

Remote Visual Inspection of Steam Turbines

**Chris Brown
Foster-Miller - Waltham, Massachusetts, USA**

and

John R. Dugas Jr.

DuPont Packaging & Industrial Polymers - Orange, Texas, USA

33rd Turbomachinery Symposium



Outline

- ❖ Remote Visual Inspection Tooling
- ❖ Case Studies
 - Worthington turbines at Sabine River Works (SRW)
 - Elliott turbine at SRW

Remote Visual Inspection Technology

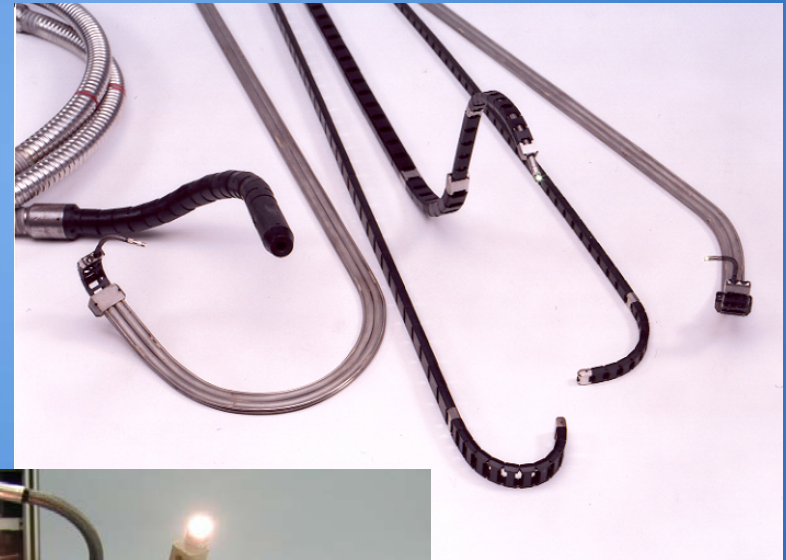
- ❖ Used extensively and regularly for a variety of equipment
- ❖ Mostly off-the-shelf 'one size fits all' tools
- ❖ Not commonly made to go to particular places in particular equipment



Typical Video Probe

Custom Tooling for Steam Turbines and Other Large Rotating Equipment

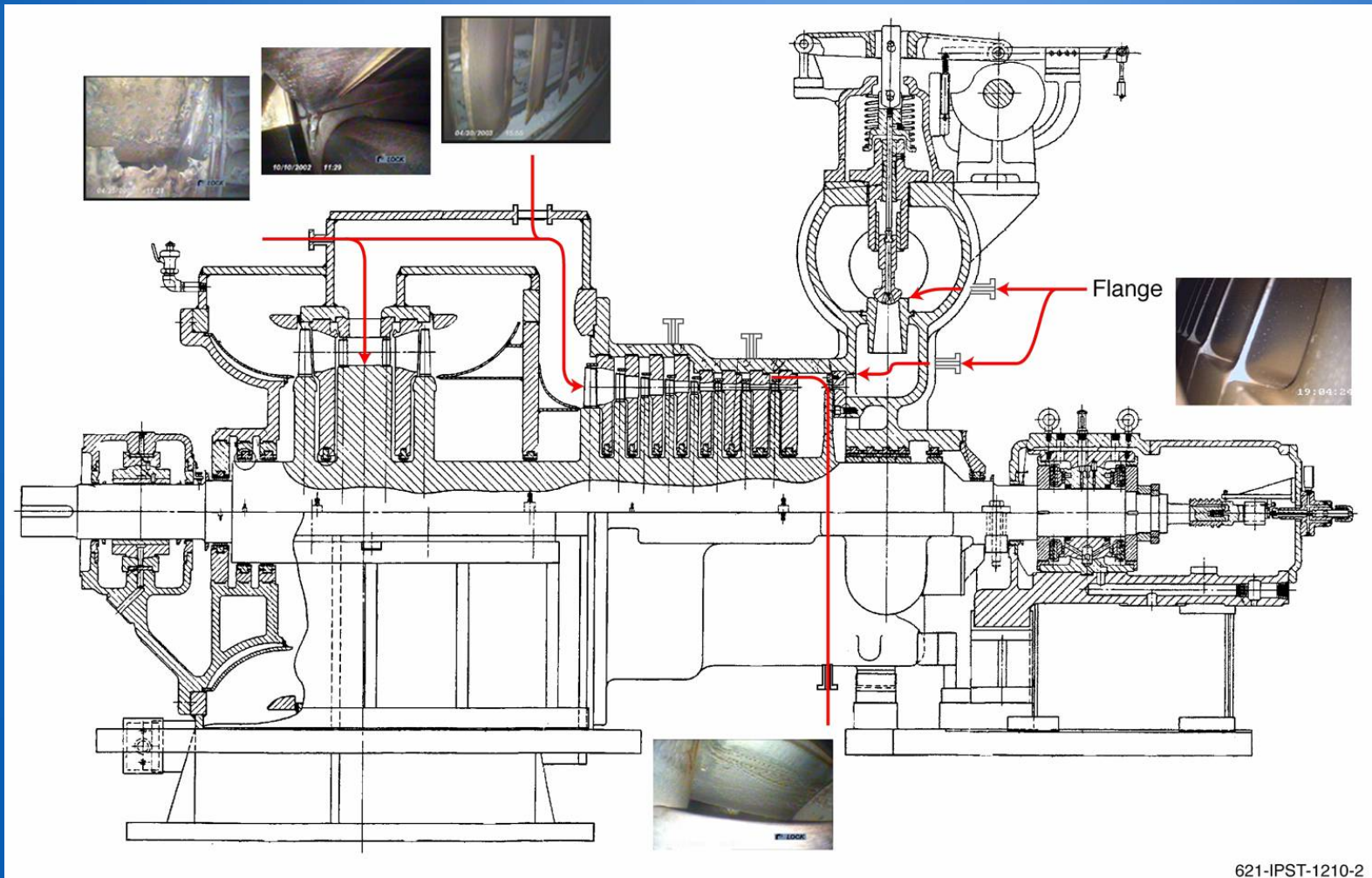
- ❖ A family of tools designed to go where off-the-shelf tools cannot
 - To reach 1st stage nozzles in large steam turbines
 - To go further down rows of turbomachinery
 - To cross long unsupported distances



S3816-3



Worthington Steam Turbines at SRW



Turbine cross section: Inspection paths marked in red

Worthington

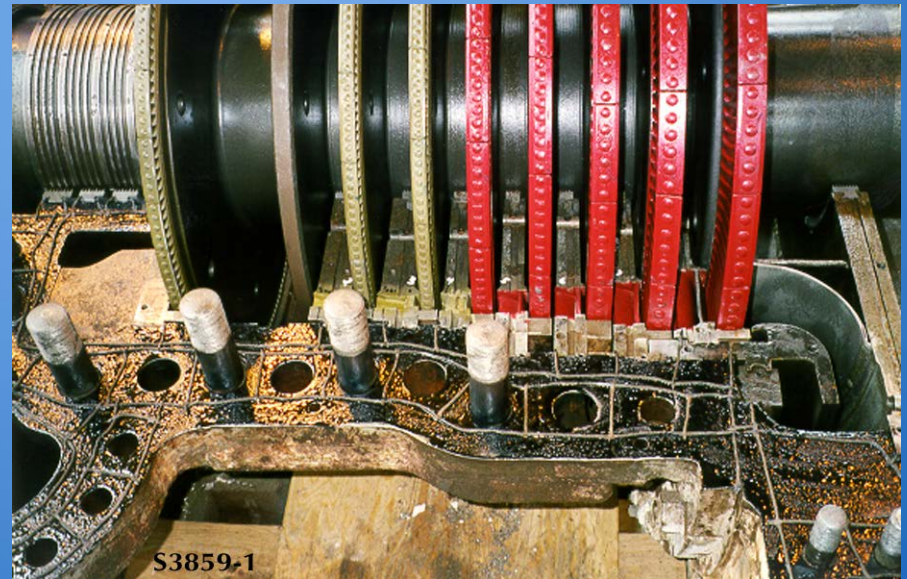
Inspection Description

- ❖ Two identical Worthington units inspected
 - GB201 and GB501
- ❖ Inspection took place in the first three days of a five week turnaround
 - Afforded maximum time possible for any maintenance action
- ❖ Both critical units fully instrumented:
 - Vibration monitoring
 - Efficiency, steam rate, and torque monitoring
 - Monthly oil analysis

Worthington

Diagnostic Triggers

- ❖ Loss of performance on one unit (GB201) due to fouling
 - GB201 typically ran at full capacity
 - Required monthly online water wash to maintain capability
 - Concern about resulting erosion/corrosion
- ❖ No mechanical issues (vibration, torque, etc) detected
- ❖ Primary goal of inspection was to evaluate status of nozzles, buckets, and coatings

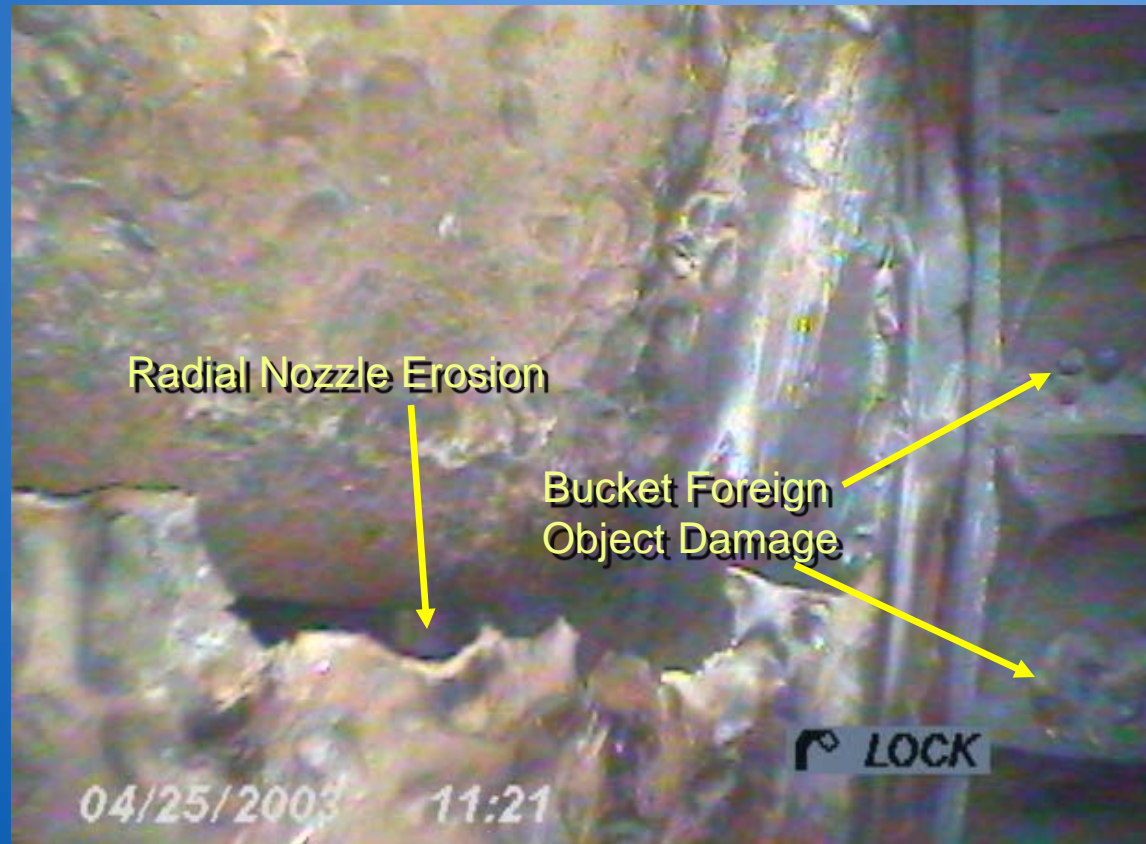


Worthington

Low Pressure Stage

- ❖ Access through pressure tap port
- ❖ Stiff tooling 'parked' at the leading edge of the first stage nozzles
- ❖ Flexible video scope extended through the nozzles and the radial guide nozzles to the second stage rotating buckets

Worthington: *Low Pressure Stage*
Key Find: *Eroded Radial Nozzles*



Worthington

Low Pressure Stage Eroded Radial Nozzle Stills



Worthington: *Low Pressure Stage*

Maintenance Action: *Immediate Maintenance Required*

- ❖ Erosion was severe enough to warrant opening casing and replacing exhaust end radial vanes on both turbines
- ❖ One spare was in stock
- ❖ The other set of vanes was rebuilt and reinstalled
- ❖ There was foreign object damage (FOD) on the buckets which required repairs to one of the removed rotors prior to reinstallation

Worthington: *Low Pressure Stage*

Maintenance Action: *Remove Casing to Replace Nozzles*



Pictures above were taken after casing was removed

Worthington: *Low Pressure Stage*

Maintenance Action: *Radial Nozzle Replacement*

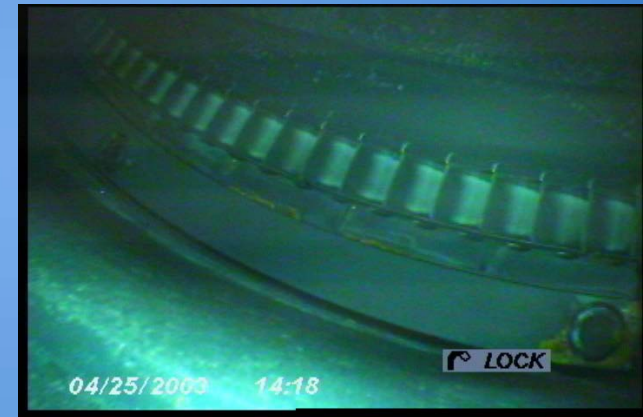
Radial guide nozzles
replaced with
in-stock spares



Worthington: *High Pressure Stage*

Key Find: *Coating Evaluation*

- ❖ An antifoulant coating had been added to the entire steam path
- ❖ Inspection revealed it had eroded away on the first stage buckets
- ❖ No further damage was seen



Worthington: *High Pressure Stage*

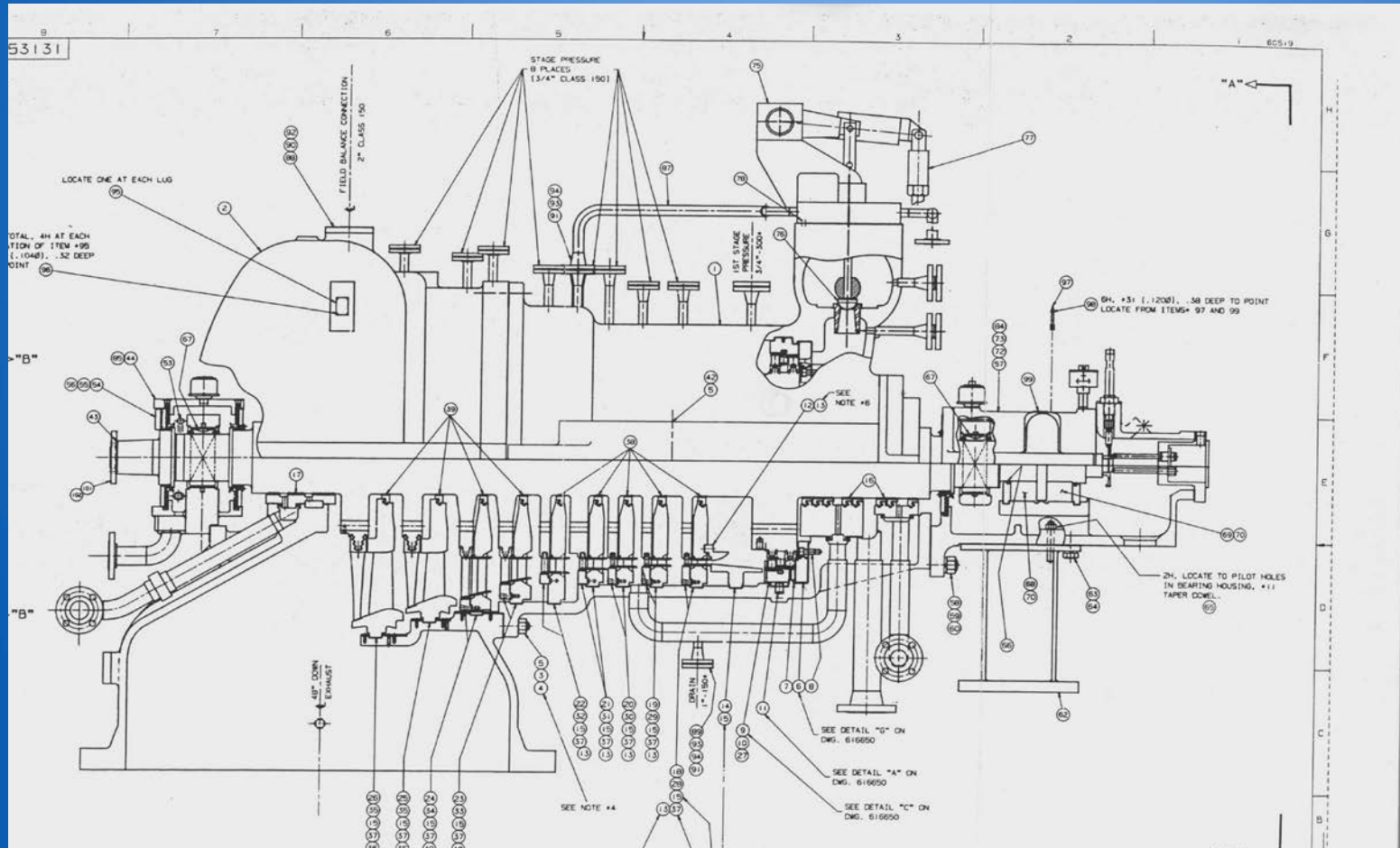
Maintenance Action: *No Immediate Maintenance
Action Required*

- ❖ Blade coating status obtained from inspection
 - Top antifoulant coating was gone
 - Intermediate and base coats meant to prevent erosion/corrosion of base materials was still present
 - Antifoulant coating was gone due to poor steam quality
 - Poor steam quality due to surface condenser leaks and treatment chemicals

Case

Elliott Steam Turbine at SRW

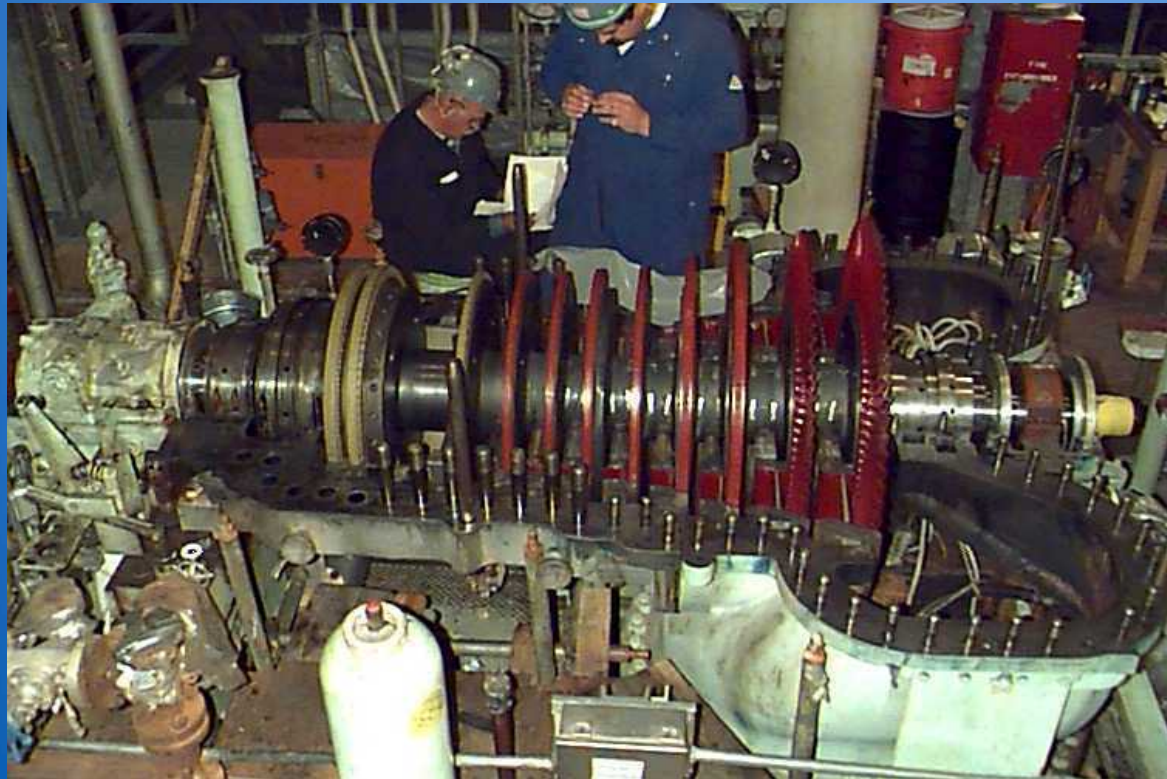
11 stage turbine



Elliott

Inspection Description

- ❖ Each stage accessed through stage-specific pressure ports
- ❖ Below: Unit with Casing Off in 1999



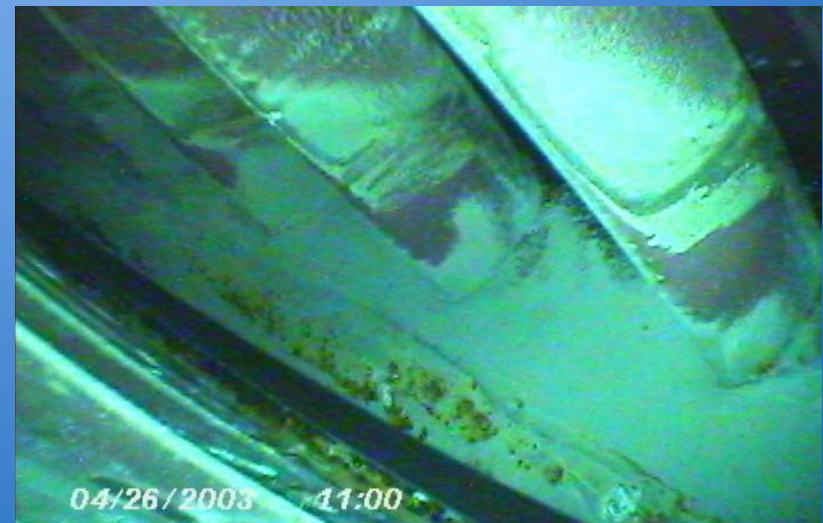
Elliott

Exhaust End Stages



- ❖ Fouling deposits visible

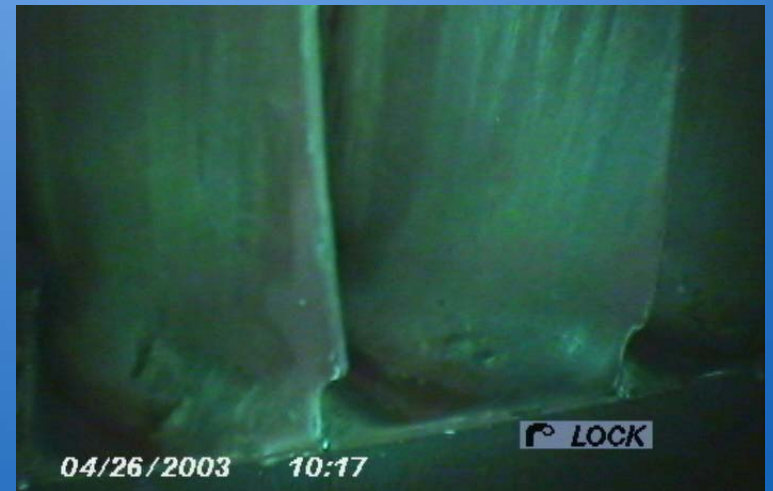
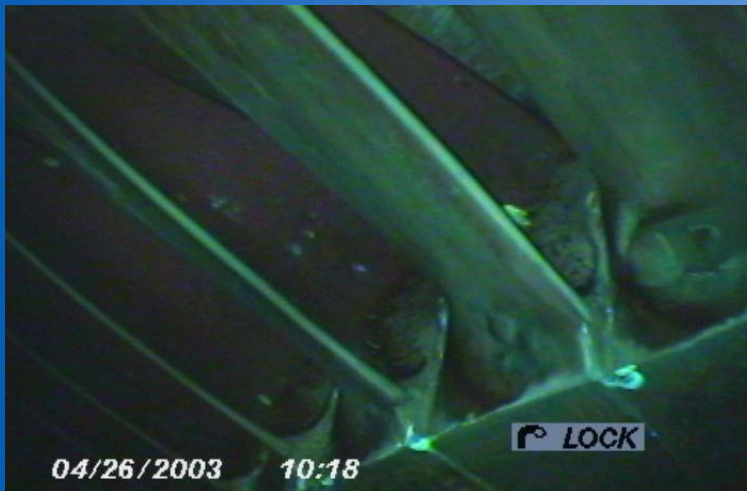
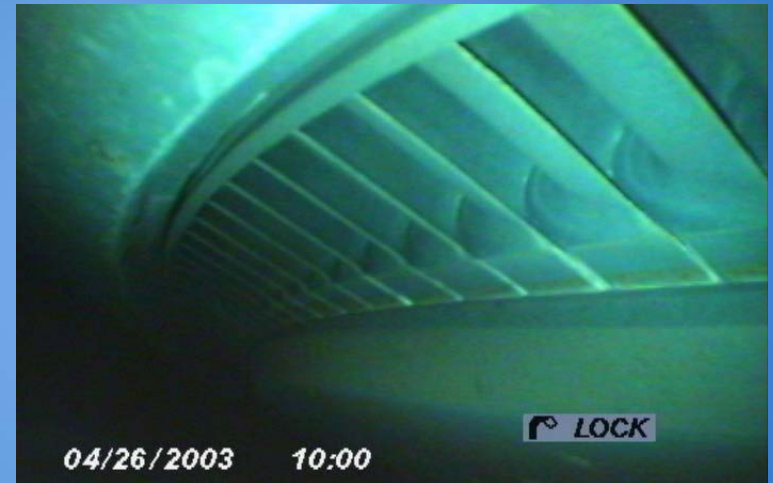
- ❖ Coating has eroded away
- ❖ Otherwise buckets are in adequate condition



Elliott

Inlet End Stages

- ❖ Nozzles and Buckets in better condition than on the exhaust stages
- ❖ Less evidence of corrosion or deposits



Elliott

Maintenance Action

- ❖ Condition not unexpected given
 - The unit's time in service
 - The online water washing that had been done
- ❖ No immediate maintenance action is required

Summary

- ❖ Turnarounds are a rare opportunity to assess the condition of large rotating machinery
- ❖ Tooling specially designed to maximize coverage inside the machinery makes the best use of the turnaround opportunity
- ❖ If the inspections are done early in the turnaround, maintenance can be performed if problems are found
- ❖ Spare parts and maintenance planning are enhanced even if no problems are found requiring immediate maintenance action

