Managing Releases from Containment

IPEC

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Typical Airborne Releases from PWR Vapor Containment (VC)

- Pressure Reliefs:
  - approx every 4 days
  - periodicity depends on in-leakage
  - from weld channel, Nitrogen systems, as well as RCS leaks.
  - Also known as “vents” - NO fresh replacement air.
- Purges:
  - Generally only at end of an operating cycle.
  - Most plants elect NOT to purge above 200 degrees
  - Some allow purging on line for VC Entries.
- Integrated Leak Rate Test (ILRT)
  - IST- usually performed every 10-15 years.

Terms

- Batch or Continuous?
  - Reg Guide 1.21 defines BATCH as:
    "Discontinuous, over a finite period of time, usually hours or days"
  - Reg Guide 1.21 defines CONTINUOUS as:
    "…uninterrupted for extended periods during normal operation…"

Don't confuse these with NUREG-0133's definitions of "long term and short term" releases.

NUREG 0133, page 8

- Long Term
  - Generally continuous and stable (normal ventilation)
  - Dose calcs should use annual average met data.
- Short Term
  - Intermittent in nuclide conc or flow (PWR vent and purge).
  - May be due to operational variability resulting in releases exceeding 50% of long term releases
  - Total 500 hours or less per year, but not more than 150 hours in any quarter.
  - Can still use annual average met data if:
    - Sufficiently random with respect to duration and time of day
    - Releases are not “planned” to coincide with a specific MET condition.

Pressure Relief (vent) Criteria

- How to quantify the source term-
  - Grab sample, Rad Monitor, or both
- Volume Determination
  - Flow rate * Time (generally continuous) or
  - Fixed Volume (generally batch)
- Batch or Continuous
  - They are BATCH releases, but can generally be quantified per NUREG 0133 as “long term”.
  - This means annual average X/Q should be OK.

Pressure Relief Source Term

- IPEC method is to use a periodic sample of containment gas, with valid Rad Monitor readings for subsequent releases: For example:

Mar 2: Obtain a marinelli and rad mon reading in containment:
2.11E-6 uCi/cc 3.0E-6 uCi/cc

Mar 6: Rad mon reading = 3.2E-6. VCPR source term =
2.11E-6 uCi/cc * 3.2E-6 / 3.0E-6 = **2.25E-6**

Mar 10: Rad mon reading = 2.8E-6. VCPR source term =
2.11E-6 uCi/cc * 2.8E-6 / 3.0E-6 = **1.97E-6**

Update to a new marinelli at least once per month, but generally more often, as determined by Staff, based on isotopic mixture changes.

Press Relief Volume Determination

- Flow rate * Time
  - Max rated cfm from fan is usually conservative
  - Flow is generally not “measured”
  - No real quantitative measurement leads to large volume of non-helpful data, no way of determining health of the fan
- Fixed Volume Measurement from Press Change
  - Not necessarily straight forward
  - Requires defendable instrumentation, not normally designed for this purpose and well outside the intended range of these instruments (SI).
- Error terms needs to be known

Pressure Change Method

START DATE	START TIME	END TIME	Dur (min)	INITIAL PRESS (psig)	FINAL PRESS (psig)		Ideal Gas 10,000 SCF	Ideal Gas Flow (SCFM)
28-Feb	**13:49**	**14:55**	66	0.50	-0.20		---	---
6-Mar	**02:01**	**02:55**	54	0.40	-0.20		9.3	1700
7-Mar	**17:27**	**18:29**	62	0.40	-0.20		9.2	1485

$$V_{PR} = [(P_2 - P_3) + (P_2 - P_1) * (t_3 - t_2)/(t_2 - t_1)] * 1.55E5$$

1.55E5 = 2.6E6ft^3/ (311ºK * 0.0538 psig/ºK)

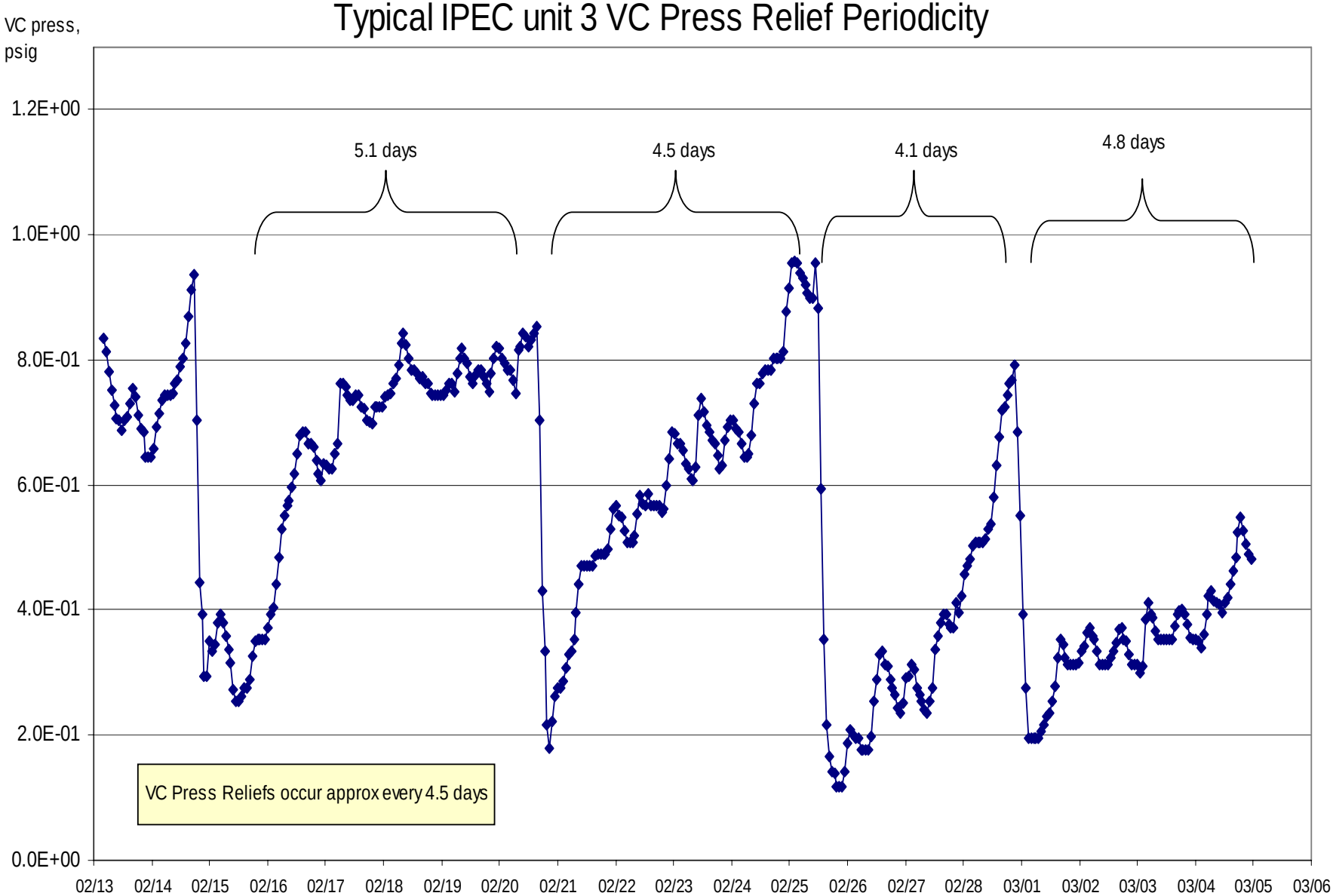
2.6E6 = volume of free air

311ºK = 100ºF in absolute scale

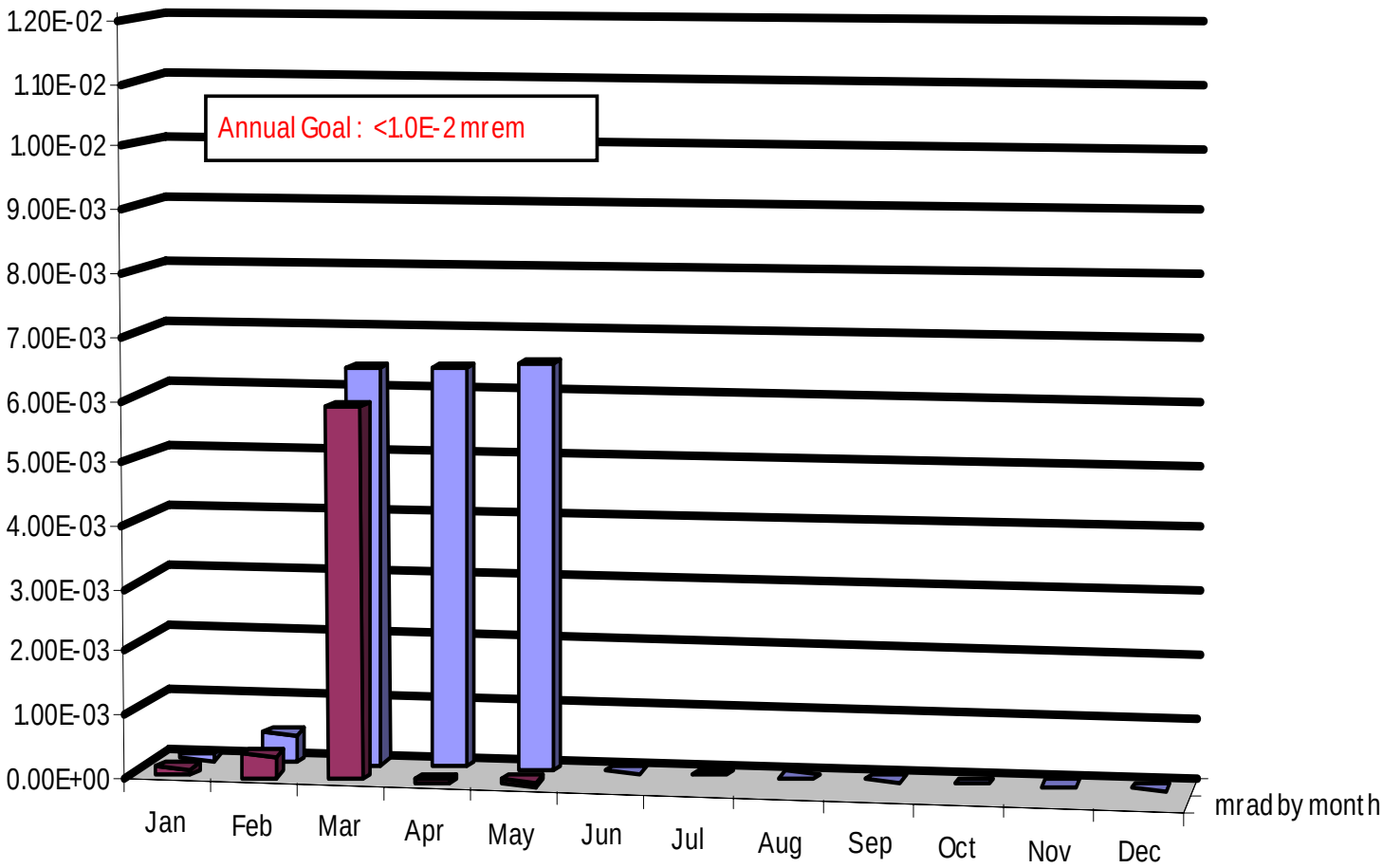
0.0538 psig/ºK= 0.082057(liters*atm)/moles*ºK)

Rad Monitor and Grab Sample

- Assumes you have a program to aggressively correlate Rad Monitor readings with grab samples.
- The ODCM requires monthly samples, but they are collected weekly, WITH the Rad Monitor readings recorded with each sample for future comparison.
- Rad Mon reading is used for subsequent releases with this mixture, PROVIDED the mixture doesn’t change.
- Chem determines if another marinelli should be placed on file, from our weekly samples.
- Update the sample on file monthly, or when the mix changes, generally more frequently after refueling.


Typical IPEC unit 3 VC Press Relief Periodicity
VC press, psig
1.2E+00
1.0E+00
8.0E-01
6.0E-01
4.0E-01
2.0E-01
0.0E+00
5.1 days
4.5 days
4.1 days
4.8 days
VC Press Reliefs occur approx every 4.5 days
02/13
02/14
02/15
02/16
02/17
02/18
02/19
02/20
02/21
02/22
02/23
02/24
02/25
02/26
02/27
02/28
03/01
03/02
03/03
03/04
03/05
03/06

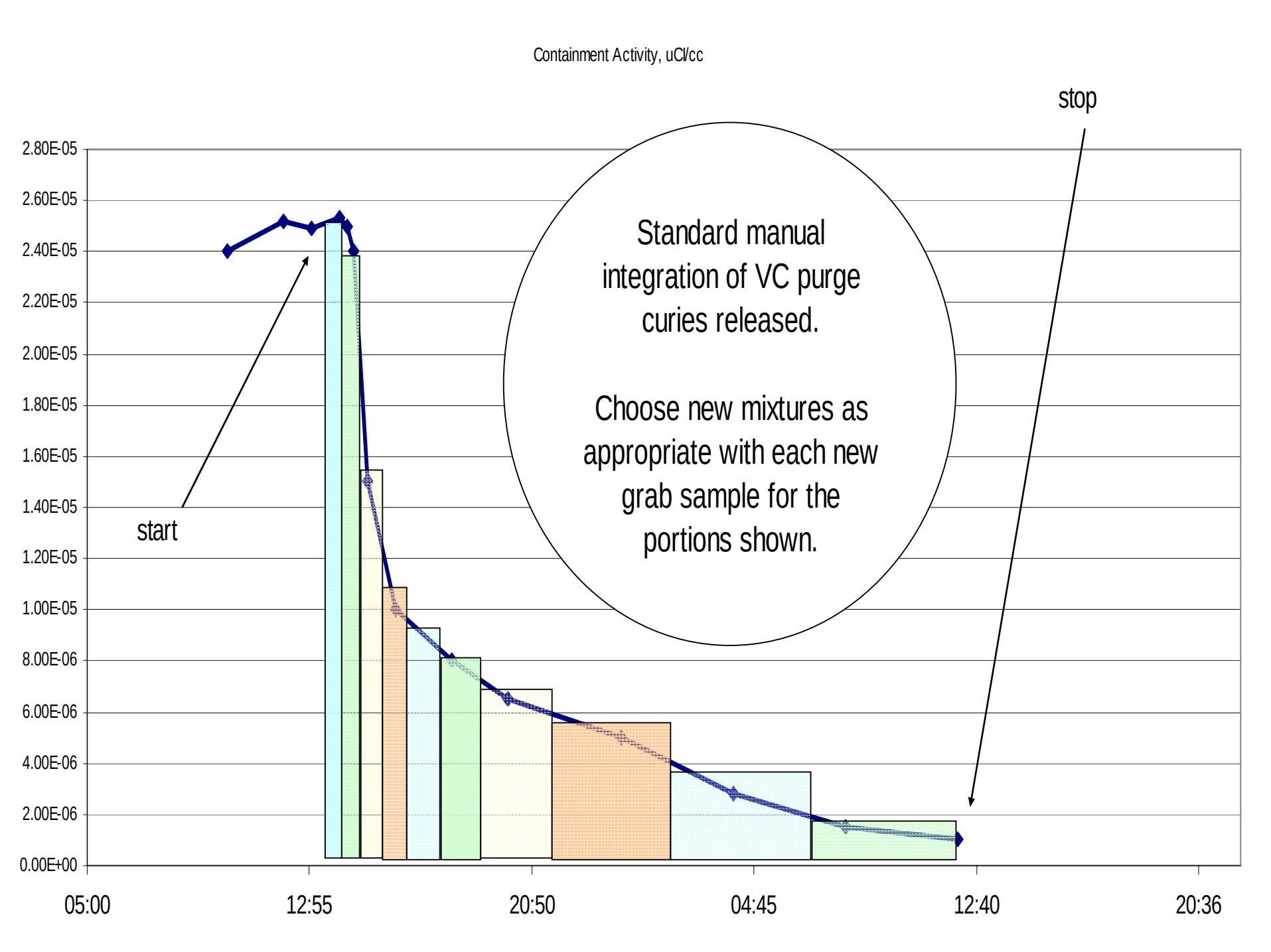
2005 Beta Air Dose to Date (mrad) at IP3



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
mrad by month	1.01E-04	3.56E-04	5.94E-03	5.05E-05	7.00E-05							
2005 YTD	1.01E-04	4.57E-04	6.40E-03	6.45E-03	6.52E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Containment Purge

- Manual integration of multiple grab samples.
- Assisted by Plant Vent rad monitor integration.
- Must determine an END time (reclassification).
- May or may NOT use the SUPPLY fan.
- Plant ventilation systems need to be balanced.
- Minimize Purge down time when it is needed.

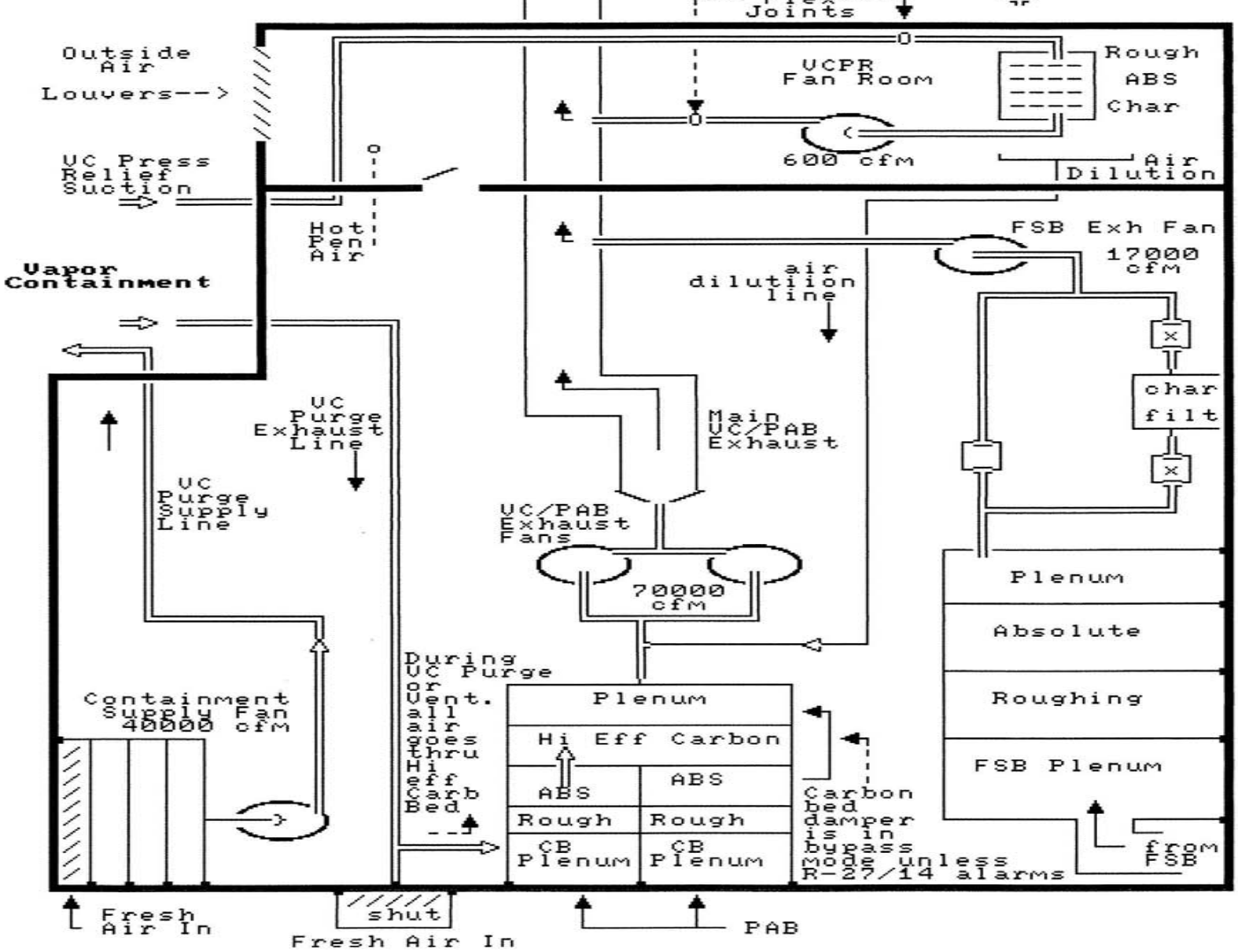

Containment Activity, uCi/cc
stop
2.80E-05
2.60E-05
2.40E-05
2.20E-05
2.00E-05
1.80E-05
1.60E-05
1.40E-05
1.20E-05
1.00E-05
8.00E-06
6.00E-06
4.00E-06
2.00E-06
0.00E+00
Standard manual integration of VC purge curies released.
Choose new mixtures as appropriate with each new grab sample for the portions shown.
start
05:00
12:55
20:50
04:45
12:40
20:36

Sample Containment or Plant Vent

- Plant Vent may include other sources
- VC sample is a sample of the SOURCE
- Initially, a sample of ***both*** can help you determine VC exhaust flow rate:

  VC exhaust flow = PV flow * PV act/VC act

- Probably best to QUANTIFY from the VC samples until “no longer PURGING”


Joints
Outside Air Louvers-->
UCPR Fan Room
Rough ABS Char
600 cfm
Air Dilution
UC Press Relief Suction
Hot Pen Air
FSB Exh Fan 17000 cfm
Vapor Containment
air dilution line
char filt
UC Purge Exhaust Line
Main UC/PAB Exhaust
UC Purge Supply Line
UC/PAB Exhaust Fans
70000 cfm
Plenum
Absolute
Roughing
FSB Plenum
During UC Purge or Vent. all air goes thru Hi Eff Carb Bed
Containment Supply Fan 40000 cfm
Plenum
Hi Eff Carbon
ABS
ABS
Rough
Rough
CB Plenum
CB Plenum
Carbon bed damper is in bypass mode unless R-27/14 alarms
from FSB
Fresh Air In
shut
Fresh Air In
PAB

So, WHEN is the PURGE complete?

- Existing (old) regulation does not offer a alternative definition to PURGE, such that continuous control is maintained, but the PURGE requirements are relaxed.
- So use 50.59 and make some.
- Call the PURGE complete when the VC concentration is reduced to that amount which, if run for 31 days, would NOT result in approaching the 31-day dose projection limits.

Back-Calculate from 31-day dose projection limits

- Usually, Noble Gas will be limiting:

$$beta\ \ air\ \ mrad = 3.17E-8*\sum_{i} \mathrm{Ni}\,[(\mathrm{X/Q})\,(\tilde{\mathrm{Q}}\mathrm{i})\,]$$

- After determining dose factor from a known mixture (N), solve for microcuries (Q) at 0.4 mrad Beta Air Dose. Convert to VC concentration at known release rate.

Advantages of reclassifying the Purge

- Once you identify the continuous introduction and removal of air in containment as “building ventilation” (instead of “purge”) you have some relaxation with regard to :
  - containment integrity
  - operability requirements of Fan Cooler units
  - operability requirements of radiation monitors
  - Auto-closure requirements
- The VC Noble Gas Rad Monitor isn’t an LCO risk, you really only need the Plant Vent monitor.

Continue Quantification

- While no longer a PURGE, you STILL need to perform quantification!
  - However, it is now a CONTINUOUS release, like trace levels of Xe-133 in the Primary Bldg.
- Perform periodic grab samples and Rad Monitor readings per your ODCM implementing procedures.
- Be aware of evolutions that would SPECIFICALLY add activity to containment. Do you need to temporarily re-establish integrity ?

Iodine

- So far, we have only thought about noble gas.
- Iodine can be most limiting. A sample is required for the initial permit for part 20 concerns!
- Need to understand shutdown chemistry
- Timing is critical for capturing as much iodine as possible on cleanup systems.
- A weakness throughout the industry as the pressure for short refueling outages merges with the reality of brain-drain in the RETS business.

Primary Shutdown Chemistry

- Phases: (***EPRI primary water guidelines***)
  - Routine Operation: elevated pH, no oxidation
  - Acid Reducing: no oxidation, but pH dropping
  - Acid Oxidizing: peroxide addition to loosen crud
- As a PWR shuts down, Lithium is removed and boric acid is injected, shifting the pH down.
- However, the Iodine, originally in iodide form is now changing to Iodate form due to oxidation.

Keys to Limiting Iodine Releases

- Iodine remains in Iodide form until completely oxidized to Iodate (still being ion exchanged).
- Maximize time and flow rate on the Primary Mixed Bed while it is still in ionic form.
- Place a Deborating Bed in service at Cold Shutdown + 600 ppm B.
  - Significantly reduces iodine levels before adding peroxide.

Adding Peroxide

- Usually around 190 F, peroxide is added.
  - start of acid-oxidizing phase.
- At this point, the left over Iodide and the Iodate changes to gaseous Iodine (I_2) as pH drops !
- Must EDUCT elemental gaseous Iodine from the coolant BEFORE opening primary systems.
- Eduction is directed via Maintenance Exhaust header to VC exhaust plenum, NOT directly dumped into the containment atmosphere !

Why Educt?

- 10CFR50 App I, General Design Criteria, and common sense say to use ALARA.
- The cleanup system for primary Iodine is the Charcoal in the VC exhaust plenum.
- The trick is to minimize the amount you need to cleanup, AND be sure you get the gaseous Iodine there without surrendering Iodine uptakes to workers as you push for a 3 week outage!

One last part

- Soon after eduction starts, Operations will want to start draining the Pressurizer, and SECURE all Reactor Coolant Pumps.
- When the pumps are stopped, more degassing occurs. Must continue to educt.
- Often, this added gas, especially iodine, escapes because eduction is prematurely halted, thinking that there has been sufficient removal.

10 yr IST: Integrated Leak Rate Tests

- Interface with EPRI primary water guidelines and shutdown chemistry is critical for this evolution.
- Not worried about gas!
- Iodine can be “burped” from the fuel, to the RCS, to the containment atmosphere, upon depressurization after leak rate test.

Perform a calculation for 31-day dose projection limits

The limiting factor will probably be ensuring your “ground level” release out the special test rig does NOT contain too high I-131, such that you violate the 31-day dose projection limits (which would REQUIRE the use of cleanup systems that are BYPASSED in this special evolution)!

Consider a contingency plan

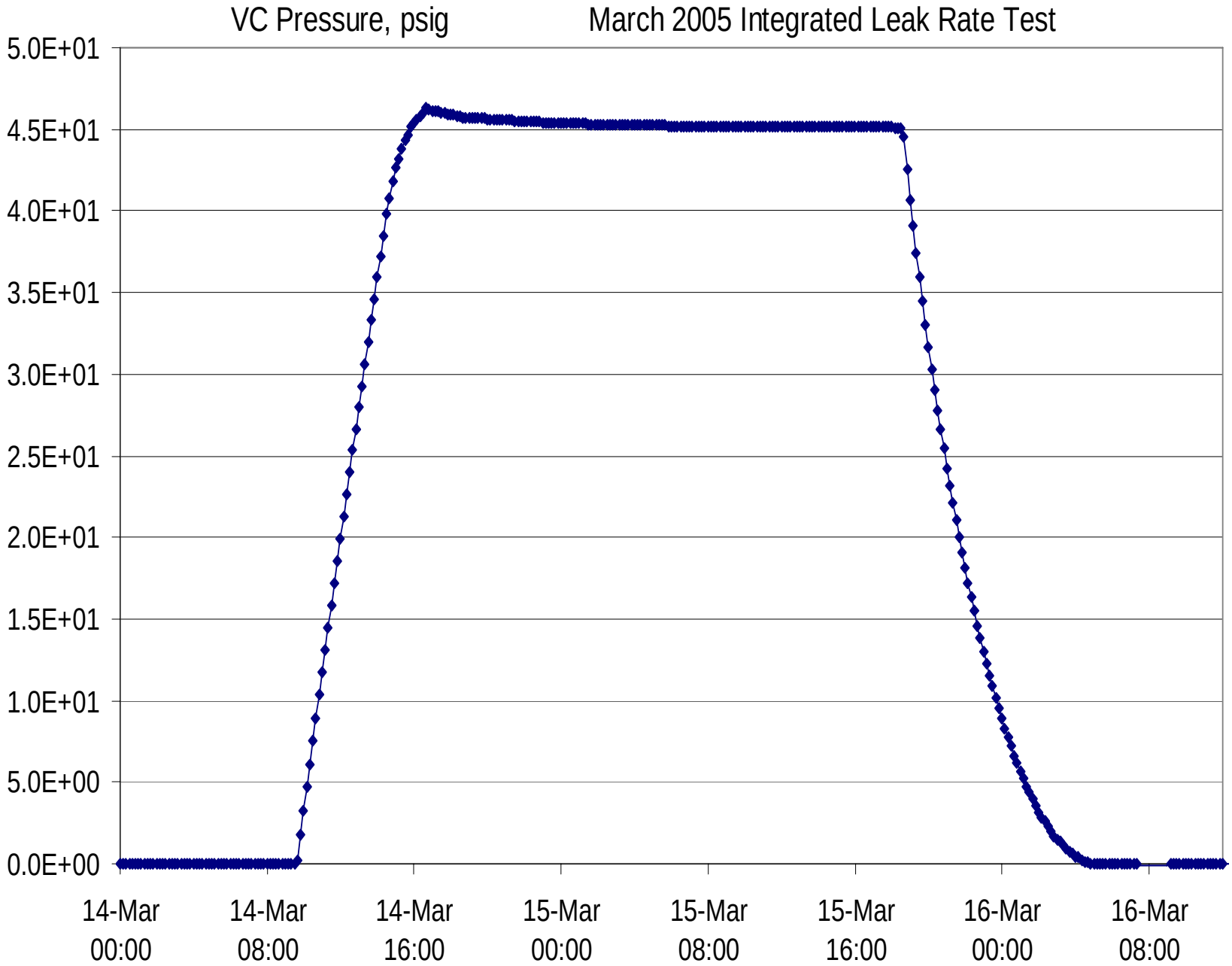
- Continuous sampling is required during bleed-off. It is not sound to imagine the concentration of I-131 will remain at the initial sample concentration
- If Iodine reaches threshold value, have a prepared method to bleed off the air through plant systems (exhaust plenum) which will remove some Iodine.

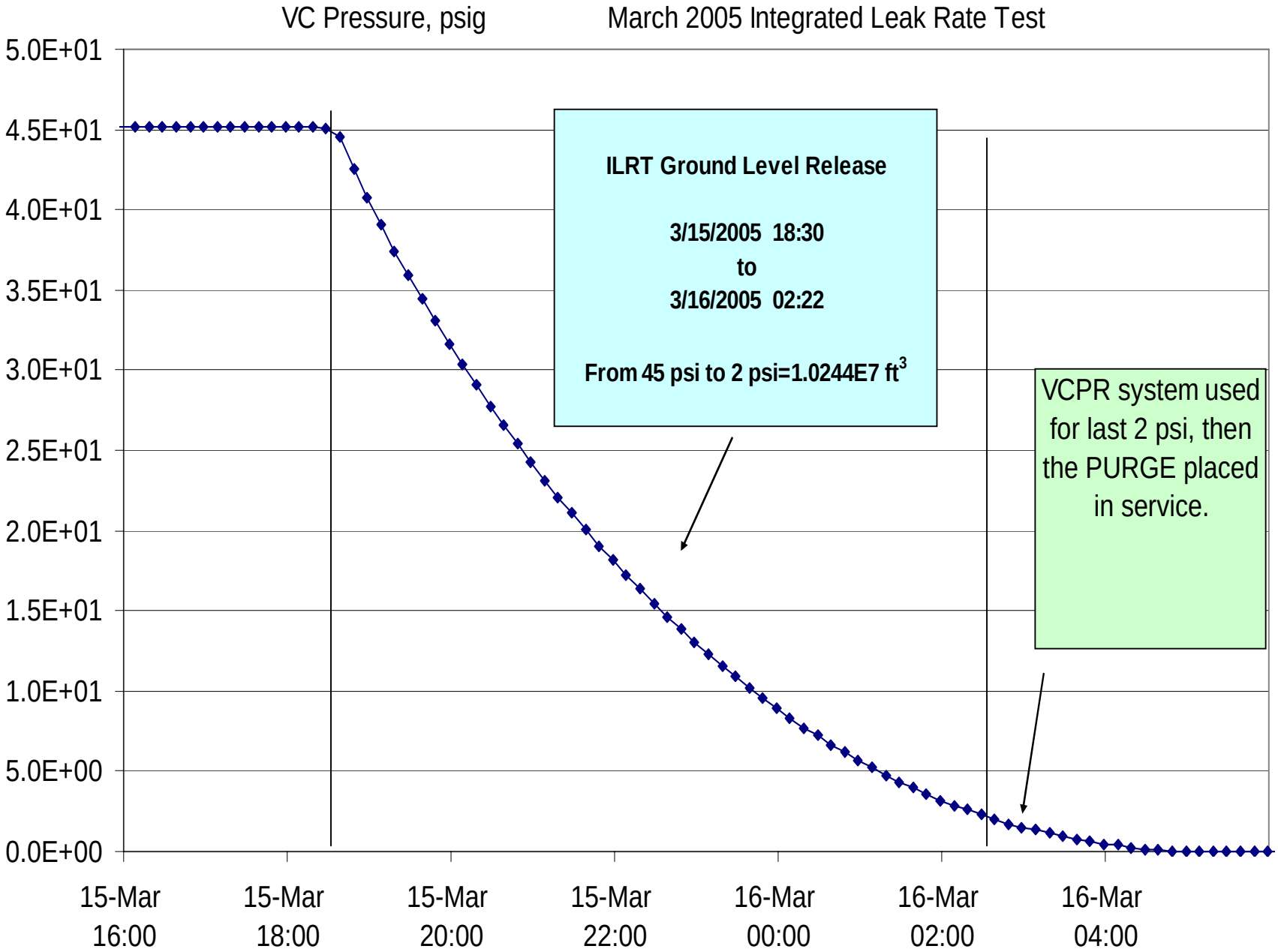
Limitations for ILRT vent-off contingency plans

- Clearly, you will NOT be able to vent off 2.6 million cubic feet in a few hours!
- Going up the plant vent will significantly reduce the venting rate…
- This may be bounded by a routine effluents permit, but it is more likely to be bounded by the physical limitations of your plenum's ability to handle the flow rate.

Contingency = vent slower

- Which sounds good until you announce this to the outage planners….
- Woe be unto you….
- We felt it necessary to remove any chance of Iodine limiting our “outage schedule”.


VC Pressure, psig
March 2005 Integrated Leak Rate Test
5.0E+01
4.5E+01
4.0E+01
3.5E+01
3.0E+01
2.5E+01
2.0E+01
1.5E+01
1.0E+01
5.0E+00
0.0E+00
14-Mar 00:00
14-Mar 08:00
14-Mar 16:00
15-Mar 00:00
15-Mar 08:00
15-Mar 16:00
16-Mar 00:00
16-Mar 08:00


VC Pressure, psig
March 2005 Integrated Leak Rate Test
5.0E+01
4.5E+01
4.0E+01
3.5E+01
3.0E+01
2.5E+01
2.0E+01
1.5E+01
1.0E+01
5.0E+00
0.0E+00
15-Mar 16:00
15-Mar 18:00
15-Mar 20:00
15-Mar 22:00
16-Mar 00:00
16-Mar 02:00
16-Mar 04:00
ILRT Ground Level Release
3/15/2005 18:30
to
3/16/2005 02:22
From 45 psi to 2 psi=1.0244E7 ft3
VCPR system used for last 2 psi, then the PURGE placed in service.

ILRT vent-off samples

Periodic grab samples for Noble Gas & Continuous I&P sample collection

start	stop	CFM	I-131		Xe-133
3/15/2005 18:30	3/15/2005 19:32	4.49E+04	2.10E-11		9.73E-07
3/15/2005 19:32	3/15/2005 20:58	3.64E+04	1.76E-11		1.70E-06
3/15/2005 20:58	3/16/2005 2:12	1.38E+04	1.46E-11		2.28E-06

I-131 uCi	Xe-133 uCi	min	cubic feet
1.66E+00	7.67E+04	62	2.78E+06
1.56E+00	1.51E+05	86	3.13E+06
1.79E+00	2.80E+05	314	4.33E+06

Average uCi/cc for the entire ILRT Vent-off:

I-131 = 1.73E-11 Xe-133 = 1.75E-6

Big Picture

- To grasp a properly integrated view of the entire objective, we must convince Operations and Outage Management of the significance of aggressively reducing Iodine in the containment atmosphere BEFORE the ILRT begins (before pressurization).
- If so, everyone wins. Outage remains on schedule. Minimal offsite dose.
- If not, all lose. Outage delayed DAYS. Your Iodine/Particulate dose will be 5^{th} quartile.