Criticality Safety in Waste Streams

Robert Wilson

2017 NCSD topical meeting

What Value do Criticality Safety Programs add?

- Personnel Protection
  - Our prime focus
  - We attribute a high value to human life
- Mission and Financial Impact
  - Even non fatal criticality accidents will significantly effect our facility
  - 1978 Idaho accident shut down plant for some two years (mission loss) and cost a large part of a billion dollars

Typical issues with handling waste

- How does use of “expert knowledge” effect the safety basis?
  - D&D of cell in Idaho
  - Array of 4 liter bottles in Rocky Flats glovebox
- What do we know about the waste received form others?
  - Containers from Rocky Flats in Idaho
  - Pathfinder Fuel bundles in storage
  - Idaho 1978 accident

Story 1
Expert Knowledge in Accountability
Idaho example

- A process campaign at the Idaho Chemical Plant ended and an apparent discrepancy was noted between input and output uranium mass values.
- The plant stopped until problem resolved.
- Weeks spent re-assessing the measurement data.
- Several statisticians determined the deviation was within measurement error and we could proceed with operations.

Uranium solution in D&D operation

- Years later an unused and isolated cell was being prepared for demolition. Liquid samples taken from cell's large tanks.
- Laboratory results showed a uranium concentration about 10 g/l, (reported to me at 2:00 AM)
- I noted that the cell had not been used for decades and foolishly requested an additional sample;
- Called Operations superintendent and asked why samples were been taken in D cell.
- Superintendent did not know of activity
  - not on plan of the day.

Response

- Got second call (4 AM) with second U laboratory concentration-12 g/l.
- Criticality Safety status was unknown and unanalyzed (uranyl nitrate subcritical limit is 11.8 g U/l)
- Requested team get out of D cell and inform shift super.

Investigation

- Large tanks in D cell had been used to process and store desirable radioisotopes – task became obsolete
- All lines accessing the cell were caped.
- The operating corridor control panel for the cell in was not maintained, looked bad and was removed to make the corridor more presentable.
- During a maintenance upgrade later a temporary transfer line was installed through the cell.
- The uranium discounted previously had found a path into the isolated cell.

Accountability

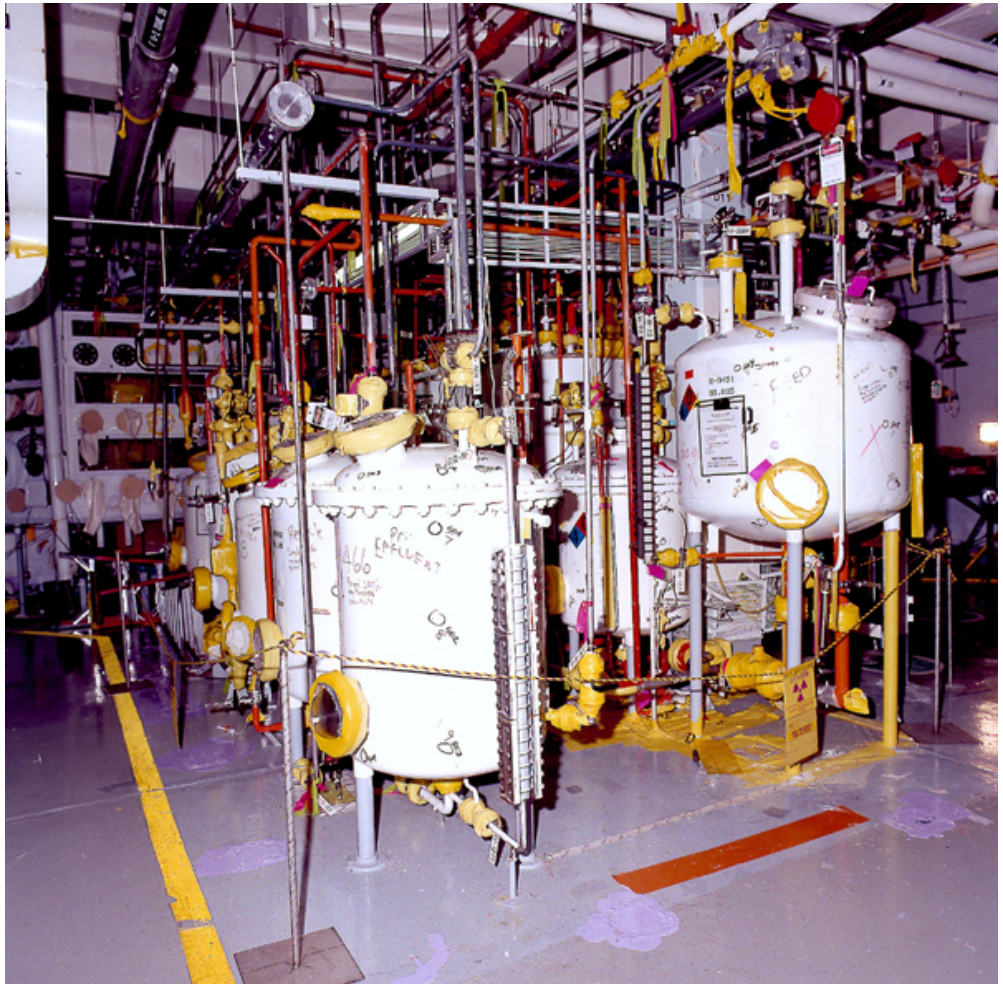
- Accountability controls are oft concerned with deviations of large numbers.

  NCS concerned with smaller amounts on large places.
- Accountability concerns not the same as NCS concerns
- Response measures to lessen dependence on expert knowledge
  - Sending and receipt volume logs
  - Expand operational monitoring during maintenance
- The basis for expert judgement of other groups needs to be understood by NCS groups

Story 2
Operator Expert Knowledge
Rocky Flats example

- Plant had been a Pu metal parts production plant, but mission abruptly changed to Pu material removal in preparation for D&D.
- Rapid change; same people, practices, and controls.
- High concentration Pu solution, now considered waste, was stored in various safe tanks and pipes in facility 771.
- To avoid newly imposed fines, this waste needed to removed from tanks and lines and disposed of.
- Plans were made to drain the 771 vessels and lines into 4 liter bottles, which would be dealt with elsewhere.

Tanks in Building 771



Culture at Plant

- Worrisome issues
  - Immature work authorization systems
  - Many CONOPS events
  - Wide perception that a criticality event was not credible with “waste”
  - NCS staff were line operation support without oversight role
- Communicate worry
  - NCS leadership sent several memos and letters to senior management warning of issues that increased the risk of a criticality accident
  - Senior management, however, was not impressed

Incident

- Three tanks were drained using a Task Information Package (TIP 5) in early summer, 1994
- A late summer tank draining operation, using TIP 5, filled 55 bottles from another tank (Tuesday, September 27)
- Following the evolution, one operator, proceeded to line up values and drained another tank, based on “process knowledge” that the process would also work there. He knew from experience the tank content.
- Operator collected 4 bottles of a solution unexpectedly more viscous and darker.

Initial Response

- As the second tank solution, by appearance, was clearly not from the first tank, the solution was dispersed to other bottles, diluted with water, and then surrounded in an array by the other lighter color bottles.
- Several levels of management participated in this response but one sent a sample from a darker bottle for analysis.
- As the sample results exceeded the 4 liter bottle Pu concentration limit, other management layers were then contacted, and operations were halted.

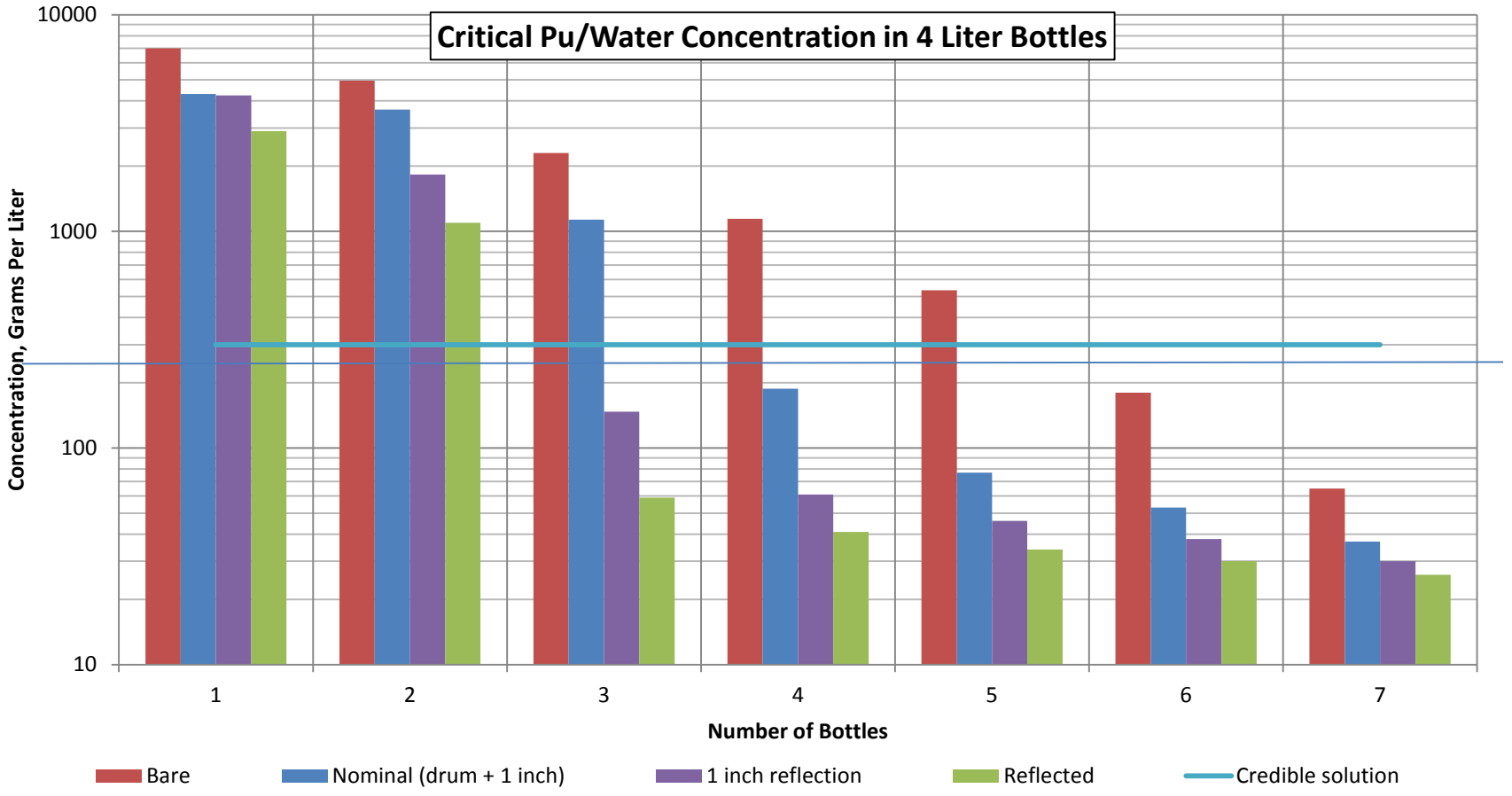
Culture Environment

- Operations were slowed greatly in the building due to ventilation concerns
- Operators were demoralized and frustrated due to the lack of progress
- Operators and line management had the view that “the 4 liter bottles kept the contents safe”.
- Line management and operators tried to cover up the unauthorized operation.

Safety Significance

- If the second tank had drained more of the same liquid, 6 or 7 bottles could be critical in an array
- 3 four liter bottles are usually subcritical and 4 are critical at many concentrations.

Critical Concentration for arrays of 4 liter bottles



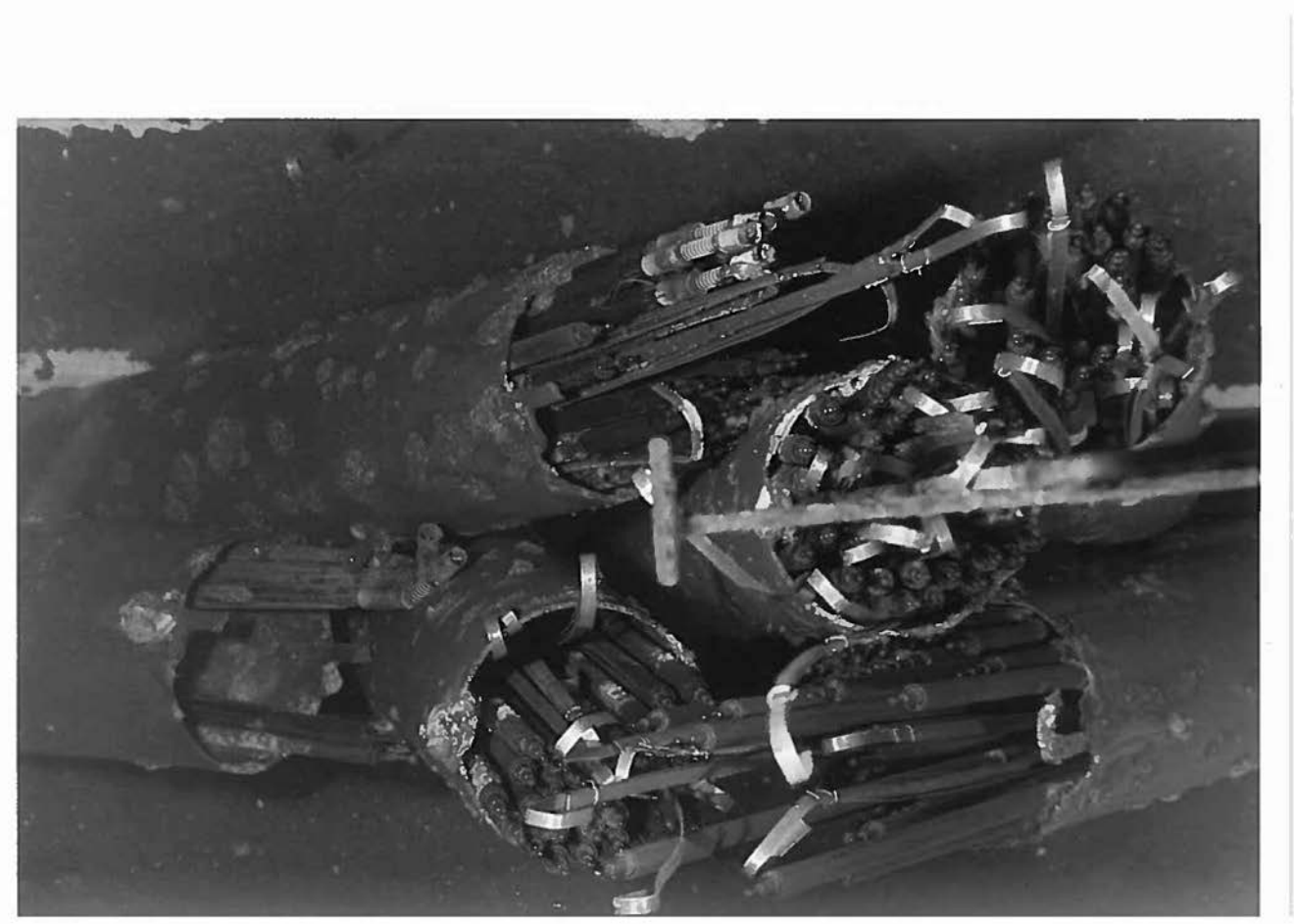
Observations

- The operator initiated the unauthorized draining while alone (TIP 5 required supervision presence during solution movement)
- All involved in the event (operator and two layers of management) had expired criticality safety training
- Operator fired before any investigation started.
- The immature nature of work authorization and control documents as well as the frustrating culture led to “expert knowledge” operator actions at the site.
- “Expert knowledge” is a recurring theme in waste processing

How do we know what we get?
Story 3

- Pathfinder Fuel Bucket Event in Idaho
  - Routine NCS inspection of underwater fuel storage basin noticed seven buckets, normally suspected on a rail two feet apart, jack-strawed on basin floor.
  - Safety basis assumption was a maximum of two in contact

Found Array of Fuel Buckets



As found Condition response

- NCS developed calculations to support recovery.
  - Fuel was cylindrical with a burnable poisoned (B_4C) central core.
  - Calculations, using information from the Fuel Processing Contract, showed an infinite number of fuel elements would not go critical.
- We reasoned that this was unlikely for spent fuel from a reactor.
  - The fuel shipper had not retained records of fuel details-
- Tracked down the chief startup engineer-

  who had fuel details in his basement.

Pathfinder continued

- The reprocessing contract listed the amount of B_4C in the core was substantially more than the reactor startup records .
- 77 of the fuel elements had the poisoned core removed
- The minimum critical number of elements was a fraction of the pile observed.
- Strips of cadmium were hand inserted in each of the buckets and recovery was completed.

- Lessons Learned
  - Shipper's attention to waste stream by does not receive attention paid to product stream.
  - Events determined to be incredible, like seven jack-strawed buckets, periodically happen

NDA measurement
Story 4

- Container sent from Rocky Flats to Idaho
  - Container Manifest labeled fissile content “low”
  - Item Description Code – “odd material”
- Assay needed to enter facility preparing shipments to WIPP
- Assay used Imaging Passive/Active Neutron system (IPAN)
  - IPAN developed to meet requirements for shipment to WIPP

NDA measurement

- In 2006 a Real Time Radiography showed dense content
- IPAN subsequent assay recorded

  3,420 ± 1141 g Pu
- Container did not meet Pu limit for next facility
- The Expert Technical Review process determined that the correct value was

  158 ±26 g Pu
- This meet the NCS limit

  package sent to repackaging facility

NDA measurement

- March 2013: Container distributed into 26 55 gal drums.
- Each daughter drum received NDA measurement
  - Drum 10483042 measured 885 ± 251 g Pu
  - Total of 26 drums measured 978.5 ± 260 g Pu
- More sophisticated review of original NDA data determined 1430 ± 430 g Pu

NDA measurement

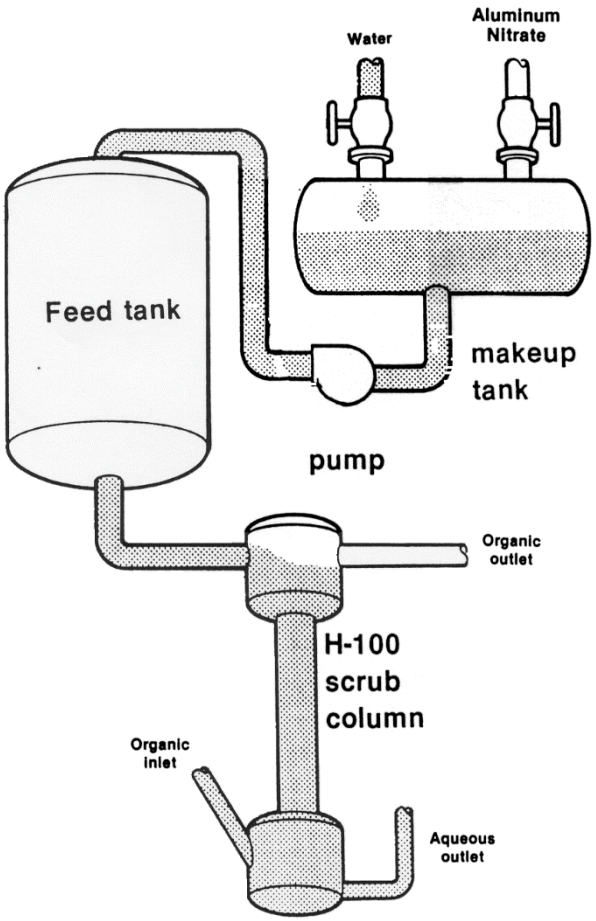
- The safety analysis had covered the 2013 Pu mass measurement and even the more sophisticated interpretation of the 2006 data.
- Lessons learned
  - Expert judgement is not always correct and needs to be managed
  - Expectations based on shippers manifest can effect judgements

Drum 10483042

1978 Idaho Accident
Story 5

- Primary causes
  - Hazard assessment incomplete
  - Control Implementation flawed
    - Correct operational procedures not used.
    - Measurement device inoperative.
    - Plant controlled drawings incorrect.
    - Operators did not notice or respond to abnormalities.

1978 Idaho Accident



Precipitating Cause

- Why the month delay which allowed so much scrub dilution?
  - Fuel element dissolution and first cycle extraction run in sequence
  - Fuel element misidentified, inserted in dissolver, did not dissolve
  - Took weeks to fish it out and continue campaign.
- Sensitivity to fuel element identification not adequate

Conclusions

- A heathy suspicion of shippers understanding of what is in waste they sent elsewhere is appropriate
- Systems to lessen the temptation of “expert judgement” are needed as are defense in depth measures to perhaps manage the risk

  (a back up safety net)