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SOUTHERN COMPANY
Energy to Serve Your World℠

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U. S. Nuclear Regulatory Commission
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Washington, D. C. 20555-0001

Edwin I. Hatch Nuclear Plant
Measurement Uncertainty Recapture Power Uprate (MURPU)
Post MURPU Steam Dryer Performance Monitoring and Inspections

Ladies and Gentlemen:

By letter dated December 19, 2002, Southern Nuclear Operating Company (SNC) submitted to the NRC a license amendment request for the Edwin I. Hatch Nuclear Plant Units 1 and 2. The proposed amendment increases the authorized maximum power level for both units from the current limit of 2763 MWt to 2804 MWt. Although the requested power level is a 1.5% increase above the current maximum power level, it will represent a 15% increase above the original maximum power level.

Recently, the NRC identified issues in Information Notice 2002-26, Supplement 1 "Additional Failure of Steam Dryer After Recent Power Uprate," related to the potential generic implication of extended power uprates with respect to steam dryer failures. Hatch has been operating at extended power uprate (EPU) since 1999 for Unit 1 and 1998 for Unit 2. The EPU power level represents approximately 113.4% of the original power level.

By letter dated September 4, 2003 (NL-03-1798), SNC described actions in response to the impending revision of General Electric SIL-644. On September 5, 2003, General Electric Nuclear Energy issued SIL No. 644, Supplement 1 "BWR Steam Dryer Integrity." The commitments noted in the September 4, 2003, letter are superseded by compliance with SIL No. 644, Supplement 1.

This correspondence is to notify the NRC that SNC will implement GE SIL No. 644, Supplement 1, Recommended action 3 (BWR/4 and later steam dryer designs) as outlined in the services information letter provided by GE with respect to the Unit 1 and Unit 2 Steam Dryers at Plant Hatch. SIL No. 644, Supplement 1 is provided as an enclosure to this letter for your information.

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This letter contains no NRC commitments. If you have any questions, please advise.

Sincerely,

H. L. Sumner, Jr.

HLS/whc

Enclosures: Enclosure 1 – SIL No. 644 Supplement 1

cc: Southern Nuclear Operating Company
Mr. J. D. Woodard, Executive Vice President
Mr. G. R. Frederick, General Manager – Plant Hatch
Document Services RTYPE: CHA02.004

U. S. Nuclear Regulatory Commission
Mr. L. A. Reyes, Regional Administrator
Mr. S. D. Bloom, NRR Project Manager – Hatch
Mr. D. S. Simpkins, Senior Resident Inspector – Hatch

GE Nuclear Energy

SIL
Services Information Letter

BWR steam dryer integrity

SIL No. 644 Supplement 1

September 8, 2003

SIL No. 644 ("BWR/3 steam dryer failure"), issued August 21, 2002, described an event at a BWR/3 that involved the failure of a steam dryer cover plate and the generation of loose parts, some of which then migrated into a main steam line (MSL). The most probable cause of this event was identified as a flow regime instability that resulted in localized, high cycle high pressure loadings near the MSL nozzles. The high vibratory stresses from the pressure loading eventually resulted in the high cycle fatigue failure of the cover plate.

SIL No. 644, applicable only to plants with BWR/3-style steam dryers, included recommendations for monitoring moisture content and other reactor parameters, and for those plants operating at greater than the original licensed thermal power (OLTP), an inspection of the cover plates at the next refueling outage.

The purpose of this Supplement 1 to SIL No. 644 is to describe a second steam dryer failure that occurred at the same BWR/3 approximately one year following the initial steam dryer failure. The location of the failure (refer to Figure 1) and the root cause are different than the earlier failure. As a result, additional monitoring and inspections are recommended for all BWR plants that are operating, or plan to operate, at power levels greater than the OLTP. SIL 644 applied to BWR/3-style steam dryer design plants. This Supplement 1 to SIL No. 644 presents revised recommendations for plants with BWR/3-style steam dryers and provides recommendations applicable to plants with BWR/4 and later steam dryer designs.

Discussion

On April 16, 2003, with the plant operating at extended power uprate (EPU) conditions, an inadvertent opening of a pilot operated relief valve (PORV) occurred. The unit was shut down and the PORV replaced. On May 2, 2003, following return to EPU conditions, a greater than four-fold increase in the moisture content was measured. The moisture content continued to gradually increase until it exceeded a pre-determined threshold of 0.35% on May 28, 2003. The power level was reduced to pre-EPU conditions that resulted in a moisture content reduction to 0.2%. The moisture content remained steady at this value following the power reduction with no significant changes in other reactor operating parameters observed by the operators.

A detailed statistical evaluation of key plant parameters concluded that a subtle change in the MSL flows had occurred following the April 16, 2003 PORV event. Based on this information, concurrent with the moisture content increase, the utility elected to shut down the unit on June 10, 2003 and perform a steam dryer inspection.

Inspection results

Detailed visual inspection of the accessible external and internal areas of the steam dryer revealed significant steam dryer damage. The damage was most severe on the 90-degree side of the steam dryer, the side that was closest to the PORV that had opened. On the 90-degree side, a through-wall crack approximately 90 inches long and up to three inches wide was observed in the top of the outer hood cover plate and the top of the vertical hood plate (refer to Figure 2). Three internal braces in the outer hood were detached and one internal brace in the outer hood was severed. The detached braces were found on top of the steam separator. All detached parts were accounted for and retrieved. On the opposite side of the steam dryer (270-degree side), incipient cracking was observed on the inside of the outer hood cover plate and one vertical brace in the outer hood was cracked. No damage was found in the cover plates that had been replaced following the first steam dryer failure in 2002.

Three tie bars on top of the steam dryer connecting the steam dryer banks were also cracked. Tie bar cracking has been observed on several other steam dryers (including plants that have not implemented EPU); therefore, tie bar cracking is believed to be unrelated to the other damage noted above.

Root cause of steam dryer failure

Extensive metallurgical and analytical evaluations (e.g., detailed finite element analyses, flow induced vibration analyses, computational fluids dynamics analyses, 1/16th scale model testing and acoustic circuit analyses) concluded that the root cause of the steam dryer failure was high cycle fatigue resulting from low frequency pressure loading. There are two potential contributing factors to the failure:

1. Continued operation for approximately 1 month following the failed cover plate in 2002 which resulted in additional stress loading on the vertical hood plate, and
2. Inadvertent opening of the PORV resulting in a decompression wave which subjected the steam dryer to two to three times the normal pressure loading. (It is believed that there was incipient cracking in the steam dryer and the PORV event caused the cracks to open up).

The root cause identified in the first steam dryer failure was high cycle fatigue cause by high frequency pressure loading. The low frequency pressure loading was identified as the dominant cause in this failure. The low frequency pressure loading may have also been a significant contributing factor in the first failure.

Steam dryer modifications

The following repairs and pre-emptive modifications were made to both the 90 and 270-degree sides of the steam dryer:

1. replaced damaged ½ inch outer hood plates with 1 inch plates
2. removed the internal brackets that attached the internal braces to the outer hood
3. added gussets at the outer vertical hood plate and cover plate junction
4. added stiffeners to the vertical welds and horizontal welds on the outer hood

The combined effect of these modifications was to increase the natural frequency of the outer hood, reduce the maximum stress by at least a factor of two, and reduce the pressure loading by reducing the magnitude of vortices in the steam flow near the MSLs.

Following the steam dryer modifications, the unit was returned to service on June 29, 2003.

Generic Implications

There are two key attributes that determine the susceptibility of a particular plant to steam dryer degradation. The dominant attribute is the steam dryer configuration. There are three general types of steam dryer configurations (refer to Figure 3):

1. BWR/3-style steam dryers with a square hood and internal braces. This design results in maximum stresses where the internal braces attach to the outer hood. The crack initiation at the BWR/3 occurred at this high stress location. Higher stresses result in a greater susceptibility of the components to crack initiation. Some BWR/3-style steam dryers do not incorporate the internal braces. This design eliminates the stress concentration associated with the brace attachment.

BWR/2-style dryers also have a square hood; however, the internal configuration of the dryer banks and hood support is different from the BWR/3-style dryers.

2. BWR/4-style steam dryers that have slanted hoods. This design replaced the internal braces with internal plates that substantially reduced the maximum calculated stresses.

3. BWR/5 and later steam dryer designs that incorporated curved hoods to optimize the steam flow. This design retained the internal plates, further reducing the maximum calculated stresses.

The second attribute is the maximum MSL steam velocity. The BWR/3 unit that experienced the steam dryer damage has small (20 inch diameter) MSLs and consequently the highest steam velocities at EPU conditions of any BWR. Higher MSL steam velocity increases the amplitude of flow induced and acoustic load forcing functions that lead to high cycle fatigue.

Using these two attributes, a screening matrix was developed for all BWRs. An assessment of the screening matrix results supports the conclusion that the BWR/3-style steam dryer is most susceptible to steam dryer damage. This assessment concluded that other steam dryer designs are substantially less susceptible to steam dryer damage when compared to the BWR/3 unit that experienced the steam dryer failure. Consequently, no significant steam dryer damage is expected for BWR/4 and later steam dryer designs, even at EPU conditions. No BWR/2 has been evaluated for EPU conditions to date.

Recommended action:

GE Nuclear Energy recommends that owners of GE BWRs consider the following if currently operating, or planning to operate, above the OLTP:

1. BWR/3-style steam dryers with internal braces in the outer hood:

a. Review available visual inspection records to determine if there are any pre-existing flaws or undersized welds in the cover plate and outer hood locations.

b. Measure moisture content, as determined by Na-24 measurements in the reactor water and condenser hotwell, to establish a baseline value for operation near maximum core thermal power operating conditions. Measure and record the moisture content to a resolution of 0.1% or smaller. Isolate (or account for) flow through paths where reactor water can flow directly to the hotwell (e.g., reactor water cleanup reject flow, sample lines).

   Establish reactor pressure, water level, steam flow, and feedwater flow values consistent with the baseline moisture content values. Moisture content can change during the operating cycle due to changes in core power, core flow, or core radial peaking.

c. Monitor reactor pressure, water level, individual steamline flow, and feedwater flow on a daily basis for significant anomalies (such as step changes in indicated values) that may indicate a steam dryer failure. Monitor and compare indications on each instrument reference leg; a dryer failure near the reference leg tap may affect the indications for the sensors on that reference leg. The step changes that were observed during the 2002 cover plate failure were usually small (2-3 psi for reactor pressure, ~two inches for reactor level, ~5% for steamline flow); therefore, trend plots of the data will be useful for performing the recommended monitoring.

d. Implement a moisture content monitoring program that measures moisture content at least once per week. If a significant change or a steadily increasing trend is observed, monitor moisture content daily and evaluate recent plant maneuvers or events and associated plant parameters to identify the cause of the increased moisture content. If the cause of the increased moisture content cannot be determined, consider a reduction in power or an orderly plant shutdown for inspection.

   The moisture content action level for initiating the increased monitoring and evaluations must be determined from the observed baseline values and normal variations. For example, an observed moisture carryover of 0.2% would be a significant change for an efficient dryer (normal moisture carryover of ~0.05%). For a plant that operates with high moisture levels, an observed moisture carryover 0.1% higher than the normal range would be significant.

   Following a transient event that may result in pressure loading of the steam dryer (relief valve opening, turbine stop valve closure, etc.), monitor moisture content daily until the structural integrity of the dryer is confirmed. Once it has been established that the dryer has sustained no damage, routine monitoring may be resumed.

e. Perform a visual inspection ("best effort" VT-1) of the steam dryer at the next scheduled refueling outage. This inspection should include the most susceptible locations as determined by a dryer stress analysis (refer to Figure 4). This inspection should include both an external and internal inspection of the accessible areas. Remove trapped bubbles to ensure complete coverage of internal areas.

f. Repeat the visual inspection in 1.e at subsequent refueling outages.

Note: The recommendations above supercede the recommendations in SIL No. 644 for BWR/3-style steam dryers.

2. BWR/3-style steam dryers with no internal braces in the outer hood:

   a. Implement recommendations 1.a, 1.b and 1.c.

   b. Implement a moisture content monitoring program that measures moisture content at least once every two (2) weeks when operating above the OLTP. If a significant change or a steadily increasing trend is observed, evaluate recent plant maneuvers or events and associated plant parameters to identify the cause of the increased moisture content. If the cause of the increased moisture content cannot be determined, consider a reduction in power or an orderly plant shutdown for inspection.

      The moisture content action level for initiating the increased monitoring and evaluations must be determined from the observed baseline values and normal variations. For example, an observed moisture carryover of 0.2% would be a significant change for an efficient dryer (normal moisture carryover of ~0.05%). For a plant that operates with high moisture levels, an observed moisture carryover 0.1% higher than the normal range would be significant.

      Following a transient event that may result in pressure loading of the steam dryer (relief valve opening, turbine stop valve closure, etc.), monitor moisture content daily until the structural integrity of the dryer is confirmed. Once it has been established that the dryer has sustained no damage, routine monitoring may be resumed.

c. Perform a visual inspection ("best effort" VT-1) at the outage prior to initial operation above the OLTP or at the next scheduled refueling outage if already operating above the OLTP. This inspection should include the most susceptible locations as determined by a dryer stress analysis (refer to Figure 5). This inspection can be limited to an external inspection of the most susceptible locations.

d. Repeat the visual inspection in 2.c at every other refueling outage.

3. BWR/4 and later steam dryer designs:

a. Implement recommendations 1.a, 1.b and 1.c.

b. Implement recommendation 2.b. However, the moisture content monitoring frequency can be relaxed to once per month.

c. Perform a visual inspection ("best effort" VT-1) prior to initial operation above the OLTP or within the next two scheduled refueling outages if already operating above the OLTP. This inspection should include the most susceptible locations as determined by a dryer stress analysis (refer to Figures 6 and 7), including the vertical rib areas on each of the outer hoods and the end plates on the two outermost banks. This inspection can be limited to an external inspection of the most susceptible locations.

d. Repeat the visual inspections in 3.c at every other refueling outage.

Note: These inspection recommendations do not supercede existing utility program requirements or other inspections recommended as a result of industry operating experience.

To receive additional information on this subject or for assistance in implementing a recommendation, please contact your local GE Nuclear Energy Service Representative.

This SIL pertains only to GE BWRs. The conditions under which GE Nuclear Energy issues SILs are stated in SIL No. 001 Revision 6, the provisions of which are incorporated into this SIL by reference.

Product reference

B11 — Reactor Assembly
B13 — Reactor System

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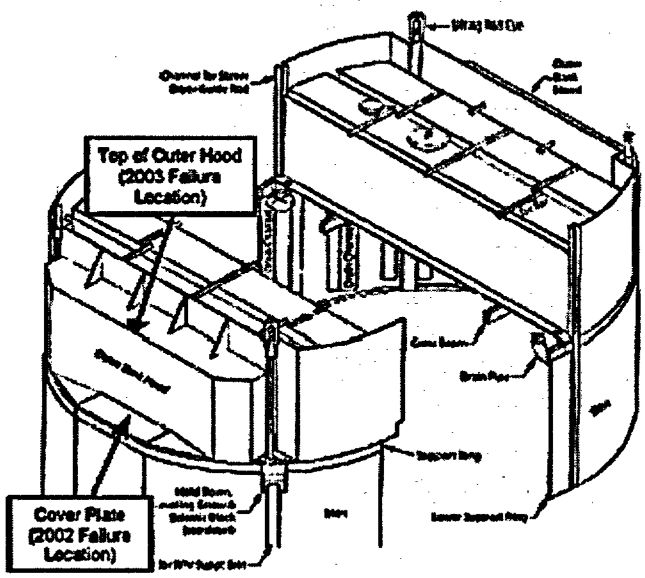

Figure 1 — Steam Dryer Failure Locations, 2002 and 2003

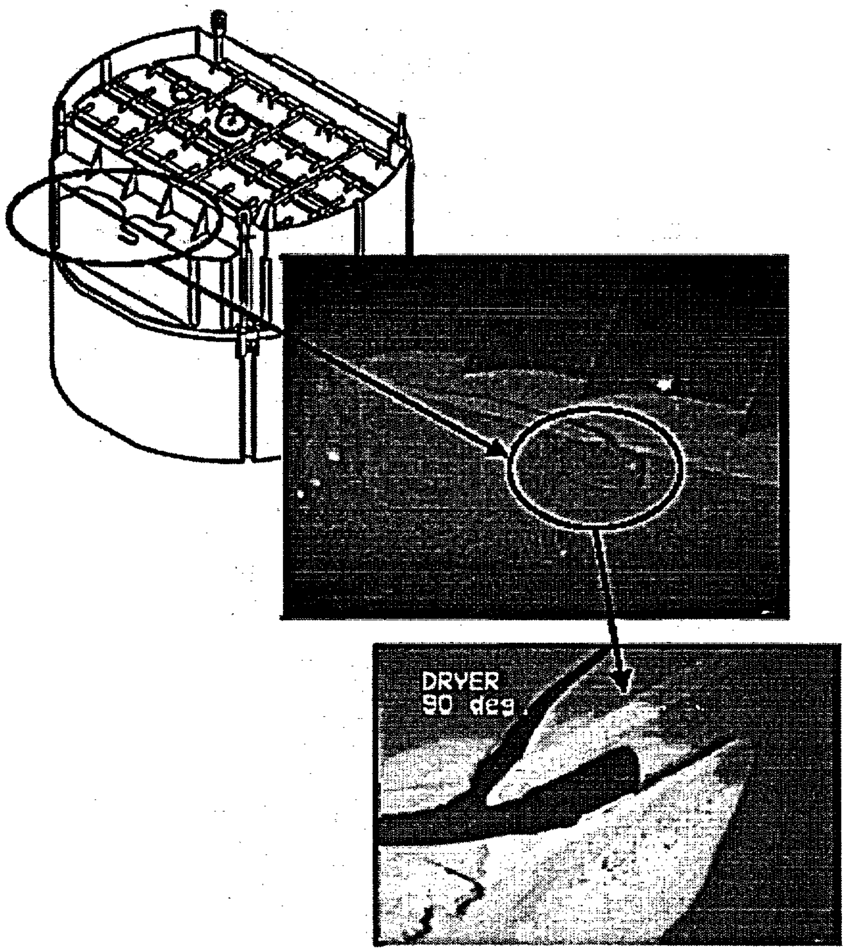

Figure 2 — Steam Dryer Damage 90 Degree Side

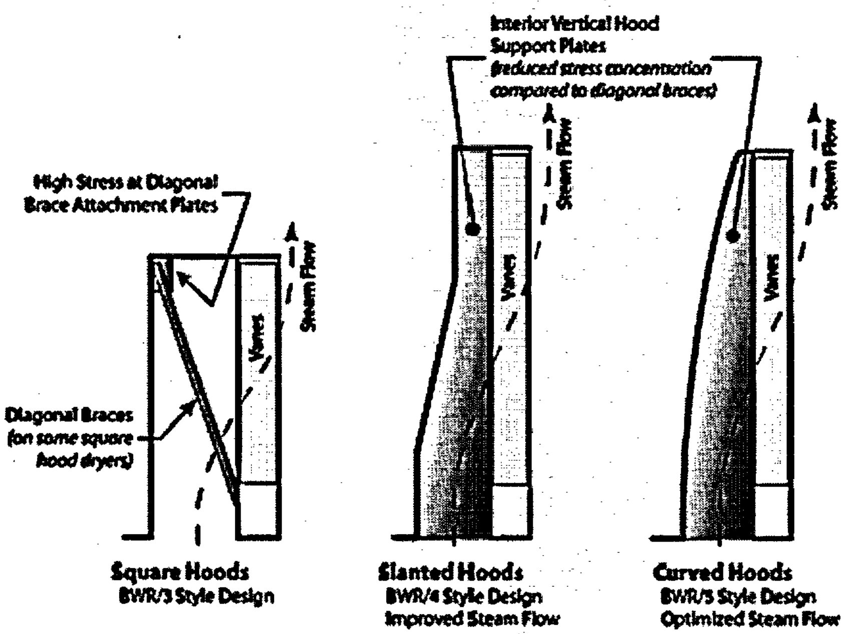

Figure 3 — Steam Dryer Hood Configurations

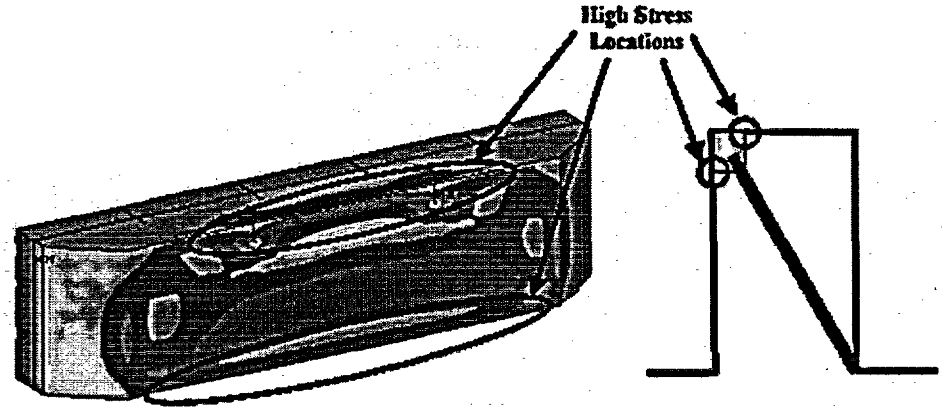

Figure 4 — High Stress Locations
Square Hood with Braces

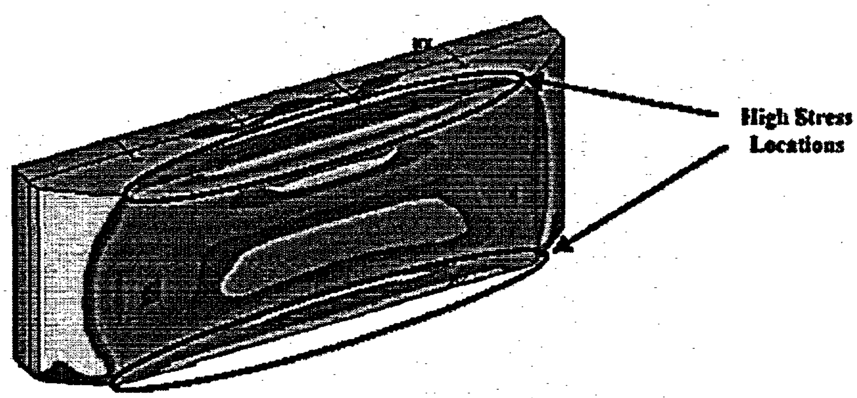

Figure 5 — High Stress Locations
Square Hood without Braces

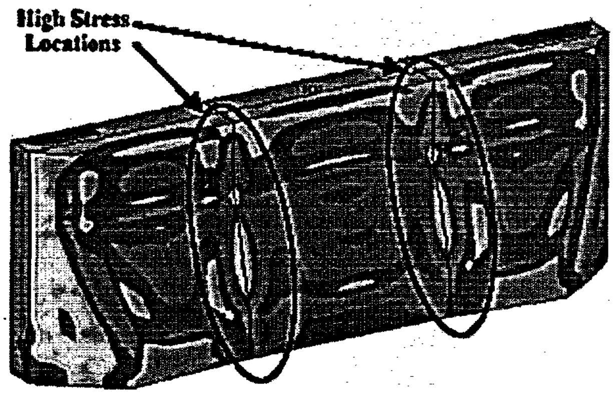

Figure 6 — High Stress Locations
Slanted Hood

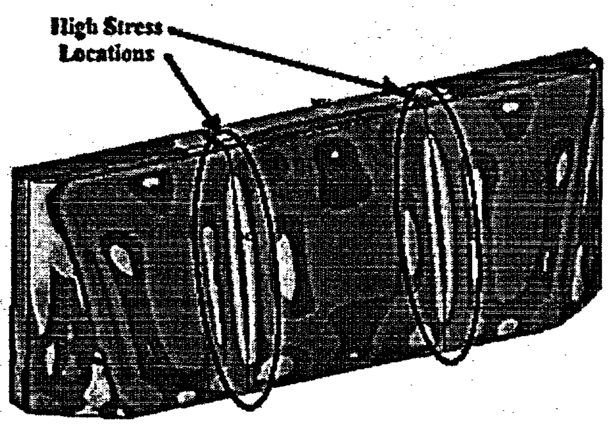

Figure 7 — High Stress Locations
Curved Hood