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ACCESSION NBR: 8708250220 DOC. DATE: 87/08/21 NOTARIZED: NO DOCKET #
FACIL: 50-389 St. Lucie Plant, Unit 2, Florida Power & Light Co. 05000389
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SUBJECT: Forwards written explanation of plans for insp of steam generators, specifically plans for tubes in batwing area. Supporting documentation encl.

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AUGUST 2 1 1987

L-87-351

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

Gentlemen:

Re: St. Lucie Unit 2
Docket No. 50-389
Steam Generator Inspection Plan

St. Lucie Unit 2 will shutdown for a refueling outage in early October 1987. During this refueling outage, Florida Power & Light Company (FPL) will be conducting an inspection of both steam generators as required by St. Lucie Unit 2 Technical Specification 3.4.5. On August 4, 1987, FPL discussed with the NRC Staff the plans for the inspection of the steam generators, specifically, the plans for inspection of the tubes in the "batwing" area. The staff requested that FPL provide a written explanation of the plans for these inspections.

Attached is the requested explanation. If further discussions are required on this topic, please contact us.

Very truly yours,

C. O. Woody
Group Vice President
Nuclear Energy

COW/MSD/gp

Attachment

cc: Dr. J. Nelson Grace, Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, St. Lucie Plant

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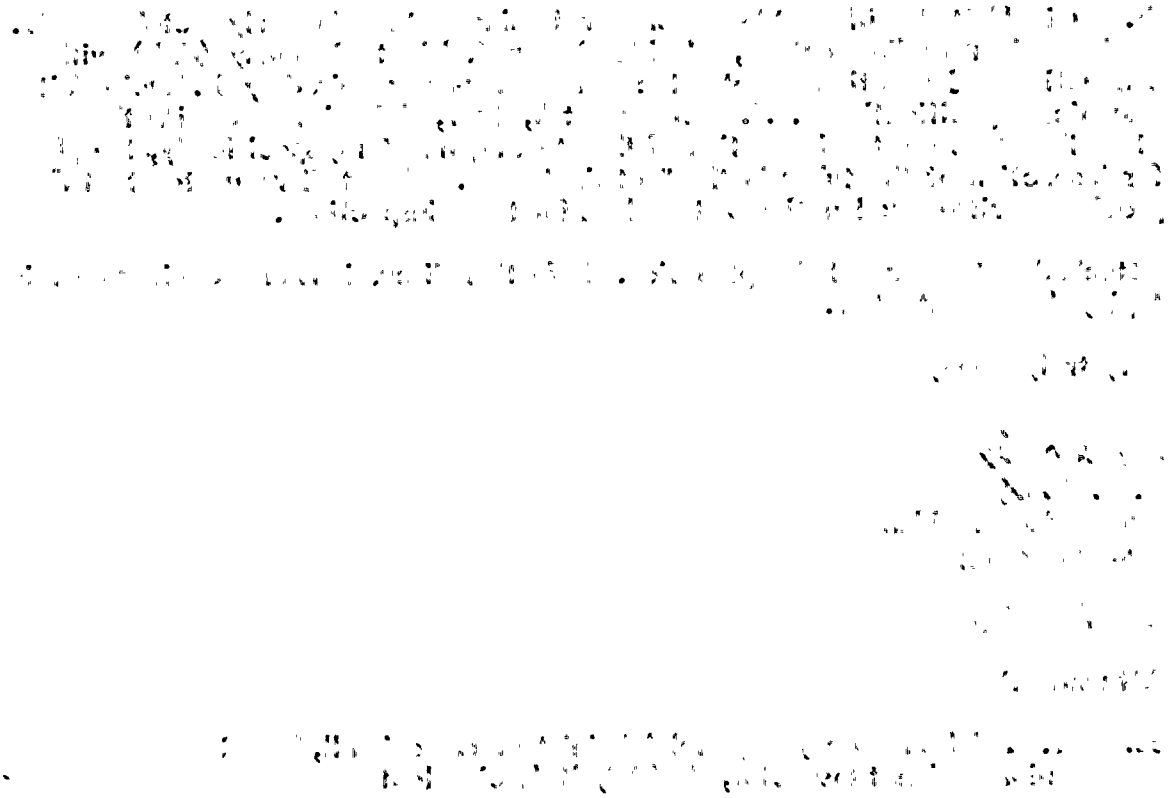
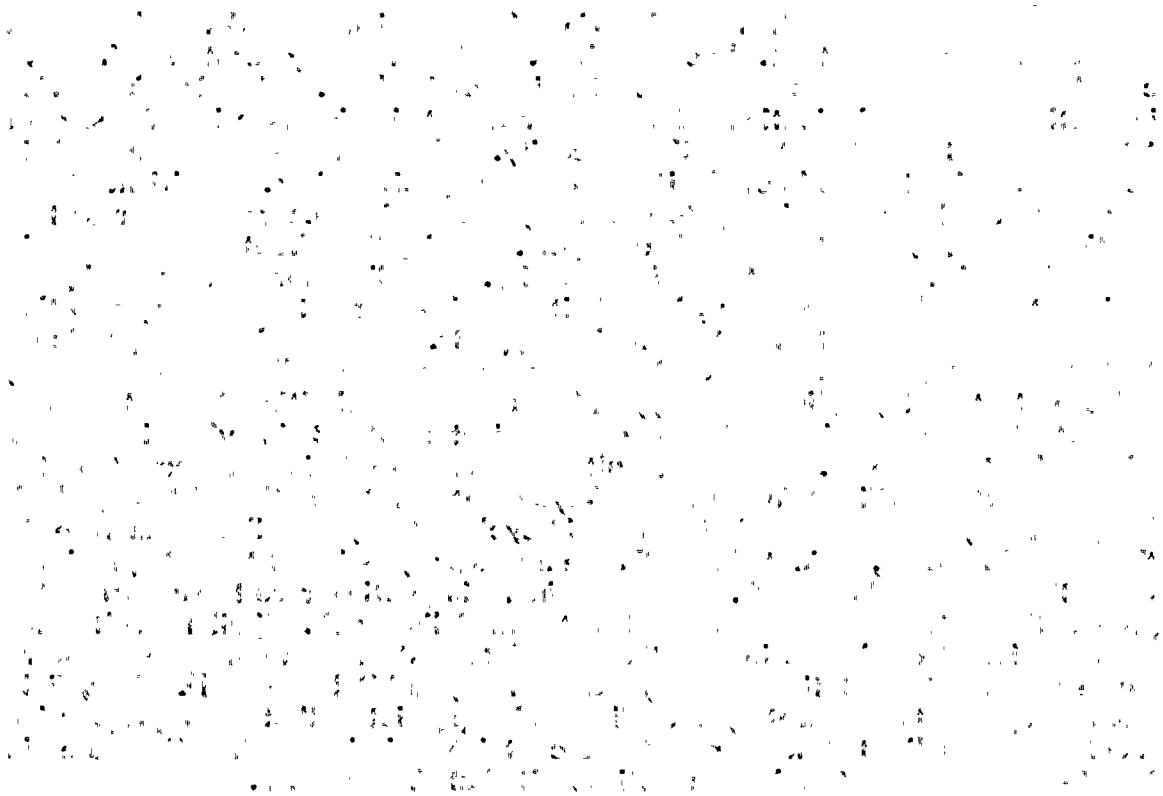


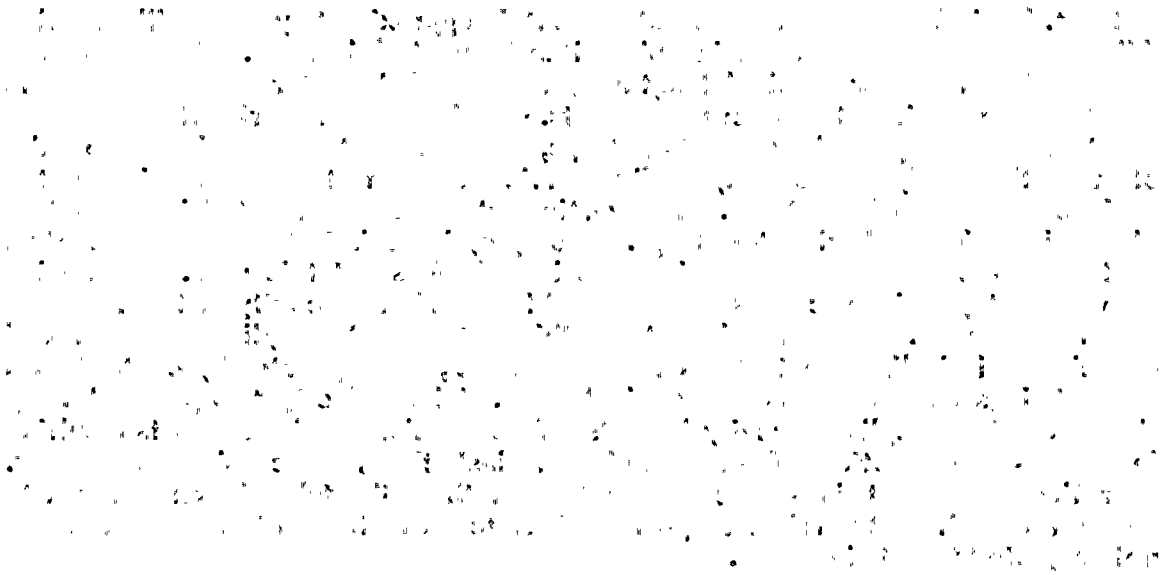
ATTACHMENT

There are two Combustion Engineering (CE) designed Model 3410 steam generators installed at St. Lucie Unit 2. The steam generators will have completed three fuel cycles of operation in October1987. The first in-service inspection produced indications of tube wear at batwing intersections for several tubes adjacent to the stay cylinder cavity. These tubes were plugged in accordance with the St. Lucie Unit 2 Technical Specifications. Additional tubes were plugged due to a primary to secondary leak which occurred as a result of continued wear during the second fuel cycle. Again, the affected tubes were in the region adjacent to the stay cylinder cavity. Modeling work performed by CE defined the problem to be wear, in a limited region of the tube bundle, resulting from out-of-plane vibration of the batwing supports. The modeling work predicted that the wear phenomenon should be restricted to a small number of tubes, adjacent to the stay cylinder cavity, and should be self-limiting due to the angle of contact of the batwing on the tube and reduction of batwing vibration deeper within the tube bundle. The CE results were used to define the extent of the plugging pattern utilized during the mid-cycle outage. Inspection of tubes, which had previously been plugged during the mid-cycle outage, as well as other tubes in the area of concern, indicated that the wear was progressing at the rate predicted from the CE modeling work. The remaining inspection results supported the propagation pattern developed as part of the modeling work. Similar results have been obtained from inspection of other Model 3410 steam generators (San Onofre Nuclear Generating Station 2 and 3, Waterford 3, and Palo Verde 1). Thus, field results support the laboratory modeling which predicted that wear progression should affect a limited number of tubes contained within a well defined area in the steam generator at their intersections with batwing supports.

STEAM GENERATOR DESIGN

Both St. Lucie Unit 2 steam generators contain approximately 8200 mill annealed Alloy 600 tubes arrayed in a triangular pitch U bundle (Figure 1). These tubes are supported along their vertical lengths by seven full diameter eggcrate supports and two partial diameter eggcrate supports. The U-bend and horizontal lengths of the tubes are supported by batwing straps, which cross the tubes just below the start of the bend, and as many as five vertical support straps (depending on the horizontal length of the tube). The vertical straps are connected in the out of plane dimension by horizontal straps. A stay cylinder is installed at the central portion of the tubesheet to permit reduction of tubesheet thickness. The region above the stay cylinder cannot be tubed and forms a hollow cavity at the center of the tube bundle. Tubes adjacent to this untubed stay cylinder region and contained within lines 65 to 103 and rows 1 to 59, are supported by contact with the batwings and as few as one vertical strap. High velocity two phase flow up the untubed stay cylinder cavity imparts a force on the batwing supports resulting in out-of-plane motion of the batwing against the tube causing tube wear. Vibration of the batwings ceases when the length of the tubes is long enough to encounter additional vertical supports. Thus, tubes further out in the bundle are not subjected to batwing wear.





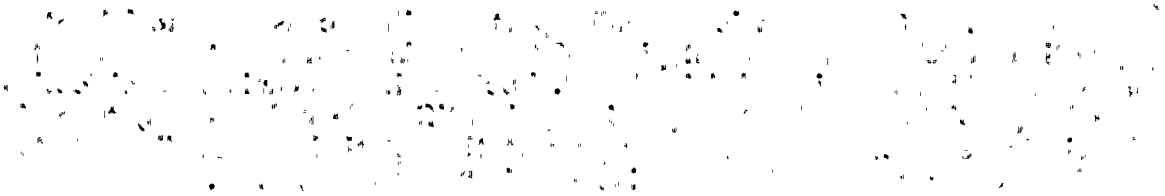
MODELING

The St. Lucie Unit 2 steam generators were modeled using two phase flow tests, fatique tests and vibration tests to predict the extent of tubes affected by the batwing vibration. Results of these tests were used to develop a computer model capable of predicting the extent and rate of wear for affected tubes. The model has received minor updates incorporating results of field inspections. The modeling work predicted that the wear phenomenon should proceed at a reduced rate of attack due to an increased area of contact between the tube and batwing as the wear progresses. Thus, the depth and rate of penetration should be self-limiting. Additionally, the affected tubes were contained within a relatively narrow area adjacent to the stay cylinder cavity (Figure 2). During the second refueling outage inspection of the St. Lucie Unit 2 steam generators, model predictions were checked by inspection of all tubes in the affected area including 29 tubes which had been plugged during previous outages. The 29 tubes were deplugged, inspected and replugged following inspection. The inspection results were in good agreement with the model predictions. Thus, laboratory testing and modeling were confirmed by the field inspections.

PROPOSED INSPECTION PATTERN

The tubes within the projected batwing wear region are as deep as row 59 in from the stay cylinder (Figure 3). Previous inspections resulted in plugging of 200 tubes in the A steam generator and 145 tubes in the B steam generator: conservative plugging limits were used in the affected region ($<40\%$ throughwall). The proposed inspection pattern will include all unplugged tubes within the projected 40% wear region, as noted on Figure 3, with a minimum of two rows of indication free tubes at the periphery of the inspection pattern. All pluggable indications within this pattern will be geometrically bounded by inspection of two tube rows beyond the pluggable indications. Thus, the affected region of tubes will be geometrically bounded by an inspection pattern with at least two rows of indication-free tubes at the periphery of the pattern. Similar bounding patterns have been used in other steam generators for corrosion and wear indication which were associated with geometric design features. This geometric approach will effectively monitor progression of batwing wear and will provide additional verification of the wear model for future inspections.

The results from the geometrical bounding pattern will be considered to fall into a population of tubes which are atypical of the remainder of the steam generator tubes and will not be included in the St. Lucie Unit 2 Technical Specification S^1 tube population. All other previously identified degraded tubes, tubes in historically suspect areas and a representative statistical sampling of the remainder of the tube bundle will be included in the S^1 tube sample.



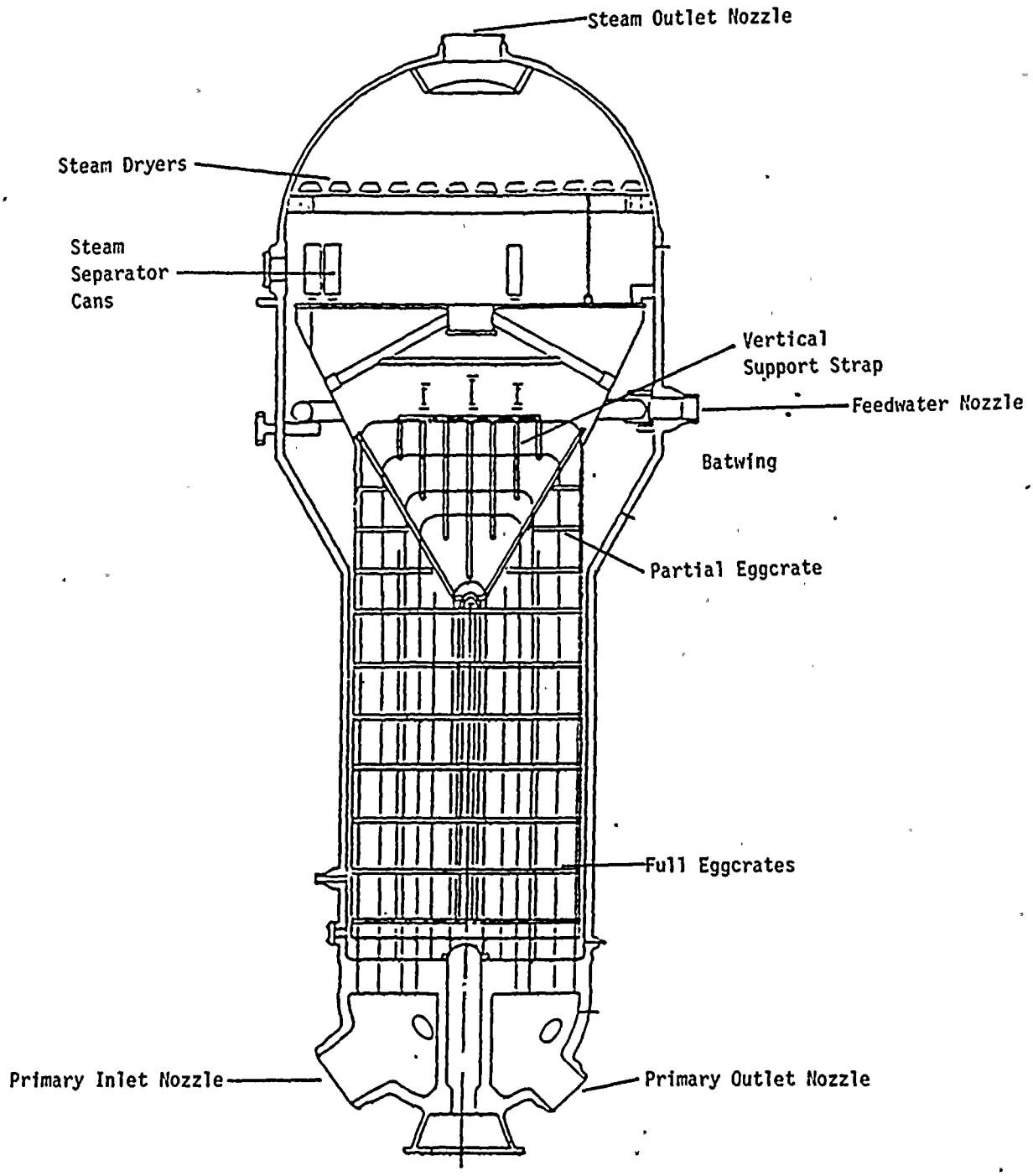


Figure 1. St. Lucie 2 Steam Generator

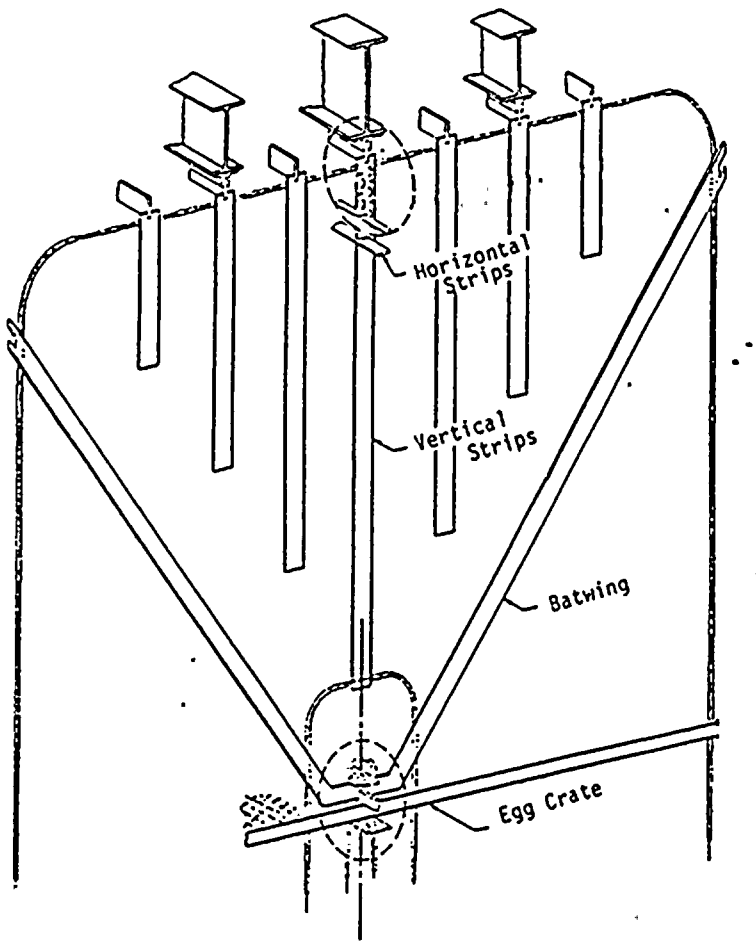


Figure 2. Upper Support Structure

St. Lucie 2 Steam Generator

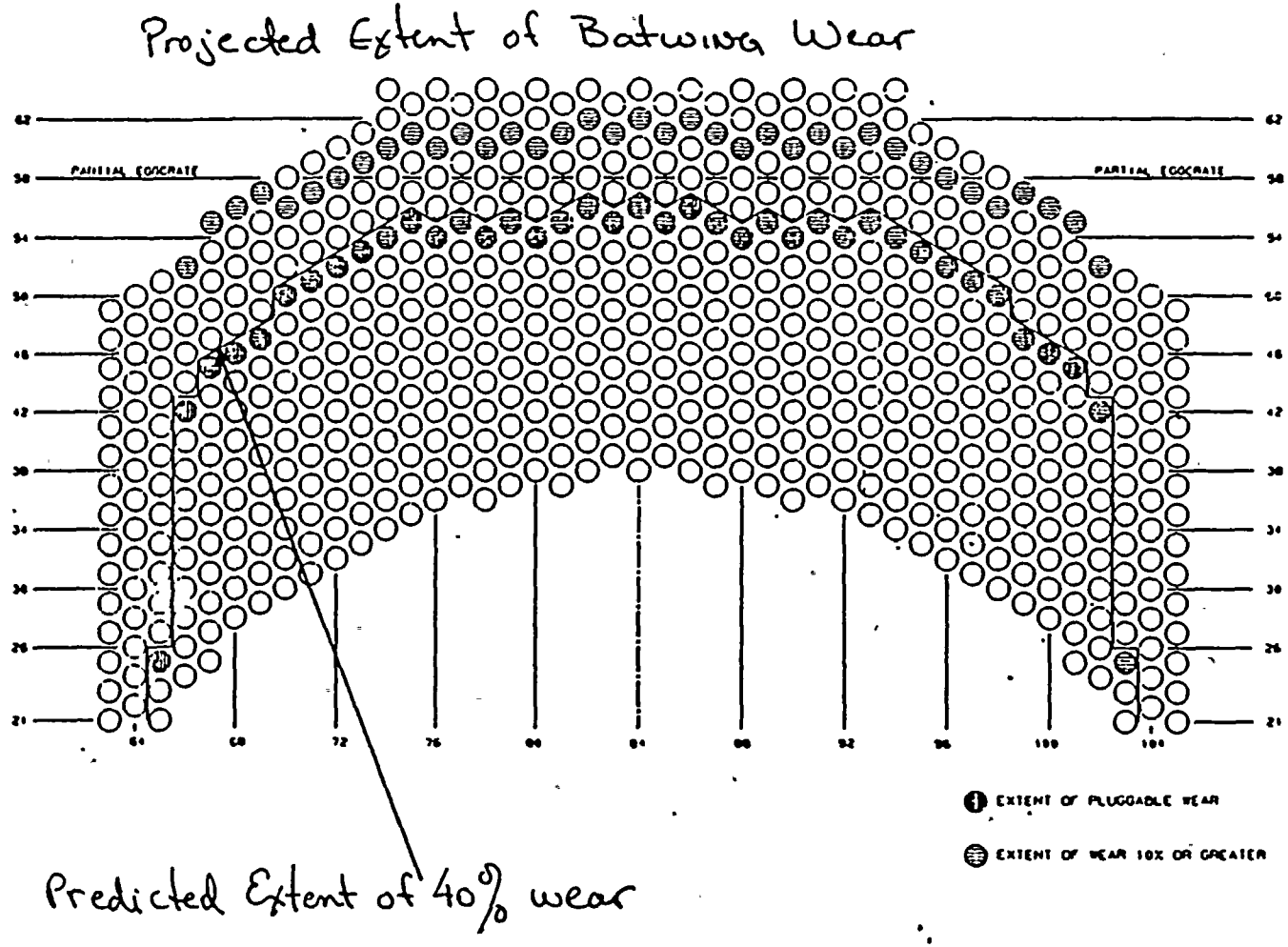


Figure 3. Predicted Extent of Batwing Wear

for 40-Year Life of Steam Generator