

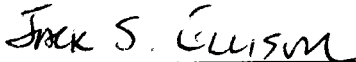
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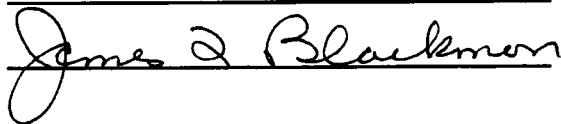
I am submitting herewith a thesis written by Charles Nicholas Carter, entitled "What Basic Knowledge Is Needed In Order To Become A Certified Crane Inspector", I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Safety Education and Service.



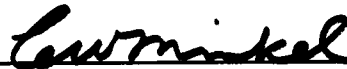
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We have read this thesis and
recommend its acceptance:





Accepted for the Council:



Associate Vice Chancellor and
Dean of the Graduate School

**WHAT BASIC KNOWLEDGE IS NEEDED
IN ORDER TO BECOME
A CERTIFIED CRANE INSPECTOR**

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Charles Nicholas Carter

December 1994

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This unusual page for a Master's thesis is required to tender appreciation for the guidance by all of the unseen faces who participated in this study. Special thanks are offered to the professionals of the Construction Safety Association, the Operation Engineers Training Institute of Ontario, and the International Union of Operating Engineers who possessed the perseverance to examine and comment on both questionnaires; to Kingsley Cole, Director of The Operating Engineers Institute of Ontario for his ability to listen and motivate; to Dr. Bob Kirk for his professional assistance during the long hours of preparation, review and re-review motivating me to produce a document I would be very proud to present; to Dr. Jack Ellison for all his assistance in listening, writing, rewriting and motivating; and to Dr. Pete Blackmon, a dedicated education professional who also knows how to listen and encourage.

Last, but certainly not least, many thanks are extended to the fourteen professional owners, operators and inspectors of the Crane Industry, and the professionals from the Operating Engineers Training Institute and the International Union of Operating Engineers who participated in this study. Heres hoping we stay in contact and further the cause of safe crane operations.

ABSTRACT

This study was undertaken for the purpose of determining the basic criteria needed for crane inspections. The motivation for this study was *Main Causes for Crane Accidents - A Report on Craning in the United States*. The report published by The Crane Institute of America outlining an industry problem, alleged that members of the crane industry operating as crane inspectors did not meet the basic criteria needed to inspect cranes, and that government regulations as written, did not spell out the basic criteria that must be met to be a crane inspector.

This study began with the assumption that if the charges were true, most members of the crane industry wanted to find ways to rectify this situation and with a further assumption that the industry needed to register the opinions of experts involved in the day to day operations and inspections in the crane industry. It was believed that the industry needed to know who should know what, which codes should govern, and how the respondents perceived what was the most important concern in the crane industry.

These questions were addressed by submitting statements concerning crane inspections and crane operator requirements to groups of experts - a group of crane owners, a group of OSHA instructors, a group of state crane inspectors, and a group of industrial trade instructors and a group from a

local operating union. These experts rendered opinions regarding: (1) the relevancy of each statement to crane inspection, (2) an opinion concerning who in the industry should know the information contained in each statement, and (3) how codes requirements should be developed to control the training program.

The resulting opinions resulted in a documented compilation of statements concerning cranes and crane inspections. It should be noted that the information contained in each statement was not tested to determine whether the statement was fact, opinion, theory, or fiction. The study further found that the crane industry as a whole was communicating well internally, even though federal agencies such as OSHA were not communicating well with them. There were a number of individuals within the crane industry willing to spend several hours to render opinions and to make comments concerning this study.

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CHAPTER I

THE PROBLEM

We live in one of the most technologically advanced nations in the world, yet each year 2000 plus workers are killed or severely injured across the country in accidents involving crane operations. The vast majority of these accidents are totally avoidable.¹ This points to a fact that even though the crane industry has adopted numerous standards and codes within its own ranks, overall there are no mandatory standard requirements for training or qualifying experience for those people in charge of the inspection and safe operation of this very vital machine.

The data presented in table I-1 cover a six month period in New York City.² During this time period 158 people were killed in accidents that were, after investigation, ruled avoidable. The report stated that more regulatory oversight was needed to insure that attention was paid to crane safety by the owners and operators. Most owners meet the minimal safety standards and were content with federal and local codes. Often, however, both the

¹ *Crane Accidents and Fatalities, Knowledge of the Low, Cranes Today*, Crane Association of America, Vol. 2, Oct. 1991, p. 24.

² *Cranes, Hazardous Pay for Hazardous Work*, Engineering News Record, May 1, 1988, p. 14.

Table I-1 Crane Fatalities

Number Killed	Type of Accident
78	Contacted overhead powerlines
12	Crane tipped over on employee
9	Boom disassembly
9	Boom fell on employee
8	Crushed/hit by rotating counter weight
8	Struck by falling/dropped load
6	Boom hoist cable broke
6	Struck by swing load
5	Rigging failed
4	Fall from elevated platform
2	Line broke and dropped man basket
2	Fall while riding load
2	Derrick boom collapsed
2	Brake failed allowing boom to fall
1	Run over by crane with failed brakes
1	Rope jumped sheave and hit operator
1	Man basket lowered into confined space
1	Used flammable to clean grease
1	Load was two-blocked and snapped ³

3

Source: Crane Institute of America, Inc. February 1993

owner and operator assume that the codes as written provide completely adequate safety measures rather than minimal ones.

Often as not, the owner in accordance with current standards and codes, has appointed the operator to act as the inspector of his machinery, which means that if he, the operator/inspector finds a problem with his equipment, he must stop operations until the problem is resolved. This code philosophy is along the same lines of the old saying "let the fox guard the hen house." True, if the Code of Federal Regulations were followed in their intent, the equipment would be shut down or taken out of operation and repairs made. This however, was not always the case; not all operators do the necessary inspections, and if they do, not all are trained well enough to know what to look for in conducting an adequate inspection.

In a number of states, including Tennessee, state safety officials and crane industry leaders have proposed new laws and regulations that would require operators and inspectors to be licensed much the same as the Department of Transportation (DOT) has done with the Certified Drivers License for truck drivers and inspectors.⁴ This in addition to the implementation of new standards by the

⁴ Helander, M.G., *Safety Hazards and Motivation for Safe Work in the Construction Industry*, International Journal of Industry, Vol. 8. No. 3, p. 205.

federal government and private industry could alleviate a substantial number of needless accidents. The question was, "How should the federal government, through the Occupational Safety and Health Act, become more involved, and what requirements should be written into regulations." Further, "Who should be trained, and what requirement for training and experience should be met to become a certified crane inspector."

One way to answer the question of training and qualification would be to gather the opinions of selected persons in the crane industry to determine those areas of knowledge most in need of improvement. Then, those responsible for such matters could prepare the necessary educational programs, and write suggested amendments to the various codes and standards. A belief that the crane industry could help to minimize the loss of life from crane accidents was the foundation on which this study was based.

I. PURPOSE OF THE STUDY

The purpose of this study was to determine the basic criteria needed for crane inspection and certification.

II. THE RESEARCH PROBLEM

The basic premise of this study was that during the set up and operation phases of crane use the inspector is held responsible for the safe inspection of the crane . The essence of the research problem was to determine: (1) what information a crane inspector should possess from the various codes and standards, and (2) which uniform set of codes or standards should apply, to the conveying of this information.

Two factors complicating the problem were: (1) whether the judges, being from different segments of the crane industry, held the same crane safety viewpoints, and (2) what crane safety information was considered important by these judges.

III. BASIC ASSUMPTIONS

Assumption 1. The statements selected for the Initial Instrument were considered to be relevant to crane safety inspections.

Assumption 2. The opinions rendered by The Operating Engineers Training Institute of Ontario, a well qualified set of judges, were assumed to be valid and reliable.

IV. LIMITATIONS OF THE STUDY

The scope and broadness of the study was the major limitation, in as much as twelve basic types of cranes can be identified, all with numerous broad categories identified as being important to crane safety and inspection. An attempt was made to present several criteria about each type of crane.

V. DELIMITATIONS OF THE STUDY

The study was delimited to:

1. Crane inspection and safety.
2. Groups and individuals responsible for crane inspection and safety.

VI. NEED FOR THE STUDY

*"Operator Error Found To Be Cause Of Crane Accident," "Unqualified Operator Held Responsible," "Blame For Accident Placed On Crane Inspector."*⁵ The operator, or the inspector has been found to be responsible for over 80% of crane accidents. In most accidents studied, the inspector of the crane has also been its operator. What is addressed was not

⁵ Headly, James, *Crane Safety, In Defense of the Operator/Inspector*, *Cranes Today*, Dec. 1988, p. 44.

a peripheral issue, but an area which had been labeled by many safety experts as having the highest potential for accidents and liabilities of all heavy equipment utilized in industry and construction. There was often a reliance on untrained personnel to inspect and then operate these machines.

Donald Dickie, internationally known crane expert and author of the widely acclaimed book, *"Mobile Crane Manual,"* stated;

"There still is no other piece of equipment that has the potential of causing so much damage or harming so many people as does a crane in an accident." ⁶

Here are some facts. It is significant to note that the pattern is relatively consistent from year to year, and from what has been learned, is consistent throughout North America and Europe.

-----Cranes were involved in more serious accidents than any other type of heavy construction equipment.

-----Crane accidents were more costly in terms of insurance claims.

-----There were more construction fatalities caused by cranes and hoisting equipment than any other single cause.

⁶ Dickie, D.E., *Mobile Crane Accidents,*
Construction Safety Association of Ontario,
Revised Sept. 1986.

-----Lack of proper crane inspection leads to 80% of all crane accidents.⁷

Facts such as these must be taken seriously, especially in light of criminal charges being brought for workplace injuries and deaths. Of particular interest were the first criminal charges filed, initially, against a subcontractor, foreman, crane operator and the crane inspector because of a serious crane accident involving a pedestrian in New York City.⁸

New rules and regulations, standards and laws must be established to separate inspection from the other aspects of crane operation and provide the crane industry with guidance to help prevent future worst case accidents from occurring.⁹

VII. DEFINITION OF TERMS USED

Accident: An unwanted transfer of energy, because of lack of barriers and/or controls, producing injury to persons, property or process.

⁷ Ibid., Sept. 1991.

⁸ Dickie, D.E., *Subcontractor Found Guilty*, Engineering News Record, May 1, 1986, p. 14.

⁹ Ibid., p. 206.

ANSI/ASME: Standards of extent, quantity, quality and measurement of value established by the American National Standards Institute of the American Society of Mechanical Engineers.

Codes: Codified Rules and regulations issued by a state or the Federal Government to instruct and give guidance in a given situation.

Crane: A hoisting machine, usually having a projecting movable arm by which a heavy object can be raised and moved.

Engineer: A person trained in, skilled at, or professionally engaged in a branch of engineering; however, for the purpose of this study the term can mean but is not limited to the following discipline: operation and inspection of cranes.

Expert: Having, involving, or displaying special skill or knowledge derived from training or experience.

Injury: Harm, damage, or grievous distress inflicted or suffered.

Initial Instrument: This questionnaire contained statements, which were answered by the Construction Safety Association of Ontario and used as a guide for the selection of the statements contained in the Crane Safety Survey.

Crane Inspector: A person who inspects, an official examiner or checker.

Crane Inspection: The act of inspecting, careful or critical examination.

Crane Operator: A person who operates a crane.

Standard: Any established measure of extent, quantity, or value: a standard of weight, any type, model, or example for comparison; a criterion of excellence: a standard of conduct.

VIII. SUMMARY OF CHAPTER I

Chapter I presented the basic problem of crane safety and inspection, and to determine the basic criteria needed for crane inspection.

In order to collect data an organization was needed that could render valid and reliable opinions on questions relating to crane safety and inspection. To this end, The

Operating Engineers Training Institute of Ontario was contacted and agreed to act as a base line for the initial instrument.

Major limitations of the study were to locate members of the crane industry that would be willing to respond to the survey. The study was delimited to crane safety and crane inspection.

A brief review of the concept of the Code of Federal Regulations, a short review of ANSI Standards, a look at the relationship of people and accidents, are presented in Chapter II. An explanation of the approach that was followed as well as the detailed techniques that were used in conducting this study are presented in Chapter III. The results of the study are contained in Chapter IV, and Chapter V summarizes the findings and presents conclusions and recommendations resulting from the investigation.

CHAPTER II

REVIEW OF THE LITERATURE

I. INTRODUCTION

In order to have an understanding of current rules and regulations regarding accident prevention and safety inspection processes, a review of the literature on the history of mans attempts to regulate injury prevention through laws, rules, codes, and inspections were conducted.

II. THE FIRST CODES AND LAWS

Indemnification - the first attempt to control injuries was introduced by Hammurabi, a famous king and lawmaker more than 2,000 years before the Christian period.

Ancient Babylon concerned itself with the accidents of the time and prescribed a method for indemnifying the injured. Hammurabi (2100 B.C.) during the 30th year of his reign, regained independence for Babylon and ordered the compilation of a body of laws. These were carved on a diorite column in 3,600 lines of cuneiforms which now is in Paris. The Code of Hammurabi survived to influence Syro-Roman and later Mohammedan law.¹

¹ Grimaldi, John V., Ph.D., P.E., CSP, Rollin H. Simonds, Ph.D., *Safety Management*, Irwin Press, Homewood, Il. 60430, p. 27.

This was the beginning of Codes or Regulations and had in some cases severe punishment for code violations. Since shipping by sea was commonplace, the shipping industry and more specifically, the shipbuilder was the focus of the first codes. The code required the shipbuilder to make good on defects of construction and the damage it caused within a year of delivery. The captain was responsible for the freight and the ship. He was required to replace all loss at sea. Even if he refloated the ship, he had to pay a fine of half the value before it sank. The details were clearly worked out so that in the case of collision, the boat underway was made responsible for damages to the boat at anchor.

In the case of a slave who was injured by someone other than his master, the code specified a fine to be paid the master. The code recognized the importance of intent. A man who killed another must swear he did not do so intentionally and was then only fined according to the rank of his position and that of the deceased.

The owner of an ox which gored a man on the street was responsible for damages if the ox was known by him to be vicious. Carelessness and neglect were severely punished, as in the case of an unskilled physician. If through his errors he caused a loss of life or limb, then his hands were cut off. A slave that did not survive treatment had to be

replaced and in the case of a veterinary surgeon, if an ox did not survive, he had to replace the ox.²

These were the early beginnings of our safety laws, and made the owner responsible for the accidents and injuries caused. The Williams-Steiger Act, or Public Law 91-596, as it is better known, was signed into existence in 1970. It became The Occupational Safety and Health Act of 1970, (OSHA). The law became effective on April 28, 1971, and authorized the federal government to establish and enforce occupational safety and health standards for all places of employment engaged in interstate commerce. The standards were to be enforced by criminal and civil penalties for violations.³

III. AMERICAN NATIONAL STANDARDS

The American National Standards Institute (ANSI) along with the American Society of Mechanical Engineers (ASME) published a number of standards and rules to govern the way safety issues would be addressed, long before the OSHA Act went into effect. The ANSI/ASME Standards were published to serve as guidance to government authorities with

² Ibid., p. 31.

³ Hakkinen, K., *Aspects of Strategies and Solutions in Accident Prevention*, Scandinavian Journal of Work, Environment and Health, Vol. 9, No. 2, May 24-25 1982, p. 189.

jurisdiction over subjects coming within the scope of the Standard. It was expected however, that the Standard would find a major application in industry, serving as a guide to manufacturers, purchasers, and users of the equipment.⁴

The Standard was divided into separate volumes, as seen in Table II-1. When adopted for government use, the references to other national codes and standards in specific volumes may be changed to refer to the corresponding standard for governmental authorities.

The use of cabways, cranes, derricks, hoists, hooks, jacks, and slings are subject to certain hazards that could not occur by other mechanical means, but only by the lack of exercising of intelligence, care, and common sense. It was therefore essential to have personnel involved in the use, operation, and inspection of the equipment who were competent, careful, physically and mentally qualified, and trained in the safe operation and inspection of the equipment.

The standards committee fully realized the importance of proper design factors, minimum or maximum size, and other limiting dimensions of wire-rope or chain and their fastenings, sheaves, sprockets, drums, and similar equipment

⁴ American National Standard, *Safety Standard for Cableways, Cranes, Derricks, Hoist, Hooks, Jacks, and Slings*, ASME/ANSI B30.5c-1992, ADDENDA to ASME/ANSI B30.5-1989, Mobile and Locomotive Cranes, The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th St. New York, NY 10017, p. 1.

Table II-1 ANSI STANDARD

ANSI STANDARD	DESCRIPTION
B30.1	Jacks
B30.2	Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)
B30.3	Hammerhead Tower Cranes
B30.4	Portal, Tower, and Pillar Cranes
B30.5	Mobile and Locomotive Cranes
B30.6	Derricks
B30.7	Base Mounted Drum Hoist
B30.8	Floating Cranes and Derricks
B30.9	Slings
B30.10	Hooks
B30.11	Monorails and Underhung Cranes
B30.12	Hanging Loads Suspended From Rotorcraft
B30.13	Storage/Retrieval (S/R) Machines and Associated Equipment
B30.14	Side Boom Tractors
B30.15	Mobile Hydraulic Cranes
B30.16	Overhead Hoist (Underhung)
B30.17	Overhead and Gantry Cranes (Top Running Bridge)
B30.18	Stacker Cranes
B30.19	Cabways
B30.20	Below-the-Hook Lifting Devices
B30.21	Manually Lever Operated Hoist
B30.22	Articulating Boom Cranes ⁵

⁵ Source Ibid., p. 1.

covered by the Standard. All these items are closely connected with equipment operations. These factors depended on the condition of the equipment or material, on the load, on the acceleration or speed of the ropes, chains, sheaves, sprockets, or drums, on the type of attachments, on the number, size, and arrangement of sheaves or other parts, on the environment causing corrosion or wear, and on many other factors that must be taken into consideration in each case.⁶ The rules within the Standard were to be interpreted accordingly, and good judgement used in determining their application. However, no where in the Standard did the Committee place any rules about equipment inspection or who was to conduct it.

The B30 series Standard, mentioned previously, applies to the construction, installation, operation, inspection and maintenance of jacks, power-operated cranes, monorails, and crane runways, power-operated and manually operated derricks and hoist. The entire Standard was designed to guard against and minimize injury to workers, and otherwise provide for the protection of life and limb, and the property of the owner by prescribing safety requirements. It was also intended to inform owners, employers, supervisors and others concerned with, or responsible for Standard's application, and to act as a general guide to governments and other

⁶ Ibid., p. 2.

regulatory bodies in the development, promulgation, and enforcement of other safety directives.⁷

The ASME/ANSI B30 series spelled out requirements for inspection of all the various cranes covered and stated that the manufacturers would furnish required field information. Yet ASME/ANSI never spelled out requirements on how or who should be entrusted to perform this vital function.

IV. U. S. CODE OF FEDERAL REGULATION

OSHA CONSTRUCTION REQUIREMENTS

29 CFR 1926.550

CRANES AND DERRICKS

As previously stated OSHA or the Williams-Steiger Act became effective on April 28, 1971, and authorized the federal government to establish and enforce occupational safety and health standards.⁸ OSHA 29 CFR 1926.550 was written to be specific to cranes and derricks in the construction industry and incorporated much of what had previously been published by ASME/ANSI. As with ASME/ANSI, 29 CFR 1926 addressed the need to have qualified individuals install and inspect on cranes and derricks. OSHA continued

⁷ Miller, H. and H. Gottling, *Damage to Tower Cranes - Causes and Prevention*, Journal of Occupational Accidents, April 1978, Vol. 1, No. 4, p. 353.

⁸ Ibid., p. 17.

to discuss the need for the owner to insure the existence of trained and qualified inspectors to perform set maintenance and inspection schedules. In the opening to the general requirements of 29 CFR 1926, OSHA stated:

"The employer shall comply with the manufacturers specifications and limitations applicable to the operation and inspection of any and all cranes and derricks. Where the manufacturer's specifications are not available, the limitations assigned to the equipment shall be based on the determinations of a qualified engineer or inspector competent in this field and such determinations will be appropriately documented and recorded. Attachments used with cranes shall not exceed the capacity, rating, or scope recommended by the manufacture."⁹

OSHA continued to state that the employer would "designate a competent person who shall inspect all machinery and equipment prior to each use, and during use, to make sure it is in safe operating condition."¹⁰ 29 CFR 1926.550 further stated that the employer would insure that a thorough, annual inspection of hoisting machinery would be conducted by a competent person or by a government or private agency recognized by the U.S. Department of Labor. Also, the employer would maintain a record of the dates and results of these inspections for each hoisting machine and piece of equipment.

⁹ Ibid., p. 4, 1992.

¹⁰ Ibid., p. 4, 1992.

29 CFR 1926.550 further expressed the need for a competent person as an inspector by the incorporation by reference of ANSI B30.5 of 1968, which reads:

"All crawler, truck, or locomotive cranes in use shall meet the applicable requirements for design, inspection, construction, testing, maintenance, and operation as prescribed in ANSI B30.5-1968, Safety Code for Crawler Locomotive, and Truck Cranes. However, the written, dated and signed inspection reports and records of the monthly inspection of critical items prescribed in section 5-2.1.5 of the ANSI B30.5-1968 standard are not required. Instead, the employer shall prepare a certification record which includes the date the crane items were inspected; the signature of the person who inspected the crane items; and a serial number, or other identifier, for the crane inspected. The most recent certification record shall be maintained on file until a new one is prepared."¹¹

Here again the government stated through incorporation, the need and requirement for inspections, and even went so far as to require the records be signed and certified. However, the requirements for training or level of experience of the individual were not addressed. Also, 29 CFR 1926 opened the door for employers to use the operator as the inspector when in the general requirements they stated that the employer shall designate a person who is competent to inspect the machinery and that this person may, in fact be the crane operator.¹² The regulation failed to explain what constituted a competent person.

¹¹ Ibid., p. 4, 1992.

¹² Ibid., p. , 1992.

V. U. S. CODE OF FEDERAL REGULATIONS**OSHA GENERAL INDUSTRY REQUIREMENTS****29 CFR 1910.180****CRAWLER, LOCOMOTIVE, AND TRUCK CRANES**

This study has reviewed the literature of the early history of codes and regulations, and has looked at the ASME/ANSI standard and the Code of Federal Regulations 1926.550, which governs the construction industry. The Code of Federal Regulations that governs employers as a whole needs to be considered. 29 CFR 1910 was written as the general industry health and safety guide and like 29 CFR 1926 this regulation had sections that were pertinent to the operation and inspection of cranes. The specific section reviewed for this study was 29 CFR 1910.180 Crawler, Locomotive and Truck Cranes.

As with the ANSI Standards and 29 CFR 1926, this standard is very specific in addressing the need for cranes to be inspected by a qualified individual. But as noted in the other standards and regulations, 1910.180 did not define a qualified or competent person. Neither did it go into detail as to what training or amount of experience was recommended to become an inspector.

The regulation in 29 CFR 1910.180 incorporated large areas of the ANSI B30 series and too laid out more specifically the inspection requirements. OSHA 29 CFR

1910.180 called for initial inspections, regular inspections, frequent inspections, and periodic inspections. For example:

"The initial inspection shall occur prior to initial use on all new and altered cranes, and shall be conducted to insure compliance with provisions of this section. Regular inspection of cranes in regular use and service is divided into two general classifications based upon the intervals at which the inspection should be performed. The intervals in turn are independent upon the nature of the critical components of the crane and the degree of their exposure to wear, deterioration, or malfunction. The two general classifications are designated as "frequent" and "periodic", with respective intervals between inspections as defined in this section."¹³

The code defined frequent inspection as a daily to monthly inspection interval and periodic inspections as monthly to annually dependent on recommendations of the manufacturers. In laying out what could almost be called an inspection guide, 29 CFR 1910 spelled out items that were to be inspected and when the inspections were due.

Under frequent inspections, the regulation listed all control mechanisms used to counter human error and assure proper operations, excessive wear of components, and contamination of lubricants by foreign matter did not occur. It also included all safety devices, deterioration or leakage in air lines, hook deformation, and rope reeving for noncompliance with manufactures recommendations, and all

¹³ Ibid., p. 6, 1992

electrical apparatus for signs of excessive wear and malfunction.

Frequent inspections are due daily to monthly, which leads the employer to appoint a qualified individual as the inspector.¹⁴ In most cases, as discussed previously, this person is the operator. It should be evident that under 29 CFR 1910 allowing the employer to appoint the operator as inspector, the employer is asking this individual to not only be a qualified operator, but an electrician, mechanic, and a laboratory technician in order to test lubricants for contamination.

K. Hakkinen stated in *"Aspects of Strategies and Solutions in Accident Prevention"* that one sure way that management could improve accident prevention was for management to insure that the individual doing the job was trained to the best of management's ability and never intentionally allow a worker to take on jobs outside his realm of expertise.¹⁵

E. K. Jarasunas related in *"Crane Accidents: Causes and Prevention"*, that one individual can not be expected to operate, maintain and inspect such a complicated piece of equipment, yet industry is guilty of doing just that.¹⁶

¹⁴ Ibid.

¹⁵ Ibid., p. 190.

¹⁶ Jarasunas, E.K., *Crane Accidents: Causes and Prevention*, Hazard Prevention, Vol. 20, No. 1, Jan. 1984, pp. 4-5.

OSHA regulations contained in 29 CFR 1910.180 gave the employer the basics for the beginnings of a check list to inspect cranes, but unfortunately also gave them the opportunity to place the responsibility for this inspection on the very person who is responsible for the operation. In writing the regulation in this manner OSHA did not solve a problem, but as seen in the review of many accidents, actually added to the problem. Furthermore OSHA failed to give adequate guidance on who and how this qualified individual is trained and thereby becomes a certified crane inspector.

VI. PEOPLE AND ACCIDENTS

An accident is defined as an unwanted transfer of energy that produces injury to persons, property, or processes. Crane accidents are defined as accidents resulting from improper inspection or operation of crane equipment. K. Hakkinen in *"Crane Accidents and Their Prevention"*, stated that crane accidents could be factually analyzed and that results of surveys of the circumstances leading to the cause of the accident, nature of the injury and extent of the damage were readily available within a short time of the incident.¹⁷

¹⁷ Ibid., p. 357.

Heinrich in his studies stated that a lack of knowledge could be described as faulty instruction which could carry the following subtitles:

1. No instruction.
2. Incomplete instruction.
3. Erroneous instruction.
4. Unenforced instruction.¹⁸

Heinrich published data covering a period from 1915 to 1929. These data caused him to draw the following conclusions:

1. 2% of all industrial accidents are unpreventable.
2. 98% are preventable.
3. 88% of the preventable accidents could be classified supervisory in nature which simply means:
 - a. Faulty instruction
 - b. Inability of the employee
 - c. Poor discipline
 - d. Lack of concentration
 - e. Unsafe practice
 - f. Mentally unfit
 - g. Physically unfit.
4. 10% of the preventable accidents could be classified as physical in nature, meaning:
 - a. Physical hazards
 - b. Poor housekeeping
 - c. Defective equipment
 - d. Unsafe building conditions
 - e. Improper working conditions
 - f. Improper planning
 - g. Improper dress or apparel.¹⁹

Heinrich's conclusions indicated a relationship of 1:29:300; that is, for each disabling-type injury there

¹⁸ Heinrich, H.W., *Industrial Accident Prevention - A Scientific Approach*, New York: McGraw-Hill, 1931, pp. 46-47.

¹⁹ *Ibid.*, pp. 46-47.

could be expected twenty-nine minor injuries and three hundred no-injury accidents.²⁰

Frank E. Bird in *Damage Control* presented an analysis of ninety thousand accidents gathered over a seven-year period. Bird's analysis indicated a different ratio, 1:100:500. For each disabling injury there would be an average of one hundred minor injury accidents and five hundred property damage accidents.²¹ Further research by Bird, Fletcher, and Douglas indicated that the cost of these property damage accidents ranged from \$34.67 to \$51.50 per accident.²²

Studies conducted by the Department of Labor using data from a two year study concluded in 1987 indicate that crane accidents and deaths are caused by the following:

- a. 44% Electrocution
- b. 15% Rigging
- c. 14% Load handling
- d. 7% Operator error
- e. 7% Overloaded
- f. 5% Dismantling boom
- g. 3% Wire rope failure
- h. 3% Stress on load bearing parts of crane
- i. 2% Other²³

²⁰ Ibid., pp. 90-96.

²¹ Fletcher, J.A., *Total Environmental Control, Risk Management*, October, 1971. p.9.

²² Ibid., p. 10.

²³ J. Headley, "Cranes Today", *In Defence of the Operator/Inspector*, December 1988, p. 44.

Other studies conducted by the Operating Engineers Training Institute of Ontario, suggest different results. Results of a study conducted by Kingsley Cole found the following:

- a. 33.1% Inspection failure
- b. 31.5% Operator error
- c. 22.6% Support failure
- d. 11.2% Failure of outriggers/structural failure
- e. 1.6% High wind²⁴

Cole concluded that the regulations governing the inspection of cranes and crane operations were ineffective and that the government and industry had done little to provide protection to the operators and the public. He felt the Code of Federal Regulations, ANSI Standards and manufacturing guidelines, left too much for interpretation and were too broad in scope to effectively control the employer/industry inspection of these dangerous machines.

This review of accident causes suggest that government and industry must develop a specific discipline with specific guidance for the inspection of cranes.

²⁴ Cole, K., *Stay Clear of the Crane*, Operating Engineers Training Manual, May 1991, Vol. 2 No. 7, p. 39.

VII. SUMMARY OF CHAPTER II

The objective of an OSHA Code or an ANSI Standard is the preservation of life and property. Preventing a crane accident, whether structural or operator error is the major goal. The current codes however, do not provide a clear direction for crane inspection, thus allowing the industry to interpret the codes as they see fit. The way the codes and standards have been written allows for poor enforcement and an inability to ensure safe daily operation. Such codes should be able to assure maximum safety at all times to every person associated with the industry as well as every passer-by.

Inadequate protective measures exist to ensure that each hoisting machine in the work force meets federal or local standards and the inspector "is too often required to perform daily, monthly and annual inspections on the crane without proper training."²⁵ Clearly the days of operating a crane "by the seat of the pants" must come to an end.

The literature search revealed that a lack of properly written guidelines, on the part of the Federal Government, spelling out basic inspection qualification requirements and complacency on the part of an industry that sees itself as being on the cutting edge, are very important factors in

²⁵ Headley, J., *In Defence of the Operator/Inspector-Part II*, Crane Safety, Cranes Today, Feb. 1988,

each accident that involves a crane. Evidence indicated that few training centers really go into the specifics of teaching crane inspection. Therefore, the majority of contractors, owners, and operators of cranes know little about the inspection of the machines they operate. The crane operators and owners that responded to this research, along with the Crane Institute of America, The Operating Engineers Institute of Ontario, and the International Union of Operating Engineers, Local 917, of Knoxville, Tennessee all agree that there has got to be a better way to write codes and regulations so they are not vague and open to individual interpretation and can reflect safety concepts from the one set of rules.

CHAPTER III

METHODS AND PROCEDURES

I. INTRODUCTION

In a society where occupational safety and health has moved to the fore front in the last thirty years, finding a selection of statements on the thinking of the crane industry was a very difficult task. Though the existing literature in print was not vast, the review of this material became very meaningful. Many of the alternative selections available that could have been used were not, because of the limitation of time on the part of the instrument respondents and particularly in preparation of the instrument used. Selection for the Initial Instrument was made with several factors in mind.

II. INSTRUMENTATION

First, it was believed that the Initial Instrument had to be "all conclusive" in order to cover all the areas of concern including knowledge and opinions. This belief was confirmed in the correspondence from the organization that had agreed to review and respond to the Initial Instrument.

Second, after deciding to use this type of approach, the problem of reducing the Instrument to a workable and practical survey was addressed. If the survey was not broad enough or sufficient to cover the field, then it would be of little or no value. On the other hand, if the survey was too complex, then participant response would likely be small and again of little value. The approach was to abstract and paraphrase statements that would apply to those that might have responsibility for or knowledge of inspections of cranes. The objective was to provide depth and breadth of opinion on the subject of crane inspection. This selection process was based not only on intuition but to some extent experience with cranes.

The development and completion of the Initial Instatement phase of the study required three separate independent steps:

1. To find an organization within the crane industry consisting of crane experts that were willing to spend the time to evaluate the instrument.
2. To tabulate the results, answers, and comments.
3. To revise and reissue the survey and tabulate the final results.

Step 1. During the fall semester of 1993, and spring semester of 1994, a literature search was conducted including correspondence with, and a number of telephone

conversations with persons in positions of knowledge regarding crane safety and the crane inspection process. The purpose of these activities was to determine whether a study of this type had ever been contemplated or conducted.

A second purpose of this search was to establish contact with a group that would be willing to participate in the study. Interest in participating was expressed by all. The Operating Engineers Training Institute of Ontario was accepted for review of the Initial Instrument because of the initial interest shown by their Director of Studies in developing:

1. Recommendations for uniform educational programs in crane inspection and safety,
2. Guidelines for crane inspectors,
3. General government improvement in the writing of codes and regulations that govern the inspection of, and operation of hoisting machinery.

The possibility that the institute might be biased was offset by the vast amount of experience and knowledge in crane inspection, operation and safety of the institute. Correspondence from the Institute is contained in Appendix A, with other correspondence of interest. Additionally, because the Operating Engineers Training Institute is located in Canada, The International Union of Operating Engineers, Local # 917 was contacted and agreed to participate. As a contributing member with representation

to the Federal Code of Regulations, the union added the ability to ask questions regarding the suitability of the study and it's relevance to the Code of Federal Regulations.

Step 2. A critique of the study emphasized the need for the Initial Instrument to be broad and give coverage to not only inspection but safety, and not limit the survey to strictly crane inspection. The Training Institute agreed with the approach and with the necessity of a long Initial Instrument.

The concepts of what was deemed important to this study are summarized in Table III-I. This table further reflects the specific subject areas believed necessary for a complete understanding of crane inspection.

Next began the task of selecting the statements that would illustrate the specific study areas. The statements were selected by the processs of abstracting or paraphrasing from textbooks, handbooks, correspondence, journals, standards books, code books, laws and magazines related to crane inspection and safety. More than sixty separate articles, chapters, and/or books were used in the preparation of the selected statements. No attempt was made to differentiate among the statements as per fact, opinion or theory. Statements were used if they appeared valid based on personal experience and training, seemed plausible, and applied to the specific area of the study.

TABLE III-I CRANE INSPECTION SAFETY SUMMARY

Category	Number of Statements	Broad Category Title	Specific Subject Areas
#1	14	REQUIRED KNOWLEDGE	WHAT SHOULD BE KNOWN ABOUT HISTORY, OPERATIONS AND STANDARDS
#2	26	EQUIPMENT	GENERAL EQUIPMENT KNOWLEDGE
#3	30	INSPECTION PROCEDURES	WHAT SHOULD BE LOOKED FOR IN CONDUCTING INSPECTIONS
#4	39	RELATED INFORMATION	INFORMATION RELATING TO INSPECTION AND OPERATION THAT AN INSPECTOR SHOULD KNOW

* Category: Number of areas of importance to Crane Inspection Safety Survey

A computer program "SAS Statistics, Version 5 Edition" was used for the analysis of data received from the instrument and Crane Safety Survey. More specifically, that portion of the program called "General Linear Models," or GLM with the Repeated Measures Analysis of Variance was used. After each statement was chosen it was then entered into the computer system. This program had been developed to allow a computer to produce an individualized test, to administer the test, and to score the test utilizing a pool of test items similar to the ones entered as part of this study. This program has been used in various disciplines such as psychology, chemistry, computer sciences, economics, English, speech therapy, accounting, and education.

The original instrument was computer generated after all statements were entered and the program instructed to generate the questions in a random fashion so that all areas of the study were evenly distributed.

Step 3. The selection process generated an instrument containing 109 items. A copy of the original instrument including instructions for answering the questions and explanations for decoding the reference materials may be found in Appendix B.

The original instrument was mailed to The Operating Engineers Training Institute of Ontario where copies were made for those individuals selected to participate. The

instrument requested each recipient to state whether the information in each statement was relevant to crane inspection and safety and to render an opinion for each statement by stating whether the recipient strongly agreed, agreed, had no opinion, disagreed, or strongly disagreed with each statement. Upon completion, the responses were returned for tabulation and analysis.

The answers on the Initial Instrument were tabulated, and the statements were reassembled into the broad categories indicated in Table III-1. Selection in all categories was determined by dividing the number of Initial Instrument respondents stating that the question was relevant into the number stating the question was nonrelevant. All 109 Initial Instrument statements were treated in this manner with those statements answered not relevant or disagree/strongly disagree being dropped from selection for the new survey.

The revised 86 question Crane Industry Survey was distributed to the fourteen individuals within the organizations originally contacted, The International Union of Operating Engineers, Local 917, and returned to The Operation Engineers Training Institute for validation. Survey recipients in each organization were requested to state their beliefs as to (1) who in the crane industry should possess the information expressed in the statement,

(2) whether the statement was relevant or nonrelevant to crane inspection and safety, (3) the usefulness of each statement for crane inspection and safety by weighing the statement along a scale of 0 to 100 percent, and (4) should the statement be considered for inclusion in the Code of Federal Regulations. The groups asked to assist in the survey were with:

1. Crane and Equipment Consultants
2. Crane Institute of America
3. Tennessee Department of Occupational Safety and Health
4. Crane Technical Training and Inspection Inc.
5. Southland Erectors and Riggers
6. Overhead Crane Service
7. Veterans Steel Erection Co., Inc.
8. C. Reed Davis Contractors, Inc.
9. Sunbelt Sales and Rental, Inc.
10. ASARCO, Inc.
11. Crane Inspection Service Inc.
12. California-OSHA
13. California-OSHA Crane Consultants
14. OSHA Training Institute
15. The International Union of Operating Engineers,
Local #917 of Knoxville, TN
16. The Operation Engineers Training Institute

A copy of the entire Initial Instrument, including instructions for answering, may be found in Appendix A. A complete copy of the final Crane Inspection Survey with instructions may be found in Appendix B.

III. STATISTICAL DESIGN

The method for fulfilling the purpose of this study was to solicit opinions from the aforementioned crane specialists. The predominant question appeared to be the differences in the opinions involving the diverse group of judges used in this study.

The survey respondents were asked to render an opinion about material which was not quantitative in nature. It is difficult to measure an opinion quantitatively when data cannot be arranged in an orderly manner. Therefore, nonparametric techniques were required to measure the degree of correlation between variables in the sample. Using a nonparametric test in the SAS General Linear Models program for nonparametric procedures the NPAR1WAY procedure calculated four scores:

*Wilcoxon scores are the ranks $Z_i = R_i$ and are locally most powerful for location shifts of a logistic distribution.

***Median scores** are 1 for points above the median, 0 otherwise: $Z_i = (R_i > (n+1)/2)$ and are locally most powerful for double exponential distributions.

***van der Waerden scores** are approximations to the expected values of the other statistics for a normal distribution $Z_i = \Phi^{-1}(R_i/(n+1))$ where Φ is the distribution function for the normal distribution.

***Savage scores** are expected values minus 1 of order statistics for the exponential distribution $Z_i = \sum_{r=i}^n 1/(n-j+1) - 1$ and are powerful for comparing scale differences NPAR1WAY subtracts 1 to center the scores around 0.3.

This testing method was one of several significant tests that could be used for ranking frequency of data. Ranks were established from the total number of responses received from the judges. The Means statement process from SAS GLM was used for this ranking process. Rank 1 was based on the largest number of responses, rank 2 on the second largest, rank 3 on the third largest, with the highest rank corresponding to the lowest number of responses. When a FREQ statement appears, each observation in the data set is assumed to represent n observations in the experiment, where n is the value specified in the FREQ statement.

If the value of the FREQ statement variable is less

than 1, the observation is not used in the analysis. If the value is not an integer, only the integer portion is used.

The analysis produced using a FREQ statement is identical to an analysis produced using a data set that contains n observations in place of each observation of the input data set, where n is the value of the variable specified in the FREQ statement. Therefore, means and total degrees of freedom reflect the expanded number of observations.¹

The ranking of opinions came next. For this, the SAS GLM PROC RANK Statement was used. Proc Rank options are;

```
TIES=MEANS  
TIES=HIGH  
TIES=LOW
```

The option names the SAS data set to be used by PROC RANK. If DATA= is omitted, the most recently created SAS data set is used. GROUPS= n request grouping scores, where n is the number of groups. The scores are the integers 0 to ($n - 1$). FRACTION F request fractional ranks. RANK divides each rank by the number of observations having nonmissing values of the ranking variable. PERCENT P ask RANK to divide each rank by the number of observations having nonmissing values and then multiply the results by 100 to

¹ Ibid., p. 444.

get percentages. If NORMAL = is specified, either BLOM, TUKEY, or VW must be given. The formulas are as follows:

$$\text{BLOM} \quad Y_i = YC(r_i - 3/8) / (n + 1/4)$$

$$\text{TUKEY} \quad Y_i = YC(r_i - 1/3) / (n + 1/3)$$

$$\text{VW} \quad Y_i = YC(r_i) / (n + 1)$$

where YC is the inverse cumulative normal (PROBIT) function, r_i is the rank, and n is the number of nonmissing observations for the ranking value. VW stands for ven der Waerden, whose scores are used for nonparametric location tests. These scores are approximations to the exact expected order statistics for normal distribution, also called normal scores.

SAVAGE request (exponential) scores to be computed from the ranks. The scores are computed by the formula:²

$$Y_i = \frac{\left[\begin{matrix} n \\ \sum (1/j) \\ j = n - r_i + 1 \end{matrix} \right]}{j = n - r_i + 1}$$

The significance of X was tested by determining the probability associated with the occurrence of the judge's response. The formula for calculating X was as follows:³

$$X'X\beta = X'Y$$

² Ibid., p. 230

³ Ibid., p. 467.

The normal equation $X'X\beta=X'Y$ is solved using a modified sweep routine that produced a generalized (g2) inverse $(X'X)$ and a solution $b=(X'X)^{-1}X'Y$ (Pringle and Raynor 1971).⁴

The procedures for testing the significance of the judges' opinions regarding placement of information in a code or standard utilized the ranking method for GLM's Repeated Measures Analysis of Variance. The test procedure was based on the multivariate test for interactions of within-subjects (repeated measures) factors and between-subjects factors produced by testing the hypothesis $L\beta M = 0$, where the L matrix is the usual matrix corresponding to Type I, Type II, Type III, or Type IV hypothesis test, and the M matrix is one of several matrices that can be specified in the REPEATED statement. A single distribution of T-n observations was made, and ranks from T-one to T-n were assigned to the observations with one representing the highest number observed. The ranks were designated T-n1 and T-n2 and each was equal to fourteen (representing the number of observations). The ranks were totaled, T was used to test the significance at the 5 percent level by comparing it with the value of T in the Hypothesis Testing GLM.⁵

⁴ Pringle, R.M., and A.A. Raynor, *Generalized Inverse Matrices with Applications to Statistics*, Hafner Publishing Co., New York, 1971

⁵ Ibid., p. 463

The next test was to establish data MEANS. Using the LSMEANS Statement (LSMEANS effects/options) least-squares means are computed for each effect listed in the LSMEANS statement.

Least-squares estimates of marginal means (LSMs) are unbalanced designs as class and subclass arithmetic means are balanced designs. LSMs are simply estimators of the class or subclass marginal means that would be expected had the design been balanced. Least-squares means can be computed for any effect involving class variables as long as the effect is in the model. An example of the LSMEANS statement is:

```
PROC GLM;  
CLASS A B;  
MODEL Y=A B A*B;  
LSMEANS A B A*B;
```

Least-squares means are printed for each level of the A, B, and A*B effects.⁶

The final test of the respondent's answers was a Weighted Gains Data check. Although the nonparametric tests were developed for continuous distributions, tied values do occur in practice. Ties are handled in all methods by assigning the average score for the different ranks corresponding to the tied values. NPAR1WAY produces a table

⁶ Ibid. p.444

for each rank score and includes the following for each level of classification:

1. the LEVEL
2. the number of observations in the level (N)
3. the SUM OF SCORES
4. the EXPECTED sum of scores UNDER H_0 , the null hypothesis
5. STD DEV, the standard deviation estimate of the sum of scores, and
6. the MEAN SCORE.

For two or more levels, NPARIWAY produces

1. a chi-square statistic (CHISQ)
2. its degree of freedom (DF), and
3. $\text{PROB} > \text{CHISQ}$, the significance probability.

If there are only two levels, NPARIWAY reports

1. the smallest sum of scores as S
2. the ratio $(S - \text{expected}) / \text{std}$ as Z, which is approximately normally distributed under the null hypothesis
3. $\text{PROB} > [Z]$, the probability of a greater observed Z value, and
4. T-TEST APPROX, the significance level for the t-test approximation.

Using this criteria SAS GLM produced weighted gain results for each statement produced by a respondent.⁷

IV. SUMMARY OF CHAPTER III

The most difficult task in this study was the location of respondents willing to participate in completing the survey. This chapter has presented a discussion on the steps required to prepare the Initial Instrument, including the rationale establishing the various categories of statements and their selection.

The chapter included a discussion of the test used to measure the degree of correlation between the opinions of the judges. The tests used to produce the means and weighted score values and produce the statistical results to support the value of this study as postulated in Chapter I. These tests were the SAS General Linear Models Hypothesis Testing GLM and the SAS General Linear Models Repeated Measures Analysis of Variance GLM and the SAS NPAR1WAY Procedure for nonparametric procedures.

⁷ Ibid. p. 611

CHAPTER IV

I. PRESENTATION AND DISCUSSION OF RESULTS

This chapter presents the results of the Initial Instrument and a discussion of the results of the Crane Safety Survey. Included is a discussion of the statistical testing of the Operating Engineers Training Institute for the Initial Instrument, and the Operating Engineers, the International Union of Operating Engineers, and the Operating Engineers Training Institute for the Crane Safety Survey.

II. SUMMARY OF INITIAL INSTRUMENT RESPONSES

The Initial Instrument was distributed to six members of the Operating Engineers Training Institute of Ontario, Canada. The institute was asked to render opinions regarding the validity of statements about crane inspection, including the degree of agreement or disagreement with the statement. The institute was not asked to give reasons for agreement or disagreement nor was it asked to give a reason why a statement might be relevant or nonrelevant because as a Canadian organization they have no input into OSHA rules or regulations. The full Initial Instrument is presented in Appendix A with the response to each individual statement

presented in Appendix B. Each statement was statistically broken down by category title. Table IV-1 indicates by statement number, and category title which statements were in each of the four broad categories indicated in Table III-1. A summary of responses, classified by category and subject matter, is presented in Table IV-2. Appendix B will give the reader an indication of the broad approach used for the Initial Instrument which was explained in Chapter III. While no specific statistical design was planned to test the answers received for the Initial Instrument, SAS GLM was used to rule out the possibility that answers were the result of chance. SAS GLM found that the probability of receiving a response by chance was greater than 0.001 out of 1000.¹ This probability was obtained by using SAS NPAR1WAY to produce a Probability > CHI Square for the significance of probability.

III. INFORMATION RECEIVED FROM THE CRANE SAFETY SURVEY STATEMENTS

In Chapter I, it was assumed that the inspector held responsibility for the safe inspection of cranes. The essence of the research problem was to analyze the basic criteria needed for crane inspection. As explained in Chapter III the Crane Safety Survey was distributed to the

¹ Ibid., p 237.

TABLE IV-1 STATEMENTS BY CATEGORY NUMBER

<u>CATEGORY NUMBER AND TITLE</u>	<u>STATEMENT NUMBER</u>
CATEGORY #1 REQUIRES KNOWLEDGE	1,2,3,9,14,21,23,27,30,72,73,85, 87,101,108
CATEGORY #2 EQUIPMENT	4,5,8,11,18,19,38,39,41,44,50,53, 54,55,56,75,76,79,82,83,84,86,96, 98,102,104
CATEGORY #3 INSPECTION PROCEDURES	6,12,15,22,25,31,32,42,43,46,47,48, 49,57,58,60,61,62,63,64,65,66,67, 68,69,70,71,74,88,107
CATEGORY #4 RELATED INFORMATION	7,10,13,16,17,20,24,26,28,29,33,34, 35,36,37,40,45,51,52,59,77,78,80, 81,89,90,91,92,93,94,95,97,99,100, 103,105,106,109

* Category: Categories by number and statements by number in each.

TABLE IV-2 SUMMARY OF INITIAL INSTRUMENT RESPONSE

CATEGORY	STATEMENT	SA	A	NOD	D	SDA	R	NR
1	REQUIRED KNOWLEDGE 15 STATEMENTS	61	26.6	8	2.2	2.2	95.6	4.4
2	EQUIPMENT 26 STATEMENTS	48.1	36.5	12.2	2	1.2	96.8	3.2
3	INSPECTION PROCESS 30 STATEMENTS	49.4	34	13.3	2.2	1.1	96.7	3.3
4	RELATED INFORMATION 38 STATEMENTS	46.5	38.5	11.5	2.2	1.3	96.5	3.5

RESPONSE LEGEND:

SA = STRONGLY AGREE

A = AGREE

NO = NO OPINION

DA = DISAGREE

SDA = STRONGLY DISAGREE

R = RELEVANT TO CRANE INSPECTION

NR = NOT RELEVANT TO CRANE INSPECTION

three groups of judges, the Operating Engineers Training Institute of Ontario, The International Union of Operating Engineers, and fourteen Operating Engineers. Questions asked of the twenty-six judges were; 1) their agreement or disagreement with each of the statements, and its applicability to the Code of Federal Regulations; 2) a ranking of each statement by percentage, 0 to 100%, of its usefulness and applicability to crane safety and inspections. Examination of each segment will help draw a picture of the opinions offered by the judges.

Each package provided to the judges contained an instruction sheet on how to answer the statements. Table IV-3 provides the results of the cumulative responses to the Initial Instrument and the Crane Safety Survey. As indicated there was less than a ten percent difference in any of the opinions rendered by the judges. Additionally, the judges were asked to rate the relevance or nonrelevance of each statement to crane inspection and the Code of Federal Regulations. Appendix B provides an overview of the judges opinions of the relevance/nonrelevance to crane inspection and the Code of Federal Regulations.

TABLE IV-3 CUMULATIVE RESPONSE TO THE INITIAL INSTRUMENT
AND THE CRANE SAFETY SURVEY

INITIAL INSTRUMENT

<u>6 JUDGES</u>	<u>109 STATEMENTS</u>		<u>654 TOTAL RESPONSES</u>	
			Cumulative	Cumulative
	Frequency	Percent	Frequency	Percent
Strongly Agree	357	54.6	357	54.6
Agree	226	34.6	583	89.2
No Opinion	48	7.3	631	96.5
Disagree	16	2.4	647	98.9
Strongly Disagree	7	1.1	654	100.0

THE INTERNATIONAL UNION OF OPERATING ENGINEERS

<u>6 JUDGES</u>	<u>86 STATEMENTS</u>		<u>516 TOTAL RESPONSES</u>	
			Cumulative	Cumulative
	Frequency	Percent	Frequency	Percent
Strongly Agree	235	45.0	235	45.0
Agree	224	43.5	459	89.0
No Opinion	34	6.5	493	95.5
Disagree	14	3.0	507	98.2
Strongly Disagree	9	2.0	516	100.0

OPERATING ENGINEERS

<u>14 JUDGES</u>	<u>86 STATEMENTS</u>		<u>1204 TOTAL RESPONSES</u>	
			Cumulative	Cumulative
	Frequency	Percent	Frequency	Percent
Strongly Agree	601	49.9	601	49.9
Agree	418	34.7	1019	84.6
No Opinion	149	12.4	1168	97.0
Disagree	18	1.5	1186	98.5
Strongly Disagree	18	1.5	1204	100.0

TOTAL COMPOSITE

<u>26 JUDGES</u>	<u>281 STATEMENTS</u>		<u>2374 TOTAL RESPONSES</u>	
			Cumulative	Cumulative
	Frequency	Percent	Frequency	Percent
Strongly Agree	1193	50.0	1193	50.0
Agree	868	37.0	2061	86.8
No Opinion	231	9.7	2292	96.5
Disagree	48	2.0	2340	98.5
Strongly Disagree	34	1.3	2374	100.0

III. ORDER OF IMPORTANCE FOR THE STATEMENTS IN THE CRANE SAFETY SURVEY

Each judge was asked to provide a ranking of value for each statement. This ranking was on a scale of 0 to 100 percent as each statement applied to the process of crane inspection and crane safety. The SAS GLM LSMEANS effect/options system was used to analyze each statement by category and percent of use/applicability as indicated by each judge. Each statement was placed in it's appropriate category, and each category was then analyzed for a MEAN and Standard Deviation. All categories were then combined together to provide an overall MEAN and Standard Deviation for the entire survey. This overall Mean and Standard Deviation is provided as Table IV-4A through IV-4D, with graphic analysis provided in IV-4A1 through IV-4D1.

As stated, each statement was ranked for applicability and use by each judge. Using this percentage ranking each statement was then ranked according to it's precedence in the order of statements. Table IV-5 provides a listing of the statements as ranked by the judges. Numerous statements competed for the same order therefore statements are arranged by category too. A complete listing of the statements may be found in Appendix D.

TABLE IV-4A OVERALL MEAN AND STANDARD DEVIATION

Obs	Variable	N	Minimum	Maximum	Mean	Std Dev
26	COL1	26	78.00	100.00	92.57	7.29
	COL2	26	85.00	100.00	96.93	4.78
	COL3	26	85.00	100.00	97.86	4.02
	COL4	26	0	100.00	80.86	35.04
	COL5	26	83.00	100.00	93.71	6.69
	COL6	26	89.00	100.00	96.86	3.44
	COL7	26	87.00	100.00	97.50	4.11
	COL8	26	50.00	100.00	83.71	18.38
	COL9	26	80.00	100.00	94.36	6.25
	COL10	26	56.00	100.00	89.78	13.89
	COL11	26	85.00	100.00	94.78	5.41

* Variable indicates statement number and category

Table IV-4 Series 1 Graphic Analysis

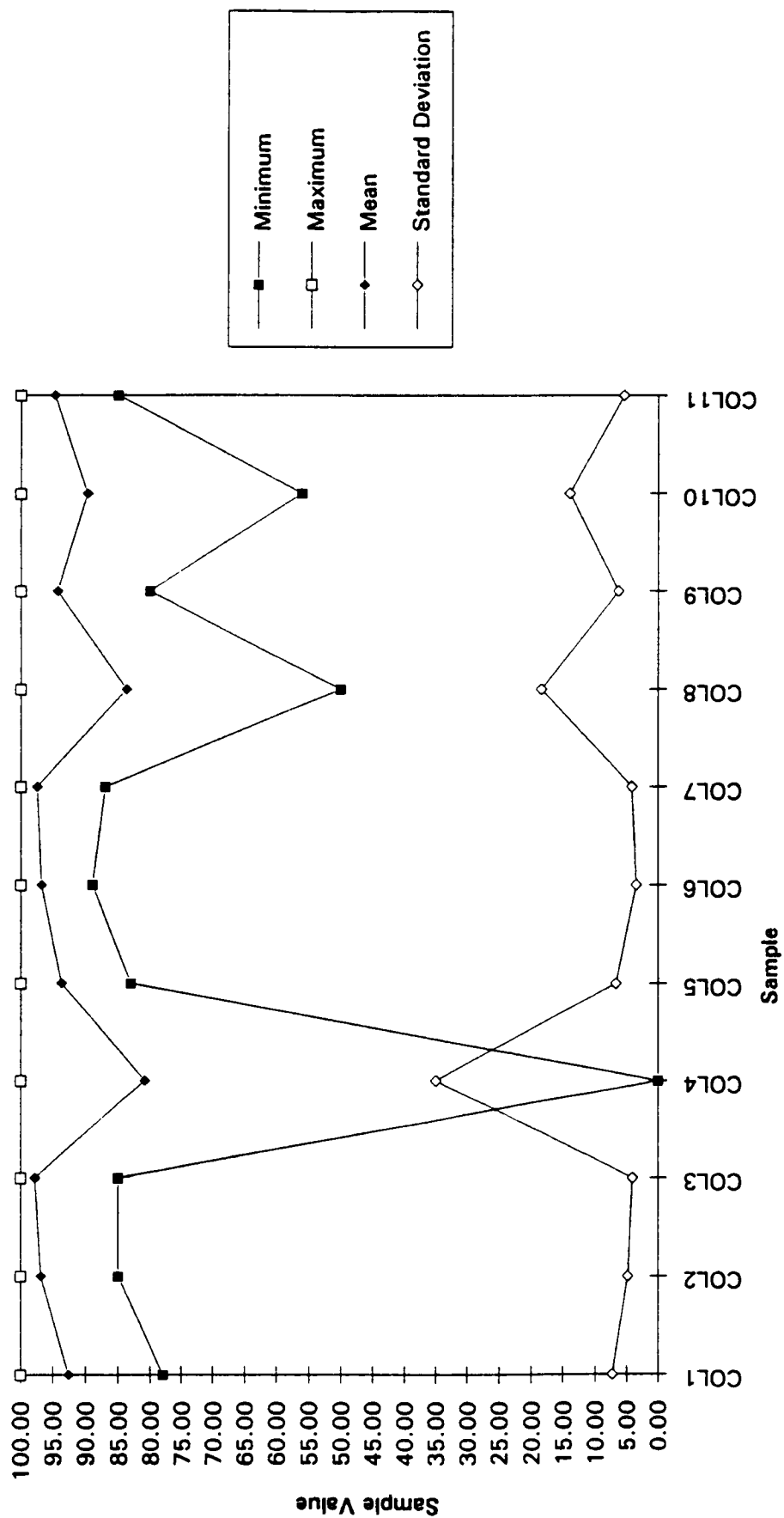


TABLE IV-4B OVERALL MEAN AND STANDARD DEVIATION

Obs	Variable	N	Minimum	Maximum	Mean	Std Dev
26	COL1	26	78.00	100.00	94.07	7.74
	COL2	26	90.00	100.00	97.78	3.31
	COL3	26	90.00	100.00	97.00	3.62
	COL4	26	85.00	100.00	97.78	4.35
	COL5	26	72.00	100.00	93.21	7.86
	COL6	26	0	100.00	73.93	40.61
	COL7	26	70.00	100.00	93.71	8.71
	COL8	26	0	100.00	87.50	25.89
	COL9	26	0	100.00	81.28	34.96
	COL10	26	0	100.00	85.07	25.51
	COL11	26	90.00	100.00	97.36	3.69
	COL12	26	28.00	100.00	87.86	21.00
	COL13	26	73.00	100.00	90.71	8.94
	COL14	26	85.00	100.00	96.00	4.67
	COL15	26	0	100.00	89.36	26.20
	COL16	26	75.00	100.00	93.57	7.96
	COL17	26	85.00	100.00	96.93	5.23
	COL18	26	78.00	100.00	93.50	6.91
	COL19	26	0	100.00	87.71	26.00
	COL20	26	0	100.00	85.00	26.19
	COL21	26	0	100.00	82.93	26.84

* Variable indicates statement number and category

Table IV-4 Series 2 Graphic Analysis

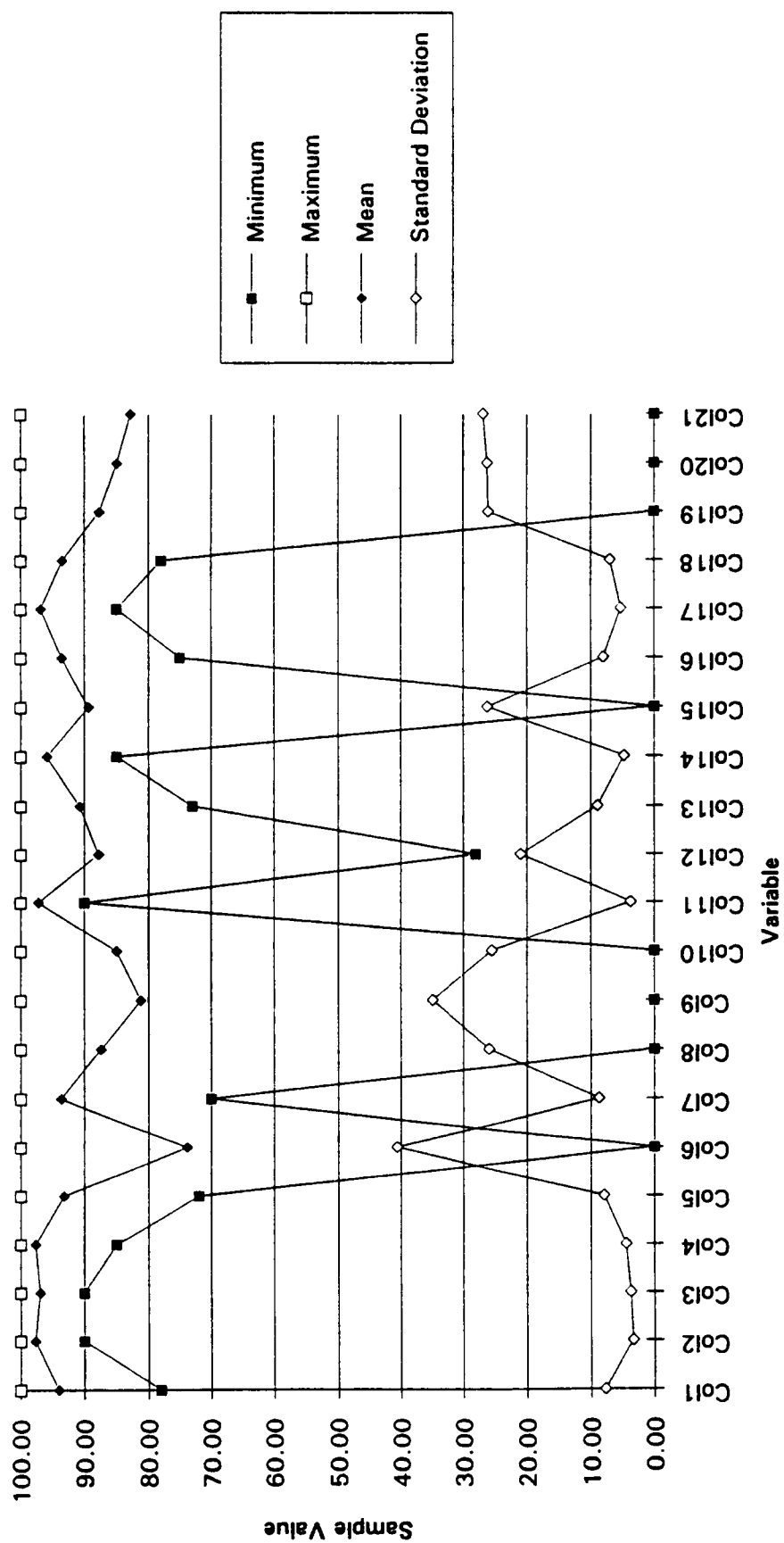


TABLE IV-4C OVERALL MEAN AND STANDARD DEVIATION

Obs	Variable	N	Minimum	Maximum	Mean	Std Dev
26	COL1	26	91.00	100.00	97.57	2.71
	COL2	26	85.00	100.00	96.50	4.85
	COL3	26	93.00	100.00	98.00	3.04
	COL4	26	85.00	100.00	96.86	4.35
	COL5	26	98.00	100.00	99.36	0.93
	COL6	26	0	100.00	90.28	26.42
	COL7	26	80.00	100.00	97.14	5.82
	COL8	26	80.00	100.00	94.86	6.50
	COL9	26	75.00	100.00	93.78	8.34
	COL10	26	0	100.00	80.07	34.69
	COL11	26	75.00	100.00	96.50	7.05
	COL12	26	50.00	100.00	93.21	13.67
	COL13	26	0	100.00	86.71	26.85
	COL14	26	73.00	100.00	94.21	8.02
	COL15	26	0	100.00	88.93	25.97
	COL16	26	85.00	100.00	92.64	5.11
	COL17	26	85.00	100.00	95.86	4.72
	COL18	26	90.00	100.00	97.86	3.21
	COL19	26	75.00	100.00	93.07	9.48
	COL20	26	80.00	100.00	94.36	6.58
	COL21	26	80.00	100.00	93.71	6.95
	COL22	26	78.00	100.00	94.14	7.75
	COL23	26	80.00	100.00	94.21	7.06

* Variable indicates statement number and category

Table IV-4 Series 3 Graphic Analysis

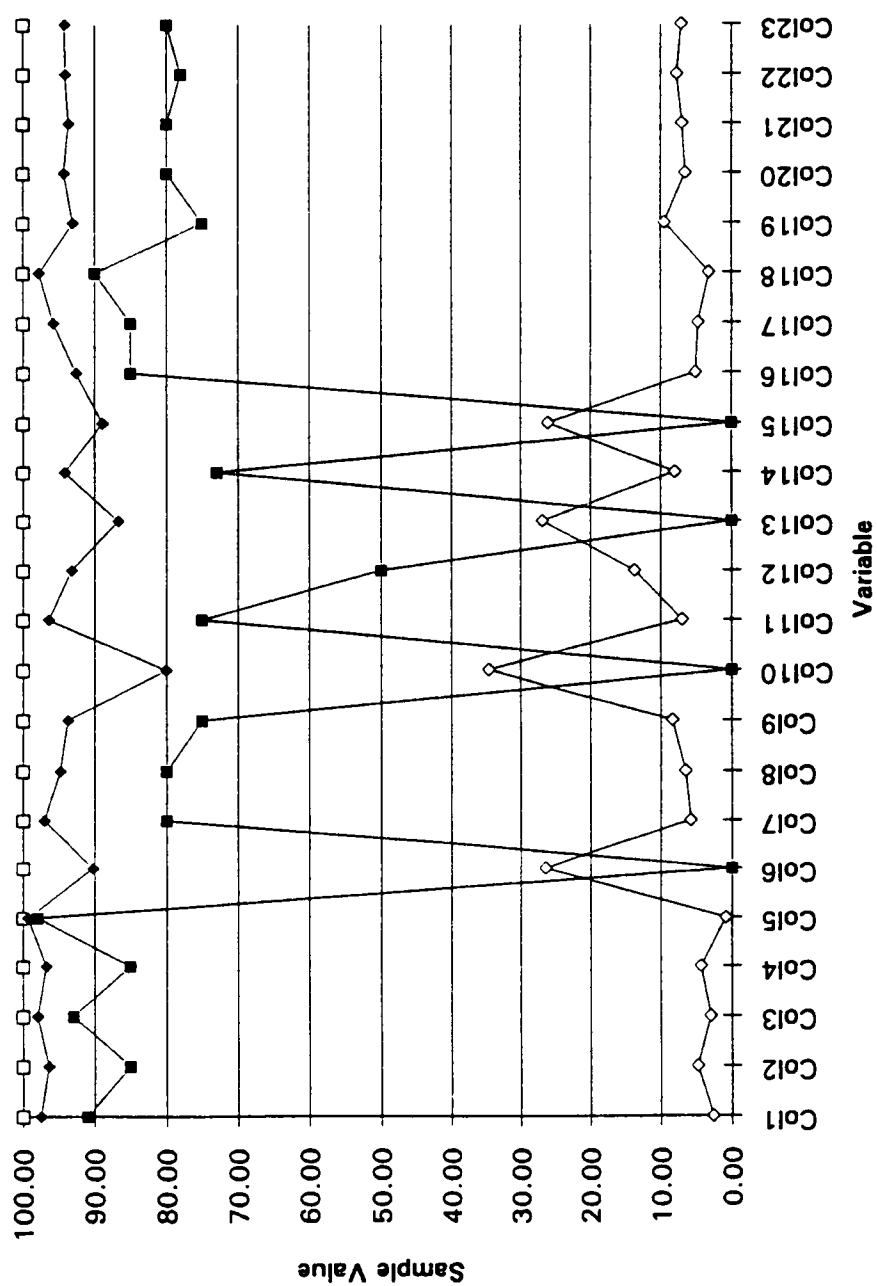


TABLE IV-4D OVERALL MEAN AND STANDARD DEVIATION

Obs	Variable	N	Minimum	Maximum	Mean	Std Dev
26	COL1	26	89.00	100.00	97.00	3.21
	COL2	26	0	100.00	80.00	34.59
	COL3	26	7.00	100.00	89.00	23.92
	COL4	26	73.00	100.00	97.57	7.14
	COL5	26	75.00	100.00	92.36	7.22
	COL6	26	0	100.00	82.64	28.28
	COL7	26	93.00	100.00	98.93	1.98
	COL8	26	95.00	100.00	99.21	1.48
	COL9	26	85.00	100.00	93.93	5.25
	COL10	26	85.00	100.00	94.50	5.34
	COL11	26	0	100.00	89.28	26.54
	COL12	26	70.00	100.00	93.64	9.29
	COL13	26	70.00	100.00	94.14	7.84
	COL14	26	90.00	100.00	96.64	3.69
	COL15	26	0	100.00	83.57	35.52
	COL16	26	0	100.00	84.78	25.32
	COL17	26	0	100.00	77.43	33.91
	COL18	26	85.00	100.00	94.57	4.68
	COL19	26	30.00	100.00	90.43	18.73
	COL20	26	85.00	100.00	93.14	5.85
	COL21	26	75.00	100.00	95.57	6.79
	COL22	26	90.00	100.00	97.78	3.12
	COL23	26	78.00	100.00	95.36	6.72
	COL24	26	0	100.00	77.86	34.16
	COL25	26	75.00	100.00	91.28	8.21
	COL26	26	38.00	100.00	88.36	16.21
	COL27	26	0	100.00	86.07	26.07
	COL28	26	75.00	100.00	91.50	9.20
	COL29	26	0	100.00	82.93	26.32
	COL30	26	0	99.00	80.86	26.63

* Variable indicates statement number and category

Table IV-4 Series 4 Graphic Analysis

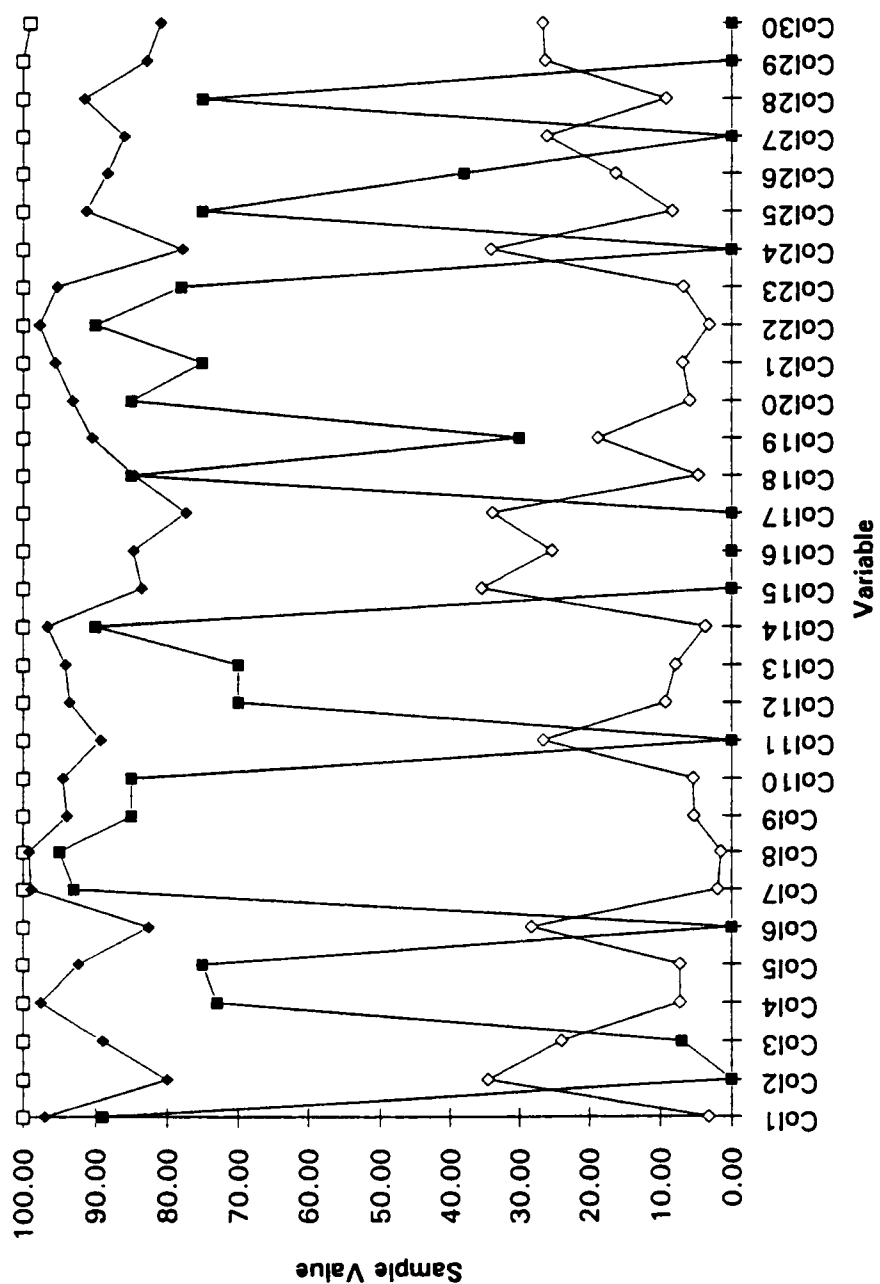


TABLE IV-5 RANKING OF STATEMENTS

CATEGORY ONE STATEMENTS IN ORDER OF RANKING IMPORTANCE

Statement Number:3, 23, 2, 21, 85, 30, 1, 72, 27, 14, 9

CATEGORY TWO STATEMENTS IN ORDER OF RANKING IMPORTANCE

Statement Number:(5, 11), 50, 8, 79, 56, 4, (38, 82), 76, 86, 18,
55, 75, 54, 46, 39, 44, 58, 41, 19

CATEGORY THREE STATEMENTS IN ORDER OF IMPORTANCE

Statement Number:25, 15, 66, 22, 6, 32, 63, (12, 47), 42, 69,
(57, 68), 60, 74, 43, 71, 48, 67, 31, 62, 49,
70

CATEGORY FOUR STATEMENTS IN ORDER OF IMPORTANCE

Statement Number:26, 24, 81, 16, 7, 36, 80, 84, 51, 29, 35, 28,
34, 59, 17, 61, 52, 33, 13, 73, 53, 40, 37,
(83, 77), 20, 65, 10, 78, 45

* Numbers located in parenthesis indicate either could
be first in order.

CHAPTER V.

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY

This study was undertaken for the purpose of determining the basic criteria needed for crane inspection. The motivation for this study was the reading of *Main Causes for Crane Accidents - A Report on Craning in the United States*. The report published by The Crane Institute of America outlining an industry problem, alleged that members of the crane industry operating as crane inspectors did not meet the basic criteria needed to inspect cranes, and that the government regulations as written did not spell out specific criteria that must be met to be a crane inspector. The literature search presented in Chapter II confirmed a number of the ideas presented in *The American National Standards*, and OSHA Code of Federal Regulation 1926.550, and 1910.180 regarding the lack of training requirements or training received by those persons responsible for the inspection of crane and crane safety. Chapter III presented an after-the-fact explanation of the thoughts underlying the selection and grouping of statement items for both the Initial Instrument and the Crane Safety Survey.

Chapter IV presented the results of the statistical tests which were conducted to analyze the results of the Initial Instrument and the Crane Safety Survey. A careful study of the results found that there was little difference of opinion among the judges which was hard to believe, especially when 28 people of varying backgrounds participated in both the Initial Instrument and Crane Safety Survey. It was only after rank order coefficients were calculated that it was found that the fifteen groups used in this study plus, the Operating Engineers Training Institute of Ontario, the International Union of Operating Engineers and the Operating Engineers were seemingly all of a common viewpoint. Correlation calculations concerning the views held by all indicated an almost total consensus.

II. FINDINGS

The return of the Initial Instrument from the Operating Engineers Training Institute revealed a general agreement among the judges with the statements that had been presented. These statements were reassessed and reconfigured to form the statements for the Crane Safety Survey. This survey was resubmitted to the Institute, the Local International Union of Operating Engineers, and to fourteen Operating Engineers.

Upon receipt of all surveys, the statements were

reviewed and the results placed into the SAS program, which was discussed in chapter three. The resulting responses were computed by organization and analyzed for response, as shown in chapter IV, Table IV-3.

An analysis of the results in Table IV-3 showed some small percentage difference in the areas of "strongly agree" and "agree", among the three groups of judges. The statements were then reviewed to see if there was any correlation or trend to the responses or if any one category within the survey had developed a trend. In these two areas the three groups tended to agree overall, and there was no trend in statements or category where disagreement had been noted.

The analysis also showed a small statistically significant difference in the areas of "strongly disagree" and "disagree". These areas were analyzed and the statements reviewed in the same manner to determine any trend development in categories or correlation of statements in any one area. The review revealed that there was no trend and the statement disagreements appeared to be at random.

The one area that revealed the largest percentage of disagreement was "no opinion". The "no opinion" section of the Operating Engineers survey was 12.4 percent, more than twice that of other two sets of judges. The Operating Engineers Training Institute had a 7.3 percent "no opinion"

rate, while the International Union of Operating Engineers had a 6.5 percent rate.

The statements from the Operating Engineers were reviewed for trends of agreement, statements answered, and no opinion, among their ranks. The results were as follows:

a. In category one, Required Knowledge, two statements, number 21 and 27 were answered most frequently as no opinion. Number 21 was answered 10 of 14 times as number 27 was answered 7 of 14 times.

b. Category two, Equipment, had six statements that were most frequently answered as no opinion. They were:

1. number 18 answered 7 of 14 times
2. number 19 no opinion 9 of 14 times
3. number 41, 8 of 14 responses
4. number 50, 7 of 14 responses
5. number 53, 8 of 14 responses
6. number 55, 7 of 14 responses

c. Category three, Inspection process, had two statements, number 42 and 58 appearing most frequently as no opinion. Number 42 was answered no opinion 8 of 14 times and number 58, 10 of 14 times.

d. In category four, Related Information, had eight statements answered most frequently as no opinion. They were:

1. Number 7 answered no opinion 7 of 14 times
2. number 10, answered 8 of 14 times
3. number 33, answered 9 of 14 times
4. number 34 answered 7 of 14
5. number 36 answered 7 of 14
6. number 40 answered 7 of 14
7. number 45 answered 7 of 14
8. number 77 answered 8 of 14 times

These statements were then compared to those of the other two sets of judges to evaluate whether there was a trend to be found.

Comparison of the category one statements, number 21 and 22, found no correlation between either of the other groups, nor did the category three statements, number 42 and 58. However, in category two, Equipment, two statements, number 41 and 53 were found to have been answered the same by all three groups of judges. In category four, Related Information, statements 7 and 36 were also found to have been answered "no opinion" by all three groups. These four statements were studied to determine; 1) if they were good statements, and 2) if the statements were good, were they worded in understandable terms for all participants concerned.

Statement number 53 was found to be poorly worded and a statement that was not relevant to crane inspection, number 7 was found to be more of a structural engineering

statement. Statements number 36 and 41 were determined to be relevant to the inspection of a crane being set up for operation or one already in operation. The reason for "no opinion" was clearly poor wording.

The remaining statements in categories 2 and 4, though not having any trends with the other two groups, were reviewed in the same manner. The four remaining statements in category two were found to be good, well worded statements that were applicable to cranes. Of the remaining six statements in category four, two, though not clear in meaning, could have been clarified for better understanding. The remaining four were good statements that were appropriate to cranes.

A careful study of the remaining statements in category two and four that were found to be well worded and acceptable suggested that the Operating Engineers "no opinion" response was not because the statements were not applicable, but because, in the course of their daily work these statements applied to inspections and operations they would conduct on a routine bases. Therefore, though they did not agree that these statements were relevant to the survey, they did not disagree.

II. CONCLUSIONS

The conclusions drawn from the study were:

1. Overall there was general agreement among the judges that the statements, as presented, were relevant to knowledge required for a crane inspector.
2. There was an overall agreement that the four categories of statements were relevant to day to day crane operations and the inspection process.
3. The 12.4 percent "no opinion" response given by the Operating Engineers indicated, after a careful review of the statements, that in the areas of equipment and related information, the operating engineers did not necessarily agree with the other two groups of judges. By answering the statements as "no opinion"; however, they also did not disagree.

Keeping in mind these people, whether union or non-union, are the ones conduct the daily inspections and operate the equipment. They have developed their own opinions of how to conduct an inspection and the knowledge level that an individual should have to be a competent crane inspector.

The Operation Engineers, though participating completely with the study, were more opinionated about subject matter contained in the survey, than either of the other two groups. By contrast, the Operating Engineers

Training Institute of Ontario was very enthusiastic about the project, but from the onset, looked at it more from an academic view point, where as the Union was more interested in the regulatory and operational aspects, leading to a conclusion that these two groups would tend to agree more so than the operating engineers.

III. RECOMMENDATIONS

This study located some "where's", "what's", and "who's" about crane inspection. It is hoped that the crane operating industry will suggest that the various technical groups and trade unions expand upon this limited data base by finding out something about the "why's" and "how's" of crane safety and "how" the information should be used to create new regulations and standards and improve on those currently in existence.

Specifically, it is recommended that the International Union of Operating Engineers utilize their lobbying power to assist OSHA in the development of these standards. Since this study was undertaken there has been one major crane accident that took the lives of three individuals and injured several others. Though the investigation continues, the initial report indicates improper inspection as the primary cause.

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APPENDICES

APPENDIX A

COMPLETE INITIAL INSTRUMENT

This appendix contains the transmittal letter, instructions, and the questions which were submitted to the Operating Engineers Training Institute of Ontario.

Each question was paraphrased from published literature and coded in the answer section of each question.

124 Northview Ln.
Powell, TN
37849
11 February 1994

Mr. Steve Sheridan
Operating Engineers Training Institute of Ontario
Rt #1 P.O. Box 636
Morresberg, Ontario, Canada
KOC1X0

Dear Mr. Sheridan:

The purpose of this letter is to thank you for the conversation we held yesterday 11 February 1994, and to again express my appreciation for your participation in a piece of research being undertaken in partial fulfillment of the requirements for my Degree of Master of Science in Health Education and Safety from the University of Tennessee. Other members of the crane industry along with you and your constituents are being asked to spend several hours of your valuable time to answer a series of questions and to write your opinions. I sincerely appreciate your joining me and the other fourteen members from the crane industry in an attempt to determine how persons conducting crane inspections should be trained and how OSHA Regulations and ANSI Standards should be changed to reflect exactly what is required to be a crane inspector. The proposed size of the panel is smaller than I would like; however, economics and time are considerations as this is a personally funded study. As I stated in our conversation I would like to use the Operating Engineers Training Institute as my standard and to that end I am enclosing six additional copies of the questionnaire.

A review of the literature available indicates that the industry has taken substantial steps in educating personnel to act as crane inspectors even though OSHA and ANSI do not clearly explain requirements for inspectors. I believe that it is important to understand not only the rules and regulations, but also the opinions of those involved in day to day operations of these massive machines. I also feel that in many respects the Federal Government has left the crane industry and its operators to their own devices, thus the reason in part for this study.

In closing, I feel that you should know that this graduate student is 45 years old, (2) was in the Navy in a safety position for 21 years, (3) has worked for the State

of Tennessee in a regulatory position, (4) is currently working for a sub-contractor to the U.S. Department of Energy in a safety position and has some experience and understanding of cranes and the crane industry, (5) it my belief that those of us that have the ability to present a complex subject in factual understandable language have a responsibility to do so.

If you would like a copy of the completed study, please indicate so in your comments, and I will see that you receive one. Most of all however, I would like to take this opportunity to thank you for your time and efforts in considering this request and I look forward to hearing from you soon.

Very truly yours,

C. N. Carter

STATEMENTS AND REMARKS

Please use additional paper if needed.

Signature

Date

Please check if you desire a copy of the summary of the study.

DIRECTIONS

On pages 74 through 95 you will find a number of phrases or questions. Beneath these phrases or questions are spaces marked 1 to 5. Using a set of descriptors (such as "strongly agree - strongly disagree"). You are asked to indicate how you feel about the phrase or questions in relation to each pair of descriptors.

If you feel that the phrase or question is relevant or very closely related to one end of the scale, you should place your check-mark as follows:

<u>X</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>X</u>	Remarks:
1	2	3	4	5	

1=strongly agree

2=agree

3=no opinion

4=disagree

5=strongly disagree

Remarks: is this statement relevant?

The direction toward which you check depends upon which of the two ends of the scale seems most characteristic of the phrase or question you are judging.

If you consider both sides of the scale equally associated with the phrase or if you are undecided, then you should place your check-mark in the middle space.

<u> </u>	<u> </u>	<u>X</u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

Important:

1. Be sure you check every scale for every phrase.
2. Never put more than one check-mark on a single scale.
3. Your first impression is most valid.
4. Do not look back and forth through the phrases.
5. Make each check-mark a separate and independent judgement.

1. To be certified as a crane inspector, the candidate should have a minimum of 3 years experience as an operator with no accidents on his record.

1 2 3 4 5 Remarks:

2. In order to be certified as a crane inspector, the candidate must be able, to read and write English and any other language as applicable to his location.

1 2 3 4 5 Remarks:

3. The candidate for inspector must at a minimum be familiar with the basic terminology associated with crane operation (eg:mechanical load-brake, inching, plugging, skewing).

1 2 3 4 5 Remarks:

4. The candidate must be familiar with, and be able to pass a written test on the safety rules governing crane operations.

1 2 3 4 5 Remarks:

5. The candidate shall be able to locate and understand the rated load marking and know the significance of multiple rated load markings.

 Remarks:

1 2 3 4 5

6. When inspecting overhead and gantry cranes the candidate inspector must understand the importance of minimum clearance overhead (3"), and lateral clearance (2").

 Remarks:

1 2 3 4 5

7. For overhead and gantry cranes the candidate shall know that foundations and anchorages must be such that an outside crane can withstand a wind pressure of 30 pounds per square inch (psi).

 Remarks:

1 2 3 4 5

8. The inspection candidate must have a thorough knowledge of the requirements of "the rated load test", regarding any crane that has been modified and re-rated.

 Remarks:

1 2 3 4 5

9. For electrical cranes equipped with spring-return controllers or momentary contact pushbuttons the inspector shall inspect their to insure all motors are disconnected and in the off position when these devices are engaged.

1 2 3 4 5 Remarks:

10. The inspector shall insure the arrangement of controllers conforms to E.O.C.I. specification #61..

1 2 3 4 5 Remarks:

11. The inspector shall insure that floor operated cranes, shall automatically return to "off" position when the operator releases the controller.

1 2 3 4 5 Remarks:

12. On remote controlled cranes the inspector shall insure that if the control signal to the crane becomes ineffective the crane operation will stop.

1 2 3 4 5 Remarks:

13. The inspector must be familiar with and know the minimum percentage of full load hoisting torque when the holding brake is used with a control braking means other than mechanical (125%) or when used in conjunction with mechanical control brakes (100%), if two holding brakes are provided (100%).

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

14. The inspector shall be familiar with hoist control braking means such as regenerative, dynamic or countertorque braking.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

15. On bridge or trolley cranes the inspector shall be familiar with and inspect brakes to insure that the trolley or bridge can stop within a distance in feet equal to 10 percent of full load speed.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

16. The inspector must understand and ensure that all electrical equipment on cranes and all electrical operating cranes must comply with OSHA, USA National Standard Electrical Code, ANSI/NFPA 70-1981.

____ 1 ____ 2 ____ 3 ____ 4 ____ 5 ____ Remarks:

17. The crane inspector should have the following knowledge of cab construction, 1) OSHA and USAS A12-1932 requirements for floor and wall openings, railings and toe boards, 2) roof requirements, 3) hot metal handling, crane cab exposure to heat requirements.

____ 1 ____ 2 ____ 3 ____ 4 ____ 5 ____ Remarks:

18. The inspector should be familiar with OSHA and USA standard safety code for fixed ladders, A14.3-1956.

____ 1 ____ 2 ____ 3 ____ 4 ____ 5 ____ Remarks:

19. The crane inspector shall be familiar with crane lubricating points, frequency of lubricating, and different types of lubricants and their applicability.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

20. The inspector candidate shall have a full understanding of machines regarding principles that will apply to such items as gears, screws, chains, sprockets, reciprocating components and other normal operation hazards.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

21. Candidates for crane inspector must have a thorough knowledge and understanding of the role of the inspector in reducing crane accidents and liability expenses.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

22. The crane inspector must know inspection procedures, techniques and have checklists that meet all requirements for a particular crane.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

23. Crane inspectors must know how to use and interpret OSHA and ANSI standards.

 Remarks:

1 2 3 4 5

24. Crane inspectors must know step-by-step, how to interpret a load chart and how to perform a load test.

 Remarks:

1 2 3 4 5

25. Crane inspectors candidates must have thorough knowledge of the inspection of booms, jibs, structures, gears, drums, shears, blocks, hooks, operating and control systems.

 Remarks:

1 2 3 4 5

26. Crane inspection candidates must have a working knowledge of operator and rigging responsibilities.

 Remarks:

1 2 3 4 5

27. Crane inspection candidates must have an understanding of crane history, and how cranes have changed over time.

 Remarks:

1 2 3 4 5

28. Crane inspection candidates must understand and have a working knowledge of OSHA Construction Industry Standard, 1926.550.

 Remarks:

1 2 3 4 5

29. Crane inspectors must have a working knowledge of OSHA General Industry Standard, 1910.180.

 Remarks:

1 2 3 4 5

30. The crane inspector must know and understand industry requirements (voluntary), ANSI/ASME B30.5.

 Remarks:

1 2 3 4 5

31. The crane inspector must know inspection frequencies, how to check company records, and how to properly document his inspection.

 Remarks:

1 2 3 4 5

32. Crane inspectors must know and thoroughly understand the objectives of the inspection based on both OSHA and ANSI standards.

 Remarks:

1 2 3 4 5

33. Crane inspectors must understand the causes and results of crane accidents.

 Remarks:

1 2 3 4 5

34. Crane inspectors must know the requirements for inspections of slings, chain, wire rope and rigging gear.

 Remarks:

1 2 3 4 5

35. The crane inspector should have a working knowledge of the various types of rope and shall be able to spot potential stress problems during an inspection.

 Remarks:

1 2 3 4 5

36. Crane inspectors must have a working knowledge of rigging operations, terminology, determining load weights, and preparing a lift plan...

 Remarks:

1 2 3 4 5

37. The crane operator should not be the crane inspector.

 Remarks:

1 2 3 4 5

38. Crane inspectors should have an understanding of crane operation terminology such as "tag line".

 Remarks:

1 2 3 4 5

39. Crane inspectors should know and be able to explore the importance of repairing damaged booms immediately.

 Remarks:

1 2 3 4 5

40. Inspectors should be able to evaluate proper set up of cranes on various types of ground conditions.

 Remarks:

1 2 3 4 5

41. The inspector shall make sure that outriggers can be fully extended.

 Remarks:

1 2 3 4 5

42. The inspector shall determine that test loads on mobile cranes should not exceed 100% of the rated load at any selected working radius.

 Remarks:

1 2 3 4 5

43. The inspector should be observant for effects of shock loading on wire rope.

1 2 3 4 5 Remarks:

44. The inspector shall note that all cab windows are made of safety glass.

1 2 3 4 5 Remarks:

45. Part of the inspection shall include all landings and walk ways on the crane.

1 2 3 4 5 Remarks:

46. If the equipment is internal combustion run, the inspector shall inspect for proper exhaust ventilation.

1 2 3 4 5 Remarks:

47. The inspector shall make sure all jibs have positive stops to prevent their movement of more than 5° above the straight line of the jib and boom on conventional type crane booms.

1 2 3 4 5 Remarks:

48. On a hammerhead tower crane the inspector shall observe for additional clearance of rotating structures and fixed objects.

 Remarks:

1 2 3 4 5

49. Inspection of cranes mounted on rail track shall include the inspection for limited switches.

 Remarks:

1 2 3 4 5

50. Annual inspection of cranes shall also include an inspection of all rope.

 Remarks:

1 2 3 4 5

51. The inspector shall be knowledgeable of how to inspect for broken, worn and frayed ropes.

 Remarks:

1 2 3 4 5

52. The inspector must insure that all parts subject to impact, wear, and rough usage have adequate strength for the rated use of the crane.

 Remarks:

1 2 3 4 5

53. The inspector shall determine that gantry cranes used for outdoor storage are provided with a parking brake.

 Remarks:

1 2 3 4 5

54. The inspector shall observe that on gantry cranes, a wind-indicating device shall be provided that gives an audible as well as visible alarm, when set at a pre-determined wind velocity.

 Remarks:

1 2 3 4 5

55. The inspector shall insure that all cab controls are located within easy reach of the operator and no control modifications have taken place.

 Remarks:

1 2 3 4 5

56. The inspector will insure that each controller and operating lever is properly marked for the action and direction it controls.

 Remarks:

1 2 3 4 5

57. On cranes not equipped with spring-return controllers, spring-return master switches or momentary contact push buttons, the inspector shall insure that they are provided with a device to disconnect all motors from the line in the event of a power failure.

 Remarks:

1 2 3 4 5

58. The inspector shall insure that all machinery, equipment and material hoist operating on rails, tracks, or trolleys are equipped with positive stops or limiting devices to prevent over running.

 Remarks:

1 2 3 4 5

59. The inspector shall insure that all lubrication fittings are accessible without hazardous exposure.

 Remarks:

1 2 3 4 5

60. The inspector shall insure that all platforms, footwalks, steps, handholds, and guardrails are provided with intermediate rails and toe boards.

 Remarks:

1 2 3 4 5

61. The inspector must insure that all cabs/or bridge walkways are provided with conveniently placed fixed ladders.

1 2 3 4 5 Remarks:

62. When inspecting a crane, the inspector shall insure that a dry chemical or equivalent fire extinguisher is located in the cab.

1 2 3 4 5 Remarks:

63. The inspector shall insure that if contact can be made with gears or other moving parts, they are totally enclosed, covered by screen guards or placed out of reach.

1 2 3 4 5 Remarks:

64. The inspector shall insure that no overhung gears are in use unless means to prevent falling are in place.

1 2 3 4 5 Remarks:

65. All gears, pins, and moving parts shall be thoroughly inspected for wear at least annually.

 Remarks:
1 2 3 4 5

66. The crane inspector shall insure that all limit devices operate on a normally closed circuit.

 Remarks:
1 2 3 4 5

67. The inspector shall insure that all wiring and electrical equipment is installed in accordance with article G10, Cranes and Hoist, of NFPA 70.

 Remarks:
1 2 3 4 5

68. The inspector shall insure that no guard or safety appliance have been removed or made inoperable.

 Remarks:
1 2 3 4 5

69. The inspector shall insure that on traveling cranes warning devices are in operating order.

 Remarks:
1 2 3 4 5

70. The inspector shall inspect all sheaves and drums to assure normal wear and that no grooving has occurred.

1 2 3 4 5 Remarks:

71. The inspector shall insure that there is a minimum of two wraps of rope on the drum when the rope is fully extended.

1 2 3 4 5 Remarks:

72. All structural and load bearing points must be inspected at least annually.

1 2 3 4 5 Remarks:

73. The crane inspector shall be knowledgeable of the use of and hazards associated with aerial baskets.

1 2 3 4 5 Remarks:

74. The inspector shall insure that all hoists are securely attached to their supports, and that no missing, broken or loose bolts can be found.

1 2 3 4 5 Remarks:

75. In the inspection of the crane, the inspector must pay close attention to hooks for signs of wear, opening of the throat and missing or non functional safety latches.

 Remarks:

1 2 3 4 5

76. In the inspection of electromagnets and hook-on devices, the inspector shall insure that the metal body of the electromagnet is properly grounded.

 Remarks:

1 2 3 4 5

77. On monorail systems and underhual cranes, the inspector shall insure the system is designed for maximum load, and that the maximum load has not been exceeded.

 Remarks:

1 2 3 4 5

78. All bridge cranes used outside should be inspected for floors and footwalks that prevent drainage.

 Remarks:

1 2 3 4 5

79. In a bridge crane the inspector shall check to insure that the cab is constructed of fire-resistant material and no cab alterations have been made.

 Remarks:

1 2 3 4 5

80. On bridge cranes, overhead cranes, gantries and tower cranes the inspector shall insure that there is an emergency escape provided for the operator.

 Remarks:

1 2 3 4 5

81. On electrical cranes the inspector shall insure that the main line switch is constructed such that it can be locked in the open position.

 Remarks:

1 2 3 4 5

82. On mobile cranes, the inspector shall insure that all electrical equipment is grounded in accordance with ANSI C2, NFPA code.

 Remarks:

1 2 3 4 5

83. The inspector shall determine that mobile cranes are provided with self setting brake and locking panel or other positive locking devices.

 Remarks:

1 2 3 4 5

84. The inspector shall insure that anti-two blocking devices are operational.

 Remarks:

1 2 3 4 5

85. In lattice boom cranes all lattice work must be inspected at least annually.

 Remarks:

1 2 3 4 5

86. The inspector shall note for replacement, parts on lattice boom cranes where there are dents of greater than $\frac{1}{8}$ the thickness of the part.

 Remarks:

1 2 3 4 5

87. The inspector shall insure that no modifications have been made to the crane without proper recalculation of the load rating.

 Remarks:

1 2 3 4 5

88. In the inspection of lattice boom cranes the inspector shall insure all parts are in place.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

DIRECTIONS

On pages 97 through 100 you will find a number of phrases or questions requiring an explanation in order to properly be answered. Beneath these phrases or questions are spaces marked 1 to 5 and a remarks area. Using a set of descriptors (such as "strongly agree - strongly disagree"), you are asked not to answer the question, but to comment on whether the question is a good statement and is it relevant.

If you feel that the phrase or question is relevant or very closely related to one of the scale, you should place your check-mark as follows:

$\frac{X}{1}$	$\frac{\quad}{2}$	$\frac{\quad}{3}$	$\frac{\quad}{4}$	$\frac{\quad}{5}$	Remarks:
---------------	-------------------	-------------------	-------------------	-------------------	----------

$\frac{\quad}{1}$	$\frac{\quad}{2}$	$\frac{\quad}{3}$	$\frac{\quad}{4}$	$\frac{X}{5}$	Remarks:
-------------------	-------------------	-------------------	-------------------	---------------	----------

1=strongly agree

2=agree

3=no opinion

4=disagree

5=strongly disagree

Remarks: is this statement relevant?

The direction toward which you check depends upon which of the two ends of the scale seems most relevant. Again do not answer the actual question, states only whether you agree or disagree and the questions relevancy.

89. What shall be plainly marked on the side of each crane.

 Remarks:

1 2 3 4 5

90. Explain the term incorporated by reference when referring to a standard.

 Remarks:

1 2 3 4 5

91. How long must a company maintain monthly inspections?

 Remarks:

1 2 3 4 5

92. When is it permissible to modify or make adjustments to a crane.

 Remarks:

1 2 3 4 5

93. Side boom cranes shall meet what requirements.

 Remarks:

1 2 3 4 5

94. A bird cage in wire rope is evidence of what type of operation.

 Remarks:

1 2 3 4 5

95. Wire rope safety factors shall be in accordance with what ANSI standard.

 Remarks:

1 2 3 4 5

96. Under what circumstances must bolts, gears, pulleys, sprockets, spindles, drums, fly wheels and other reciprocating equipment be guarded.

 Remarks:

1 2 3 4 5

97. What is a notification of machine guarding.

 Remarks:

1 2 3 4 5

98. Fire extinguishers must be of what rating.

 Remarks:

1 2 3 4 5

99. In transporting, storing and handling fuels for transfer what CFR must be met.

 Remarks:

1 2 3 4 5

100. ANSI standard B30 series covers how many types of cranes and hoisting devices.

 Remarks:

1 2 3 4 5

101. OSHA requires a thorough inspection of hoisting machinery by a certified person how often.

 Remarks:

1 2 3 4 5

102. When should wire rope be taken out of service.

 Remarks:

1 2 3 4 5

103. Explain the working radius of a crane.

 Remarks:

1 2 3 4 5

104. Explain and give an explanation of "two blocking".

 Remarks:

1 2 3 4 5

105. Government regulations require that all safety devices be inspected with what frequency for malfunction?

 Remarks:

1 2 3 4 5

106. When inspecting a crane set up, why should the inspector look at how level the crane is?

 Remarks:

1 2 3 4 5

107. Truck mounted cranes on outriggers are rated at what % of their capacity.

 Remarks:

1 2 3 4 5

108. Explain "D/d ratio" and the effect it has on wire rope.

 Remarks:

1 2 3 4 5

109. What is the minimum amount of wire rope that an inspector should look for on the drum at any time.

 Remarks:

1 2 3 4 5

APPENDIX B

TABULATION OF OPINIONS FROM INITIAL INSTRUMENT

This appendix contains tabulations of the opinions rendered on the Initial Instrument. The opinions are reviewed in tables B-1 through B-8. Each table represents one of the four categories of crane safety.

APPENDIX B-1
TABULATIONS OF OPINIONS FROM INITIAL INSTRUMENT

STATEMENT #	REQUIRED KNOWLEDGE						NR
	SA	A	NO	DA	SDA	R	
1	5	1	-	-	-	6	-
2	6	-	-	-	-	6	-
3	5	1	-	-	-	6	-
9	3	2	1	-	-	5	-
14	5	1	-	-	-	6	-
21	6	-	-	-	-	6	-
23	5	1	-	-	-	6	-
27	4	2	-	-	-	6	-
30	4	1	1	-	-	5	-
72	2	4	-	-	-	6	-
73	-	1	1	-	4	2	4
85	-	4	2	-	-	4	-
87	-	-	-	4	2	-	6
101	-	-	-	2	4	-	6
108	-	-	-	1	5	-	6

APPENDIX B-2
TABULATIONS OF OPINIONS FROM INITIAL INSTRUMENT

STATEMENT #	SA	A	EQUIPMENT			SDA	R	NR
			NO	DA				
4	5	1	-	-		-	6	-
5	3	3	-	-		-	6	-
8	3	3	-	-		-	6	-
11	4	2	-	-		-	6	-
18	4	2	-	-		-	6	-
19	1	5	-	-		-	6	-
38	1	3	1	1		-	4	1
39	3	-	2	1		-	3	1
41	2	1	2	1		-	3	1
44	1	4	-	-		1	5	1
50	2	4	-	-		-	6	-
53	-	1	-	1		4	1	4
54	1	3	1	1		-	4	1
55	5	-	1	-		-	5	-
56	5	-	1	-		-	5	-

APPENDIX B-3
TABULATIONS OF OPINIONS FROM INITIAL INSTRUMENT

STATEMENT #	SA	A	EQUIPMENT				R	NR
			NO	DA	SDA			
75	1	4	1	-	-	5	-	
76	3	3	-	-	-	6	-	
79	5	1	-	-	-	6	-	
82	6	-	-	-	-	6	-	
83	-	-	-	4	2	-	6	
84	-	-	-	1	5	-	6	
86	2	4	-	-	-	6	-	
96	3	2	1	-	-	6	-	
98	3	1	1	1	-	4	-	
102	-	-	1	5	-	-	5	
104	-	1	1	4	-	1	4	

APPENDIX B-4
TABULATIONS OF OPINIONS FROM INITIAL INSTRUMENT

INSPECTION PROCEDURES

STATEMENT #	SA	A	NO	DA	SDA	R	NR
6	4	2	-	-	-	6	-
12	5	1	-	-	-	6	-
15	3	3	-	-	-	6	-
22	3	3	-	-	-	6	-
25	5	1	-	-	-	6	-
31	5	1	-	-	-	6	-
32	4	2	-	-	-	6	-
42	3	1	1	1	-	4	1
43	-	3	2	-	1	3	1
46	4	1	-	-	1	5	1
47	4	1	1	-	-	5	-
48	3	-	2	-	1	3	1
49	2	-	4	-	-	2	-
57	3	3	-	-	-	6	-
58	-	1	-	-	5	1	5

APPENDIX B-5
TABLATIONS OF OPINIONS FROM INITIAL INSTRUMENT

INSPECTION PROCEDURES

STATEMENT #	SA	A	NO	DA	SDA	R	NR
60	5	-	1	-	-	5	-
61	-	-	1	-	5	-	5
62	3	2	1	-	-	5	-
63	5	1	-	-	-	6	-
64	-	1	-	-	5	1	5
65	-	-	-	3	3	-	6
66	2	3	1	-	-	5	-
67	3	3	-	-	-	6	-
68	-	-	1	4	1	-	5
69	4	1	1	-	-	5	-
70	3	2	1	-	-	5	-
71	3	3	-	-	-	6	-
74	2	4	-	-	-	6	-
88	-	-	-	1	5	-	6
107	-	-	-	2	4	-	6

APPENDIX B-6
TABULATIONS OF OPINIONS FROM INITIAL INSTRUMENT

RELATED INFORMATION

STATEMENT #	SA	A	NO	DA	SDA	R	NR
7	1	3	2	-	-	4	-
10	3	-	3	-	-	3	-
13	2	3	1	-	-	5	-
16	4	2	-	-	-	6	-
17	3	3	-	-	-	6	-
20	3	3	-	-	-	6	-
24	4	2	-	-	-	6	-
26	6	-	-	-	-	6	-
28	4	1	1	-	-	5	-
29	4	1	1	-	-	5	-
33	3	3	-	-	-	6	-
34	4	2	-	-	-	6	-
35	4	2	-	-	-	6	-
36	3	2	1	-	-	5	-
37	3	2	-	-	1	5	1

APPENDIX B-7
TABULATIONS OF OPINIONS FROM INITIAL INSTRUMENT

RELATED INFORMATION

STATEMENT #	SA	A	NO	DA	SDA	R	NR
40	2	2	1	1	-	4	1
45	2	2	2	-	-	4	-
51	3	3	-	-	-	6	-
52	4	2	-	-	-	6	-
59	4	2	-	-	-	6	-
77	-	-	1	3	2	-	5
78	-	-	-	4	2	-	6
80	4	1	1	-	-	5	-
81	3	2	1	-	-	5	-
89	2	3	1	-	-	5	-
90	4	2	-	-	-	6	-
91	3	3	-	-	-	6	-
92	2	4	-	-	-	6	-
93	-	6	-	-	-	6	-
94	-	5	-	1	-	5	-

APPENDIX B-8
TABULATIONS OF OPINIONS FROM INITIAL INSTRUMENT

STATEMENT #	RELATED INFORMATION						
	SA	A	NO	DA	SDA	R	NR
95	3	3	-	-	-	6	-
97	2	4	-	-	-	6	-
99	-	-	1	3	2	-	5
100	-	-	-	4	2	-	6
103	-	-	2	3	1	-	5
105	-	-	-	3	3	-	6
106	-	-	-	4	2	-	6
109	-	-	-	5	1	-	6

APPENDIX C

COMPLETE CRANE SAFETY SURVEY

This appendix contains the instruction sheet and questions distributed to the International Union of Operating Engineers Local 917, Knoxville Tennessee a group of crane operators and inspectors working with cranes on a daily basis as well as the other 14 participating judges.

The survey form contains statements selected by the Operating Engineers Training Institute of Ontario from the 109 item Initial Instrument (Appendix A). These 86 questions were believed by the committee to be the most relevant to crane safety and inspection.

C. N. (Nick) Carter
124 Northview Ln.
Powell, TN
37849
15 March 1994
(615)945-7042

Ms. Jean Holliday
International Union of Operating Engineers
Local 917
1715 N Central
Knoxville, TN
37917

Dear Ms. Holliday:

The purpose of this letter is to thank you for the conversation we held yesterday 15 March 1994, and to again express my appreciation for your participation in a piece of research being undertaken in partial fulfillment of the requirements for my Degree of Master of Science in Health Education and Safety from the University of Tennessee. Other members of the crane industry along with you and your constituents are being asked to spend several hours of your valuable time to answer a series of questions and to write your opinions. I sincerely appreciate your joining me and the other fourteen members from the crane industry in an attempt to determine how persons conducting crane inspections should be trained and how OSHA Regulations and ANSI Standards should be changed to reflect exactly what is required to be a crane inspector. The proposed size of the panel is smaller than I would like; however, economics and time are considerations as this is a personally funded study. As stated in our conversation, I am enclosing a copy of the questionnaire for you to make additional copies from. If it is possible to get 10 to 15 additional members to answer this, I would be most appreciative.

A review of the literature available indicates that the industry has taken substantial steps in educating personnel to act as crane inspectors even though OSHA and ANSI do not clearly explain requirements for inspectors. I believe that it is important to understand not only the rules and regulations, but also the opinions of those involved in day to day operations of these massive machines. I also feel that in many respects the Federal Government has left the crane industry and its operators to their own devices, thus the reason in part for this study.

In closing, I feel that you should know that this graduate student is 45 years old, (2) was in the Navy in a safety position for 21 years, (3) has worked for the State of Tennessee in a regulatory position, (4) is currently working for a sub-contractor to the U.S. Department of Energy in a safety position and has some experience and understanding of cranes and the crane industry, (5) it my belief that those of us that have the ability to present a complex subject in factual understandable language have a responsibility to do so.

If you would like a copy of the completed study, please indicate so in your comments, and I will see that you receive one. Most of all however, I would like to take this opportunity to thank you for your time and efforts in considering this request and I look forward to hearing from you soon.

Very truly yours,

C. N. Carter

STATEMENTS AND REMARKS

Please use additional paper if needed.

Signature

Date

Please check if you desire a copy of the summary of the study

DIRECTIONS

On pages 115 through 132 you will find a number of phrases or questions. Beneath these phrases or questions are spaces marked 1 to 5. Using a set of descriptors (such as "strongly agree - strongly disagree"). You are asked to indicate how you feel about the phrase or questions in relation to each pair of descriptors.

If you feel that the phrase or question is relevant or very closely related to one end of the scale, you should place your check-mark as follows:

<u> X </u> 1	<u> </u> 2	<u> </u> 3	<u> </u> 4	<u> </u> 5	Remarks:
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<u> </u> 1	<u> </u> 2	<u> </u> 3	<u> </u> 4	<u> X </u> 5	Remarks:
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1=strongly agree

2=agree

3=no opinion

4=disagree

5=strongly disagree

Remarks: should this be part of a Federal Regulations mark R for Regulation and NR if not belonging in a Federal Regulation, and using a scale of 0 to 100% indicate the value of each statement as applied to crane inspection and crane safety..

The direction toward which you check depends upon which of the two ends of the scale seems most characteristic of the phrase or question you are judging.

If you consider both sides of the scale equally associated with the phrase or if you are undecided, then you should place your check-mark in the middle space.

<u> </u> 1	<u> </u> 2	<u> X </u> 3	<u> </u> 4	<u> </u> 5	Remarks:
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Important:

- 1.Be sure you check every scale for every phrase.
- 2.Never put more than one check-mark on a single scale.
- 3>Your first impression is most valid.
- 4.Do not look back and forth through the phrases.
- 5.Make each check-mark a separate and independent judgement.

1.To be certified as a crane inspector, the candidate should have a minimum of 3 years experience as an operator with no accidents on his record.

1 2 3 4 5 Remarks:

2.In order to be certified as a crane inspector, the candidate must be able, to read and write English and any other language as applicable to his location.

1 2 3 4 5 Remarks:

3. The candidate for inspector must at a minimum be familiar with the basic terminology associated with crane operation (eg:mechanical load-brake, inching, plugging, skewing).

1 2 3 4 5 Remarks:

4. The candidate must be familiar with, and be able to pass a written test on the safety rules governing crane operations.

1 2 3 4 5 Remarks:

5. The candidate shall be able to locate and understand the rated load marking and know the significance of multiple rated load markings.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

6. When inspecting overhead and gantry cranes the candidate inspector must understand the importance of minimum clearance overhead (3"), and lateral clearance (2").

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

7. For overhead and gantry cranes the candidate shall know that foundations and anchorages must be such that an outside crane can withstand a wind pressure of 30 pounds per square inch (psi).

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

8. The inspection candidate must have a thorough knowledge of the requirements of "the rated load test", regarding any crane that has been modified and re-rated.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

9. For electrical cranes equipped with spring-return controllers or momentary contact pushbuttons the inspector shall inspect their to insure all motors are disconnected and in the off position when these devices are engaged.

 Remarks:

1 2 3 4 5

10. The inspector shall insure the arrangement of controllers conforms to E.O.C.I. specification #61..

 Remarks:

1 2 3 4 5

11. The inspector shall insure that floor operated cranes, shall automatically return to "off" position when the operator releases the controller.

 Remarks:

1 2 3 4 5

12. On remote controlled cranes the inspector shall insure that if the control signal to the crane becomes ineffective the crane operation will stop.

 Remarks:

1 2 3 4 5

13. The inspector must be familiar with and know the minimum percentage of full load hoisting torque when the holding brake is used with a control braking means other than mechanical (125%) or when used in conjunction with mechanical control brakes (100%), if two holding brakes are provided (100%).

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

14. The inspector shall be familiar with hoist control braking means such as regenerative, dynamic or countertorque braking.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

15. On bridge or trolley cranes the inspector shall be familiar with and inspect brakes to insure that the trolley or bridge can stop within a distance in feet equal to 10 percent of full load speed.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

16. The inspector must understand and ensure that all electrical equipment on cranes and all electrical operating cranes must comply with OSHA, USA National Standard Electrical Code, ANSI/NFPA 70-1981.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

17. The crane inspector should have the following knowledge of cab construction, 1) OSHA and USAS A12-1932 requirements for floor and wall openings, railings and toe boards, 2) roof requirements, 3) hot metal handling, crane cab exposure to heat requirements.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

18. The inspector should be familiar with OSHA and USA standard safety code for fixed ladders, A14.3-1956.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

19. The crane inspector shall be familiar with crane lubricating points, frequency of lubricating, and different types of lubricants and their applicability.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

20. The inspector candidate shall have a full understanding of machines regarding principles that will apply to such items as gears, screws, chains, sprockets, reciprocating components and other normal operation hazards.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

21. Candidates for crane inspector must have a thorough knowledge and understanding of the role of the inspector in reducing crane accidents and liability expenses.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

22. The crane inspector must know inspection procedures, techniques and have checklists that meet all requirements for a particular crane.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

23. Crane inspectors must know how to use and interpret OSHA and ANSI standards.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

24. Crane inspectors must know step-by-step, how to interpret a load chart and how to perform a load test.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

25. Crane inspectors candidates must have thorough knowledge of the inspection of booms, jibs, structures, gears, drums, shears, blocks, hooks, operating and control systems.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

26. Crane inspection candidates must have a working knowledge of operator and rigging responsibilities.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

27. Crane inspection candidates must have an understanding of crane history, and how cranes have changed over time.

1 2 3 4 5 Remarks:

28. Crane inspection candidates must understand and have a working knowledge of OSHA Construction Industry Standard, 1926.550.

1 2 3 4 5 Remarks:

29. Crane inspectors must have a working knowledge of OSHA General Industry Standard, 1910.180.

1 2 3 4 5 Remarks:

30. The crane inspector must know and understand industry requirements (voluntary), ANSI/ASME B30.5.

1 2 3 4 5 Remarks:

31. The crane inspector must know inspection frequencies, how to check company records, and how to properly document his inspection.

1 2 3 4 5 Remarks:

32. Crane inspectors must know and thoroughly understand the objectives of the inspection based on both OSHA and ANSI standards.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

33. Crane inspectors must understand the causes and results of crane accidents.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

34. Crane inspectors must know the requirements for inspections of slings, chain, wire rope and rigging gear.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

35. The crane inspector should have a working knowledge of the various types of rope and shall be able to spot potential stress problems during an inspection.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

36. Crane inspectors must have a working knowledge of rigging operations, terminology, determining load weights, and preparing a lift plan...

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

37. The crane operator should not be the crane inspector.

1 2 3 4 5 Remarks:

38. Crane inspectors should have an understanding of crane operation terminology such as "tag line".

1 2 3 4 5 Remarks:

39. Crane inspectors should know and be able to explore the importance of repairing damaged booms immediately.

1 2 3 4 5 Remarks:

40. Inspectors should be able to evaluate proper set up of cranes on various types of ground conditions.

1 2 3 4 5 Remarks:

41. The inspector shall make sure that outriggers can be fully extended.

1 2 3 4 5 Remarks:

42. The inspector shall determine that test loads on mobile cranes should not exceed 100% of the rated load at any selected working radius.

1 2 3 4 5 Remarks:

43. The inspector should be observant for effects of shock loading on wire rope.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

44. The inspector shall note that all cab windows are made of safety glass.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

45. Part of the inspection shall include all landings and walk ways on the crane.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

46. If the equipment is internal combustion run, the inspector shall inspect for proper exhaust ventilation.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

47. The inspector shall make sure all jibs have positive stops to prevent their movement of more than 5° above the straight line of the jib and boom on conventional type crane booms.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

48. On a hammerhead tower crane the inspector shall observe for additional clearance of rotating structures and fixed objects.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

49. Inspection of cranes mounted on rail track shall include the inspection for limited switches.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

50. Annual inspection of cranes shall also include an inspection of all rope.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

51. The inspector shall be knowledgeable of how to inspect for broken, worn and frayed ropes.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

52. The inspector must insure that all parts subject to impact, wear, and rough usage have adequate strength for the rated use of the crane.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

53. The inspector shall observe that on gantry cranes, a wind-indicating device shall be provided that gives an audible as well as visible alarm, when set at a pre-determined wind velocity.

1 2 3 4 5 Remarks:

54. The inspector shall insure that all cab controls are located within easy reach of the operator and no control modifications have taken place.

1 2 3 4 5 Remarks:

55. The inspector will insure that each controller and operating lever is properly marked for the action and direction it controls.

1 2 3 4 5 Remarks:

56. On cranes not equipped with spring-return controllers, spring-return master switches or momentary contact push buttons, the inspector shall insure that they are provided with a device to disconnect all motors from the line in the event of a power failure.

1 2 3 4 5 Remarks:

57. The inspector shall insure that all lubrication fittings are accessible without hazardous exposure.

1 2 3 4 5 Remarks:

58. The inspector shall insure that all platforms, footwalks, steps, handholds, and guardrails are provided with intermediate rails and toe boards.

1 2 3 4 5 Remarks:

59. When inspecting a crane, the inspector shall insure that a dry chemical or equivalent fire extinguisher is located in the cab.

1 2 3 4 5 Remarks:

60. The inspector shall insure that if contact can be made with gears or other moving parts, they are totally enclosed, covered by screen guards or placed out of reach.

1 2 3 4 5 Remarks:

61. The crane inspector shall insure that all limit devices operate on a normally closed circuit.

 Remarks:

1 2 3 4 5

62. The inspector shall insure that all wiring and electrical equipment is installed in accordance with article G10, Cranes and Hoist, of NFPA 70.

 Remarks:

1 2 3 4 5

63. The inspector shall insure that on traveling cranes warning devices are in operating order.

 Remarks:

1 2 3 4 5

64. The inspector shall inspect all sheaves and drums to assure normal wear and that no grooving has occurred.

 Remarks:

1 2 3 4 5

65. The inspector shall insure that there is a minimum of two wraps of rope on the drum when the rope is fully extended.

 Remarks:

1 2 3 4 5

66. All structural and load bearing points must be inspected at least annually.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

67. The inspector shall insure that all hoists are securely attached to their supports, and that no missing, broken or loose bolts can be found.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

68. In a bridge crane the inspector shall check to insure that the cab is constructed of fire-resistant material and no cab alterations have been made.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

69. On bridge cranes, overhead cranes, gantries and tower cranes the inspector shall insure that there is an emergency escape provided for the operator.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

70. On electrical cranes the inspector shall insure that the main line switch is constructed such that it can be locked in the open position.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

71. On mobile cranes, the inspector shall insure that all electrical equipment is grounded in accordance with ANSI C2, NFPA code.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

72. In the inspection of the crane, the inspector must pay close attention to hooks for signs of wear, opening of the throat and missing or non functional safety latches.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

73. In the inspection of electromagnets and hook-on devices, the inspector shall insure that the metal body of the electromagnet is properly grounded.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

74. In lattice boom cranes all lattice work must be inspected at least annually.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

75. The inspector shall note for replacement, parts on lattice boom cranes where there are dents of greater than $\frac{1}{8}$ the thickness of the part.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

76. In the inspection of lattice boom cranes the inspector shall insure all parts are in place.

<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	Remarks:
1	2	3	4	5	

DIRECTIONS

On pages 134 through 135 you will find a number of phrases or questions requiring an explanation in order to properly be answered. Beneath these phrases or questions are spaces marked 1 to 5 and a remarks area. Using a set of descriptors (such as "strongly agree - strongly disagree"), you are asked not to answer the question, but to comment on whether the question is a good statement and is it relevant.

If you feel that the phrase or question is relevant or very closely related to one of the scale, you should place your check-mark as follows:

$\frac{X}{1}$	$\frac{\quad}{2}$	$\frac{\quad}{3}$	$\frac{\quad}{4}$	$\frac{\quad}{5}$	Remarks:
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$\frac{\quad}{1}$	$\frac{\quad}{2}$	$\frac{\quad}{3}$	$\frac{\quad}{4}$	$\frac{X}{5}$	Remarks:
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1=strongly agree

2=agree

3=no opinion

4=disagree

5=strongly disagree

Remarks: should this be part of a Federal Regulation mark R for Regulation, NR if not belonging in a Federal Regulation, and using a scale of 0 to 100% indicate the value of each statement as applied to crane inspection and safety..

The direction toward which you check depends upon which of the two ends of the scale seems most relevant. Again do not answer the actual question, states only whether you agree or disagree and the questions relevancy.

77. What shall be plainly marked on the side of each crane.

 Remarks:

1 2 3 4 5

78. Explain the term incorporated by reference when referring to a standard.

 Remarks:

1 2 3 4 5

79. How long must a company maintain monthly inspections?

 Remarks:

1 2 3 4 5

80. When is it permissible to modify or make adjustments to a crane.

 Remarks:

1 2 3 4 5

81. Side boom cranes shall meet what requirements.

 Remarks:

1 2 3 4 5

82. A bird cage in wire rope is evidence of what type of operation.

1 2 3 4 5 Remarks:

83. Wire rope safety factors shall be in accordance with what ANSI standard.

1 2 3 4 5 Remarks:

84. Under what circumstances must bolts, gears, pulleys, sprockets, spindles, drums, fly wheels and other reciprocating equipment be guarded.

1 2 3 4 5 Remarks:

85. What is a notification of machine guarding.

1 2 3 4 5 Remarks:

86. Fire extinguishers must be of what rating.

1 2 3 4 5 Remarks:

APPENDIX D

A COMPLETE CRANE SAFETY SURVEY BY ORDER OF IMPORTANCE

This Appendix contains the complete Crane Safety Survey arranged by order of importance. Since numerous statements were competing for the same positions this survey is divided into groupings of possible statements, and by the category grouping from Table III-1.

APPENDIX D-1 STATEMENTS ARRANGED BY ORDER OF IMPORTANCE AND CATEGORY

CATEGORY ONE

3. The candidate for inspector must at a minimum be familiar with the basic terminology associated with crane operation (eg:mechanical load-brake, inching, plugging, skewing).
23. Crane inspectors must know how to use and interpret OSHA and ANSI standards.
2. In order to be certified as a crane inspector, the candidate must be able, to read and write English and any other language as applicable to his location.
85. What is a notification of machine guarding.
21. Candidates for crane inspector must have a thorough knowledge and understanding of the role of the inspector in reducing crane accidents and liability expenses.
30. The crane inspector must know and understand industry requirements (voluntary), ANSI/ASME B30.5.

APPENDIX D-2 STATEMENTS ARRANGED BY ORDER OF IMPORTANCE AND CATEGORY

CATEGORY ONE

1. To be certified as a crane inspector, the candidate should have a minimum of 3 years experience as an operator with no accidents on his record.
72. In the inspection of the crane, the inspector must pay close attention to hooks for signs of wear, opening of the throat and missing or non functional safety latches.
27. Crane inspection candidates must have an understanding of crane history, and how cranes have changed over time.
14. The inspector shall be familiar with hoist control braking means such as regenerative, dynamic or counter torque braking.
9. For electrical cranes equipped with spring-return controllers or momentary contact pushbuttons the inspector shall inspect their to insure all motors are disconnected and in the off position when these devices are engaged.

CATEGORY TWO

5. The candidate shall be able to locate and understand the rated load marking and know the significance of multiple rated load markings.

OR

11. The inspector shall insure that floor operated cranes, shall automatically return to "off" position when the operator releases the controller.

50. Annual inspection of cranes shall also include an inspection of all rope.

8. The inspection candidate must have a thorough knowledge of the requirements of "the rated load test", regarding any crane that has been modified and re-rated.

79. How long must a company maintain monthly inspections?

56. On cranes not equipped with spring-return controllers, spring-return master switches or momentary contact push buttons, the inspector shall insure that they are provided with a device to disconnect all motors from the line in the event of a power failure.

APPENDIX D-2 STATEMENTS ARRANGED BY ORDER OF IMPORTANCE AND CATEGORY

CATEGORY TWO

4. The candidate must be familiar with, and be able to pass a written test on the safety rules governing crane operations.
38. Crane inspectors should have an understanding of crane operation terminology such as "tag line".
- OR
82. A bird cage in wire rope is evidence of what type of operation.
76. In the inspection of lattice boom cranes the inspector shall insure all parts are in place.
86. Fire extinguishers must be of what rating.
18. The inspector should be familiar with OSHA and USA standard safety code for fixed ladders, A14.3-1956.

APPENDIX D-3 STATEMENTS ARRANGED BY ORDER OF IMPORTANCE AND CATEGORY

CATEGORY TWO

55. The inspector will insure that each controller and operating lever is properly marked for the action and direction it controls.
75. The inspector shall note for replacement, parts on lattice boom cranes where there are dents of greater than $\frac{1}{4}$ the thickness of the part.
54. The inspector shall insure that all cab controls are located within easy reach of the operator and no control modifications have taken place.
46. If the equipment is internal combustion run, the inspector shall inspect for proper exhaust ventilation.
39. Crane inspectors should know and be able to explore the importance of repairing damaged booms immediately.
44. The inspector shall note that all cab windows are made of safety glass.

APPENDIX D-4 STATEMENTS ARRANGED BY ORDER OF IMPORTANCE AND CATEGORY

CATEGORY TWO

58. The inspector shall insure that all platforms, footwalks, steps, handholds, and guardrails are provided with intermediate rails and toe boards.
41. The inspector shall make sure that outriggers can be fully extended.
19. The crane inspector shall be familiar with crane lubricating points, frequency of lubricating, and different types of lubricants and their applicability.

CATEGORY THREE

25. Crane inspectors candidates must have thorough knowledge of the inspection of booms, jibs, structures, gears, drums, shears, blocks, hooks, operating and control systems.
15. On bridge or trolley cranes the inspector shall be familiar with and inspect brakes to insure that the trolley or bridge can stop within a distance in feet equal to 10 percent of full load speed.
66. All structural and load bearing points must be inspected at least annually.
22. The crane inspector must know inspection procedures, techniques and have checklists that meet all requirements for a particular crane.
6. When inspecting overhead and gantry cranes the candidate inspector must understand the importance of minimum clearance overhead (3"), and lateral clearance (2").

CATEGORY THREE

32. Crane inspectors must know and thoroughly understand the objectives of the inspection based on both OSHA and ANSI standards.
63. The inspector shall insure that on traveling cranes warning devices are in operating order.
12. On remote controlled cranes the inspector shall insure that if the control signal to the crane becomes ineffective the crane operation will stop.
- OR
47. The inspector shall make sure all jibs have positive stops to prevent their movement of more than 5° above the straight line of the jib and boom on conventional type crane booms.
42. The inspector shall determine that test loads on mobile cranes should not exceed 100% of the rated load at any selected working radius.

CATEGORY THREE

69. On bridge cranes, overhead cranes, gantries and tower cranes the inspector shall insure that there is an emergency escape provided for the operator.
57. The inspector shall insure that all lubrication fittings are accessible without hazardous exposure.
- OR
68. In a bridge crane the inspector shall check to insure that the cab is constructed of fire-resistant material and no cab alterations have been made.
60. The inspector shall insure that if contact can be made with gears or other moving parts, they are totally enclosed, covered by screen guards or placed out of reach.
74. In lattice boom cranes all lattice work must be inspected at least annually.
43. The inspector should be observant for effects of shock loading on wire rope.

CATEGORY THREE

71. On mobile cranes, the inspector shall insure that all electrical equipment is grounded in accordance with ANSI C2, NFPA code.
48. On a hammerhead tower crane the inspector shall observe for additional clearance of rotating structures and fixed objects.
67. The inspector shall insure that all hoists are securely attached to their supports, and that no missing, broken or loose bolts can be found.
31. The crane inspector must know inspection frequencies, how to check company records, and how to properly document his inspection.
62. The inspector shall insure that all wiring and electrical equipment is installed in accordance with article G10, Cranes and Hoist, of NFPA 70.

CATEGORY THREE

49. Inspection of cranes mounted on rail track shall include the inspection for limited switches.
70. On electrical cranes the inspector shall insure that the main line switch is constructed such that it can be locked in the open position.

CATEGORY FOUR

26. Crane inspection candidates must have a working knowledge of operator and rigging responsibilities.
24. Crane inspectors must know step-by-step, how to interpret a load chart and how to perform a load test.
81. Side boom cranes shall meet what requirements.
16. The inspector must understand and ensure that all electrical equipment on cranes and all electrical operating cranes must comply with OSHA, USA National Standard Electrical Code, ANSI/NFPA 70-1981.
7. For overhead and gantry cranes the candidate shall know that foundations and anchorages must be such that an outside crane can withstand a wind pressure of 30 pounds per square inch (psi).

CATEGORY FOUR

36. Crane inspectors must have a working knowledge of rigging operations, terminology, determining load weights, and preparing a lift plan...
80. When is it permissible to modify or make adjustments to a crane.
51. The inspector shall be knowledgeable of how to inspect for broken, worn and frayed ropes.
29. Crane inspectors must have a working knowledge of OSHA General Industry Standard, 1910.180.
35. The crane inspector should have a working knowledge of the various types of rope and shall be able to spot potential stress problems during an inspection.

CATEGORY FOUR

28. Crane inspection candidates must understand and have a working knowledge of OSHA Construction Industry Standard, 1926.550.
34. Crane inspectors must know the requirements for inspections of slings, chain, wire rope and rigging gear.
59. When inspecting a crane, the inspector shall insure that a dry chemical or equivalent fire extinguisher is located in the cab.
17. The crane inspector should have the following knowledge of cab construction, 1) OSHA and USAS A12-1932 requirements for floor and wall openings, railings and toe boards, 2) roof requirements, 3) hot metal handling, crane cab exposure to heat requirements.
61. The crane inspector shall insure that all limit devices operate on a normally closed circuit.

CATEGORY FOUR

52. The inspector must insure that all parts subject to impact, wear, and rough usage have adequate strength for the rated use of the crane.
33. Crane inspectors must understand the causes and results of crane accidents.
13. The inspector must be familiar with and know the minimum percentage of full load hoisting torque when the holding brake is used with a control braking means other than mechanical (125%) or when used in conjunction with mechanical control brakes (100%), if two holding brakes are provided (100%).
84. Under what circumstances must bolts, gears, pulleys, sprockets, spindles, drums, fly wheels and other reciprocating equipment be guarded.
53. The inspector shall observe that on gantry cranes, a wind-indicating device shall be provided that gives an audible as well as visible alarm, when set at a pre-determined wind velocity.

CATEGORY FOUR

40. Inspectors should be able to evaluate proper set up of cranes on various types of ground conditions.
37. The crane operator should not be the crane inspector.
64. The inspector shall inspect all sheaves and drums to assure normal wear and that no grooving has occurred.
77. What shall be plainly marked on the side of each crane.
20. The inspector candidate shall have a full understanding of machines regarding principles that will apply to such items as gears, screws, chains, sprockets, reciprocating components and other normal operation hazards.
65. The inspector shall insure that there is a minimum of two wraps of rope on the drum when the rope is fully extended.
10. The inspector shall insure the arrangement of controllers conforms to E.O.C.I. specification #61..

CATEGORY FOUR

- 78. Explain the term incorporated by reference when referring to a standard.
- 45. Part of the inspection shall include all landings and walk ways on the crane.
- 83. Wire rope safety factors shall be in accordance with what ANSI standard.
- 73. In the inspection of electromagnets and hook-on devices, the inspector shall insure that the metal body of the electromagnet is properly grounded.

VITA

Charles Nicholas Carter (Nick) was born in Nashville, Tennessee, in 1949. He is a graduate of the 1967 Class from Hillwood High School in Nashville. After graduation he worked at Vanderbilt University Hospital, as a Respiratory Therapist before entering the United States Navy in 1971.

Mr. Carter worked as a Hospital Corpsman and Radiation Health and Safety Officer in the Navy's Nuclear Submarine Propulsion Program. He served on nine submarines and as Radiation Health and Safety Officer for Submarine Squadron Eleven before participating in Operation Desert Shield/Desert Storm with the Second Medical Battalion, Second Marine Division. He received his Bachelor of Science degree in Safety Management and Engineering Technology from National University, San Diego, California in January 1991, and retired from the Navy at Naval Hospital, San Diego in February 1992.

Since retirement he has worked for the State of Tennessee, Department of Environment and Conservation as an Environmental Programs Manager, and is currently employed by PAI Incorporated as a Safety Engineer contracted to the Department of Energy, Oak Ridge. He is a Certified Hazard Control Manager.

He is married to the former Norma Jean Sanders of Nashville, and father of daughters-Jennifer, Aimee' and Nikki.