Decontamination and Dismantling (D&D) of Explosive Contaminated Process Piping in High Explosive Load Lines

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Problem

- Gradient Technology has had to D&D three facilities containing hazardous material piping
  - Piping contaminated with hazardous materials is common throughout facilities
    - Explosive contaminated process piping, vacuum lines, drain lines, steam lines, etc.
    - Flammable solids, liquids, and gases in piping
    - Compressed liquids and gases
  - Identification of the extent of contamination may be difficult in older buildings

Quick!
Which Pipes Are Contaminated?

Photo: Gradient Technology

Issues

- Contamination can be on the interior, exterior, or both
  - Example: Huddersfield (UK) fire from external explosive contamination on steam line
- Information on pipe contamination may be limited (or even wrong) due to age or lack of adequate recordkeeping
  - Especially true in research and development (R&D) areas

Project Goals

- The three projects all had common goals
  1. Minimize overall risk to the maximum extent possible
  2. Minimize the number and exposure of personnel on the project to the maximum extent possible
  3. No significant damage to the facility
     - Intended for refurbishment and reuse
  4. Minimize cost and schedule
  5. Minimize environmental release

In-Situ Decontamination

- Hot gas decontamination in-situ
  - Excellent high tech method – best left to experts
- Thermal decontamination by total building incineration ("burn down") is commonly employed, very safe, and very effective
  - Excellent low tech method **IF**:
    - You don't intend to reuse the building
    - You're not going to affect other process lines, etc.
    - Environmental concerns can be adequately addressed

But, …. what if you want to SAVE the BUILDING?

- There are two major approaches to piping systems cleanup without damaging the building
  1. Decontaminate – then dismantle or reuse
     - Standard practice among chemical processing plants with liquid hazardous materials
     - More easily said than done with explosive contamination
       - Contamination can be insidious
       - Chemical / Mechanical decontamination has **high risk** during both decontamination and later dismantling

Sage Advice About Explosives Decontamination

"No amount of flushing can positively remove explosives from pipes such that the pipes no longer present explosion hazards"

– Doyle, C. (1998). *Buildings and Equipment Contaminated with Explosives*, 28th DDESB Seminar. ADA513625

Second Major Approach

2. Dismantle – then decontaminate
   - Somewhat scary to contemplate and the process has risks, but is achievable with a trained crew
     - Hazards Analysis must **ALWAYS** be performed to thoroughly understand the issues and risks associated with the process
     - Full procedures must be developed
   - Standard procedure in some locations:

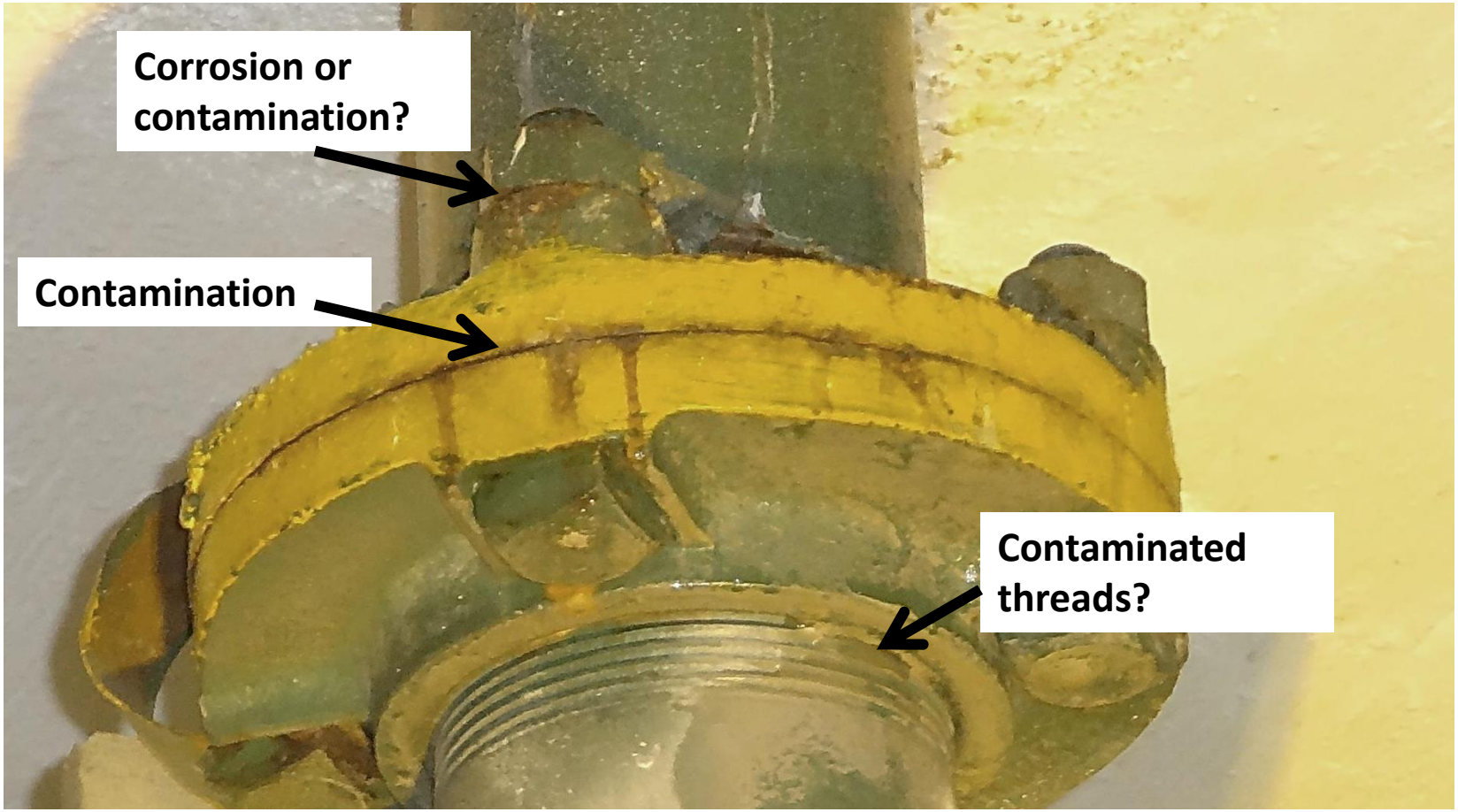
"Vacuum lines should be presumed contaminated and removed for thermal treatment"

Anderson and Ricks "Naval Surface Warfare Center - Indian Head Division's Explosive Decontamination Experience," *29th DDESB Seminar* (2000)

General Techniques for Line Breaking

- It is “possible” to disassemble piping in the same manner as it was assembled
- HOWEVER – **Resist the urge** unless you’re sure
  - Understand the risks and if they are worth it
  - **NEVER** unscrew a contaminated threaded pipe
    - No known way to assure pipe threads are clean
  - Flanged pipes can have trapped spaces, contaminated (asbestos?) gaskets, and contaminated flange bolts
    - Flanges **MUST NOT** bang into or rub against each other

Flanged Pipe Joint



Line Breaking by Cutting

- Often the best approach is to just cut the pipe so it can be removed and decontaminated
  - The Department of Energy (DOE) has had to address this problem since the 1960s with nuclear reactor decommissioning
  - For references see:
    - *Decommissioning Handbook*, U.S. Department of Energy, DOE/EM-0142P (1994)
    - *Decommissioning Handbook - Procedures and Practices for Decommissioning,* DOE/EM-0383
    - *Pipe Cutting and Isolation System*, DOE/EM-0448

Cutting Processes

- DOE lists several methods
  - Thermal (e.g., torch, plasma arc, arc saw, etc.)
    - Not realistic for flammable or explosive contamination
  - Explosive cutting (e.g., linear shaped charge, etc.)
    - Before you laugh, see Doyle, C. (1998). "Buildings and Equipment Contaminated with Explosives," *28th DDESB Seminar*, ADA513625
  - Abrasive cutting (e.g., abrasive saw, angle grinder, diamond wire saw, etc.)
    - Concerns about heat, sparks, and wire snapping energy

Abrasive Saw Operations

Cutting Processes

- Shear Cutting (e.g., hydraulic shears, “Jaws of Life” [Hurst tool])
  - Great for inert pipes up to DN 65 (2.5 NPS) and vehicle rescue
  - Some events have occurred on live munitions
- Displacement Cutters (e.g., “traditional” pipe cutters)
  - Some concern about the point of breakthrough as thin metal gets hot

Cutting Processes

- Rotary pipe lathes
  - Used by DOE extensively; some concern about heat at breakthrough:
    - "Workers can watch the cut and when the metal turns blue it indicates that the metal is very thin and thermally hot. Break-thru is about to occur" – *DOE Decommissioning HDBK* (1994)

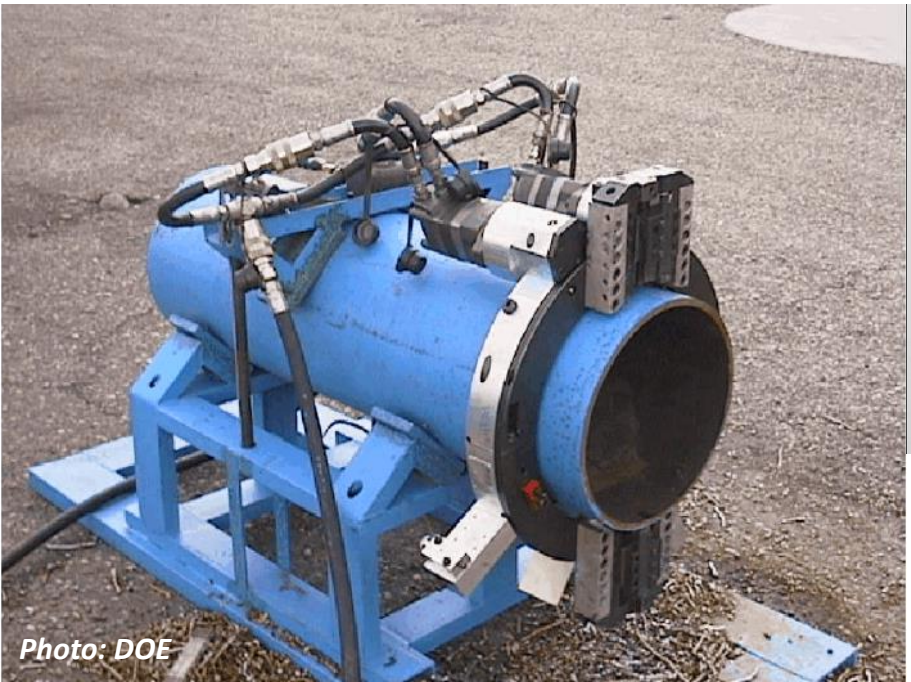


Photo: DOE

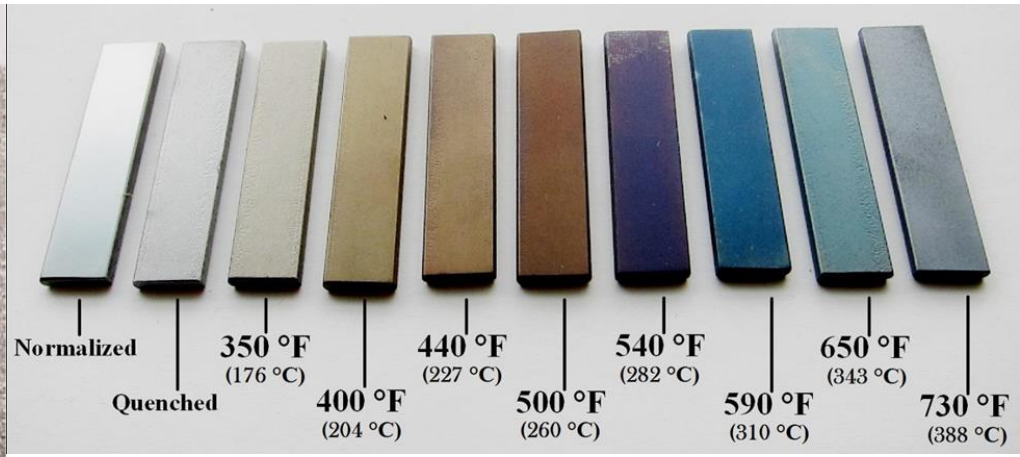


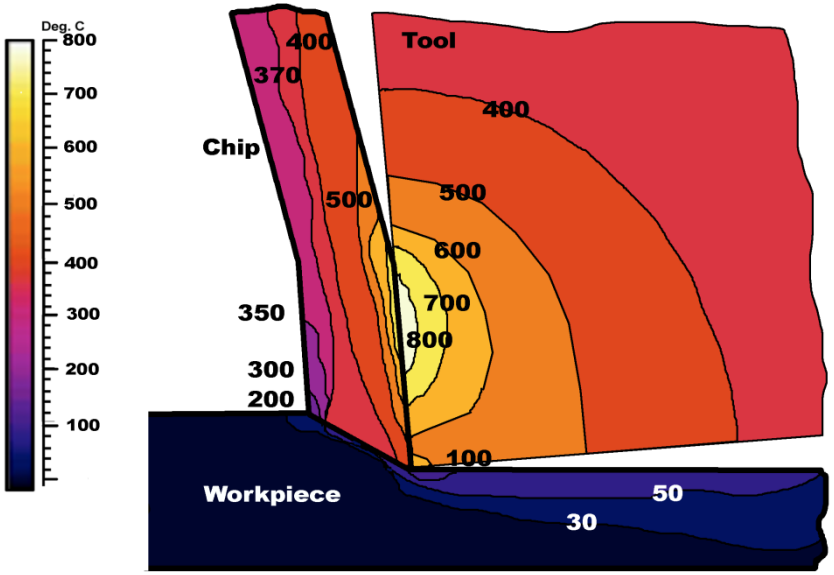
Photo: Wikipedia

Cutting Processes

– Mechanical Cutting

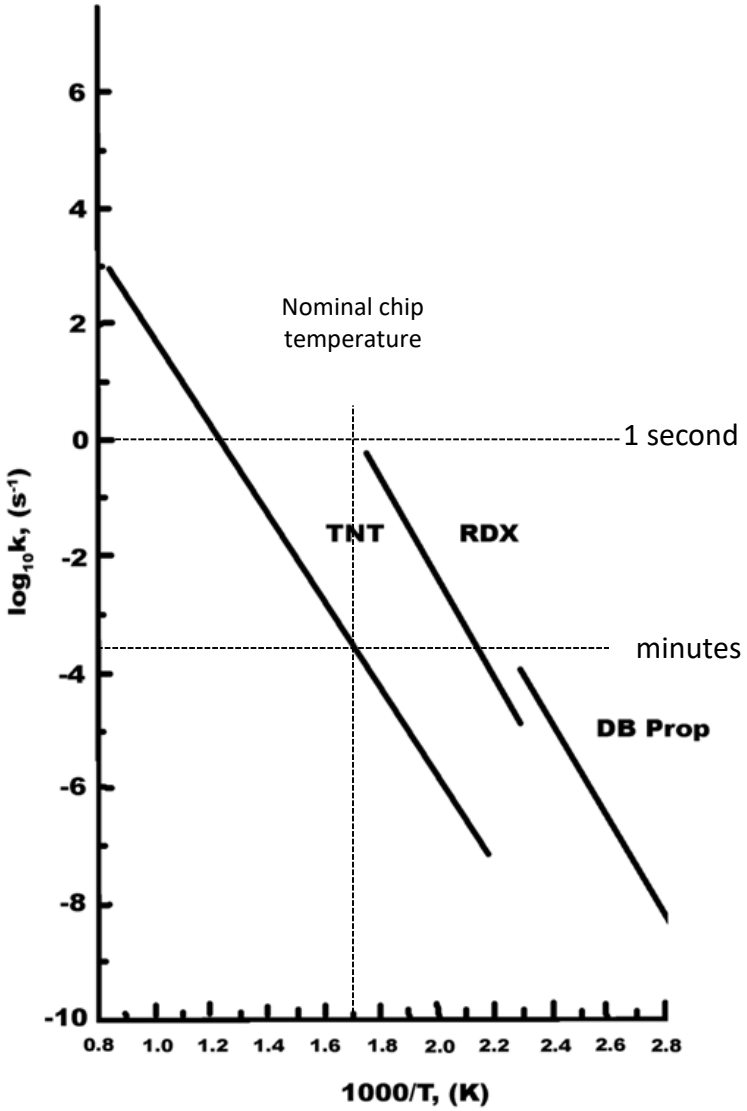
- Toothed cutters are by far the most common in industry; e.g., chop saws, hacksaws, and bandsaws
- Can be effective with certain explosives if the heat can be controlled with coolant – do the hazards analysis!

Portable bandsaw cutting DN 25 (1-in NPS) stainless steel pipe



Adapted from: Shaw (2005)

Temperature vs. Time



It all gets down to "how much risk are you comfortable with?"

Process might be safe for TNT, but not for RDX based materials

Source: Kondrikov, B. N. and E. I. Alyoshkina (2002). "Thermal Decomposition of Nitrocompounds in a Broad Range of Temperatures and Pressures," *Proceedings of the Twelfth International Detonation Symposium*.

Abrasive Waterjets (AWJ)

- Internal hazard analyses favored using AWJs for cutting the piping due to high risk cutting RDX
  - PROs
    - Well established technology (since 1980s)
    - Demonstrated high safety for use around flammable materials and secondary high explosives
      - Independently vetted by DOE for flammable environments
    - Remotely operated
    - Cuts through all metals without jamming
  - CONs
    - Messy, uses consumables
    - Jet follow through can cut up to a meter away
    - Loud
    - Requires training to use properly

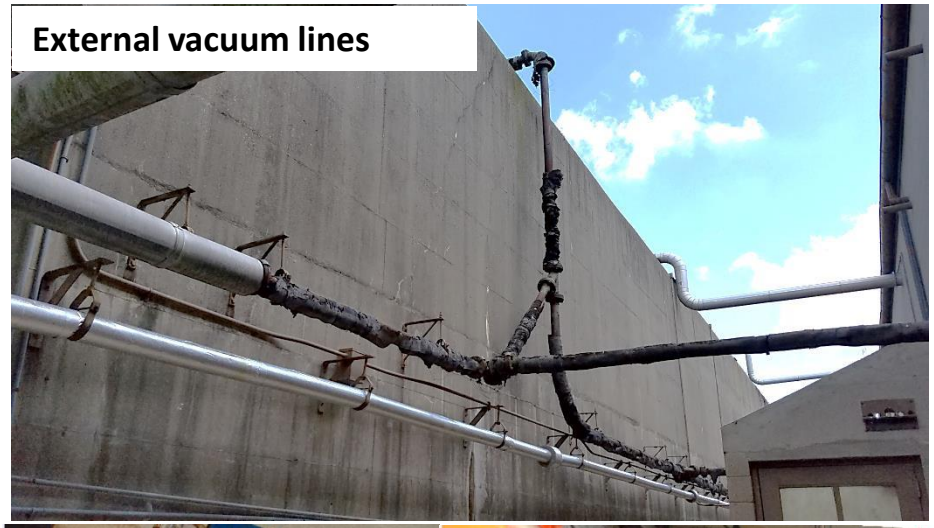
AWJ Parameters

- Operated at 380 MPa (55ksi) using 3.8 l/min water and 1 kg/min of garnet abrasive
  - Garnet abrasive was used as it had no free silica and was not piezoelectric
  - Waste water, garnet, and swarf was captured using plastic sheeting and vacuumed up afterwards
- Cutting standoff distance was up to 15 cm (6 in) allowing free clearance around obstructions
  - Sacrificial shielding was used to stop or deflect jet follow through

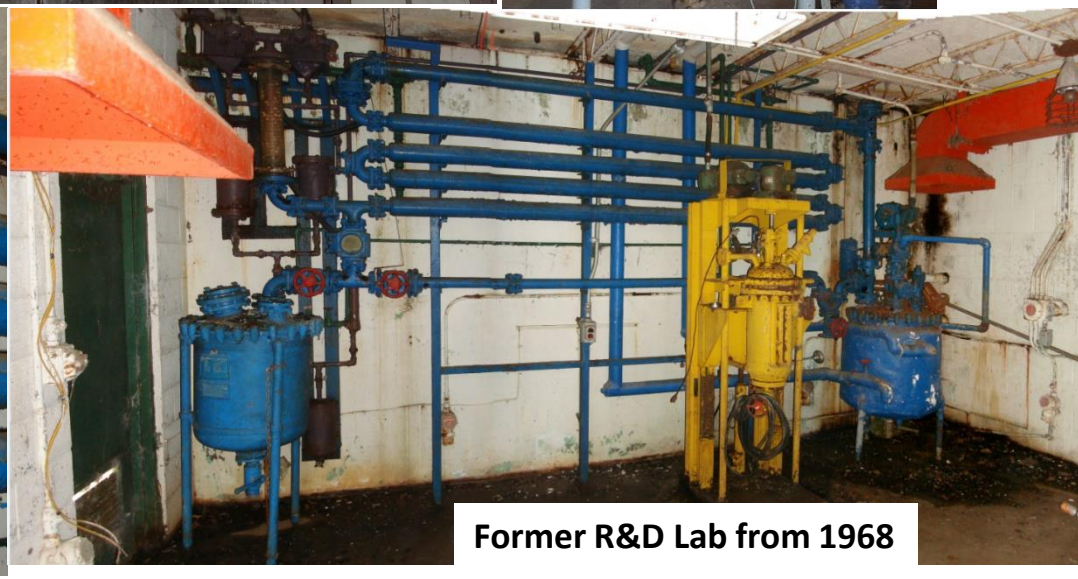
Jet Follow Through and Deflector

Pre-Op Inspection

External vacuum lines



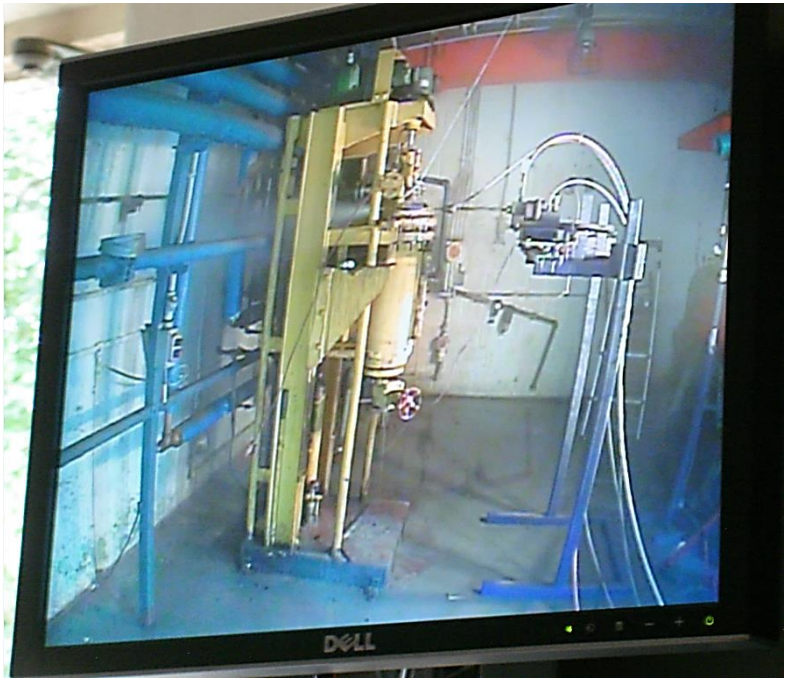
Vacuum dust collector



Former R&D Lab from 1968

Remotely Operated

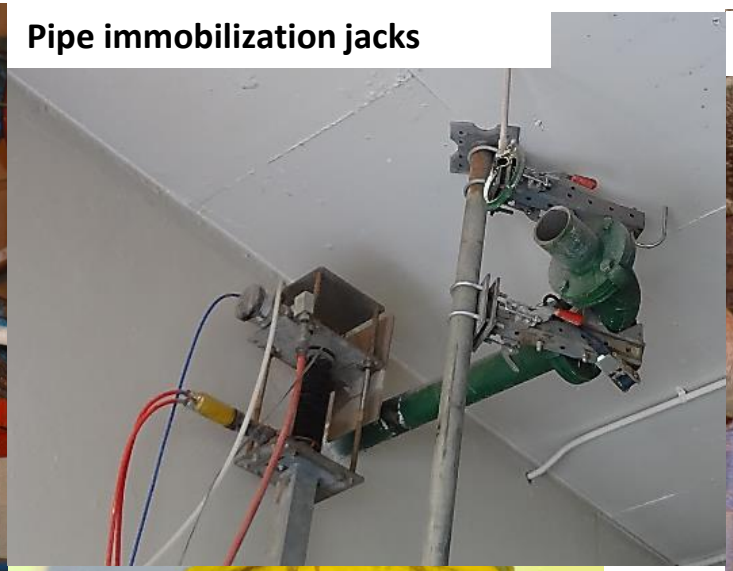
- The system was remotely operated and monitored using fiberoptic cable
  - Minimizes operational risk
  - Max range ~2 km



Some of the 500+ cuts

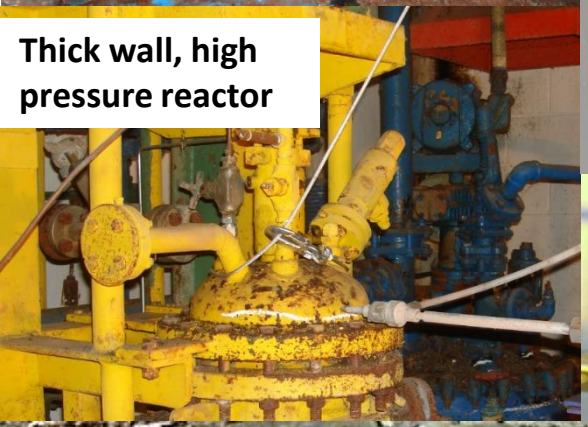
Glass-lined reactor

Pipe immobilization jacks



Cutting concentric pipes

Thick wall, high pressure reactor

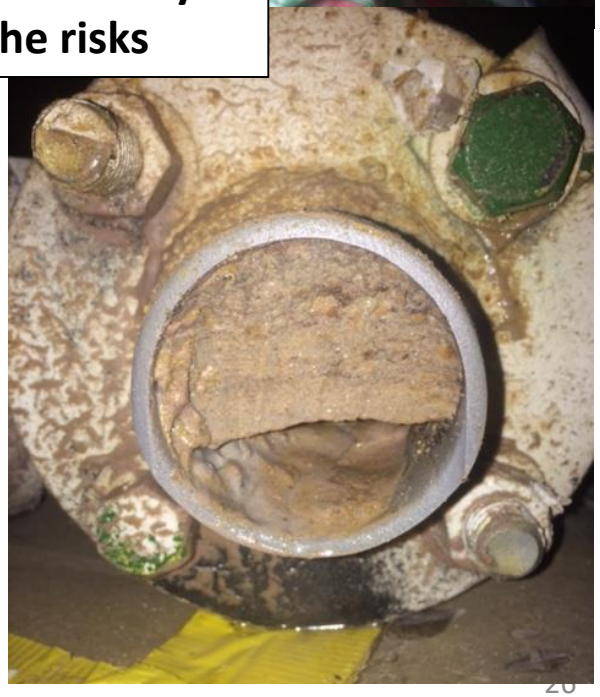


Just another hazard waiting to bite you …

Post-Cut Bone Piles

Were We Too Cautious?

No, I think we correctly identified the risks



Bob Ross Was Wrong!

As seen in the *Chuck Wagon* restaurant outside of Redstone Arsenal