Liquid Nitrogen Storage in a High-Containment Laboratory-Why AAHL is Moving Away from It

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AUSTRALIAN ANIMAL HEALTH LABORATORY
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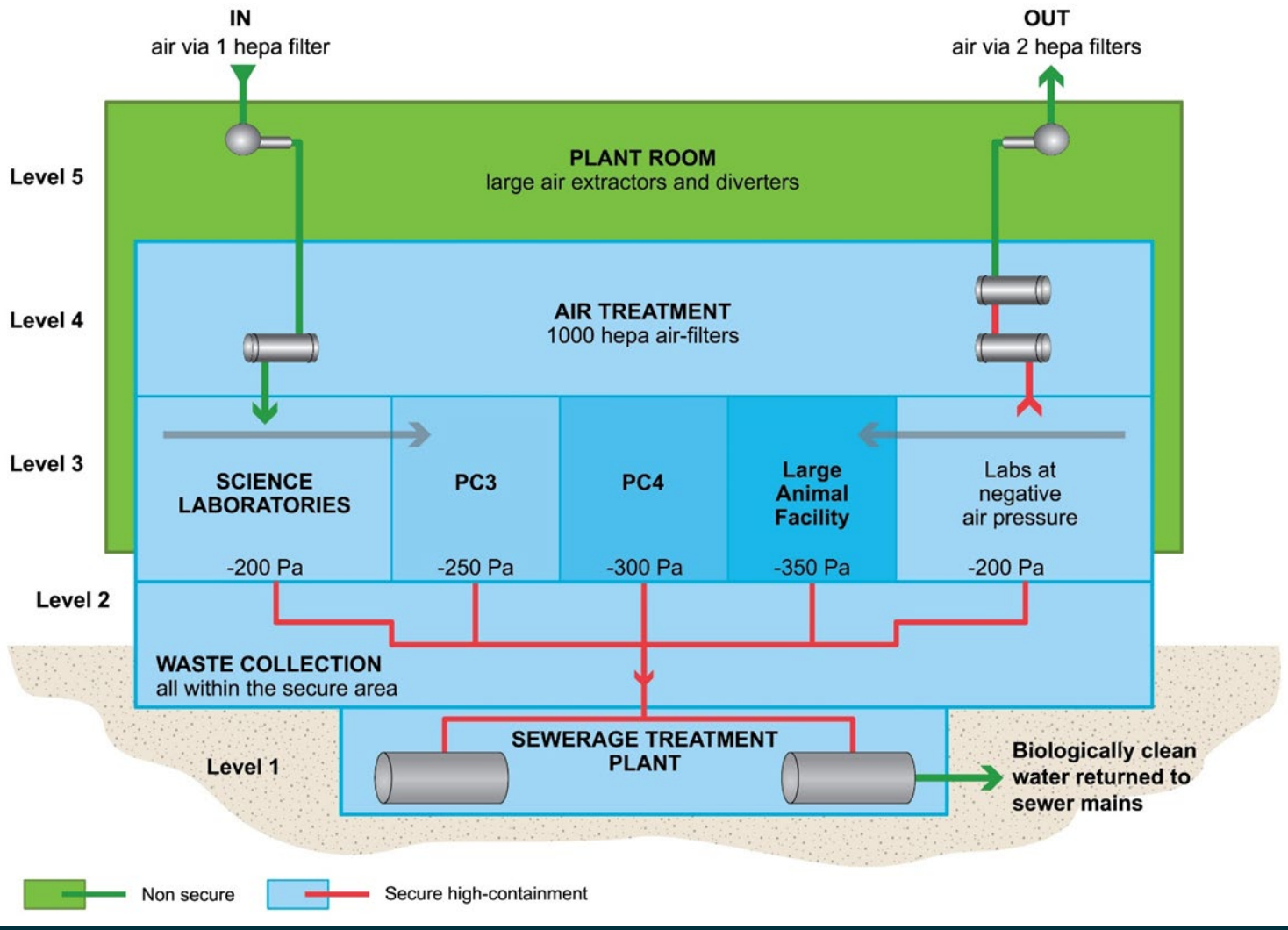
IN
air via 1 hepa filter
OUT
air via 2 hepa filters
Level 5
PLANT ROOM
large air extractors and diverters
Level 4
AIR TREATMENT
1000 hepa air-filters
Level 3
SCIENCE LABORATORIES
-200 Pa
PC3
-250 Pa
PC4
-300 Pa
Large Animal Facility
-350 Pa
Labs at negative air pressure
-200 Pa
Level 2
WASTE COLLECTION
all within the secure area
Level 1
SEWERAGE TREATMENT PLANT
Biologically clean water returned to sewer mains
Non secure
Secure high-containment

Background and History

- December 7th 2001
  - Combination of circumstances result in fatality within the facility
  - Coronial inquest
  - Significant improvements
    - Comprehensive risk assessment, multiple engineering controls & training
      - Interlocked doors, O_2 monitoring, 'out of hours' locked out
    - Satisfaction that the contributing 'issues' had been adequately addressed
    - Reticulated LN system retained

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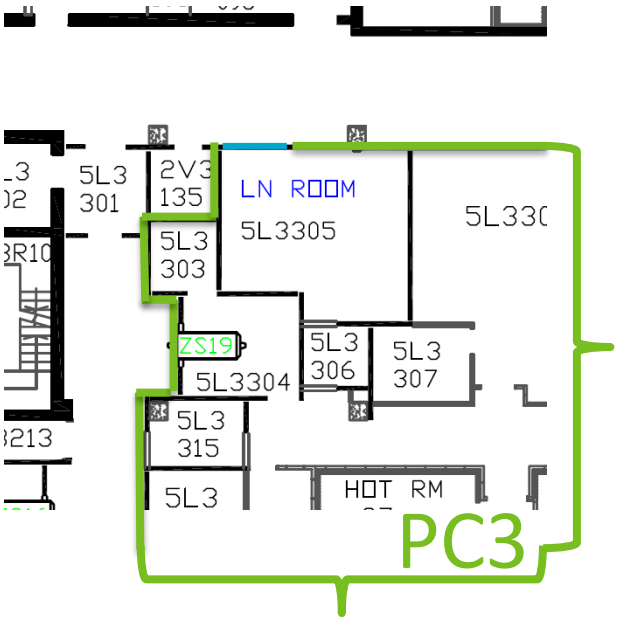
Room overview



- Airlocked room within the PC3 (BLS-3) North Suite
- ~100m^3 (3,500ft^3)
- 2x HEPA filter on supply & exhaust air
- Normal operation -250Pa to atm. 270L/s flow.
- 8 LN vessels

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Monday November 19th 2018

- Bulk delivery of Liquid Nitrogen (7am)
- The delivery process is interrupted by an electrical issue
- Power restored, LN flow resumed
- A number of alarms raised
  - Air handling/pressure
  - Fire
  - Low Oxygen
- After ~20mins- Alarms cleared

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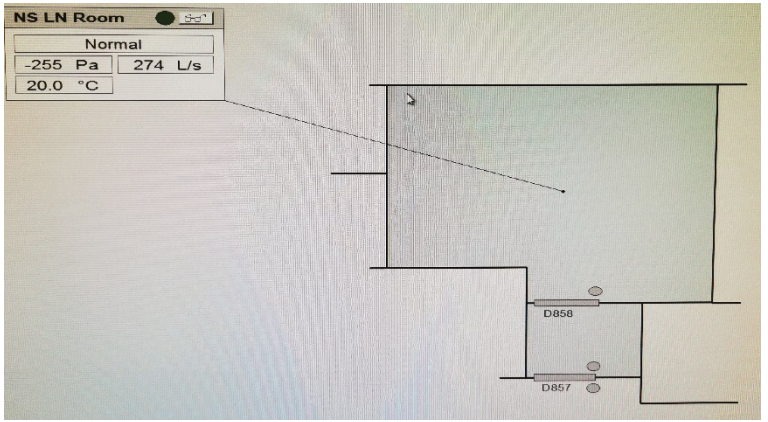
Room Environment

- Un-controlled release of Liquid Nitrogen
- Temperature and Oxygen dropped rapidly
  - Unlikely time to escape
- Room locked until 9am



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Physical impact

- Significant pressure increase

Physical impact

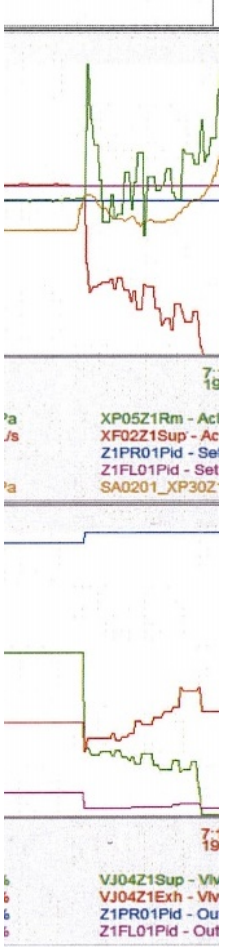
Physical impact

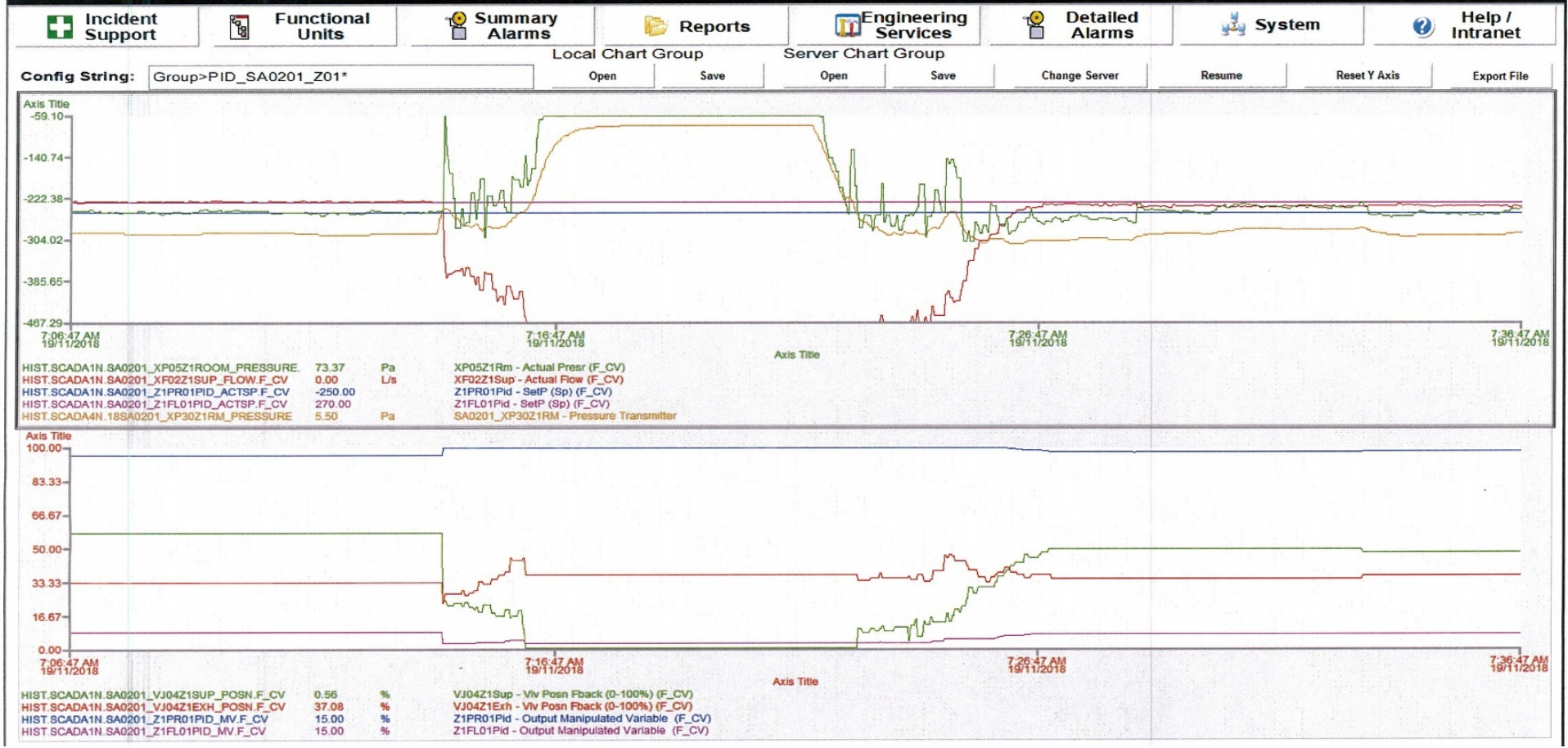
- Significant pressure increase
  - Displaced door seal – above 1kPa doors are braced
  - Bent hinge
- Sewerage ‘P’ Trap emptied
  - 200mm = 2kPa
- External window undamaged

- Room nominally -250Pa

Air Handling System

- Off scale +ve pressure ‘spike’ –> various automated responses
- Room is ‘Pressure over Flow’ controlled – supply valve closes in response
- Exhaust to 100%
  - Overload-> 35%. Fortunately not fully closed.
- Corridor pressure outside LN room (inside PC3) momentarily increases.
  - Assumption this is when the door seal is displaced and door deflects bending the hinge.




Incident Support
Functional Units
Summary Alarms
Reports
Engineering Services
Detailed Alarms
System
Help / Intranet
Local Chart Group
Server Chart Group
Config String:
Group>PID_SA0201_Z01*
Open
Save
Open
Save
Change Server
Resume
Reset Y Axis
Export File
Axis Title
-59.10
-140.74
-222.38
-304.02
-385.65
-467.29
7:06:47 AM 19/11/2018
7:16:47 AM 19/11/2018
7:26:47 AM 19/11/2018
7:36:47 AM 19/11/2018
Axis Title
HIST.SCADA1N.SA0201_XP05Z1ROOM_PRESSURE. 73.37 Pa XP05Z1Rm - Actual Presr (F_CV)
HIST.SCADA1N.SA0201_XF02Z1SUP_FLOW.F_CV 0.00 L/s XF02Z1Sup - Actual Flow (F_CV)
HIST.SCADA1N.SA0201_Z1PR01PID_ACTSP.F_CV -250.00 Z1PR01Pid - SetP (Sp) (F_CV)
HIST.SCADA1N.SA0201_Z1FL01PID_ACTSP.F_CV 270.00 Z1FL01Pid - SetP (Sp) (F_CV)
HIST.SCADA4N.18SA0201_XP30Z1RM_PRESSURE 5.50 Pa SA0201_XP30Z1RM - Pressure Transmitter
Axis Title
100.00
83.33
66.67
50.00
33.33
16.67
0.00
7:06:47 AM 19/11/2018
7:16:47 AM 19/11/2018
7:26:47 AM 19/11/2018
7:36:47 AM 19/11/2018
Axis Title
HIST.SCADA1N.SA0201_VJ04Z1SUP_POSN.F_CV 0.56 % VJ04Z1Sup - Vlv Posn Fback (0-100%) (F_CV)
HIST.SCADA1N.SA0201_VJ04Z1EXH_POSN.F_CV 37.08 % VJ04Z1Exh - Vlv Posn Fback (0-100%) (F_CV)
HIST.SCADA1N.SA0201_Z1PR01PID_MV.F_CV 15.00 % Z1PR01Pid - Output Manipulated Variable (F_CV)
HIST.SCADA1N.SA0201_Z1FL01PID_MV.F_CV 15.00 % Z1FL01Pid - Output Manipulated Variable (F_CV)

Follow up

- Pressure/integrity test
  - All ductwork, Room, Sewerage pipes
  - both supply and both exhaust HEPA filters
  - All intact – no breach of containment

- Isolate reticulated LN system

Questions - incident

- Cause?
  - Combination of circumstances
  - Lowest relief valve – vessel
  - Valves not maintained
- Source?
  - Tanker, Bulk storage, Vessel
  - Bulk storage owned/maintained by LN supplier
    - 2 x onsite, both different
- Volume of LN released?
  - Exhaust at 35% x room volume x off scale ~15min = ~350L LN
- Maximum pressure?
  - Will never know (>2kPa)
- PC3 containment ‘breach’?
  - Room pressure test passed and filter integrity confirmed
  - Vent through a vessel? – no samples were disrupted.

Questions – ongoing provision

- Why have LN inside PC3 containment?
  - Hybridoma cells – Some highly valuable virus and bacteria stocks and lots and lots of ‘just because’
- Do we retain it or remove it?
  - Options
    - Mechanical -140/-150°C – Reliability-BSL4ZNet – Temp resilience on failure? (~2 weeks of LN), almost instant warming of mechanical freezer failure? Heat load generated?
    - Facility Safety upgrade – Unknown costs and problems – Achievable – acceptance of safety??

- Is reticulated liquid nitrogen really compatible with a traditional biocontainment facility?

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Biocontainment and Liquid Nitrogen

- AS1894 – ‘Control of non-flammable cryogenic gasses’
  - “all vents and control valves should relieve to a safe open space.”

- Contemporary biocontainment requirements
  - Air leakage rate compliance (seal-ability)
  - Interlock of supply and exhaust – fan and valve/damper operation
  - Control of pressure in preference to directional flow
  - Backflow protection/prevention

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Resulting actions

- Remove reticulated LN from service in secure area – Hazard Elimination
  - However, we have a similar but not identical provision in a PC2 facility outside of 'secure'.
- 'Rescue' all samples (>800 boxes) from LN vessels and place at -80°C for temporary storage
  - Ongoing -80°C hold since end November 2018
- Identify and procure mechanical -150°C freezers
  - 6 month lead time plus cosmetic and necessary power refurbishment of room

- Currently
  - 3 x -150°C freezers arrived, still waiting on room refurbishment

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Thank you

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