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Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Attention: Mr. J. J. Hayes, Jr.

SUBJECT: Virgil C. Summer Nuclear Station
Docket No. 50/395
Operating License No. NPF-12
L* Tube Plugging Criteria

Gentlemen:

In a submittal dated August 1, 1988, South Carolina Electric & Gas Company (SCE&G) requested an amendment to the Virgil C. Summer Nuclear Station Technical Specifications to incorporate an alternative tube plugging criterion designated L*. On October 25, 1988, a telephone conference was held between NRC and SCE&G staff personnel to discuss some of the technical aspects of the requested change. As a result of that discussion, SCE&G was requested to provide additional technical information in several areas. The enclosed attachments to this submittal provide the requested additional information.

A meeting with NRC personnel to review the technical details of the L* criterion is offered. If such a meeting would be deemed beneficial by members of your staff, please contact Mr. A. R. Koon (phone number - [803] 345-4204) of my staff to make formal arrangements.

If you should have any additional questions, please advise.

Very truly yours,

O S Bradham

O. S. Bradham

AMM/OSB:grs
Attachment

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ATTACHMENT 1

EDDY CURRENT TESTING (ECT) UNCERTAINTY

Application of the L* plugging criteria to a steam generator with full depth mechanical expansion involves establishing, within approximately 2.5 inches of the bottom of the roll transition (BRT), axial length(s) of cracked tubing interspersed with length(s) of sound roll expansion. The measurement uncertainties associated with establishing the required location and length parameters using 0.125 inch diameter rotating pancake coil (RPC) probes has been evaluated. The evaluation has determined the following:

- The probable error in the location of each individual crack-tip was estimated by laboratory measurement to be ± 0.030 inch.
- For the case of crack bands separated axially by distance > 1/16 inch, the uncertainty in length is given by the square root of $(0.030^2 + 0.030^2)$.
- The uncertainty in the location of the BRT using 0.125 inch coil RPC is ± 0.030 inch. The uncertainty in visually locating the BRT is ± 0.040 inch. Combination of the uncertainties associated with the estimated distance between the BRT and the start or end of a crack or crack band is calculated thusly:

Feature	Uncertainty Relative to Datum on ECT Screen, Inch
BRT (Lab)	± 0.040
BRT (Field)	± 0.030
Crack Tip (Top or Bottom)	± 0.030

Combination	Uncertainty, Inch
Crack Length	$\sqrt{0.030^2 + 0.030^2} = \pm 0.040$
BRT-to-Any Crack Band Top or Bottom	$\sqrt{0.040^2 + 0.030^2 + 0.030^2}$ $= \pm 0.058 = \pm 0.060$

It is intended that the uncertainties be applied to the sound roll lengths only. Unnecessary overlapping of uncertainties would occur if the same uncertainties were applied to both the sound roll band lengths and the cracks. In addition, due to the variable bias inherent in the ECT technique, supplemental "overestimates" of the crack lengths are present but not included in the error analysis.

These factors help to ensure that the cracks identified by ECT in tubes being considered for L* criterion incorporation are well within the acceptance criteria as documented in WCAP-11857.

Attachment 2

The Relationship of

L* to F*

The F* and L* criterion are based on a pullout load reaction length of tube such that the existence of sufficient friction is developed between the tube and tubesheet to prevent tube pullout under normal and design basis accident conditions. The same assumptions and calculational inputs for determining the friction between the tube and tubesheet that were utilized in the development of F* were also used for the evolution of L*. While the same F* friction methodology was utilized by L*, the L* criterion allows the frictional forces to be accumulated over bands of sound roll expanded tube that are separated by bands of defected tubing as opposed to one full, unbroken length at the very top of the tubesheet.

The unique aspects of L* which differ from F* are relative to leak rate and crack orientation. The assumptions and calculational inputs in these two areas were derived to support L* solely and were not necessary for the utilization of F*. WCAP-11857 was developed to detail these L* specific parameters and contains the test results and calculations necessary to support the L* criterion. As noted above, and in WCAP-11857, L* is fundamentally based on the principals of F* and differs technically only in the areas of leak rate and crack orientation.

Attachment 3

Crack Length and Growth Rate

Until the recent development and domestic acceptance of alternative tube plugging criteria for primary water stress corrosion cracking (such as F*), all tubes exhibiting greater than 40% thru wall indications were plugged. For this reason, growth rate data from cycle-to-cycle is essentially nonexistent for domestic utilities. However, several foreign utilities have utilized a "critical crack length" approach to steam generator plugging for several years, and therefore, some data exists on cracks in inservice tubes.

SCE&G has obtained information from a foreign plant which has roll transitions similar to those at the Virgil C. Summer Nuclear Station. Because the rolls at the plant are deep within the tubesheet and cannot burst due to the restraining effect of the tubesheet, cycle-to-cycle growth rates were not tracked and are not available. However, subsequent to ten years of operation, tubes were removed from these generators and metallographic examinations of the tubes were performed. The results of these examinations indicated that the maximum length of cracks after 10 years of operation was 14 mm (or 0.55 inch).

The F* criterion has been utilized at two refueling outages at the Virgil C. Summer Nuclear Station. The eddy current data on tubes left in service utilizing the F* criteria shows the character of the signal to be virtually unchanged from cycle-to-cycle. Therefore, data indicates that the crack has not changed measurably over the cycle. To date, all tubes left in service utilizing the F* criteria continued to meet the criteria after one cycle of operation (approximately 18 months).

Currently it is hypothesized that cracking itself relieves residual stresses. In addition, as a crack appears and propagates into an area of reduced tensile stress, continued propagation is prevented. The data available to date, both foreign and domestic, appears to support this hypothesis.

The experimental and calculational basis to support the proposed L* distance of 0.56 inch, combined with the foreign data on crack length not exceeding 0.55 inch, provides the assurance that unacceptable crack growth will not occur between inspections. Experimental evidence completed to date will actually support a much smaller L* distance; however, until additional supporting experimentation can be accomplished, the conservative 0.56 inch distance has been chosen. Considering all the conservatisms included in the development of the proposed L* criteria, no additional allowance for crack growth was necessary.

NRC Bulletin 88-02, "Rapidly Propagating Fatigue Cracks in Steam Generators," discusses cracking that results from support plate denting. Implementation of the L* criterion would have no impact on the issue discussed in NRCB 88-02. The L* criterion addresses cracking in the tubesheet region resulting from primary (pure) water stress corrosion cracking and is therefore not applicable to the issue of fatigue induced crack failure.

Attachment 4

Calculation of L* Distance

Several factors exist which are variables in the determination of the L* distance. These factors include operating conditions (normal or accident), total number of degraded roll expansion tubes considered, the allocation fraction (or assumed leakage per steam generator), and the L* distance itself. By choosing values for the allocation fraction and number of potentially affected tubes, a specific maximum flow rate (overall leakage rate of m_{max}) is determined for a specific operating condition. Under test conditions, leakage flow rates (m_{test}) from degraded tubes are determined. This testing provides data on flow rates as a function of crack distance (X) from the end of the roll expansion. For the various X distances, the resulting m_{test} is compared to the m_{max}. If m_{test} is less than or equal to m_{max} for a value of X, that X distance is an acceptable L* value. If m_{test} is greater than m_{max}, that particular X value is an unacceptable L* value and either 1)a longer X is needed, or 2) a lower number of affected tubes and/or a higher allocation fraction must be assumed.