Commonwealth Edison Company
1400 Opus Place
Downers Grove, IL 60515

September 19, 1995

ComEd

Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attn: Document Control Desk

Subject: Response to Request for Additional Information Regarding the Increase in the Interim Plugging Criteria for Byron Unit 1 and Braidwood Unit 1
NRC Docket Numbers:50-454 and 50-456

Reference: D. Lynch letter to Commonwealth Edison Company dated August 24, 1995, transmitting Request for Additional Information

In the reference letter, the Nuclear Regulatory Commission transmitted to the Commonwealth Edison Company (ComEd) a request for additional information (RAI) questions 58 to 65, regarding the technical bases supporting the pending license amendments, which involves an increase in the interim plugging criteria for steam generator tubes at Byron Unit 1 and Braidwood Unit 1. Attached is ComEd's response to those questions.

If you have any questions concerning this correspondence please contact this office.

Sincerely,

Denise M. Saccomando
Nuclear Licensing Administrator

Attachment
cc: D. Lynch, Senior Project Manager-NRR
R. Assa, Braidwood Project Manager-NRR
G. Dick, Byron Project Manager-NRR
S. Ray, Senior Resident Inspector-Braidwood
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H. Miller, Regional Administrator-RIII
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A001

NRC Request for Additional Information Number 6

58. (Refer to Item 35 in the staff's letter dated June 22, 1995.)

The staff believes that the use of a 0.590 inch diameter probe appears to be non-conservative when used to ensure that no dents exceed 65 mils, thereby ensuring the integrity of the tube support plate (TSP) ligaments. Accordingly, discuss the need to use either a different size probe, method, or criterion to ensure that the size of a dent is sufficiently small so as to ensure structural integrity of the TSP ligaments.

Response

ComEd has revised its position on how to gauge if a 65 mil dent is present in a SG tube. In the September 1, 1995, Technical Specification Amendment Supplement for a 3 Volt IPC, ComEd specified that an appropriately size probe will be used as a go/no-go gauge for detection of a 65 mil dent. The appropriately sized probe will be the nominal 0.610 inch diameter bobbin coil probe. The Staff will be informed if the 0.610 inch diameter go/no-go probe fails to pass through a tube intersection adjacent to an expanded tube if this intersection has passed a 0.610 inch diameter probe in the past. Also, stated in required by the September 1, 1995, 3 volt Technical Specification Amendment Supplement, if a 0.610 inch diameter probe will not pass through a portion of a tube, IPC will not be applied to this portion of the tube and IPC will not be applied to the adjacent intersections. This information was presented in the response to question 52 of the RAI issued August 11, 1995. The response to question 52 also addressed the structural integrity of TSP as it relates to corrosion induced dents.

59. (Refer to Item 36 in the staff's letter dated June 22, 1995, for Items 59 and 60)

In your response to Item 36, you provided further detail on how the TSP displacements were calculated. It appears that this calculation is non-conservative in that the reference position for the hot standby and full power SG conditions were taken to be equivalent. Accordingly, provide a reassessment of the TSP displacements for the SG tube expansion matrix presently proposed for the worst case postulated accident condition (e.g., a main steamline break (MSLB) initiated from both the hot standby and full power conditions, assuming that the TSPs are free to move between all modes of operation (i.e., cold shutdown, hot standby and full power). In addition, the calculation of the TSP displacements should include any other effects which may result in relative movement between the SG tubes and the TSPs, unless exclusion of these other effects would result in more conservative estimates of the TSP displacements under all conditions (i.e., inclusion of these other effects would lower the displacements at all other locations of the TSPs). If

the TSP displacements resulting from this assessment are greater than the currently estimated maximum displacement, provide an assessment of the significance of these larger displacements with respect to acceptable structural and leakage integrity of the SG tube indications of outer diameter stress corrosion cracks (ODSCC) accepted for continued service.

Response

Two scenarios (cases) were evaluated in response to this question. Case 1 is that the TSPs become "locked" to the tubes by corrosion products during operating conditions and as such the indications remain centered within the TSPs at all operating modes (i.e., cold shutdown, hot standby and full power). ComEd believes this is the realistic scenario based on the information discussed in this response. Case 2 assumes that the TSPs do not become locked to the tubes during operation and are free to move under all operating modes. ComEd does not believe that this is a credible scenario for the case of the Braidwood Unit 1 and Byron Unit 1 SGs but has evaluated this case in response to the question.

CASE 1

ComEd believes that the Case 1 evaluation which is that the TSPs become "locked" during operation is the only credible scenario for the case of the Braidwood Unit 1 and Byron Unit 1 SGs. This is based on the following information:

- If the TSPs were free to move between all modes, the eddy current inspection which is performed at cold shutdown would be expected to detect indications outside the thickness of the TSPs. No indications outside the TSP have been found in any Braidwood-1 or Byron-1 inspection or in the inspection of any other plant for ODSCC at TSP intersections. This is further supported by the Byron and Braidwood tube pull analysis results which show no ODSCC to be present outside the TSP areas. In fact, the pulled tube data shows that the cracks were centered within the TSP.

- During the Byron Unit 1 Refuel 6 outage a test to determine if the tubes were locked at the TSPs was performed on a total of 8 tubes in 2 SGs. Testing was performed after completion of secondary side chemical cleaning. The process involved centering an eddy current probe at an upper hot leg TSP elevation and heating the tube in the region of the lower TSPs. If the tubes were not locked at the TSPs, thermal growth would be seen by the tube lengthening and moving the eddy current probe away from the TSP. Results indicated that 7 of the 8 tubes were clearly locked at the TSPs. The results from 1 of the 8 tubes indicated that the tube was not locked at the TSPs. A similar test was performed on a Westinghouse Model D-2 SG at another utility with results indicating that all 9 tubes tested were locked at the TSPs. The Model D-2 steam generator TSPs are similar in design.

• Tubes become locked to the TSPs at full power conditions due to packing of the crevices with deposits, general corrosion processes, ect. For a TSP that has become locked due to this process, the individual forces may be small, but on a cumulative basis the total force is large and able to permit the TSPs to move with the tubes.

• During the Braidwood Unit 1 Refuel 4 outage and the Byron Unit 1 Refuel 6 outage, a total of 7 tubes (4 - Braidwood , 3 - Byron) were removed for analysis in support of IPC. The breakaway pull forces after TIG relaxation of the tubesheet expanded area ranged from 408 lbs to 3345 lbs for Braidwood and 1194 lbs to 2885 lbs for Byron. Although the breakaway forces are unable to distinguish between the force required to break the tube away from the tubesheet verses breakaway from the TSPs, the data suggests that the tubes are locked at the TSP intersections.

Based on this data ComEd has concluded that tubes are locked in all operating modes. Therefore, only the transient SLB displacements contribute to tube to TSP displacement. To apply this conclusion consistently during a SLB as shown in WCAP 14273, ComEd conservatively assumes that the maximum TSP displacements for the SLB event do not return to the time zero (no SLB displacement) location. That is, the associated packed crevices prevent the TSPs from returning to the time zero position after the peak SLB pressure drops return to steady state conditions.

<u>CASE 2</u>

ComEd believes that the Case 2 evaluation, in which is the tubes are free to in the TSP during all modes of operation (i.e., cold shutdown, hot standby and full power) is not a credible scenario based on the previous evaluation. But as requested by the question, evaluations have been performed under this assumption.

Most important to understand in this scenario is that, if the TSPs are free to move, this allows them to return to time zero displacement independent of the SLB hydraulic loads as long as the plates remain elastic in the event after about 3 seconds. Later in the event, the primary to secondary pressure differential increases as the emergency core cooling system repressurizes the primary system while the secondary system in the faulted loop has depressurized. The repressurization becomes significant in the time frame of about 15 or more minutes. Only after this repressurization is there a potential for increased leakage or burst of a tube. By this time, with the TSPs free to move scenario, the TSPs have returned to their steady state positions enveloping the cracks. Therefore, burst is zero and leakage is as defined by the IRB leak tests for cracks contained within the TSP. The more conservative leakage calculation uses a bounding IRB leakrate determined for a crack extending outside the TSP.

Although the assumption of no tube to TSP contact force is <u>unrealistic</u>,

analyses were performed to develop the TSP displacements for a hot standby SLB under the tubes free to move assumption. The tubes free to move assumption would not impact the full power SLB displacements since the tubes become locked to the TSPs and indications are formed within the TSP at the nominal full power positions. Table 59-1 shows the TSP/tube displacements, under the no contact force assumption, between full power and hot standby conditions (thermal growth, tubesheet bow, full power displacements, etc.), the SLB displacements relative to time zero and the combined full power to hot standby SLB displacements. With tube expansion, it is seen that the maximum full power to hot standby crack to TSP displacements at time zero are bounded by about 0.02" for the first TSP and 0.08" for the top TSP. If the transient SLB displacements relative to time zero are added to the "thermal" displacements at time zero, the maximum SLB crack to TSP displacements range from 0.04" for the first TSP to 0.15" for the top TSP. These maximum displacement values occur in the first 2 seconds after the SLB when there is no significant Δ P. As discussed previously, the TSPs return to their time zero displacement after about 3 seconds, which is before repressurization becomes significant (> 15 minutes). It can be noted that the maximum displacements from the upper two table boxes in Table 59-1 are not directly added to obtain the combined maximum SLB displacements since the maximums for thermal and transient displacements do not occur at the same location and the combined SLB displacements are obtained by combining the thermal and transient displacements on a specific tube location basis.

In summary, for the condition of the TSP to tube crevices being open, and the TSP being free to move between all modes, only the full power to hot standby displacements (< 0.08") contribute to TSP displacements since the SLB transient TSP displacements will return to the time zero displacements early in the SLB event (before the ΔP across the tube significantly increases). In other words, the assumption that the TSPs are free to move allows them to return to time zero displacement independent of the SLB hydraulic loads as long as the plates remain elastic in the event after about 3 seconds. Later in the event, the primary to secondary pressure differential increases as the emergency core cooling system repressurizes the primary system while the secondary system in the faulted loop has depressurized. The repressurization becomes significant in the time frame of about 15 or more minutes. Only after this repressurization is there a potential for increased leakage or burst of a tube. By this time, with the TSPs free to move, the TSPs have already returned to their steady state positions enveloping the cracks. Therefore, burst is zero and leakage is as defined by the IRB leak tests for cracks conservatively estimated to extend <0.10" outside the TSP. In fact, under this condition any cracks of the lengths likely to develop in a plant applying 3.0 volt IPC would remain within the TSP during a SLB. The more conservative IRB leakrate value as determined in the IRB test program still applies.

In response to the portion of the question that states that the calculations appear non-conservative in that the reference position for the hot standby and

full power SG conditions were taken to be equivalent. ComEd believes that the hot standby and full power tube/TSP positions would be the same based on the tube to TSP contact forces created by crevice deposits as confirmed by the fact that no indications have been identified by NDE to be outside the TSPs at cold shutdown conditions. This is further supported by data presented in case 1.

In conclusion adjustments of the SLB displacements under the assumption that the tubes are free to move results in unnecessary conservative in the displacement estimates. Clearly, if the tubes were free to move, the TSPs would also return to their time zero positions after the first few seconds of a SLB and there would be no TSP displacements at the time of maximum primary to secondary pressure differential.

The following paragraphs address the second part of this question relative to other effects which may influence movement between the tubes and the TSPs. The SLB displacement analyses relative to time zero steady state conditions include all effects which increase TSP to tube relative displacements. The analyses include the dynamic SLB pressure drops and tubesheet bow effects. Temperature changes over the two seconds of significant pressure differential across the TSPs are negligible. However, the reporting of maximum TSP displacements for the SLB event very conservatively ignores that the displacement analyses predict the TSPs to return to the time zero (no SLB displacement) after a few seconds. In the first few seconds of the event at which the TSP displacements occur, the primary to secondary pressure differential across the tube tends to decrease due to the rapid decrease in both the primary and secondary system pressures. After about 3 seconds of the event, the TSP displacements return to the prior steady state positions as shown in Figures 8-20 and 8-21 of WCAP-14273, (again no credit is taken for this in the analyses).

Overall, the expected TSP displacements in a SLB event are zero for significant leakage and burst considerations. The maximum SLB TSP displacements in the first few seconds have been very conservatively used for leakage and burst analyses under the arbitrary assumption that the TSPs become locked to the tube at the maximum displacement positions and do not return to the steady state positions. Given this conservative assumption in the displacement analyses, ComEd disagrees with the comment in the question that the displacements are non-conservative since the relative tube/TSP positions are taken to be the same at full power and hot standby conditions in the displacement analyses.

60. In response to Item 36.b., you indicated that a SG tube which has been expanded to create a new "tierod" and then plugged, may act to pull the TSPs down relative to the hotter, in service, SG tubes due to differences in the thermal growth between a plugged and unplugged SG tube. This assumes that the TSPs are locked in the "hot" condition and that the SG tube to TSP contact forces of the unplugged tubes are small enough so that the new

"tierod" can pull the TSP down. If this were to occur, the potential exists that SG tube ODSCC degradation previously confined within the TSP crevices, may be exposed. As a result, the ODSCC degraded area of the SG tube may be longer than the thickness of the TSP (i.e., 3/4-inch). Furthermore, the maximum length of an SG tube ODSCC indication exposed during a postulated MSLB accident may be greater than the maximum displacement calculated to date (i.e., 0.1-inch) which presently assumes that the SG tube ODSCC indications are fully confined within the TSPs. Consistent with the comments cited above, perform a calculation which determines the maximum length of a crack which may be exposed during a postulated MSLB in light of these assumptions. If the resultant crack length displacement (i.e., the TSP displacement plus the relative crack displacement as a result of the newly created tierods) are greater than the currently estimated 0.1-inch maximum displacement, provide an assessment of the significance of these larger crack length displacement with respect to ensuring acceptable structural and leakage integrity of the SG tube ODSCC indications accepted for continued service.

Response

Question 59 addressed both the "locked" tube and the very conservative, tube free to move assumption for consideration of TSP displacements under expanded tube conditions. This question relates to potential changes in tube to TSP positions at full power, where the cracks are formed, between before and after tube expansion for tubes adjacent to an expanded tube. The assumed scenario is a locked tube condition prior to expansion, tube expansion at cold shutdown, heatup to full power following expansion causes forces that break the locked tube condition on tubes immediately adjacent to the expanded tubes. Under this scenario, tubes adjacent to the expanded tubes have relative tube to TSP displacement between full power before expansion and full power after expansion while tubes away from the expanded tubes remain locked and have no relative displacement between before and after expansion. Thus, the only tubes of interest to responding to this question are tubes adjacent to the expanded tubes.

For the assumed scenario, the total tube to TSP displacement for a crack formed at the edge of the plate prior to tube expansion through a post-expansion SLB event would consist of: 1) the relative displacement at full power between before and after expansion due to heatup and full power conditions, 2) the relative displacement between full power after expansion to hot standby after expansion due to reductions in temperature and no flow conditions and 3) the transient SLB displacements after tube expansion due to transient flow conditions. For a tube location adjacent to an expanded tube, the transient displacements (contribution #3) can be approximated as zero since the SLB loads cause negligible TSP displacement at expanded tube locations. Therefore, the only contributors to tube to TSP displacement for this scenario are items 1 and 2 above, which are principally contributions from differential thermal growth. Due to difficulties in defining an appropriate

"locked" tube to TSP contact force and modeling this contact force as a breakaway force in the displacement analyses, an upper bound contribution from items 1 and 2 was obtained by assuming tubes are free to move. Relative displacements for the locked condition with a breakaway assumption cannot exceed that for no tube to TSP contact force (tubes free to move) as the contact forces act to reduce relative displacements.

Analyses to bound the contributions from items 1 and 2 were then performed under the tubes free to move assumption. For further conservatism, the maximum relative displacements at any tube location on a plate are applied to bound the displacements for a tube next to an expanded tube. For these conservative assumptions, the tube to TSP displacements at full power between before and after expansion (item 1) are given in Table 60-1. With the wedges included in the analyses, the maximum displacements for item 1 are about 0.068". The influence of the wedges is only significant before tube expansion at the tubelane corners of the J (7H) plate as shown by the results in Table 60-1 without the wedges. The J plate displacements ignoring the wedges results from the full power pressure drops across the TSP at the unsupported corners of the plate. The wedges prevent this displacement prior to expansion. It is appropriate to ignore the no wedge assumption prior to expansion as being excessively conservative. After expansion, the J plate displacement at full power is essentially eliminated by the tubes expanded in Rows 5 or 6 (including a redundant expansion), specifically to limit the SLB displacement at this location. The effect of these expansions limit displacement of the J plate in this region at both full power operation and SLB loads. This is numerically demonstrated in Table 59-1, where the full power to hot standby displacements with tube expansion and without wedges is shown to be small for plate J.

The total displacements for items 1 plus 2 are given in Table 60-2 as the full power (without expansion) to hot standby (with expansion) values. It is seen that the maximum displacement for items 1 plus 2 is 0.1". Again, it should be emphasized that this is a bounding estimate based on the limiting value anywhere on the plate (versus tube adjacent to an expanded tube) and the tubes free to move assumption (versus breakaway of a locked tube condition adjacent to an expanded tube).

In summary, the relative tube to TSP displacements for a tube adjacent to an expanded tube is bounded by 0.1" between full power prior to expansion and a SLB event at hot standby after expansion. These displacements are dominated by relative thermal growth (items 1 and 2 above) since the SLB transient displacements next to an expanded tube would be negligible.

To characterize the <u>extremely conservative</u> case of all tubes free to move between full power prior to expansion and a SLB at hot standby after expansion, the results of Table 60-2 include the transient displacements and the sum of the time zero and transient displacements. However, as extensively discussed in the response to Question 59, the tubes free to move

assumption leads to the TSPs returning to the time zero positions after a few seconds of the SLB event and prior to significant increases in the primary to secondary pressure differential. Thus the tubes free to move assumption results in the maximum displacement of 0.1" as found for time zero in Table 60-2. It can be noted that even the sum of time zero and transient displacements results in only 0.2" displacements. This displacement is bounded by total crack lengths outside the TSP test in the IRB leak test program.

61. To quantify the uncertainty in the SG tube leakage measurements for an indication restricted from burst (IRB), the leakage from a set of orifices has been measured as part of your IRB test program. Discuss any modifications and/or repairs preformed on the test rig and/or facility since the original SG tube specimen IRB leak rate testing was performed. Discuss whether these modifications and/or repairs, if any, would alter your conclusions derived from the orifice testing. For example, if a valve in the test rig was leaking by the seat, the leakage from this valve could result in an underestimate of the leakage. If a leaking valve was replaced or repaired prior to the orifice testing, uncertainties in the leakage measurements may not be fully quantified.

Response

Figure 61-1 is a schematic of the test rig that shows the connection among the source tank, shim autoclave, test autoclave, air operated dump valve and the condenser/accumulators. The test process was to establish the desired conditions in the source tank with the dump valve closed, opening the dump valve to vent the test autoclave to the condensers at atmospheric conditions, and collecting and measuring the condensed leakage volume in the accumulators. Thus, any repairs or modifications that could affect the leakage measurement would have to occur between the test autoclave and the accumulators. Only those repairs/ modifications that addressed a test rig condition that resulted in leakage to the atmosphere, downstream of the test autoclave, could have resulted in an error in the measured leak rate, since the measured test leak rate is a dynamic time differential of the accumulated volume with the internal system (source tank to condenser exit) wide open. Leaks upstream of the test autoclave, including the test autoclave head, would only have affected the test process (i.e. ability to establish desired conditions) and would not have affected the leak rate measurement. No tests were performed with any known leakage in the test rig, and no repairs/ modifications were made that could affect the leakage measurements.

The repairs/modifications performed on the hot leak test facility during the time of testing the original specimens (test sequence numbers 1 through 4) and completion of the additional tests (test sequence numbers 11 and 12, and calibrated orifice tests) are summarized below, and their effect on leak rate measurements is discussed:

1. A bypass valve was added to the test and shim autoclaves on the upstream (input) side to bypass the autoclaves in the event of a leak. No leaks were observed, and this valve was never utilized. No leakage through this valve was observed during subsequent testing.

2. Rupture disks were added to the shim and test autoclaves as protection against an overpressure event. The rupture disks had no effect on the testing.

3. The bulk secondary thermocouple was replaced. This repair had no effect on the testing.

4. A leak on the inlet line to the autoclave was repaired by cleaning the leaking connection. The repair was made prior to initiation of a test. Inlet line leaks do not effect the leakage measurement since the inlet conditions are measured at the test specimen, and the outlet (leakage) flow is condensed and collected.

5. The air operated valve on the condenser loop 2 was stuck open at the end of a test during sequence 11-2. Repairs were made prior to continuing any testing. No leakage through the air operated valves was observed after repairs to the valve were completed. Valve maintenance, consisting of lubricating the spring in the actuating mechanism, was performed prior to performing the calibrated orifice tests. The seating and sealing function of the valves was not affected.

The function of the air operated valves is to close the system until the desired primary conditions are established in the system, then to open the system to the condensers at atmospheric pressure so that leakage through the test specimen occurs. Leakage through either valve would have prevented establishing loop equilibrium prior to venting to the condensers, and would have been observed as an increase in the condensed leakage volume prior to initiating the test. The increase volume in the accumulators would not have affected the leak rate measurements since these are made as a dynamic time differential of the accumulated volume during the test with the system wide open.

62. For those tubes which are proposed to be expanded, discuss the need for rotating pancake coil (RPC) examinations to ensure that no circumferential cracks are present (i.e., circumferential cracks are neither initiated nor opened up as a result of the expansion process). Discuss the need for such an RPC examination to establish baseline data.

Response

In addition to the bobbin profilometry to verify proper expansion dimensions, inspections shall be performed by probes capable of detecting both axially and

circumferentially oriented indications in sleeved tubes. The purpose of this examination is to ensure that no circumferential cracks are present, either initiated or propagated. If circumferential cracks are detected, the proposed tube to be expanded will be stabilized and plugged. An alternate tube will be selected for expansion and the same examinations will be performed following the expansion process. These examinations will also provide baseline data for any future examinations. Future examinations of the expanded tubes are discussed in response to Question 65.

63. In attachment B to your letter dated July 7, 1995, you stated that the ODSCC database has been updated to include the latest Byron 1 and Braidwood 1 SG tube pull data. The staff believes that there is additional pulled tube data available from at least one other nuclear power plant (e.g., South Texas). Discuss whether this data will be included in the database.

Response

The South Texas pulled tube data will be evaluated for inclusion in the database. Only NRC approved data exclusion criteria will be applied to the data evaluation. The resulting data will be included in the correlations for burst, probability of leakage and leak rate.

64. Your proposed license amendments currently rely on several SG internal structures to limit the displacement of the TSPs during postulated accident conditions. As such, the structural integrity of these components is important to safety by ensuring that the displacements of the TSPs are limited to an acceptable value. Accordingly, provide your inspection plans which are intended to ensure the structural integrity of those components necessary to limit the TSP displacements (e.g., wedges, vertical bars and tierods). Your response should address, but not be limited to, the following considerations:

1. The scope of the inspection of the SG internal structures; e.g., the TSPs wedges, vertical bars and tierods. Provide a discussion of the available inspection technologies, including visual, eddy current and any other available state of the art inspection techniques, which have been considered in defining the scope of the inspection. Discuss any limitation in their application.

2. The capabilities, limitations, and qualification of the inspection techniques to be used. This discussion should address the capability of the proposed inspection techniques to identify cracking and other degradation mechanisms whose characteristics would impair the structural integrity of any SG internal component for which credit was taken in calculating the TSP displacements.

3. The need to clean or prepare the surface of each SG internal structural

component required to limit the TSP displacements, prior to its inspection.

4. The applicability of the inspections of the SG internal structures performed at one location within a SG to assess the potential for degradation at other locations in the SG if only limited inspections can be performed. For example, if inspections are performed at the vertical bars at the bottom and top TSPs, discuss how the conditions at these specific SG locations are representative of other TSP locations.

Response

The ComEd SG Internals inspection plan was submitted to the staff on September 2, 1995. This program encompasses all portions of ComEd's response to question 64.

65. In your pending request for license amendments, you propose to expand certain SG tubes into the TSPs, thereby adding additional structural restraint to the TSPs and resulting in limited TSP displacements under accident conditions. As part of this process, you propose to insert sleeve stabilizers into these selected SG tubes where they will then be hydraulically expanded at the TSP intersections. You cited certain corrosion tests and operating experience for similar hydraulically expanded joints, in part, as your basis for conducting delayed inspections of these joints rather than conducting earlier inspections. For example, you propose to inspect a minimum of three expanded SG tube joints every third planned SG inspection after installation. In light of the limitations of corrosion tests to simulate field conditions, including both installation and in-service conditions, and the importance of the expanded SG tubes in minimizing the TSP displacements during postulated accident conditions, the staff believes that conducting inspections of these expanded SG tube joints at the first planned SG inspection after installation would verify that no significant degradation had developed during the first portion of the in-service life of these expanded joints.

Response

As discussed in the response to RAI Question 22, the basis for the three cycle inspection period is supported by more than laboratory and field experience. The bases for the three year inspection interval can be summarized as follows:

<u>Laboratory and Field Experience</u>

- Estimated time to develop circumferential cracking at the low plugged tube temperatures of about 540°F is > 15 years.

- The shortest time to develop circumferential cracking in hardroll expansions, which bound the range of residual stresses for the TSP expansions, at operating temperatures of about 618°F is three operating

cycles.

Additional Bases for Three Year Inspection Interval

- A circumferential crack must essentially sever the tube before it impacts the ability of the expansion to limit TSP displacements due to the low axial load on the joint (< 500 lb., Table 8-13, WCAP-14273). No circumferential cracks of this magnitude have been found in expansion transitions including tubes that had not been inspected for > 3 cycles. The likelihood of a corrosion crack severing the expansion in less than three operating cycles is extremely low when initiation is estimated at about 15 years at the plugged tube temperature.

- The tube expansion design function to limit TSP displacements with the sleeve is independent of severing of the joint for the lower three TSPs for which the TSP displacements are in the down direction (for SLB at both hot standby and full power conditions) toward the tubesheet. The sleeve prevents lateral displacement of a severed tube for loads directed toward the tubesheet and the expansion continues to perform its intended function.

- Redundant tube expansions were incorporated into the tube expansion matrix to accommodate a severed expansion at locations of potentially significant displacements. Thus, two expansions at nearly adjacent locations must sever at the same elevation to impact the displacements. The design objective of < 0.1" displacements is satisfied without the redundant expansions.

- For a postulated SLB at full power conditions which is about 30 times more probable than a SLB at hot standby conditions, the maximum TSP displacements on the TSPs above the lower three plates, which are independent of a severed expansion, are < 0.1" (Table 8-1, WCAP-14273). This displacement includes a factor of 1.75 on TRANFLO and does not take credit for the expanded tubes.

Based on the above, the expansion features such as the sleeve, redundancy, etc. have been included in the expansion design and tube location matrix to accommodate postulated severed tubes. These features, as well as the low temperatures leading to long crack initiation times, are the basis for requiring inspection of the expanded tubes at three cycle intervals. Given that there is no basis to expect cracking in one cycle and that extensive cracking can be accommodated by the expansion design, there is no need to inspect the expansions after one cycle of operation and the three cycle inspection period remains the proposed inspection interval.

In addition, substantial cost and exposure per unit (≈ \$220,000 - \$250,000 / 1.5 - 2 Person Rem) is associated with the removal of plugs and subsequent inspection of locked tubes. If the locked tubes were to remain in service, inspection after each outage would be feasible. However, based upon the

occurrence of circumferential cracks in hard rolled joints and HEJ sleeve joints under normal operating conditions, there is no evidence to suggest that inspection after 1 cycle is necessary. Therefore, ComEd does not plan to remove plugs, inspect and replug tubes used to lock TSP's in place any more frequently than after three cycles of operation.

Table 59-1
Summary of Plate/Tube Displacements

SLB From Hot Standby with Uncertainty Factor
Full Power With Expansion to Hot Standby With Expansion
Wedge Support Removed

Relative Plate/Tube Displacements
Full Power (With Exp) to Hot Standby (With Exp)
Time = 0.

Plate	Min	Max
A	-0.0379	0.0082
C	-0.0007	0.0214
F	-0.0065	0.0312
J	-0.0025	0.0399
L	-0.0035	0.0546
M	0.0297	0.0610
N	0.0385	0.0669
P	0.0432	0.0758

SLB Relative Plate/ Tube Displacements
with Respect to Time = 0.

Plate	Min	Max
A	-0.5904	0.0116
C	-0.0580	0.0286
F	-0.0786	0.0402
J	-0.0379	0.0404
L	-0.0206	0.0684
M	-0.0187	0.0692
N	-0.0196	0.0885
P	-0.0213	0.0961

Combined SLB Displacement Results
(Developed from Location Dependent Data)

Plate	Min	Max
A	-0.6283	0.0139
C	-0.0585	0.0371
F	-0.0839	0.0566
J	-0.0322	0.0640
L	-0.0204	0.0809
M	0.0240	0.1024
N	0.0300	0.1281
P	0.0487	0.1472

Table 60-1
Summary of Plate / Tube Displacements
Full Power (W/O Exp) to Full Power (With Exp)

With Wedges at 10 Degree Location for A(1H), C(3H), and J(7H)

Plate	Min	Max
A	-0.0000	0.0005
C	-0.0059	0.0458
F	-0.0132	0.0147
J	-0.0030	0.0269
L	-0.0159	0.0678
M	-0.0104	0.0353
N	-0.0051	0.0498
P	-0.0047	0.0579

Without Wedges at 10 Degree Location for A(1H), C(3H), and J(7H)

Plate	Min	Max
A	-0.0000	0.0003
C	-0.0014	0.0208
F	-0.0134	0.0148
J	-0.2751	0.0227
L	-0.0127	0.0673
M	-0.0102	0.0382
N	-0.0049	0.0530
P	-0.0047	0.0605

Table 60-2
Summary of Plate / Tube Displacements

SLB From Hot Standby with Uncertainty Factor
Full Power W/O Expansion to Hot Standby With Expansion

Relative Plate / Tube Displacements
Full Power (W/O Exp) to Hot Standby (With Exp)
Time = 0.

(Without Wedge Support)

Plate	Min	Max
A	-0.0377	0.0083
C	-0.0007	0.0248
F	-0.0196	0.0334
J	-0.2578	0.0516
L	-0.0023	0.1009
M	0.0304	0.0751
N	0.0448	0.0976
P	0.0618	0.1070

(With Wedge Support)

Plate	Min	Max
A	-0.0037	0.0070
C	-0.0004	0.0535
F	-0.0193	0.0333
J	0.0014	0.0468
L	-0.0024	0.1014
M	0.0303	0.0725
N	0.0446	0.0952
P	0.0617	0.1048

SLB Relative Plate / Tube Displacements
with Respect to Time = 0.

(Without Wedge Support)

Plate	Min	Max
A	-0.5904	0.0116
C	-0.0580	0.0286
F	-0.0786	0.0402
J	-0.0379	0.0404
L	-0.0206	0.0684
M	-0.0187	0.0692
N	-0.0196	0.0885
P	-0.0213	0.0961

(With Wedge Support)

Plate	Min	Max
A	-0.5603	0.0115
C	-0.0581	0.0288
F	-0.0788	0.0402
J	-0.0378	0.0404
L	-0.0205	0.0683
M	-0.0187	0.0692
N	-0.0196	0.0877
P	-0.0213	0.0958

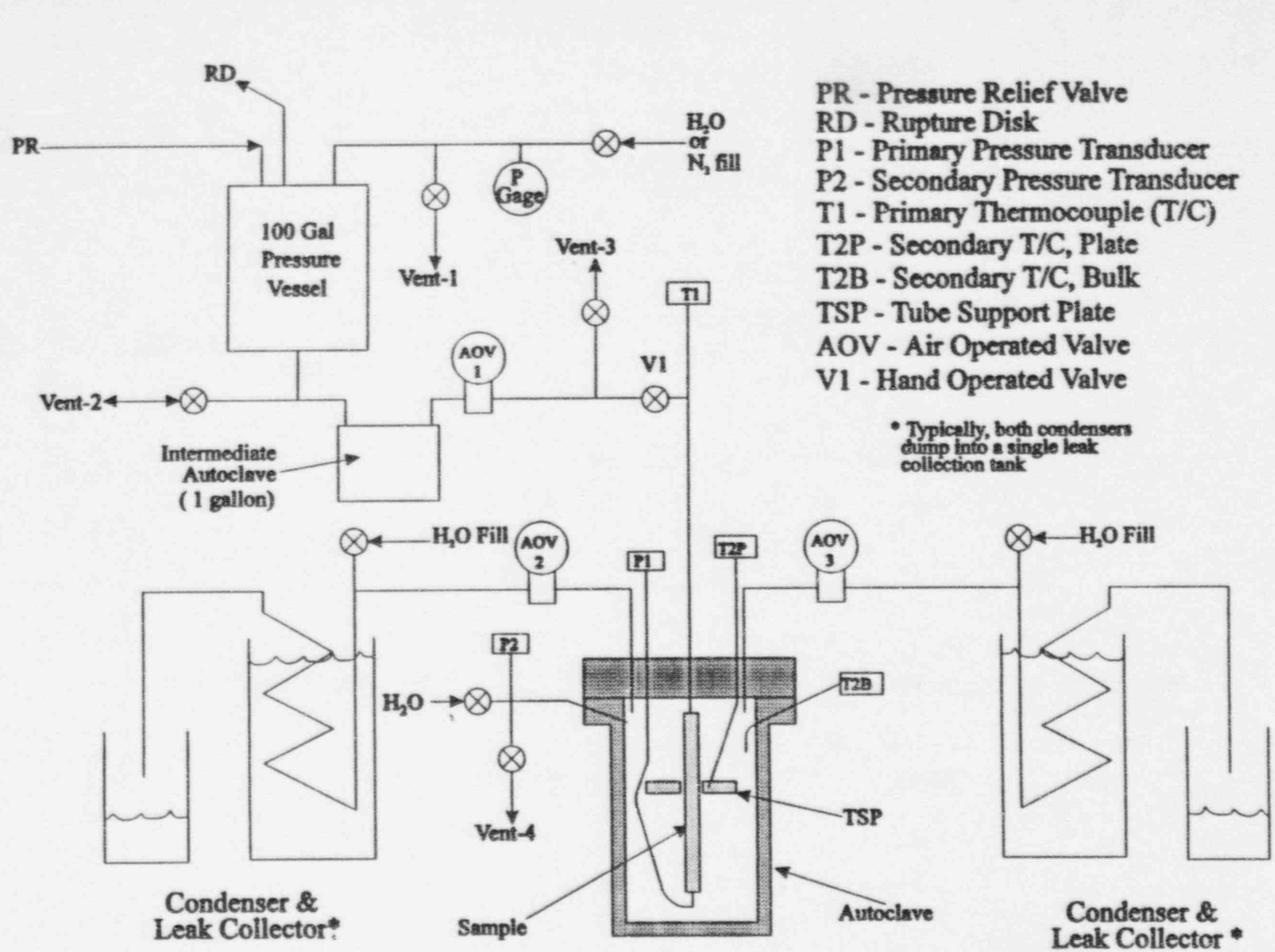
Combined SLB Displacement Results
(Developed from Location Dependent Data)

(Without Wedge Support)

Plate	Min	Max
A	-0.6280	0.0139
C	-0.0583	0.0431
F	-0.0974	0.0581
J	-0.2814	0.0662
L	-0.0193	0.1256
M	0.0147	0.1360
N	0.0251	0.1782
P	0.0528	0.2020

(With Wedge Support)

Plate	Min	Max
A	-0.5585	0.0139
C	-0.0585	0.0616
F	-0.0973	0.0580
J	-0.0290	0.0713
L	-0.0193	0.1261
M	0.0144	0.1303
N	0.0250	0.1742
P	0.0529	0.1986



Large Leak Test Facility Operating Schematic

Figure 61-1