

---

UMR-MEC Conference on Energy / UMR-DNR Conference on Energy

---

13 Oct 1977

## Attitudes Towards Quality in the Design and Construction of Nuclear Power Plants

Daniel L. Babcock  
*Missouri University of Science and Technology*

Larry G. Harmon

Follow this and additional works at: <https://scholarsmine.mst.edu/umr-mec>



Part of the [Energy Policy Commons](#), [Nuclear Engineering Commons](#), and the [Operations Research, Systems Engineering and Industrial Engineering Commons](#)

---

### Recommended Citation

Babcock, Daniel L. and Harmon, Larry G., "Attitudes Towards Quality in the Design and Construction of Nuclear Power Plants" (1977). *UMR-MEC Conference on Energy / UMR-DNR Conference on Energy*. 291. <https://scholarsmine.mst.edu/umr-mec/291>

This Article - Conference proceedings is brought to you for free and open access by Scholars' Mine. It has been accepted for inclusion in UMR-MEC Conference on Energy / UMR-DNR Conference on Energy by an authorized administrator of Scholars' Mine. This work is protected by U. S. Copyright Law. Unauthorized use including reproduction for redistribution requires the permission of the copyright holder. For more information, please contact [scholarsmine@mst.edu](mailto:scholarsmine@mst.edu).

ATTITUDES TOWARDS QUALITY  
IN THE DESIGN AND CONSTRUCTION  
OF NUCLEAR POWER PLANTS

Daniel L. Babcock  
Associate Professor  
Engineering Management  
University of Missouri-Rolla

Larry G. Harmon\*  
McClelland Engineers  
Saudi Arabia Operations

ABSTRACT

Adequate regulation of construction (and operation) of nuclear power plants has become a matter of growing national concern. Published statements by individuals speaking from two viewpoints, those of the regulatory agencies and the nuclear power industry, suggest divergent attitudes. Nineteen statements from these two points of view were evaluated for agreement or disagreement by 38 knowledgeable persons from both industry and government (of 50 solicited in a mail survey). Survey results showed a general appreciation of the need for some level of regulation and also for the possibility of over-regulation. Differences existed within as well as between the two groups, and the lack of total polarization suggests an environment in which dialog leading to rational evaluation of regulation is possible.

INTRODUCTION

An area of growing concern to many Americans is the problem of adequate regulation of nuclear power plants to insure public safety. Various consumer groups and anti-nuclear activists are quite vocal in their opposition to further utilization of nuclear power plants to meet future energy needs. Proponents of nuclear power tell us that nuclear power is the logical means of meeting the increasing world demands for energy and that nuclear power plants have a history of safe operation. The activists call for increased assurance

from the federal government that the public will not be endangered, while the nuclear industry complains of over-regulation and quality assurance programs which drive costs far beyond any benefit derived from the programs. Obviously, there is potential disagreement between viewpoints of governmental officials (presumably representing the public) and industry representatives, and these differences can affect the design and construction of nuclear power plants. Some of these differences are evident in published statements.

\*Acknowledgement: The work reported in this paper is based wholly on the thesis "Federal Regulation to Assure Quality in the Design and Construction of Nuclear Power Plants" written in 1976 by Mr. Harmon to complete his M.S. in Engineering Management at the University of Missouri-Rolla. Although Mr. Harmon had originally proposed to write this paper, the complexities of a new position in Saudi Arabia made this impractical and Dr. Babcock, his thesis advisor, prepared it. Accordingly, the original work and data are Mr. Harmon's, but Dr. Babcock assumes responsibility for the conclusions drawn from them in this paper.

## THE REGULATOR'S VIEWPOINT

Regulation of nuclear power plant construction by the U.S. Government is vested in the Nuclear Regulatory Commission (NRC), which inherited the regulatory function of the old Atomic Energy Commission. The NRC position on the adequacy of and requirements for regulation of the design and construction of nuclear power plants is best stated in a series of papers presented by NRC officials at several conferences on quality assurance for construction of nuclear power plants.

The NRC spokesmen find it difficult to understand why the incentives of adherence to construction schedules, plant reliability, and safety do not make enforcement action by the NRC totally unnecessary.

(1) These NRC officials feel that compliance with the law should not cause undue delays in getting the job done. (2)

The federal government looks to the utilities to take the lead in assuring the quality of their plants and operations. Industry's responsibility is to assure that nuclear power plants are built and operated to comply with NRC regulations.

(3) While quality assurance can't solve all the problems, quality is a key component in the safety of a nuclear plant. The full development of quality assurance, with management aid and endorsement, will significantly influence the achievement of safe and reliable nuclear power plants. (4)

An important issue with respect to quality assurance for construction is whether quality assurance programs contribute to project delays. The NRC's position is that, far from being a delaying factor, good quality assurance programs actually facilitate the timely completion of the construction project. (5) However, the

NRC feels that there is a great amount of evidence that quality assurance programs may actually be used more as recordkeeping exercises rather than to provide a safe, reliable facility. (6)

Past experience has made it clear to the NRC that special effort is needed to develop and apply improved quality assurance practices. (7) William A. Anders, Chairman of the NRC, states (3) that nuclear quality requirements are exceptional because of their public safety implications and that they are not merely contractual--they are mandatory and enforceable under federal law. He feels that quality assurance is an area where leadership from both the industry and the government is not only desirable, it is essential. Mr. Anders further states that, as part of the NRC approach toward effective and efficient regulation, there is recognition that decisions can have far-reaching effects and that decisions must be made in a framework where both the costs and the benefits are clearly understood.

L. M. Muntzing (5) states that, in monitoring the performance of applicants and their contractors, the NRC has the advantage of a constantly enlarging fund of information based on actual experience in the field. He further states that a number of societies representing trade and professional groups are building upon the collective experience of the nuclear industry in the development of new standards. (3) Mr. Muntzing believes (8) that the miraculous safety record of nuclear power plants to date has been based upon extensive defense-in-depth, safety philosophy, tough standards, critical independent evaluation, enforcement

measures, and quality assurance programs.

#### PUBLISHED INDUSTRY VIEWPOINTS

Before presenting the "industry viewpoint" perhaps we should define "nuclear power industry". The nuclear power industry is composed of numerous utilities, architect/engineer firms, component fabricators, contractors, consultants, testing agencies technical societies, suppliers and laboratories involved in the design, construction, operation, and maintenance of nuclear power plants. The nuclear power industry would exclude the federal regulatory agencies and the public sector.

Martin Goland, President of Southwest Research Institute, has stated the nuclear industry's position well. (9) He feels the nuclear power industry is affected by the increasing insistence on perfection. The public, whether consciously or unconsciously, accepts a degree of risk in their daily lives that is roughly one thousand times greater than those in which participation is imposed by the society and culture in which one lives. Mr. Goland presents the idea that, while an occasional aircraft accident is accepted as an inevitable counterpart to the benefits of improved transportation, the nuclear power plant is given no such tolerant treatment. "It must be recognized that there is no such thing as a perfectly reliable product." (9)

Mr. Goland further believes that a safe product is one which does not constitute a public hazard beyond a socially acceptable level and that this level differs from one product to another and in the course of time. "The current 'if-we-can-place-a-man-on-the-moon-we-can-do-anything' syndrome reflects itself in the public expectation for near perfect technology." (9) As Goland sees it, public groups and

the federal government are agitating to oversee the quality of products in terms of safety and performance.

Mr. Goland has stated that, while the public makes common sense relative judgments about risks, something seems to happen to this common sense when matters become official. Traditionally industry has policed itself, often relying on trade associations and professional societies to promulgate standards and codes of ethical practices, but the federal government is now superseding these functions. According to Goland, proponents of increased regulation feel that the process of establishing industry standards is largely controlled by the industry with inadequate input from sources which reflect and protect the public interest. He states that the practical effect of government regulation is to make the government the plaintiff rather than the individual, thus reversing the balance of power between public and industry. In Goland's view the public and the industry face the danger that bureaucracy will become over-conservative and over-zealous, and will exceed its intended authority.

Mr. Goland believes that today industry is on the defensive and is often at the mercy of headline-seeking politicians or private groups pursuing their particular brand of sensational fanaticism. He feels the industry must continue to emphasize the importance of achieving a sound base of scientific and engineering knowledge from which decisions can be made. Mr. Goland provides the opinion that regulatory excesses effect our national productivity, our economic health, and ultimately our standard of living and must be avoided. (9)

Erlandson (10) states that over-inspection is not the answer. Better inspection and better training will go a long way in keeping quality within necessary limits. Meininger (11) feels that the overwhelming quality assurance aspects associated with nuclear power plants are as important as performing the work. Techniques tried and found successful in the exploration of space, applied to nuclear power, can bring technical maturity to the public trust. (12)

Muntzing (8) states that an effort to determine what is important and what isn't important in assurance quality is missing from many industry programs. He thinks organizations go overboard on such things as documentation and number of inspections apparently with the idea that this will keep them out of trouble with the NRC. He further states that controls need to be established and implemented which are efficient but not overdone.

Meininger bears out Muntzing's views when he states that "The present and future opportunities for concrete production on nuclear work represent a challenge to the ready mixed concrete industry. The work cannot be considered to be equivalent to typical commercial construction. . . consideration must be given to potential delays due to the strict enforcement of quality requirements." (11) He further states that "For those concrete producers interested in bidding on nuclear work the quality control and quality assurance aspects of the work will be more difficult to quantify than the effort and expense required to establish the needed materials handling, batching, and mixing for the job".

These viewpoints are contradictory to some extent and it is not clear which are simply opinions of single individuals and

which can be taken as a general viewpoint of some part of industry or government or even as a consensus of both. It was the intent of this research to take some of the viewpoints offered by these individuals and determine, through a mailed survey, the extent to which they were held by persons knowledgeable in nuclear power construction.

#### THE MAIL SURVEY

A questionnaire was sent to fifty individuals prominent in the nuclear field. These individuals were from industry, government, and the private sector. Names of potential respondents were taken from membership lists for various codes and standards working groups and committees, and transcripts from public hearings on nuclear power plant licensing matters. Individuals were selected from design and construction firms, utilities, government agencies and functions, consumer interest groups, consulting firms, and manufacturing firms. Consideration was given to the individuals geographical location and his company or organization affiliation in an attempt to provide a representation for all sectors of the nuclear power industry.

The intent was to obtain the opinions of these experts on nineteen statements prepared from positions presented by various government and industry spokesmen. In addition to the nineteen opinion statements, there were six questions to determine educational background, age, experience, current employment, job title, and the section of the United States in which most nuclear power plant experience was gained. In order to increase the number of responses individuals surveyed were provided with a stamped, addressed envelope and were offered a copy of the results of the survey.

No reference to the author's affiliation with the nuclear industry was made in the cover letter although the author (Mr. Harmon) was known to some of the respondents. A respondent's answers were kept confidential in a further attempt to encourage response from all sectors of the industry.

Each statement in the questionnaire was designed to require a minimum of time to answer. The respondent was asked to simply place an "X" next to the appropriate response. Simple instructions were provided at the top of the first sheet along with a short explanation of the source of the statements. The first six questions dealt with the background of the respondent and were meant to fulfill the secondary purpose of a "warm-up" for the survey.

Each item consisted of a statement with several choices except for one question concerning job title which was a "fill in the blank" question. Answering this question was made optional since some of the job titles could reveal the employer of the respondent and possibly compromise confidentiality. The nineteen opinion items could be answered by responding to the choices: Strongly agree, Agree, No Opinion, Disagree, or Strongly disagree. The "NO Opinion" answers were treated not as neutral positions, but rather as true absence of opinion. The sample size of a statement having no opinion was to be reduced by the number of "No Opinion" responses.

The survey was sent out in mid-October 1976 with a followup appeal November 1. By mid-November 40 replies had been returned. Of these, two declined to answer the questionnaire (one claiming lack of knowledge and the other proprietary reasons); the remaining 38 replies

(76% return) are analyzed below.

The first five questions provided a demographic background on respondents. They were

1. The geographical area of the United States where I have had most of my nuclear experience is (by reference to an attached map which outlined areas essentially corresponding to the five administrative regions of the NRC):

Western United States	9
Plains & Rocky Mountain States	3
Middle West	10
Northeastern United States	9
Southeastern United States	6
No Response	1

2. I would best describe my background and experience as:

Utility	10
Architect/Engineer	8
Consulting	5
Manufacturing	5
Testing	2
Government	8

3. My current position would best be described as relating to:

Design	13
Manufacturing	2
Construction	7
Testing	1
Utility	10
Government	5

4. My formal education has been in:

Engineering	31
Law	4
Business	1
Other Technical	2
Other Non-technical	0

5. My age falls within the following category:

21-25 years	0
26-35 "	3
36-45 "	13
46-55 "	17
56-65 "	4
Over 65 years	1

Respondents were also asked to provide a job title if it would not reveal their employer. Of 38 respondents, 35 did so as follows:

Consultant	1
Supervising or Senior Engineers	12
Project or Function Managers	16
Attorneys	3
Vice Presidents	3

## ANALYSIS OF OPINIONS QUESTIONS

Questions 7 through 25 (which appear on Table I following) asked for one of five responses to these 19 questions. Table I measures the "Extent of Agreement" with each question by scoring as follows:

Strongly Agree	+2
Agree	+1
Disagree	-1
Strongly disagree	-2

The total score was then divided by the number of responses (30 to 38 reduced by those offering "no opinion" on specific questions) to obtain the "mean extent of agreement" given (with standard deviation) on Table 1.

Questions were worded so that agreement with some implied a bias towards "more" regulation and with others a bias towards "less" regulation as identified on Table I. When signs are changed so that a positive score always implied favoring more regulation the mean score for each question becomes that tabulated in the right hand column of Table I. These means have an average value of -0.16, implying a modest bias of respondents toward the feeling the industry is over-regulated.

On four of these questions the relationship between agreement with the question and implied belief in the need for "more" or "less" regulation is less than clear. For example, questions 7 and 15 achieved the highest level of agreement (essential 0.9 of a possible 2.0) of the 19 questions. However, one might agree with question 7 that

The nuclear power industry is greatly concerned over increased government regulation during the design and construction of nuclear power plants.

while still believing increased regulation is necessary. Similarly one could agree in question 15 that

A sound base of scientific and engineering knowledge is the key to wise

decisions related to the regulation of the nuclear industry.

while preferring to use this knowledge base either to decrease the need for regulation (as Table I implies) or to make stricter regulation possible. Again, one can disagree with question 18

Most of the detailed recordkeeping requirements have been imposed by the industry through its various codes and standards and not by federal regulations.

and with question 22

The Nuclear Regulatory Commission has effectively demonstrated its willingness to accept industry self-regulation.

without reaching the conclusion of Table I that less regulation is desirable.

When these four questions are deleted from the right hand column of Table I the "average value" at the bottom of the column drops from -0.16 to -0.03, suggesting that individual biases toward "more" or "less" regulation were fairly balanced in the sample population.

Responses to five other questions show some net agreement worth discussion. There is general agreement that the industry has a commitment to a "viable quality assurance program" (mean response of -0.76 to the statement of question 8 that industry "lacks a strong committal", and the eight who disagreed at least did not do so "strongly"). Respondents generally agree (mean +0.58) in question 16 that "nuclear quality requirements are exceptional due to their potential effects on public safety" and do not believe (question 11, mean -0.30) that public safety can be protected without federal regulation.

On the other hand, respondents showed significant agreement (mean +0.44) to question 25

The federal government has over-

reacted to a few vocal individuals and consumer groups without regard to the overall cost-benefits in imposing an unnecessary regulatory program on the nuclear power industry.

A smaller majority (mean +0.34) also agreed with question 13 that

The public must accept a certain degree of risk in the interest of economy.

The mean response to the remaining ten questions lay between -0.23 and +0.22, implying lack of strong agreement or disagreement. (Indeed, chi-square analysis showed that in eight of these the sign was inconclusive at the 95% confidence level.) Nonetheless, the very fact that a consensus did not exist deserves some comment. For example, ambivalent answers to questions 9 and 10 show lack of consensus about the direction and amount of public expectation. Questions 17 and 18 show ambivalent opinions about the origin of need for and use of quality records. Finally, questions 20, 21, and 24 show mixed opinions as to both the ability and willingness of industry to practice self-regulation.

#### ANALYSIS OF RESPONDENT ATTITUDES

Just as the response to each question (7 through 25) was analyzed to identify an implicit bias toward "more" or "less" regulation, so were the 19 opinions (from "strongly agree" to "strongly disagree") expressed by each of the 38 respondents. Only nine of these 38 persons reported positions that suggested bias toward "more" or "less" regulation when questions were scored as shown on Table I and measured at the 95% confidence by chi-squared test. Seven of these nine seemed opposed to the current level or an increased level of federal regulation. All seven of these respondents indicated an engineering background; two are managers

and five are supervising engineers. No more than two are from the same geographical area. One individual is in the 56-65 age group, three are in the 46-55 age group, and three are in the 36-45 age group. Three respondents work for utilities, two are employed by architects/engineers, one is in government, and one is in the testing sector of the nuclear power industry.

The two individuals supporting federal regulation seemed to have nothing in common. One is in the 36-45 age group with a law background, is from the Middle West, and is employed by the federal government. The other individual is an engineer in the 46-55 age group. He indicates most of his experience in the Western section of the United States and is a Supervising Engineer for an architect/engineer firm.

(As previously stated, it was less than clear that agreement with questions 7 and 15 indicated a bias towards less regulation or that agreement with questions 18 and 22 showed bias toward more regulation. Data for individual respondents have not been adjusted by deleting these questions but a scan of the data suggests such "correction" would tend to balance the number of respondents favoring "more" and favoring "less" regulation.)

#### CONCLUSIONS

While differences naturally occur between individuals and between government and industry viewpoints, my general conclusion is that opinions are less polarized than one might expect. It was generally recognized that the nuclear power industry was "greatly concerned" over increasing government regulations, and that regulation should be based on scientific and engineering knowledge, but the implications of



this consensus on the level of regulation are unclear. Industry representatives recognize the essential public safety aspect of nuclear power plant construction and generally accept the need for some level of federal regulation. The minority who disagreed with statements that industry was committed to quality in nuclear construction and that government had somewhat "over-reacted to a few vocal individuals" at least did not "strongly disagree" with such statements.

What emerges from this analysis is a picture of attitudes towards regulation of quality in nuclear power construction that show differences of opinion within as well as between the two groups studied (government regulators and industry). Also evidenced is a general appreciation of (though seldom total agreement with) the viewpoint of the "other side". The survey suggests an environment of opinion in which dialog can continue and reasonable regulatory practices evolve.

#### BIBLIOGRAPHY

1. Keppler, J. G., Director, Region III USAEC. "The Regional Office Perspective." Paper read at the American Society for Metals Conference on Non-destructive Testing in the Nuclear Industry, June 10-13, 1974, Denver, Colorado.
2. Morrison, W.M., Chief, Design Standards Branch, USAEC. "AEC Regulatory Guidance on Quality Assurance Requirements During Construction Phase of Nuclear Power Plants." Paper presented at the American Society for Metals Conference on Nondestructive Testing in the Nuclear Industry, June 10-13, 1974, Chicago, Illinois.
3. Anders, William A., Chairman, Nuclear Regulatory Commission. Keynote speech before the American Society for Metals Conference on Nondestructive Testing in the Nuclear Industry, December 1, 1975, Denver, Colorado.
4. Vollmer, Richard H., Chief, Quality Assurance Branch, Directorate of Licensing, USAEC. "Quality Assurance for Construction, The Licensing Perspective." Paper presented at the American Society for Metals Conference on Nondestructive Testing in the Nuclear Industry, June 10-13, 1974, Philadelphia, Pennsylvania.
5. Muntzing, L. M., Director of Regulation, USAEC. "Quality Construction of Nuclear Plants - Today's Challenge, Tomorrow's Reward." Paper presented at the American Society for Metals Conference on Nondestructive Testing in the Nuclear Industry, June 10-13, 1974, Atlanta, Georgia.
6. Long, Frank J., Chief, Operations Branch, Directorate of Regulatory Operations, USAEC. "Quality Assurance for Construction." Paper presented at the American Society for Metals Conference on Nondestructive Testing in the Nuclear Industry, June 10-13, 1974, Denver, Colorado.
7. Guidance on Quality Assurance Requirements During the Construction Phase of Nuclear Power Plants - USAEC, May 10, 1974. Washington: Government Printing Office, 1974.
8. Muntzing, L. M., Partner, LeBoeuf, Lamb, Leiby & MacRae. "Safety, Reliability and Availability in Nuclear Plants: Equal Partners." Remarks at the Third Annual Mid-Atlantic Nuclear Energy Quality Assurance Seminar, March 4, 1975, New York, New York.
9. Goland, Martin, President, Southwest Research Institute. "Quality Assurance and the Public Interest." Paper presented to the American Society for Nondestructive Testing Fall Conference Banquet, October 15, 1975, Atlanta, Georgia.
10. Erlandson, E.E., Construction Manager, Stone & Webster Engineering Corporation. "Reliability in Construction - Nuclear Power Plants." Remarks at the Third Annual Mid-Atlantic Nuclear Energy Quality Assurance Seminar, March 4, 1975, New York, New York.
11. Meininger, R.C., Assistant Director of Engineering, National Sand and Gravel Association. "A New Code on the Scene" A paper presented to the National Sand and Gravel Association and National Ready Mixed Concrete Association, May 20, 1975, Silver Spring, Maryland.
12. McGrady, J., "The Role of Quality Assurance in Nuclear Plant Reliability and Availability." A paper presented at the Third Annual Mid-Atlantic Nuclear Quality Assurance Seminar, March 4, 1975, New York, New York.

TABLE I: SURVEY OPINION QUESTIONS

<u>No.</u>	<u>Question</u>	<u>Extent of Agreement* mean/s.dev.</u>	<u>Agreement favors Regulation</u>	<u>Score for Increased Regulation</u>
7.	The nuclear power industry is greatly concerned over increased government regulation during the design and construction of nuclear power plants.	+ .89 .64	less**	-.89**
8.	The nuclear industry lacks a strong committal to a viable quality assurance program during design and construction of nuclear power plants.	-.76 .72	more	-.76
9.	The public demands that federal regulation of design and construction of nuclear power plants be increased.	-.09 .66	more	-.09
10.	The public expects perfection in the design and construction/fabrication of consumer products and this expectation has been carried over to the nuclear industry.	+ .13 .77	more	+ .30
11.	Our advancing technology in design and construction of nuclear power plants can solve the problem of public safety without federal regulation.	-.30 .72	less	+ .30
12.	The technical level required for the nuclear industry is much higher than for any other undertaking of this century.	+ .22 .81	more	+ .22
13.	The public must accept a certain degree of risk in the interest of economy.	+ .34 .68	less	-.34
14.	We have gone beyond the realm of "common sense" in our current commitments to assure quality.	-.09 .65	less	+ .09
15.	A sound base of scientific and engineering knowledge is the key to wise decisions related to the regulation of the nuclear industry.	+ .91 .60	less**	-.91**
16.	Nuclear quality requirements are exceptional due to their potential effects on public safety.	+ .58 .63	more	+ .58
17.	There is a great amount of evidence that quality assurance programs are used for recordkeeping rather than to provide an assurance of quality.	+ .20 .77	more	+ .20
18.	Most of the detailed recordkeeping requirements have been imposed by the industry through its various codes and standards and not by federal regulations	-.18 .77	more**	-.18**
19.	Past experience has made it clear that there is a need for augmented efforts by the federal government to assure development and application of improved practices to assure quality.	+ .14 .80	more	+ .14
20.	The nuclear power industry has demonstrated its willingness to self-regulate its activities and assure quality during the design and construction of nuclear power plants.	+ .12 .71	less	-.12

TABLE I (Cont.)

No.	Question	Extent of Agreement* mean/s.dev.	Agreement favors Regulation	Score for Increased Regulation
21.	The nuclear power industry has the capability to self-regulate its activities and assure quality during the design and construction of nuclear power plants.	+ .10 .50	less	-.10
22.	The Nuclear Regulatory Commission has effectively demonstrated its willingness to accept industry self-regulation.	-.50 .57	more**	-.50**
23.	The design and construction phases of nuclear power plant development are overly regulated by the Nuclear Regulatory Commission.	+ .10 .62	less	-.10
24.	Lack of meaningful effort by the nuclear power industry to assure quality and protect the public forced the federal regulation we have today.	-.23 .76	more	-.23
25.	The federal government has over-reacted to a few vocal individuals and consumer groups without regard to the overall cost-benefits in imposing an unnecessary regulatory program on the nuclear power industry.	+ .44 .79	less	-.44
Average values		+ .11 .69		-.16**

\* Scored as +2 for "Strongly agree", +1 for "agree", -1 for "disagree", and -2 for "strongly disagree", with "no opinion" answers eliminated from averaging.

\*\* Scoring agreement with questions 7 and 15 as favoring less and 18 and 22 as favoring more regulation is debatable; if these are deleted the mean "score for increased regulation" drops from -.16 to -.03.

#### BIOGRAPHIES

Dr. Daniel L. Babcock has been since 1970 Associate Professor of Engineering Management at the University of Missouri-Rolla where he specializes in the project management and quality assurance fields. Before that he worked six years as a rocket propulsion supervisor and specialist for Rockwell International's Space Division, preceded by nine years experience in other industrial and governmental engineering positions. Dr. Babcock holds a Ph.D. in Engineering from UCLA and an M.S. in Chemical Engineering from MIT. He is a Registered Professional Engineer (Missouri) and a Certified Quality Engineer (American Society for Quality Control).

Mr. Larry Gene Harmon obtained a B.S. in Civil Engineering in 1967 at the University of Missouri-Rolla (UMR), followed by six years service as an Army officer and four years in the nuclear construction industries. In 1976 he wrote the thesis on which this paper is based to complete an M.S. degree in Engineering Management at UMR. Mr. Harmon was then Supervising Engineer, Quality Assurance for Union Electric Company's Callaway (Missouri) nuclear plant construction site. In mid-1977 he joined McClelland Engineers. Mr. Harmon is a Registered Professional Engineer (Missouri) and a Registered Quality Engineer (California).