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Index of Risk Exposure and Risk Acceptance Criteria

Prepared by B. Miller, R. E. Hall

Brookhaven National Laboratory

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U.S. Nuclear Regulatory Commission

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Index of Risk Exposure and Risk Acceptance Criteria

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Washington, D.C. 20555
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ABSTRACT

This report contains abstracts of articles which address various aspects of quantitative risk analysis, covering the subjects of numerical risk criteria, methodology and data. The articles were published primarily from 1976 to date in technical journals, reports, papers, etc. The articles selected for this report were judged to have relevance to nuclear power plant risk evaluations and to the possible establishment of the acceptability (or unacceptability) of calculated nuclear power plant risks. A matrix of the various risk criteria proposed is presented.

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INTRODUCTION

This document is a compilation of abstracts of various articles, reviews, symposiums, reports, etc., which cover numerical risk analysis with specific consideration given to those involved in formulating and utilizing numerical risk criteria. Emphasis has been placed on articles from the nuclear industry, however articles from non-nuclear related fields which were deemed relevant to nuclear risk evaluations and numerical risk criteria are included.

Articles are classified by three categories: criteria, methodology and data. Articles meeting the qualifications of each category are so indicated in the "Title" table of contents, as well as in the abstract format. The criteria for each classification are as follows:

Criteria: Articles that discuss the need for, the pros and cons of, the development of, and/or the philosophy of criteria are indicated with a "C" or "yes".

Methodology: Articles that discuss the pros and cons of various methodologies, methodology requirements for probabilistic evaluations, or actually present a methodology that may assist in the development of a risk criteria are indicated with an "M" or "yes".

Data: Articles that discuss the problem with lack of data for risk analysis, or present numerical values that may assist in the development of a criteria are indicated with a "D" or "yes".

Examples on how this classification system is applied are as follows:

- Articles that present a numerical criteria would be indicated with a "C" and "D"
- Articles that discuss the methodology requirements for probabilistic evaluations, including input data required would be indicated with an "M" and "D"
- Articles that discuss a criteria along with various methodologies, but do not present numerical data will be indicated with a "C" and "M"
- Articles that present historical information on risk statistics would be indicated with a "D"
- Articles that present risk comparisons would be indicated with a "D"

The format by which the abstracts are written is as follows:

File #: Brookhaven National Laboratory file number.

Title: Title of article.

Author(s): Name of author(s) or principal investigator.

Affiliation: Corporation or university with which author is affiliated.

Paper, Periodical, Report, Document, etc.: Presented or published (e.g. symposium paper presented, NUREG, report number, periodical and volume.)

Date: Date associated with previous category.

Contents: Article data (pages, figures, tables, appendices, etc.) and the classification.

Abstract: Abstract of article as presented by author and possibly modified slightly to meet the requirement of this document, or abstract written by this author.

In presenting the abstracts, we have attempted to summarize the results, findings, and/or conclusions along with stating any uncertainties or confidence levels as presented in the articles without injecting the viewpoints of the authors of this report.

Due to the frequent use of the word "risk" throughout the abstracts, it was deemed necessary to clarify the specific meaning of the word. Thus following the initial use of the word "risk" within an abstract, it will be followed by a symbol that corresponds to one of the following definitions:

$risk^{e}$ - risk expressed as expected consequence

$risk^{pc}$ - risk expressed as probability vs. consequence curve

$risk^{f}$ - risk expressed as probability of fatality

$risk^{g}$ - risk used in the general context to mean some measure of consequence or harm

While the report presents a matrix of the various proposed risk criteria, see Table 1, it is intended to provide a bibliography of articles which cover numerical risk analysis for those involved in formulating and utilizing numerical risk criteria.

Table 1

Proposed Risk Criteria

Author	Affiliation	Date	Descriptor	Code
AIF	Atomic Industrial Forum	5-80	Average number of public fatalities per year attributable to the operation of nuclear power (US only) exclusive of fuel cycle should be lower than .1 per year per 1000 MW(e).	F
			Frequency of serious core damage per reactor shall be lower than 10^{-4} per reactor year.	M
Atchison, R.	Canadian Atomic Energy Control Board	7-79	Each special safety system shall be readily tested, as a system, and shall be tested to demonstrate that any special safety system is no higher than 10^{-3}.	S
			Radioactive effluent due to normal operation shall be such that the dose to any individual member of the public, from all sources shall not exceed 0.5 rem per reactor year whole body or 3 rem per year thyroid	R
			Total expected dose to the population around the reactor site shall not exceed 10^4 man-rem per year.	D
			For any postulated combination of an initiating event and failure of a specific safety system the predicted dose to any individual shall not exceed 25 rem whole body, 250 rem thyroid, and 10^6 man-rem.	D
Bowen, J. from Okrent, D.	UKAEA UCLA	12-75	The frequency per reactor year for loss of life shall be 10^{-5} with some higher degree of confidence levels assigned to more severe consequence events.	F
Burns, D.	Los Alamos Scientific Lab.	1979	The frequency of core melt accident 5×10^{-7}/ry.	M

Table 1 (Cont'd)

Author	Affiliation	Date	Descriptor	Code
Canadian Atomic Energy Control Board	Proposed Safety Requirement for Licensing of CANDU Power Plants	11-78	Criteria on frequency of any initiating event assuming no special safety system action - exposure in SV*	R

Consequence at Event		Accident Freq. (per reactor unit per annum)
Whole Body	Thyroid	
0-0.0005	0-0.005	10^{-1}
0.0005-0.005	0.005-0.05	10^{-2}
0.005-0.05	0.05-0.5	10^{-3}

Criteria on frequency of any serious event sequence combining initiating event and safety system failure - exposure in SV* — R

Consequence at Event		Accident Freq. (per reactor unit per annum)
Whole Body	Thyroid	
0.05-0.1	0.50-1.0	10^{-4}
0.1-0.3	1.0-3.0	10^{-5}
0.3-1.0	3.0-10.0	10^{-6}

*1SV = 100 rem

Author	Affiliation	Date	Descriptor	Code
Farmer, F	UKAEA	4-67	Suggested acceptable fatality rates for events that lead to various iodine releases	R

Consequences of Event (curies released)	Fatality Rate (persons per 10^3 ry)
10	0.3
10^2	2
10^3	3
10^4	2
10^5	0.7
10^6	0.2

Arrived at this result by (1) presenting a thyroid dose for a given release, (2) assumed thyroid cancer rate per man-rem, and (3) calculated fatality rate per reactor years.

Table 1 (Cont'd)

Author	Affiliation	Date	Descriptor	Code
Griesmayer, M.	IEEE W.G. 5.4 meeting of 5-15-80	5-80	An event causing > 10% of noble gas inventory to be leaked into the primary coolant shall have a frequency less than once in 5 plant lifetimes (5×10^{-3}/ry)	R
			The frequency of large scale core melt (> 10% of core) shall be less than once in 25 plant lifetimes (1×10^{-4}/ry).	M
			The frequency of large scale uncontrolled release (> 10% of iodine inventory) shall be less than once in 125 plant lifetimes (2×10^{-5}/ry).	R
Herbst, J Hubbard, F.R.	Combustion Engineering	10-76	Prescribed safety criteria relating the radiological dose at site boundary as a function of incident frequency:	D
			Incidents of moderate frequency (10 CFR 50 Appendix I) 1-0.5/r-y.	
			Infrequent incidents (0.1% of 10 CFR 100) $0.5\text{-}1.25 \times 10^{-2}$/r-y.	
			Incidents not likely to occur (small fraction) (1% of 10 FR 100) $1.25 \times 10^{-2}\text{-}10^{-3}$/r-y.	
			Incidents of low probability (well within) 10% of 10 CFR 100) 10^{-3} - 10^{-4}/r-y.	
			Incidents of exceedingly low probability up to 10 CFR 100 (10 CFR 100) 10^{-4} - 10^{-7}/r-y	
Kinchin, G.H.	UKAEA	8-78	The frequency of early death close to boundary shall be less than 10^{-6} per person per reactor year.	F
			The frequency of delayed death shall be less than 3×10^{-5} per person per reactor year.	F

Table 1 (Cont'd)

Author	Affiliation	Date	Descriptor	Code
Lellouche, G.	EPRI	10-79	If the event probability carries along with it unacceptable* consequences and is greater than 10^{-4}/yr, then it must be fixed.	E
			If the event probability is greater than 10% of 10^{-4}/yr, its consequences must be thoroughly evaluated and decision made on the basis of value/impact.	E
			If the event probability is greater than 1% but less than 10% of 10^{-4}, it should be thoroughly evaluated and a decision made (probably) on the basis of risk comparison with other local risks (as well as value/impact).	E
			If the event probability is less than 1% of 10^{-4}/yr, it should be accepted	E
			*Author does not define unacceptability, he feels such a definition clearly must arise from the socio-political not the technical process.	
Okrent, D & Whipple	UCLA School of Engineering and Applied Science	1977	Proposed risk acceptance criteria for the most exposed individuals: 1. For essential technologies, 2 x 10 per year at 90% confidence level 2. For beneficial technologies, 10 per year at 90% confidence level 3. For peripheral technologies, not generally beneficial to society, 2 x 10^{-6}/year at 90% confidence level.	F
Otway, H. & Erdmann, R.C.	UCLA School of Engineering and Applied Science	1970	The concept of risk, based on the authors evaluation of passed history is as follows:	F
			For accidents with frequencies of fatality above 10^{-3} per person per year (py) immediate action is taken to reduce the hazard(s).	F

Table 1 (Cont'd)

Author	Affiliation	Date	Descriptor	Code
Otway, H. & Erdmann, R.C. (cont'd.)			For accidents with frequencies of fatalities in the vicinity of 10^{-4} py, people are willing to spend money to control hazard.	F
			For accidents with frequencies of fatalities in the vicinity of 10^{-5} py, people still recognize the risk and may accept a certain amount of inconvenience to avoid these risks.	F
			For accidents with frequencies of fatalities of the order of 10^{-6} py, they are considered to be of no great concern by the average person. They are considered an act of God by some.	F
Wall, I.	EPRI	5-80	A tentative guideline for the frequency of significant cladding degradation such as TMI 2 would be in the range of $\leq 10^{-4}$/r-y.	C
			Return period for TMI 2 like events for all reactors shall be no greater than 30 to 60 years.	C
			Expected accidental population dose < 500/pr/r-y	D
			Expected accidental latent cancer fatalities < 0.05/r-y.	F
			Probability of 1 latent cancer fatality < 10^{-4}/r-y.	F
			Probability of early death at site boundary $<10^{-8}$/r-y.	E
			ATWS goal of causing significant cladding degradation $\leq 10^{-5}$/r-y.	A
Zebroski, E.		3-80	Accidents which reach the stage of core melt, taking account of actual population of civilian reactors in operation in the U.S., shall have a frequency of no more than one such occurrence in 30 years.	M

Table 1 (Cont'd)

Author	Affiliation	Date	Descriptor	Code
Zebroski, E. (cont'd.)			Reactor safety systems and containments shall be maintained and operated so that even if core melt occurred a radiation release leading to a dose of 1R or more to the public will have a frequency per reactor year no higher than 1×10^{-3}.	R

Code Classification:

M - core melt
R - release
D - dose
S - safety system
C - cladding
F - fatalities
A - ATWS
E - event

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File #39

Title: Historical Perspectives on Risk for Large-Scale Technological Systems

Author(s): W. Baldewicz, E. Haddock, Y. Pragoto, R. Whitley, V. Denny

Affiliation: University of California School of Engineering and Applied Science

Report/Date: UCLA-ENG-7485, November 1974

Contents: 165 pages, 19 figures, 65 tables
Criteria no, Methodology no, Data yes

Abstract: An empirical study of historical trends in the risks[e] sustained by participating populations for various large-scale technological systems is presented. Results are reported for three system categorizations: Natural Hazards, Man-Made Hazards, and Occupational Hazards. A new model for risk assessment is introduced that avoids the problems associated with assessing the value of a human life in risk-benefit decision making. The model treats risk in terms of loss of life expectancy. From the historical trends in L_f (the rate of loss of life expectancy) for the rate systems studied, it concluded that: (1) appreciable disparities exist in L_f for occupational hazards, despite nearly similar benefits for the population at risk; (2) federal legislation can have a significant impact on risk abatement; (3) federal safety legislation efforts appear to be most responsive to high publicized disastrous accidents rather than to chronic, low-level hazards; (4) the introduction of a new technology as well as lack of maintenance of old technology can result in risk level increases; and (5) natural hazard risk levels are extremely low and can further be reduced in some cases, either by collective or individual precautionary measures.

File #30

Title: The Concept of a Threshold of Effect in Estimating the Human Health Risk of Chemical Toxicants

Author(s): William M. Upholt

Affiliation: Office of Water and Hazardous Materials, Environmental Protection Agency

Publication: Risk Benefit Methodology and Application; some papers presented at the Engineering Foundation Workshop held at Asilomar, California, September 22-26, 1975

Report/Date: UCLA-ENG-7598, December 1975

Contents: 10 pages
Criteria yes, Methodology no, Data no

Abstract: Article states no numerical threshold value is useful in setting a "safe" level, even if such a level exists in theory. When exposed to radiation, toxic chemicals or corengenics a safe level is considered as being the highest dose at which no effects would be observed. With the term effect being defined in some sense that requires a significant reaction by a organism as a whole, then there will be a clearly defined dosage below which there would be no evidence of a reaction. In all regulatory decisions the scientist should describe as clearly as possible, what they believe the risk to be at each of the achievable control levels. They should describe the model or rationale for arriving at these estimates together with the rationale for higher or lower estimates, thus providing evidence of their degrees of uncertainty. This would provide the decision maker with a usable estimate of reduction in risk that he can balance against the social cost of the regulation.

File #30

Title: The Economic Approach to Risk-Benefit Analysis

Author(s): J. Hirshleifer

Publication: Risk-Benefit Methodology and Application; some papers presented at the Engineering Foundation Workshop held at Asilomar, California, September 22-26, 1975

Report/Date: UCLA-ENG-7598, December 1975

Contents: 12 pages
Criteria yes, Methodology yes, Data yes

Abstract: Article covers some of the strengths and weaknesses of cost-benefit analysis as a general procedure, then accents the special feature that distinguishes risk-benefit analysis. The need to account for a particular type of "external" or non-marketed effect: the chance of loss of life, or other injury suffered by members of the community as a result of adoption of a public policy alternative under consideration is discussed. The author states that it seems highly unrealistic to assert that the supply and demand for risk taking will determine a definite "price of survival probability," a price that everyone will be aware of and can adapt to, and consequently a risk-taking equilibrium.

File #30

Title: Development of Approaches for Acceptable Levels of Risk

Author(s): W. D. Rowe, Ph.D.

Affiliation: U.S. Environmental Protection Agency

Publication: Risk-Benefit Methodology and Application; some papers presented at the Engineering Foundation Workshop held at Asilomar, California, September 22-26, 1975

Report/Date: UCLA-ENG-7598, December 1975

Contents: 16 pages, 5 tables, 1 figure
Criteria yes, Methodology yes, Data no

Abstract: The acceptability of new technology options depends upon the development of methods to establish acceptable levels of risk[e] for society against which these options may be compared. Insight into the problems of developing acceptability criteria is provided which may lead to the development of such criteria. Discussed are the process of risk determination, objective and subjective risk parameters, valuation of consequences, societal risk estimates and elements of a methodology for acceptable level of risk determination, based on risk vs. benefit.

File #18

Title: An Approach to Societal Risk Acceptance Criteria and Risk Management

Author(s): D. Okrent, C. Whipple

Affiliation: UCLA School of Engineering and Applied Science

Report/Date: UCLA-ENG-7746, June 1977

Contents: 27 pages, 2 tables, 1 figure
Criteria yes, Methodology no, Data yes

Abstract: A quantitative approach to risk acceptance criteria and risk management is proposed for activities involving risk to individuals not receiving direct benefits, such as employment, from the activity. Societal activities are divided into major facilities or technologies, all or part of which are categorized as essential, beneficial, or peripheral, and a decreasing level of acceptable risk to the most exposed individual is proposed (2×10^{-4}/year for essential, 10^{-5}/year for beneficial, and 2×10^{-6}/year for peripheral activity). The risk[f] probability of death from a technology or situation, would be assessed at a high confidence level (say, 90%), thereby providing an incentive for gaining better knowledge.

Each risk-producing facility, technology, etc. would have to undergo assessment of risk both to the individual and to society. The cost of the latter would have to be internalized, probably via a tax paid to the federal government, which in turn would redistribute the benefit as national health insurance or reduced taxes to the individual. Risk aversion to large events would be built into the internalization of the cost of risk.

File #26

Title: The Comparative Risks of Different Methods of Generating Electricity

Author(s): A policy statement of the American Nuclear Society

Report/Date: ANS Document PPS-3, October 1979

Contents: 3 pages
Criteria yes, Methodology no, Data yes

Abstract: The risks[f] associated with producing electric power with nuclear energy are small when compared with either the risks associated with other methods of electricity production, coal, solar, fusion, etc. or the societal risks to which we are exposed in our daily lives. Scientific data supporting this position are well documented. The public, upon whom ultimate energy decisions rest, should become aware of these data. The consequence of poor decisions in the development of electric energy resources is at least an unwarranted increase in the costs of electricity, and at worst may lead to long-term society-wide economic trauma. This position statement considers studies of the comparative risks of several electrical energy sources, as well as other societal risks. The American Nuclear Society concludes that compared with all the sources that have the potential to supply large amounts of electric power, nuclear energy is as safe as or safer than the available alternatives and endorses nuclear power in conjunction with the use of coal as the fuel sources for America's electrical power needs.

File #22

Title: Methods for the Evaluation of Risk

Author(s): J. R. Beattie, E. D. Bell, J. E. Edwards

Affiliation: UKAEA Authority Health & Safety Branch

Report/Date: AHSB(S) 159, 1969 reprinted 1971

Contents: 37 pages, 7 figures, 5 tables
Criteria no, Methodology yes, Data no

Abstract: Mathematical methods are presented which are used to evaluate the risk to the population distribution surrounding a hypothetical large power reactor. The reactor is assumed to satisfy a control curve of the Farmer type relating the activity released in a given range of curies on a logarithmic scale to the probability that the release will occur. Probability versus consequence results are presented for cases in which the release of iodine is postulated to have been released. The results are expressed in the form of curves relating number of cases of thyroid cancer to

the probability that the number lies in a given range also on a logarithmic scale. After a general mathematical discussion has been given, a variety of particular solutions are examined which reveal or illustrate the effects of the release control curve, the dose-risk curve for the individual, and the population distribution for the site, upon the form of the frequency-casualty curve (in this case the f-N curve where N is the number of cases, and f is frequency). A method for computing risk, ^{pc} of thyroid dose due to a release, using the population figures and meteorological data for a site is given, including an outline of the "STRAP" program for this purpose. The f-N curves derived in this way are given for seven population distributions, and general conclusions regarding comparative risks are discussed.

File #119

Title: Initial Quantification of Human Errors Associated with Reactor Safety System Components in Licensed Nuclear Power Plants

Author(s): W. J. Luckas, R. Hall

Affiliation: Brookhaven National Laboratory, Upton, N.Y. 11973

Report/Date: NUREG/CR 1880/BNL-NURE 51323, December 1980

Contents: 34 pages, 5 tables
Criteria no, Methodology yes, Data yes

Abstract: This report provides a methodology for an initial gross quantification of human errors made in conjunction with several reactor safety system components operated, maintained, and tested in licensed nuclear power plants. The resultant human error rates provide the first real systems bases of comparison for existing derived and/or best judgement equivalent set of such rates or probabilities.

File #22

Title: Risks to the Population and the Individual from Iodine Releases

Author(s): J. R. Beattie

Affiliation: UKAEA, Authority Health and Safety Branch

Memorandum: Appendix to "Siting Criteria - A New Approach" by F. R. Farmer

Report/Date: Appendix to SM-89/34, 1967

Contents: 8 pages, 3 figures
Criteria yes, Methodology yes, Data yes

Abstract: Evaluates the risk of releasing iodine from a reactor in or near a populated area. This is achieved first by assessing the total number of cases likely to arise in the populated area, and secondly, by assessing the risk, development of thyroid cancer, to an individual living near the reactor.

File #44

Title: Proposed Criteria for Reactor Risk Assessment

Author(s): R. D. Burns, III

Affiliation: Energy Division, Los Alamos Scientific Laboratory

Report/Date: Response to a letter by W. E. Veseley (NRC), 1979

Contents: 7 pages
Criteria yes, Methodology yes, Data yes

Abstract: Author proposes criteria which would require a sufficiently low chance of core melt such that accidents involving large radioactivity release would contribute negligibly to risk during the expected life of the nuclear industry. Risk^{f} would be dominated instead by the more frequent, low-level releases from LOCAs, steam generator tube ruptures, and fuel-handling accidents. The proposed criteria are: (1) one core melt accident per 2,000,000 year per reactor; (2) an average individual latent cancer risk of 10^{-7} per year per person; (3) accident probability vs consequence curves which predict annual cumulative low-level accident releases below 500 person-rem per reactor year average. No discussion on associated confidence levels are given.

File #45

Title: Nuclear Reactor Philosophy and Criteria

Author(s): R. J. Atchison

Affiliation: Director, Assessment Branch, Atomic Energy Control Board

Paper: Presentation on July 18, 1979, to the Select Committee on Ontario Hydro Affairs Summer Schedule on Hearings on the Safety of Nuclear Reactors

Date: July 1979

Contents: 23 pages, 1 table, 1 figure
Criteria yes, Methodology yes, Data yes

Abstract: The Canadian Reactor Safety Philosophy Criteria and Principles are explained, philosophy being the defense - in depth concept. Five lines of defense are named and it is noted that emphasis is placed on quality assurance throughout. In addition, the paper states that particular care is taken to eliminate opportunities for human error during operation or during postulated accident situation. In applying this basic philosophy, a number of specific criteria and principles are evolved and discussed in detail: (1) design and construction are to conform to the best applicable codes, standards, and procedures; (2) all process systems essential to the reactor shall be designed such that the total of all serious failures does not exceed 1 per 3 years; (3) safety systems shall be physically and functionally separate from process systems to the extent possible; (4) each special safety system shall be readily testable, as a system, to demonstrate that its unavailability is less than 10^{-3}; (5) standards are set for radioactive effluents due to normal operation, for the effectiveness of special safety systems in case of a process failure, and for "dual" failures (process and safety system failure).

File #2

Title: Probabilistic Risk Assessment in Nuclear Power Plant Regulation

Author(s): I. B. Wall

Affiliation: Electric Power Research Institute

Paper: Paper presented at the Second International Seminar, Structural Reliability of Mechanical Components & Subassemblies of Nuclear Power Plants, Berlin (West), Germany, August 20, 1979

Date: August 1979

Contents: 38 pages, 2 figures, 2 tables
Criteria yes, Methodology yes, Data yes

Abstract: A specific program is recommended for more effective use of probabilistic risk assessment in nuclear power plant regulation. It is based upon the engineering insights from the Reactor Safety Study (WASH-1400) and some follow-up risk assessment research by USNRC. The Three Mile Island accident is briefly discussed from a risk viewpoint to illustrate a weakness in current practice. The development of a probabilistic safety goal is recommended with some suggestions on underlying principles. Some ongoing work on risk perception and the draft probabilistic safety goal being adopted by Canada is described. Some suggestions are offered on further risk assessment research. The author does not specifically propose a criteria, but comments and evaluates various findings and criteria that exists today. Finally, some recent actions by the U.S. Nuclear Regulatory Commission are described.

File #31

Title: The Recognition - If Not the Acceptance - of Risk in an Industrial Society

Author(s): F. R. Farmer

Affiliation: UKAEA

Periodical: Journal of the Institute of Nuclear Engineering (Nuclear Energy), Volume 18, No. 4, pp. 99-105, August 1977

Contents: 7 pages
Criteria yes, Methodology no, Data yes

Abstract: A discussion of the recognition and acceptance of risk within our society. Examines the problem of drafting acceptable risk criteria for both nuclear and non nuclear risks.

File #32

Title: Principles and Standards of Reactor Safety

Author(s): L. Cave

Affiliation: Pollution Prevention (consultants)

Periodical: Nuclear Engineering International, Volume 18, No. 203, pp. 365-66, April 1973

Contents: 2 pages
Criteria yes, Methodology no, Data no

Abstract: Reviews the 45 papers presented at the IAEA International Symposium on Reactor Safety, held at Julich, February 5-9, 1973. The paper summarizes topics discussed: Acceptable Risk, Accident Effects and Consequences, Standards and Criteria, Operation Experience.

File #33

Title: Risk Benefit Evaluation for Large Technological Systems

Author(s): D. Okrent

Affiliation: UCLA School of Engineering and Applied Science

Periodical: Nuclear Safety, Volume 20, No. 2, March-April 1979

Contents: 16 pages, 8 figures
Criteria yes, Methodology yes, Data no

Abstract: The related topics of risk-benefit analysis, risk analysis, and risk-acceptance criteria (how safe is safe enough?) are of growing importance. An interdisciplinary study on various aspects of these topics, including applications to nuclear power, was undertaken. A final report, entitled, "A Generalized Evaluation Approach to Risk-Benefit for Large Technological Systems and its Application to Nuclear Power," was issued in 1978. This article briefly summarizes portions of the final report dealing with general aspects of risk-benefit methodology, societal knowledge and perception of risk and risk acceptance criteria.

File #42

Title: Comparative Biological Hazards of Chemical Pollutants and Radiation

Author(s): R. N. Mukherjee

Affiliation: International Atomic Energy Agency

Periodical: International Atomic Energy Agency Bulletin, Volume 20, No. 3, pp. 31-38, June 1978

Contents: 8 pages, 3 tables
Criteria no, Methodology no, Data yes

Abstract: Chemical pollutants from conventional energy and industrial sources pose a hazard to man's health. Insufficient knowledge of their detailed mechanisms of interaction with biological systems represents the greatest handicap in current attempts to realistically assess the health risks of chemical pollutants in the short and long terms. The author's position is that so far nuclear power has succeeded in achieving a remarkable health safety record. A projection from past experiences, together with continued efforts to improve health safety aspects, seems to justify an expectation that proposed expansions in the nuclear power program will not have an unfavorable environmental impact. The author concludes by saying the potential hazards and challenges from the associated radiation in man's environment have proven manageable. More attention now needs to be paid urgently to safeguard human health and environment against the chemical pollutants.

File #35

Title: An Index of Hazard for Radioactive Waste (Revised)

Author(s): S. R. Watson

Affiliation: Lawrence Livermore Laboratory, Livermore, California

Report/Date: Interim Technical Report PR 78-10-80R, June 1978

Contents: 67 pages, 3 figures
Criteria yes, Methodology yes, Data no

Abstract: This is an interim report of a study to establish a risk measure for radioactive waste repositories and to generate radiological performance objectives. The index of hazard ought to depend upon the nature and severity of possible consequences and the probabilities of those consequences. The problem of regulating radioactive waste repositories is reviewed, and the difficulties are discussed. Risk-benefit analysis as a tool for regulation has been suggested, and its contribution is assessed. Decision analysis as a development of risk-benefit analysis is suggested as an alternative approach, in particular, use of the concept of expected utility. A utility function describing the possible consequences of a radioactive waste repository is discussed in some detail, with particular attention to the public concerns which such a function must be address and how it is recommended to capture them. A specific utility function is developed, and its elicitation from a particular subject described. The representation of public values in a decision-analytic approach presents some problems and these are fully discussed; recommendations are made as to appropriate methods to carry out this approach. The vexing question of determining an acceptable safety limit is studied and recommendations are made concerning the most suitable way to determine "how safe is safe enough." Setting an acceptable limit on hazards may be approached by determining the acceptable risk by: (1) expressed preference, (2) revealed preference, (3) comparison with background radiation, (4) implication from accepted nuclear hazards, (5) comparison with the cost of safety, and (6) comparison with alternatives. Finally, a brief discussion is given of how these concepts may be employed to generate radiological performance objectives.

File #41

Title: The Role of Reliability and Risk Assessment in LMFBR Design: Implementation of Reliability in LMFBR Design

Author(s): J. Grahan, P. P. Zemanick

Affiliation: Westinghouse Electric Corporation, Advanced Reactor Division

Periodical: Nuclear Engineering and Design, Volume 22, No. 1, 1977

Contents: 9 pages, 2 tables, 1 figure
Criteria yes, Methodology no, Data yes

Abstract: This paper concerns future developments in LMFBR Licensing Technology. Potential future roles of reliability and risk assessment are discussed in the context of providing additional confirmation of the safety of LMFBR designs. Potential acceptability criteria for risk evaluations are outlined. The reliability

implications of designing components to the ASME Code Section III requirements are discussed. General judgments are provided as well as the preliminary results of probabilistic studies of selected specific limits.

File #34

Title: Quantitative Safety Analysis - Chapter 2 - Safety Criteria

Author(s): G. D. Bell

Affiliation: UKAEA, Health and Safety Branch

Periodical: Nuclear Engineering and Design, 13(2), pp. 187-190, August 1970

Contents: 4 pages, 4 figures
Criteria yes, Methodology no, Data no

Abstract: From the author's viewpoint representation of a safety criterion for reactors by means of an acceptable frequency distribution of curie releases conforms with a realistic philosophy of safety in which all sequences of events not at variance with the laws of nature are to be considered. The frequency-curie release criterion, Farmer's curve, has been given a precise interpretation and can be used directly by designers and by safety assessors in evaluating the adequacy of the safety provisions. To accomplish this evaluation, the method has stimulated examination of reliability considerations of systems and components and the accumulation of reliability data. Finally, by evaluating the consequences to the population around a site expected from a reactor conforming with criterion, it is possible to compare the nuclear risk with risks associated with other activities of man and with the natural risks to which we are all exposed.

File #38

Title: Reactor Siting and Design from a Risk Viewpoint

Author(s): H. J. Otway, R. C. Erdmann

Periodical: Nuclear Engineering and Design, Volume 13, No. 2, pp. 365-376, August 1970

Contents: 12 pages, 6 figures, 4 tables
Criteria yes, Methodology yes, Data yes

Abstract: This paper proposes a method for assessing reactor safety, based upon the individual mortality risk[f] which allows: (1) the determination of necessary site exclusion radii, and (2) the evaluation of safeguards in terms of the risk reduction provided. Discussed are risk concepts, biological risk, and reactor risks. To demonstrate this method, a hypothetical 1,000 MW(e) PWR was evaluated. Results indicate that for a maximum individual mortality

risk of 10^{-7} per year (at the site boundary), an exclusion radius of 350 m is required. For a densely populated urban site, the total risk[f] was found to be 0.003 deaths over a 30-year reactor lifetime. Risk[f] was found to be not particularly sensitive to accident probabilities.

File #5

Title: The Impact on New York City of Reactor Accidents at Indian Point

Author(s): Jan Beyea

Affiliation: Research Staff, Center for Energy and Environmental Studies, Princeton University

Paper/Date: Statement to the New York City Council June 11, 1979 (corrected June 20, 1979)

Contents: 34 pages, 7 figures, 6 tables
Criteria no, Methodology no, Data yes

Abstract: Discusses: (1) the probability of serious accidents at Indian Point; (2) the consequences of such accidents for residents of N.Y.C.; (3) and actions the city and state might take to reduce the consequences of such accidents. Recommends that technical studies be made to: (1) investigate alternatives to Indian Point, noting that other energy sources have risks associated with them; (2) improve the safety, such as filtered venting of containment building, emergency planning, iodine stockpiling.

File #10

Title: Design Criteria, Concepts and Features Important to Safety and Licensing

Author(s): G. H. Kinchin

Affiliation: Safety and Reliability Directorate, United Kingdom Atomic Energy Authority

Date: 1978

Contents: 8 pages, 3 figures, 2 tables
Criteria yes, Methodology yes, Data yes

Abstract: This paper states that quantitative risk assessment can be used to compare the relative safety of different plants, but to be of greatest value, the method must be used in conjunction with numerical acceptance criteria. This paper considers criteria for individual and for societal risks. Existing non nuclear hazards

are taken into account in determining the criteria, (See Table 1 of this report) and it is pointed out that the risks, both individual and societal, from nuclear plants designed to these criteria are much lower than those from other causes.

File #8

Title: Application of the Concept of Total Risk to the Licensing of Nuclear Power Stations (Draft)

Author(s): H. McNeill

Affiliation: Consultant

Date: May 1979

Contents: 16 pages, 1 figure
Criteria yes, Methodology no, Data no

Abstract: The author's position is that advances in the technique of risk assessment, heightened public awareness of safety, and the pressure from industry has demonstrated the need for improved safety standards and criteria for the design and operation of nuclear power stations. This study investigates the problems associated with the interpretation and application of current regulations and criteria in the "licensing process," and concludes that the concept of limited risk9 from a single event which is the basis for present regulations and guidelines is a necessary but not adequate criterion for licensing. The concept of "total risk" is advocated as a basis for establishing quantitative safety standards and to support licensing decisions. The author uses the following expression to define risk: Risk to the public involving both economic and health consequences is determined by the integrated or total risk due to all events which can occur during a time interval. The total risk is the summation of all risks and not just the risk for one event (the limiting event) that might occur during the time interval.

File #6

Title: Supplemental Testimony Regarding Health Effects Attributable to Coal and Nuclear Fuel Cycle Alternatives

Author(s): R. L. Gotchy

Contents: 25 pages, 6 tables
Criteria no, Methodology no, Data yes

Abstract: The author's viewpoint is that it is extremely difficult to provide precise quantitative values for excess mortality and morbidity, particularly for the coal fuel cycle. While future technological improvements in both fuel cycles may result in significant reductions in health effects, it is concluded that the nuclear fuel cycle is considerably less harmful to man than the coal fuel cycle. The author notes that although there are large uncertainties in the estimates of most of the potential health effects of the coal cycle, the impact of transportation of coal is based on firm statistics, with this impact alone being greater than the conservative estimates of health effects for the entire uranium fuel cycle.

File #46

Title: Incremental Net Social Benefit Associated with Using Nuclear-Fueled Power Plants

Author(s): I. Maoz

Affiliation: University of California, Los Angeles, Department of Energy and Kinetics

Report/Date: UCLA-ENG-76117, December 1976

Contents: 52 pages, 9 figures, 7 tables
Criteria no, Methodology yes, Data yes

Abstract: This paper assesses the "incremental net social benefit" (INSB) resulting from nuclear-fueled, rather than coal-fired, electric power generation. The INSB is defined as the difference between the "incremental social benefit" (ISB) -- caused by the cheaper technology of electric power generation, and the "incremental social cost" (ISC) -- associated with an increased power production, which is induced by cheaper technology. Section 2 focuses on the theoretical and empirical problems associated with the assessment of the long-run price elasticity of the demand for electricity, and the theoretical-econometric considerations that lead to the reasonable estimates of price elasticities of demand from those provided by recent empirical studies. Section 3 covers the theoretical and empirical difficulties associated with the construction of the long-run social marginal cost curves (LRSMC) of electricity. Sections 4 and 5 discuss the assessment methodology and provide numerical examples for the calculation of the INSB resulting from nuclear-fueled power generation.

File #16

Title: Catastrophic Events Leading to De Facto Limits on Liability

Author(s): K. A. Solomon, D. Okrent

Affiliation: University of California, School of Engineering and Applied Science

Report/Date: UCLA-ENG-7732, May 1977

Contents: 24 pages, 3 tables, 1 figure
Criteria no, Methodology no, Data yes

Abstract: This study takes an overview of large technological systems in society to ascertain the prevalence, if any, of situations that can lead to catastrophic effects where the resultant liabilities far exceed the insurances or assets subject to suit in court, thereby imposing de facto limits on liability. Several different potential situations are examined, including dam rupture, aircraft crash into sports stadium, chemical plant accident, shipping disaster, and a toxic drug disaster. All these events are estimated to have probabilities per year similar or larger than a major nuclear accident.

File #1

Title: A Catalog of Risk

Author(s): B. L. Cohen, I. S. Lee

Affiliation: Department of Physics and Astronomy, University of Pittsburgh

Periodical: Health Physics, Volume 36, June 1979

Contents: 15 pages, 28 tables
Criteria no, Methodology no, Data yes

Abstract: Information on risks[f] is collected from various sources and converted into loss of life expectancy throughout life and in various age ranges. Risks included are radiation, accidents of various types, various diseases, overweight, tobacco use, alcohol and drugs, coffee, saccharin, and the pill, occupational risks, socioeconomic factors, marital status, geography, serving in U.S. armed forces in Vietnam, catastrophic events, energy production, and technology in general. Information is also included on methods for reducing risks, risks in individual actions, "very hazardous" activities, and priorities and perspective. Risks of natural and occupational radiation and exposure to radioactivity from the nuclear industry are compared with risks of similar or competing activities.

File #3

Title: The German Risk Study for Nuclear Power Plants

Author(s): Reactor Safety Company (Gesellschaft fur Reaktorscherheit-GRS)

Affiliation: For the German Federal Minister for Research and Technology

Report/Date: Press Release, August 14, 1979.

Contents: 5 pages
Criteria no, Methodology no, Data yes

Abstract: In this study, the risk due to accidents or incidents in nuclear power plants was investigated with particular reference to the specific German situation. Risks due to normal operation or other fuel cycle facilities are not taken into account. Any contribution from war, sabotage, etc. was also neglected. Risk analyses suffer from considerable uncertainties due to the present stage of development of the methods and the available data basis. The results, therefore, can only be considered as estimates of the risk to be evaluated. The study takes into account many results from investigations that are also applied in nuclear licensing processes. A peculiarity of risk analyses is the fact that the introduction of additional safety features will reduce the occurrence probability, but not the resulting damage of an accident. Even with optimum safety provisions, the occurrence probability cannot be made exactly zero. Therefore, the question of risk acceptability cannot be separated from the accident probability.

File #20

Title: Risk Assessment of Storage and Transport of Liquefied Natural Gas and LP-Gas

Author(s): J. A. Simmon

Affiliation: Science Applications, Inc. for the Environmental Protection Agency

Date: November 25, 1974

Contents: 90 pages, 3 appendices, 15 tables, 9 figures
Criteria no, Methodology yes, Data yes

Abstract: This report presents the results of a study to develop a method for assessing the societal risk of transporting LP-Gas (liquefied petroleum gas) and LNG (liquefied natural gas). The method is illustrated through its application to the transport of LP-Gas by tank truck and LNG by tankship in the U.S. The measure of risk used was the probability of fatalities resulting from accidental leaks and tank ruptures. Fatalities are a direct, unambiguous measure that facilitates comparison with the risk of other activities via available historical accident data (e.g., fire, explosions, etc.).

File #4

Title: The Nuclear Power Debate - Moral, Economic, Technical and Political Issues

Author(s): D. Myers III

Affiliation: IRRC - Investor Responsibility Research Center

Date: 1977

Contents: 153 pages
Criteria yes, Methodology no, Data no

Abstract: A review of the issues surrounding nuclear power including reactor safety, waste management, safeguards, economic comparisons, etc., with the views of pro and antinuclear experts frequently interspersed, shows unresolved issues and reasons for the current slowdown in plant licensing and construction.

File #99

Title: The Health and Environmental Effects of Electricity Generation - A Preliminary Report

Author(s): Edited by L. D. Hamilton

Affiliation: Brookhaven National Laboratory
Biomedical and Environmental Assessment Group (BEAG)

Report/Date: BNL 20582, BEAG-HE/EE, July 30, 1974

Contents: 131 pages, 10 figures, 11 tables
Criteria no, Methodology yes, Data yes

Abstract: This paper describes the total effort of the BEAG at BNL, including the effort to estimate resultant deaths and health effects due to air pollutants caused by burning fossil fuels, including SO_2 particulates. Shows derivation of tables of increased mortality and morbidity due to operation of single 1000 MW plants using various fuels (coal, oil, gas, uranium, hydro).

File #40

Title: The Index of Harm: A Measure for Comparing Occupational Risk Across Industries

Author(s): K. A. Solomon, S. C. Abrahan

Affiliation: Rand Corporation,

Report/Date: R-2409-RC, June 1979

Contents: 36 pages, 9 tables, 1 figure
Criteria no, Methodology yes, Data yes

Abstract: This report explores the implications of an index of harm methodology that compares occupational risk among works exposed to radiological and non radiological harms. The author describes the index of harm as being an empirically derived measure of occupational risk in an industry and is defined as being the fraction of years lost in a particular industry from any cause or event by a population exposed to those causes or events for a period of one year (250 working days). Using methodology proposed by ICRP and assigning weighting factors to arrive at an "index of harm," the authors try to compare risks of harms based on raw number of fatalities and various perceptions of the "value" of different fatalities to show what happens to relative increases of harm when different values are assigned to perception.

File #49

Title: A General Evaluation Approach to Risk Benefit for Large Technological Systems and Its Application to Nuclear Power

Author(s): Edited by D. Okrent

Affiliation: UCLA School of Engineering & Applied Science

Report/Date: UCLA-ENG-7777, December 1976

Contents: 37 pages
Criteria yes, Methodology yes, Data yes

Abstract: This report briefly reviews various aspects of risk-benefit analysis, by condensing 37 UCLA Engineering reports on risk-benefit analysis. The objective of the overall study was to: (1) make significant strides in the provision of improved bases or criteria for decision-making involving risk to the public health and safety (where a risk involves the combination of a hazard and the probability of that hazard); (2) make significant progress in the structuring and development of improved, and possibly alternative, general methodologies for the assessment of risk and risk-benefit for technological systems; (3) develop improvements in the techniques for the quantitative assessment of risk and benefit; and (4) apply methods of risk and risk-benefit assessment to specific applications in nuclear power (and possibly other technological systems) in order to test methodologies, to uncover needed improvements and gaps in technique and to provide a partial, selective, independent assessment of the levels of risk arising from nuclear power. The principal chapters of this report are Risk-Benefit and Risks in Society, On the Role and Methods of Risk-Benefit Analysis and Decision Analysis, Historical Perspectives on Risk and Risk Management, Societal Knowledge

of Hazards and Risks, Psychological Aspects of Risk-Benefit and the Perception of Risk, On Economic Aspects of Risk-Benefit, Risk Acceptance Criteria and Risk Management, Risk Assessment Methodology, Applications to Nuclear Reactor Safety.

Following is a list of the 37 UCLA reports that were condensed and made up this report:

TITLE

Mathematical Methods of Probabilistic Safety Analysis

Bio Statistical Aspects of Risk-Benefit: The Use of Competing Risk Analysis

Applying Cost-Benefit Concepts to Projects Which Alter Human Mortality

Historical Perspectives on Risk for Large-Scale Technological Systems

A Prediction of the Reliability of the Core Auxiliary Cooling System for a High-Temperature Gas Cooled Reactor

Pressure Vessel Integrity and Weld Inspection Procedure

A Survey of Expert Opinion on Low Probability Earthquakes

On the Average Probability Distribution of Peak Ground Accelerations in the U.S. to Strong Earthquakes

The Effect of a Certain Class of Potential Common-Mode Failures on the Reliability of Redundant Systems

Risk-Benefit Methodology and Application: Some Papers Presented at the Engineering Foundation Workshop, September 22-26, 1975, Asilomar, California

A Computer-Oriented Approach to Fault Tree Construction

The Effect of Human Error on the Availability of Periodically Inspected Redundant Systems

An Integrated Safe Shutdown Heat Removal System for Light Water Reactors

On the Failure Modes of Alternate Containment Designs Following Postulated Core Meltdown

Probability Intervals for the Top Event Unavailability of Fault Trees

Statistical Models for Competing Risks Analysis

TITLE

On Risk Assessment in the Absence of Complete Data

Cost-Benefit Analysis and the Art of Motorcycle Maintenance

Relative Hazard Potential - The Basis for Definition of Safety Criteria for Fast Reactors

On the Probability of Loss of D.C. Power following A.C. Failure in a Nuclear Power Plant

Some Probabilistic Aspects of the Seismic Risk of Nuclear Reactors

Incremental Net Social Benefit Associated With Using Nuclear Fueled Power Plants

On Risks from the Storage of Hazardous Chemicals

Failed Tendon Inspection via Monte Carlo

Decision-Table Development for Use with the Cat Code for the Automated Fault-Tree Construction

How Safe is Safe Enough? A Psychometric Study of Attitudes Towards Technological Risks and Benefits

A Parametric Utility Comparison of Coal and Nuclear Electricity Generation

A Look at Alternative Core Disruption Accidents in LMFBR's

Liability and Safety in Nuclear Power Plants

Catastrophic Events Leading to DeFacto Limits on Liability

An Approach to Societal Risk Acceptance Criteria and Risk Management

Some Aspects of the Fire Hazard in Nuclear Power Plants

Probability Intervals For the Reliability of Complex Systems Using Monte Carlo Simulation

Earthquake Ordances for the City of Los Angeles, California - A Brief Case Study

The Safety Incentive Theory of Liability

Post-Accident Filtration as a Means of Improving Containment Effectiveness

A Look at Alternative Core Disruption Accidents in LMFBR's, Part II.

File #48

Title: Sulfur Control in Coal Fired Power Plants: A Probabilistic Approach to Policy Analysis

Author(s)/ Affiliation: M. G. Morgan, W. R. Rish, Carnegie-Mellon University
S.C. Morris, Brookhaven National Laboratory
A.K. Meir, University of California at Berkeley

Periodical: Journal of the Air Pollution Control Association, Volume 28, No. 10, October 1978

Contents: 5 pages, 4 figures, 1 table
Criteria no, Methodology no, Data yes

Abstract: The authors state that the optimum level of sulfur pollution control for a coal fired power plant is the point where the sum of societal costs, due to pollution, and control costs is minimized. This basic micro-economic concept has been of limited practical value because of considerable uncertainty in estimating both costs. A probabilistic approach is used to characterize these uncertainties quantitatively for a hypothetical 1000-MW(e) plant located near Pittsburgh, Pennsylvania. Mortality effects within a distance of 80 km of the plant have only been included. The results allow explicit consideration of attitude toward risk and appropriate level of investment to prevent deaths. Limitations of the findings are discussed. Implications are described for policy based on alternative sets of values and assumptions.

File #47

Title: Mathematical Methods of Probabilistic Safety Analysis

Author(s): G. Apostolakis

Affiliation: UCLA School of Engineering and Applied Science

Report/Date: UCLA-ENG-7464, September, 1974.

Contents: 317 pages, 64 figures, 17 tables
Criteria no, Methodology yes, Data no

Abstract: This report presents the mathematical methods useful in reliability and safety studies. The problems that these studies deal with concern: (1) the prediction of the probability that a specified function will be performed satisfactorily over a period of time or per demand; and (2) the identification of events and their probabilities which may lead to unfavorable circumstances endangering the health of the public. This document includes summaries of illustrative applications as well as references to the literature. Chapter 2 describes the methods of handling problems involving one component or simple logical configurations -- reliability

theory. An introduction to the fundamentals of probability theory and statistics is given. The modeling of the failure of components by statistical distributions is discussed, followed by the mathematical description of various maintenance policies. Chapter 3 deals with analysis of complex systems. Fault-tree methodology is developed in detail, and its uses and limitations are investigated. Methods, like the failure modes and effects analysis are described. Special problems arising from software and human errors as well as the possibility of common mode failures also are discussed. Finally, the use of statistical techniques to handle major natural phenomena and methods of dealing with systems without exploiting their logical structure are investigated.

File #17

Title: How Safe is Safe Enough? A Psychometric Study of Attitudes Towards Technological Risk and Benefits

Author(s): B. Fischhoff, P. Slovic, S. Lichtenstein, S. Read, B. Combs

Affiliation: UCLA School of Engineering and Applied Science

Report/Date: UCLA-ENG-7717, January 1977

Contents: 47 pages, 8 figures, 7 tables
Criteria no, Methodology, yes, Data yes

Abstract: One of the fundamental questions addressed by risk-benefit analysis is "How safe is safe enough?" Chauncey Starr has proposed that economic data be used to reveal patterns of acceptable risk-benefit tradeoffs. The present study investigates an alternative technique, in which psychometric procedures were used to elicit quantitative judgments of perceived risk, acceptable risk, and perceived benefit for each of 30 activities and technologies. The participants were seventy-six members of the League of Women Voters.

The results indicated little systematic relationship between perceived existing risks and benefits of the 30 risk items. Current risk levels were generally viewed as unacceptably high; when they were adjusted to what would be considered acceptable risk levels, however, risk was found to correlate with benefit. Nine descriptive attributes of risk were also studied. These nine attributes seemed to tap two basic dimensions of risk. One dimension apparently discriminated between high and low technology activities, with the high end being characterized by new, involuntary, poorly known activities, often with delayed consequences. The second dimension primarily reflected the certainty of death given that adversity occurs. These dimensions proved to be effective predictors to the tradeoff between acceptable risk and perceived benefit. The limitations of the present study and the relationship between this technique and Starr's technique are discussed, along with the implications of the findings for policy decisions.

File #43

Title: Social Decision Making for High Consequence, Low Probability Occurrences

Author(s)/
Affiliation: National Planning Association and Haldi Associates

Report/Date: October 1978

Contents: 216 pages, 5 figures, 12 tables
Criteria yes, Methodology no, Data yes

Abstract: This study deals with the process of reaching social decisions that involve low-probability, high-consequence outcomes. It is in 3 major parts. Part I reviews the two main classes of criteria proposed for social decisions: (1) market mechanisms and cost-benefit analysis and (2) the approaches of Rawls and Buchanan to achieving a social consensus. The authors propose a criteria composed of eight elements for evaluating a social decision process capable of application in judicial, legislative, academic, and managerial situations.

Parts II and III are case studies of different decision procedures. The former inspects the administrative law procedure using the U.S. EPA chlordane/heptachlor suspension hearings as an example. The legal procedure is concluded to be a forward-looking decision process which attempts to increase social acceptability of the outcome. The latter examines the disjointed decision procedure concerning the disposal of nuclear waste. In both cases the eight criteria proposed in Part I nevertheless provide a useful tool for evaluating the process.

File #30

Title: Risk-Benefit Methodology and Application: Some Papers Presented at the Engineers Foundation Workshop, September 22-26, 1975, Asilomar, California

Author(s): Edited by D. Okrent

Affiliation: UCLA School of Engineering and Applied Science

Report/Date: UCLA-ENG-7598, December, 1975

Contents: 28 papers, 644 pages
Criteria yes, Methodology yes, Data yes

Abstract: The goal of this workshop is to assess quantitatively the state of the art on risk-benefit methodology. Two new large technology areas are considered for risk evaluations: (1) nuclear reactors;

and (2) shipment and storage of liquefied natural gas. Engineering failures in neither of these technologies can result in incidents of large consequence. Decision or event-tree techniques, fault-tree techniques, or failure-mode and effects analysis are discussed as methods for risk analysis.

File #37

Title: Risk Assessment and Health Effects of Land Application of Municipal Wastewater and Sludges, (Proceedings)

Author(s): B. P. Sagik, C. A. Sorber

Affiliation: University of Texas at San Antonio, Center for Applied Research and Technology, Proceedings of Conference held December 12-14, 1977

Contents: 23 papers, 330 pages
Criteria no, Methodology no, Data yes

Abstract: These proceedings are intended as a record of the conference on risk assessment and health effects of land application of municipal wastewater and sludges. The topic on agents of health significance covers health hazards associated with wastewater effluents and sludges; chemical agents of health significance in municipal wastewater effluents and sludges; and conventional methods of epidemiology appropriate for risk assessment of virus contamination of water. The examination of the impact on the food chain includes discussions on opportunities for virus transport; land application of sewage wastes; problems in proving that parasites pass to people from foods produced with refuse; the impact of metals present in municipal sludges; and the potential health hazard and risk assessment of toxic organic chemicals in wastewater and sludge. The impact on water resources is discussed in terms of minimizing the impact of viruses on water resources; minimizing the virological impact on water resources from spray irrigation of municipal wastewater; potential impact on water resources of bacterial pathogens; obligate parasites; limitations for land disposal of wastewater and sludges; and viruses in the environment. Pathogenic aerosols are discussed in terms of aerosol monitoring for microbial organisms and a model for predicting pathogen concentrations in wastewater aerosols. Factors affecting risk assessment are evaluated in terms of wastewater unit process efficiency; extrapolation models for risk assessment; and public choice and the land application of municipal wastewaters and sludges.

File #36

Title: High Level Radioactive Waste from Light-Water Reactors

Author(s): B. L. Cohen

Affiliation: Department of Physics, University of Pittsburgh

Periodical: Reviews of Modern Physics, Volume 40, No. 1, January 1977

Contents: 20 pages, 13 figures, 6 tables
Criteria no, Methodology no, Data yes

Abstract: The production of radioactive nuclei during the operation of a light-water reactor is traced, and their decay history is followed. The potential environmental impacts of this waste are calculated and shown to be comparable to those of other materials we produce. Assuming deep burial, it is shown that there are important time delays which prevent the waste from reaching the biosphere in the first few hundred years while its toxicity is decreasing by several orders of magnitude. In the long term, the most important pathway to man was found to be through groundwater into food and water supplies, with consequences calculated to be 0.4 fatalities in 10^6 years from each year of all-nuclear power in the U.S. Other pathways considered and found to be less important include meteorites, volcanism, release through ground water to airborne particulate, and human intrusion by drilling and mining for unspecified materials and for salt. For time scales longer than 10^6 years, nuclear power is shown to reduce man's exposure to radiation by consuming uranium. A cost-benefit analysis is developed for surveillance of buried waste. Under the models and assumptions it is shown that buried high-level waste is environmentally much less dangerous than uranium mill tailings.

File #50

Title: Measuring Social Risk and Determining Its Acceptability

Author(s): J. Lathrop

Affiliation: Lawrence Livermore Laboratory, Lawrence, California

Report/Date: UCRL-81060, July 14, 1978

Contents: 26 pages, 4 figures
Criteria no, Methodology yes, Data no

Abstract: The implementation of a nuclear waste management technology raises several issues concerning the regulation of social risk. This paper presents a decision analytic approach to resolving some of those issues. A methodology for developing a radiological risk measure is presented, and several approaches to defining acceptable levels of that risk measure are considered. The methodology presented is oriented toward the development of radiological performance objectives for use as guidance in the drafting of regulations.

File #51

Title: Education and Public Acceptance of Nuclear Power Plants

Author(s): G. Delcoigne

Affiliation: International Atomic Energy Agency, Vienna, Austria

Report/Date: Nuclear Safety, Volume 20, No. 6, November-December 1979

Contents: 8 pages
Criteria yes, Methodology no, Data no

Abstract: The evolution of the so-called nuclear debate from the late 1960 to the present time is reviewed, and the current manifestations of the antinuclear movement in many countries are described. Despite the emergence of pronuclear groups and discussions in many countries, the author concludes that public education is the crux of the problem and he discusses the role of the International Atomic Energy Agency.

File #52

Title: Proceedings of Quantitative Environmental Comparison of Coal and Nuclear Electrical Generation and Their Associated Fuel Cycles Workshop, Volumes I and II

Author(s): MITRE Corporation, McLean, Virginia

Report/Date: MTR-7010, Volumes I and II

Contents: 2 volumes, 15 papers, 545 pages
Criteria no, Methodology yes, Data yes

Abstract: This document, Volumes I and II, contains the edited transcripts of the presentation and discussions at a workshop on the Quantitative Environmental Comparison of Coal and Nuclear Electric Generation and Their Associated Fuel Cycles held at the MITRE Corporation in McLean, Virginia, on May 27 and 28, 1975. The purpose of the workshop, sponsored by the National Science Foundation, was to compile the information and expert opinions to quantify the risks arising from the various phases of coal and nuclear fuel cycles to assess the economic costs and environmental consequences associated with electric generation.

File #53

Title: Collision Risk and Economic Benefit Analysis of Composite Separation for the Central East Pacific Track System

Author(s): A.C. Busch, B. Colomosca, J. VanderVeer

Affiliation: Department of Transportation, Federal Aviation Administration

Report/Date: FAA-EM-77-5, June 1977

Contents: 100 pages, 3 appendices, 36 tables, 22 figures
Criteria yes, Methodology yes, Data yes

Abstract: This report presents an evaluation of the application of composite separation to the Central East Pacific (CEP)track system. Criteria for the evaluation were a collision risk[9] and an economic benefits comparison of the existing four-route and proposed composite six-route systems. Collision risk is defined as the expected number of mid-car accidents in 10 million track system flying hours due to the loss of the planned separation. A six-month data collection was performed. Radar data from land-based facilities in California and Hawaii and from Ocean Station Vessel November were processed to determine aircraft navigation performance. Utilization of the existing system was gauged from air traffic control facility data, and flight crew survey forms were used to collect information necessary for comparative analysis purposes. The report describes estimation of collision risk model parameters from the data. Lateral, longitudinal, and composite collision risks were estimated for the existing and proposed composite systems based upon accepted North Atlantic Systems Planning Group (NAT/SPG) methodology, while vertical collision risk was calculated based upon previous NAT/SPG studies. Lateral collision risk for the proposed composite system was found to be lower than for the existing structure. Comparisons of fuel burn and flight times indicated that the proposed composite system would be more economically beneficial than the existing route configuration. As a result of the study, the proposed composite system was recommended for implementation on a trial basis.

File #54

Title: Some Probabilistic Aspects of the Seismic Risk of Nuclear Reactors

Author(s): Hsieh, T., Okrent, D.

Affiliation: University California School of Engineering and Applied Science

Report/Date: UCLA-ENG-76113, December 1976

Contents: 75 pages, 22 tables, 10 figures
Criteria no, Methodology no, Data yes

Abstract: The potential for existing cracks in piping systems to grow to critical size and cause system failure during a severe earthquake was examined, and the critical crack size based on linear elastic mechanics was reviewed. A crude method of relating the initial crack size, the range of strain produced in a component, and the number of cycles to failure was proposed and discussed. The significance of piping failure due to ordinary crack growth

other than the intergranular stress corrosion under seismic loading was found to be comparable to the potential for failure due to crack growth under severe seismic loads. A simplified piping system with only a few snubbers and hangers as seismic restraints was devised. The authors state that the inverse of the maximum Von Mises ratios at a few nodal points of the piping system was used as the basis for indicating the change in safety factor due to piping restraint failures. The potential importance of seismic events leading to a core melt accident was examined by factoring the effect of design errors and system degradation into an estimate of the probability of a core-melt accident due to seismic events.

File #55

Title: Applying Cost-Benefit Concepts to Projects which Alter Human Mortality

Author(s): Hirshleifer, J., Bregstrom, T., Rappaport, E.

Affiliation: University California School of Engineering and Applied Science

Report/Date: UCLA-ENG-7478, November 1974

Contents: 144 pages, 2 Appendices
Criteria no, Methodology yes, Data yes

Abstract: The authors contention is that a cost-benefit analysis represents the only established technique at hand for evaluating and weighing the consequences of large technological systems. The "ordinary" net benefits of large technological systems like nuclear power, the consequences other than those involving risks to life and limb, can be evaluated by aggregating the impacts upon all individuals, weighted in accordance with the values placed upon those impacts by the idividuals themselves. For goods and resources traded in markets, the marked prices represent these values. For unmarketed effects, like damage to environment, it is possible to infer market-value equivalents. The net benefit, at a moment of time, of a technological system like nuclear power can be divided into two components: (1) the cost saving due to displacement of more costly conventional power sources; and (2) the consumer benefit or surplus associated with the net increment of power supplied. Summation over time is accomplished by the Present-Value formula which discounts future cost and benefit elements so as to reduce them to an equivalent in present worth. Also included are discussions on the "Value of Life" -- willingness-to-pay approach and the value of survival in life-cycle models.

File #56

Title: The Risks of Nuclear Power Reactors (A Review of the NRC Reactor Safety Study, WASH-1400 NUREG-75/014)

Author(s): H.W. Kendall, Study Director

Affiliation: Union of Concerned Scientists

Report/Date: Union of Concerned Scientist, August 1977

Contents: 210 pages, 5 appendices
Criteria no, Methodology yes, Data yes

Abstract: An examination of WASH-1400 with a review of the major technical issues that undermined the validity of WASH-1400 was conducted by the Union of Concerned Scientist. Issues addressed are methodology, common cause failures, design adequacy, safety issues, radiation dispersion model, emergency response, radiological effects, misinformation and misuse, reassessment of risk. Summation of the technical evaluations presented, resulted in some of the following risk reassessment values: (1) that the chance of melting accompanied by large radioactive release maybe 1 in 10,000 per reactor year (twenty times greater than the RSS value), (2) prompt injuries and fatalities maybe 100 to 1,000 times greater than the RSS estimates, and (3) correction of the RSS risk results for understatement of long-term consequences shows that the largest accident considered could result in over 300,000 total fatalities.

File # 57

Title: On the Evaluation of Biological Hazards and Competing Risks

Author(s): Watson, G.S.

Affiliation: Princeton University, Department of Statistics

Report/Date: TR-132-SER-2, September 1977

Contents: 14 pages
Criteria no, Methodology no, Data yes

Abstract: This report is an expanded version of some extemporaneous remarks made at the end of a meeting held at the Institute for Energy analysis, Oak Ridge Assoc. Univ. Oak Ridge, Tennessee, September 7-8, 1977. An effort is made to find a biological basis for the competing risk model and potential lifetimes. Clifford's results with illness and death models are described. Miscellaneous remarks are made on several other related topics.

File #58

Title: Determination of Acceptable Risk Criteria for Nuclear Waste Management

Author(s): Cohen, J.J.

Affiliation: Lawrence Livermore Laboratory, University California, Livermore California

Report/Date: UCLA 52404 October 1977

Contents: 65 pages, 4 appendices
Criteria yes, Methodology yes, Data yes

Abstract: A general methodology is developed, in this report, for use in the development of an acceptable risk criteria (ARC) for waste management operations, which consists of performing a "scoping" study to define issues, determine an optimal methodology for their resolution, and compile a data base for ARC development. The issues, spanning technical, psychological, and ethical dimensions, are categorized in several major areas: (1) unplanned or accidental events, (2) present vs future risks, (3) institutional controls and retrievability, (4) dose-response mechanism and uncertainty, (5) spatial distribution of exposed populations, (6) different types of nuclear wastes, and (7) public perception. The optimum methodology for developing ARC was determined to be multiattribute decision analysis encompassing numerous specific techniques for choosing, from among several alternatives, the optimal course of action when the alternatives are constrained to meet specified attributes. The data base developed during the study comprises existing regulations and guidelines, maximum permissible dose, natural geologic hazards, nonradioactive hazardous waste practices, bioethical perspectives, and data from an opinion survey.

File #59

Title: Rating the Risk

Author(s): Slovic, P., Fischhoff, B., Lichtenstein, S.

Affiliation: UCLA School of Engineering and Applied Science

Report/Date: Environment, Volume 21, No. 3, April 1979

Contents: 39 pages, 3 tables, 6 figures
Criteria no, Methodology no, Data yes

Abstract: Members of four different groups, 30 college students, 40 League of Women Voters, 25 business and professional people, and 15 persons selected for their professional experience with risk assessment, are asked to rate thirty different activities and technologies according to their present and perceived risk and where and how nuclear power plants relate. Paper briefly looks at the biases by which people judge, analysis of those judgements, what determines risk perception, and the failibility of judgement.

File # 29

Title: Proposed Safety Requirements for Licensing of CANDU Nuclear Power Plants

Author(s): Atomic Energy Control Board of Canada

Report/Date: November 1978

Contents: 26 pages, 2 tables, 1 figure
Criteria yes, Methodology yes, Data yes

Abstract: This paper explains the Canadian Reactor Safety Philosophy, Criteria and Principles. The philosophy used is a defense-in-depth concept, naming five lines of defense and noting that emphasis is placed on quality assurance throughout. This document proposes basic requirements that could form the framework for detailed licensing regulation that would govern the design, construction and operation of a nuclear power plant in Canada. Foremost among these requirements are: (1) the use of diversity to ensure that there is more than one way to perform a function, (2) the use of redundancy to ensure that a single malfunction cannot disable a system, (3) the insistance that safety systems shall, as far as practicable, be independent from each other and from process systems, (4) the prevention of process failures that could lead to the release of radioactive substances and the need to limit the frequency of such failures to value that is as low as reasonably achievable, and (5) the judicious use of probability arguments in which values for unavailability and for failure frequency must be based on direct experience or reasonable extrapolations therefrom.

In applying this basic philosophy, a number of specific criteria and principles were evolved and discussed in detail, those briefly being: (1) design and construction is to the best applicable codes, standards and procedures; (2) all process systems essential to the reactor shall be designed such that the total of all serious failures do not exceed 1 per 3 years; (3) safety systems shall be physically and functionally separate from process systems to the extent possible; (4) each special safety system shall be readily testable, as a system, to demonstrate that its unavailability is less than 10^{-3}; (5) sets standards for radioactive effluents due to normal operation, for the effectiveness of special safety systems in case of a process failure, and for "dual" failures.

File #60

Title: A Parametric Utility Comparison of Coal and Nuclear Electricity Generation

Author(s): Maures, K.M.

Affiliation: UCLA School of Engineering and Applied Science

Report/Date: UCLA-ENG-7719, February 1977

Contents: 65 pages, 4 tables, 6 figures
Criteria no, Methodology no, Data yes

Abstract: In this paper the advantages and limitations of a quantitative model for decision making were discussed. Several different quantitative models are presented. (The model chosen was the expected utility maximum model, considered was the expected value maximization rule, the mini max rule, the maxi max rule and the Hurewicz rule.) Choosing a multivariant risk neutral extension, using constant absolute risk aversion utility function for monetary effects and for increased mortality, parameters of this utility function can be selected to represent the decision maker's preference. After describing an illustrative set of data on the risks inherent in coal burning and nuclear generation facilities, the chosen utility model was used to compare the overall risks associated with each technology, using the expected utility model described earlier to evaluate the overall desirability of a coal-burning plant and an alternative nuclear reactor. The value of the absolute risk aversion for increased mortality risks proved to be the most significant value in determining the preferred technology. Nuclear facilities are preferable if $R(y) < 5 \times 10^{-3}$, and coal-burning facilities are more advantageous if $R(y) > 15 \times 10^{-3}$. For the intermediate case, when $R(y) = 10 \times 10^{-3}$, the nuclear facility is preferred for larger risk aversion for monetary risks, $R(x)$, while the choice of a coal facility results from larger values of life. The different risk distributions considered for coal and nuclear technologies did not produce a significant effect on these results.

File #61

Title: Review of Issues Relevant to Acceptable Risk Criteria for Nuclear Waste Management

Author(s): Cohen, J.J.

Affiliation: Lawrence Livermore Laboratory, Conference on Waste Management 78, University of Arizona, March 1978

Report/Date: Conf-780316-2, February 22, 1978

Contents: 13 pages, 4 figures
Criteria yes, Methodology yes, Data no

Abstract: This report states that waste management programs require definitive objectives against which one could adequately judge the acceptability of any operation or methodology. The development of acceptable risk criteria for nuclear waste management re-

quires the translation of publicly determined goals and objectives into definitive issues which, in turn, require resolution. Since these issues are largely of subjective nature, they cannot be resolved by technological methods. The author's viewpoint is that development of acceptable risk criteria might best be accomplished by application of a systematic methodology for the optimal implementation of subjective values. Multi-attribute decision analysis is well suited for this purpose.

File #62

Title: Energy and the Environment - A Risk Benefit Approach

Editors: Ashley, H. Rudman, R., Whipple, C.

Affiliation: Stanford University, EPRI

Report/Date: Pergamon Press, NY, 1976

Contents: 11 papers, 305 pages
Criteria yes, Methodology no, Data no

Abstract: The editors present a collection of seminars delivered during the fall of 1974 that were sponsored by Stanford University and EPRI. These seminars were a set of expositions under the title given above. Nuclear power related seminars were entitled: general philosophy of risk-benefit analysis; future alternatives and technical options for the national energy system; health effects of electricity generation from coal, oil, and nuclear fuel; public aspects of energy systems; the rate of discount for long-term public investment; benefit-risk trade-offs in nuclear power generation; fault tree analysis as an example of risk methodology; energy and human welfare; and energy and the environment.

File #63

Title: Quantitative Environmental Comparison of Coal and Nuclear Generation Workshop Summary

Author(s): Bernardi, R., Borko, B.

Affiliation: MITRE Corporation

Report/Date: MTR-7004, September 1975.

Contents: 12 papers, 90 pages, 16 charts
Criteria no, Methodology yes, Data yes

Abstract: On May 27-28, 1975 the MITRE Corporation held a workshop addressing the quantitative environmental comparison of coal and nuclear generation, as part of a continuing program of MITRE technical and administrative support to the National Science

Foundation, Office of Energy R&D Policy. A study entitled, The Economic and Social Costs of the Coal and Nuclear Electric Generation: A Framework for Assessment and Illustrative Calculations for the Coal and Nulear Fuel Cycles, presented by members of the Stanford Research Institute provided some input and served as a basis for the discussions of the workshop. The agenda was planned to summarize the risks arising from the various elements of the coal and nuclear fuel cycles to assess the economic and environmental consequences associated with electrical generation. The following papers are summarized:

Decision Analysis Methodology to Coal and Nuclear Fuel Cycles
Routine Risks and Social Cost of Coal
Climate Modification Risk
Reactor Accident Risks
Nuclear Risks and Accident Sensitivities
Reactor Accidents and Consequences
Diversion and Sabotage
Release Mechanisms of Fuel Reprocessing Plants
Transportation Accidents and Safeguards
Risk Comparison of Recovery U.S. Reactor Plants
Nuclear Waste Management: Problems and Prospects
Nuclear Waste Disposal

File #64

Title: Risk Assessment and the Social Response to Nuclear Power

Author(s): Otway, H.J.

Affiliation: Project Leader, Joint IAEA/IIASA Research Project International Atomic Energy Agency

Report/Date: Journal of the British Nuclear Energy Society, Volume 16, No. 4, October 1977.

Contents: 7 pages, 2 tables, 2 figures
Criteria no, Methodology yes, Data yes

Abstract: A general theoretical framework for risk assessment studies is pre-sented. Methodologies from various disciplines can be used within this framework to allow a scientific approach to the understanding of complex interactions between technological and social systems. A pilot application of an attitude-formation model to examine the underlying determinants of groups for and against nuclear power is summarized.

File #65

Title: Risk-Benefit Evaluation of Nuclear Power Plant Siting

Author(s): Miettiner, J., Savolainen, I., Silvennoiner, P., Torino, E., Vuor, S.

Affiliation: Technical Research Center of Finland

Report/Date: Annals of Nuclear Energy, Volume 3 (11/12), 1976

Contents: 12 pages, 11 tables, 7 figures
Criteria no, Methodology no, Data yes

Abstract: An assessment scheme is described for the risk benefit analyses of nuclear power versus conventional alternatives. Given the siting parameters for the proposed nuclear plant, an economic comparison is made with the most advantageous competitive conventional production scenario. The economic benefit is determined from the differential discounted annual energy procurement cost as a function of the real interest rate and amortization time. The risk analysis encompasses the following factors: radiation risks in normal operation, reactor accident hazards and economic risks, atmospheric pollutants from the conventional power plants, and fuel transportation. The hazards are first considered in terms of probabilistic dose distributions. In the second stage risk components are converted to a form where excess mortality is used as the risk indicator.

To apply the general approaches, calculations are performed for the power production alternatives of Helsinki where district heat would be extracted from the nuclear power plant. At an interest rate of 10% and amortization time of 20 years the 1000-MW(e) nuclear option is found to be $9.1m per year more economical than the optimal conventional scenario. Simultaneously the nuclear alternative is estimated to reduce excess expected mortality by 2 to 5 fatal injuries annually.

File #19

Title: Principles and Standards of Reactor Safety

Author(s): International Atomic Energy Agency

Report/Date: Proceedings of a Symposium on Principles and Standards of Reactor Safety, February 5-9, 1973.

Contents: 45 papers, 650 pages
Criteria yes, Methodology yes, Data yes

Abstract: Symposium for the exchange of information on recent developments in nuclear reactor safety. Forty papers are presented, edited by the IAEA, in which the major topics are Philosophy of Safety Design, Quality Assurance and Reliability, Safety Evaluation Methods for Power Reactor, Design for Natural and Man-Induced Disasters, Siting Consideration for Power Reactors, Standards and Criteria for Design and Construction of Power Reactors, Design Safety Features, Safety in Operation, HTGCR Safety.

File #66

Title: Usefulness of Alternative Integrative Assessment Methodologies in Public Decision Making

Author(s): Erickson, L.E., Litchfield, J.W., Currie, J.W., McDonald, C.L., Adams, R.C.

Affiliation: Battelle Pacific Northwest Laboratories

Report/Date: PNL-RAP-24 UC-11, July 1978

Contents: 45 pages
Criteria no, Methodology yes, Data no

Abstract: This paper argues for more frequent use of formal integrative assessments in public decision making. Integrating assessment values for all of the impacts of competing alternatives to a particular event in common units so that they can be more readily compared to identify the preferred alternatives is stressed by this paper.

Aspects of integrative assessment methodologies are discussed and the steps necessary to the performance of integrative assessments are outlined. This paper compares the two major integrative assessment methodologies, benefit cost analysis and multi-attribute utility analysis as decision aides.

The key difference between these approaches is that in benefit-cost analysis all consequences are values in dollars while in multi-attribute utility analysis they are valued in units called utils, which are specific to the analysis. Thus, the most important factor influencing the selection of benefit-cost or multi-attribute utility analysis to perform an integrative assessment is whether one believes that all consequences to be included in the analysis can be adequately valued in dollar terms.

Most of the paper focuses on the different approaches which benefit-cost and multi-attribute utility analysis have taken to the estimation of the values of the consequences of decision alternatives in common units. The intention in doing this is to provide the information necessary to decide whether benefit-cost or multi-attribute utility analysis should be selected in any particular instance.

This paper discusses various aspects of the following questions: (1) Should an integrative assessment methodology be used for the overall assessment of these costs, risks, and benefits? (2) If an integrative assessment methodology is to be used, what alternative methods are available and what should be the basis for selecting a method? (3) Is it possible to use one of the available alternatives for one portion of the assessment and another for another portion of the assessment?

File #73

Title: On a Rational Basis for Designing for Safety and Operability

Author(s): G.S. Lellouche

Affiliation: Electric Power Research Institute

Date: October 11, 1979

Contents: 13 pages
Criteria yes, Methodology yes, Data yes

Abstract: The author describes some of the perceived reasons behind the inefficiency of the current NRC designing-for-safety philosophy and for the failure of the single-failure criterion as applied. The author goes on to state that even if the licensing issued are more closely related to socio-political-bureaucratic aspects of life than to the scientific basis on which they should be founded, it seems appropriate to improve the latter. He states that risk assessment should be mandated and implemented in the hope of rationalizing the licensing process. Examines the limitation, needs, and obstacles of such a process and concludes that what is needed is a means of interpreting whether the risk due to a specific accident or class of accidents are important enough to warrant consideration. Proposes decision criteria for risk acceptability, (see Table 1 of this report).

File #74

Title: Risk in Hydroelectricity Production

Author(s): H. Inhaber

Affiliation: Atomic Energy Control Board, Ontario, Canada

Report/Date: Energy Volume 3, pages 769-778, 1978

Contents: 9 pages, 8 tables, 2 figures
Criteria no, Methodology no, Data yes

Abstract: As in any energy system, hydroelectricity can present risks to workers and to the public. When "risk accounting," or the summing of the risk to human health from the entire energy cycle, is used, the result from this method showed that hydroelectricity has fairly substantial values. (The sources of risk considered were construction, operation and maintenance, transportation and dam failures, with the risk values being occupational man-days lost per megawatt year net energy.) It ranks fourth lowest in a selected group of 11 energy technologies, whose order is as follows: natural gas, nuclear, ocean thermal, hydroelectricity, solar space heating, solar thermal electric, solar photovoltaic, wind, methanol, oil and coal. About half the risk in hydroelectricity generation is due to material acquisition and construction.

File #89

Title: Risk Management Decision Rules for LWRs

Author(s): M. Griesmayer

Report/Date: Presentation to ACRS PRA Subcommittee meeting on April 30, Risk Management Framework for LWRs - Source A.K. Bhattacharyya, IEEE Committee WG 5.4, meeting May 30, 1980.

Contents: 9 pages
Criteria yes, Methodology no, Data yes.

Abstract: Viewgraph presentation to the ACRS PRA subcommittee on risk management framework for LWRs. Outlines the aims, features, problems, and considerations necessary in risk decision making, in addition to the features, certification, and maintenance of a safety profile. Then goes into the basic premises and rules necessary in a criterion, followed by stating his particular hazard limits, (see Table 1 of this report.)

File #67

Title: Risks Associated with Nuclear Power

Author(s)/
Affiliation: National Academy of Sciences

Report/Date: Nuclear Safety, Volume 20, No. 6, November-December 1979

Contents: 7 pages, 1 table, 1 figure
Criteria no, Methodology no, Data yes

Abstract: The report from which this article is adopted is a critical review of the literature pertaining to the risk associated with nuclear power. This article presents highlights from the "summary and synthesis" chapter. Concludes that nuclear power risks, to which the present report is devoted, pertain to only one square in the matrix of kinds of information needed for decision making on energy programs. Even for electrical energy, one must decide among a number of alternative technologies or sources for producing it, and for each of these, one must estimate its benefits, costs, time scale, and risks; one must also bear in mind the costs and risks of not producing it.

File #68

Title: Comparative Risk - Cost - Benefit Study of Alternative Sources of Electrical Energy

Author(s)/
Affiliation: Adapted by the National Science Information Staff

Report/Date: Nuclear Safety, Volume 17, No. 2, March-April 1976.

Contents: 13 pages, 2 figures, 2 tables
Criteria no, Methodology no, Data yes

Abstract: This study quantifies, normalizes, and compiles conventional and societal costs associated with the production of electrical energy by currently available alternative systems based on coal, gas, nuclear fuels, and hydroenergy. Particular emphasis is placed on examining each energy system in its entirety, both the power plant and its supporting fuel cycle. The study is restricted to routine impacts, (health, safety, environmental degradation, etc.), including routine accidents whose frequencies can be established from historical data. From the available data, which are thoroughly referenced herein, it is concluded that natural gas incurs minimal environmental and human impact costs but remaining supplies are small; oil presents considerably greater environmental and human impacts but substantially less than those from coal, which is both the most serious environmental offender and the most abundant domestic fuel source. Nuclear fuels, which are abundant, have somewhat less environmental and human impacts than gas. The conventional fuel costs of coal and nuclear fuel cycles are found to be comparable and considerably less expensive than gas or oil, the author concludes saying that it appears that the cost of abatement and health and safety measures will significantly increase the cost of energy from coal over that from nuclear fuel.

File #85

Title: Application of Risk Acceptance Criteria

Author(s): D. Johnson and W. Kastenburg

Report/Date: From A.K. Bhattacharyya, meeting of IEEE WG 5.4 on May 15, 1980

Contents: 6 pages
Criteria yes, Methodology no, Data yes

Abstract: Slide presentation to ACRS PRA Subcommittee meeting on April 30 on application of risk acceptance criteria. Probability vs fatalities are shown primarily for Indian Point, Zion, and WASH-1400.

File #75

Title: Safety Design Criteria and Operating Experience

Author(s): J.J. Herbst and F.R. Hubbard

Affiliation: Nuclear Power Systems, Combustion Engineering, Inc.

Report/Date: Presented at the Fourth National Conference on Energy and the Environment, October 7, 1976.

Contents: 11 pages, 5 figures
Criteria yes, Methodology no, Data yes

Abstract: Shows that a quantitative definition of a probability and criteria categorization matrix can be developed within the present regulatory requirements. Concludes that plant operating experience and the application of existing methodology should be factored into the regulatory process. This permits, in the author's viewpoint, a formal and consistent method for matching criteria with event probabilities in an equal risk per event approach which suggests a rational limit to the NRC licensing escalation process.

File #76

Title: The Role of Reliability in the LMFBR Industry

Author(s)/ Affiliation: J.R. Penland, TVA; A.M. Smith, GE; and D.K. Goeser, GE.

Report/Date: Presented at the International Conference on Nuclear Systems Reliability Engineering and Risk Assessment held in Gatlinburg, Tennessee, June 20-24, 1977.

Contents: 20 pages
Criteria yes, Methodology no, Data no

Abstract: The authors' position is that the mission of a reliability program for an LMFBR should be to enhance the design and operational characteristics relative to safety and to plant availability. Successful accomplishment of this mission requires proper integration of several reliability engineering tasks (analysis, testing, parts controls, and program controls). Such integration requires, in turn, that the program be structured, planned, and managed. This paper describes the technical integration necessary and the management activities required to achieve mission success for LMFBRs.

File #76

Title: Nuclear Systems Reliability Engineering and Risk Assessment

Author(s)/ Affiliation: edited by J.B. Fussell, University Tennessee and G.R. Burdick, EG&G Idaho, Inc.

Report/Date: International Conference on Nuclear Systems Reliability Engineering and Risk Assessment, held June 20-24 1977 at Gatlinburg, Tennessee.

Contents: 34 presentations, 850 pages
Criteria yes, Methodology yes, Data yes

Abstract: The objective of the conference was to update the latest information concerning theory as well as applications of reliability and risk of nuclear systems. Thirty-four papers are presented on the following topics: Policy and Social Aspects, Evaluations and Applications, Common Cause Failure Analysis, Methodology, Reliability Approaches and Programs, Automated Logic Model Construction.

File #77

Title: Probabilistic Analysis of Accidental Transients in Nuclear Power Plants

Author(s)/
Affiliation: J. Amesz, G. Volta, CEC, Joint Research Center, 21020 Ispra (Varese), Italy, and S. Garribba, CESNEF, Nuclear Engineering Dept. Politecnico di Milano, Italy

Report/Date: Presented at the International Conference on Nuclear Systems Reliability, Engineering and Risk Assessment held at Gatlinburg Tennessee, June 20-24 (97)

Contents: 15 pages, 7 figures
Criteria yes, Methodology no, Data no

Abstract: The aim of this work is to establish a theoretical frame for computing probability distribution of loads and residual strength in the primary cooling system of nuclear power reactors. Random point processes are presented in order to provide a general framework for describing operational and accidental load transients. Once failure modes have been ascertained and a failure hypothesis has been established, strength appears represented by a filtered process and reliability can be in principle computed.

Information concerned with failures and performance characteristics of components allows us to infer the statistical structure of the random processes. The case is displayed where advantage is taken of all information which is available prior to the design. The case is then considered where use is made of additional data obtained through operation practice of the system.

File #78

Title: Safety Criteria Applied in the Design of the Polish Test Reactor 'Maria' and Evaluation of the Effectiveness of the Proposed Containment System

Author(s): C. Nycz

Affiliation: Institute of Nuclear Research, Swierk, Poland

Report/Date: Presented at the International Atomic Energy Agency Symposium on Principles and Standards of Reactor Safety, February 1973.

Contents: 8 pages, 3 figures, 3 tables.
Criteria yes, Methodology no, Data yes

Abstract: In the early design stage of the Polish high flux test reactor (30 MW), the evaluation of the possible sequences of accidents was performed and the maximum credible accident chosen. The failure of the pressure loop in the core followed by the SPERT-type nuclear excursion and rupture of the remaining pressure loops in the core appeared to be the most dangerous sequence of the credible accidents. For this case, the time-dependence of the pressure buildup in the containment and the activity release to the environment was evaluated, taking into account the ventilation system characteristics and the semi-tightness of the concrete containment building. The influence of the safety system parameters which are most important from the standpoint of the exposure in the reactor environment, such as the filter efficiency, the tightness and shielding effectiveness of the containment walls and the stack height, was evaluated and compared in order to meet the safety criteria and to obtain the equivalence of the potential exposures from all sources of irradiation.

File #90

Title: Policy Statement on Use of PRA in the Regulatory Process

Author(s): E.D. O'Donnell

Affiliation: Policy Statements East Coast AIF

Report/Date: Atomic Industrial Forum, Committee on Reactor Safety and Licensing Policy Statement on the Use of Probabilistic Risk Assessment in the Regulatory Process, April 4, 1980.

Contents: 11 pages
Criteria yes, Methodology yes, Data no

Abstract: Policy statement of the Atomic Industrial Forum on Probabilistic Risk Assessment (PRA) is presented. Basic principles expressed are: (1) probabilistic analysis should support, not supplant, deterministic requirements; (2) probabilistic analysis should be used as the basis for setting generic requirements, not as a condition for licensing of individual plants; (3) PRA should be adopted as the basis for addition to or for departures from applicable deterministic licensing requirements; (4) quantitative safety goals or risk criteria must be established for PRA based decision making; and (5) a common methodology must be established for performance of PRA analysis. Specific applications of the five general recommendations applied to the regulatory process are then discussed, (see Table 1 of this report for criteria).

File #79

Title: Standards and Criteria in Use or Being Developed for Reactor Safety

Author(s): R.B. Minogue

Affiliation: U.S. Atomic Energy Commission

Report/Date: Presented at the International Atomic Energy Agency Symposium on Principles and Standards of Reactor Safety, February 1973.

Contents: 21 pages
Criteria yes, Methodology no, Data no

Abstract: The importance of standards, criteria, and codes for achieving safe, dependable, and economic nuclear power has been recognized by the nuclear industry and the regulatory agencies of the United States of America for a long time. This paper describes the current nuclear standards program of the U.S. Atomic Energy Commission and its role in promulgating these standards for the design, construction, and operation of nuclear facilities. AEC regulations relating to radioactivity releases are historically traced from their inception to presently proposed modifications. Other regulations such as the general design criteria, the quality assurance criteria, and the seismic and geologic siting criteria for nuclear power plants are also described, as well as proposed regulations and rule changes currently in preparation.

Since 1970, the AEC has issued safety guides for water-cooled nuclear reactors which are used to aid nuclear power plant applicants and licensees in complying with the general requirements and guidance provided in the Code of Federal Regulations. Many of these guides are in the area of quality assurance, where much more detailed guidance is needed and many standards are now being developed. Quality assurance program requirements for the design, construction, and operation phases of nuclear power plants are presented, and present and future standards efforts in this area are described. Guides are also presented which describe good practices to be used to assure that structures, systems, and components important to safety are designed, fabricated, erected, and tested to adequate quality standards. Also described are guides which specify acceptable analytical methods and assumptions for evaluating various postulated accidents and guides which identify the information that is needed to evaluate applications for construction and operation of nuclear power plants.

File #80

Title: Recommended Design Criteria for Nuclear Power Merchant Ships

Author(s)/
Affiliation: R.W. Dickinson, Babcock and Wilcox Co., and Z. Levine, Office of Maritime Technology, U.S. Department of Commerce

Report/Date: Presentation at the International Atomic Energy Agency Symposium on Principles and Standards of Reactor Safety, February 1973.

Contents: 24 pages
Criteria yes, Methodology no, Data no.

Abstract: Existing regulations of the U.S. Atomic Energy Commission provide that an application for a construction permit must include the principle design criteria for a proposed nuclear facility. The principal design criteria establish the necessary design, fabrication, construction, testing, and performance requirements for structures, systems, and components important to safety. General design criteria have evolved in recent years for use in the design of central station nuclear electric generating plants. The need for analogous design criteria for nuclear-powered merchant ships has been recognized. Recommended design criteria for nuclear ships have been developed under an ongoing program sponsored by the U.S. Maritime Administration and have been submitted to appropriate regulatory groups in the U.S.

The criteria, although they have no official sanction, do establish recommendations for minimum design requirements for the principal design criteria for water-cooled nuclear power plants to be used in merchant ship propulsion. Wherever practicable, these propulsion plants are similar in design to land-based plants for which construction permits have already been issued by the AEC. The Recommended General Design Criteria for nuclear powered merchant ships have been based on the USAEC's General Design Criteria and accepted practice for safe design and operation of nuclear merchant ships. This paper reviews the recommended criteria for nuclear ships with emphasis on those areas where the nuclear propulsion plant is uniquely different from its land-based counterpart. In addition, the authors point out the need for international acceptance of general design criteria.

File #93

Title: Possible Forms for Top Level Criteria

Author(s): M. Temme

Affiliation: General Electric Corp. Sunnyvale California

Report/Date: Presented at the IEEE WG 5.4 meeting on May 15, 1980

Contents: 1 page
Criteria yes, Methodology no, Data no

Abstract: Outlines attributes of risk criteria; eleven separate points are presented: 1) acute fatalities (a) sensitive to biological effects model, (b) negative connotation; 2) latent fatalities (a) sensitive to biological effects model, (b) not observable; 3) probability distribution of ground and/or air release from con-

tainments; 5) probability distribution of release from site; 6) probability of extensive core damage; 7) man-rem; 8) totality of plant release and/or risk is the measurable: not individual sequences; 9) there may (will) exist an acceptable as well as an unacceptable level or limit; 10) (a) totality is compared to unacceptable limit, (b) individual sequence compared to acceptability limit, (c) horse and trade; 11) authenticity (uncertainty in risk assessment) must be included.

File #94

Title: Attributes of Risk Criteria

Author(s): R.E. Jaquith

Affiliation: Combustion Engineering

Report/Date: Presented IEEE WG 5.4 meeting of May 15, 1980

Contents: 5 pages
Criteria yes, Methodology no, Data no

Abstract: Presented are the pros and cons of numerical criteria. Addressed are fatalities, economics, probability, frequency parameters (top level and non-inclusive), and comparative criteria.

File #69

Title: The Application of Risk Allocation to Reactor Siting and Design

Author(s): H. Otway

Affiliation: Los Alamos Scientific Laboratory

Report/Date: LA-4316, UC-41 Health and Safety and UC-80, Reactor Technology TLD-4500, June 1970.

Contents: 28 pages, 12 figures, 8 tables, 3 appendices
Criteria yes, Methodology yes, Data yes

Abstract: Individual mortality risk^{f} is proposed as a basis for assessing reactor safety. The method evaluates reduction of risk by safe-guards, and determines radii of exclusion from sites. Accidents are divided into two categories: random independent failures of systems, and "site-induced" accidents, such as earthquakes, that destroy operation of more than one system simultaneously. Fission-product release vs accident probability is determined for both types of accident in a typical 1000-MW(e) pressurized water reactor.

Calculations from medical data indicate mortality risks of 1 x 10^{-6} per person per rad from thyroid irradiation, assuming a

1-rad threshold, and 30 x 10^{-6} per person per rad from whole-body irradiation, with a 100 mrad threshold. Total individual mortality risk per year is determined by applying these dose and risk criteria to the fission-product release curve, and integrating. From the author's viewpoint, societal risk acceptance indicates 10^{-7} as an acceptable yearly death risk to the nearest resident continuously exposed to a nuclear plant. This risk is calculated to occur at the boundary of a 350 meter-radius site of a 1000-MW(e) pressurized water reactor. Calculated risk from reactivity accidents is insignificant compared to that from loss-of-coolant accidents, indicating an imbalance in safeguard design. Earthquake risk is the most significant unknown.

The mortality risk concept (neglecting earthquake risk) indicates that 1000 MWe thermal reactor siting need be restricted only by the physical size of the facility.

File #98

Title: Secretary's Report of the Third Meeting of IEEE WG 5.4

Author(s): A.K. Bhattacharyya

Affiliation: National Safety Analysis Center

Report/Date: Meeting notes of IEEE WG 5.4, May 30, 1980

Contents: 15 pages
Criteria yes, Methodology no, Data yes

Abstract: A review is made by R. Paddleford on probabilistic risk assessment in licensing and the role of numerical safety goals. In addition to risk criteria development, scope of application is formulated and commented on by attendees. Twenty-one separate papers were presented.

File #97

Title: On the Selection of Risk Criteria

Author(s): V.B. Parr, B.M. Tashjian

Affiliation: Southwest Research Institute

Report/Date: May 13, 1980

Contents: 4 pages
Criteria yes, Methodology no, Data no

Abstract: The authors state that the risk analysis method of forming criteria vary in complexity from the "cost of saving a life" to "design reliability" with multiattribute utility function, effects (fatalities, injuries) risk budget and acceptable probability of accident sequence all falling within these two. In addition, criteria should be valid for present and future plants, including complete nuclear cycle, but excluding property damage. Discusses risk attributes, early and latent fatalities as seen by the public, and property damage in a facility and cost of replacing power by utility.

File #95

Title: A Proposed National Nuclear Safety Goal

Author(s): E.L. Zebroski

Report/Date: Presented at the Seventh Energy Technology Conference in Washington, D.C., March 24-26, 1980.

Contents: 9 pages
Criteria yes, Methodology yes, Data yes

Abstract: The author states that several implications of the four major government studies of the Three Mile Island accident are not sustained by the industry studies. He states that the safety record is unparalleled by almost any other human activity, either in energy production, transportation, or industry generally.

Nevertheless, the occurrence of the event is significant and the industry has taken the main "lessons learned" very seriously and has implemented, or is committed to, actions which will make another accident involving core damage as severe as the TMI accident highly unlikely in this century in the U.S. He then elaborates on a practical safety goal, a perspective on core melt-downs, and a proposed national nuclear safety goal. He proposes that: (1) reactor design, operation, and regulation should ensure that accidents which reach the stage of core melting have a probable frequency of no more than one such occurrence in 30 years, taking into account the actual population of civilian reactors in operation in the U.S.; (2) reactor safety systems and containments shall be maintained and operated so that even if core meltdown were to occur, there would be less than one chance in 1,000 that a radiation release leading to a dose of 1 R or more to any member of the public will result.

File #81

Title: Development of Adequate Risk Standards

Author(s): F.R. Farmer

Affiliation: Safety and Reliability Directorate, United Kingdom Atomic Energy Authority

Report/Date: Presented at the International Atomic Energy Agency Symposium on Principles and Standards of Reactor Safety, February 1973.

Contents: 7 pages
Criteria yes, Methodology no, Data no

Abstract: The author states that there have been many studies, from WASH 740 onwards, of the effect of releasing to the atmosphere various fractions of fission products. This paper does not set out to exaggerate or over-emphasize the effect of nuclear accidents, but outlines the likely consequences of releasing 10% of gas and volatile fission products under average weather conditions. An argument is developed leading to a proposition that the risk^{pc} of such an event occurring at any time, anywhere, from the reactors now being built or commissioned in this decade should be less than 1 in 10, and preferably 1 in 100. This may be translated as a risk from any one reactor, in any year, of less than 10^{-6}. Formulating an objective of this kind helps clear our minds about the degree of confidence we need to have technology of nuclear power engineering. Having as our clear aim the achievement of such a definitive low risk, we may see more clearly the gaps in our defenses left by present organizational arrangements, and we may reasonably question whether our capabilities - both to engineer and to organize - are good enough.

File #23

Title: Assessment of Acceptable Risk (using nuclear waste as an example)

Author(s): National Council on Radiation Protection and Measurements

Report/Date: A preliminary statement of the study group on acceptable risk (nuclear waste), November 14, 1979

Contents: 50 pages, 5 tables
Criteria yes Methodology no, Data yes

Abstract: This statement gives the preliminary views of a group established by the NCRP to study risk assessment, using as a model the hazards posed by the radioactive wastes that result from generating electricity by nuclear power, and having the principal goal of indicating how the public may participate with confidence in the assessment of the risks of nuclear waste and of controlling, handling, and isolating it. Basic elements of the problem are identified and some of them are briefly discussed.

File #70

Title: Areas of Uncertainty in Estimates of Health Risks

Author(s): L.D. Hamilton

Affiliation: Biomedical and Environmental Assessment Division, National Center for Analysis of Energy Systems, Brookhaven National Laboratory

Report/Date: Presented at Symposium on Energy and Human Health: Human Costs of Electric Power Generation, sponsored by University of Pittsburgh and Ohio River Basis Energy Study, Pittsburgh, March 19-21, 1979.

Contents: 70 pages, 15 figures, 8 tables
Criteria yes, Methodology no, Data yes

Abstract: This paper is concerned with several currently prominent uncertainties in estimating health risks[9] from electric power generation: (1) health effects of air pollution, especially acid sulfates and respirable particulates; and (2) low-level radiation effects. With these uncertainties in mind, state-of-the-art current assessments of various fuel cycles on a unit plant basis are given and a method is outlined for using these results in national or regional energy assessment.

File #21

Title: Approaches to Acceptable Risk (Draft)

Author(s)/
Affiliation: B. Fischhoff, S. Lichtenstein, P. Slovic; Decision Research
S. Derby, Stanford University, R. Keeney, Woodward-Clyde Consultants, San Francisco, California

Report/Date: Preliminary draft of report to the NRC, Winter 1980

Contents: 309 pages, 20 tables, 14 figures
Criteria yes, Methodology no, Data yes

Abstract: Deciding "How Safe is Safe Enough?" is a stumbling block in the management of many technological hazards. This report provides an analysis of acceptable risk decisions and the ability of various approaches to cope with the risks. It attempts to do this by: (a) characterizing the essential features of acceptable risk problems that make them so hard to manage, (b) offering a taxonomy of decision-making methods, each identified by its ability to address the features of acceptable risk problems, (c) specifying the objectives that an approach should satisfy in order to guide social policy, and (d) rating the success of the approaches in meeting these objectives. Although no solution to acceptable risk problems is advanced, recommendations are made for how society might better address these problems in practice, and through research.

File #92

Title: Decision Criteria for the Selection of Risk Criteria

Author(s): M. Temme

Affiliation: General Electric Corporation, Sunnyvale, California

Report/Date: Presented at the IEEE, WG 5.4 meeting of May 15, 1980

Contents: 4 pages
Criteria yes, Methodology no, Data no

Abstract: Outlines the decision criteria for the selection of a risk criteria; 29 separate points are discussed. Some highlights of the outline are as follows: criteria should be definitive, address risk, be quantitative, allow flexibility in design, consider operating and committed plants, consider cost-benefit, address normal vs operating risk, consider population and site location, be addressed in relative and martinal risk, consider risk comparisons, consider perceptions of risk, and address uncertainties.

File #82

Title: Disasters as a Necessary Part of Benefit-Cost Analyses

Author(s): R.K. Mark, D.E. Stuart-Alexander

Affiliation: Branch of Western Environmental Geology at the U.S. Geological Survey

Report/Date: Science Volume 197, September 16, 1977

Contents: 3 pages
Criteria no, Methodology no, Data yes

Abstract: Benefit-cost analyses for water projects generally have not included the expected costs (residual risk) of low-probability disasters such as dam failures, impoundment-induced earthquakes, and landslides. Analysis of the history of these types of events demonstrates that dam failures are not uncommon and that the probability of a reservoir-triggered earthquake increases with increasing reservoir depth. The author's contention is that because the expected costs from such events can be significant and risk is project specific, estimates should be made for each project. The cost of expected damage from a "high-risk" project in an urban area could be comparable to project benefits.

File #96

Title: Determining Acceptable Risk

Author(s): C. Starr, C. Whipple

Affiliation: Electric Power Research Institute

Report/Date: Presented at the American Association for the Advancement of Science meeting on Risk in the Technological Society, San Francisco, California, January 7, 1980

Contents: 36 pages
Criteria yes, Methodology no, Data no

Abstract: The author's viewpoint is that it is important to explore the subject of risk assessment and acceptability in order to assist the public process of decision making.

In Part I the concept of acceptable risk is considered, and contrasts the principal methods of judging the balance among risk, benefit, and the costs of risk reduction are contrasted. Analytical approaches are reviewed, encompassing decision analysis and cost-benefit analysis (also referred to as risk-benefit analysis), and the intuitive or subjective approach. The importance of individual intuitive judgments of risk acceptability on the social acceptance of specific risks is then considered. The available information about subjective judgments of risk, benefit, and the trade offs between them are briefly discussed and the degree to which the important factors in these decisions, as well as the decision processes themselves, are considered. In Part II a much narrower question is considered: Can acceptable risk be defined by numerical criteria for allowable levels of risk for specific technologies? This section describes the incentives to develop and implement numerical criteria of this type, as well as the problems which the authors think would arise with their use.

File #84

Title: A Possible Standard of Risk for Large Accidental Releases

Author(s): J.R. Beattie, G.D. Bell

Affiliation: Safety and Reliability Directorate, UKAEA

Report/Date: Presented at the International Atomic Energy Agency Symposium on Principles and Standards of Reactor Safety, February 1973.

Contents: 16 pages, 5 figures, 5 tables
Criteria yes, Methodology no, Data yes

Abstract: The author's position is that everything which is reasonable should be done in the design, construction, and operation of nuclear reactors to ensure that accidental releases of radioactive fission products cannot occur. Nevertheless, even when all such measures have been taken, there will remain a residue of faults which in combination could lead to releases of radioactive fission products having significant adverse effects on the safety of the public, although the probability of occurrence of such releases will be very small. The nature and probabilities of these accidental events are predicted in this paper for a range of releases mainly of gaseous and volatile fission products. Taking into account the probabilities of the events, one is led to consider rates of loss of life and of loss of property, and both of these may be regarded as monetary loss per unit time if desired.

File #71

Title: What Others Think (Will the Past Be Prologue?)

Author(s): A. VanHorn, R. Wilson

Affiliation: Energy and Environmental Policy Center, Harvard University

Report/Date: Public Utilities Fort Nightly, February, 1977

Contents: 3 pages, 1 table
Criteria no, Methodology no, Data yes

Abstract: The past health effects (fatalities) of fossil fuel and nuclear electricity generation are examined, primarily for the years 1967 through 1976 in which there was a total nuclear contribution of 750×10^6 megawatt-hours. Alternative means of production are substituted for this power. Estimates are then drawn showing U.S. fatalities from this substitute generation. The additional deaths which would have resulted in the U.S. from replacing nuclear power by fossil fuel electricity generation up to December 1976 is in the range of 1,900 to 27,500 deaths and a little more than twice that world wide.

File #72

Title: Assessment of Energy Parks vs. Dispersed Electric Power Generating Facilities

Author(s): General Electric Company

Affiliation: Center for Energy Systems, Washington, D.C.

Report/Date: Submitted to the National Science Foundation, May 9, 1979

Contents: 96 pages, 1 appendix
Criteria yes, Methodology no, Data no

Abstract: Paper describes the approach which the General Electric Company proposes to take in analyzing the advantages and disadvantages of energy parks. A brief discussion is given of the advantages and disadvantages of such a park. Major areas considered are site, size, cost-effectiveness and barriers.

File #87

Title: What ATWS Risk Would be Cause for Concern?

Author(s): I. Wall

Affiliation: Electric Power Research Institute

Report/Date: Presented to the ACRS ATWS - Subcommittee from A.K. Bhattacharyya, IEEE Committee WG 5.4, May 30, 1980

Contents: 4 pages
Criteria yes, Methodology no, Data yes

Abstract: The author strongly supports the idea of a acceptable risk criteria. He suggests a tentative guideline in the range of $\leq 10^{-4}$/r-y for significant cladding degradation such as TMI-2. In addition, concomitant probabilities for serious release would be equivalent to: return period for TMI-2 events > 30 to 60 years, expected accidental population dose <0.05/r-y; probability of one latent cancer fatality $<10^{-4}$/r-y, probability of early death at site boundary $<10^{-8}$/r-y; risk for nuclear fuel cycle would be much less than that from fuel cycles for alternative sources; Anticipated Transients Without Scram goals of $\leq 10^{-5}$/r-y of causing significant cladding degradation, require value impact analysis for all accident sequences whose probability is greater than 10% of above guidelines, for older plants, make some allowance for plant size, lower population and remaining useful life.

File #91

Title: AIF Position Statement on Quantitative Safety Goals

Author(s): Atomic Industrial Forum

Affiliation: Policy Statement West Coast AIF

Report/Date: Atomic Industrial Forum Committee on Reactor Safety and Licensing, West Coast Policy Statement on the Use of Probabilistic Risk Assessment in the Regulatory Process, April 4, 1980

Contents: 1 page
Criteria yes, Methodology no, Data yes

Abstract: This paper gives the AIF endorsement of the concept of a quantitative safety goal for central station nuclear power plants. This safety goal should be chosen to assure (1) that the number of disruptions in the life of residents in the vicinity nuclear power plants is low and (2) that nuclear power generation is as safe as alternative means used to generate electrical power and as safe as practical. AIF proposes the following quantitative safety goals: (1) frequency of serious core damage should be lower than 10^{-4} per reactor year; (2) average number of public fatalities attributable to the operation of nuclear power plants in the U.S. (exclusive of the fuel cycle) should be lower than 0.1 per year per 1000 MW(e) for latent fatalities and .01 per year per 1000 MW(e) for acute fatalities.

File #123

Title: Use of PRA in Evaluation Safety of Nuclear Power

Author(s): V. Joksimovic - General Atomic Company; W.E. Vesely - Nuclear
Affiliation: Regulatory Commission

Report/Date: Reliability Engineering, An International Journal, Volume 1, No. 1 July-September 1980

Contents: 9 pages, 1 figure
Criteria no, Methodlogy yes, Data no

Abstract: This paper offers an overview of uses and limitations of probabilistic risk assessment (PRA) techniques in evaluating safety of nuclear power in the U.S. as seen and experienced by the authors. It discusses subjects like PRA contributions to the defense-in-depth philosophy adopted in the U.S. many years ago for licensing nuclear power plants, needs to expand its present role, present pitfalls, the Three Mile Island (TMI) accident sequence, retrospective and prospective safety improvements, quantitative safety goals and the nuclear fuel cycle.

File #110

Title: Role of Risk Assessment in the Nuclear Regulatory Process

Author(s): S. Levine

Affiliation: Nuclear Regulatory Commission

Report/Date: Nuclear Safety, Vol. 9, No. 5, September-October 1978

Contents: 9 pages, 2 tables, 2 figures
Criteria yes, Methodology no, Data no

Abstract: The author's viewpoint is that the judicious application of risk-assessment techniques can help to reduce regulatory uncertainties, and the acceptability of such techniques is gaining support. Although the application of these techniques, in the manner of Report WASH-1400 (the Reactor Safety Study), to each plant would be formidable, a probabilistic approach can guide the decision makers concerned with the licensing process. Several examples of the use of a probabilistic approach are given. The risk-assessment tools will be improved under a plan submitted to Congress to improve reactor safety. The question of acceptable risk criteria will be addressed in the ongoing Nuclear Regulatory Commission (NRC) research program. It is expected that the continued use of risk-assessment techniques will help to improve the efficiency and the stabilization of the regulatory process by focusing the attention of the NRC staff on the important contributors to risk.

File #113

Title: Radioactive Releases from Nuclear Installations

Author(s): R. H. Clarke, H. F. MacDonald

Affiliation: Berkeley Nuclear Laboratory, Gloucestershire, England

Report/Date: Progress of Nuclear Energy, Volume 2, No. 2, 1978

Contents: 73 pages, 31 tables, 42 figures
Criteria yes, Methodology yes, Data no

Abstract: In this paper a description is given of the methods available which can be used to study the consequences of reactor releases. This paper considers the various stages in the pathway from irradiated nuclear fuel to man as separate modules, in each of which mathematical models are derived to represent the transfer of radioactivity. There is then a detailed treatment of the behavior of the effluent in the atmosphere including effective height of release, building entrainment, meteorological dispersion, mechanisms for ground deposition, and the effects of the duration of release. Finally, applications of the methods are described in reanalyzing the 1957 Windscale accident and in the planning of procedures for reactor accident monitoring as well as in the implications of future reactor designs to assessments of accidental releases. A brief summary of the reactor siting criteria adopted in the United Kingdom and in the United States is also given as a background against which to review the predictive techniques and results from the range of studies of accidents considered.

File #108

Title: Nuclear Power: The Answer That Became a Question, an Assessment of Accident Risks

Author(s): B. Sorensen

Affiliation: University of Copenhagen

Report/Date: Ambio Volume 8, No. 1, 1979

Contents: 8 pages, 9 figures
Criteria yes, Methodology no, Data no

Abstrect: Some of the problems and uncertainties in evaluating the probability of a significant fission reactor accident and the damage that could follow such an accident are discussed, using as a basis recent American and Scandinavian studies. The problem areas discussed are accident considerations, probability evaluations, damage evaluations, risk asssment, etc. It is concluded that the upper risk limit implied by present knowledge is disturbingly high. As a result, the viewpoint is presented that societies having or building nuclear reactors must include the possibility of catastrophic accidents very directly into their planning, and they must obtain social acceptance of the associated risk interval.

File #102

Title: Cost-Benefit Comparison of Nuclear and Non-Nuclear Health and Safety Protective Measures and Regulations

Author(s): E.D. O'Donnell, J. J. Mauro

Affiliation: Ebasco Service, Inc.

Report/Date: Nuclear Safety, Volume 20, No. 5, September-October 1979

Contents: 15 pages, 8 tables, 3 figures
Criteria yes, Methodology no, Data no

Abstract: This article compares the costs and benefits of health and safety measures and regulations in the nuclear and nonnuclear fields. A cost-benefit methodology for nuclear safety concerns is presented and applied to existing nuclear plant engineered safety features. Comparisons in terms of investment costs to reduce mortality rates are then made between nuclear plant safety features and the protective measures and regulations associated with nonnuclear risks, particularly with coal-fired power plants. The paper's position is that comparisons reveal a marked inconsistency in the cost effectiveness of health and safety policy, in which nuclear regulatory policy requires much greater investments to reduce the risk of public mortality than

is required in nonnuclear areas where reductions in mortality rates could be achieved at much lower cost. A specific example is presented to show regulatory disparity regarding gaseous effluent limits for nuclear and fossil fuel power plants.

File #103

Title: Potential Radiation Dose to Man from Recycle of Metals Reclaimed from a Decommissioned Nuclear Power Plant

Author(s): F.R. O'Donnell, S.J. Cotter, D.C. Kocher, E.L. Etnier, A.P. Watson

Affiliation: Oak Ridge National Laboratory, Tennessee, Department of Energy

Report/Date: ORNL/NUREE/TM-215

Contents: 131 pages, 66 tables
Criteria no, Methodology yes, Data yes

Abstract: A generic methodology is presented for estimating potential radiation doses to man from recycling radioactively contaminated scrap metals reclaimed from decommissioned nuclear facilities. The heart of the methodology is a set of tables of radionuclide-specific, radiation-dose factors that may be used to estimate doses to individuals and population groups from recycling any radioactively contaminated scrap metal. The dose factors are based on detailed radiological assessments of several options for recycling scrap metals. Assessments were made for each of 27 nuclides which might contaminate metals recovered from a decommissioned nuclear power plant. Each assessment was of a reference quantity of scrap metal that was assumed to contain a reference level of a potentially contaminative radionuclide. The radiological assessments are described, and the dose factors in assessments of many recyclable metals, for estimating critical-organ doses from the given dose factors that were derived for total-body exposures, and for ranking the radionuclides considered according to their relative potential for delivering radiation doses to man.

File #118

Title: On Risk Assessment in the Absence of Complete Data

Author(s): W. L. Kastenberg, T. C. McKone, D. Okrient

Affiliation: UCLA School of Engineering and Applied Science

Report/Date: UCLA-ENG-7677, July, 1976

Contents: 42 pages, 4 figures, 12 tables
Criteria no, Methodology yes, Data yes

Abstract: A major problem in assessing risks in advanced systems is that: (1) all the potential consequences are not known or anticipated; and (2) even when risks are anticipated there is uncertainty in the data. Several mathematical risk-assessment theories are summarized in this report, and their deficiencies in the absence of complete data are discussed. The mathematical basis of risk assessment is considered, and the basic problems of moving from a discrete to a continuous consequence-frequency distribution are discussed. The application of these concepts to waste disposal and storage of high level radioactive waste, risk to ground populations due to airline crashes, and nuclear power plant risks are reviewed and discussed.

File #100

Title: Environmental Impact of Radioactive Releases from Accidents in Nuclear Power Reactors

Author(s): J.R. Beattie, R.F. Griffiths, G. O. Kaiser, G. H. Kinchin

Affiliation: United Kingdom Atomic Energy Authority

Report/Date: June, 1978

Contents: 60 pages, 7 tables, 20 figures
Criteria no, Methodology no, Data yes

Abstract: A survey of accidental releases of radioactivity from thermal and fast reactors is presented. Following a general discussion on the hazards involved, the nature of the environmental impact of radioactive releases is examined. This includes a brief review of the natural radiation background, the effect on human health of various levels of radiation and radioactivity, permissible and reference levels, and the types of hazards from both passing clouds of airborne radioactive material and ground-deposited material. The problem of atmospheric dispersion and methods of calculating radioactive materials in the atmosphere are examined in order for the consequences of accidental release to be analysed. National accidents and their environmental consequences are then examined. Finally, there is a review of the risks to which man is always exposed because of his environment. Common and collective risks are also considered. Conclusions are reached as to the acceptability or otherwise of the environmental impact of reactor accidents.

File #101

Title: Criteria for Risk Acceptance: A Health Physicist's View

Author(s): A. P. Hull

Affiliation: Brookhaven National Laboratory

Report/Date: CONF-770409-8 April 24, 1977

Contents: 4 pages, 2 tables
Criteria yes, Methodology no, Data yes

Abstract: The author presents the following picture and viewpoint. A controversy over the safety of nuclear energy has grown in the U.S. since about 1970 and has now spread to near worldwide proportions. This controversy has been fueled by a variety of issues. Initially, in the U.S., the most prominent issue concerned the degree of hazard of low-level radiation, in particular that associated with the nuclear fuel cycle. Since then, attention has shifted successively to the reliability of emergency core cooling systems, the longevity of nuclear wastes, the possible misuse of radioactivity by terrorists, and the potential for diversion of nuclear-power-produced plutonium to weapons fabrication. Underlying each of these issues has been the implication that the employment of nuclear power will entail an unacceptable risk to the public. If comparison is made to the level of natural hazards such as earthquakes, floods, hurricanes, and tornados, a reasonable perspective in this regard is a yearly risk of 1×10^{-6}. Following a satisfactory demonstration of the safety of nuclear energy, it is hoped that the nuclear argument can be terminated. Society could then move on to the real issues affecting energy, population, and quality of life.

File #106

Title: A Method for Risk Analysis of Nuclear Reactor Accidents

Author(s): M. Maekawa, N.C. Rasmussen, W.E. Vesely

Affiliation: M.I.T., Cambridge Department of Nuclear Engineering, N.R.C.

Report/Date: MITNE/NUREG-205 January 1978

Contents: 243 pages, numerous tables and figures
Criteria no, Methodology yes, Data no

Abstract: A method is developed for deriving a set of equations relating the public risk in potential nuclear reactor accidents to the basic variables, such as population distributions and radioactive releases, which determine the consequences of the accidents. The equations can be used to determine the risk for different values of the basic variables without the need of complex computer programs and can be used to determine the variable values which are needed to satisfy various risk criteria. The methodology development in the study involves fitting risk distribution of frequency versus consequence to parametric distribution and then relating the distribution parameters to the basic variable of interest using regression techniques. The

Weibull distribution was found to be appropriate for the early fatalities distributions for hurricanes, tornadoes, earthquakes, dam failures and nuclear reactor accidents. A set of equations is then derived which relate the population distribution and the parameters of the Weibull distribution for early fatalities from PWR accidents.

File #105

Title: The Approach to (Nuclear Reactor) Safety Philosophy

Author(s): A. Birkhofer

Affiliation: Managing Director, Gesellschaft Fier Reaktorsicherheit (GRS)

Report/Date: Nuclear Engineering International, (GB) Volume 23, No. 279 December 1978

Contents: 2 pages
Criteria yes, Methodology no, Data no

Abstract: The author's position is that the efficiency of engineered safeguards is checked by accident analyses. Redundancy and physical separation are key concepts to obtain the required system reliability. Safety regulations are being codified to make them more predictable, probabilistic methods are being applied to quantify the safety of nuclear power plants, and quantitative risk assessment is influencing both safety assessment and research on safety.

File #116

Title: Risk Analysis of the Fuel Cycle in the Netherlands

Author(s): R. W. Van Otterloo, N. V. Kema

Affiliation: IAEA

Report/Date: Nuclear Power and Its Fuel Cycle, Salzburg, Austria, May 2-13, 1977

Contents: 12 pages, 5 tables, 2 figures
Criteria no, Methodology no, Data yes

Abstract: The risk analysis of the fuel cycle has been made by order of the Minister of Economic Affairs and has been prepared by personnel of the interested parties. The analysis is based on a total output capacity of nuclear power stations of approximately 3500 MW(E). The risks of all the phases of the fuel cycle have been assessed as far as this is or will be applied in the near future within our frontiers, together with normal operation of the power plants and the risk of radioactive releases. The

predominant risk of the fuel cycle is the risk caused by a core melt in a nuclear power plant. The risk analysis of the two existing power stations Borssele and Dodewaard has been applied analogous to WASH-1400. The reliability analysis method (fault trees and event trees) and the computer codes and failure data were applied as far as this was justifiable. The risk caused by a core melt of the three new 1000 MW(e) plants has been assessed by using WASH-1400 results (figures from Peach Bottom (BWR) and Surry (PWR) about probability and releases) in Dutch circumstances. A conclusion that can be drawn from this study is that the risks for the Dutch population from an installed nuclear capacity of 3500 MW(e) are determined by the nuclear power stations. The risks resulting from secondary activities, such as fuel enrichment, fuel fabrication, transport and waste treatment are small as compared with those from the nuclear power plants and are, moreover, in many cases more easily influenced by technical measures and/or regulations.

File #115

Title: Criteria for Radioactive Waste - A Time for Reason

Author(s): E. N. Cramer, T.L. Grebel

Affiliation: Transactions of the American Nuclear Society

Report/Date: 25th Annual Meeting of the American Nuclear Society, Atlanta, Georgia, June 3-7, 1979

Contents: 1 page, 1 figure
Criteria yes, Methodology no, Data no

Abstract: This paper discusses issues involving radioactive wast criteria. The Environmental Protection Agency (EPA) proposes criteria for disposal of all forms of radioactive waste. The Natural Resources Defense Counsel (NRDC) proposes alternative criteria. The papers posturize that the final EPA criteria should make risks from this disposal comparable to the risks from disposal of other hazardous materials; the criteria should be developed independent of the origin of the waste and should also consider relative toxicity. Strict interpretation of the EPA-NRDC criteria of zero risk to future generations, which rejects all benefits, could preclude use of all energy forms including solar, wind, coal, geothermal, natural gas, as well as nuclear; conceivably, energy conservation activities could be precluded and disposal costs for trivial sources of radiation exposure could be greatly increased.

File #109

Title: The Assessment of Risk: Its Value and Limitations (Nuclear Installations)

Author(s): Dunster, H.J., Vinck, W.

Affiliation: Health and Safety Executive, London, England

Report/Date: Nuclear Engineering International (G.B.) Volume 24, No. 289, August 1979

Contents: 3 pages
Criteria yes, Methodology no, Data no

Abstracts: It is the author's viewpoint that quantitative risk assessments may, in the short term, make public acceptance of certain nuclear installations more difficult to achieve. The authors believe that in the long term, however, such assessments will encourage public acceptance. Industry should do more to defend its own safety standards, while avoiding brash over-confidence.

File #114

Title: Is Solar Power Riskier Than Nuclear?

Author(s): Inhaber, H.

Affiliation: Atomic Energy Control Board, Ontario, Canada

Report/Date: Transaction of the American Nuclear Society, Winter Meeting, November 12-16, 1978.

Contents: 2 pages, 1 figure
Criteria no, Methodology no, Data yes

Abstract: A study that evaluates the risk, both occupational and public, of 11 different energy systems is summarized. For the first time a comparison, man-days lost, is made between non-conventional technologies - like solar, wind, and methanol - and conventional technologies - like coal, oil, and nuclear power. The total energy or fuel cycle, rather than just one small part, was evaluated, accounting for some of the following results. The calculated risk, man-days lost, per net energy output is as follows: Natural gas is lowest, at about 6 man-days lost per megawatt-year, followed by nuclear power, with about 10. Non-conventional technologies have substanitally higher risks, with the lowest in this group being ocean thermal at 30 man-days lost, and the highest being methanol at about 1300. Solar space heating, which has attracted widespread attention in the last few years, results in about 110 man-days lost. Highest overall is coal and oil, each with about 2000 man-days lost per megawatt-year. A preliminary analysis indicates that hydro-electricity probably would rank fourth lowest, behind natural gas and nuclear.

File #107

Title: Low-Level Radiation, A Review of Current Estimates of Hazards to Human Populations

Author(s): Myers, D.K.

Affiliation: Chalk River Nuclear Laboratories, Chalk River, Ontario

Report/Date: AECL-5745, December 1977

Contents: 52 pages, 13 tables, 8 figures
Criteria no, Methodology no, Data yes

Abstract: The author's viewpoint is that the internationally accepted estimates of risks suggest that the numbers of cancers and genetic defects induced in the general population by natural background radiation are not more than about 1% of the numbers of cancers and genetic defects normally present in the general population. The added risks to the general public due to any prospective nuclear power program are minute compared to those from background radiation. At the maximum permissible levels of radiation exposures for occupational workers, the predicted number of induced genetic defects is small (~2 % of natural incidence), while the predicted number of fatal cancers induced would reduce the average lifespan from 73.0 years to about 72.7 years. Since occupational exposures are usually much less than maximum permissible levels, the risks are correspondingly reduced. These occupational risks are comparable to those in most other industries and occupations. Some areas of uncertainty in the accepted risk estimates are discussed in detail.

File #104

Title: Medical Aspects of Power Generation, Present and Future

Author(s): Linnemann, R.E.

Affiliation: University of Pennsylvania School of Medicine

Report/Date: Medical Research Engineering Volume 13, No. 1, August 1979

Contents: 5 pages, 3 tables
Criteria no, Methodology no, Data yes

Abstract: The author presents information which shows that the radiation emissions of nuclear power plants are small indeed, compared to natural background radiation and other man-made sources of radiation. For example, it is shown that the population is exposed to 100 times more radiation from television sets than from nuclear power reactors. The assumed risks[f] to the people in the USA from nuclear power reactors are also small compared to the normal risks which are tolerated in this society. The author's position is that the complete elimination of all hazards is a most difficult if not impossible task.

File #112

Title: Nuclear Power as a Public Issue, Protection of the Public Interest

Author(s): J.M. Doderlein

Affiliation: Institute for Atomenergi, Kjeller, Norway

Report/Date: International Atomic Energy Agency Bulletin (Austria), Volume 20, No. 1, February 1978.

Contents: 8 pages, 2 tables
Criteria yes, Methodology no, Data no

Abstract: Discusses the desired role of nuclear power in the overall perspective of the role of energy in society. Topics include technological risk as a factor in public acceptance; the nuclear controversy, some comments; the philosophical and societal background; public interest and the professional; systematic technology evaluation; the place of facts in a world of values.

File #111

Title: Occupational Doses in the Ontario Hydro Nuclear Power Program

Author(s): R. Wilson

Affiliation: Radioactivity Management and Environmental Protection Department, Nuclear Generation Division, Ontario Hydro, Ontario, Canada

Report/Date: Health Physics, (GB) Volume 33, No. 3, September 1977.

Contents: 6 pages, 5 figures, 5 tables
Criteria no, Methodology no, Data yes

Abstract: The average doses received by Ontario Hydro Nuclear Station workers of various categories have been extracted from the computer-based dose record system. Extrapolations of the data have predicted average lifetime doses for the highest exposed categories of workers in the range 43 to 114 rem. The estimate depends pends on the data base selected for extrapolation. The total risk[e] facing a worker in any industry is comprised of two components: the risk from a chronic insult and the risk[f] from an accident with immediate effects. The total risk facing radiation workers in the Ontario Hydro Nuclear Program is compared with the total risk as far as it is known facing workers in some other industries. On this basis, nuclear power station work is comparable to the average risk in North American industry.

File #117

Title: Recent Developments in Training of the Emergency Organization at SSPB's Nuclear Power Stations in Sweden.

Author(s): S. Ekholm

Affiliation: Nuclear Safety Division, Swedish State Power Board, Vollingby. Sweden.

Report/Date: Handling of Radiation Accidents, Vienna, Austria, February 28-March 4, 1977.

Contents: 5 pages
Criteria yes, Methodology no, Data no

Abstract: This paper presents information on the emergency organization at Swedish State Power Board in Sweden. The emergency organization is concerned with the safety of plant, personnel, and district under the joint management of the nuclear power station and the county administration. The training program includes two films about nuclear risks during normal operation and emergency conditions including evacuation, which are shown at the nuclear sites to all workers and to the general public. There is also a special instruction film for the emergency organization, a 150-page lecture book used in conjunction with a 1 to 3 day basic course, and two check-list manuals, one for station personnel, and one for county administration bodies. Before stations are permitted to produce power, a full-scale emergency exercise must be carried out with press and TV coverage. Within two years, a cheap iodine monitor and a computer producing a printout with isodose curves will be added to the emergency research program. The program satisfies Swedish regulations and current American requirements, and an English translation of the training package is available.

File #122

Title: A Feasibility Study of the Application of Numerical Risk Criteria in the Licensing of Nuclear Power Plants in the United States

Author(s): S.P. Mitra, A. Coppola, B. Miller, R. Hall

Affiliation: Brookhaven National Laboratory, Upton N.Y. 11973

Report/Date: Working Draft, October 1980

Contents: 183 pages
Criteria yes, Methodology yes, Data yes

Abstract: This report describes the interim results of a continuing investigation on the feasibility of developing and using a set of probalistic risk criteria to aid in judging the safety of nuclear power plants. Brookhaven National Laboatory (BNL) performed the investigation for the Methodology and Data Branch of the Division of Systems Reliability Research in the Nuclear Regulatory Commission. The principal aim of the report was to critically review and examine the implications and ramifications of the different proposals for numerical risk critria from a unified viewpoint. The report did not address the general approaches and issues involved in risk acceptability.

File #121

Title: Risk Comparison

Author(s): A. Coppola, R. Hall

Affiliation: Brookhaven National Laboratory, Upton, N.Y. 11973

Report/Date: January, 1981

Contents: 80 Pages, 16 tables, 21 fig. es
Criteria no, Methodology no, Data yes

Abstract: This report presents data for the comparison of societal risk from natural and man-made hazards. Only fatalities resulting from the hazards are used in the comparison, with the data and the comparative analysis taken from current literature. In comparing societal risks for most of the hazards, both expected values and frequency vs consequence curves are presented. For a subset of hazards, notably the power generation technologies (nuclear, coal, oil and gas), which have not exhibited high consequence events (catastrophes), the comparisons are based on estimated expected values only.

Individual risk data are presented in two ways, a probability of death within a year or the amount of life shortening of an average life span. Wherever possible the authors have attempted to extract the individual risk from the data presented in the references. The authors state that the important variable which must be consistent for comparison is the estimate of the population at risk, which has ben reproduced from a given reference or is estimated by the authors and is clearly indicated throughout the report.

File #124

Title: Sensitivity of Risk Parameters to Human Errors in Reactor Safety Study for a PWR

Author(s): P.K. Samanta, A.L. Swoboda, R. Hall

Affiliation: Brookhaven National Laboratory, Upton, N.Y. 11973

Report/Date: NUREG 1879/BNL-NUREG 51322 December 1980

Contents: 57 pages, 4 appendices
Criteria no, Methodology yes, Data yes

Abstract: The study provides quantitative evaluation of the impact of human errors in the risk from nuclear power plants by measuring the sensitivities of various risk parameters. Sensitivities of the risk parameters - emergency safety system unavailabilities, accident sequence probabilities, core melt probability and release category probabilities, were investigated for changes in the unavailability contributions of the human errors (referred to as human error rates) within the general methodological framework of Reactor Safety Study (WASH-1400). Impact of individual human errors were assessed both in terms of their structural importance to core melt and reliability importance to core melt probability. It was found that the opportunity for reduction in core melt probability by reducing the human error rates without simultaneous reduction of hardware failures is limited, but core melt probability showed significant increase due to increase in human error rates. More importantly, most of the dominant accident sequences showed significant increase in their probabilities and many of the emergency safety systems -- containment spray injection system, auxiliary feedwater system, high pressure recirculation system, low pressure recirculation system and low pressure injection system, showed large sensitivity to human errors. Also, release categories resulting in high consequences showed much larger sensitivity to human errors comparted to categories resulting in low consequences.

File #120

Title: TMI and the Future of Reactor Safety

Author(s): S. Levine

Affiliation: NUS Corporation

Report/Date: Presented at an International Public Affairs Workshop, Atomic Industrial Forum, Inc., June 16, 1980

Contents: 12 pages, 4 figures
Criteria yes, Methodology yes, Data no

Abstract: The author states that since the basic framework of our approach to reactor safety already contains qualitative probability judgements, there can be little question in anyone's mind that we would be better off by being more quantitative. The quantitative technique, too new and uncodified for actual use as a part of the formal reactor licensing process, should be used the

same way as the current qualitative judgements have been used, that is to help decide what should or should not be used in the licensing process. Continuing, the author feels that with the growing emphasis on the application of PRA techniques to judge the safety adequacy of plants or various aspects of plants, it is clear that quantitative criteria for acceptable levels of risk, or safety goals, are needed if the benefits of these techniques are to be realized.

The author felt that while further exploration and understanding of Class 9 accidents should be done because it will enhance the overall understanding of the safety of nuclear power plants, it would be unwise at this time to extend the licensing process to consider accidents more severe than currently defined design basis accidents. These DBA's represent the culmination of a long series of carefully considered steps and should not lightly be changed. Furthermore, many studies both in the U.S. and Europe have shown that the use of these DBA's has resulted in the establishment of sets of engineered safety systems for LWR's that have significant capability to mitigate the consequences of more severe accidents. The study of severe accidents should be used to provide greater assurance that these systems have the performance characteristics necessary to ensure their successful operation in reducing the consequences of severe accidents rather than to extend the definition of DBA's to encompass these more severe accidents.

File #22

Title: Siting Criteria - A New Approach

Author(s): F. R. Farmer

Affiliation: UKAEA, Authority Health and Safety Branch

Paper: Presented to IAEA Symposium on Containment and Siting of Nuclear Power Reactor held in Vienna, April 3-7, 1967

Report/Date: SM-89/34, 1967

Contents: 24 pages, 13 figures, 3 tables
Criteria yes, Methodology yes, Data yes

Abstract: Assess the spectrum of risk in a quantitative-related manner. A method of reactor siting is described which takes into account the probability of occurrence of an event and the consequences associated with that event. In addition, the analysis involves establishment of failure-rate data for components and/or engineering systems. The author shows how this may affect the choice of sites for nuclear power plants. The author, in proposing probabilistic analysis be employed in reactor safety assessment, suggests that the safety criterion of less than 0.01 premature deaths per reactor year be adopted. In addition, he proposed

that a risk acceptance limit line be used to judge the acceptability of the estimated occurrence frequency for any particular accident. The severity of the accident was measured by the release in curies of iodine-131, one of the volatile fission products of greatest importance in thermal reactor accidents.

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This report contains abstracts of articles which address various aspects of quantitative risk analysis, covering the subjects of numerical risk criteria, methodology and data. The articles were published primarily from 1976 to date in technical journals, reports, papers, etc. The articles selected for this report were judged to have relevance to nuclear power plant risk evaluations and to the possible establishment of the acceptability (or unacceptability) of calculated nuclear power plant risks. A matrix of the various risk criteria proposed is presented.

17. KEY WORDS AND DOCUMENT ANALYSIS

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Hazards
Accidents
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Exposure

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