Browns Ferry Unit 1 update: ISOE
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Where We Were:

- Browns Ferry Unit 1 was shut down in 1985.
- In 2002 a decision was made to recover the unit.
- On December 26, 2006 Fuel load was completed on BFN1.
- Start up was June 2007.

Overview

- Review of unit 1 recovery and restart valve replacements, showed that cobalt reduction was not being actively pursued.
- A level B PER was initiated and a HIT was formed to improve the process on Unit 1.
- Units 2 and 3 also have a standing PER for increase of source term.
- EPRI and INPO were contacted to provide Industry experience in cobalt reduction.
- Hatch, Fermi, Quad Cities, and Limerick were identified as industry leaders in Cobalt reduction efforts.
- Plant Hatch cobalt reduction project manager provided a presentation to the HIT on their successful effort in the 1990’s.
- Using industry benchmarking, an overall cobalt reduction plan was developed and is being implemented.
- EPRI critique indicates that BFN1 plan is comprehensive and aggressive.

Cobalt in Perspective

- Cobalt-60 is the principle contributor to out-of-core radiation fields in both boiling and pressurized water reactors. A hard facing alloy trade name Stellite®, which has high cobalt-59 content, is identified as the primary source of cobalt-60 in reactors. Cobalt is released through erosion, corrosion, friction, and through debris left from work on components containing Stellite®. When cobalt is released in systems with a flow path to the reactor, it can become activated to cobalt 60. Cobalt-60 is a high energy gamma emitter with a 5.3 year half life. This contaminant plates out in plant piping systems and produces long term high radiation areas in the plant.
- 1 gram of cobalt-60 is equal to 1,132 Curies of radioactivity and as a point source (a metal sphere 6 mm in diameter) emits a radiation field of 1,500 R/hr at 1 meter.

Cobalt in Perspective

- Chemistry sampling on BFN operating units indicates 800 gm/yr of cobalt 59 is being inputted into the reactor via turbine blades, valves, control rod blade pins and rollers, jet pump components, and stellite® debris from maintenance activities.
- The majority of this is deposited on the fuel and vessel components. However, a portion is deposited on associated piping in the drywell and reactor building.
- Based on EPRI research, 70% of the dose accrued on BFN operating units is due to cobalt-60. This is equal to 330 man-rem for FY 04.
- For each gram of cobalt introduced into the reactor, $1000/yr of depleted zinc (DZO) injection into the feed water is required to suppress the deposition on plant piping systems.
- Less than 1/10th of a gram of cobalt-60 is removed during chemical decon of the drywell recirculation piping at a cost of $2 million.

What We Did:

- 74 valves containing stellite® will be replaced with non-stellite® material. 26 of the valves were identified with high impact by the team and 48 were identified by Design after the level B PER.
- 22 of the 74 valves have now been installed. The team is now monitoring to ensure completion.
- All Control Rod Blades on BFN 1 will be replaced with “cobalt free” i.e., <0.5% versions. The team was able to negotiate with the vendor to reduce the cobalt content of blade material from <0.05% to <0.02%. The team continues to monitor production of the blades.
- All Low Pressure Turbines will be replaced. The final stage blades will be flame hardened chrome moly last stage blades instead of stellite®. The team continues to monitor production of the turbines.
- Removed 20 guide tubes and vacuumed the bottom head of the vessel.
- Placed a mobile demineralizer on the Refueling floor to remove any additional impurities prior to placing systems in service.

What We Did:

The team identified debris from work on cobalt containing components as a major cobalt contributor. Procedures were revised to install dams and barriers to ensure cobalt debris containment. Tools such as vacuums and cameras were purchased to enhance cleanup after valve maintenance. New valve lapping machines were purchased to improve work performance and reduce personnel time In radiation areas. X-Ray fluorescence technology was used to empirically identify elemental cobalt debris left after component work. Craft and Supervision were briefed on the problems associated with cobalt dust and fines. The technique tested during BFN 3 outage with initial analysis post outage showing lower soluble cobalt concentration in the reactor coolant system. The technique of smearing valve internals for elemental cobalt debris is now being used on units 1, 2, and 3 at BFN for the 18 systems with a flow path to the reactor vessel.

- Valve technicians were assigned to sample after component work to ensure component cleanliness and follow up on failures.
- Filter septa and resin. BFN 1 plans to install 10 micron condemin filter elements to increase cobalt removal. Resin being tested on BFN 2 is showing promise of increased cobalt removal.

What We Did:

- Design, Maintenance, Planning, Chemistry, and Radiation Protection procedures have been revised in order to enhance cobalt removal.
- 14 valves and 2 pumps with historical dose problems were processed by vendor to improve surface finish. Twelve reactor water clean up valves, 2 RHR valves, and 2 reactor water cleanup pumps were mechanically polished, electro polished, chromed, and pre-oxidized. This EPRI approved process provides a long term finish that minimizes cobalt plate out in valve bodies and seats.
- Reactor water cleanup heat exchangers, Recirculation piping, and Reactor water cleanup piping mechanically polished, electro polished, and pre-oxidized. This EPRI approved process will provide long term finish that minimizes cobalt plate out.
- Ultra-sonically cleaned 92 bundles of fuel for initial Unit 1 Core Load.

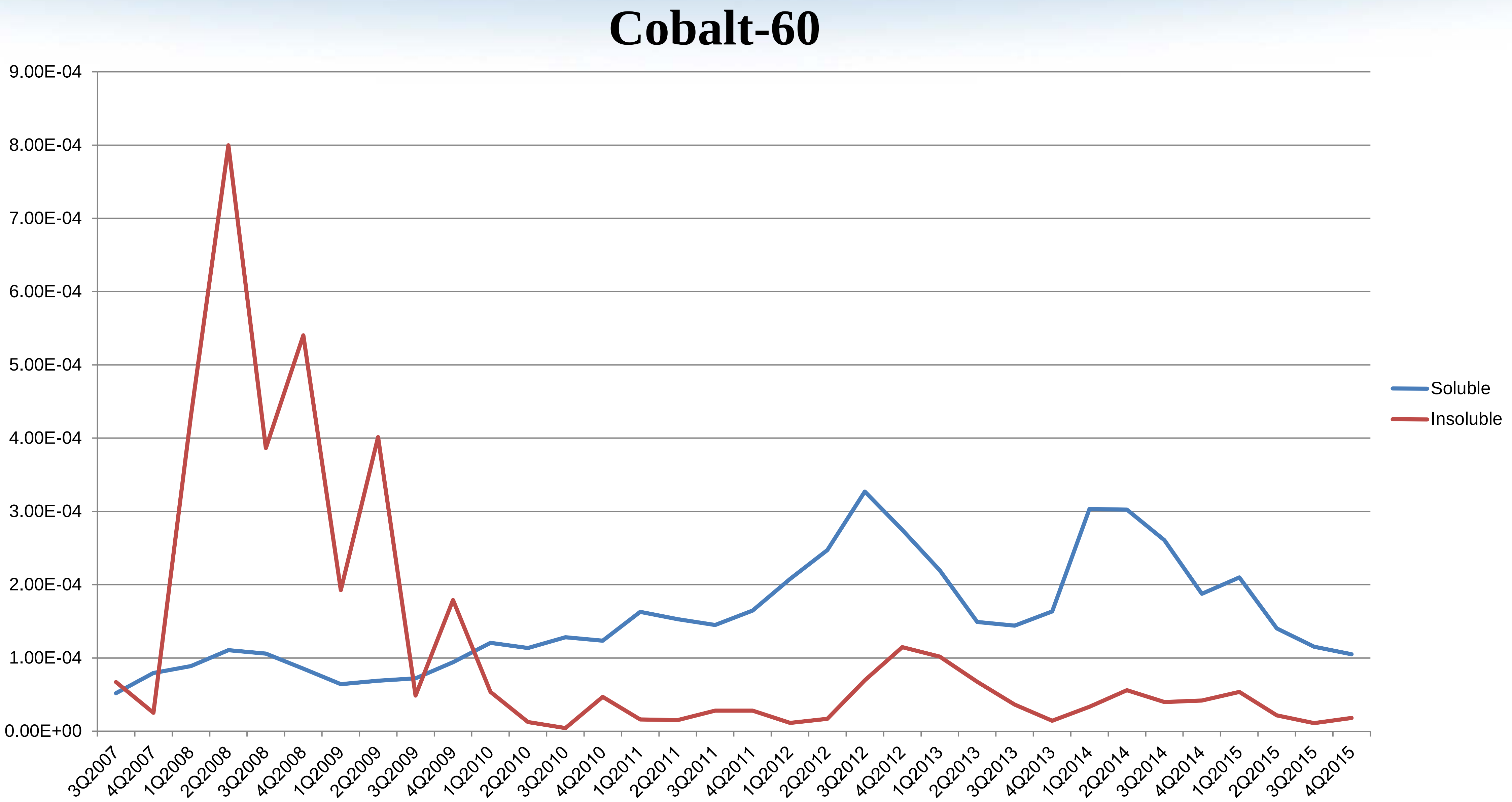
Where the team came up short:

- **Condenser tubes were installed without requiring cobalt content certification. Material was tested after arrival and found to be cobalt free i.e., <0.5%, but contained 0.124 % cobalt. Lower cobalt levels could have been specified in the contract.**
- **Core Spray Testable check valves were installed without electro polishing, chrome, and pre-oxidation. These valves have historical dose from work performed. (PER 67558)**
- **The team was unable to get all valve vendors qualified for mechanical polishing, electro-polishing, chrome application, and pre-oxidation for stainless steel valves. This allowed some stainless steel valves that were already contracted to not receive the process.**
- **Three RHR valves were ordered with non-cobalt material, but were later changed to cobalt due to schedule and vendor inability to provide cobalt free material in time to meet schedule. (PER 69532)**
- **The Cobalt reduction initiative was not initiated at the onset of recovery effort. Additional improvements could have been made.**

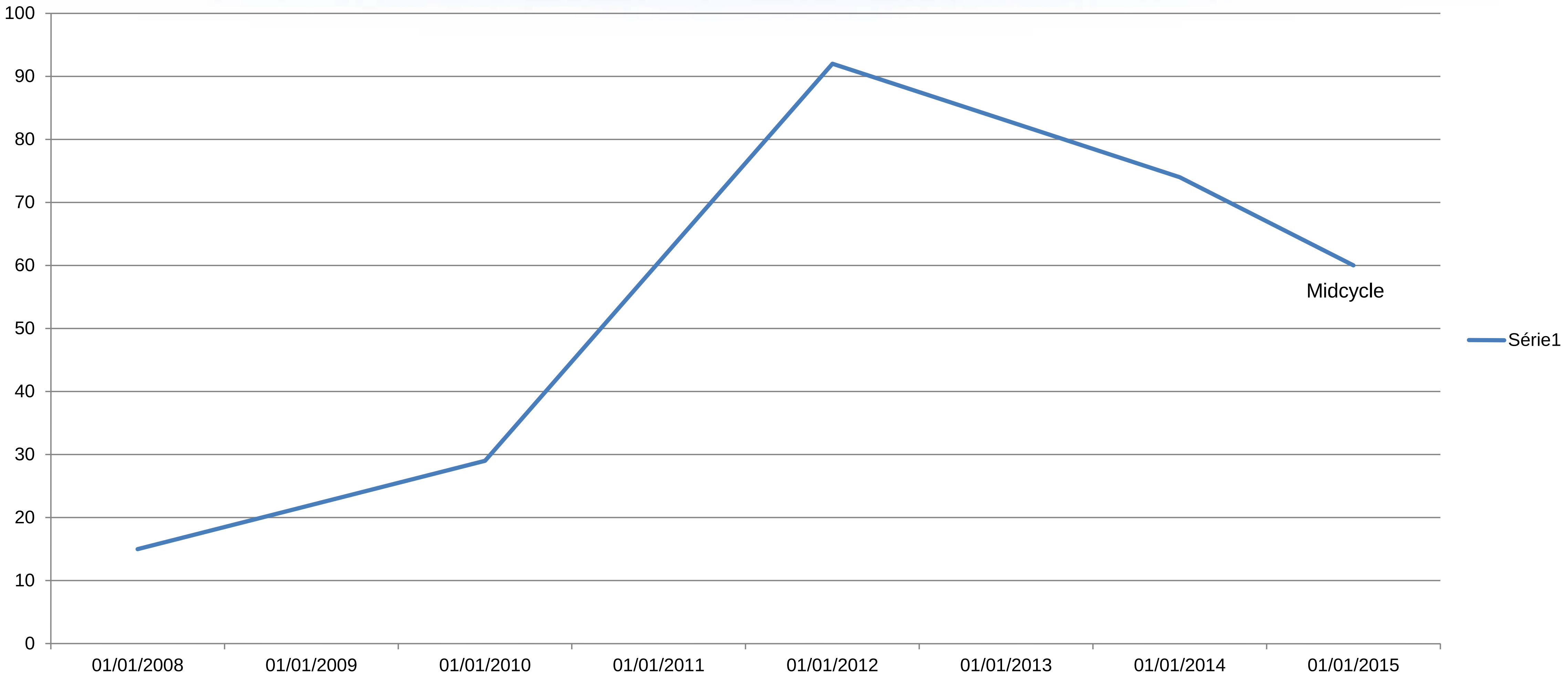
What We Learned:

- **Prioritize your objective money vs. Need.**
- **Time is needed to get what you want. Vendor delivery time on valves is 26 weeks from order at minimum.**
- **Full buy in is needed. Fifteen people from different organizations played on the team.**
- **GL-89-10 valves must have stellite®. The friction factors will prevent other alloys.**
- **You can’t get all you want.** Prioritize
- **Get EPRI,INPO,ISOE etc… on board early. They have the resources to help.**

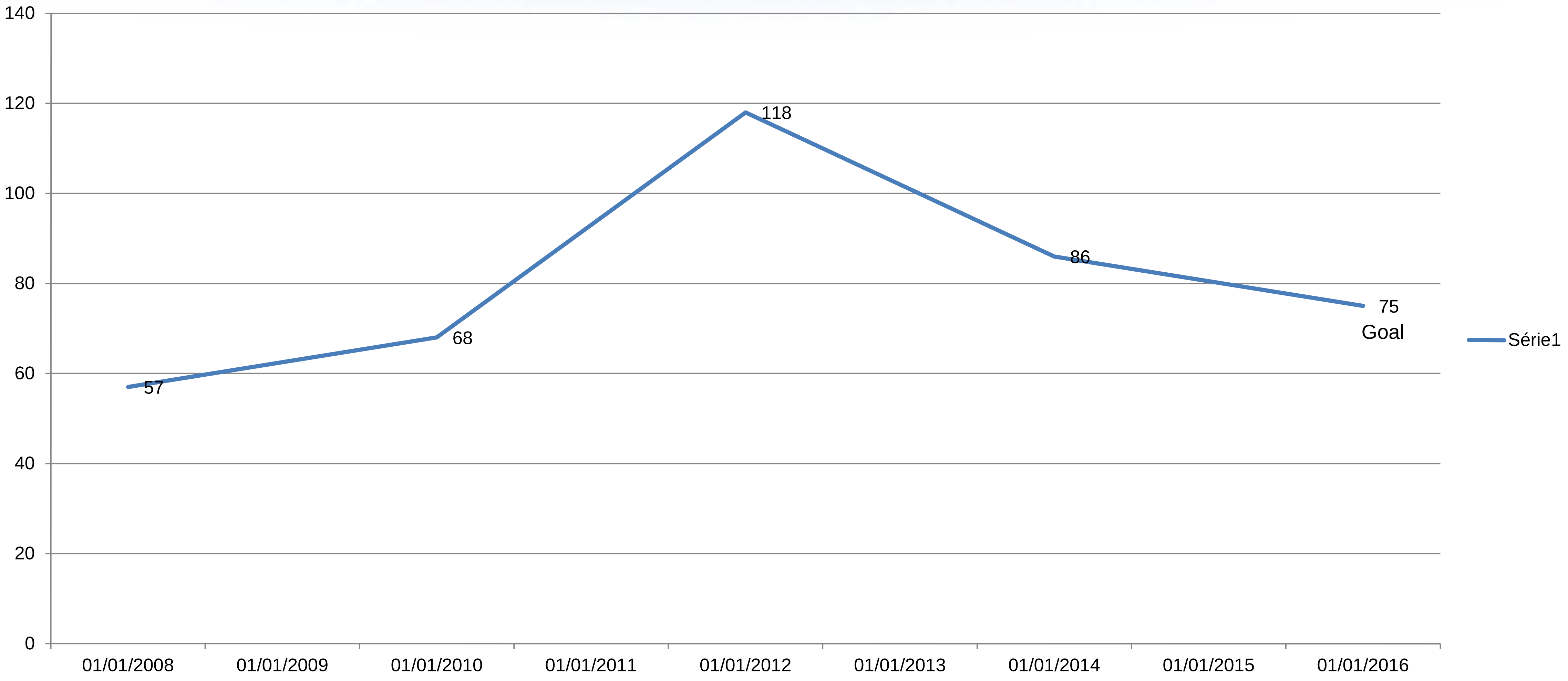
BFN1 Soluble and Insoluble Cobalt 60 data



BFN1 BRAC data



BFN1 outage dose data



What’s Next?

- **AP-1000 and the ABWR can use the applications from BFN 1 and further improve the processes.**
- **Operating Plants can choose from a menu of the applications in order to improve on-going source term reduction plans.**

BFN1 Update

- Questions?