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

FEB 07 1978

MEMORANDUM FOR: Warren Minners, Technical Assistant to the Director, Division of Systems Safety

FROM: Malcolm L. Ernst, Assistant Director, Environmental Technology, DSE

SUBJECT: DRAFT SUMMARY OF ATWS VALUE-IMPACT ANALYSES

I found the recent exchanges between ourselves and our respective staffs to be useful in the development of this subject draft. Based on our brief conversation today, I think you agree with my evaluation of the deficiencies in the previous draft. The enclosed redraft is a major rewrite which I trust will accomplish the following:

1. Correct some factual inaccuracies;

2. Improve communications through some editorial changes;

3. Improve communications by rearranging portions of the draft to eliminate some confusing redundancy and make other improvements. The flow of the enclosed draft is:

   a. A brief statement of the staff's ATWS safety goal and the structure of the value-impact analysis.

   b. A summary of the impact analyses, including the parameters considered, assumptions, possible uncertainties in analysis, and an evaluation of the cumulative impacts of making modifications on all reactors for the next 30 years.

   c. A summary of the value analyses, including the parameters considered, assumptions, possible uncertainties in analysis, and an evaluation of the 30-year cumulative values of making modifications.

   d. A description of the staff's philosophy in judging the value-impact analysis to be supportive of the staff's safety goal.

   e. A summary value-impact analysis demonstrating that ATWS modifications can be phased in over a reasonable time period, rather than requiring prompt retrofit.

4. Improve the understanding of how the staff utilizes the value-impact analysis to support the ATWS decisional process. This is hopefully done to everyone's satisfaction by an addition to the previous draft, and is item 3.d., above.

Please advise, if you have any comments or suggested changes to the enclosed draft.

Malcolm L. Ernst, Assistant Director
for Environmental Technology
Division of Site Safety and
Environmental Analysis

Enclosure:
Draft Summary Value-Impact Analysis

cc: HDenton
RMattson
BJYoungblood
SCoplan
AThadani
TNovak

1978 ATWS

2/7/78	Memo to W. Minners from M. Ernst re DRAFT SUMMARY OF ATWS VALUE-IMPACT ANALYSES
1/24/78	Memo to A. Thadani from V. Panciera re COMMENTS ON PROPOSED ATWS RULE AND GUIDE
1/17/78	Note to Multiple Addressees from S. Hanauer re ANOTHER DRAFT OF ATWS DRAFT 3
1/17/78	Memo to Mattson, Hanauer, Ross, Tedesco, Novak, Panciera, Tondi, Ippolito, Malsch, Schroeder from A. Thadani re ATWS RULE AND ATWS REG GUIDE
1/16/78	Memo to T. Novak from R. Bosnak re REVIEW OF ATWS DRAFT 2 REPORT DATED 12/15/77
1/10/78	Memo to A. Thadani from Vassallo re COMMENTS - DRAFT NO. 2 - ATWS REPORT
1/10/78	Memo to A. Thadani from C. Graves re EXPERIMENTAL CONFIRMATION OF SAFETY/RELIEF VALVE CAPACITY AND OPERATING CHARACTERISTICS FOR ATWS CONDITIONS
1/6/78	Note to M. Williams and D. Vassallo from J. Stolz re SECOND ROUND REVIEW OF ATWS IMPACT-VALUE ANALYSIS (DRAFT #2 REPORT)
1/3/78	Note to R. Mattson from S. Hanauer re ATWS - A ROUTE TO DRAFT 3

2.1 ATWS Safety Objective

2.1.1 Introduction

Safety objectives are needed for nuclear power plants to assure that the risks to the general public from nuclear power plants remain below acceptable levels. The NRC staff believes that ATWS should be a design basis accident and therefore it should have a safety objective associated with it which limits the risk from ATWS to a small portion of the overall reactor risk. Safety objectives come in two general categories: deterministic, and probabilistic. An example of a deterministic objective is that of LOCA:

> The LOCA objective is to meet assuming a spectrum of pipe breaks, with loss of either on-site or off-site power only, and assuming a single active failure.

This sort of objective takes no account of the probabilities of pipe break, power loss, or single failure (or their combined probabilities). One advantage is that it is relatively easy to understand and regulate. One disadvantage (according to some industry) is that such deterministic objectives are excessively conservative. We could quite easily postulate a similarly deterministic ATWS safety objective. As for LOCA, it could be easy to understand, and to regulate. We have, however, explored the alternate, probabilistic method in order to better take into account the likelihood of an event in combination with its consequences, as part of the decision process in specifying the need to either reduce the likelihood or mitigate the consequences.

2.1.2 History in WASH-1270

Part of our exploration was a reassessment of the objective of WASH-1270. The objective there was to limit the recurrence frequency of a serious accident to no more often than once per 1,000 years. From that, we assumed a 1,000 reactors in operation (ultimately) which would generate the per-reactor-year number of 10^{-6}. This number has been interpreted in two ways:

(1) The probability of achieving core melt should not exceed 10^{-6} per RY (although not all core melts exceed 10CFR100 guidelines), and

(2) The probability of exceeding 10CFR100 should not exceed 10^{-6} per RY (although part 100 can be exceeded by other events than core melt)

Of the derived 10^{-6} per RY, one-tenth was allocated to ATWS, giving the oft-quoted goal, objective, or "aiming-point" of 10^{-7} per RY for ATWS.

The specific ~~ology~~ of WASH-1270 was that:

"...the safety objective will require that there be no greater than one chance in one million per year for an individual plant of an accident with potential conseqneuces greater than the Part 100 guidelines".

Again, the objective was keyed to ~~not~~ a recurrence interval of at least a thousand years, on the average, of accidents not included in the design basis envelope.

On reexamination of the WASH-1270 viewpoint, we note that:

(1) the number of reactors, by the year 2,000, may be close to 500

(2) "Some" ~~of~~ core melts may not exceed part 100, yet are not in the design basis envelope (i.e., are not considered on individual plants).

As a result of the staff's reevaluation of ATWS, the staff has revised its ATWS safety objective. The revised safety objective is less conservative than that of the WASH-1270. It can be summarized as follows: the probability of ATWS events leading to serious consequences (see Section 3.2 for details) should be of the order of 10^{-6}/RY when calculated in a realistic manner. ~~(Using the calculational methods discussed in Section .)~~ Achievement of this objective would make the ATWS risk an acceptably small contribution to the total risk, even if other safety improvements later decrease the overall risk.

In view of the difficulty and controversial nature of calculations intending to demonstrate compliance of a given plant with such an objective, the ATWS safety objective is to be regarded as an aiming point rather than as a fixed number which must be demonstrated for a given plant design.

2.1.3 Present Status

At present, LWR plant designs do not include any specific ATWS safety objective. In 1973 via WASH-1270, a specific set of ATWS safety objectives was provided by the AEC Regulatory staff. To date, the NSSS vendors and the licensees have not implemented the design changes which are necessary

to meet the WASH-1270 safety objectives. Based upon the staff's recent reevaluation of ATWS, the staff recommends an ATWS safety objective (section 3.2) which is less stringent than that of WASH-1270. ~~However,~~ The present reactor designs are not able to meet the staff's new, less stringent ATWS safety objective without plant modifications.

The staff reevaluation is based upon the methodology and results of the Reactor Safety Study. The Reactor Safety Study provided a quantitative estimate of the relative risks for various events, including ATWS, for the two reactors studied. The RSS did not in itself deal with safety objectives but did illustrate the cumulative effect of the safety objectives and licensing requirements on the risk due to accidents in the reactors that were assessed. The RSS provided insight in terms of core melt probability and consequences and the relative contribution that different events have upon core melt. The RSS showed that the large LOCA was not a significant contributor to the overall reactor risk. Because of the extensive measures taken to mitigate the consequences of such an event. Similarly, for the PWR studied (Surry 1), the RSS showed that ATWS constitutes a small fraction of the overall reactor risk. However, for the BWR studied (Peach Bottom 2), ATWS was shown to be a significant contributor to overall reactor risk.

~~2.1.4 STAFF RECOMMENDATIONS~~

~~The staff's present recommendation for an ATWS safety objective can be stated as:~~

The probability of having an Anticipated Transient Without Scram in which there are serious consequences should be of the order of one chance in one million per reactor year. (10^{-6}/Reactor Year). This safety objective s less conservative than the staff's previous (WASH-1270) ATWS safety objective. i.e., WASH-1270 states that the probability of having an ATWS in which there are serious consequences should be no greater than one change in ten million per reactor year (10^{-7}/Reactor Year). The acceptance limits and other detailed requirements are given in Chapter 3 of this report.

2.1.4 Risk Allocation for Other Events

Specification of an appropriate safety objective for ATWS should consider what we have said for objectives for other potential accident situations. As noted earlier, the LOCA safety objective is purely deterministic. We have provided some probabilistic acceptance criteria in Section 2.2.3 of the NRC Standard Review Plan. This plan pertains to potential accidents involving hazardous materials or activities in the vicinity of the plant (as contrasted to ATWS or LOCA, which arise within the plant). According to SRP 2.2.3, design basis events resulting from the presence of hazardous materials or activities in the vicinity of the plant are acceptable, provided that:

(1) the design accomodates those for which a realistic estimate of the probability of occurrence of potential exposures in excess of 10CFR100 guidelines excees the objective of approximately 10^{-7} per year, or

(2) the design similarly accommodates the events having a probability of occurrence of potential exposures in excess of 10CFR100 guide-

lines of approximately 10^{-6} per year, using a conservative calculation, provided that a reasonable qualitative argument can show the realistic probability is lower.

Our observations are that

1) these objectives do not take into account the probability of exceeding part 100 guidelines from reactor system related events (e.g., LOCA, ATWS).

2) they do not consider what the overall safety objective is, nor the allocation to materials or events in the plant vicinity.

3) they are plant-related, as contrasted with the WASH-1270 objective which averaged the safety objective over the national LWR population.

The Reactor Safety Study, WASH-1400, concludes that the core melt probability is approximately 5×10^{-5} per reactor year. Another finding of the RSS was that most core melts are benign and that some core melts in the 10^{-5} probability range probably do not even exceed the 10 CFR 100 guideline values. During the review of the RSS, the Regulatory Staff concluded (Ref.....) that the RSS estimates on core melt frequency had been assessed rather conservatively. This conclusion did not include the Regulatory staff positions on ATWS which had been previously enumerated in WASH-1270. Yet another indication of the possible overestimate of core melt frequency was the ....study on the Oyster Creek Nuclear Power Plant. This study concluded that a significant core melt sequence (Transient followed by decay heat removal system failure) on Oyster Creek had lower probability of

occurrence than had been estimated for Peach Bottom in the RSS. There are uncertainties in the applicability of the RSS to a large population of reactors. In particular, improvements are being implemented in the nuclear power plant designs which would further reduce the frequency of events with potentially serious consequences. Some examples of these improvements are requiring changes to reduce interface LOCA frequency, modifications in the decay heat removal systems, suggested modifications to reduce ATWS contributions, etc..... These changes and improvements in the availability of systems are expected to reduce the probability of exceeding 10 CFR Part 100 guideline values to less than 10^{-5} per reactor yr.

If one accepts the view that the probability of exceeding 10 CFR Part 100 is held to 10^{-5} or less per reactor year (more serious consequences have much lower probabilities as can be perceived from Figure 6-1 of the RSS), then it is necessary to assess the impact in the future when several hundred reactors may be operating. If a very conservative analysis, assuming 500 reactors and addition of latent effects to prompt effects from accidents, is performed, the risk from nuclear accidents is a small fraction of total man-caused accidents and only slightly lower than the risk to people on the ground from aircraft crashes. A realistic assessment would in all likelihood suggest that the nuclear risk is considerably lower than the risk to persons on the ground from aircraft crashes. Therefore, it is prudent to reduce the ATWS contribution to a small fraction, e.g. 10 percent of total probability of exceeding 10 CFR 100. Details of ATWS sequences from RSS are discussed in Appendix ..... .

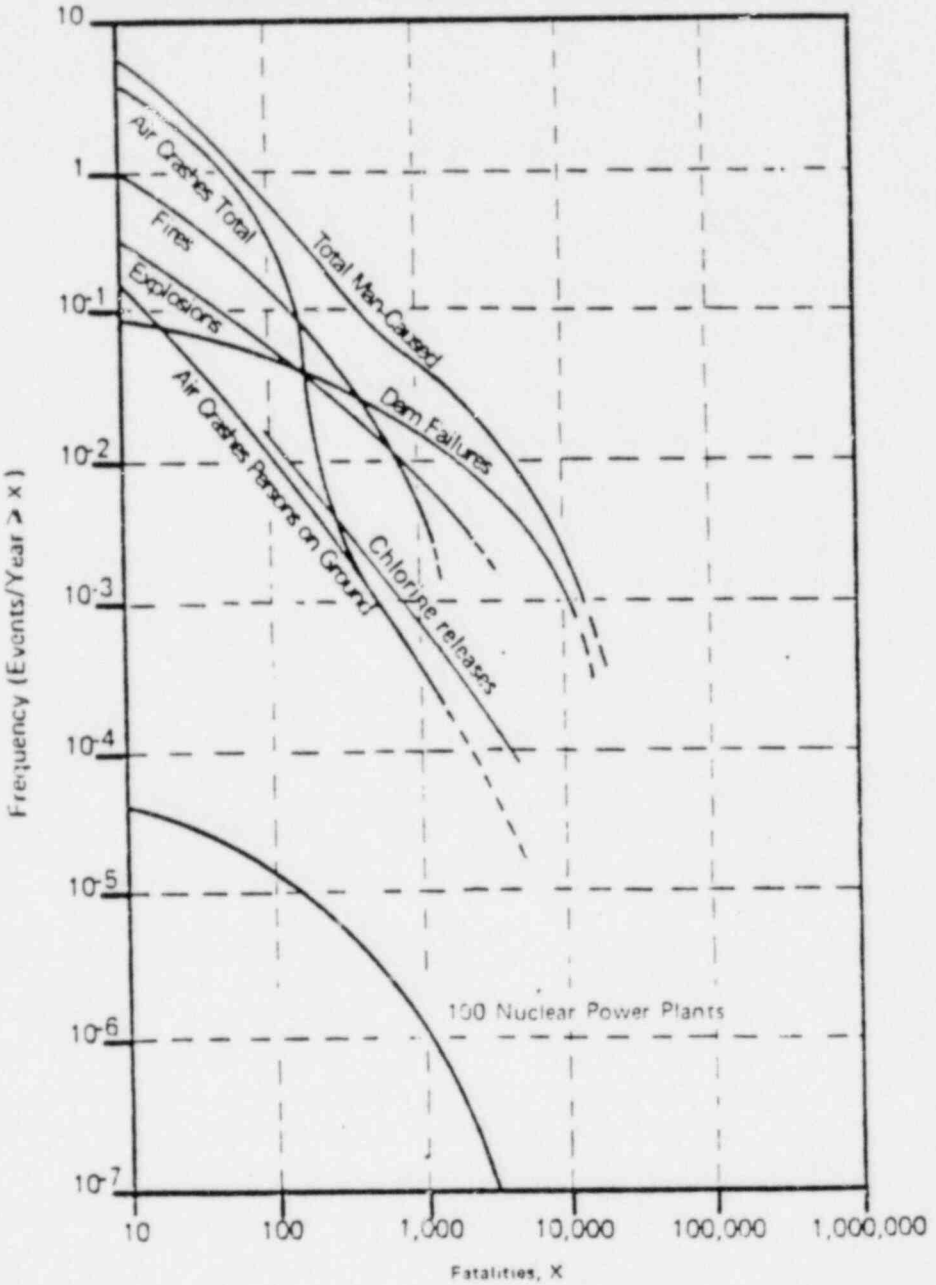

FIGURE 6-1 Frequency of Man-Caused Events Involving Fatalities.

Notes

1. Fatalities due to auto accidents are not shown because data are not available for large consequence accidents. Auto accidents cause about 50,000 fatalities per year.
2. See section 6.4 for a discussion of confidence bounds applicable to the non nuclear curve. See section 5.5 for the confidence bounds on the nuclear curve.

This objective of assuring probability level below 10^{-6} for exceeding 10 CFR 100 from ATWS could be looked upon to include some implicit conservatisms. While the evaluation models are essentially realistic, the conservatisms are introduced in the form of CRDM unreliability estimate fuel damage limits and the primary system pressure limits.

This objective of limiting ATWS to 10^{-6} level is not entirely inconsistent with the SRP 2.2.3 recommendation. The SRP 2.2.3 addresses external events of which there are many (e.g. natural gas explosion, aircraft impingements, missiles, etc.) and further the consequences of such events may be considerably greater than the guideline values of 10 CFR 100. This would suggest that maintenance of the same level of risk (Probability x Consequences) the frequency of these events should be shown to be 10^{-6} or less in a conservative manner. Thus, if there are any differences between the SRP 2.2.3 and the present safety objective, they are limited to the degree of conservatism for ATWS may be lower than that used in the evaluation of external events. The potential for more serious consequences from external events than ATWS events may be judged to be a sufficient reason for the more conservative estimate.

2.1.6 General Design Criteria

In consideration of a safety objective for ATWS we considered the initial and boundary conditions appropriate to the event. GDC 2 states that structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena without loss of safety function. The design bases should reflect:

1) appropriate consideration of history of natural phenomena

2) appropriate combinations of normal and accident phenomena, with the natural phenomena, and

3) the importance of the safety function to be performed.

This criterion does not address whether events such as LOCA or ATWS can be caused by natural phenomena. It states, rather, that mitigating features be designed to withstand them (at least without loss of safety functi... Adherence to this criterion would require use of so-called "safety-grade" equipment for all ATWS mitigating features.

Similarly the proposed ATWS approach may be in conflict with other General Design Criteria (e.g. #34 on RHR safety function). The GDCs, various codes (IEEE and ASME), Regulatory Guides, etc. were developed at a period when very little quantitative information on initiating accident probabilities and the mitigating system unreliabilities was available. The present approach on ATWS does not restrict the applicant from proposing ATWS fixes which satisfy the GDCs, however, it does go further in recommending that alternative proposals on mitigating systems (e.g. reliability based) would also be acceptable. The staff believes sufficient experience has been gained to warrant the application of this alternative. The staff has used the results of the RSS to develop criteria for mitigating systems as discussed in Chapter 3 of this report. It should be noted that the use of the RSS in this application is not in conflict with the AEC's August 1974

Interim General Statement of Policy (IGSP). The IGSP addresses the draft version of the RSS. Subsequent to the issuance of the IGSP, public comments on the safety study were received and a final report was issued in 1975. The staff believes that the combination of information obtained from WASH-1400 (regarding specific equipment and system failure, accident sequences and societal risk), and from independent calculations which use the WASH-1400 type probabilistic analysis methods, when coupled with additional data (shutdown system experience data) and engineering judgment justify the relaxation of the ATWS safety objective. The staff believes that tne net result of this relaxation will not pose an undue risk to the public. However, the staff believes that the application of the aforementioned methodology and experience data leads to the conclusion that many plants are not in compliance with the relaxed safety objective. This report provides detailed bases for this conclusion.

References for Section 2.1

1. Ian Wall, private communication.

2. CENPD-158, Rev. 1, Section 2.9; BAW 10099, Rev. 1, Section 4.2; RSS Appendix I, Table I 4-11, footnote (d).

3. "Discussion of Alternatives to the Previous Staff Position on Anticipated Transients Without Scram for Construction Permit Applications," NRC Staff Working Paper, Sept. 12, 1975; "Alternatives to Staff Position Regarding Anticipated Transients Without Scram (ATWS)," Letter W. Kerr, Chairman, ACRS, to Lee V. Gossick, EDO, October 17, 1975; "Modification of Staff Position on Anticipated Transients Without Scram (ATWS), NRC-SECY-75-668, November 18, 1975.