



Considerations for Long Service Life for Fast Start HRSGs

John DiVitto
330-860-2134
jgdivitto@babcock.com

Mel Albrecht
330-860-6431
mjalbrecht@babcock.com

Babcock & Wilcox Power Generation Group, Inc.
20 S. Van Buren Avenue
Barberton, OH 44203

© 2013 BABCOCK & WILCOX POWER GENERATION GROUP, INC. ALL RIGHTS RESERVED. This document is the property of Babcock & Wilcox Power Generation Group, Inc. (B&W) and is "CONFIDENTIAL AND PROPRIETARY" to B&W. Recipient and/or its representatives have, by receiving same, agreed to maintain its confidentiality and shall not reproduce, copy, disclose or disseminate the contents, in whole or in part, to any person or entity other than the Recipient and/or Recipient's representatives without the prior written consent of B&W.

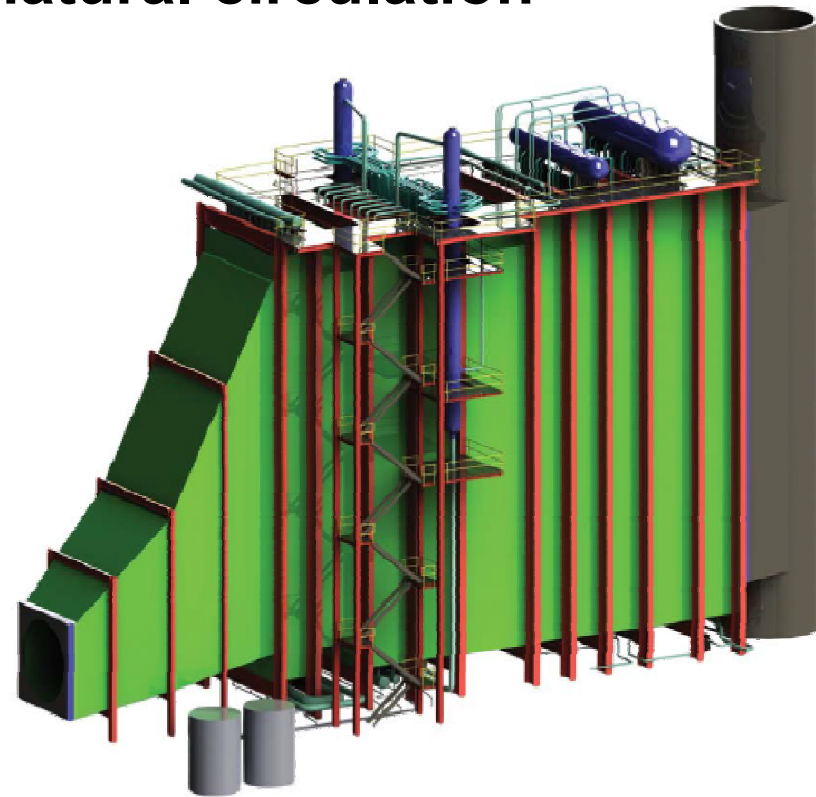
Fast Start / Rapid Load Response

- **Emissions limits**
- **Improve efficiency**
- **Follow load from renewables**



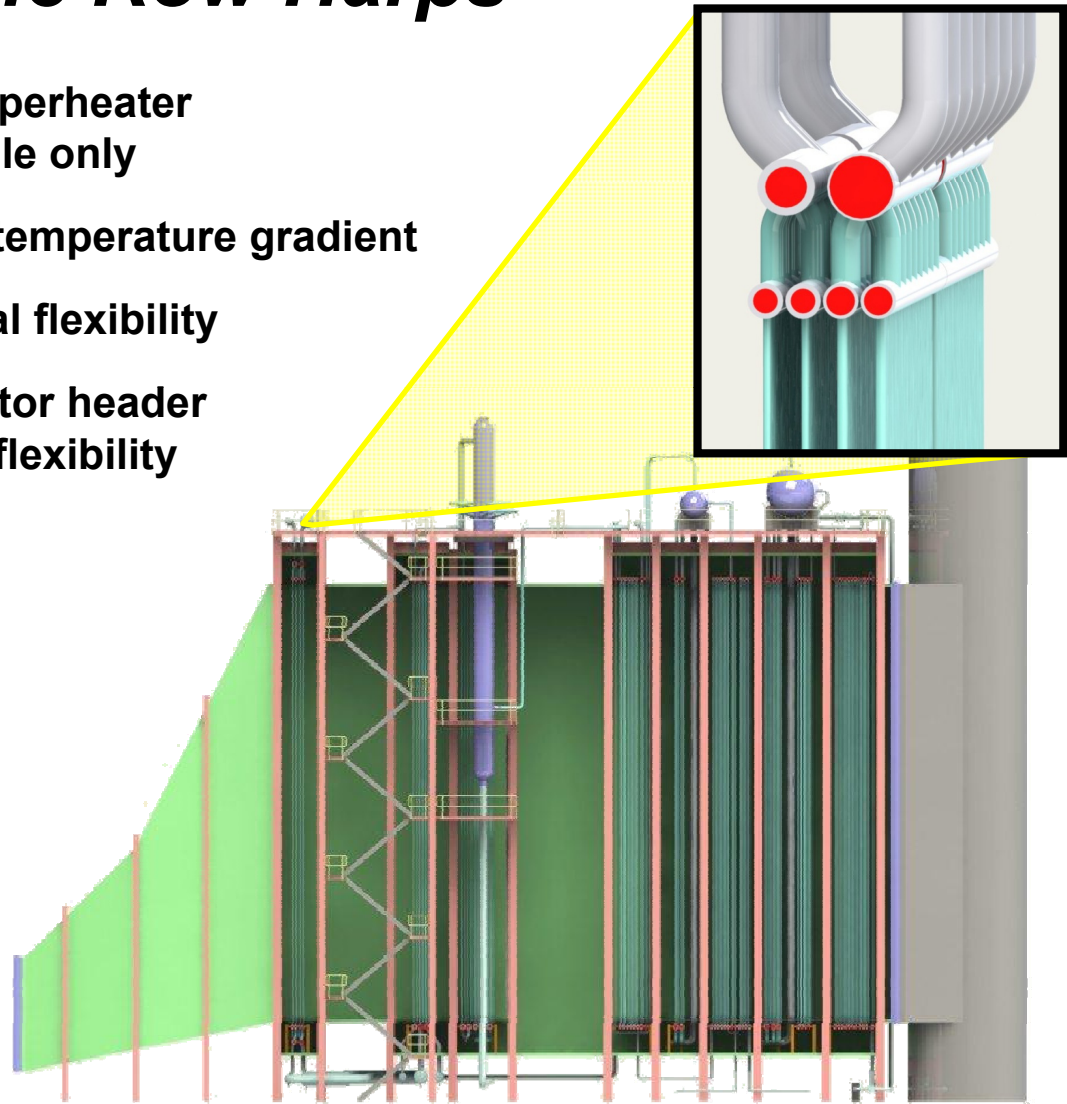
HRSG Considerations

- ▶ **Superheater (SH) / reheater (RH) design**
- ▶ **Drain system**
- ▶ **Vertical separators with natural circulation**
- ▶ **Circulation design**



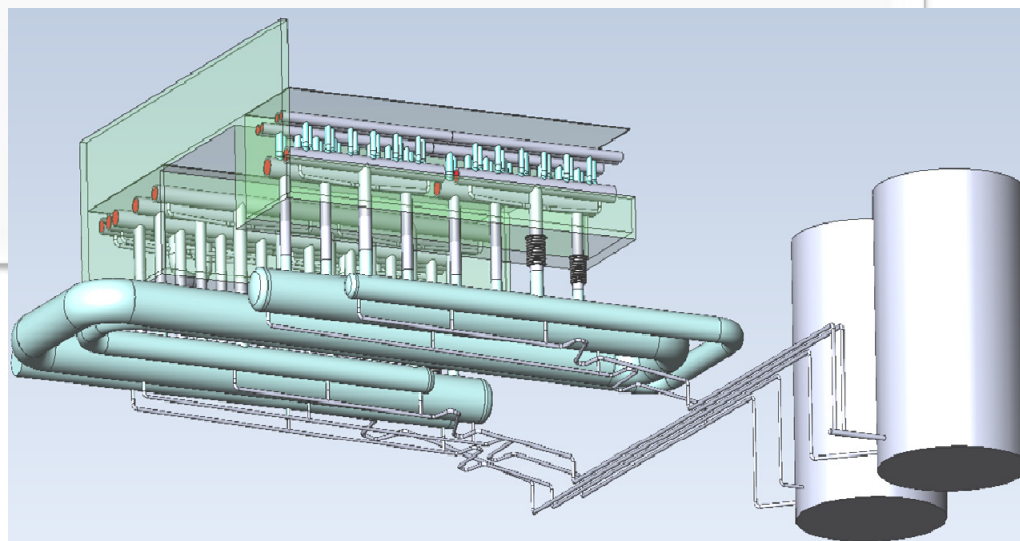
Single Row Harps

- ▶ **Single row harps for secondary superheater and reheater (SSH/SRH) tube bundle only**
- ▶ **Reduced tube header to tube wall temperature gradient**
- ▶ **Thinner headers result in additional flexibility**
- ▶ **Small diameter headers and collector header interconnects provides additional flexibility**
- ▶ **Expansion between tube rows is accommodated in the system, not the tube to header weld**



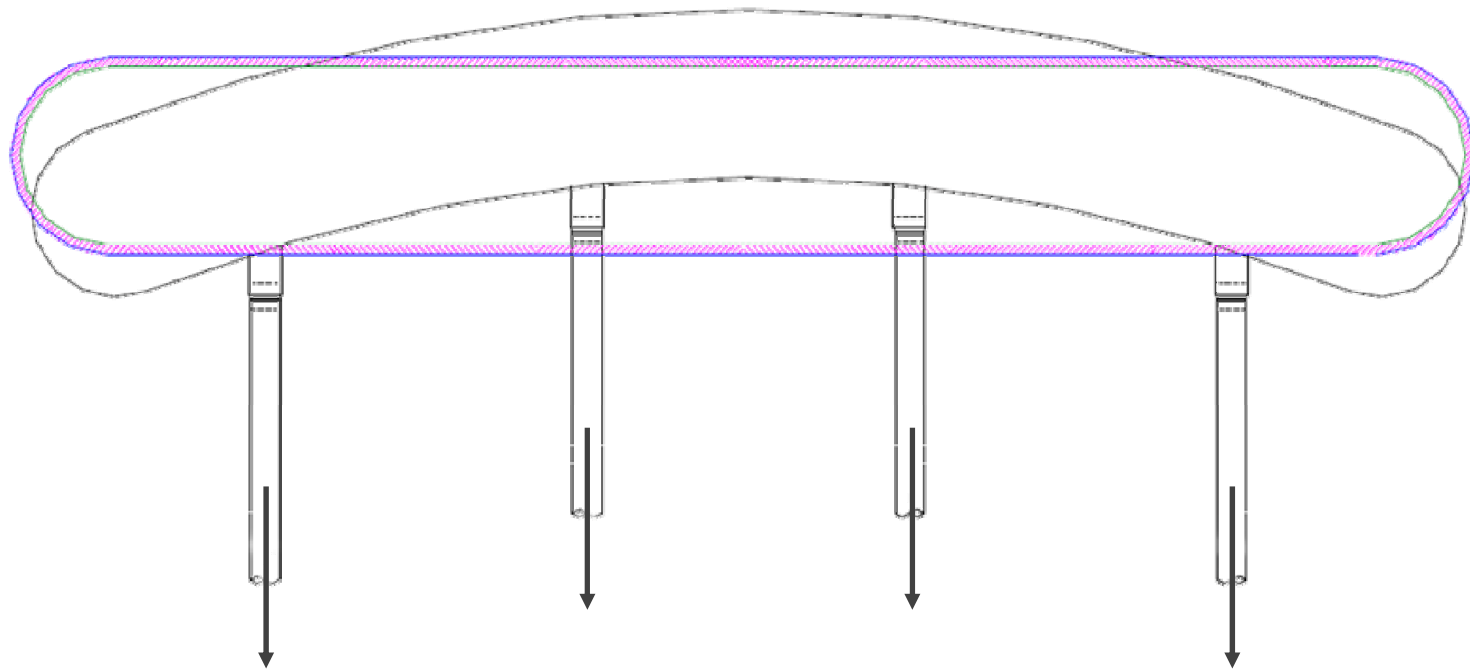
High Flow Drain System

- ▶ **Designed to evacuate the tube bundles during GT purge and light-off conditions where high condensate generation occurs**
- ▶ **Utilizes many of the recommendations of EPRI report “Guidelines on Optimizing Heat Recovery Heat Generator Drains” and industry experts**



Drawbacks of Conventional HP Drum

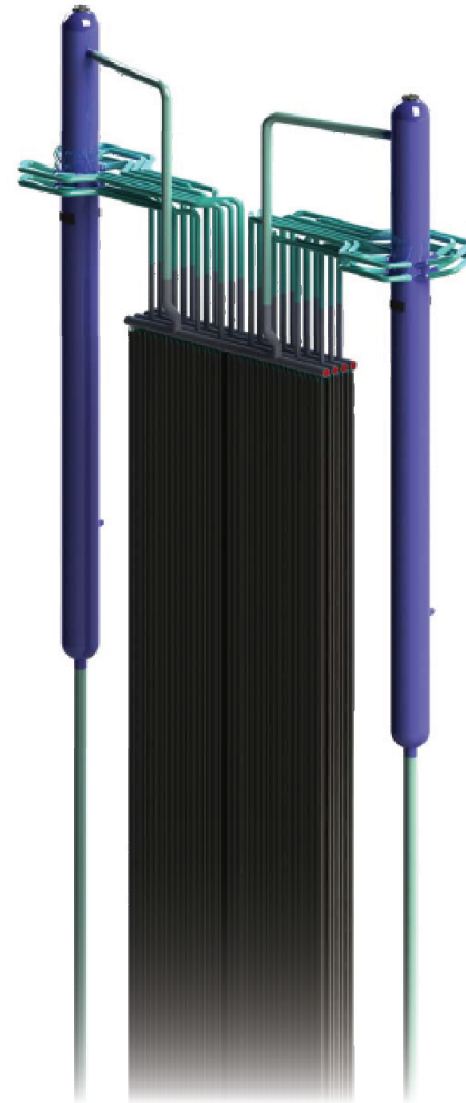
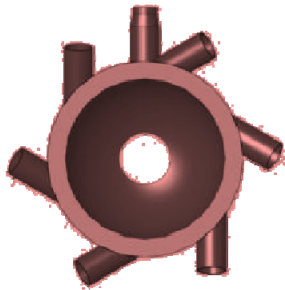
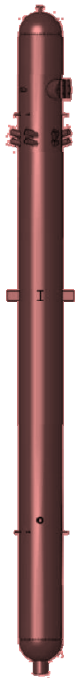
- ▶ **Thick Walls (~7" for a 2400 PSI unit) – limits startup time / HP drum life**
- ▶ **Drum hump during startup and transients**



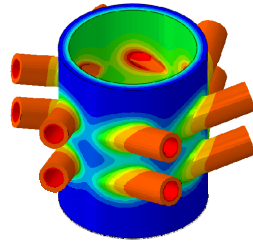
B&W's FastCirc™ Vertical Separator

Vertical Separator Benefits

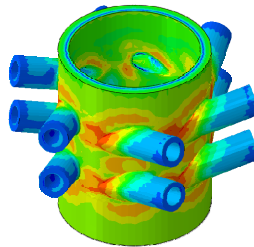
- ▶ **Thin walls (~3" for 2400 PSI units)**
- ▶ **Integral internals**
- ▶ **Increased response to load changes**
- ▶ **Eliminates drum hump problems**
- ▶ **Same steam purity as conventional drum**
- ▶ **Expands in the vertical direction (same as tube bundles)**



Vertical Separator Analysis



Temperature contour plot



von Mises stress contour plot

FastCirc Vertical Separator vs. HP Drum

Cycles	Vertical Separator	HP Drum	Design Cycles
Cold	1%	10%	200
Warm	6%	32%	1170
Hot	18%	140%	4680
Total	25%	182%	6050

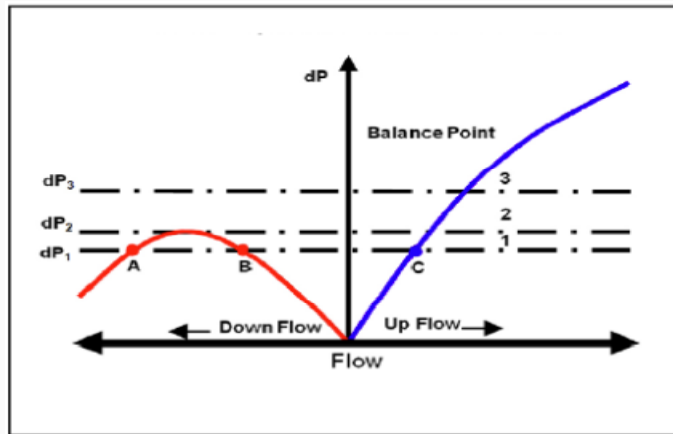
Circulation Design Criteria

- **Exit quality**
- **Saturated water head**
- **Departure from nucleate boiling (DNB)**
- **Supply / riser / downcomer velocity limits**
- **Flow stability**
- **Circuit velocity limits**
- **Flow sensitivity**
- **Drum internals**



Flow Stability and DNB

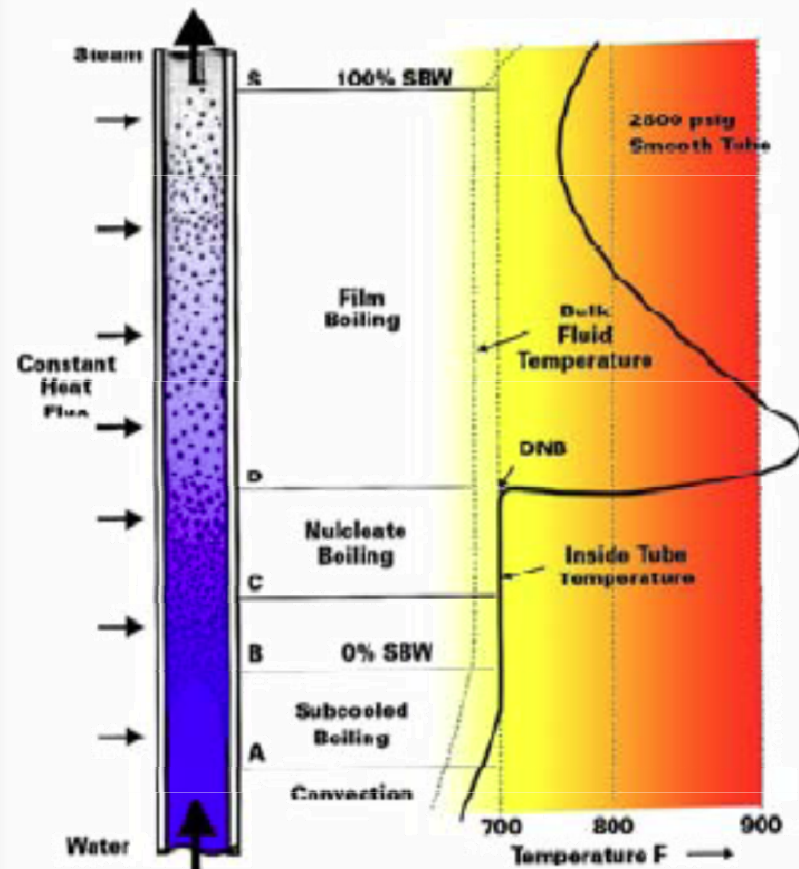
Flow Stability



Flow Sensitivity

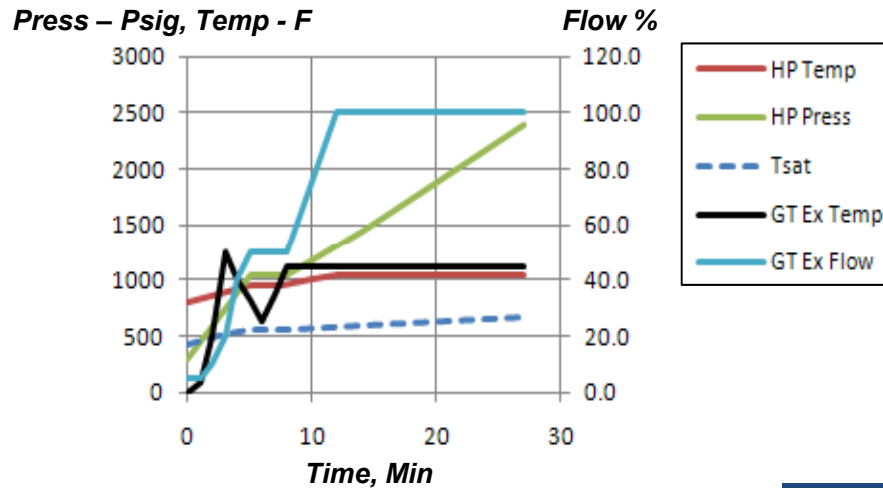
- In a natural circulation system, steam-water mixture flow increases with increased heat input until a point when maximum flow is reached
- Mixture flow then begins to decrease as specific volume and frictional pressure losses offset the pumping head increase due to increased heat absorption.
- Beyond this point, the flow begins to decrease and circuits become unstable and may flow erratically (*flow upward, stagnate or flow backwards*)

Departure from Nucleate Boiling (DNB)



Startup Time

Typical Gas Turbine Ramp Rate For Hot Startup



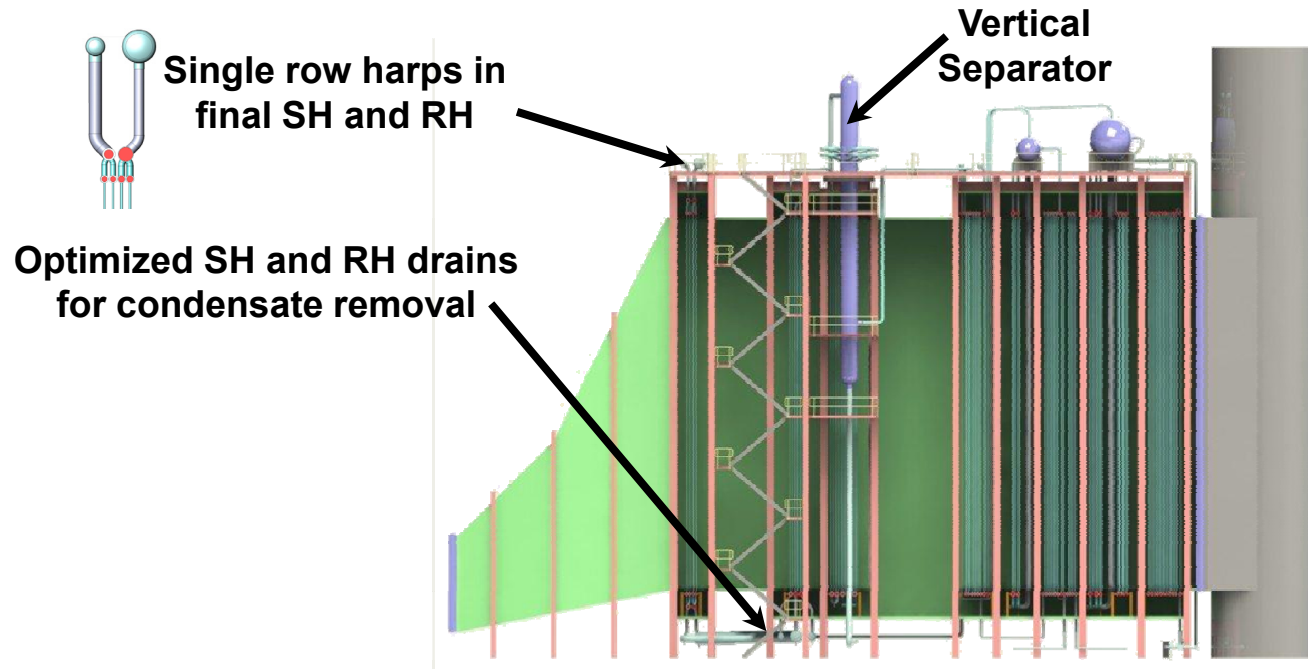
- ▶ Hot start ≤ 8 hours
- ▶ Warm start > 8 hours and ≤ 72 hours
- ▶ Cold start > 72 hours

HRSG Startup Transient Conditions

Start Type		Cold	Warm	Hot
Time to MCR	Minutes	100	96	27
Drum	Press., psig	2430	2430	2430
	Temp., F	665	665	665
SSH Out	Press., psig	2400	2400	2400
	Temp., F	1050	1050	1050
Lifetime Cycles (30 years)		200	1170	4680

Conclusions

- ▶ New concept for rapid start HRSG through the use of vertical separators
- ▶ Developed to meet the demands and needs for an HRSG into today's environment
- ▶ Enhanced fatigue tolerance for dispatching and cycling a combined cycle plant through thinner pressure part components





Thank you.

Questions?

