Maanshan Unit 2 Steam Generator Water Level Oscillation and Cleaning

Department of Nuclear Regulation
Atomic Energy Council
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Outline

- Maanshan Steam Generator (S/G)
- S/G C Water Level Oscillation
- Upper bundle Cleaning Experience
- Inspection and Cleaning Method
- Inspection and Cleaning Results
- Conclusions
- Future Work

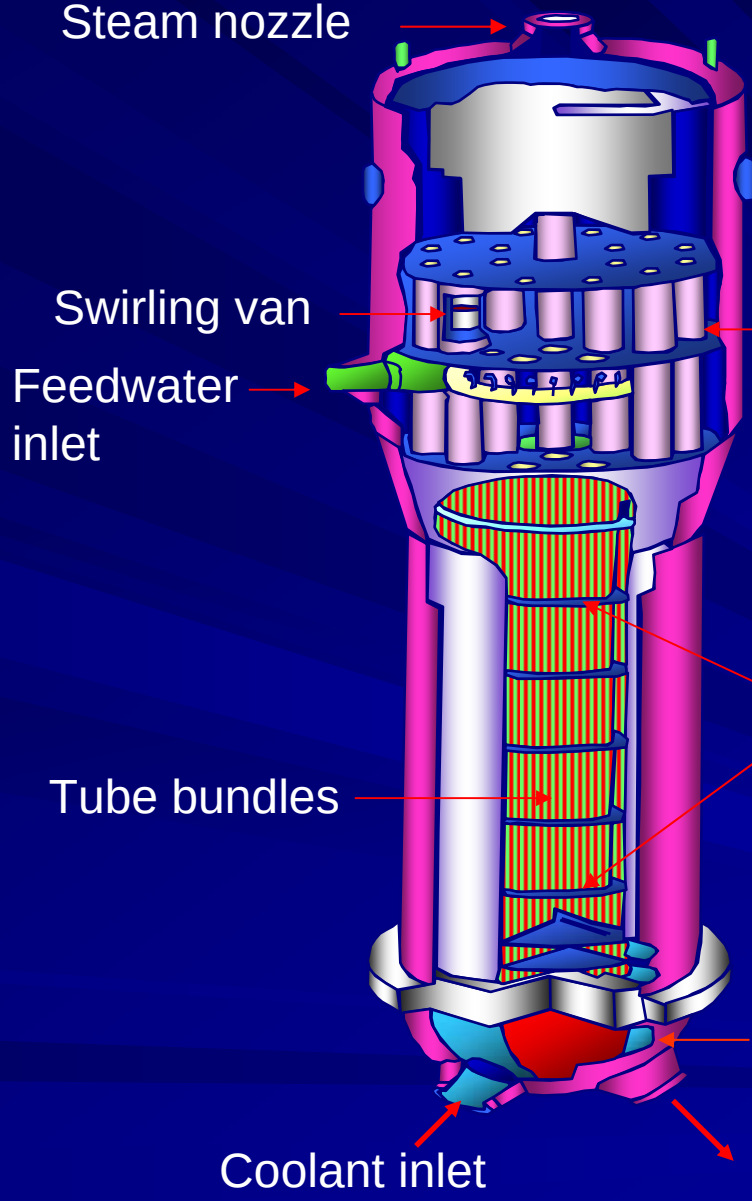
Maanshan Steam Generator (1/2)

- Maanshan Nuclear Power Plant has twin units Westinghouse PWR 3-loop reactor, with installed capacity of 951 MWe.
- The steam generators are Westinghouse type F model, each generator has 5626 inversed-U tubes, made of Inconel-600TT (Thermal Treatment) material. Each tube has an outer diameter of 0.688”, thickness of 0.04”.
- Model F S/G tube support plate has quatrefoil design for better flow path to avoid deposit of particles and the possibility of tube corrosion.

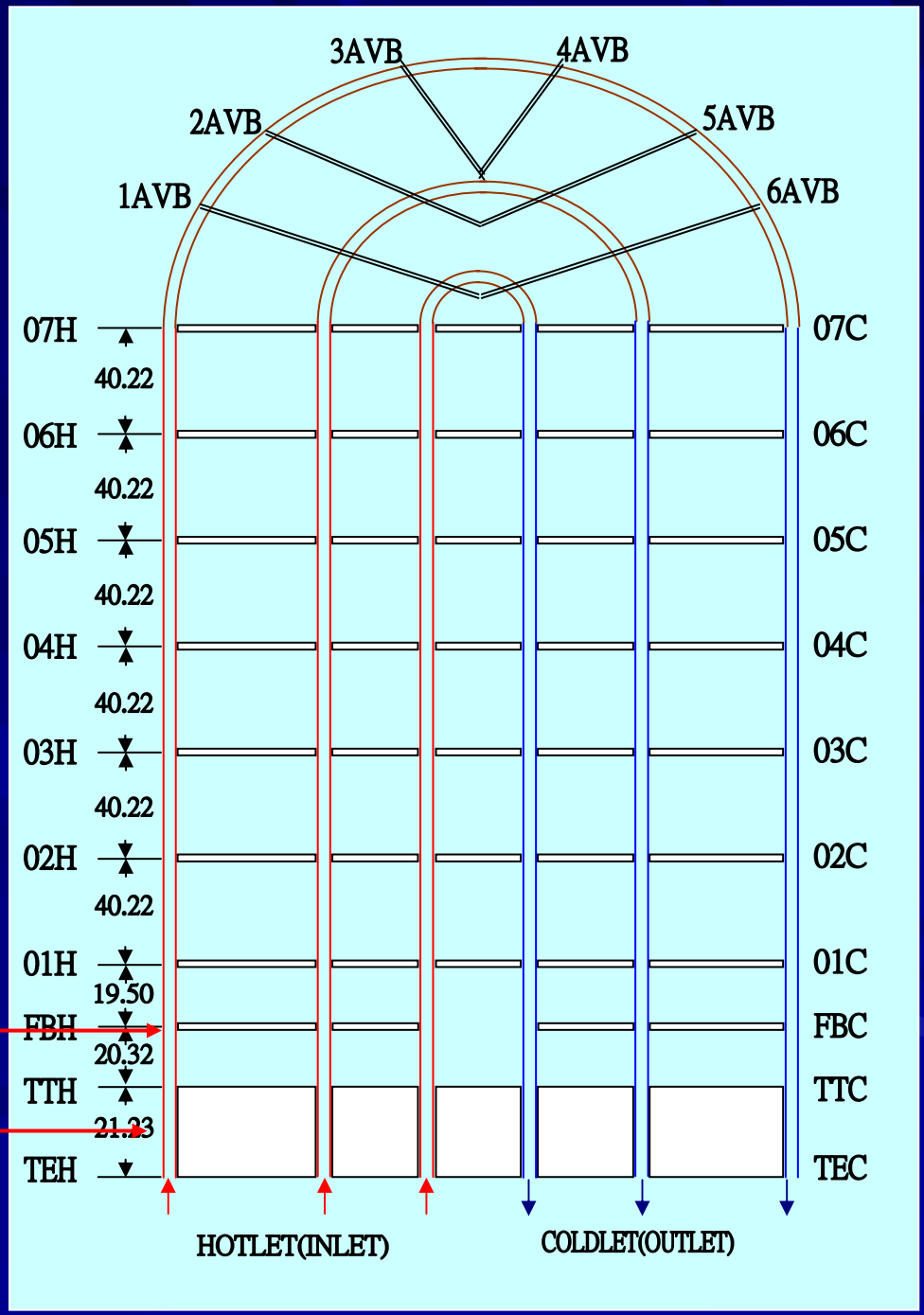
Maanshan Steam Generator (2/2)

- For the general configuration the model F S/G, from bottom to top, there are tube sheet with 21” thickness, flow baffle plate, and seven tube support plates. The very top has three sets anti-vibration bars.
- The shell side of the SG tube bundle has the effects of sludge from feedwater flow, carrying foreign objects, corrosive materials, that may cause fretting and corrosion of the tubes and scale deposit at the upper portion of the TSPs

Model F S/G


Steam nozzle
Man hole
Swirling van
Steam Dryer
Feedwater inlet
Tube support plates
Tube bundles
Hand hole
Coolant inlet
Coolant outlet

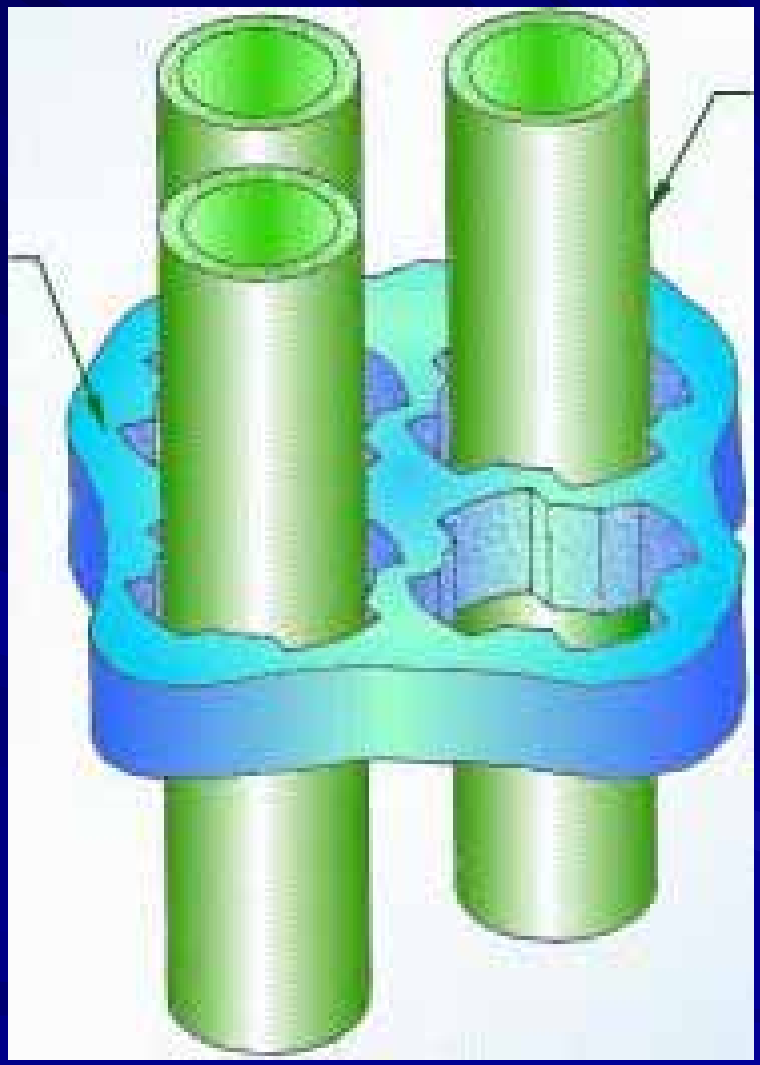
Model F S/G Tube Bundle & Supports Configuration



Flow Distribution Baffle Plate

Tube Sheet

Quatrefoil Tube Support Plate

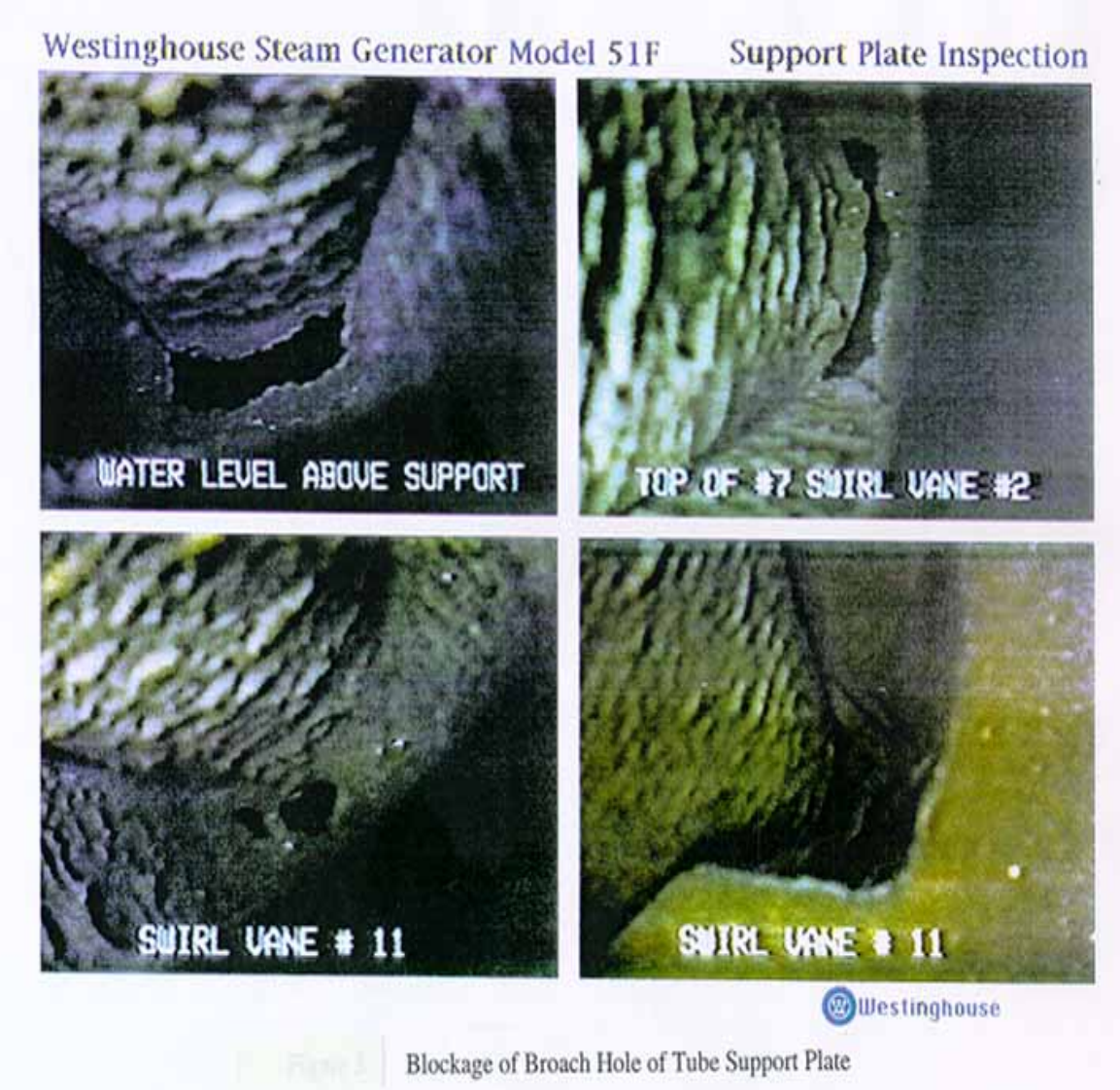


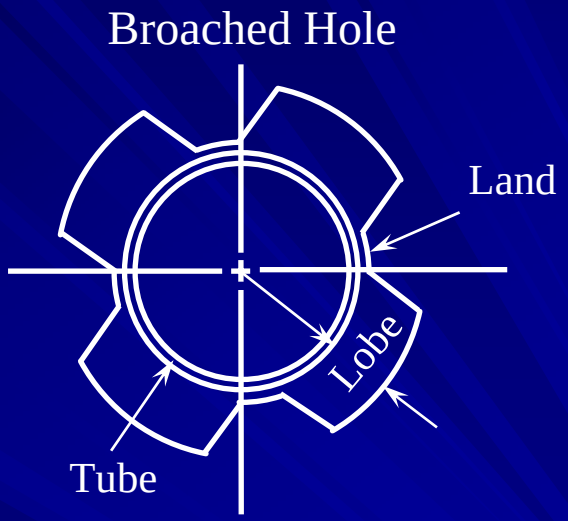
U-Tube

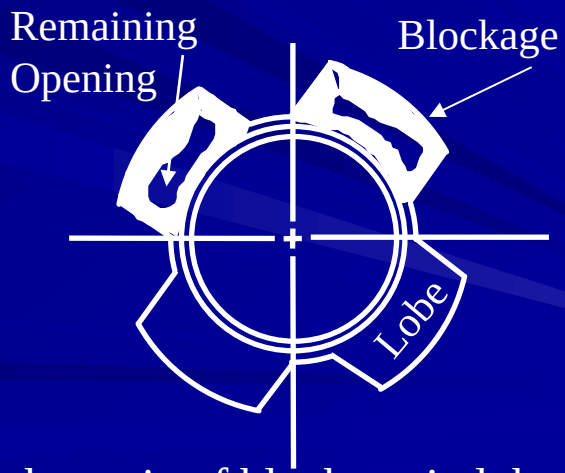
Maanshan S/G C Water Level Oscillation

- Maanshan Unit 2 S/G C started having water level oscillation (flow instability) in October 2004.
- From reviewing the operating experience, U.S plant Surry-2 had the same situation of S/G water level oscillation and found the quatrefoil flow path blockage after shutdown examinations.
- Maanshan Unit 2 reduced power to 97% operation in late November 2004, and further reduced to 95% in March 2005.
- Unit 2 started 15th refueling outage on 12 April, 2005 and S/G cleaning was a major working item.

Surry 2: Blockage to Broached Hole Flow







Schematic of blockage in lobe

S/G Upper Bundle Cleaning Experience

- Vogtle 1 & 2
  - First use of upper bundle Hydraulic cleaning (UBHC) in 1997
  - First use of Full Bundle ASCA (Advanced Scale Cleaning Agent) in 2002.
  - ASCA Cleaning – removed 350kg from 4 S/Gs at Unit1 and 550kg from 4 S/Gs at Unit 2.
- Wolf Creek
  - Preventive inspection and Cleaning – Cleaning started in 1994 and planned to use ASCA in 2005.
- Tomari 2 (Japan)
  - Perform a full-bundle ASCA Maintenance Cleaning
  - The use of full bundle ASCA resulted in removal of 2 cycles worth of accumulated TSP quatrefoil deposits.

Inspection and Cleaning Method (1/2)

- Maanshan Unit 2 S/Gs shell side inspection and cleaning were performed at EOC-15 in April.
- **UBIB** (Upper Bundle In-Bundle Inspections)

  This work was contracted to Westinghouse using periscope head sets to inspect tube support plates through flow slots. Video images were made during the operation.
- **Scale Conditioning (Chemical Cleaning)**

  Adding deposit softening and dissolve agent and use Nitrogen purging to have a complete mixing to enhance the cleaning effect.

Inspection and Cleaning Method (2/2)

- **HVBF** (High Volume Bundle Flush)

  With 2000 GPM circulating water to flush from the Moisture Separator swirling vans to clean the tubes, TSP, and Quatrefoil flow paths.

- **Sludge Lansing**

  Cleaning area concentrated at lower TSP and top of the tube sheet and the space between tubes

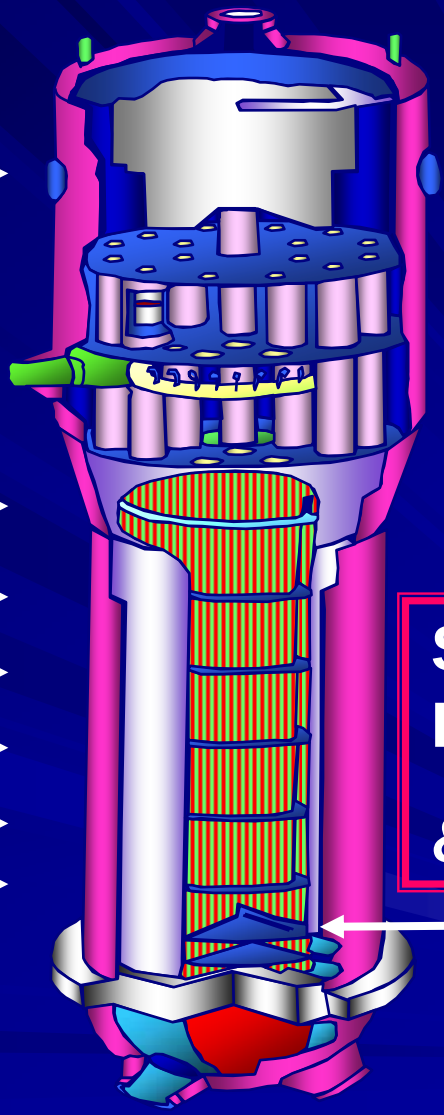
- **FOSAR** (Foreign Object Search and Retrieval)

  Using special designed tool to grab foreign objects at lower support plates.

HVBF

Scale Conditioning

UBIB



Sludge Lancing

& FOSAR

Inspection and Cleaning Results (1/2)

- Each S/G has been cleaned twice.
- Before cleaning, video pictures show that severe quatrefoil fouling for S/G B&C. UBIB inspection can not be performed at S/G A because of misalignment of flow-slots at tube support plate.
- After cleaning ,comparatively large amount of deposits have been removed, significant improvement of quatrefoil fouling cleanup is evident.

Maanshan S/G Sludge Removed Weight (kg)

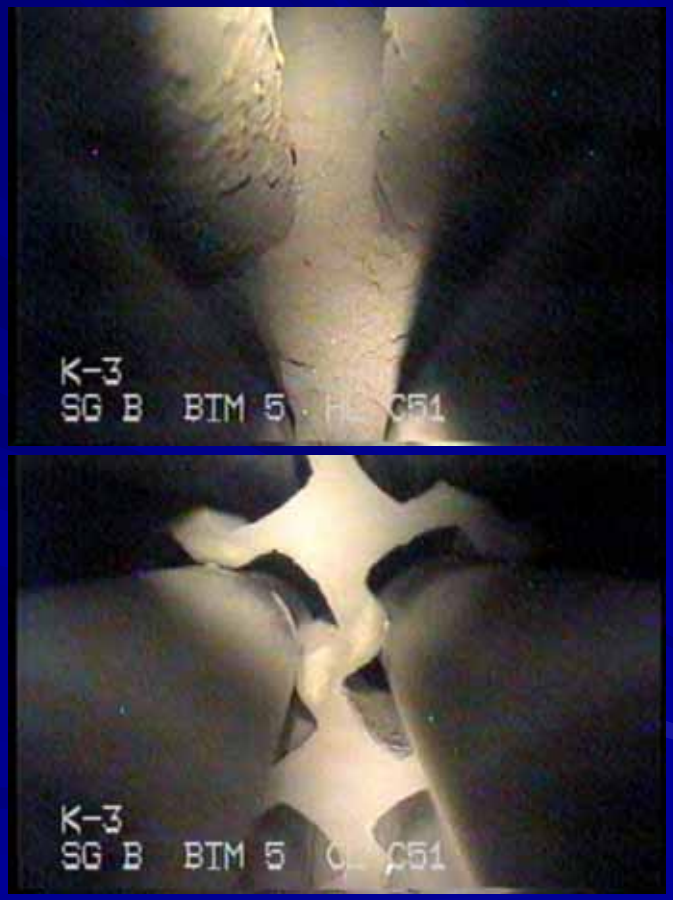
unit 1	A	B	C	Hold-up Tank		note
EOC-10	33.9	24.4	27.4		85.70	
EOC-11	60.68	93.3	39.94		193.92	
EOC-12	202.46	68.8	73.77	138.3	482.61	HVBF
EOC-13	99.56	122.18	83.68	180	485.42	HVBF
EOC-14	78.08	79.08	65.08	66.2	288.44	
EOC-15	170.5	130.5	191		492.00	HVBF
unit 2	A	B	C	Hold-up Tank		
EOC-11	134.6	73.3	96.1		304.00	
EOC-12	128.9	130.76	123.84	172.	555.50	HVBF
EOC-13	134.43	98.25	91.81	158	482.49	HVBF
EOC-14	72.68	81.43	82.2	168	404.31	HVBF
EOC-15	**851.6**	**892.4**	**1060.6**	**82**	**2886.60**	

Inspection and Cleaning Results (2/2)

- The UBIB visual examination at S/G C tube bundles before cleaning indicates that the tube surfaces are relatively clean without any trace of streaking or spall .
- Possible reason should contribute to the good work of sludge lancing and HVBF, and also FOSAR during previous refueling outages.

Severe Quatrefoil Fouling both Hot Leg and Cold Leg Sides

Maanshan 2

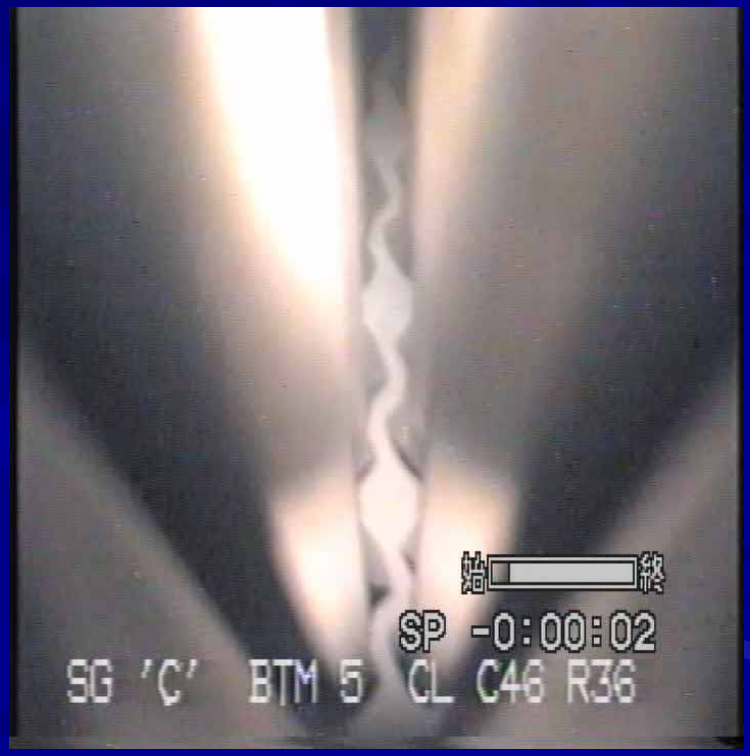


Other Plant

Comparison before and after Cleaning

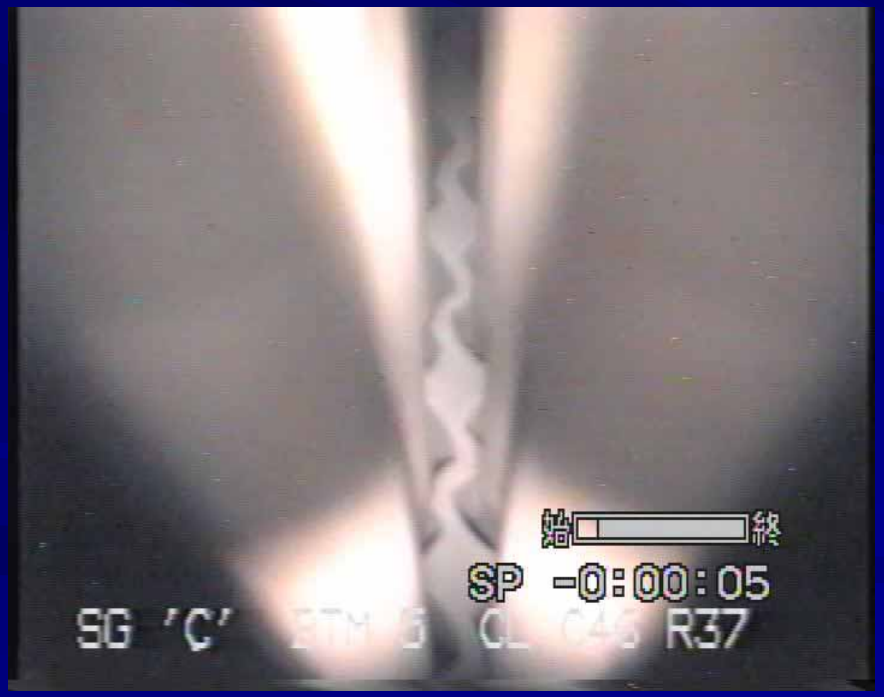
5th TSP Bottom

5th TSP Bottom

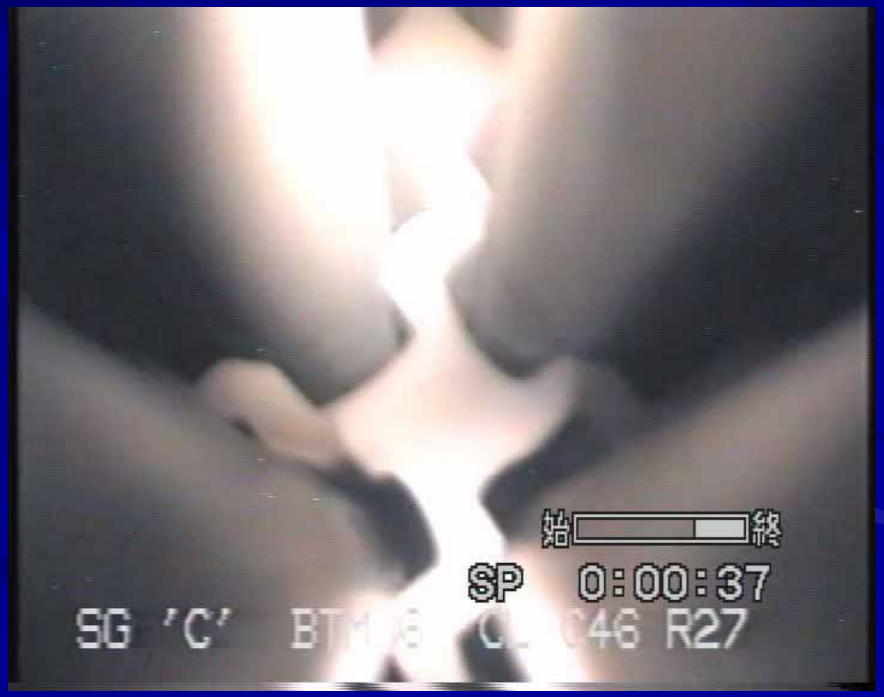


Quatrefoil Fouling has been removed

5th TSP **BOTTOM**



6th TSP **BOTTOM**

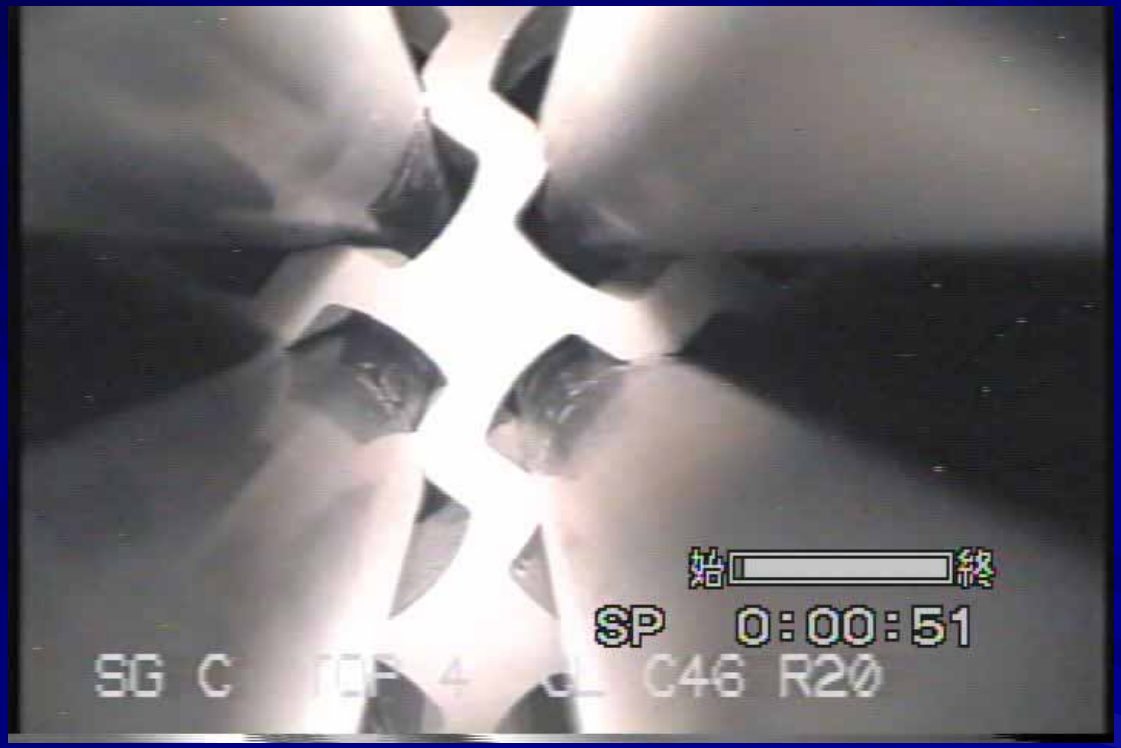


Scale on TSPs Less than Expected

Maanshan 2

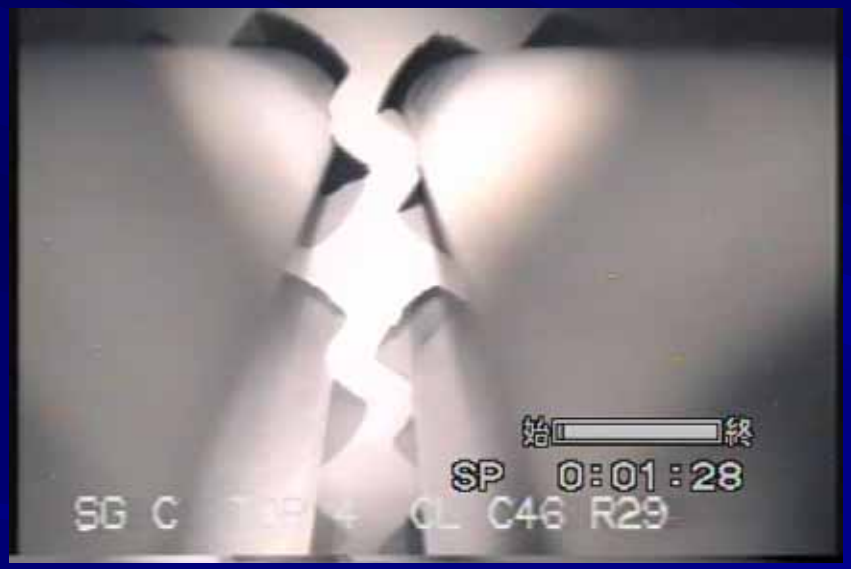
Other Plants

Top of TSPs Appear Clean



4th TSP

Some Tube Surface Deposits have been removed



Before

After

Conclusions

- Maanshan Unit 2 Steam Generator cleaning was effective by visual inspection results and comparing the amount of sludge removed at EOC-15 with previous outages.
- Most of the quatrefoil deposits causing water level oscillations have been removed from all 3 SGs. Unit 2 returns to full power operation after restart as expected.
- All S/G tube surfaces and top of TSPs are relatively clean could be contributed by Maanshan's effective cleaning methods.

Future Work

- Develop visual inspection tool by local laboratory.
- Establish correlation between eddy current test data and TSP blockage.
- Evaluate the world SG cleaning experience for future application.