Steam Generator Tube Inspection Discussion Points – Briefing Paper

1. Discuss whether any primary to secondary leakage existed in this unit prior to shutdown

PVNGS met the requirements and limits of the EPRI *PWR Primary to Secondary Leak (PSL) Guidelines* during Unit 3 Cycle 11. Leakage monitoring prior to shutdown indicated that no or negligible leakage (0.44 gpd) existed prior to Unit 3 shutdown on 10/02/2004. It should be noted that the PVNGS PSL Shutdown limit is administratively controlled at 50 gpd. No special actions (e.g., secondary pressure tests) are employed for pre-outage leak rates less than 1 gpd.

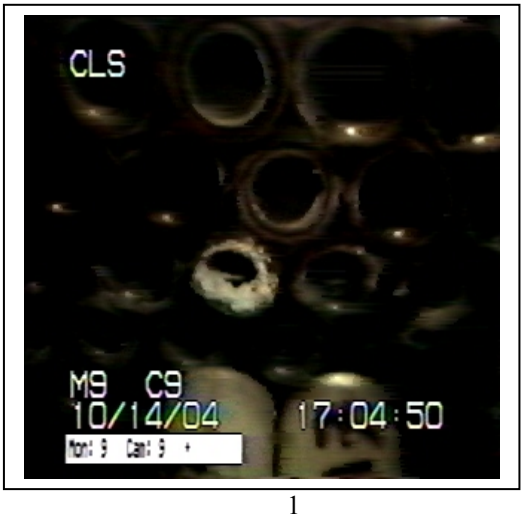
2. Discuss the results of secondary side hydrostatic tests

PVNGS conducts secondary side hydrostatic tests if

- There is evidence of PSL (> 1 gpd) prior to shutdown of the affected unit
- If it has been determined that physical work has damaged the RCS pressure boundary in the steam generators (e.g., plug drilling, welded tube plugs etc)

These conditions did/do not exist. As such, no secondary pressure test has been performed. PVNGS has conducted a visual examination of the tubesheet to determine if evidence of leakage from plugs and/or tubes exists. The visual examination is performed per procedure 73TI-9ZZ78 and PVNGS utilizes a library of historical examples in the training and application of the visual exams. The visual exam performed during U3R11 revealed a single plugged tube (R3C12 in SG 32 cold leg) with evidence of potential leakage (see attached photo). With no evidence of operational PSL, it is likely that the tube does not contain a through-wall indication. This tube was preventatively plugged prior to initial plant operation. APS is developing a work plan to remove the field welded plug and the 188” stake in this tube. The work plan will include:

- Removing existing plug by drilling
- Ensure tube is dewatered on the cold leg side (TMI lessons learned)
- Perform bobbin coil examination
- Perform video examination of tube to verify replacement plug sealing surface
- Perform visual examination of tubesheet and adjacent tube-tubesheet welds
- Install replacement stake and mechanical plug



3. For each steam generator, provided a general description of the areas examined, including expansion criteria and type of probe used in each area. Also be prepared to discuss your inspection of the tube within thee tubesheet, particularly the portion of the tube below the expansion/transition region.

The PVNGS inspection and test scope is attached (Page 4 and 5).

4. Discuss any exceptions taken to the industry guidelines.

APS meets all the requirements of Rev 06 of the EPRI *PWR Steam Generator Examination Guidelines* with the following documented exceptions

- Calibration notches – EPRI GL requires notch length of 0.375" – APS uses 0.250" to accommodate all PVNGS calibration standard items. Study indicates that shorter length has no impact
- Analyst Feedback – APS takes exception to review requirements on overcalls. APS conservatively excludes a review that may desensitize the analyst.
- Site Specific Performance Demonstration – APS excludes Level III analysts that prepare SSPD test from taking the test. Excluded analyst(s) is considered qualified

No exceptions are taken to the other NEI 97-06 EPRI Guidelines

5. Provide a summary of the number of indications identified to-date of each degradation mode and SG tube location (e.g., tube support plated, top-of-tubesheet, etc.). Also provide information, such as voltages, and estimated depths and lengths of the most significant indications.

To be discussed during briefing - See attached preliminary plug summary based on 10/20/04 0800

6. Describe repair/plugging plans for SG tubes that meet repair/plugging criteria

The PVNGS Administrative Plugging Criteria is attached (page 7). The criteria meet/exceeds the PVNGS Technical Specifications and commitments per Generic Letter 97-05.

7. Discuss the previous history of SG tube inspection results, including any "look backs" performed. Specifically for significant indications or indications where look backs are used in support of disposition (e.g., degradation mode or location of degradation new to this unit).

To be discussed during briefing

8. Discuss, in general, the new inspection findings (e.g., degradation mode or location of degradation new to this unit).

APS employs a rotating coil inspection in the upper region (referred to as ARC region) for freespan and support ODSCC. This region has been known to contain conditions to promote tube deposits (e.g., dryout, tube bowing) and has been discussed and reviewed with the NRC Staff on many occasions. The extent of the inspection is based on a thermal hydraulic model and empirical review of NDE results from all three PVNGS units. APS also employs a program designed to detect the need for expansion of the affected region. During U3R11, APS identified two tubes in SG 32 with freespan indications that were not seen with bobbin coil. The indications were small and as such not expected to be detectable by bobbin. A review of the condition was conducted and a Plus Point expansion was conducted in both steam generators. APS has provided additional figures for further discussion during the briefing.

9. Discuss your use or reliance on inspection probes (eddy current or ultrasonic) other than bobbin and typical rotating probes, if applicable.

PVNGS is currently using standard bobbin and Plus Point probes for Unit 3 tube inspection. The small radius U-bend inspections are being supplemented with high frequency Plus Point. PVNGS also employs the GHENT probe to inspect tubes with permeability calls to ensure permeability does not mask flaw signals.

10. Describe in situ pressure test plans and results, if applicable and available, including tube selection criteria

No tubes currently require in situ pressure testing. PVNGS pre-screening criteria attached (pages 8-10). Flaws that exceed prescreening criteria are further interrogated using Appendix B condition monitoring software developed for APS by APTECH

11. Describe tube pull plans and preliminary results, if applicable and available, include tube selection criteria

PVNGS has no plans for tube pull during U3R11.

12. Discuss the assessment of tube integrity for the previous operating cycle (i.e., condition monitoring).

To be discussed during briefing

13. Provide the schedule for SG related activities during the remainder of the current outage

To be discussed during briefing

Inspection Program U3R11

Location/Area	Inspection Method	Extent	SG 3-1	SG 3-2	Basis
Bobbin 100% Full Length Program	Bobbin	Full Length	10,512	10,405	Standard refueling outage bobbin program since 1993
Hot Leg Upper Bundle Region	+ Point	07H- VS3	3,584	3,561	100% of Critical Area and buffer zone of established dryout region based on PVNGS Degradation Assessment.
Cold Leg upper bundle	+ Point	VS5-07C	600	600	20% Sampling program to detect possible onset of free span cracking in cold leg.
Top of Tubesheet Hot Leg	+ Point	TSH (+2 - 12) Unit 1 TSH (+2 - 12) Unit 3	10,512	10,405	100% Inspection for circumferential indications in the transition region per response to GL 95-03. Critical Area Extent within tubesheet is based on testing and analysis per WCAP 16208.
Cold Leg Tubesheet	+ Point	TSC(+2 - 12)	2,146	2,131	20% sample Program based on PVNGS Degradation Assessment. Expand to 100% upon detection of SCC (none to date)
U-Bend Row 1 through 5	+ Point	07H-07C	288	281	100% of Critical Area and Buffer Zone for Short Radius U-bend
U-Bend Row 6 through 18	+ Point	07H-07C	184	183	20% Large Radius U-Bend inspection program based on PVNGS Degradation Assessment of industry events. Inspection to include 100% of all bends with Apex geometric anomalies (bobbin). Expand to 100% of U-bends if SCC detected (none to date).
Hot Leg Dents / Dings (DNT)	+ Point	02H-09H	148	167	100% Inspection of all hot leg dents at eggcrate supports and BW1 greater than 2 Volts
Manufacturing Buff Marks (MBM) and Bulge (BLG)	+ Point	Freespan and Support	30	31	Exploratory sample in lower Hot Leg Region to determine presence of corrosion indications.
Previous Wear Calls and I-Codes	+ Point	Freespan and Support	1,937	1,456	100% Inspection Program to verify defect characterization of previous bobbin wear Calls and historical distorted bobbin calls.
100% of all new bobbin calls	+ Point	Freespan and Support	368	288	100% Inspection Program to verify defect characterization of possible wear and all new distorted bobbin calls (I-Codes).

Expansion Criteria

- Axial ARC Region Indications:
  - Five (5) tube expansion zone (all directions)
  - Additional regions may be specified based on ARCRISK Software
    - Formal evaluation by SGPG
  - Cold Leg Region, expansion **– Expand to 100% of CA if free-span SAI is detected**
- **Outside ARC region Indications**
  - Additional regions may be specified based on ARCRISK Software
    - Formal evaluation by SGPG

- Short Radius U-bends
  - 100% of adjacent row if SAI is detected – expansions based on GEOs will be evaluated by SGPG Engineering and Level III
- Row 6-18 U-bends
    - Evaluate CA and perform 100% if SAI is detected
- ARC Region Dents
  - 100% of all dents > 2 volts if dent-related SAI is detected
- RC Exam of any Bobbin indications that exceed PVNGS Plugging Criteria
- RC Exam PLP/PLI region as specified by APS Level III and SGPG Engineering
- RC Exam of all I codes and bobbin indications per 73TI-9RC01
- RC Exam all new Dents greater than 2 volts.

RC Exam of all:

MBM, BLG – 100% of critical size locations below elevation of detected defect

Circumferential Cracks (Cold Leg)

- Expand to 100% of tubesheet if cold leg SCI is detected
- Expand to 100% of Cold Leg if C-3 condition occurs in Hot Leg MRPC Program

Mixed Mode Indications

- Five (5) Tube buffer zone (all directions)

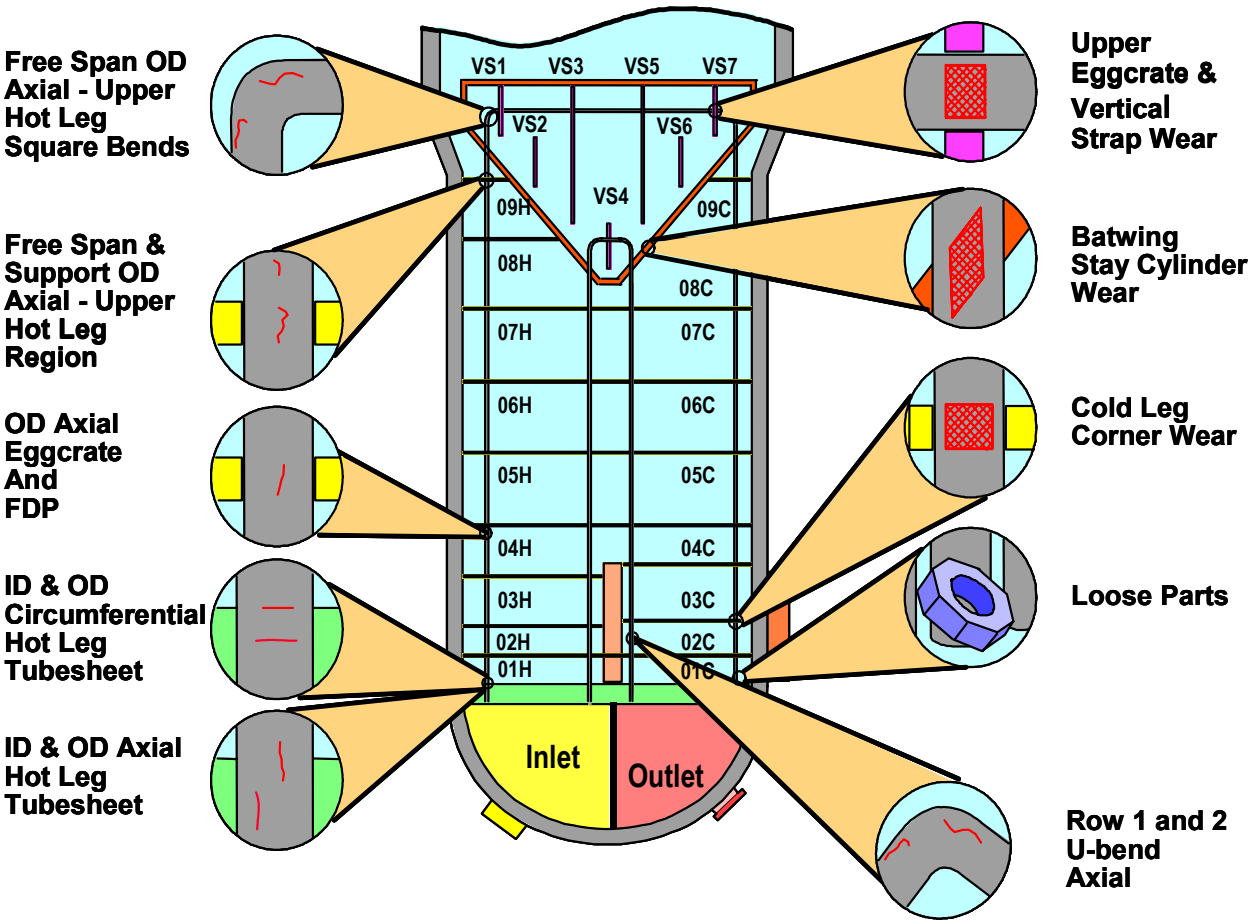
Plug Inspection

Per EPRI ISI Guidelines and Technical Justification 99-SGPG-TJ-001 - A plug visual inspection for structural and leakage integrity is required. Inspection to be performed per Procedure 73TI-9ZZ78.

FOSAR

Required for both Steam Generators per 81DP-9RC01, Hot and Cold leg top of tubesheet annulus and outer periphery tubes.

Typical Damage Mechanisms – PVNGS Steam Generators



PVNGS Administrative Plugging Criteria

1. Wear indications ≥ the Technical Specification repair limit of 40% as called by either bobbin or RPC techniques. The highest call shall be the call of record.

2. Wear indications ≥ 20% (by bobbin) for Stay Cylinder Batwing Wear. The affected tube population is identified in 73TI-9RC01. Tubes may require stakes in accordance with the PVNGS Staking Guidelines N001-6.03-440.

3. Wear indications ≥ 20% (by bobbin) for Cold Leg Corner Wear. The affected tube population is identified in 73TI-9RC01. Tubes may require stakes in accordance with the PVNGS Staking Guidelines N001-6.03-440.

4. Batwing Wrapper Bar (BWW) indications ≥ 20% (by bobbin) wear. If the defect indicates a wear rate >40% per cycle, the tube shall be staked.

5. Repair wear indications ≥ 35% (by bobbin) for tubes with no previously identified wear. A historical review of the previous inspection results is permitted for this evaluation.

6. All detected loose parts (PLPs) with detectable wear. Tubes may require staking based on engineering evaluation and FOSAR results.

7. All detected cracks and mix mode indications. All detected circumferential cracks and mixed mode indications shall be staked as required.

8. GEO indications in Row 1-5 U-bends

9. Volumetric indications (SVIs) which indicate corrosion behavior (SVI with change that is not attributable to ET process tolerances) Change shall be based on present data compared to a minimum of two (2) cycles earlier.

10. SVIs identified as tube-to-tube wear (TTW) indications (Reference V-PENG-TR-004 Examination of Palo Verde 3 Steam Generator Tubes During the 1994 Outage) which indicate ≥ 35% by RPC.

PVNGS In situ Screening (Prescreen) Criteria

Circumferential Cracks

At PVNGS there are four primary initial screens for circumferential cracks. These are:

- Critical Crack Length or Angle – **CA_{TWSL}** and Percent Degraded Area - **PDA_{THR}**. This is a structural integrity screen. The CA_{TWSL} value is the angular extent below which a 100% TW circumferential crack will not burst at the proof test pressure. The basis for screening value is provided in calculation AES-C-3091-1, Burst Pressure of Tubes with Circumferential Cracks for Palo Verde Nuclear Generating Station. A bounding value of 72% PDA has been established. This value bounds both ID and OD cracks (Note: ID cracks have a lower critical PDA than corresponding OD cracks due to the crack face pressure effect.). In order to compare the PDA value to a NDE measurement the PDA value is converted to crack length in inches. Based on the calculated limit the CA_{TWSL} limit for PVNGS is set at 1.5 inches See below:

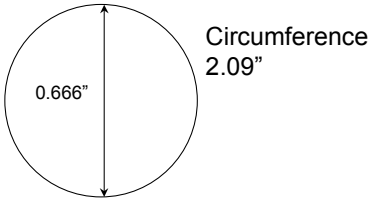
PVNGS Circ Crack Criteria

PDA limit $_{100\%}$ = 259°

CA_{TWSL} = 1.50

PDA_{SL} = 0.72

AV_{SL} = 0.35



- Voltage Threshold – VM_{THR} – The voltage threshold per the EPRI Guidelines is an NDE indicator of leakage potential. VM_{THR} is intended to represent the lowest maximum voltage with a significant (90%) probability of no leakage. Per Table 4-1 of the EPRI Guidelines 1.25 volts is the value that satisfies the criteria. As a further comparison, SGPG reviewed past PVNGS test results. Circumferential cracks with voltage range from 1.23 to 15.33 volts (pancake) have been tested. Only one (1) crack developed a leak (Tube R35C60) in Unit 1 in 1993. This indication had a pancake voltage of 15.33 volts. Based on PVNGS specific results, the industry supported VM_{THR} of 1.25 volts is considered an appropriate value for the voltage screen for circumferential cracks at PVNGS.

- Maximum Depth (Leakage) – **MD_{THR-L}** – Palo Verde uses a prescreen value that subtracts the documented NDE uncertainty from 100%. Flaws exceeding this depth are profiled and evaluated further using APTECH OPCON Software.

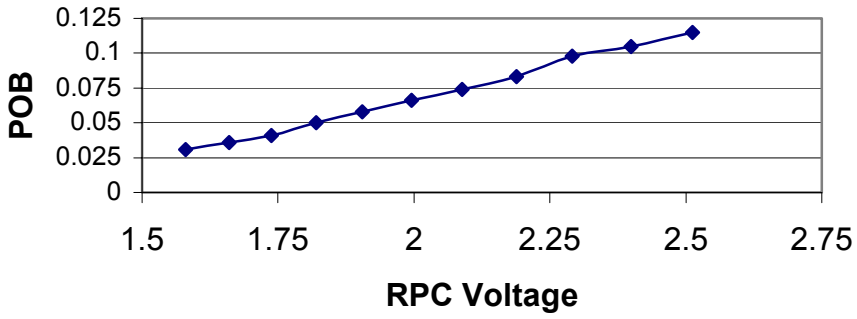
- Exclusions
  - Circumferential flaws detected below 12 inches from the tubesheet secondary tubesheet face are excluded based on WCAP 16208.
  - The OPCON software calculates potential leakage via a Monte Carlo simulation. Results that indicate accident leakage less than 1% of site allowable can be excluded as meeting the POL criteria of Appendix A of the EPRI In Situ Guidelines.

Axial Cracks

At PVNGS there are four (4) primary initial screens for axial cracks. These are:

- Structural Length $\mathbf{L_{STR}}$ – is defined as the critical axial flaw length to ensure structural integrity for a 100% through-wall flaw. The flaw size is dependent on tubing material properties. A bounding value of 0.4 inches is used for PVNGS based on APTECH Calculation AES-C-1893-5. This screen is for structural integrity only. Cracks less than 0.4 inches still need to be evaluated for leakage.
- Maximum Depth $\mathbf{MD_{THR\text{-}P}}$ – is the structural limit depth independent of length. For PVNGS this value is 64% through-wall per APTECH Calculation AES-C-1893-5. This screen is not used a final screen (per EPRI GL) if the voltage values exceed the threshold screen.
- Voltage Screen – $\mathbf{V_{THR\text{-}S}}$ - PVNGS employs a plant specific prescreen based tube pull results at PVNGS. As shown below, a panckake coil voltage of 1.6 volts satisfies a 95/95 structural integrity criteria. For a prescreen, PVNGS uses a plus point voltage and SIZ voltage screen of 1.0 volt which is equivalent to 0.7 pancake coil voltage. The ERPI Guidelines, Table 4-1 provide voltage screening for axial SCC that range from 1.04 to 1.89 volts. As such the PVNGS value is bounded. This screen is used to determine if flaws should be further interrogated by profiling and evaluation with OPCON condition monitoring software.
- Maximum Depth (Leakage) – $\mathbf{MD_{THR\text{-}L}}$ – Palo Verde uses a prescreen value that subtracts the documented NDE uncertainty from 100%. Flaws exceeding this depth are profiled and evaluated further using APTECH OPCON Software.

Figure 1. Probability of Burst: OD Axials



In situ candidate selection is performed by taking flaws from this prescreening process and evaluating structural and leakage integrity via the OPCON condition monitoring modules. This evaluation meets all the applicable evaluation criteria in the EPRI In Situ and Steam Generator Integrity Assessment Guidelines.

Wear Indications

Wear indications are evaluated deterministically in accordance with Section 4 of the EPRI In Situ Guidelines. Burst pressures for Batwing Stay Cylinder flaws are evaluated in accordance with plant specific burst testing. Structural limits for other volumetric indications are evaluated per the EPRI Guidelines and the formulas contained in the EPRI Flaw Handbook.

U3R11

SG 31 "preliminary"

≥ 40%	OUTSIDE ARC S/MAI	ARC S/MAI	ARC S/MAI	CLC WEAR	BWSC WEAR	MMI	≥ 35% W/0% HIST	TSH S/MCI	R 1-5 U BEND	SVI	GEO	PLI PLP	PREVENT
5	TS – 13 01H - 4 Ecrate - 0	HL 51	CL 0	0	0	0	0	2	0	3	0	0	1 DNT

79 TOTAL TBP's

SG 32 "preliminary"

≥ 40%	OUTSIDE ARC S/MAI	ARC S/MAI	ARC S/MAI	CLC WEAR	BWSC WEAR	MMI	≥ 35% W/0% HIST	TSH S/MCI	R 1-5 U BEND	SVI	GEO	PLI PLP	PREVENT
1	TS -19 01H – 3 Ecrate - 3	HL 38	CL 3	0	0	0	0	5	0	0	0	4 PLI	0

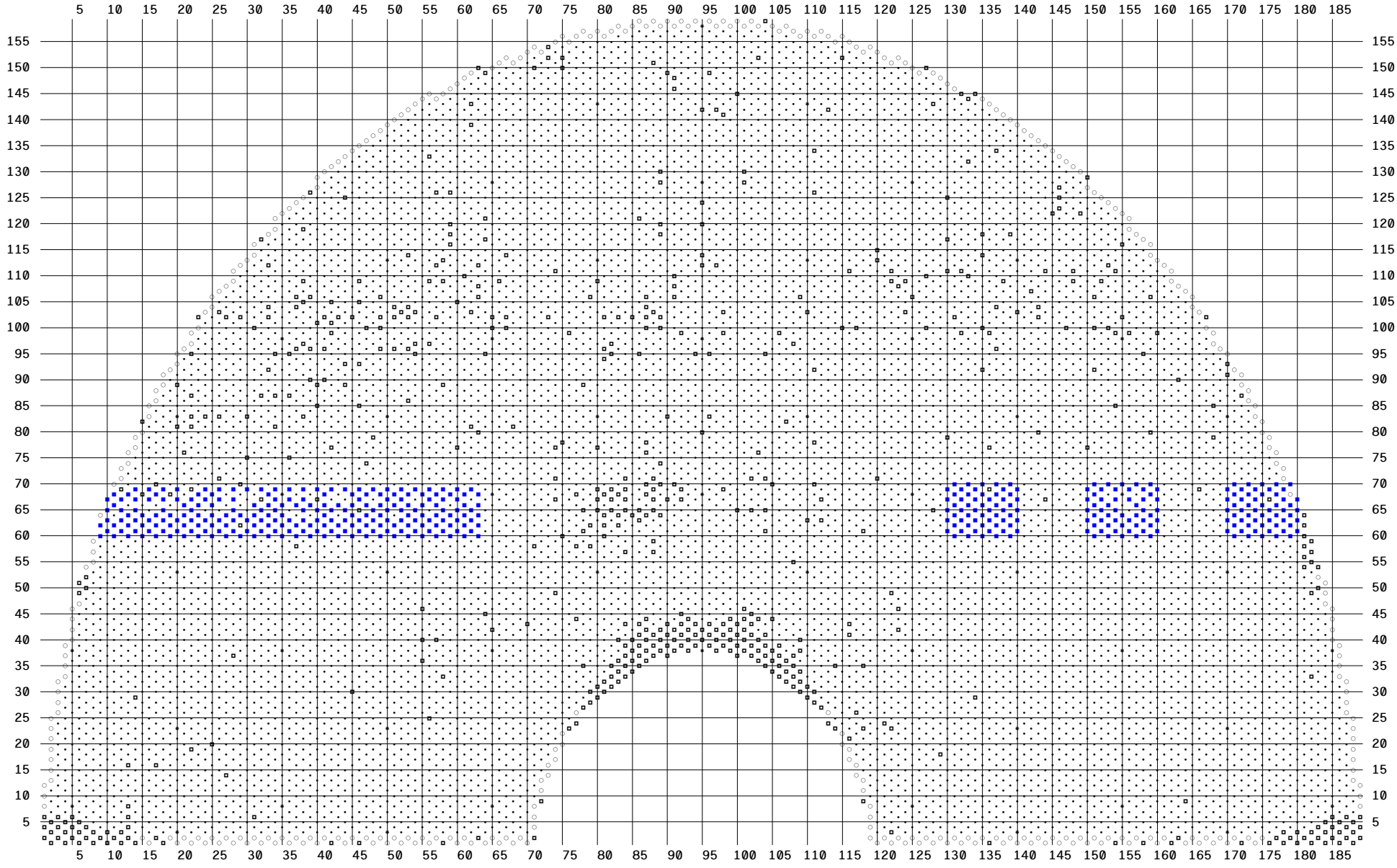
75 TOTAL TBP's

SG - 32 HL ARC Expansion 1

Palo Verde U3R11 PVNGS3 80

▫ 604 Plugged Tube

* 53 Stay Rod



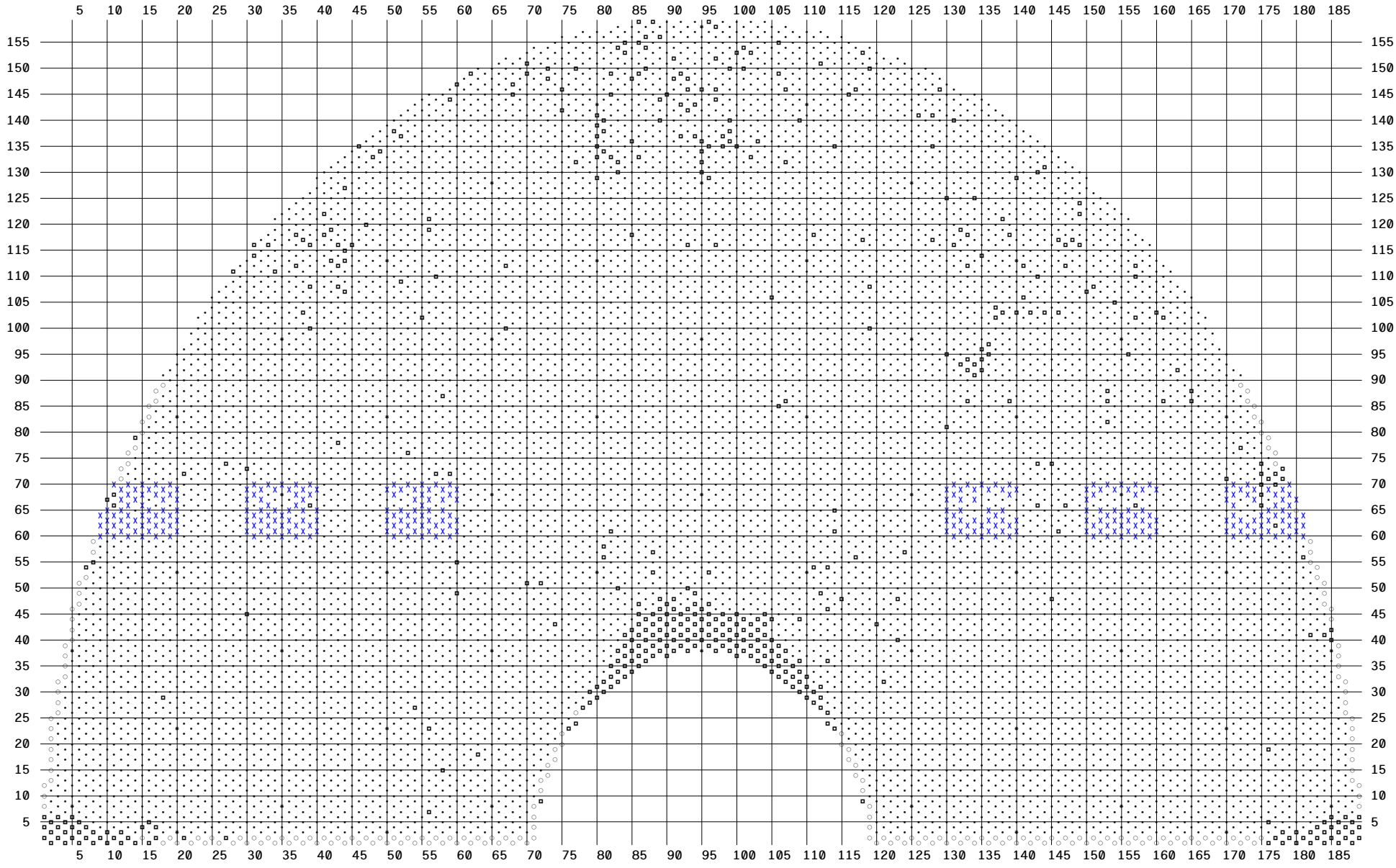
SG - 31 HL ARC Expansion 1

Palo Verde U3R11 PVNGS3 80

▫ 500 Plugged Tube

* 53 Stay Rod

X 293 Test 07H-VS3



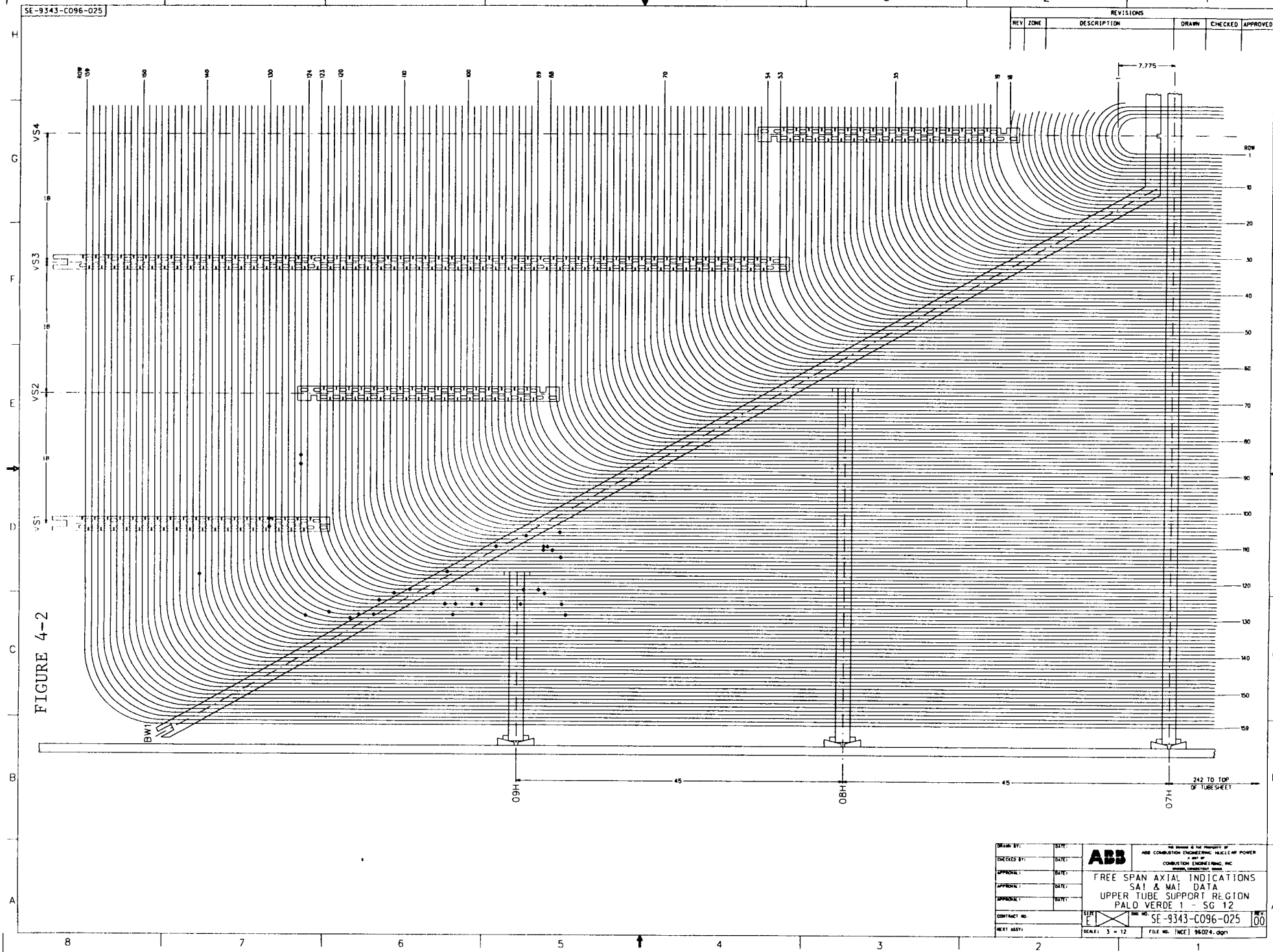


FIGURE 4-2

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