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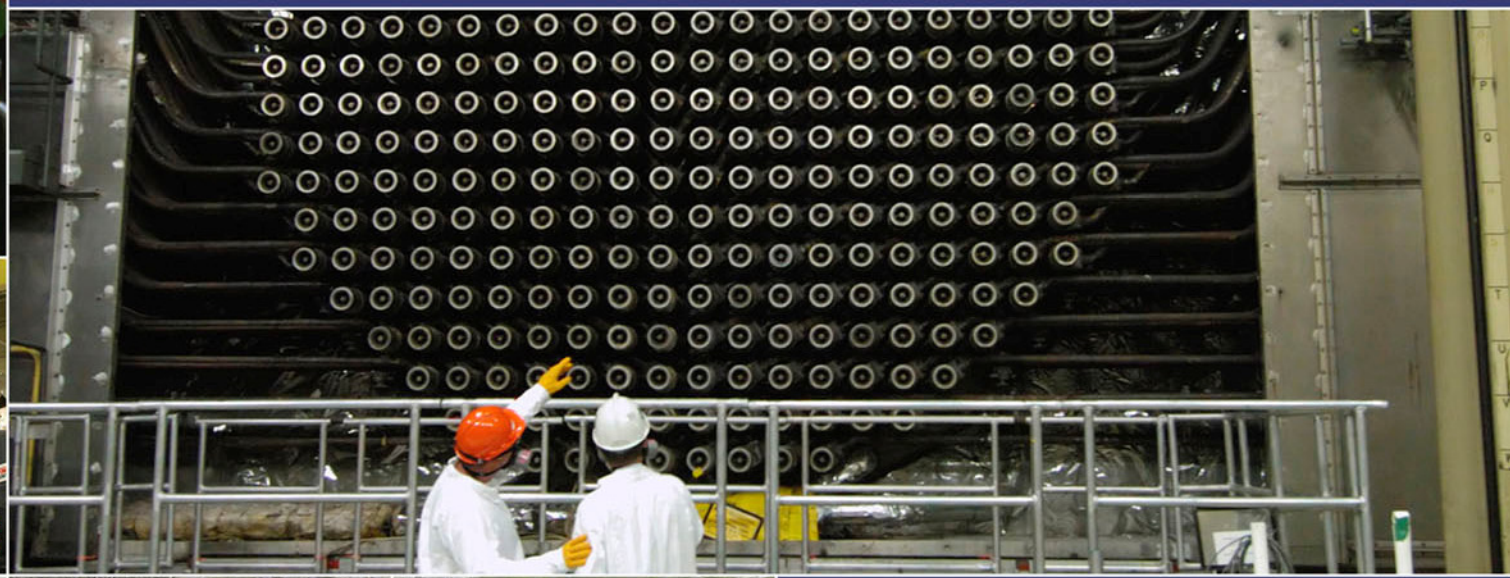
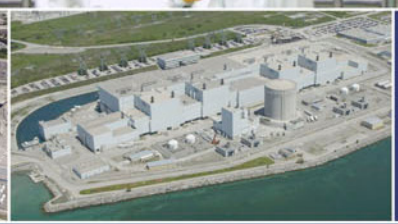
OPG NUCLEAR

Airborne Tritium Mitigation Successes at Darlington





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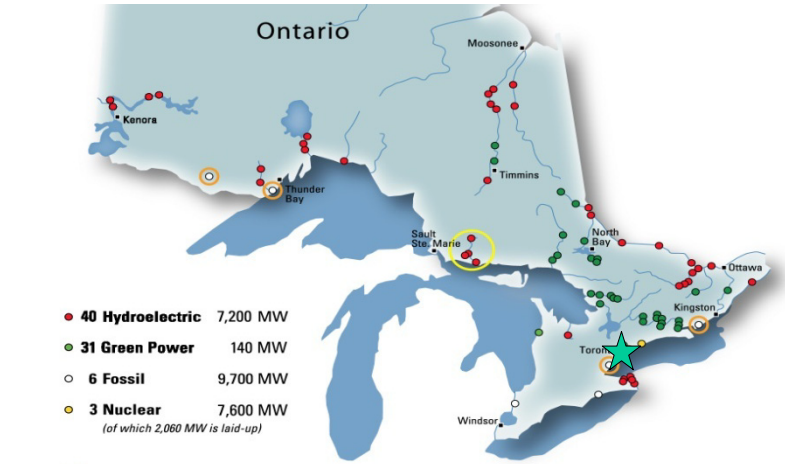
2008 ISOE NA ALARA Symposium/EPRI RP Conference
January 12-14, 2009

ONTARIO POWER GENERATION

Darlington Nuclear

- Located on the north shore of Lake Ontario
- 4 CANDU units of 935 MW(e) rated output
- In-service dates:
  1st Unit – Oct/90
  Last Unit – Jun/93
- Capacity factor (2008): 93.5%



Overview

- Tritium: Source and Protection
- Tritium Mitigation Initiatives
  1. System Leakage Reduction
  2. Increase drying capability
  3. Human Performance Improvement
- Future Challenges

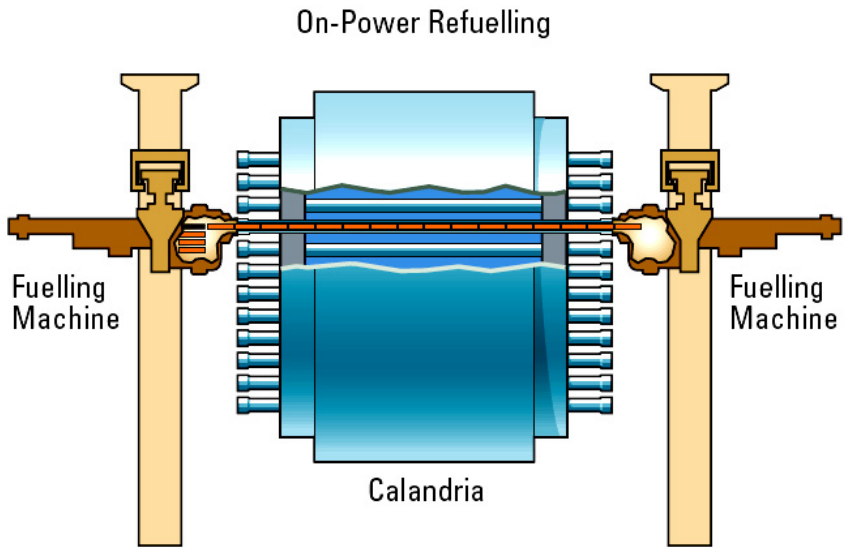
Tritium Source and Protection

CANDU Reactors:

- Natural Uranium
- Heavy water moderation
- On-power refueling

Tritium:

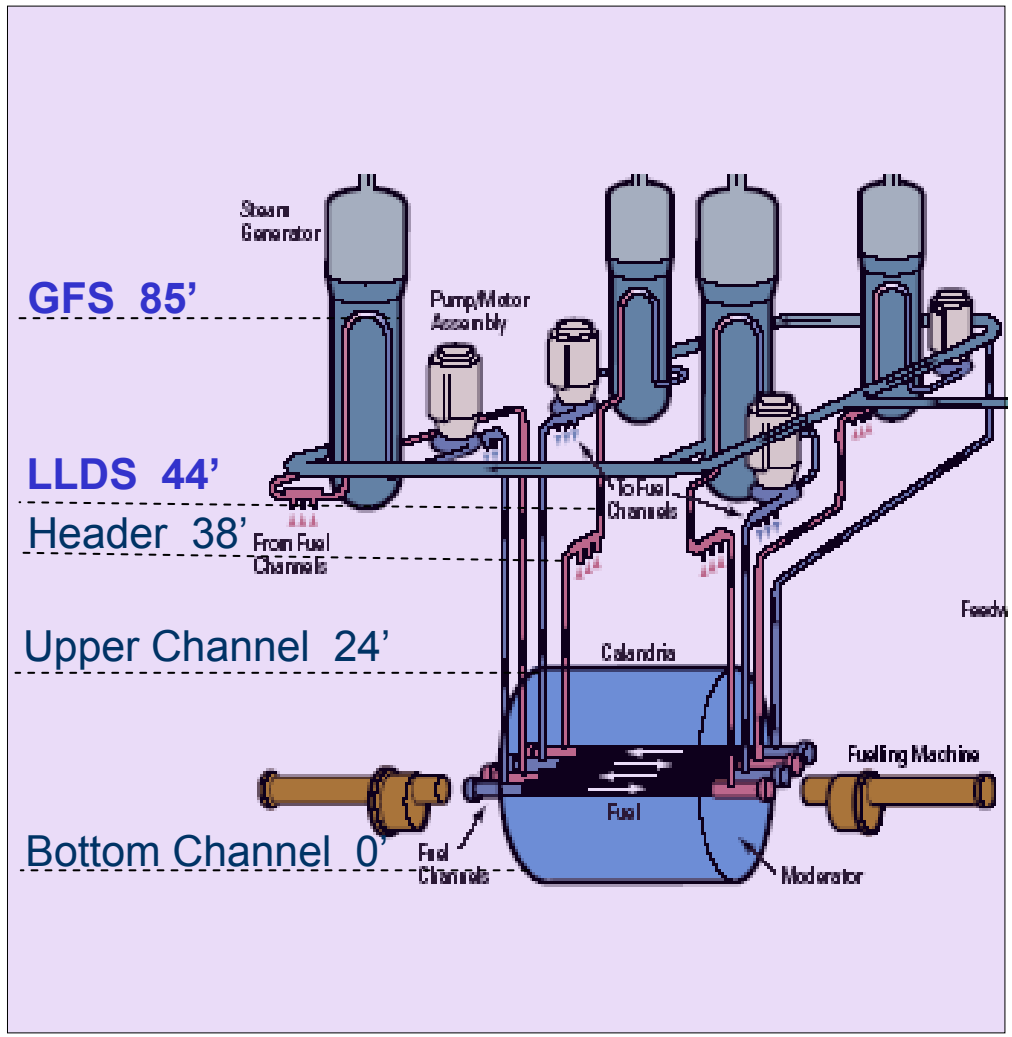
- Low energy beta Emax=18 KeV
- Effective half-life = 10 days
- Pathway: inhalation, absorption
- Protection: Air-supplied suit
- Hazard: leaks, open system work
- 25% of worker dose and the main contributor to public dose



$$ {}^{1}_{0}n + {}^{2}_{1}H \rightarrow {}^{3}_{1}H + \gamma $$

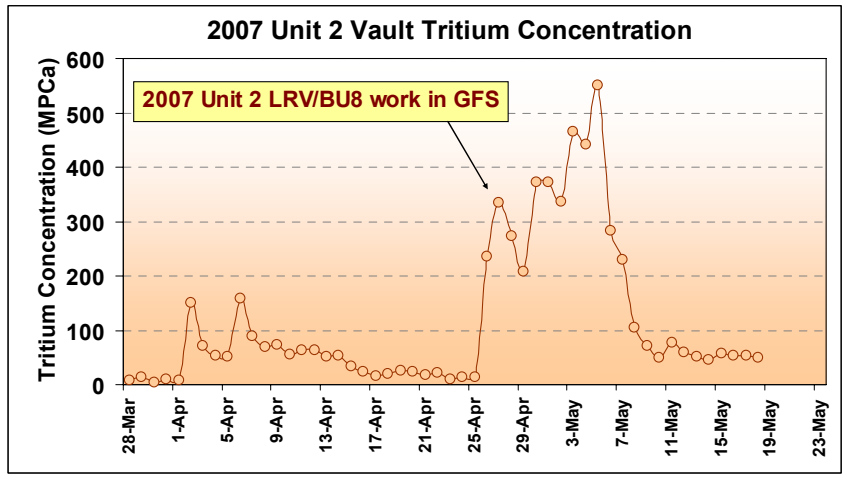
Leakage Reduction

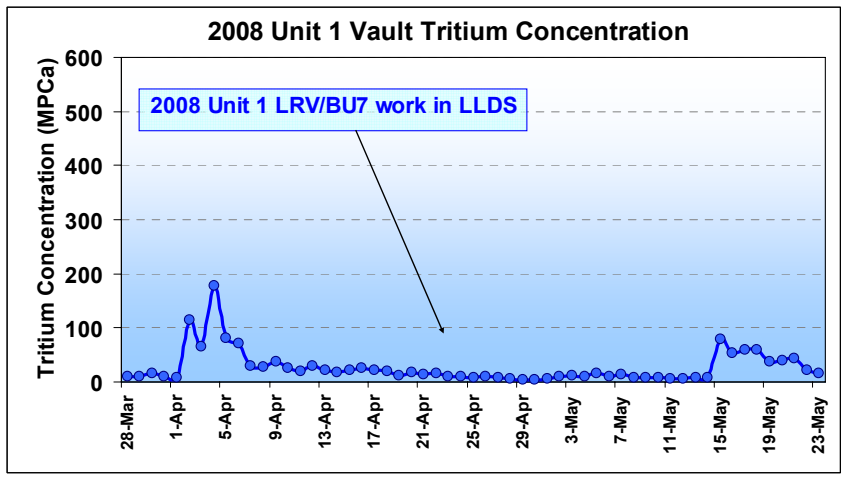
- ☑ CP leakage is a dominant source of tritium inside containment
- ☑ Leakage is caused by CP seal disc deformation (creep)
- ☑ Pressure window leakage possible: 0.12 - 2.3 MPa
- ☑ Leak rate is 20x more likely at GFS than at LLDS
- ☑ Bottom channels are more likely to leak than upper channels



Leakage Reduction

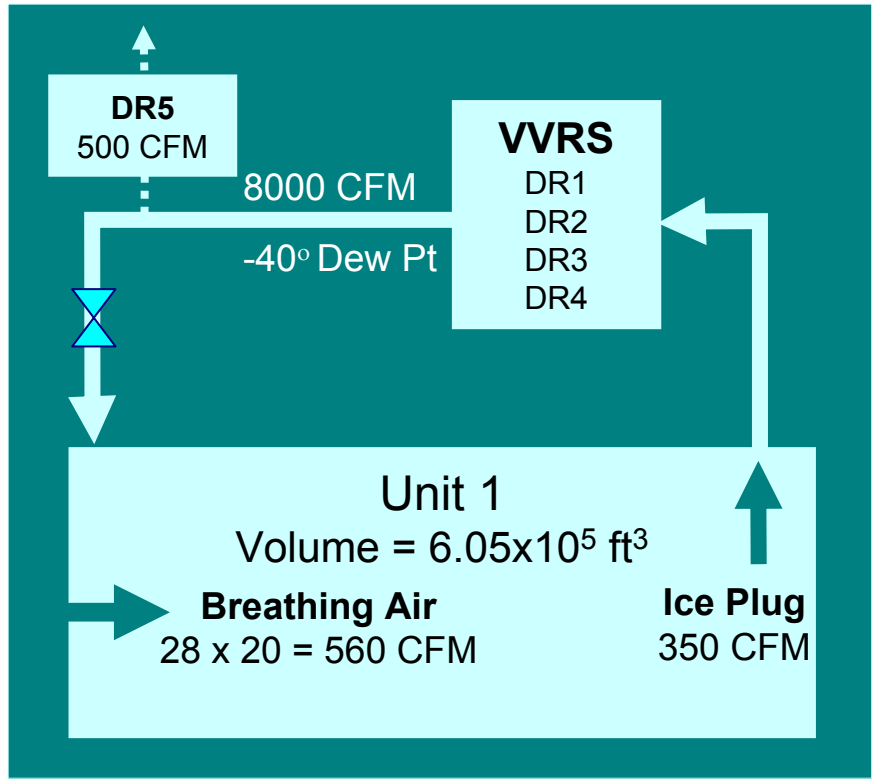
- ☑ Identify outage activities requiring GFS (e.g. LRV & BU7/8)
- ☑ Plant manager chaired ODM meetings to analyze and address reactor safety concerns
- ☑ Residual work activities (e.g. PV70) requiring GFS were scheduled at end of outage when vault occupancy was low
- ☑ Dose savings: 8.1 rem during 2008 spring outage





Improving Drier Capability

- During major ice-plug work reactor vault may become O_2 deficient in less than 1 shift
- VVRS must be reconfigured for N_2 venting with reduced tritium removal capacity
- Extensive ice plug work in recent outages has adversely affected VVRS effectiveness



Installation of Portable Driers

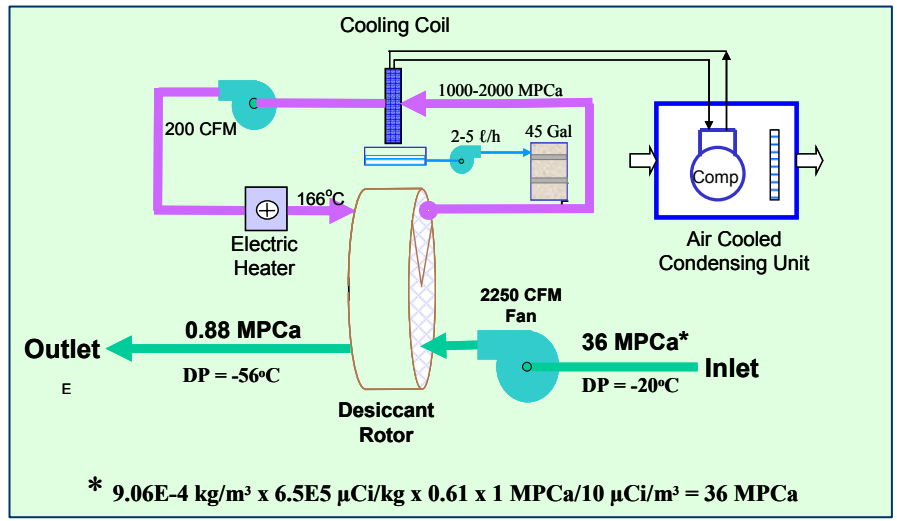
Three 2250 CFM portable driers (Munters) were installed

2008 Performance Statistics:

- Total volume of tritiated water collected: 3100 kg (24 drums)
- Condensate [H3]: 0.4 Ci/kg
- Total activity extracted: 1250 Ci
- Reliability improvement: from 56% in 2007 to 96% in 2008
- Tritium removal Half-life:

$[H^3]_t = [H^3]_o e^{-(f/v)t}$

$T_{1/2} = 0.693/(6750/605,000) = 1\ h$



Drier Reliability Improvements

Critical Steps to improve system reliability:

① Munter readiness included as outage pre-requisite, pre-service testing tasked for completion 4 weeks before outage
② Reliable power supply – 600Vac/40 amp
③ On-line monitoring of operating status
④ Delineation of responsibility between RP & Ops with ALARA maintaining overall ownership
⑤ Class room and in-field training of CM and RP staff
⑥ Spare part availability

Result: Reliability improved from 56% in 2007 to 96% in 2008

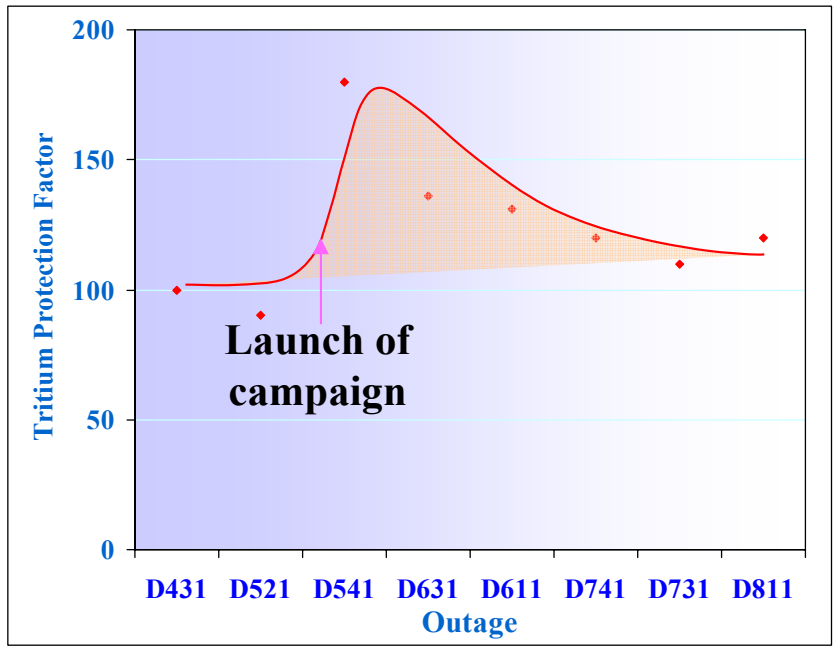
Lessons Learned:

❶ 3-phase connection problem affecting fan rotation
❷ Power down sequence causing heater damage
❸ Lack of proper turn-over to ALARA

Human Performance (HU) Improvement

HU has a large impact on the effectiveness of protective measures

- An intensive communication campaign was launched to increase worker awareness
- A factor of 2 step change in PF was observed followed by gradual reduction of effectiveness
- Intense campaign unless repeated regularly will not generate lasting effect
- Gentle message applied relentlessly is key to long term success



Human Performance Improvement:
Monitoring, Follow-up and Coaching

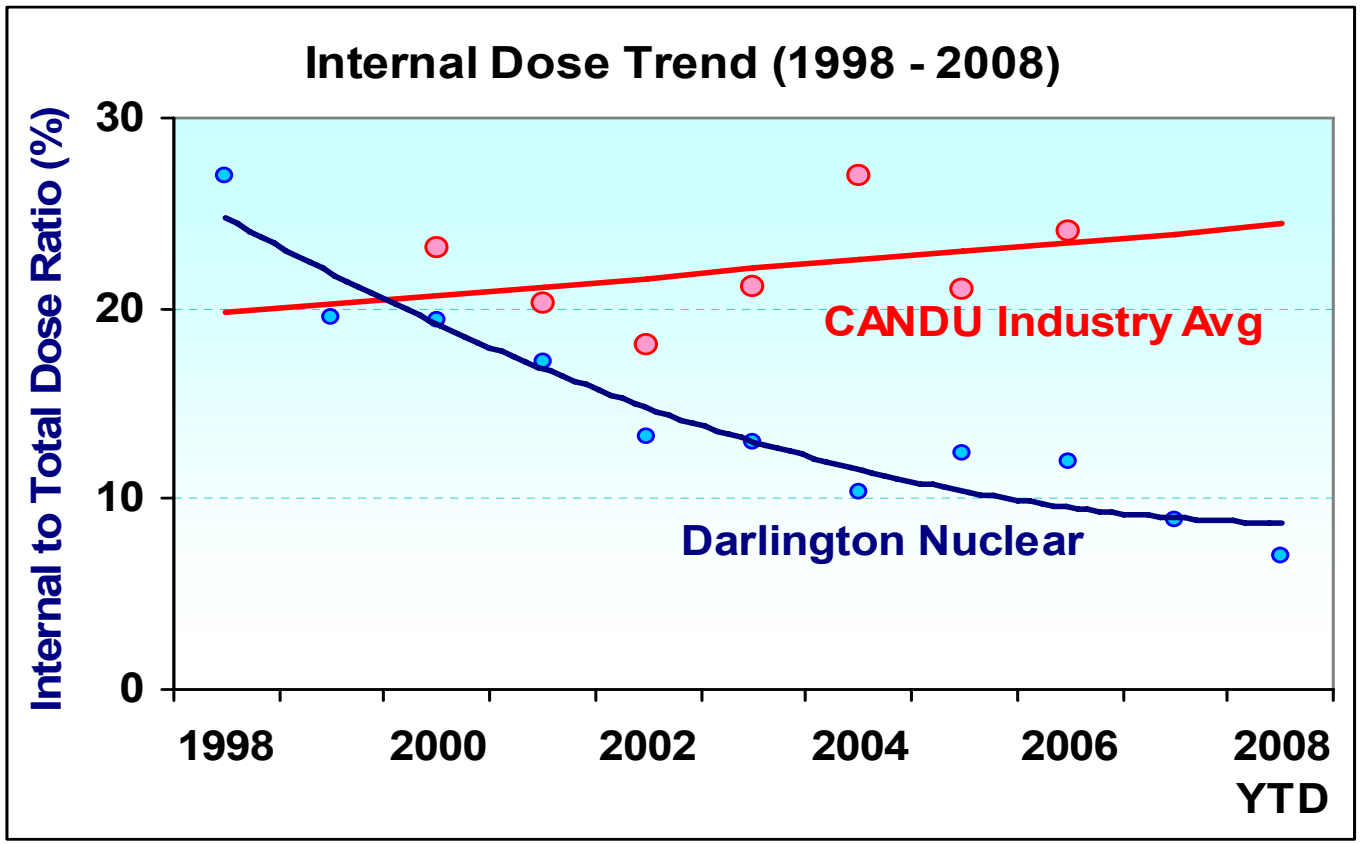
Daily monitoring and follow-up of tritium uptake

Action levels:

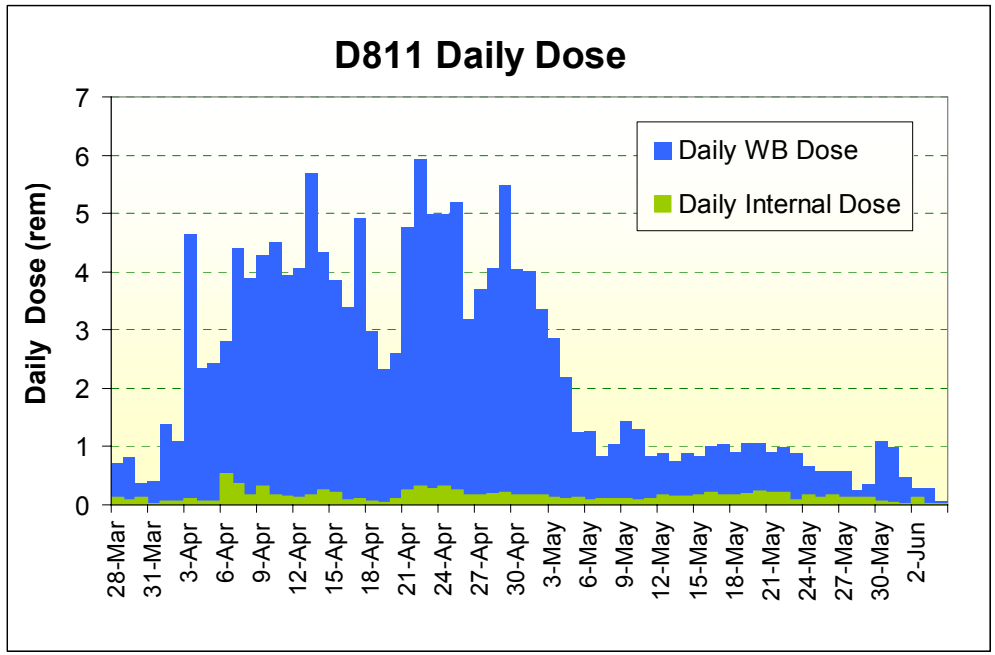
- ❑ 3 uCi/l (9 mrem) – follow-up with worker/FLM
- ❑ 10 uCi/l (30 mrem) – department EFDR, SCR, supervisory investigation
- ❑ 35 uCi/l (105 mrem) – Bravo SCR, root cause investigation team to include line, RP and PINO

Tritium exposure planning – worker/supervisor must discuss and agree on the level of protection

Tritium Mitigation: Performance Trend



Internal Dose Performance: 2008 Spring Outage



Internal dose performance highlights:

- ❑ Internal dose savings - 8.1 rem
- ❑ Internal to total dose ratio - 6%
- ❑ Record low tritium levels (as low as 1.7 MPCa)

Tritium Mitigation: Future Challenges

Long Term Goal:

- ☑ Reduce Tritium in Reactor Vault to <1MPCa

Initiatives to move us from good to great:

- ☑ Closure Plugs redesign to ensure leak-tightness
- ☑ Preserve VVRS functionality during ice plug work
- ☑ Increase drier capacity

Benefits:

- ☑ Eliminate plastic suit use
- ☑ Reduce outage critical path duration
- ☑ Reduce worker dose and emission