

January 18, 1982

Docket Nos: STN 50-470, 50-528,
50-529 and 50-530

MEMORANDUM FOR: Robert L. Tedesco, Assistant Director for Licensing, Division of Licensing, NRR

FROM: L. S. Rubenstein, Assistant Director for Core and Plant Systems, Division of Systems Integration, NRR

SUBJECT: SUPPLEMENTAL SAFETY EVALUATION REPORT INPUT FOR THE CESSAR SYSTEM 80 FDA AND THE PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2 AND 3

As requested in your memorandum dated December 30, 1981, Enclosure 1 is the supplemental input to the Auxiliary Systems Branch's (ASBs) safety evaluation report concerning the CESSAR (Combustion Engineering) System 80 FDA. This input addresses the ACRS's concern identified in the December 15, 1981 letter involving the need for a reliable shutdown heat removal capability in view of the lack of a direct means of rapid primary system depressurization. Our evaluation focuses on the three aspects of this concern as follows, auxiliary feedwater system reliability, steam generator integrity, and the need for additional primary system valves to facilitate rapid depressurization and includes input from the Reactor Systems Branch and Materials Engineering Branch.

Enclosure 2 is the ASB's supplemental input to the safety evaluation report concerning the Palo Verde Nuclear Generating Station, Units 1, 2 and 3. This input addresses the ACRS's concern identified in the December 15, 1981 letter for alternative decay heat removal and primary system depressurization. This concern is similar to that previously identified for CESSAR as Palo Verde is a CESSAR reference plant. Enclosure 3 addresses the confirmatory item concerning the applicants revised response to NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants" covered in Section 9.1.4, "Fuel Handling System" of the SER.

Note that the following ASB areas are still unresolved for Palo Verde:

1. Section 3.6.1 - Plant Design Protection Against Postulated Piping Failures in Fluid Systems Outside Containment - The applicant has not yet provided the confirmatory subcompartment pressurization analyses and evaluation of the effects on safety related systems for the postulated auxiliary steam and CVCS letdown line breaks.

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2. Section 9.2.5 - Ultimate Heat Sink (UHS) - The applicant has not yet responded to our concern for tornado missile protection of the essential spray pond (UHS) spray nozzles.

We will report resolution of the above concerns in a future SER supplement.

In addition, we note that the applicant has not yet submitted the safe shut-down analysis for fires (Appendix R, Parts III.G and III.L). We will review this analysis when it is received and provide our evaluation as a secondary review to the Chemical Engineering Branch.



L. S. Rubenstein, Assistant Director
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SUPPLEMENTAL SAFETY EVALUATION

FOR CESSAR (SYSTEM 80) FDA

AUXILIARY SYSTEMS BRANCH

ACRS CONCERN REGARDING RELIABILITY OF SHUTDOWN HEAT REMOVAL SYSTEM

In the CESSAR letter, the ACRS stated:

"In recent years, the availability of reliable shutdown heat removal capability for a wide range of transients has been recognized to be of great importance to safety. The System 80 design does not include capability for rapid, direct depressurization of the primary system or for any method of heat removal immediately after shutdown which does not require use of the steam generators. In the present design, the steam generators must be operated for heat removal after shutdown when the primary system is at high pressure and temperature. This places extra importance on the reliability of the auxiliary feedwater system used in connection with System 80 steam generators and extra requirements on the integrity of the steam generators. The ACRS believes that special attention should be given to these matters in connection with any plant employing the System 80 design. The Committee also believes that it may be useful to give consideration to the potential for adding valves of a size to facilitate rapid depressurization of the System 80 primary coolant system to allow more direct methods of decay heat removal. The Committee wishes to review this matter further with the cooperation of Combustion Engineering and the NRC Staff."

In order to fully respond to the concern, the staff position is presented in three parts as follows: (1) auxiliary feedwater system reliability, (2) steam generator integrity and (3) the need for additional primary system valves to facilitate direct rapid system depressurization for decay heat removal.

In regard to the ACRS concern for "extra importance on the reliability of the auxiliary feedwater system used in conjunction with System 80 steam generators", we will require that Combustion Engineering include an auxiliary feedwater system unavailability acceptance criterion as an interface in CESSAR to be satisfied by referencing applicants for their auxiliary feedwater system designs. The criterion will be the same as that identified in the Standard Review Plan (NUREG-0800), Section 10.4.9 for meeting General Design Criteria 34, Residual Heat Removal and 44, Cooling Water as follows:

"An acceptable AFWS should have an unavailability in the range 10^{-4} to 10^{-5} per demand based on an analysis using methods and data presented in NUREG-0611 and NUREG-0635. Compensating factors such as other methods of accomplishing safety functions of the AFWS or other reliable methods for cooling the reactor core during abnormal conditions may be considered to justify a larger unavailability of the AFWS."

We conclude that this interface adequately addresses auxiliary feedwater system reliability for CESSAR reference plants.

In regard to the ACRS concern for "extra requirements on the integrity of the steam generators", the following is the staff position.

The System 80 steam generators incorporate multiple design features to minimize the instances of problems which have been identified to date in operating plants steam generators. These features include improvements in materials of construction and fabrication techniques. We note that there is no operating experience associated with the System 80 steam generators. Therefore, we know of no reason to impose additional requirements at this time for assuring their integrity. If operating experience indicates that additional requirements are warranted, we will incorporate them as necessary.

It should also be noted that the CESSAR SER (NUREG-0852) includes discussion and staff conclusion on steam generator integrity and certain aspects of steam generator performance as follows:

- (a) Materials and fabrication and their acceptability against applicable ASME Codes and General Design Criteria are addressed in SER Section 5.4.2.1

(b) Design features for prevention of damaging water hammer is addressed in SER Section 10.4.

(c) Secondary water chemistry is addressed in SER Section 10.3.1.

Based on the above, we conclude that the integrity of the System 80 steam generators is adequate to assure their availability for decay heat removal and that further requirements in this area are not necessary.

In regard to the ACRS concern for "consideration to the potential for adding valves of a size to facilitate rapid depressurization of the System 80 coolant system to allow more direct methods of decay heat removal," the following is the staff position in this matter.

BACKGROUND

In some pressurized water reactors, an alternate method of decay heat removal has been identified in the event all feedwater to the steam generators is lost. This method of decay heat removal, termed "feed and bleed," involves coolant addition to the primary system via the HPI pumps, and liquid discharge via either safety or relief valves. To date, the loss of all feedwater is not an event required to be designed for by NRC regulations.

mechanism, the HPI system must be capable of injecting a sufficient quantity of coolant at the prevailing system pressures.

For plants without a manual depressurization capability (i.e., PORV system with enough relief capacity to sufficiently depressurize the primary system), the prevailing system pressure following a loss of all feedwater will be the safety valve set pressure (usually 2500 psi). Thus, in order to have a viable feed and bleed capability in plants without PORVs, the HPI pumps must be capable of injecting sufficient quantities of coolant at the safety valve set pressure. This implies the need for an HPI pump shutoff head considerably above the safety valve set pressure.

For plants with HPI pumps that do not have shutoff heads above the safety valve set pressure, a means to manually depressurize the primary system to a pressure sufficiently below the HPI pump shutoff pressure in an acceptable amount of time would be necessary.

PORVs would typically be relied upon to provide this manual depressurization for viable "feed and bleed" capability.

CE SYSTEM 80 DESIGN

Combustion Engineering (System 80)

The present ^A standard plant design ~~being licensed by Combustion Engineering (System 80)~~ does not include power-operated relief valves (PORVs). The HPI system employs the pumps with a shutoff pressure of 1750 psig. Thus, in the event of a loss of all feed-

water, the System 80 design does not have the capability to depressurize the primary system to below the HPI shutoff pressure. Thus, in this design, reliance cannot be placed on "feed and bleed" for decay heat removal.

STAFF POSITION

While the staff recognizes the potential benefits of a feed and bleed capability, there are presently no design requirements or criteria which would require CE system 80 plants to install an alternate decay heat removal system independent of the steam generator system. The staff has recognized the need for reliable decay heat removal. The staff acceptance criteria^{on} for auxiliary feedwater system (AFWS) reliability (as identified in SRP Section 10.4.9) is based on probability ^{an acceptance of the mean value of the} of risk of core melt ~~as a result~~ ^{from} feedwater transients ^{that was} derived ⁱⁿ from WASH-1400. ^{This criterion} has been required of Palo Verde (the first System 80 design to be licensed) and will be satisfied by all future System 80 plants (refer to Part 1 above). Additional mitigating features available to satisfy the core melt risk probability would be evaluated on a plant specific basis. This is discussed further in the Palo Verde SER Supplement addressing similar ACRS concerns.

Notwithstanding the present reliability requirements for AFW systems and overall decay heat removal capability, the staff has initiated work on the unresolved safety issue of decay heat removal reliability (USI A-45). A key element of this program will be an evaluation

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The staff recognizes the limitations in WASH-1400 as delineated in previous statements. However, in using the study, we have taken the applicable component part which has an adequate data base for purposes of comparison and applied a generally accepted fault tree technique uniformly to determine weaknesses in the AFWS design when compared with other plants. The staff decision on acceptability is not strictly based on meeting an absolute value. The staff has not discarded the deterministic acceptance criteria and requires that they ^{also} be satisfied.

of the risk reduction that would be afforded by a viable "feed and bleed" capability. If it is concluded that a cost beneficial reduction in risk could be achieved by incorporating a "feed and bleed" capability in operating plants that presently do not have such a capability, then a backfit order would be considered.

However, until this study is completed, the staff concludes there is no need to require a "feed and bleed" capability be installed in System 80 plants since adequate heat removal system reliability will be assured ~~with the addition of~~ ^{by} the AFWS reliability criterion as an interface requirement in CESSAR. It is the staff position that the present AFW reliability criterion must be met by applicants of the CE System 80 design. Meeting this position provides a sufficiently low probability of core melt for this design, and further assures a reliable decay heat removal capability.

In summary, we conclude that the CESSAR System 80 design for decay heat removal conforms to applicable General Design Criteria and guidance and is sufficiently reliable to assure safe shutdown. ~~without further requirements~~

ENCLOSURE 2
SUPPLEMENTAL SAFETY EVALUATION
FOR PALO VERDE NUCLEAR GENERATING
STATION, UNITS 1, 2 AND 3
AUXILIARY SYSTEMS BRANCH

ACRS CONCERN REGARDING RELIABILITY OF SHUTDOWN HEAT REMOVAL SYSTEM

In the Palo Verde letter, the ACRS stated:

"In the Palo Verde design the primary system does not include capability for rapid, direct depressurization when the plant has been shut down. This places extra importance on the reliability of the auxiliary feedwater system and makes it necessary that the NRC Staff and the Applicant assure the availability and dependability of this system for a wide variety of transients. It also places extra requirements on the continued integrity of the two steam generators as the only method of heat removal immediately after shutdown. The ACRS recommends that the NRC Staff and the Arizona Public Service Company give additional attention to the matter of shutdown heat removal for Palo Verde and develop a detailed evaluation and justification for the position judged to be acceptable. The Committee wishes to be kept informed."

In regard to the ACRS concern for extra importance placed on the reliability of the AFWS in view of the lack of a rapid, direct depressurization capability for the primary system, and the ACRS recommendation for a detailed evaluation and justification for the position judged to be acceptable, the following is the staff position on this matter.

In the Section 22 of the Palo Verde SER (NUREG-0857) under Item II.E.1.1 of the TMI-2 Requirements, we have identified the fact that the applicant submitted an AFWS reliability study in accordance with staff guidance. The staff reviewed the study and determined that the AFWS met the system unavailability acceptance criterion (10^{-4} to 10^{-5} per demand) for a loss of all feedwater as a result of a feedwater transient or loss of offsite power initiating events. We also determined that the AFWS design met all deterministic criteria of Section 10.4.9 of the Standard Review Plan (NUREG-0800).

In addition, as the AFWS unavailability acceptance criterion is derived from a risk of core melt frequency of 5×10^{-6} per reactor year (Reactor Safety Study, WASH-1400) consideration was given to additional plant features available to bridge the gap from the AFWS system unreliability acceptance criterion (10^{-4} to 10^{-5} per demand) to the core melt frequency (5×10^{-6} per reactor year). These mitigating features include a stable grid and long steam generator boil dry time (approximately 20 minutes) which

allows for operator recovery. The grid and offsite power supply line arrangement at Palo Verde is comparable to most operating nuclear power plants. Thus, the frequency of occurrence of a loss of offsite power should be equivalent to the average assumed in past analyses, approximately 0.2 to 0.4 per reactor year. Further, the 20 minutes of steam generator water inventory after a loss of main feedwater allows time for plant operators to restore the AFWS should it fail initially, or restore offsite power and main feedwater. Previous estimates indicate approximately a 40% chance of restoring offsite power within 20 minutes. These features provide additional confidence that the risk of core melt probability of 5×10^{-6} is not exceeded for an extended loss of feedwater condition.

Based on the above, we conclude that the Palo Verde AFWS meets the staff reliability acceptance criterion and further that it is unlikely that the risk of core melt probability of 5×10^{-6} will be exceeded as a result of feedwater transients.

In regard to the ACRS concern for "extra requirements on continued integrity of the two steam generators as the only method of heat removal immediately after shutdown," the following is the staff position.

The integrity of the System 80 steam generators has been reviewed by the staff and found to be acceptable. Refer to the CESSAR SER Supplement addressing ACRS concerns on this subject. Further, the Palo Verde SER (NUREG-0857) includes discussion on the acceptability of the following relative to steam generator integrity:

- a) The steam generator inservice inspection program is addressed in SER Section 5.4.2.1;
- b) The secondary water chemistry monitoring and control program is addressed in SER Section 10.3.3; and
- c) Preoperational testing for steam generator/feedwater waterhammer prevention is addressed in SER section 10.4.7.

Based on the above, we conclude that the Palo Verde steam generators provide a reliable means for shutdown decay heat removal without the need for additional requirements for assuring their continued integrity.

In summary, we conclude that the Palo Verde shutdown heat removal capability is sufficiently reliable and conforms to applicable General Design Criteria and guidance without further requirements.

SUPPLEMENTAL SAFETY EVALUATION

FOR PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2 AND 3

AUXILIARY SYSTEMS BRANCH

9.1.4 FUEL HANDLING SYSTEM

In the Safety Evaluation Report, we indicated that the applicants initial response to NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants" only addressed heavy load lifts required prior to initial fuel load. The applicant subsequently revised the response to NUREG-0612 to address safe handling of all heavy loads in safety related plant areas including those required when performing plant maintenance. The review and evaluation of this information will be performed at a future date in connection with the long term review of NUREG-0612. We conclude that this response is acceptable at this time.



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

February 5, 1982

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MEMORANDUM FOR: L. S. Rubenstein, Assistant Director for Core and Plant Systems, Division of Systems Integration, NRR

THRU: Olan D. Parr, Chief, Auxiliary Systems Branch, Division of Systems Integration, NRR

FROM: Richard M. Lobel, Section Leader, Section B, Auxiliary Systems Branch, Division of Systems Integration, NRR

SUBJECT: REVIEW OF RES ANALYSIS "FEED AND BLEED ISSUE FOR CE APPLICANTS"

We have reviewed the RES memorandum "Feed and Bleed Issue for CE Applicants" which discusses the "risk implications of CE reactor designs which lack a capability for cooling via HPI injection and deliberate venting of the reactor coolant system, in absence of feedwater replenishment." Our comments are given below.

We particularly considered the comments on the reliability of the auxiliary feedwater system (AFWS) under both normal and abnormal conditions and continue to believe that the current reliability criterion for the AFWS given in Section 10.4.9 of the Standard Review Plan is adequate.

Three events were examined in the RES paper, a loss of main feedwater (not associated with a loss of offsite power), loss of offsite power and a very small LOCA.

The loss of offsite power case was examined by means of an event tree which demonstrated the need to provide emergency power to a third auxiliary feedwater pump (or more than one source of power to the single motor driven pump). Our experience in evaluating the reliability analyses submitted by OL applicants has also shown this to be the case and we have been requiring applicants for OLs whose auxiliary feedwater systems consist of less than three safety grade pumps to modify their auxiliary feedwater systems to meet the Standard Review Plan unreliability criterion. The Byron power plant design was modified as a result of our review to meet the 10^{-4} /demand criterion by means of a swing bus between Units 1 and 2. The Palo Verde power plant design was modified by providing emergency power from a vital bus to a non-safety related third feedwater pump in addition to the two pump safety related AFWS originally proposed. Both of these modifications are in agreement with the first recommendation on Page 6 of the RES paper to reduce the core melt frequency resulting from loss of offsite power. The event tree for loss of offsite power in the RES paper shows that, with the addition of a third auxiliary feedwater pump or the

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addition of a second independent source of power to the existing pump that the resulting core melt probability is acceptable.

Our experience in reviewing the analyses of AFWS reliability submitted by OL applicants has shown that it is probably not possible to significantly improve on the current SRP reliability criterion of 10^{-4} to 10^{-5} per demand for AFWS unreliability. A two pump system can meet the criterion with an unreliability lower than but very close to 10^{-4} per demand. (This is based on the review of Westinghouse and CE designed reactors and may not be true for a B&W designed reactor because of a shorter steam generator dryout time. A three pump AFWS can attain an unreliability in the middle of the 10^{-5} decade.

On page 2 of the transmittal memorandum and Pages 6 and 13 of the attachment, there is an implication that a capability should be provided to transfer an auxiliary feedwater pump (motor driven) from one divisional safety bus to a redundant division bus in the same unit to improve the reliability of the AFWS system. To provide for any kind of interconnections between redundant power divisions undermines the very concept of separation and independence requirements promulgated by GDC 17. While this approach may improve reliability on one system (AFWS), it builds in, by design, the potential for failure which could result in the total loss of redundant safety buses. We have had a number of indications in recent years of the importance of considering operator error in determining potential safety consequences. This approach builds in the potential for operator error in transferring loads between redundant buses under certain conditions to result in unacceptable consequences. We do not believe that the approach to improve reliability in a design should erode the benefits gained by the defense-in depth concept in maintaining complete separation and independence of redundant ac power systems. In the Byron review, as discussed above, the transfer of power between redundant power divisions is to be between units so that independence of each unit is maintained.

Another issue raised in the RES paper concerned the difference in reliability of "new" versus "mature" auxiliary feedwater systems. "New" systems were given an unreliability factor of 10 higher than "mature" systems. It is well to keep in mind that although a pump that may not be operable in the strict sense of the technical specifications or other NRC requirements it may be capable of delivering adequate flow in an emergency situation. Thus, the capability of a "new" system to respond to an emergency is probably greater than that obtained from LER data.

For the Small Break Loss of Coolant Accident (SBLOCA) the analysis in the RES paper shows that an AFWS which meets the unreliability criterion of the SRP provides adequate protection.

We therefore conclude that a requirement for a feed and bleed capability should be justified on a basis other than the unreliability of the AFWS for those plants with auxiliary feedwater systems meeting the SRP reliability criterion (for example, postulated simultaneous failure of both steam generators). Other changes to the AFWS such as additional pumps or redundant power supplies seem to provide reasonable core melt probabilities.

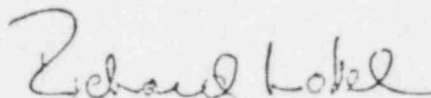
In addition, the RES paper has not addressed all aspects of the risks associated with bleed and feed. The thermal hydraulic aspects must be adequately addressed. Questions of two phase and liquid flow from PORVs need to be addressed. It appears that timing could be important. For example, CENPD 144 shows that, if an operator opens two PORVs 10 minutes following the loss of all feedwater the core will be uncovered to greater than 8 feet and the peak cladding temperature will be greater than 2000°F. These results, as well as results from other PWR vendors, indicate that timing is important to effectively overcome a loss of all feedwater event. Thus, there is a probability of failure in feed and bleed which appears to be greater than the unreliability of the HPI pump(s).

Some CE designed operating reactors have only two auxiliary feedwater pumps. It has been our intent that after gaining some experience in applying the SRP AFWS reliability criterion to several NTOLS we will then apply the same criterion to operating reactors which have two auxiliary feedwater pumps. A current status of auxiliary feedwater systems on CE-designed reactors is given in the accompanying table (updated from information presented in NUREG-0635, "Generic Evaluation of Feedwater Transients and Small Break Loss-of-Coolant-Accidents in Combustion Engineering Designed Operating Plants.")

The accompanying table also lists the number of PORVs for all operating CE-designed reactors as well as several NTOLS. All operating CE designed reactors have two PORVs with the exception of ANO-2 which has no PORVs. In addition, ANO-2 has only two AFW pumps with no backup non-safety related third pump available. The shut off head of the HPI pumps for the operating CE plants is also provided on the accompanying table. The ANO-2 HPI pumps are incapable of lifting either the PORVs or the primary safety valves (a questionable safety alternative in any case). Thus, in view of the concerns raised in the RES paper, ANO-2 seems to warrant further regulatory attention in this area.

In summary, after review of the RES paper we conclude that no information has been presented which shows that the SRP AFWS reliability criterion is not adequate. Work should continue on upgrading the auxiliary feedwater systems of the operating reactors to meet the SRP reliability criterion. The discussion in the RES paper does not lead to the conclusion that feed and bleed is necessary.

Although it is shown to reduce the core melt probability, other aspects of risk relating to the effectiveness of feed and bleed were not addressed and other methods of increasing AFWS reliability could result in the same reduction in core melt probability.



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	Millstone 2	Palisades	St. Lucie 1/2	San Onofre 2/3	Waterford	Palo Verde
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ine r	600/turbine 300/motor	415 each	500/turbine 250/motor	860 each	700/turbine 440/motor	875 each
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han, normal reactor coolant pressure.