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SUBJECT: Application for amend to license DPR-58,modifying TS 3/4.4.5 to allow use of laser-welded sleeves to repair defective SG tubes.Westinghouse nonproprietary & proprietary repts describing repair process encl.Proprietary rept withheld. See 2 Reports

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April 13, 1995 AEP:NRC:1129D

Docket Nos.: 50-315

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

Gentlemen:

Donald C. Cook Nuclear Plant Unit 1
TECHNICAL SPECIFICATION CHANGES TO ALLOW
USE OF LASER-WELDED SLEEVES FOR
STEAM GENERATOR TUBES

This letter and its attachments constitute an application for amendment to the technical specifications (T/Ss) for the Donald C. Cook Nuclear Plant Unit 1. Specifically, we are proposing to modify T/Ss 3/4.4.5 (Steam Generators) and the accompanying Bases section to allow use of laser-welded sleeves to repair defective steam generator tubes.

A detailed description of the proposed changes and our analysis concerning significant hazards considerations are included in Attachment 1 to this letter. Attachment 2 contains marked up pages of the current T/Ss. Attachment 3 contains the proposed revised T/Ss pages. Attachment 4 contains a copy of the proprietary report prepared by Westinghouse Electric Corporation, WCAP-13088 Revision 3, describing the sleeving repair process. Attachment 5 contains a copy of the non-proprietary version of the same Westinghouse Electric Corporation report, WCAP-13089 Revision 3. Attachment 6 contains a Westinghouse authorization letter, CAW-95-786, Application For Withholding Proprietary Information From Public Disclosure and accompanying affidavit.

We believe the proposed changes will not result in (1) a significant increase in the amounts, and no significant change in the types, of any effluent that may be released offsite, or (2) a significant increase in individual or cumulative occupational radiation exposure.

These proposed changes have been reviewed by the Plant Nuclear Safety Review Committee and will be reviewed at the next regularly scheduled Nuclear Safety and Design Review Committee meeting.

Appl Change: NRC PDR 1/1 Ltr 1 Encl w/out Prop

In compliance with the requirements of 10 CFR 50.91(b)(1), copies of this letter and its attachments have been transmitted to the Michigan Public Service Commission and to the Michigan Department of Public Health.

The T/S pages submitted with this letter will be impacted by the T/S page changes in our letter AEP:NRC:1166R, "2.0 Volt Interim Steam Generator Tube Plugging Criteria for Cycle 15."

Sincerely,

E. E. Fitzpatrick
Vice President

SWORN TO AND SUBSCRIBED BEFORE ME

THIS 13th DAY OF April 1995

Notary Public

My Commission Expires: 6-28-99

eh

Attachments

cc: A. A. Blind
G. Charnoff
J. B. Martin
NFEM Section Chief
NRC Resident Inspector - Bridgman
J. R. Padgett

ATTACHMENT 1 TO AEP:NRC:1129D

DESCRIPTION OF THE PROPOSED CHANGES AND

ANALYSIS CONCERNING SIGNIFICANT HAZARDS CONSIDERATIONS

INTRODUCTION

This amendment request proposes a change to Cook Nuclear Plant (CNP) Unit 1 steam generator technical specification (T/S) 4.4.5.2, 4.4.5.4.a, 4.4.5.4.c, 4.4.5.5.b.1, and Basis 3/4.4.5 on page B 3/4 4-3, to allow steam generator tube sleeving under specific conditions. The change permits the installation of Alloy 690 laser-welded tube sleeves at degraded tube support plate (TSP) intersections and within the tubesheet (TS) area of CNP Unit 1 steam generators. Per the current technical specifications, steam generator tubes with eddy current indications exceeding the current plugging limit for these locations can be repaired using existing sleeving requirements or be removed from service. This proposed amendment permits laser-welded tube sleeves to be installed to repair degraded steam generator tubes either at the TSP intersections (TSP sleeves), within the TS area (TS sleeves), or a combination of both within the same tube.

DESCRIPTION OF THE AMENDMENT REQUEST

As required by 10 CFR 50.91 (a)(1), this analysis is provided to demonstrate that a proposed license amendment to implement repair of tubes using laser-welded tube sleeves for CNP Unit 1 steam generators represents no significant hazards consideration. In accordance with 10 CFR 50.92(c), implementation of the proposed license amendment was analyzed using the following standards and found not to: 1) involve a significant increase in the probability or consequences for an accident previously evaluated, 2) create the possibility of a new or different kind of accident from any accident previously evaluated, or 3) involve a significant reduction in a margin of safety.

The laser-welded sleeving repair method secures to the inside of the original tube a short length of sleeve tubing with an outer diameter slightly smaller than the inside diameter of the tube, spanning the degraded area of the parent tube. The TSP sleeve is attached to the degraded tube by producing an autogenous weld between the original tube and sleeve at each end of the sleeve. TSP sleeve welds are produced in the free span sections of the tube above the top of the tubesheet. The free span weld provides the structural joint between the tube and sleeve, and, since it is a hermetic seal, it also provides positive (leaktight) leakage integrity. The TS sleeve is secured and supported structurally at the upper joint section by a free span autogenous weld performed identically to the TSP sleeve welds while the lower joint is secured by a mechanical hardroll. An optional seal weld can also be included within the TS sleeve lower joint at an elevation coincident with the approximate midpoint of the TS cladding. However, for the TS sleeve lower joint, the hardroll area supplies the necessary structural requirements for the lower joint since the seal weld is optional for this location. Both the lower hardroll

and free span laser weld joints provide structural integrity characteristics which exceed the structural requirements for the sleeve. Therefore, it is expected that a loss of structural integrity in one of the sleeve joints will not result in a loss of structural integrity for the sleeve. The sleeve structural integrity requirements include safety factors inherent to the requirements of the ASME Code. Installation of TSP sleeves and/or TS sleeves restores the integrity of the primary pressure boundary to a condition consistent with that of the originally supplied tubing. All welds must be produced a minimum distance from any detected tube degradation as described in WCAP-13088, Rev. 3 (Attachment 4).

Absent provisions for tube repair by sleeving, tubes with indications of degradation in excess of the plugging criteria at TSP and/or TS locations would have to be removed from service in accordance with technical specification tube plugging criteria. Removal of a tube from service results in a small reduction of reactor coolant flow through the steam generator. This small reduction in flow has an impact on the margin in the reactor coolant flow through the steam generator with regard to core cooling capacity and on the heat transfer efficiency of the steam generator. Repair of a tube by sleeving maintains the tube in service and results in a much smaller flow reduction as opposed to plugging. Therefore, the use of sleeving in lieu of plugging would minimize loss of margin in reactor coolant system flow and assist in assuring that minimum flow rates are maintained in excess of that required for operation at full power. Any combination of sleeving and plugging utilized at CNP Unit 1 up to a level such that the effect of sleeving will not reduce the minimum reactor coolant flow rate to below the current technical specification limit is acceptable. Also, minimizing the reduction in flow has operational benefits by limiting the increase in heat flux across the tubes remaining in service. Increased heat fluxes have been associated with an increased potential for tube corrosion.

The proposed amendment would modify Technical Specifications 3/4.4.5 "Steam Generators," and Bases B 3/4.4.5, "Steam Generators," to permit the use of Westinghouse laser-welded sleeves and will provide the sleeve/tube inspection requirements and acceptance criteria to determine the level of degradation which would require the sleeved tube to subsequently be removed from service.

EVALUATION

Sleeve/Tube Integrity

During the development of laser-welded sleeving, Section III of the ASME Code was used for the minimum wall thickness determination and bounding stress and fatigue levels for the sleeve. By showing that the sleeve design meets the applicable subsections of Section III of the Code, the sleeve design meets the design requirements of the original tubing. (Draft) Regulatory Guide (RG) 1.121, "Bases for Plugging Degraded PWR Steam Generator Tubes," is used to develop the plugging limit of the sleeve determined by non-destructive examination (NDE), should sleeve wall degradation subsequently occur. Potentially degraded sleeves at the plugging level were shown (by analysis) to retain burst strength in excess of three times the normal operating pressure differential at end of cycle conditions, per RG 1.121 guidelines. The structural analysis outlined in Attachment 4 utilizes a generic set of loading inputs which was intended to bound the operating regimes of all plants with Westinghouse Series 44 and 51 steam generators. The current normal operating pressure differential for CNP Unit 1 is approximately 1410 psi, which is bounded by the value used in Attachment 4 of 1530 psi for normal operating conditions. Due to the relatively low steam pressure developed in Model 51 steam generators, the normal operating condition (with appropriate safety factor of 3 applied) results in the limiting loading condition for determination of the required minimum wall thickness to satisfy the ASME Code, and subsequently RG 1.121. Additionally, the sleeve wall plugging limit for CNP Unit 1 LWSs has been established using a normal operating condition primary to secondary pressure differential of 1600 psi (discussed later). The requirements of RG 1.83, "Inservice Inspection of PWR Steam Generator Tubes," are implemented, and a baseline eddy current inspection of the installed sleeves is performed prior to operation. An ultrasonic inspection of the free span weld joints is also performed prior to operation. The ultrasonic inspection is used to verify that the minimum acceptable fusion zone thickness of the weld is achieved. A separate minimum weld fusion zone thickness has been shown by analysis to satisfy the requirements of the ASME Code with regard to acceptable stress levels during operating and accident conditions. The acceptance criteria for the ultrasonic testing (UT) inspection of the weld requires a minimum weld fusion zone width. This minimum UT based weld width is approximately 50% larger than the minimum acceptable weld width based on stress limitations, therefore, structural margin above that provided merely by compliance with the ASME Code is inherently provided for each sleeve weld. Additionally, field experience has indicated that nominal weld widths are approximately twice the minimum weld width required for UT acceptance.

[illegible]

As stated previously, a generic set of loading conditions was used for structural analysis of the sleeved tube assembly in Attachment 4. A fatigue analysis was performed for the sleeved tube assembly, the critical location being the free span laser weld. The loading cycles that were applied to the sleeve assembly analysis were those for a 40 year plant life cycle. Therefore, the fatigue analysis is conservative for an operating plant. The results of the fatigue analysis indicate acceptable usage factors for the entire range of permitted weld thicknesses. A comparison of the number of loading cycles used in the generic analysis indicates that the generic inputs are conservative compared to CNP Unit 1 in this area. Using the generic inputs, the cumulative fatigue usage factor was found to be much less than 1.0 (actual value less than 0.10). The pressure differentials used for the generic analysis were found to be conservative compared to CNP Unit 1 values for the majority of the transient curves evaluated. Several transients for CNP Unit 1 involved slightly higher pressure differentials compared to the inputs used in the generic analysis. However, the difference was determined to be insignificant with regard to the applied range of stress intensity and also insignificant with regard to its input to cumulative fatigue usage loading. Recalculation of cumulative fatigue usage indicates virtually no change in the calculated usage factor (actual value for CNP Unit 1 remains less than 0.1). A conservative set of transients applicable to CNP Unit 1 were used for the comparison with the transient set defined in Attachment 4: The CNP Unit 1 transients are applicable for plant operation at both 2250 psi and 2100 psi RCS pressure. A range of T_{hot} values are also included in the CNP Unit 1 transient set.

Leakage testing under conditions considered to be more severe than expected during all operating plant conditions has shown that the LWS does not introduce additional primary to secondary leakage during a postulated steam line break event. Laser-welded sleeved tube assemblies were subjected to thermal and fatigue cycling and then leak tested at pressure differences of up to 3110 psi, which far exceeds the maximum expected CNP Unit 1 feedline break/steamline break (FLB/SLB) pressure differential of approximately 2335 to 2560 psid. No leakage was detected in any welded joint (both free span and TS joints). Leakage testing has also shown that the seal weld of the TS sleeve lower joint is not required in order to preclude leakage during normal operation or accident conditions at 600°F. Non-welded lower joint TS sleeve/tube leakage test specimens were subjected to both fatigue and thermal cycling tests prior to final leak rate evaluation testing. The load level applied during the fatigue testing exceeded the maximum axial load applied to the sleeve during the most severe pressure loading condition. Thermal cycling tests simulated a standard plant heatup/cooldown cycle. No leakage was detected in any non-welded TS sleeve lower joint at 600°F after both thermal and fatigue loading. Primary to secondary leakage

through non-welded TS sleeve lower joints would not be expected at 0% power (T_{hot} = 547°F).

Sleeving of Previously Plugged Indications

The sleeve installation requirements applicable to active tubes which have been identified as containing degradation which exceeds the repair limit are no different for the sleeving of previously plugged tubes. A new "baseline" inspection of the entire tube length must be performed prior to sleeve installation in a previously plugged tube. The location of the identified tube degradation must be verified to be a minimum distance of one-inch from the weld joints (same for active tubes). Historically, the areas of the tube which have suffered outside diameter initiated corrosion degradation are the TSP intersections and the sections of tube within the thickness of the TS where secondary side contaminants have collected due to the operating crevices. The expansion transition region can experience either outer diameter or inner diameter initiated corrosion. The sleeve free span (structural) weld joints are not located in these areas, and should not be affected by any previously identified degradation mechanism which caused the tube to be removed from service. The structural analysis has also supported sleeve installation in a circumferentially separated tube, therefore, the extent of identified degradation should not affect sleeve installation provided the degradation is one inch from the weld joints. Additionally, the area of the tube where the tube plug was installed must be visually inspected prior to sleeve installation. Surface finish requirements for this area have been developed which help to maintain the ability of the joint to form a leaktight seal. Conformance to the surface finish requirements for the lower joint will help to ensure a leaktight sleeve joint, regardless of whether or not the seal weld has been produced. The ability of the weld to sufficiently penetrate the tube wall has been shown by test in cases where a localized gap (up to 2 mils) existed between the tube and sleeve. The penetrating capabilities of the weld will also help to ensure a leaktight joint in cases where slight surface imperfections due to tube plug removal may be present.

Flow Margin Considerations

By reducing the number of tube plugs installed in the steam generator, the proposed amendment would minimize the loss of margin in reactor coolant flow through the steam generator during a postulated events when core cooling capacity is required. Also, sleeving will provide greater margin above the required minimum flow for full power operation, than if equal numbers of tubes were plugged as opposed to sleeved.

The installation of a sleeve into a tube results in an additional flow restriction within the primary system, with an associated increase in pressure drop in the steam generator. The effects of this flow restriction on plant operation are evaluated in the same manner that tube plugging effects are analyzed. Attachment 4 identifies the reduction in primary coolant flow caused by the projected sleeving under normal operating conditions and identifies the number of sleeves or combination of sleeves which result in a flow reduction equivalent to one plugged tube. Evaluation of core cooling capability for the minimum reactor coolant system flow rate will bound the effects on all core and system parameters for a combination of plugging and sleeving up to the equivalent resistance associated with the minimum reactor coolant flow rate. The hydraulic equivalency values contained in Attachment 4 can be used to estimate the impact of laser-welded sleeving on RCS flow capability. Using worst case flow conditions of Attachment 4 (judged to be conservative compared to CNP Unit 1 conditions), a single hot leg TS sleeve would represent approximately 1/23 of the flow reduction of a plugged tube. Additional combinations of TSP sleeves and TSs sleeves and their flow reduction effects are included in Attachment 4.

ANALYSIS

Conformance of the proposed amendments to the standards for a determination of no significant hazard as defined in 10 CFR 50.92 (three factor test) is shown in the following:

1) Operation of CNP Unit 1 in accordance with the proposed license amendment does not involve a significant increase in the probability or consequences of an accident previously evaluated.

   The TS and/or TSP intersection LWS configuration has been designed and analyzed in accordance with the requirements of the ASME Code and RG 1.121. Fatigue and stress analyses of the sleeved tube assemblies produced acceptable results. Mechanical testing has shown that the structural strength of the Alloy 690 sleeves under normal, faulted and upset conditions is within acceptable limits. Leak testing has demonstrated that primary to secondary leakage is not expected during all plant conditions, including the case where the seal weld is not produced in the lower joint of the TS sleeve. Testing shows that non-welding TS sleeve lower joints remained leaktight at temperature and pressure conditions representative of normal and accident conditions. Since laser welding produces a hermetic seal between the tube and sleeve, no leak path can be realized under any condition. Therefore, installation of LWSs will not influence offsite dose calculation for a postulated steam line break event.

The proposed technical specification change to support the installation of Alloy 690 LWSs does not adversely impact any previously evaluated design basis accident or the results of accident analyses for the current technical specification minimum reactor coolant system flow rate. The results of the qualification testing, analyses, and plant operating experience demonstrate that the sleeve assembly is an acceptable means of maintaining tube integrity. These aforementioned analyses and tests demonstrate that installation of sleeves spanning degraded areas of the tube will restore the tube to a condition consistent with its original design basis. Plugging limit criteria are established using the guidance of RG 1.121. Furthermore, per RG 1.83 recommendations, the sleeved tube can be monitored through periodic inspections with present eddy current techniques.

Conformance of the sleeve design with the applicable sections of the ASME Code and results of the leakage and mechanical tests, support the conclusion that installation of laser-welded tube sleeves will not increase the probability or consequences of an accident previously evaluated. Depending upon the break location for a postulated steam generator tube rupture event, implementation of tube sleeving could act to reduce the radiological consequences to the public due to reduced flow rate through a sleeved tube compared to a non-sleeved tube based on the restriction afforded by the sleeve wall thickness.

2) The proposed license amendment does not create the possibility of a new or different kind of accident from any accident previously evaluated.

Implementation of laser-welded sleeving will not introduce significant or adverse changes to the plant design basis. Stress and fatigue analysis of the repair has shown the ASME Code and RG 1.121 allowable values are met. Implementation of laser-welded sleeving maintains overall tube bundle structural and leakage integrity during all plant conditions at a level consistent to that of the originally supplied tubing. Leak and mechanical testing of sleeves supports the conclusions of the calculations that the sleeve retains both structural and leakage integrity during all conditions. Sleeving of tubes does not provide a mechanism resulting in an accident outside of the area affected by the sleeves. Any hypothetical accident as a result of potential tube or sleeve degradation in the repaired portion of the tube is bounded by the existing tube rupture accident analysis. Since the sleeve design does not affect any other component or location of the tube outside of the immediate area repaired, in addition to the fact that the installation of sleeves and the impact on current plugging level analyses is accounted for, the possibility that laser-

welded sleeving creates a new or different type of accident is not supported.

The design of thermally treated Alloy 600 and Alloy 690 sleeved tube assemblies have performed well historically with regard to corrosion. There are no reported instances of Alloy 600 thermally treated or Alloy 690 sleeve degradation for the greater than 35,000 sleeves that Westinghouse has installed in the U.S. Accelerated corrosion test results show the free span laser-welded joint (LWJ) (with post weld heat treatment) is capable of exhibiting a resistance to corrosion of greater than 10 times that of rolled tube transitions. Most LWS corrosion specimens did not experience degradation and were subsequently removed from the corrosion test media after a substantial testing period (supporting the 10x factor compared to roll transitions) was achieved. Several mill annealed Alloy 600 material heats were used for corrosion specimen preparation. All were documented by previous test to have been highly susceptible to PWSCC. The post weld heat treatment process applied to LWS free span joints is designed to achieve a minimum tube OD wall temperature of 1400°F adjacent to the weld and within the laser weld heat affected zone. Since the target temperature of 1400°F is achieved on the tube OD, a slightly higher temperature is achieved at the tube ID surface, where the weld cooling stresses are concentrated. Also, since the axial length of the laser weld and laser weld heat affected zone are relatively narrow compared to other sleeve welding processes, a narrower section of tube is required to be heat treated. Since the length of tube required to be heat treated is shorter in the LWS process than with other sleeving processes, lower residual stresses in the tube can be expected. Accelerated corrosion tests also show that non-heat treated laser-welded free span joints exhibit resistance to stress corrosion cracking equal to or greater than rolled tube transitions. An extensive data base exists on LWS joint performance in foreign plants in which the free span joints are not heat treated. Of the approximately 18,000 non-heat treated joints in service, none has exhibited a rapid corrosion potential. Corrosion testing of the TS sleeve lower joint LWJs exhibit a resistance to corrosion cracking of three to four times that of rolled tube transitions. These factors suggest postulated sleeve/tube assembly degradation would occur at a rate less than rolled transitions, and the potential for a sleeve/tube assembly with accelerated degradation rate characteristics more severe than roll transitions is negligible.

Approximately 800 LWSs are currently in operation in the U.S. Some of these have been in service since April 1992. The plants in which these sleeves are installed have not experienced any adverse operational issues (such as primary to

[illegible]

secondary leakage) as has been detected at other plants with sleeves which have experienced rapid corrosion of the parent tube.

3) The proposed license amendment does not involve a significant reduction in a margin of safety.

The laser-welded sleeving repair of degraded steam generator tubes as identified in WCAP-13088 Rev. 3 has been demonstrated to restore the integrity of the tube bundle under normal and postulated accident conditions. The safety factors used in the design of sleeves for the repair of degraded tubes are consistent with the safety factors in the ASME Boiler and Pressure Vessel Code used in steam generator design. The plugging limit criteria for the sleeve has been established using the methodology of RG 1.121. The design of the sleeve joints have been verified by testing to preclude leakage during normal and postulated accident conditions. Implementation of laser-welded sleeving will reduce the potential for primary to secondary leakage during a postulated steam line break while maintaining available primary coolant flow area in the event of a LOCA. By removing from service degraded intersections through repair, the potential for tube leakage during a steam line break is reduced. These degraded intersections now are returned to a condition consistent with the design basis. While the installation of a sleeve causes a reduction in flow, the reduction is far below the reduction incurred by plugging. Therefore, far greater primary coolant flow area is maintained through sleeving. Use of RG 1.121 criteria assures that the margin of safety with respect to structural integrity is the same for the sleeves as for the original steam generator tubes.

The portions of the installed sleeve assembly which represent the reactor coolant pressure boundary can be monitored for the initiation and progression of sleeve/tube wall degradation, thus satisfying the requirements of RG 1.83. Portions of the tube bridged by the sleeve joints are effectively isolated from the pressure boundary, and the sleeve then forms the pressure boundary in these areas. The areas of the sleeved tube assembly which require inspection are defined in Attachment 4.

In addition, since the installed sleeve represents a portion of the pressure boundary, a baseline inspection of these areas is required prior to operation with sleeves installed. As stated previously, weld fusion zone width is established using UT testing. The minimum acceptable weld width as determined by UT examination is approximately 50% wider than the minimum weld width which satisfies the stress conditions of the ASME Code.

The generic evaluation uses the pressure stress equation of Section NB 3224.1 of the ASME Code which is used to establish

the minimum required wall thickness for the sleeve design and subsequently used to determine the level of sleeve wall degradation (depth by eddy current determination) that would require the sleeve to be removed from service. Using the $\Delta P_{Norm.\ Op.}$ value of 1530 psi from Attachment 4 the limiting minimum required sleeve wall thickness is established. The sleeve wall plugging limit (using Attachment 4) of 25% is subsequently established, and includes an allowance of 10% for eddy current uncertainty and 10% for growth, although sleeve wall degradation has not been observed to date in Westinghouse sleeves. The generic evaluation used the ASME Code minimum property values to establish the sleeve plugging limit. Certified material test reports indicate that the sleeve material properties are significantly higher than the ASME Code minimum values. The generic evaluation considered a primary to secondary pressure differential of 1530 psia, with a steam pressure of 720 psia, for normal operating conditions. CNP Unit 1 can operate at full power with a reduced T_{hot} value and RCS pressure of 2250 psi. Steam pressure can be maintained as low as 650 psi (to keep T_{hot} as low as possible), but cannot go lower than 650 psi or the steam generator operating requirement of a primary to secondary ΔP of 1600 psi (max) will be exceeded. At this $\Delta P_{Norm.\ Op.}$ value of 1600 psi, the sleeve minimum wall thickness requirement (and subsequently sleeve pressure boundary plugging limit) using ASME Code minimum material properties can be recalculated. For this condition (normal operating ΔP equal to 1600 psi), the sleeve minimum wall plugging limit is defined to be 23%. An allowance for eddy current uncertainty and continued degradation are included in this value. The minimum required wall thickness is determined by examining plant conditions at normal, upset, faulted, and test conditions. For Model 51 steam generators, the normal operating condition results in the limiting minimum wall thickness requirement.

CONCLUSION

Based on the preceding analysis it is concluded that operation of CNP Unit 1 following the installation of Alloy 690 LWSs at the tube support elevations and within the TS region of the steam generators, in accordance with the proposed amendment does not result in the creation of an unreviewed safety question, an increase in the probability of an accident previously evaluated, create the possibility of a new or different kind of accident from any accident previously evaluated, nor reduce any margins to plant safety. Therefore, the license amendment does not involve a significant hazards consideration as defined in 10CFR50.92.