Pt. Lepreau Refurbishment Project

Retube Overview

Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

January 12, 2009

Prepared by:

Colin Pritchard

Senior Health Physicist

ALARA Manager

AECL

CANDU 6 Reactors

Plant	Country	Commercial
Point Lepreau	New Brunswick Canada	1983
Wolsong 1	Korea	1983
Wolsong 2	Korea	1997
Wolsong 3	Korea	1998
Wolsong 4	Korea	1999
Gentilly 2	Quebec Canada	1983
Cernavoda 1	Romania	1996
Cernavoda 2	Romania	2007
Embalse	Argentina	1984
Qinshan 1	China	2002
Qinshan 2	China	2003

ALARA Strategy

1. Identify and understand the hazards
2. Understand the scope of work and duration
3. Design the tooling for ease of execution and risk mitigation
4. Plan the work to minimize risk
5. Train staff for safe & efficient work execution
6. Apply appropriate ALARA Fields controls
7. Provide oversight and coaching to maintain focus

Hazard Knowledge

- **System materials and reactor operating history used in neutron activation calculations to derive radiation hazard rates on a per component basis**
- **The aggregate of these studies used in the theoretical models of dose rates for a number of different work locations.**
- **The theoretical dose rates are then rationalized by comparing to previous field survey data and then pro-rated as source term is removed.**

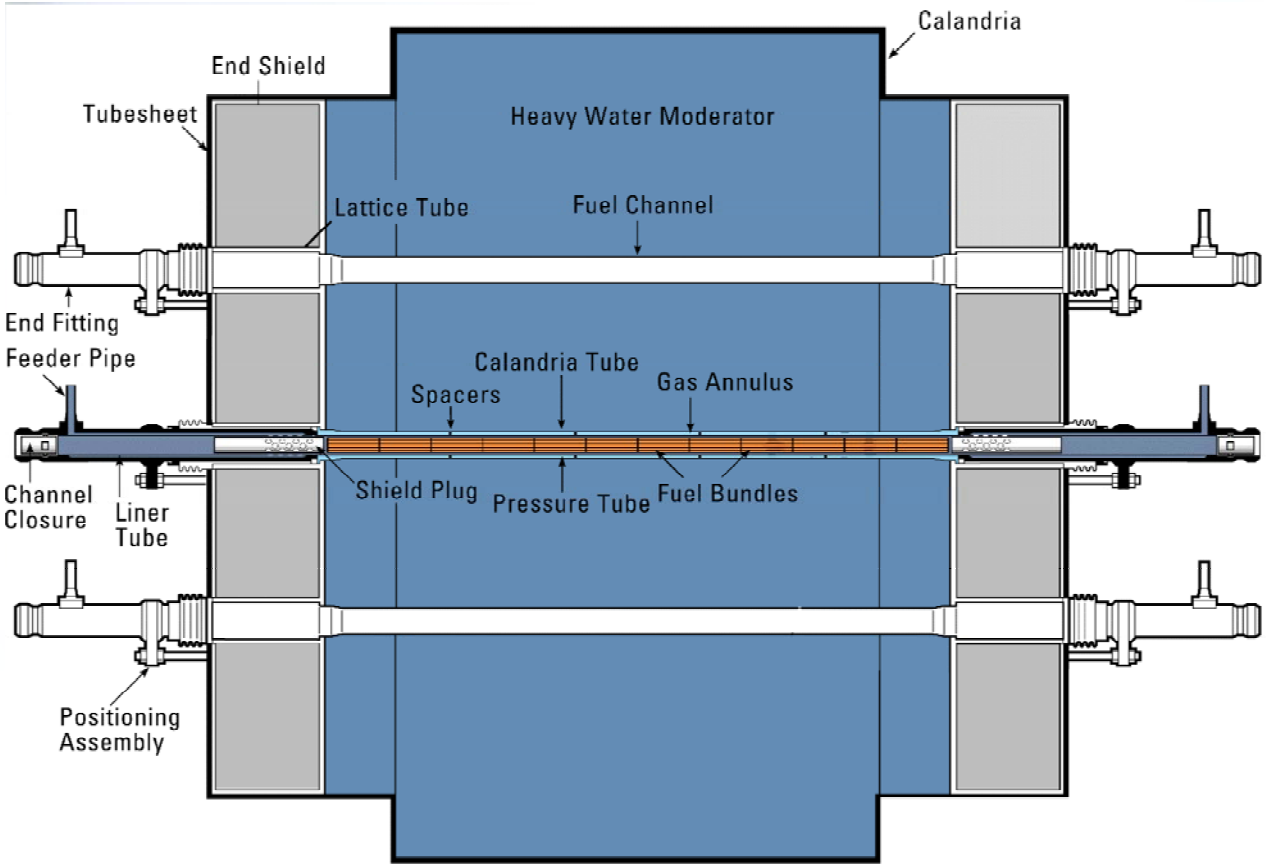
Work Flow Sequence

- **Overriding Principle:**
  - **Eliminate radiological hazards as early as possible in the project to mitigate risks for subsequent activities.**

- **For work activities containing significant schedule float, plan for these to occur after source term is removed and maximize decay time for remaining sources.**
- **Look for opportunities in contingency planning to reduce total dose.**

RETUBE – REACTOR CORE COMPONENT REPLACEMENT

All fuel channels (end fittings, closure plugs, shield plugs, pressure tubes and positioning assemblies) plus calandria tubes will be replaced.



Cross section of reactor core

Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

PHT Vacuum Drying

Will draw down the PHT main circuit to ~ 2 kPa

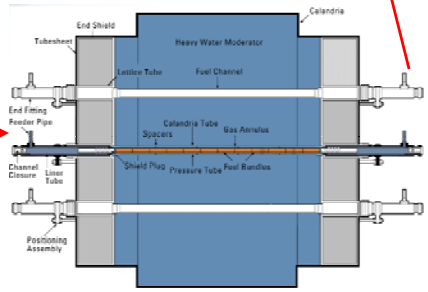
Vacuum Skid

Vacuum Pump Skid

Condensate Collection Skid

PHT D_2O Collection

Air Injection Skids



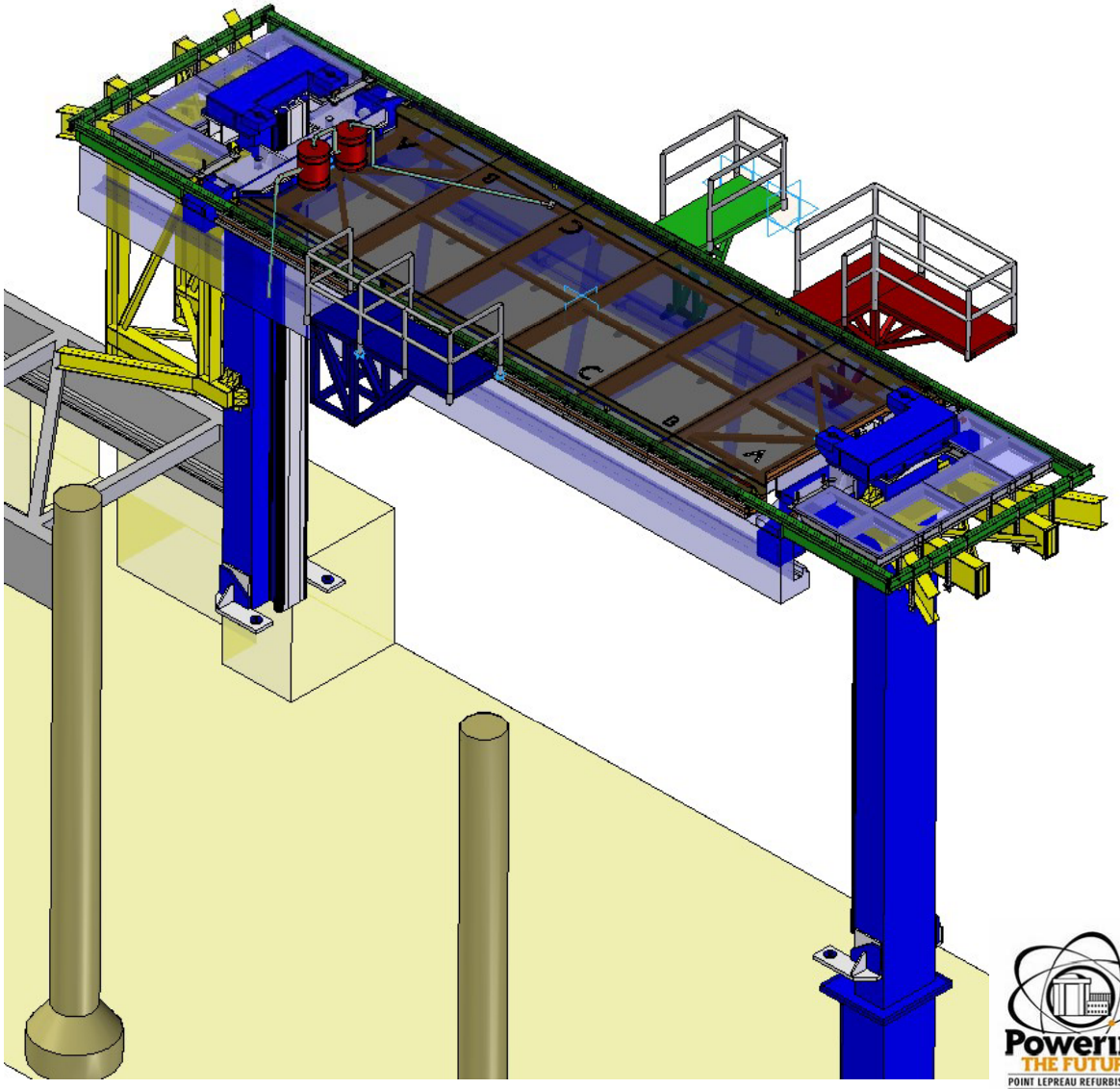
Remove Concrete Cooling Ductwork

- **Cooling fans removed by NBPN.**

Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Install Feeder Platform

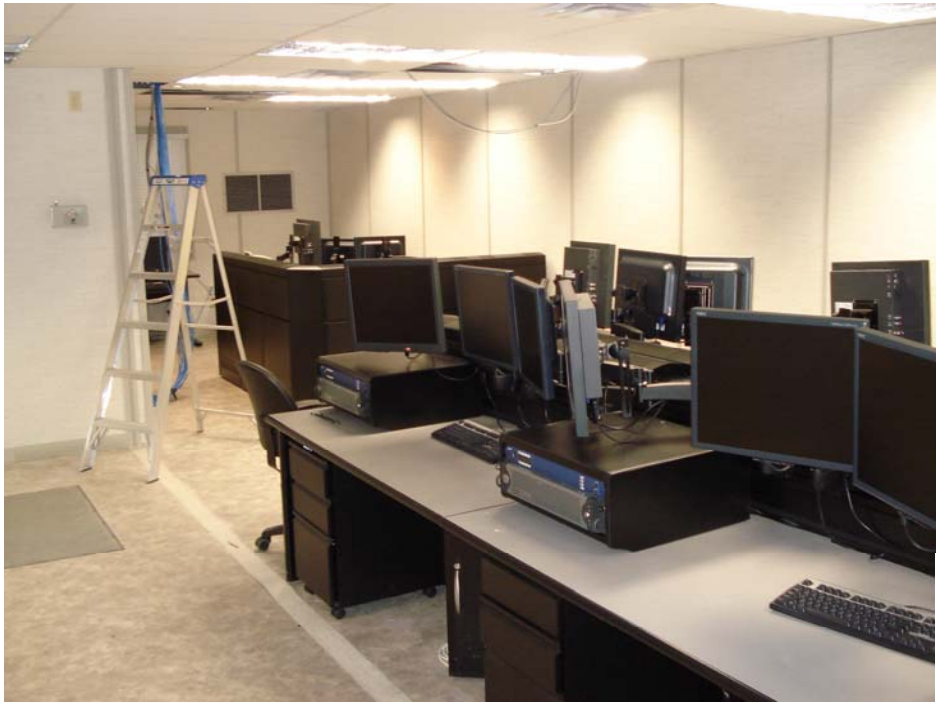
Feeder Platform mounted on FM bridge with column extensions

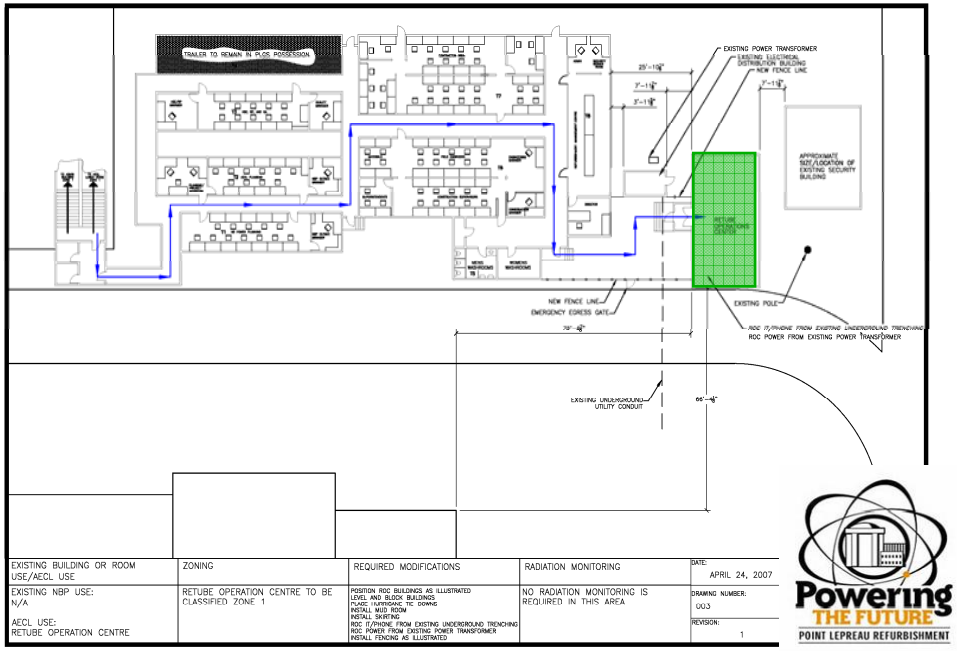


Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Commission ROC

- **To monitor/record and communicate with retube activities (including QC)**
- **No control from the ROC.**





Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

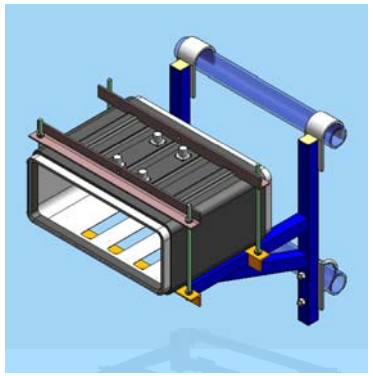
Install Vault Services

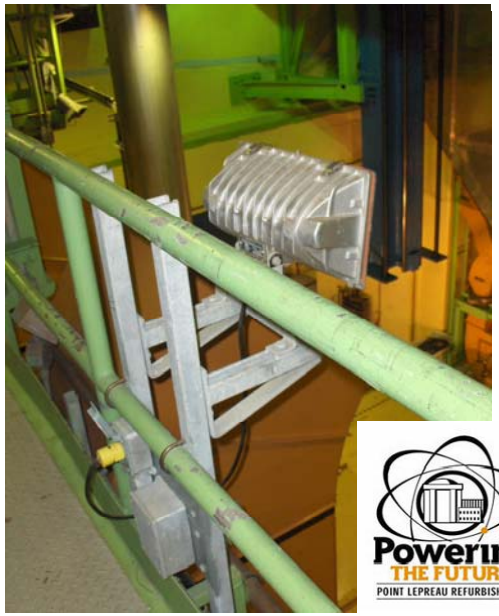
- **VOS: Video Observation System**
- **Allows multiple views within the vault (pan/tilt zoom controlled from ROC)**
- **4 cameras on back walls of vaults**
- **2 cameras on each side of platform**
- **One monitor on each side of platform**
- **6 video ports for tool specific cameras**

Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Install Vault Services (Cont'd)

- **VCS: Voice Communication System**
- **Both wired and wireless headsets for communication between workers and from workers to/from ROC.**

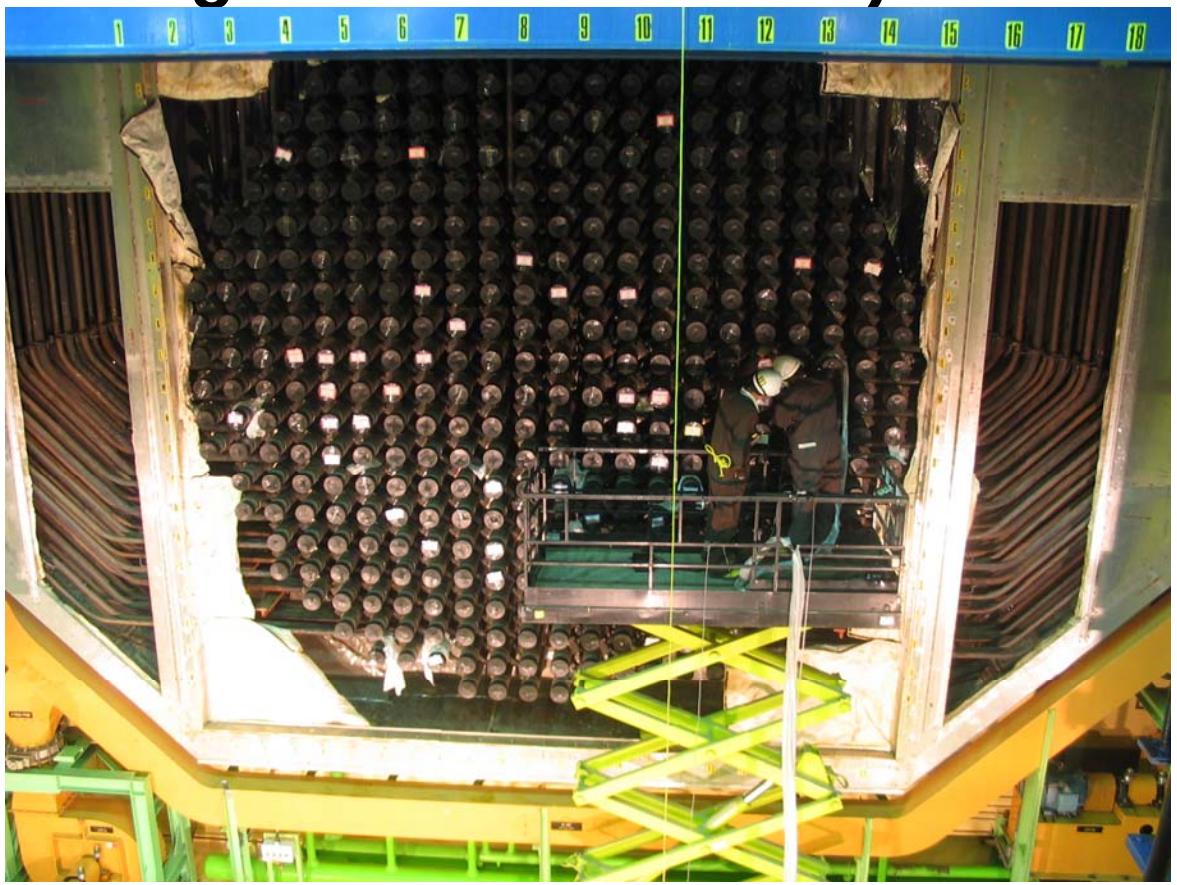




Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Remove Reactor Face Insulation Panels (blankets)

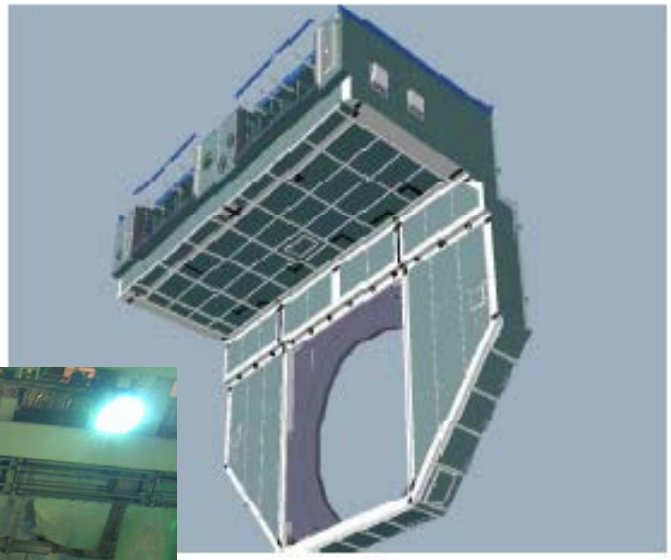
- **Removed in a similar manner as currently done (using FM Bridge and scissor lifts).**

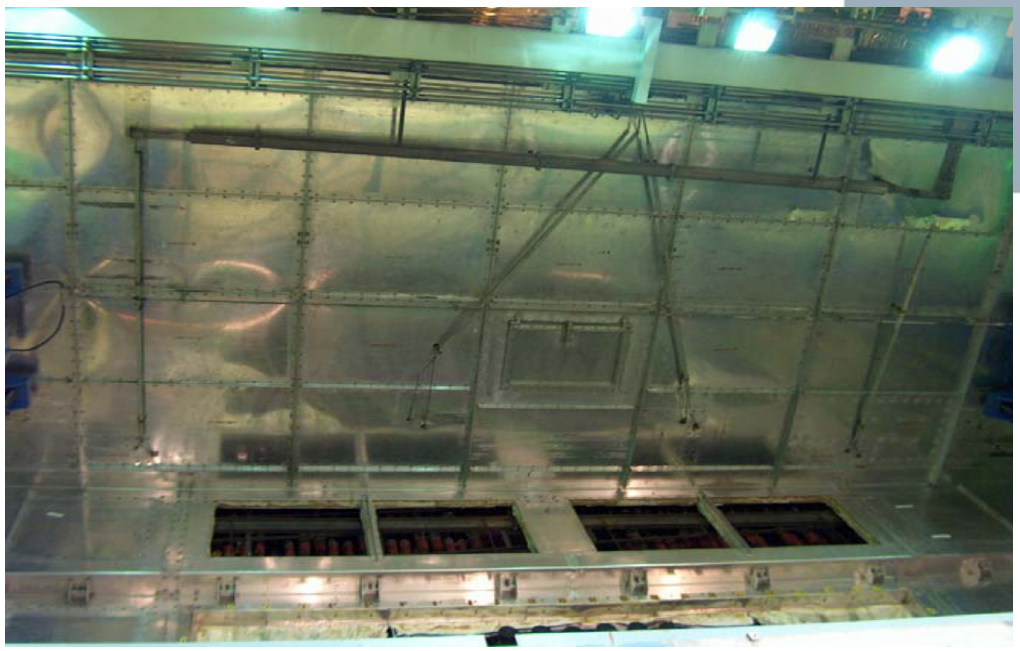


Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Remove Feeder Cabinets

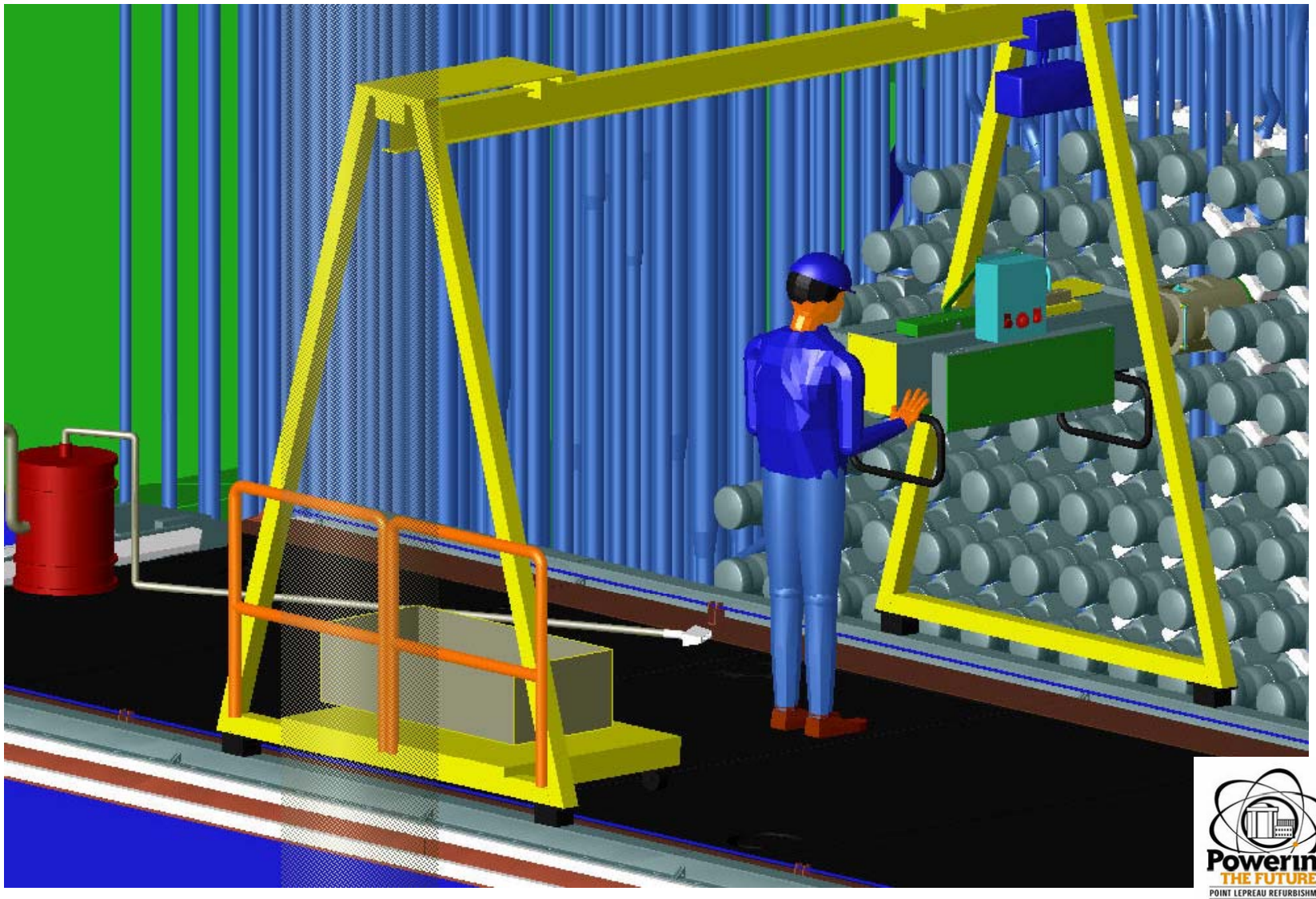
- **Cabinet frames and insulation panels will be removed, bagged and sent to SRWMF.**





Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

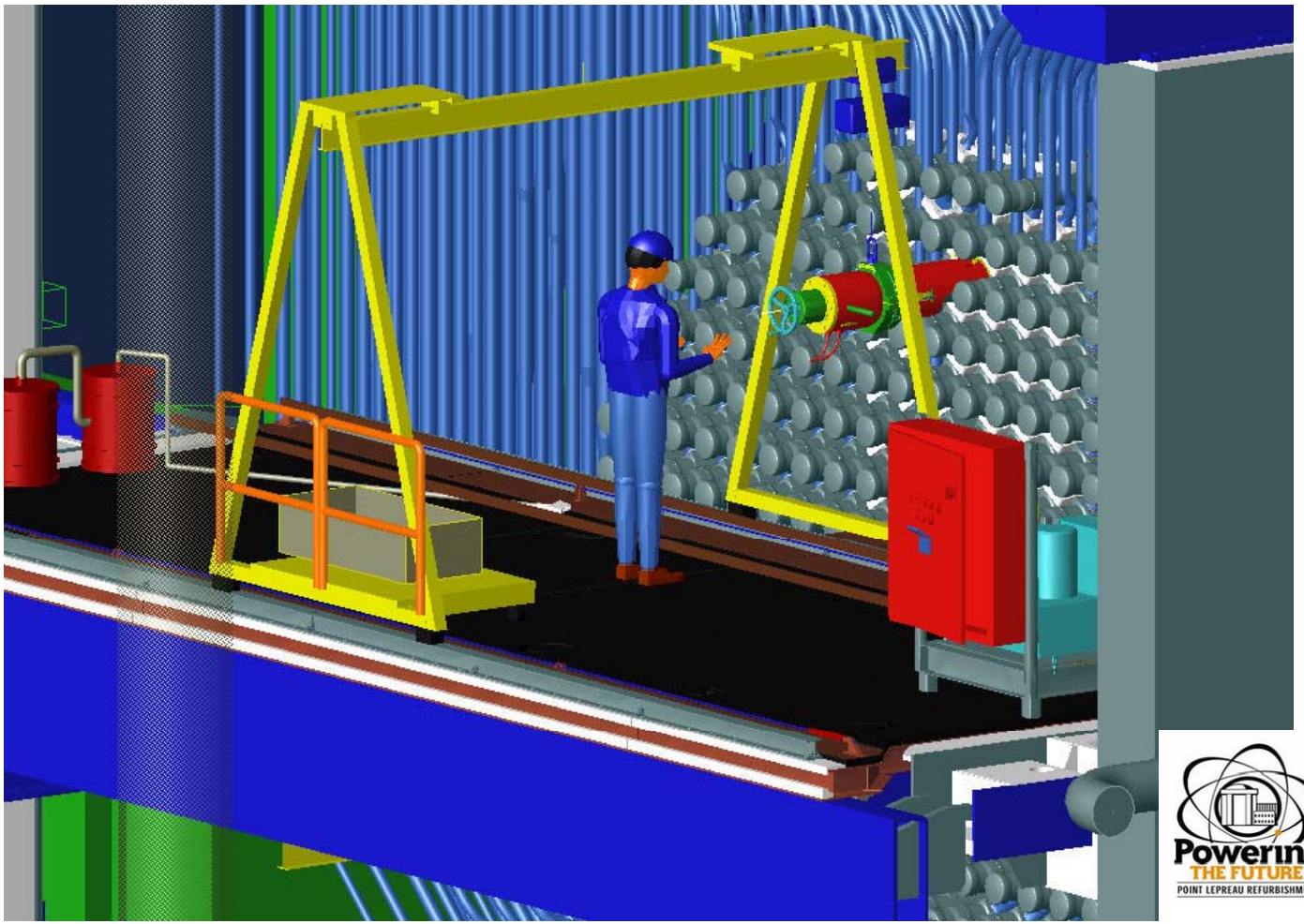
Remove Closure Plugs



Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Break Feeder Connections

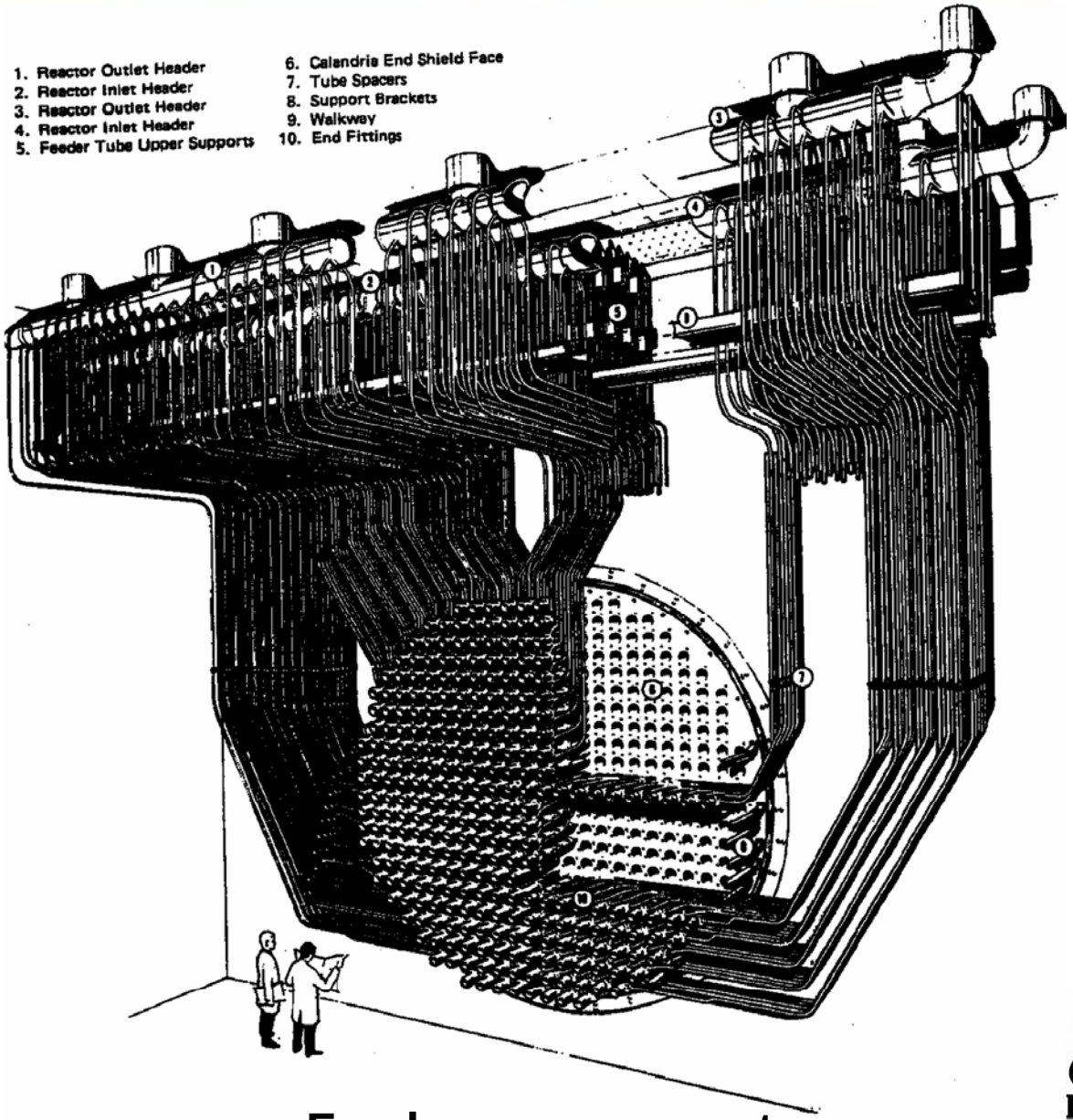
Exerts ~100 000 lb force to shear off feeder connection bolts



Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

RETUBE – FEEDER REPLACEMENT

All reactor inlet and outlet feeders (760 in total) will be replaced.



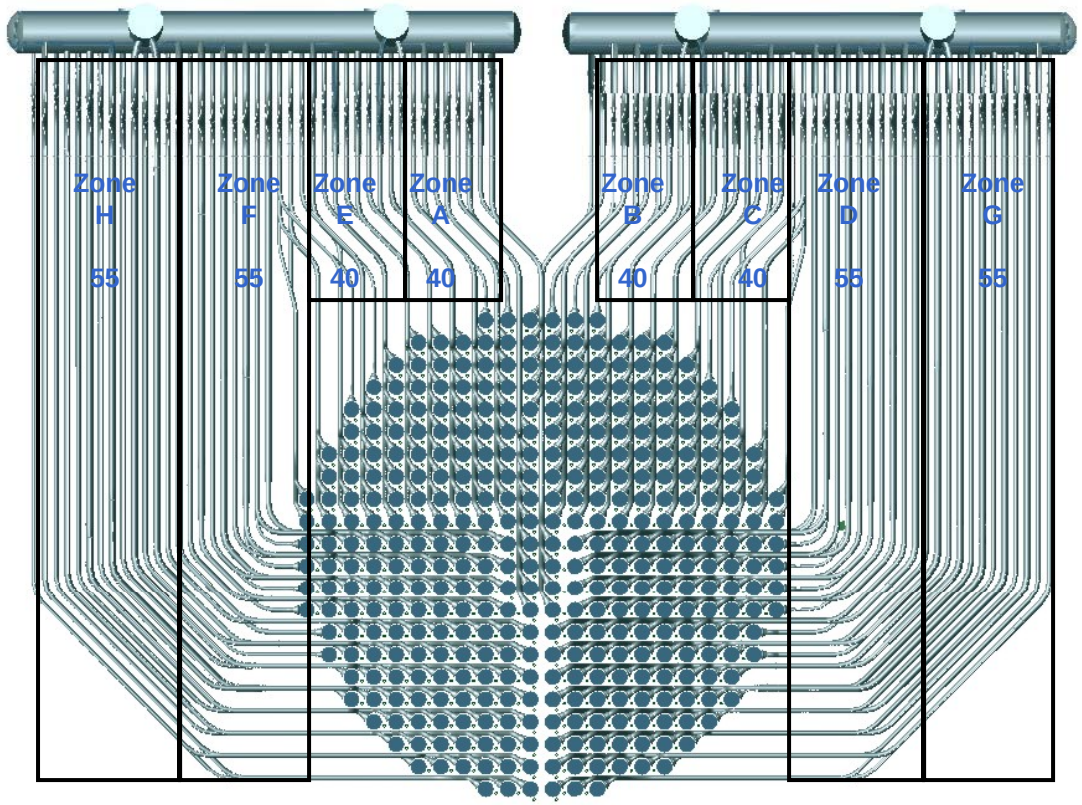
Feeder arrangement

Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

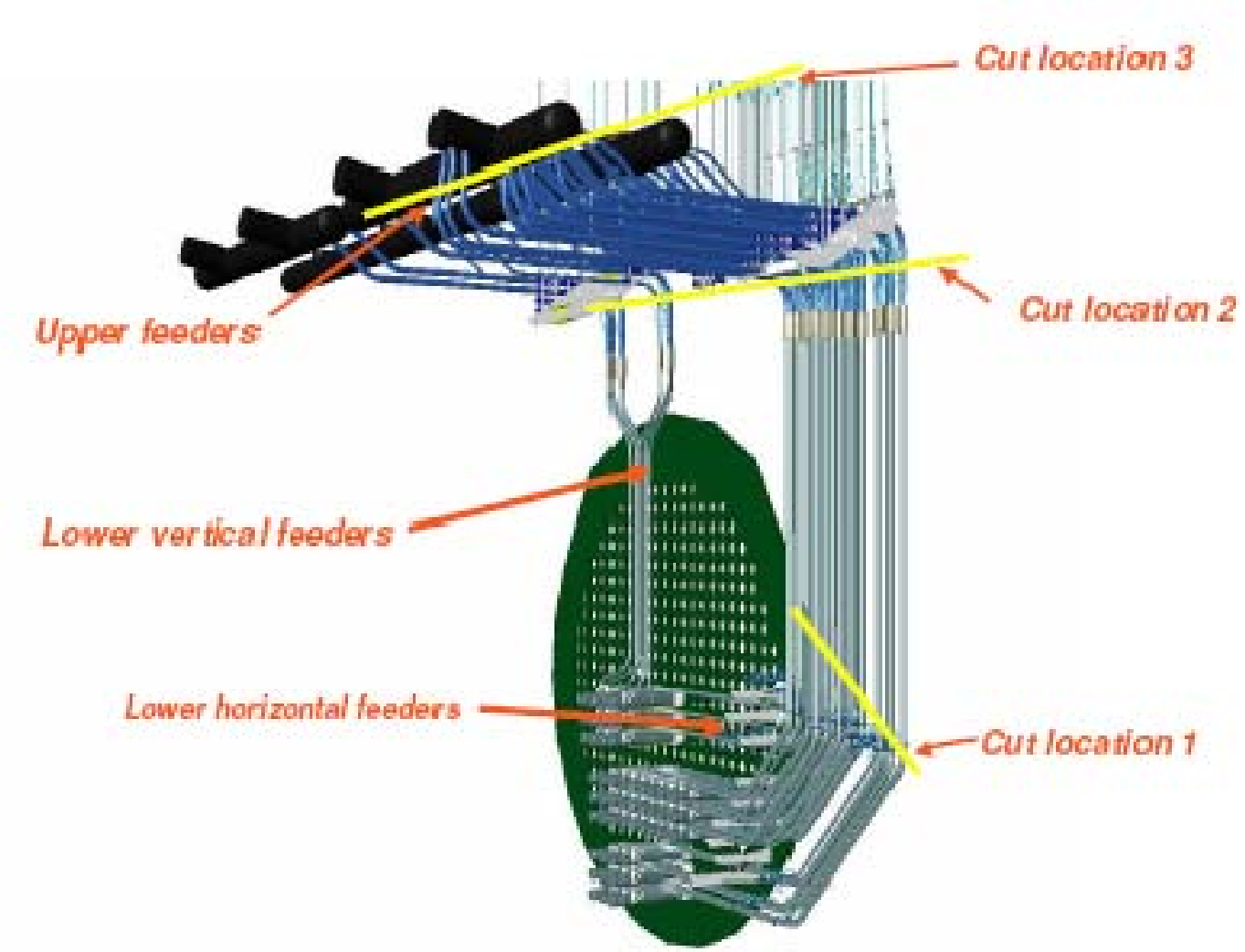
Feeder Removal Sequence

- **Dose Rates on Feeder Platform between 1 mSv/h and 2.5 mSv/h**

- **Dose Rates will be lowest at centre line of reactor between A and B feeder banks about 1.5 mSv/h**



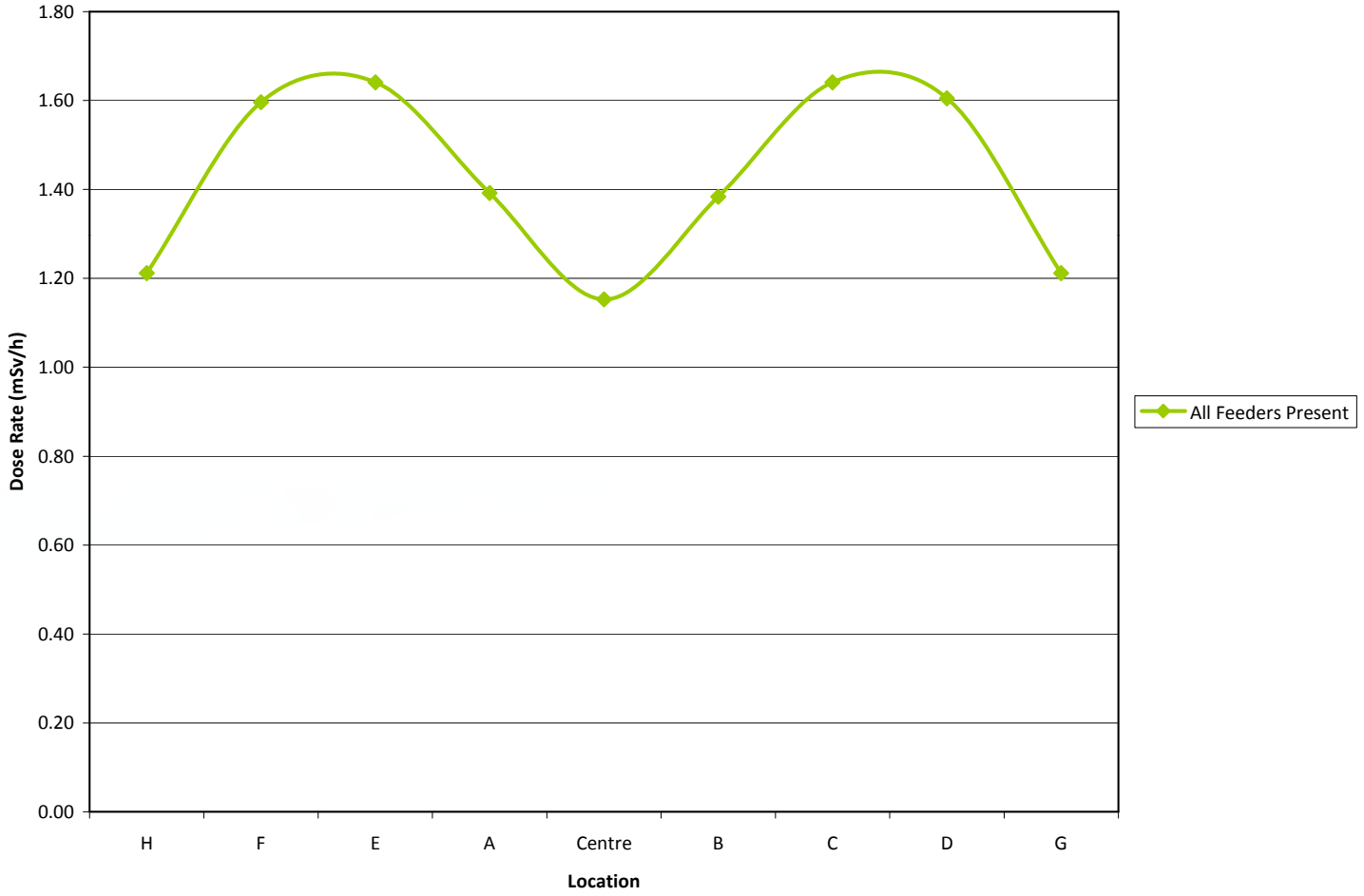
Feeder Cut Locations



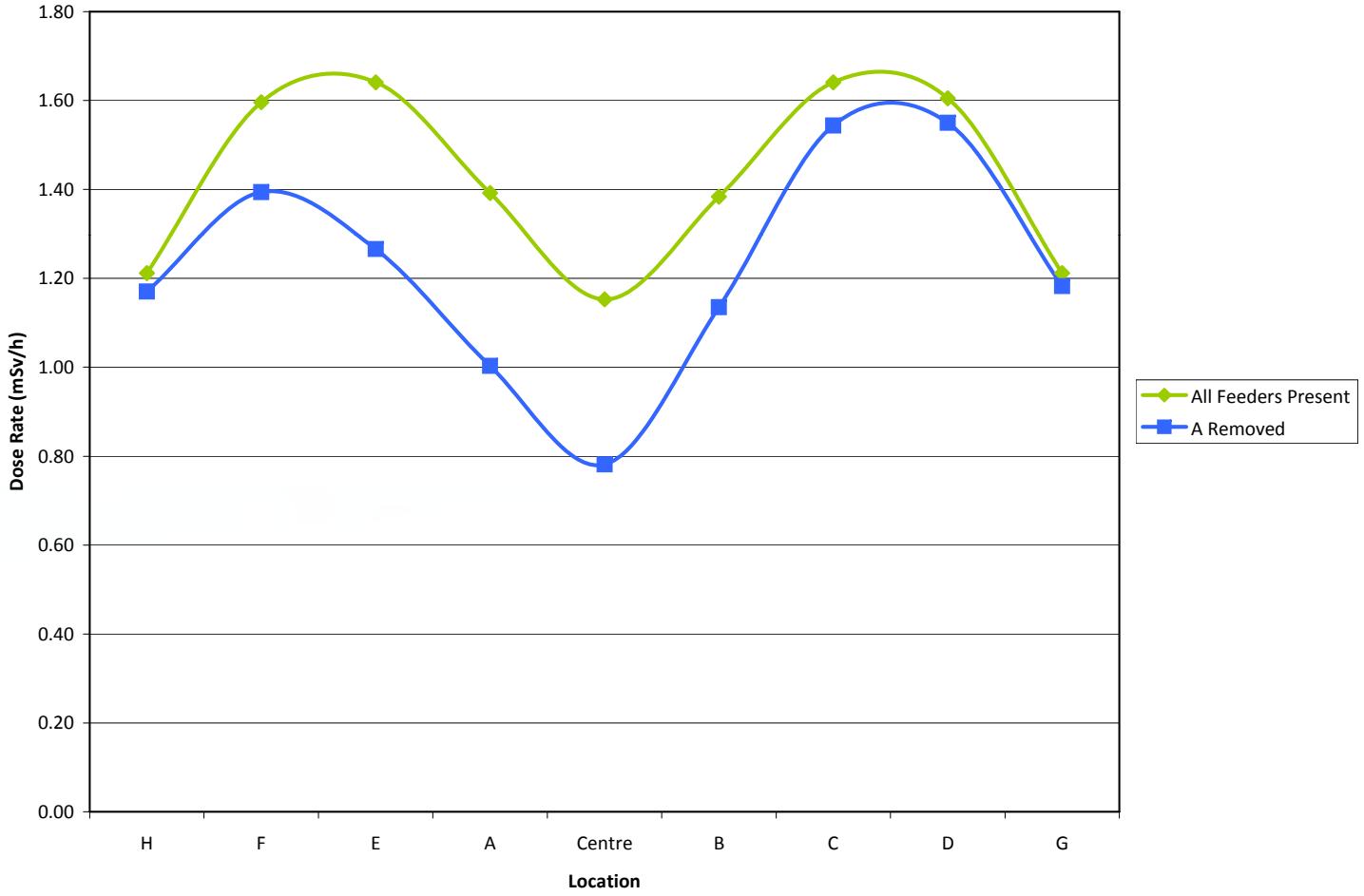
Header Nozzle Area

Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

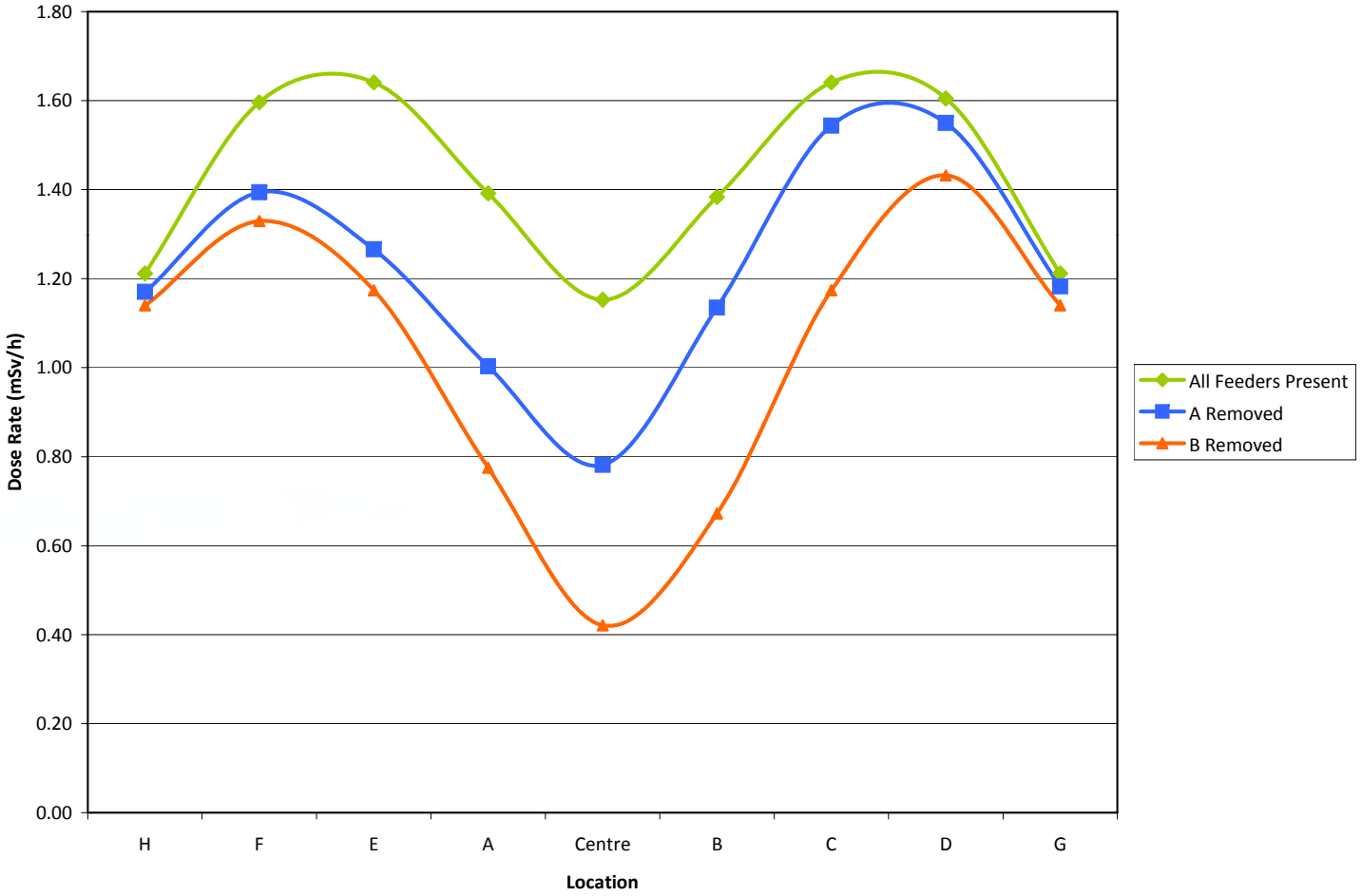
Changing Dose Rates Across Front of Feeder Platform During Feeder Removal



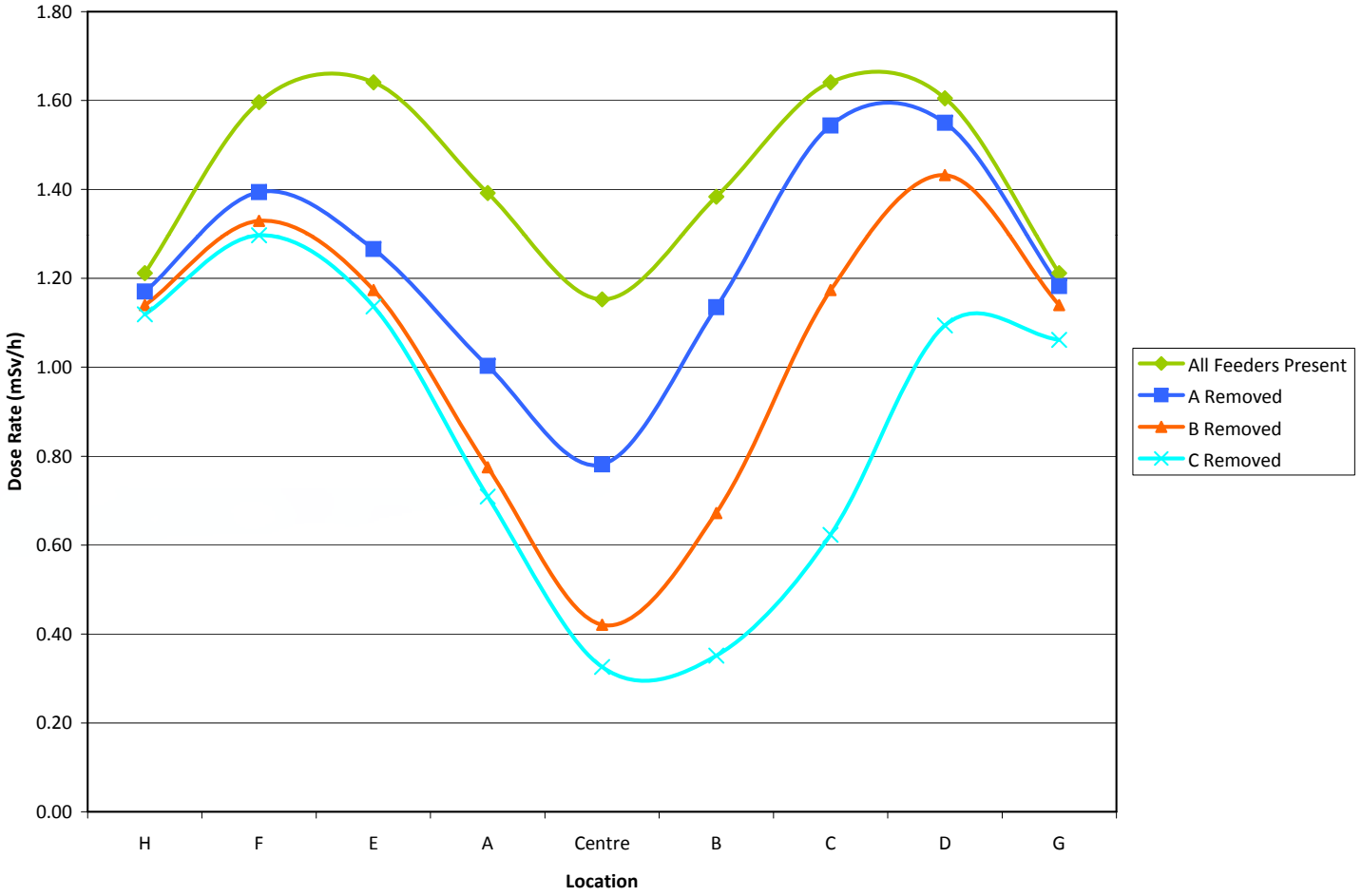
Changing Dose Rates Across Front of Feeder Platform During Feeder Removal



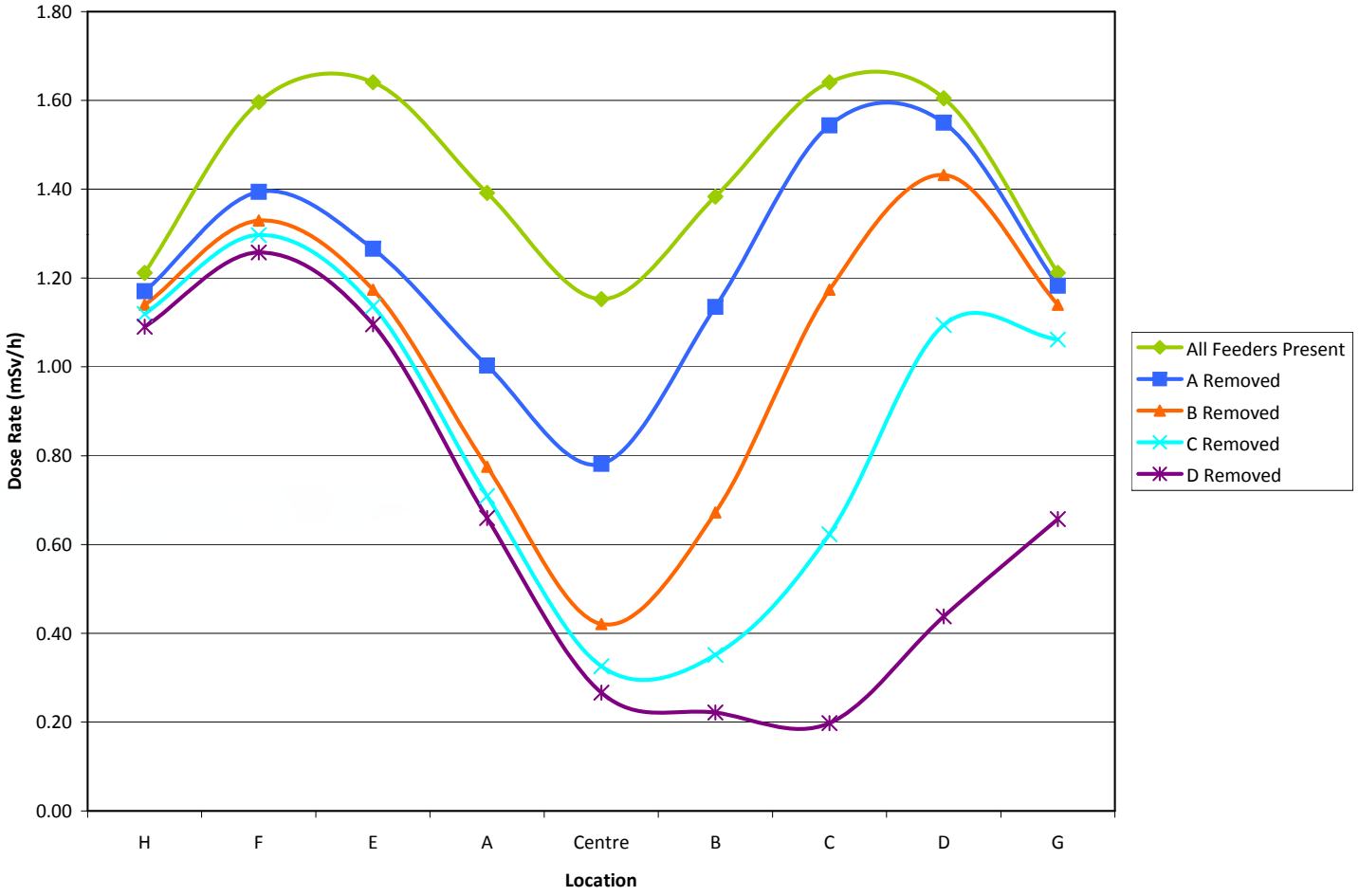
Changing Dose Rates Across Front of Feeder Platform During Feeder Removal



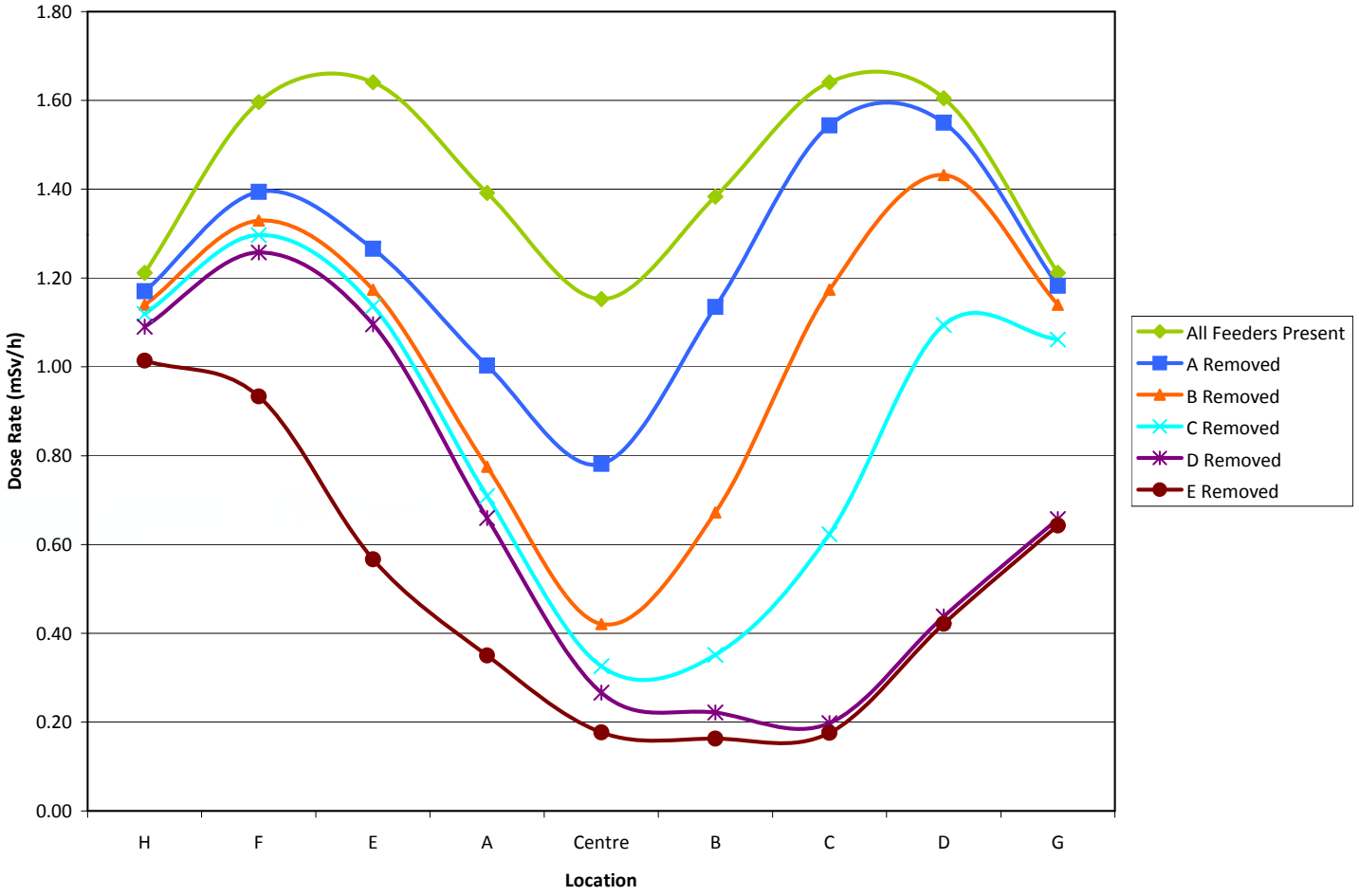
Changing Dose Rates Across Front of Feeder Platform During Feeder Removal



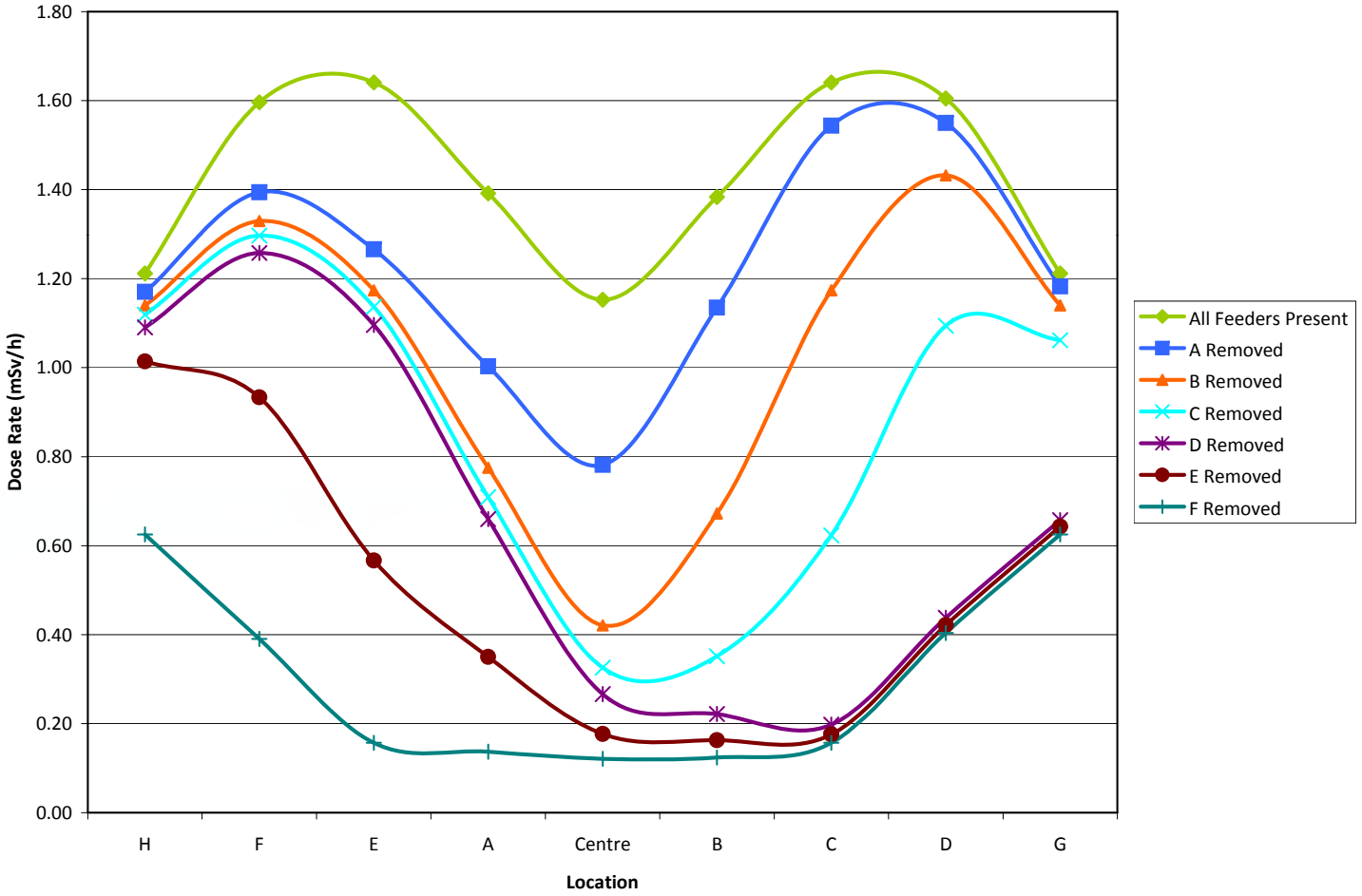
Changing Dose Rates Across Front of Feeder Platform During Feeder Removal



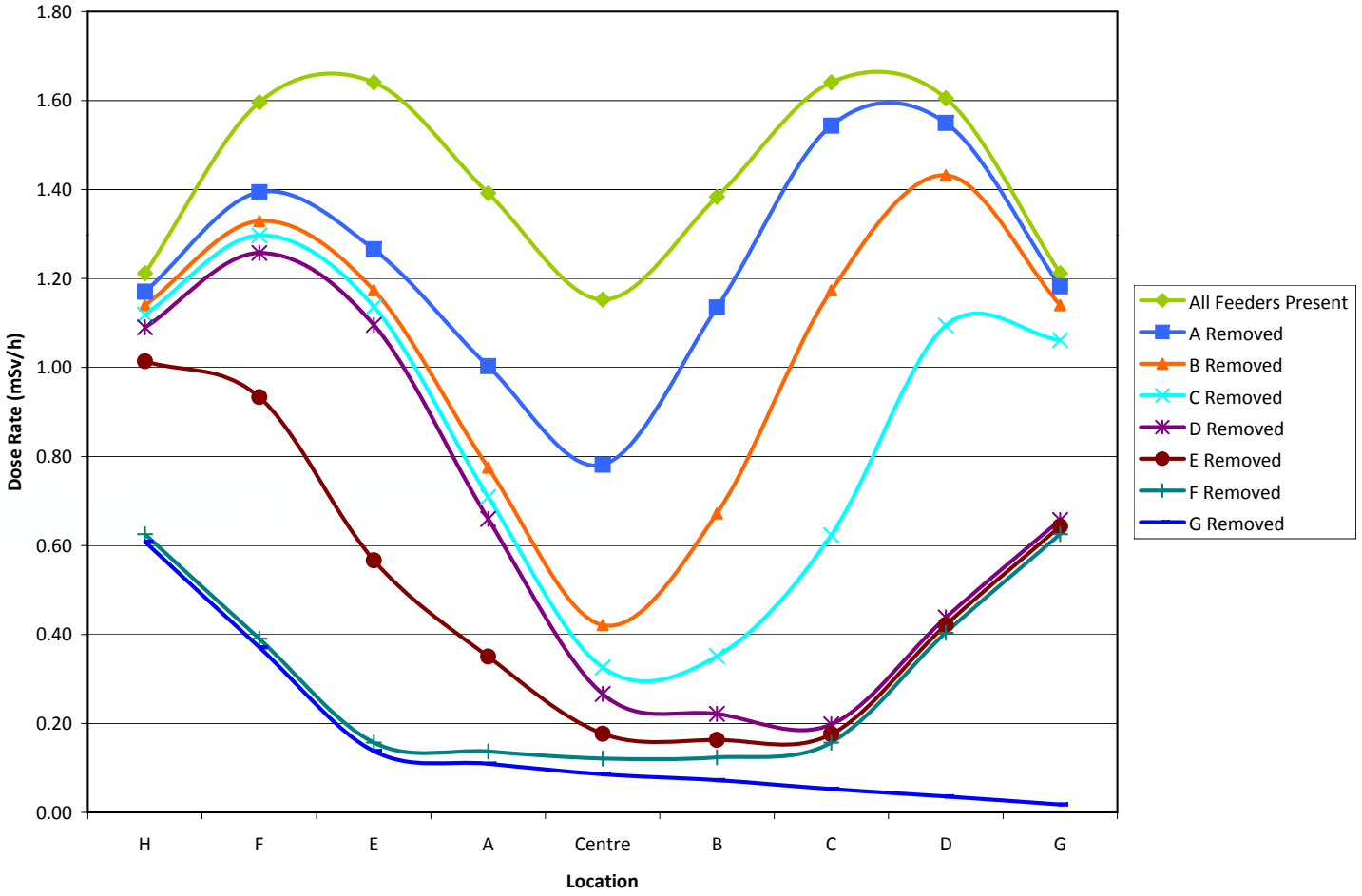
Changing Dose Rates Across Front of Feeder Platform During Feeder Removal



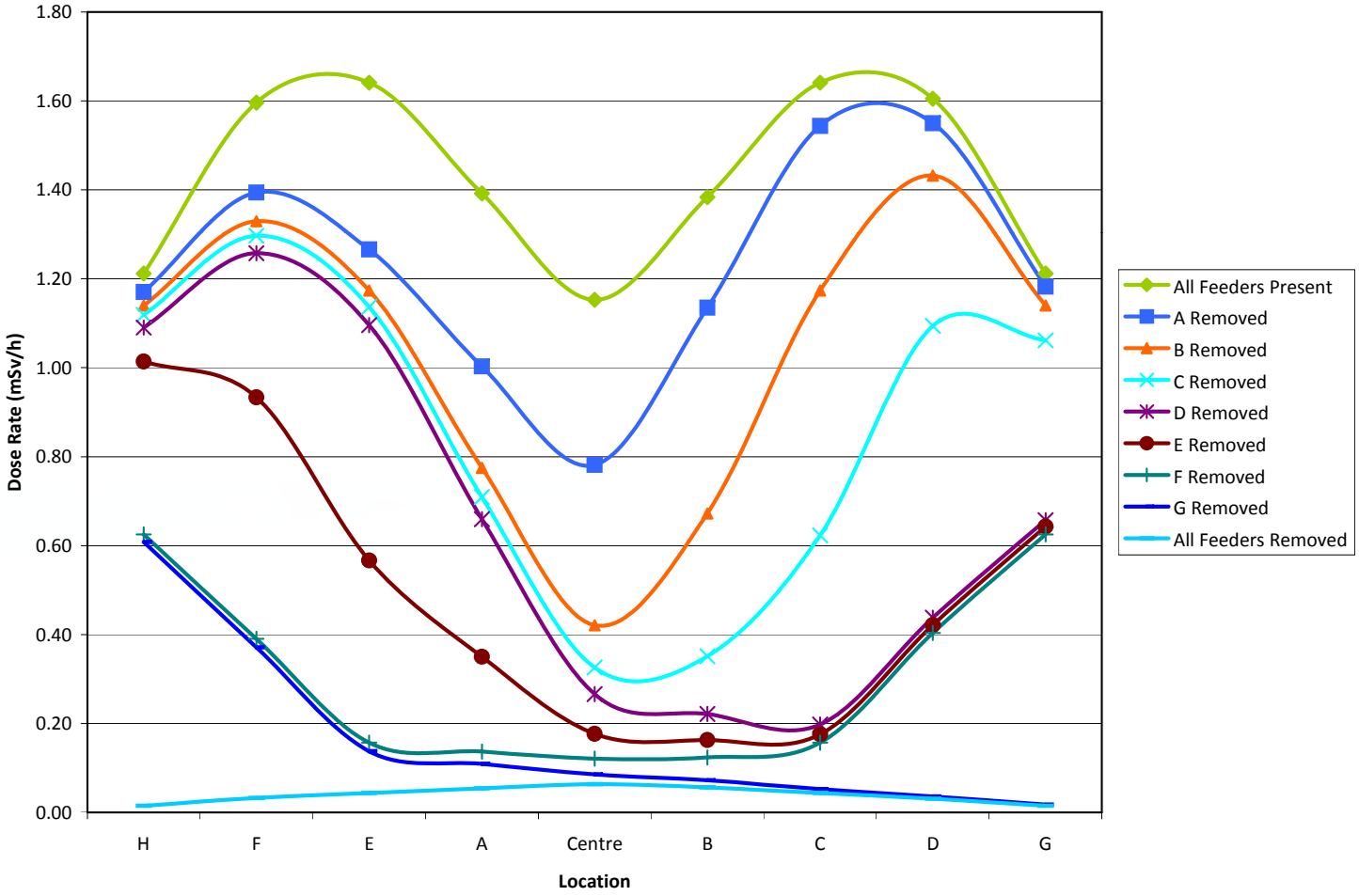
Changing Dose Rates Across Front of Feeder Platform During Feeder Removal



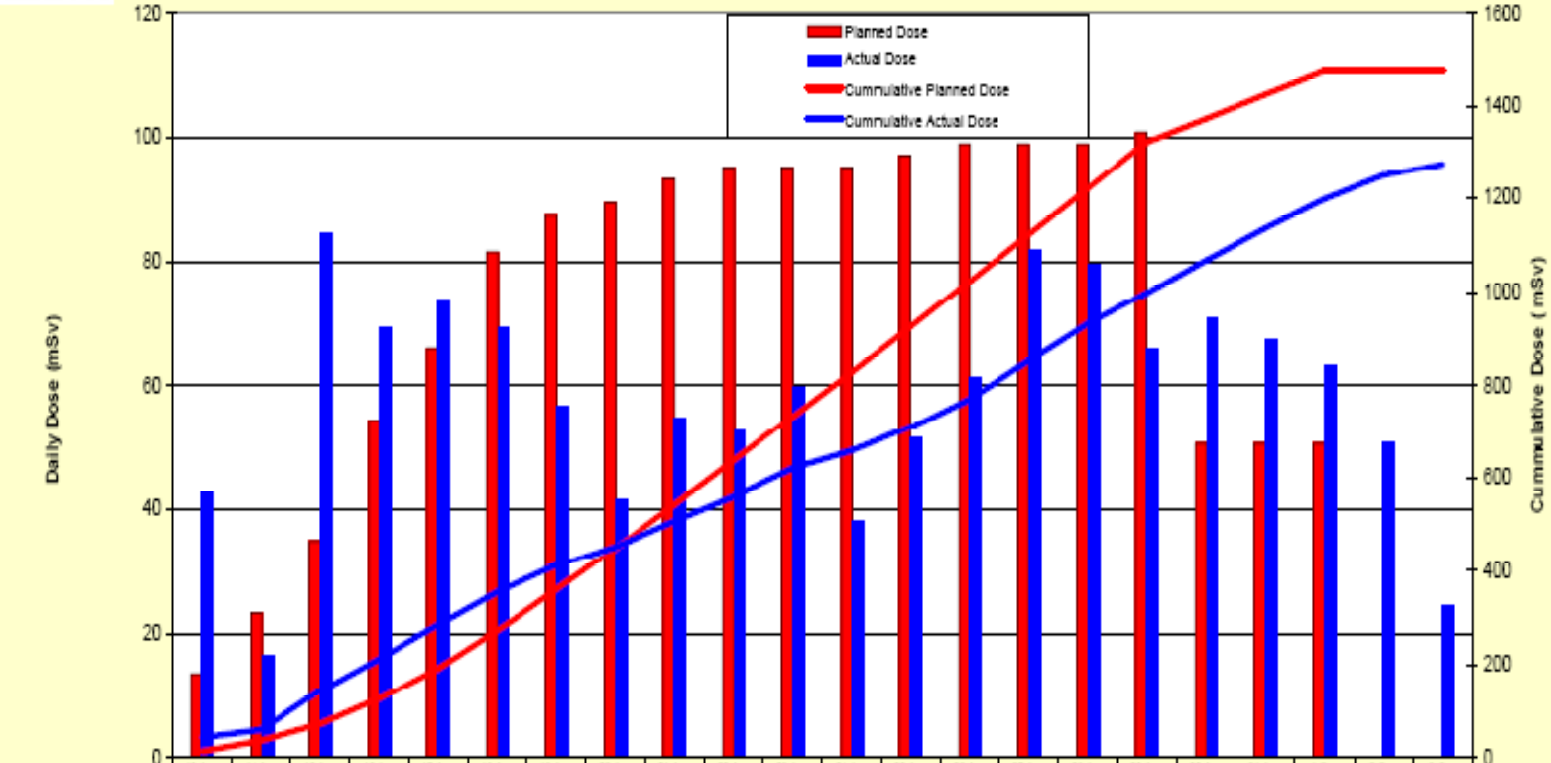
Changing Dose Rates Across Front of Feeder Platform During Feeder Removal



Changing Dose Rates Across Front of Feeder Platform During Feeder Removal

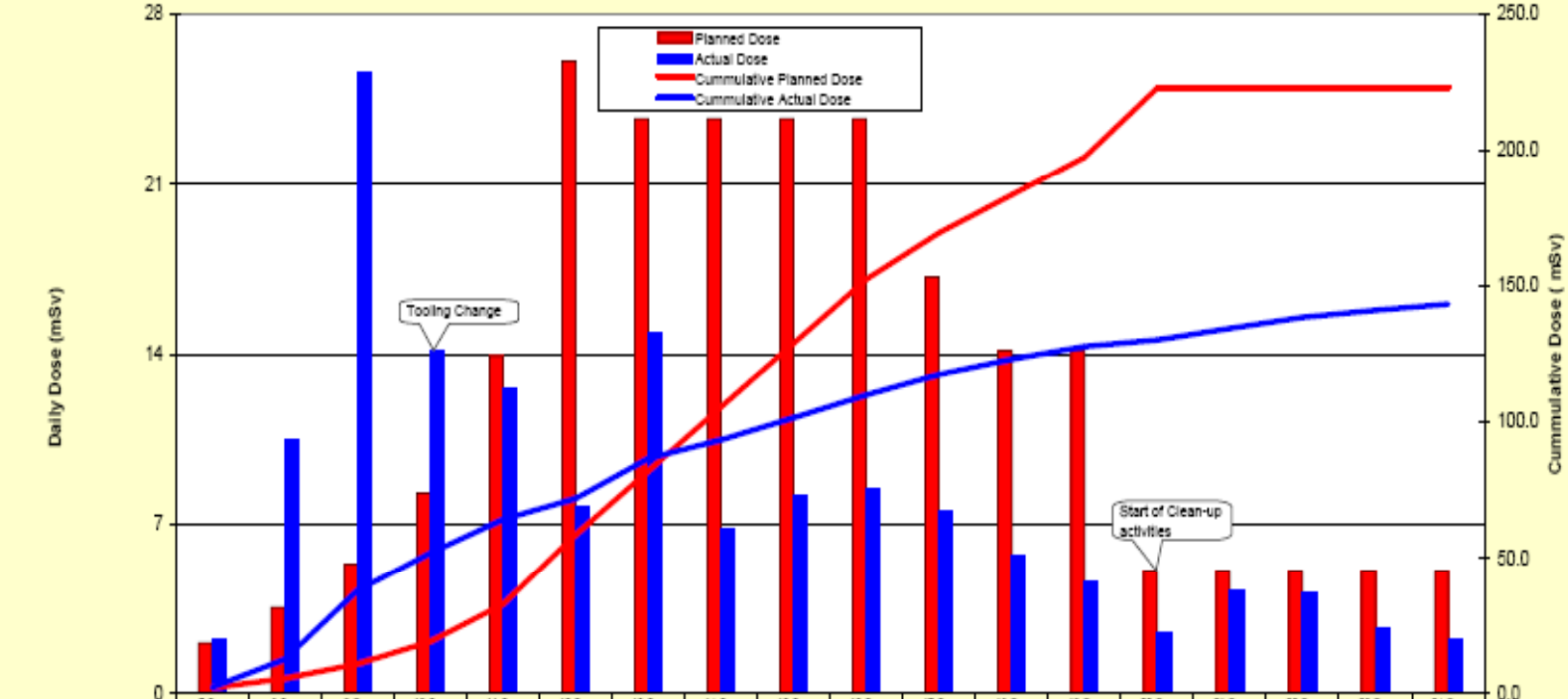


Collective PAD Dose -Feeder Removal



	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug	31-Aug	1-Sep	2-Sep	3-Sep
Planned Dose	14	23	35	54	66	82	87	89	93	95	95	95	97	99	99	99	101	50	50	50		
Actual Dose	42.64	16.5	84.32	69.15	73.37	69.37	56.7	41.51	54.81	52.56	59.72	38.12	51.38	61.26	81.71	79.53	65.83	70.73	67.21	63.66	50.56	24.4
Cummulative Planned Dose	13.6	36.9	71.8	126.2	192.1	273.7	361.0	450.3	543.4	638.5	733.6	828.7	925.8	1024.7	1123.7	1222.7	1323.6	1374.1	1424.5	1475.0	1475.0	1475.0
Cummulative Actual Dose	42.6	59.1	143.5	212.6	286.0	355.4	412.1	453.6	508.4	560.9	620.7	658.8	710.2	771.4	853.1	932.7	998.5	1069.2	1136.4	1199.5	1250.1	1274.5

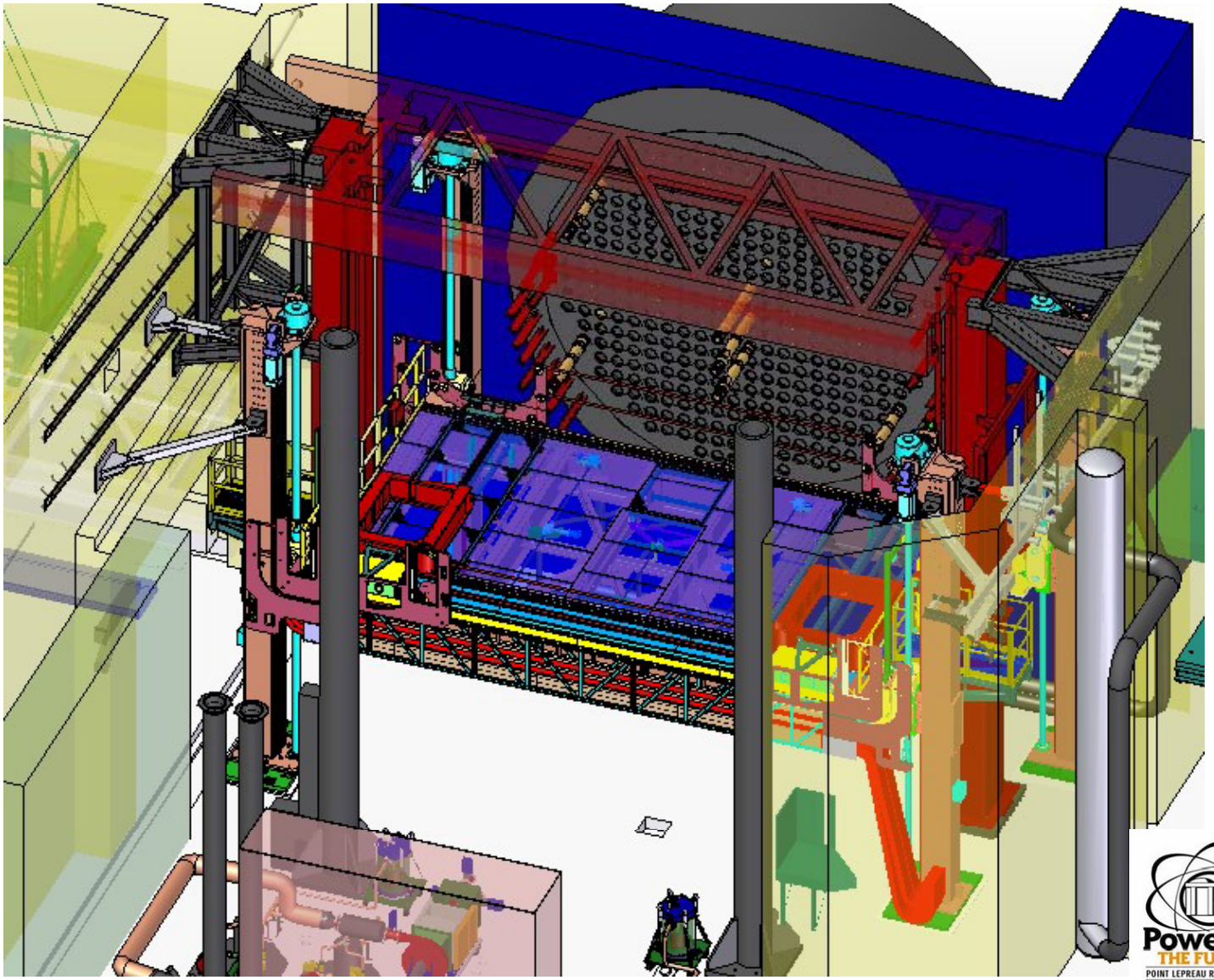
Collective PAD Dose -Feeder STUB Removal
REP 14677



	7-Sep	8-Sep	9-Sep	10-Sep	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep	21-Sep	22-Sep	23-Sep	24-Sep
Planned Dose	2	4	5	8	14	26	23	23	23	23	17	14	14	5	5	5	5	5
Actual Dose	2.22	10.56	25.33	14	12.44	7.65	14.74	6.76	8.14	8.4	7.5	5.64	4.61	2.46	4.19	4.03	2.82	2.24
Cummulative Planned Dose	2.1	5.6	10.9	19.1	32.9	58.7	82.2	105.6	128.1	152.6	169.6	183.6	197.6	223.0	223.0	223.0	223.0	223.0
Cummulative Actual Dose	2.2	12.8	37.9	51.9	64.4	72.0	86.7	93.5	101.7	110.1	117.6	123.2	127.8	130.3	134.5	138.6	141.2	143.4

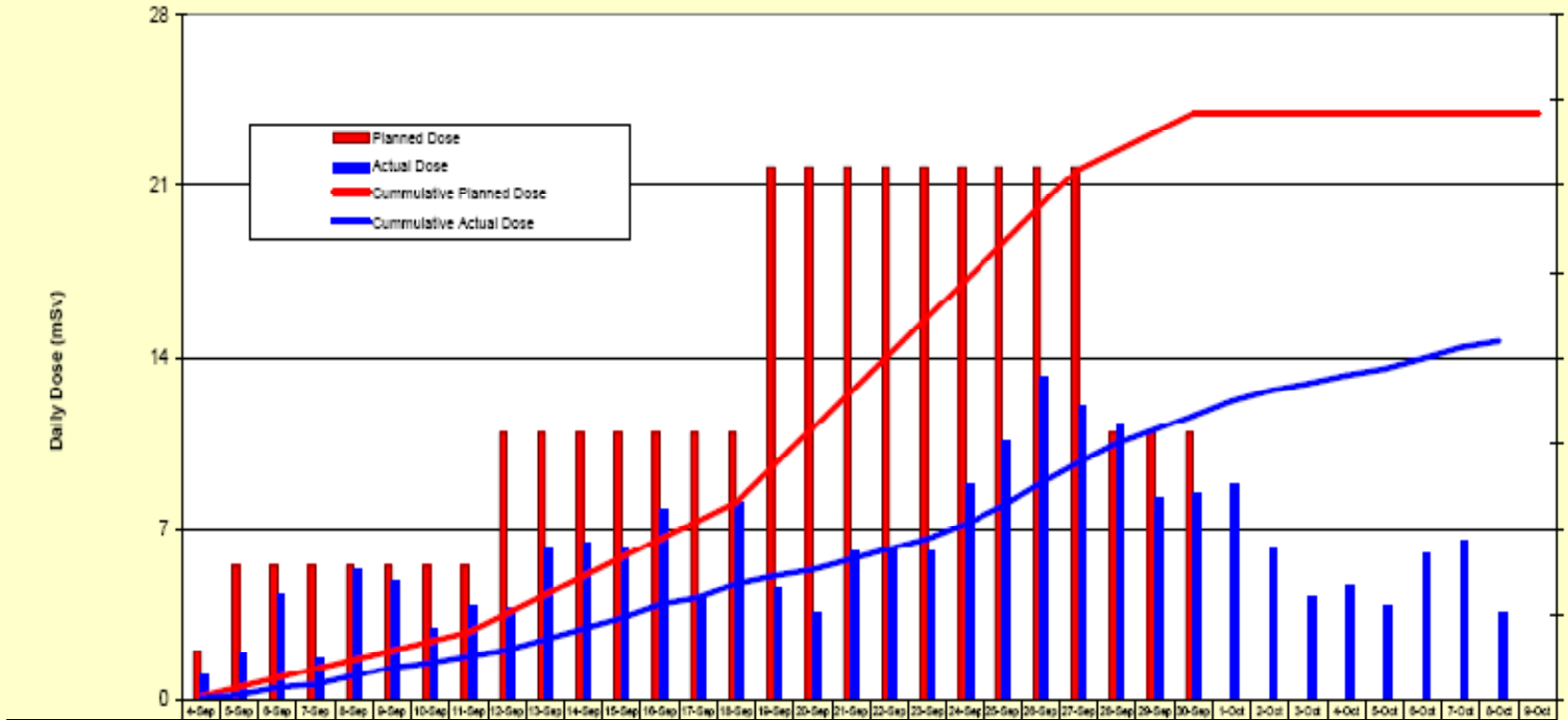
Stub removals completed Sept 19

Install Fuel Channel Platform



Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

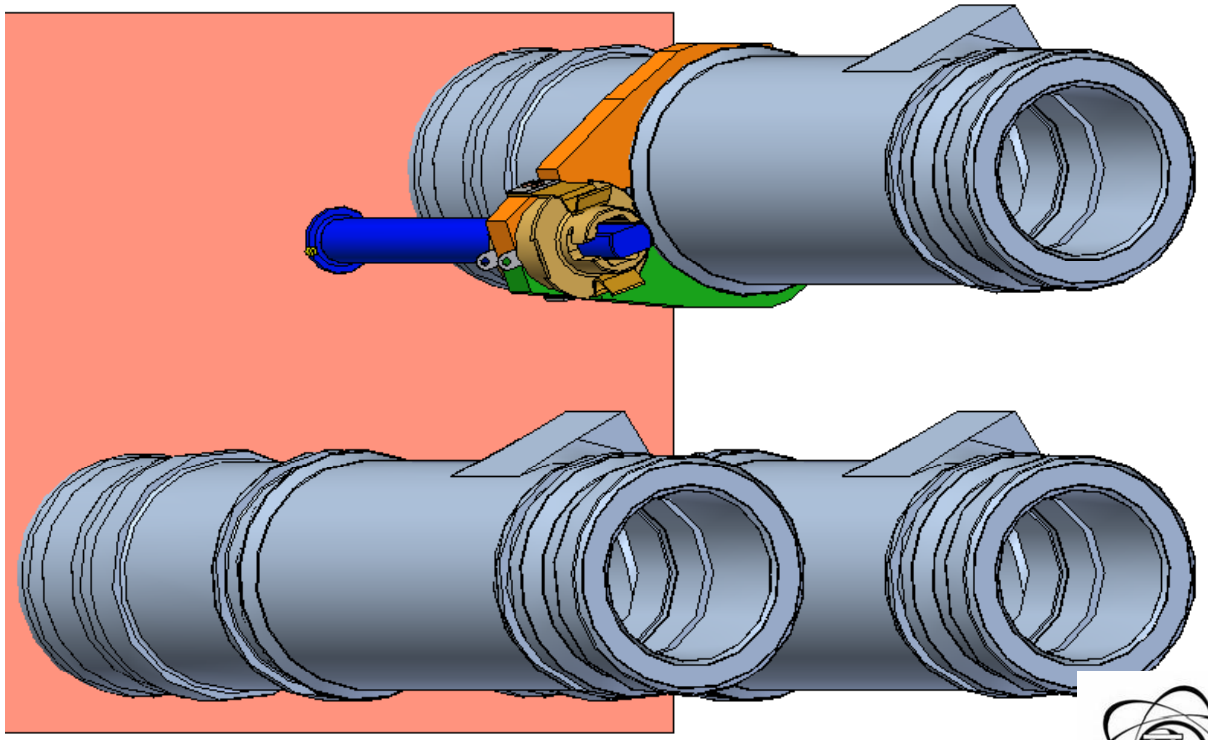
Collective PAD Dose -Fuel Channel Platform
REP #s 14910, 14918, 14923
September 1- October 7



	4-Sep	5-Sep	6-Sep	7-Sep	8-Sep	9-Sep	10-Sep	11-Sep	12-Sep	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep	21-Sep	22-Sep	23-Sep	24-Sep	25-Sep	26-Sep	27-Sep	28-Sep	29-Sep	30-Sep	1-Oct	2-Oct	3-Oct	4-Oct	5-Oct	6-Oct	7-Oct	8-Oct	9-Oct
Planned Dose	2.0	5.4	5.4	5.4	5.4	5.4	5.4	5.4	10.8	10.8	10.8	10.8	10.8	10.8	10.8	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	10.8	10.8	10.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Actual Dose	1	1.88	4.31	1.76	5.24	4.85	2.88	3.66	3.69	6.1	6.37	6.19	7.7	4.12	6.02	4.58	3.56	5.97	6.2	5.97	6.69	10.5	13.07	11.92	11.15	8.19	8.36	6.89	6.1	4.21	4.62	3.6	5.94	6.42	3.56	
Cummulative Planned Dose	2.0	7.4	12.8	18.3	23.7	29.1	34.5	40.0	50.8	61.6	72.4	83.2	94.0	104.8	115.6	137.2	158.8	180.4	202.0	223.6	245.2	266.8	288.4	310.0	320.8	331.6	342.4	342.4	342.4	342.4	342.4	342.4	342.4	342.4	342.4	342.4
Cummulative Actual Dose	1.0	2.9	7.2	9.0	14.2	19.0	21.9	25.6	29.3	35.4	41.8	48.1	55.8	60.0	66.0	73.0	76.1	82.1	88.3	94.3	101.0	111.5	124.6	136.5	147.6	155.8	164.2	171.1	175.2	179.4	184.0	187.6	193.6	200.0	203.6	

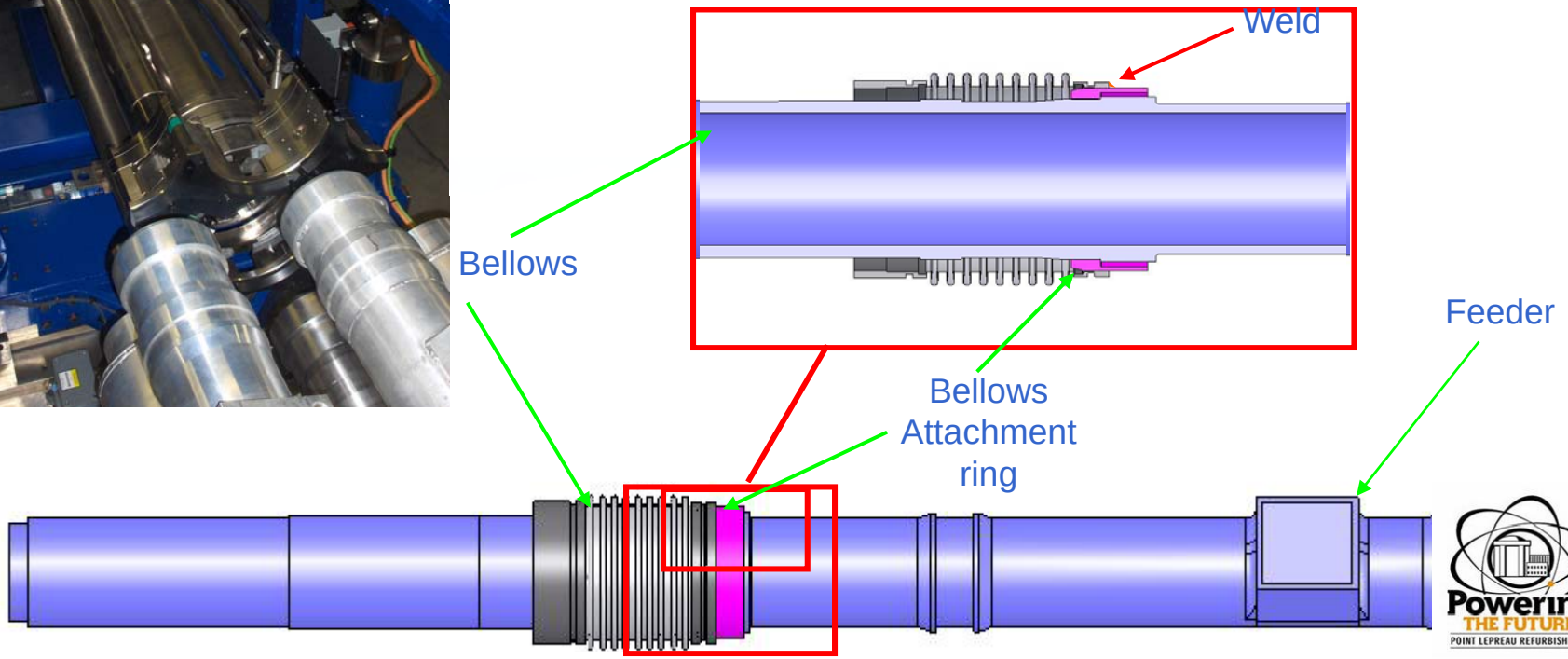
Positioning Assembly Removal

Variety of hand tools (including catch trays) to remove PA hardware

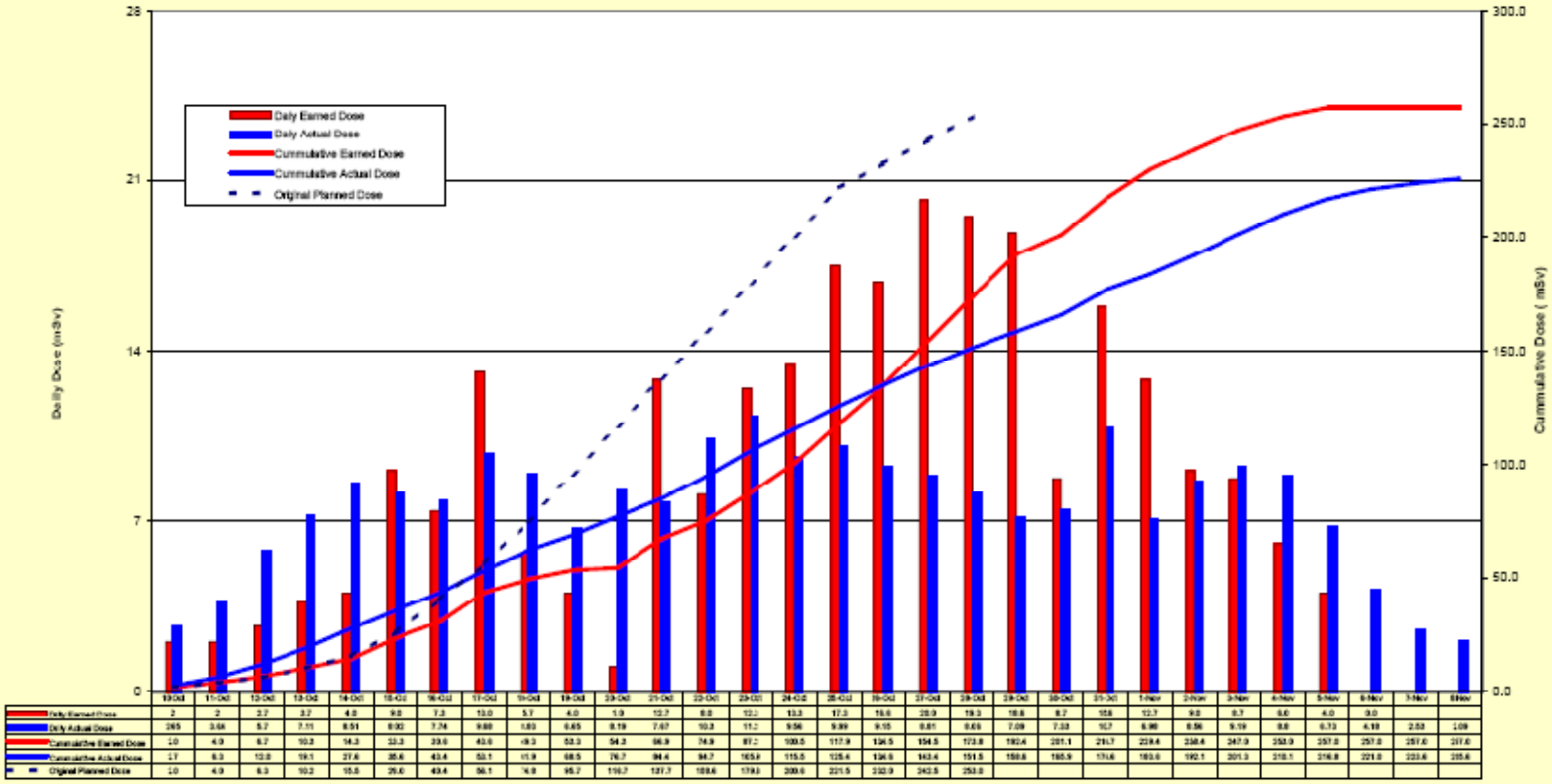


Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Cut Annulus Bellows from End Fitting



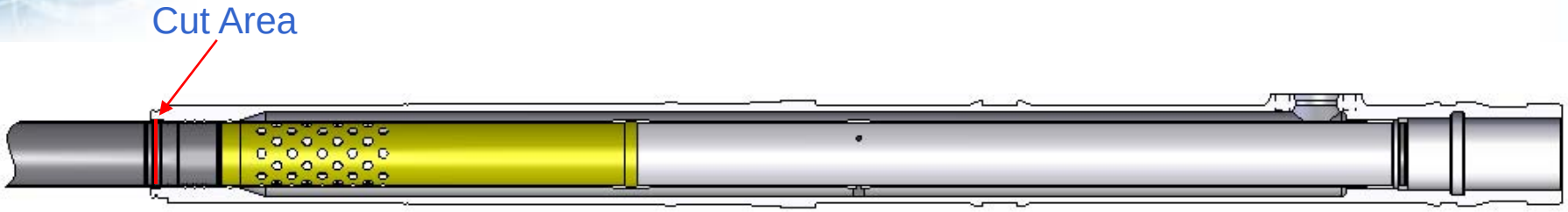
Collective PAD Dose -Bellows Cutting
REP #s: 14747, 14751

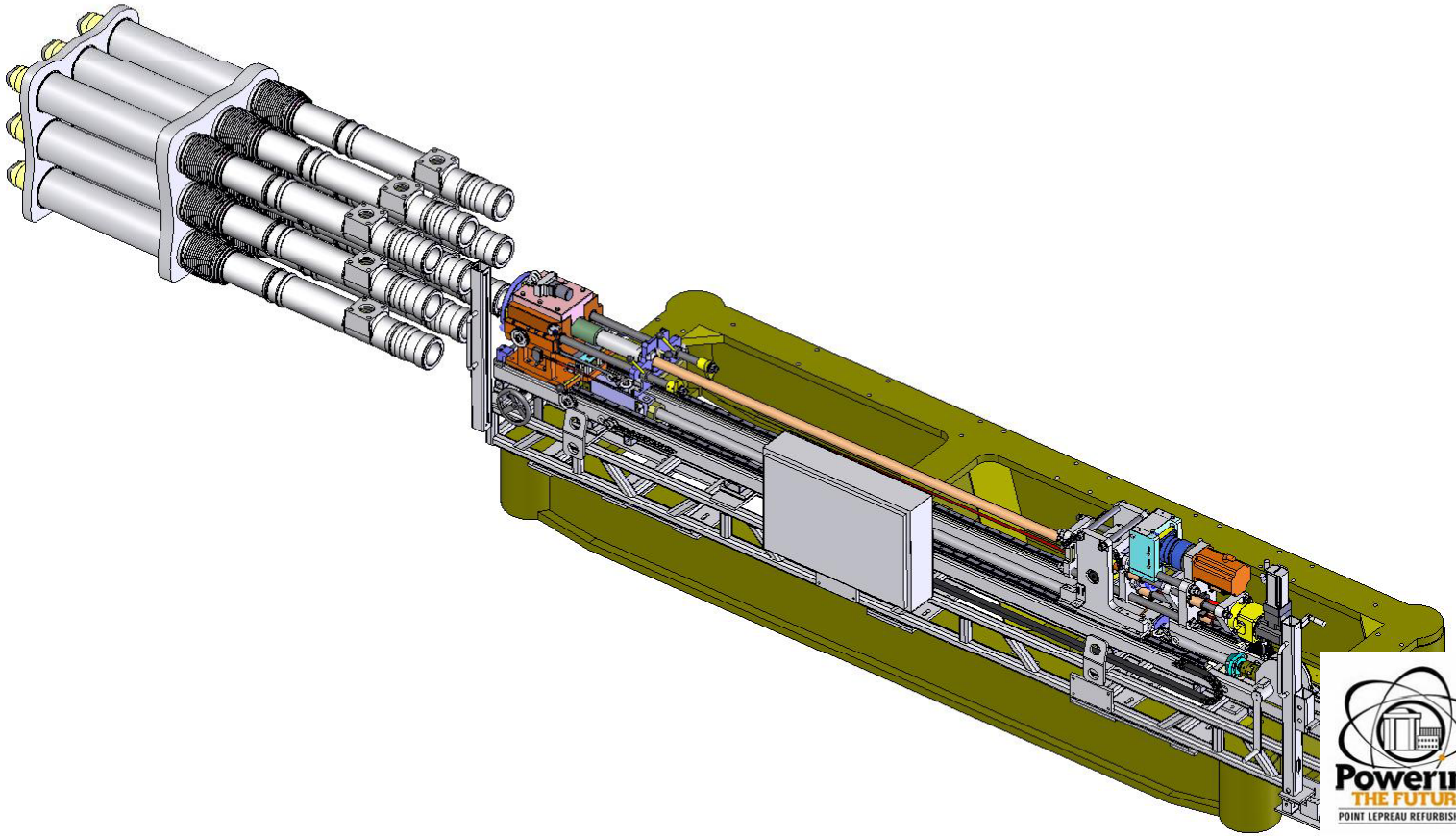


	10-Oct	11-Oct	12-Oct	13-Oct	14-Oct	15-Oct	16-Oct	17-Oct	18-Oct	19-Oct	20-Oct	21-Oct	22-Oct	23-Oct	24-Oct	25-Oct	26-Oct	27-Oct	28-Oct	29-Oct	30-Oct	31-Oct	1-Nov	2-Nov	3-Nov	4-Nov	5-Nov	6-Nov	7-Nov	8-Nov
Daily Earned Dose	2	2	2.7	3.7	4.8	9.8	7.3	13.8	5.7	4.0	1.9	12.7	8.8	12.1	13.3	17.3	15.8	20.9	19.3	10.8	8.7	15.8	12.7	9.8	8.7	6.6	4.0	3.0		
Daily Actual Dose	265	3.66	5.7	7.11	8.51	9.92	7.74	9.88	1.83	6.65	8.19	7.67	10.3	11.2	9.56	9.89	9.15	8.81	8.69	7.09	7.33	10.7	6.96	8.56	9.19	9.8	6.73	4.18	2.53	1.09
Cummulative Earned Dose	2.0	4.0	6.7	10.2	14.3	23.3	33.0	43.8	49.3	53.3	54.2	66.9	74.9	87.2	100.5	117.9	134.5	154.5	173.8	182.4	191.1	216.7	229.4	238.4	247.9	253.9	257.8	257.8	257.8	257.8
Cummulative Actual Dose	2.7	6.3	12.0	19.1	27.6	35.6	43.4	53.1	61.9	68.5	76.7	84.4	94.7	105.9	115.5	125.4	134.6	143.4	151.5	158.6	165.9	176.6	183.6	192.1	201.3	210.1	216.8	221.0	223.6	225.6
Original Planned Dose	2.0	4.0	6.3	10.2	15.8	26.0	40.4	56.1	74.8	95.7	119.7	137.7	159.6	179.0	200.6	221.5	232.9	242.8	253.0											

Final Update

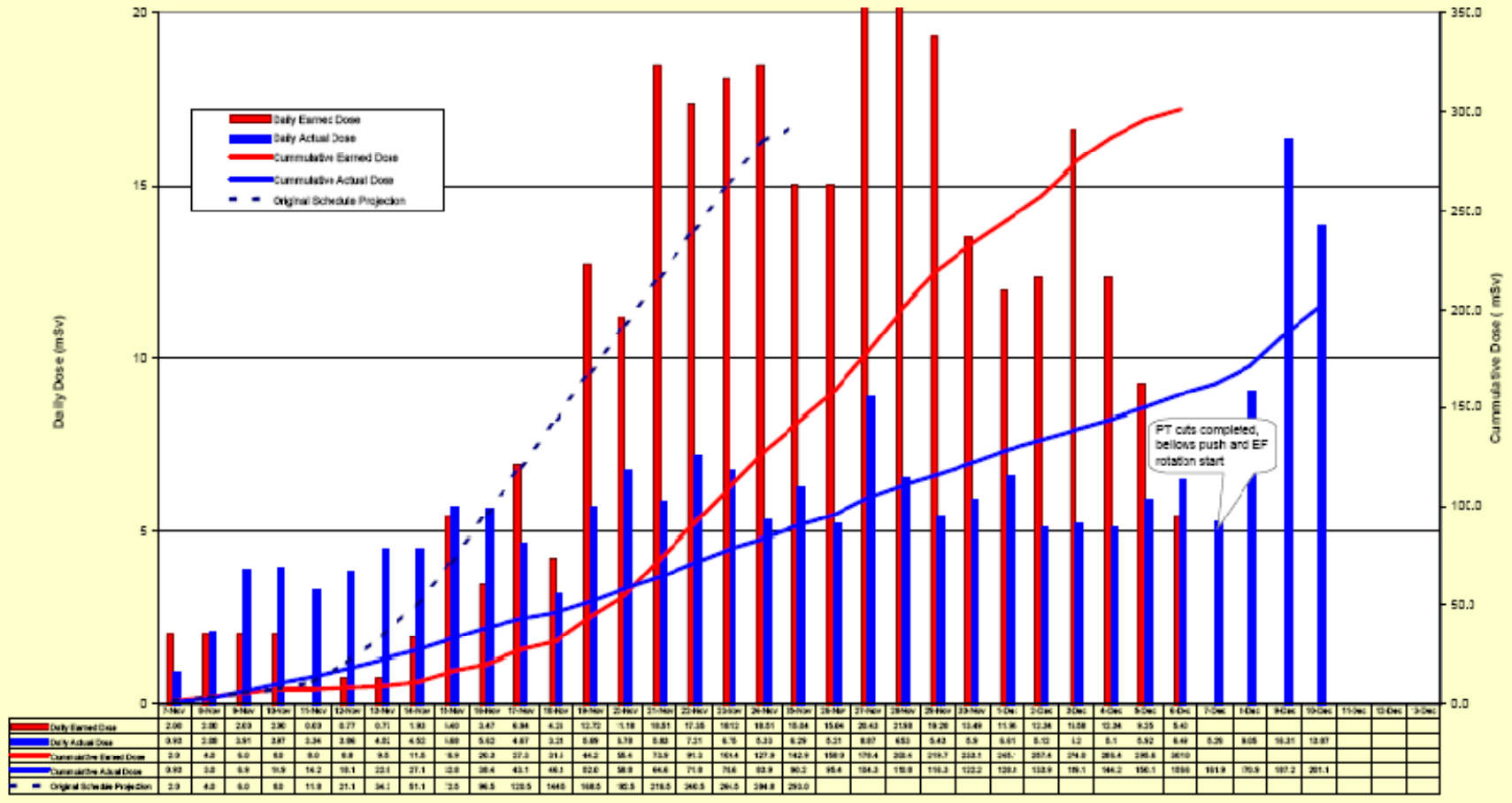
Cut Pressure Tubes





Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

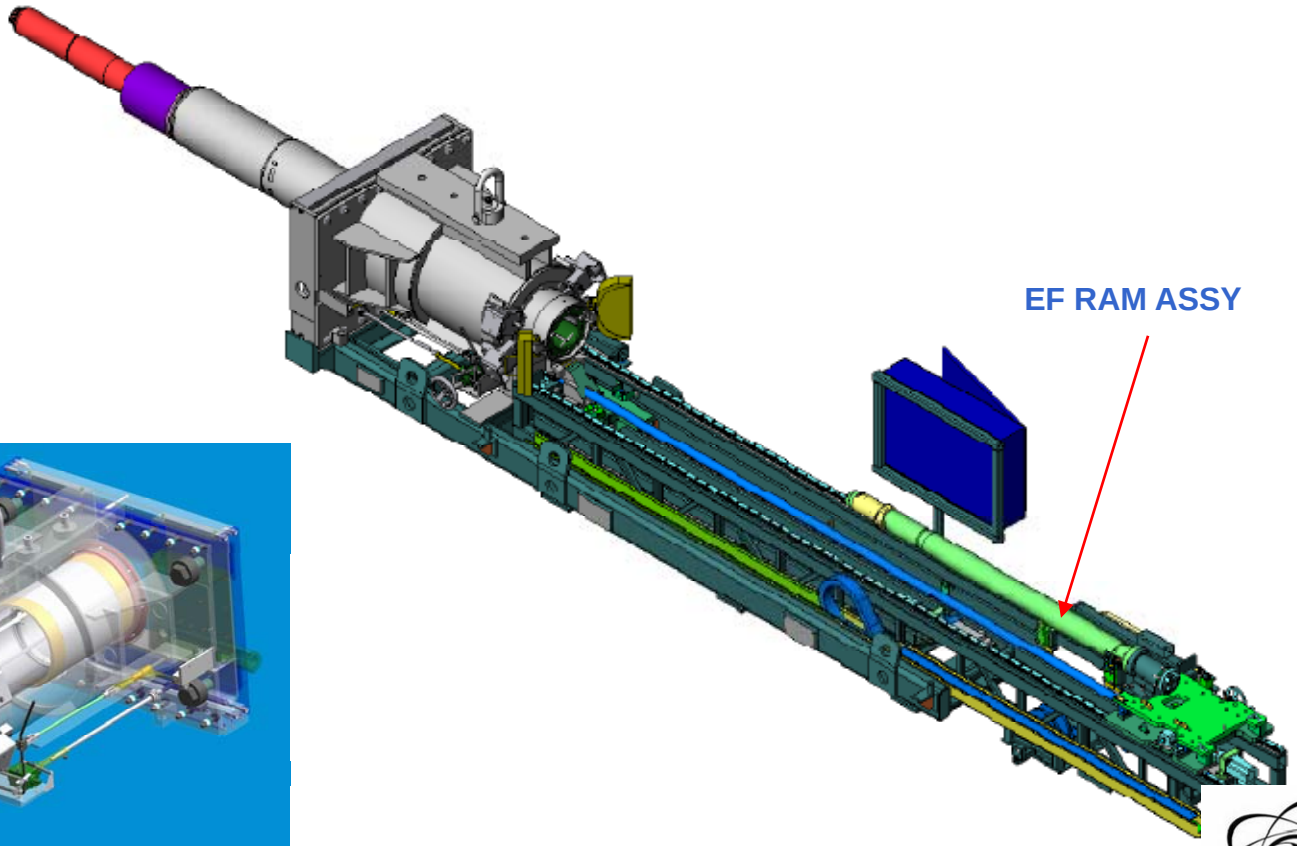
Collective PAD Dose -Pressure Tube Cutting
REP #s: 15103, 15116

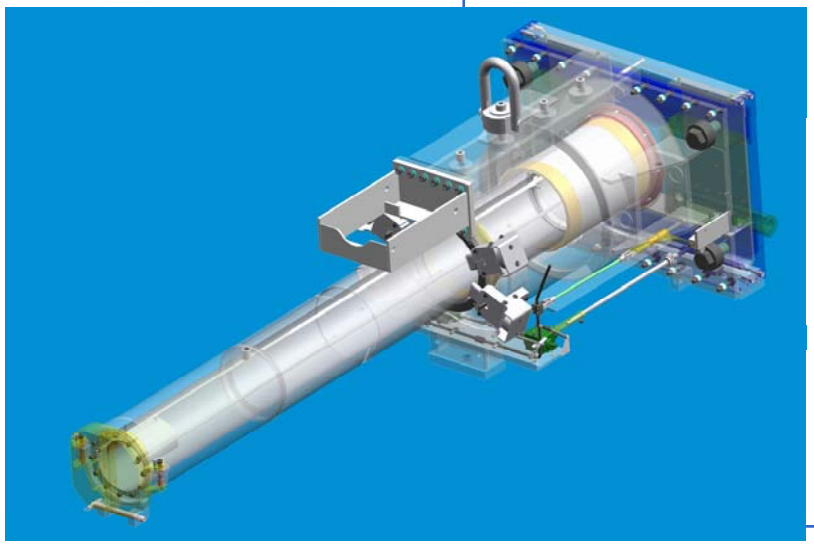


	7-Nov	8-Nov	9-Nov	10-Nov	11-Nov	12-Nov	13-Nov	14-Nov	15-Nov	16-Nov	17-Nov	18-Nov	19-Nov	20-Nov	21-Nov	22-Nov	23-Nov	24-Nov	25-Nov	26-Nov	27-Nov	28-Nov	29-Nov	30-Nov	1-Dec	2-Dec	3-Dec	4-Dec	5-Dec	6-Dec	7-Dec	8-Dec	9-Dec	10-Dec	11-Dec	12-Dec	13-Dec
Daily Earned Dose	2.00	2.00	2.03	2.00	0.63	0.77	0.71	1.93	1.60	3.47	6.94	4.21	12.72	11.18	18.51	17.35	18.12	18.51	18.04	15.06	20.43	21.59	19.28	13.49	11.96	12.34	11.58	12.34	9.35	5.40							
Daily Actual Dose	0.93	3.00	3.91	3.97	3.34	3.86	4.61	4.52	5.80	5.62	4.87	3.21	5.89	5.78	5.83	7.21	6.75	5.33	6.29	5.31	8.07	6.53	5.43	5.9	5.61	5.12	5.2	5.1	5.92	6.49	5.26	9.05	16.31	13.97			
Cummulative Earned Dose	2.0	4.0	6.0	8.0	8.6	8.8	9.5	11.5	13.1	16.6	23.5	27.8	40.5	51.7	70.2	87.5	105.6	124.1	142.1	157.2	177.6	199.2	218.5	232.0	243.9	256.3	267.9	280.3	289.7	295.1							
Cummulative Actual Dose	0.93	3.9	7.8	11.8	15.2	19.1	23.7	28.2	34.0	39.6	44.5	47.7	53.6	59.4	65.2	72.4	79.2	84.5	90.8	96.1	104.2	110.7	116.1	122.0	127.6	132.7	137.9	143.0	148.9	155.4	160.7	169.7	186.0	199.9			
Original Schedule Projection	2.0	4.0	6.0	8.0	11.0	21.1	34.1	51.1	72.6	96.5	123.5	144.5	168.5	192.5	216.5	240.5	264.5	288.5	312.5																		

~300 EFs still require rotation

Remove End Fittings



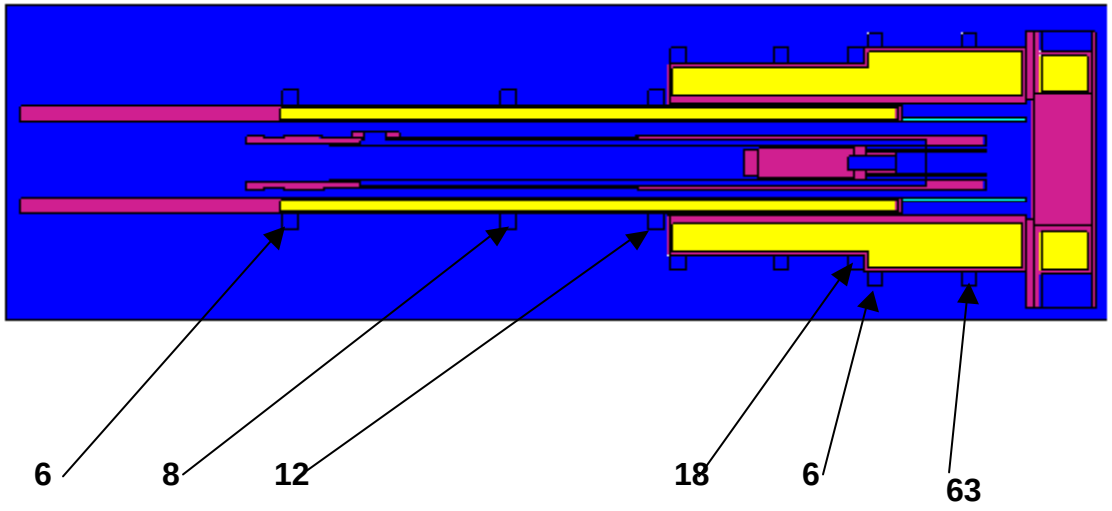


Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

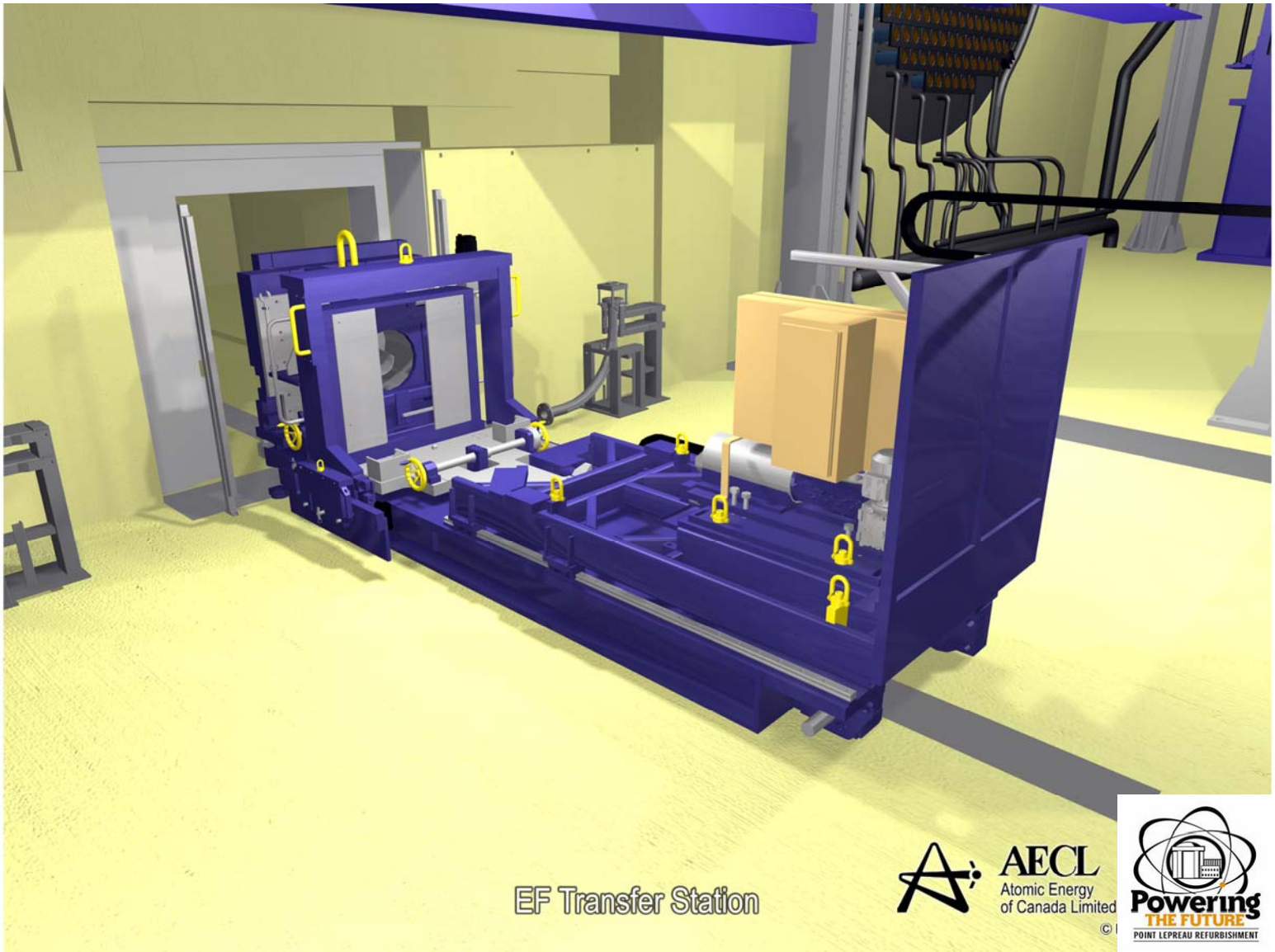
Shuttle Flask Dose Rates

- **Shielding Features**
  - **Hot End**
    - **5.6” of lead**
    - **0.5” of tungsten**
  - **Mid**
    - **3.5” of lead**
    - **1.5” of lead**
  - **Cold End**
    - **1.5” of lead**

Dose Rates in microSv/h

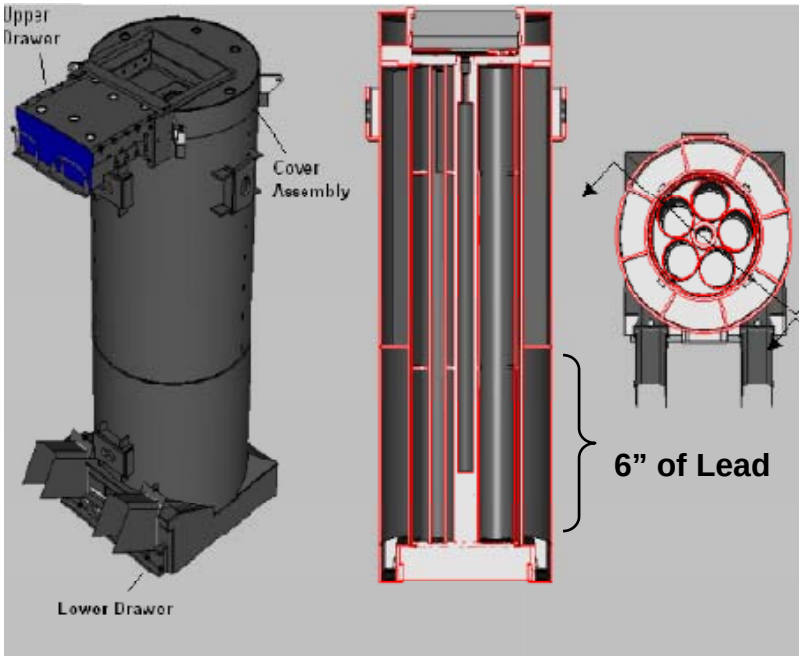


Remove End Fittings (Cont'd)



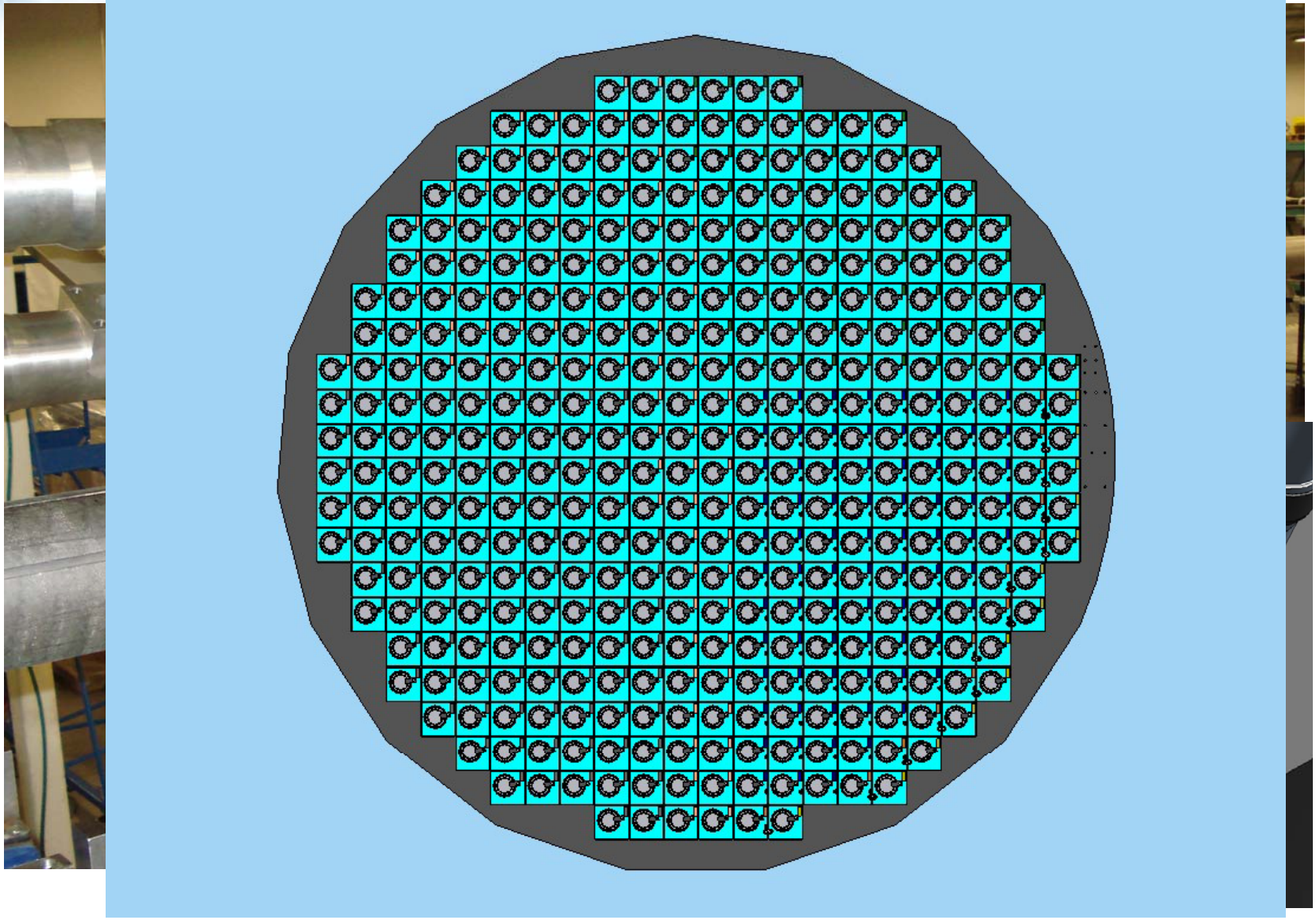
LWTF

- **Features 6” of lead shielding on hot end**



- **Maximum calculated contact dose rate of ~90 microSv/h from 5 EFs**
- **Dose rates in air region peak at ~60 microSv/h**
- **At the time of analysis PT stub was not included, However Shield Plug was modeled outside of the EF (Bounding Case)**

Remove End Fittings (Cont'd)



Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

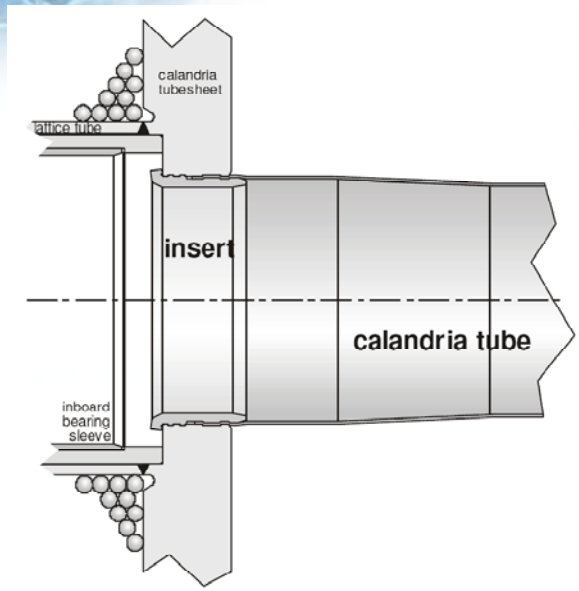
Remove End Fittings (Cont'd)

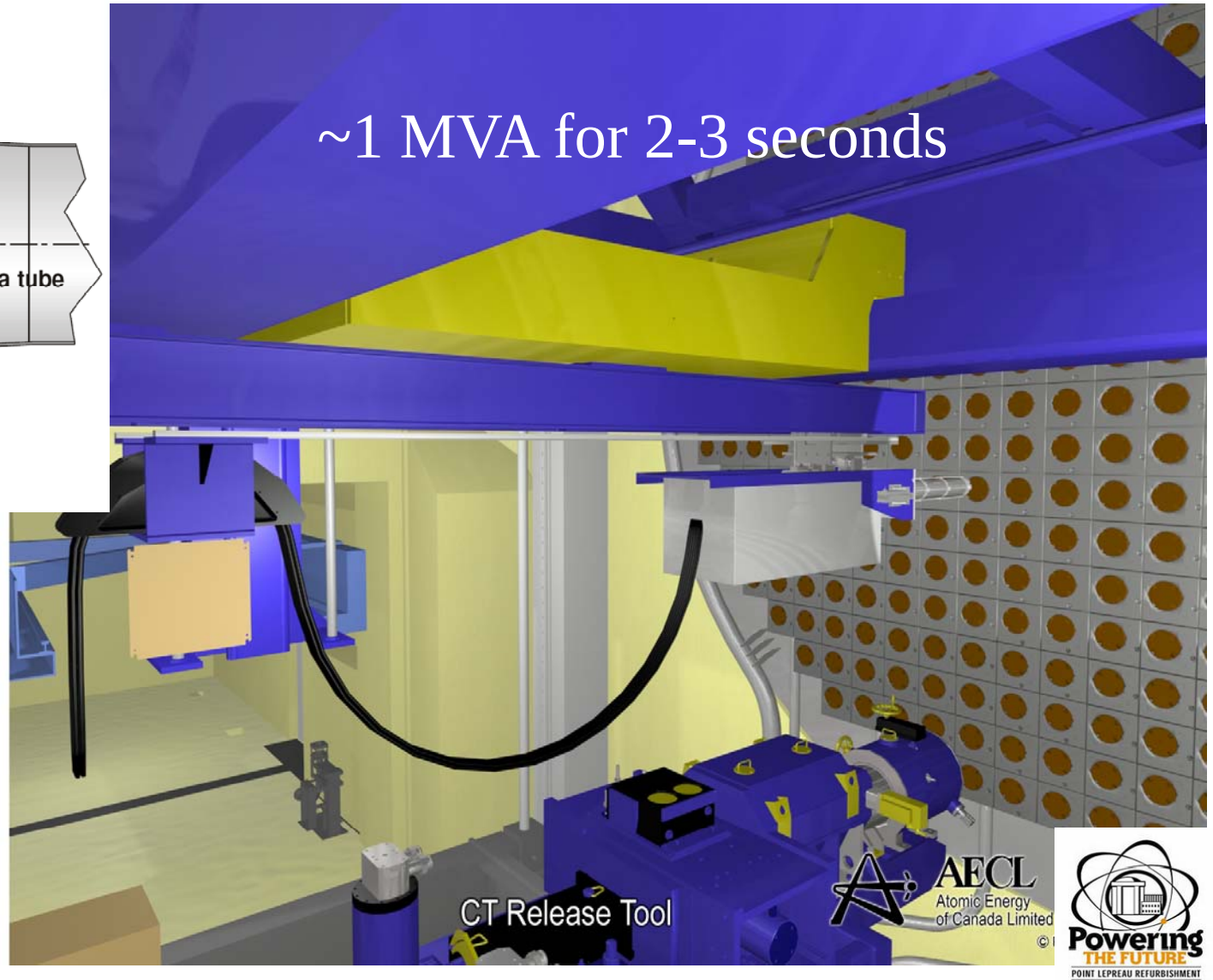
Remove Pressure Tubes

PTs are crushed and collected in the Small Waste Transfer Flask

Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

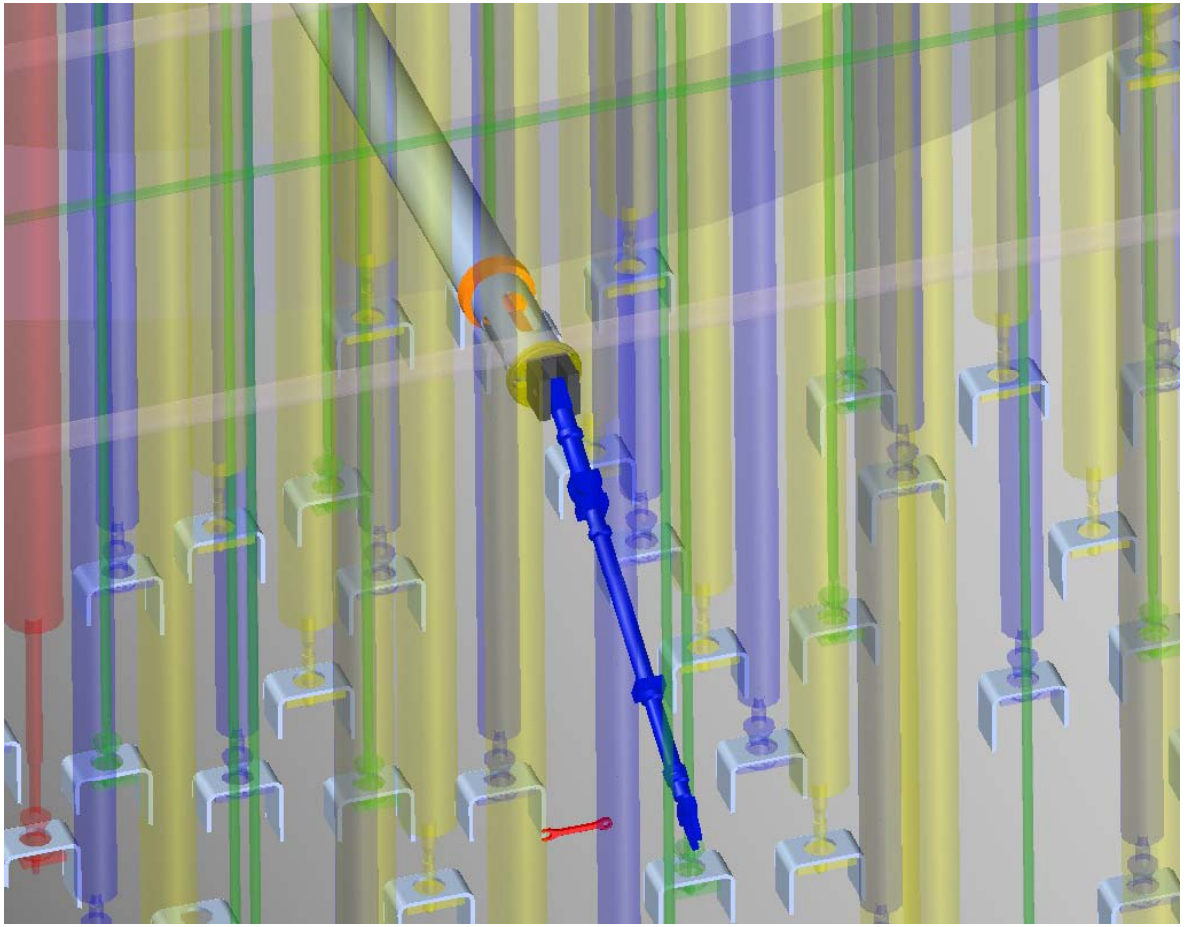
Release/Remove Calandria Tube Inserts





Calandria Vessel Inspection

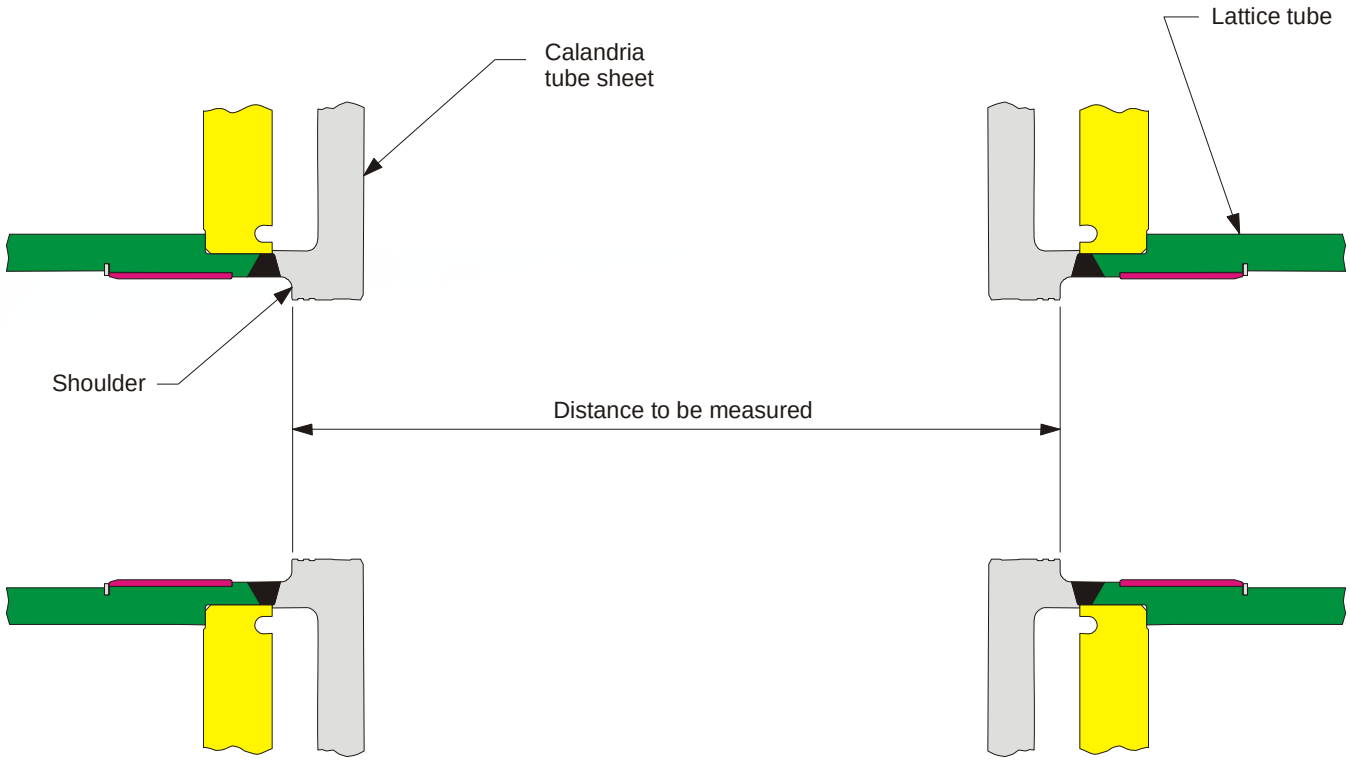
- **Internal inspection of calandria vessel.**



Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Measure Tubesheet-to-Tubesheet Distance

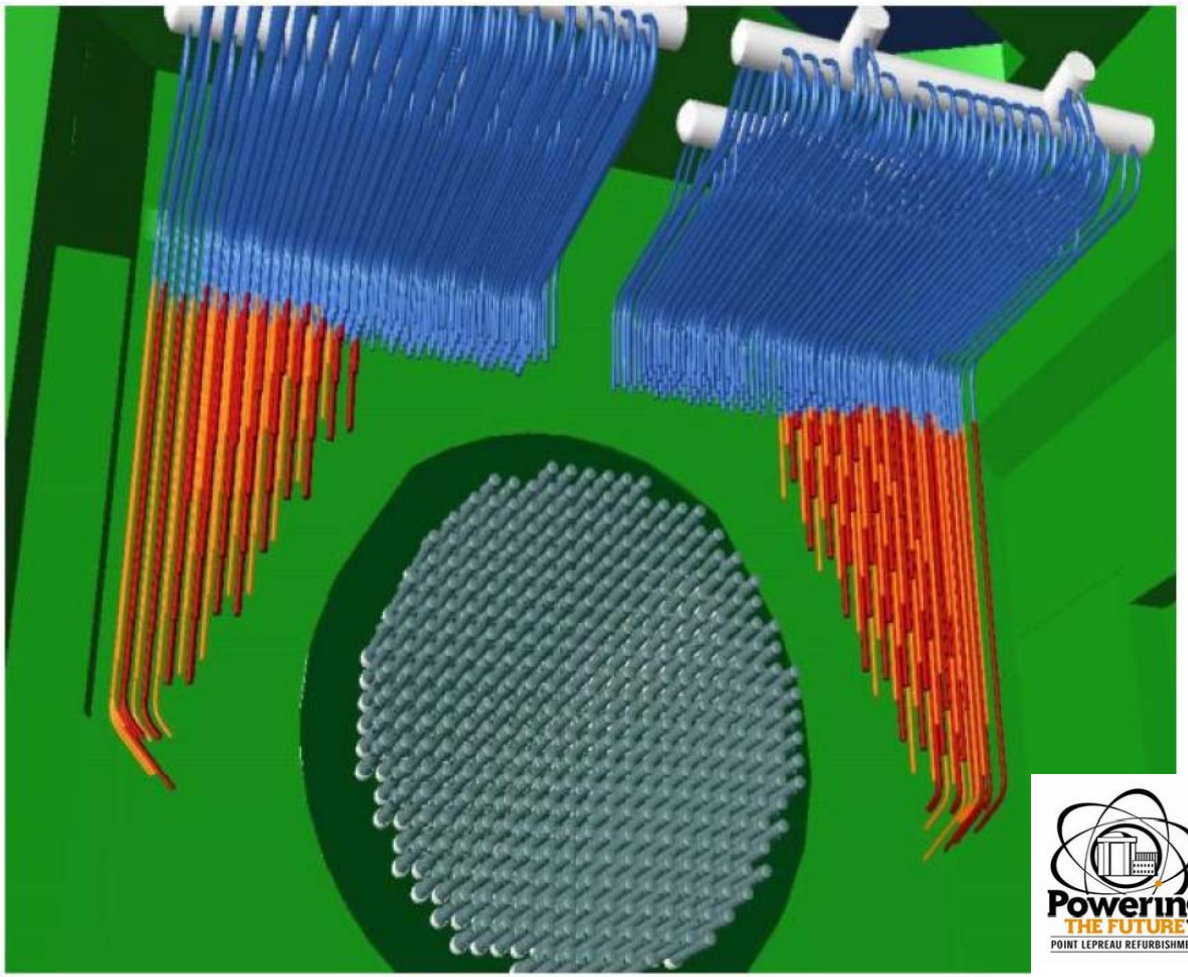
- **Needed for new CT trimming.**
- **Uses a laser tracker system.**



Install Upper Feeders

- **Upper feeders are fit up and welded.**

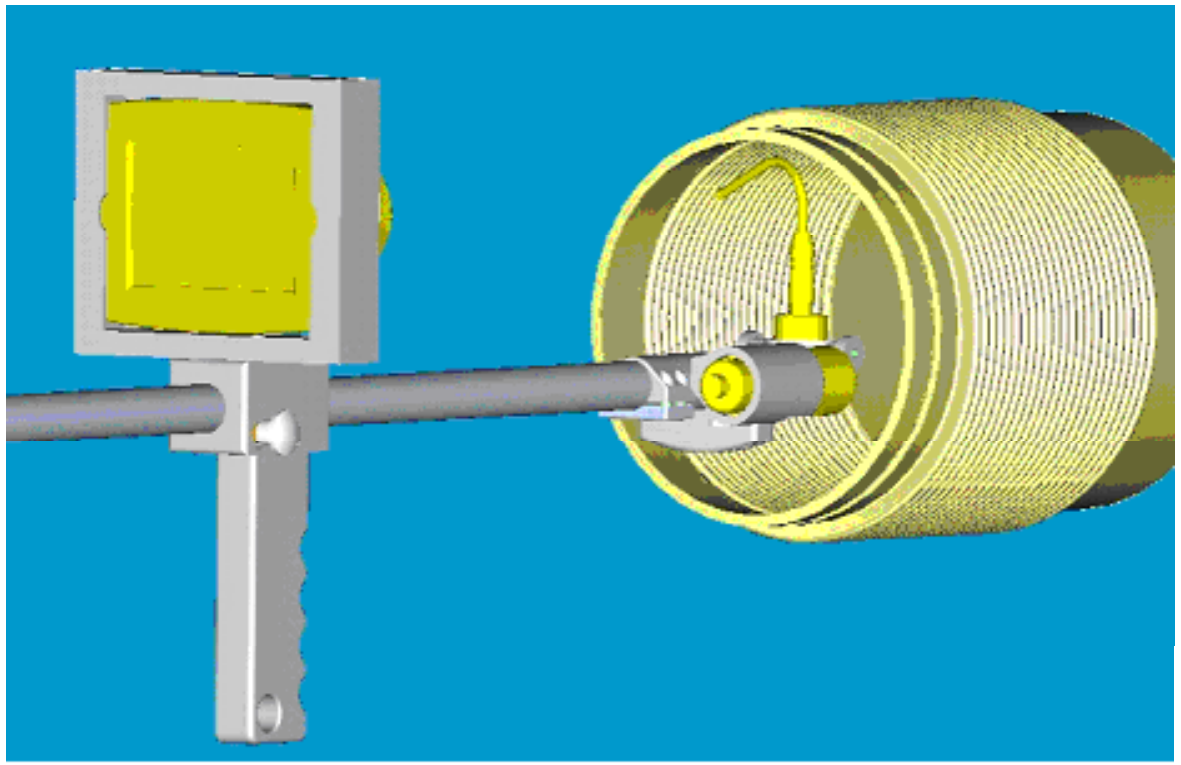
  760 welds requiring NDE
- **RTDs and DN lines are also reinstalled.**



Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Bellows Deburring/Cleaning/Gauging/ Inspecting

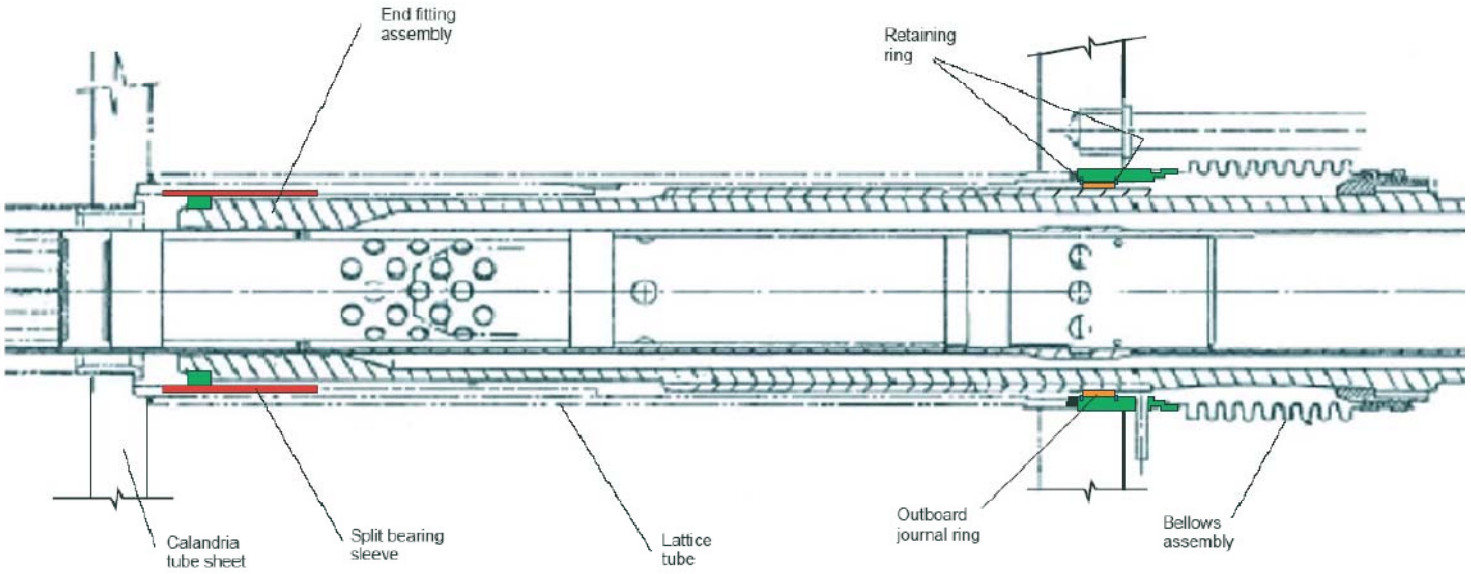
- **Assessing fitness for extended service**



Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Clean and Inspect Lattice Tube and Bearings

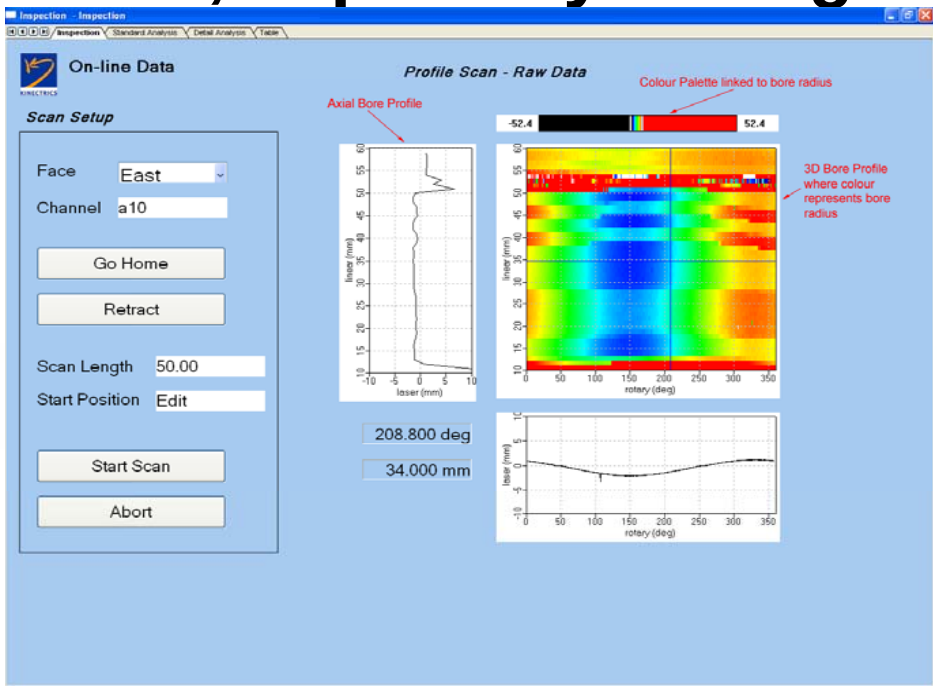
- **Assessment of fitness for extended service.**
- **Bearings can be replaced if required.**

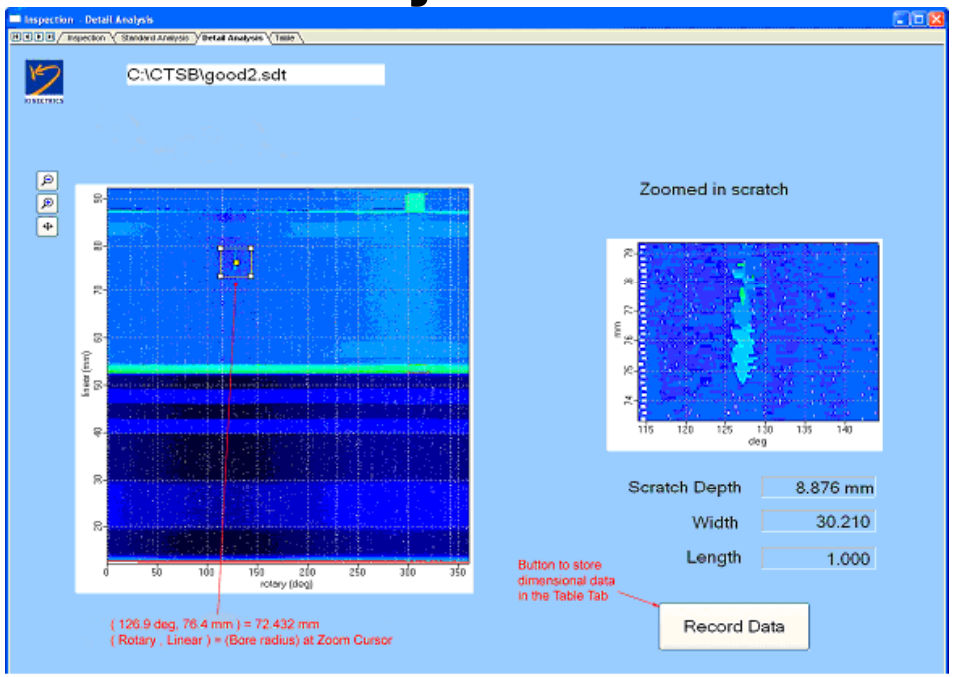


Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Calandria Tubesheet Bore Cleaning and Inspection

- To ensure the CTSB is fit for extended service life, especially for a good CT rolled joint.

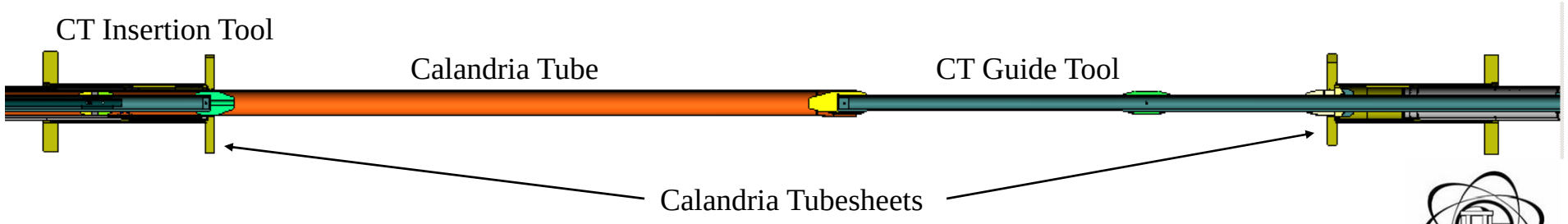




Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Insert/Roll New Calandria Tubes

- **Coodinated effort from both reactor faces:**
- **New CTs are loaded onto worktable and inserted into lattice site**
- **Tool on receiving side travels part-way across core to “pick up” the CT and guide to the far tubesheet.**



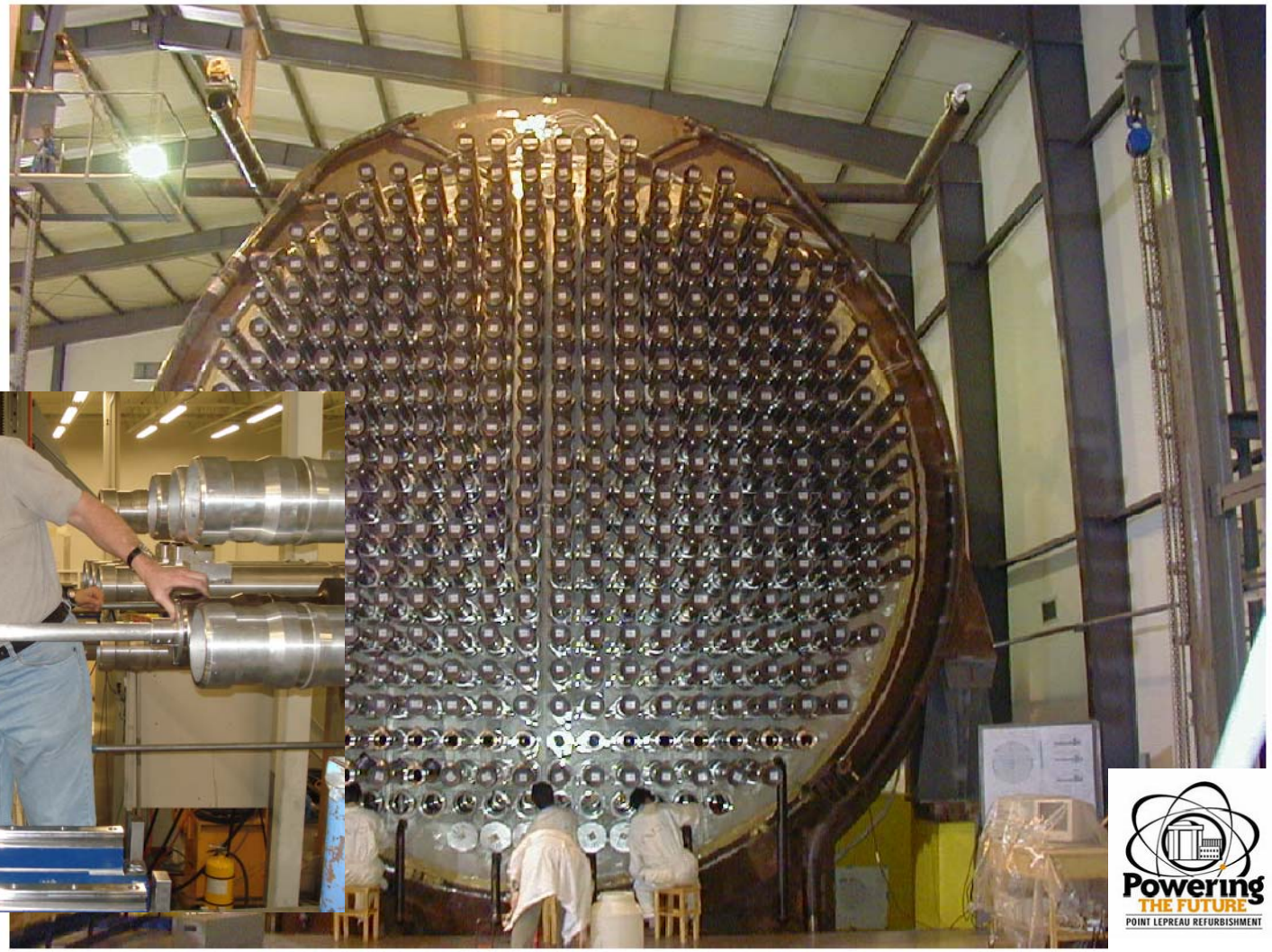
Subassembly Prep and Insertion

- **Subassemblies (PT with EF rolled on one end) are prepared in the AECL Saint John facilities.**
- **Subassemblies are inserted from the A side (east).**
- **Datum plane reference is used to place and restrain subassemblies.**

Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Position and Roll Second End Fitting

- On west face end fittings will be rolled onto the PTs.



Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Weld Annulus Bellows to End Fitting

- **Done using the “green machine” from previous projects.**

Install Lower Feeders

- Lowers feeders are first connected to the end fittings, then aligned to the upper feeders for the field weld.
- No other retube work can take place at this time.
- Installed using both Feeder Platform and Fuel Channel Platform

Feeder NDE

- **Conventional Radiography**
  - **1520 Welds**
  - **Up to 4 shots per weld**
- **Significant Critical Path Impact**
  - **Radiography would be CP Activity**
- **Significant Radiolgical Risks**
  - **Safe Work Area delineation and coordination with multiple Cameras**

Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Feeder NDE

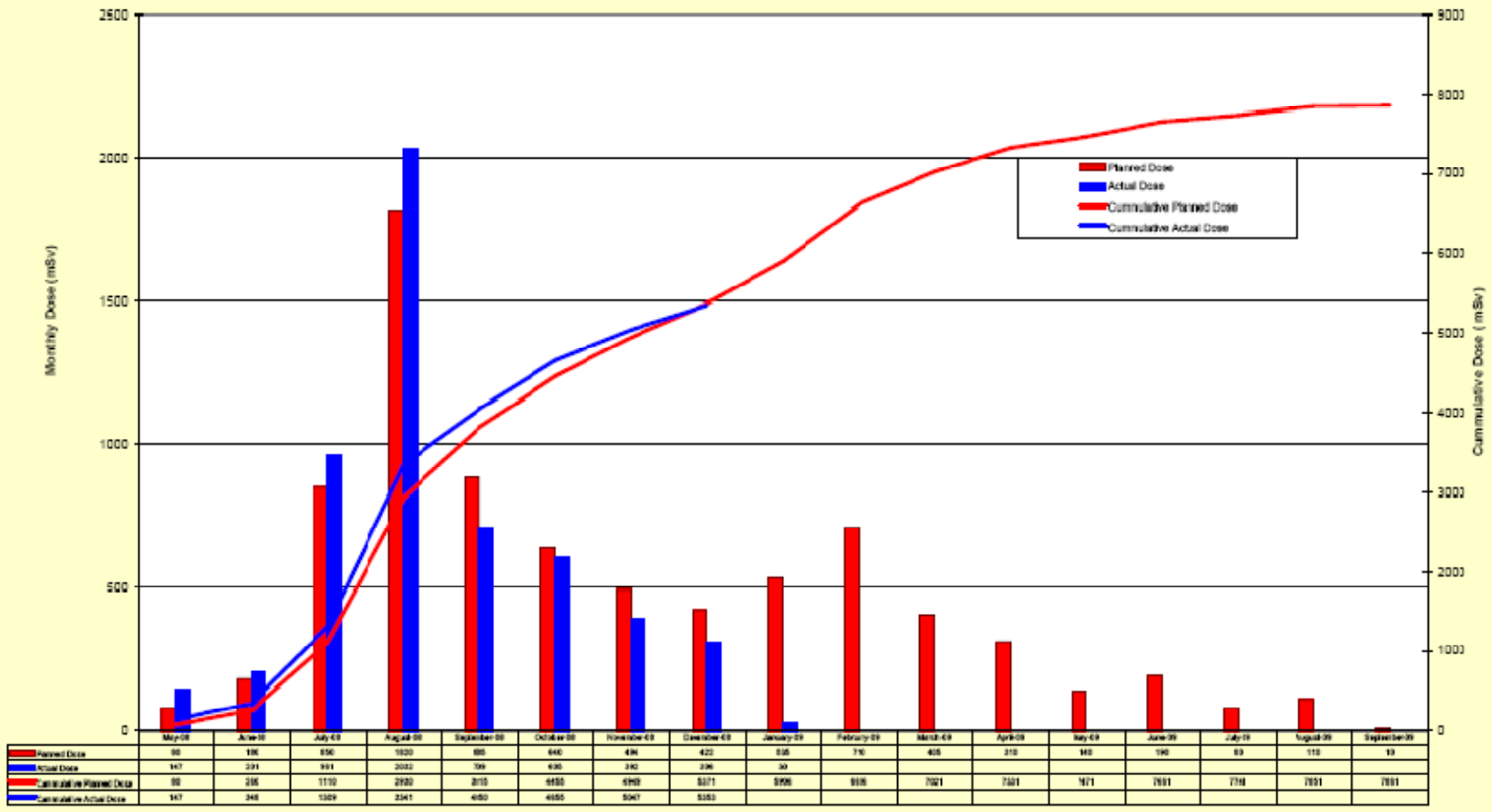
- **Pursuing application of ASME Code Case N-659-2 "Use of Ultrasonic Examination in Lieu of Radiography for Weld Examination"**

- **Commonly referred to as PAUT or Phased Array**
  - **Currently performing qualification tests to as part approval process with Canadian Regulator**

- **Significant Savings to project**
  - **Over 1200 hours**
  - **Over 30 Rem of dose**

Powering THE FUTURE
POINT LEPREAU REFURBISHMENT

Collective Dose - Retube + Refurb



	May-08	June-08	July-08	August-08	September-08	October-08	November-08	December-08	January-09	February-09	March-09	April-09	May-09	June-09	July-09	August-09	September-09
Planned Dose	90	196	850	1820	885	640	496	423	535	710	405	310	140	190	83	119	19
Actual Dose	147	201	951	2032	709	606	382	296	30								
Cumulative Planned Dose	90	286	1136	2956	3841	4481	4977	5371	5906	6616	7021	7331	7471	7661	7744	7863	7882
Cumulative Actual Dose	147	348	1299	3341	4050	4655	5047	5353									

Questions?

AECL
EACL