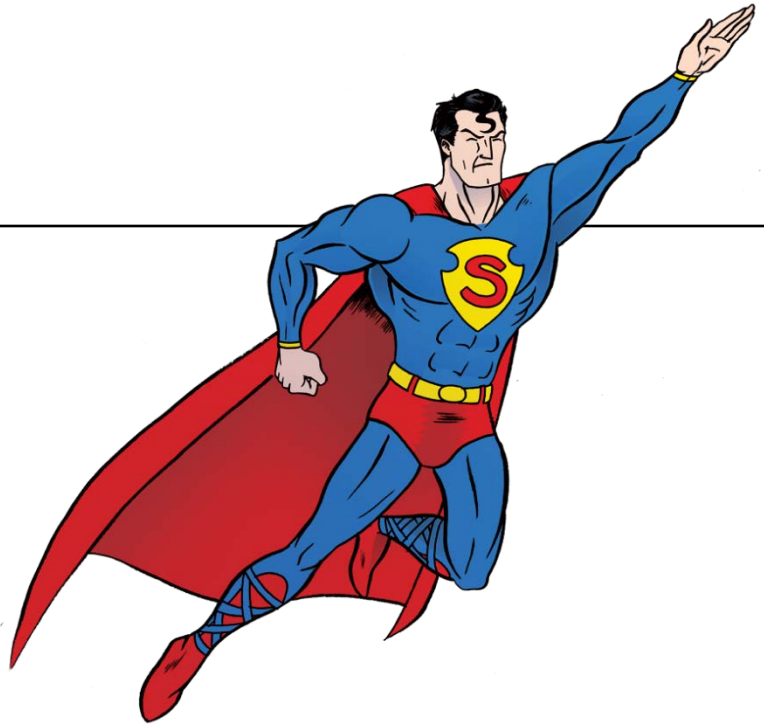
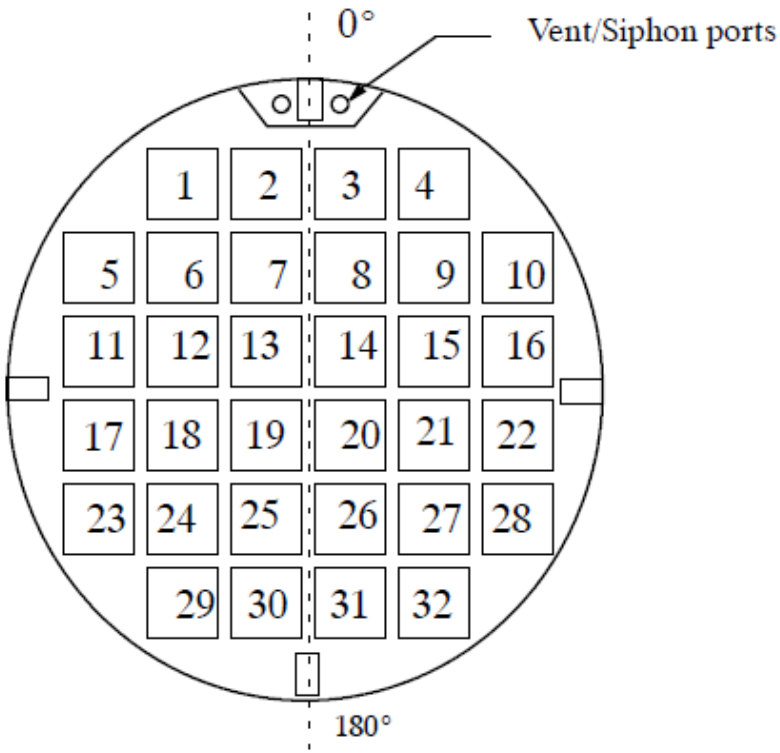
The Krypton Caper



Unplanned release of Kr-85
at Millstone Unit 2 during spent fuel packaging

Introduction

- Third campaign of transfer of spent fuel to Millstone Unit 2 ISFSI.
- 98 spent fuel assemblies into dry storage canisters (DSC).
- Was on third DSC.



Fuel Loading Pattern

Loading Process

- Fuel inspected for anomalies including cladding defects.
- Good fuel loaded into DSC.
- Inner lid seal-welded and water drained (blow down) from DSC.
- Vacuum dry (to 0.015 psi) with vent line directly to SFP room air vent out.

Not Expecting the Unexpected

- Dominion had loaded over 2,500 fuel assemblies with only one instance of a release.
  - At Surry in 2008.
- During discussions with Nuclear Fuel personnel before start of operation the potential for a radioactive release was downplayed.
- Expecting the Vent Effluent Monitor to function as normal.

Timeline

5/10 @ 1120 - increasing trend on RM8132, Unit 2 Vent Effluent Radiation Monitor, from the normal background of 55 cpm.

5/11 @ 1258 to 2345 – loaded 32 fuel assemblies.

5/11 @ 1500 – vent gas sample less <MDA with monitor reading about 70 cpm.

5/12 @ 0700 - vent gas sample less <MDA with monitor reading about 150 cpm. Appeared that there was no gaseous release in progress and that this increase may be a radiation monitor issue.

Timeline

5/12 @ 0930 – DSC partially dewatered in SFP.

5/12 @ 1035 – Placed DSC in cask pit.

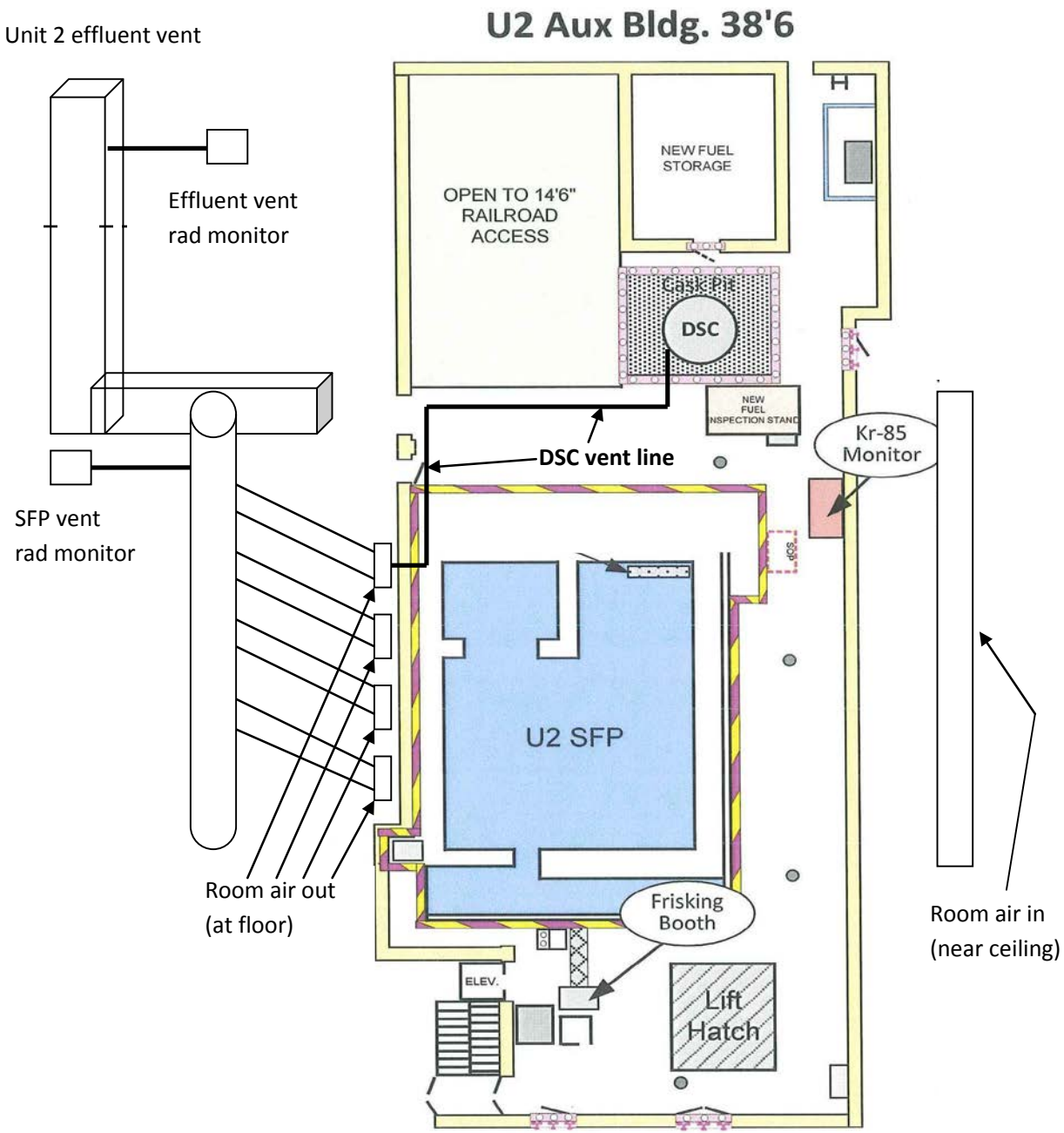
5/12 @ 1100 - RM-8132 declared nonfunctional.

5/12 @ 1102 – Inner cover installed.

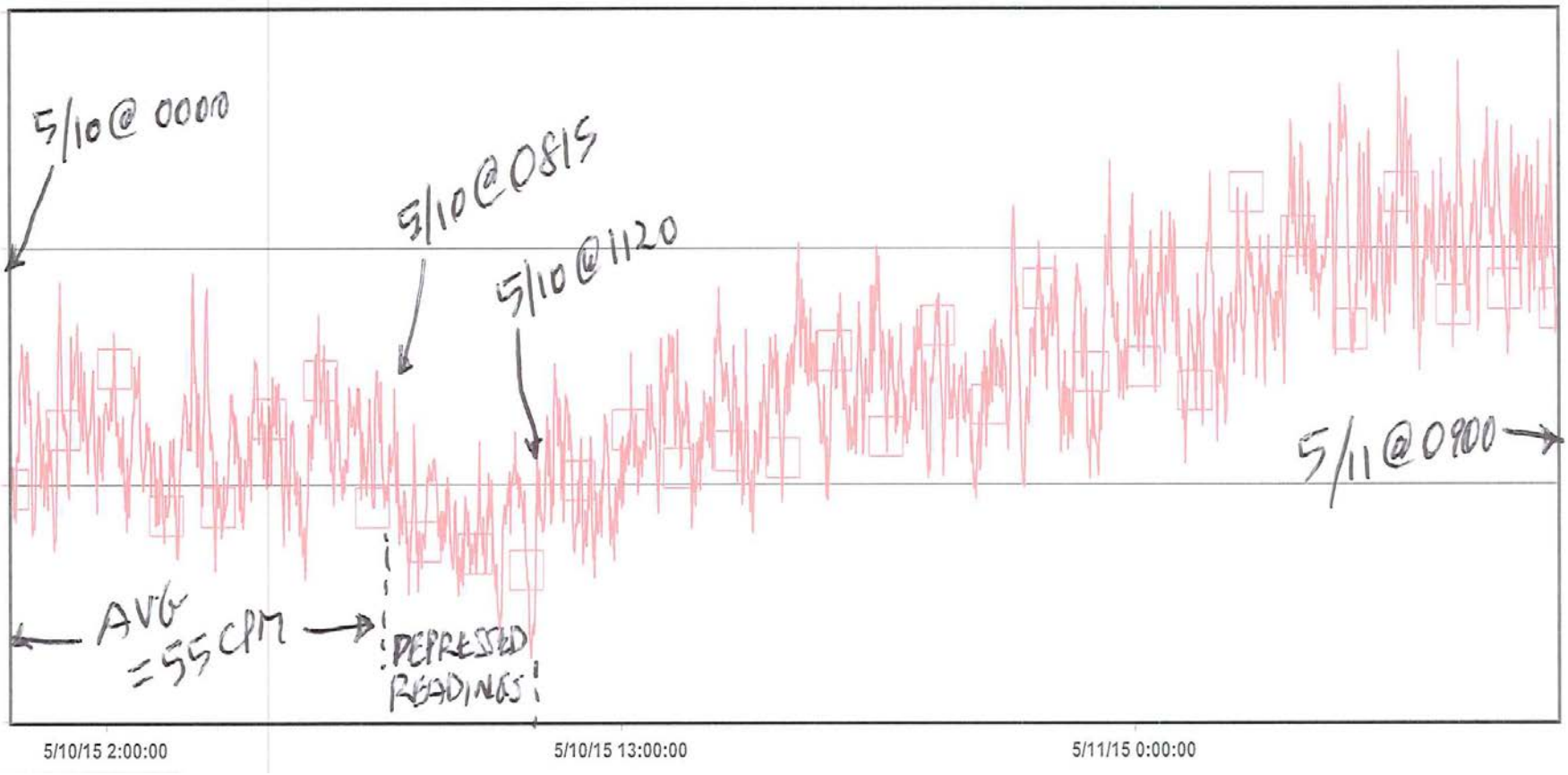
5/12 @ 1419 – DSC dewatering in cask pit.

5/12 @ 2015 – Inner cover welded shut.

5/12 @ 2147 – Installed vent line piping in preparation for vacuum drying of DSC.

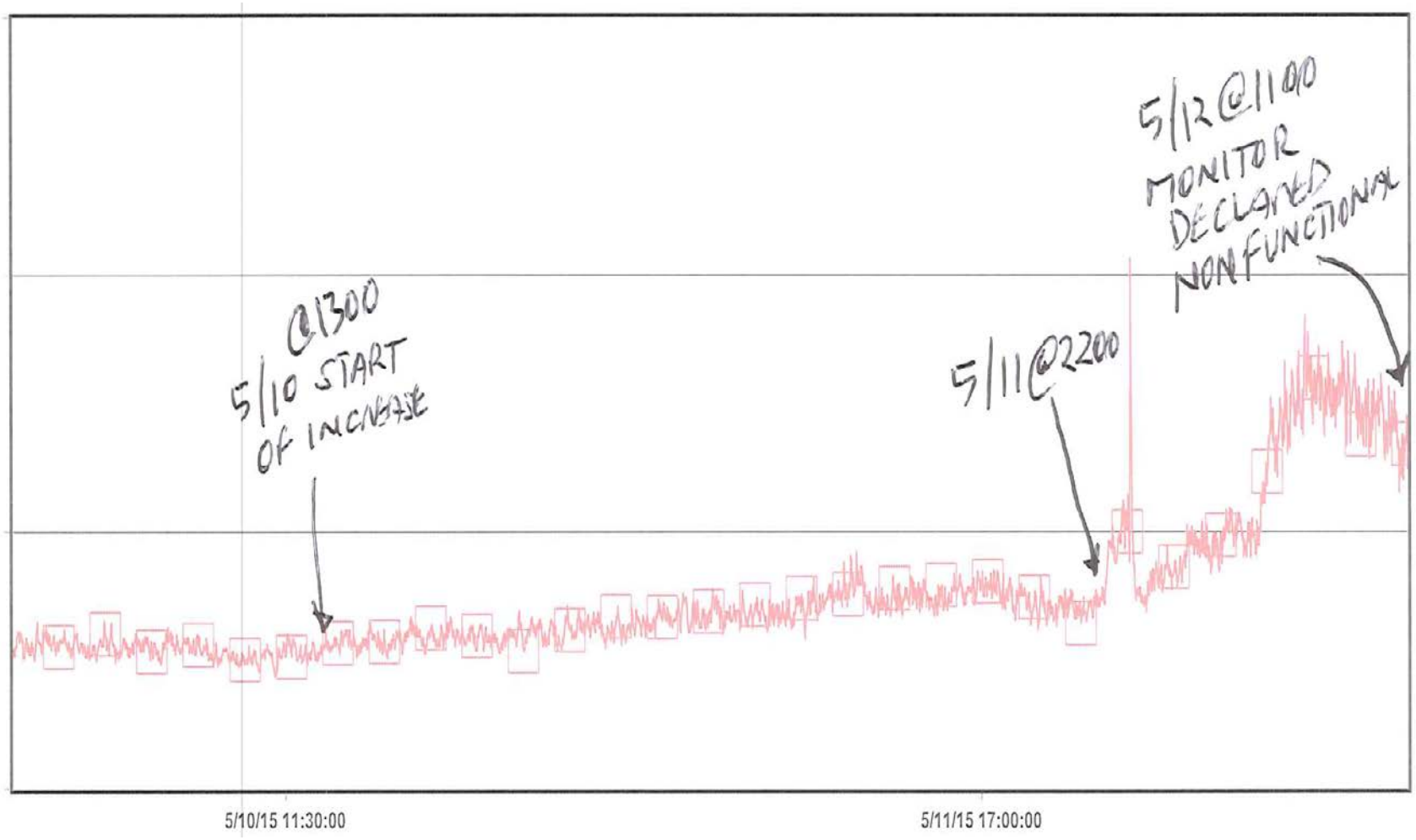

Unit 2 effluent vent
U2 Aux Bldg. 38'6
Effluent vent
rad monitor
OPEN TO 14'6"
RAILROAD
ACCESS
NEW FUEL
STORAGE
Cask Pit
DSC
NEW
FUEL
INSPECTION STAND
DSC vent line
Kr-85
Monitor
SFP vent
rad monitor
U2 SFP
Room air out
(at floor)
Frisking
Booth
ELEV.
Lift
Hatch
Room air in
(near ceiling)

Vent Effluent Radiation Monitor increase from normal 55 cpm to 70 cpm



Vent Effluent Radiation Monitor

reading up to 150 cpm before declared out of service



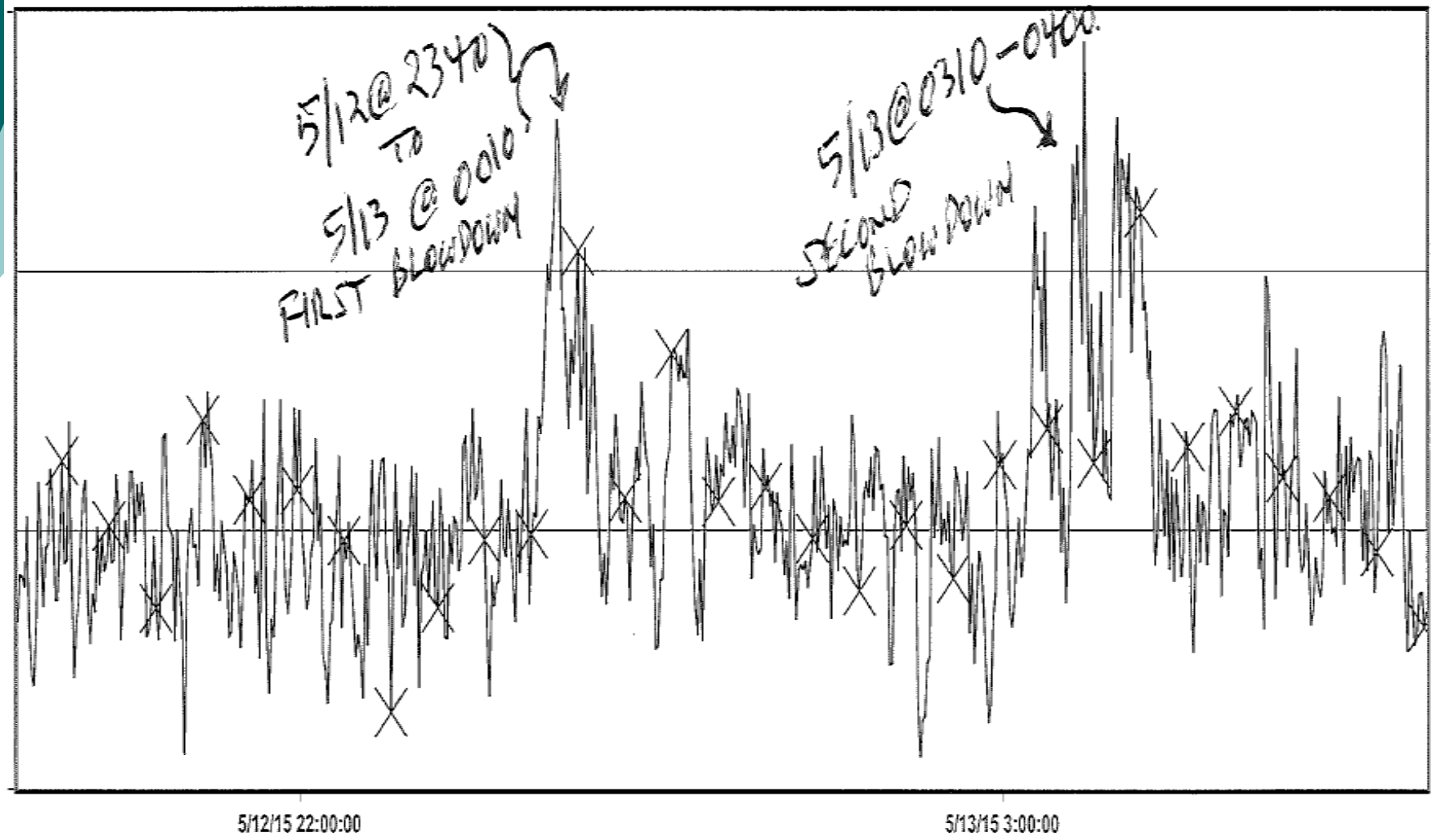
Unplanned Release

5/12 @ 2330 – during vacuum drying of DSC the friskers located on the SFP Floor alarmed.
Surveys and gas sample were inconclusive.
SFP Vent Radiation Monitor increased to 120 cpm.

5/13 @ 0310 – next vacuum drying resulted in a lower increase on SFP Vent Radiation Monitor.
A grab sample Vent Effuent Radiation Monitor had no detectable nuclides.
This phenomenon had not been experienced in previous ISFSI campaigns or with the first two DSCs of this campaign.
Vacuum drying was postponed until further understanding of this issue could be achieved.

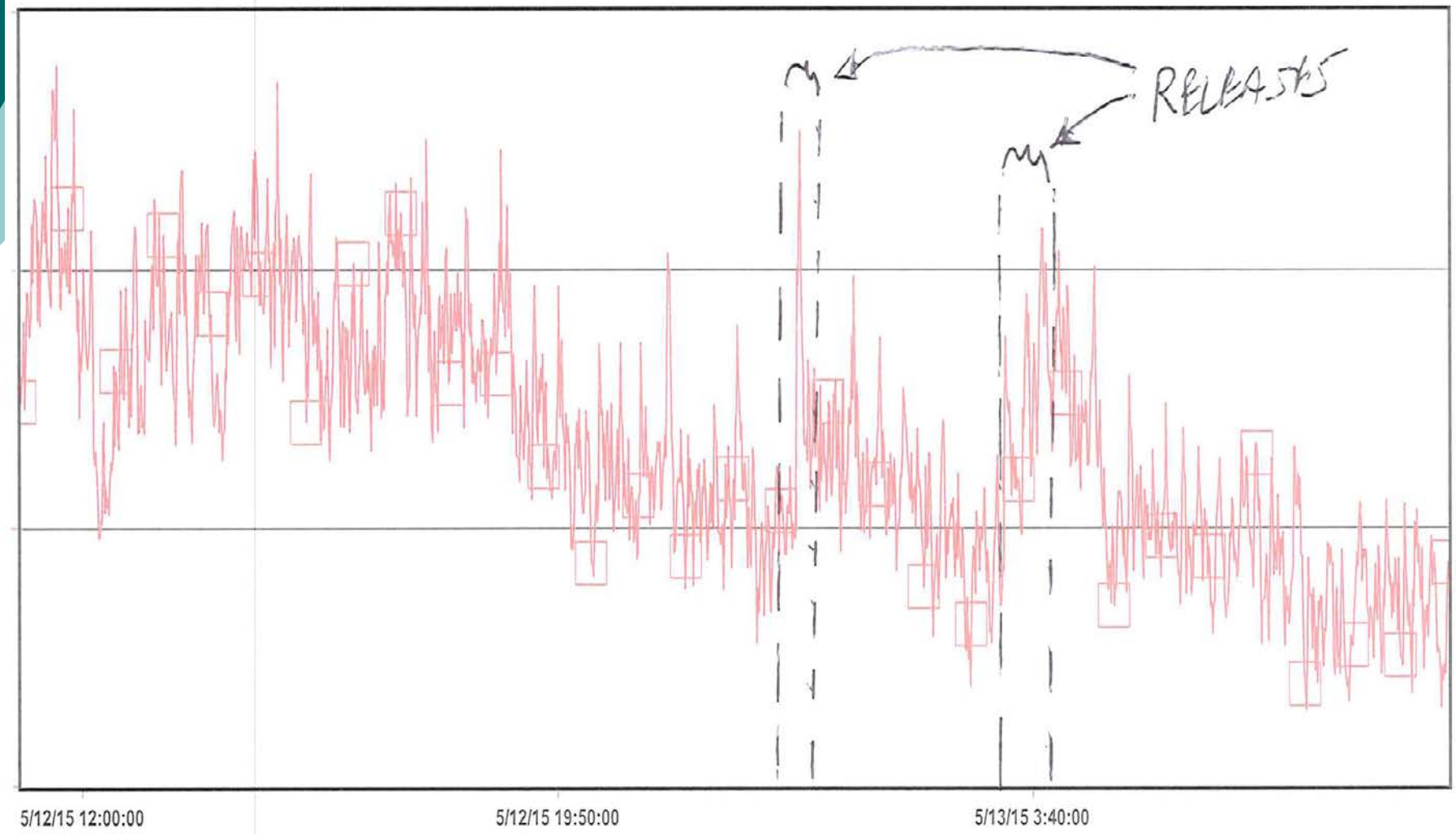
SFP Vent Radiation Monitor

responses to unplanned releases on May 12-13



Vent Effluent Radiation Monitor

responses to unplanned releases on May 12-13



Chapter Two Timeline

5/20 @ 1030-1041 – sampling DSC cavity gas

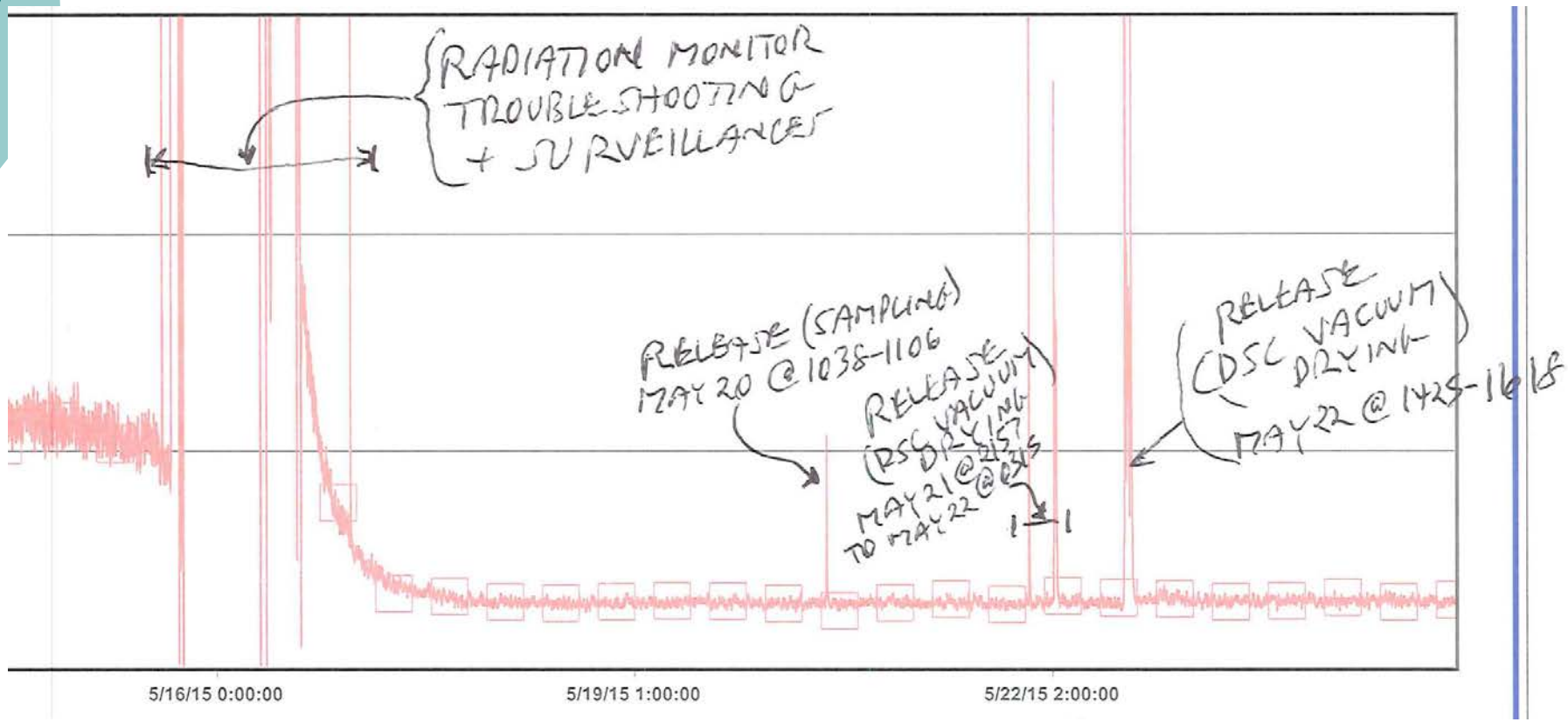
5/21 @ 2156 - Commenced vacuum drying

5/21 @ 2158 – Vent effluent radiation monitor alarm (maximum = 726cpm)

5/21 @ 2223 - Reset alarm and rad monitor settled to background of 30 cpm

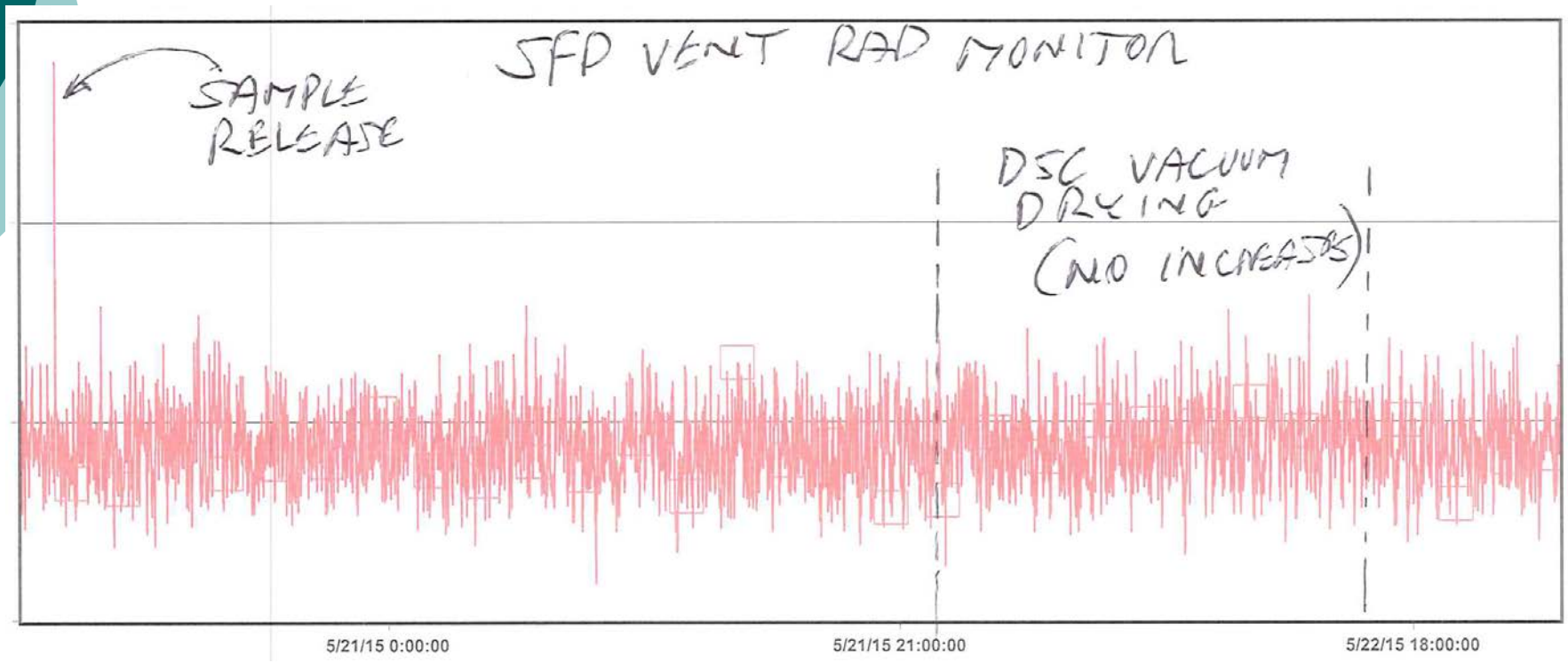
Vent Effluent Radiation Monitor

responses to sampling and planned releases on May 21-22



SFP Vent Radiation Monitor

responses during sampling and vacuum drying



Radiation monitoring issues

- Grab sample counted on gamma detector – not sensitive to low abundance Kr-85 peak
- HP frisker on refuel floor very sensitive to Kr-85 beta radiation
- Vent effluent monitor (beta scintillator) responds but monitor was declared out-of-service during draindowns.
- SFP vent monitor (beta scintillator) responds but DSC discharge piping and ventilation piping defeated the ability to capture release during vacuum drying.

Radiation monitoring issues - Vent Effluent Radiation Monitor

- Could have considered release unmonitored as well as unplanned but SFP vent radiation monitor did respond to first releases.
- Initial troubleshooting did not find any problems with electronics.
- Was effluent monitor erratic or was there an ongoing release from the SFP?
- Followup investigation faulted Operations for declaring monitor nonfunctional.

Radiation monitoring issues - Vent Effluent Radiation Monitor

Prompt Issue Review Team Report:

"Missed opportunity to fully understand what were potential causes when it was first identified that RM 8132B was trending up on Sunday, May 10 when there were no ISFSI activities in progress. Ultimately this led to Operations removing RM 8132 from service due to indications of increasing trends with no supporting samples showing activity (ties into knowledge item below on RM 8132 sensitivity versus gamma spectrum analysis)."

But a Nuclear Fuels technical evaluation stated:

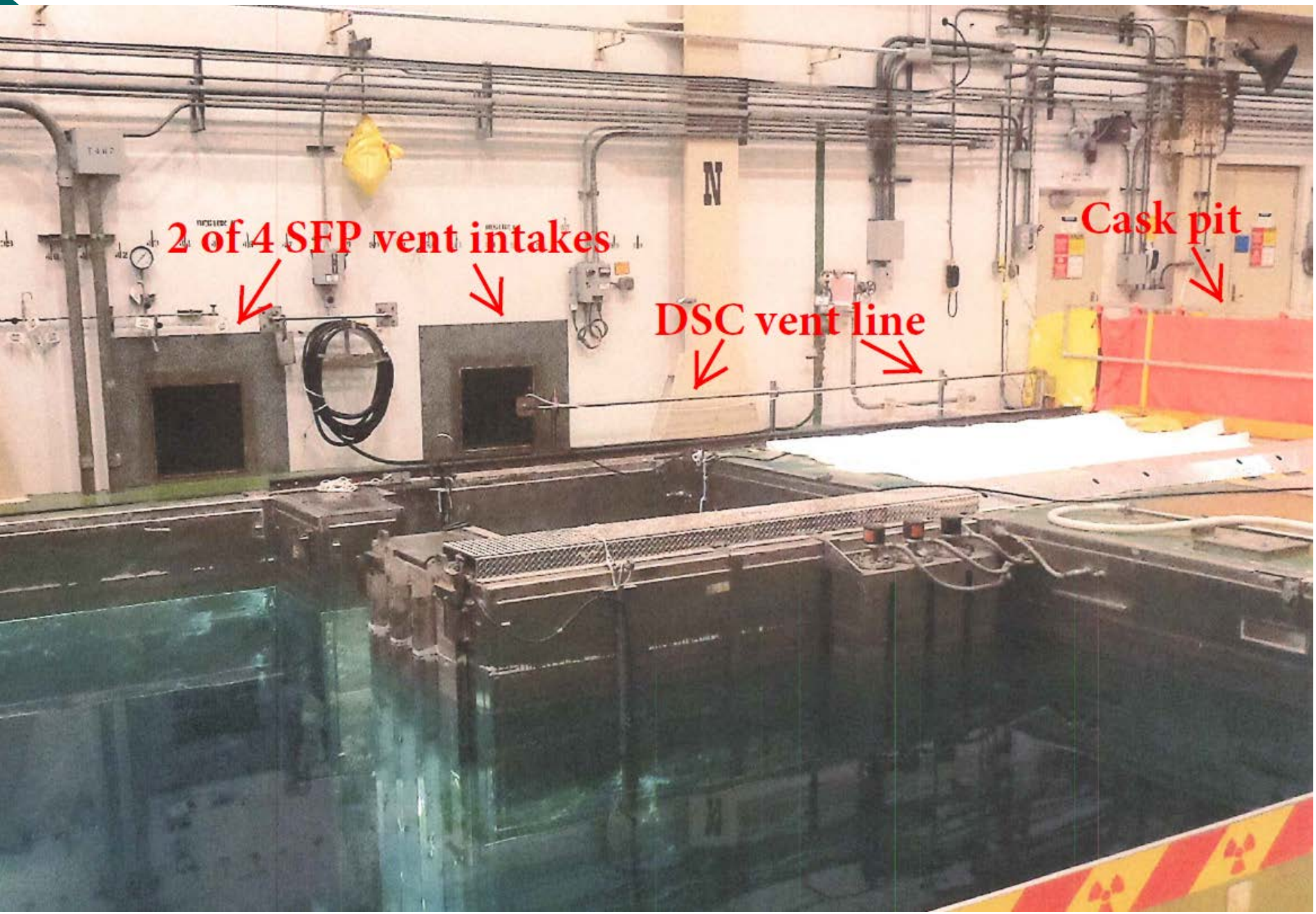
"This amount of Kr-85 indicates that a cladding failure occurred during DSC draindown/blowdown. A cladding failure prior to that (i.e., during reactor operation or pool storage) would have resulted in the release of most of the Kr-85 before the fuel assembly was placed in the DSC."

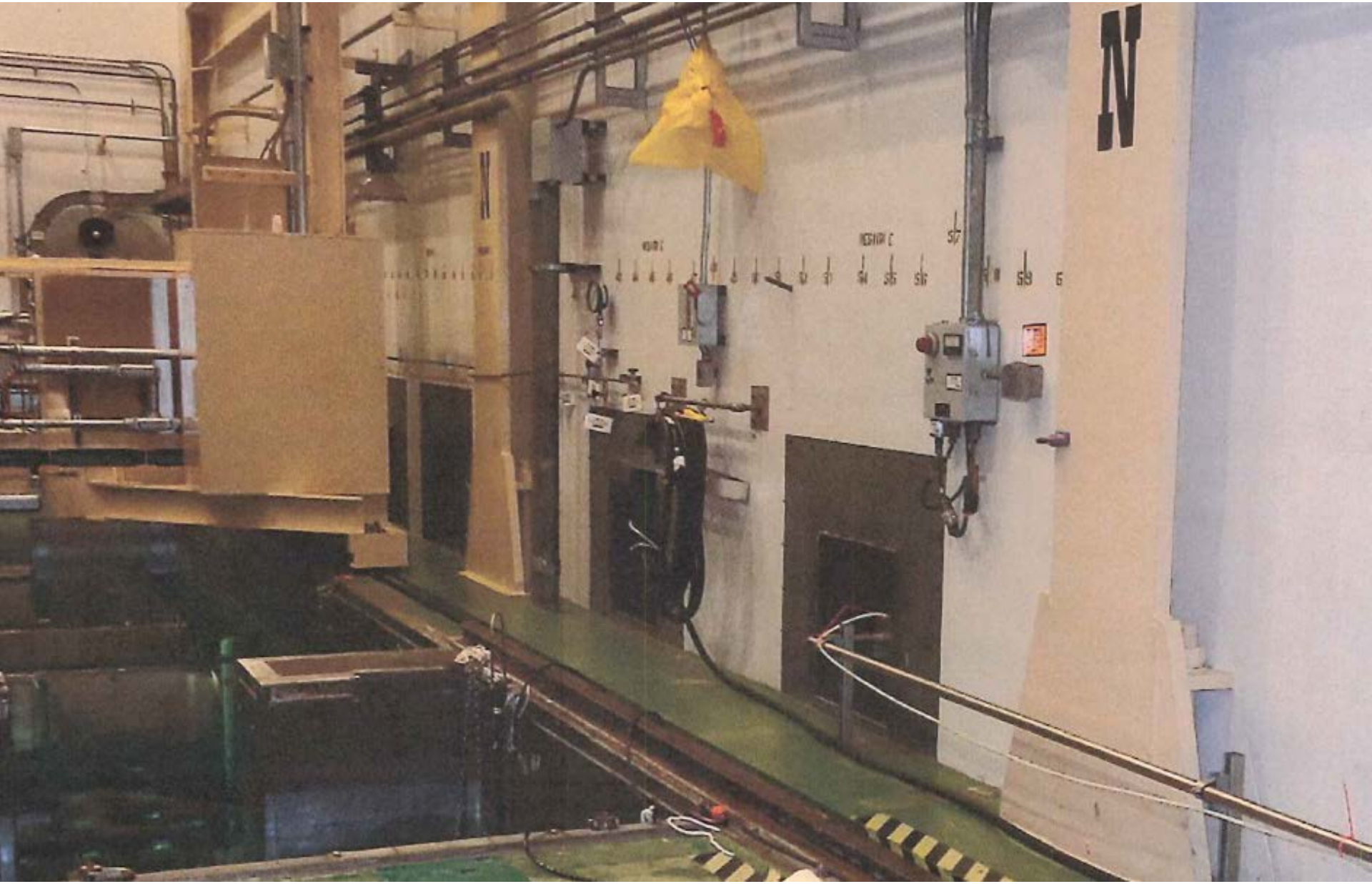
Radiation monitoring issues - Vent Effluent Radiation Monitor

- After check of monitor did not reveal any electronic problem the sample chamber was opened and loose debris was found.
- CRUD BURST !
  Debris found to have long half-life Cs and Co.
- Chamber had never been decontaminated. 40 years of operation.
- Long term buildup on chamber wall dislodged causing random readings according to placement of debris within chamber.
- After cleaning background decreased from 55 to 30 cpm.

Radiation monitoring issues - SFP Vent Radiation Monitor

- Same design as effluent monitor with beta scintillator.
- Responded to release via SFP water during initial vacuum drying.
- Did not respond to release via DSC vent line during final vacuum drying.
- DSC vent line piping directed to closest of four ventilation intakes in SFP area.
- Bypass of sampling input in ventilation duct.


2 of 4 SFP vent intakes
DSC vent line
Cask pit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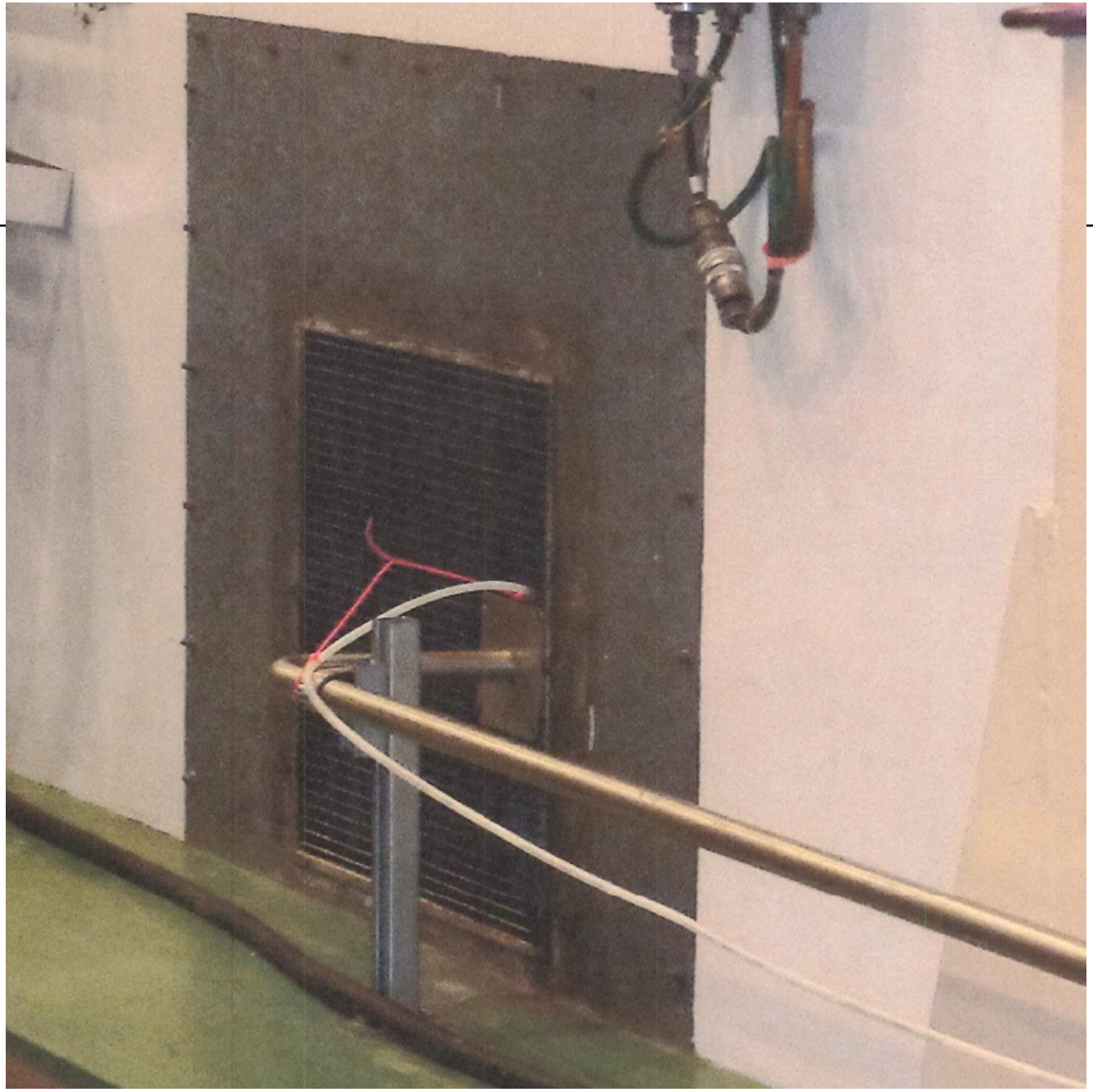
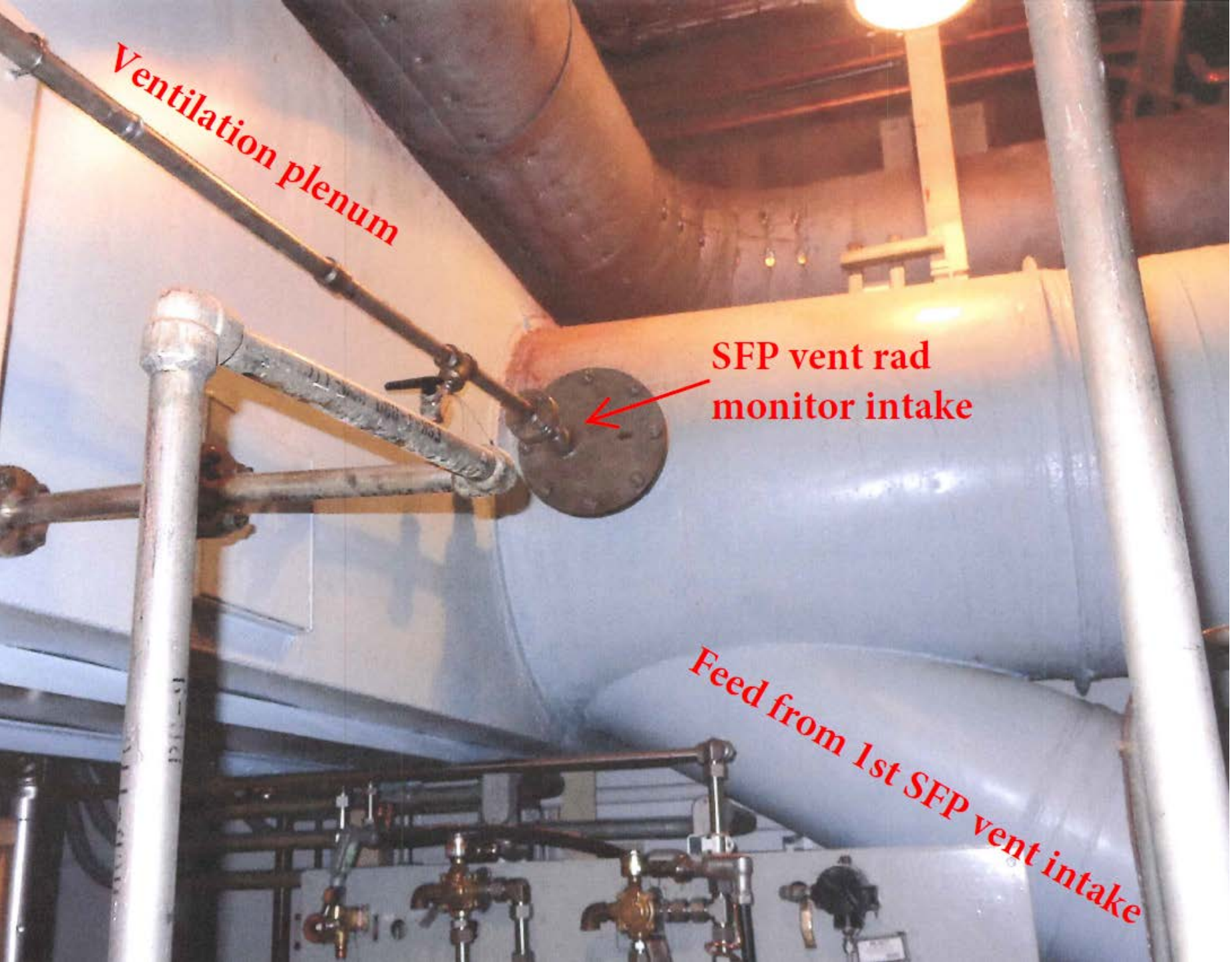


Ventilation pipe
Feed from 1st SFP vent intake
Feed from 2nd
SFP vent intake


Ventilation plenum
SFP vent rad
monitor intake
Feed from 1st SFP vent intake

Corrective actions

- Procedure
  - Note added to review canister documentation for potential for a release to the environment.
  - Added step stop if one of the affected radiation monitors becomes unavailable.
  - Added continuous communication with Control Room.
  - Ensure the control room and RP are notified of a potential to release Kr-85 gas during vacuum drying.
  - Step added to assess DSC cavity air space for the presence of noble gases (primarily Kr-85) and particulates and to assess future DSC's, as applicable, if similar events occur.

Corrective actions

- **Radiation Monitors**
  - **On 5/16 and 5/17, I&C calibrated the Vent Effluent and the SFP Vent Radiation Monitors (all data was within acceptance criteria and no adjustments were required). I&C purged the skid and monitor was returned to service by Operations.**
  - **HP moved Kr-85 gas monitoring instrument (frisker) to optimize early gas release detection. Based on area air flows, the continuous air monitor was relocated and an additional frisker was installed near the vent intake screen (where the VDS piping discharges into the SFP ventilation system). Implementation of these two changes will increase HP's ability to detect, monitor and assess early noble gas Release.**

Event Documentation

- Technical evaluation - Fuel assemblies located are not grossly breached and acceptable to be stored in ISFSI.
- Release and dose calculation - No state or federal release limits were exceeded and no reportability or classification issues.

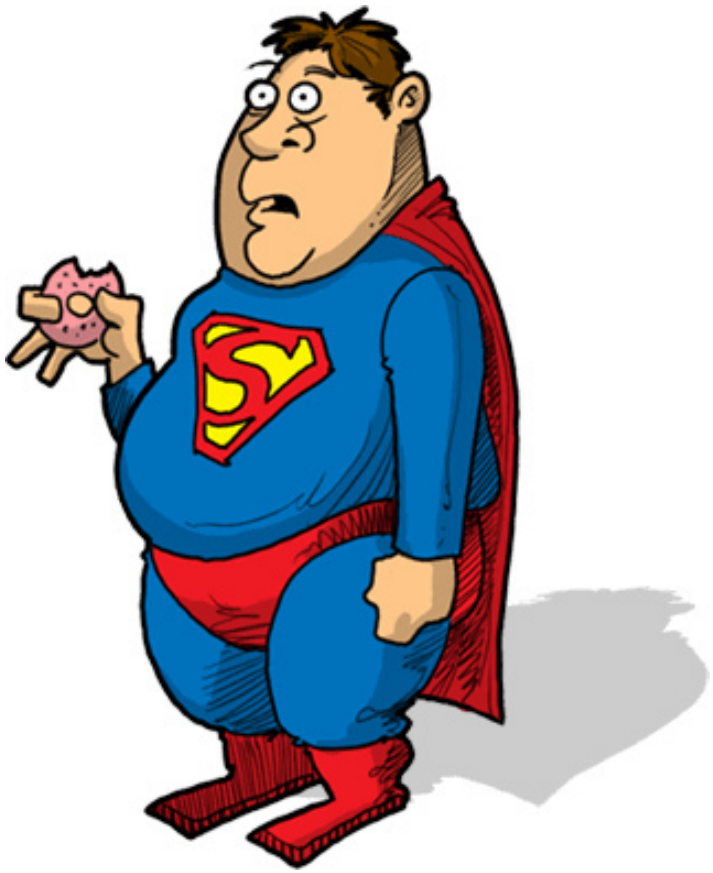
Release evaluation and reporting

- Conservative estimate of Kr-85 that could be released from a single fuel rod was be 3.5 Curies.
- Measurements of the Kr-85 released from this event totaled 1.8 curies.

Release evaluation and reporting

Effluent reporting

Unit 2	*1st Quarter*	*2nd Quarter*	*3rd Quarter*	*4th Quarter*	*Annual Total*
Max Air	mrad	mrad	mrad	mrad	mrad
Beta	1.61E-05	1.30E-3 [1]	1.05E-07	1.05E-07	1.32E-03
Gamma	3.95E-05	1.16E-5 [1]	2.50E-07	2.50E-07	5.16E-05
Max Individual	mrem	mrem	mrem	mrem	mrem
Whole Body	1.24E-03	2.58E-02	1.73E-02	2.18E-03	4.65E-02
Skin	1.34E-04	1.75E-03	7.84E-04	8.91E-04	3.56E-03
Thyroid	1.27E-03	2.68E-02	1.78E-02	2.19E-03	4.81E-02
Max organ [2]	6.05E-03	1.50E-01	9.80E-02	7.56E-03	2.62E-01

1 - Air Beta and Air Gamma doses in 2nd quarter include dose from Kr-85 released during fuel loading

Questions?