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IP2 issues being reviewed as part of DPO process — see memo from Travers — Scott

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 17, 2000

MEMORANDUM TO: James T. Wiggins
Chairman of the Differing Professional Opinion
Ad Hoc Review Panel
Office of the Executive Director for Operations

cc: Jim
Louise
Rick
alan

FROM: Jack R. Strosnider, Director
Division of Engineering
Office of Nuclear Reactor Regulation

JS 5/17/00

SUBJECT: ISSUES PRESENTED IN SUPPLEMENT TO DIFFERING PROFESSIONAL OPINION REGARDING STEAM GENERATOR TUBE INTEGRITY

In his memorandum to the Executive Director for Operations (EDO) dated April 5, 2000, Dr. Joram Hopenfeld supplemented his original differing professional opinion (DPO) whereby he provided his rationale for the linkage between his DPO and the steam generator tube failure at Indian Point Unit 2. The Office of the EDO requested that the Office of Nuclear Reactor Regulation provide a memorandum to you indicating whether or not Dr. Hopenfeld's DPO supplement involved any new issues and to provide an assessment of the information in the supplement.

We have completed the assessment and the results are provided in the attached summary.

Attachment: As stated

Contact: J. Andersen
415-1437

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EE/14

## STAFF ASSESSMENT OF THE ISSUES PRESENTED IN

## SUPPLEMENT TO DIFFERING PROFESSIONAL OPINION

## REGARDING STEAM GENERATOR TUBE INTEGRITY

### INTRODUCTION

In his memorandum to the EDO dated April 5, 2000, Dr. Hopenfeld addressed the following issues. The issues are not presented in the order that they appear in the April 5, 2000, memorandum.

Limitations of NDE Methods and Use of Historical Data

1. Should not leave indeterminably defective steam generator tubes in service on the basis of historical data on stress corrosion cracking.

2. Experience shows that it is not possible to predict stress corrosion cracking.

3. Historical data does not provide a valid basis for predicting crack growth during each cycle.

4. Steam generator tube environment is dynamic and local state of tube stress and local chemistry change unpredictably. Steam generator tube crack growth is also dynamic and proceeds in several distinct stages (initiation, growth, arrest and growth) each exhibiting different dependence on the environment.

Crack Behavior During Accident Conditions

5. Because of the inability of existing methods to effectively characterize defects during inspection, cracks can open catastrophically during MSLBs, resulting in the melting of the core and containment bypass.

6. Even if only few cracks opened initially during the accident, a high velocity jet from a ruptured tube could, under certain conditions, cut adjacent tubes causing them to rupture, thus triggering a cascade effect and damaging numerous other tubes.

7. Three initiating events which could lead to core melt if tubes with stress corrosion cracks are not removed from service: (1) stuck open SRV [main steam line safety relief valve], (2) MSLB, and (3) a steam generator tube rupture which causes a stuck open SRV.

Other Issues

8. The core melt frequency for the IP-2 precursor is 4 X $10^{-5}$/reactor-year (RY) which exceeds Commission guidelines.

ATTACHMENT

9. The criteria from shutting down a plant when a leak is suspected should include the rate at which the leak increases because the allowable primary-to-secondary leakage is unrelated to the leakage that would result following an MSLB accident.

10. NRC should not approve the NEI document until the DPO is resolved.

11. The NRC should require a comprehensive defect assessment following discovery of any new stress corrosion indications. The assessment should be from a qualified third party, outside the agency.

STAFF ASSESSMENT

The EMCB staff reviewed the issues presented in the April 5, 2000, memorandum to assess whether the DPO supplement provided new issues that were not raised in the original DPO. The staff used the November 1, 1999, memorandum from the EDO to Dr. Hopenfeld and Dr. Hopenfeld's reply dated December 15, 1999, as part of this assessment. The November 1, 1999, memorandum also forwarded a copy of the staff's DPO Consideration Document dated September 22, 1999, which grouped the DPO issues into five broad areas: (1) limitations of NDE methods, (2) primary-to-secondary leakage during postulated MSLB conditions, (3) increased risk due to tube degradation and implementation of alternate repair criteria, (4) iodine spiking assumptions, and (5) tube integrity under severe accident conditions. Since the staff reviewed a significant number of documents in preparation of the DPO consideration, the DPO Consideration Document provided a baseline discussion of the staff's understanding of the technical issues.

Limitations of NDE Methods and Use of Historical Data

With regard to Dr. Hopenfeld's issues about NDE performance, the dynamic environment within steam generator tubes, and the use of historical data to predict end of cycle condition, Dr. Hopenfeld raised similar issues in letters dated September 25, 1998, and December 15, 1999. In the DPO Consideration Document, the staff acknowledged limitations with eddy current testing capabilities and, in that context, discussed the integrated set of actions licensees take to address steam generator tube integrity. These actions include inspection qualification, use of examination guidelines, a plug on detection strategy for most degradation, in-situ testing to evaluate performance, shortened inspection intervals in some cases, and other actions. This strategy relies, in part, on plant-specific prior cycle growth rates as the best possible indicator of the upcoming cycle growth rates and has been shown to be a generally successful approach.

In addition, the DPO Consideration Document discusses the predictability of growth rates in the context of the voltage-based repair criteria where certain degradation can be left in service and more useful growth rate projections (of the voltage of indications) can be obtained. Thus, the staff has already addressed Dr. Hopenfeld's issues in these areas.

Crack Behavior During Accident Conditions

With regard to crack behavior during accident conditions, the impact of cracks was discussed in the DPO Consideration Document for both design basis and severe accident conditions. This includes the effect of ablation during design basis and severe accident scenarios, as well as the cutting of adjacent tubes. The staff understands the DPO author's issues and has considered the potential impact that the issues might have on the current and future regulatory approaches for addressing steam generator tube integrity. In addition, the staff notes in the DPO Consideration Document that additional information is needed to confirm prior assumptions regarding the phenomenological issues related to steam generator tube leakage during severe accident sequences.

The DPO Consideration Document presented the staff's perspective of the risk from MSLB-induced tube leakage and SBO core damage sequence induced leakage and ruptures. In the DPO author's April 5, 2000, letter, he discusses three initiating events which could lead to core melt if tubes with stress corrosion cracks are not removed from service: (1) stuck open SRV [main steam line safety relief valve], (2) MSLB, and (3) a steam generator tube rupture which causes a stuck open SRV. In NUREG-1477, the staff explicitly analyzed steam generator tube leakage during secondary side depressurization events, including MSLB, main feedline break, and stuck open main steam line safety valve. These results were discussed in the DPO Consideration Document. Thus, the overall issue of system performance and risk from secondary depressurization and primary-to-secondary leakage has been addressed. The staff does not believe that new issues were raised in this area.

Other Issues

With regard to Dr. Hopenfeld's statement that the core melt frequency for the Indian Point 2 precusor is 4 X $10^{-5}$ / RY, the staff's Consideration Document discusses the increase in risk as a result of proposed relaxations to steam generator tube repair criteria and methods. The staff does not believe that new issues were raised in this area.

Dr. Hopenfeld's statement about the appropriateness of using the rate of change in primary-to-secondary leakage as a criterion for plant shutdown was not discussed in the earlier DPO documents. This appears to be a recommendation or observation by Dr. Hopenfeld and does not appear to be a supplement to the five DPO issues discussed above.

With regard to Dr. Hopenfeld's statement that the staff should not approve the NEI document until the DPO is resolved, the EDO addressed this issue in his November 1, 1999, memorandum to Dr. Hopenfeld. In SECY-00-0078, "Status and Plans for Revising the Steam Generator Tube Integrity Regulatory Framework," the staff stated that the resolution of the DPO concerns does not depend on reaching agreement with the industry on NEI 97-06 issues and the accompanying revised regulatory framework. Further, the staff stated that as it prepares the safety evaluation that documents its review of the NEI initiative, it would assess the implications of the Indian Point 2 experience with regard to the new regulatory framework.

Lastly, Dr. Hopenfeld now recommends that the NRC require an independent and comprehensive defect assessment following discovery of any new stress corrosion indications. This also appears to be a recommendation by Dr. Hopenfeld and does not appear to be a supplement to the five DPO issues discussed above.

Summary

In summary, the staff has assessed the issues raised in the April 5, 2000, supplement to the DPO and finds that it does not raise any new issues. It provides, in part, further explanation of prior issues and how Dr. Hopenfeld believes the Indian Point 2 event supports his issues.

May 9, 2000

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your file

MEMORANDUM TO: Joram Hopenfeld
Engineering Research Applications Branch
Division of Engineering Technology
Office of Nuclear Regulatory Research

FROM: William D. Travers
Executive Director for Operations

Original signed by
William D. Travers

SUBJECT: SUPPLEMENT TO THE "DIFFERING PROFESSIONAL OPINION ON STEAM GENERATOR TUBE INTEGRITY ISSUES"

This memorandum is in response to your April 5, 2000, memorandum regarding the supplement to your Differing Professional Opinion (DPO) on Steam Generator Tube Integrity Issues.

The concerns expressed in your supplement will be reviewed as part of the DPO process to the extent possible. Your concerns have been forwarded to the Office of Nuclear Regulatory Regulation for review relative to the Indian Point-2 (IP-2) steam generator tube integrity issue as well as other generic steam generator issues.

In your April 5, 2000, memorandum, you requested that we make it publicly available. Accordingly, this memorandum and its attachment has been made publicly available in ADAMS.

Attachment: As stated (ML003699813)

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April 5, 2000

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Executive Director for Operations

FROM: Joram Hopenfeld /RA/
Engineering Research Applications Branch
Division of Engineering Technology
Office of Nuclear Regulatory Research

SUBJECT: SUPPLEMENT TO MY DPO REGARDING MULTIPLE STEAM GENERATOR LEAKAGE (Originally Filed as a DPV in December 1991 and Filed as a DPO in July 1994)

In a letter to Mr. David Lochbaum dated March 31, 2000, Mr. Samuel Collins stated that I could supplement the DPO if I determined that the accident at Indian Point 2 (IP2) is pertinent to my DPO. I have so determined, and therefore I am submitting the attached supplement to the DPO for consideration by the ad-hoc panel.

The IP2 event is a precursor to the much more serious accident which is discussed in the DPO which is an unresolved, high priority, generic safety issue. Because the accident addressed in the DPO is a low frequency event, it is important to examine the IP2 event from the perspective of a near miss of the DPO accident. The common factors to the IP2 event and the DPO accidents must be recognized and actions must be taken to reduce public safety risk to a tolerable level. It is therefore important to resolve the nine year old DPO employing an impartial and thoroughly knowledgeable panel.

The most important link between the IP2 event and the DPO is the issue of leaving indeterminably defective steam generator tubes in service on the basis of historical data on stress corrosion cracking. The DPO position is that it is impossible to predict tube wall integrity at the end of a fuel cycle, based on prior cycles. The NRC management disagrees. The NRC permitted Con-Edison to operate their plant's steam generators with indeterminably defective tubes on the presumption that cracks would grow slowly because they had done so for 23 years. This presumption was proven to be wrong at IP2. The attached supplement discusses in more detail the relationship between the IP2 event and the DPO, and proposes certain actions for consideration by the ad-hoc panel to provide assurance to the general public that a catastrophic steam generator tube failure accident is improbable.

I am most concerned and disappointed that the NRC has taken the position that my DPO is not related to the IP2 event because the DPO addresses a generic problem. I do not see how one can separate the specific IP2 event outside the context of the generic problem. The two are inseparable. I recommend that the staff consider the attached Supplement to the DPO prior to IP2 start-up.

Your memo to me dated November 1, 1999 and the above letter to Mr. Lochbaum clearly demonstrate that NRC management predetermined, prior to the resolution of the DPO that the DPO does not raise immediate safety concerns. As I have already indicated to you in my memo dated December 16, 1999, I strongly disagree with this management position. As discussed in the attachment, the IP2 event demonstrates that the DPO raises serious and immediate safety concerns. The pending agreement with the Nuclear Energy Institute (NEI) regarding steam generator license changes is also based on the assumption that historical crack behavior is a valid measure of future crack behavior. I recommend that NRC management delay approval of the pending agreement with NEI until the DPO safety issues are resolved.

The above March 31 letter states that the public had an opportunity to comment on the DPO during the public comment period in January 1999. This statement is misleading because even though there were no public comments regarding the DPO, the staff significantly changed their DPO Consideration document in October 1999. Since I revised my DPO accordingly, the fact is that the public did not have the opportunity to comment on the final DPO documents.

Please file this memorandum in the PDR. Please also place all my outgoing documents in ADAMS, including on the external server so that external stake holders may have access to them.

**SUPPLEMENT TO DPV/DPO AND THE REPLY TO STAFF CONSIDERATION DOCUMENT**

Based on (1) the recent tube leakage at Indian Point Station, Unit 2, (2) the pending NRC approval of the industry steam generator generic license change, and (3) a memorandum to David Lochbaum, Union of Concerned Scientists from Samuel Collins, NRC, dated March 31, 2000, I am supplementing references 1 through 5 as follows:

The DPO addresses a class of accidents under conditions where Pressurized Water Reactor (PWR) power plants are allowed to operate with steam generators that have been determined to have significant stress corrosion cracking of their tubes. Because of the inability of existing methods to effectively characterize such defects during inspection, these cracks can open catastrophically during main steam line breaks, resulting in the melting of the reactor core and containment by-pass. The scenario considered in my DPO will result in the opening of many cracks during the accident, with the resultant primary to secondary side water loss possibly exceeding 1000 gpm. Under this rapidly occurring transient, the operator would not be able to depressurize the reactor primary system and bring the plant to a controlled safe shutdown. PWRs were not designed in a manner which would allow operators to manage accidents when the plant loses its coolant rapidly to the atmosphere. Even if only few cracks opened initially during the accident, a high velocity jet from a ruptured tube could, under certain conditions, cut adjacent tubes causing them to rupture, thus triggering a cascade effect and damaging numerous other tubes.

Because the type of accidents described above do not occur frequently, there is no valid data to accurately assess their risk. However, because the consequences of such a core melt are catastrophic, especially in populated areas, one must err on the side of caution in assessing public risk. The DPO adopted that philosophy, i.e., to err on the side of safety when public risk is concerned. The events which led to the Indian Point 2 (IP2) and the nine years of delay in resolving the DPO indicate that the NRC is using a different approach in dealing with stress corrosion cracking (SCC) of steam generator tubes.

The NRC permits degraded tubes to remain in service on the basis of historical data. Though experience with SCC indicates that it is not possible to predict this type of degradation, the NRC does not err on the side of safety. Con-Edison stated in their May 12, 1999 letter to the NRC that for the first time they found a stress corrosion indication in a row 2 U bend. Furthermore Con-Edison stated that "As this represents the first detected U-bend indication after approximately 23 years of operation, any growth rates associated with this indication would be considered minimal." Consistent with its approval of using historical data to project end of cycle (EOC) allowable degradation under GL-95-05, the NRC accepted the Con-Edison rationale. One of the main DPO positions is that historical plant data does not provide a valid basis for predicting crack growth rates during each cycle. It is this NRC position which allows plants to operate with SCC degradations that makes the Indian Point accident pertinent to the DPO. Behind the NRC position is the premise that the tube environment is static and therefore even if stress corrosion cracking is not completely understood, crack growth will not vary appreciably from cycle to cycle. This premise can not be supported. Steam generator tube environment is dynamic. The local state of tube stress and the local chemistry change unpredictably. Steam generator tube crack growth is also dynamic. It proceeds in several distinct stages (initiation, growth, arrest & growth) each exhibiting different dependance on the environment. The IP2 event demonstrates the validity of the DPO premise. How close the IP2 accident was a near miss of the DPO accident could only be determined after the current Con- Edison inspection report does become available and the number of stress corrosion cracks which were left in service at the start of cycle 14 is identified.

There are no valid criteria to assess whether the DPO approach is overly conservative. It is therefore, necessary to examine event precursors to determine what they show about the safety of allowing plants to operate with indeterminable stress corrosion cracking defects. The IP2 accident is such a precursor. At IP2, tubes which developed stress corrosion cracking during cycle 13, or previously, were not removed from service prior to start of cycle 14. From the available information to date, one of these tubes developed a leak which exceeded 100 gpm. NRC risk studies indicate that the IP2 type accident could lead to a stuck open safety relief valve with a frequency of $4 \times 10^{-5}$/RY (Reference 6). In the DPO scenario, when the secondary side depressurizes rapidly due to a stuck-open safety relief valve, the opening of stress corrosion cracks and a leakage exceeding 1000 gpm would prevent the operator from depressurizing the primary eventually leading to a core melt and containment by-pass. Thus the core melt frequency for the Indian Point precursor is $4 \times 10^{-5}$/RY which exceeds the Commission's safety guidelines.

My September 28, 1999 memo (Reference 8) states that allowing defective steam generators to remain in service represents a major revision of the FSAR and should be granted only after all uncertainties for tube-to-tube damage propagation have been considered. I indicated that it should be unacceptable to substitute a formal assessment of steam generator tube defects with "staff beliefs" as was done in granting Southern Nuclear Company relief for fuel cycle 16 at J. M. Farley, Unit 1. To preclude events such as IP2 of re-occurring the NRC should require plant operators to provide a comprehensive defect assessment to the NRC following a discovery of any new stress corrosion indications. NRC management should require a documented assessment from a qualified third party, outside the agency, which includes at least one stress corrosion expert and one fracture mechanic expert who are experienced in defect assessments. The third party assessment team must be unbiased and must have no direct, or indirect, financial interests in the outcome of the assessment.

Another major difference in opinion between the author of the DPO and the staff relates to leakage prior to, and during, main steam-line break accidents. The NRC claims that it is possible to predict leakage during the accident while the DPO claims that it is not possible to predict such leakage because of factors such as tube plugging, crack morphology and jet erosion. The IP2 event suggests that the criteria for shutting down a plant when a leak is suspected should include the rate at which the leak increases, because the allowable primary to secondary leakage is unrelated to the leakage that would result following a steam line break accident. Ligaments between cracks and deposits in the cracks could severely restrict the flow under normal loads. Under accident loads the deposits would likely be blown off and the ligaments torn, thereby reducing flow restriction and increasing leakage exponentially. Prior to the steam line break, small fluctuations in the applied stress, could cause stress corrosion cracks to open more gradually, but sufficiently to reduce flow restrictions through the cracks. Therefore, monitoring the rate of leak increase affords perhaps a better indicator of a leak before break.

In conclusion, there are three initiating events which could likely lead to a core melt if tubes with stress corrosion cracks are not removed from service. These events are: (1) a stuck open

SRV, (2) Main Steam Line Break, and (3) an SGTR event which causes a stuck open SRV. During the IP2 event, the steam generators were allowed to operate with SSC degradations on a basis which is at issue in the DPO. This is the reason why the IP2 event is pertinent to the DPO and why it supports the DPO position that tubes with indeterminable cracks must be removed from service.

In Reference 7, the NRC indicated that the agreement with the Nuclear Energy Institute (NEI) does not depend on the resolution of the DPO. I strongly disagree with this position, the NEI methodology specifically relies on the assumption that historical data on stress corrosion cracking can be used to allow plants to operate with degraded tubes. The NEI agreement relies on GL-95-05 the validity of which is a DPO issue. The IP2 event further supports my protest (Reference 5) of separating the DPO resolution from the NEI agreement. The NRC should not approve the NEI document until the DPO is resolved.

**References**


1. Memo, J. Hopenfeld to E. Beckjord, Differing Professional Opinion, December 23, 1991

2. Memo, J. Hopenfeld to E. Beckjord, " New Generic Issue: Multiple Steam Generator Leakage" and March 27, 1992

3. Memo, J. Hopenfeld to E. Beckjord, "Addendum to March 27, 1992 Regarding Degraded Steam Generator Tubes," Sept. 11, 1992.

4. Memo, J.Hopenfeld to J.M. Taylor, "Differing Professional Opinion Regarding Voltage-Based Interim Repair Criteria for Steam Generator Tubes,". July 13, 1994.

5 Memo, J. Hopenfeld to W.D. Travers " Differing Professional Opinion On Steam Generator Tube Integrity Issues" , December, 16, 1999

6- NUREG/CR -4550 Vol 1 . 3, Rev 1, Part 1 ( SGTR event, 0.01/RY; RCS-XHE-FO-DPRT7; Operator fails to depressurize/cooldown RCS during the SGTR event, Prob. 0.029; Probability of PORV blocked and SRV fails to shut is 0.15 and 1 respectively)

7. Memo, W.D. Travers to J. Hopenfeld, Same Subject, November, 1 1999

8. Memo, J.Hopenfeld to W.D. Travers, Same Subject, September 28, 1999