PWR Dispersant Review & Update
OptiSperse PWR6600
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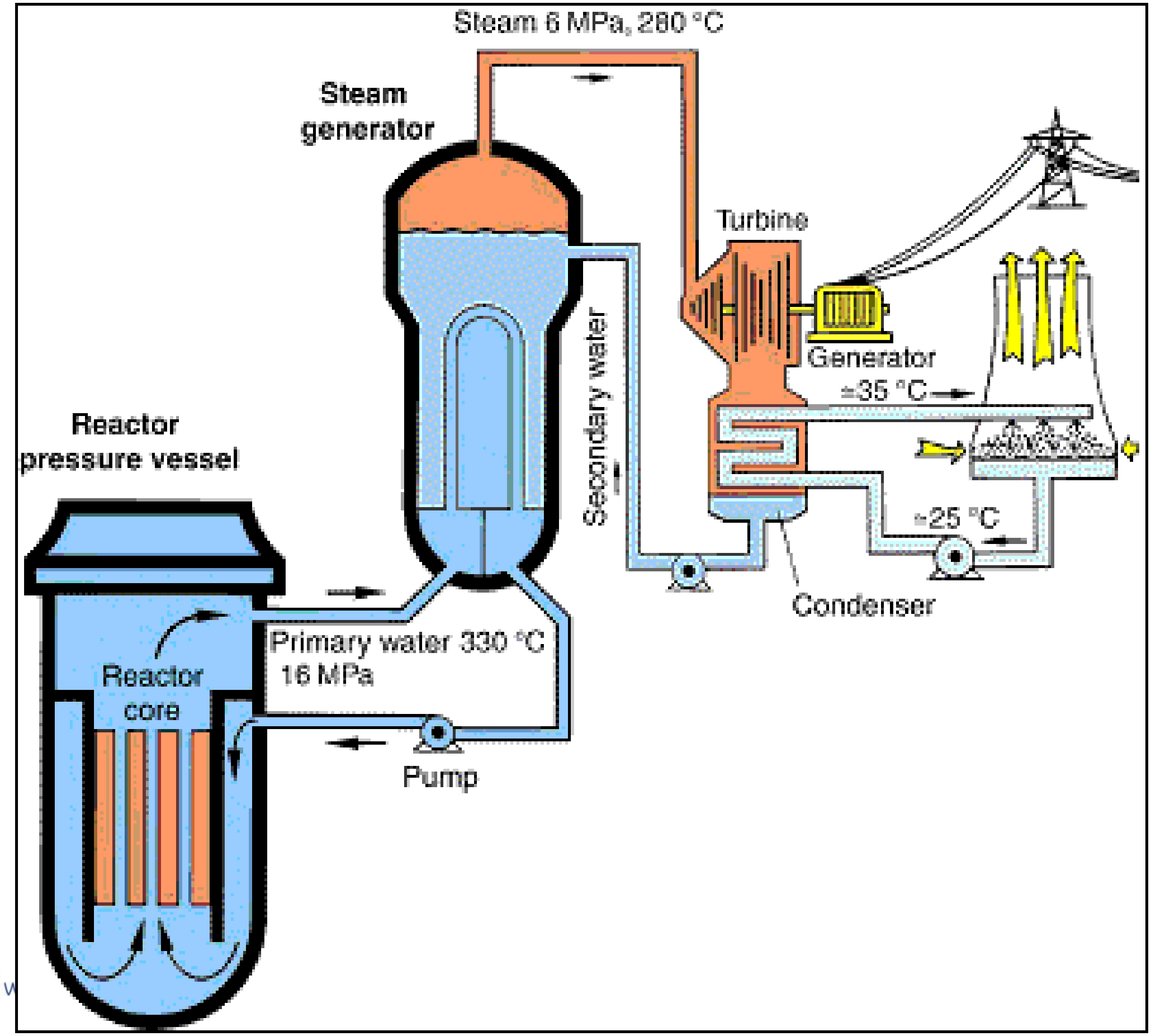
OptiSperse PWR6600
Performance Goals & Development History

PWR –> Pressurized Water Reactor

We will specifically discuss the application of a polymeric dispersant for control of iron oxide deposition in the "secondary-side" steam generators which receive as the heat source radioactive primary water from the reactor core, and utilize the thermal energy to product 900 to 1000 psig saturated steam for power generation in traditional steam turbines. The units to which the dispersant is applicable on-line are recirculating PWR designs with continuous blowdown, versus once-through SG designs. Typical recirculating PWR designs include a set of 2 to 4 Steam Generators producing approximately 800 to 1200 Megawatts of electrical power at peak capacity, and generating between 1.2 and 1.6 billion pounds of steam per hour.

Pressurized Water Reactor (PWR) Schematic



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OptiSperse PWR6600 Dispersant Development

- Joint development effort – CommEd (now Exelon) and BetzDearborn (now GE Water) –> 3 active patents
- Unique, high molecular weight polyacrylate with high-purity organic initiators – no sulfates, chlorides
- More than an order of magnitude higher in MW of typical synthetic polymers used in fossil boiler applications
- Laboratory testing showed surprisingly high iron oxide dispersion activity at very low Polyacrylate (PAA) dosages
- At SG pressure of 900 psig, dispersant is well within normal pressure range of fossil boilers
- EPRI – Electric Power Research Institute – Has managed, evaluated and monitored the process to trial and qualify the dispersant since 2000 ->
  - Dr. Keith Fruzzetti – EPRI Nuclear Chemistry Program Manager

Goals of PWR Dispersant Application in PWRs

- Sustainable, long-term reduction of iron corrosion product accumulation in SG of 50% or greater
  - Current level of accumulation of iron corrosion product is > 95%
  - Reduced potential for corrosion under deposits in occluded areas
  - Reduced possibility of thermohydraulic instabilities caused by blockage of tube supports

- Long-term SG thermal performance benefit
  - Improved heat transfer efficiency and thermal margin

- Potential for long-term reduction in routine off-line cleaning frequency -> sludge lancing

- Long-term goal is reduction in frequency or complete avoidance of full bundle steam generator chemical cleaning procedures

- Negligible or easily-managed secondary effects on operations, SG and BOP materials

EPRI Evaluation Project
Short Term Trial Results
Arkansas Nuclear ANO-2

Short-Term Trial- ANO 2- Spring 2000
Key Performance Summary

- Heavily fouled Westinghouse 1st generation Steam generator (SG)
- Iron rejection to SG blowdown increased from 1-2% (negligible) to 20 – 60% with 0.5 to 12 ppb active PAA dispersant fed to the SG feedwater
- Small but measurable increase in global fouling factor (14 uh-ft^2-^{0}F/BTU) at elevated PAA feedrate of 6 – 12 ppb
- No measurable effect on FF at feedrates up to 4 ppb PAA
- No changes in cation conductivity were observed
- No impact on ion exchange resins
- Performance met pre-trial goals, except for small increase in measured fouling factor at elevated PAA feedrate

EPRI Evaluation Project
PWR Dispersant
Long Term Trial Results

Long-Term Trial – Duke McGuire 2
Aug. 2005 – Aug. 2007

- At 1.5 to 4 ppb active PAA feedrate, steady-state iron rejection to blowdown increased from < 5% to 45 – 50% - See Fig 1

- Initial injection removed large quantity of easily dispersed iron – see Fig 2
  - Lesson - Blowdown filter management at outset

- Approx. 200 lbs total iron removed from Aug 2005 > June 2006 - Fig 3

- Small but measurable effect on cation conductivity + 0.15 uS/cm
  - Amine chemistry is major CC contributor – Range 0.2 – 1 uS/cm

- Change is steam flow indications
  - Attributed to defouling of secondary steam separators/outlet venturis
  - Caused no operational issues as steam flow measurement not used

- Slight fouling factor decrease - 4 uh-ft^2-^{0}F/BTU
  - Opposite the effect observed at ANO-2 STT

Figure 2 - McGuire Unit 2 Iron
Chronological history of PAA trial
FW Iron/Blowdown Iron/FW PAA concentrations vs. time

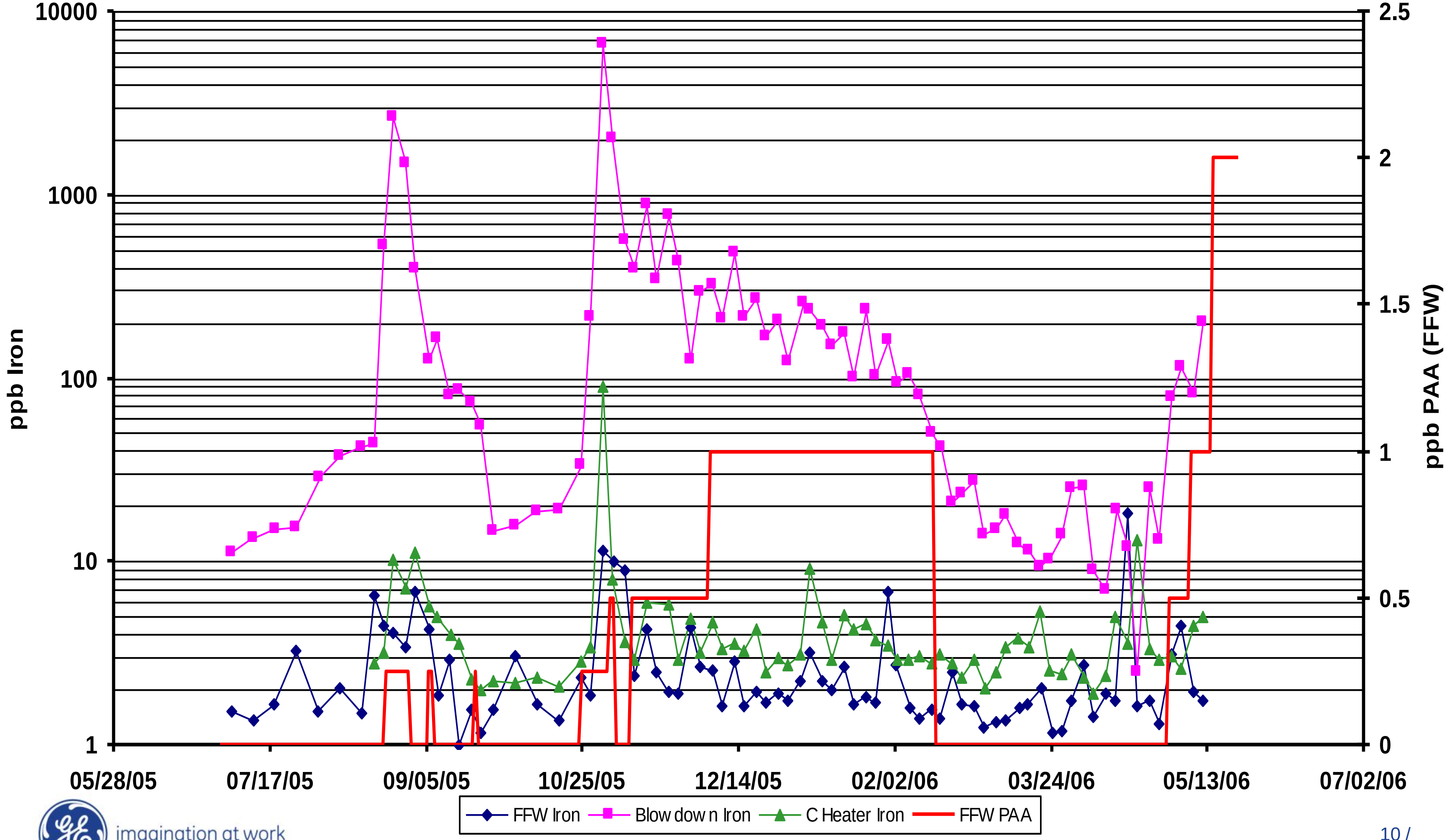

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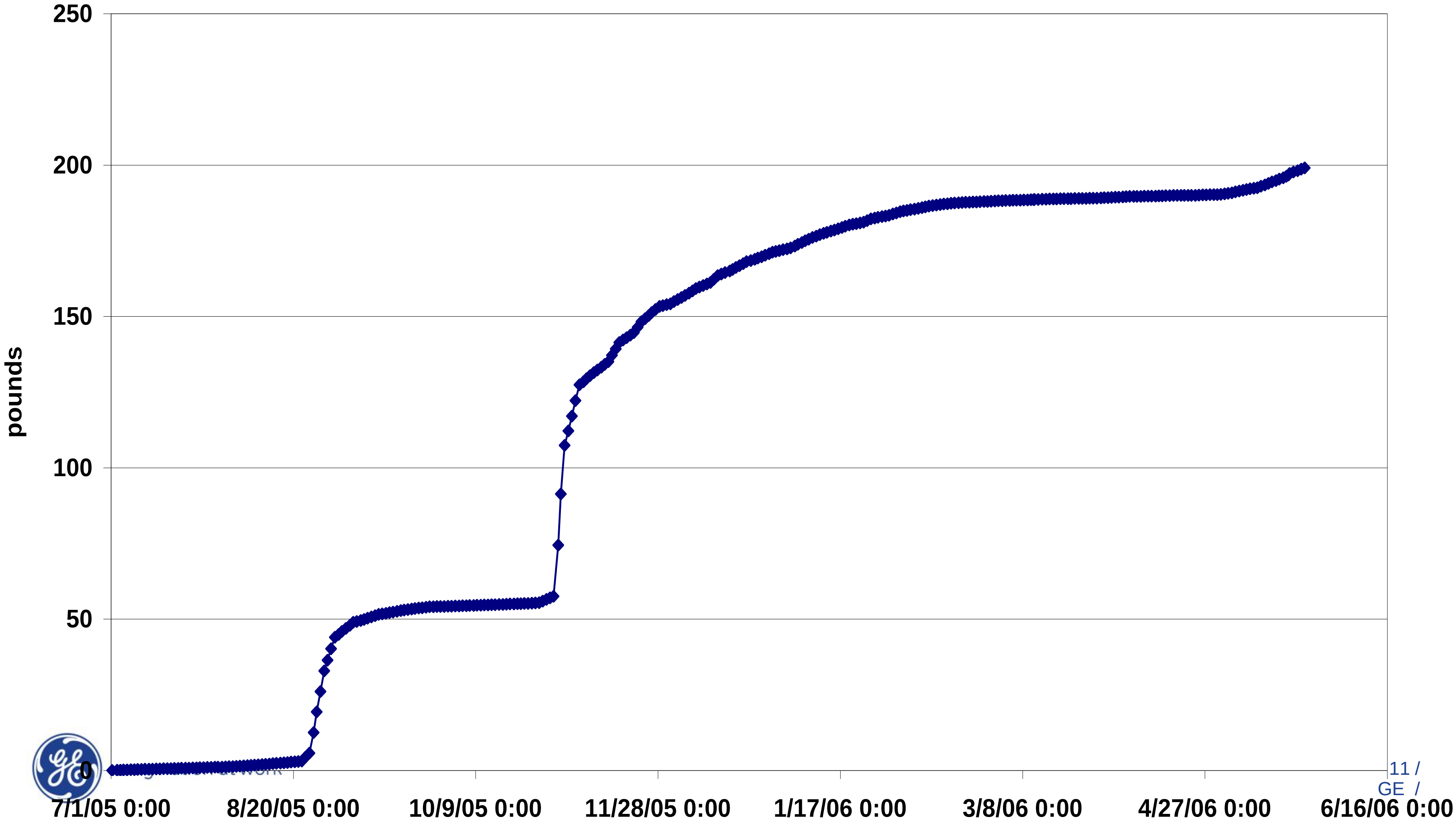
Figure 3 - McGuire Unit 2
Progressive Total Pounds of Iron Removed
Aug 2005 through June 2006



Long-Term Trial – Duke McGuire 2
Key Experiences & Learning

- ✓ PAA performed effectively and reproducibly as iron dispersant
  - o 2 – 4 ppb PAA in Boiler feedwater effective for average of 1 – 2 ppb FW Fe
  - o 45 – 50% rejection of FW iron to SG blowdown (vs. < 5% without disp.)
  - o Plant-specific optimization of PAA:Fe stoichiometry

- ✓ Effect on cycle chemistry is manageable
  - Dispersant addition became routine

- ✓ Changes in steam flow indications due to defouling of moisture separators

EPRI Qualification & Application

EPRI Dispersant Qualification and Application Guidelines Development

- Dispersant Guidelines and Application Sourcebook published
  - Dec 2007 – EPRI Publication 1015020
  - The Dispersant Sourcebook provide comprehensive application and monitoring guidance

- Dispersant included as approved chemistry for management of iron oxide accumulation in recirculating PWR Steam Generators in 2009 revision of EPRI PWR Secondary Steam Generator Chemistry Guidelines

- INPO credits dispersant use by reducing the CEI iron term for those applying dispersant
  - INPO – Institute of Nuclear Power Operations

Update

2010 Exelon Dispersant Application Update

Exelon Byron 1 Dispersant Application Update

Byron 1 initiated PWR6600 feed in April 2009. Results through May 2010:

- Significant rejection of existing iron inventory at 1 ppb PAA in feedwater > 100% iron rejection initially

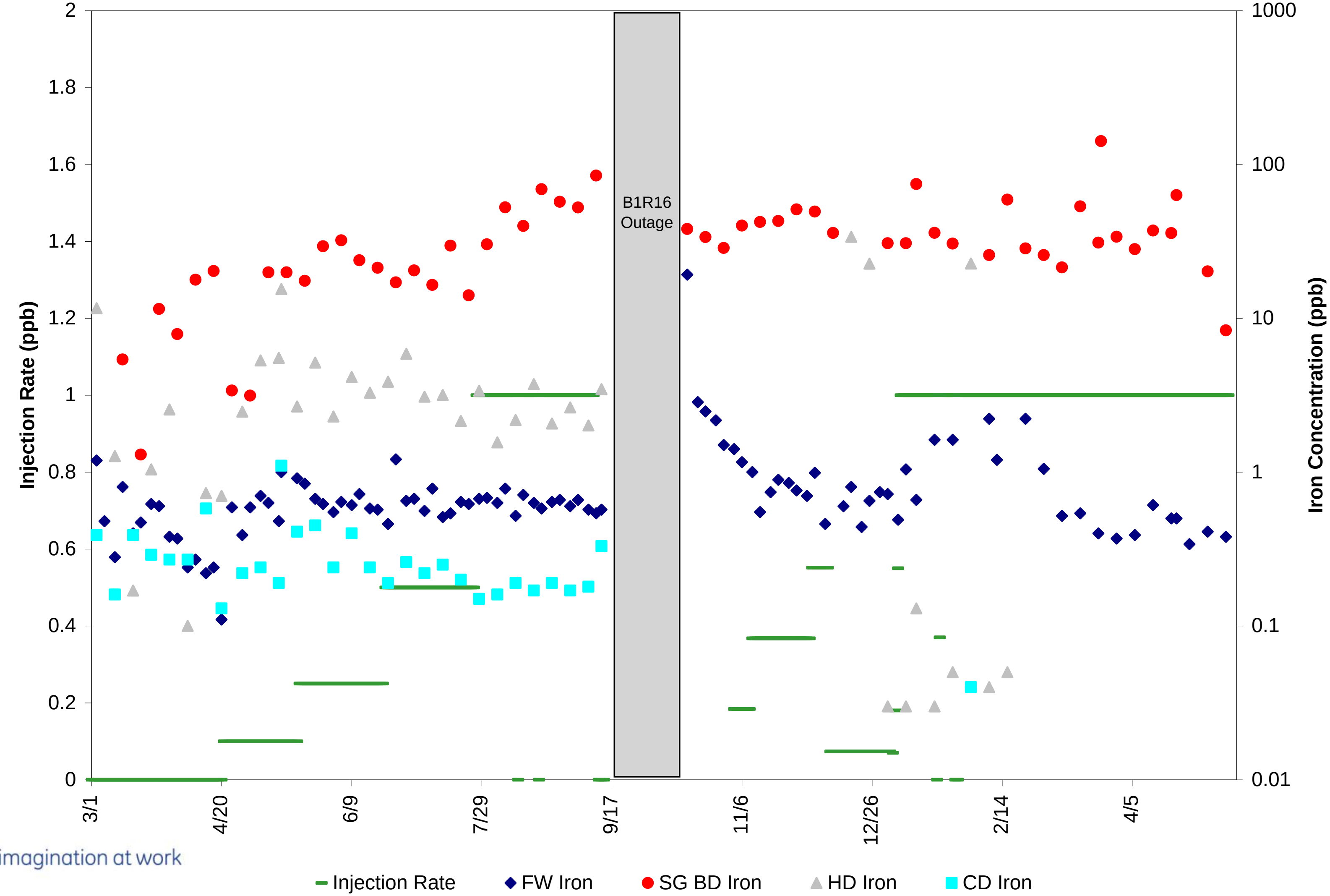
– Sustained rejection of BFW iron to blowdown of greater than 50% (increased from pre-PAA iron transport < 5%)

– Enhanced thermal performance

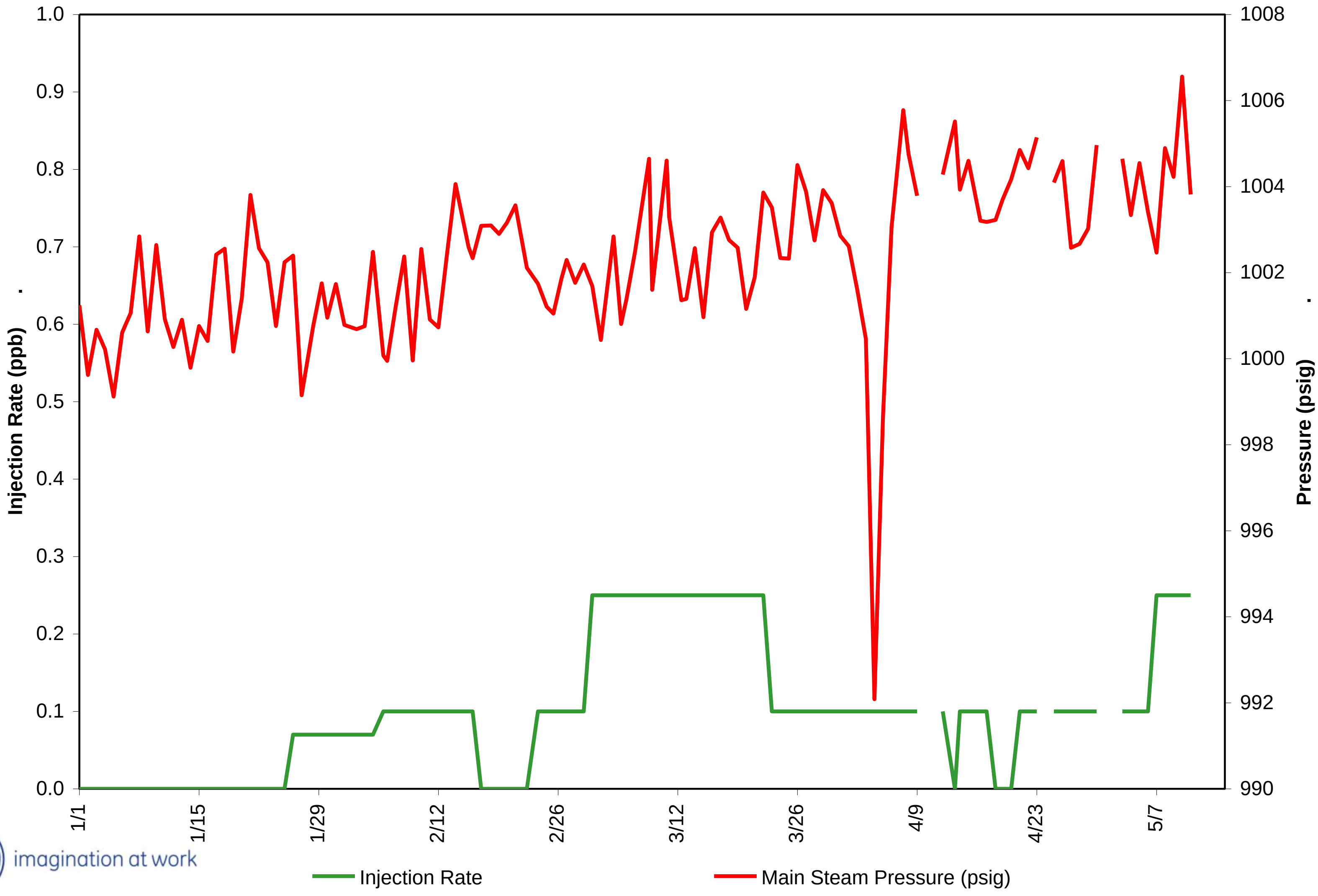
- Indicated steam flow values returning to "new steam generator performance
- Main steam pressure increase –> Increased power output potential
- Positive impact on thermal margin –> Valve Wide Open (VWO) margin has increased significantly –> 7% valve travel or approx. 1% increased steam flow margin

Exelon Byron 1 PWR Dispersant Spring 2010 Update
Steam Generator Blowdown Iron Concentration

Application period: March 2009 -> April 2010



Exelon Byron 1 – Main Steam Pressure Increase with PWR Dispersant Feed



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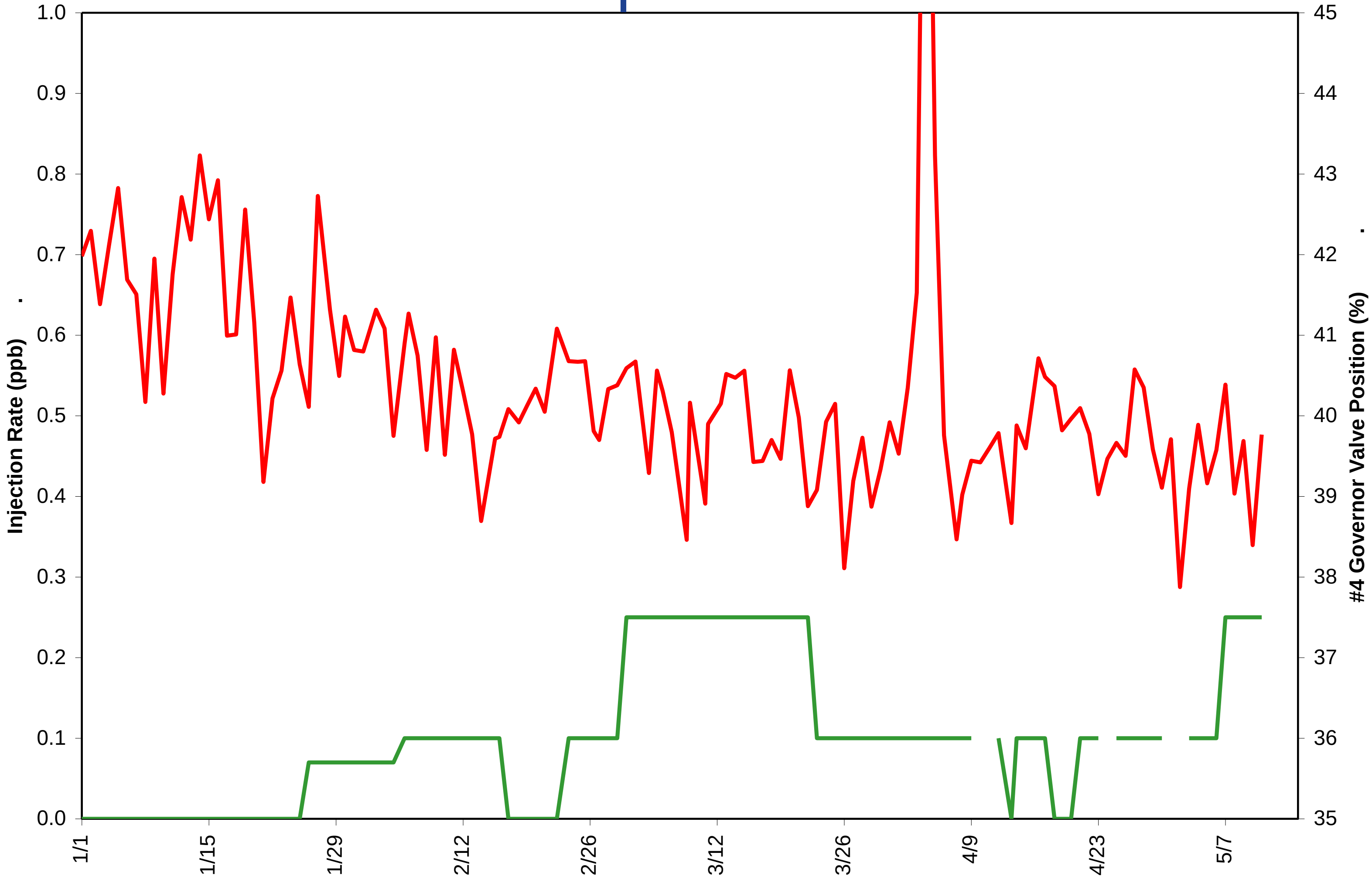
Exelon Byron 1
#4 Steam Governor Valve Position versus VWO with PWR Dispersant Feed



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Exelon Braidwood/TMI Application Updates

- PWR6600 injection initiated at Braidwood 1 in January 2010
  - Results through May2010 very similar to Bryon 1

- Three Mile Island (TMI) Off-line Soak Dispersant application
  - OptiSperse PWR6600 increased iron removal from PWR once-through steam generator when added as off-line soak/wet lay-up additive

- EPRI-sponsored "long-path recirculation" condensate flush demonstration scheduled for Spring 2011 at Exelon Byron PWR

Thank You

This Session is now
Open for Questions