UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JAN 15 1980

MEMORANDUM FOR: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

FROM: Saul Levine, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER # 80 - "DETERMINING EFFECTIVENESS OF ALARA DESIGN AND OPERATIONAL FEATURES"

80

Introduction and Summary

This memorandum transmits the results of completed research to evaluate quantitatively the usefulness and effectiveness of Regulatory Guide 8.8, "Information Relevant to Maintaining Occupational Exposures as Low as is Reasonably Achievable (Nuclear Power Reactors)." This work was performed by United Nuclear Industries, Inc. under the direction of the Environmental Effects Research Branch of RES in response to Research Request NRR 76-12.

The purpose of this program was to identify and quantitate the exposure reduction potential of the design and operational guidelines given in Regulatory Guide 8.8 and to assess the costs involved in implementing them. In addition, the results provide a data base to support a cost-benefit methodology for determining that occupational radiation exposures at light water reactors are maintained as low as is reasonably achievable.

Methodology

The program was carried out in two phases. In the first phase, the recommendations in Regulatory Guide 8.8 were analyzed with respect to the N Reactor at Hanford, Washington. Operational activities included normal operations, in-service inspections, radwaste handling, routine maintenance, special maintenance, and refueling.

A method of cost-benefit analysis of exposure reduction actions was developed and a format for the data base was designed. During development of the methodology, Safety Analysis Reports (SAR) for several plants were chosen as data sources. SAR data evaluations were made according to whole plant, system, subsystem, class, component, working groups, task, or according to source of exposure.

In the second phase, operating data were obtained from eight utility stations, representing a cross-section of plant types, sizes and geographical locations. The data from each plant represented up to

one full operating year of experience. These data were used to demonstrate the validity of the methodology developed during the first phase.

Results

The development and application of the methodology for determining the effectiveness of ALARA design and operational features for light water reactors is presented in the enclosed report[1] which demonstrates the validity of the methodology by discussing its application at eight power plants.

Application of the ALARA methodology involves two steps: (1) determining the possibility for exposure reduction, and (2) determining the best alternative for realizing the exposure reduction. The first involves use of the "Apparent Reduction Potential (ARP)" formula to calculate a number which can be compared with standard ARP values established for areas of highest ALARA concern. This formula was developed from the consideration that the potential for exposure reduction depends on a combination of exposure, dose-rate, and occupancy factors. The magnitude of personnel exposure exerts a strong influence on the potential for exposure reduction; dose-rates exert a weaker influence. Thus ARP is defined as follows:

$$ARP = \alpha E D^{n}$$

Where $\alpha = 1$
E = exposure (rem)
D = dose-rate (rem/hour)
$n = 1/3$

The factor α and the exponent n, were experimentally derived and defined to provide ARP values in the range of 0-100. The derivation is explained in an appendix to the report and tables of standard ARP values are provided.

The second step consists of a cost-benefit analysis of the proposed exposure reduction actions. This involves the use of the "Achievability Index (AI)" formula to calculate a number to rank the alternatives with regard to costs and benefits. This formula was developed from considerations of exposure limits, exposure usage histories, dose-rates, salaries, associated costs,

[1] Determining Effectiveness of ALARA Design and Operational Features, NUREG/CR-0446.

effect on exposure usage, and the planning required. Determination of the worth of exposure was based on the assumption that any dose, no matter how small, involves human risk and that the worth varies inversely as the limits and directly as the salaries and exposure usage. Dose-rates were taken into account as an implicit factor. Thus AI is defined as follows:

$$AI = \left[\frac{k\, R\, G\, E_{ai}\, E_{ag}\, E_{qi}\, E_{qg}}{C\, L_a^{\,2}\, L_q^{\,2}} \right]^B \left[P\, F_d \right]$$

Where B = +1 if exposure is decreased and cost is increased by the action (dimensionless)

B = -1 if exposure is increased and cost is decreased by the action (dimensionless)

k = a constant (dimensionless)

R = net exposure difference (rem)

G = annual salary and overhead of individual employee (dollars)

C = net cost of action (dollars)

E_{ai} = maximum annual individual exposure (rem)

E_{ag} = average annual individual exposure (rem)

E_{qi} = maximum quarterly individual exposure (rem)

E_{qg} = average quarterly individual exposure (rem)

L_a = annual exposure limit (rem)

L_q = quarterly exposure limit (rem)

P = planning and coordination factor

F_d = dose-rate factor

The derivation of this formula and an explanation of the factors are given in an appendix to the report.

Future Work

All work on this project has been completed.

Conclusions and Recommendations

As a result of this study, it was determined that Regulatory Guide 8.8 does address the significant methods of exposure reduction. With proper data inputs, the ARP-AI methodology can be used to assess quantitatively the usefulness and effectiveness of the guidance in the Facility and Equipment Design Section of Regulatory Guide 8.8 and to assess qualitatively nearly all the guidance in Regulatory Guide 8.8.

The computer codes developed by this project provide a method for identifying aspects of site operations that may require changes to meet ALARA guidelines. We recommend that your staff use the ARP-AI methodology in evaluating the ALARA programs of reactor license applicants.

For further information on this study, please contact Dr. Judith D. Foulke (427-4358).

Robert D. Bunt

~~Saul Levine~~, Director
Office of Nuclear Regulatory Research

Enclosure: NUREG/CR-0446

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Robert Budnitz

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NRC FORM 318 (9-76) NRCM 0240 ★ U.S. GOVERNMENT PRINTING OFFICE: 1978 - 265 - 769

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