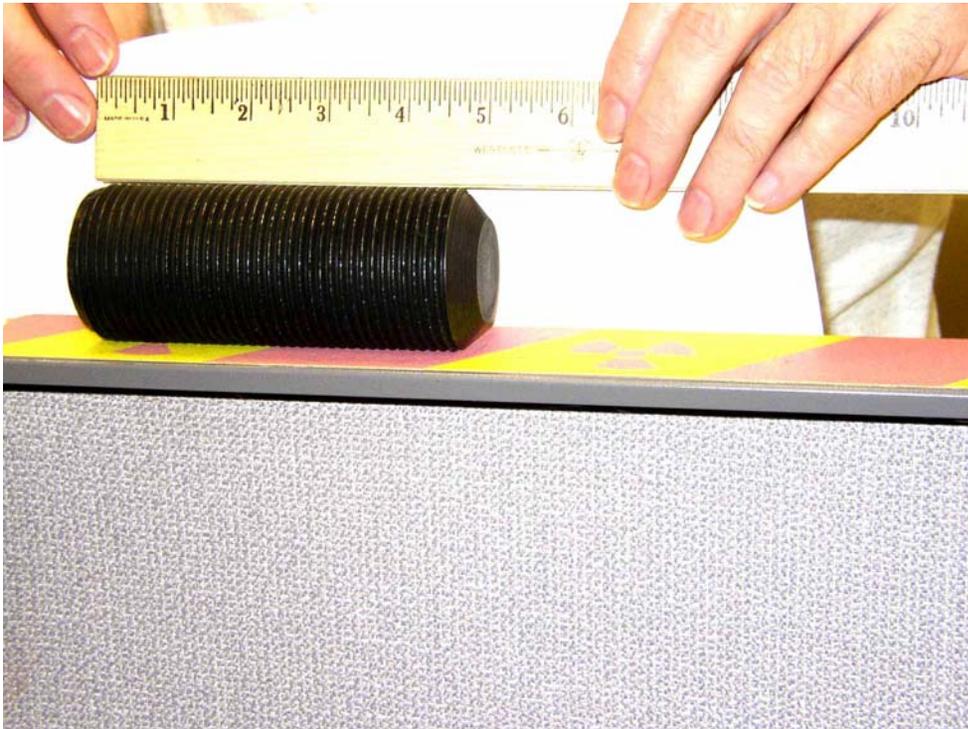




U3R11 SG Loose Part

Kevin Sweeney
System Engineering

Loose Part removed from SG 32



11/5/2004

Tubesheet FOSAR – Affected Tubes

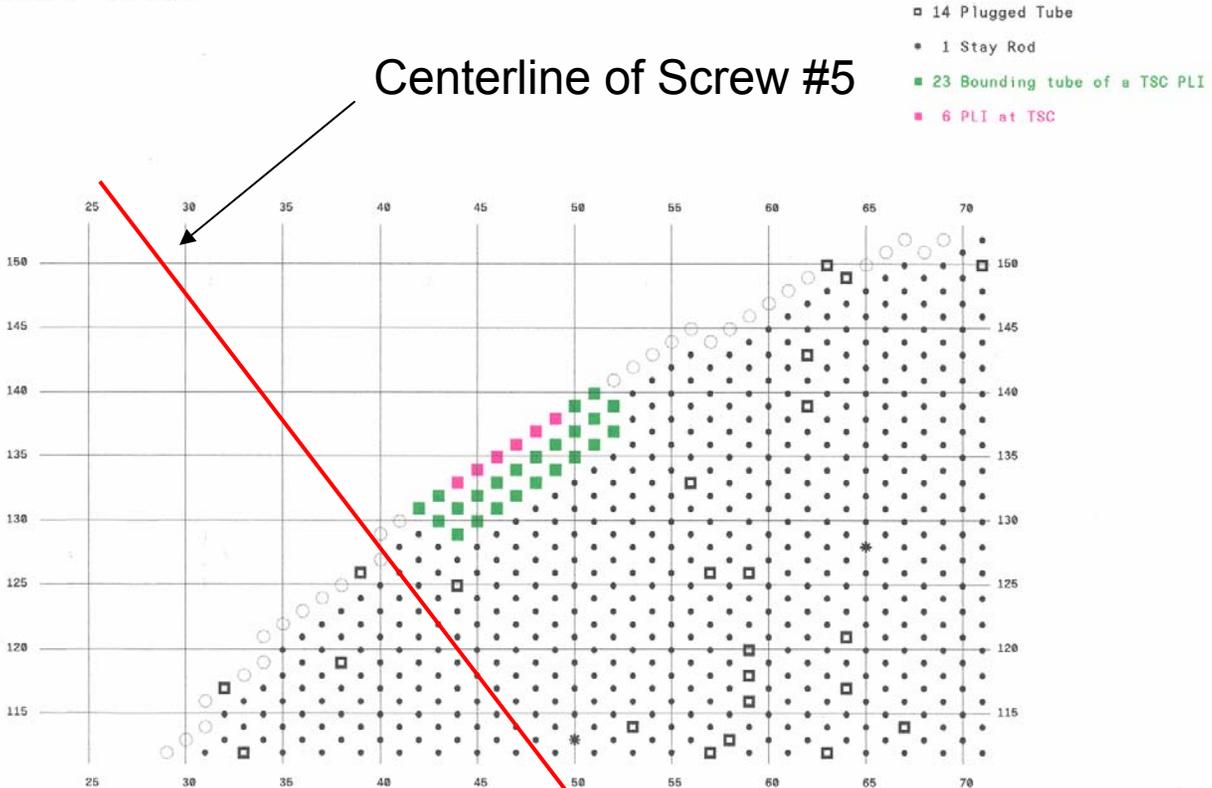


11/5/2004

PLP/PLI Affected Tubes

SG - 32 PLI with Bounding

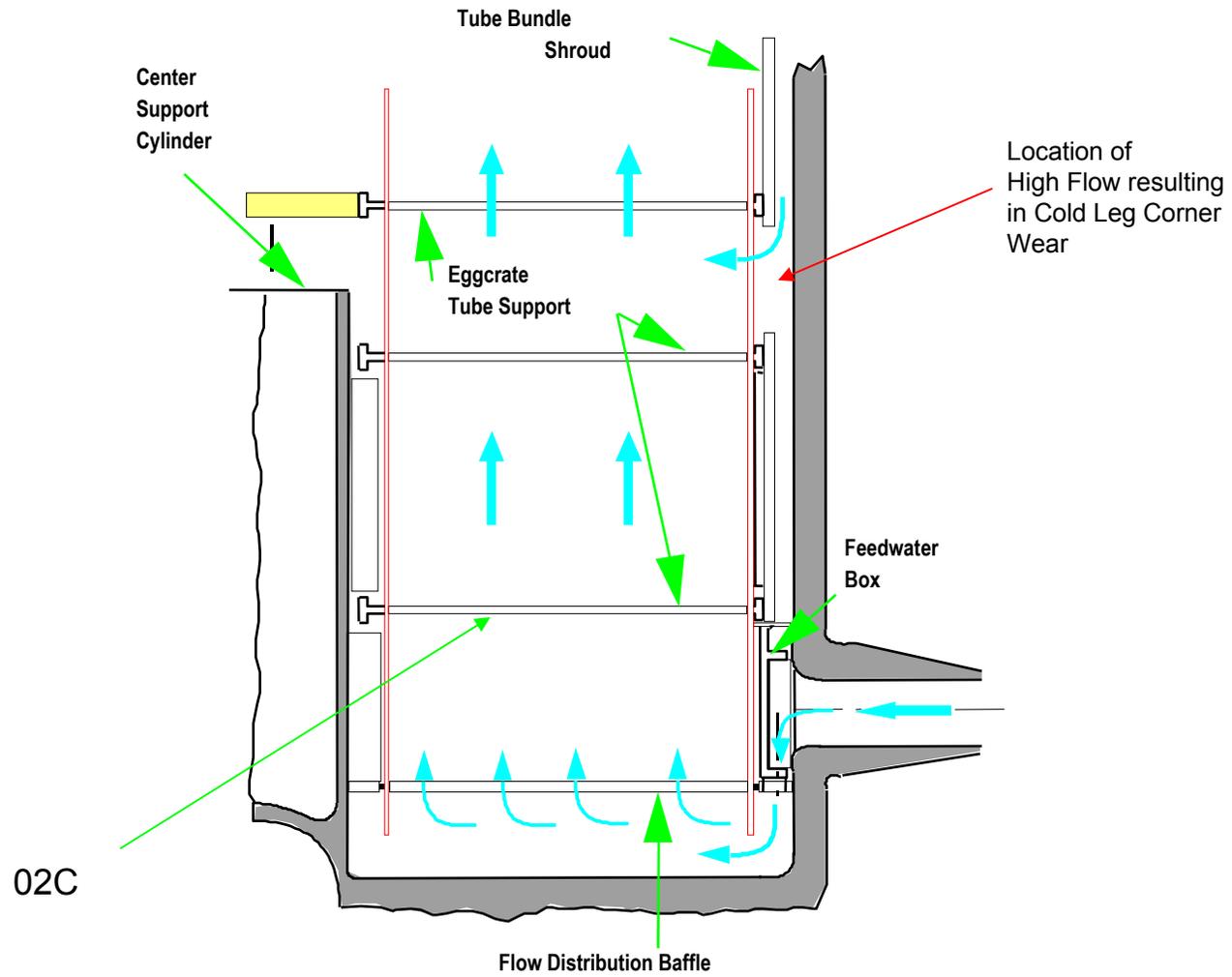
Palo Verde U3R11 PVNGS3 80



11/5/200

Westinghouse Electric Company LLC - ST Max: 10/22/2004 04:33:28

Economizer Elevation View

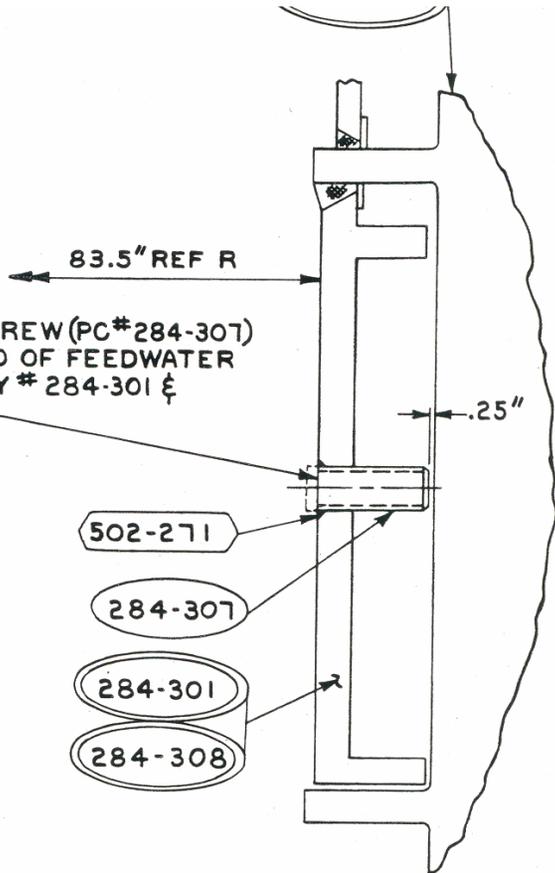


34-210

AIL "J"(G-4)

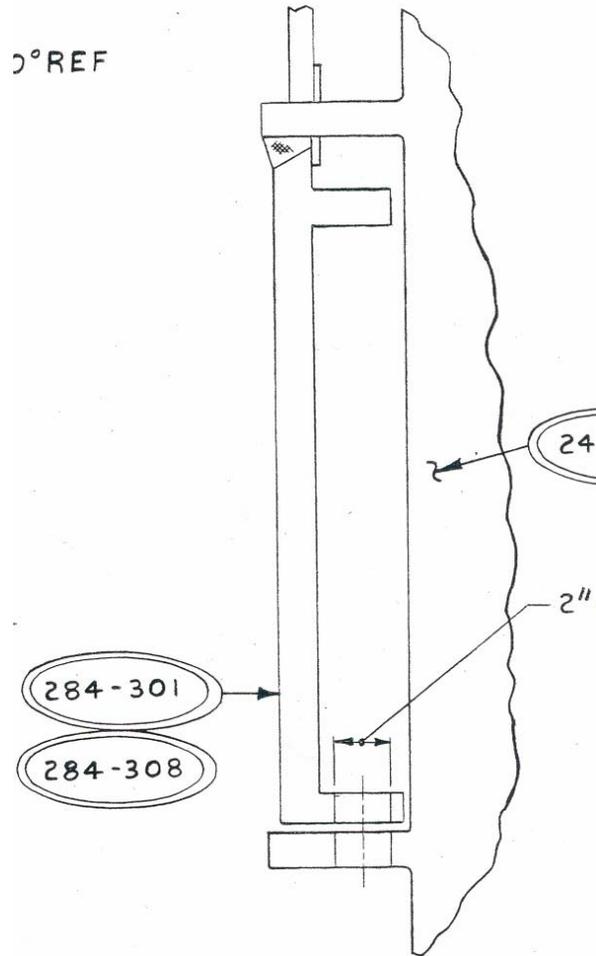
TYPICAL 8 PLACES
SCALE 3"=12"

GRIND SET SCREW (PC#284-307)
FLUSH WITH ID OF FEEDWATER
BOX ASSY (ASSY # 284-301 &
284-308).

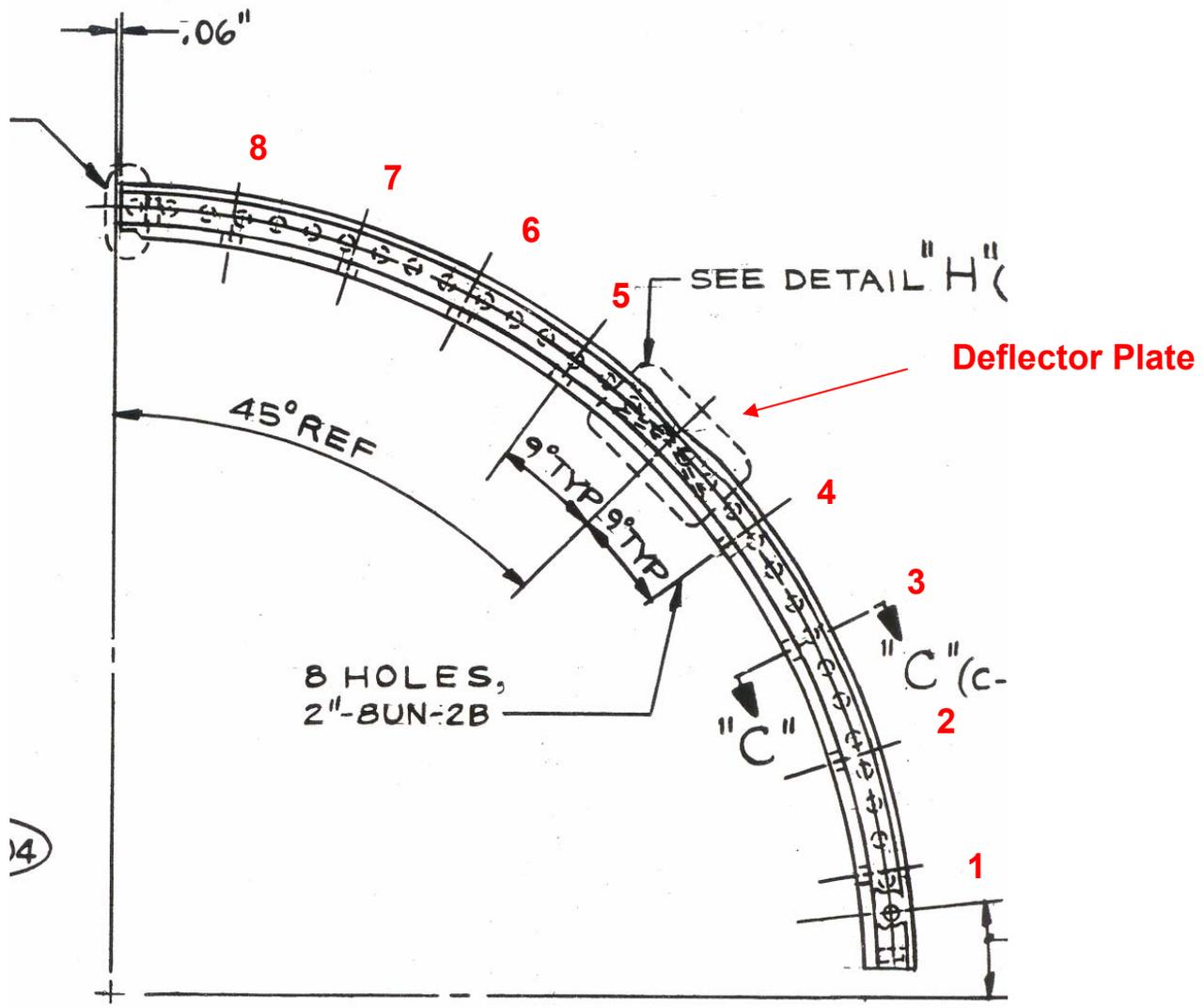


SECTION "D-D"(G-6)
TYPICAL 16 PLACES
SCALE 2"=12"

0° REF



SECTION "A-A"(G-5.6)
TYPICAL 64 PLACES
SCALE 2"=12"



11/5/2004

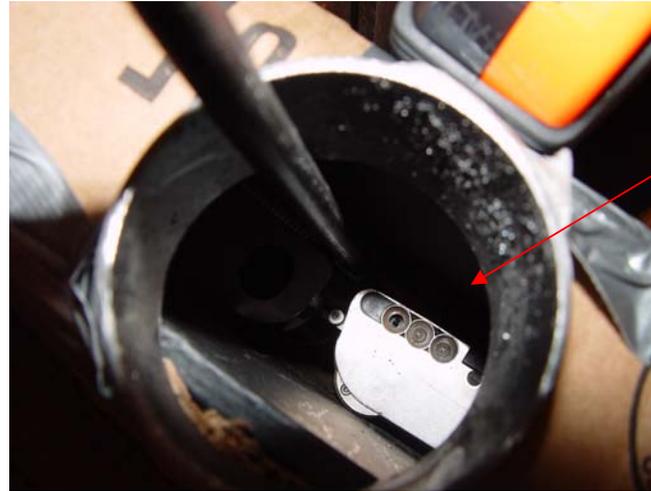
°30'

Feedbox cutout BE SG



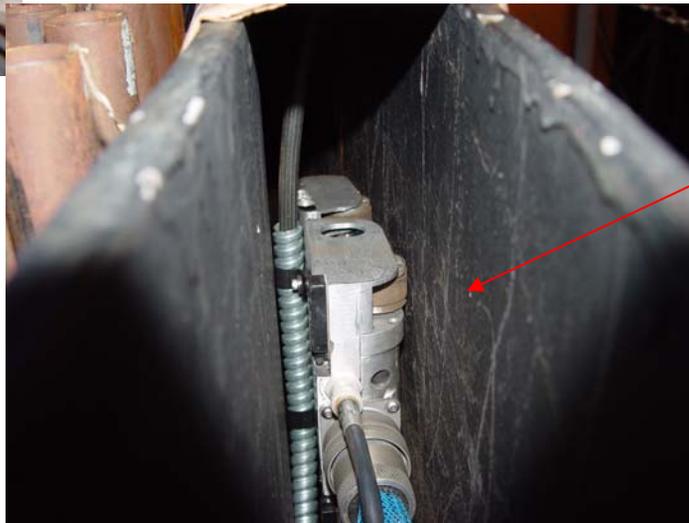
11/5/2004

Brooks Robot/Camera



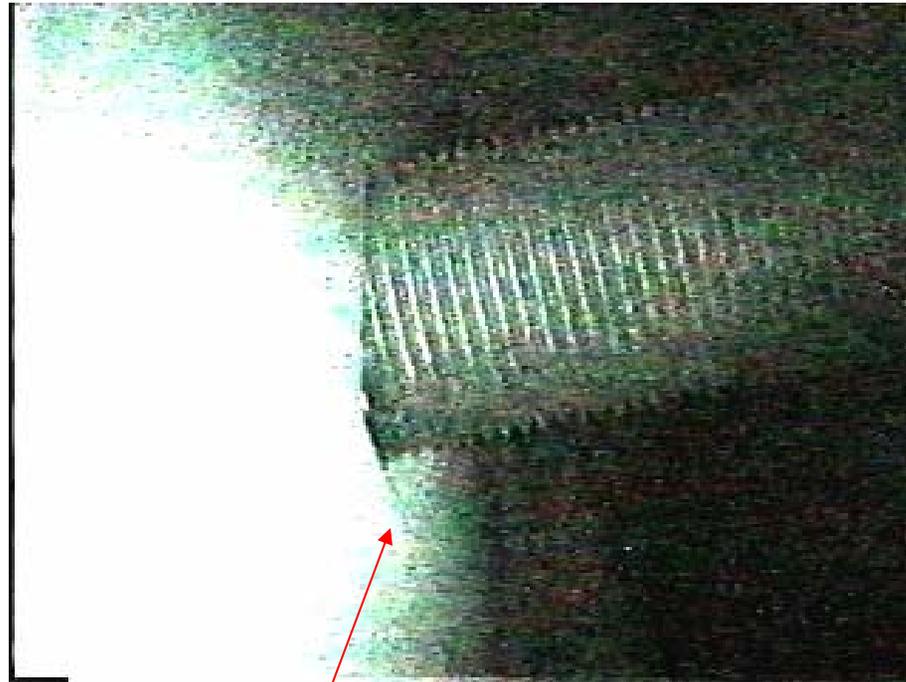
Camera &
Light to look
up FW
box holes

If needed to confirm
presence of screws
an articulating camera
can be extended



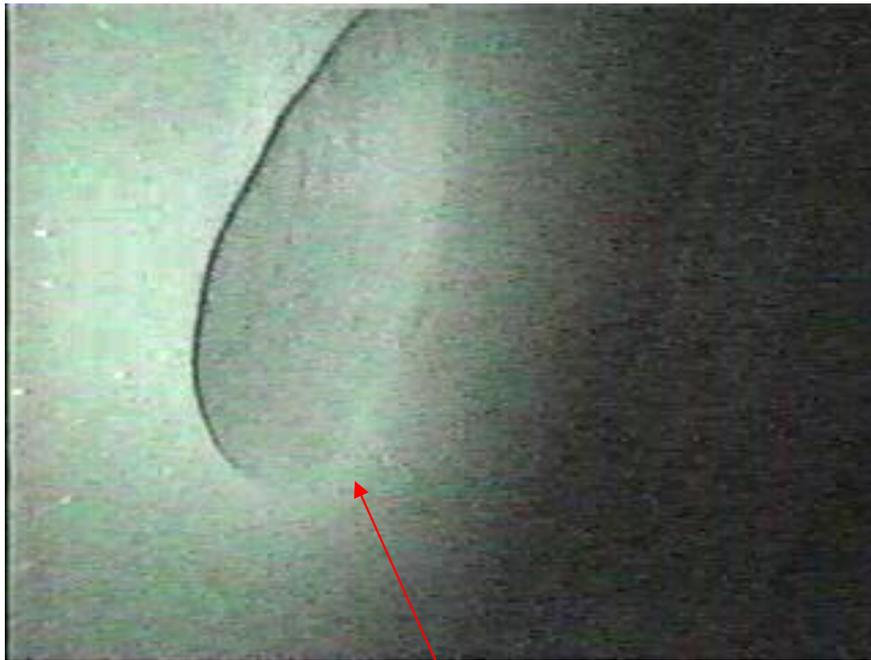
Magnetic
Wheels –
Robot to
roll along
the shell

Inspection Results – Set Screw #4



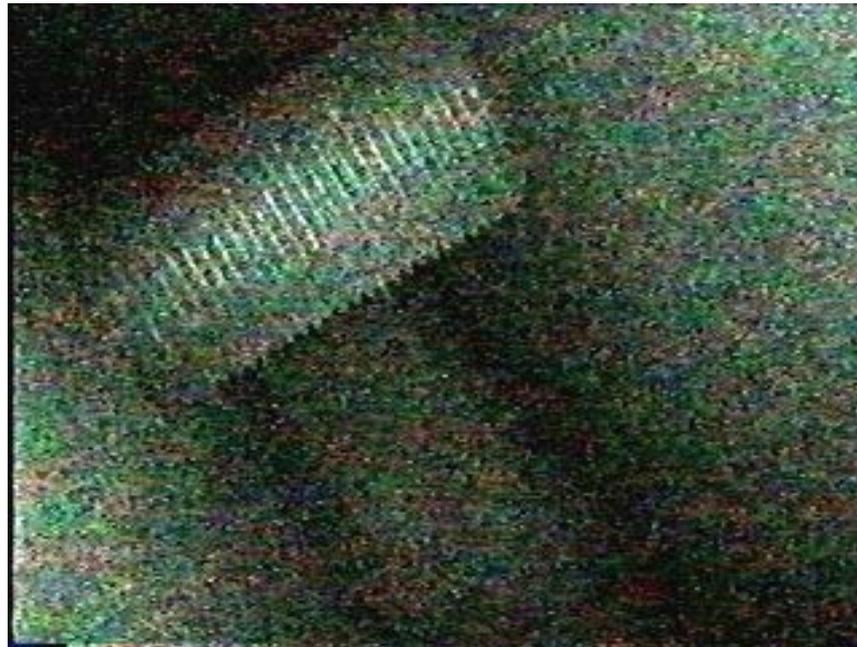
Evidence of erosion or skewness

Inspection Results – Set Screw #5



Set Screw missing

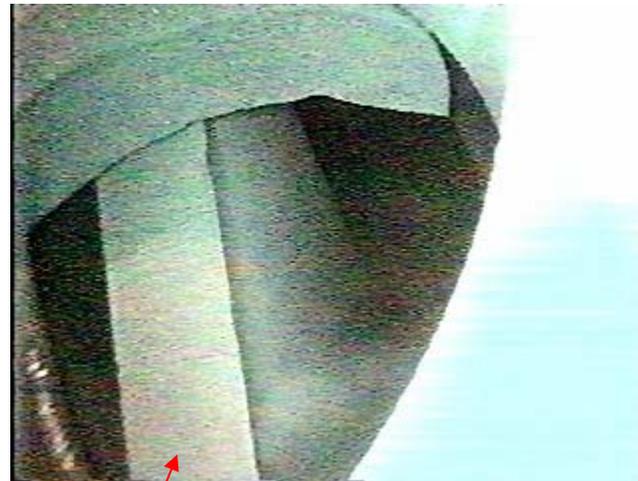
Inspection Results – Proper Installation



Set Screw #12 (SG 31)



Feeding Flow Holes



Deflector Plate

Rereview of Eddy Current

- Eddy current results from U3R11 reviewed after FW Box FOSAR Findings
 - All calls from TSC to 03C
 - Three (3) tubes found with wear at 02C
 - R127C40 – 10% wear
 - R129C40 – 20% wear
 - R130C41 – 25% wear
 - Historical review indicated no previous wear or precursors
 - Further review indicated tubes directly inline with #5 hole
 - Confirmed by Westinghouse

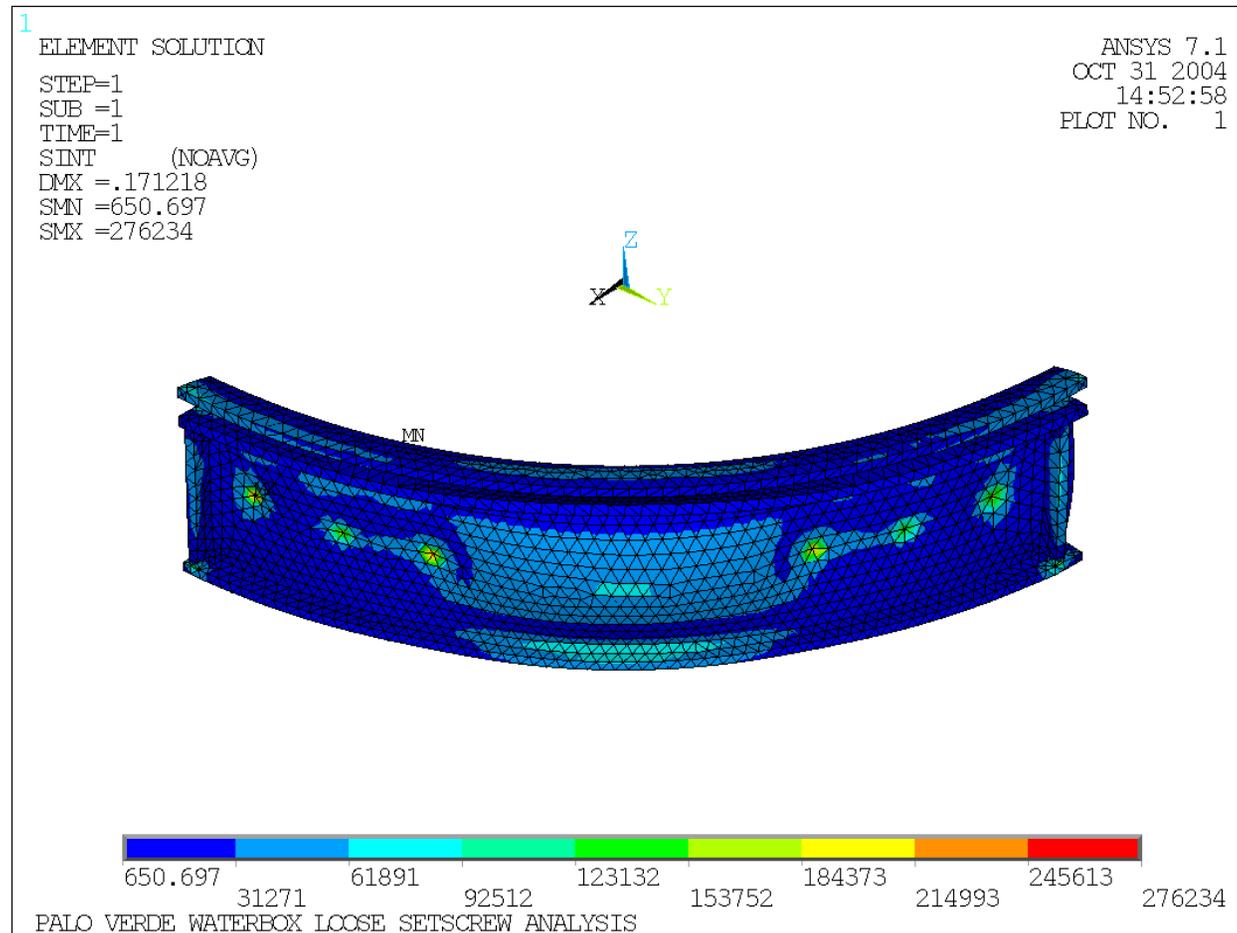
Analysis/Evaluation Approach

- Four (4) impact assessment areas addressed
 - Feedwater box integrity
 - Streaming Flow through screw hole
 - Tube wear
 - FIV
 - SG Performance
 - Loose Part Wear
 - Transport Probability
 - Projected Wear Rates
 - Impact Damage
 - Active and Inactive tubes
 - Unit 1 Operability

Feedwater Box Integrity

- Set Screw Design Function
 - Prevent Feedwater Box collapse during FWLB
 - Feedwater Box/Economizer not credited during FWLB
 - Assure negative impact to tubing not generated
- Analysis
 - Westinghouse developed 3-D FEA model
 - Assumed two (2) set screws per 90 degree section missing
- Results
 - Insignificant increase in elastically calculated stresses
 - Box deflects outwards away from tube bundle
 - Maximum displacement less than $\frac{1}{4}$ inch

FEA Model Feedwater Box with screws missing



11/5/2004

18

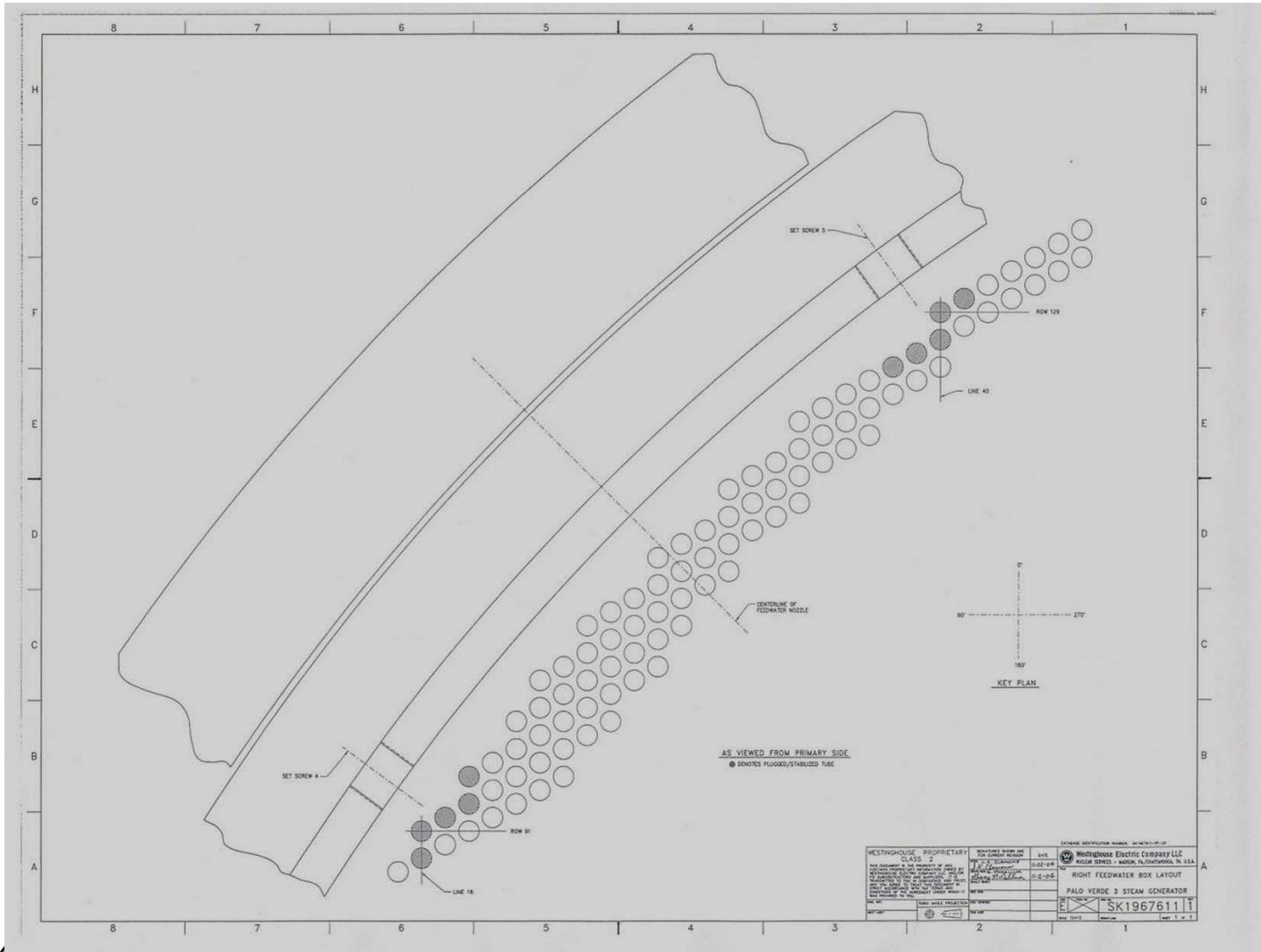
Streaming Flow

- Analysis Approach
 - FIV analysis
 - Similar to analytical effort performed for SG mods
 - Calculate stability ratio
 - Acceptance criteria - ≤ 1.0
 - Ratio > 1 – increased potential for fluid-elastic instability and wear
 - ATHOS model used
- Results
 - Stability ratio slightly greater than 1
 - Consistent with observed wear
 - Flow rates much less than cold leg corner phenomenon
 - 27 ft/sec vs 46 ft/sec
 - Negligible impact on SG performance (< 1 psi)

Streaming Flow

- Recommended Actions – Unit 3
 - Three tubes with indicated wear
 - Plugged and Staked
 - Develop preventative plugging strategy for screw locations adjacent to deflector plates
 - Determined that five (5) tubes per location affected
 - Recommend plugging and staking each location in both steam generators
 - Twenty tubes (minimum) per SG
 - Reviewed ECT data in U2 OSGs and Unit 1
 - No indication of wear or wear precursor at any locations

Tube Pattern – Streaming Flow



11/5/2004

Loose Part Wear

- Analysis Approach
 - Address wear potential
 - Transport probability
 - Geometric Probability
 - Wear rate analysis
 - Archard Theory
 - Impact analysis
 - Active tubes
 - Inactive tubes
 - Loose part wear approach consistent with Engineering Study 02-MS-A76

Loose Part Wear

- Transport Probability

- **Factors**

- Diameter of Screw relative to feeding hole diameter
 - Both two (2) inch
 - » Set Screw has chamfered end
 - » Flow holes may be slightly enlarged (erosion)
 - » Probability estimate
 - Flow hole must be aligned
 - Unlikely
 - » Inspection indicates mis-alignment (cold condition)
 - Cross flow and drop angle make vertical alignment unlikely
 - Cross Flow force 10 lb vs 4 lb set screw

- **Conclusion** –

- Most likely location – lying on feedwater ring with no access to tube bundle – flows and flow direction insufficient to upright screw

Loose Part Wear

- Wear Rate Analysis
- Archard Theory of Wear $V = KF_N D$
- Wear Rates projected to be low
 - Weight/Shape of screw in expected low flow field (1.5 ft/sec) results in low contact force
 - Fixity of tubes at the tubesheet minimizes sliding motion
 - Expected position to be horizontal
 - Consistent with U3R11 findings
- No operating cycle restrictions for Units 3 or 1 with respect to loose part wear

Loose Part Wear

- Impact damage
 - Active tubes
 - Condition is pure impact without sliding
 - Based on combination of flow and weight, test data indicates that resulting dents would be slightly greater than 1 mil
 - Inactive tubes
 - Industry experience (Ginna) of loose part impact interaction resulting in collapse of plugged, unpressurized tube
 - Despite minimal impact load – Engineering elected to provide “caging” of plugged, unstaked tubes on tube bundle periphery in regions considered within expected transport range
 - 15 rows from hole locations
 - Action taken in both SGs

Unit 1 Operability

- **Operability evaluation**
 - Design of Feedwater Box – no difference
 - Similar erosion/corrosion can not be ruled out
 - Wear Review
 - ECT Data from U1R11 and U2R10 (OSGs) shows no indication of wear in the affected regions
 - Condition (streaming flow) assumed not to exist at end of Cycle 11
 - FOSAR
 - FOSAR exam performed in both SGs
 - No evidence of loose part
 - Analysis
 - Analysis in support of Unit 3 indicates no expected impact to tube integrity
 - Tube plugging in Unit 3 preventative in nature
 - Integrity
 - Leak and burst testing/industry experience validate leak stability for wear indications – should leak occur timely, orderly shutdown would result
 - PVNGS shutdown limits more conservative than EPRI limits

Remaining Actions

- Complete Plugging and Staking in Unit 3
 - 30 tubes total in SG 32
 - 37 tubes total in SG 31
 - Expected completion – 11/7
- Westinghouse to provide final QA'd analysis reports
 - FEA Analysis
 - Wear Analysis
 - Expected 11/12
- DFWO
 - DFWO to include Condition Monitoring (CM) Report per NEI 97-06
 - CM will document all the actions and analyses to conclude no impacts on tube integrity – Mode 4 restraint
- CRDR
 - Document all actions taken and address transportability
 - No corrective measure for Unit 1 – last cycle of operation for OSG
 - Evaluate potential need for future inspections in RSG