WBN U2 STEAM GENERATOR FOSAR

FROM MANUFACTURE AND MODIFICATIONS TO READINESS FOR OPERATION - OVER 35 YEARS

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SPECIAL THANKS TO EDWARD J. HYP VISTAS CORPORATION
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UNIT 2 WAS 80% COMPLETED BUT START UP WAS HALTED FOR OVER 20 YEARS
WATTS BAR UNIT 2

STEAM GENERATOR HISTORY

IN 2007 20% S/G EDDY CURRENT AND THE 1ST SECONDARY SIDE VISUAL INSPECTIONS WERE PERFORMED.

THE 1ST SECONDARY SIDE REMOTE VISUAL INSPECTIONS FOUND A LARGE AMOUNT OF LOOSE FOREIGN MATERIAL IN THE ANNULUS REGION OF EACH S/G TUBE SHEET. THIS FOREIGN MATERIAL RANDED FROM GLOVES, ROPE, PAPER AND TAPE, TO AN 8.0” HIGH CLUSTER OF MACHINE CURLS WHICH REACHED FROM THE TUBE SHEET TO THE TOP OF THE 1ST TSP AND ANOTHER CLUSTER IN THE WRAPPER TO SHELL SPACE.
WBN 2
PREPARATION FOR OPERATION

IN FEBRUARY 2010, WESTINGHOUSE DID 100% ECT OF THE 4674 ¾” TUBES IN EACH OF THE 4 S/GS AND IDENTIFIED A TOTAL OF 244 POSSIBLE LOOSE PARTS.

WESTINGHOUSE PERFORMED S/L AND FOSAR AS THE N STAMP CONSTRUCTION VENDOR

S/L AMOUNTS:
S61 47.5 LB
S62 57.0 LB
S63 39.0 LB
S64 31.5 LB

- THE ORIGINAL FOSAR VENDOR REDUCED THE PLP COUNT TO 149, BUT WERE UNABLE TO ACCESS THESE REMAINING PLP LOCATIONS.
- TVA CONTRACTED VISTAS TO PERFORM FOSAR ON ALL FOUR STEAM GENERATOR TUBE SHEETS, INCLUDING THE WRAPPER AND THE SHELL DIRECTLY ABOVE THE TUBE SHEET AND ONE 2.6” UPPER PENETRATION.
Fosar Challenges and Evolution

- Each phase of the Fosar led to >20 new objects not seen by ECT.
- Some foreign material retrieved was larger than the size of the 2.0” port.
- Performed 360 degree inspections between the wrapper/shell and wrapper/bundle space.
- The wrapper to TSP spacing varied from ¼” to ¾” depending on location.

Began another phase of inspection and retrievals until the initial remaining 149 PLPs were either retrieved or dispositioned.

Breaking up pieces inside the S/G for individual removal.

Developed special articulating 25FT guide tubes and 30FT retrieval tools to access remote areas within the generators.

Specific tooling utilizing a 36’ articulating video probe with custom long range 36’ retrieval tools.

A gauge was developed onsite to pre-check foreign object exit paths.
S/G 2, BETWEEN THE WRAPPER AND SHELL A 48” LONG X 3” WIDE X 1/32” THICK PIECE OF SHEET METAL WAS FOUND. IT WAS RETRIEVED THROUGH THE 6.0” HH WITH A SNARE DEVICE AND HEAVY DUTY GRIPPERS.
IN S/G 3 AND 4 H/L, ON THE TUBE SHEET WERE MOUNDS OF SOLIDIFIED FERROUS DIRT THEY MEASURED 2” HIGH X 6” LONG AND 2” HIGH X 14” LONG

A CUSTOM TOOL WAS DESIGNED ONSITE TO BREAK UP DEBRIS, REVEALING EMBEDDED WIRE AND MACHINE CURLS.

ALL DEBRIS WAS RETRIEVED AND THE ANNULUS WAS VACUUMED CLEAN.
FOSAR INSPECTION AND FINDINGS

S/G 2 R25 C7 C01 MACHINE CURL
S/G 2 C/L ANNULUS FOIL TAPE
S/G 4 C/L ANNULUS 18" METAL RULER
S/G 3 C/L LARGE MACHINE CURL IN DRAIN
S/G 1 C/L MACHINE CURLS IN DRAIN
S/G 2 C/L ANNULUS LEATHER GLOVE
In order to disposition 9 PLPs of unknown origin, a 3.9mm custom video probe was inserted through the ¾” Gamma plug and manifold assembly to the tubes behind.

Duct tape was retrieved through the Gamma plug from manifold flow limiter at the 5 o’clock hole (shown right).
In SG4, a 3.0” long piece of weld slag and debris in an old dust mask and an 18” piece of duct tape were retrieved from a block 25 ft down from the 3rd steam drum deck in the wrapper to shell space.
S/G 2 – This PLP was the 1st aluminum tube guide identified and found by snaking a specialized guide tube through the 2.6” penetration, through a 120 degree curve, and four feet across into the wrapper bundle space. Next, the 6mm video probe was dropped down 4 TSPs to R40,C19, C09. It was 3.625” long x .725” wide.
While inspecting via the 2.6” field installed penetration in S/G 1 to access a PLP, two 2” metal rings were retrieved.

It was recommended to TVA to inspect all 2.6” penetrations to look for more rings.

One more ring was retrieved in S/G 3 and other debris due to this expansion of the inspection.

The rings were break-through remnants of the field installed penetrations.
WBN U2 FOSAR PHASE II

360 DEGREE INSPECTION OF SHELL TO WRAPPER AND WRAPPER TO BUNDLE SPACE
Due to all the unexpected Foreign Object discoveries, most importantly the tube guide, it was recommended to TVA to do a 360 degree visual of the wrapper to bundle area.

This was accomplished by removal of the picture-framed hatch on the third deck of the S/G and working from the actual tube bundle top support plate. The object on the left was discovered during this inspection.

In addition, a 360 degree FOSAR of the wrapper to shell space from the 3rd deck of the S/G down to the T/S area was recommended and performed. This included all of the wrapper blocks.
The rod discovered was 34” long x 1/4” diameter. It was wedged diagonally between the wrapper and the bundle in the H/L. It was between TSP 4 and TSP 5 of S/G 2. The rod had a wrapping which was treated as asbestos and confirmed as asbestos through sampling. Appropriate safety measures were instituted. The rod had a wire attached at one end which impeded retrieval. An additional similar rod was retrieved from the H/L approximately 90° away.
HATCH CUT OUT TO BUNDLE, RETRIEVAL AREA FOR 1ST TUBE EXPANDER ROD.
A 2nd tube guide was found stuck fast between TSP C12 and the S/G Wrapper.

A plan was devised to thread the hole in the tip of the tube guide with an aircraft cable, then retrieve the cable end and secure it. The guide was now captured on the cable. Next, the tube guide was tapped out until free with a 9 ½ ft x 1/2 in flexible steel rod and retrieved with the cable through a pre-measured exit path.
IN SG 3 TWO TIG WELD RODS ON H06 WERE RETRIEVED, A FULL SCOTCHBRITE PAD H08, FOIL TAPE, AND NUMEROUS MACHINE CURLS ON THE T/S. AN 8” WELD ROD WAS RETRIEVED FROM S/G 2 ON H04.
FOSAR
INSPECTION AND FINDINGS

S/G 4 contained numerous machine curls stuck between in the wrapper to shell blocks, foil tape T/S, a 12” long wire brush C14, a 12” long heavy welding glove H06, all retrieved.
FOSAR INSPECTION AND FINDINGS

All 4 generators had debris in the shell to wrapper gap, which included: weld rods, metal rings, the inside of a hard hat (which included metal buckles), and many machine curls on support blocks and stuck between the shell and wrapper blocks. All were retrieved.
WBN U2 FOSAR PHASE III

TUBE PULLS FOR UNREACHABLE PLPS IN THE PREHEATER
The FOSAR Vendor, Vistas, suggested tube pulls as a path to reach and identify the remaining PLPs in the sealed pre-heater area periphery and in the middle of the bundle.

Due to constraints with tube pulling close to the periphery, tubes had to be pulled 8–10 tubes away from the PLP targets. In some areas, an additional tube was pulled to provide access to either a left or right tube space.

Using the partially pulled tube as a guide, a video-probe was then pushed up 8–21 ft vertically, articulated, and arced over as many as 10 tubes to inspect these locations.

10 tubes were pulled and 3 additional tube guides were identified at the PLP sites which were un-retrievable due to space constraints. Machine curls were also identified and retrieved.
TUBE PULLS FOR INACCESSIBLE PLPs

- 3 more tube guides were found
- Two in S/G 1— one on the periphery and one in-bundle in ½ inch flow hole. The third at the periphery location in S/G 2.

S/G 1 R23, C6 C06

S/G 2 R4, C114 C06
Other PLPs indicated by ECT were machine curls and retrieved via the partially pulled tubes in S/G 2. R23, C40, C06 and R11, C27, C04 respectively.
Watching the tube pull from inside the tube in order to stop at the TSP and then locate the PLP. (PLP was retrieved through the pulled tube)
PENETRATIONS FOR INACCESSIBLE PLPs

- Westinghouse installed two penetrations, which allowed access to two PLPs.
- In S/G 4 penetration R39,C95, C01, 14.36” up – two machine curls were observed and retrieved.
- In S/G 1, penetration R1,C50, H04, 8.0” up – after an extensive inspection, nothing was observed.
Only one area of the original 149 PLPs is left to be inspected and identified. This area was to be a penetration, but unfavorable UT indications prevented its installation. There are 8 PLPs remaining in one area of SG 2, near R45.C26 C04 on the periphery.

A FUTURE TUBE PULL IS NECESSARY FOR FOSAR IN THIS AREA.
FOSAR SO GOOD!