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Validation of a Selection Test Battery through Use of a Task Analysis

Joseph August Saccaro
Loyola University Chicago

VALIDATION OF A SELECTION TEST BATTERY THROUGH USE OF A TASK ANALYSIS

BY

JOSEPH AUGUST SACCARO

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VITA

The author, Joseph August Saccaro Jr., is the son of Joseph August Saccaro Sr. and Theresa (Nania) Saccaro. He was born on November 25, 1951, in Chicago, Illinois.

His elementary education was obtained in public and private schools in the Chicago area. His secondary education was completed in 1969 at J. Sterling Morton High School, Berwyn, Illinois.

Mr. Saccaro's college education began at the University of Illinois at Chicago Circle, where he was a member of the Illini, the student newspaper. He ultimately attained a Bachelor's degree in English at Northwestern University of Chicago in 1978.

He currently resides in Joliet, Illinois with his wife, Sharon, and three children.

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INTRODUCTION

PURPOSE

The intent of this investigation was to improve the safety, reliability and efficiency of fossil-fueled generating stations at Commonwealth Edison Company (CECo). This was accomplished by helping to ensure that employees in the position of Quality Control (Q.C.) Inspector are properly selected and well trained.

Proper selection of Q.C. Inspectors was ensured by determining that only prospects for this position who had the ability to master the necessary job skills that would make up the final selection population. This was to be accomplished by identifying a selection instrument with both face and predictive validity. Effective training was to be ensured by providing the foundation for a systematically developed, comprehensive, training program. This foundation was a set of task-based behaviorally stated training objectives for the QC. position.

RATIONALE

One important factor for the economic health of a geographical area is the supply of electrical power. Ideally, electrical service should be reliable and competitive in cost both when compared to other electrical utilities in the country, and compared with other forms of energy such as natural gas or oil. Low cost, dependable service encourages existing business and industry to remain, and encourages new business and industry to locate in the electrical utility's area.

As with other businesses, electric utilities remain reliable and cost-competitive when the personnel working at the utility are competent, and the equipment used is efficient and reliable. This investigation was intended to improve worker competence and equipment reliability in two ways.

The first approach was by providing a valid selection instrument for those who are hired as Q.C. Inspectors. This would have been of benefit to both CECo management and the employees who bid on the Q.C. Inspector position. This approach was based on the assumption that the company would benefit by the increased probability that the properly selected employee would master the position's responsibilities, and would do so in a reasonable amount of time. Further, since new Q.C. Inspectors would have demonstrated the ability to learn how to perform competently, they would be less likely to encounter problems while working that might frustrate them to the extent that their performance deteriorates.

The second approach was to improve the effectiveness of Q.C. Inspector training by basing that training on a set of task-based training objectives. Employees who have been properly trained will be far more likely to be satisfied with their work, and satisfy their employers, than those who have not.

BACKGROUND

Position Description: Q.C. Inspector is a management position at fossil-fueled generating stations but non-management personnel are permitted to bid on the job. In some cases, then, it is a entry-level management position, filled by personnel who were not previously in management; and in other cases the position is filled by existing managers.

The following responsibilities take up most of a Q.C. Inspectors typical work day:

1. Approving the work of others: When critical mechanical components of the plant are repaired and reassembled, the machinists or electricians doing the work stop at "hold-points".

   These are stages of the reassembly where the Q.C. Inspector examines the work and either approves it or recommends remedial actions.

2. Inspecting welds: A weld must be made using the proper material and equipment under exacting conditions. Q.C. Inspectors ensure that the material, equipment and conditions are correct before the weld is begun and test the weld afterward using sophisticated non-destructive examination (NDE) techniques.

3. Written and verbal communications: The type of communications Q.C. Inspectors engage in is difficult from both a technical and interpersonal perspective. It is difficult technically because they must present information and convey instructions regarding complex industrial processes to a wide range of company personnel. These personnel range from degreed mechanical and electrical engineers to apprentice craftsmen who may not have a high school education.

Interpersonal communications are challenging because the Q.C. Inspector is responsible for recommending that work be redone if it does not meet specific standards. Often this work was expensive, and performed under adverse circumstances. It is not uncommon for generating station personnel to work outside all day during the winter, or inside a power plant where high temperatures, loud noises, and presence of moving machinery make working stressful and hazardous. And sometimes the delay involved in redoing a job may cost the utility millions of dollars in "lost power" (electricity that must be purchased from another utility instead of being generated by the out-of-service equipment). In spite of these difficult circumstances, a Q.C. Inspectors must consider the quality of an operation or product when making an evaluation, not the effort or money that was involved. Most importantly, they must communicate their findings to the proper personnel.

In addition to making these difficult recommendations, Q.C. Inspectors must also accept, or attempt to refuse, work assignments. This may be illustrated by the comments of several Q.C. Inspectors who stated that their supervisors do not always understand the extent and limits of Quality Control, and consequently would assign the QC Inspectors inappropriate work.

4. Inspecting equipment: Many types of equipment in a generating station are considered critical to either plant

reliability or worker safety. These are checked by Q.C. Inspectors. Some of the specific physical inspections are: Coupling alignments between motors and the equipment the motors drive; balancing tests on rotating equipment; boiler, turbine, and condenser repairs; the calibration of measuring equipment; and supplies delivered or returned to storage.

5. Interpreting technical documents: The above four responsibilities often require referral to technical documents. These include welding code books, maintenance manuals, bid specifications, procedures, schematics, and chart and tables. Many at these documents would be completely obtuse to a casual reader so a new Q.C. Technician must devote time to learning what references to check when data is needed, and how to interpret the reference that is selected.

Need For A Selection Instrument: During the fall of 1982, Fossil Station Quality Control supervisory personnel held several meetings with corporate program development personnel. The purpose of the meeting was to establish the training needs of Q.C. Inspectors and establish company resources were available to meet the identified needs.

Several important points related to selecting and training of Q.C. Inspectors were agreed upon by the time these meetings concluded. First; while the general responsibilities of Q.C. Inspectors were clearly described in various company reports and instructions, there was no listing of specific, behaviorally-defined performances. Second, since the company was planning on increasing the number of personnel assigned to this position relatively rapidly, training techniques that were successful in the past might not work quickly enough to meet present needs. Developing competent Q.C. Inspectors in less time required more effective training and required a prescreening for their ability to master the skills provided by the training. Third, the consequences of errors in Q.C. procedures were expensive enough that the additional cost of developing a training program and selection instrument could be easily justified by a cost/benefit study.

Quality Control has long been an established practice at Commonwealth Edison Company. During the time that Quality Control policies have been in force, the company has been selecting new Q.C. Inspectors without the use of a formal selection instrument. Why then, was there agreement that one was needed at this time?

The cost of mistakes, in both human and economic measures, had escalated sharply. The amount of thermal, kinetic, and electrical energy present in generating stations had increased steadily due to improvements in technology. Consequently, the potential for injuries to people and damage to equipment, should this energy be misdirected, has also increased. Also, during the past decade, the cost of fossil fuels have increased at a far greater level than the overall cost of living. At the same time the laws regulating the emission of pollutants into the environment had become increasingly stringent.

As a consequence of these three trends, the operating limits for equipment within the generating station had become far more narrow than they were previous to the 1960's. Failure rates and errors that were acceptable in the past are no longer acceptable. The need for quality work had made it necessary that Q.C. Inspectors perform at a high level of competence, and that the number of Q.C. Inspectors be increased. Since new QC Inspectors were under the burden of meeting higher standards (and doing to in less time than Q.C. Inspectors used to be alloted for learning their job), everyone involved in determining Q.C. training needs agreed that a valid selection test would be helpful in identifying prospects capable of meeting these demands.

General Strategy: Once agreement had been reached that a training program and selection instrument were needed by the Quality Control department, the program development personnel working with the project implemented a series of steps to collect the data necessary for both selection and training.

First, a needs analysis was performed. In order to determine if the conclusions reached during the meetings were correct, it was necessary to communicate with the people actually doing Quality Control work.

At this time, a group of trainers visited the generating stations with two purposes in mind; they wanted to confirm the tentative conclusions about selection and training that they had reached, and they wanted to assess more specific needs relative to Q.C. selection and training. They accomplished the first purpose with informal interviews. Q.C. Inspectors and trainers discussed current Quality Control training. In order to establish the significance of the project, the trainers informed the Q.C. Inspectors that the Inspectors input would be necessary if a worthwhile training program was to be developed. After the interviews were completed Q.C. Inspectors were given a formal survey to complete. The survey listed all the responsibilities of Q.C. Inspectors (as best as the trainers could determine them from existing CECo literature), and a list of the existing training and development classes the Q.C. Inspectors attended.They rated the first part of survey on how soon training was needed, and they rated the second part of the survey relative to the value of the existing classes. Figures 1 and 2 present the first page of each part of the survey. The information gathered from the interviews and the formal survey were used to justify and develop a detailed task analysis.

Needs Analysis: The Q.C. technicians were given a list of their major job responsibilities and asked to rate the importance of training in developing proficiency in these responsibilities. This was followed up by interviews, in which the Q.C. Inspectors were asked why they rated particular items as high or low.

One benefit of using a formal survey might be mentioned here. Most useful information came out of the oral interviews after the written surveys were completed. The same Inspectors who had been interviewed before they were surveyed thought of more topics to discuss afterwords. This may be because they were complimented by the fact that the company had took this much interest in their work, and this made them more willing to communicate. They may have also been more communicative because filling out the formal survey stimulated them to think of more ideas about their job.

PART 1: TRAINING NEEDS

What priority should be set for training new Q.C. technicians for these job responsi-ilities? If any responsibilities have been left out, include them in one of the blank spacs

I. TOTAL JOB MANAGEMENT	NEVER	SOMETIME	SOON	IMMEDIATELY
I. TOTAL JOB MANAGEMENT				✓
1. Implimenting T.J.M. at the station.				✓
2. Reviewing Work Requests.				✓
3. Training Maintenance personnel regarding "Hold Points".		✓		
4. Processing improper Work Requests.				✓
5. Processing proper Work Requests.				✓
6. ______				
7. ______				

II. PROCURMENT DOCUMENTATION	NEVER	SOMETIME	SOON	IMMEDIATELY
1. Credit Inspections.			✓	
2. Receipt Inspections.			✓	
3. Receiving Inspections.			✓	
4. Selecting the best supplier.			✓	
5. Cost analysis of supplies.	✓			
6. Interpreting a vendor's Q.C. data.			✓	
7. Bid specifications reveiw.		✓		
8. ______				
9. ______				

II. MAINTENANCE REPAIR MANUALS	NEVER	SOMETIME	SOON	IMMEDIATELY
1. Locating Data.				
2. Following repair procedures.				
3. Following inspection procedures.				
4. Establish "witness/hold points".				
5				

IV. WELDING INSPECTIONS	NEVER	SOMETIME	SOON	IMMEDIATELY
1. Code acceptance criteria.		✓		
2. Visual inspection techniques.			✓	
3. Codes and standards.		✓		
4. Basic welding.			✓	
5. Welding technology.		✓		
6. Using the S.P.P.M. manual.			✓	
7. ______				
8. ______				

V. COUPLING ALIGNMENT	NEVER	SOMETIME	SOON	IMMEDIATELY
1. Large equipment (Shafts with a 3" or larger diameter)		✓		
2. Small equipment (Shafts with less than a 3" diameter)		✓		
3. ______				
4. ______				

VI. BALANCING INSPECTIONS OF ROTATING EQUIPMENT	NEVER	SOMETIME	SOON	IMMEDIATELY
1. Static techniques	✓			
2. Dynamic balancing with I.R.D. equipment.	✓			
3. ______				
4. ______				

VII. BOILER INSPECTIONS	NEVER	SOMETIME	SOON	IMMEDIATELY
1. Sootblower erosion		✓		
2. Boiler foaling		✓		
3. Steam drum inspection		✓		
4. Other boiler internals				
5. [illegible]		✓		
6. ______				

Figure 1: Sample Page Of Needs Analysis

1d. WORK AIDS		Never	1 to 4 Times a Year	About Once a Month	Once a Week or More Often	Outage Related
1d.01	Block & tackle	0	1	2	3	4
1d.02	Cart (hand truck)	0	1	2	3	4
1d.03	Chain fall	0	1	2	3	4
1d.04	Choker	0	1	2	3	4
1d.05	"Come-Along"	0	1	2	3	4
1d.06	Drop light	0	1	2	3	4
1d.07	Extension cord	0	1	2	3	4
1d.08	Flashlight	0	1	2	3	4
1d.09	Label maker	0	1	2	3	4
1d.10	Multi-outlet strip	0	1	2	3	4
1d.11	Rubber gloves (oil and acid handling)	0	1	2	3	4
1d.12	Scaffolding	0	1	2	3	4
1d.13	Vacuum cleaner	0	1	2	3	4
1d.14	Phillip gauges	0	1	2	3	4
1d.15	All purpose weld gauges	0	1	2	3	4
1d.16	Mirrors	0	1	2	3	4
1d.17	Magnifying glass	0	1	2	3	4
1d.18	P.T. kits (dye penetrant)	0	1	2	3	4
1d.19	M.P.T. (Magnetic Particle Test)	0	1	2	3	4
1d.20	U.T. (Ultrasonic - Thickness)	0	1	2	3	4
1d.21	Film viewers	0	1	2	3	4

1.6

Figure 2: Sample Page From "Tools and Equipment" Section of Task Analysis

Task Analysis: A committee of five Q.C. Inspectors, representing a wide range of experience, and two Program Developers, wrote a Q.C. Inspector job description. This was devided into the following four sections:

1. Tools and Equipment
2. References
3. Tasks
4. Abilities and Characteristics

The first, (Figure 1-3) second, (Figure 1-4) and fourth, (Table 1-6) section consisted of lists. The third section, (Figure 5) which comprised the bulk of the document, was written in the form of behavioral tasks, although the tasks did not always include clearly defined cues and conditions. The final document was sixty-seven pages long. It included seventy different types of tools and equipment, eighty references, two-hundred and seventy tasks and eighty-six abilities and characteristics.

This document was written in the form of survey, with all the items being rated on a numerical scale. The scale was used in the first two sections to rate frequency of use, which ranged from "never" to "weekly or more often." There was also a column labeled "outage related" for items that were used frequently when the generating station was out of service for repairs, but not used often otherwise.

The third section, tasks, were rated on four scales, with each scale representing distinctly different concept references. The scale titles, and the definition of each scale value, follows:

PERFORMANCE

1. Can do simple parts of the task.
2. Can do most parts of the task.
3. Can do all parts of the task.
4. Can do all parts of the task quickly and accurately and instruct others.

KNOWLEDGE

1. Know simple facts about the task.
2. Know the procedures related to the task.
3. Know the operating principals of the task.
4. Know the complete theory about the task.

SAFETY

1. No effect on safety for personnel and/or equipment in the plant.
2. Might cause safety problem for personnel and/or equipment in plant.
3. Will seriously endanger personnel and/or equipment in the plant.
4. Will cause personnel to be injured and/or extensive, serious equipment damage and/or plant trip.

FREQUENCY

0. Never
1. 1 to 4 times a year.
2. About once a month.
3. Once a week or more often.
4. Outage related.

2a. REFERENCES (continued)		Never	1 to 4 Times a Year	About Once a Month	Once a Week or More Often	Outage Related
2a.43	Instrument cross-reference	0	1	2	3	4
2a.44	Instrument book (technical manual)	0	1	2	3	4
2a.45	Instrument drawings	0	1	2	3	4
2a.46	Instrument set point list	0	1	2	3	4
2a.47	Integrated circuit data book	0	1	2	3	4
2a.48	Loop diagrams (P&ID's)	0	1	2	3	4
2a.49	Maintenance work request	0	1	2	3	4
2a.50	Mechanical work request (job order)	0	1	2	3	4
2a.51	Parts catalog	0	1	2	3	4
2a.52	Plant emergency procedures	0	1	2	3	4
2a.53	Parts list	0	1	2	3	4
2a.54	Periodic maintenance guide	0	1	2	3	4
2a.55	Piping diagrams (P&ID's)	0	1	2	3	4
2a.56	Plant layout	0	1	2	3	4
2a.57	Safety rule book	0	1	2	3	4
2a.58	Surveillance procedures	0	1	2	3	4
2a.59	Wiring diagrams	0	1	2	3	4
2a.60	Technical specifications	0	1	2	3	4
2a.61	Machinery handbook	0	1	2	3	4
2a.62	Welding handbook	0	1	2	3	4
2a.63	QC handbook	0	1	2	3	4

2.4

Figure 3: Sample Page From "References" Section Task Analysis

3i. TESTING EQUIPMENT (continued)	Performance				Knowledge				Safety				Frequency
	Can Do Simple Parts	Can Do Most Parts	Can Do All Parts	Do All Parts & Instruct	Know Simple Facts	Know Related Procedures	Know Operating Principles	Know Complete Theory	No Affect on Safety	May Cause Safety Problems	Endanger Personnel & Equipment	Cause Injury or Damage	Never / 1 to 4 Times a Year / About Once a Month / Once a Week or More Often / Outage Related
3i.15 Use standards to check precision measuring instruments (e.g., micrometers, calipers, gauges).	1	2	3	4	1	2	3	4	1	2	3	4	0 1 2 3 4
3i.16 Apply a known weight to equipment (e.g., weight-meter, scale, etc.) to check for correct reading.	1	2	3	4	1	2	3	4	1	2	3	4	0 1 2 3 4
3i.17 Use leak detectors (e.g., Halogen detector, ultrasonic detector) to locate leaks in pipes, tubes, etc.	1	2	3	4	1	2	3	4	1	2	3	4	0 1 2 3 4
3i.18 Inspect components or equipment using precision tools such as torque wrench and hydraulic ram.	1	2	3	4	1	2	3	4	1	2	3	4	0 1 2 3 4
3i.19 Inspect components or equipment using pressure instruments that measure physical parameters (e.g., pressure temperature, hardness, etc.).	1	2	3	4	1	2	3	4	1	2	3	4	0 1 2 3 4
3i.20 Inspect components using electronic aids (e.g., computer, special calculator).	1	2	3	4	1	2	3	4	1	2	3	4	0 1 2 3 4
3i.22 Inspect bearing loadings using load cell/dynameter.	1	2	3	4	1	2	3	4	1	2	3	4	0 1 2 3 4

3.23

Figure 4: Sample Page From "Tasks" Section Of Task Analysis

4a. ABILITIES & CHARACTERISTICS (continued)	Unimportant	Not Very Important	Important	Very Important	Absolutely Crucial
4a.23 Willingness to work while wearing protective equipment such as breathing apparatus, hearing, eye and head protection.	0	1	2	3	4
4a.24 Willingness to work around decaying matter and sewage.	0	1	2	3	4
4a.25 Willingness to work in confined spaces.	0	1	2	3	4
4a.26 Ability to understand mechanical principles such as gear trains, centrifugal force, heat flow, etc.	0	1	2	3	4
4a.27 Ability to understand electrical principles such as voltage, amperage, resistance, etc.	0	1	2	3	4
4a.28 Ability to visualize changes in the position of moving objects in three dimensions (e.g., removal and rigging of a generator rotor).	0	1	2	3	4
4a.29 Ability to analyze and solve equipment and/or system problems.	0	1	2	3	4
4a.30 Ability to draw correct or sensible conclusions when given a set of relevant facts.	0	1	2	3	4
4a.31 Ability to think of new ways to solve a problem or accomplish a task.	0	1	2	3	4
4a.32 Ability to understand complicated equipment or entire systems; to anticipate the results of changes or malfunctions to equipment or systems.	0	1	2	3	4
4a.33 Ability to remember information.	0	1	2	3	4

4.4

Figure 5: Sample Page From "Abilities and Characteristics:

Section Of Task Analysis

The abilities and characteristics were rated as to how important they were to the job. Figure 1-6 lists the instructions for filling out this section of the survey and the definitions of each number in the numerical scale.

This survey was filled out by all of the fossil station Q.C. Inspectors.

SECTION 4.0
ABILITIES AND CHARACTERISTICS

This section of the questionaire contains abilities and characteristics which may or may not be necessary for performing successfully on your job. Please read each one and decide how important you believe this ability or characteristic is for successful performance in your job using the following scale. (Please note this scale is slightly different from the importance scale you used in rating your job activities.)

0 = Unimportant. Not really necessary for effective performance on this job; very much less important than most other abilities/characteristics.

1 = Not Very Important. Somewhat desirable for effective performance on this job; less important than most other abilities/characteristics.

2 = Important. Quite desirable for effective performance on this job; about the same level of importance as many other abilities/characteristics.

3 = Very Important. Highly desirable for effective performance on this job; more important than most other abilities/characteristics.

4 = Absolutely Crucial. Essential for effective performance on this job; very much more important than most other abilities/characteristics.

Level 0 represents abilities and characteristics which are not necessary at all for performing your job. Level 1 represents abilities and characteristics it might be nice to have, but which aren't vitally necessary. Level 3 and 4 represent abilities or characteristics that are necessary in day-to-day performance.

Table 1: Instructions For Filling Out "Abilities and Characteristics" Section.

The results were computed for arithmetic averages, number of responses, and standards of deviation. Since the Q.C. Instructors listed their station as one of the answers in a short biographical section, the survey results were cross indexed by station as well as by job category.

Instructional Objectives: The committee that first developed the document reconvened and selected tasks that required training. Any task that was rated over an agreed upon minimum was automatically included. Tasks rated below the setpoints were discussed until a consensus was reached as to whether or not they should be included.

The selected tasks were first grouped into related topics, and then subgrouped into skill-levels. The committee then wrote behavioral objectives to cover each subgroup. These objectives form the bulk of a Training Standard, a document that states what knowledge and skills an an individual with a specific job title will have upon completing training.

DELIMITATIONS

One of the purposes of this thesis was to apply the principles of instructional design within an industrial environment. This environment did place some constraits upon the techniques used to gather data and also had some effect over both the content and format of the final program. The following major delimitations would be noted:

1. The time taken to develop the program, for example, was limited. The investigator was committed to a schedule which specified a completion date for each phase of the project. Gathering data, interpreting data, and developing the final products of the

investigation all had to be planned so that they could be completed in the time allotted by the schedule. Also, reasonable limitations had to be made on the amount of time the subject matter experts were able to contribute to the project, as well as on the time of the people who were surveyed. These employees had other responsibilities, and developing a training program was not the highest priority among the many work roles performed by each person. They were not always all available at the same time for meetings and some of the participation that would have been generated by having the Advisory Committee members meeting frequently, and on a casual basis, was lost. Meetings were often scheduled several months apart, and they were sometimes rushed so that not all the meeting objectives could be accomplished. When these meetings did take place, the subject matter experts exerted some control over the format, as well as the content, of the surveys and other documents.

2. Time was not the only limitation on the extent of the investigation. The number of Quality Control Inspectors available to test made it difficult to establish statistically significant results. There were twelve Quality Control Inspectors working at the nine Commonwealth Edison fossil stations at the time the investigation took place, with five being used for job development efforts.

3. The investigator was committed to protecting the anonymity of the subjects because they, and the evaluators, had been assured that

no one other then the investigator would be privy to the results. Some of the raw data, the completed evaluations and tests, were discarded after it was gathered and compiled.

4. When statistical relationships were established, there were some limitations on the assumptions that could be inferred from the results. Their was no record found in testing literature, for example, of the FIT battery being validated for the position of Quality Control Inspector. In fact, in the "Validity" section of the FIT Examiners Manual none of the positions discussed were even similar to Quality Control Inspector. The position description that resembled Quality Control Inspector most closely, Electronics Inspector, had as its highest validity coefficient .33. This was for the "Pattens" and "Electronics" test, equally weighted. The use of the FIT test battery was also validated against the QC Inspector task analysis. However, literature describing previous work on the test battery's application to the position in question would have improved the credibility of the test.

5. Any relationship established by the investigation would be between the performance of Quality Control Inspectors' test performance and the evaluation. One cannot assume that relationships between the evaluation and existing QC Inspectors' test performance can be generalized to the work of prospective Q.C. Inspectors. Any relationships would have to be validated for this specific group before the tests were used as a selection instrument.

6. The subject matter experts working in this project contributed to the task selection techniques used, and the phrasing of the training objectives. Their judgement did not always coincide with that of the investigator.

DEFINITION OF TERMS:

The terms listed below will be operationally defined as follows:

Fossil Station Quality Control Inspector: This is a specific job title assigned to certain employees of Commonwealth Edison Company. Quality Control (QC) Inspectors determine that maintenance work that is performed in the generating station for which they are responsible meets established standards. In some cases they are also responsible for recommending corrective action when they determine that work does not meet these specified standards.

Needs Analysis: A systematic process for determining whether the solution to a given problem lies in improving human performance.

Task: A behavior that, of itself, provides a meaningful product or service. It generally has a discrete beginning and end and is described by an observable performance, the conditions under which the performance takes place, and the cues that begin and end the performance.

Task Analysis: The process of examining tasks, and gathering information about their performance for the purpose of determing which tasks require training.

Training Standard: A document that lists the performance components of all the objectives of a given position. The objectives are divided into those that are cognitive and those that are psychomotor. Cognitive objectives are further classified into those that are traditionally academic subjects and those that would probably be learned in a powerplant. Objectives from either domain that are related to certain company-related topics are also listed separately.

CHAPTER II

RELATED LITERATURE

SECTION ONE: BEHAVIORAL OBJECTIVES

OVERVIEW

If modern, systematic training has one foundation, it is the behavioral objective. The behavioral objective provides the link between observing a given performance and guiding others in developing the ability to repeat that performance, be it a mental ability or a physical skill. The behavioral objective is simply a concise and observable description of what the learner will be able to do as a result of the training that the learner receives.[1]

There are three major considerations that one must address in describing a behavior. The first, and most obvious, is, What is observed when the behavior occurs? The observor must know that the behavior is taking place. A performance is involved. If a physical skill is being observed, (eg. throwing a basketball into a hoop) the performance is identical to the skill. If mental skill is being observed (eg. Calculating the length of the third side of a triangle given the length of the other two sides and the angle between them) the actual mental processes are not observable, but the result of those processes (the answer to the calculation) always will be.[2]

If the observed performance matches the intended performance, this aspect of the objective has been met.[3]

Some examples of observable performances that could be used in writing objectives are as follows:

1. Welding a sheet of steel.
2. Dancing the Fox Trot.
3. Writing a complete sentence.
4. Performing long division.
5. Helping an injured person.
6. Donating money to support a charity

One could watch a person doing any of these. One would not necessarily know the physiological, psychological, or cognitive factors that preceeded and caused the behaviors; this would be complicated and difficult, if possible at all. But it is relatively easy to determine that the behavior has taken place.

An objective, however, is more than a statement of performance. Performance, though helpful in preparing training, is not adequate to describe behavior. Consider the first example, spot welding a sheet of steel. Steel varies in make-up, and some types are easier to weld than others. Likewise spotwelding machines are of different designs and levels of complexity. A trainee might perform competently on one spotwelder but not on another. Finally, the environment a trainee works in affects his performance.[4] Welders who perform satisfactorily in a clean, pleasant environment will not necessarily do as well if they are exposed to auditory and visual distractions, and/or forced to wear uncomfortable protective equipment.

In addition to performance, then, another aspect of behavior that must be specified if we are to describe an observable behavior is the conditions under which the performance is demonstrated.[5] In the psychomotor domain, as in the example of welding just given, conditions are usually composed of environmental factors, tools, and supplies.

In the cognitive domain, conditions are usually available references and computational aids. Two examples, one from a "hard" cognitive discipline, mathematics, and one from a "soft" discipline, literature, will illustrate the concept of cognitive conditions:

Example #1. Calculate a coeficient of correlation.

Conditions: With or without a formula?

With or without a calculator?

Are standards of deviation given, or merely raw data?

Example #2. Discuss the symbolism associated with the rose in The Scarlet Letter.

Conditions: Is the text available as a reference, or the students notes?

Will spelling be considered, or just content?

Finally, a behavioral objective should state a standard which the performance should meet as well as the conditions under which the performance takes place Standards usually consist of time, accuracy (quality) or quantity.[6] In the welding example given previously, the standard could be that the weld would pass certain non-destructive testing (quality), that the weld must be set up and completed in seven minutes, (time) or that the welder must be capable of fifteen spotwelds per hour (quantity).

In the first cognitive objective given, the trainee would probably the evaluated by all three standards. Most math tests are limited in duration (time). They have a specific number of questions (quantity), of which a predermined percentage must be answered correctly for a given grade (accuracy).

Objectives, obviously, require a great deal of work on the part of the Instructional Designer. Formulating performances, conditions, and standards for a multitude of intended behaviors is tedious at its best. At its worst it is achingly difficult to state all three parts in observable or quantifiable terms, and the final product is a dry, often mundane sentence that does not give much indication of the effort that was devoted to its creation.

While objectives are difficult to prepare, their benefits justify the effort. These benefits will be classified into three general catagories; course development, evaluation, and communication.

1. Course Development: There are two guidelines that form the basis of sound course development. First, training should be comprehensive. No knowledge, skills, or attitudes that are critical to performing a task safely and effectively should be unaddressed by the training program. Second, training should be targeted; it should not include extraneous information. Using other words, the training program should be "aimed" at the trainee.[7]

Task-based objectives are quite helpful in following both of these guidelines. During the task analysis process the position, or work in question is first described in detail, with every major responsibility broken into tasks. A task is: "A logically related set of actions required for the completion of a job objective."[8] This description should be reviewed by people who actually perform the job, and people who supervise those performing the job. This process ensures that the first guideline, comprehensiveness, is adhered to.

Descriptions like this cannot be converted directly into training objectives. Most jobs include a number of tasks for which no training is required. They may be easy enough to learn without training, or they may be performed so infrequently that any training will be forgotten by the time the performance is required.

Valuable time will be wasted if tasks like these are formally trained; and the trainee, lacking any motivation to learn, becomes disinterested, Unfortunately this lack of interest may carry over into critically important training sessions. One process that prevents this problem from occurring is called task selection. It is another important step in writing task based training objectives.

Again, the people performing the tasks, and their supervisors, are surveyed. They provide information about each task that allows the progam developer to determine whether or not a given task should be included in a training program.[9] Information about the tasks may include any of the following:

1. Intelligence, memory, or mental speed necessary to perform the task.
2. Physical strength or dexterity required.
3. Frequency of performance.
4. Criticality of the task to the process or product that is being generated.

5. Consequences to human safety of doing the task improperly.

6. Possible damage to equipment that may occur from improper performance.

7. Bad publicity that may result from improper performance.

This list is not inclusive. It is presented here as an example of the kind of information frequently of concern in a task analysis. The criteria used to select tasks for training will vary with the job being considered. The important fact about task selection is that it ensures the objectives that are derived from the tasks meet the second guideline - they are targeted to the needs of the employe.

When the program developers build a training program, the objectives provide a reference for determining if their efforts are effective. When considering the training program's environment, audio/visual aids, tests, written-material, in fact every aspect of the training program, the program developers should always ask themselves: "Is this aiding the learner in meeting the task-based objectives?" An affirmative answer to this question is the best justification for including the aspect in question in the course.[10]

2. Evaluation: One aspect of evaluation, ability testing, was discussed in chapter one. One of the best ways to establish that ability testing is fair is to match it to the job tasks. Some other topics that fall under evaluation are pre and post testing and course evaluation.

Pre and post testing techniques are closely tied to the development of task-based objectives. One rationale for pretesting, perhaps the most important one, is to determine which objectives the learner has already mastered so that teaching time can be rationed effectively. Post testing establishes if the objectives have been mastered, and also indicates the degree to which the learner who has not mastered the objectives has fallen short.[11]

Comprehensive evaluation consists of considering every aspect of the learning process and assessing its effectiveness. How do we establish a operational definition of effectiveness? By relating it to mastery of objectives.[12] Without careful referencing to objectives, the objects of evaluation may well be rated by their visual appeal or entertainment value. Even if those two errors are not made, any evaluation of course components that is disassociated from objectives will reflect the biases of the evaluators more than it will the value of course. With objectives, evaluators are far more likely to make judgements on a program's effectiveness or performance that can be used to determine the cost/benefit ratios that industry demands.[13]

Every instructor has a personal preferred teaching style. By using objectives as the standard for evaluation, the evaluator can be sure that instructors' effectiveness, not style, is being evaluated. As long as the instructor are successful in helping the trainees master the objectives, they can be free to pursue whatever style they feel is most effective. They are protected, because of the objectives, from drifting literally "off course" and going off on unprofitable tangents.

However, before objectives are used for evaluation, they must be validated in comparison to the task analysis from which they were derived. Learning objectives are valid only to the degree that they describe the proper behaviors. If these behaviors have been identified by a task analysis, then the objectives are valid to the degree that they describe the skills needed to perform the tasks that are selected for training. Once the objectives have been validated in this manner, they may be ultilized to evaluate four elements of a training program; the appropriateness of the learning environment, the effectiveness of the teaching aids, the competence of the instructor, and the performance of the student.

The learning environment will be most helpful to the student if it resembles the actual performance environment as this affords the trainee "real-life" experience. There are, however, some practical restraints on how realistic the learning environment can be: Safety and cost. The instructor certainly does not want the trainee exposed to the same hazards that they might be exposed to on the job, and in most cases the institution providing the training cannot afford the expense of duplicating the on-the-job environment exactly. By referring to the conditions and standards included in the objectives, the evaluator can make a point by point comparison of the learning environment to the ideal one. This will prevent the actual occurrence of a common problem in technical instruction, over-reliance on the classroom environment when teaching psychomoter skills.

The relationship of the objectives to the teaching aids is quite similar to the relationship of the objectives to the learning environment. As with the learning environment, the objectives are the primary reference for evaluation. If tools are included in the conditions of the objectives (given a micrometer, using a dye-penetrant kit, etc), the evaluator should determine if those tools are available to the trainee, and the tools should be of sufficient quality and proper design to allow the trainee to work at the levels of speed and accuracy designated by the standards of the objectives.

Knowing the objectives also allows students to easily evaluate their progress and devote their mental energy to learning, instead of to determining what the teacher really wants. In some studies correlating objectives to learning speed, objectives have been proven to be of value. Students given course objectives have learned more quickly than control groups without objectives. Other studies, however, show no difference.[14] Several studies have also established that students appreciate objectives, and that objectives improve the students attitude toward a course.[15]

Instructors may need to communicate course content to others besides their students. Other instructors who may have to teach the course, and evaluators, all need task-based objectives if they are to communicate effectively. These are the reasons that behavioral objectives are required for all training programs at CECo.[16]

Domains of Objectives.

1. Psychomotor.

Consider again the list of performances on page 24. The first two, "Welding a sheet of steel", and "Dancing the Fox Trot", both involved skills that were primarily physical. This does not suggest that intelligence, concentration, and memory are unnecessary for either performance; they certainly are. But another critical element is evident, physical coordination. Behaviors like these, that require a high degree of mind/muscle interaction, belong to the first of three domains of objectives, the psychomotor domain. Behavioral scientists have proposed that this domain can be divided into levels of performance. The levels are defined as follows in the Commonwealth Edison Advanced Instructor text.[17]

Naturalization: Combined skills are nearly "automatic" they can be performed without heavy concentration.

Articulation: Several skills can be combined at a consistent level of performance.

Precision: A single skill be performed consistently and accurately without continual reference to a performance aid.

Manipulation: Ability to perform a skill with coaching or prompting, but without step-by-step mimicry.

Imitation: Ability to mimic a performance if given an example and continual guidance.

Table 2: Levels of Performance in the Psychomotor Domain.

2. Cognitive

The next two objectives listed on page 23 were "Writing a complete sentence" and "Performing long division". While some mind/body coordination is required here also, the skills involved are predominantly mental. The performance is a display of knowledge - of English grammer and the parts of speech in the first case, and of mathematical laws in the second. Skills like these are in the Cognitive Domain.

A book titled: Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook I: Cognitive Domain listed the levels of cognitive skills. A brief definition of each level somewhat modified to be more applicable to the position of Quality Control Inspector, follows: [18]

Evaluation:	Ability to make a value judgement based on a thorough understanding of a subject.
Synthesis:	The ability to put already existing parts together so that they serve a new function.
Analysis:	Problem-solve, or troubleshoot, a system, based on the understanding of the functioning of all the component parts, and the inter-relationship of the parts.
Application:	Using a system as it was designed to be used; performing the necessary maintenance functions to keep it operating.
Comprehension:	Restate facts and principles in ones' own words. Interpret the meaning of facts and be able to extrapolate these meanings.
Knowledge:	Being able to recall specific facts and concepts about a subject.

Table 3: Levels of Performance In The Cognitive Domain

3. Affective

The last two objectives on page illustrate the third and final domain of behavior, the affective. Both helping an injured person and donating money to a charity require a sense of value. That is, the performer of the action must view the action as being worthwhile enough to demand his or her attention, time, resources, or money. There are even cases when taking action involves a threat to the performers life. These types of behaviors have been broken down as follows in Taxonomy of Educational Objectives: The classification of educational goals. Handbook II: Affective Domain. They are listed starting at the most complex level and working down to the least complex:[19]

Characterizing:	Internalized attitude - one that affects a persons total behavior.
Organizing:	Exhibits behavior that is consistent with a belief or attitude.
Valuing:	Voluntarily displaying behavior that relects a belief or attitude.
Responding:	Exhibits active interest in a belief or attitude by responding to stimuli regarding it.
Receiving:	Being aware of some belief or attitude; paying attention to it.

Table 4: Levels Of Performance In The Affective Domain

SUMMARY

Objectives, because they clearly describe the intended behavior of the trainee, are the foundation of systematic training. An effective objective is derived from systematically selected tasks and it consists of an observable performance, condition, and standard. Though objectives are difficult to write, their many benefits make them worth the trouble.

These benefits include comprehensive and targeted course development, fair trainee and course evaluation, and clarity in communication amoung teachers, student, and outside agents.

The performance that objectives describe has been broken into three domains: psychomotor, cognitive, and affective. Each of these domains have been sub-divided into levels that describe progressively complex behaviors within the domain.

SECTION TWO: ABILITY TESTING

Socrates recorded the following dialogue between himself and Plato:

> "... in the first place, no two people are born exactly alike, but each differs from each in natural endowments, one being suited for one occupation, and another for another. Do you not think so?"
> "I do"
> "... From these considerations, it follows that all things will be produced in superior quantity and quality, and with greater ease when each man works at a single occupation in accordance with his natural gifts...."
> "But we cautioned the shoemaker, you know, against attempting to be an agriculturist, or a weaver, or a builder besides, with a view to our shoemaking work being well done; and to every artisan we assigned in like manner one occupation; namely, that for which he is best fitted...Now is it not of the greatest moment that the work of war should be done well? Will it not also require natural endowments suited to this particular occupation?"
> "Then apparently, it will belong to us to choose out, if we can, that special order of the natural endowments which qualifies its possessors for the guardiansip of the state"
> "Certainly it belongs to us."
> "Then, I assure you, we have taken upon ourselves no trifling task."[20]

Since the late nineteenth century, the ability to select the proper person for a given job has excited great interest in both the public and private sector.[21] Perhaps the earliest historical example of this is the Chinese Civil Service Exam instituted during the Chan Dynasty (206 BCE-220 AD).[22] From this test on to the present attempts by government, business, and industry, Socrates' prediction that personnel selection is "...no trifling task." has been proven true.

Selection testing has simultaniously been condemned as a technique for restricting the entry of certain ethnic and economic groups into upper level schools and jobs, and praised as the best method of avoiding economic and ethnic biases.[23] Some businessmen even believed that scientific selection testing would largly eliminate the accidents and employee turnover that plagued American Industry. They believed this should happen "...when a scheme has been devised to make it possible to select the right man for the right place"[24]

While that has obviously not occurred, and many of the criticisms against selection testing have been established as having some validity, testing has been proven to be more predictive of on-the-job proficiency than are the common alternatives to testing.

There are several good reasons why selection tests have not been good predictors of job proficiency. Some argue that a test can be predictive and culturally biased at the same time. For example, a test used to predict successful salespersons may be validated against the test results of existing successful salespersons. Or, the results of a value survey can be matched against the values of those who are currently successful in sales. But if the existing sales force is limited to one gender and one ethnic group because of previous discriminatory practices, the only factor being validated is the bias of the test, not its predictiveness.[25]

In spite of confusing and difficult problems like the one mentioned above, testing has always played a role in selection. Supporters point out that every society relies on some type of selection criteria.[26] People are <u>not</u> randomly assigned to jobs to see how they will work out, and most would agree this is for the best. Many jobs require specific entry skills, and most require at least a certain level of learning ability. Testing is one method of determining these skills and abilities.

The American Civil Services force of the nineteenth century was a good example of the problems that occur when selection testing is not used. Most of the jobs were filled by patronage employees, and every presidential election resulted in a major turnover of the Federal clerical staff. The effect of this policy on the continuity of government services was, of course, highly deleterious.[27] It even played a part in the assasination of a president. In 1883 President James Garfield was shot and killed by a disappointed Federal office seeker.[28]

Later that same year Americans saw the first major application of standaralized selection testing, the Civil Service Act (S USC 3304). It was deliberately written to measure practical skills so that it would not resemble the British Civil Service Exam, which was designed to identify and reward member of the classically educated British elite.[29]

American society was in turmoil at this time because of the Industrial Revolution and the resulting rapid transfer of the population from an agricultural to an urban environmnent. The need for testing to establish reasonable selection standards was obviously not limited to the public sector. One of the strongest and most persuasive voices calling for standardized testing in the academic sector was Joseph Rice. His massive survey of American public schools, completed in 1903, emphasized the need for standardized testing.[30] Coincidentially, it was only a year later that Alfred Benet, a French educator, was assigned by the French government the task of identifying children with learning difficulties. He worked on task with a subordinate named Theodore Simon. Together they developed a test battery that was purported to measure intelligence, with intelligence defined as "the ability to learn."[31]

Lewis Tunman, a Psychologist at Stanford University came across Benet's work while he was searching for a method that could be used to measure intelligence. He adapted the tests for use in United States. According to Landy and Trumbo in The Psychology of Work Behavior, "Shortly thereafter they were used in Industrial settings."[32] Tunman himself described a validation study in which the tests were used in the selection of policemen and firemen in San Jose, California. The article appeared in the first issue of The Journal of Applied Psychology in 1917.[33]

By the 1920's, IQ tests were used to determine if students should follow a vocationally or academically oriented curriculum in high school. The army also drew from the Stanford/Binet IQ test battery to develop the "Army Alpha Test", which was used for recruit selection during World War I.[34] It is accurate, then, to say that by the 1920's ability test was being utilized by every facet of American Society; Government, Academic, Industrial, and Military.

It was not long before both the public and the academic community became disenchanted with the efficacy and fairness of ability testing. Some abuses were evident; scores were used as labels, often by people who misunderstood what the test measured. At times the tests were instruments of discrimination. Test readings were considered fixed and based on immutable genetic traits.

Often, ability test performance was the sole criteria used for making irreversible decisions. Several examples of such abuse are: The student who wanted to attend college, but was forced into a vocational course of study, the citizen denied a civil service position, and the employee refused a job or promotion. These people had little recourse.

Their lack of ability, after all, had been "scientifically" established by tests. These tests were used to make decisions regarding abilities they were never designed to measure. Written tests, for example, were used to measure psychomotor skills because written tests are easier to administer and grade than are psychomoter performance tests.[33]

MODERN SELECTION TESTING

The public and academic disenchantment with testing eventually led to some government regulation of test use. Although proponents argued that selection tests replaced more subjective measures such as interviews, background research, letters of recommendation, or social status; critics maintained that tests gave an impression of scientific technique where none really existed - thus giving the whim of the selector more, not less, authority.[40]

The primary source of this government regulation of testing is the 1964 Civil Rights Act. The Act resulted in considerable government involvement in the application and interpretation of test results. The Federal guidelines on testing are maintained by the Equal Employment Opportunity Commission. (EEOC). A sub-division of the EEOC, the OFCC, Office of Federal Contract Compliance, has the authority to restrict

Federal funding to institutions that do not follow EEOC guidelines. Since many institutions have Government contracts, or rely at least partially on Government grants for their funding, the EEOC guidelines have considerable economic power behind them.

The future of ability testing is dependent upon several factors. Large scale users of the tests, such as the business community, must be convinced that the laws regulating test-based selection are clear and consistent.These users must be reasonably confident that, if they follow established guidelines, they will not be subject to Government penalties or private lawsuits. Lawmakers must be confident that ability tests are valid; that they are indeed measuring job-related ability, and not some characteristic that is actually unrelated to job performance.

Finally, the general public must perceive these tests as fair. Most of the people who must take these tests, whether in Government, Industry, or Education, may not understand the definition of validity or reliability. They do, however, have an intuitive sense that a test used to evaluate their potential for on-the-job performance should measure abilities that are related to the job. This is commonly referred to as face validity.

It is the legal and moral responsibilities of those who administer these tests to ensure that ability tests are instruments for identifying potential, and not used for the purpose of institutionalizing inequity.

CHAPTER III

METHODOLOGY

Statement of the Problem

The position of fossil Station Quality Control Inspector had become increasingly important at Commonwealth Edison Company for several reasons: The cost of fuel had escalated, making it more important to burn it efficiently; the equipment used to process the fuel had become more complex; and the consequences of inadequate quality control were more serious than they had been in the past. The supervisors of Q.C. Inspectors decided that three steps were necessary to resolve this problem: First, the competency of Q.C. Inspectors must be improved through systematic training; secondly, the number of Q.C. Inspectors must be increased rapidly; and third; Q.C. Inspectors must be selected from those bidding on the job by the use of a predictively valid selection instrument.

Hypothesis

The following overall null hypothesis will be tested: There will be no significant correlation between the performance of Quality Control Inspectors on any part, or combination of parts, of the Flannagan Industrial Test Battery, with any section, or combination of sections of a form for the evaluation of the Quality Control Inspectors completed by the employes' existing and previous Supervisors.

The hypothesis, in mathematical terms, is as follows:

H_0: R= 0

(where R = the Pearson Product Moment calculated between any single test or combination of tests in the Flannagan Industrial Battery and a specific evaluation.

Population

The subject population for this investigation was twelve Fossil Station Quality Control Inspectors at CECo. At the time this investigation was performed, they comprised the entire population of employees with this title. They were distributed amoung the ten CECo Generating Stations that burn fossil (coal or oil) fuels. All were high school graduates. Some had attended college, though none had earned college degrees. They ranged in age from 29 to 64 with a median age of 45. All the members of the population were white males.

The primary responsibility of Q.C. Inspectors is to use non-destructive examination techniques to monitor maintenance work at the generating stations while it is being done, and test the products of the work after the work is completed. The techniques used include visual inspection, radiography, and sonic testing. Some of the vendors who provided maintenance and/or testing equipment provided training on the use of their product, but no comprehensive training program was available for people in this position.

Procedure

The investigator had been requested to develop a new selection instrument, or identify an existing selection instrument, that would be predictive of potentially competent Q.C. Inspectors. He reviewed a number of tests with a committee of existing Q.C. Inspectors. They selected the Flannagan Industrial Tests II (FIT II) as the test battery with the greatest face validity. This test battery was administered to the twelve men who comprised the entire population of Fossil Station Quality Control Inspectors at the time of the investigation.

The results of the test battery were correlated with the ratings the Q.C. Inspectors had received on an evaluation that had been completed by their existing and immediately-previous supervisors. This evaluation was derived from a task analysis of the Q.C. Inspector position. The task analysis consisted of a list of tools and references, which the Q.C. Inspectors rated on frequency of use; a list of tasks, which were rated on physical difficulty, mental difficulty, frequency, and impact on safety; and a list of abilities and characteristics, which were rated on importance to the job of Q.C. Inspector. References, tools, tasks, abilities, and characteristics which were rated highly on the task analysis were included in the evaluation.

Developing the Survey Instrument

Rating Scale: The evaluation instrument developed for this work was derived directly from the Task Analysis and Training Standard. It consisted of two parts; "Subject Matter Knowledge," and "Abilities and Characteristics." Both sections shared the same rating method. Specifically, the evaluators indicated, on a five point numerical scale, their degree of agreement with respect to the knowledge or qualities listed. The points on the scale were defined as follows:

0	1	2	3	4
Does Not Apply	Strongly Disagree	Disagree	Agree	Strongly Agree

Table 5: Numerical Scale on Evaluation

A cover letter attached to the survey explained that the survey was confidential, that it was only being used for this study, and not for consideration or a promotion of job advancement. It also explained that if the evaluator was not familiar with the Q.C. Inspectors performance in any area, or if, for any reason, felt uncomfortable rating him/her in a particular category that he should circle the zero.

Subject Matter Knowledge: This part of the evaluation was initially derived from the Traning Standard, and modified after consultation with the committee that originally developed the task listing. It listed the tasks that the respondents rated at 3.5 or above in all four of the categories. It also listed some tasks that were not rated as highly, but were recommended by the committee.

Abilities and Characteristics: All of the abilities and/or characteristics that were rated as 'very important' or 'crucial' on the task analysis by the respondents were included in this section.

Disbursement: Each evaluation was mailed to two people, the immediate supervisor of the Q.C. Inspectors, which was the Station Technical Staff Supervisor, and the Supervisor the Q.C. Inspector had prior to his present job. The title of this second supervisor would vary, depending upon what department the Q.C. Inspector had come from. The surveys were filled out anonymously, so that a completed survey could not be matched with any single individual.

SELECTING THE TESTS

Program Developers reviewed Vocational Tests and Reviews, edited by Oscar Buros, for tests that had been used for screening Q.C. Inspectors. The Flannagan Industrial Test Battery had been used for many job classifications that required skills similar to those of Q.C. Inspectors; for example, Machinists, Maintenance Mechanics, and Service Technicians. But although the tests had been used in various forms since World War II, there were no records of it being administered specifically to Q.C. Inspectors.

Validating the Tests: The face validity of the tests had already been established by having them reviewed and approved by a group of Q.C. Inspectors who were respresentative, in terms of job experience, of the entire population. The investigator then endeavored to establish the predictive validity of the tests. Predictive validity of the tests was to be established by determining if there was significant correlation between the test scores when the battery was given to the Q.C. Technicians, and the ratings of the Q.C. Technicians on the evaluations. The correlation would be calculated for all possible combinations of the six tests against the two separate parts of the evaluation, and the average of the two parts. A statistically significant correlation would be interpreted as evidence that the FIT II test battery was predictive of Q.C. Inspector competence.

Procedure: The data from the tests and evaluation was processed using a computer program called SAS (Statistical Analysis System). The relationship between the average evaluation score and the tests was examined using three correlation techniques; multiple regression, cannonical correlation, and Spearman rank. The last method, Spearman Rank, is the most appropriate one in the investigator's opinion. This is because the Spearman rank technique is specifically designed for ordinal data, which is the catagory of the evaluations and test scores. However, since many researchers have made strong arguments that the treatment of ordinal data as if it were interval data is an acceptable research approach, multiple regression and cannonical correlation were also applied to the data. Multiple regression is the better of these two techniques since it is designed for one dependent variable, which is all that was used in this investigation (the evaluation scores).

A brief description of the six tests follows. They are listed here in the order that they were given to the Q.C. Inspectors:

- Ingenuity: A problem is briefly stated, and the testee is asked to give a one or two word solution. He is given, as clues, the number of letters, and the first and last letter, of each word in the solution.
- Inspection: A line of eleven small parts is written across a page. The first part is drawn properly. One or more of the remaining parts have minor "defect" in comparison to

the first part. The testee has five minutes to mark all defective parts. Partial credit is given for identifying some, but not all parts.

- Assembly: An exploded drawing of a component, illustrating three to five sub-assemblies, and the sides that fit together, is given. The testee is given ten minutes to select, from five choices, what the component will look like when it is assembled.
- Components: The trainee must identify one of five simple figures that is part of a more complex drawings. He/she is given 10 minutes.
- Electronics: The testee is given fifteen minutes to answer questions about electronics theory, second generation electronics devices, and electrical schematics.
- Scales Two graphs are presented. A point on the X or Y axis is given, and a specific curve on graph. The trainee must estimate the proper value on the other axis.

Although not all of the Q.C. Inspectors were tested at one time, they were tested under similar conditions with the test given in the same order, and with breaks between the test permitted in the same places and for equal duration. The directions in the Instructor's manual for administering the battery were clear and explicit and they were followed consistently.

Figures 6 through 11 contain samples of two questions from each test in the battery.

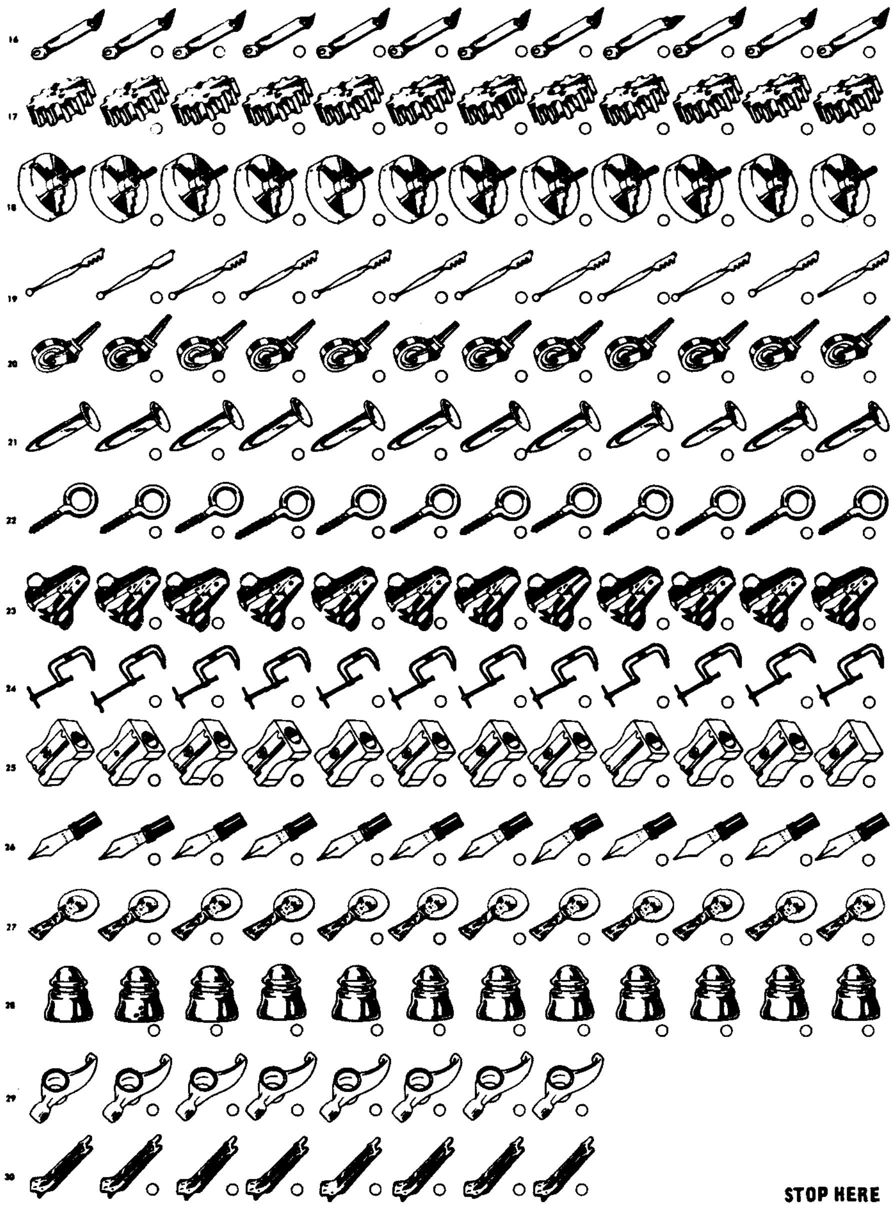
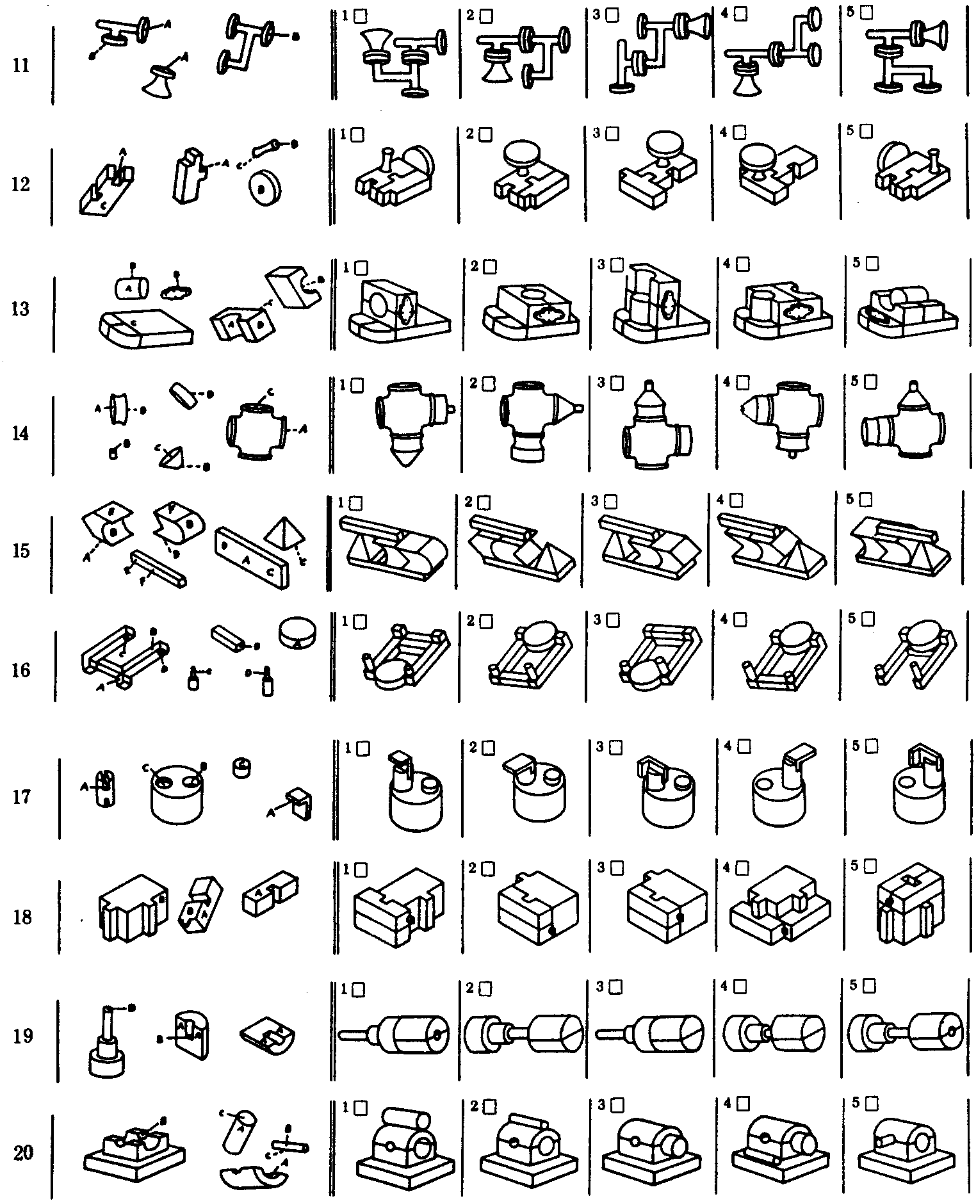


Figure 6: Sample Of Inspection Test



STOP HERE.

Figure 7: Sample Of Assembly Test

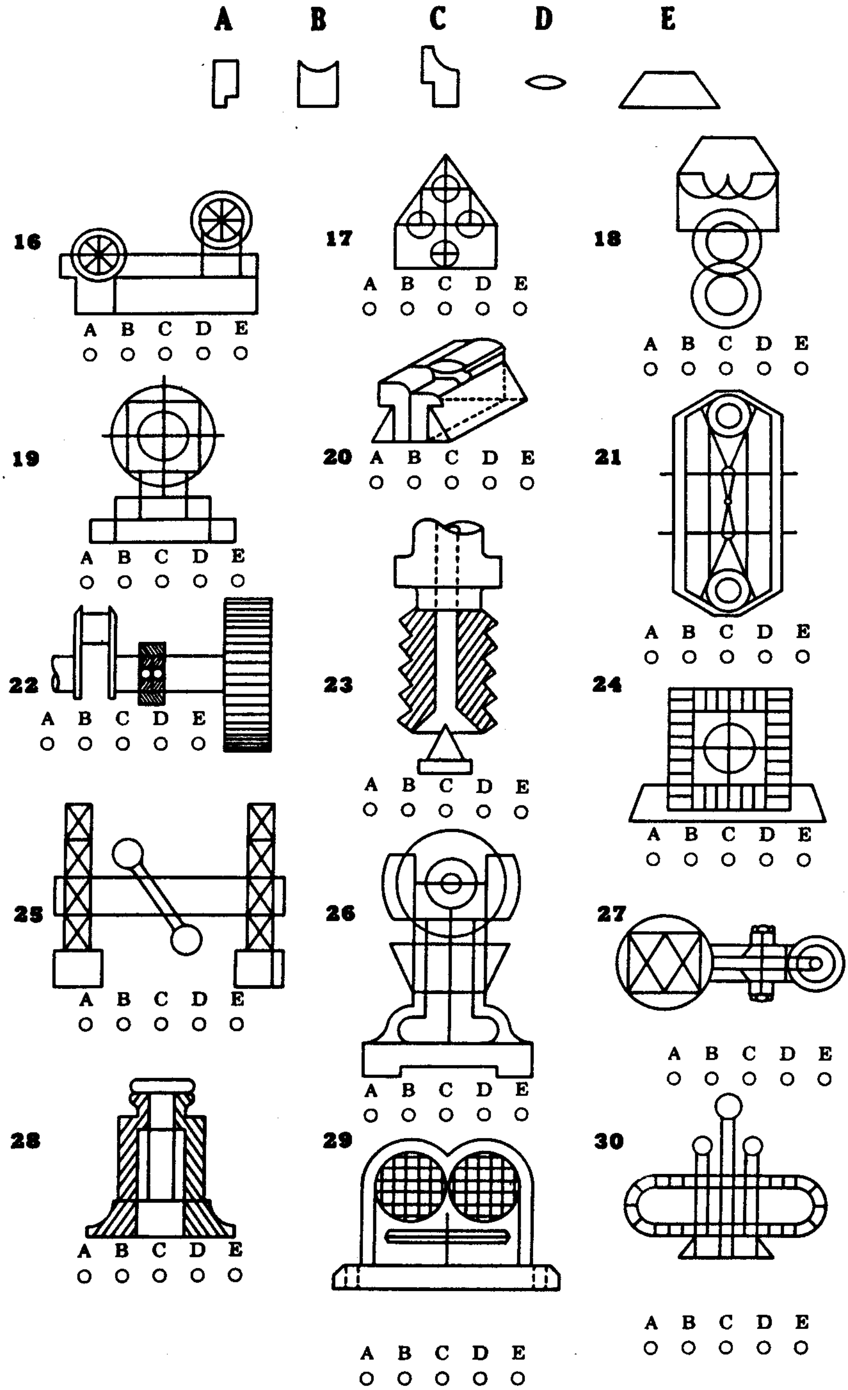
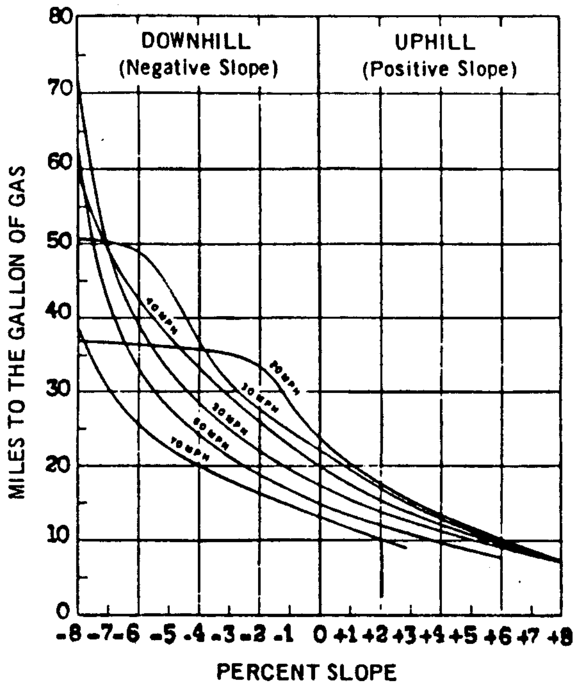


Figure 8: Sample Of Components Test



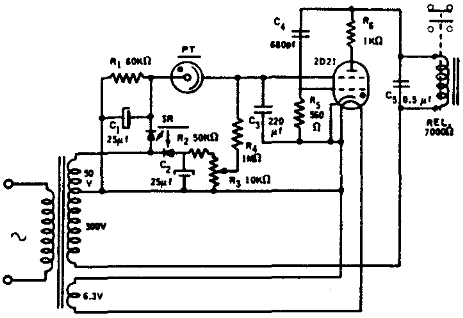
	Slope	Speed M.P.H.	Number of miles to the gallon A	B	C	D	E	Answer Column
17.	−6.0%	70	33	30	26	22	20	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
18.	+2.0%	40	26	22	20	15	12	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
19.	−3.0%	50	25	21	18	13	10	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
20.	+2.0%	20	10	13	18	20	32	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
21.	−2.0%	50	13	16	19	22	25	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
22.	−4.0%	70	8	10	13	17	20	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
23.	0.0%	20	13	18	20	24	30	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
24.	+4.0%	40	12	14	18	20	24	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

	Mile/ Gal.	Speed M.P.H.	Slope A	B	C	D	E	
25.	20	70	−6.0	−2.0	−4.0	+2.0	+8.0	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
26.	12	60	+2.0	+4.0	+5.0	0.0	−2.0	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
27.	36	20	−2.0	−1.0	0.0	−6.0	+1.0	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
28.	8	60	+4.0	+6.0	+2.0	0.0	−2.0	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
29.	22	50	+1.0	−1.0	0.0	−4.0	−2.0	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
30.	28	30	−2.0	−4.0	−1.0	0.0	−5.0	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

Figure 9: Sample Of Graphs Test

19. In the diagram of an electrical circuit, the symbol —\/\/\/— refers to
- O a bell
- O a buzzer
- O a multicell battery
- O a fixed condenser
- O a fixed resistor

20. Which one of the following is used for changing alternating current into direct current?
- O Rheostat
- O Relay
- O Solenoid
- O Rectifier
- O Transformer



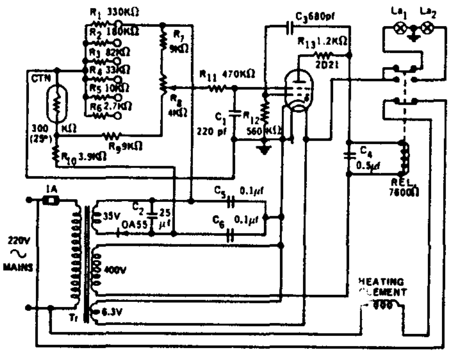
To answer questions 21-24, use the diagram above.

21. The above diagram shows the circuit for a simple photoelectric switch. In order for it to function properly the photocell PT must receive a DC voltage. What circuit element(s) convert(s) the 50V AC voltage to DC?
- O SR
- O C_1 and R_1
- O C_1 and SR
- O 2D21
- O C_3 and R_3

22. Which component allows for the influence of background illumination?
- O R_1
- O R_2
- O R_3
- O R_4
- O C_2

23. The function of the relay in the circuit is to
- O act as the switch for the external circuit
- O limit the 2D21 tube plate current
- O short out C_5 when necessary
- O protect the 2D21 tube from possible damage due to accidentally high voltage
- O protect the photocell PT from very bright light sources

24. The resistor R_2 is used to
- O regulate the anode voltage of the thyratron
- O regulate the cathode voltage
- O adjust the bias on both grids
- O adjust the bias on the first grid
- O adjust the bias on the second grid



To answer questions 25-30, use the diagram above.

25. In the above temperature stabilization circuit, the element CTN is a
- O diode
- O thermistor
- O thermostat
- O variable resistor
- O heat source

26. The bridge output is used to
- O bias the first grid of the 2D21 tube
- O bias the second grid of the 2D21 tube
- O provide an anode voltage for the 2D21 tube
- O open the relay
- O close the relay

27. In the circuit containing C_2, C_5, C_6, and OA55, the OA55 component functions as
- O a rectifier
- O an oscillator
- O an amplifier
- O a power stabilizer
- O a phase tuner

28. The relay is operated by the
- O capacitor C_4
- O 6.3 volts from the Mains
- O 35 volts from the Mains
- O anode current of the 2D21 tube
- O La_1 and La_2

29. The heating element shown is powered by
- O 35 v. AC
- O 35 v. DC
- O 220 v. AC
- O 220 v. DC
- O 400 v. AC

30. Element 1A is a
- O diode
- O fuse
- O capacitor
- O switch
- O rectifier

STOP HERE.

Figure 10: Sample Of Electronics Test

11. When the presidents of several oil companies sent microfilmed letters from Texas to the oil industry's 100th anniversary ceremony in Pennsylvania, they sent them by a method of transport typical of today's oil industry. The unusual method of communication was by

- O p _ _ e l _ _ e.
- O o _ _ l t _ _ k.
- O f _ _ l c _ _ r.
- O a _ _ r m _ _ l.
- O h _ _ d l _ _ e.

12. A new lightweight hand sickle that can be kept very sharp has a blade that is inexpensive and simple to replace. The blade is made of several ordinary

- O b _ _ _ w w _ _ _ _ s.
- O r _ _ _ r b _ _ _ _ s.
- O s _ _ _ r b _ _ _ _ s.
- O c _ _ _ d e _ _ _ _ s.
- O l _ _ _ r t _ _ _ _ s.

13. To protect floors when dripping umbrellas are left standing, a manufacturer has produced a small device that looks like an ordinary kitchen utensil with a bottom added. It looks like a

- O d _ _ _ _ e.
- O l _ _ _ _ k.
- O f _ _ _ _ l.
- O r _ _ _ _ o.
- O s _ _ _ _ h.

14. A type of tubing for toothpaste tubes has been developed that can be made very compact for shipping. The tubing is seamless and made of very thin but strong metal. Long lengths of tubing are pressed flat for shipping. When they are delivered to the plant where they are to be cut into short tubes and filled, the manufacturer first

- O d _ _ _ _ _ _ s them.
- O c _ _ _ _ _ _ s them.
- O i _ _ _ _ _ _ s them.
- O m _ _ _ _ _ _ s them.
- O n _ _ _ _ _ _ s them.

15. An oil drilling crew drilled a hole 20 feet deep and about 2 feet in diameter at the top. The hole narrowed considerably toward the bottom. A large wooden block fell into it and lodged about three-quarters of the way down – too far to reach with hooked poles. The drill could not be operated with this block in the way. The men tried unsuccessfully to reach it with longer poles, and then one of them suggested a simple way to remove the block. His plan called for the use of

- O i _ _ _ e.
- O w _ _ _ r.
- O p _ _ _ s.
- O h _ _ _ s.
- O l _ _ _ e.

16. A manufacturer is producing a small device that helps a truck driver see what is behind his truck. This device, which is attached so that it can be seen and used through the windshield, acts as a miniature

- O l _ _ _ _ _ _ _ b.
- O t _ _ _ _ _ _ _ n.
- O e _ _ _ _ _ _ _ r.
- O r _ _ _ _ _ _ _ o.
- O p _ _ _ _ _ _ _ e.

17. A two-foot hole had to be cut in a high ceiling of a factory while the plant was in operation. Falling dust and debris from this procedure would harm the machinery underneath. The men were able to do their job without covering the machinery for more than a few minutes because after they cut a small hole, they used an inverted _ _ _ _ _ _ _ _ to catch the debris.

- O u _ _ _ _ _ _ a
- O c _ _ _ _ _ _ h
- O l _ _ _ _ _ _ r
- O e _ _ _ _ _ _ r
- O c _ _ _ _ _ _ e

18. A team of British scientists has announced a new way of collecting insects that is a great improvement over the old butterfly net. The scientists found that they were able to collect more insects by this means without great damage to the specimens. The new way uses a device similar to a

- O c _ _ _ _ m e _ _ _ _ _ e.
- O m _ _ _ _ m e _ _ _ _ _ e.
- O s _ _ _ _ r h _ _ _ _ _ r.
- O s _ _ _ _ c i _ _ _ _ _ e.
- O v _ _ _ _ m c _ _ _ _ _ r.

19. A new system for handling flour in bulk reduces operating costs. This system replaces handling flour in 75 and 100 lb. bags, loading it on dollies, and wheeling it to distant elevators. In the new system, which is fast, safe, and self-contained, the flour is transported through

- O p _ _ _ s.
- O w _ _ _ s.
- O d _ _ _ s.
- O l _ _ _ s.
- O g _ _ _ s.

20. When an adjustable wrench is not available, it is possible to make an emergency adjustable wrench to fit any size nut by putting two square nuts on a long

- O m _ _ l.
- O b _ _ t.
- O c _ _ d.
- O h _ _ g.
- O t _ _ k.

STOP HERE.

Figure 11: Sample Of Ingenuity Test

CHAPTER IV

ANALYSIS OF DATA

Introduction: By this time the investigator had accumulated a substantial amount of both raw and processed data on all the components of the investigation. The time was appropriate for organizing and analyzing the data in preparation for drawing some conslusions regarding the hypothesis and other issues that came to the investigator's attention.

The data analysis will be presented in the following format: The method used to analyze the responses to the task surveys so that tasks could be selected for training will be discussed first.
Next, the average ratings that Q.C. Inspector received from their existing and previous supervisors will be presented, and these scores will be compared to the Q.C. Inspectors' performance on the FIT II battery. Relationships between the evaluation scores and various test scores will be examined using multiple regression, Spearman rank, and cannonical correlation techniques. An additional potential relationship that surfaced during the study, age vs test scores, will also considered using the Pearson product moment in addition to the three listed above.

Finally, the task survey data will be examined for notable trends, and the tasks that were rated exceptionally high or low will be discussed.

SAS 6

VARIABLE	N	MEAN	STD DEV	MEDIAN	MINIMUM	MAXIMUM
EV	11	3.17727273	0.28305798	3.17999935	2.72000000	3.60000000
IN	11	13.81818182	5.15399227	19.00000000	10.00000000	26.00000000
AS	11	9.63636364	4.27253384	10.00000000	4.00000000	17.00000000
CO	11	13.54545455	6.23479970	13.00000000	3.00000000	27.00000000
EL	11	16.09090909	5.55795904	15.00000000	9.00000000	22.00000000
SC	11	11.63636364	5.33428022	14.00000000	3.00000000	18.00000000
IG	11	13.09090909	5.28118444	14.00000000	1.00000000	20.00000000
TT	11	82.31818182	23.40862312	85.00000000	53.00000000	122.00000000
AV	11	13.78000000	3.89032903	14.15999985	8.83000000	20.30000000
AGE	11	45.68181818	14.17087282	45.00000000	29.00000000	64.00000000

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 11

	EV	IN	AS	CO	EL	SC	IG	TT	AV	AGE
EV	1.00000 0.0000	0.16893 0.6195	0.15786 0.6430	0.03266 0.9241	-0.36214 0.2738	-0.09940 0.7712	0.17679 0.6031	-0.00099 0.9977	0.00025 0.9994	-0.40548 0.2160
IN	0.16893 0.6195	1.00000 0.0000	0.45082 0.1640	0.35193 0.2885	0.16914 0.5775	0.16831 0.6208	0.37173 0.2603	0.56249 0.0717	0.56432 0.0705	-0.39862 0.2246
AS	0.15786 0.6430	0.45082 0.1640	1.00000 0.0000	0.87536 0.0004	0.56582 0.0696	0.77902 0.0047	0.33843 0.3087	0.91114 0.0001	0.90942 0.0001	-0.75113 0.0077
CO	0.03266 0.9241	0.35193 0.2885	0.87536 0.0004	1.00000 0.0000	0.73141 0.0105	0.69211 0.0183	0.10160 0.7663	0.86612 0.0006	0.86624 0.0006	-0.56715 0.0688
EL	-0.36214 0.2738	0.16914 0.5775	0.56582 0.0696	0.73141 0.0105	1.00000 0.0000	0.77363 0.0052	0.05079 0.8821	0.77490 0.0051	0.77610 0.0050	-0.11260 0.7417
SC	-0.09940 0.7712	0.16831 0.6208	0.77902 0.0047	0.69211 0.0183	0.77363 0.0052	1.00000 0.0000	0.15393 0.6514	0.81628 0.0022	0.81462 0.0023	-0.48917 0.1268
IG	0.17679 0.6031	0.37173 0.2603	0.33343 0.3087	0.10160 0.7663	0.05079 0.8821	0.15393 0.6514	1.00000 0.0000	0.44666 0.1684	0.44667 0.1684	-0.09578 0.7794
TT	-0.00099 0.9977	0.56249 0.0717	0.91114 0.0001	0.86612 0.0006	0.77490 0.0051	0.81628 0.0022	0.44666 0.1684	1.00000 0.0000	0.99995 0.0001	-0.54056 0.0850
AV	0.00025 0.9994	0.56432 0.0705	0.90942 0.0001	0.86624 0.0006	0.77610 0.0050	0.81462 0.0023	0.44667 0.1684	0.99993 0.0001	1.00000 0.0000	-0.53774 0.0880

Figure 12: Portion Of Computer Program Output

Selecting Tasks: Analysis of the data gathered during the investigation began with the results of the task analysis. In order to facilitate understanding of the survey responses, they were organized into tables for each task, the results consisted of the task identification number, mean frequency of performance, standard of deviation of the frequency, and the mean ratings for the performance difficulty scale, mental difficulty scale, and impact of safety scale. This information was computed separately for each station, and for the combined responses from all the stations. Figure 12 illustrates a portion of the output of the computer program used to analyze the data for each major section.

Using this data, the committee of Program Developers and Subject Matter Experts who originally developed the task survey selected tasks for training. They decided that any task performed once a year or more would be automatically selected for training if it was rated at 2.5 or higher on the performance difficulty, mental difficulty, or safety scale. The committee did not consider the number of people performing the task. They intended for the document to be comprehensive and generic; they preferred to err on the side of including too many tasks for training rather than too few. Many tasks were selected for training even though only a few people in the field performed them so that training would be available for those people. The final program would be designed to be modular. Trainers at the generating stations could easily tailor the program so that it addressed only the training needs of their stations.

A number of tasks were also selected for training that did not meet the criteria mentioned above. If any member of the committee believed, based on his experience, that a task required training, it was included. Also, a number of tasks were included that were not even listed on the original task survey. These came from two sources; handwritten comments on the surveys (those filling out the survey were encouraged to do this), and tasks that committee members thought of after the time the survey was printed.

Evaluation Results: As stated in chapter three, these tasks, plus the abilities and characteristics rated as "important", "very Important", or "crucial" were used as the basis of the evaluation sent out to the Quality Control Inspectors' existing immediate suprvisor and his previous immediate supervisor. The average of the responses to those evaluations were as presented in Table 5.The averages were calculated by averaging of all the ratings on the survey and then averaging the two surveys filled out for each Q.C. Inspector. These, in turn, were averaged to produce a grand average or grand mean.

Employee	Average Evaluation Score
A	3.09
B	3.27
C	3.05
D	3.60
E	3.18
F	3.46

Employee	Average Evaluation Score
G	2.72
H	2.77
I	3.40
J	3.41
K	3.05
L	3.00

Table 6: Average Responses To Evaluation Survey

These responses were correlated against the scores of the Q.C. Inspectors on the six FIT tests included in the battery. The FIT test responses were as presented in Table 6.

A	3.09	24	6	8	10	3	11	62	10.33
B	3.27	24	11	12	15	15	14	91	15.10
C	3.05	26	17	27	22	17	13	122	20.30
D	3.60	21	13	19	22	18	15	108	18.00
E	3.18	16	4	3	8	8	16	54	9.00
F	3.46	15	6	9	9	4	10	53	8.83
G	2.72	15	12	15	21	16	20	100	16.60
H	2.77	10	4	12	20	11	1	58	9.66
I	3.40	19	9	15	15	7	20	85	14.16
J	3.41	14	14	16	13	15	10	82	13.60
K	3.05	23	10	13	22	14	14	96	16.00

Table 7: FIT II Battery Results

The first column on the left lists the letters standing for the employee who took the test. The next column lists the grand average of the employee's evaluation by his supervisors. The next six columns record employee test scores on the FIT II Battery. The sum totals are listed in the next column, and the average totals in the final column.

Table 7 presents the correlation between the trainees performance on the FIT test battery and their average of the two evaluations. The rationale for each procedure used is discussed in the "procedure" section of the previous chapter.

Test	Multiple Regression	Spearman Rank	Canonical Correlation
Ingenuity	0.015	-0.00547	0.2032
Assembly	0.030	0.15069	0.1899
Components	0.019	0.10046	0.0393
Electrical	0.010	0.31726	-0.4356
Scales	0.027	-0.04556	-0.1196
Ingenuity	0.023	-0.04577	0.2126
Average	0.270	0.00025	0.0003

Table 8: Relations between Supervisor Evaluations and Test Battery Performance

Upon initial observation there seemed to be an inverse relationship between the age of the Q.C. Inspectors and their test performance.

Table 9 illustrates the extent of the relationship.

Q.C. Inspector	Age	Average Test Score
A	64	10.33
B	63	15.10
C	61	20.30
D	58	18.00
E	48	09.00
F	45	08.83
G	43	16.60
H	32	09.66
I	30	14.16
J	29	13.60
K	29	16.00
Pearson Product:	-0.42727	
Spearman Rank	-0.42727	
Correlation Coefficient:	-0.4877	

Table 9: Age vs Test Performance

Interestingly, their appears to be a much stronger relationship, although an inverse one, between age and test performance than there was beween the evaluation and any of the test. The relationship is not statistically significant only because of the small sample.

Summary:

The investigation began with a survey of training needs, in which existing Q.C. Inspectors indicated, regarding their primary responsibilities, what priorities should be set for training new

Quality Control technicians. The survey also gave them an opportunity to express their opinions regarding how worthwhile existing Quality Control training programs were.

With this completed, the Advisory Committee began developing a task survey. They wrote a highly detailed task listing, and also included a list of tools and references used on the job, and abilities and characteristics that might affect job performance. The tasks were rated for frequency, physical and mental difficulty, and impact on safety on a scale of one to four. Each number on the scale was carefully defined. The tools and references were rated as to frequency, and the abilities and characteristics were rated regarding importance to the job. The data from this survey was used for two purposes; selecting tasks for training and developing an evaluation.

A battery of six tests from the Flannagan Industrial Test II group was administered to the Q.C. technicians. Data from their performance on the test was correlated against the average of the two supervisors' evaluations. Because their seemend to be an inverse relationship between age and test performance, the test results were also correlated to the age of the Q.C. technicians.

Task Analysis Data: This is a brief summary of the results of each part of the task analysis:

HAND AND POWER TOOLS (These two sections are combined because there was only one item in the Power Tools section).

Hand tools, as well as power tools, safety equipment, and work aids, were rated for frequency only. The two lowest frequency hand tools were paint brushes and scrapers, both rated at 1.3.

The highest rated hand tools were rulers (3.1) and taper gauges (3.0). These were followed by micrometers (both inside and outside) rated at 2.9, and calipers (both inside and outside) rated at 2.8. Fifteen of the twenty-five hand tools, or eighty percent, were rated as being used at least once a month. The only power tool listed, pneumatic grinder, was rated at 2.3. Only eight employes used this tool, and in all cases they used it at home, not work.

SAFETY EQUIPMENT

55% of the twelve pieces of safety equipment listed were used monthly or more often. The two lowest rated pieces were fire extinguisher (1.0) and respirator (1.6). One additional item was handwritten into the list, a sky climber. This device slowly lowers a person to the ground should he or she be suspended in a bosum's chair or scaffold malfunctioning.

WORK AIDS

Of the thirty work aids listed, twenty four, or 80%, were used monthly or more often. "Vacuum cleaner" rated a 4.0, which means everyone considered it outage related. Rubber gloves, hand truck, and surface finish comparator, all received the lowest ratings one to four times a year.

REFERENCES

Seventy-nine references appeared on the original list, and three were handwritten in by those surveyed: Technical Staff procedures, station files, and college and high school texts. The most frequently used references, with a rating of over 3.0, were Maintenance Work

Requests, plus the second two handwritten additions. The additions, however, were rated by only one person each.

READING JOB MATERIALS

The next section, tasks, comprised the bulk of the task analysis. The first subsection was Reading Job Materials. Two tasks were added; "Read and interpret welding guides", and Read and interpret the Q.A. manual." Both received high ratings in all catagories by the individuals who wrote them. Only two tasks in this section, "Read and interpret technical written manuals," and "Read and interpret written instructions," received ratings of over 2.5 in the performance or knowledge catagories. None of the tasks originally included in the survey received a rating of higher then 3.0 for safety, but the individual who included the task on reading welding instructions assigned it a 3.0 for safety.

CREDIT/RECEIPT INSPECTIONS

Received ratings between 2.0 and 2.7 in the Performance, Knowledge, and Safety catagories. No additional tasks were written.

ORAL AND WRITTEN COMMUNICATION

Two tasks were added; "Signing off release orders" and "Maintaining hold tag logs." The tasks in this section received, in general, high ratings for performance and knowledge. Thirty-five out of forty-one tasks had ratings of over 2.5 when these two catagories were averaged together.

CLEARANCE PROCEDURES

One of the tasks; "Requesting Clearance for Personnel Protection cards," was rated extremely high by the four people who performed the task over 3.0 in the Performance, Knowledge and Safety catagories. The remaining six tasks were rated between 2.1 and 2.8 in these catagories.

SAFETY/SECURITY

As might be expected in this subsection, all the ratings were high for performance, knowledge, and safety. Numbers of people performing the tasks ranged between four and ten. Three of the tasks were rated over 3.0 in Performance, Knowledge and Safety. They were, "Selecting and wearing proper clothing and apparatus for the job," "Place or remove safety/warning devices," and "Extinguish fires by using hoses or proper extinguishers."

SUPERVISING

Task ratings ranged from 2.2 to 2.6 in the first three catagories. The highest rating for performance was "Direct or monitor the activities of others" which nine Q.C. technicians marked with an average rank of 2.8. The lowest average, marked by five of those surveyed, was "Coordinate contractor assistance outside of plant areas."

GENERAL ADMINISTRATION

The task that was marked by the most trainees (ten), was "Plan own work activities". This was rated at 2.8 for performance and 3.1 for frequency, the highest rating in the section. The two next most commonly marked tasks (nine each) were "Coordinate work activities with other departments" and "Recommend retest requirements following completed work." The task that was rated most difficult (3.0 in both performance and knowledge) was "Determine quantity of materials to be used for job." This was, however, only marked by five people. The one lowest frequency tasks, both rated at 18, was "Bid specifications review."

STOREKEEPING/WAREHOUSING

One task was rated the highest in all four catagories, "Receipt inspection of incoming materials." This was also marked by the highest number of people (ten). One additional task in this catagory was rated at 3.0 for both Performance and knowledge: "Receive and tag tools, parts, materials, and supplies." The lowest rated task in the Performance and Knowledge catagories was "Maintain inventories of tools and supplies." It was marked by four people, with an average of 2.0 in each catagory.

TESTING EQUIPMENT

This was one of the largest sections of the survey, containing thirty-six tasks. The following five tasks were rated at 3.0 or above in either the Performance or Knowledge catagory: "Use soapy solution to check for leaks in pipes, tubing, etc."; "Inspect bearing loadings using load cell/dynameter"; "Check tolerance using a micrometer"; "Measure distance using a ruler" (The highest rated task in the section, with averages or 3.7 and 3.8 in the first two catagories); and "Interpret test gauges."

LABORATORY TESTING

This section only contained one task, "Obtain samples of materials (eg. SMAD material analysis, oil, etc.)". It was rated at 2.4 in the first two catagories and 1.8 in the second two.

TESTING

None of these eleven tasks were rated extremely high. The highest performance rating, (2.7) was for the most frequent (2.2), and performed by the most people, (10). It was "Perform simple non-destrictive testing eg. dye penetrant or ultrasonic thickness test." The task receiving the highest rating in the Safety catagory (2.3), was "Perform complex non-destructive testing (eg. magnetic particle test, ultrasonic flaw detection.)"

GENERAL INSPECTING

Of the seventeen tasks in this section, none were rated above 3.0 in the performance catagory. Only one, "Inspect completed work of others.", was rated at 3.0.

INSPECT TURBINE INSTRUMENTS

The single task in this catagory, "Inspect Overspeed Trip Sensors" was completed by three people with none of the ratings over 2.0.

INSPECT METAL TEMPERATURE

The single task, "Inspect Turbine Exhaust Hood Spray Systems" was completed by six people with none of the ratings over 2.1.

INSPECT TURBINE MISCELLANEOUS

Of the none task in this section, eight of then were ranked at over 3.0 for frequency and they were filled out by five to nine people. None of the ratings were particularly high in other catagories. The highest was "Check for cracks in turbine blades", rated at 2.4 in both Performance and Knowledge.

INSPECT OTHER EQUIPMENT AND CONTROLS

This was a large section, containing twenty five tasks. Only one of them was rated at over 3.0 in any catagory, "Inspect Globe Valves" (3.1 in Performance and Knowledge). The most commonly performed task, which was also at the highest frequency, was "Inspect Safety/Relief Valves" (Ten people at a frequency of 2.5). This also received the highest safety rating at 2.7.

Three of the tasks were completed by ten of those surveyed, they were "Inspect welds", "Make external visual inspections of equipment, parts, materials, or structures to detect abnormal conditions (eg. leaks, cracks, loose components or connections, dirt, signs of overheating," and "Listen to operating machinery or equipment to detect loose parts, slipping belts, or rubbing on rotating equipment." The highest rating in a safety catagory (2.8) was for "Use analyzer (eg. Oxygen, combustion gas) to inspect area for safe entry or leaks".

INSPECT MAIN AND REHEAT ATTEMPORATOR SYSTEM

The single task in this section was a verbatum repeat of the section's title. It was rated at 2.0 in the first three catagories and 1.2 in the last.

INSPECT CYCLONES

One again, the was only one task listed here, "Inspect cyclone shear gates." Three people marked in with average ratings of 2.3, 2.0, 1.0, and 1.3 in the four catagories.

INSPECT COAL WEIGHING ITEMS

Of the three tasks in this section, all were filled out by four people. None of ratings were over 2.0

INSPECT WELDING

Although Quality Controls Inspectors frequently mentioned this as one of their most demanding and time consuming activities, only nine tasks were listed, and only one additional task was added- "Witness welders qualification and testing". This was written in by eight of those surveyed. The frequency ratings were not particularly high - only one task, "Inspect certified SMAN welding"., was rated at over three. Three of the tasks received performance ratings of over 3.0:The "SMAN welding" task, "Inspect certified GTAV welding" (3.6 - the highest in the entire survey) and "Inspect non-certified welding". The task performed by the most people was "Verification of Proper Welding Procedures."

PERFORM MISCELLANEOUS ACTIVITIES

This catch-all section contained fourteen tasks. Four of them received ratings of over 3.0 in Performance. None of the other ratings were notably high in any of the catagories. The four high performance ratings were as follows: "Participate in on-the job training as a learner" (3.0); "Attend classroom training (eg. apprentice, safety, or requalification courses" (3.0) "Attend plant or workcrew meetings" (3.1), and "Escort visitors, inspectors, manufacturers' representitives, and contractors around plant" (3.0). This last task was performed by the highest number of people (10).

PHYSICAL INSPECTION

This section included twenty-four tasks. Physical Inspection comprises visual checking of major components that make up a generating station, such as mills, fans, pumps, and piping. As with welding, many Q.C. Inspectors said during the oral interviews that this is a major responsibility. Yet the tasks did not receive generally high ratings. The task that received the highest performance rating (3.1) was, "Inspect boiler (ie. steam and mud tubes, etc.)". This task also received the highest knowledge (3.2) and one of the highest frequency (2.9) ratings. None of the other Performance or Knowledge ratings averaged over three the task with the highest safety rating was "Inspect Turbine Valves" (3.0). This is to be expected since these valves control steam at temperatures upwards of 1000^{o}C and pressures upwards of 1800 pounds. No additional tasks were written in by any of those surveyed.

ABILITIES AND CHARACTERISTICS

Eighty-six abilities and characteristics were listed. Thirty-nine of them were clearly characteristics such as "Willingness to long and/or irregular hours, overtime, any day of the week, including holidays," or "Willingness to work in high places off temporary work platforms, scaffolds, or climbers." Most of the remaining forty-seven were abilities - either cognitive e.g. (ability to analyze and solve equipment and/or system problems.) or psychomotor (eg. muscular precision; ability to make finely controlled muscular adjustments, such as moving a lever). A few did not easily fit into any of these catagories.

Abilities and characteristics were rated on the following scale:

0 = Unimportant. Not really necessary for effective performance on this job; very much less important than most other abilities/ characteristics.

1 = Not Very Important. Somewhat desirable for effective performance on this job; less important than most other abilities/characteristics.

2 = Important. Quite desirable for effective performance on this job; about the same level of importance as many other abilities/ characteristics.

3 = Very Important. Highly desirable for effective performance on this job; more important than most other abilities/characteristics.

4 = Absolutely Crucial. Essential for effective performance on this job; very much more important than most other abilities/ characteristics.

The following fourteen abilities and characteristics received the highest average ratings:

1. Ability to work closely with other people. (3.8)
2. Ability to work without supervision. (3.6)
3. Ability to speak and understand English. (3.6)
4. Ability to follow directions and procedures. (3.5)

5. Conscientious (Planful, deliberate, careful). (3.4)
6. Willingness to work in confined spaces. (3.3)
7. Willingness to work in dirty places. (3.2)
8. Ability to accept and deal with change on the job leg. in work assignments, in crew members, in supervisors (etc). (3.2)

9. Ability to perceive small details, and make quick and accurate comparisons between them. (3.2)
10. Interest in learning how things work, curious. (3.2)
11. Likeable (Agreeable, pleasant, good natured). (3.2)
12. Patient. (3.2)
13. Ability to perform work duties effectively under extraordinary conditions (eg. extra hours, time pressures, in dangerous situations, etc.) (3.2)
14. Training in welding, machine shop, instrumentation, etc. (3.2)

The following eleven Abilities and Characteristics received ratings of lower than 2.0:

1. Willingness to work in bad weather. (1.8)
2. Interest in business jobs or activities (eg. office work, accounting, banking, organizing and planning.) (1.8)
3. Interest in social jobs or activities (eg. teaching, social work, counselling). (1.7)
4. Ability to use algebra (eg. Using formulas to solve for one unknown. (1.6)
5. Physical Stamina (ability to perform physically demanding task over long periods of time. (1.6)
6. Interest in physically active jobs or activities (eg. trucking, warehousing, construction). (1.5)
7. Ability to use trigonometry (eg. determining length or angle of a triangle). (1.5)

8. Willingness to work arround decaying matter and sewage. (1.5)

9. Willingness to work in rough terrain. (1.5)

10. Muscular strength (ability to lift weights, operate stiff valves manually or control pneumatic or hydraulic wrenches). (1.3)

11. Ability to understand, use, and/or compute logorithms, exponents, scientific notation. (1.0)

CHAPTER V

CONCLUSIONS

The performance of this investigation briefly stated, was as follows: A task analysis was developed and administered and the results of the task analysis were used as the basis for two documents. The first document was a set of task-based objectives, and the second document was an evaluation instrument that could be used in a selection instrument validation study. That study was subsequently performed using six tests from the Flannagan Industrial Test II battery.

The intent of the investigation was to improve the performance of Fossil Station Quality Control Inspectors through systematic training and valid selection techniques. The degree to which the investigation satisfied the original intent of the investigator can be established by reviewing the conclusions that can be drawn from the numerical data.

The numerical data collected in this investigation can be generally catagorized into three large groups; the Task Analysis ratings, the Flannagin Test Battery performance, and the evaluation results. The written portion of the Task Analysis and the Training Standard can also be considered data; they represent the collective opinions of the Advisory Committee of subject matter esperts and the actual Quality Control Inspectors. All this information, both numerical and written, will be considered in this chapter.

The Task Analysis, both the document and the procedure used to write the document, will be considered first. The basic procedure followed in writing the Task Analysis; researching the job and writing a rough draft based on the results, then inviting a committee of subject matter experts to review the results, was extremely successful in generating an accurate, highly detailed information. The committee radically revised, and enlarged the first draft. Their final draft was a far more specific and detailed description of the job of Quality Control Inspector than existed in any of the literature this investigator had access to.

During the meetings of the subject matter experts, a strong synergism was evident in the combined efforts of the members. They encouraged, corrected, and most importantly, stimulated each other constantly. Because of the variety of perspectives the committee provided in terms of years of experience, technical familiarity, and maintenance procedures, the task survey was regarded as substantially complete by the Quality Control Inspectors at the stations. Only a few tasks were handwritten into the survey by those who filled it out.

The investigator was interested to note how little weight the Advisory Committee gave to the results of the survey when they wee selecting tasks for training. Virtually <u>all</u> of the tasks in the task survey werre selected to be incorporated into objectives. The Advisory Committee also included all of the additional tasks that werre handwritten into the survey. Collecting the data was by far the most expensive part of the Task Analysis process because of the manhours expended in filling out the survey and entering the results into a computer for processing. While the procedure of taking a list of tasks to the people actually performing the job, and allowing them to rate the tasks, seems criticals to a proper task analysis, it did not contribute much of value in this instance. The most plausible explanation for this lies in the makeup of the Advisory Committee. Nearly all the members were current or ex-Quality Control Inspectors. All of them were intimate with the job responsibilities of this position. And as stated earlier, they were deliberately selected to represent a range of perspectives. The Advisory Committee members were thinking in terms of training when they wrote the tasks, and were unwilling to delete any tasks they had collectively considered. Also, the Advisory committee was planning on assigning different types of training to the objectives once they written, and they believed that even the simplest tasks should be retained so that they be assigned to the on-the-job training section.

An alternative method of conducting the survey that might have generated more useful data would have been to directly ask the Quality Control Inspectors if they believed a given task required training, and then asked them to give reasons for their answer. This may have generated more handwritten comments. Another approach that may have been useful would have been to allow those surveyed to discuss the tasks in groups. This would have provided the same stimulus that the Advisory Committee had when they were writing the survey. It would have also eliminated any confusion over the meanings of the task selection factors, since they could have been discussed as a group. Despite the best efforts of the surveyors to explain the meaning of the task selection factors, some confusion was evident during follow-up interviews. The "Safety" catagory in particular caused problems. Some Quality Control Inspectors were not sure if they were rating the tasks on their level of risk if performed properly, or on the safety consequences of not performing the task properly. They also were unsure if the risk involved was to themselves only, or to coworkers. These questions were answered before the Quality Control Inspectors began filling out the survey, but apparantly the answers were not clear to everyone.

The task survey has provided some additional benefits in addition to providing task selection data for this project. A training program is being developed at Commonwealth Edison for the position of Nuclear Quality Control Inspector and both Fossil and Nuclear Quality Assurance personnel. The Fossil Quality Control Inspector Task Survey and Training Standard were the primary references used in writing the objectives for this program. The research needed to develop these objectives requied only a fraction of the manhours it would have had these documents not been available.

Many of the problems that occurred while collecting the task data were avoided while administering the test Battery. There is one primary reason for this- better control. All of the Q.C. Inspectors were in one room during the testing, and any questions could be resolved for the whole group. The instructions given in the Instructor's Manual for the Flannagin Battery are excellent; the students understood what was expected from them for each test, and the investigator understood how to give the tests and grade them.

As the analysis of data indicated in Chapter IV, the test results could not be used to disprove the null hypothesis - that there was no significant correlation between the evaluation and any of the tests in the Flannagan Battery. Neither the multiple regression nor the canonical correlation yielded any statistically significant relationships.

Like many negative findings, some positive benefits can be derived from these. Because of this investigation, these tests will not be used to select Q.C. Inspectors at fossil generating station. Therefore a possible source of unfair selection criteria has been eliminated.

This is especially significant because of the apparent face validity of the tests. Many of those involved in the project have seen an on-the-job demonstration of the principle that face validity alone cannot be depended upon to establish if a potential selection instrument is worthwhile.

In summary, then, the investigation generated the following products; a detailed task survey and a list of objectives. These have already proven useful to the company in developing training for fossil station Q.C. Inspectors, and three other positions as well. At this time as consulting firm - General Physics Corporation, is writing a training program that is largely based on the date gathered during this investigation.

The null hypothesis could not be disproved. This means that candidates for the positions of Quality Control Inspector will not be administered the Flannigan Test Battery as a selection instrument. More importantly, this investigator, and those who requested the initial research into establishing a selection instrument, will be highly sceptical of any instrument that has not been fully validated. This is a small, but nonetheless significant step supporting fairness in testing policies.

FOOTNOTES

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28. Ibid., p. 86.

29. Ibid., p. 87.

30. Ibid., p. 9.

31. Ibid., p. 16.

32. Ibid., p. 13.

33. Landry and Trumbo, Work Behavior, p. 33.

34. Ibid., p. 55.

35. Lasdin, "Trouble with Testing", p. 79.

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APPROVAL SHEET

The thesis submitted by Joseph A. Saccaro has been read and approved by the following committee:

Dr. Todd J. Hoover, Director
Associate Professor, Curriculum and Instruction, Loyola

Dr. Barney M. Berlin
Associate Professor, curriculum and Instruction, Loyola

Dr. Robert J. Klemm
Department Head, Program Development, Commonwealth Edison Company

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval by the Committee with reference to content and form.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Arts

May 19, 1986
Date

Todd Hoover
Director's Signature