AN ANALYSIS OF THE ORGANIZATION AND MANAGEMENT OF THE INDUSTRIAL ENGINEERING FUNCTION

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AN ANALYSIS OF THE ORGANIZATION AND MANAGEMENT OF THE INDUSTRIAL ENGINEERING FUNCTION

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PREFACE

Is there an agreement among the many managers of industrial engineering organizations in the United States as to how their functions should be organized and managed?

The two major employers of industrial engineers are industry and the United States Government. An attempt to answer the above question has been made in this study by comparison of replies to a questionnaire mailed to industrial engineering managers. The results were compared by the two groups of responses, those from government and those from industry.

The author expresses his thanks to all who have helped with the research and its development to this final form. Professors Bentley and Torgersen were instrumental in providing suggestions and guidance during the full course of development. Dr. Stanley M. Trail assisted with comments on statistical validation of the results. Those who responded so courteously to the questionnaire made the study possible.

Special thanks are due the officials of Robins Air Force Base, Georgia, who secured the time and backing for the author to complete this study.

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CHAPTER I

INTRODUCTION

The author, a manager of industrial engineering functions for the Air Force, has been interested for some time in methods used by his contemporaries in government and industry. A manager has a responsibility to carry out the stated missions, or functions, of the organization. In managing, he invariably must develop policies to guide his personnel. It was felt that a comparison of functions and policies could be made by a review of responses to a questionnaire. The information obtained could be useful to these managers and other interested parties.

Review of the Literature

The management activity, as discussed by Lohmann (1954) in his dissertation, A Concept of Organization and Management, is one of communication to the members of the organization to aid them in agreeing upon organizational goals, the incentives available to members, and actions necessary by them to aid in reaching the goals. An employee so informed and motivated, according to Lohmann, is equipped to contribute to the organization's success. So put it in other words, he knows where the organization must go, what desirable benefits will accrue to him by his taking part, and what the nature of his participation should be. The "communicative" activity is separated by Lohmann from other "preparatory" activities, saying that the latter are not truly managing. This

classification has been used as a guide in preparation of the questionnaire.

Many other authors in the field of management have used these "preparatory" activities as the complete requirements of the management function. Koontz and O'Donnell (1955) state:

> There are those who feel that a manager first plans, then organizes, then staffs, directs, and controls. [Koontz and O'Donnell believe that] the manager undertakes all these functions simultaneously.

Harold B. Maynard (1959), after making the point that "the logical path of promotion for industrial engineers is into the ranks of management," quotes a committee report of the Association for Consulting Management Engineers. The Committee found that the task of management is to (1) establish objectives, (2) direct the attainment of objectives, and (3) measure results. The Committee then classified these three into eleven elements:

1. Synthesize Data
2. Plan
3. Decide
4. Organize
5. Communicate
6. Motivate
7. Direct
8. Guide and Counsel
9. Measure, Evaluate and Control
10. Develop People
11. Promote Innovation.

With the exception of item 5, which is Lohmann's term for the activity of

management (communication), the list is comprised of "preparatory" actions by management.

In order to compare the functions in industrial engineering organizations, one should have a concept of what is included. Since many of the engineering specialties participate in the workloads of such organizations, an understanding of the variety of work performed is needed. Laitala (1959) relates the practice of engineering to almost every industrial organization function: budget, design, production, product evaluation, selling, buying, maintenance, accounting, and personnel. Amrine, Ritchey, and Hulley (1957) divide engineering into pure research and applied research. Under applied research, they make the following three alignments:

Product Engineering

1. Design of Components
2. Preparation of Specifications
3. Production Standards
4. Product Testing
5. Engineering Services

Manufacturing Engineering

1. Design of Processes
2. Tooling and Equipment
3. Methods
4. Layout and MHE
5. Quality Control
6. Economic Evaluation

Plant Engineering

1. Installations
2. Plant Services
3. Maintenance
4. Safety.

With all these functions to perform, engineers need on-the-job type training to ease the stresses of technological change (Reith, 1957). They are sometimes provided in distant places, such as the graduate

engineering training centers which are maintained in New York, Chicago, and Winston-Salem by the Western Electric Company (Shea, 1958).

Some engineers join unions to get representation, and, therefore, overtime compensation, professional advancement, job classification, grievance procedures, and more fringe benefits (Taft, 1957).

Engineers demand appraisal of their job accomplishments, which can be an opportunity for counseling them (Richards, 1960).

These literature references express some of the subject matter intended for highlighting in the questionnaire; for example, union membership, plant engineering functions, and training.

CHAPTER II

METHOD AND PROCEDURE

Two excellent references are available on the use and preparation of questionnaires and cover letters, as well as procedures for their application.

Koos (1928) justifies them as a necessity for complete educational research in a number of fields. He states:

> Thus, not only is the questionnaire method used in large proportions of educational investigations, not only do we find it applied in many divisions and on all levels of the field of education to ascertain practices, basic data, and judgments, but it is also a valuable source of data procurable usually in no other way.

He states the expected advantage of the oral questionnaire over the written form, but as in the case of this study, emphasizes that the former is not always practicable. His material on "relationships" in questionnaire investigation is summarized as follows:

1. Material is regarded as confidential.
2. Intercession by a third party aids in securing response.
3. Cover letter explains the project and motivates the respondent.
4. Advance inquiry sometimes helps.
5. Promise of information on results if desired by respondents helps.
6. Approach in person, where possible.

7. Keep the questionnaire brief.
8. Questionnaire investigations vary as to whether full participation by all intended respondents is required.
9. A try-out or pre-test, using a form as nearly like those to be mailed out in bulk, will discover ambiguities and other undesirable features.

Good and Scates (1954) show the derivation of the questionnaire technique in experimental psychology in the last century. The author of this study found no hostile attitude on the part of respondents as termed likely by them. Their material on the psychology of the respondent, the participation basis, and a U. S. Bureau of the Budget outline of steps to be followed in use of questionnaires, are recommended for any who may consider their use. The outline follows, as modified by the author:

1. Determine purpose.
2. Determine relation to other surveys or programs.
3. Develop the survey plan to include:
    a. Respondents.
    b. Extent of coverage.
    c. Frequency and timing of mailings.
    d. Method of collection.
    e. Consideration of nonsampling errors.
    f. Standard definitions and classifications.
    g. Processing and interpretation of the data.
    h. Allowance for pre-tests and follow-ups.
    i. Comparison with data from other sources.
    j. Proposed calendar.
    k. Cost estimates.

4. Questionnaire and instructions are prepared.

5. Pre-tests and follow-ups are made.

6. Develop plan for partial coverage surveys.

7. Manuals and other instructions are prepared.

8. Progress and cost reporting are performed.

9. Final report is prepared.

Also helpful is their treatment of length, construction, pre-testing, validity, and editing of responses. In addition, they show a bibliography of the literature on the questionnaire technique and investigations.

Construction of the Instruments

Since the author desired to obtain responses which could be compared by categories, the definition of management by Lohmann, discussed in Chapter I, was selected. Questions for securing information on the following were constructed and assembled into preliminary form:

Communicative Activities

a. Define organizational goals.

b. Define means available for reaching these goals.

c. Define incentives offered members of the organization to encourage their goal-centered actions.

Preparatory Activities

d. Other management actions.

A proposed cover letter was attached to the questionnaire. A first revision was then prepared, placing the questionnaire and cover letter near their final form.

The questions, shown in final form in Appendix A, and contained in the first revision, are categorized thus:

Category	Questions	Tabulation
a.)	2, 3, 24	Table I
(goals) a.)	4, 5, 24	Table II
b.)	1, 9, 13	Table III
b.)(means)	6, 7	Table IV
b.)	14, 15, 27	Table V
c.)	8, 25, 26, 28, 29	Table VI
c.)(incentives)	12, 18, 20, 21	Table VII
c.)	16, 17, 30	Table VIII
d.)(preparatory)	10, 11, 19, 22, 23	Table IX

There was some overlapping of questions applying to more than one subject category. Questions 10, 16, 22, 23 and 30 could also be appropriately listed under b., question 19 under c., and questions 4 and 5 under d. Tables I through IX are in Appendix B.

The Pre-Test and Response

The first revision was given to six managers of industrial engineering functions, five in a government agency and one in industry. They were to be returned as soon as possible, preferably within a week. Four of the government people and the industry manager complied. Since three of these were nearby, their responses were reviewed orally with them by the author. The other two responses, and one which came in after the general mailing, were similar to the three checked orally. All six were used in the over-all study.

Revisions were made based on this pre-test, so that the questionnaire was then in final form, ready for mailing.

Selection of Mailing Lists

The author wanted responses of a comparative number of managers from government and industry. Selection of 36 government organizations was made from a list of approximately 500 government agency locations. An effort was made to get at least one location from each type agency.

Poore's Index was used to make up a list of 72 industrial manaufacturing firms, three each from company names beginning with most letters of the alphabet.

The total number was 114, including those from the pre-test. Mailings were made April 5, 1963, requesting responses by May 10, 1963.

Composition of Respondents

Including the six pre-test responses, all of which were used in the results, the following responses were made. Only those received by May 15 were used, and they are shown below as "positive."

	Government	Industry
Positive (Includes pre-test)	18	18
Late arrival	0	1
Organization disbanded	2	0
Partly filled in, unsigned	0	1
No identifiable industrial engineering function	5	6
Time for response not available	0	1
Other information than questionnaire response	1	0
Totals:	26	27

This is a 47% response rate. Courtesy was notably present in all responses.

Treatment of the Data

The individual responses have been arranged in Tables I-IX, in Appendix B. Since there were 18 government and 18 industrial responses, arbitrary designation was made to government responses of code numbers 1-18 consecutively, and 21-38 for industrial responses. Their answers are arranged in each of these nine tables in descending order by quantity of direct workers reported (Q. 24). Six did not show this information and were placed arbitrarily at the end in each table. The subjective categories and questions covered in each table were defined under "Construction of the Instruments," earlier in this chapter. Data in the tables are representative of the original replies as brevity permits.

CHAPTER III

RESULTS

The results of this questionnaire are, like those from any other, based upon individual interpretations made by responding individuals. Some bias is, no doubt, present. The spread of responding managers across the nation would appear to increase the likelihood of various interpretations of the meaning of the questions. It is hoped that such bias is not too large a factor in the results.

The only other study found which in any way parallels this one is an industrial engineering survey performed by Barnes (1949). The survey was done in 1945-1946, and again in 1948 with three questions added to the earlier questionnaire. Most of Barnes' study had to do with types and application of labor standards and wage incentives. His questions 1, 2, and 5 are similar to three in this study, and will be compared as they appear in the order of the discussion. For clarity, the former are listed here:

Q. 1. To whom do you, as head of industrial engineering or time study, report?

Q. 2. To whom do you think you should report?

Q. 5. Average percentage of female factory employees?

Discussion of Summarized Responses by Category

The development of the general inequality form in Appendix C explains

the approach to be used in discussing the summarized results contained in Table X (Appendix C). Twenty-six of the question responses are shown in the table. Sample sizes and proportions of samples for government are n_G and $^xG/n_G$, respectively, for question elements being compared. Similarly, n_I and $^xI/n_I$ apply to industry. The values R_G and R_I are the ranges of the "true" proportion, p, as obtained by reading the upper and lower values of p from Figure 1. Values for n and x/n are those resulting from summarized question element responses.

Of the eleven elements compared from Questions 2, 3, 4 and 5 of subject category a., difference in application between industry and government to goal definition is found in only three out of eleven.

Of the 12 elements compared from Questions 1, 9, 13, 14, 15 and 27 of subject category b., difference in application to the means of reaching organizational goals is found in only three out of the 12. One of the differences is a borderline case, since one value of x/n lies just out of the range of p, while the other x/n value lies just inside the range of p.

Of the 24 elements compared from Questions 12, 16, 17, 18, 20, 21, 25, 26, 28, 29 and 30 of subject category c., difference in application to incentives definition is found in eight out of the 24. Two of the eight are borderline differences.

Of the eight elements compared from Questions 10, 11, 19, 22 and 23 of subject category d., difference in application to the "preparatory" activities of management is found in only one out of the eight.

Discussion of Responses to Individual Questions

The following discussion is given in the order of Tables I through IX, as the questions and elements appear from left to right in their

respective tables, and by subjective management category. Unless stipulated otherwise, comparison is always between government and industry.

a. Define organization goals.

(1). Q. 24 - "Number of direct (production) workers which your functions support." Size of population supported certainly should affect how much is expected of the industrial engineering function. Barnes' question 5, quoted earlier in this chapter, showed a range of plant sizes of 50 to 15,000 employees. This study shows a range from 26 to 25,000, which is of a similar order of magnitude.

(2). Q. 2 - "Are projects directed from your superiors, internally originated by you, or suggested by production organizations?" A comparison of responses follows:

	Government	Industry
Directed from Superiors	37%	28%
Internally Originated	38%	49%
Suggested by Production Organizations	25%	23%

As shown in Table X, there is no significant difference in the sources for projects.

(3). Q. 3 - "Are assignments given orally, by form with inserts, by special project directive, or by other means?" Comparison of responses shows:

	Government	Industry
Orally	37%	64%
By Form	7%	10%
Special Directives	38%	9%
Other	18%	17%

Table X demonstrates that there is significant difference in the means of giving assignments by oral transmission and in the use of the special directives. Industry relies heavily upon verbal instructions, while government managers use about equal amounts of oral and special directive type instructions.

(4). Q. 4 - "How do you plan your projects for accomplishment and content?" Choices and responses follow:

	Government	Industry
Critical Path Scheduling or Gantt Charts, Singly	28%	12%
Two or More Techniques or Neither of Above	72%	88% .

Table X shows no significant difference for project planning.

(5). Q. 5 - "Who participates in control of priorities and progress of projects?"

	Government	Industry
I. E. Supervisor and one Superior	22%	50%
I. E. Supervisor Alone or Not at All	22%	11%
I. E. Supervisor Plus More Than one Other	56%	39% .

Table X shows significant difference only where the industrial engineering supervisor and one other superior control priorities and progress of the projects, with industry using this means of control in a significantly larger degree. Comparatively large portions in both government and industry are controlled by three or more people.

b. Define means available for reaching goals.

(1). Q. 1 - "What are the functions for which your organization is responsible?" Choices and responses listed in Table X are:

	Government	Industry
Plant Layout	12%	6%
Methods Study	23%	30%
Material Handling	7%	8%
Labor Standards	25%	17% .

Although no significant difference is found in these figures, as noted in the table, it is interesting to note that wage incentives activity is still not found in government, while industry's industrial engineering functions devote 12% of their time to it. This was expected by the author, since to the best of his knowledge, labor standards in government are used to support standard cost systems and for obtaining information on organization effectiveness, but not for wage incentives payment.

(2). Q. 9 - "Engineers do project work":

	Government	Industry
Singly	69%	65%
In Groups	31%	35% .

There is no significant difference in whether engineers do project work singly, or in groups, as indicated in Table X. Perhaps the scope of the projects demands the group-type effort on approximately two-thirds of them.

(3). Q. 13 - "Are your engineering projects sometimes supplemented by consulting firms?" This means of reaching goals

is used by government in only 17% of the sample compared to 41% by industry. Table X shows that this represents a significant difference in practice.

(4). Q. 6 - "What job titles are represented in your technical personnel?" The responses here are not summarized in Table X. Table IV, Appendix B, shows good agreement in types of engineering job titles. Special titles in government are "aerospace" and "missile" engineers; those in industry include "time study," "manufacturing," and "methods" engineers. There is little agreement in job titles for non-engineers or technicians. This possibly stems from their very specialized uses in both groups.

(5). Q. 7 - "Of engineers having 4 years or more engineering experience, how many have engineering degrees?" No information on responses on this question appears in Table X. However, it is of interest that there are approximately 3.3 experienced graduate engineers per thousand direct employees in government, and 3.6 per thousand in industry. These figures are of a comparable order of magnitude.

(6). Q. 14 - "Do your engineers' field engineer their projects?" Similar policies appeared here in that the great majority require their engineers to "field engineer" jobs during construction and after put into use. Table X shows no significant difference in the rates indicated:

	Government	Industry
During Construction	94%	83%
After Put Into Use	83%	89% .

These are certainly "means" of reaching goals.

(7). Q. 15 - "Do engineers have assigned desk locations other than in the industrial engineering office?" Table X shows a small percentage decentralize their engineers, with no significant difference between the two.

Government	Industry
22%	17%

Most managers evidently felt no advantage can be gained from this practice.

(8). Q. 27 - "How are installation or construction projects accomplished?" Here, a significant difference in practice is found, as shown in Table X.

	Government	Industry
Plant Trades Work	34%	66%
Contract Work	66%	34% .

In the author's experience, government organizations in the past used their own plant trades in a much larger proportion. Pressures by industrial suppliers and contractors on higher levels of government have reversed the tendency. Manufacturing firms, of course, have no major pressures from outside to use products and services of other firms.

c. Define incentives available to encourage goal-centered actions by members of organization.

(1). Q. 8 - "How many experienced (4 years), graduate engineers are members of a union?" The response on this question is not shown in Table X. Table VI shows only three out of some 40-plus experienced engineers as interpolated from responses

on Questions 6, 7, and 25. These three were from government.

(2). Q. 25 - "What is the hiring turnover rate in your engineers annually?" Table X shows:

Government	Industry
18%	9%

This does not represent a significant difference on turnover rates.

(3). Q. 26 - "What reasons do engineers express for leaving?"

	Government	Industry
Promotion	89%	80%
Type Assignments	2%	1%
Other	9%	19%

Table X shows no significant difference in any of these. Of course, the large proportion leave for promotion, which can entail status as well as money.

(4). Q. 28 - "Does your own job title include the designation 'engineer'? If yes, specify."

	Government	Industry
Yes	72%	83%
Industrial Engineer	77%	53%

There is no significant difference in these responses, as indicated in Table X. The percentage of industrial engineers by title is based on that portion of "yes" answers in each case.

(5). Q. 29 - "How many of your (experienced) engineers have professional registration?"

	Government	Industry
	15%	50% .

A significant difference is indicated here, as shown in Table X. However, those eligible was a small number, as can be seen in the figure of only about three experienced engineers per thousand direct employees, discussed under the results of Q. 7, this chapter.

(6). Q. 12 - "How is performance of engineers judged?"

	Government	Industry
Output Included	71%	77%
Output Not Included	29%	23% .

Table X shows no significant difference in these. It is noted that about one-fourth of those querried did not list output as a criterion.

(7). Q. 18 - "How are engineers ranked?" Table X indicates:

	Government	Industry
Performance Alone	76	79 .

No significant difference is present here. Both groups look for "results."

(8). Q. 21 - "How do you identify superior performance?" Table X displays:

	Government	Industry
Subjective Judgment Only	16%	44%
Per Job Description Only	56%	12%
Combinations of These and Others	28%	44% .

There is significant difference in practices on the first two of

these. Industry prefers subjective judgment, while government prefers reference to the job description.

(9). Q. 20 - "How is superior individual engineering performance recognized?" Table X summarizes:

	Government	Industry
Monetary Only	17	53
Monetary and/or Others	83	47 .

The practices in this case are significantly different, wherein industry uses "money only" better than one-half of the time, while the government uses it in combination with others, or not at all, a large proportion of the time. It is noted from Table VII that the manager in industry does not use written appreciation much, whereas it is common in government.

(10). Q. 16 - "Does your firm or organization sponsor graduate work or have an education plan leading to advanced degrees for engineers?" Table X shows:

	Government	Industry
Yes	56%	61% .

There is no significant difference in these.

(11). Q. 17 - "If answer to Q. 16 was 'yes', check the following as applicable."

	Government	Industry
On Duty	10%	0%
Off Duty	50%	89%
On-and-Off Duty	40%	11%
Employee Paid	22%	18%
Organization Paid	67%	36%
Jointly Paid	11%	46% .

Table X indicates significant difference concerned with off-duty preparation, in that industry prefers it heavily; thus, there is also a significant difference in policy for on-and-off duty preparation in that industry still indicates it much prefers off-duty preparation. Government has few cases wherein it shares the burden with the employee, whereas about one-half of industrial organizations will do so. Government organizations do pay for about two-thirds of their engineers' graduate work.

(12). Q. 30 - "Are management or engineering seminars given for your engineers?"

	Government	Industry
Local Only	27%	44%
Above 100 Miles Distance and Other	73%	56% .

There is no significant difference in these, as shown in Table X. Table VIII has a variety of alternatives, such as participation in technical societies by engineers from both, with somewhat heavier sponsorship by industry.

d. Other management actions

(1). Q. 22 - "Who is your immediate superior?" Table X compares:

	Government	Industry
Engineer in Title	29%	0% .

These are significantly different. No case in industry was reported wherein 'engineer' appeared in the title of the superior of the industrial engineering manager, whereas about three-tenths of those in government reported that it did appear. A

great variety of titles were reported, as listed in Table IX.

(2). Q. 23 - "Who should be your superior, if different to Q. 22?" Table X indicated:

	Government	Industry
Would Not Change	82%	94%
Would Change	18%	6% .

There is no significant difference in the desires of managers in this respect. Questions 22 and 23 correspond to questions 1 and 2 in Barnes' study. He showed 18% of those contacted felt their superiors should be different in 1945 and 19% in 1948. This study shows a composite of 12% would change their superiors' level if they could, which is somewhat less than Barnes' figures.

(3). Q. 19 - "Who determines ranking of engineers as to comparative worth?"

	Government	Industry
I.E. Manager	41%	35%
I.E. Manager and/or Others	59%	65% .

Table X notes no significant difference. Ranking by multiple-supervisory judgment is in the greater proportion in both.

(4). Q. 10 - "When projects require funds expenditure and methods or facilities changes, who must approve?" In Table X:

	Government	Industry
Organizations Including Shops	44%	22%
Organizations Not Including Shops	56%	78% .

No significant difference is found. It is interesting to see that better than one-half of the industrial engineering

organizations in government and three-fourths in industry do not secure production shop approvals on these projects.

(5). Q. 11 - "What percentage of projects in Q. 10 are approved?" From Table X:

Government	Industry
83%	85% .

There is no significant difference indicated. This is a larger percentage than the author would have anticipated from his own experience.

CHAPTER IV

INTERPRETATION OF RESULTS

Summary and Conclusions

Lohmann's definition of the activity of management is that of communication to the members of the organization to aid them in (a) agreeing upon organizational goals, (b) actions necessary by them to aid in reaching the goals, and (c) incentives available. He designates all other actions by managers as (d) preparatory. The alphabetical designations above are the author's, and correspond to the categorization of questions and responses in Chapter III.

The individual parts of 26 of the 30 questions are compared in Table X. All of the 30 questions are discussed in Chapter III. The data shows that 40 of the 55 parts of questions summarized in Table X are not significantly different when comparing government and industry as groups. The question responses must be viewed individually for answers to specific querries on the management of the organizations included. In many cases, the two groups of managers see the exercising of their functions much alike, but in some others they are decidedly different. Thus, under goal definition, government managers assigned projects to engineers in writing, while the industrial counterparts preferred oral assignments. Again, under goals definition, industry showed more emphasis on control of projects' progress by the immediate supervisor and his superior,

whereas government preferred multiple judgment in this control. In regard to means of reaching organizational goals, government policies and regulations play a large part. There is no machinery for payment of wage incentives; therefore, no wage incentives effort. Staffs of engineers are used rather than any appreciable use of consultants, whereas contract work for installation of projects is common. Lobbying, where legislation is made, may strongly influence the latter. Differences in incentives definition are evidenced by higher professional registration, subjective judgment on superior performance toward primarily monetary rewards, and off-duty, jointly paid graduate work by industry. Government uses the job description, and written appreciation combined with money, in recognizing superior performance. It pays for two-thirds of employees' graduate work, and permits on-and-off duty pursuit 40% of the time. An interesting difference under other management actions (preparatory), was that none of industry's immediate supervisors had superiors with engineering titles, whereas 29% of those in government did have.

Whether a larger sample, or one composed of different groupings, would show other results cannot be predicted.

In examining the responses, the author believes his confidence would have improved with a larger sample.

No common solution to the job of managing and organizing industrial engineering functions resulted from this study.

Suggestions for Future Study

A study using the same questions, but requiring a greater response, would be of interest for comparison. The author advocates no means of

obtaining the information other than by written or oral questionnaire, or both. A comparison could be made by questioning journeyman engineers, rather than their supervisors.

A study could be made of the extent of the use of the analytical techniques such as operations research, EDPE systems control, and others.

Various groupings, such as stratifications by size or from common industries, might produce different results.

BIBLIOGRAPHY

Amrine, H. J., J. A. Ritchey, and O. S. Hulley. Manufacturing Organization and Management. Englewood Cliffs, New Jersey: Prentice-Hall, 1957, pp. 92-94.

Barnes, Ralph M. Industrial Engineering Survey. Industrial Engineering Report No. 1, College of Engineering, University of Iowa, 1949, p. 3.

Freund, John E. Modern Elementary Statistics. Englewood Cliffs, New Jersey: Prentice-Hall, 1960, pp. 226-228.

Good, Carter V, and Douglas E. Scates. Methods of Research. New York: Appleton-Century-Crafts, Inc., 1954, pp. 604-634.

Koontz, Harold, and Cyril O'Donnell. Principles of Management. New York: McGraw-Hill, 1955, p. vi, preface.

Koos, Leonard V. The Questionnaire in Education. New York: Macmillan Company, 1928, pp. 31-68, 121-167.

Laitala, Everett. Engineering and Organization. Homewood, Illinois: Richard D. Irwin, Inc., 1959, pp. xi and xii, contents.

Lohmann, Melvin R. A Concept of Organization and Management. Ames, Iowa: University of Iowa, College of Engineering, 1954, p. 277.

Maynard, Harold B. "Industrial Engineering - Training for Management." Journal of Industrial Engineering, January-February, 1959, pp. 3-7.

Reith, J. L. Jr. "Training Engineers on the Job." Personnel, January-February, 1958, pp. 73-76.

Richards, Kenneth E. "New Insights Into Performance Appraisal." Personnel, July-August, 1960, pp. 28-38.

Shea, J. E. "Making the Most of Engineering Abilities." Personnel, May-June, 1958, pp. 72-78.

Steel, Robert G. D., and James H. Torrie. Principles and Procedures of Statistics. New York: McGraw-Hill, 1960, p. 458.

Taft, John E. "Why Engineers Join Unions." Personnel, September-October, 1957, pp. 66-71.

APPENDIX A

APPENDIX A

COVER LETTER AND QUESTIONNAIRE USED IN MAILING

AND FOR SECURING DATA

April 5, 1963

Dear Sir:

I hope that the manager of your Industrial Engineering function will share his knowledge by completing the attached questionnaire. The material supplied will be used to supplement the development of my Master's thesis on the subject, "Analysis of the Organization and Management of the Industrial Engineering Function."

As manager of such a function, I am much interested in its improvement, and believe it can be done through concentrated study and application.

Please return the questionnaire by May 10th, if at all possible. I will be pleased to forward you a copy of the results if you so request.

Sincerely,

NORRIS A. GRIFFITH
c/o School of Industrial Engineering
and Management
Oklahoma State University
Stillwater, Oklahoma

INDUSTRIAL ENGINEERING QUESTIONNAIRE

Answers to the following are desired from the Manager of the Industrial Engineering function:

1. What are the functions for which your organization is responsible:

		Indicate Percentage Devoted to Applicable Functions
a.	Plant Layout	____
b.	Methods Study	____
c.	Materials Handling Systems or Equipment	____
d.	Labor Standards Development or Application	____
e.	Wage incentives administration or development	____
f.	Other _____ (specify)	____
g.	Other _____ (specify)	____
	Total _____	100%

2. Are projects: (Show Percentage)

a.	Directed from your superiors.	____
b.	Internally originated by you or groups reporting to you.	____
c.	Suggested by Production Organizations.	____
	Total _____	100%

3. Are assignments given: (Show Percentage)

a.	Orally	____
b.	In Writing	
	(1) Form with inserts for dates and other particulars	____
	(2) Specially developed project directive	____
c.	Other _____ (specify)	____
	Total _____	100%

4. How do you plan your projects for accomplishment and content? (Check Where Applicable)

a.	Critical path scheduling	____
b.	Gantt Charts	____
c.	Other (attach sample if necessary)	
	Type _____	____

5. Who participates in control of the priorities and progress of your projects? (Check Where Applicable)

   a. Plant Manager _____ c. Yourself _____

   b. Next superior _____ d. Other (specify)

   _____ _____

6. What job titles are represented in your technical personnel? (Enter Personnel Quantities)

   a. Industrial Engineers _____ e. Civil Engineers _____

   b. Mechanical Engineers _____ f. _____(Other) _____

   c. Electrical Engineers _____ g. _____(Other) _____

   d. Electronic Engineers _____

7. Of engineers having 4 years or more engineering experience, how many are college graduates in engineering? (Quantities)

   a. Industrial Engineers _____ d. Electronic Engrs. _____

   b. Mechanical Engineers _____ e. Civil Engineers _____

   c. Electrical Engineers _____ f. Other Engineers (specify type) _____

8. How many of these are members of a union? _____

9. Do your engineers do project work: (Specify Percentage)

   a. Individually _____

   b. In groups _____

   c. Other (specify) _____ _____

   Total _____ 100%

10. When project is at the completion stage requiring funds expenditure and methods or facilities changes, who must approve: (Check Where Applicable)

    a. Your superior _____ d. Shops supervisors _____

    b. His superior _____ e. Others (List)

    c. Higher levels (Specify) _____ _____ _____

    _____ _____

11. What percentage of these are approved for implementation? _____

12. How is performance of engineers judged? (Check if Applicable)

    a. Output _____

    b. Other _____ _____

    _____ _____

13. Are your engineering projects sometimes supplemented by consulting firms? Yes _____ No _____

14. Do your engineers "field-engineer" their projects? (Yes) (No)
(On-site presence of assigned engr.)

a. During construction or implementation _____ _____

b. After put in use _____ _____

15. Do your engineers have assigned desk locations other than in your central office? Yes _____ No _____

If yes, where? _____

16. Does your firm or organization sponsor graduate work or have an education plan leading to advanced degrees for engineers? Yes ___ No ___

17. If answer to (16) is yes, check the following as applicable.
Graduate work is:

a. On duty hours _____ d. Employee paid _____

b. Off duty hours _____ e. Firm or organization paid _____

c. On-and-off duty hours _____ f. Jointly paid _____

18. Are engineers ranked by: (Check if Applicable)

a. Performance _____

b. Other (specify) _____

19. Who determines ranking?

a. You _____

b. You and Others _____

Give title of others _____ _____

c. Others (Give Titles)

_____ _____

20. How is superior individual engineering performance recognized?

a. Publish in house organ _____ c. Monetary _____

b. In writing to engineers _____ d. Other (specify, but not promotion)

_____ _____

21. How do you identify superior performance? (Check if Applicable)

a. Subjective judgment _____ c. Other (specify)

b. Against identified characteristics in job description _____

_____ _____

22. Who is your immediate superior: _____
(Attach organization chart, if available).

23. Show superior to whom you should report if different from above:

_____

24. Number of direct (production) workers which your functions support? _____

25. What is the hiring turnover rate in your engineers? (Number of vacancies per year) _____

26. What reasons do they express for leaving? (Show Percentages)

a. Promotion _____ c. Your firm's policies (specify)

b. Type assignments _____ _____ _____

d. Other (specify)

_____ _____

27. Through what means are your installation or construction projects accomplished? (Show %)

a. Internal Plant Trades _____

b. Contract _____

c. Other (specify)

_____ _____

Total _____ 100%

28. Does your own job title include the designation "engineer". Yes _____ No _____ If yes, specify _____

29. How many of your engineers have professional registration?
Quantity _____

30. Are management or engineering seminars given for your engineers? (Check as Applicable)

a. Firm or organization staffed

(1) Local _____ (2) Above 100 miles distant _____

b. University staffed

(1) Local _____ (2) Above 100 miles distant _____

c. Other (specify)

_____ _____

Please elaborate on any item or idea brought up in the questionnaire as you may wish. Attach sheets as necessary.

Person preparing questionnaire:

Last	First	Middle Initial

Street	City (Zone)	State

Official Title

Date _____ _____
Month/Day/Year Organization or Firm

No information given to me as a result of this questionnaire will be identified to you or your firm/organization.

Norris A. Griffith

Questionnaire is to be mailed as follows, please:

To: Norris A. Griffith
c/o School of Industrial Engineering
and Management
Oklahoma State University
Stillwater, Oklahoma

APPENDIX B

TABLE I

DATA FROM INDUSTRIAL ENGINEERING QUESTIONNAIRE, QUESTIONS 2, 3, AND 24

ORGANIZATION CODE	Q. 24 NUMBER DIRECT WORKERS SUPPORTED	Q. 2 % PROJECTS ORIGINATED			QUESTION 3 METHOD OF GIVING ASSIGNMENTS ON PROJECTS: (SHOW PERCENTAGE)				
						WRITTEN		OTHER METHODS	
		SUPERIORS	I.E. SUPERVISOR	PROD. ORG'NS.	ORALLY	FILLED-IN FORM	SPECIALLY DEVEL-OPED DIRECTIVE	%	TYPE
8	25000	75	10	15	25	-	75	-	---
13	6000	10	30	60	40	30	10	20	WRITTEN REQUESTS RE FEASIBILITY
14	4500	5	65	30	50	30	20	-	---
23	4000	20	50	30	90	10	-	-	---
10	3482	100	-	-	-	-	-	100	SIMPLE WORK SCHEDULE
16	3400	40	40	20	20	10	30	40	MEMORANDUM
24	3000	10	80	10	40	30	30	-	---
22	3000	33	33	33	80	-	-	20	WRITTEN; TYPE NOT SHOWN
18	2927	60	25	15	40	20	40	-	---
11	2600	55	25	20	15	-	85	-	---
9	2330	40	40	20	30	-	-	70	WRITTEN; TYPE NOT SHOWN
17	2250	40	40	20	40	-	20	40	HIGHER HEADQUARTERS DIRECTIVES
15	2000	60	20	20	50	30	20	-	---
26	2000	10	85	5	90	10	-	-	---
4	1800	30	60	10	10	-	90	-	---
1	1400	10	90	-	80	-	20	-	---
12	900	25	50	25	100	-	-	-	---
21	900	25	50	25	80	-	20	-	---

TABLE I (Continued)

ORGANIZATION CODE	Q. 24 NUMBER DIRECT WORKERS SUPPORTED	Q. 2 % PROJECTS ORIGINATED: SUPERIORS	I.E. SUPERVISOR	PROD. ORG'NS.	QUESTION 3 METHOD OF GIVING ASSIGNMENTS ON PROJECTS: (SHOW PERCENTAGE) ORALLY	WRITTEN: FILLED-IN FORM	SPECIALLY DEVELOPED DIRECTIVE	OTHER METHODS: %	TYPE
34	800	10	70	20	30	-	10	60	WRITTEN; TYPE NOT SHOWN
35	700	25	25	50	80	-	20	-	---
29	600	40	35	25	40	-	30	30	PLAN BOOK
2	432	50	10	40	10	-	90	-	---
30	400	25	60	15	20	40	40	-	---
31	320	40	40	20	90	10	-	-	---
38	300	30	40	30	50	-	-	50	INFORMAL NOTES
32	200	-	100	-	70	-	-	30	WRITTEN; TYPE NOT SHOWN
5	190	25	75	-	80	-	20	-	---
28	125	10	70	20	30	-	-	70	FORM MEMORANDUM
33	103	-	100	-	75	-	-	25	5% WORK ORDERS; 20% OTHER, WRITTEN
37	26	5	90	5	100	-	-	-	---
7	*	20	80	-	-	-	40	60	MEMORANDUM
3	*	20	20	60	70	-	30	-	---
27	*	20	10	70	90	-	-	10	MEMORANDUM
6	*	-	-	100	-	-	100	-	---
25	*	10	70	20	15	80	5	-	---
36	*	10	80	10	95	-	-	5	WRITTEN; TYPE NOT SHOWN

*Quantity not supplied in response to questionnaire.

TABLE II

DATA FROM INDUSTRIAL ENGINEERING QUESTIONNAIRE, QUESTIONS 4, 5, AND 24

ORGANIZATION CODE	Q. 24 NUMBER DIRECT WORKERS SUPPORTED	QUESTION 4 HOW ARE PROJECTS PLANNED FOR ACCOMPLISHMENT AND CONTENT? (CHECK WHERE APPLICABLE)			QUESTION 5 WHO PARTICIPATES IN CONTROL OF PRIORITIES AND PROGRESS OF PROJECTS? (CHECK WHERE APPLICABLE)			
		CRITICAL PATH	GANTT CHARTS	OTHER (SPECIFY TYPE)	PLANT MANAGER	NEXT SUPERIOR	I.E. SUPERVISOR	OTHER (SPECIFY)
8	25000	-	X	---	-	-	X	HEADQUARTERS
13	6000	X	X	---	X	X	X	---
14	4500	X	X	---	-	X	X	PROD. AND I.E. SUPERVISORS
23	4000	-	X	UNDEFINED TYPE	-	-	X	PLANT AND ASS'T. PLANT I.E.
10	3482	-	X	---	-	X	-	---
16	3400	X	X	CHECK LIST	X	X	X	SUBORDINATE SUPERVISORS
24	3000	X	-	SCHEDULE FORM	-	X	X	ASS'T. SUPERINTENDENTS
22	3000	X	-	---	X	X	X	PLANT MGR. AND EQUIP. ENGR.
18	2927	-	X	PROJECT REPORTS	-	X	X	COMMANDER AND HIGHER HQS.
11	2600	(NO ANSWER GIVEN)			X	X	X	HIGHER HEADQUARTERS
9	2330	X	-	OUTLINE	-	X	X	SUBORDINATES
17	2250	X	-	PROJECT RECORD	-	X	X	SECOND LEVEL SUPERIOR
15	2000	-	X	---	-	X	X	---
26	2000	X	X	---	-	X	X	---
4	1800	X	X	---	-	X	X	---
1	1400	X	X	STAFF MTG. INSTR'S.	-	-	X	---
12	900	(NO ANSWER GIVEN)			-	X	X	---
21	900	-	-	VERBAL INSTRUCTIONS	-	-	X	---

TABLE II (Continued)

ORGANIZATION CODE	Q. 24 NUMBER DIRECT WORKERS SUPPORTED	QUESTION 4 HOW ARE PROJECTS PLANNED FOR ACCOMPLISHMENT AND CONTENT? (CHECK WHERE APPLICABLE)			QUESTION 5 WHO PARTICIPATES IN CONTROL OF PRIORITIES AND PROGRESS OF PROJECTS? (CHECK WHERE APPLICABLE)			
		CRITICAL PATH	GANTT CHARTS	OTHER (SPECIFY TYPE)	PLANT MANAGER	NEXT SUPERIOR	I.E. SUPERVISOR	OTHER (SPECIFY)
34	800	X	X	L.O.B.	X	-	X	---
35	700	X	X	---	X	X	X	---
29	600	X	-	PLAN BOOK	-	X	X	NEW PRODUCT SPECIALIST
2	432	X	-	---	-	-	-	PLANNING DIVISION
30	400	(NO ANSWER GIVEN)			-	X	X	---
31	320	X	X	---	X	-	X	---
38	300	-	-	MANUAL FOLLOW-UP	-	-	X	PRESIDENT
32	200	(NO ANSWER GIVEN)			X	-	X	---
5	190	(NO ANSWER GIVEN)			-	-	X	---
28	125	X	X	---	-	-	X	---
33	103	-	-	UNDEFINED TYPE	-	X	X	---
37	26	X	-	---	X	-	X	---
7	*	(NO ANSWER GIVEN)			-	X	X	TECH. OPERATIONS ORG'N
3	*	X	X	---	X	X	X	---
27	*	-	-	WORK ASSIGNMENT SHEET	X	-	X	---
6	*	X	-	FUTURE PLANT WORKLOADS	X	-	X	---
25	*	-	-	UNDEFINED TYPE	X	X	X	DISTRICT I.E.
36	*	X	-	WEEKLY REPORTS	-	-	X	SUPERIORS

*Quantity not supplied in response to questionnaire.

TABLE III

DATA FROM INDUSTRIAL ENGINEERING QUESTIONNAIRE, QUESTIONS 1, 9, AND 13

ORGANIZATION CODE	QUESTION 1: WHAT ARE THE FUNCTIONS FOR WHICH THE I.E. ORGANIZATION IS RESPONSIBLE? (SHOW PERCENTAGES)						Q. 9: ENGINEERS DO PROJECT WORK: (SHOW %)		Q. 13: ARE PROJECTS SUPPLEMENTED BY CONSULTANTS?	
	PLANT LAYOUT	METHODS STUDY	MAT'L HANDLING	LABOR STANDARDS	WAGE INCENTIVES	OTHER SPECIAL DESIGNATIONS	SINGLY	IN GROUPS	YES	NO
8	5	15	-	-	-	TRAINING - 50; CONSULTING - 30	50	50	-	X
13	2	21	2	15	-	PLANT SERVICES - 60	90	10	X	-
14	25	25	-	40	-	EQUIPMENT DESIGN - 10	50	50	-	X
23	5	10	10	30	30	TRAINING - 10; COST STUDIES - 5	50	50	-	X
10	-	10	-	90	-	---	-	100	-	X
16	10	30	30	10	-	EDPE SYST - 10; PROCEDURAL CONTR. - 10	60	40	-	X
24	10	5	5	10	20	MFG. FACILITIES - 25; PROCESS DEV. - 25	50	50	X	-
22	10	10	10	25	25	UNION MATTERS - 5; VARIOUS REPORTS - 15	50	50	X	-
18	5	35	5	20	-	ORG'N, FUNCTIONS, SUPPORT, CONSULT, EDP-35	60	40	-	X
11	5	15	-	70	-	WORK SIMPLIF. INSTR., UTILITIES STUDY-10	70	30	-	X
9	-	9	20	21	-	SYSTEMS-ORG'N STUDY - 22; VAR. ADMIN. - 28	80	20	-	X
17	5	40	-	40	-	QUAL. CONTR. - 5; MANPOWER-COSTS - 10	70	30	-	X
15	12	13	-	35	-	SYSTEMS - 30; MANPOWER - 10	80	20	-	X
26	10	2	1	40	18	ROUTING OR PROCESSING - 24; COSTS - 5	30	70	-	X
4	10	20	5	50	-	SYSTEMS - 15	85	15	-	X
1	10	-	10	5	-	SYSTEMS - 75	60	40	-	X
12	20	40	20	20	-	---	75	25	X	-
21	5	35	5	10	25	PACKAGING - 20	70	30	-	X

TABLE III (Continued)

ORGANIZATION CODE	QUESTION 1: WHAT ARE THE FUNCTIONS FOR WHICH THE I.E. ORGANIZATION IS RESPONSIBLE? (SHOW PERCENTAGES)						Q. 9: ENGINEERS DO PROJECT WORK: (SHOW %)		Q. 13: ARE PROJECTS SUPPLEMENTED BY CONSULTANTS?	
	PLANT LAYOUT	METHODS STUDY	MAT'L HANDLING	LABOR STANDARDS	WAGE INCENTIVES	OTHER SPECIAL DESIGNATIONS	SINGLY	IN GROUPS	YES	NO
34	-	25	-	-	-	PROJECT MGMT.-CONTROL, PROD. CONTR - 75	20	80	-	X
35	5	-	-	-	-	NOT DESIGNATED - 95%	90	10	X	-
29	10	15	5	30	-	TOOLING - 20; MECHANIZATION - 20	100	-	X	-
2	40	40	10	10	-	---	80	20	X	-
30	15	40	15	10	5	PRODUCTION CONTROL - 15	80	20	-	X
31	1	77	1	1	-	TOOLING - 10; PROBLEM SOLVING - 10	80	20	X	-
38	-	10	-	30	20	OPERATION PLANNING - 40	80	20	X	-
32	10	40	10	-	-	TOOLING - 30; SPECIAL MACHINERY - 10	100	-	-	-
5	30	50	20	-	-	---	95	5	-	X
28	-	40	-	30	20	COSTS - 10	100	-	-	X
33	-	-	-	-	-	LAYOUT, METHODS, STDS, PROD. CONTR - 100	50	50	-	X
37	1	40	50	4	5	---	-	100	-	X
7	-	-	-	-	-	FULL SCOPE PERF. IN SUB-STRUCTURE	60	40	-	X
3	25	25	-	-	-	SYSTEMS - 40; CONSULTING - 10	80	20	-	X
27	10	70	-	20	-	---	80	20	-	X
6	-	-	-	-	-	PLANT UTILIZATION - 70; EXPANSION - 30	100	-	-	X
25	-	-	-	-	-	LAYOUT, METHS, MHE, STDS., COSTS - 100	50	50	X	-
36	-	-	-	-	-	LAYOUT, METHS, STDS, SYSTS., REPROD.-100	90	10	-	X

TABLE IV

DATA FROM INDUSTRIAL ENGINEERING QUESTIONNAIRE, QUESTIONS 6 AND 7

QUESTION 6 - What job titles are represented in your technical personnel (quantities)?

QUESTION 7 - Of engineers having 4 years or more engineering experience, how many have engr. degrees (quantities)?

ORGANIZATION CODE	QUESTION NO. 6 AND NO. 7	ENGINEERS												PROCEDURES OFFICER	I.E. TECHN.	EDUCATION SPEC.	MANAGEMENT TECHN.	DESIGNERS	DRAFTSMEN	MANAGEMENT ANAL.	ALL OTHERS
		INDUSTRIAL	MECHANICAL	ELECTRICAL	ELECTRONIC	CIVIL	GENERAL	TIME STUDY	MANUFACTURING	CHEMICAL	METALLURGICAL	METHODS	OTHERS								
8	6	X														3		1		1	
	7	1											1								
13	6	28	24	4	4		14														
	7	16	14	3	1	1							5								
* 14	6	58	9	3						1					70						
	7	52	8	3									1								
** 23	6	X	X																		X
	7	4	4																		
10	6																4			2	
	7																				
* 16	6	20															24				4
	7	16																			
** 24	6	X	X	X		X				X			X								
	7	10	65	60		5	3			5			3								
** 22	6	X																			
	7	(90% of these are engineering graduates)																			
18	6	2															1			12	
	7	2																			
11	6																			9	
	7																				
9	6	20												10	34				2		
	7	4	4																		
** 17	6	X																		X	
	7	14																			
15	6	17															16			5	
	7	2																			
** 26	6	X																			X
	7	6	3	2		1					1										
4	6	10															17				
	7	6																			
** 1	6	X	X																		
	7		2																		
12	6	5																			
	7	3																			
21	6	7	(All have degrees)																		
	7	2																			

TABLE IV (Continued)

QUESTION 6 - What job titles are represented in your technical personnel (quantities)?

QUESTION 7 - Of engineers having 4 years or more engineering experience, how many have engr. degrees (quantities)?

ORGANIZATION CODE	QUESTION NO. 6 AND NO. 7	ENGINEERS												PROCEDURES OFFICER	I.E. TECHN.	EDUCATION SPEC.	MANAGEMENT TECHN.	DESIGNERS	DRAFTSMEN	MANAGEMENT ANAL.	ALL OTHERS
		INDUSTRIAL	MECHANICAL	ELECTRICAL	ELECTRONIC	CIVIL	GENERAL	TIME STUDY	MANUFACTURING	CHEMICAL	METALLURGICAL	METHODS	OTHERS								
34	6								20												
	7	2	2																		
35	6		(Not answered)																		
	7		(Not answered)																		
29	6	X							X			X									
	7																				
2	6	1	2	5			2								7						
	7	1	1	3			1														
** 30	6	X											X								
	7																				
** 31	6	X											X								
	7																				
** 38	6	X	X	X	X																
	7	1	20	3	2																
32	6	14								2											10
	7	2								2											
5	6	4		1		1															
	7	4		1		1															
28	6	3						2													
	7																				
33	6	1						2					9								
	7																				
** 37	6	X	X																		
	7		1																		
7	6	1	20	5	2		5						5								
	7	(Not answered)																			
* **3	6	X																			
	7	X																			
27	6	6	4																		15
	7	4	2																		
* **6	6		X	X						X											
	7		2	2						1											
** 25	6																				71
	7	3	5			2															
36	6	19																			
	7	14																			

*Four years experience not indicated, but degree is.

**Quantities not given.

TABLE V

DATA FROM INDUSTRIAL ENGINEERING QUESTIONNAIRE, QUESTIONS 14, 15, AND 27

ORGANIZATION CODE	Q. 14 ARE PROJECTS FIELD ENGINEERED?				QUESTION 15 DO ENGINEERS HAVE ASSIGNED DESK LOCATIONS OTHER THAN IN I.E. OFFICE?			QUESTION 27 HOW ARE INSTALLATION OR CONSTRUCTION PROJECTS ACCOMPLISHED? (SHOW PERCENTAGE)		
	DURING CONSTR.		AFTER IN USE		YES	NO	IF "YES" WHERE?	INTERNAL PLANT TRADES	CONTRACT	OTHER (SPECIFY)
	YES	NO	YES	NO						
8	X	-	X	-	X	-	VARIOUS FIELD ORG'NS. ON REQUEST	-	100	
13	X	-	X	-	X	-	PRIMARY ORG'N SUPPORTED	10	90	
14	X	-	X	-	-	X		60	40	
23	X	-	X	-	-	X		80	20	
10	X	-	X	-	-	X		(NO ANSWER SUPPLIED)		
16	X	-	X	-	-	X		60	40	
24	X	-	X	-	-	X		75	25	
22	X	-	X	-	X	-	IN MFG. PLANTS	75	25	
18	X	-	X	-	-	X		66	34	
11	X	-	X	-	X	-	IN SHOP SERVED WHEN LONG-TERM JOB	7	93	
9	X	-	X	-	-	X		10	90	
17	X	-	X	-	-	X		50	50	
15	X	-	X	-	X	-	IN PRODUCTION AREAS	-	100	
26	X	-	X	-	-	X		70	30	
4	X	-	-	X	-	X		90	10	
1	X	-	X	-	-	X		(NO ANSWER SUPPLIED)		
12	X	-	X	-	-	X		50	50	
21	X	-	X	-	-	X		30	70	

TABLE V (Continued)

ORGANIZATION CODE	Q. 14 ARE PROJECTS FIELD ENGINEERED? DURING CONSTR. YES	DURING CONSTR. NO	AFTER IN USE YES	AFTER IN USE NO	QUESTION 15 DO ENGINEERS HAVE ASSIGNED DESK LOCATIONS OTHER THAN IN I.E. OFFICE? YES	NO	IF "YES" WHERE?	QUESTION 27 HOW ARE INSTALLATION OR CONSTRUCTION PROJECTS ACCOMPLISHED? (SHOW PERCENTAGE) INTERNAL PLANT TRADES	CONTRACT	OTHER (SPECIFY)
34	X	-	X	-	-	X		(NO ANSWER SUPPLIED)		
35	-	X	X	-	-	X		50	50	
29	X	-	X	-	-	X		50	50	
2	X	-	-	X	-	X		-	100	
30	X	-	X	-	-	X		50	50	
31	X	-	X	-	-	X		90	10	
38	X	-	X	-	-	X		X	X	
32	X	-	-	X	-	X		(NO ANSWER SUPPLIED)		
5	X	-	X	-	-	X		50	50	
28	X	-	X	-	-	X		80	20	
33	-	X	X	-	-	X		80	20	
37	X	-	X	-	-	X		100	-	
7	X	-	X	-	-	X		-	100	
3	X	-	X	-	-	X		90	10	
27	X	-	X	-	X	-	DECENTRALIZED TO MAJOR SHOPS SERVED	20	80	
6	-	X	-	X	-	X		-	100	
25	X	-	X	-	X	-	IN OR CLOSE TO INDIVIDUAL DEPTS.	80	20	
36	-	X	-	X	-	X		(NO ANSWER SUPPLIED)		

X: %'s not spec. in Q. 27

TABLE VI

DATA FROM INDUSTRIAL ENGINEERING QUESTIONNAIRE,
QUESTIONS 8, 25, 26, 28 AND 29

ORGANIZATION CODE	QUESTION 8 — QTY. ENGRS. MEMBERS OF A UNION	QUESTION 25 — QTY. ENGRS. LEAVING FOR OTHER JOBS YEARLY	QUESTION 26 — WHAT REASONS DO ENGRS. EXPRESS FOR LEAVING? (SHOW %)				QUESTION 28 — DOES I.E. SUPV. BEAR THE DESIGNATION "ENGINEER"?			QUESTION 29 — QTY. ENGRS. REGISTERED
			PROMOTION	TYPE ASSIGNMENTS	ORGANIZATION POLICIES (SPECIFY)	OTHER (SPECIFY)	YES	NO	IF "YES", SPECIFY	
8	3	(25%)	100	-	---	---	-	X	---	2
13	0	5	70	20	---	PERSONALITY 10%	X	-	GENERAL	4
14	UNKNOWN	12	100	-	---	---	X	-	INDUSTR.	8
23	0	3	X	X	---	---	-	X	---	4
10	0	1	10	-	---	MILITARY LEAVE - 90%	-	X	---	0
16	NO QTY. SHOWN	7	100	-	---	---	X	-	INDUSTR.	5
24	0	8	X	X	---	MONETARY	X	-	ENGR. SUPT.	54
22	0	NO QTY. SHOWN	100	-	---	---	X	-	INDUSTR.	NO. QTY.
18	0	1	X	X	---	---	X	-	INDUSTR.	0
11	0	1	100	-	---	---	-	X	---	0
9	0	11	(NO INFORMATION GIVEN)				X	-	INDUSTR.	2
17	0	4	100	-	---	---	X	-	INDUSTR.	2
15	0	10	80	-	---	LOCATION - 20	X	-	INDUSTR.	0
26	0	5	90	-	---	LOCATION - 10	X	-	INDUSTR.	4
4	0	2	100	-	---	---	X	-	INDUSTR.	1
1	0	NO QTY. SHOWN	100	-	---	---	X	-	INDUSTR.	0
12	0	0	(NOT ANY TURNOVER)				X	-	INDUSTR.	0
21	0	1/3	-	-	---	SICKNESS - 50 MONETARY - 50	X	-	INDUSTR.	0

TABLE VI (Continued)

ORGANIZATION CODE	QUESTION 8 QTY. ENGRS. MEMBERS OF A UNION	QUESTION 25 QTY. ENGRS. LEAVING FOR OTHER JOBS YEARLY	QUESTION 26 WHAT REASONS DO ENGRS. EXPRESS FOR LEAVING? (SHOW %)				QUESTION 28 DOES I.E. SUPV. BEAR THE DESIGNATION "ENGINEER"?			QUESTION 29 QTY. ENGRS. REGISTERED
			PROMOTION	TYPE ASSIGNMENTS	ORGANIZATION POLICIES (SPECIFY)	OTHER (SPECIFY)	YES	NO	IF "YES" SPECIFY	
34	0	5%	X	X	---	---	X	-	INDUSTR.	1
35	0	2	100	-	---	---	X	-	PRODUCTION	0
29	0	NO QTY. SHOWN	(NO INFORMATION GIVEN)				X	-	MFG.	0
2	0	1	100	-	---	---	X	-	NOT SHOWN	0
30	0	1	(NO INFORMATION GIVEN)				X	-	METHODS	2
31	0	2	100	-	---	---	X	-	INDUSTR.	0
38	0	10	(NO INFORMATION GIVEN)				-	X	----	3
32	0	1/3	X	-	---	DEATH	X	-	PRODUCTION	4
5	0	1	100	-	---	---	-	X	----	1
28	0	0	(NO TURNOVER)				-	X	----	0
33	0	1/4	75	-	---	INABILITY TO PERFORM - 25	X	-	INDUSTR.	1
37	NO QTY. SHOWN	0	(NO TURNOVER)				X	-	PLANT	0
7	0	10	100	-	---	---	X	-	MISSILE	NO QTY.
3	0	NO QTY. SHOWN	(NO INFORMATION GIVEN)				X	-	INDUSTR.	NO QTY.
27	0	5	95	5	---	---	X	-	INDUSTR.	0
6	0	0	(INTERNAL PROMOTION ONLY)				-	X	----	0
25	0	NO QTY. SHOWN	(NO INFORMATION GIVEN)				X	-	INDUSTR.	1
36	0	NO QTY. SHOWN	(NO INFORMATION GIVEN)				X	-	NOT SHOWN	NO QTY.

TABLE VII

DATA FROM INDUSTRIAL ENGINEERING QUESTIONNAIRE,
QUESTIONS 12, 18, 20 AND 21

ORGANIZATION CODE	QUESTION 12: HOW IS PERFORMANCE OF ENGRS. JUDGED? (CHECK IF APPLICABLE)		QUESTION 18: ARE ENGRS. RANKED BY: (CHECK IF APPLICABLE)		QUESTION 21: HOW DO YOU IDENTIFY SUPERIOR PERFORMANCE? (CHECK IF APPL.)			QUESTION 20: HOW IS SUPERIOR INDIVIDUAL ENGR. PERF. RECOGNIZED? (CHECK IF APPL.)			
	OUTPUT	OTHER (SPECIFY)	PERFORMANCE	OTHER (SPECIFY)	SUBJ. JUDGMENT	PER JOB DESCRIP	OTHER (SPECIFY)	IN HOUSE ORGAN	PERSONAL LETTER	MONETARY	OTHER (SPECIFY, BUT NOT PROMOTION)
8	X	QUALITY	X	---	-	X	---	X	-	X	PUBLISHED ARTICLES
13	X	QUALITY	X	---	-	X	JOB STANDARDS	X	-	X	---
14	X	---	X	---	-	X	---	-	-	-	CIVIL SERVICE PERF. RATINGS
23	X	JOB KNOWLEDGE	X	---	-	-	OVER AND ABOVE SPECS.	-	-	X	PLANT MGMT. JOBS
10	X	QUALITY	X	EXPERIENCE	-	X	---	-	X	X	---
16	X	COMPLETENESS, MEET DATES	X	EXPERIENCE, QUALIFIED	X	X	---	-	-	X	OUTSTANDING RATING; AWARDS
24	X	QUALITY, COST	X	---	X	-	RESULTS	X	-	-	PERF. RATING
22	X	QUALITY, JUDGMENT	(NO ANSWER SUPPLIED)		X	-	---	-	-	X	VERBALLY TO INDIVIDUALS
18	X	QUALITY	X	---	-	X	---	X	X	X	---
11	-	MAJOR DUTY PERF. STD'S.	-	CAREER PROG. APPRAISALS	-	X	WRITTEN PERF. STD'S.	X	X	X	---
9	X	---	X	---	-	X	---	X	X	X	---
17	X	QUALITY	X	---	X	X	---	-	X	X	---
15	X	ATTITUDE	X	---	-	X	---	-	-	X	---
26	X	QUALITY, INITIATIVE	X	---	X	X	---	-	-	X	---
4	X	QUALITY	X	---	X	-	---	X	-	X	---
1	-	SELF-STARTER MEETS DATES	X	---	-	X	---	-	X	X	---
12	-	QUAL., QTY., ADAPTIVE	(NOT RANKED)		X	-	---	X	X	X	---
21	X	QUALITY	X	---	X	-	---	-	-	X	---

TABLE VII (Continued)

ORGANIZATION CODE	QUESTION 12 HOW IS PERFORMANCE OF ENGRS. JUDGED? (CHECK IF APPLICABLE)		QUESTION 18 ARE ENGRS. RANKED BY (CHECK IF APPLICABLE)		QUESTION 21 HOW DO YOU IDENTIFY SUPERIOR PERFORMANCE (CHECK IF APPL.)			QUESTION 20 HOW IS SUPERIOR INDIVIDUAL ENGR. PERF. RECOGNIZED? (CHECK IF APPL.)			
	OUTPUT	OTHER (SPECIFY)	PERFORMANCE	OTHER (SPECIFY)	SUBJ. JUDGMENT	PER JOB DESCRIP.	OTHER (SPECIFY)	IN HOUSE ORGAN	PERSONAL LETTER	MONETARY	OTHER (SPECIFY, BUT NOT PROMOTION)
34	X	QUALITY, COST	X	VALUE, PRES. AND FUTURE	X	X	---	-	-	X	---
35	X	LEADERSHIP, INITIATIVE	(NO ANSWER SUPPLIED)		X	-	---	-	-	X	---
29	X	INNOVATION	X	---	X	X	---	X	-	X	---
2	X	---	X	ADAPTABILITY	X	-	---	-	X	X	---
30	X	---	X	---	X	X	---	-	-	X	---
31	X	---	X	---	X	-	---	-	X	-	---
38	-	NOTHING FORMAL	-	NOTHING FORMAL	X	-	---	-	-	-	NOTHING FORMAL
32	-	RESULTS	X	---	(NO ANSWER SUPPLIED)			-	-	X	---
5	X	PERSONAL QUALITIES	X	---	-	X	---	-	-	X	---
28	-	RESULTS	X	---	-	X	---	-	-	-	MERIT RATING PLAN
33	X	COMPLETE WORK	X	---	(NO ANSWER SUPPLIED)			X	-	X	---
37	X	---	(NO ANSWER SUPPLIED)		X	-	---	-	-	X	---
7	(NO ANSWER SUPPLIED)		X	---	-	X	---	-	X	-	---
3	-	PROJ. SCOPE-IMPL. RATE	X	---	-	X	PERF. STANDARDS	-	X	X	---
27	X	---	X	EXPERIENCE	X	-	---	-	-	X	---
6	-	QUANTITY	X	---	-	X	---	-	-	X	---
25	-	ABILITY, PERS QUALS.	-	ABILITY, PERS. QUALS	X	X	---	-	-	X	BROADER JOBS
36	-	QUALITY	X	---	-	X	---	-	-	X	---

TABLE VIII

DATA FROM INDUSTRIAL ENGINEERING QUESTIONNAIRE, QUESTIONS 16, 17 AND 30

ORGANIZATION CODE	QUESTION 16: DOES ORG'N SPONSOR GRAD WORK OR OTHER WORK LEADING TO ADV. DEGREES FOR ENGRS?		QUESTION 17: IF ANSWER ON (16) IS "YES", CHECK FOLLOWING AS APPL:						QUESTION 30: ARE MANAGEMENT OR ENGR. SEMINARS GIVEN FOR YOUR ENGRS.?				
									ORG'N STAFFED		UNIVERSITY STAFFED		
	YES	NO	ON DUTY	OFF DUTY	ON-AND-OFF DUTY	EMPLOYEE PAID	ORG'N. PAID	JOINTLY PAID	LOCAL	ABOVE 100 MI. AWAY	LOCAL	ABOVE 100 MI. AWAY	OTHER (SPECIFY)
8	X	-	-	X	-	X	X	-	-	X	-	X	---
13	X	-	X	X	-	-	X	-	X	X	X	-	---
14	-	X	-	-	-	-	-	-	X	X	X	X	---
23	-	X	-	-	-	-	-	-	X	-	-	X	---
10	X	-	-	X	-	-	X	-	(NO INFORMATION GIVEN)				
16	X	-	-	X	-	X	-	-	X	-	-	-	---
24	X	-	-	X	-	X	-	-	X	X	-	-	---
22	-	X	-	-	-	-	-	-	X	X	X	X	ALL TYPES
18	X	-	X	-	-	X	-	-	X	-	-	-	AMA
11	-	X	-	-	-	-	-	-	-	-	-	-	ARMY MGT. ENGR. TRNG. AGENCY, ROCK ISLAND, ILL.
9	X	-	-	X	-	(NO ANS. GIVEN)			X	-	X	-	---
17	X	-	-	-	X	-	X	-	(NO INFORMATION GIVEN)				
15	-	X	-	-	-	-	-	-	-	X	-	X	---
26	X	-	-	X	-	-	-	X	-	-	X	-	---
4	X	-	-	X	-	-	X	-	X	-	X	-	---
1	X	-	-	-	X	-	X	-	X	X	X	X	---
12	-	X	-	-	-	-	-	-	X	-	X	-	---
21	X	-	-	X	-	-	X	-	-	-	-	-	E.I.T. EXAM PREP.

TABLE VIII (Continued)

ORGANIZATION CODE	QUESTION 16: DOES ORG'N SPONSOR GRAD WORK OR OTHER WORK LEADING TO ADV. DEGREES FOR ENGRS?		QUESTION 17: IF ANSWER ON (16) IS "YES", CHECK FOLLOWING AS APPL.:						QUESTION 30: ARE MANAGEMENT OR ENGR. SEMINARS GIVEN FOR YOUR ENGRS.?				
									ORG'N STAFFED		UNIVERSITY STAFFED		
	YES	NO	ON DUTY	OFF DUTY	ON-AND-OFF DUTY	EMPLOYEE PAID	ORG'N PAID	JOINTLY PAID	LOCAL	ABOVE 100 MI. AWAY	LOCAL	ABOVE 100 MI. AWAY	OTHER (SPECIFY)
34	X	-	-	X	-	-	X	-	-	-	-	-	M.T.M., A.M.A., A.I.I.E., etc.
35	X	-	-	X	-	-	-	X	-	-	X	-	---
29	X	-	-	X	-	X	-	-	X	-	-	-	CO. SPONSORED BY SERVICE ORGANIZATIONS
2	-	X	(NO UNIV. CONVENIENT)						-	-	-	-	AT PARENT BUREAU PRESCRIBED LOCATIONS
30	X	-	-	-	X	-	X	-	-	-	X	-	---
31	X	-	-	X	-	-	-	X	X	-	X	-	---
38	-	X	-	-	-	-	-	-	-	-	X	-	---
32	X	-	(NO ANS. GIVEN)				-	X	-	-	X	-	SERIES OF MGMT. DEVEL. COURSES
5	-	X	-	-	-	-	-	-	X	-	X	-	---
28	X	-	-	X	-	-	-	X	-	-	-	-	VARIOUS PROF. ORG'NS AND COMPANIES
33	-	X	-	-	-	-	-	-	X	-	-	-	---
37	-	X	-	-	-	-	-	-	-	-	-	-	SIZE OF FIRM DOES NOT WARRANT - ONLY ONE ENGR.
7	X	-	-	-	X	-	X	-	-	-	-	X	INDUSTRY
3	-	X	-	-	-	-	-	-	(NO INFORMATION GIVEN)				
27	-	X	-	-	-	-	-	-	-	-	-	-	A.I.I.E. PARTICIPATION ENCOURAGED
6	-	X	-	-	-	-	-	-	-	-	X	-	VARIED
25	-	X	-	-	-	-	-	-	X	-	X	-	---
36	X	-	NO ANS. GIVEN)				-	X	-	(NO INFORMATION GIVEN)			

TABLE IX

DATA FROM INDUSTRIAL ENGINEERING QUESTIONNAIRE
QUESTIONS 10, 11, 19, 22 AND 23

ORGANIZATION CODE	QUESTION 22 WHO IS I.E. ORGANIZATION SUPV.'S IMMEDIATE SUPERIOR ?	QUESTION 23 WHO DOES I.E. SUPV. THINK IT SHOULD BE IF DIFFERENT FROM (22)?	QUESTION 19 WHO DETERMINES RANKING OF ENGRS. AS TO COMPARATIVE WORTH? (CHECK AS APPL.)			QUESTION 10 COMPLETED PROJECTS NEEDING FUNDS, METHODS AND FACILITIES CHANGES, ARE APPROVED BY: (CHECK AS APPLICABLE)					Q.11 % OF (10) APPROVED?
			I.E. SUPV.	I.E. SUPV. AND OTHERS (GIVE TITLES)	OTHERS (GIVE TITLES)	NEXT SUPERIOR	2nd SUPERIOR	HIGHER LEVELS (SPECIFY)	SHOP SUPVS.	OTHERS (SPECIFY)	
8	MILITARY OFFICER	- -	X	- -	- -	X	X	(NOT SPECIFIED)	X	NONE IF UNDER $50	85
13	DIRECTOR OF MAINT.	- -	X	IMMED. SUPERIOR	- -	X	X	IF AMOUNT IS LARGE	X	- -	25
14	DIRECTOR OF MAINT.	- -	-	IMMED. SUPERIOR	- -	X	-	IF AMOUNT IS LARGE	X	- -	95
23	V.P. OF MFG.	- -	-	GRP. LDRS.- PLANT I.E.	- -	X	X	V.P.	X	- -	95
10	MANPOWER OFFICER	- -	-	AIR FORCE COMMAND	- -	-	-	IF AMOUNT IS LARGE	X	HQ. OF COMMAND	NOT AVAL.
16	MGMT. DIVISION	NEXT LEVEL	X	PERSONNEL	- -	-	X	CMDR. AFLC	X	- -	80
24	ASS'T WORKS MGR	- -	-	ALL SUPV. INVOLVED	- -	X	X	BD. OF DIRECTORS	-	- -	95
22	V.P. OF OPER	- -	X	PLANT MGR.	- -	X	X	IF AMOUNT IS LARGE	-	- -	90
18	COMP-TROLLER	- -	X	- -	- -	X	X	CMDR. AND HIGHER	-	- -	90
11	COMP-TROLLER	MGMT. DIV.	X	DA REFERRAL	- -	-	-	- -	X	VARIOUS LEVELS	80
9	DIVISION CHIEF	- -	-	SUPERIORS AND PERS.	- -	-	-	CMD. LEVEL	-	- -	100
17	MGMT. DIVISION	- -	X	SUBORD. SUPVS.	- -	X	X	HIGHER HQS.	-	- -	60
15	MILITARY OFFICER	- -	X	- -	- -	X	-	- -	-	- -	80
26	TECH. SERV.MGR.	- -	-	DIV. I.E.'S	- -	X	-	PLANT MGR.	X	- -	70
4	PLANS AND MGMT.	- -	X	- -	- -	-	X	- -	X	- -	75
1	PROD.ENGR. CHIEF	- -	X	- -	- -	-	-	LARGE EXPEND.	-	- -	95
12	MGMT. ENGR.DIV.	- -	(NO ANSWER GIVEN)		- -	X	X	WEAPONS BUREAU	-	- -	90
21	PLANT MGR.	- -	X	PLANT MGR.	- -	-	-	PLANT MGR.	-	PRES.	95

TABLE IX (Continued)

ORGANIZATION CODE	QUESTION 22 WHO IS I.E. ORGANIZATION SUPV'S IMMEDIATE SUPERIOR?	QUESTION 23 WHO DOES I.E. SUPV. THINK IT SHOULD BE IF DIFFERENT FROM (22)?	QUESTION 19 WHO DETERMINES RANKING OF ENGRS. AS TO COMPARATIVE WORTH? (CHECK AS APPL.)			QUESTION 10 COMPLETED PROJECTS NEEDING FUNDS, METHODS AND FACILITIES CHANGES, ARE APPROVED BY: (CHECK AS APPLICABLE)					Q. 11 % OF (10) APPROVED?
			I.E. SUPV.	I. E. SUPV. AND OTHERS (GIVE TITLES)	OTHERS (GIVE TITLES)	NEXT SUPERIOR	2nd SUPERIOR	HIGHER LEVELS (SPECIFY)	SHOP SUPVS.	OTHERS (SPECIFY)	
34	GEN. SUPT.	- -	-	VARIOUS MGRS.	- -	X	-	- -	-	- -	NO QTY.
35	ASST. PLANT MGR.	- -	X	- -	- -	-	X	(NOT SPEC.)	-	- -	95
29	MGR. MFG.	- -	X	MGR. MFG.	- -	X	X	IF AMOUNT IS LARGE	-	- -	95
2	(NO ANSWER)		-	PERSONNEL	- -	-	X	CMD. LEVEL	-	- -	95
30	V.P. OF PROD.	- -	X	NOT SPEC.	- -	X	X	NOT SPEC.	-	- -	98
31	FACTORY MGR.	- -	-	ENGRS. RANKED	- -	X	X	GEN. MGR.	-	- -	100
38	PRES.	PLANT MGR.	-	PRES.	- -	X	-	- -	X	- -	80
32	PLANT MGR.	- -	X	- -	- -	-	X	- -	-	- -	90
5	PLANT ENGR.DIV.	- -	X	- -	- -	X	-	- -	-	- -	85
28	DIRECTOR OF MFG.	- -	X	- -	- -	-	-	- -	-	VARIES WITH PROP.	90
33	PLANT MGR.	- -	X	- -	- -	-	-	BOARD MEMBERS	-	V.P. OF MFG.	92
37	OWNER (MGR)	- -	(NOT APPLICABLE ONLY ONE ENGR.)			X	-	- -	-	- -	50
7	ENGR. DIV.	- -	-	IMMED. SUPV.	- -	-	-	IF AMT. IS LARGE	-	- -	NO QTY.
3	MGMT. ENGR.DIV.	- -	-	2nd LEV. SUPV.	- -	X	-	NOT SPEC.	X	- -	90
27	ASS'T. WKS.MGR.	- -	X	- -	- -	X	-	- -	-	- -	90
6	ASS'T MGR. OPER.	DEPUTY ASS'T. MGR	X	- -	- -	X	-	AEC, WASH., D.C.	-	BUREAU OF BUDGET	100
25	V.P. OF OPER.	- -	-	DIV. AND DIST. IEs	OTHER DEPTS	X	X	BOARD OF DIRECTORS	X	- -	40
36	OPER. SERV.MGR.	- -	X	- -	- -	-	-	PROD. DEPT. MGR.	-	- -	80

APPENDIX C

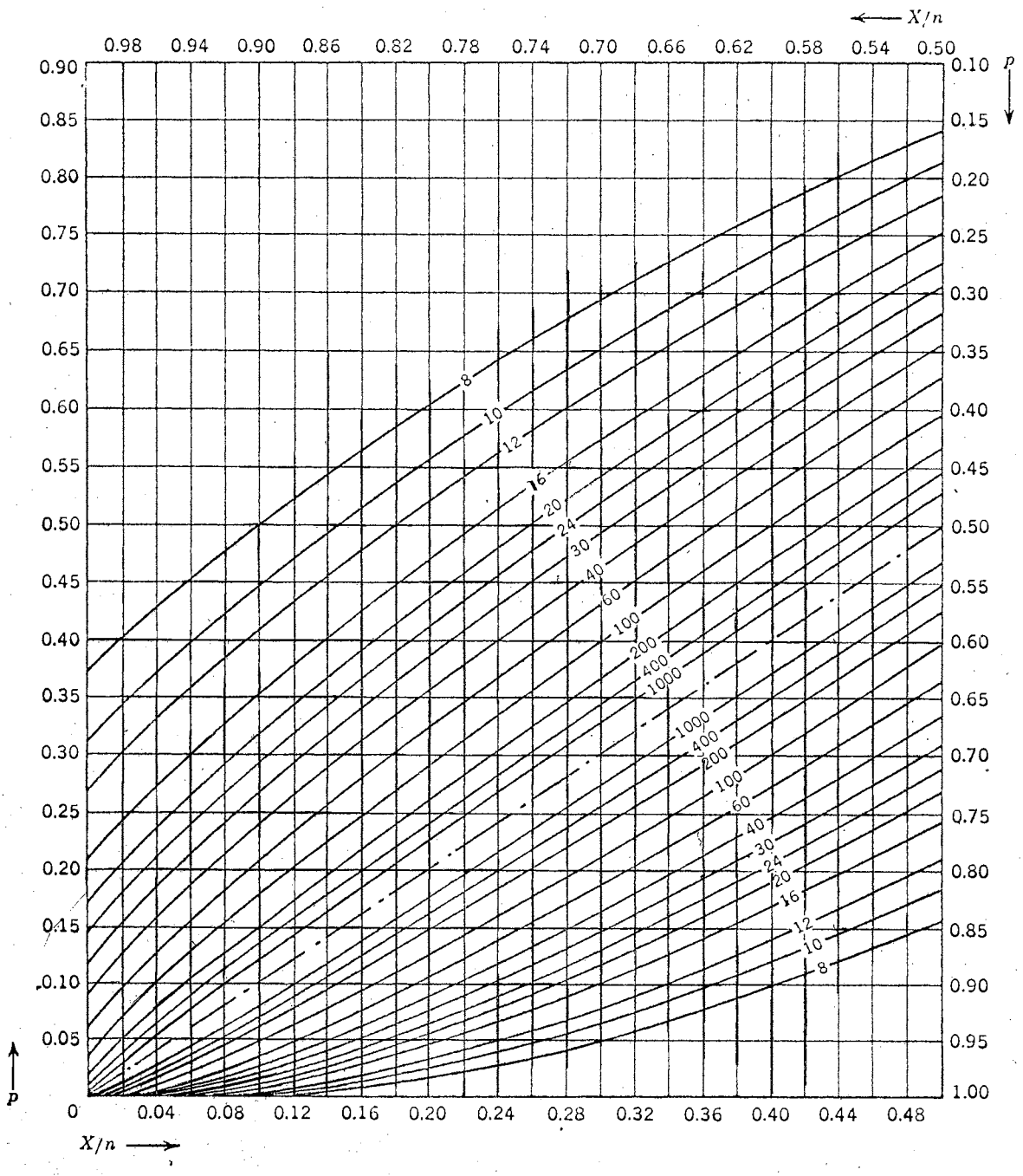
APPENDIX C

DERIVATION OF RELATIONSHIPS FOR COMPARISON OF RESULTS OF QUESTIONNAIRE

The statistical comparison of individual elements of the questionnaire is based on material from Freund (1960). Figure 1 is a graphical display for visually determining ranges on proportions of samples, p, designated in Table X as R_G (government) and R_I (industry), with 0.95 confidence that if x/n values are within the respective ranges, no significant difference exists between two x/n values being compared. R_I determines significance of agreement of x_G/n_G and R_G determines significance of agreement of x_I/n_I. The general development follows:

> If an event occurs x times out of a sample sized n, x/n is an estimate of p, the true proportion of the population that is to be evaluated.
>
> Using the normal curve approximation of the distribution of the population, one can say that if x is converted into standard units, the probability of its Z-value (displacement from the mean) lying between -1.96 and 1.96 standard units is 0.95. This Z-value is obtained by subtracting from x the mean of its probability distribution and then dividing by the standard deviation, so that

$$Z = \frac{x - np}{\sqrt{np(1-p)}}$$



(Reprinted from Steel and Torrie (1960), p. 458; original source, with permission for use in Steel and Torrie, was from E. S. Pearson and H. A. Hartley, Biometrika Tables for Statisticians, Vol. 1, Cambridge University Press, 1954.)

Figure 1. Confidence Belts for Proportions: Confidence Coefficient of 0.95

and it can then be asserted, with 0.95 probability, that

$$-1.96 < \frac{x - np}{\sqrt{np(1-p)}} < 1.96 \quad .$$

This may be simplified to

$$x/n - 1.96\sqrt{\frac{p(1-p)}{n}} < p < x/n + 1.96\sqrt{\frac{p(1-p)}{n}}$$

which is the inequality that defines the chart of Figure 1, giving ranges for p based on experienced values of x/n.

TABLE X

COMPARISON CHART FOR RANGE OF PROPORTIONS, 0.95 CONFIDENCE

QUESTION	ELEMENT COMPARED	n_G	x_G/n_G	R_G	n_I	x_I/n_I	R_I	COMPARISON
1. TYPE WORK:	PLANT LAYOUT	18	0.12	$\frac{0.02}{0.36}$	18	0.06	$\frac{0.00}{0.28}$	NO SIGNIFICANT DIFFERENCE
	METHODS STUDY	18	0.23	$\frac{0.07}{0.48}$	18	0.30	$\frac{0.11}{0.56}$	"
	MATERIAL HANDLING	18	0.07	$\frac{0.00}{0.29}$	18	0.08	$\frac{0.01}{0.31}$	"
	LABOR STANDARDS	18	0.25	$\frac{0.08}{0.51}$	18	0.17	$\frac{0.04}{0.42}$	"
2. PROJECT SOURCE:	FROM SUPERIORS	18	0.37	$\frac{0.16}{0.62}$	18	0.18	$\frac{0.04}{0.43}$	"
	INTERNALLY ORIGINATED	18	0.38	$\frac{0.17}{0.63}$	18	0.60	$\frac{0.35}{0.82}$	"
	SUGGESTED BY PROD. ORG'NS.	18	0.25	$\frac{0.09}{0.52}$	18	0.22	$\frac{0.07}{0.47}$	"
3. WORK ASSIGN-MENT:	ORALLY	18	0.37	$\frac{0.16}{0.62}$	18	0.64	$\frac{0.38}{0.85}$	DIFFERENT
	BY FORM	18	0.07	$\frac{0.00}{0.29}$	18	0.10	$\frac{0.02}{0.33}$	NO SIGNIF-ICANT DIFF.
	SPECIAL DIRECTIVE	18	0.38	$\frac{0.16}{0.63}$	18	0.09	$\frac{0.02}{0.32}$	DIFFERENT
4. PROJECT PLANNING	GANTT OR CRITICAL PATH SCEDULING	14	0.28	$\frac{0.08}{0.57}$	16	0.12	$\frac{0.02}{0.38}$	NO SIGNIF-ICANT DIFF.
	2 OR MORE TECH-NIQUES OR OTHER	14	0.72	$\frac{0.42}{0.92}$	16	0.88	$\frac{0.62}{0.99}$	"
5. PRIORITY CONTROL	I.E. SUPV. PLUS ONE SUPERIOR	18	0.22	$\frac{0.07}{0.47}$	18	0.50	$\frac{0.26}{0.74}$	DIFFERENT
	I.E. SUPV. ALONE OR NOT AT ALL	18	0.22	$\frac{0.07}{0.47}$	18	0.11	$\frac{0.02}{0.35}$	NO SIGNIF-ICANT DIFF.
	I.E. SUPV. PLUS 2 OR MORE OTHERS	18	0.56	$\frac{0.32}{0.79}$	18	0.39	$\frac{0.17}{0.64}$	"
9. ENGRS. DO PROJ. WORK:	SINGLY	18	0.69	$\frac{0.43}{0.88}$	18	0.65	$\frac{0.40}{0.85}$	"
	IN GROUPS	18	0.31	$\frac{0.12}{0.57}$	18	0.35	$\frac{0.15}{0.60}$	"
10. PROJECTS APPROVED BY:	ORGN'S INCLUD-ING SHOPS	18	0.44	$\frac{0.21}{0.68}$	18	0.22	$\frac{0.07}{0.47}$	"
	ORGN'S NOT IN-CLUDING SHOPS	18	0.56	$\frac{0.32}{0.79}$	18	0.78	$\frac{0.53}{0.93}$	"
11.	% PROJECTS APPROVED	16	0.83	$\frac{0.56}{0.97}$	17	0.85	$\frac{0.59}{0.97}$	"
12. ENGR. PERF. JUDGED	OUTPUT INCLUDED	17	0.71	$\frac{0.44}{0.90}$	17	0.77	$\frac{0.51}{0.93}$	"
	OUTPUT NOT INCLUDED	17	0.29	$\frac{0.10}{0.56}$	17	0.23	$\frac{0.07}{0.49}$	"
13.	PROJECTS SUPPL. BY CONSULTANTS	18	0.17	$\frac{0.04}{0.42}$	17	0.41	$\frac{0.18}{0.67}$	DIFFERENT (BORDERLINE)

TABLE X (Continued)

QUESTION	ELEMENT COMPARED	n_G	x_G/n_G	R_G	n_I	x_I/n_I	R_I	COMPARISON
14. PROJECTS FIELD ENGR'D:	DURING CONSTRUCTION	18	0.94	0.72 / 0.99	18	0.83	0.58 / 0.96	NO SIGNIFICANT DIFF.
	AFTER IN USE	18	0.83	0.58 / 0.96	18	0.89	0.65 / 0.98	"
15.	ENGRS. ASSIGNED DESKS ELSEWHERE	18	0.22	0.07 / 0.47	18	0.17	0.04 / 0.42	"
16.	SPONSOR GRADUATE WORK	18	0.56	0.31 / 0.79	18	0.61	0.36 / 0.82	"
17. GRADUATE WORK IS:	ON DUTY	10	0.10	0.00 / 0.41	9	0.00	0.00 / 0.34	"
	OFF DUTY	10	0.50	0.18 / 0.82	9	0.89	0.51 / 1.00	DIFFERENT
	ON-AND-OFF DUTY	10	0.40	0.12 / 0.73	9	0.11	0.00 / 0.48	DIFFERENT (BORDERLINE)
	PAID BY EMPLOYEE	9	0.22	0.03 / 0.60	11	0.18	0.02 / 0.52	NO SIGNIFICANT DIFF.
	PAID BY ORGANIZATION	9	0.67	0.30 / 0.93	11	0.36	0.11 / 0.69	"
	PAID JOINTLY	9	0.11	0.00 / 0.43	11	0.46	0.17 / 0.77	DIFFERENT
18.	ENGR. RANKED ON PERFORMANCE ONLY	17	0.76	0.49 / 0.93	14	0.79	0.49 / 0.95	NO SIGNIFICANT DIFF.
19. WHO RANKS ENGRS:	I. E. SUPERVISOR	17	0.41	0.18 / 0.67	17	0.35	0.14 / 0.62	"
	I. E. SUPERVISOR AND OTHERS	17	0.59	0.33 / 0.82	17	0.65	0.38 / 0.86	"
20. REWARD SUPERIOR ENGR. PERF.	MONETARY ONLY	18	0.17	0.04 / 0.42	17	0.53	0.28 / 0.77	DIFFERENT
	MONETARY AND/OR OTHERS	18	0.83	0.58 / 0.96	17	0.47	0.23 / 0.72	"
21. SUPERIOR ENGR. PERF. IDENT.	SUBJECTIVE JUDGMENT ONLY	18	0.16	0.03 / 0.41	16	0.44	0.20 / 0.70	DIFFERENT
	PER JOB DESCRIP. ONLY	18	0.56	0.32 / 0.79	16	0.12	0.02 / 0.38	"
	COMBINATIONS OF THESE AND OTHERS	18	0.28	0.10 / 0.54	16	0.44	0.20 / 0.70	NO SIGNIFICANT DIFF.
22.	SUPER HAS "ENGR" IN TITLE	17	0.29	0.10 / 0.56	18	0.00	0.00 / 0.20	DIFFERENT
23. SUPERIOR TO WHOM REPORTS	WOULD NOT CHANGE	17	0.82	0.56 / 0.96	18	0.94	0.72 / 1.00	NO SIGNIFICANT DIFF.
	WOULD CHANGE	17	0.18	0.04 / 0.44	18	0.06	0.00 / 0.28	"
25.	ENGR. STAFF VS. TURNOVER	11	0.18	0.02 / 0.52	6	0.09	0.00 / >0.49	"

TABLE X (Continued)

QUESTION	ELEMENT COMPARED	n_G	x_G/n_G	R_G	n_I	x_I/n_I	R_I	COMPARISON
26. ENGRS. LEAVE FOR:	PROMOTION	13	0.89	$\frac{0.59}{0.99}$	7	0.80	$\frac{0.39}{0.97}$	NO SIGNIFICANT DIFF.
	TYPE ASSIGNMENTS	13	0.02	$\frac{0.00}{0.28}$	7	0.01	$\frac{0.00}{0.38}$	"
	OTHER	13	0.09	$\frac{0.00}{0.38}$	7	0.19	$\frac{0.02}{0.59}$	"
27. PROJECTS INSTALLED	PLANT TRADES	16	0.34	$\frac{0.13}{0.61}$	14	0.66	$\frac{0.37}{0.88}$	DIFFERENT
	CONTRACT	16	0.66	$\frac{0.39}{0.87}$	14	0.34	$\frac{0.12}{0.63}$	"
28. SUPV. ENGR. TITLE	YES	18	0.72	$\frac{0.46}{0.90}$	18	0.83	$\frac{0.58}{0.96}$	NO SIGNIFICANT DIFF.
	INDUSTRIAL ENGR.	13	0.77	$\frac{0.46}{0.95}$	15	0.53	$\frac{0.26}{0.78}$	"
29.	EXP. ENGRS. WHO ARE REGISTERED	12	0.15	$\frac{0.02}{0.47}$	6	0.50	$\frac{0.16}{0.84}$	DIFFERENT (BORDERLINE)
30. SEMINARS FOR ENGRS.	LOCAL ONLY	15	0.27	$\frac{0.08}{0.56}$	16	0.44	$\frac{0.20}{0.70}$	NO SIGNIFICANT DIFF.
	ABOVE 100 MILES DIST. AND OTHERS	15	0.73	$\frac{0.44}{0.92}$	16	0.56	$\frac{0.30}{0.80}$	"

VITA

Norris Aldredge Griffith

Candidate for the Degree of

Master of Science

Thesis: AN ANALYSIS OF THE ORGANIZATION AND MANAGEMENT OF THE INDUSTRIAL ENGINEERING FUNCTION

Major Field: Industrial Engineering and Management

Biographical:

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