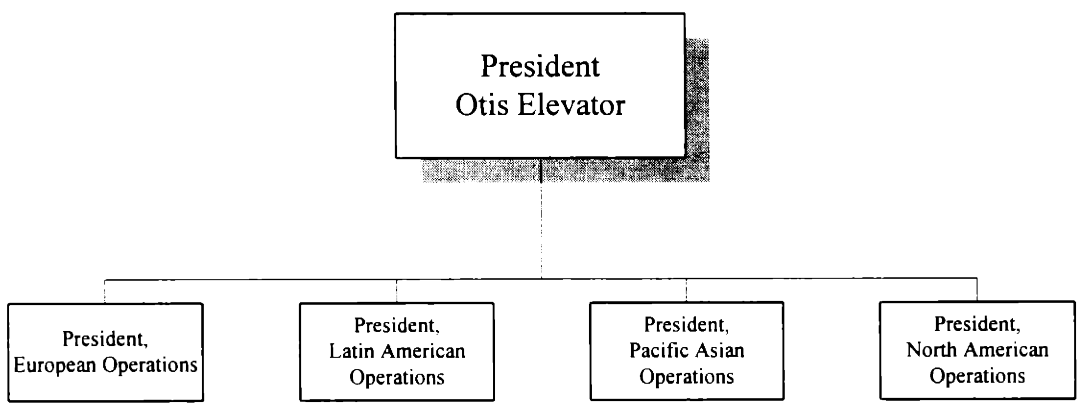

Figure 5

2.3.1. Bloomington's Organization

The manufacturing plant for the North American Operations is located in Bloomington, Indiana. The facility also contains a variety of other support functions as outlined in the organizational chart below:

OTIS ELEVATOR COMPANY

Bloomington Organizational Structure

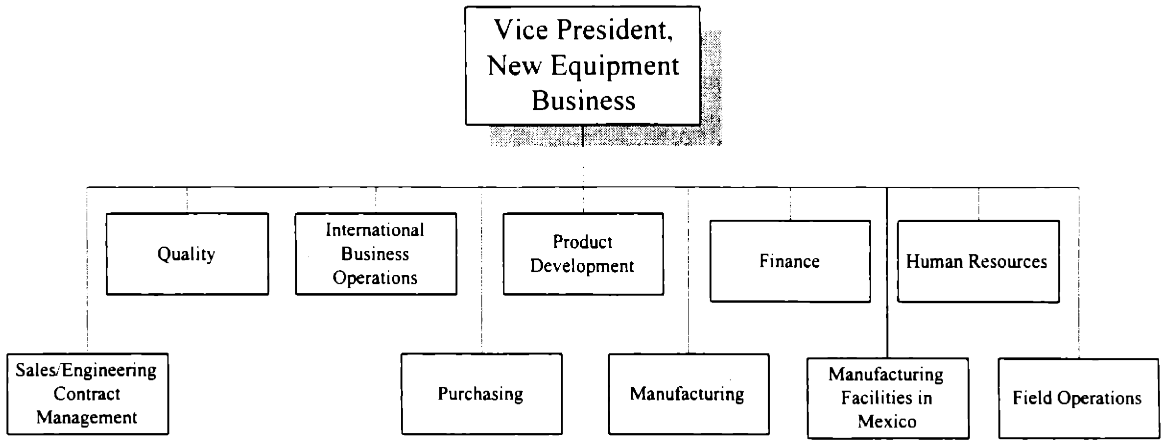

Figure 6

2.3.2. New Equipment Process

There are three distinct phases that occur after the sale of an elevator: manufacturing, installation, and service.

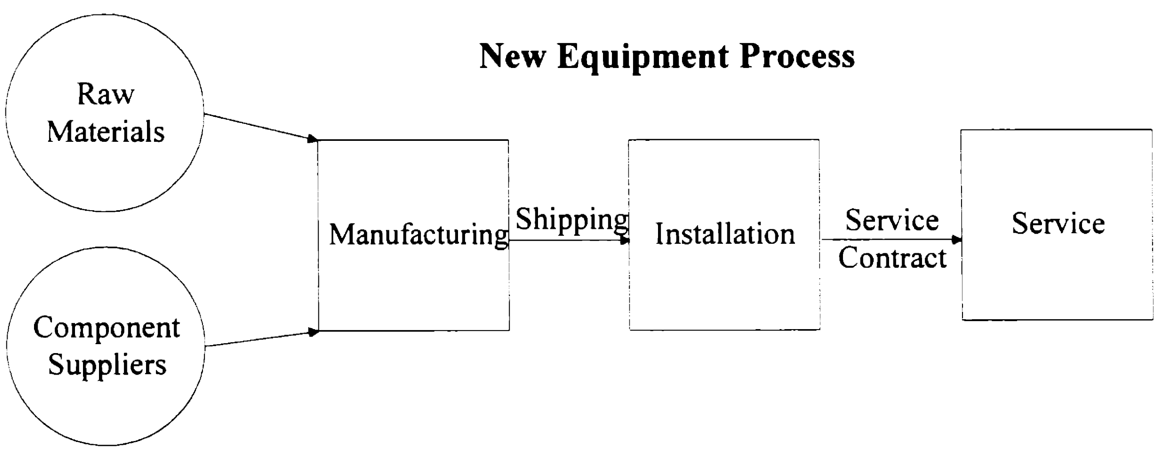

Figure 7

The Bloomington factory ships all elevator orders for North America, as well as many international locations. When the factory ships a contract order, it is not a complete, assembled elevator unit. A single hydraulic elevator shipment will average 22 boxes of parts, with some weighing in excess of 500 pounds. The reason for shipping parts, rather than a complete elevator is primarily due to the sheer size, weight, and complexity of an elevator system, in addition to the space constraints involved with installing an elevator in a building.

The shipment will be unloaded at the construction site by Otis installation mechanics who work at a local office. The boxes will remain on site until the building construction progresses to allow installation. A quality installation requires the mechanics to possess a great deal of training and skill, and consumes a great deal of the total elevator cost.

The last phase is the elevator service contract, often negotiated separately from the sales contract. Simply, the service contract obligates Otis to perform preventative maintenance and correct all callbacks (breakdowns) on the specified elevator. In exchange, the owner typically will pay Otis a flat monthly fee. The service contract generates literally all of Otis' profits, as the New Equipment and Modernization businesses do well to break even. Figure 8 shows each segment's revenue contributions for 1993.

Otis Revenues by Segment

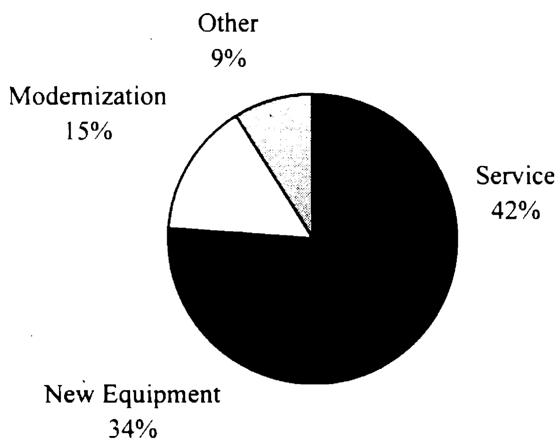

Figure 8

2.3.3. Pricing Strategy

Otis' pricing strategy is similar to most in the industry. Elevator companies will charge a low initial price to attract the General Contractor (GC) to purchase the elevator. GC's are typically very cost conscious, as margins in the construction business are comparatively low. Once the elevator is installed and the GC completes the building, the owner will be approached for the service contract. He has little choice for the elevators that operate over 1000 feet/minute, as they are too complex and proprietary to be serviced by any other company. Hydraulic elevators have a lower contract conversion rate because many small companies will offer to service the elevator for a lessor price. The service contract can amount to as much as the original purchase price of the elevator over the course of many years. This is also a high margin activity, as there are little associated costs in servicing elevators.

This type of pricing strategy is a pure form of price discrimination known as a two-part tariff. Customers pay a fee for the product and then pay additional fees to continue to utilize the product. It is designed to extract the most consumer surplus possible over a long period of time. Other forms of two-part tariffs are inexpensive Polaroid cameras and costly Polaroid film; shaving razors and expensive replacement razorblades.[10]

This type of pricing policy does not emphasize profitability in the manufacturing facilities and during the installations, because these activities are not treated as profit centers. In fact, elevators are occasionally sold for an amount that will actually lose money for the company. The holistic view is that a service contract will be obtained and the difference recouped over time.

2.3.4. Relationship to Field Offices

The Bloomington facility performs many support functions in addition to the manufacturing. Engineering, Field Support, and even Sales Departments are co-located within the factory. The support exists to the manufacturing operations, but is primarily geared to the field locations. These offices are responsible for the local sales, installation and service of the elevators within a given distance. This can range from a single Borough in New York City to several states in the midwest. The field offices are given

[10] Robert S. Pindyck and Daniel L. Rubinfeld, Microeconomics (New York: Macmillan Publishing Co., 1992) 388-392.

profit and loss responsibility for their operations, and Bloomington assumes a support role rather than another profit center.

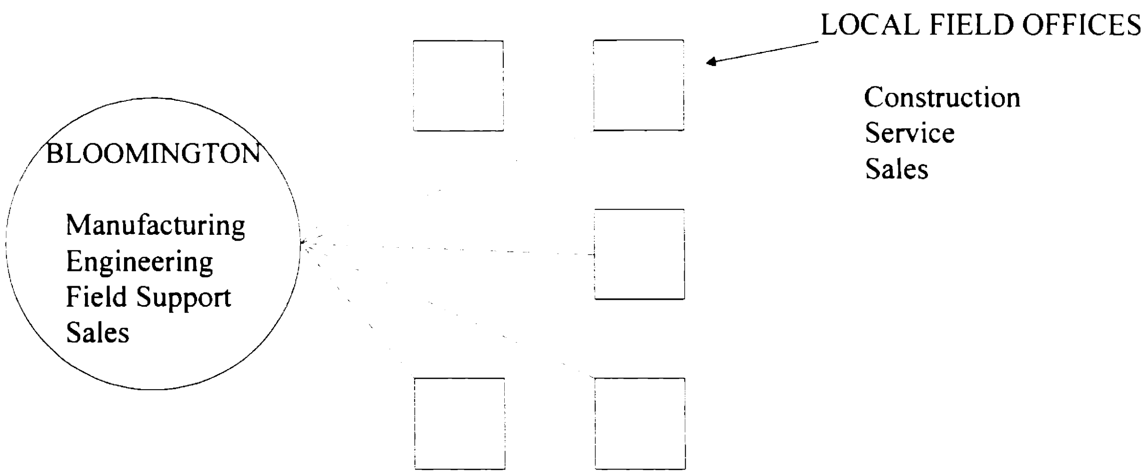

Figure 9

2.3.5. Role of Field Support Department

I worked with the Field Support Department. Its mission was to assist the field with installations and service as needed, drive productivity and quality improvements, and act as the interface with corporate headquarters. Field Support is comprised of three distinct teams. The first is Construction Support, which focuses on construction-related problems. Often this entails generating installation instructions and working with manufacturing and design to solve installation difficulties. Construction Support also monitors and drives field productivity.

The second group is the Callback Reduction team, which manages all for strategic products. This team interprets the quality level of the products through the callback rate. It rigorously pursues callbacks that trend by callback type or by building. Buildings that have uncharacteristically high callback rates are notified and closely monitored by higher management. This team also discovered several product design flaws by monitoring callbacks by type. The Callback Reduction team has measurable improved product reliability through a combination of managerial involvement and product improvements.

The last group is the Field Engineering team. Members are among the most knowledgeable in elevators and are a very valuable resource for Otis. These employees receive telephone calls from locations that cannot get their elevators to run correctly, and are asked to solve the problem(s). They spend many hours on the phone diagnosing problems, and occasionally have to personally visit a site in order to assist.

2.4. Otis' Problem

Otis frequently experiences reliability problems with its newly installed units. The company determines the quality of its elevators by two easily measured metrics: Ride Quality and Number of Callbacks. The two are often related; ride quality is correlated with few callbacks. The focus of this paper is only the callback issue. By introducing solutions to the early quality problems, the callback measurement can be driven down substantially. This also improves customer satisfaction and increases profitability through the reduction in maintenance costs.

2.4.1. Quality measured by callbacks

Callbacks are caused by one of the following: design flaws, improper installations, parts quality, parts wearing out, vandalism, and general customer abuse. Otis has dedicated vast amounts of resources to reduce design flaws and improve the quality of the manufactured parts. The service end of the business attempts to prevent the parts wear and the general customer abuse. Proper installations are accomplished through continuous training sessions, as well as final installation inspections, known as Handover Inspections.

2.4.1.1. Callbacks cost of millions of dollars annually

There are approximately 100,000 elevator units in North America with some type of Otis service contract. An estimated cost of the service to Otis can be calculated if an average callback rate of 4 per year per elevator is used:[11]

100,000 x 4 = 400,000 callbacks per year.

Using an estimated average cost of $200 per callback yields

400,000 x 200 = **$80,000,000 per year**

Obviously, any savings to the frequency or the cost of the callback will have substantial impact to the company's annual service costs.

2.4.2. "New Installation Service" (NIS) callback rate

Otis usually sells a special service contract to cover the first several months after an elevator has been turned over to the customer. The contract will provide for preventative maintenance, any mechanical adjustments required during break-in, and immediate response to any break downs. This is known as New Installation Service (NIS) and can last from one to twelve months, depending upon the arrangement with the customer. The average length of NIS is six months. A particularly interesting callback phenomenon

[11] Ed Curvino, Director of OTISLINE.

occurs early in the life of an elevator. The callback rate of elevators during NIS is much higher than elevators on Otis Maintenance (O-Maintenance).[12] The reasons for this anomaly are unclear. It would seem as though the callback rate during the early periods of elevator operation would be significantly lower, as all the parts are new, and the operation has been properly tested by Otis employees. However, as evidenced by the graph below of 311/411 elevators, the NIS callback rate is approximately twice as high as the O-Maintenance rate, with an average annualized callback rate of 4.99 on NIS, and 2.42 during O-Maintenance.

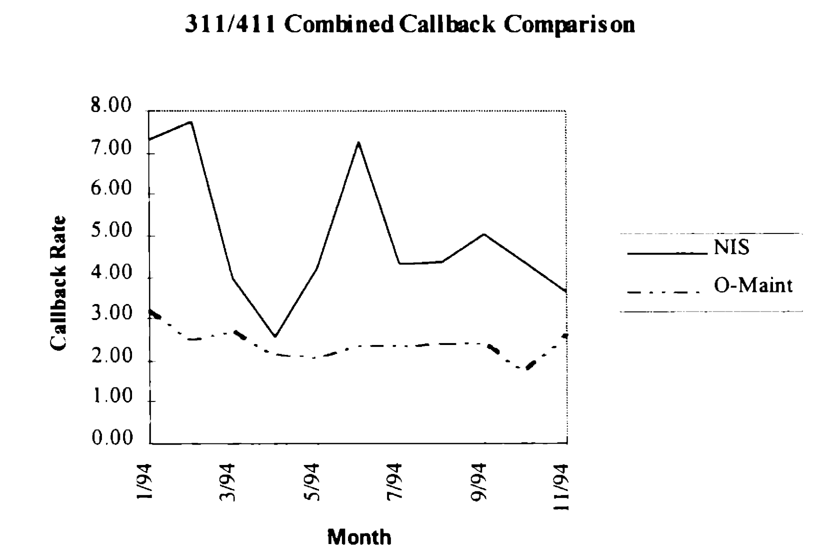

Figure 10

For general product comparisons of the callback disparity between NIS and O-Maintenance, see Table 2 on the following page.

[12] O-Maintenance is the regular service which occurs after the NIS expires.

The body of this thesis will uncover significant reasons for the difference in callback rates, review the solutions to this problem, and analyze the implementation process of policy change in a decentralized company with autonomous business units.

The table below demonstrates the financial consequences of the callback rate differential. Again, hydraulic elevators are for low-rise buildings, Geared elevators serve mid-rise buildings, and Gearless are installed in high-rise buildings. Field Support tracks the annualized NIS and O-Maintenance rates. Multiplying the number of units sold by the difference in callback rates (assuming an average six month NIS period) and by the average cost of a callback yields the cost to Otis of this variance, by product category. In sum, one can see that the callback delta costs Otis approximately $269,400 annually.

Using '94 YTD numbers

Major Callbacks

	Projected sales for '94	***Annualized NIS callback rate***	***Annualized O-Maint callback rate***	***Cost of Callback Rate Difference (6 month period)***	***Total NIS Cost***
Hydraulic	2800	1.82	1.15	$187,600	$509,600
Geared	400	4.19	2.36	$73,200	$167,600
Gearless	50	4	2.28	$8,860	$20,000
			Totals:	**$269,400**	**$697,200**

Callback cost =	**$200**

Table 2

2.4.3. Field resistance to corporate "assistance"

Another problem that Otis has stems from its decentralized organizational structure. By allowing the field locations to act autonomously, as well as to be responsible for the ultimate profit or loss, they tend to react negatively to any forms of control by headquarters. Clearly, the local offices resist corporate intervention because it reduces their power base.

Another reason not as obvious is that the locations are much more customer focused than corporate headquarters. Literally all field employees have continuos interaction with customers. Much of NAO headquarters' involvement appears to concentrate more upon profits than the customer. The often opposing objectives can place the locations in an uncomfortable position.

Lastly, many of the corporate policies tend to cost the offices money to enforce or implement. Employees in the local offices are attempting to maximize profit, for either recognition, promotion or incentive compensation. They are often dissatisfied with orders from higher authority, even when they are in the best interests of the locations, as it may detract from the profit line on the balance sheet.

This attitude fosters a cynical culture among the field employees. Field impressions of corporate management, especially from the lower ranks, are that of disapproval. I was told the best analogy by a mechanic. He felt that Bloomington was acting out a "Big Brother" role from Orwell's 1984, rather than a parental role which would be a better fit from the viewpoint of the field.

2.4.3.1.Specific examples

There are numerous examples of corporate involvement or policy to support the mindset of the field. From my conversations with field personnel, the most pessimism comes from the large number of different quality initiatives that have been enacted and then replaced over the past 10 years.

2.4.3.1.1.Various quality programs

In an interview with the NAO Director of Quality, he admitted that there had been too many programs for the employees in the field to learn and accept. The first quality initiative began in the mid-80's and was Crosby-oriented, meaning that the program would focus upon zero-defect policies. The Quality Director commented that although the program had noble intent, it fell short during the implementation phase due to low managerial commitment and improper training of those who would be participating in the process. Another initiative that occurred in the late 1980's upset the field labor force the most. Management felt the need to improve quality by increasing field productivity. The reasoning was that productivity could be improved by reducing the number of hours allocated for elevator installation. The field was disturbed because corporate had cut the number of hours to install an elevator without giving any new tools or techniques to assist in the productivity. The net result of the cut in hours is difficult to measure, given the many years that have elapsed. Management comments that field productivity has not improved for many years. The field employees protest that they are now very rushed to complete the installations in the allotted time that the quality is less of a priority. Other quality programs have been introduced since then, but many have had limited success in the field.

2.4.3.1.2. Factory shorts/wrongs

Incorrect factory shipments also play a part in the field's cynicism. If the factory ships an incorrect part, the installers rarely have the time to call the factory and wait for the correct part to be shipped. Rather, it usually becomes the field's responsibility to correct the error by a local purchase or on-site part fabrication. Given the time pressures to complete the job, the mechanics quickly foster ill feelings toward the factory for shipping the wrong parts, and to the management for not fixing the problem. Field employees often told me that I should fix the problems in the factory before I tried to fix the problems in the installation process.

The Director of Quality at the factory listened to the field comments and devised a process called the Shipment Accuracy Report (SAR) to report shortages and other discrepancies in materials shipped to the field. Essentially, he is sampling installation sites, receiving feedback, and then returning to the factory to solve the problem at the source. Figure 11 below indicates the extent of the problem, as well as demonstrates that his efforts are creating a decline in the number of factory shorts and wrongs:

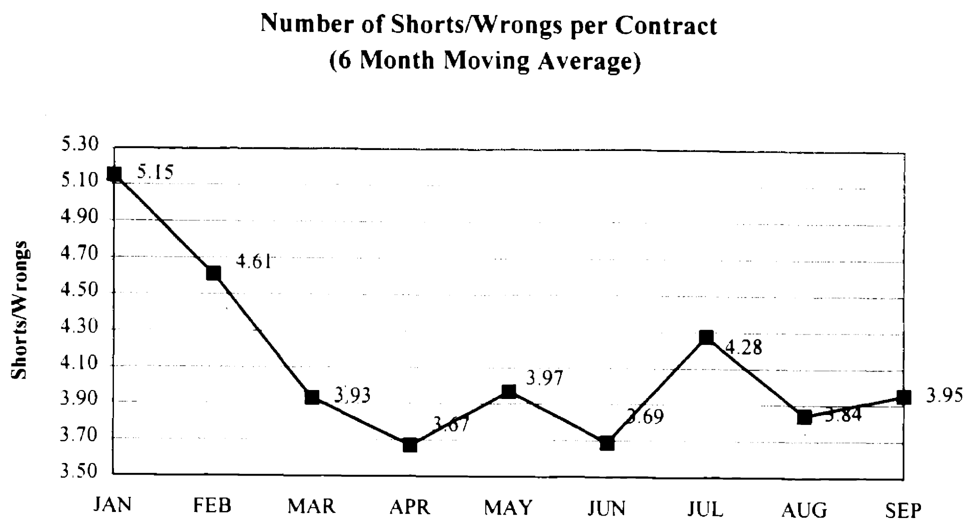

Figure 11

With an average of 4 incorrect or missing parts per contract, the field mechanics feel as though managerial involvement is in word only and not deed. The factory problems automatically cause field productivity problems in the form of lost time on the job due to getting the right parts. Also, Figure 12 shows the cost of quality per contract. This cost is comprised of materials and the lost time on the installation.

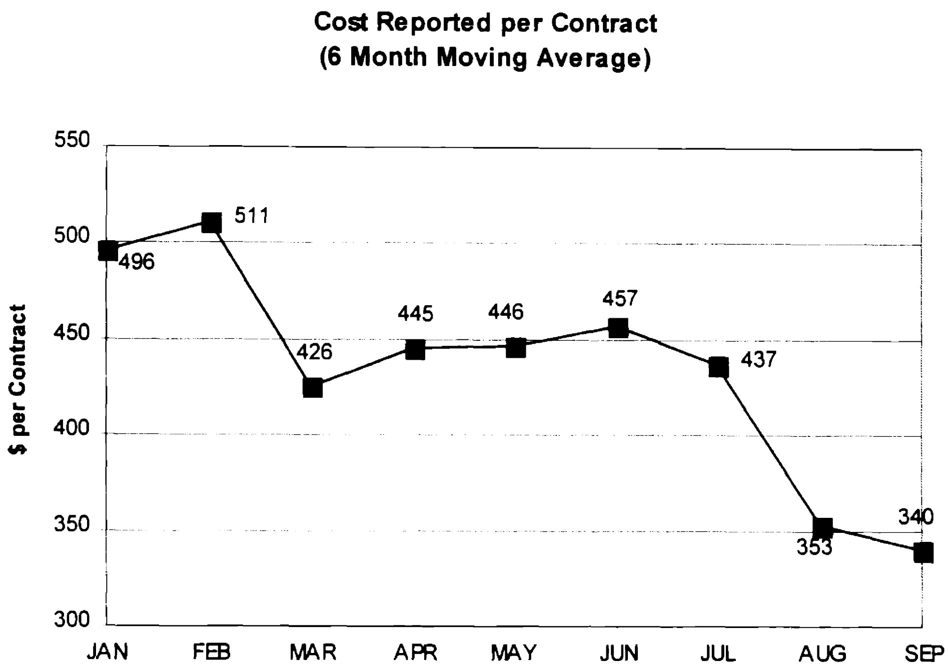

Figure 12

2.4.3.1.3.Harness rule

The last significant reason for field resistance to management intervention is the body harness rule. Though Otis has the best installation safety record compared to other elevator companies in North America, several mechanics every year were killed on the job due to falling down the elevator shaft. The president of the company issued a rule that called for all Otis employees to wear a full body harness at all times during the installation process. Failure to wear the harness results in a two day suspension. Although this rule makes sense for several obvious reasons, the field employees are demoralized because the harness is extremely uncomfortable and unwieldy to wear while working. Though no employee has died from a fall since this rule as been in effect, it has caused much resentment in the field.[13]

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[13] The company is currently taking steps to create a uniform that has the harness built-in. This should alleviate much of the problem in this area.

3. Identification of High Callback Areas

In order to determine the root causes of the appreciably high callback rates of New Equipment products during NIS, the first line of research I performed was that of straightforward data collection and categorization. By starting from this position, I could ascertain the relative importance of the problem in two ways:

1. Discover the number of callbacks occurring during the first months of NIS.
2. Categorize the callbacks into the various elevator components, and determine if certain elements were more prone to failure than others.

Additionally, (and probably more importantly) I could then present this data to field personnel and attempt to uncover the reasons for the early component failures.

3.1. Process of Data Collection

A brief explanation of how the Otis service system functions, as well as how the company records and stores callback information, is important to understanding the way in which personnel can retrieve and interpret callback data.

If an elevator is under a service contract with Otis, when the unit fails to respond to calls or otherwise acts abnormally, the customer may call a toll-free number to inform Otis of the problem. All trouble calls are answered by operators staffing an information systems network called OTISLINE,™ who gather the skeletal information and then page the service staff who are responsible for the building. Personnel known as examiners receive the page on a communications device called a KDT which captures the information that the operator recorded. After the examiner arrives and completes the elevator repairs, he will again use the KDT to record the problem, repairs made, and any other pertinent information. He will then transmit the data to OTISLINE in order to "close out" the callback. The data remains stored in the OTISLINE database for a period of three years, at which time it will be removed from the records. This database served as the initial information collection point, from which I derived all callback records.

In order to access the OTISLINE information, employees download the data with the assistance of a software program called SAS. A very complicated program must be designed in this software language to interface with the OTISLINE network. The Field Support Team has written such a program, and only minor modifications were required to access the information I desired. My goal was to look at all callbacks that occurred during the average length of the NIS service contract. The data fields that held the pertinent information were few:

- Callback date: date the customer telephoned OTISLINE
- NIS start date: date the elevator began the warranty period
- Machine number: Unique elevator number, used to identify elevators
- Upper problem[14]: General classification of callback category
- Lower problem: Specific classification within the Upper problem classification
- Technical description of problem: Examiners type in the nature of the callback

[14] The Upper and Lower problems were determined by a complex program written by the Field Support Team, based upon the words used in the examiner's close-outs.

- Comments: Any other comments that the examiner wishes to add (typically left blank).

Using SAS, I downloaded the callback information for two predominant product lines, the E311/E411(traction) and the LHM (Hydraulic) into text (.txt) files. Next, I imported the .txt files into a database program which would allow me to filter the callback data to only those occurring within the six month period. By simply comparing the Machine number's Callback date and NIS Start date, I formed my own database of callbacks occurring within 6 months of the NIS Start date.

One obstacle that I encountered was that OTISLINE did not have the NIS start dates for nearly 400 of the newly installed elevators. In this instance, I found it most reliable to contact the local offices by fax for the exact date. To prevent making 400 telephone calls, I created a database query that would trace the callback in question to the location responsible for the service. I then created a standardized letter to the Construction Superintendent that requested the NIS start date for the attached machine numbers, and merged the machine numbers that were in his location into the letter.

The drawing below depicts a simplified process of the data collection:

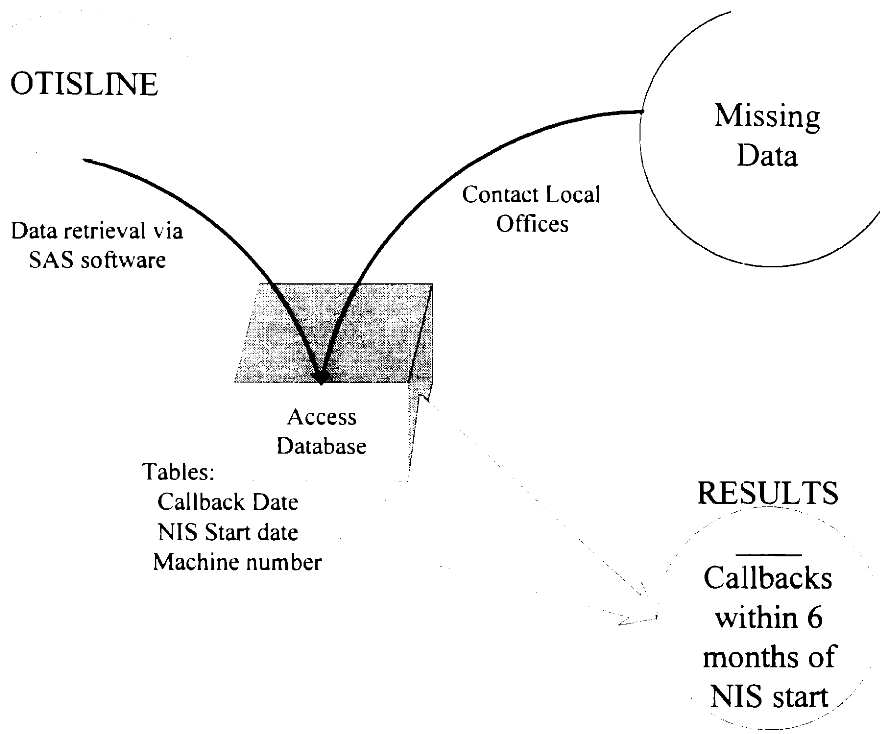

Figure 13

3.1.1. Comparison of all callbacks within 6 months of Handover date

Subsequent to creating my new database, I categorized the callbacks by Upper Problem and Lower Problem. The results of the E311/E411 and the LHM callback categorization were surprisingly similar, as the following pages will demonstrate.

This research method proved to be quite enlightening to me, as I now had a solid footing to base future research aimed at reducing callbacks in the most troublesome components. The Callback Reduction team had never looked at the callback data in this light, but found it to be generally consistent with their current assessment of the most unreliable parts within the elevator.

3.2. Analysis of the E311/E411 Callbacks

The group that I was assigned to in Field Support Department focused primarily upon E311/E411 callbacks, so I first downloaded OTISLINE information specific to these products. The E311 and E411 elevator products are very similar in design, the basic difference being that the E311 is for mid-rise buildings, and the E411 is for high-rise buildings. This translates to different machine sizes, car speeds, and power requirements. However, when analyzing callback data, the units behave in such a similar fashion that they are grouped together.

E311/E411 elevators contain state of the art electronics that minimize passenger wait time. Each elevator performs calculations that determine which can respond to a call the fastest. Additionally, the elevators can "learn" traffic patterns during peak periods of demand, and adjust call priorities accordingly to maximize the flow of passenger traffic during these times. As a result of the complexity, Otis converts 96% of the installations to a service contract. Thus, the following data for the 311/411 represents nearly all callbacks for these products.

Research showed that as of June 1, 1994, there had been 5014 total callbacks, of which 1473 calls fell within 6 months of the completed installation. The Upper Problem callbacks are categorized below:

3.2.1. Graph of significant callbacks for 311/411

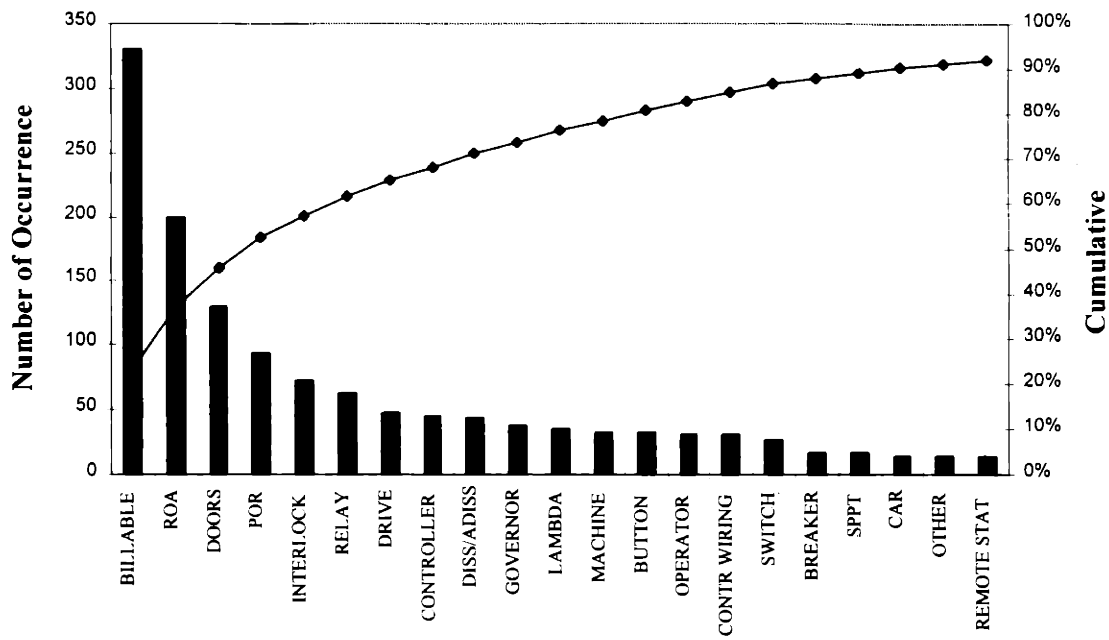

Figure 14

The first category, "Billable," accounts for 23% of all the 311/411 calls within the six month window. A Billable callback is one in which Otis bills the customer for the call, because the elevator did not break down through a fault of its own. Most of these calls are derived from the completion of the elevator prior to the conclusion of all the building construction, and the construction related activities affect the proper operation of the elevator. For example, the frequent occurrence of a drywall nail getting caught in the elevator door and causing it to jam would be counted as a Billable call. Vandalism would also fall under this category. Because Otis cannot prevent these types callbacks, and it also receives revenues from the callbacks, I did not rigorously pursue means to reduce these types of callbacks.

The second category is ROA, which is the abbreviation for Running On Arrival. This category is used for examiners who respond to a call, but cannot find anything wrong with the elevator when they arrive on site. Although these callbacks account for 13% of the total callbacks within six months, they also were of little help in finding traceable problems with the NIS callbacks, and are basically treated as the price of customer service.

Another negligible category is POR, which stands for Power On Reset. Callbacks get categorized to this "ghost" classification when an examiner turns the mainline disconnect power off; back on; and the problem cannot be duplicated. After "resetting" the system, the examiner can no longer find evidence of any problem that resulted in the callback. There are very few leads to indicate recurring problem areas in this category.

3.2.2. Doors

Door callbacks are high on the callback category, attributing 9% of all the calls. Door callbacks are a problem that has plagued Otis for decades. Many attribute this to the manufacturing process. Briefly, door fabrication consists of spot welding sheet metal in many locations. The uneven heating and cooling effects throughout the thin surface of the material cause warping, which can substantially decrease door performance and reliability. Installers complain about Bloomington's problems with shipping straight doors, while Bloomington's research indicates much of the problem lies with the installation methods.

3.2.2.1. Graph of Breakdown of Door Callbacks

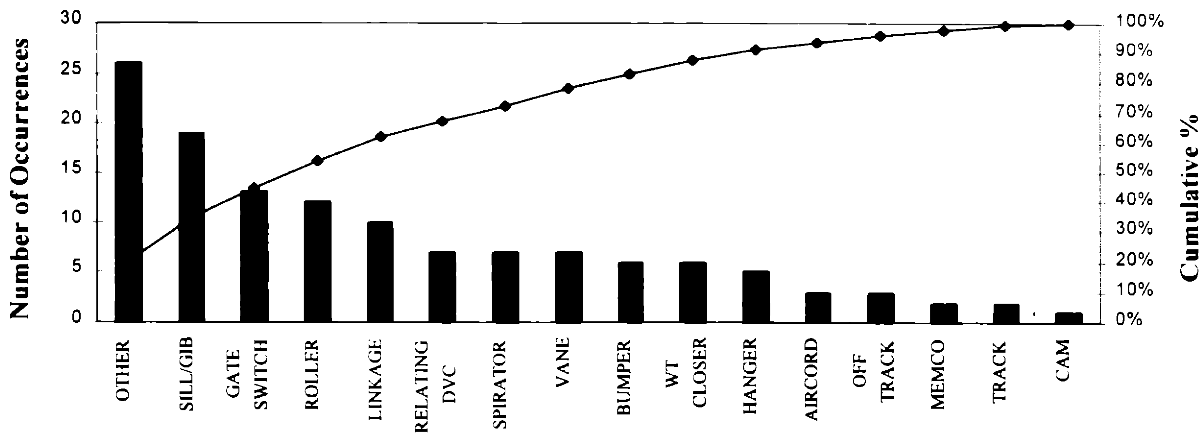

Figure 15

3.2.3. Interlocks

Interlocks were also leading in the high callback areas. Interlocks, or door locks, are elector-mechanical devices that keep the hoistway elevator doors (the entrance doors at every floor) closed during the times that the elevator car doors are not open at that landing. The interlocks are reputed as being somewhat unreliable, as they are difficult to install correctly, due to tight design tolerances. As evidenced by the graph below, nearly all of the interlock callbacks were corrected by simple adjustments to the part.

3.2.3.1. Graph of Breakdown of Interlock Callbacks

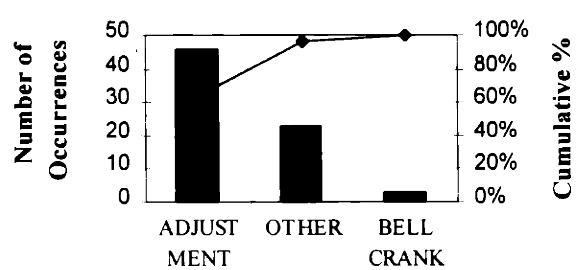

Figure 16

3.3. *Analysis of the LHM Callbacks*

The hydraulic LHM product serves a different market than the E311/E411. Hydraulic elevators are usually used in 2-4 story office buildings. They are limited in rise primarily because of the considerable slower carspeed than traction elevators (150 fpm vs. 500+ fpm). Also, the drilling requirements to install a hydro can be cost prohibitive for the higher rises. Most hydros operate on a plunger-cylinder system, which is placed in a vertical hole at the bottom of the elevator shaft. The hole is drilled exactly as deep as the elevator rise. Operation is straightforward: oil is pumped into the cylinder, and the hydrostatic pressure forces the plunger to rise and thus lift the car.

As of July 1, 1994, there were 523 LHM callbacks in OTISLINE records. The low number of occurrences is significantly less than the E311/E411 for two main reasons:

1. The hydraulic elevator has been around for years, and many of the reliability issues have been addressed.
2. The LHM product is significantly newer than the E311/E411, and therefore has had less time to build a large database of callbacks.

The callback pareto graph in Figure 17 below is very similar to the E311/E411 graph. "Billable" leads the categories again, and ROA, Doors, Interlocks, and POR are still also major contributors. The "Other" category typically stems from callbacks that were closed out with no examiner remarks. New additions to the top callback categories are Machine and Rails.

3.3.1. Graph of significant callbacks for LHM

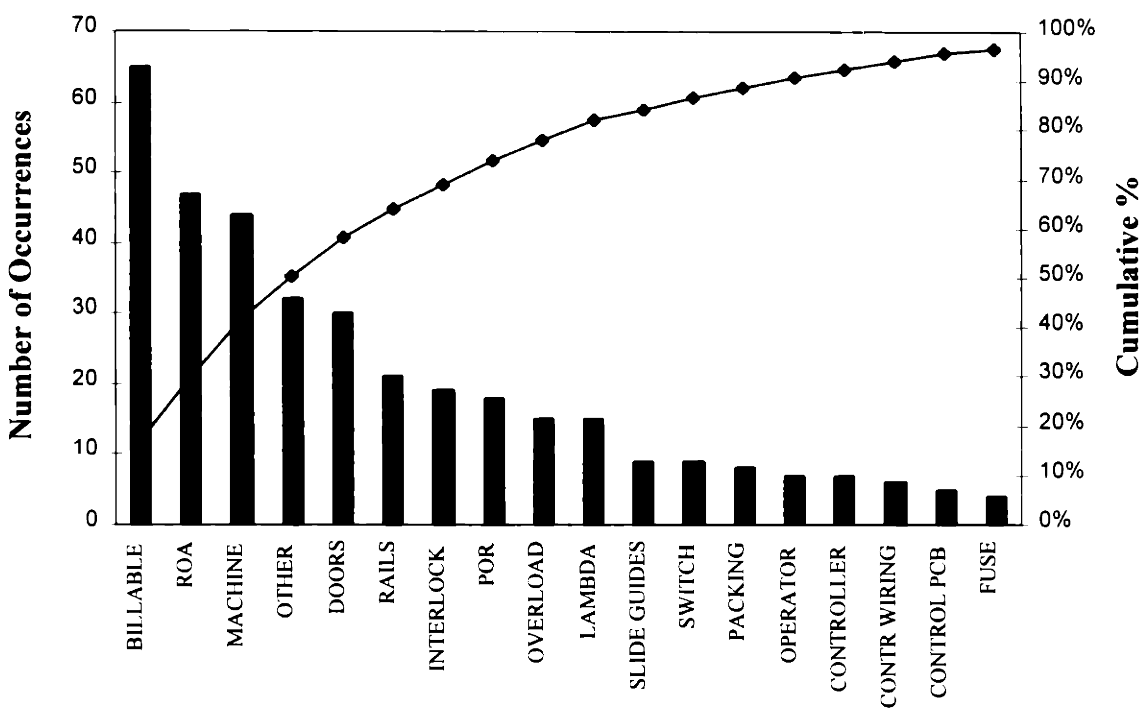

Figure 17

3.3.2. Machine

The Machine callbacks can be further broken down into the Lower Problems. Recurring problems during the first six months stem from adjusting the oil pump valves, repairing oil leaks, and having to simply add oil.

3.3.2.1. Graph of Breakdown of Machine Callbacks

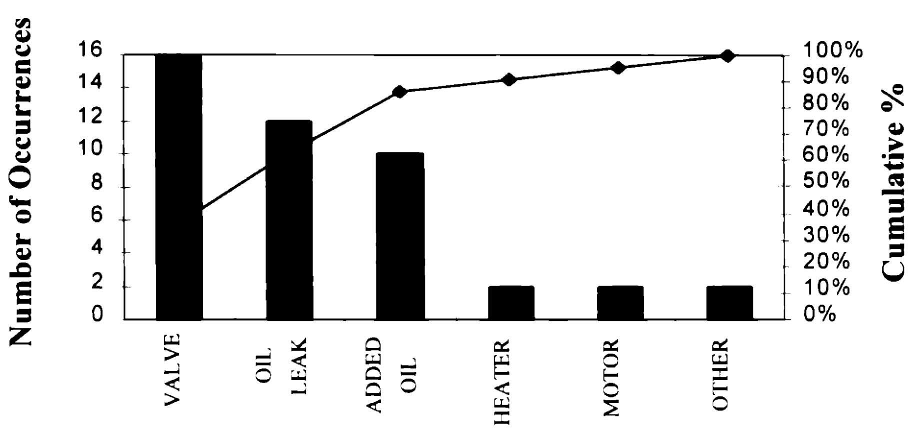

Figure 18

3.3.3. Doors

The door subcategories are different than the E311/E411. The "Other" subcategory is, again, a close out with no examiner comments as to what repairs he performed. The subcategory "Spirator" is a part that mechanically pulls the hoistway doors closed. It too has beset Otis callbacks for years.

3.3.3.1. Graph of Breakdown of Door Callbacks

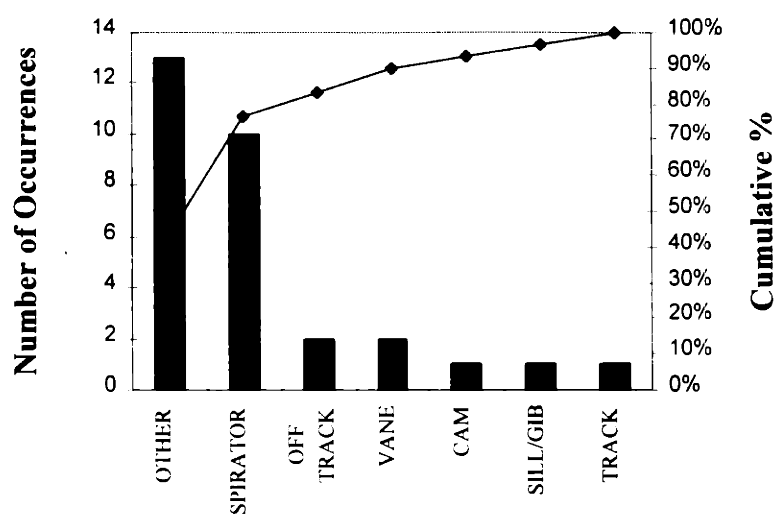

Figure 19

3.3.4. Interlocks

The LHM interlock graph is nearly identical to that of the 311/411 interlock graph.

3.4. Installation-Related Callbacks

From both product lines, (E311/E411, LHM) many of the callbacks occurring within 6 months of the NIS Start date appear to be caused by improper installations, meaning that the elevator is not installed according to the engineering drawings. Design flaws do play a role, but the large extent of the callbacks are due to the way the mechanics assemble the elevator. Installation mechanics are the last people in a long process to deliver an elevator to a customer. Unfortunately, this saddles them with the responsibility of getting the installation completed with whatever means or parts that they have available. Often times dealing directly with an impatient customer or construction superintendent, the installers will make (or make due with) improper parts in order to finish the job.

I felt that I could obtain a much better appreciation of the field if I were to direct the next step in my research towards understanding the field's current method of handover, and then visit and interview field employees to understand their perspective.

4. Field Research

4.1. *Current Method of Quality Inspection*

Otis has a very traditional method of inspecting its elevator systems. At the conclusion of every installation, the Construction Superintendent meets with the Service Supervisor at the job site to perform a Handover Inspection. Together, they review an extensive checklist called a Handover Inspection Report, which is used to ensure a quality installation. If there are no deficiencies at the conclusion of the inspection, both will sign the form, and the unit will then become the responsibility of the service department. Otis has a somewhat lengthy policy paper that explains the standards and procedures that must be followed when "handing over" an elevator to the service department.

4.1.1. Handover Policy

Otis' existing Handover Policy began in the mid-eighties. Its purpose is to ensure the delivery of a quality product to the end user, as well as having an "official" point of responsibility transference from construction to service. Since the introduction there has been one revision, however for the most part the policy has been unchanged. Essentially, the policy clearly states that every elevator must have a Handover Inspection completed prior to presenting the unit to the customer and financially closing the contract. Further, it also states that all defects found during the inspection must be corrected before the Handover Inspection Report can be signed and processed. Most of the document explains the various exceptions to the policy, and procedures to follow in the event of discovered defects. The last section of the policy addresses the reporting and measuring system that tracks the number of handovers and categorizes the defects.

4.1.2. General problems with the system

There were numerous indications that the current policy was not adequate in the role of quality assurance. First, as mentioned previously in Chapter 2, the NIS callback rate was typically twice that as a standard O-maintenance elevator. If anything, the NIS callback rate should be lower than the O-maintenance rate, because all of the mechanical components are brand new, and have had no time to deteriorate. Second, there had been numerous written comments from the field that expressed dissatisfaction with the current policy/inspection. Third, and least quantitative, was a sentiment from Bloomington that there was a disconnect between the written policy and reality. To them, the system had somehow "broken-down" and no one was certain as to why, or what actions were required to insure quality installations.

My supervisor and I both agreed that in order to understand all of the problems associated with the Handover Policy, I needed to spend time with mechanics during an installation.

4.2. Installations

I visited three different hydraulic elevator installations--two for a period of several days, and one for several hours. With just myself and two mechanics, I rapidly learned the high level of craftsmanship that was involved in order to install a complete elevator. I grew to know four mechanics fairly well and was soon able to get candid responses to my questions about their views on quality and the handover policy.

4.2.1. Perspective of installers

Mechanics will install elevators to different quality standards. These "levels" of quality can depend upon three main circumstances: the mechanics' level of experience; time pressures to complete the installation; and individual quality standards. Though all are very significant, I feel that the main difference in an installation depends upon the standards of the individual, as it is the installer who must decide when an activity has been properly completed in order to move on to the next task.

Many of the mechanics whom I interviewed stated that they desired to install an elevator to a high quality standard. However, they were quick to point to time pressures and factory part shortages that would cause them to install substandard (but functional at the time of handover) installations. The most salient point they made is that they install against time and not against quality. Better explained, a contract is sold at a price that is based upon the number of estimated hours that it will take to install. The construction department is held accountable to this number of sold hours, usually regardless of the future construction developments. The Construction Superintendent emphasizes speed to his mechanics, who in turn accomplish this by delivering substandard installations--which cause rework, callbacks, and customer dissatisfaction. If the mechanics complete the installation in under the specified number of hours, the company makes money, and the installers get a pat on the back. However, should the mechanics' work exceed the estimated hours, the company can actually lose money on the sale of the elevator. This causes (at a minimum) the Construction Superintendent to scrutinize the mechanics' future elevator installations.

4.3. Handovers

After I gained a reasonable understanding of the elevator installation process, as well as an appreciation of how the mechanics viewed their trade, I planned a trip to view two handover inspections in different regions.

My first inspection took place in Anaheim, California. The Construction Superintendent and I were scheduled to meet the Service Supervisor at the job site, and jointly inspect the four elevators. The Service Supervisor informed us that morning that he would be unable to attend the inspection due to an unavoidable conflict that just arose. The Construction Superintendent informed me that joint handover inspections were actually quite rare for him for several reasons:

1. Other job demands of the two Supervisors.
2. Large distances to the various job sites.
3. A trusting working relationship between the two departments.

He and I elected to conduct the inspection ourselves. As we began the inspection, the Construction Super's pager went off, and we had to stop while he answered the call. I immediately realized that field personnel felt that the Handover Inspection was more of a distraction than a value-added activity, and thereby placed a low priority on it.

Eventually, we continued with the inspection, but were interrupted twice more by the pager. Going down the questionnaire line by line, we found several questions that had become outdated due to advances in elevator technologies. The Super informed me that he typically did more of an informal inspection, only checking specific areas that he knew were prone to failure, and the remainder of the inspection would be more of a "walk-through" just to ensure everything appeared in order.

I performed the next inspection in Denver, Colorado. This time the Service Supervisor met the Construction Superintendent and me at the job site and we jointly began to inspect the newly installed hydraulic unit. The mechanics who had installed the elevator, as well as the routeman who would be servicing the unit also joined us. Both supers readily admitted that they rarely did a personal inspection for most handovers. Instead, they would have the mechanic meet the routeman at the job, and those two would inspect. This arrangement works well, because the person who knows the most about the installation, the mechanic, could explain the installation issues, as well as readily answer any questions that the routeman may have. The routeman is also an excellent person to attend the inspection. He has a vested interest to inspect the unit thoroughly, as it becomes his responsibility for servicing future callbacks at the conclusion of the inspection.

4.3.1. Perspective of Construction Superintendents/Service Supervisors

During the Handover inspections, I noticed that the supers place little emphasis on a rigorous inspection. In fact, it was very obvious that the inspection was cutting into their busy schedule. Supers were not ashamed to admit that not every elevator was physically inspected--again blaming distance to the job, unforeseen events, etc. To them, the inspection is not about quality assurance, but rather a transfer of responsibly from construction to service. One of the driving reasons for their philosophy is the issue of time. The Construction Superintendent is measured on his efficiency, which means his main concern is keeping the number of man-hours to install a unit to a minimum. Quality comes a distant second, and is not reflected in any measurements. As an exception, if the installed unit is rampant with callbacks, the Construction Superintendent will be notified. Otherwise, there is very little feedback on the quality of the installation.

One super informed me that if, at the time of an inspection, he discovered a part incorrectly installed for some reason, but the elevator still functioned properly, he would not fix the problem. The rework would cost time and money, both of which are scarce commodities in the field. The customer would use the elevator until the part failed, and at that time, would be replaced.

4.4. Best Practices

After viewing the small sample of actual handovers, I looked to locations within NAO that were reputed as having the best handover practices. The answer to the poor handover system could very well lie within a location that has modified or changed the policy to best serve the goal of an elevator that would have no callbacks.

4.4.1. Seattle

Members of Field Support informed me that a Field Operations Manager in Seattle was well-known within the company for having an effective method of elevator handovers. When I interviewed him, he told me that the key to success in his region was communication. He then provided me several forms that he had created to foster a high level of communication in his office.

Field Operations Manager's best idea is the Project Awareness Report. The mechanic will complete a "fill in the blanks" form, that outlines basic information about the unit that is under construction. It also details the date that the unit is expected to be completed, and a proposed handover date and time. The Project Awareness Report is then passed around throughout the office for review by the Service department, sales personnel, and the location manager. All concerned are asked to visit the site prior to the inspection date. Not only does this facilitate a strong communications network that will keep everyone informed, it also actively involves the office personnel in every job by emphasizing job site visits. The end result is that the managerial involvement on every installation encourages the mechanics to install quality jobs. Also, the mechanics are forced to maintain an orderly area for tools and parts--which requires discipline, but improves productivity by easy access to tools, and fewer lost parts.

4.4.2. Spokane

A Construction Superintendent in the Seattle office is known for having success in quick financial close-outs from completed elevators. This indicates satisfied customers and few defects at the time of the Handover Inspection. My ensuing conversation with him revealed that he attributes communication and supervision to this success. He visits each site prior to any installation and coordinates schedules and requirements with the General Contractor. He also conducts follow-up visits prior to starting the job to ensure the necessary construction conditions are correct. He believes that a fully prepared job site is the key to a successful installation.

The Construction Superintendent made another point in the interview worth analyzing. He believes in employee empowerment, and allows his mechanics to make many installation decisions without his council. Not only does this save time by not having to wait for the boss to return with an answer, it also develops a sense of ownership and responsibility within the mechanics. He believes that this is evidenced by the high quality installations and good efficiency ratings in his area.

4.4.3. Southern Area

As mentioned previously in Chapter 2, Otis currently divides the United States into three Areas of responsibility. Employees in Bloomington stereotype the Southern Area as one that is very conservative and resistant to change. However, this Area is also reputed to have the lowest NIS callback rate. I interviewed three Construction Superintendents in different states within the Southern Area. The consistent theme was that there was significant managerial emphasis by the vice-president of the Southern Area on the Handover Inspection. All three attested that every elevator in their location did get a handover inspection at the conclusion of the installation. The reason was simple--the vice-president demanded a personal inspection.

In order to demonstrate to the field management that managerial involvement in enforcing the Handover Inspection was critical, (and would save money) I researched the monthly hydraulic (LHM product) NIS rates by Area. The results were contradictory:

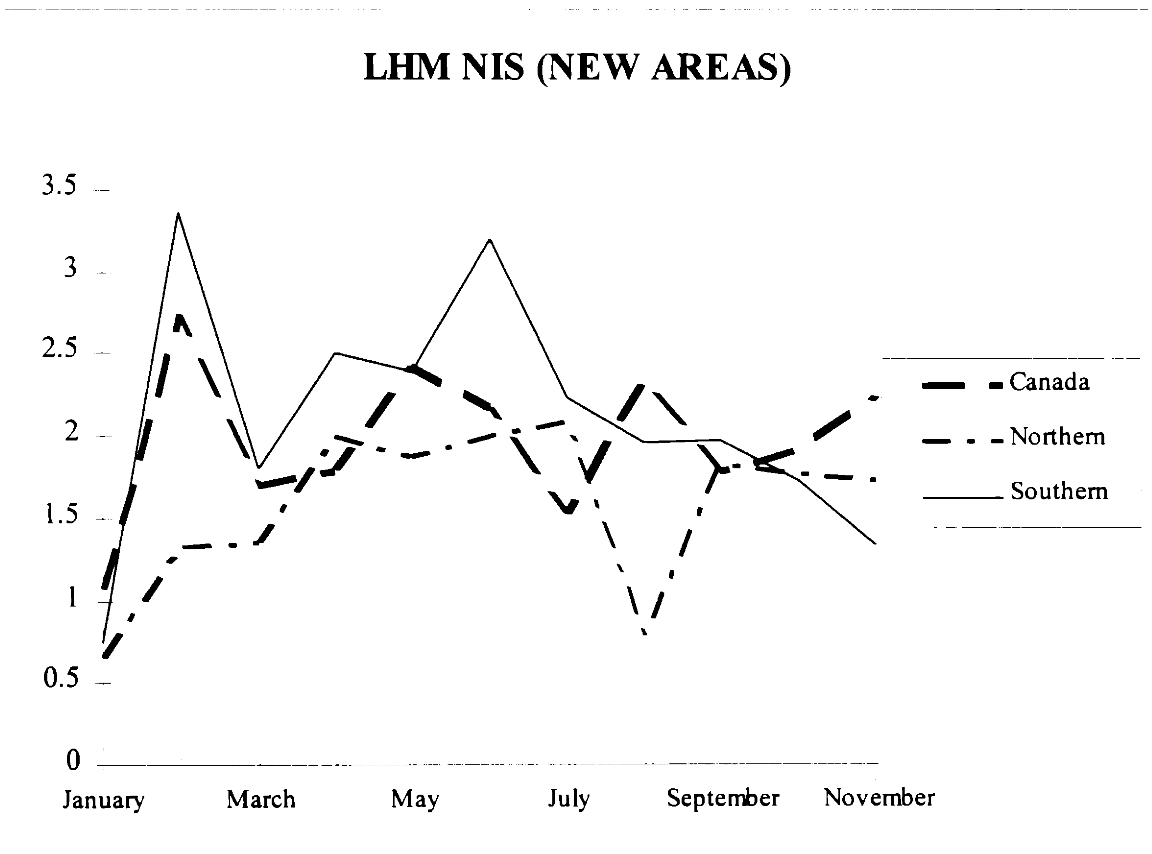

Figure 20

The Southern Area consistently had the highest NIS callback rate. I believed that this data was misleading due to recent restructuring of Areas. A more responsible approach would be to categorize the callback data by the Areas that existed prior to the reorganization. I believed that during this specific time period, the recent restructuring had not affected the NIS trends that existed in the old Areas.

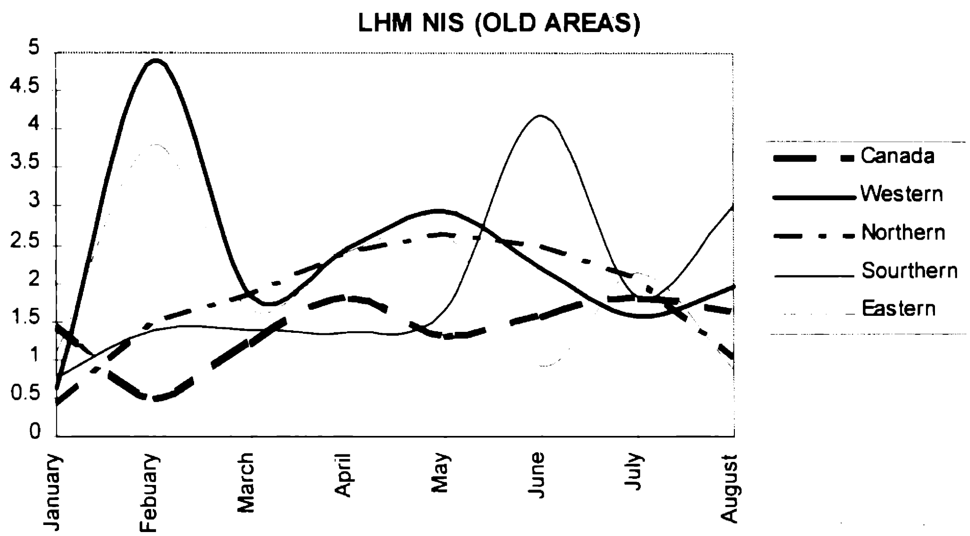

Figure 21

Yet, even when examining the data by the old Areas, the Southern Area is not appreciably better than the others. The results were surprising. Managerial participation and emphasis ensures that the quality exists before the customer gets the elevator. The Southern Area should have been appreciably higher. I would later come to believe that managerial involvement by itself is insufficient. A process must also (in this case) have the correct quality inspection questions. The two must simultaneously exist for a successful program.

4.5. Interviewing Construction Superintendents across NAO

The Field Support Department reviewed 187 hydraulic elevators that were completed and financially closed in the month of August, 1994. We selected 18 contracts which had the largest variances (both high and low) from the NAO average efficiency. Field support then directly contacted the Construction Superintendents who oversaw the outlying projects to discuss reasons for the divergence. The sampling of interviews quickly revealed key factors for project success or failure.

4.5.1. Recurring explanations for good efficiencies

Low installation hours were primarily attributed to two main reasons. First, Superintendents were quick to credit their good mechanics. Mechanics with high level of experience and training can adeptly install elevators well below the allowed hours. The key determinant for seasoned installers saving hours is their performing the final adjustments. One knowledgeable team working a job from beginning to end can prevent the wasted hours of an adjuster arriving and reviewing all of the work prior to beginning the final wiring and testing.

The second component to assuring good efficiencies was good communication with the General Contractor (GC). The GC must complete the elevator hoistway, pit, and machine room to a predetermined standard. This will allow the Otis mechanics to immediately begin work and continue with no delays. The Construction Super must establish a good working relationship and line of communication with the GC to ensure that the necessary work will be completed on or before a specified date. Serious delays will occur if the

Construction Super has scheduled two mechanics to work on a job, and the GC is not prepared for them to begin.

4.5.2. Recurring explanations for poor efficiencies

There were numerous reasons for justifying the poor efficiencies. The leading excuses were either the mechanic's lack of experience, or his overall poor abilities. Again, quality elevator installations require extensive knowledge and proficiency. The training issue will continue to be of critical importance to Otis, and will be a major factor for years to come in becoming cost competitive in the elevator industry.

Other typical problems with poor efficiencies are:

- Incomplete communication between the GC and the mechanics and/or the Construction Superintendent.
- A change in the elevator contract, that is not changed by manufacturing. This should be corrected by the SAR program discussed in Chapter 2.

4.6. Benchmarking

Benchmarking is a method by which a company observes best practices in other similar companies or industries and then incorporates them into its own processes. Looking to other divisions within Otis and even other industries to discover new methods of quality inspections proved to be very enlightening.[15]

[15] Robert C. Camp, Benchmarking: The Search for Industry Best Practices that Lead to Superior Performance (Milwaukee, Wisconsin: Quality Press, 1989) 3.

4.6.1. Carrier Corporation

Carrier, another subsidiary of UTC, and also affiliated with the construction industry, is the world's largest manufacturer of heating, ventilating, and air conditioning equipment. Although Carrier works with a very large dealer network and therefore does not install its own products, it still publishes comprehensive installation process instructions called "Commissioning New Chillers" to ensure a standardized product after assembly. This manual sets forth the roles and responsibilities of all members of the installation-service team. It explains that a meeting must be conducted by the team prior to the installation, and outlines what must be discussed. Further, the manual contains all order forms pertinent to the assembly, as well as 15 pages of comprehensive "start-up" testing questions. The most valuable item in the quality testing is that the parameters, or tolerances, are incorporated into the forms, so that the inspector will know if the values that he is checking are correct.

4.6.2. Boeing

The Boeing Company manufactures a variety of commercial and military aircraft. I chose to investigate the quality procedures at this company because every aircraft must be fully functioning and flight worthy at the time of sale, and remain as a high quality product for many years. As I imagined, quality is synonymous with safety, and both are held in high regard. Boeing uses Quality Assurance Inspectors that check all aspects of the aircraft manufacturing process. The inspector will compare the work with the drawings on the plans, and then stamp the part with his unique seal if it passes the inspection. A computer system tracks all successful parts' inspections as well as generates a "punch list" report upon demand. This type of in process test activity is expensive and time consuming, but when comparing these elements to that of the poor quality, rework time, and costs of a product this complex, it is easily justified.

More benchmarking discussion occurs in Section 6.2.

4.6.3. Otis Japan

The Japanese are a favorite culture to benchmark, due to the numerous quality products they export to the U.S. The elevator industry is no different, as Nippon Otis, Otis' Japanese elevator organization, leads the world in delivering quality elevators.

The organizational structure is different in Japan than NAO. The main difference is that Nippon does not have a Construction Department because all installations are subcontracted. This deviation mandates a very detailed handover inspection at the conclusion of the subcontractor's work. In fact, the inspection is so thorough that it involves several Otis employees, and takes the bulk of a day to complete. The subcontractors are required to complete detailed checklists for many parts and assemblies, and the inspection will begin with a review of these documents. Next, Nippon will complete a 5 page checklist (16 pages in English) that is generic for the product line, i.e., Geared, Gearless, Hydraulic. The checklist will be supplemented with another checklist specific to the elevator type, one page in length. Completing these documents require a rigorous inspection. Essentially every portion of the unit is checked. Additionally, the other countenance of elevator quality, ride quality, is checked by using a dB meter and an excellorameter to measure noise and vibration. This aspect is completely ignored in NAO.

The Japanese Handover Policy is superb, and also necessary. Otis will permanently assume responsibility for the elevator from the subcontractor at the conclusion of the inspection. Everything must be correct, or Otis must pay to have it fixed. Transferring this type of handover inspection to NAO would encounter employee resistance for several reasons. The inordinate amount of time required to inspect every unit serves as the primary deterrent. Given the sheer volume of elevator installations, the Construction and Service Supers would spend more time inspecting elevators than performing other aspects of their job. Another major argument against adopting the Japanese is the value-added by the inspection. Is it worth dedicating 5-8 people for an entire day to prevent one or two callbacks? Financially, it is not. From a customer service viewpoint, it may be worthwhile.

4.6.4. Otis Australia

Australian quality assurance is somewhat similar to Nippon, though even more paperwork intensive. To begin, Australia devoutly uses installation tools and gauges. To ensure standardization, mechanics inspect and calibrate installation tools, measuring tapes, rail gauges, steel rules, and levels monthly. The verifications must be logged on calibration sheets.

Next, Australia focuses upon In Process checks, where the mechanics verify the quality of their work <u>during</u> the installation process. The mechanics fill out up to 14 in process check forms, one for every major portion of assembly. For many of the forms, mechanics must follow a detailed drawing, and physically measure and record several dimensions for a specific part on every floor. This can quickly become a very tedious and time-consuming task. To augment every In Process check sheet; the Inspection and Test Record sheet further ensures a quality installation. It asks more detailed questions and requires a verification signature. Finally, at the completion of the job, mechanics complete the Field Test and Data Report, upon which the Construction and Service Superintendents meet to jointly inspect the unit by using a six page handover inspection report. The total number of pages involved in the installation quality assurance procedure, including instructions, surpass 100.

4.6.5. Otis France

Otis France also subscribes to the In process check method of quality assurance. However, it differs from the other countries in that the French depart from the detailed measuring and recording forms. Rather, Otis France has developed an in process booklet that that details Otis installation standards, and is completed by the installers as the job progresses. It addresses one major area per page. At the conclusion of a major area installation, the mechanic turns to the proper page in the booklet, and ensures that the work meets the standards set forth in the questions. The mechanic then removes a sticker attached to that page, signs it, and places it directly upon the part in question. The sticker remains there permanently. This system works well for the French, and the stickers provide instant accountability for poor installations.

4.6.6. Otis Pacific Asia (PAO)

In areas such as Malaysia and Singapore, the elevators are installed similarly to Nippon Otis. The company utilizes subcontractors, and is struggling with the problem of a significantly less skilled labor pool. As a result, Otis is attempting to introduce In process checks with detailed drawings and tolerances, in addition to a detailed and exhaustive handover inspection at the conclusion of the installation. As in Australia, the installers are required to measure and record several hundred different measurements during the course of an installation.

PAO is introducing an Installation In Process Checks and Field Standards Manual, that outlines a quality process for every stage of the elevator purchase. This Contract Quality Plan begins with the site preparation, and receiving inspections, then moves to equipment inspection and calibration, In process check sheets, Rework sheets, and finally, Inspection and test certificates, and a Joint Handover Inspection.

Obviously, this amount of paperwork is very burdensome. However, Otis feels that it is the correct recourse in controlling the complexity of elevator installation given the labor pool. Most of the documentation would not be helpful for an Otis mechanic in the United States.

4.6.7. How other elevator companies "handover" elevators

Other elevator companies in the United States, such as Montgomery and Dover do not utilize a formal handover inspection when completing an elevator installation. Rather, these companies perform a version of the Field Test and Data to ensure that the elevator is functioning within specified parameters. Also, an informal walk-through is customary. Otis appears to be the leading elevator company in quality assurance.

4.7. Literature Search

4.7.1. Quality

There are a number of books and articles reviewing quality theories and programs. One that was particularly relevant to my research at Otis was Incredibly American: Releasing the Heart of Quality. The book uses AT&T as a case study, and analyzes why the company has difficulty motivating its employees to perform quality work. The authors postulate that the concept of quality is a much more emotionally laden concept for Americans. Due to fundamental cultural differences, Americans view quality differently than the French, Germans, and Japanese. Quality initiatives that emerge from other countries will not yield the same results in American factories, because Americans are internally motivated by different mental models. The authors argue that statements such as "do it right the first time" and "zero defects" are "un-American" and do not motivate Americans, but rather make them feel controlled and restricted. The authors' analysis shows that Americans perform best when presented with a crisis situation. With a crisis, a shared dream and an underdog mentality quickly emerge, and yet another American success story begins.[16]

Incredibly American discusses the fundamental difference between the Japanese and American pursuit of quality. The Japanese work with discipline and consistency to

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[16] Marilyn R. Zuckerman and Lewis J. Hatala, Incredibly American: Releasing the Heart of Quality (Milwaukee, Wisconsin: ASQC Quality Press, 1992) ix-x.

obtain idealized quality targets. Striving towards the unreachable goal is a source of positive energy in their culture, and the unwavering commitment to perfection continues for decades. Americans, on the other hand, feel that this type of methodical approach is unexciting and a source of negative energy. Their approach to achieving the quality targets is quite cyclical--"Quality the American Way." It starts with a large push from a crisis situation, a trough of mistakes and defects in the quality cycle. The urgency drives quality rapidly upward: Americans responding to a challenge or impossible dream. This is the source of American's positive energy. However, this energy soon dissipates nearing the height of the movement. Once the dream is close or even obtained, Americans quickly lose interest, grow overconfident, sloppy, or begin to look for other new challenges. The level of quality soon begins to deteriorate.[17]

The authors demonstrate the cycle in three phases. Phase I is Crisis and Failure, where a shortcoming becomes public. Phase II is Support, where the individuals (or teams) transform the negative emotion of failure into positive energy. This is done by recognizing the problems, facing them honestly, and then discussing them with a mentor. Also during this phase, the individual must seek a Coach to obtain the required knowledge and tools. Lastly, Phase III is Celebration. The Champion is recognized for a job well done. "Pushed by crisis, pulled by an impossible goal"[18] the Champion's achievement is reinforced with more positive energy. Once the driving forces behind American motivation are understood, the quality programs can be developed around them. The key is to proactively create a sense of urgency before falling behind.

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[17] Ibid. 45-54.
[18] Ibid. 64.

4.7.2. Reengineering

In The Reengineering Revolution, Michael Hammer defines reengineering as "the fundamental rethinking and radical redesign of business processes to bring about dramatic improvements in performance."[19] His quick, two word definition is "starting over."[20] Companies often conduct reengineering projects after an existing process becomes so inefficient and obsolete that there is little recourse but to start over. Many rules that existed under the original process have also become outdated. Discarding these constraints allows radical redesign and dramatic improvements.

To ensure a successful reengineering effort, two essential ingredients are necessary. First, Leadership: the project must be driven from the highest levels within the organization. Second, a Reengineering Team, appointed by a senior individual designated to have complete responsibility for the process and its performance. This team must have both Insiders and Outsiders. The Insiders to contribute knowledge and experience, while the Outsiders to bring a fresh and creative perspective.[21]

Hammer also estimates that between 50% to 70% of attempted reengineering projects fall short of delivering forecasted performance improvements. He attributes this to people who do not pursue reengineering the correct way, adding that the results depend upon the "quality, intensity and intelligence of the effort."[22] Leadership and the Reengineering

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[19] Michael Hammer and Steven A. Stanton, The Reengineering Revolution (New York: HarperCollins Publishers, Inc., 1995) 3.
[20] Michael Hammer and James Champy, Reengineering the Corporation (New York: HarperCollins Publishers, Inc., 1993) 49.
[21] The Reengineering Revolution, 13
[22] Ibid. 14.

Team are critical to success, but he also adds further instructions to perform reengineering the correct way:[23]

1. The customer and his needs must be the starting point when redesigning processes.

2. True reengineering rarely produces a perfect process the first time, and is therefore an iterative process. To avoid failure, pilot sites are a necessity to obtain feedback and optimize the new process.

3. Company organizational infrastructure and use of informational technology are "essential enablers of change." Computers and networking ability can tremendously reduce process times and cross functional boundaries.

4. Expect resistance and be prepared to respond. Hammer writes that the hardest part of reengineering is getting people to discard the old, comfortable ways and accept new ones.[24]

4.7.3. Implementation

See Section 7.3 for a discussion of literature about implementation.

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[23] Reengineering the Corporation, 180-192.
[24] The Reengineering Revolution, 117.

5. Root Cause Analysis of Installation-Related Callbacks

Before making changes to any existing policies, or creating new ones, it was important to understand the reasons why the NIS callback rate was so high. Getting to "Root Cause" will yield the answers in usually the most plain and simple terms. After uncovering all the root causes, one can change policy in order to address these shortcomings.

5.1. Poor Quality Assurance Policy

Otis was correct in their belief that the Handover system was not meeting the needs of the company. Without a strong system that can guarantee the delivery of a standardized, quality product, Otis is inviting problems of ride quality and callbacks--not only for the first six months after the installation, but for many years to follow.

5.1.1. Handovers not done (properly)

Although the Southern Area employees are reputed to be the most dependable when it comes to doing a responsible Handover inspection, even they will admit that they do not attend every installation to inspect. Also, most will not faithfully and systematically inspect according to the report's checklist. The norm seems to be a casual inspection; more of a general "walk through," than a thorough examination, dictated by the policy. In other areas within North America that I visited or interviewed, a personal inspection by both (or either) of the Construction and Service Supers is a rarity. Obviously, even the minimum level of acceptable quality in an installation cannot be guaranteed without some means of quality inspection. To standardize installations across the country, the company needs to ensure that every elevator meets what is put forth as meeting "Otis standards." The current quality assurance policy does not enforce that every elevator gets inspected, nor does it have specific inspection questions to ensure standardized installations. The result is that for the most part, the Handovers are not getting done, and when they are done, they are not inspected as they should be. There are a number of other reasons why the inspections are not being performed.

5.1.1.1.Low on Priority

Supers will defend their lack of involvement in the inspection process by arguing that it is difficult to coordinate a mutually agreeable time to meet and inspect an elevator. My experience inspecting elevators in Anaheim confirmed that an uninterrupted time for two Supers can be very difficult to arrange. However, I am convinced that the real reason the Handover Inspection is held in low regard is that the Construction and Service Supers actually place little value on it.

The Construction Superintendent's main priority is keeping the jobs running smoothly so that the installation time and costs are kept to a minimum. To him, a quality inspection can detract from his immediate priorities of monitoring on-going projects. Due to managing the work teams, scheduling and managing projects, and constant meetings with the General Contractor and the final customer, the Construction Super will have very little time to drive out to a completed jobsite and spend one to two hours inspecting the work that his mechanics have performed.

Likewise, the Service Supervisor places a low priority upon the Handover inspection, but for different reasons. First, he is more concerned about his primary job, which is to survey units on O-maintenance. Every unit with a service contract must be inspected and tested annually. Although the inspection form is only 1 page, the inspection can be a time consuming process. A typical gearless unit will usually take 1 1/2 hours to inspect. For the larger buildings with many elevators, a complete building inspection can take up to 3 days. Hydraulic elevators take considerably less time, usually 15 to 30 minutes. However, there is usually only one hydraulic elevator in each inspected building. Therefore, the Service Supervisor spends an inordinate amount of time just driving to and from the inspections sites

Another time-consuming part of his job entails assisting the routemen with service problems. As often the senior service man, the Super possess a wealth of experience and knowledge that is often drawn upon by members of the service department. This type of on the job training knowledge transfer, though beneficial and ultimately essential, decreases the amount of time that the Super can expend on other aspects of his job.

5.1.1.2.Does not address "Combination Superintendents"

Another problem with the handover policy is due to the new position of Combination Superintendents. These are people who work as both a construction and service super in the same office. This position was created several years ago during a period of company downsizing. In many smaller offices, the business was so low that it was possible to merge the two positions into one. The Handover policy was in place prior to the restructuring, and has not been updated to address this situation. The intent of this policy would dictate that the "Combo" would personally visit all jobsites and conduct a personal inspection. This is a virtual impossibility.

I met with a combo who was responsible for the installations and service of all elevators in an entire state, as well as the outlying areas in three border states. He spent most of his time trying to keep up with the deluge of paperwork and day to day office responsibilities that were required of the position. Field visits still had to get done, but most were in a supporting or coordinating capacity. He freely admitted to never performing handover inspections. His first argument was the time issue, and closely followed by the distance between jobsites problem. In addition, the combo felt that his two departments functioned more as a team, as he was measured upon not only the construction efficiency metric, but also the service metrics of callbacks, dollars spent on replacement parts, and hours spent on service routes. The Combo Superintendent can organize the construction and service teams to work together in order to maximize the overall efficiency ratings.

5.1.2. Poor Inspection Questions

An important drawback of the current handover inspection report is that many of the questions are broad, unfocused, and simply unanswerable. The inspection questions do not numerically specify what the Otis standard should be. Originally, the questions were intentionally this broad, so as to be a generic enough questionnaire to meet all elevator installations across NAO. There are numerous door types and configurations, and there are two main types of interlocks. The trade-off between specificity and applicability is difficult to make, as the more focused the questions become, the less relevant they will be for all elevator installations. On the other hand, the more qualitative the question, the less effective it will be in assuring a standardized installation. Otis has erred on the side of applicability in this situation. One standardized form is used for all hydraulic inspections, and the same holds true for traction. The resulting ambiguous questions do little in specifying what meets the standard and what does not. As a consequence, field personnel often complain about the different ways to interpret the questions. This also leaves room for conflict between the Construction and Service Supers.

5.1.3. Deficient measurement system

The current handover system does incorporate a measurement system to assist the management in monitoring the number of defects at the time of handover. The system consists of a report that the Construction Superintendent must complete monthly, informing the regional office of the percentage of units inspected compared to the number of units financially closed, and the percentage of units accepted on the first inspection. The problem with the system is that many Construction Superintendents are not computer literate, and the report that he must submit requires graphs and pareto analysis. Without computers, this simple report can be a very time-consuming and exasperating process. For the most part, the result is obvious: the reports do not get done.

5.1.4. Low managerial involvement/enforcement

One of the reasons that I consider the Handover policy to be ineffective is that there is very little managerial participation. I base this first upon the low level of policy enforcement. The leadership in the company should be ensuring that their products are meeting the company's standard and the customer's satisfaction. Second, as previously mentioned, the current handover policy does have a measurement system that tracks the quality of installations at the time of the handover inspection. Except for the Southern Area, this report is simply not being completed. If the management demanded the report, it would certainly be done. However, based upon the Southern Area data in Chapter 4, managerial involvement in itself is not the only solution. Rather, it is an essential component to successful quality assurance.

5.1.5. Construction gets no feedback on quality of installation

Another root cause of the installation related callbacks is the lack of feedback to the mechanics. According to the policy, the Construction and the Service supers are the ones to meet and conduct the inspection. The mechanics should be gone and working on the next installation. They will not receive feedback on the quality of their installation. Without recognition for an outstanding job, and with small rewards (time off, better jobs) for completing the jobs in less than the sold hours, the mechanic will care much less for the quality of his installation than he will the installation time. The only exceptions to the feedback are when the installation is so poor that it does not pass the handover inspection or there are an inordinate number of callbacks once the unit is placed into service with the customer.

5.1.6. Cost prohibitive for rework at the time of final inspection

Rework is another problem that has plagued both manufacturing facilities and construction projects, and the elevator business is no exception. There are two ways to avoid rework: First, do it correct the first time. As Incredibly American argues, this is contrary to Quality the American Way, so it will not occur.[25] The avoidance measure is to create quality inspection points within the process. This prevents a defective product from continuing downstream, and having additional work put into a product that is already faulty. The Handover Inspection is a control to ensure that the customer receives a quality elevator. However, at the time of inspection the installation is already finished, so any defects that require rework will be substantially more costly to complete than if they were discovered during the installation. A prime example came from the interview of the Service Superintendent in Denver as mentioned in Chapter 4. If a defect was found during an inspection, but the elevator would still run properly, the defect may be purposely overlooked. Margins are so low on many elevator sales, that the rework could cause a profitable installation to become unprofitable.

5.2. No Ownership from Construction

Another problem that I saw as a key part of the installation related callbacks is the ownership issue. **Whose elevator is it?** Because the employees who install the elevators

[25] Incredibly American, 51.

are different from those who service them, the question of ownership is important. The answer is that during the short term, (installation through handover) the elevator is owned by the construction department. During the long term the Service department owns the elevator. Why then, would the Construction department have anything except for a myopic view when installing the units? Many of the mechanics that I interviewed listed personal pride and good reputation as reasons for proper installations. However, many more mechanics agreed with the question of ownership, and went on to complain about the way they are measured (job hours, not quality) will dictate the way they behave.

5.2.1. Efficiency metric

I have discussed the efficiency metric in earlier sections. There is no doubt that it is a major contributor to the problem of high NIS callbacks.

A good portion of the Construction Superintendent's incentive pay is derived from the efficiency metric. There is no question that this is a driving force in dictating his installation priorities. He is under constant pressure to complete installations, and has little incentive to perform a high quality installation. I recommended to the Director of the Field Support Team that the new metric should incorporate only Total Installation Cost and NIS Callbacks. These two measurements address the cost issue addressed by the efficiency metric, as well as the quality issue that is measured by the NIS callbacks. Members of upper management in Otis are reviewing the efficiency metric, and will eventually change it.

5.3. Training

In his book Head to Head, renowned economist Lester Thurow maintains that work force education and skills will be pivotal for future global economic competition.[26] Given the high level of craftsmanship involved in an elevator installation, the issue of training and skills development is a continual problem for the company. To respond to these issues, Otis has developed a comprehensive and continuing training program for mechanics. The company recognizes that a highly trained mechanic will be able to install a much more reliable elevator in a lesser amount of time.

5.4. Causal Loop

By reviewing and analyzing the data that I compiled from OTISLINE, in addition to the field visits and interviews, I drew the causal loop in Figure 22. This diagram is a comprehensive look at the cause/effect relationships that exist for installation-related callbacks. To reduce these types of callbacks, one must increase the emphasis on one or more of the outer variables.

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[26] Lester Thurow, Head to Head (New York: Time Warner Books, 1993) 23.

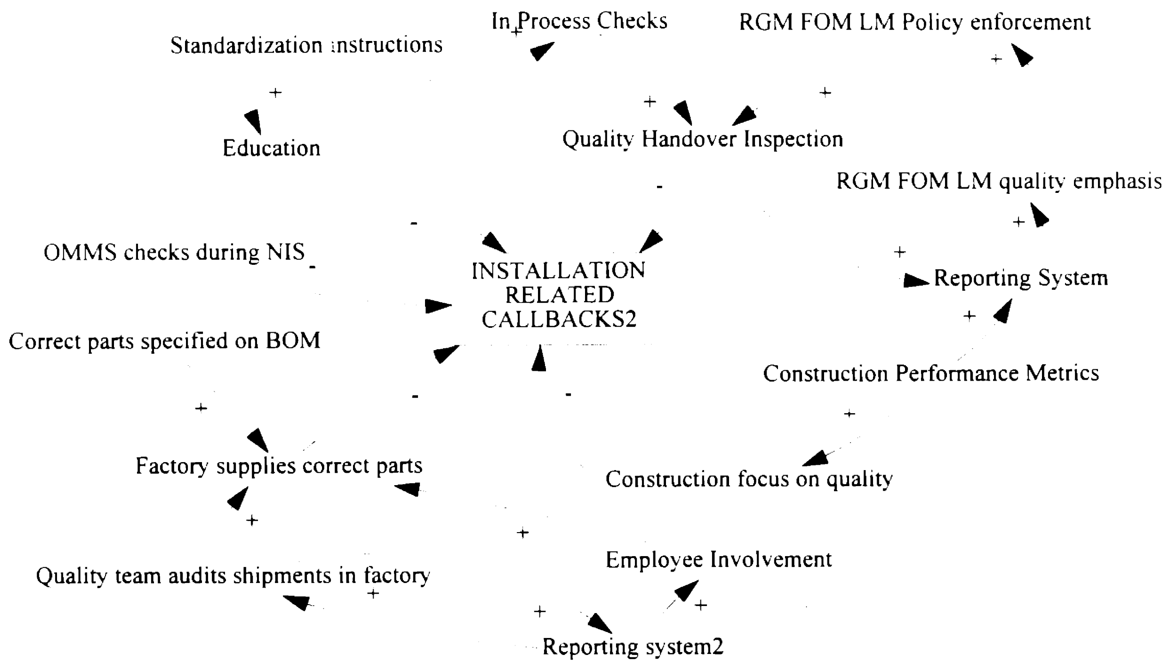

Figure 22

I focused upon the upper right hand quadrant of this causal loop diagram, as I felt this represented the most room for improvement. Briefly, more RGM, FOM, LM Policy enforcement, in addition to improved In Process checks will create a higher quality handover inspection. A better handover inspection can reduce installation related callbacks, as well as improve the reporting system for tracking handover quality. The reproting system improvement will drive more RGM, FOM, and LM emphasis on quality. The more this group emphasizes quality, the more they will enforce the Handover Policy. This causal relationship has a positive reinforcement loop, as an increase of a variable in the system can induce further growth in future time periods. The remainder of the diagram is primarily for the benefit of the company and/or is self-explanatory.

5.5. Identify Constraints

I was presented with very few constraints in developing a solution to the handover problem. Upper management was open to new ideas and desired me to travel to and interview employees at several different field locations in order to capture a representative voice of the field/customer. However, from field interviews, one constraint became apparent as my research developed.

5.5.1. Remember the end-user

The key to success of any new handover policy, lies with the participation of the Construction Department. In Reengineering the Corporation, Hammer's first rule when performing reengineering is to begin with the customer and his needs.[27] The Construction Superintendents and the mechanics must agree on any new inspection techniques and understand the reasons for the change. Otherwise, the policy is doomed to failure from the beginning, as the employees could simply complete the reports at their desks, and not physically inspect the elevators.

An understanding of whom this policy affects, as well as the background of the end-users who inspect is critical in delivering a method by which installation defects could be substantially reduced. First, most mechanics and superintendents have received little formal education. Any new policy would have to be clear and practical. Second, the construction employees are pressed for time during installations. Any changes to the current policy would be positively received if it reduced inspection times. Third, the field

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[27] Reengineering the Corporation, 180.

blames "corporate interference" for much the paperwork that is involved with their jobs. My goal was to minimize the paperwork flow, and streamline any communication processes that involved a paper trail. This too, would aid in the acceptance of the new policy, as well minimize the sentiment of corporate forcing another new policy upon the field.

6. Solutions

Many answers to the problem of high NIS callbacks must lie within a new quality system that addresses all of the current Handover policy's shortcomings.

6.1. Improve Communication

There are a number of communication channels that can be strengthened to improve overall elevator quality. First, mechanics are not being properly informed of recurring elevator callback areas. The mechanics could place more emphasis on installing the trouble areas correctly, thereby reducing the callbacks. Second, the communication between Construction and Service Supers can be improved when planning for a Handover date. Third, the location manager is excluded from involvement in the current handover system, and should be more actively involved in the process.

6.1.1. Field Articles

Otis' Field Support Department has two existing newsletters that are written exclusively for field employees. These act as a forum to increase awareness in the importance of quality for both new equipment installations and service callbacks.

6.1.1.1. Construction Newsletter

Articles in this publication pertain to installations. The newsletter is distributed bi-monthly, and contains updates in new installation techniques, safety, new tools, etc. I wrote an article to inform the mechanics about the importance of having clean door tracks when leaving a job. Dirt and other foreign articles in the tracks are a leading cause of "door category" callbacks during NIS. With more emphasis in this area, the number of door callbacks can be reduced.

6.1.1.2. CRC letter

The Callback Reduction Center (CRC) team is a group within Field Support that focuses on reducing callbacks on new equipment installations. They closely monitor the high-visibility traction elevator callbacks and scrutinize every callback that entraps a passenger. The CRC newsletter is primarily directed toward the Service departments, and the articles involve a wide spectrum of subject matters. I wrote an article discussing the importance of a thorough Handover Inspection, and suggested that two recent entrapments could have been prevented with a more thorough inspection.

6.1.2. "Punchlist" reporting sheet

To improve location manager communication within the Handover system, I developed a Handover "Punchlist" Reporting Sheet. (See Annex A). The report must be signed by the location manager if the elevator will be given to the customer with any defects. This will keep the Location Manager apprised of the more severe quality problems, as well as serve two additional purposes. First, it details the additional work required to bring the elevator to "zero defects." The report will list a date for the work to be completed and address who is responsible. This should serve as a mechanism to ensure that all final punchlist items are completed. Second, this form serves to deter defects, as the Construction and Service Supers must complete the form for every unit that has defects at handover. The Construction Super will inform his mechanics that he had to waste time completing paperwork due to an installation defect. To avoid this, the mechanics will install future elevators with more care and responsibility.

6.1.3. Advance Notification of Completion Form

I refined the Advance Notification of Completion Form to improve the communications channel between the Construction and Service Supers. (See Annex B). This form's purpose is to establish a Handover inspection date and time between the Supers. Currently, the Construction Superintendent completes the form 5 days prior to the completion of an installation, and sends it to the Service Supervisor. Construction requests three different dates and times for the Handover, and Service will select one of them. The Service will select a time, sign the bottom of the form, tear it off, and return to the Construction Super. This form was not being used by the two departments for two main reasons. First, the Construction Super could not reliably determine the day the installation would be complete 5 days before the completion of the Hydraulic units. Too much variability existed that far in advance. Also, tearing the sheet of paper in half and returning the bottom was not working, as the "scrap" paper often was lost before it returned to the Construction Super's desk.

The new form reduces the required lead time from 5 days to 2 days for Hydraulic and 4 days for Traction. This will yield more accurate inspection times, and improve the communication between the two departments. Also, like Hunter's Project Awareness Report, the form will be copied to other people in the location that need to be apprised of the elevator's status. The location manager will be more actively involved in the Handover process if he is included in the communication loop. The reinforcement will be important in establishing and maintaining managerial involvement. Lastly, the new form does away with the "tear and return." The revised form continues to have the Service Supervisor sign the form, but now the entire form will be returned to the Construction Department.

6.2. In Process Checks (IPC)

The biggest change to the proposed Handover Policy is the way newly installed units will be inspected. The problems with the large, time-consuming inspection at the conclusion of the inspection càn be curtailed by following the lead of the Japanese, French and Australians. A different means of assuring quality--moving to in process inspection points--will ensure that all inspections questions get personally inspected at a time in which corrective actions can easily be taken. The volume of inspection questions in the current handover inspection report is such that many questions do not get examined because it would simply take too long. By moving the inspection to during the installation process, the mechanic can inspect as he completes the work. This insures that each question receives a personal examination.

The in process check concept is not new to manufacturing, nor to construction. For example, the Case Corporation manufactures tractors for agriculture. On the assembly line, there was such a high variability at the point where the cab was joined to the body (primarily electronic routing) that the rework costs were extreme. The company installed a quality check prior to the joining, and the reliability improved ten-fold.

In construction, beams and columns are checked during the framing process to ensure they are level and plumb. Both procedures prevent adding value to a defective product, and minimize the amount of required rework. Installing elevators is no different. Rather than "inspecting the quality out," Otis can now "build quality in" to its units.

The questions will be categorized by elevator subassembly. Each subassembly will have a page of inspection questions that must be completed to either pass elevator code requirements, or to prevent a callback. Two areas that are particularly prone to callbacks during NIS, doors and interlocks, will have detailed drawings that outline the required dimensions and allowed tolerances. All of the in process checks will be sent to the jobsite in the erector's folder in booklet form.[28] Also included will be the Field Test and Data Report, the Advance Notice of Completion, and the new Handover Inspection Report. This new Handover Form will not have any questions on it. Rather, the final inspection between the Construction and the Service will simply be a review and random audit of the questions from the in process checks. See Annex C for the In process check sheets and new Handover Inspection Report.

6.2.1. Ownership

As mentioned, the French complement the In process checksheets with "stickers" that the mechanics and adjusters affix to the inspected subassemblies. I know of no better way to instill employee ownership into a product than to have him put his name on it. I adopted the French idea, but to a lesser degree. Rather than signing their name to all of the different parts, employees will only sign names to the components that fail the most--

[28] The erector's folder contains the elevator's architectural drawings, safety stickers, various contract forms, the Field Test and Data form, and the Handover Inspection Report.

again, doors and interlocks. Too many areas requiring stickers would detract from the parts that needed the added inspection, and would waste time. For the other inspection areas in the elevator, the NAO employees will sign the IPC page at the bottom. This still incorporates ownership, but to a lesser degree.

One significant consideration in implementing this concept is procuring Union approval. Currently, the Union contract protects mechanics from signing their name to the newly installed elevators for liability reasons. This issue will be further discussed in the next chapter.

6.3. Delegation

I introduced inspection delegation authority into the new policy to respond to complaints from both the Construction and Service Supers. They felt the high volume of elevators being installed, combined with the excessive distances between the jobs, would prohibit a personal inspection. The policy will now allow for either Super to send a responsible delegate (mechanic or examiner) to perform the inspection. This type of inspection is frequently being done now (against policy), yet it is possibly a better way to do handovers. Who knows more about the inspected elevator except the mechanics who installed it, and who cares more about a quality elevator at handover than the examiner, who will be answering the calls and servicing the system once it is handed over? Because interest and ownership levels will vary across the country, it will be the decision of the Supers to determine which responsible delegates they will allow to perform the inspections.

6.4. *Quantitative Checks*

Many of the inspection questions in the current Handover inspection report were ineffective because they were imprecise. The qualitative questions left much room for interpretation and argument, and did not set forth "Otis Standards" of a satisfactory installation. In fact, many questions on the report were extremely nebulous:

- Is the ride to Otis standards?
- Doors hung properly?
- Is the paint to Otis standards?
- Interlocks installed properly?

After the assistance of dozens of mechanics and the review of numerous engineering drawings, I developed many new inspection questions to specifically define "Otis Standards" for many elevator subsystems. The questions contain the proper measurements, and even include the allowed tolerance. Some are so specific as to include inspection drawings. I focused the most detailed questions upon the areas that failed the most often due to improper installation. Similarly, parts that never failed will receive less attention during an inspection, and I designed questions with no required physical measurements for these areas.

6.5. *Managerial Involvement*

To further connect the location manager to the Handover process, he will be involved in allowing the customer to receive a defective unit. On occasion, an inspected elevator will have defects, while the customer requires the unit immediately. The customer is willing to accept the elevator in the defective condition, given that Otis will later complete the repairs. The old policy dictated that the Regional General Manager (RGM) must approve the transfer of the unit.[29] This was too high a level. The original philosophy was if the approval source was that high, the employees would go to great lengths to avoid the scrutiny that would accompany the approval. Also, at the time that the current policy was written, the location manager was a newly created position. Rather than compound the uncertainty associated with the organizational change, the authority would rest in a known and proven source.

The new policy empowers the location manager with approval authority for two main reasons. First, he is more familiar with the unit's history and closer to the customer. He can make a better decision because he will have more complete information. Second, this autonomy is consistent with the decentralized culture that permeates the company. As the location manager is charged with the full responsibility the location, he should be making the decisions that will affect it.

6.5.1. New measuring/reporting system

Another means to elicit active managerial involvement is to transform the Handover reporting system into one that is streamlined, informative, and provides feedback to reinforce continuos participation from management. One of the main reasons that the current reporting system does not work effectively is due to the computer requirements of the Construction Superintendents. The solution comes in the structure of a "Fill in the blanks" form. (See Annex D). This form simply asks for a monthly summary of the defects found during Handover inspections, arranged by the In process Checks categories. The Construction Superintendent will also address which units were accepted by the

[29] Under no circumstances can an elevator be turned over to a customer with a safety related defect.

customer with defects, and the number of days required to rectify the problems. The form also requests other information that the Construction Super can easily access. This Monthly Handover Summary will be submitted to the Location Manager and the Field Operations Manager (FOM) for review.

On a quarterly basis, the FOM will consolidate the information and submit a similar report to the Regional General Manager, Area Vice President, (AVP) and the Field Support Team via computerized template file. (See Annex E). The report will automatically indicate which categories have the most defects at the time of handover in graphical form. Also, the report will also identify which locations have the fewest average defects per handover, in addition to the best first time acceptance rate. The RGM and AVP can better monitor the success of the handover system in their areas of responsibility, and assist those locations that require special attention. The Field Support Team can gather the summary report files by e-mail and easily conglomerate the NAO callback statistics. Through the Construction Newsletter as a feedback mechanism, Field Support can indicate which IPC sheets have the highest defect rate at Handover, and encourage the mechanics to pay special attention to these areas during future installations.

6.6. New installation Tool

As mentioned in Chapter 2, interlock callbacks are among the highest categories during NIS. There are two types of interlocks: the OVL and the 6940A. The OVL interlock has a gauge that assists in the installation, to insure that every lock is consistently installed. The 6940A interlock does not have such a gauge, yet every hydraulic elevator utilizes only the 6940A interlock. A member of the Field Support Team and I designed a tool to assist in the standardized installation of the 6940A door locks. This gauge will also reduce the installation times in two areas. First, the interlocks will be installed with the gauge and a screwdriver, and will not require the use of a door vane[30] during the installation. This will streamline the direct installation process. By using the gauge, there is only one procedure to install the interlock. Standardization, in any process, will reduce variation and speed learning effects. Currently, there are numerous ways to install the locks, as the instruction comes from fragmented, on the job training from hundreds of different senior mechanics. This leads to the second area of reducing the installation time: after the installation, adjusters and service routemen often alter the door locks to their standards, as they were taught different methods and settings to properly outfit the locks. With a gauge to detail Otis standards across NAO, the rework between the mechanic and adjuster/routeman can be substantially reduced, thus saving time on the overall installation/service hours. Moreover, many people have commented that this tool will be as important as the handover in process checks in reducing the number of installation related callbacks (See Annex F for Field Comments).

[30] An elevator part that mechanically interacts with the interlock.

6.6.1. Picture of tool

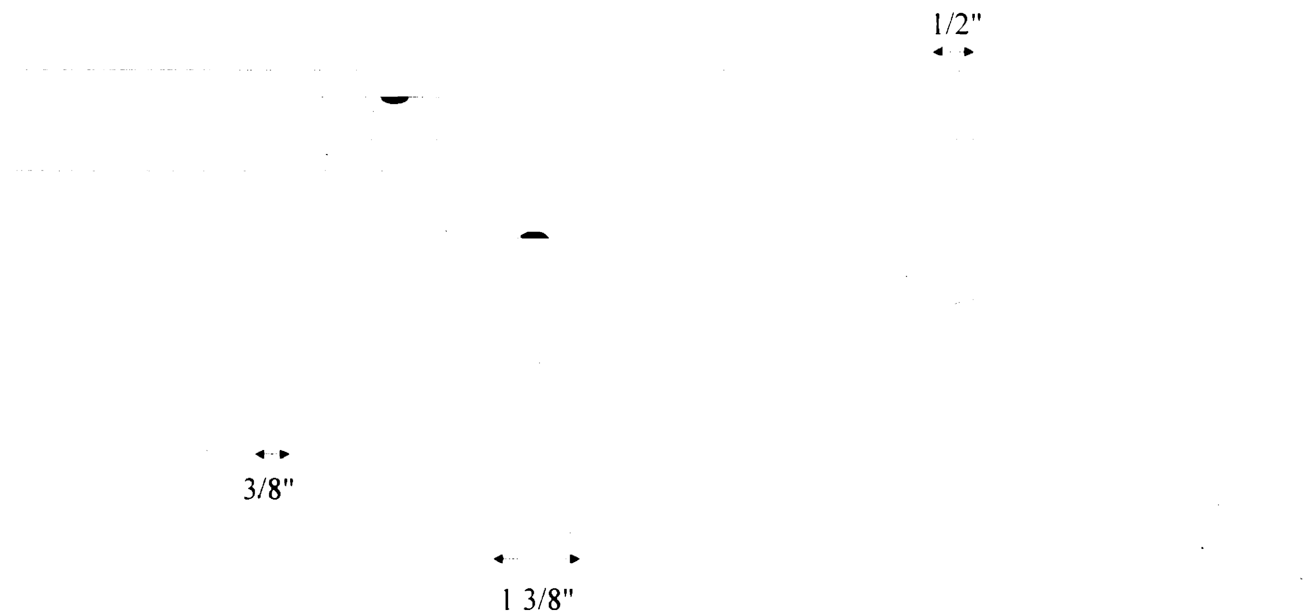

Figure 23

6.7. Standard Installation Instructions

The field employees would require directions of how to properly use the 6940A Interlock Gauge. I developed comprehensive instructions that would detail the correct use of the gauge. (See Annex G). An important requirement when writing the instructions was to use concise technical writing, combined with illustrations of the interlock and the gauge in the various stages of installation. Mechanics have little patience when on the job, pressured for time, trying to interpret unnecessarily complex engineering drawings.

I also refined the OVL interlock gauge instructions in much the same manner. They were in metric measurements, as well as being difficult to read and comprehend. (See Annex H).

6.8. Clear, Efficient, Practical Policy

The new Handover policy is summarized for the field personnel in a brief introductory letter signed by the president of NAO. (See Annex I). The letter emphasizes the importance of managerial involvement and participation to the successful deployment of the new policy.

The new Handover policy is several pages shorter than the old policy, and the writing is much more crisp and readable. (See Annex J). It addresses all of the major concepts mentioned in this chapter, as well as several minor details that must be included in any comprehensive procedure.

7. Implementation

Once I attained what I believed was a viable solution, I turned to what proved to be the most difficult and time-consuming process: implementation. Both my direct supervisor and his boss agreed that the new policy and inspection process addressed the problems that they had observed with the current policy. However, we all believed that a "reality check" was necessary. We wanted to see if the process would actually work in the field if actual mechanics performed the Handover. It was critical that the new system be easily accepted by the field, otherwise the policy would be destined for the fate of the current policy-- passive neglect. Interestingly, the decision to pilot the Handover process proved to be only the first step in a long course towards final execution.

7.1. Pilot sites

My superiors and I felt that appropriate places to conduct the testing would be in the places that I previously visited: Denver and Anaheim. We believed we could get timely, honest comments from the mechanics and supers in this pilot sites. Also, these sites had expressed an interest in how the Handover Inspections would develop as a result of my visit and their inputs.

I wrote drafts of the Handover introduction letter, the actual Handover policy, and instructions for using the 6940A interlock gauge. Also, I developed four prototype hydraulic Installation Quality Assurance booklets--complete with actual stickers, (two pilot installations per city) and the gauge made of sheet steel (1/8" thick) with line levels surface mounted.

Prior to shipping the packets, I contacted the Construction Supers in these areas directly to ensure that they were fully aware of what was expected from them. The only guidance that I gave them was to meet with the Service Supervisor and read over the documents together. I also requested that they perform the in process checks and handover inspection exactly as put forth in the policy and instructions. Finally, I asked them to contact me upon completion of the installations so that I could record their feedback.

7.1.1. Denver

Many weeks later, the Denver location was the first to complete the installations using the new policy. The Construction Superintendent, reported that the construction went smoothly, and the mechanics completed the booklets during the installation process just as they were supposed to. The Handover inspection occurred between the mechanic and the examiner and they found no defects.

The feedback was detailed and overall very positive. The Construction Superintendent stated that the policy was a great improvement over the old policy, and that he would have no hesitation transitioning to the new process. He specifically mentioned that he thought the stickers were a worthy concept. Also, he offered suggestions particular to improving the quality of the inspections. First, he recommended a change to the revised Advance Notification of Completion Form. The original form that I had modified required it to be completed 5 days before an installation. I had shortened the lead time to

4 days. He felt there was still too much variability in the installation process that would allow for an accurate handover date and time.[31] Next, he recommended changing the wording on two of the inspection questions (for clarification) which I did. Lastly, he commented on the 6940A interlock gauge. The mechanic that used it had over 10 years of installation experience. He said that he could perform the interlock set-up faster without the gauge. However, the experienced mechanic intended to give the gauge to the new mechanics to ensure that they installed all of the interlocks properly.

A follow-up conversation three months later indicated the validity of the new process, as the unit had taken no major callbacks since the Handover inspection.

7.1.2. Anaheim

The Construction Superintendent finished the pilot several weeks later. He also had valuable input to further refine the new process. He recommending rewording several inspection questions, which I did. Also, the mechanic who installed the unit sent me his comments. Overall, he welcomed the system, and did not feel that the added responsibility encroached on the time allocation to complete the installation. Further, he felt that the tool was a very useful invention, and said he would continue to utilize it on future installations. His major critique of the procedure was the policy's requirement for the mechanics to sign their name to the label. He felt that Otis could accomplish the same effect by asking for the employee's identification number instead. This, he felt, would allow mechanics to more readily accept the new inspection technique.

[31] I reviewed the installation processes and changed the required notification time to 2 days for hydros and 4 days for traction. (As discussed in Chapter 5).

The mechanic in Anaheim made a very cogent point about the issue of "signing off" on a particular subassembly. However, I disagreed. By printing the name, the mechanics will feel more direct ownership. Also, the feedback mechanism for education and communication would be significantly hampered. Routemen responding to calls would not be able to instantly discern who installed the part. An employee I.D. on the label would require the routeman to write down the number and then go back to the location office to find whose name corresponded to the number. In discussions with other former field personnel in Bloomington, we mutually concluded that this proposed change would not be as direct or efficient as the existing procedure. The general consensus was that the routemen would not go through the trouble of finding the mechanic if it required any effort.

7.2. Union

The Anaheim mechanic's proposal also would have circumvented the Union contract with respect to prohibiting Otis from requiring signatures of mechanics in any situation. However, The Director of the Field Support Team recognized the importance of the stickers inducing ownership. He felt that the best implementation approach would be to contact top Union representatives, and convince them of the significance, and belay concerns of liability. He sent copies of the inspection booklets to Otis' manager of Labor Relations and asked for input. The Labor Relations manager met with his Union counterpart, and they ruled that there would be no conflict with the intention of the contract.

Recommendation: For a clear resolution of this issue, the wording in the Union contract must be changed to specify this exception during the next contract negotiation.

7.3. Literature about Implementation

In his book, What Machines Can't Do, Bob Thomas writes of several companies that implemented technologically advanced equipment in manufacturing processes. Although new machines are much different than a quality assurance process, Thomas' ideas relating to securing a seamless execution of change are noteworthy. First, Thomas says that the segments of an organization which have the power to shape the given process (or policy) must be aligned to ensure the change.[32] In other words, understand and utilize the political structure of an organization. Second, Thomas also points out that a combination of managerial commitment to the project, as well as initial and continuous employee involvement is critical to introducing significant change into an organization. From the internship, I discovered that obtaining these structural components of "integrated change" is a continuous managerial challenge.

In Images of Organization, Gareth Morgan reinforces the importance of political involvement by discussing the relationships of interests, conflict, and power in comparing organizations to political entities.[33] He argues that by understanding the linkages between these areas in behavioral terms, one can more effectively work within an organization to control desired outcomes.

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[32] Robert J. Thomas, What Machines Can't Do (Los Angeles, CA: University of California Press, 1994) 227-228.

[33] Gareth Morgan, Images of Organization (Newbury Park, CA: Sage Publications, 1986) 148-198.

Lastly, John Guaspari's It's about Time suggests that organizations which learn to effectively manage and implement change (in product, process, and policy) will prosper by not only making a product better than its competitors, but also by getting it to the customer faster. Guaspari believes that *Time* will be the next paradigm in business.[34]

7.4. Improving the Tool

From field input, there was clearly a latent need for a tool to assist in the installation of the 6940A interlock. The concept of gauge was sound, but the field considered the prototype wanting. The tool evolved to its present condition after three series of improvements. First, it was too thin. By increasing the thickness, the line levels could be "press fit" into the gauge. This would serve not only to protect the levels. but also to bring an appearance of durability to the tool. The first prototype was approximately 4 ounces and looked very fragile.

The second generation of the tool was 1/2" thick, made of steel. The levels would fit inside nicely, but the gauge weighed over 1 pound, was unwieldy, and would pose a deadly hazard if it were dropped down an elevator shaft.. Also, the thick gauge had several sharp corners that could injure the installers. Ideas to cut the weight, but not the thickness were plentiful. The viable options were reduced to plastic or aluminum. I chose plastic primarily to keep the production costs low.

For the third revision, the tool was fabricated from a black, surface-textured, plastic. Final field tests found room for one final improvement: the space between the two

[34] John Guaspari, It's About Time (New York, Rath & Strong, Inc., 1992) 88-90.

prongs (See Chapter 6) was approximately 1/8" too far apart. The space was to allow a roller set, (See instructions in Annex I) and I had miscalculated the appropriate amount of additional space required for allowing the gauge to easily fit over the roller. The fourth revision, which incorporated this minor correction, will be listed in the Otis tool catalogue. As previously mentioned, the intellectual property division is also reviewing the invention for a patent.

7.5. Field Council Meeting

The Director of Field Support holds a quarterly meeting with 10 to 15 of the most highly regarded field employees called the Field Operations Council (FOC). Because this group holds considerable power in shaping installation practices, I presented the proposed new Handover Policy to them. Overall, the feedback was positive, and the FOC gave its recommendation to enact the new policy. With this backing, we believed that we would encounter little opposition in later presenting to the Product Committee, which would ultimately decide whether to accept the revised Handover Policy.

7.5.1. Atlanta

While waiting for the Product Committee meeting, which is held monthly, we felt that we could further insure success by piloting the process in Atlanta. We chose this city because the southern states were known to be the most resistant to change. If we could inspire the employees to become more involved in the shaping of the new policy, they would be more accepting of it. Once again, interviews with the field labor who used the process were overall positive, though they felt that the 6940A tool would make more of an impact in interlock reliability issues.

7.6. Gathering Support

I also attempted to further gather employee support. Concurrent with the Atlanta pilot site, I sent out the new policy to 10 Otis contacts that I had worked with in developing the Handover Policy for their review. The specific purpose was to make them "owners" by demonstrating to them that they had a formative role in building this new process. This would also make them advocates of this policy once it was approved by the Product committee.

7.7. Lobbying

To secure managerial commitment, proponents of the new Handover Policy met individually with some members of the product committee. The meeting allowed for "one on one" education of the new policy, and reasons for its revision. Further, we could incorporate their recommendations for improvement into the policy so that the key figures would also have ownership.

The Product Committee is comprised of the NAO President and 7 vice-presidents. The vice-president of Quality was approached by a direct report that I had been working with. The director of Field Support met with an Area vice-president who was known for being a strong supporter of the existing process. Lastly, the director of Field Support and I met with the vice-president responsible for New Equipment operations. The end result was a considerable investment in time to ensure policy acceptance at the Product Committee meeting. In fact, the point of the Product Committee meeting to discuss the Handover Policy was essentially mute, as we knew after our lobbying efforts that it would be passed. The meeting would primarily serve to ensure that the higher level management all understood the concept and operation of the policy.

After several months, the Handover Policy became ratified at a Product Committee meeting.

8. Conclusion

The research methods and findings for this project proved to be a positive learning experience for me, as well as for Otis. In my exit interviews with the company, all the representatives commented upon the success of the internship and the project.

8.1. Summary of Findings

- As demonstrated in Chapter 2, there is considerable room for reducing costs by improving elevator installation quality. Both pilot sites that used the new quality assurance process felt it was a marked improvement over the existing policy. Given the large number of revisions and improvements that I made to the process during the formulation and implementation stages, I believe that there are more areas that can and will be improved upon as more feedback becomes available from future installations.

- In process checks fundamentally ensure a quality product while ultimately saving time and money by reducing rework due to defects discovered at the end of the installation. The issue of "building quality in" rather than "inspecting quality out" can apply to areas other than traditional manufacturing. An elevator installation is an assembly, and like other assembly or manufacturing processes, the quality should not be inspected at the end of the operation. Rather, it must be inspected immediately after the subassemblies that have questionable reliability are completed, to better ensure that the end product will function as designed. These checks can also serve to foster employee ownership, which can also improve the product quality. If an employee believes that his work is important, or that others can check the quality of his work, then the employee will make the extra effort to ensure that the product is correct the first time.

- Proper use of the new Handover Policy and the new 6940A interlock gauge in the field should contribute towards the Field Support Department's goal of increasing the field's productivity by 5%. This is accomplished primarily by reducing rework time, but the gauge also will reduce installation time of the door locks. The new tool and policy are integrated in the inspection checklists, and complement each other well.
- The new Quality Assurance policy is too paperwork intensive for a world class company. When developing processes, new forms and other paperwork are often introduced. The paper is ordinarily applied as a tool for evidence of communication or ownership. Processes which are reengineered often integrate information technology as a means to substantially reduce the need for abundant paperwork. Otis is not yet at the stage at which the process can be performed by recording the data on computer and then sending the documents electronically to management, or perhaps even the customer. However, as these means develop, management of the Quality Assurance process will be much easier and efficient for all concerned if the policy were again revised to reflect gains in computer technology.
- Unquestionably, during my project I learned a great deal about implementing change in a large, decentralized organization. First, the implementation phase is the most important phase in the change process. A great plan poorly executed can easily fail,

while an average plan that is well implemented may produce successful results. For this reason implementing organizational change usually takes more time and energy than simply finding the solutions.

Second, a champion, or owner, can make the difference in swift and successful implementation of a project. The ownership issue, combined with the signal of managerial commitment to the project can improve the probability of success.

Lastly, participation from the beginning by those who will be affected by the project is essential. These people can be a tremendous resource in discovering solutions, as well as powerful allies during the implementation phase. Because the employees who will be using the process also have a stake in its success, they will be the best salesmen available when teaching others how to use the new procedures. This is possibly one of the best ways to overcome cultural resistance to change.

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Annex A

"Punchlist Reporting Sheet"

PAGE MISSING

OTIS

HANDOVER "PUNCH LIST" REPORTING SHEET

(To be completed only if additional work is required after Handover Inspection)

TO:______________________________
Location Manager

FROM:__________________________
Construction Superintendent

____
Service Supervisor

Building Name and Address: ____

____

____

Contract Number: ______________________ Elevator #: __________________

Equipment Type: ________________________

ADDITIONAL WORK	Date to be completed	Individual Responsible
1.		
2.		
3.		

How can this be prevented in future installations?

Estimated cost to OTIS to complete work:_____________

Customer informed of additional work requirements on ________________________
DATE

____
Construction Signature

____
Service Signature

Annex B

Advanced Notice of Completion Form

Advance Notification of Completion

(Hydros: send 2 days prior to completion date)
(Traction: send 4 days prior to completion date)

UNITED TECHNOLOGIES
OTIS ELEVATOR

North American Operations, Office:____________ **Date:**____________

To: ____________________
Service Supervisor

From: ____________________
Construction Superintendent

CC: LM: ________________

FOM: ________________

Service Salesperson: ________________

Account Rep: ________________

The following elevator installation will be ready for a Handover Inspection on ____________
______A.M./P.M.

If this is not convenient, I would like to propose an alternate date of ____________
______A.M./P.M.

Building Name and Address: ______________________________

____

Contract Number(s): ________________

Equipment Type: ________________

Please complete the statement below and return this form to my office as soon as possible:

A representative from the Service Department will meet to conduct the Handover Inspection of

Contract # ____________ on ____________, __________A.M./P.M.
Date Time

____
Service Supervisor

Annex C

In Process Check Sheets

HYDRAULIC

UNITED
TECHNOLOGIES
OTIS ELEVATOR

INSTALLATION QUALITY ASSURANCE

Inside:

IN PROCESS CHECKS AND

HANDOVER INSPECTION REPORT

For:

Building Name and Address: ____

____

____

Contract Number: ______________________ Elevator #: __________________

Equipment Type: ______________________

IN PROCESS CHECK SHEET

UNITED TECHNOLOGIES
OTIS ELEVATOR

MACHINE AND MACHINE ROOM

INSPECTION:	YES	NO
Maximum oil in tank? (2" from To/From hole)	☐	☐
Tank and To/From line free from oil leaks?	☐	☐
To/From line isolated and clear of tank?	☐	☐
Safety stickers present?	☐	☐
Machine and disconnect numbered?	☐	☐
Wiring properly formed and tied?	☐	☐
All fuses properly sized, one-time fuses?	☐	☐
Relays properly seated, wire retainers in place?	☐	☐
All equipment grounded to code?	☐	☐
Pipe stands installed to code?	☐	☐
Transformer voltage connections correct?	☐	☐

Remarks

IPC performed by: ______________________

IN PROCESS CHECK SHEET

UNITED TECHNOLOGIES
OTIS ELEVATOR

PIT AND BOTTOM OF CAR

INSPECTION:	YES	NO	N/A
Light and outlet working?	☐	☐	
Pit and packing free of oil leaks?	☐	☐	
Traveling Cables properly hung and protected?	☐	☐	
Slide guides correct version (white)?	☐	☐	
Pit switch works electrically?	☐	☐	
Ground wire from carframe to piston?	☐	☐	
Bottom roller guides set properly?	☐	☐	
If 2-piece plunger, smooth joint?	☐	☐	☐

Remarks

IPC performed by: ______________________

IN PROCESS CHECK SHEET

UNITED TECHNOLOGIES OTIS ELEVATOR

CAR AND CAR DOOR

INSPECTION:	YES	NO
Sills and tracks clean?	☐	☐
Lambda's working and free of dust?	☐	☐
Door close tension minimum?	☐	☐
Door nudging and closing speeds to code?	☐	☐
Sill clearance set to 1 1/4" (Maximum)?	☐	☐
Door operator braced?	☐	☐
Door linkage and vane thru bolted?	☐	☐
Gate switch set to 3/4" (±1/8")	☐	☐
Gate switch roller thru bolted?	☐	☐
Car safety circuits working?	☐	☐
Retainer screw in COP?	☐	☐

Remarks

IPC performed by: ______________________________

IN PROCESS CHECK SHEET

UNITED TECHNOLOGIES
OTIS ELEVATOR

HOISTWAY AND TOP OF CAR

INSPECTION:	YES	NO	N/A
DBG correct and rails aligned?	☐	☐	
Magnets 1/2" from inductors? ($\pm 3/32"$)	☐	☐	
Top of car inspection circuits, light and outlet working?	☐	☐	
Evacuation deterrents installed?	☐	☐	
Fascia hung correctly?	☐	☐	
Final limit set and thru bolted?	☐	☐	
Car steadying plates and roller guides set?	☐	☐	
Trough covers installed?	☐	☐	
Fire stops installed?	☐	☐	
Safety rail installed? (if req'd)	☐	☐	☐

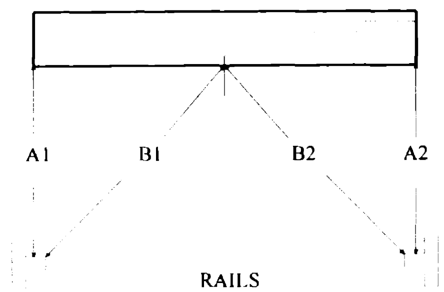
Remarks

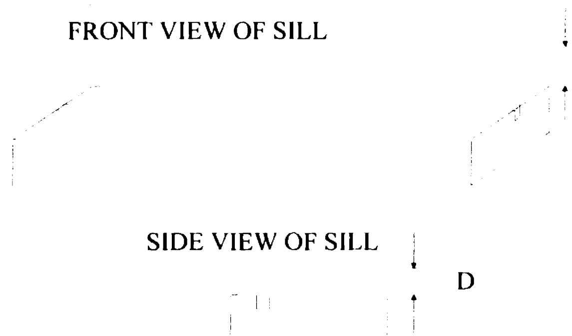
IPC performed by: ______________________

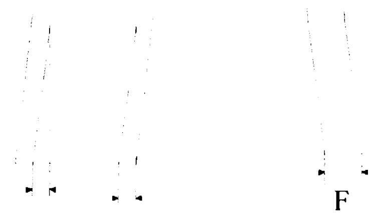
IN PROCESS CHECK SHEET

UNITED TECHNOLOGIES OTIS ELEVATOR

HOISTWAY ENTRANCES







IPC performed by: ______________________

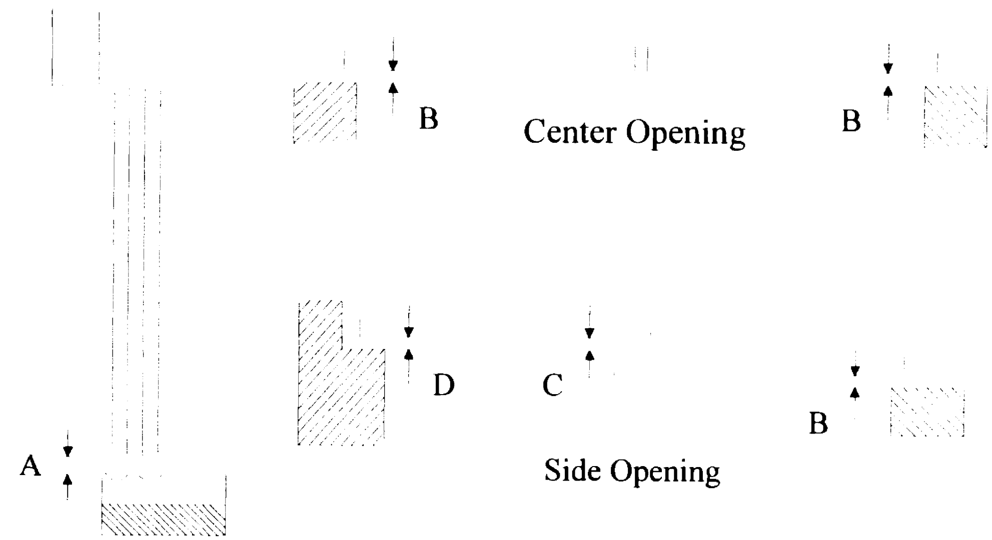
Measured points	Standard	Tolerance	
Distance from rail to sill	A1 = A2	1/32”	A1, A2
Distance from rail to center of sill	B1 = B2	1/32”	B1, B2
Level sill	LEVEL	*1/16”	C, D
Plumb door jams	PLUMB	*1/16”	E1, E2
Plumb door jams	PLUMB	*1/16”	F

ENTRANCE INSTALLED BY: ______________ PRINTED NAME	ENTRANCE INSTALLED BY: ______________ PRINTED NAME
ENTRANCE INSTALLED BY: ______________ PRINTED NAME	ENTRANCE INSTALLED BY: ______________ PRINTED NAME
ENTRANCE INSTALLED BY: ______________ PRINTED NAME	ENTRANCE INSTALLED BY: ______________ PRINTED NAME

IN PROCESS CHECK SHEET

UNITED TECHNOLOGIES OTIS ELEVATOR

HOISTWAY DOORS



Measured points	Standard	Tolerance	
Clearance between left door and sill	1/4”	1/8”	A
Clearance between right door and sill	1/4”	1/8”	A
Clearance between door and jamb (for both open and closed positions)	1/4” Center Opening	1/8”	B
Clearance between doors (for both open and closed positions)	5/16” Side opening	1/8”	C
Clearance between door and jamb (closed position)	1/4” Side opening	1/8”	D
Upthrust rollers in alignment and have proper clearance	.008” (use a feeler gauge)	.002”	

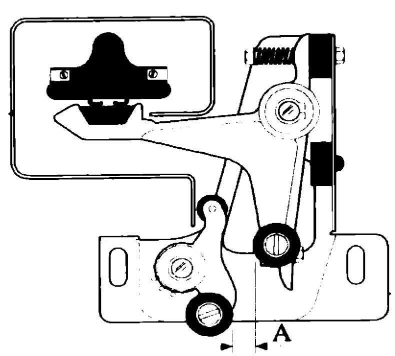
DOOR INSTALLED BY: ______ PRINTED NAME	DOOR INSTALLED BY: ______ PRINTED NAME
DOOR INSTALLED BY: ______ PRINTED NAME	DOOR INSTALLED BY: ______ PRINTED NAME
DOOR INSTALLED BY: ______ PRINTED NAME	DOOR INSTALLED BY: ______ PRINTED NAME

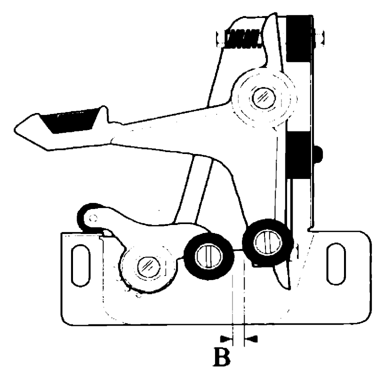
IPC performed by: ______

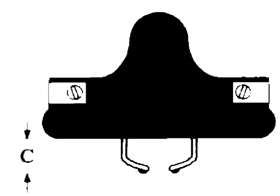
UNITED TECHNOLOGIES OTIS ELEVATOR

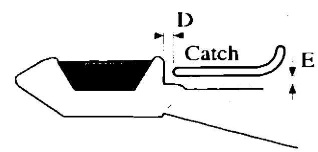
IN PROCESS CHECK SHEET

6940A INTERLOCK



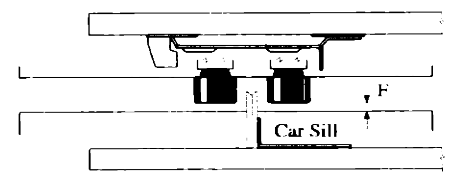






MT-121076

Gauge to be used



Measured points	Standard	
Distance between rollers (Doors closed)	1 3/8”	A
Distance between rollers (Doors open)	3/8”	B
Contact Height	3/8”	C
Clearance - main lockarm to lock	1/8”	D
Clearance - main lockarm to latch	1/8” - 1/4”	E
Clearance - latch rollers to car sill	Minimum 1/4”	F

INSTALLED BY:

PRINTED NAME

INSTALLED BY:

PRINTED NAME

INSTALLED BY:

PRINTED NAME

INSTALLED BY:

PRINTED NAME

INSTALLED BY:

PRINTED NAME

INSTALLED BY:

PRINTED NAME

IN PROCESS CHECK SHEET

UNITED TECHNOLOGIES OTIS ELEVATOR

CONTRACTOR AND MISCELLANEOUS

INSPECTION:	YES	NO	N/A
Temporary jumpers removed?	☐	☐	
Ventilation in machine room?	☐	☐	
Sump hole cover in place?	☐	☐	
Grout around well hole?	☐	☐	
Grout around door frames?	☐	☐	
Smoke detector installed?	☐	☐	
Contractor notified of any code discrepancies?	☐	☐	☐
Marked up wiring diagrams processed?	☐	☐	☐
Applicable TIPS completed and recorded?	☐	☐	☐

Remarks

IPC performed by: ____________________

Handover Inspection Report

Send booklet to Regional Field Engineer upon completion

UNITED TECHNOLOGIES
OTIS ELEVATOR

Hydraulic

North American Operations, Office:____________ Date:______________

_________________________ Construction Inspector

_________________________ Maintenance Inspector

Building Name and Address: ____

____

Contract Number: ____________________ Elevator #: ________________

INSPECTION ITEM	REFERENCE	NUMBER OF DEFECTS
Machine and Machine Room	IPC-01	
Pit and Bottom of Car	IPC-02	
Car and Car Door	IPC-03	
Hoistway and Top of Car	IPC-04	
Hoistway Entrances	IPC-05	
Hoistway Doors	IPC-06	
Interlocks	IPC-07	
Field Test and Data	992 B	☐ FE will sign original and return booklet to local office.
Contractor and Misc.	IPC-08	

Total Number of Defects: ____________________

Note: Unit cannot be placed in service until all defects have been corrected. See NAO Field Operation Policy C13-2 for exceptions.

Comments:

_________________________ Construction Signature

_________________________ Maintenance Signature

Annex D

Monthly Handover Summary Report

MONTHLY HANDOVER SUMMARY REPORT

TO:______________________________
Location Manager

FROM:______________________________
Construction Superintendent

____
Field Operations Manager

TRACTION AND HYDRAULIC		
INSPECTION ITEM	**REFERENCE**	**NUMBER OF DEFECTS**
Machine and Machine Room	IPC-01 IPC-09	
Pit and Bottom of Car	IPC-02 IPC-10	
Car and Car Door	IPC-03 IPC-11	
Hoistway and Top of Car	IPC-04 IPC-12	
Hoistway Entrances	IPC-05 IPC-13	
Hoistway Doors	IPC-06 IPC-14	
Interlocks	IPC-07 IPC15, IPC-16	
Contractor and Misc.	IPC-08 IPC17	

Units accepted by customer with defects	Days to correct defect(s)
Contract #	
Contract #	
Contract #	

Average # of days to correct defect:____________

Number of Handovers ompleted____________________

Number of units inspected with no efects:___________

First Time Acceptance Rate:__________%
(# of Units Inspected with No Defects / # of Handovers Completed) * 100

Total Number of Handover Defects:____________

Annex E

Quarterly Handover Summary Report

QUARTERLY HANDOVER SUMMARY REPORT

Total # of Handovers Completed	106

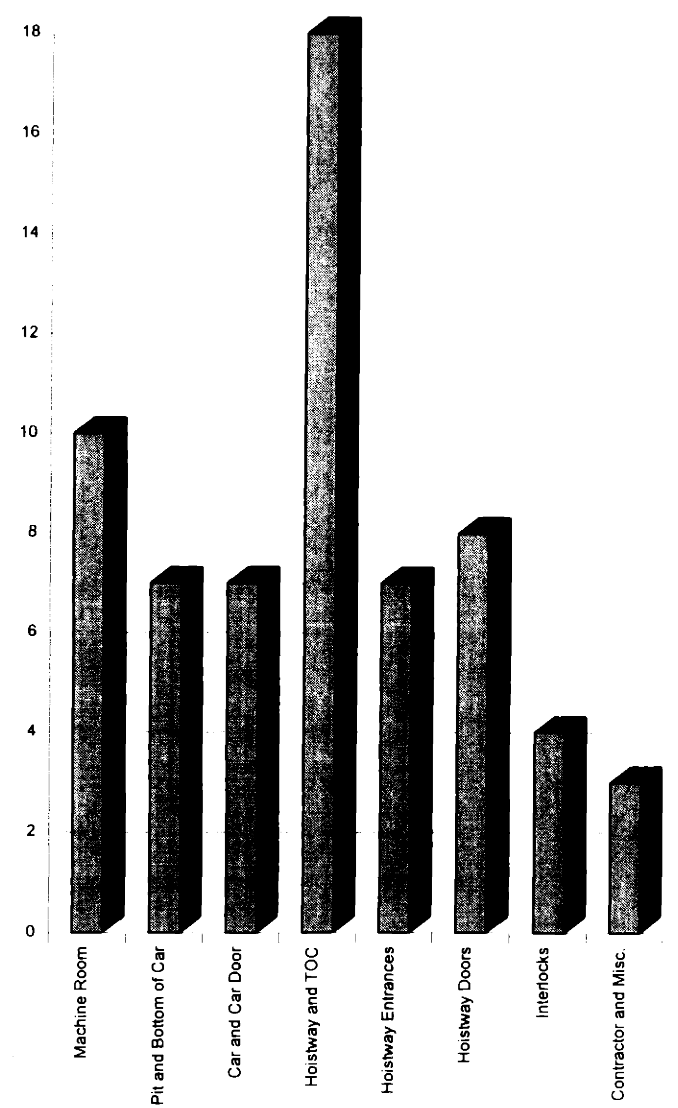
____________Region, _____Quarter

INSPECTION ITEM	# of Defects
Machine Room	10
Pit and Bottom of Car	7
Car and Car Door	7
Hoistway and TOC	18
Hoistway Entrances	7
Hoistway Doors	8
Interlocks	4
Contractor and Misc.	3
Total Number of Defects:	64
Total # of units with Zero Defects	81

SUMMARY STATISTICS:

Average Number of Defects per Handover	0.6
Average First time acceptance rate	76%
Units accepted by customer with defects	8
Average time to correct defects (Days)	10

Location with Fewest Average Defects per Handover	
Location with Best First Time Acceptance Rate	



Annex F

Field Comments

FIELD COMMENTS ON THE 6940A INTERLOCK GAUGE

DENVER

"This is a large improvement over the current installation techniques."

-Phil Neeley, Construction Superintendent

ANAHEIM

"The gauge could be useful in keeping a consistent installation on all jobs."

-Omar Magana, Mechanic

ATLANTA

"This tool works great! Every mechanic should have one. Can I keep this one?"

-Don Ledbetter, Adjuster

"The 6940A interlock gauge will complement the new handover policy nicely to ensure consistant standardized installations. It will reduce also rework time in the mechanic-adjuster transition."

-Ron Baretto, Construction Superintendent

"This tool is a good invention. I will use it from now on."

-Harold Lippitt, Mechanic

SEATTLE

"The concept of giving specific dimensions, specific and simple tools, and user-friendly drawings went over well. This process is a step in the right direction."

-Roy Russell, Construction Superintendent in a meeting with his mechanics

PITTSBURGH

"Like the idea and the overall concept."

-2 Maintenance Supervisors and Bill Fiacco (Location Manager)

Annex G

6940A Interlock Gauge Instructions

SETTING UP THE 6940A INTERLOCK ASSEMBLY

FOUR FUNCTION GAUGE

A special 4 function gauge has been designed to help adjust door lock linkages (Fig. 1).

The gauge provides:

- A level for setting the latch arm properly.
- A dimension for the locked position of the unlocking rollers.
- A dimension for the unlocked position of the unlocking rollers.
- A dimension for the contact height.

The gauge should be used for quicker setting up of 6940A door locks with reduced errors and more consistent setting between floors.

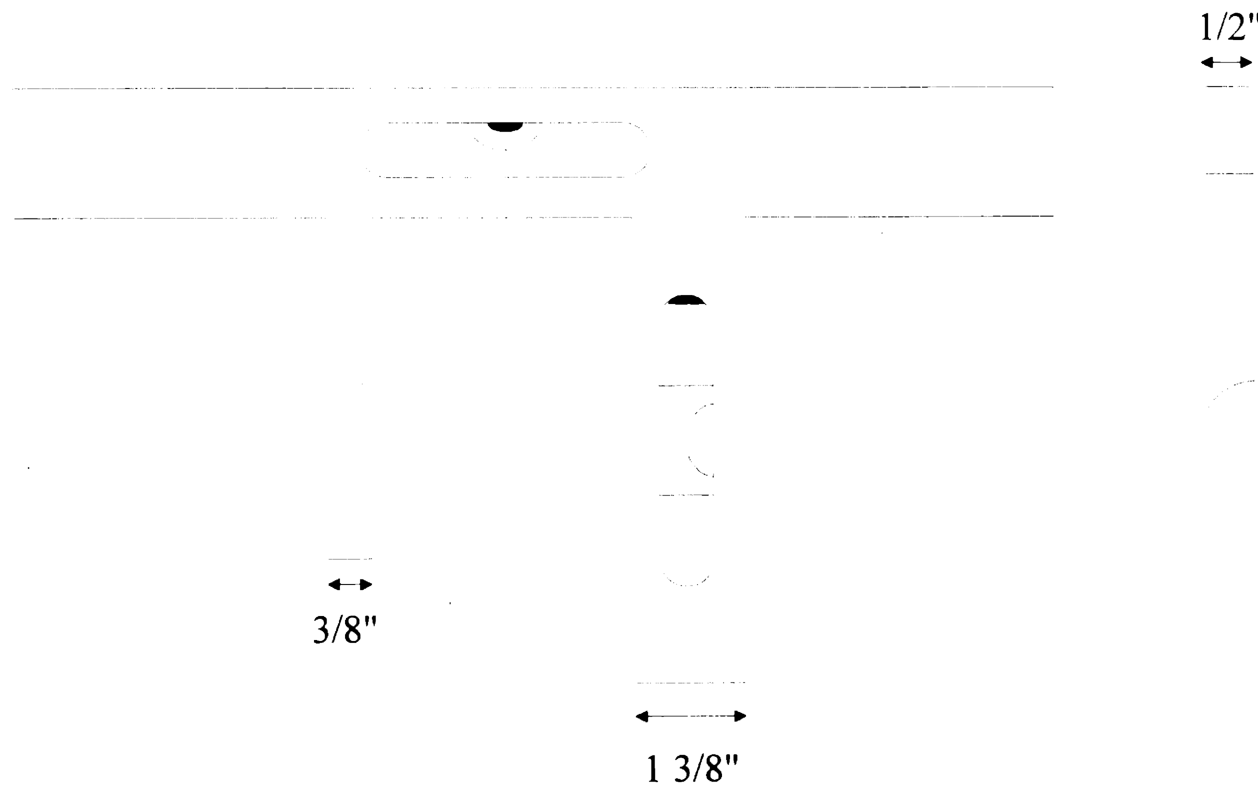


Figure 1

WARNING: Always power down and follow OTIS' Safety Standards before beginning any work.

USING THE GAUGE

Setting up the 6940A Interlock

- Note: A mechanic must first perform a few basic steps in the installation procedure before using the gauge.

STEP 1

Install electrical box. (Fig. 2)

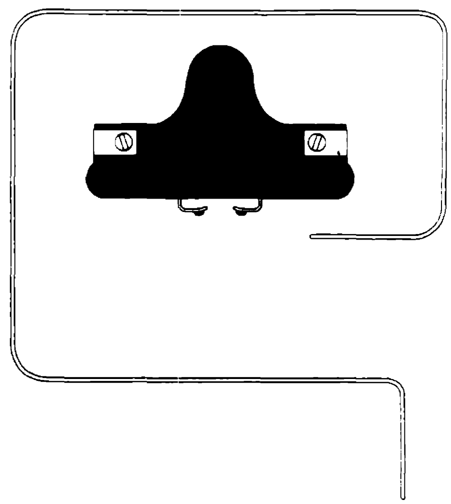


Figure 2

STEP 2

Install latch and bell crank on "master floor." Use the gauge to ensure that the assembly is straight up and down (plumb). See Fig. 3.

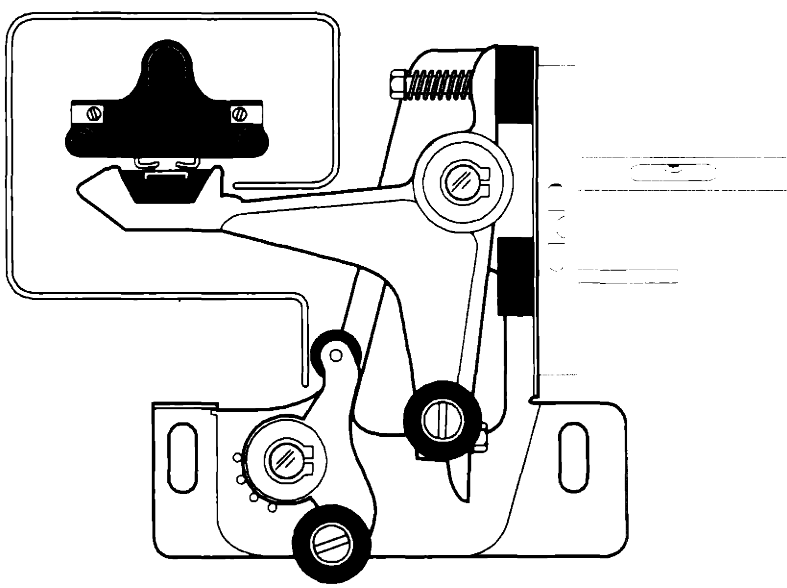


Figure 3

STEP 3

Adjust washer behind rollers to set proper distance of 1/4" from car sill. (Fig. 4) In order to ensure that all locks will be "in-line,". use the side of a roller as a reference and mark the car sill. Use this mark to set all future door locks in the hoistway.

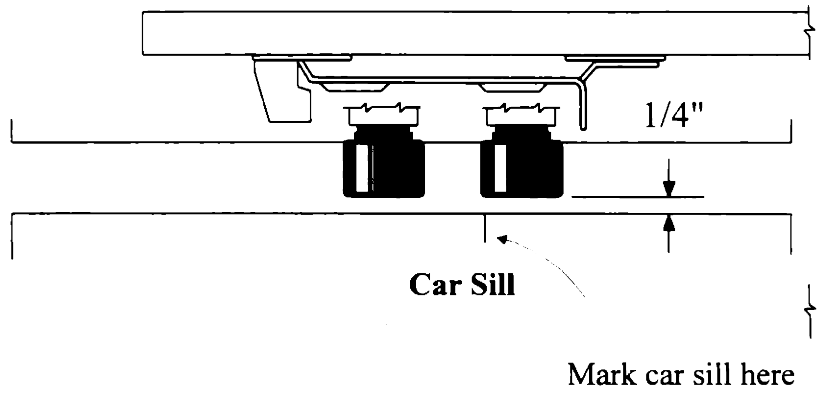


Figure 4

STEP 4

With doors open, and latch open, use the gauge to measure 3/8" (perpendicular) between the two rollers (Fig. 5). Ensure that the gauge is level.

- Adjust eccentric on bell crank roller to achieve this measurement.

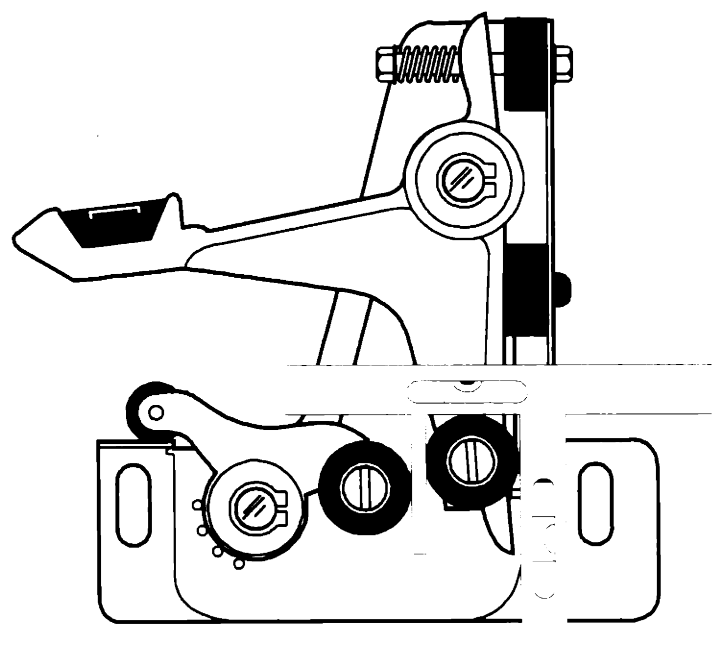


Figure 5

STEP 5

With doors closed and latch closed, use the gauge to measure 1 3/8" (perpendicular) between the rollers (Fig. 6). Again, ensure that the gauge is level. If the measurement is not exactly 1 3/8" do the following:

- Ensure that the latch has 1/2" of movement, if it does not, then shim the bolt that retains the spring.
- Otherwise, adjust the metal tab on the contact box to achieve the measurement.

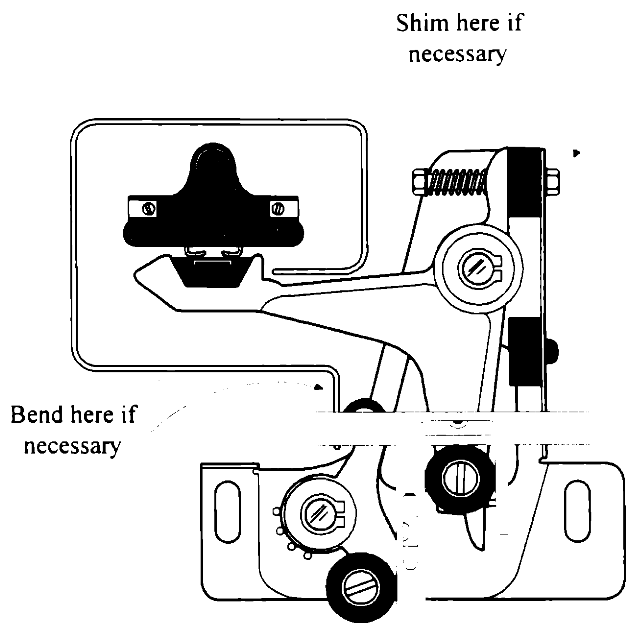


Figure 6

STEP 6

Adjust the Contact Height to 3/8," using the gauge to check the measurement (Fig. 7).

- Also check to see that the contact compression is 3/32."

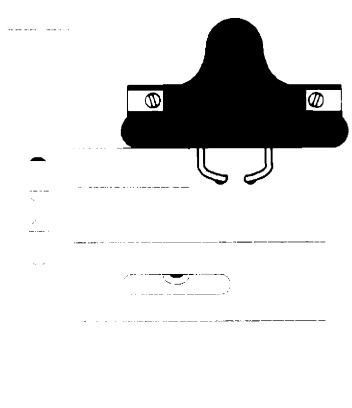


Figure 7

STEP 7

The final important adjustments do not require the gauge.

Check to ensure the clearance of the main lockarm to the latch is 1/8"to 1/4".

Check that the clearance of the main lockarm to the lock is 1/8" (Fig. 8).

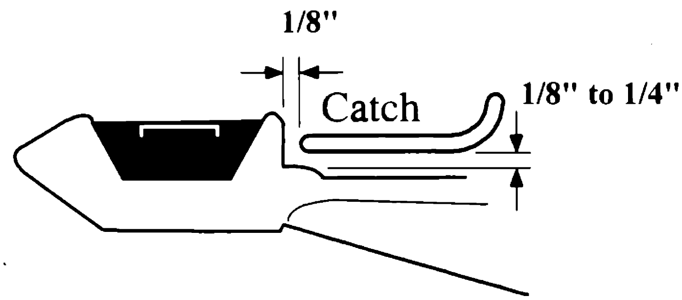


Figure 8

STEP 8

Install cover, place "Installed By" label on cover, and move to the next floor to repeat steps 1 through 8.

Annex H

OVL Interlock Gauge Instructions

SETTING UP THE OVL INTERLOCK ASSEMBLY

FIVE FUNCTION GAUGE (MT-121074)

A special 5 function gauge has been designed to help adjust door lock linkages (Fig. 1). The gauge provides:

- A dimension for the locked position of the unlocking rollers.
- A dimension for the unlocked position of the unlocking rollers.
- The contact height dimension.
- The latch spring dimension.
- The latch to catch clearance dimension.

The gauge should be used for quicker setting up of OVL doors, with reduced errors and more consistent settings between floors.

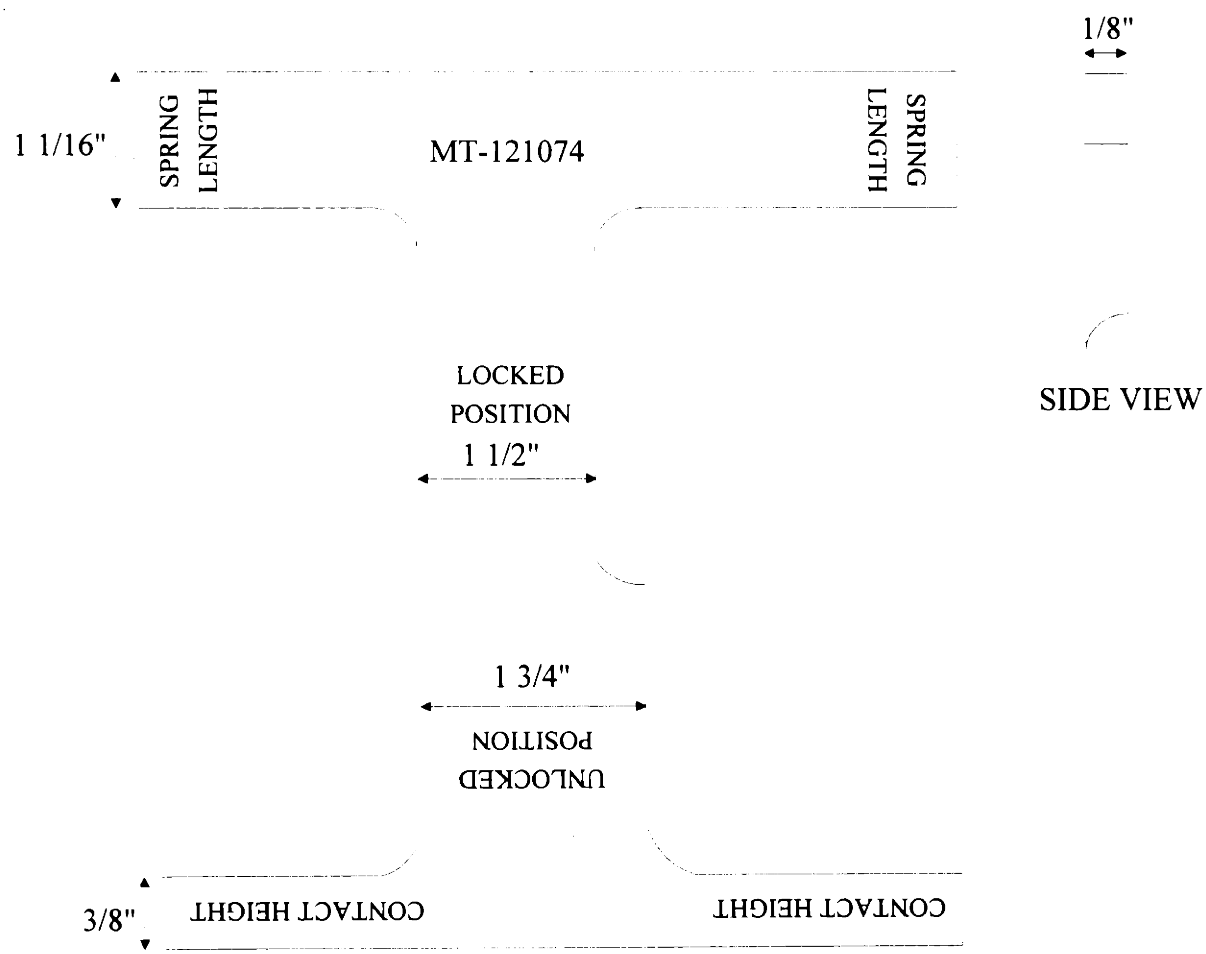


Figure 1

USING THE GAUGE

Setting up the drive lever assembly

1. Insert the wide end of the gauge (Unlocked Position) between the two rollers (Fig. 2), holding the movable roller against the rubber stop as shown.

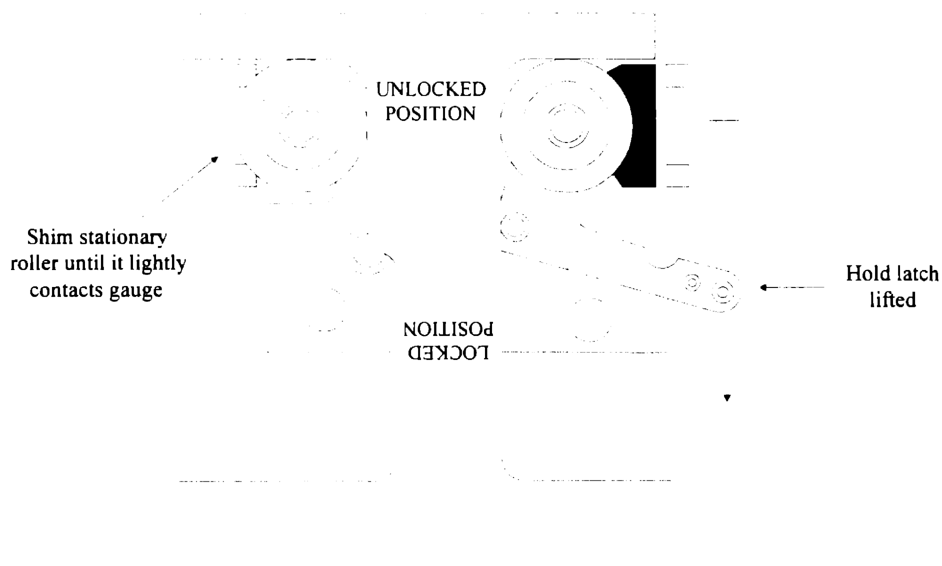


Figure 2

- The stationary roller should be lightly touching the gauge and should rotate easily as the gauge is moved up and down. If it does not rotate easily, add or remove shims to or from the roller.

2. This adjustment should be made with the doors open to prevent interference from the contact fingers.

    - Insert the narrow end of the gauge (Locked Position) between the rollers (Fig. 3). Hold it against the stationary roller.

    - Set the adjustable rubber stop so that the movable roller lays against the gauge when the drive lever contacts the adjustable rubber stop.

    - This adjustment sets the movable roller for the 1/4" of movement necessary to ensure the latch clears the lock when lifted.

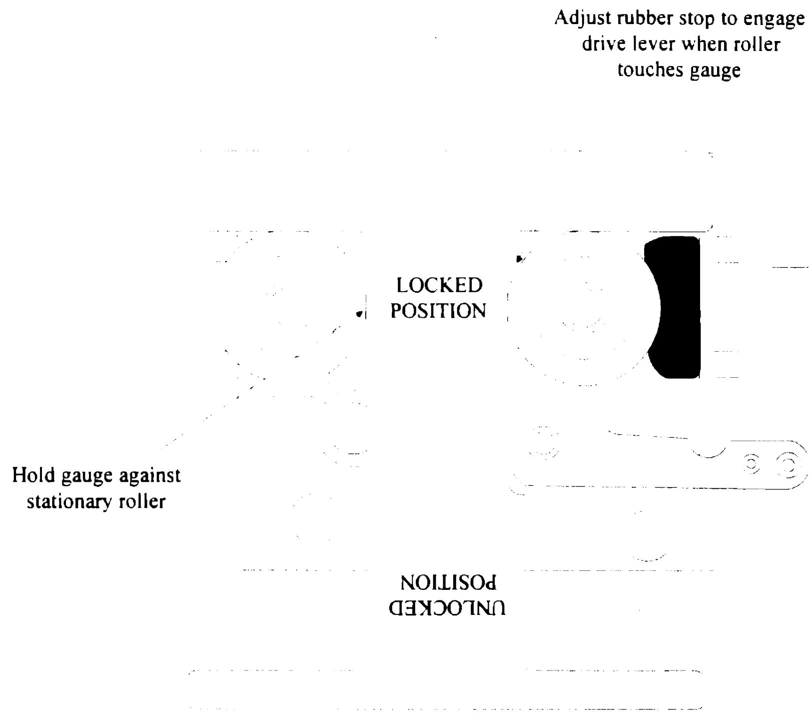


Figure 3

3. Inspect the casting of the drive lever if difficulty is experienced in achieving the required adjustment. Some castings have excess material on the shoulder (Fig. 4). Remove the drive lever and file or grind off the excess. Re-install the drive lever and re-adjust the rubber stop as described above.

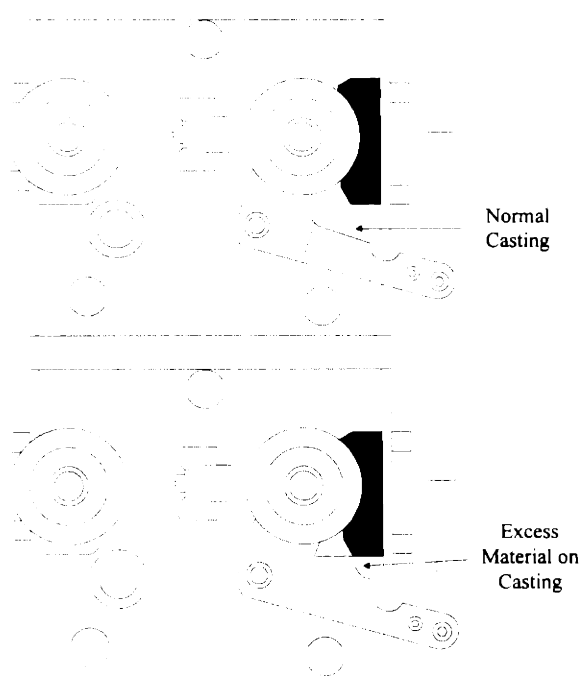


Figure 4

Adjustments to the latch assembly

1. Ensure that the adjusting rod is clean and lightly lubricated. Make sure the washer is not binding on the rod (Fig. 5).

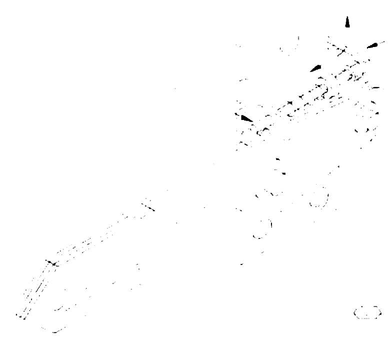


Figure 5

2. Check that the adjusting rod is in the center of its guide and moves freely. If it does not, adjust its position by bending the tab left or right as indicated on Fig. 5.

3. Open the doors so that the movable roller is against its adjustable rubber stop. Adjust the turnbuckle so that the shorting bar on the latch is horizontal. Tighten the turnbuckle. Make sure the swivel in the latch assembly remains in the center.

4. Insert the end of the 5 function gauge (Spring Length - 1 1/16") between the washer and the boss on the adjusting rod. Adjust the rod until the gauge slides into the gap easily (Fig. 6).

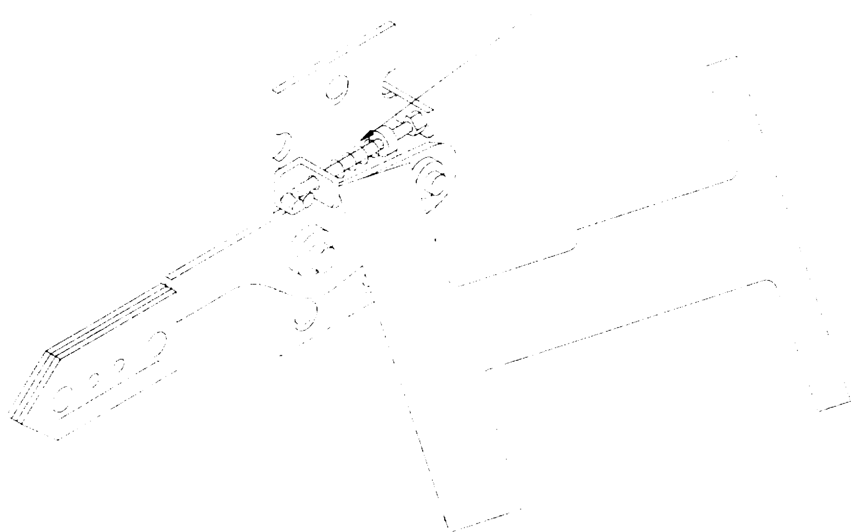


Figure 6

Adjustments to contact fingers in the switch box assembly

WARNING:
REMOVE ELECTRICAL POWER FROM DOOR LOCK

1. Push down on a contact finger where it bends round the insulated contact block with a medium flat blade screwdriver (Fig. 7). Bend the contact gently until the contact 3/8" above the top of the plastic. Repeat for other contact.

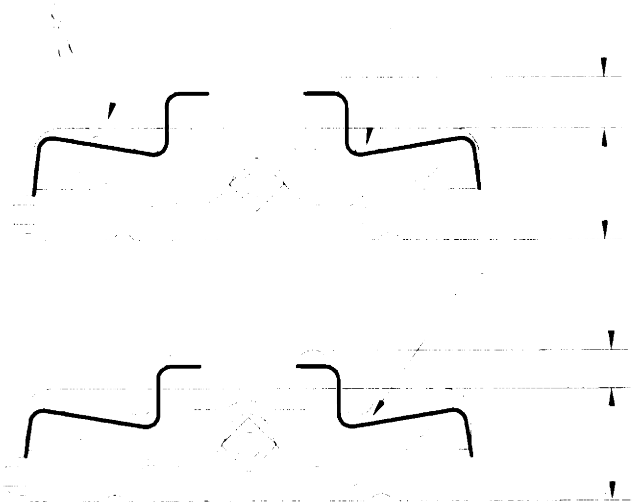


Figure 7

2. Use the edge of the 5 function gauge marked "Contact Height" to confirm a correct adjustment (Fig. 8).

Note: *The contact nearest the catch should be slightly lower than the other contact to enable the shorting bar on the latch to make simultaneous contact with both as it drops.*

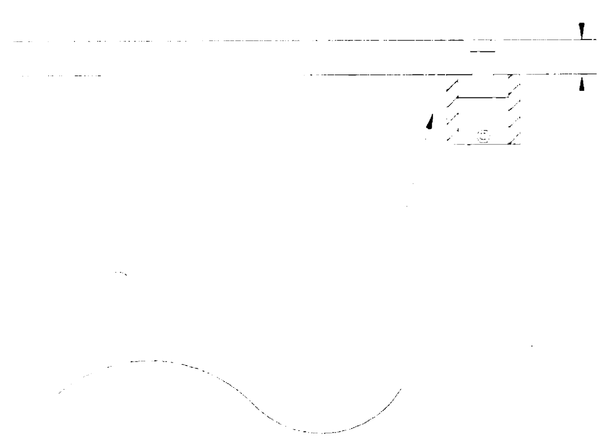


Figure 8

Latch to Catch Clearance

1. Operate the latch mechanism manually by moving the drive roller of the door drive assembly. Repeat several times and observe the latch action. The latch should rise approximately 1/2" overall. See Fig. 9.

2. Check that the clearance of the catch and latch in horizontal and vertical planes is 1/8". Measure by using the 5 function gauge which is 1/8" thick (Fig. 9).

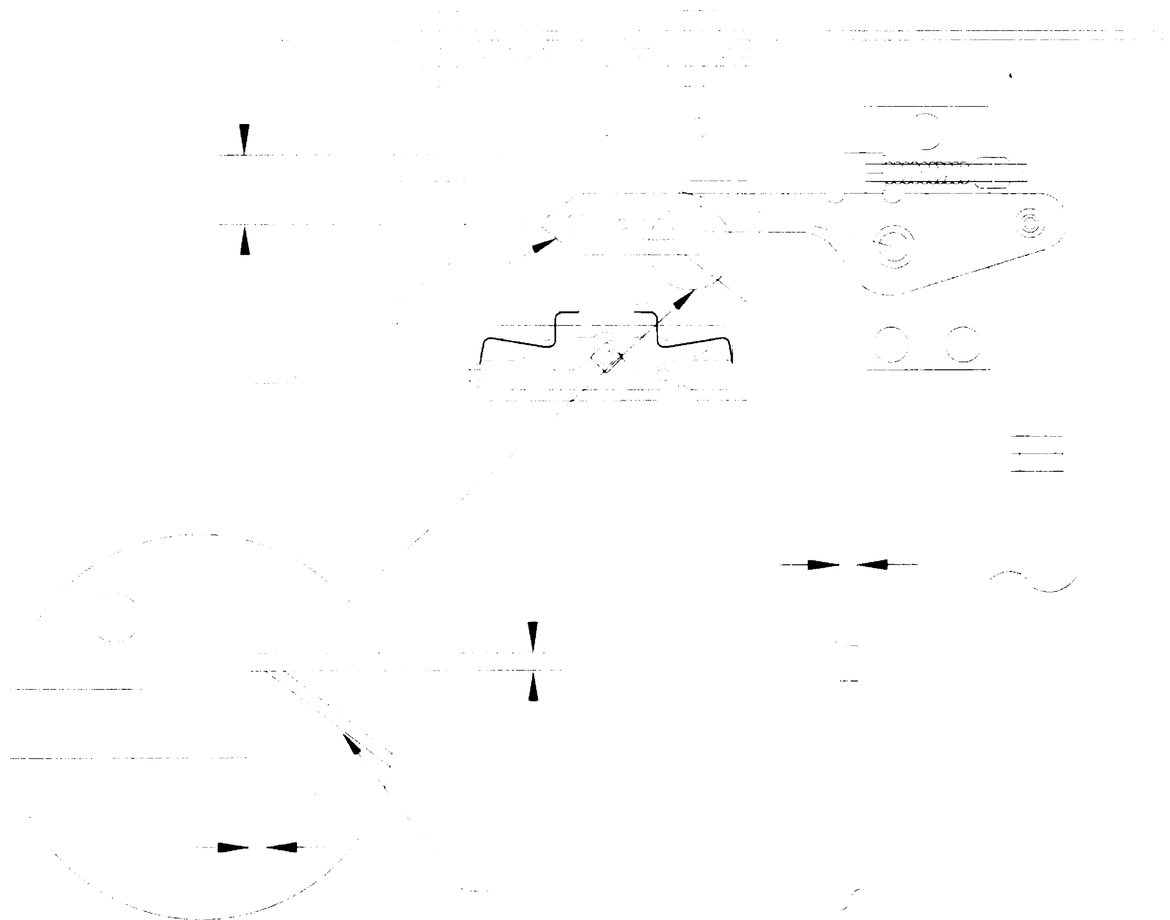


Figure 9

3. If adjustment is required, adjust the catch--DO NOT RE-ADJUST THE LATCH.

   - Add or remove shims to or from the catch as required to achieve 1/8" clearance between the underside of the latch and the catch. Slide the catch horizontally to set the back of latch to catch dimension.

Annex I

Handover Introduction Letter

Handover Introduction Letter

The Field Support Department is introducing an improved Handover system for several reasons:

- Response from numerous field requests for a better system.
- Field research indicated that the old policy was ineffective in reducing installation-related callbacks.
- Compliance with Otis' goal to become ISO 9001 certified.

We have made many changes, aimed to ensure a practical, efficient, and comprehensive method by which Otis can guarantee a quality installation, done correctly the first time. Further, our belief is that the new Handover system will guarantee that the job will have minimal installation-related callbacks.

The key to a successful execution of this policy is participation. Managers and supervisors must be involved, enforcing the policy and educating the Construction and Service Departments on the importance of the new Handover system. We benchmarked from several locations within NAO that had successful handover procedures, and all shared a common trait of managerial involvement. We cannot overemphasize the integral role that all managers, superintendents, and supervisors will play in successfully implementing this greatly improved Handover system.

Some of the more significant changes to the new Handover Policy are explained below:

- **In-Process Checks**
  The biggest change to the Handover system is the introduction of the In-Process Check (IPC). IPC's are to be done by mechanics during the installation process. Quality will be "built in" to our product, rather than "inspected out." This should alleviate many of the problems associated with a large, time-consuming inspection at the end of the installation process.

  IPC's have been successfully introduced in Japan, Australia, and France. We have tailored the IPC's to be NAO specific, with less paperwork and most IPC's requiring only a "yes or no" answer. For ease of use, we have consolidated the IPC's, Field Test & Data Report, and the Handover Inspection Report into an Installation Quality Assurance booklet. Research indicated that the callbacks during NIS were primarily due to doors and interlocks, so we have developed more detailed checks for these problem areas. (See the attached Callback Data at the end of this letter.)

  Lastly, we have incorporated OMMS measurement standards into many of the IPC's, in order to improve standardization between Construction and Service departments.

- **Delegation of handover inspections**
  A Superintendent/Supervisor can appoint a responsible delegate from within his department to act as his delegate during the Handover Inspection.

- **"Red Dots"**
  Installers will place Red Dots on equipment that required field rework, and discuss them with the Service representative during the Handover Inspection. This will allow the Service Department to be aware of potential trouble areas. Also, we ***strongly encourage*** mechanics to complete I/O's for all Red Dot areas. This also will allow for factory involvement in supplying quality parts and ultimately ease the installation process. The Red Dot system is being implemented world-wide.

- **If 5 deficiencies are found during an inspection, it should be rescheduled**
  With 5 or more defects, the Handover Inspection should be rescheduled (at the option of the Service inspector). This is a change from the old policy which allowed 10 deficiencies before rescheduling.

- **Advance Notice of Completion**
  The new Advance Notice of Completion form promotes better communication by including the Location Manager and the Service Salesperson. Also, we changed the time to submit this form from five days to two days for hydraulic jobs and four days for traction jobs to get a more accurate completion date.

- **More Location Manager involvement**
  The Handover Policy now actively involves the Location Manager in reporting and in allowing exceptions to the "zero-defect" policy.

- **New Measurements**
  The new measurements are much simpler than those in the previous policy. On a monthly basis, Construction Superintendents will report the types of defects encountered during Handovers. Area Vice Presidents will receive quarterly regional reports in summarized and graphical form, to assist in proper monitoring.

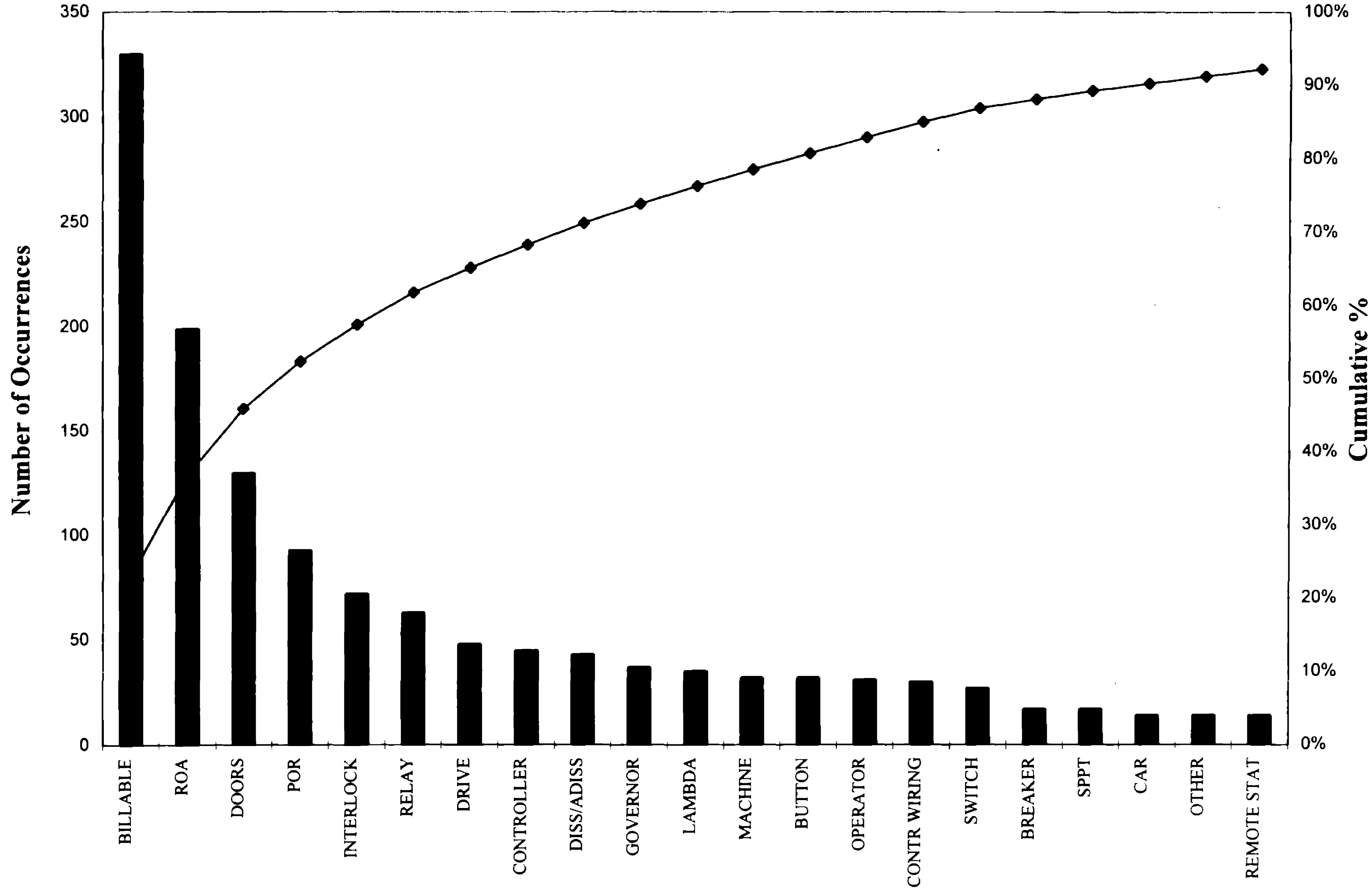
- **30 days to financially close after receiving documents**
  The revised policy NP-42 mandates financially closing a contract within 30 days, a change from 60 days. We reinforce this in the Handover Policy.

- **Field Test and Data Report**
  We have incorporated the Field Test and Data into the Installation Quality Assurance booklet. The booklet will be sent to the Regional Field Engineer (RFE) for his review and signature on the Field Test and Data Report (FT&D). The RFE will copy the FT&D for his records and will also send a copy to the FOM. The RFE will then return the booklet (with the original FT&D) to the Construction Superintendent, where it will be permanently stored in the local office contract files. Also, some small changes have been made to the Field Test and Data Report in response to I/O's.

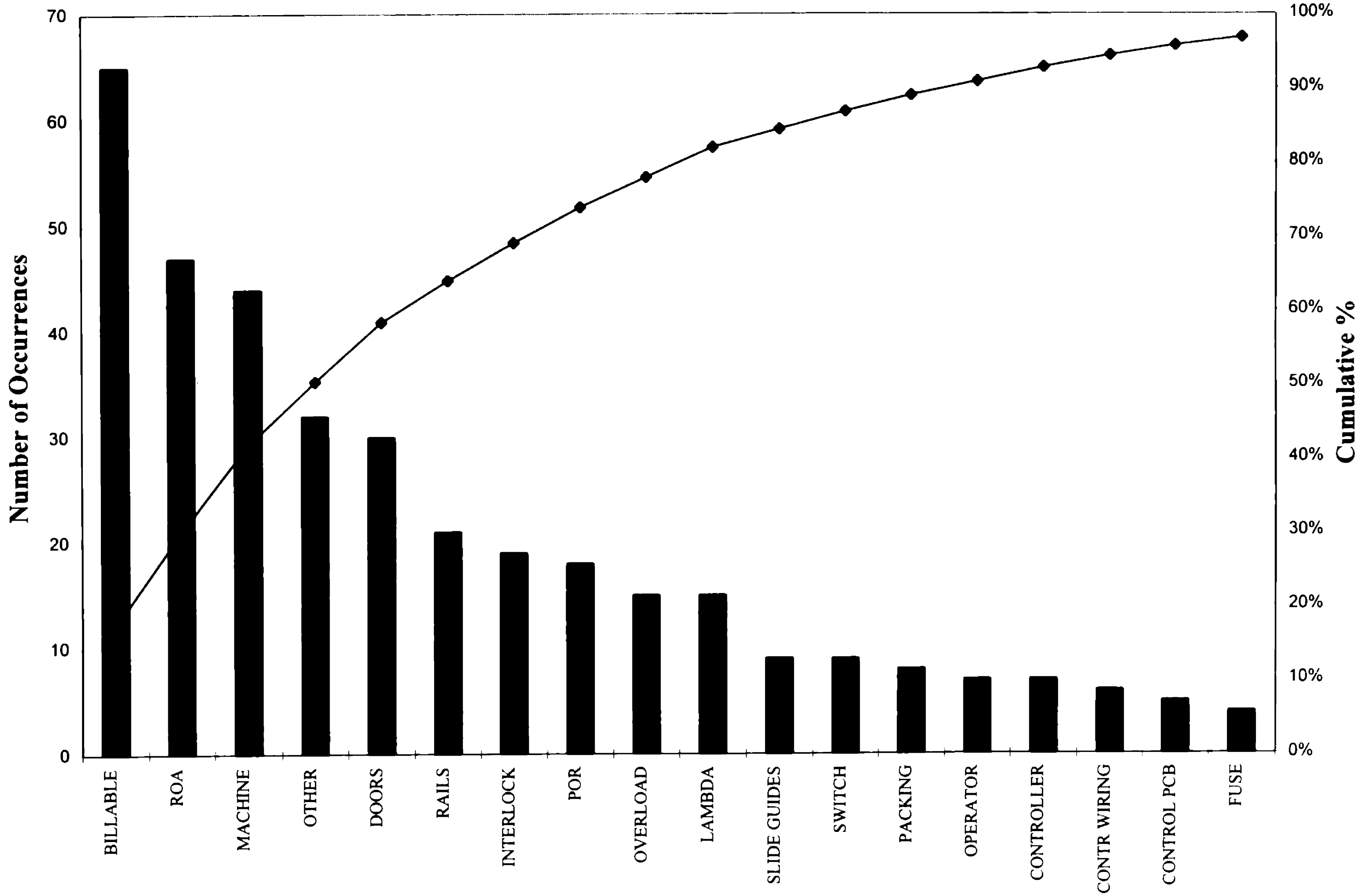
We would greatly appreciate your support in deploying the new handover policy. If you have any questions or comments regarding the procedure, please call the Field Support Team at (812) 331-5809.

Annexes: 311/411 Callback data
LHM Callback data

SIGNIFICANT CALLBACKS WITHIN 6 MONTHS OF HANDOVER 311/411



SIGNIFICANT CALLBACKS WITHIN 6 MONTHS OF HANDOVER LHM



Annex J

New Handover Policy

NAO Handover Policy

PURPOSE

The purpose of the Handover Inspection serves two meaningful ends:

1. Assures the delivery of a quality product to the customer.

2. Acts as a transfer of responsibility for the elevator from the Construction Department to the Service Department.

POLICY

- Otis Elevator Company requires a joint inspection of **all** New Equipment/major MOD elevators between the Construction and Service departments prior to financially closing a contract.
- A successful handover inspection is defined as having zero defects.
- A "defect" is defined as a physical condition of the unit that does not conform to Otis' installation instructions, policies, or specifications; to COD or project specifications; or to published TIP articles.

I. In Process Checks (IPC)

The purpose of the IPC system is to ensure a standardized, high quality installation. IPC's, in conjunction with a thorough handover inspection, will significantly reduce installation related callbacks.

IPC's will be completed by the construction mechanics during the installation process. For example, during the installation of a hoistway door, the mechanic will consult the IPC form for standards and tolerances, and then complete the IPC as required.

If the installed part cannot physically meet the IPC specifications, a new part will be ordered.

If the assembly requires rework in the field to meet the specifications, the mechanic will place a "Red Dot" sticker on the part to indicate rework took place. NAO strongly recommends that an Improvement Opportunity (I/O) Report be submitted for every Red Dot used. This will serve to reduce future field rework.

The adjuster and Construction Superintendent will be the primary auditors of the IPC forms during the installation process, spot checking IPC questions and measurements for accuracy. However, the Service Supervisor, routeman, Location Manager (LM), Field Operations Manager (FOM), Regional General Manager (RGM), and NAO Quality representatives are encouraged to visit sites and review the IPC forms as well.

II. Preparation for Handover

The Advance Notification of Completion Form will be submitted two (2) days prior to a completed hydraulic installation or four (4) days prior to a completed traction installation. The form is sent in every Installation Quality Assurance Booklet. The Construction Superintendent will submit the form to the Service Supervisor, with copies to the LM, FOM, Account Representative, and Service Salesperson. The Service Supervisor will complete the form and return it to the Construction Superintendent.

Construction Superintendents and Service Supervisors can appoint a responsible delegate to represent their respective department during the Handover Inspection. However, NAO prefers that the Supers personally attend all of the inspections whenever possible.

> If the Service Supervisor or his delegate cannot meet during the times that the Construction Superintendent submitted for a Handover Inspection, the Service Department must call the Construction Superintendent and find a mutually agreeable time.
>
> If the departments cannot agree on an inspection time, the LM will schedule a time.

If the FOM, LM, or salesperson intends to participate in the Handover Inspection, he will call the Construction Superintendent to confirm the time.

III. Inspection

Construction and Service representatives will jointly conduct the handover inspection. It will begin with a thorough review of the documents pertinent to the job to ensure accuracy and completeness. This review will also include IPC forms, submitted I/O's, and a discussion of any Red Dot areas.

At the conclusion of the paperwork inspection, the Service representative will use the completed IPC's as a handover inspection guide, randomly checking and measuring equipment that the IPC's address. The Service representative will audit as many questions or measurements from the IPC forms as he deems necessary in order to feel satisfied that a quality product has been installed, and will have no installation related callbacks. Any defects will be recorded on the Handover Inspection Sheet.

- Note: There can be other defects that are not listed on the IPC forms (non-compliance with specifications, local code, etc.).

> If a deficiency is found during the inspection and is corrected "on the spot," it will <u>not</u> be logged as a deficiency on the Handover Inspection Report.
>
> If a deficiency is found which requires rework that cannot be completed prior to the conclusion of the Handover Inspection, the Service Department can elect to do the work, in the interest of saving time and money. The Construction Department ultimately has the responsibility to correct the deficiency if the Service Department declines to fix the defect. In either case, the time will be charged against the contract. In the unusual event that the unit has been financially closed, the work will be charged to Delayed Sales Account (NP-47).

All deficiencies must be corrected prior to customer acceptance and financially closing the contract. NIS will not begin until the customer signs the Final Acceptance Report.

If the Construction and Service inspectors disagree on a possible deficiency, the FOM and LM will arbitrate.

If more than five (5) deficiencies are found, at the Service representative's option, the inspection can be stopped until the Construction Department corrects all the defects, and then reschedules a subsequent time.

If the elevator has defects, and the contractor desires an interim agreement, it can be placed into interim service, subject to LM approval, given that the Handover "Punch List" Reporting Sheet is completed. The form is sent in every Installation Quality Assurance Booklet.

If the customer requires the elevator for use, and is willing to accept it with the deficiency, the Final Acceptance Report can be completed with LM approval, given the Handover "Punch List" Reporting Sheet is completed. **Under no circumstances will an elevator be placed into service with a safety related deficiency.**

IV. Completion

After completing the Handover Inspection Checklist, the yellow copy will be sent to the Regional Financial Manager. The Installation Quality Assurance Booklet will be sent to the Regional Field Engineer (RFE) for his review and signature on the Field Test and Data Report (FT&D). The RFE will copy the FT&D for his records and will also send a copy to the FOM. The RFE will then return the booklet (with the original FT&D) to the Construction Superintendent, where it will be permanently stored in the local office contract files.

The Construction Department will ensure the contract has financial approval, and then meet with the customer to complete the Final Acceptance Report.

If the contract does not have financial approval, LM must approve the completion of the Final Acceptance Report.

If the customer is not ready to accept the elevator, an interim service agreement may be arranged for the contractor, otherwise the unit must be shut down.

When the unit is put into service, the Service Supervisor will send a letter to the customer informing him of initiation of NIS.

If an interim agreement is made, the NIS period will not begin until the conclusion of the agreement.

V. Financial Closing

The Construction Supervisor will forward the completed Final Acceptance Report and Handover Inspection Report to the Financial Department. Upon receiving these documents, the Financial

Department will then financially close the contract within 30 days of receiving these documents, in accordance with NP-42.

VI. Measurement

On a monthly basis, the Construction Supervisor will submit a Monthly Handover Report to the FOM and LM, which categorizes the types of defects encountered during the past month's handovers. An example form is attached at the end of this policy.

Quarterly, the FOM will compile the handover data in summarized and graphical form in the Handover Summary Report. The FOM will utilize a spreadsheet template file provided by the Field Support Department to provide this report. Copies of the Quarterly Handover Summary Report will be sent to the Area Vice President and the Field Support Department for review.

Locations with poor handover statistics should expect future handovers to be audited by Field Support or the Quality Department.

VII. Forms

Advance Notification of Completion	Form HO-01
Hydraulic Handover Inspection Report	Form HO-02
Traction Handover Inspection Report	Form HO-03
Final Acceptance Report	Form HO-04
Monthly Handover Report	Form HO-05
Handover "Punch List" Reporting Sheet	Form HO-06

The Installation Quality Assurance booklet, complete with the IPC's, Field Test and Data Report, and Handover Inspection Report, Advance Notification of Completion, and Handover "Punch List" Reporting Sheet will be sent in the Erector's Folder.

The In Process Check forms are numbered as follows:

INSPECTION AREA	HYDRAULIC FORM	TRACTION FORM
Machine and Machine Room	IPC-01	IPC-09
Pit and Bottom of Car	IPC-02	IPC-10
Car and Car Door	IPC-03	IPC-11
Hoistway and Top of Car	IPC-04	IPC-12
Hoistway Entrances	IPC-05	IPC-13
Hoistway Doors	IPC-06	IPC-14
6940A Interlock	IPC-07	IPC-15
OVL Interlock	N/A	IPC-16
Contractor and Miscellaneous	IPC-08	IPC-17