LaSalle Source Term Reduction Update

June 2019

John Moser
RPM LaSalle Station

L2R17

Original Estimate = 245 Rem

Business Plan = 180 Rem

- Support fleet commitments

GAP closure plan developed

- Scope optimization
- Technological improvements
- Source term reduction

Final estimate 192 Rem after GAP plan actions

L2R17

Final results = 211 Rem

- 90+ % of DLR results in
- Major scope additions/impacts
  - 2G33-F004 Emergent Internals Replacement - 20.033 Rem
  - Legacy Jet Pump Foreign Material – 4.028 Rem
  - Steam Carryover of Cobalt – 8.658 Rem

Corrected results without impacts ~180 Rem

2G33-F004 Emergent Internals Replacement

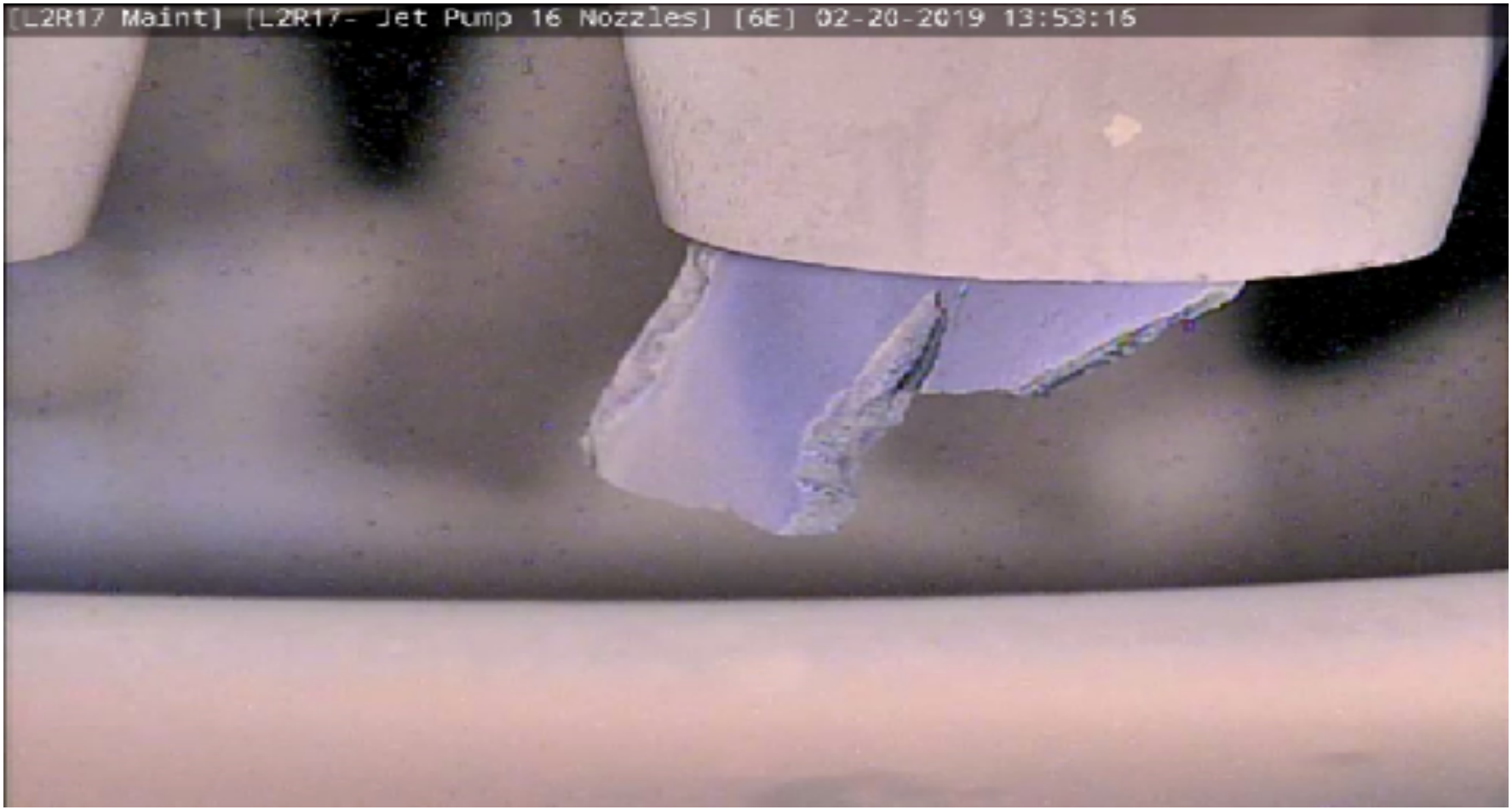
20.033 Rem impact

Dose rates inside valve

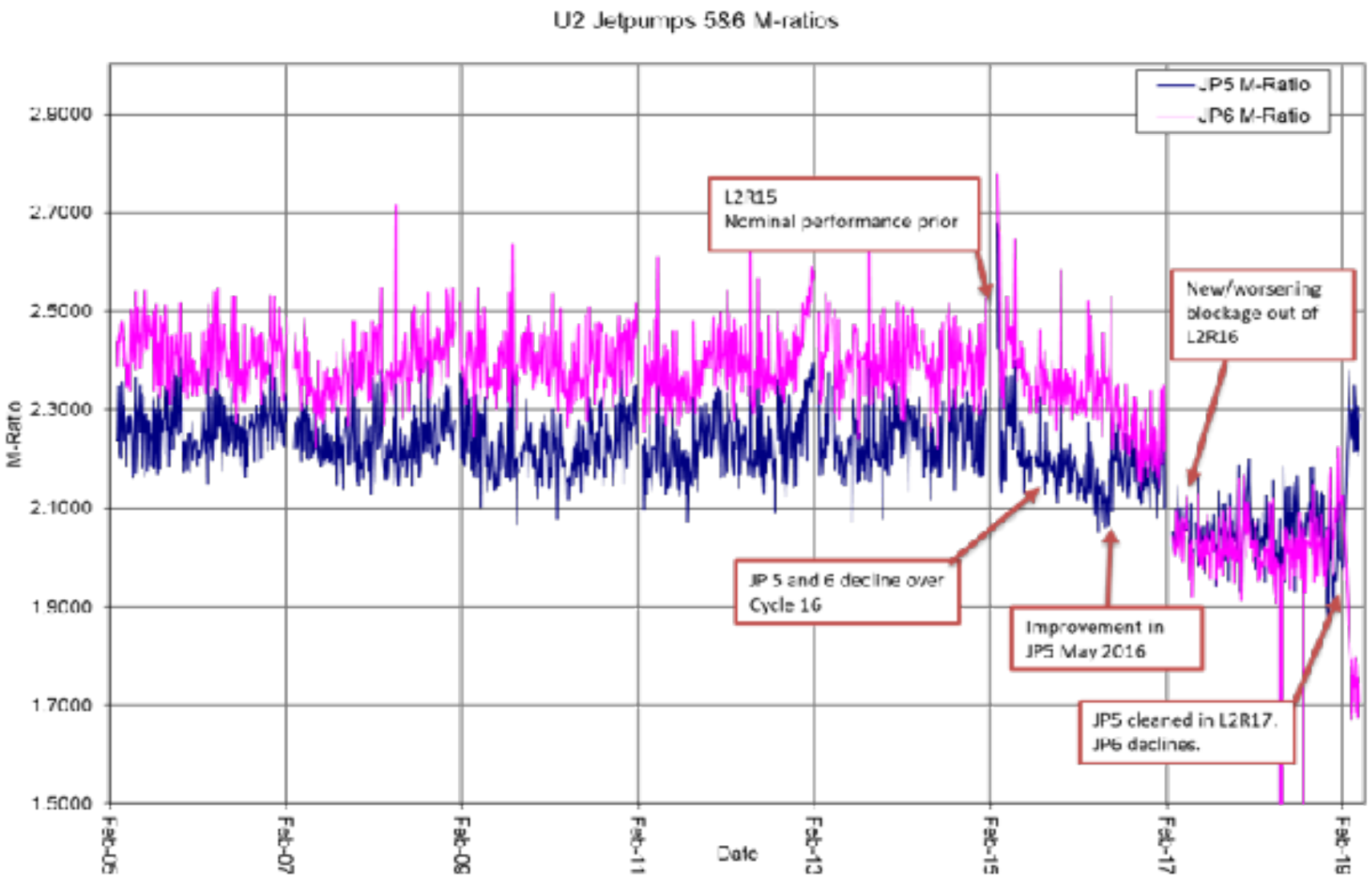
- 180 Rem/hr

Jet Pump Foreign Material

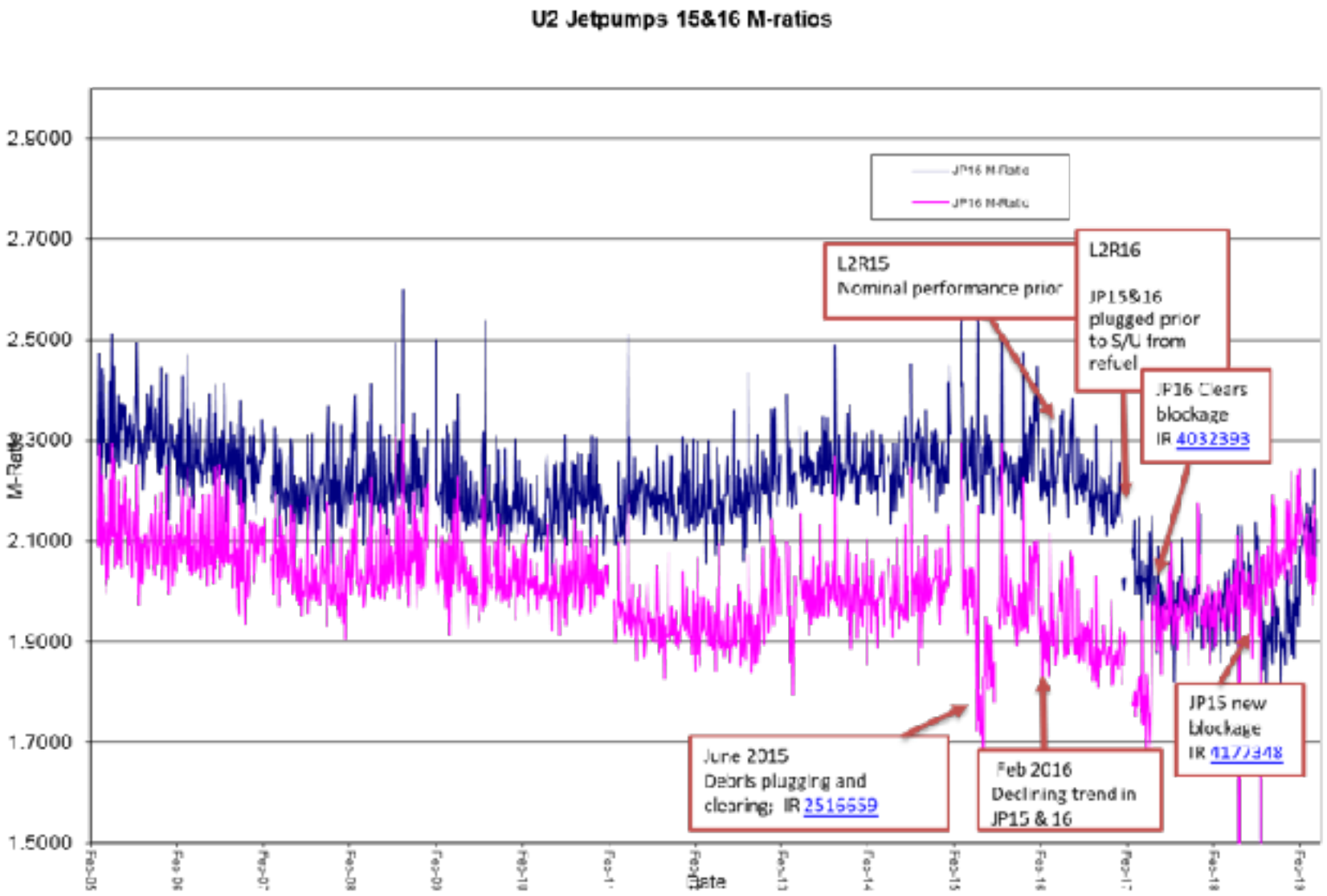
4.028 Rem impact



Jet Pump M-ratios



Jet Pump M-ratios



Exelon Generation

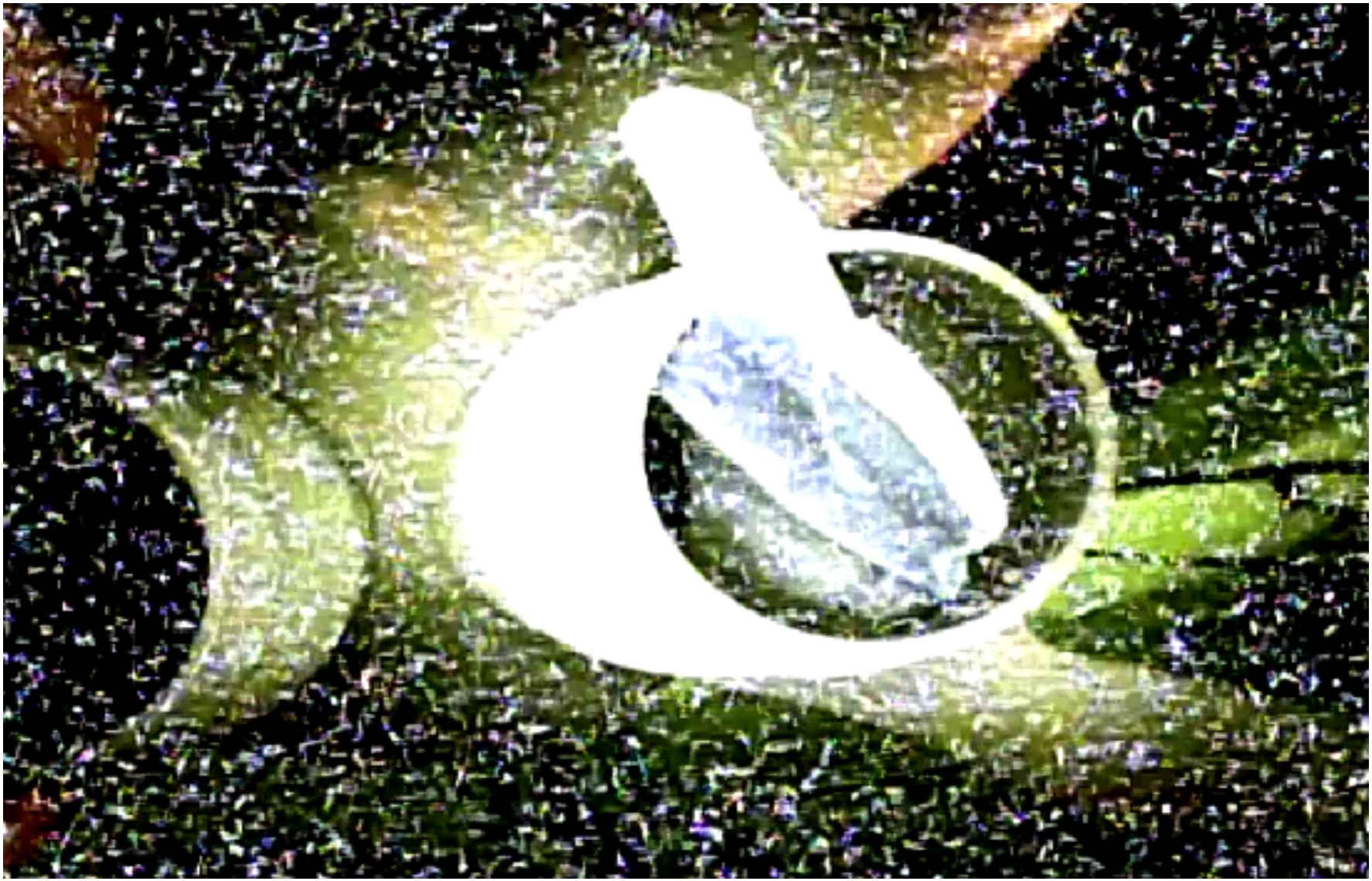
Jet Pump 5 Foreign Material

Foreign Material in JP# 11

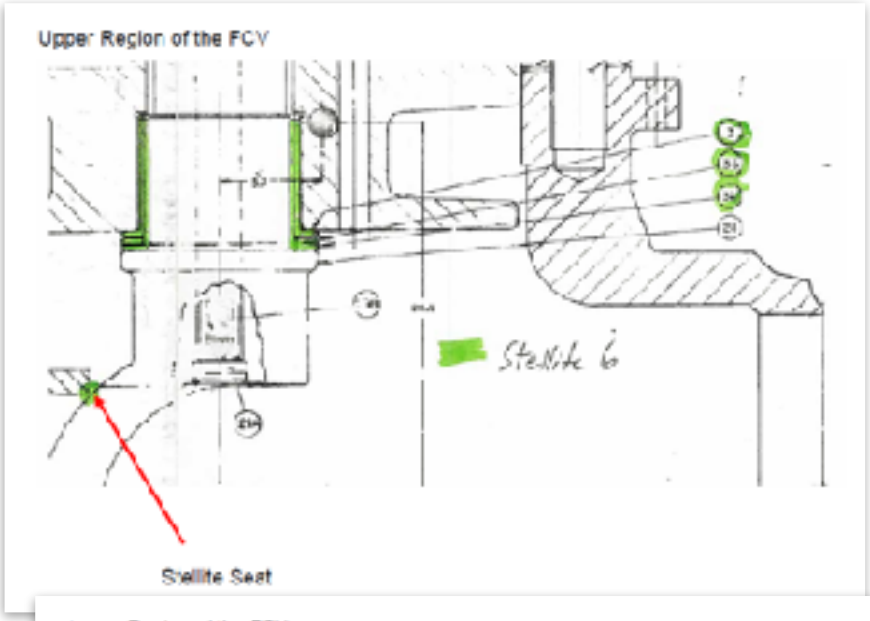
Foreign Material in JP# 12

Foreign Material in JP# 15

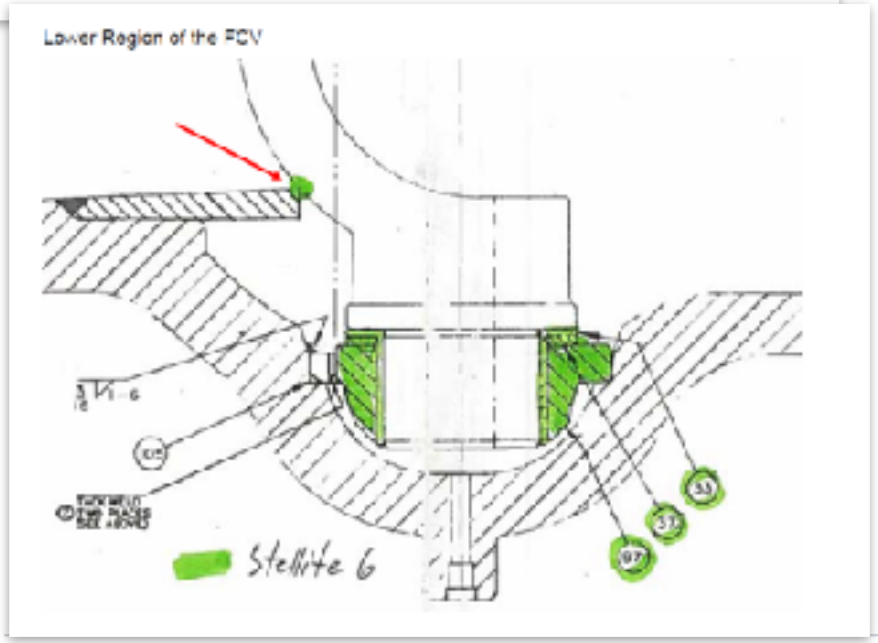
Foreign Material in JP# 16



Upper and Lower Regions of Flow Control Valve

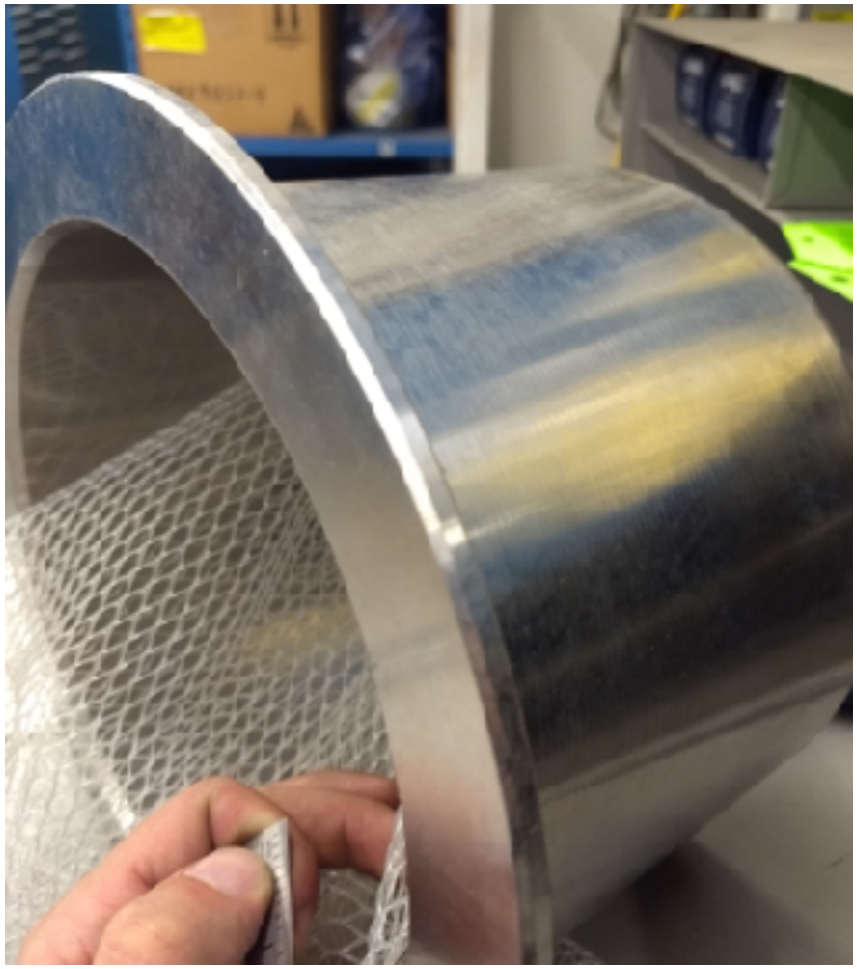


Stellite components in the upper region of the RR FCV which consist of: Lower Bonnet Bearing, Middle Shaft Bearing, Middle Spacer, and Stellite Seat.



Stellite components in the lower region of the RR FCV which consist of: Lower Shaft Bearing, Lower Spacer, and Lower Plug Guide.

Middle FCV Components

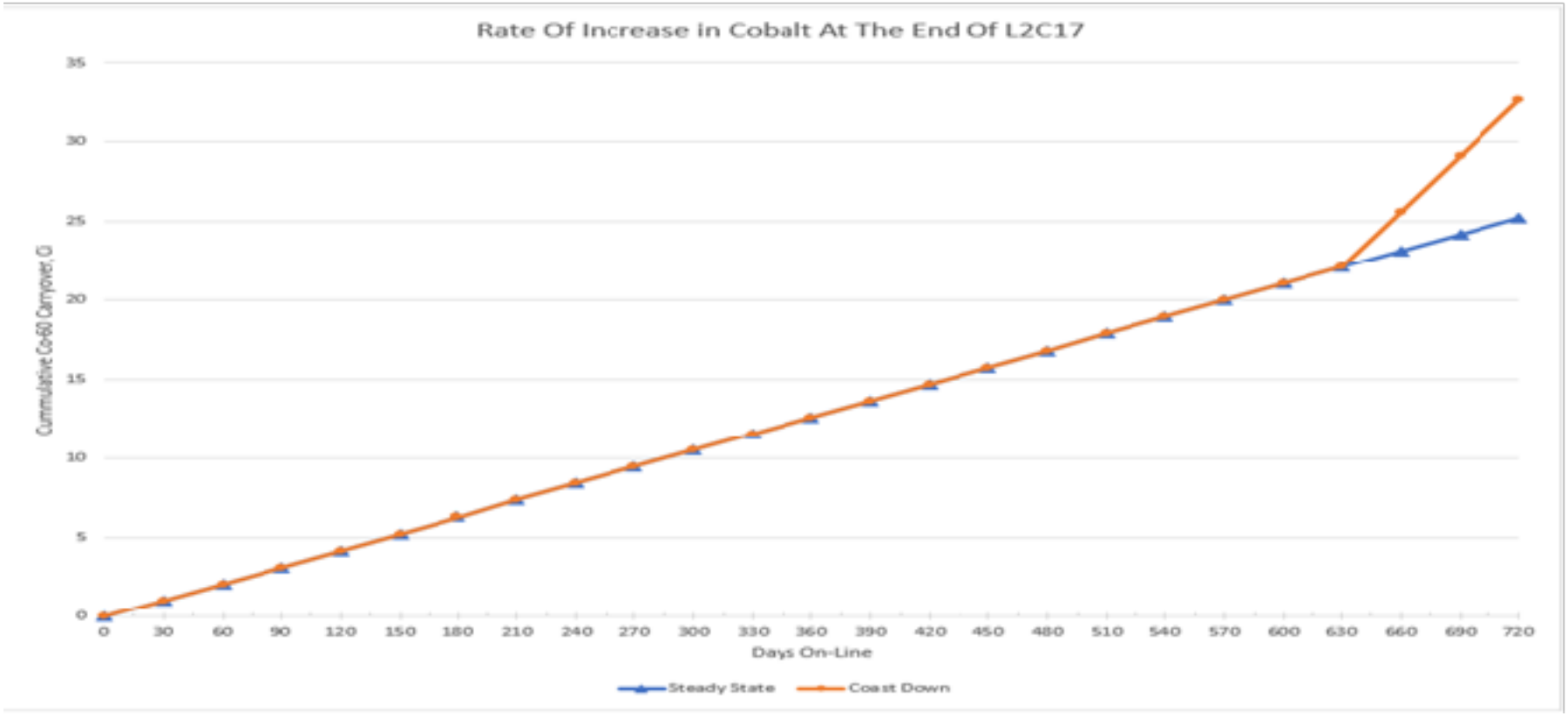


Steam Carryover of Cobalt

8.658 Rem impact

	L2C14	L2C15	L2C16	L2C17
Coast Down (days)	**50**	**0**	**10**	**58**
Coast Down start	12/23/2012		1/27/2017	12/22/2018
Coast Down end	2/11/2013		2/6/2017	2/18/2019
Median Co-60(s), uCi/g post OLNC 2nd OLNC for the cycle	4.09E-04	6.73E-04	6.79E-04	7.40E-04
Median Co-60(s), uCi/g during coastdown	6.02E-04	7.70E-04	8.31E-04	9.32E-04
Delta between the two median cobalt values	**1.93E-04**	**1.00E-04**	**1.52E-04**	**1.92E-04**
MCO (%) prior to coastdown or prior to end of cycle	0.016	0.033	0.028	0.023
MCO (%) (end of cycle/during coastdown)	0.017	0.039	0.036	0.034
Peak MCO (%) during coastdown	**0.020**	**0.039**	**0.039**	**0.057**
Total Curies (end of cycle/during coastdown)	0.83	0.20	0.52	3.7
Cumulative cycle cobalt carryover (curies)	**10.0**	**25.7**	**32.4**	**31.8**

Steam Carryover of Cobalt



L2R17 Initiatives

- HE-UFC
- AMFM B-500 filtration
- Undervessel sump cleaning
- Radvision 3d Modeling
- Cavity decontamination improvements

AMFM Update

- LaSalle has continued to perform HE-UFC

- The regenerable AMFM filter technology that enables large scale BWR HE-UFC has been adapted for other uses
  - AMFM-B500 system for general pool filtration / vacuuming
  - More recently, out-of-pool applications (undervessel sump vacuuming)

- Presentation agenda:
  - HE-UFC and AMFM-B500 performance updates
  - UV sump vacuuming

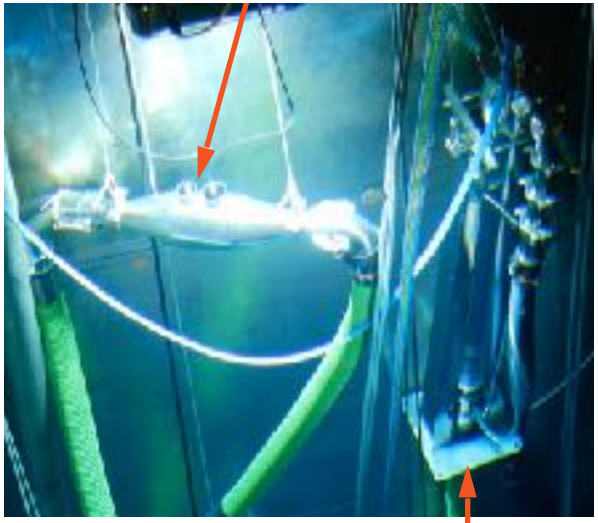
LaSalle HE-UFC Equipment Overview

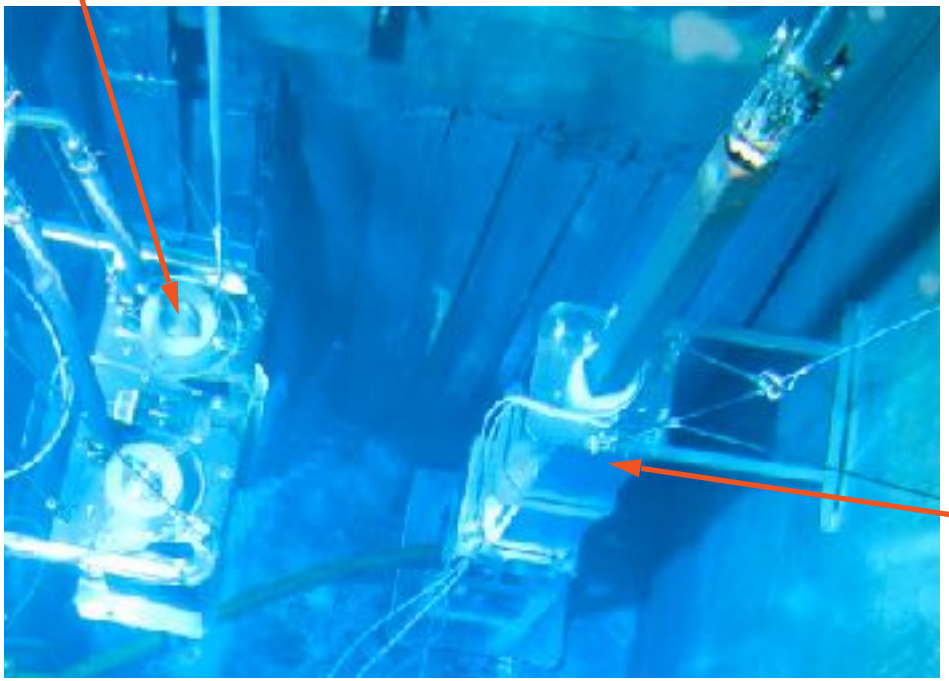
Dominion Engineering, Inc.

Topside control station

Inline gamma detector

Regenerable AMFM filters





Pump

HE-UFC

Exelon Generation

BWR HE-UFC Experience Summary

- LaSalle 2R16* (Feb 2017) + chem decon
  - One objective was to reduce Rxr water Co-60 to preserve benefit of chem decon
- LaSalle 1R17 (Feb 2018)
- Nine Mile Point 2 (May 2018) + chem decon / LT-ZiP passivation
- Laguna Verde 1 (Jan 2019)
- LaSalle 2R17* (Feb 2019)
- Laguna Verde 2 (Apr 2019) + chem decon / LT-ZiP passivation
- River Bend (May 2019)

*LaSalle 2 is lead unit for BWR HE-UFC

LaSalle 2 HE-UFC Results Comparison

L2R16

- 260 fuel bundles fully cleaned + remaining reload bundles cleaned at bottom nozzle only
- 10,400 Ci of fuel crud activity removed
- 170,000 Ci of Stellite fragments removed
- No fuel failures during Cycle 17
  - Persistent FM-related fuel failures were observed for several consecutive cycles prior to HE-UFC
- No notable observations during N+1 fuel inspections

L2R17

- 160 fuel bundles fully cleaned (remaining ~300 reload bundles uncleaned)
- 3,400 Ci of fuel crud activity removed
- 96,000 Ci of Stellite fragments removed
- No plant operational data available from Cycle 18

Notable HE-UFC Observations at LaSalle

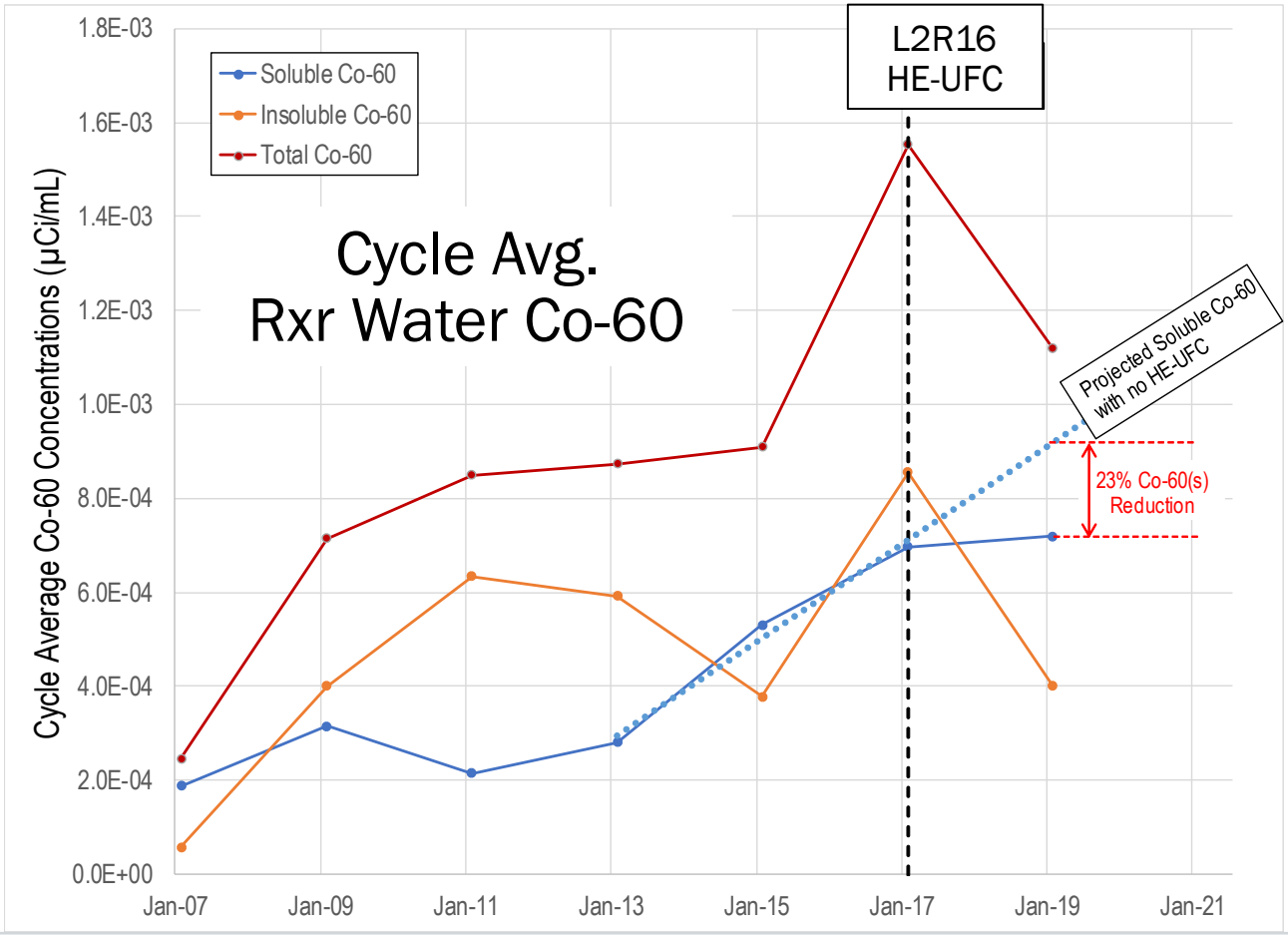
- Fuel crud activity was reduced by ~50%
  - Average removal during L2R16 HE-UFC was ~40 Ci/bundle
  - For comparison, ~20 Ci/bundle was removed during L2R17 recleans
- Suspected valve degradation continues – and activated Stellite fragments remain a significant Co source (somewhat unique to LaSalle 2)
  - Other units (including LaSalle 1) have not seen the same frequency or magnitude of activated FM removal during HE-UFC

Bottom Nozzle Cleaning Debris (L2R16)

HE-UFC Debris Basket (L2R17)

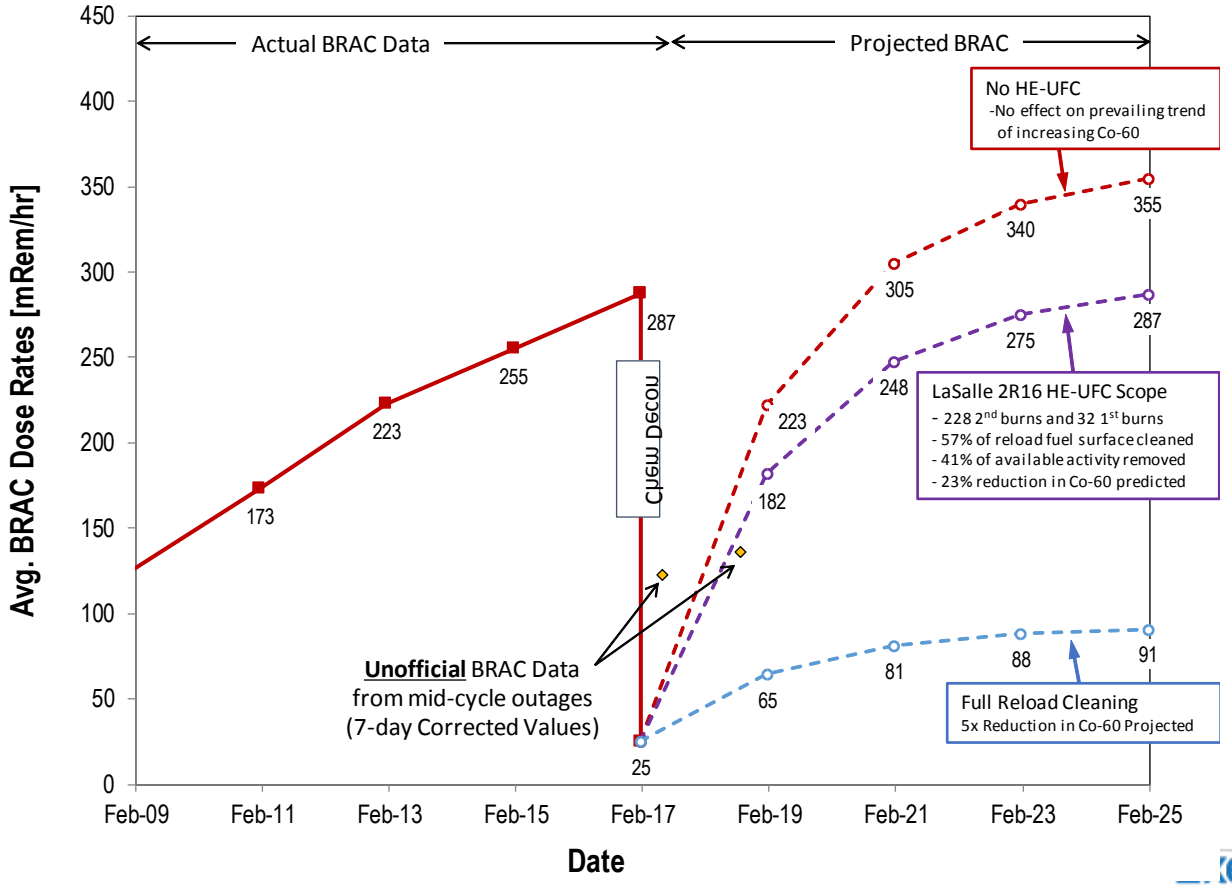
Post HE-UFC Chemistry at LaSalle 2

- Co-60 levels in Rxr water were decreased following L2R16 HE-UFC
  - >50% reduction in insoluble Co-60 during Cycle 17
  - >20% reduction in soluble Co-60, relative to prevailing trend
  - Recall, only a subset of the reload fuel was cleaned



Post HE-UFC BRAC Trends at LaSalle 2

- As expected, recontamination is observed after chem decon
  - However, HE-UFC showed a relative benefit, proportional with Rxr water Co-60 reduction (actual data consistent with predictions)
  - Significant Stellite release (believed to originate from Rxr recirc valves) remains a significant Co source and contributor to BRAC trend



Conclusions

- Even with limitations on cleaning scope, HE-UFC shows promise:
  - Decreased Rxr water Co-60
  - Curbed impact of major Co-60 source on projected BRAC dose rate trends
  - Improved fuel reliability despite significant FM transport
- Expanded HE-UFC cleaning scope (all reload bundles) being pursued at LaSalle 2 to maximize collection of activated FM from Rxr recirc valve degradation
  - LaSalle OPEX and N+1 inspections support this approach
- Parallel efforts in progress to assess the extent of degradation in suspect valves and determine appropriate mitigation/repair measures

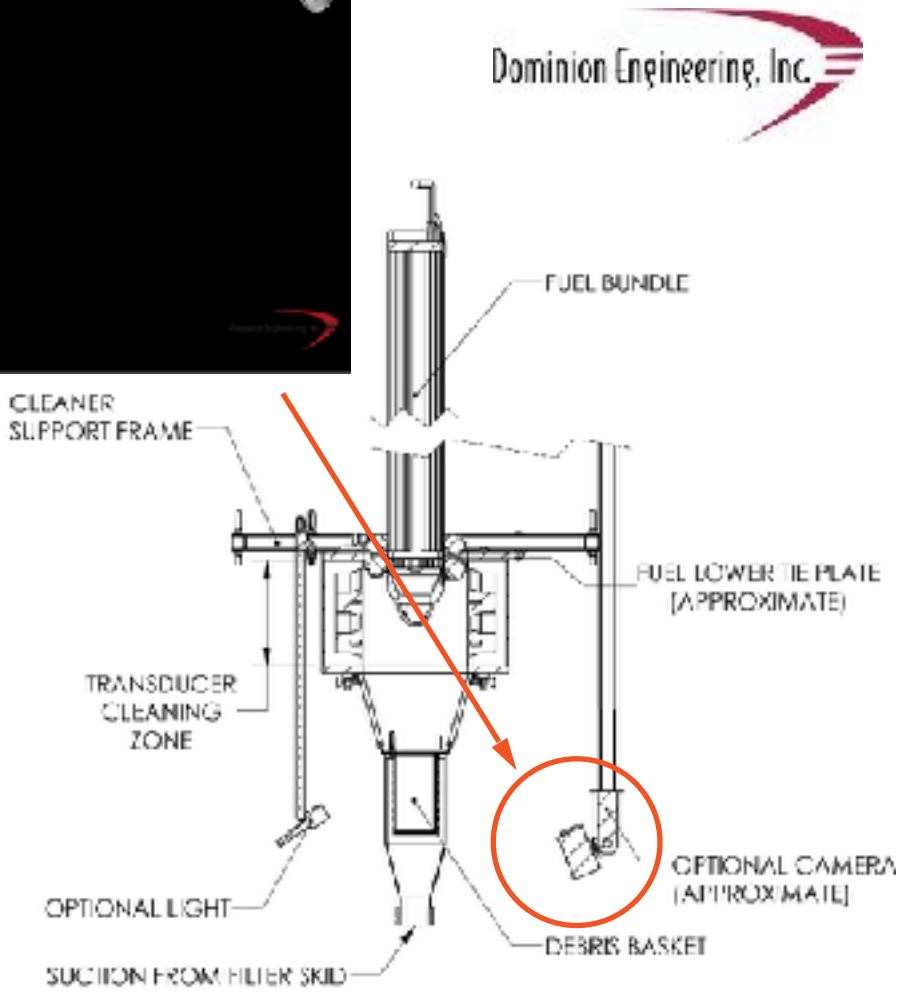
Industry Developments

- Based on LaSalle OPEX and N+1 inspections, full reload BWR HE-UFC is in progress at another unit

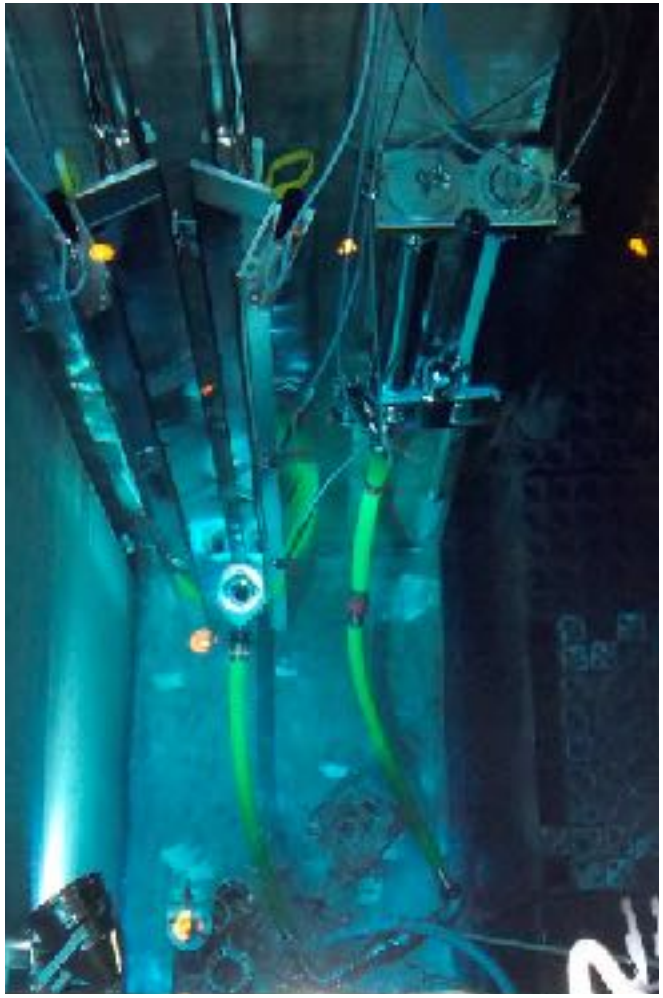
- A “side entry” HE-UFC was developed for units that prefer install location without sufficient pool depth for “top entry” design used at LaSalle
  - Deployed at Nine Mile Point, Laguna Verde and River Bend

- Fuel assembly lower tie plate cleaning / inspection system developed
  - Similar to HE-UFC, uses a combination of ultrasound and reverse flow
  - Cleans only foreign material from the bottom nozzle (not the fuel rods)
  - Deployed at Fitzpatrick and Limerick

Equipment Adaptations



Fuel Bundle Lower Tie Plate Cleaning/Inspection System



"Side Entry" HE-UFC

AMFM-B500 Use at LaSalle

- Two AMFM-B500 systems placed in service during LaSalle 1R17 outage (Feb 2018)
  - SFP is common to LaSalle 1 & 2
- LaSalle 1R17 outage (Feb 2018)
  - General pool filtration
  - Reactor cavity and guide tube vacuuming
- Summer 2018
  - Vacuuming and filtration during low level waste campaign
- LaSalle 2R17 outage (Feb 2019)
  - General pool filtration
  - Reactor cavity and guide tube vacuuming
- Spring 2019
  - Vacuuming and filtration during low level waste campaign

AMFM-B500 Performance at LaSalle

- The two AMFM-B500 systems at LaSalle have been used extensively for filtration and vacuuming
  - >100 million gallons of water filtered
  - System has strong vacuum and is effective for deep cavity vacuuming
  - Favorable economics compared to traditional filtration systems (plastic filter waste eliminated)
- The two AMFM filters associated with these systems still have remaining capacity
  - Max flow rate has decreased somewhat, but flow rates of 400-500 gpm are still achievable for general filtration
  - When smaller diameter hoses are attached for vacuuming, flow rate is decreased to 200-300 gpm to prevent pump cavitation
- Several ultrasonic backwashes have been performed and have been effective in regenerating the capacity of the AMFM filters
  - DP recovery of 8-10 psi per backwash achieved

“Out-of-Pool” AMFM Development

- The regenerable AMFM concept was recently extended to an “out-of-pool” configuration
  - Designed for applications such as torus and suppression pool vacuuming
  - Filter modules can then be transferred to the refuel floor and externally backwashed to an AMFM-B500 system

- During L2R17, LaSalle deployed this system to support undervessel sump vacuuming activities (see later slides)

Out-of-Pool AMFM Skid

UV Sump Cleaning Overview

- Undervessel activities during L2R17 were projected to result in 70 Rem of worker exposure
- A major source of dose was activity in the UV sump
- A system was developed to vacuum the UV sump to reduce dose
- Goal was to reduce exposure during UV activities by 40%

UV Sump Cleaning System Development

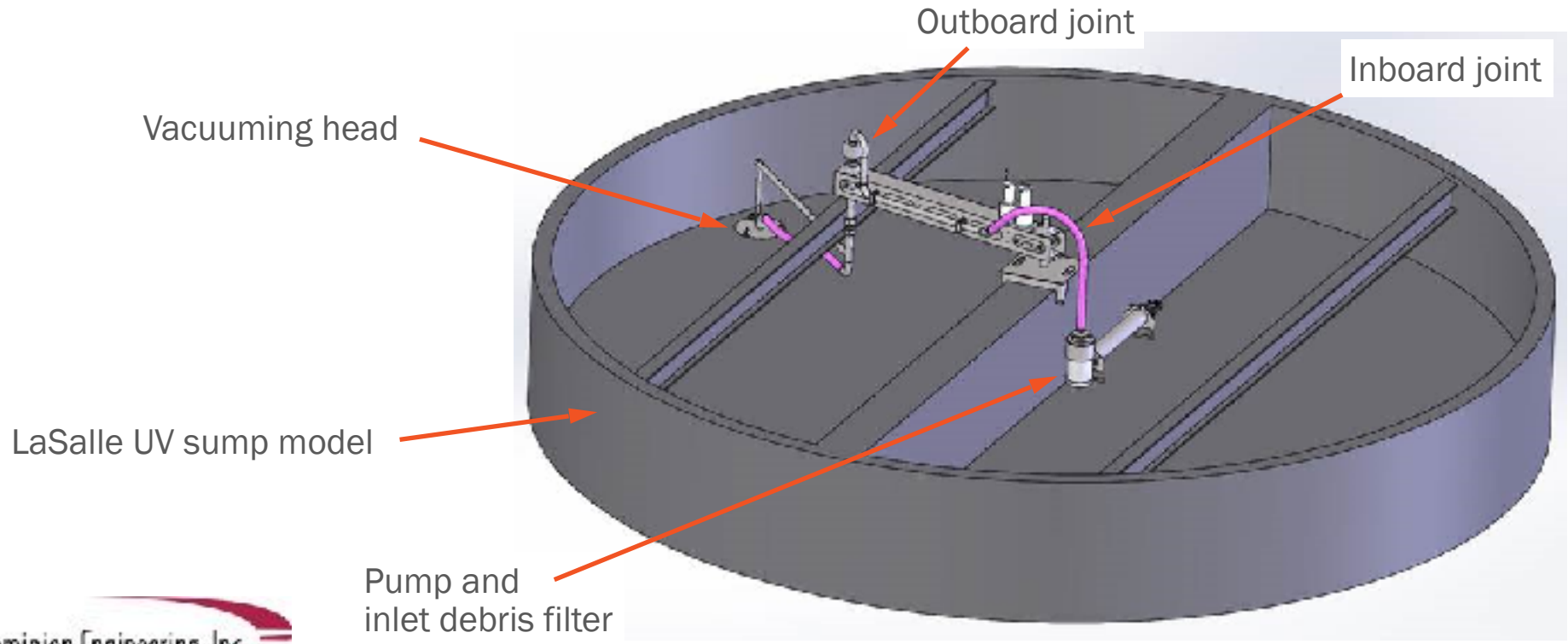
- Due to limited budget/schedule, use/development of complex robotic system was impractical

- However, remote operation was mandatory due to challenging radiological conditions in the UV sump
  –~800 mrem/hour

- Strong desire to use regenerable filtration system (similar to AMFM) to avoid the generation of disposable filter waste during UV sump vacuuming

UV Sump Cleaning System

- DEI developed, qualified, and deployed a dual-axis robotic vacuuming arm in ~8 weeks
  - Simple, remote operation
  - Arm attached to center beam of UV sump
  - Bi-directional rotation at each joint facilitates nearly complete cleaning of both UV sump compartments



UV Sump Vacuuming Arm Operation

Equipment Checkout at DEI Laboratory

UV Sump Filtration System

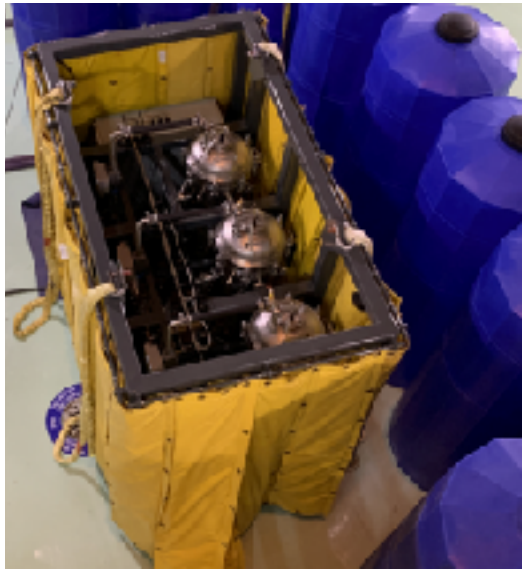
- A regenerable filtration skid was also integrated to capture particulate collected by the vacuuming arm

- Features:
  - Nominal flow rate of 30 gpm
  - Two regenerable filter modules for active filtration
  - Third regenerable filter module accepts particulate backwashed from other two filter modules
  - All three filter modules are externally backwashable to an AMFM filter

UV Sump Cleaning System Deployment

Control station and software

System operation in LaSalle UV sump



Regenerable filter skid and water shields (outside drywell)

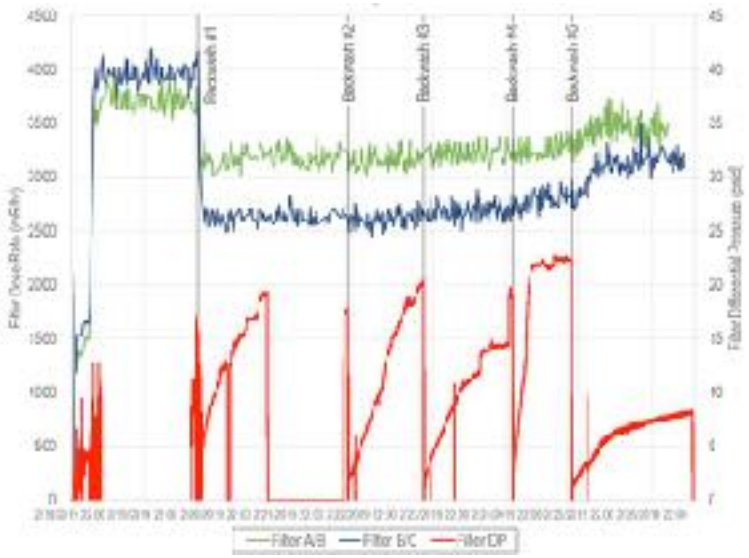
Undervessel Sump Cleaning Results

- Equipment install, cleaning and removal was completed in 2 shifts
  - No critical path impact
  - ~1500 mrem required to complete the activity

- UV sump cleaning resulted in a 40% reduction in projected dose for UV activities (15 Rem realized dose savings)
  - UV turntable GA dose rates reduced from 230 mrem/hr to 130 mrem/hr
  - UV sump dose rates reduced 90% from 1000 mrem/hr to 100 mrem/hr at 1 foot above the deck plates

UV Sump Filter Performance

- Dose rate on filter modules increased to 50 R/hr during UV sump vacuuming
  - Backwashes were effective in regenerating filter capacity (reduced DP)
  - Effective of backwashes on filter dose rates to be confirmed when activity is externally backwashed to AMFM filters



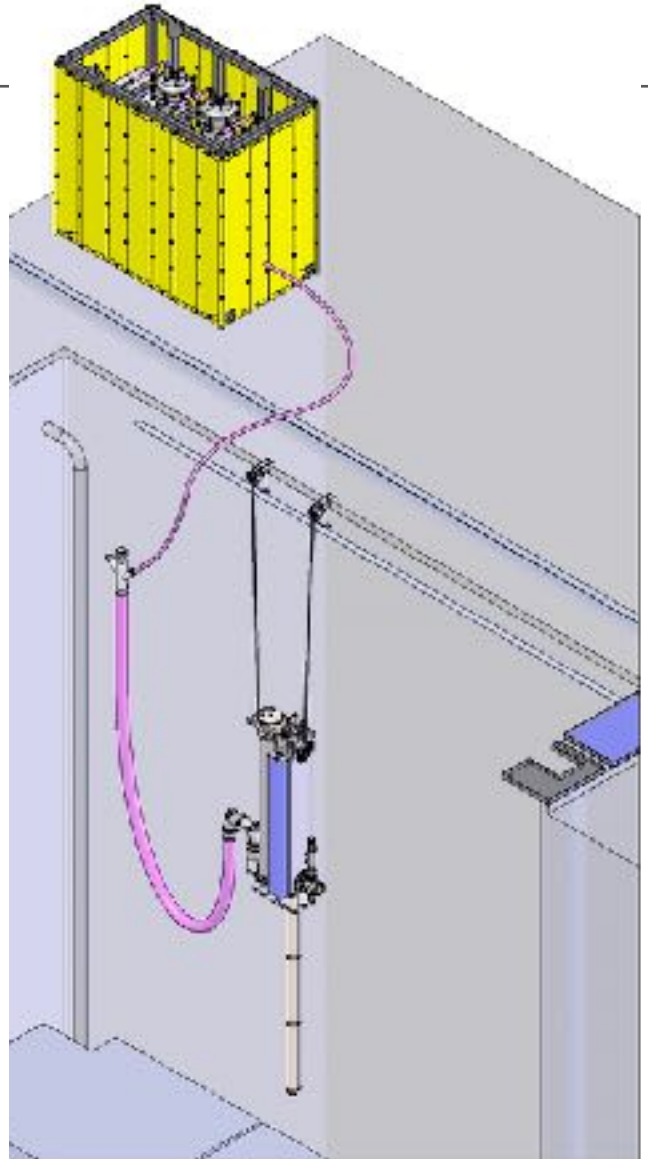
- Lead blankets and water shields were sufficient to prevent impact on radiological conditions near the filter skid
  - 5 mrem/hr dose rates measured outboard of water shields

UV Sump Cleaning Lessons Learned

- Overall, the UV sump cleaning system performed well
- However, several times, the vacuuming head and/or debris basket became clogged and entry to the UV sump was required for manual intervention
- For future deployments, provisions will be incorporated for remotely flushing the vacuum head
- Filter performance promising for use of regenerable AMFM concept in “out-of-pool” applications to eliminate plastic filter waste

Future Activities

- Backflushing of the UV filter modules to the AMFM-B500 (Spring/Summer 2019)
- The system will be used again to perform UV sump cleaning at LaSalle 1 (1R18 outage, Feb 2020)



Planned configuration for backwashing to AMFM

RadVision 3D

Unique Technology combines CZT Spectroscopy with 3D Laser Scanning

Gamma Ray Spectrometer

- Full 360° gamma image
- Completes gamma images in under 2 hours
- Software controllable scan time and resolution
- No software required to review, analyze, share
- Energy resolution: 3% FWHM @ 662 keV
- Energy range: 30 keV to 2 MeV

Packaging

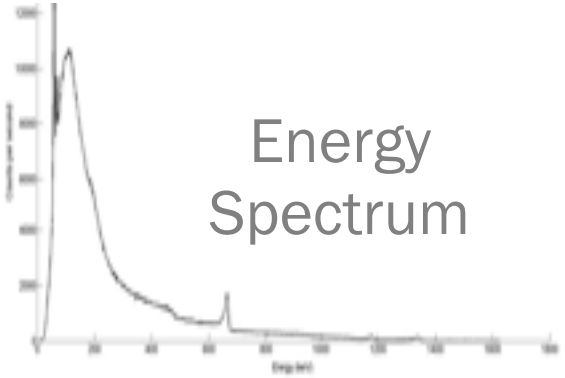
- High dose tolerant: up to 1 Sv/hr
- Fits through small apertures: 110mm OD
- Low mass: 10 – 15 kg (configurable)
- Umbilical length of up to 125m

3D Laser Scanner

- Provides measurements of surrounding surfaces
- Resulting point cloud can help better understand environment
- Point cloud can be converted into 3D model
- Range: 30 m
- Resolution: ± 2mm @ 10 m

Camera

- Produces spherical image for environment inspection
- Spherical image resolution: 12 Megapixel

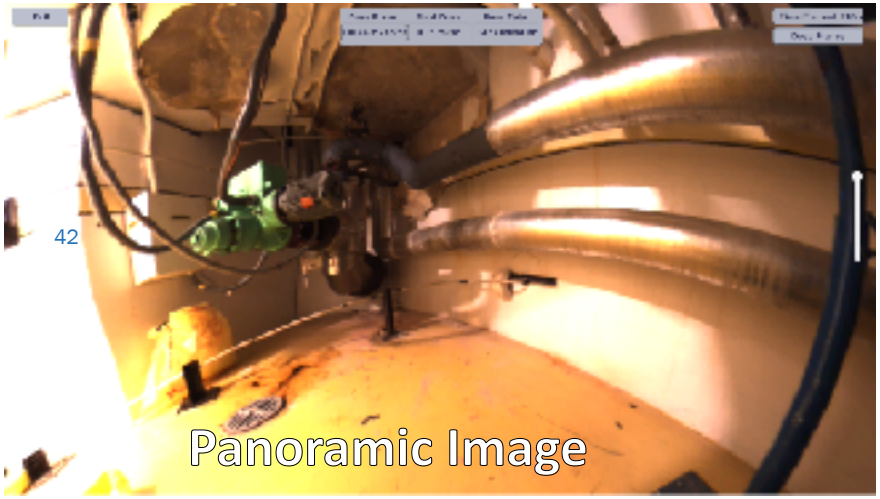


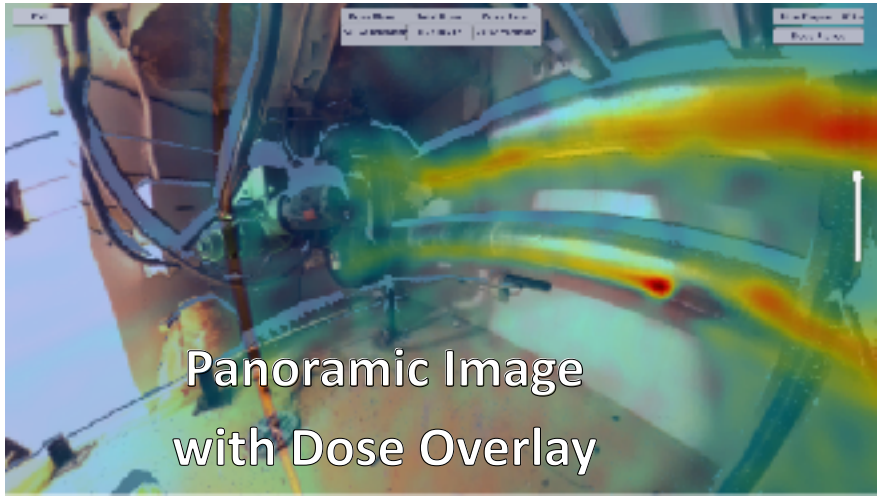
Energy Spectrum

1:1 Scale 3D Environment

RadVision 3D – L1R17 Pilot Use

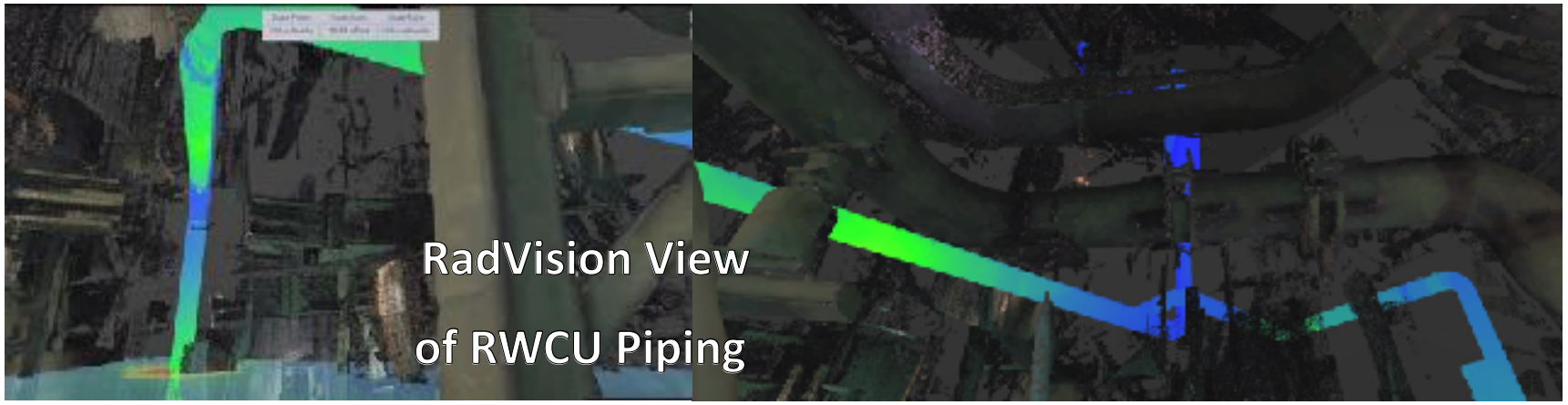
- RadVision^{3D} scanning is combination CZT, 360 camera and laser scan
- Data is compiled to produce spatially accurate model of area
- Shielding is optimized or sources removed in model to produce resultant dose rates
- L1R17 Total Dose Savings: 12,000 mRem



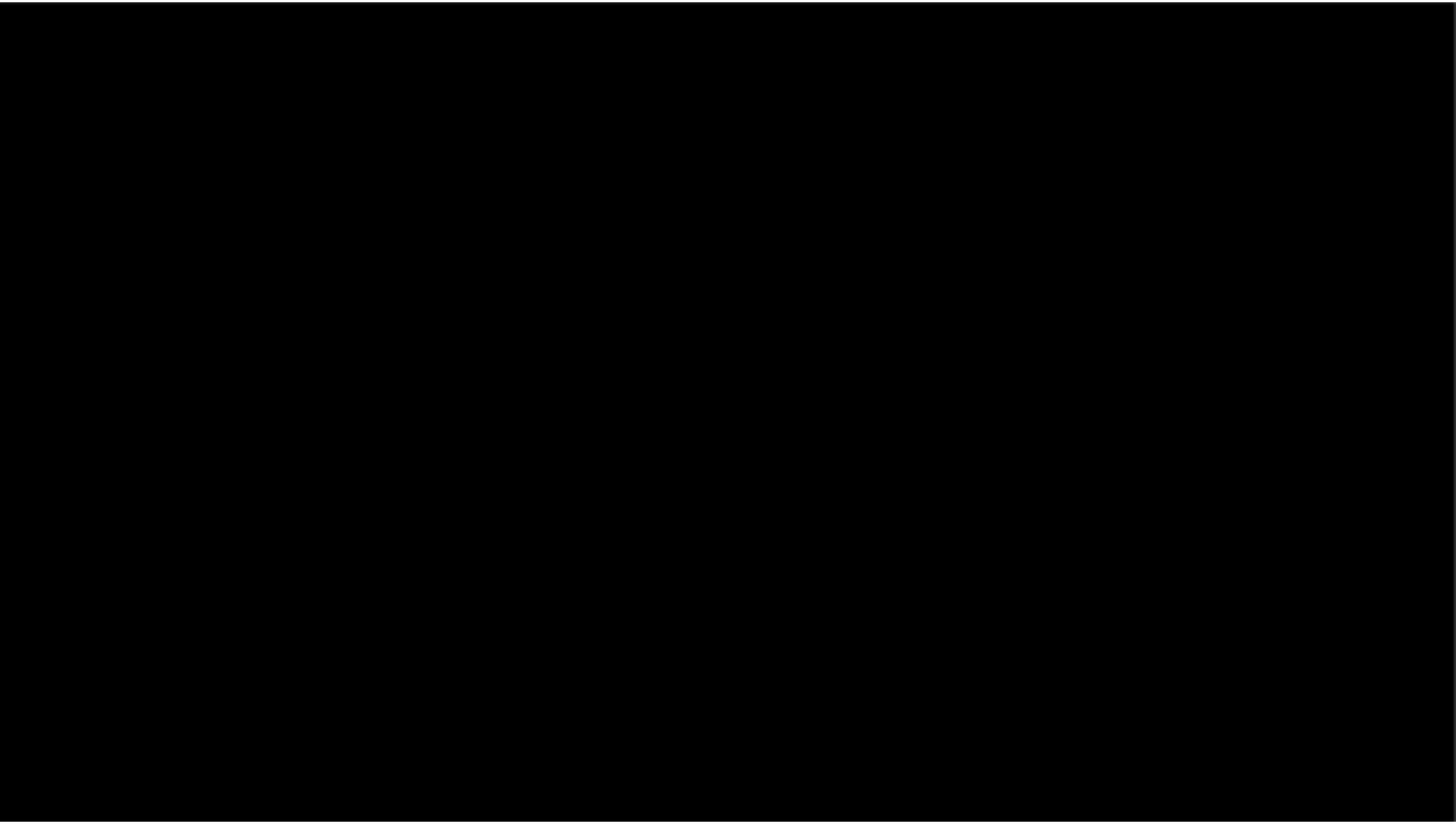


Lower Dose Rate ← → Higher Dose Rate

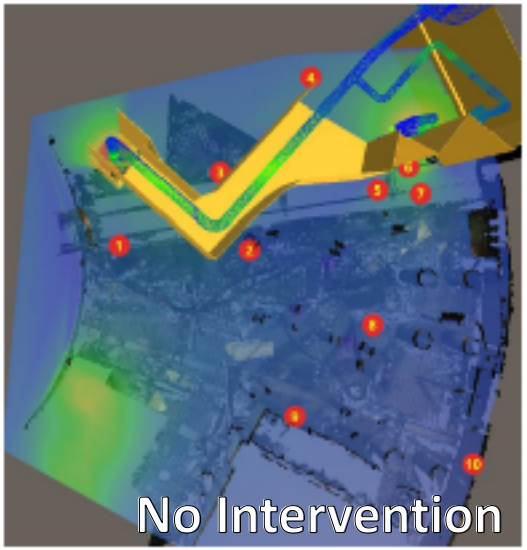
RadVision 3D- L2R17 Drywell RWCU Line

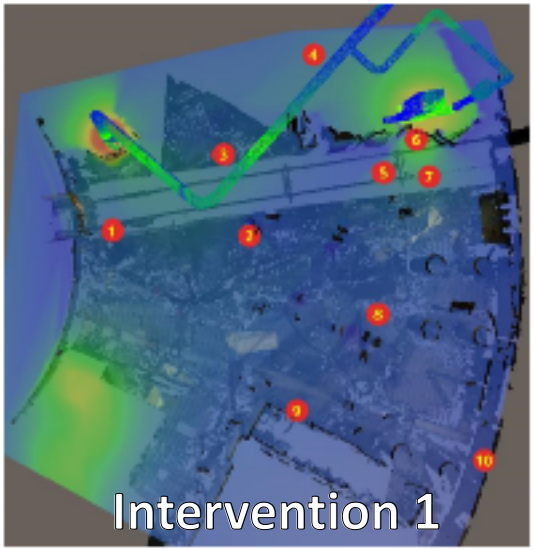


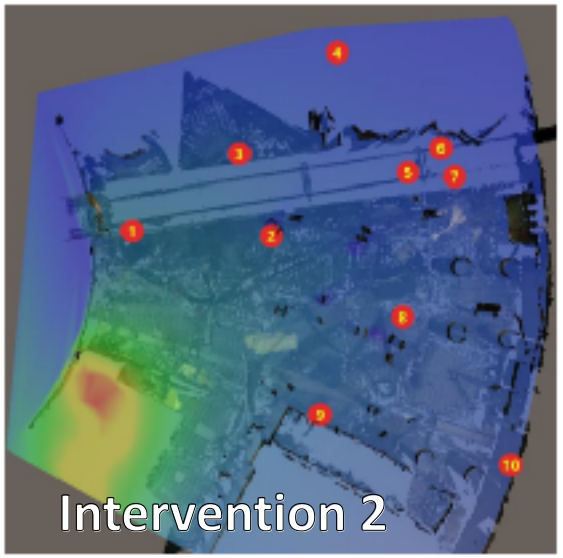
RadVision 3D- L2R17 Drywell RWCU Line



RadVision 3D- L2R17 Drywell RWCU Line







Dose Rate in mR/h at Various Locations

		1	2	3	4	5	6	7	8	9	10
No Intervention	Dose Rate	658	505	749	750	803	3796	1098	449	403	202
Intervention 1	Dose Rate	1153	845	1336	937	1275	4288	1347	499	460	216
	% Change	75%	67%	78%	25%	59%	13%	23%	11%	14%	7%
Intervention 2	Dose Rate	432	363	295	142	218	164	181	282	320	153
	% Change	-34%	-28%	-61%	-81%	-73%	-96%	-84%	-37%	-21%	-24%

*Note: % change is relative to no intervention condition, equivalent to as measured values at time of data collection.

Reactor Cavity Decontamination

Innovative use of industrial surface cleaners

L1R17

- Best-ever duration of 2 hour and 53 minutes
- Record low DAW production of <3 cubic feet
- As left conditions (15-25k) dpm/100cm²

L2R17

- Best-ever duration of 1 hour and 3 minutes
- Record low DAW production of <2 cubic feet
- As left conditions (25-60k) dpm/100cm²

L1R17 Cavity Decontamination- Tooling

Mosmatic
Surface Cleaner

Bird Cage

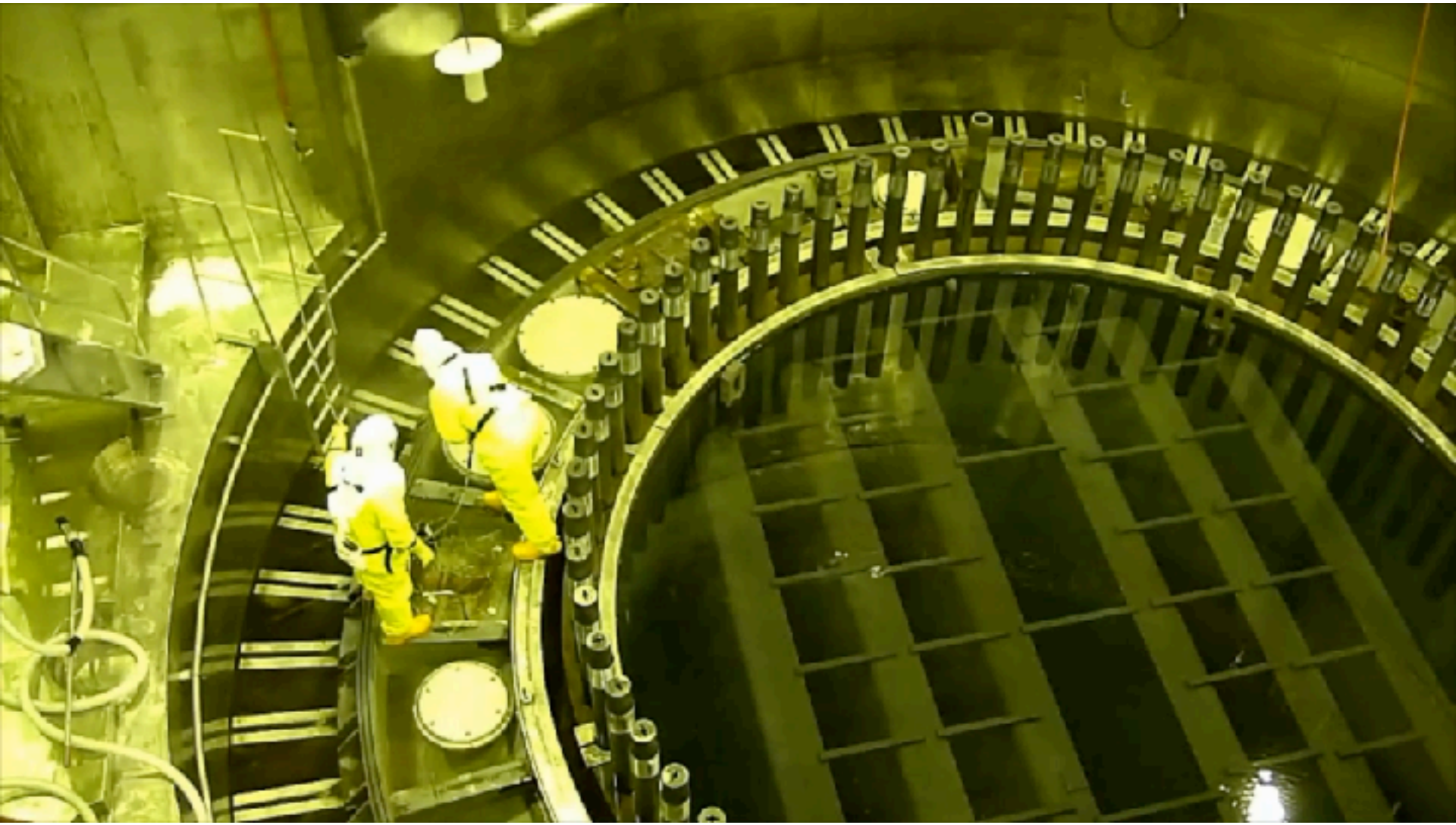
WEPA

Coated High
Pressure Hose

480V Power
Washer

High Pressure
Fittings

L1R17 Cavity Decon – Surface Cleaning



Adaptive Wireless Monitor

Exelon Generation

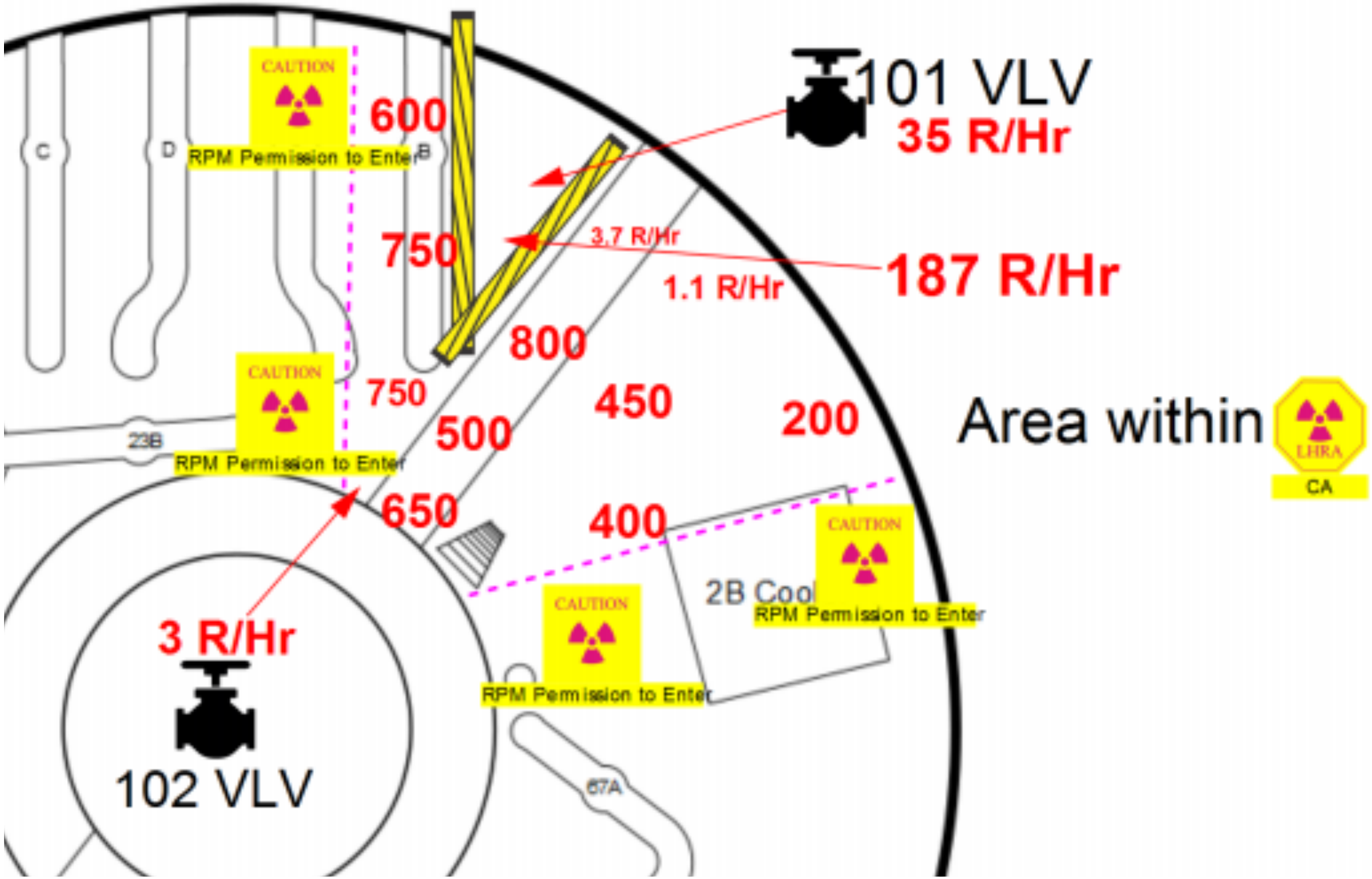
Adaptive Wireless Monitor - AWM

- Localized dose monitoring allows RP Technicians to monitor workers current dose rate and dose accumulated
- Capable of acting as a Base, Repeater and EXT transmitter allows it to fill multiple functions on site
- During Drywell entry allowed RP to monitor worker dose from a low dose area and without interrupting workers
- When every .1 mRem counts, tracking worker dose throughout the job is essential
- 6 hour internal rechargeable battery and small size allow it to be carried to locations where other monitoring equipment cannot reach

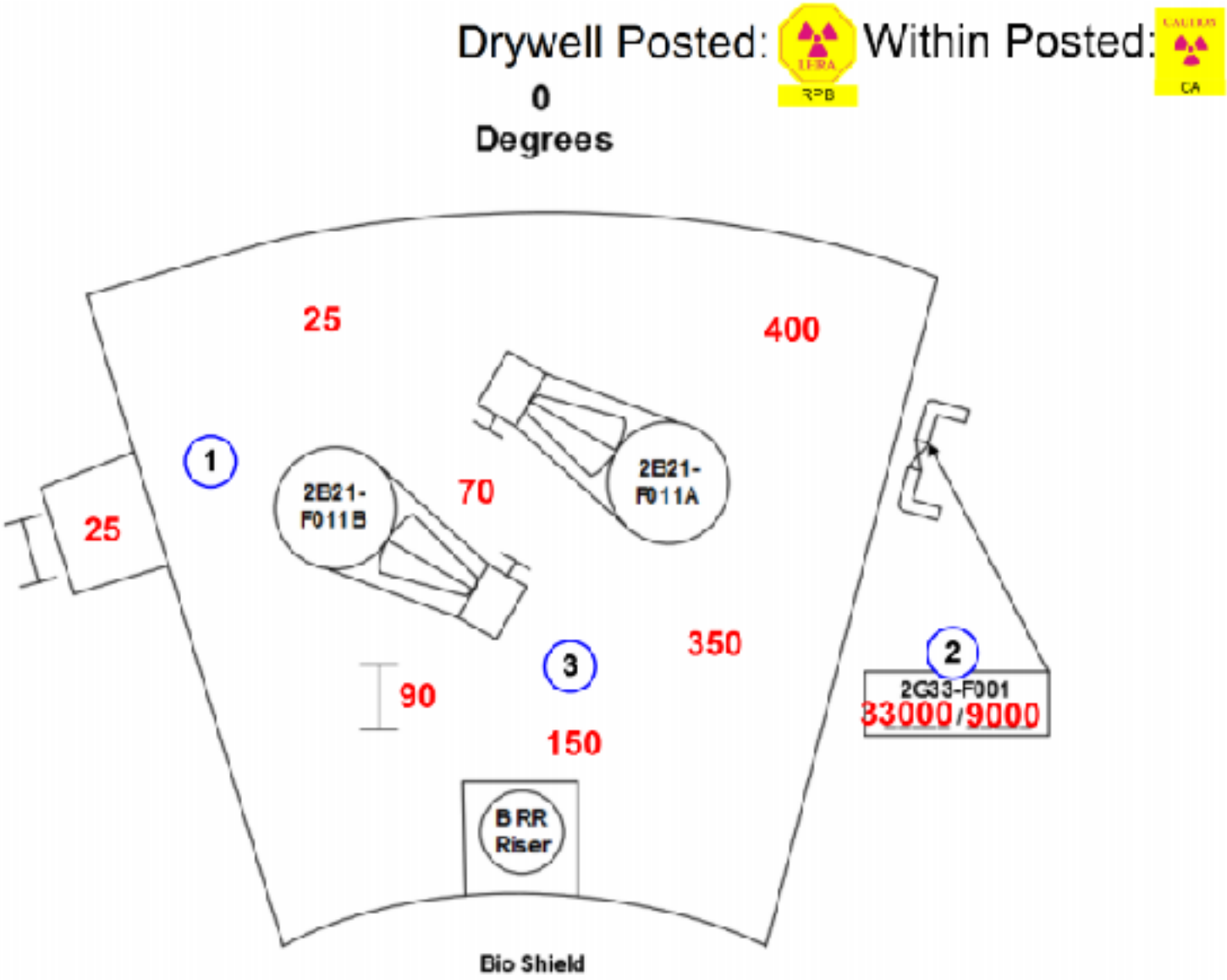
DMC 3000 TX for Dive Telemetry

- Replaced wired system with wireless system
- Reduced training requirements by eliminating an outdated system used only for this infrequent task
- Eliminated “lost contact” issue which caused extra dose received, ~400 mRem in L1R17 and ~2 Rem in L2R16. Prevented this from occurring in L2R17.
- Reduced system potential failure points by 48% and reduced required testing time by 75%.
- Improved job time be reducing setup time by 70%.
- Improved dose monitoring by reducing dosimeter update time by 80%

Observations – U2 Drywell 740



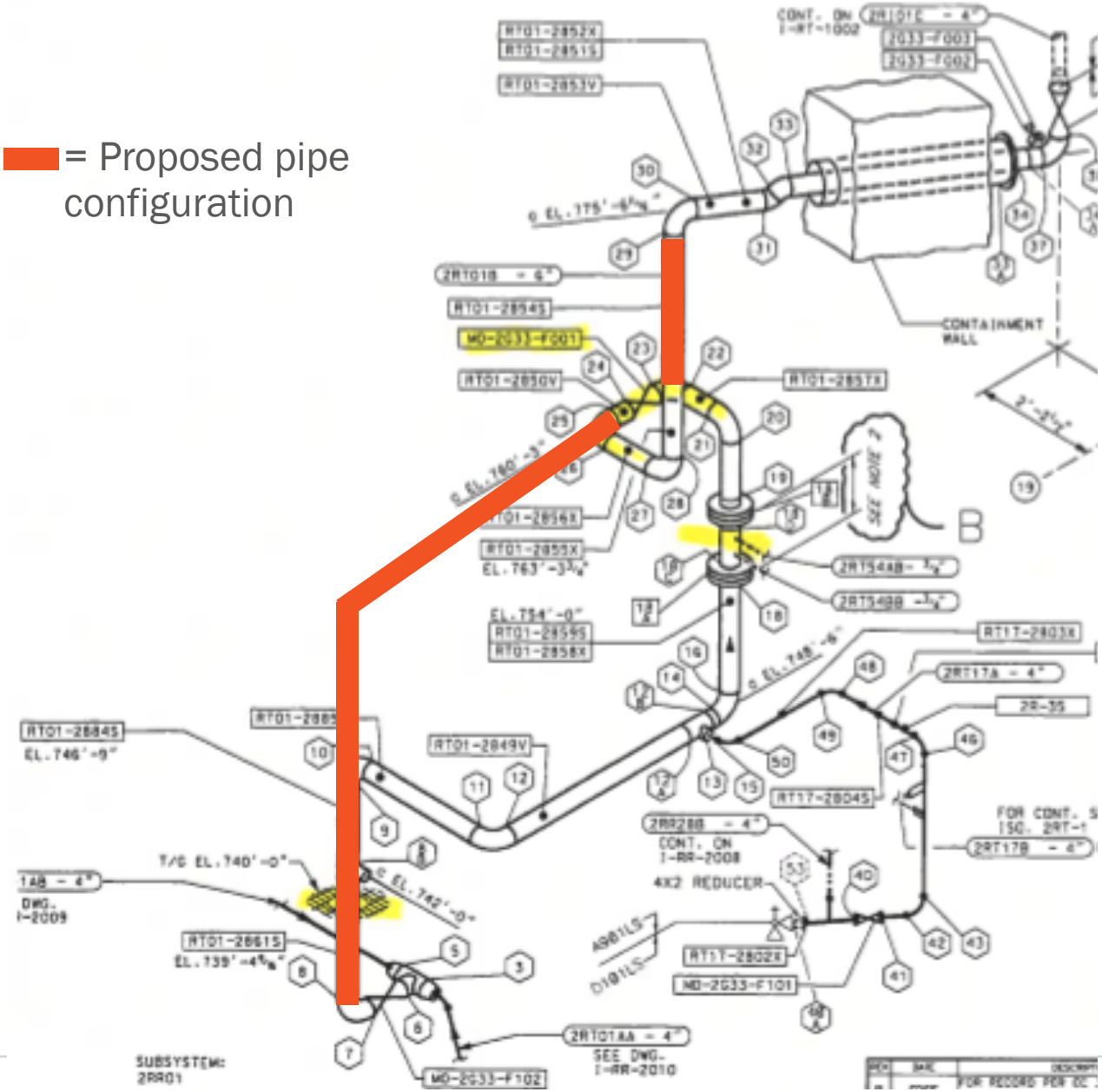
Observations – U2 Drywell 760



Exelon Generation

Observations – U2 Drywell RWCU Piping

= Proposed pipe configuration



Conclusions

- CRE challenges require immediate and aggressive action
- Mitigation of this hazard is required to arrest degrading radiological conditions and the hazards this presents our workers.
- Thru the use of emerging technologies, evaluation and optimization of tasks, and strategic initiatives LaSalle will reduce CRE and achieve 1st quartile CRE performance

Other Cost Saving Initiatives at LaSalle / Fleet

- Eliminate Hard Hat Covers (fleet savings $38K)
- Switch from Rubber Gloves to launderable dipped/knit glove (fleet savings $160K)
- Half Hood replacing Full Hood (fleet savings $100K)
- Subcontract Security inspections of incoming trucks, UniTech and Others (fleet savings $100K+)
- Vocera Communications System (Tip Award LaSalle savings $3M on time saved)
- DAW Sort Trial (see next slides)

DAW SORT TRIAL

LaSalle station shipped three separate shipments to UniTech Morris consisting of bags of waste to be sorted along with metal to be released and scrapped.

There was a total of 29,041 lbs. (1383 ft^3) of bagged waste that was shipped to UniTech for sort. UniTech sorted this waste into the following waste streams: >30 mr/hr or hazardous to be returned to LaSalle, BSFR to go to ORSC, DAW that did not meet BSFR limits to be returned to LaSalle, Tools and Equipment to be decontaminated and returned to LaSalle, metal items to be released and recycled, laundry to be washed and sent back to LaSalle, and clean trash to be released and disposed of as non-rad trash.

DAW SORT TRIAL

	Weight	Volume	%
Total Incoming	34,062	1,568	
BSFR	1,206	209	13.33%
Non-Rad Trash	82	41	2.61%
Laundry	142	45	2.87%
Tools	7	5	0.32%
Metal	32,021	1,185	75.57%
Recyclables	256	45	2.87%
Total Saved from DAW	33,714	1,530	97.58%
DAW	340	37	2.36%
Batteries	8	1	0.06%

DAW SORT TRIAL

Tools Recovered	COUNT
Parts / Cleaning Brush	5
Screw Driver	1
Drill Bit	1
Milling Bit	1
Chain Fall	1
Welding Helmet	1
Face Shield	1
Knee Pads	2
Insulation Blanket	2

Clothing Recovered	COUNT
ProTech Coveralls	10
ProTech Hoods	4
ProTech 1/2 Hoods	0
Nylon Shoe Covers	30
Rubber Gloves	41
Rubber Shoes	49
Cool Tech Shirts	3
Cool Tech Pants	2
Work Gloves	85
Chemical Gloves	2
FME Covers	12
Hard Hat Covers	7
Small Bags	4
Med. Bags	5
Large Bags	2
Tool Bags	2
Wipers	1
FR Shirts (NON-UniTech)	3
FR Pants (NON-UniTech)	2
Welding Coats	2

DAW SORT TRIAL

Item	LaSalle	UniTech
Orignial Disposal Cost	$97,757.94	$0.00
Post Sort DAW Cost	($998.76)	$0.00
UniTech Billing*	$0.00	$42,613.17
Recycle Share	$0.00	($1,859.83)
Recovered Value	$0.00	($3,474.50)
Total	$96,759.18	$37,278.84

Total Savings	Percent Savings
$59,480.34	**61.47%**