Palla

MAY 16 1984

MEMORANDUM FOR: Thomas M. Novak, Assistant Director for Licensing, DL

FROM: R. Wayne Houston, Assistant Director for Reactor Safety, DSI

SUBJECT: SSER INPUT RE: HYDROGEN CONTROL MEASURES FOR CATAWBA NUCLEAR STATION, UNITS 1 AND 2

Plant Name: Catawba Nuclear Station, Units 1 and 2
Docket Nos.: 50-413/314
Licensing Stage: Post-SER, OL
Architect Engineer: Duke
NSSS Supplier: Westinghouse
Containment Type: Ice Condenser
Responsible Branch: LB#4
Project Manager: K. Jabbour

As part of the Containment Systems Branch (CSB) review of hydrogen control for degraded core accidents, we are furnishing as Enclosure 1 our input for the next supplement to the safety evaluation report. In this report, we note that hydrogen control measures have been implemented at the Catawba Nuclear Station which are virtually identical to those approved for McGuire Units 1 and 2. These measures are adequate to permit full power licensing of Catawba, subject to the proposed license conditions we identify in Enclosure 2.

We are continuing to investigate a number of items related to hydrogen control at Catawba. The resolution of these issues is a prerequisite for staff approval of the present system as the permanent means of hydrogen control at Catawba.

On March 19, 1984, we forwarded to DL proposed license conditions for Catawba that would require resolution of a number of these issues prior to full power licensing. At about that time, we received a preliminary copy of a TVA submittal regarding operability of Tayco igniters in a spray environment. Our subsequent review of this TVA submittal indicates a possible need for supplementary spray shields for glow plug igniters. As a result, we now propose that an additional license condition to address this matter be added to the license conditions we previously proposed as cited above. The revised list of license conditions is provided in Enclosure 2.

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SURNAME▸							
DATE▸							

We have reconsidered the completion dates for the previously proposed license conditions and for the additional license condition we are now proposing. We believe that a more realistic target date for resolution of all the outstanding issues relative to hydrogen control for Catawba is December 1, 1984. Accordingly, the completion date for the revised list of proposed license conditions is December 1, 1984, rather than the date for full power licensing of Catawba, Unit 1, as we previously proposed.

A brief SALP input is provided as Enclosure 3.

Original Signed By
R. Wayne Houston

R. Wayne Houston, Assistant Director
for Reactor Safety
Division of Systems Integration

Enclosures:
As stated

cc: R. Mattson
C. Tinkler
H. Garg
C. Parcezski
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DATE	5/16/84	5/16/84	5/16/84	5/16/84			

INPUT FOR CATAWBA SSER

CONTAINMENT SYSTEMS BRANCH

6.2.5 Combustible Gas Control

The staff indicated in the SER that measures to control the hydrogen produced from a degraded core accident involving 75% of the active fuel cladding should be implemented at the Catawba Station before initial fuel loading. To satisfy this requirement, the licensee has installed and implemented a distributed hydrogen ignition system in Catawba Units 1 and 2 which is virtually identical to that which was installed in McGuire Units 1 and 2. Our review of this system was based on our previous review of the McGuire hydrogen control system, which we found acceptable. A detailed discussion of that review is provided in Supplement 7 to the McGuire SER (NUREG-0422) and a comparison between the two is discussed below.

The hydrogen mitigation system (HMS) installed at Catawba is identical to that installed at McGuire, except for minor differences in terminal box designation and igniter location. In Supplement 7 to the McGuire SER, we found the McGuire HMS to be an acceptable permanent means of degraded core hydrogen control subject to implementation of two system design enhancements. The

system enhancements involved installation of two additional lower compartment igniters and four additional upper compartment igniters to improve the spatial coverage of the igniter system, and relocation of the igniter system switches to permit manual actuation of the HMS from the main control room. These design changes have been incorporated into the HMS at Catawba.

The HMS will be manually actuated upon receipt of a safety injection signal. Procedures for securing the system are identical to those in place at McGuire. To ensure that the HMS will function as intended, Duke has proposed a surveillance testing program identical to that at McGuire.

Although the design of the Catawba HMS and containment building is virtually identical to that of McGuire, the licensee performed a containment response analysis for Catawba. The Catawba analysis was based on the latest version of the CLASIX code. This analysis was essentially a reanalysis of the McGuire base case, with minor differences in the allocation of containment volume among the various compartments, and the heat structure details. All other CLASIX input parameters were the same as those used in the McGuire

analysis. This latest version of CLASIX incorporates corrections in heat transfer models for radiation and convection, and in flow path logic for propagating flames. Deficiencies in these areas were identified during the McGuire HMS review; however, reanalysis of McGuire using a revised code was not performed since the deficiencies were judged to provide conservative results.

The CLASIX analysis shows the hydrogen combustion behavior and containment pressure response for Catawba to be similar to that predicted for McGuire. The maximum containment pressure for the base case was 27.8 psia, compared to 27.6 psia for McGuire. This is below the Catawba containment design pressure of 30.0 psia. A total of 1022 lbm of hydrogen was consumed in 6 lower compartment and 31 upper plenum burns. In contrast, 1032 lbm of hydrogen was consumed in 6 lower compartment, and 23 upper plenum burns for McGuire. With regard to containment temperatures, however, the Catawba analysis predicts significantly different results. The containment atmosphere for Catawba is predicted to be approximately 180oF prior to the first burn and approximately 225oF following the last burn. For McGuire,

should be 250°F   should [illegible]

significantly higher temperatures were predicted; more specifically, 215oF prior to the first burn and 320oF following the last burn. In addition, the ice remaining is predicted to be 3.6×10^5 lbm for Catawba versus 1.1×10^6 lbm for McGuire. These differences in results are attributed to the CLASIX code modifications and the differences in heat sink input.

215°F   320°F

The staff has reviewed the design and analysis of the HMS at Catawba. Based on our evaluation of the HMS design, we conclude that the igniter coverage, actuation procedures, and surveillance testing procedures are acceptable. Furthermore, analysis of the containment response indicates that hydrogen combustion associated with the operation of the HMS will not pose a threat to the integrity of the containment.

We are, however, continuing to investigate a number of issues concerning degraded core hydrogen control and will conclude on these matters prior to approval of the HMS as a permanent means of hydrogen control at Catawba. The items we are investigating include the condensation heat transfer models used in the latest version of CLASIX,

equipment survivability for a spectrum of accidents, air return fan and ice condenser door response to upper compartment burns and igniter spray shield effectiveness. We have requested additional information and analyses from the licensee regarding these items, and will provide the results of our review in a future supplement to the SER. Appropriate license conditions have been prepared to assure satisfactory resolution of these issues.

Accordingly, subject to the attached license conditions, we find the measures provided for hydrogen control during postulated degraded core accidents to constitute acceptable measures for full power licensing of Catawba, Units 1 and 2.

ENCLOSURE 2

LICENSE CONDITIONS FOR CATAWBA, UNIT 1

DOCKET NO. 50-413

Hydrogen Control Measures (II.B.7)

1. Before initial criticality, the distributed ignition system for hydrogen control shall be installed and operable, and shall be activated upon a safety injection signal.

2. Upgraded analyses and tests shall be completed by December 1, 1984, to resolve the following issues:

   a) thermal response of the containment atmosphere and essential-equipment for a spectrum of accident sequences using revised heat transfer models;

   b) effects of upper compartment burns on the operation and survival of air return fans and ice condenser doors; and

   c) operability of the glow plug igniter in a spray environment typical of that expected in the upper compartment of the containment.

prepared by the Containment Systems Branch
Regarding
HYDROGEN CONTROL MEASURES FOR CATAWBA NUCLEAR STATION

uation iteria		
gement Involvement	N/A	
oach to Resolution echnical Issues	2	Understanding of issues adequate with generally sound approaches to resolving i
onsiveness	2	Generally timely responses
rcement History	N/A	
rtable Events	N/A	
fing	N/A	
ning	N/A	

ENCLOSURE 3

Bob, 5/31/84

Just received. Pls let me know how ... Thks ... Jabbour

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HAL B. TUCKER
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May 22, 1984

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Ms. E. G. Adensam, Chief
Licensing Branch No. 4

Re: Catawba Nuclear Station
Docket Nos. 50-413 and 50-414

Dear Mr. Denton:

Attached herewith are twenty (20) copies of Revision 11 to Duke Power Company's report, "An Analysis of Hydrogen Control Measures at McGuire Nuclear Station." As noted in Revision 9, this report is applicable to Catawba Nuclear Station. This revision provides responses to the questions submitted to Duke Power Company by letter dated May 8, 1984 (E. G. Adensam, NRC/NRR, to H. B. Tucker, Duke Power Company). This information should be inserted in Section 7.0 of Volume 3.

Please advise if there are any questions regarding this matter.

Very truly yours,

Hal B. Tucker ew

Hal B. Tucker

ROS/php

Attachments

cc: Mr. James P. O'Reilly, Regional Administrator
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cc: Mr. Jesse L. Riley
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Response to questions submitted by letter from NRC (Elinor G. Adensam) to Duke (H. B. Tucker) dated May 8, 1984.

1. With regard to the CLASIX code, the staff has previously requested clarification of the structural heat sink heat transfer models. The following pertinent points have been derived from the responses:

   i) Heat transfer is based on a temperature difference determined by $(T_{bulk} - T_{wall})$.

   ii) Heat transfer coefficients for degraded core accident analysis are determined from a natural convection (stagnant) correlation applicable to condensation heat transfer.

   iii) CLASIX does not explicitly model mass removal due to condensation heat transfer.

   Based on the description of the CLASIX structural heat sink model, it appears that the CLASIX model differs dramatically from generally accepted approaches and is not, as is claimed, consistent with standard methods such as those used in CONTEMPT. The differences are related to the treatment of the three items cited above. By comparison, previously accepted approaches are characterized by the following:

   i) Heat transfer is based on $(T_{sat} - T_{wall})$, when the surface temperature of the heat sink is less than T_{sat}; i.e., $T_{wall} < T_{sat}$.

   ii) Heat transfer coefficients are based on condensation only when $T_{wall} < T_{sat}$.

   iii) Condensed mass removal is based on condensation heat transfer with provisions for revaporizing a small fraction of the condensate.

   A more detailed description of accepted practice is contained in NUREG-0588 and NUREG/CR-0255.

   The effect of the CLASIX models would appear to be the de-superheating of the atmosphere too rapidly thus reducing gas temperatures and possibly altering the combustion characteristics.

   Considering the above discussion, provide the results of analyses, with acceptable models to determine the effectiveness of deliberate ignition for the Catawba plant. The analyses should address the effects of hydrogen combustion on containment integrity and equipment survivability. Furthermore, the analyses should be performed to address a spectrum of appropriate degraded core accidents. Specific items that should be addressed include:

   a. Model input and analytical assumptions;

   b. Calculated compartment atmosphere pressure, temperature, and gas concentration transients;

   c. Equipment temperature response profiles;

d. Differential pressure transients between compartments which will allow for an evaluation of ΔP effects on interior structures and mechanical components (e.g., doors, fans); and

e. Considering the capability of the containment shell, crane wall, and the operating deck, perform an analysis to determine the maximum concentration of hydrogen which could be accommodated in a deflagration. Your estimate should consider realistic initial conditions and approximate combustion parameters.

Response:

A justification for the use of the heat sink models in CLASIX was presented to NRC when this question was first posed to Duke in Elinor G. Adensam's letter of August 18, 1983. That response appears on pages 7.0-129 - 7.0-133. We have reviewed that response and continue to support the case that it makes for the adequacy of the original analysis. Our conclusion is that no additional CLASIX analysis is required to justify the results of our original work.

We note, however, that the additional CLASIX analysis requested by the staff was performed by AEP using heat transfer models which were in accordance with the staff's request that the models conform to those of NUREG 0588 and NUREG/CR-0255. The results of this analysis were reported to NRC by M. P. Alexich's letter dated march 30, 1984. These results are very interesting in view of the theoretical arguments presented previously by Duke Power Company in support of the original CLASIX heat transfer models. In their work, AEP compared directly the original heat transfer models with those requested by the staff using identical geometries, initial conditions, and release rates. The AEP results indicate:

1. Pressure and temperature profiles are generally similar for the two sets of heat transfer correlations.

2. The original CLASIX analysis tends to underpredict the temperature in containment at the peaks associated with the hydrogen burning by about 100°F.

3. The original CLASIX analysis tends to overpredict the baseline containment temperatures (the temperature of the containment between hydrogen burning). This indicates that the original CLASIX heat sink models remove less energy from the containment atmosphere in the period immediately following a hydrogen burn and therefore provide a conservative baseline containment temperature profile.

4. Further evidence of the conservatism of the original CLASIX heat sink models can be found from examining the containment pressure response. In every case, pressures during the hydrogen burn period were higher for the original CLASIX analysis than for the analysis using the "corrected" heat sink models. This indicates again that the original CLASIX heat sink models remove less energy from the containment atmosphere per unit time than the heat sink models based on NUREG-0588 and those used in CONTEMPT.

In summary, analysis performed by AEP wherein a head-to-head comparison of heat sink models was made supports the position taken by Duke Power in its previous submittal concerning the question of CLASIX heat sink models (Revision 10). These models have been shown to be conservative from both a theoretical and an analytical standpoint. The higher peak temperatures during hydrogen burning predicted by the "corrected" heat sink models are of no consequence to the analysis of equipment survivability as our survivability analysis used the adiabatic flame temperature (1400°F) rather than a lower temperature predicted from CLASIX results.

The ability of the hydrogen ignition system has been shown to be effective in controlling the concentration of hydrogen to levels less than 8.5% by volume in CLASIX analyses, small scale testing, and more recently, in the large scale Nevada tests. Our structural analysis has consistently shown considerable margin in the containment design in its ability to withstand the pressures and differential pressures associated with hydrogen burning at this concentration. To seek some maximum theoretical higher concentration which could be tolerated represents an unrealistic extension of our previous work and, at best, can be considered of academic interest only, and of no consequence in proving the adequacy of the concept of deliberate ignition.

Further support for the adequacy of the CLASIX code is presented in reference (a), wherein CLASIX is compared with HECTR. For identical input conditions, and in spite of considerably increased technical complexity in many of the HECTR models, results from the two codes are nearly identical. We conclude that the models contained in CLASIX are suitable for use in analysis of beyond design basis conditions, and that further discussion of CLASIX is unlikely to affect our confidence in it as an analytical tool for the study of deliberate ignition in ice condenser containments.

2. Provide a complete evaluation of fan (both air return and hydrogen skimmer as applicable) operability and survivability for degraded core accidents. In this regard discuss the following items:

   a. The identification of conditions which will cause fan overspeed, in terms of differential pressure and duration, and hydrogen combustion events.

   b. The consequences of fan operation at overspeed conditions. The response should include a discussion of thermal and overcurrent breakers in the power supply to the fans, the setpoints and physical locations of these devices, and the fan loading conditions required to trip the breakers.

   c. Indication to the operator of fan inoperability, corrective actions which may be possible, and the times required for operators to complete these actions.

   d. The capability of fan system components to withstand differential pressure transients (e.g., ducts, blades, thrust bearings, housing), in terms of limiting conditions and components.

Response:

This identical question was submitted by letter from NRC (Elinor Adensam) to Duke (H. B. Tucker) dated August 18, 1983. It was answered in Revisions 8 and 10.

3. Provide an analysis of the pressure differential loading on the ice condenser doors created by hydrogen combustion in the upper plenum and upper compartment. Describe and justify the assumed or calculated door positions. Provide an evaluation of the ultimate capability of the ice condenser doors to withstand reverse differential pressures. Discuss the probable failure modes and the consequences of such failures; including the impact on a) adjacent equipment and structures, b) ice bed integrity, and c) flow maldistribution.

Response:

Referring to previous CLASIX results for measures of the intercompartmental differential pressures results in unrealistically conservative answers. This result is caused by the manner in which CLASIX models the lower inlet and intermediate deck doors. The dynamics of door closing contains no inertial term; therefore the doors close instantaneously whenever the net force in the closing direction is greater than zero. For example, as soon as an upper plenum burn is initiated and upper plenum pressure increases, the intermediate deck doors closed instantaneously. The pressure rise in the upper plenum will therefore be conservatively high as venting into the ice bed will be precluded. This effect was noted in the comparison of CLASIX analysis with similar analyses using HECTR and COMPARE reported in reference (a). In addition, reference (a) states:

> "During burns, CLASIX predicts fairly large pressure differentials between the compartments, which we would not expect to occur, given the large flow areas connecting the compartments. HECTR predicts rapid pressure equilibration, and only small pressure differences between compartments. As shown later, COMPARE also predicts rapid pressure equilibration".

Based on the discussion above, differential pressures obtained from CLASIX might be considered a gross upper bound for the differential pressures which would be developed in an actual hydrogen burn situation. A review of previous CLASIX analysis reveals the following results. For an upper plenum hydrogen burn initiated at 8.5% by volume, and a flame speed of 6 feet/second, the maximum indicated differential pressure across the intermediate deck doors is 1.2 psid.

As reported in an answer to a previous question, the reverse differential pressure capability of the intermediate deck door is 6 psid. There is therefore substantial margin in the intermediate deck to withstand the reverse differential pressure associated with an upper plenum burn, even under the bounding conditions of an analysis using CLASIX.

For an upper compartment burn, which is shown to be precluded except under the most extreme assumptions, the pressure rise time is relatively slow due to the length of time it takes for the flame to propagate throughout this large compartment. Results of the EPRI Nevada large scale tests show that hydrogen is reliably ignited by top ignition at 6% by volume in the presence of sprays or fans, and that the corresponding flame speed is less than 10 ft/sec. Pressure rise times are less than one psi/second generally for the cases where typical plant conditions have been modeled. We conclude that upper compartment burns cannot exert large differential pressures across the top deck doors, even if the doors are assumed to be fully closed. In an actual hydrogen burn, the differential pressure would be minimized by the increase in flow area caused by dislocation of the top deck blankets during the early portion of the accident.

4. Identify the essential equipment needed to function during and after a degraded core accident. Provide the location inside containment for this equipment.

   Response:

   This information has been furnished previously to the staff on at least two occasions. Refer to reference (b), Section 6.2, and to Section 5.2 of this volume.

5. In view of the recent TVA test results with Tayco igniters which indicate desirability of additional spray shielding, please discuss whether supplementary spray shields may be appropriate for the glow plug igniters.

   Response:

   None of the glow plug igniters found by Duke Power to be required for adequate coverage of the containment is exposed to a spray environment. The four additional igniters added to the upper compartment at the request of the staff are in the environment created by the containment sprays; however, we note the following:

   1. During the small scale testing reported in Chapter 2, there was no evidence that a spray environment had an adverse effect on the performance of the glow plug igniter.

   2. The tests performed in the large scale test vessel in Nevada, in which ignition was started by glow plug igniters located at the center and bottom elevations (and thus in the spray) show no evidence that containment spray inhibits the ignition of hydrogen by glow plug igniters.

   We conclude that no further testing or modification of the glow plug igniters is required for McGuire or Catawba.

References:

(a) Camp, Allen L., Vance L. Behr, and F. Eric Haskin, MARCH-HECTR Analysis of Selected Accidents in an Ice Condenser Containment, Sandia National Laboratories.

(b) An Analysis of Hydrogen Control Measures at McGuire Nuclear Station, Volume III, dated January 5, 1981 (this has been referred to as the "Grey Book").

J. Shapaker

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August 31, 1984

Mr. Harold R. Denton, Director
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U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Ms. E. G. Adensam, Chief
Licensing Branch No. 4

Re: Catawba Nuclear Station
Docket Nos. 50-413 and 50-414

Dear Mr. Denton:

Proposed License Condition 11, Hydrogen Control Measures, II.B.7, which was attached to Facility Operating License NPF-24 for Catawba Unit 1, addressed a number of requirements for initial criticality and 5% power.

Item 11(a) proposed that the distributed ignition system be installed and operable and demonstrated to be activated upon a safety injection signal. This is to advise that the Unit 1 Emergency Hydrogen Mitigation (EHM) System has been installed and will be operable prior to entry into Mode 2 as required by Technical Specification 3.6.4.3. Also the appropriate emergency procedure, EP/1/A/5000/1C, High Energy Line Break Inside Containment directs the operator to energize the EHM System following verification of a valid safety injection actuation signal.

Item 11(b) requests that upgraded analyses be submitted for Staff review and approval. Responses to all outstanding Staff questions on hydrogen control measures were submitted on May 22, 1984.

Very truly yours,

Hal B. Tucker

Hal B. Tucker

ROS:slb

cc: Mr. James P. O'Reilly, Regional Administrator
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C/7