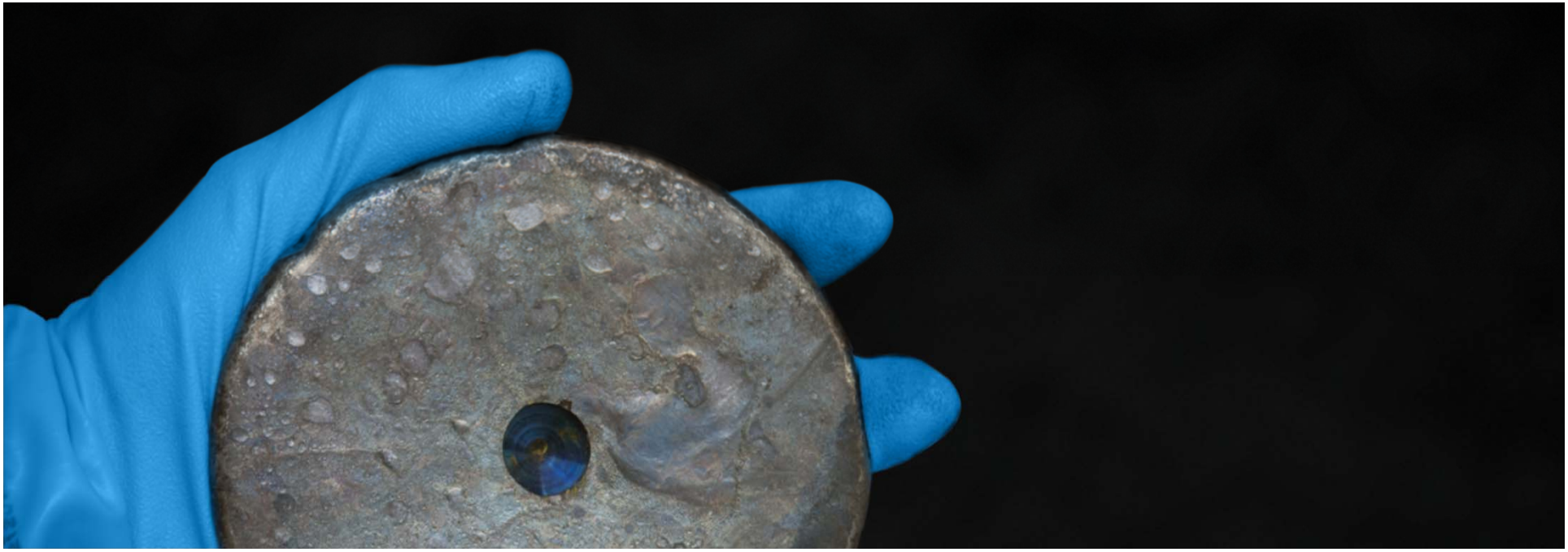


CNS | consolidated nuclear security, llc
PANTEX PLANT | Y-12 NATIONAL SECURITY COMPLEX

PG to Glycerin – Lessons Learned

Jake Greenwell
jacob.greenwell@cns.doe.gov
Y-12 Fire Protection Program Lead, Fire Protection Engineering

Y-12's AFLs

- Y-12 has 48 Antifreeze Loop (AFL) systems – typically covering docks, sheds, penthouses, etc.
- 1 Safety-Significant AFL
- 10 others fed by SC/SS Wet Pipe System (WPS)
- Antifreeze solution recently changed from 50% Propylene Glycol to 48% Glycerin…

50% Propylene Glycol

- Y-12 has been using 50% solution of Propylene Glycol for the past 30+ years.
- Y-12 has not experienced any antifreeze system breaks due to freeze up in at least the past 15 years when using 50% PG. Even through the polar vortex of 2013/2014 winter.
- The 50% PG would typically test in the -30's to -40's ^{0}F.

Why the Change?

Mandated by NFPA

- Aug 2009: Incident caused by improper design/maintenance
  - 1 killed and 4 injured.
  - Solution was found to be 71.2% concentrate
- Aug 2010: NFPA Issues Safety Alert and TIAs
  - Guidance limited to new installations in residences
  - *Life safety concern – not a system operability issue*
- March 2011: NFPA Updates TIAs
  - Guidance now includes commercial application and is made retroactive to include existing systems
  - Proposal to exclude unoccupied spaces fails by one vote

The Incident

- **The following information was obtained from the Fire and Explosion Investigation Report by Stephen Hart, Consultant dated September 17, 2009.**
- **The incident occurred on August 18, 2009 at the Henness Flats Apartments located in Truckee, CA**
- **The apartment was occupied by 5 individuals; husband and wife and three small children.**
- **The father was frying onions on an electric stove when a grease fire started. He turned 180 degrees to the sink with the flaming frying pan.**
  - This report did not specifically state water was placed on the grease fire, I have read other articles that state water was placed on the fire.
- **The sprinkler directly over him activated and a violent explosion resulted.**

Explosion and Injuries

- The blast caused window glass to be blown more than 86-feet across the adjacent parking area of the complex.
- The force of the blast caused an interior door frame and attached door to an adjacent bathroom to be pulled out approximately 3-inches from the frame.
- Eight (8) out of the ten (10) sprinklers within the unit activated from the fire and explosion.
- All five occupants received burn injuries from the blast.
- The mother died from her injuries, shortly after being airlifted.
- The husband/father was burned over 40-45% of his body.
- Three small children were treated and released that evening.

Similar Case

- Occurred October 28, 2001 at the Windandsea Restaurant in Highlands, NJ.
- Three story wood structure, the second and third story were provided with Propylene Glycol filled antifreeze system.
- 155^0F sidewall sprinklers were installed adjacent to multiple 25,000 BTU ceiling mounted heaters.
- Witnesses working or eating stated hearing a pop sound and a sprinkler activated and then saw a liquid spraying down from above. Followed by a fireball developing at the ceiling in the area where a ceiling mounted heater was located.
- 18 injuries were recorded from this incident.

Further Information

- One incident was with PG (NJ) and one with Glycerin (CA). However, both had concentrations greater than 60%.
- CA apartment fire was filled with in excess of 70% glycerin.
- Both incidents had a fire and explosion.
- Both incidents resulted in multiple injuries.
- Damage from the actual flash grease fire was minimal.
- Therefore, damage from both incidents would have been minimal with probably no or only minor injuries with a wet pipe system.

What to do for Existing Systems?

PG	Glycerin	
< 30% 30% FP = +9^{0}F = Unusable	< 38%	Safe. No change.
30% - 40% 40% FP = -6^{0}F = Unusable	38% - 50% 48% FP = -16^{0}F = Usable	Perform a deterministic risk assessment. DRA determines if solution is safe to use in that area.
> 40%	> 50%	Drain. Refill with listed solution* or employ alternative methods** * "no listed solutions currently exist" – NFPA ** dry-pipe system, heat the area, etc.

Note: NFPA TIA also requires solutions to be factory pre-mixed

Y-12's Change

- **July 2013: Letter from Contractor, stating we propose to change from PG to Glycerin in order to satisfy the life safety concern.**
  - Not contractually required (newer edition NFPA 25)
  - Not required by NFPA 25 until 2022
- **August 2013: Letter from Field Office, "Approve the Change."**
- **Spring/Summer of 2014: 45 of the 48 systems swapped PG for 48% pre-mixed glycerin**
- **Afterward: We pat ourselves on the back for being safety-minded and at the forefront of change.**

What Happened?

- **Nov 19, 2014: Fire Department responded to a water flow alarm.**
  - Found an antifreeze system had frozen.
  - 2 sprinklers had damage
  - No piping was found to be damaged
- **Temp low that day was 18^0F**
- **A limited number of antifreeze systems were tested to see if we had a site wide issue.**
- **Results suggested there was site wide issue.**

Immediate Term Actions

1. **Establish interim guidance to address impending freeze conditions**
   - < 0^0F = “pass”
   - >0^0F = isolate the system, replace solution if possible, drain the solution if possible, and implement appropriate compensatory measures
2. **Test the 45 systems which have been converted to Glycerin**
   - 14 Tested acceptable <-10^0F
   - 31 tested unacceptable per procedure >-10^0F
   - 18 tested >0^0F
     - 29 drained and refilled
     - 2 in heated area (no action)

Why the Dilution?

- System not fully pressurized when filling? (tooling issue)
- Not fully vented due to configuration?
- Forward-flow test of the backflow preventer impacting solution?
- Water migration through the backflow preventer?
- Solution deteriorating/solution separating?
- Manufacturer not mixing AFL thoroughly?
- Others?

What to do now?

- **Dedicated a FPE to look into the issue.**
  - Review procedures
    - Any steps that should be added or deleted?
  - Review field work
    - Are there any steps that are allowing water intrusion?
  - Review system designs
    - Are the systems designed correctly?
  - Speak with manufacturers of solution
    - Anyone else having similar issues?
  - Reach out to other DOE sites as well as local jurisdictions
  - Interview maintenance staff
    - Are they aware of any issues that could be creating this problem
  - Review if any systems can be eliminated

Pump Questions

- **Looked into the pump that is pressurizing the system**
  - Deadheaded at approximately 40 psi
  - No gauge on the pump
  - Average System pressure is approximately 80 psi
  - This left us with a delta of approximately 40 psi between our supply side and antifreeze loop.
  - Was water entering the AFL to equalize the pressure difference?

- **New pumps**
  - Purchased new pumps with gauges that can pump in excess of 120 psi.

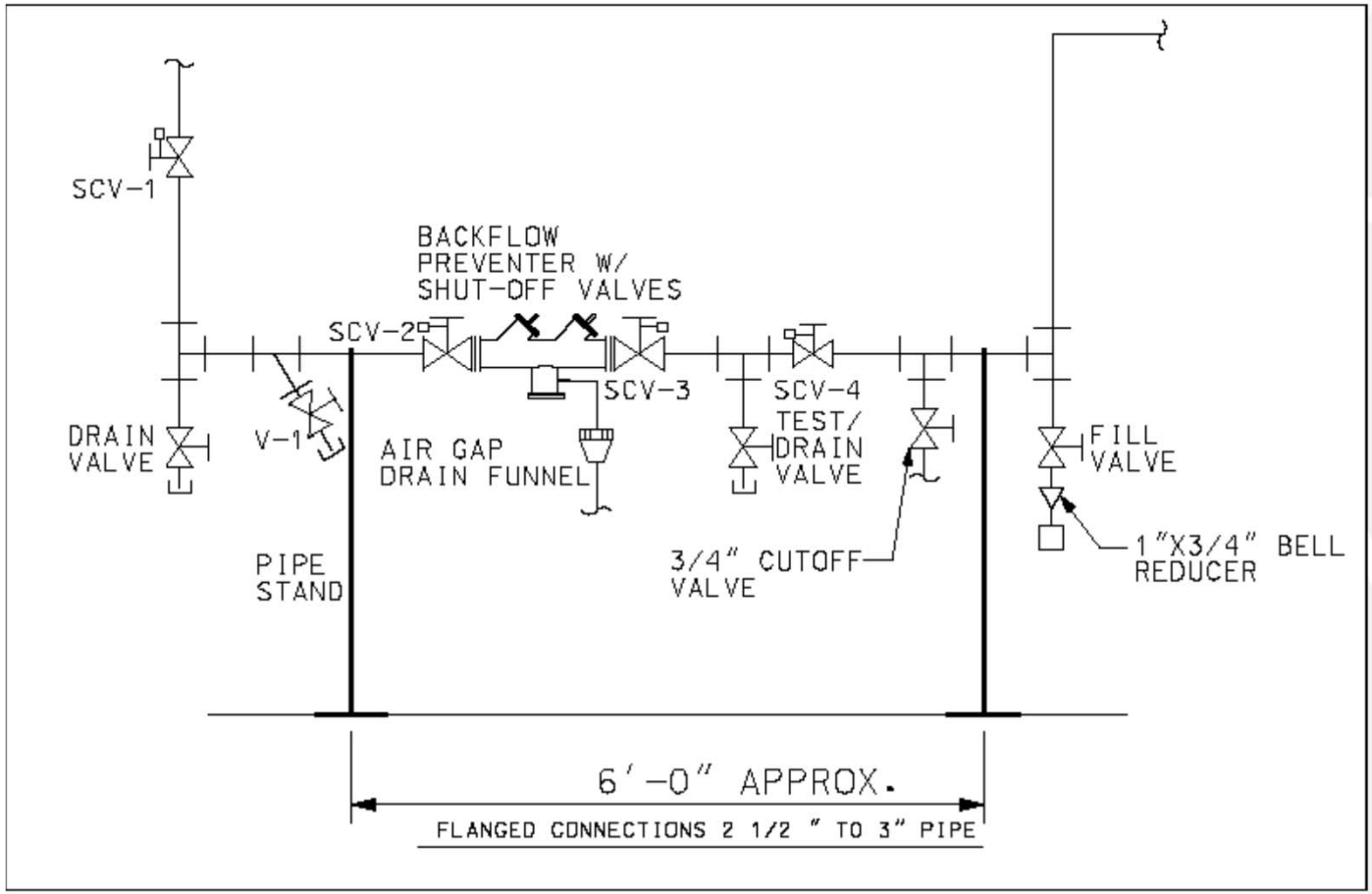
System Design

- **Systems had limited high-point vents**
  - Some systems were only provided with one high-point vent
  - Systems had multiple branch lines with no venting
  - How many air pockets existed?
- **Location of high-point vents**
  - Most high-point vents required scaffolding or are located in hard to reach places.
- **How much solution?**
  - There was no data of the volume of the system
  - How much solution needed to be added?
  - This was mainly guess work and it appears some systems were under filled due to trapped air in the system.

Forward-Flow of Backflow Preventer

- **NFPA 25 requires annual forward-flow testing of the backflow preventer.**
- **Configuration of the system**
  - Majority of our BFP are located between the WPS and AFL
  - Water is introduced to the antifreeze system during testing
- **Timing of the test**
  - Most of the testing took place after the new solution was added to the system
- **Volume of the System**
  - Most of our antifreeze systems are small systems

Typical Backflow Preventer Configuration



Procedure Review

- A detailed review of the procedures, including in the field reviews were conducted.
- Emphasis was placed on operation of valves when adding new solution.
- Similar to the backflow preventer forward flow test, opportunities for water to enter the system based upon the valve sequence were identified.
- Other procedural items were reviewed and changes are being incorporated.

Water Migration

- **Surge Problems**
  - Y-12 has a number of water surges
  - Would a surge allow water to enter the AFL?
- **Trapped Air**
  - Were the air pockets within the system allowing water to enter?
- **Other Causes?**
  - What else could be allowing water migration?

Issues with the Solution?

- **Is the solution deteriorating?**
  - The solution from the barrel was being tested every time before use.
  - Solution was consistently testing at -16^{0}F
- **Is the solution separating?**
  - Again the solution was consistently testing at -16^{0}F in the barrels even after sitting for months.
  - Spoke with manufacturers and all stated they have not heard of any issues
- **Is the solution mixed properly?**
  - Two manufacturers contradicted on how the solution is mixed.
  - One stated the glycerin and water mixture will not come out of solution and it requires a large amount of agitation to create the solution
  - Other stated it takes very little agitation for water and the glycerin to mix

Temporary Success

- No other freeze issues experienced.
- Y-12 ended up having a low temperature of 0 degrees, with below freezing conditions for 2+ days.

Further Work

1. **Answer the questions,**
   - "For how long is this data applicable?"
   - "What are we now compelled to do?"
2. **Implement procedural and further tooling fixes**
3. **System specific evaluation**
   - System still necessary or can it be eliminated?
   - System configuration fixes
   - Convert to dry-pipe/wet-pipe when cost effective to do so
   - Explore use of dry-type sidewall heads
4. **Test more frequently until we are satisfied that fixes have worked**
5. **If all else fails, revisit the NFPA guidance and determine if it is right for the plant.**

Questions?