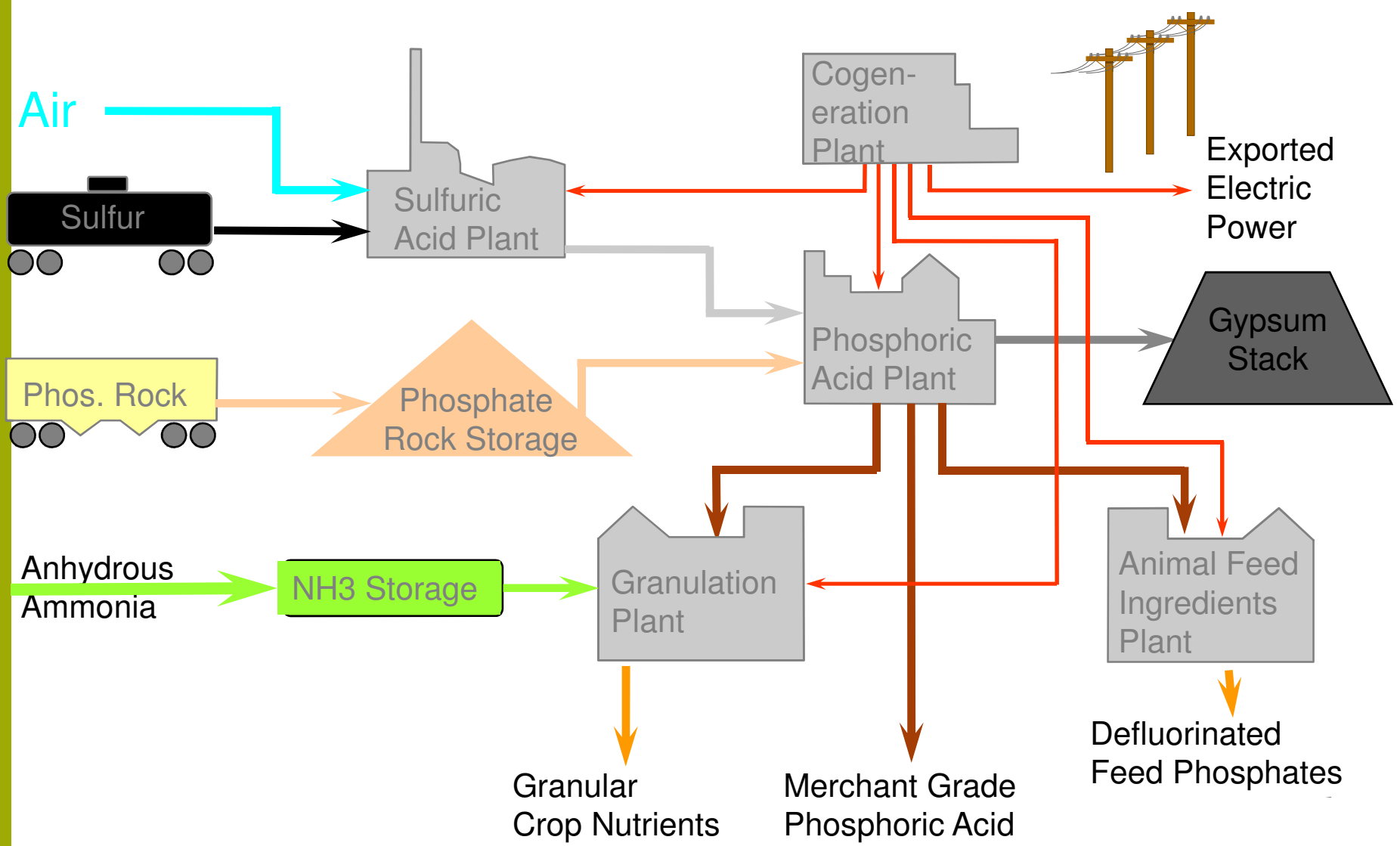
Hydrogen Safety In the Sulphuric Acid Industry

7-10 November 2011, Houston, Texas
SULPHUR 2011 Sulphur | Sulphuric Acid

Hydrogen Safety Concerns In the Sulphuric Acid Industry

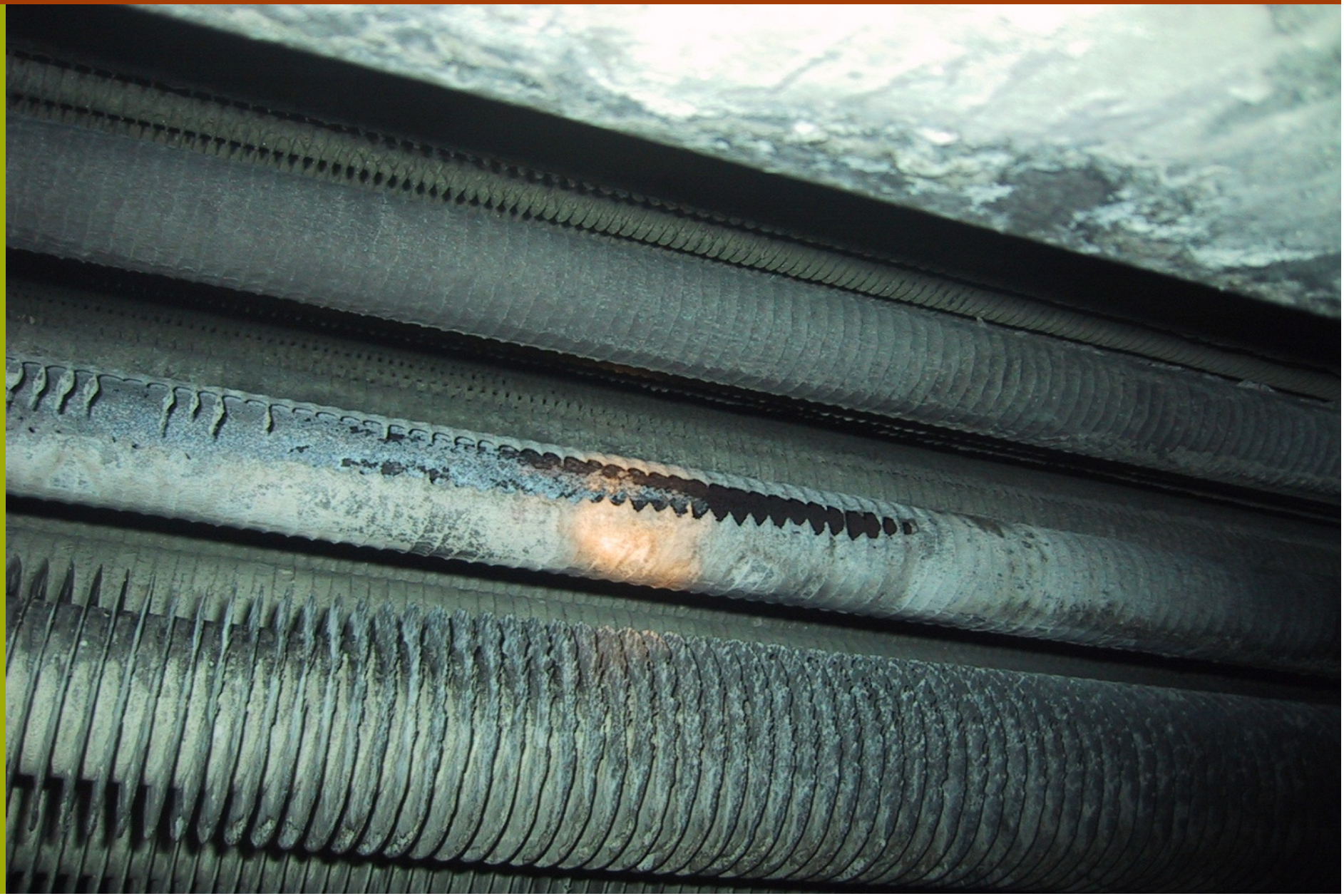
"What we didn't know we didn't know"

Simplified Manufacturing Diagram

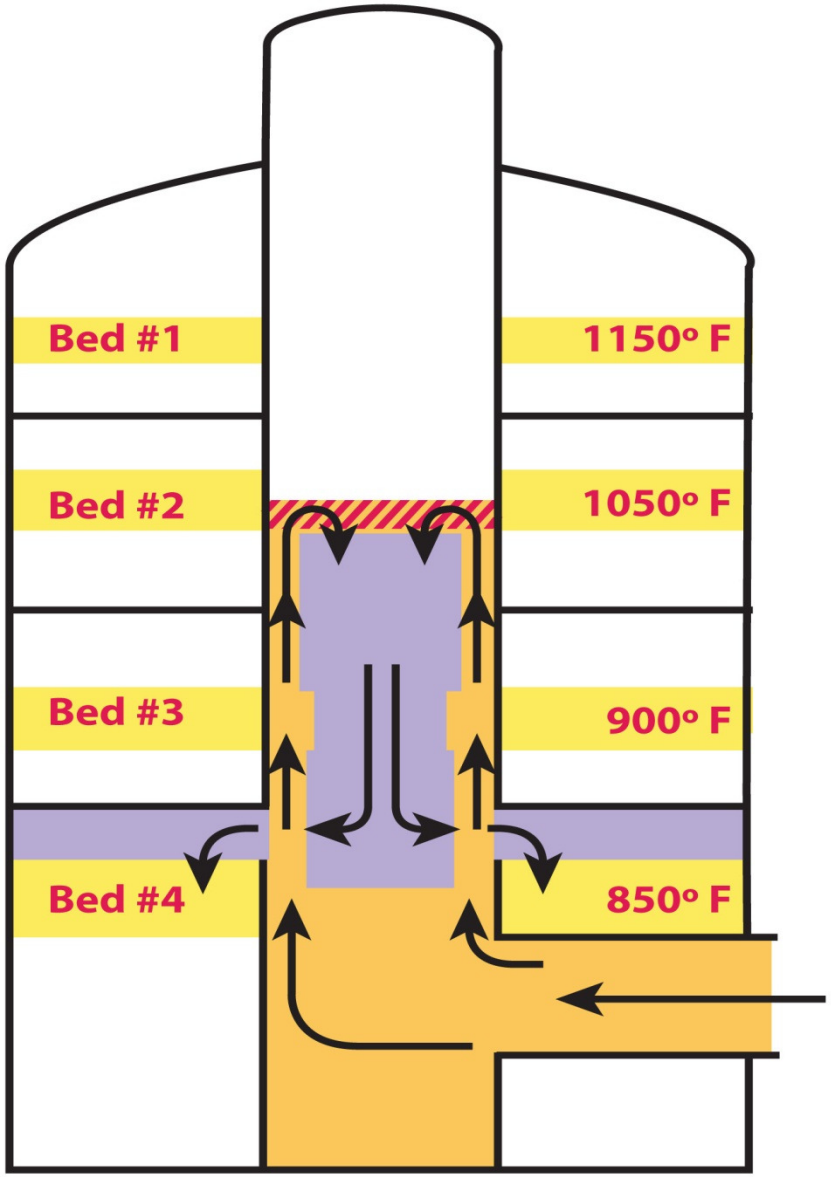


First Hydrogen Event - Waste Heat Boiler Leak

First Event / Secondary Failure – Economizer Tube



Hydrogen Concentration Build-up



First Failure – First Indication

First Failure – Radial Flow Converter Damage

First Failure – Converter Damage

First Failure – Converter Damage

Hydrogen Safety Concerns – First Failure

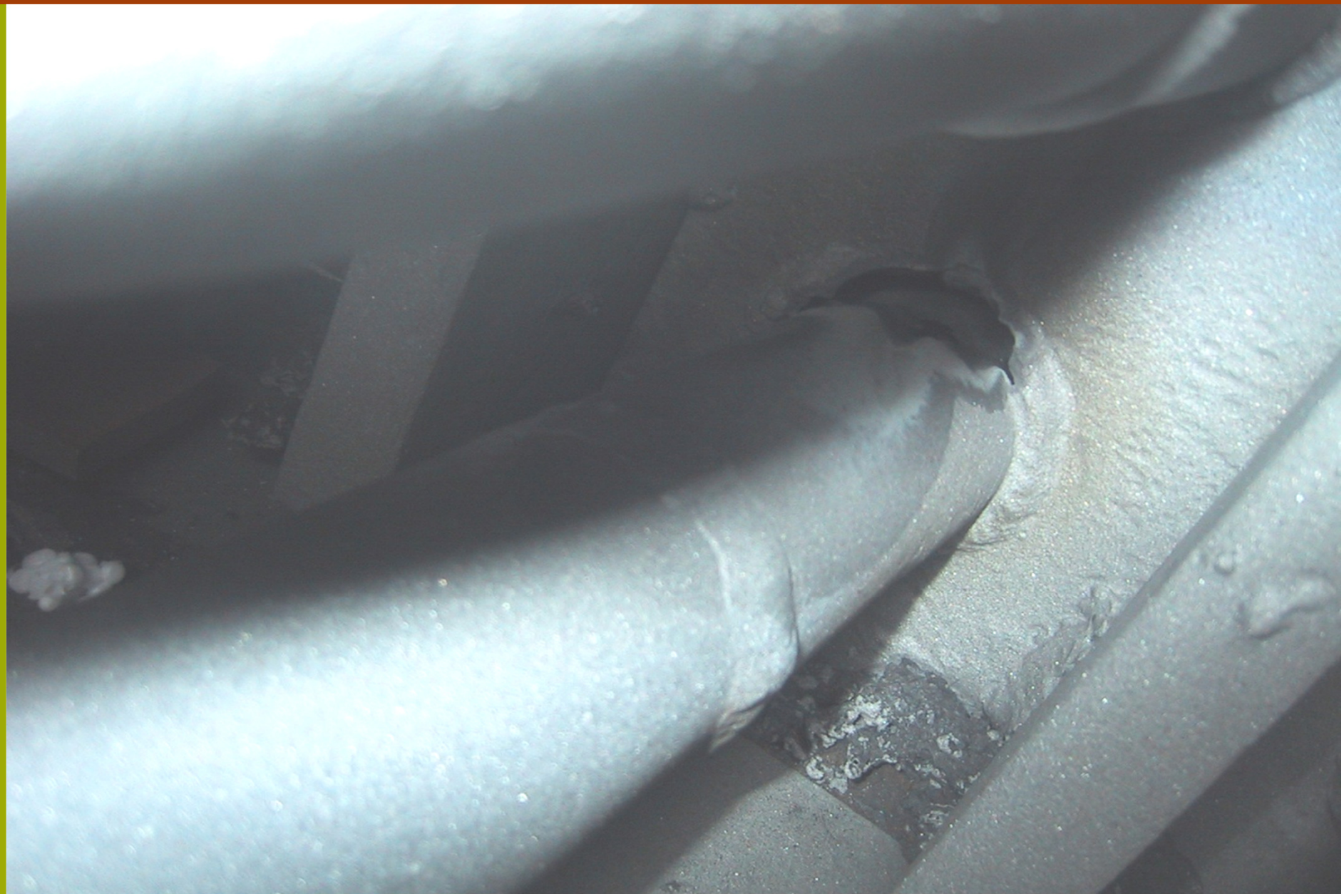
Hydrogen Safety Concerns – First Failure

Hydrogen Safety Concerns – First Failure

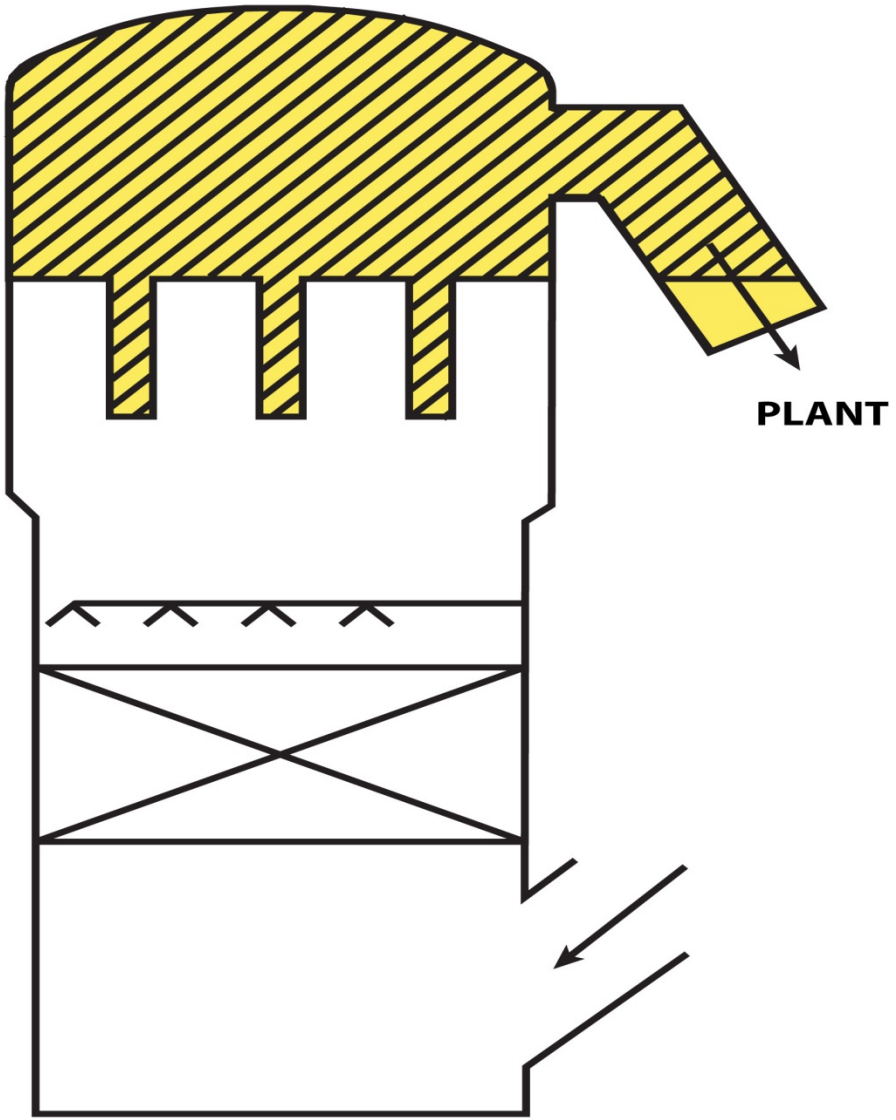
Hydrogen Safety Concerns – First Failure

Hydrogen Safety Concerns – Second Failure

Hydrogen Safety Concerns – Second Failure



Hydrogen Concentration Build-up



Hydrogen Safety Concerns – Second Failure

Hydrogen Safety Concerns – Second Failure

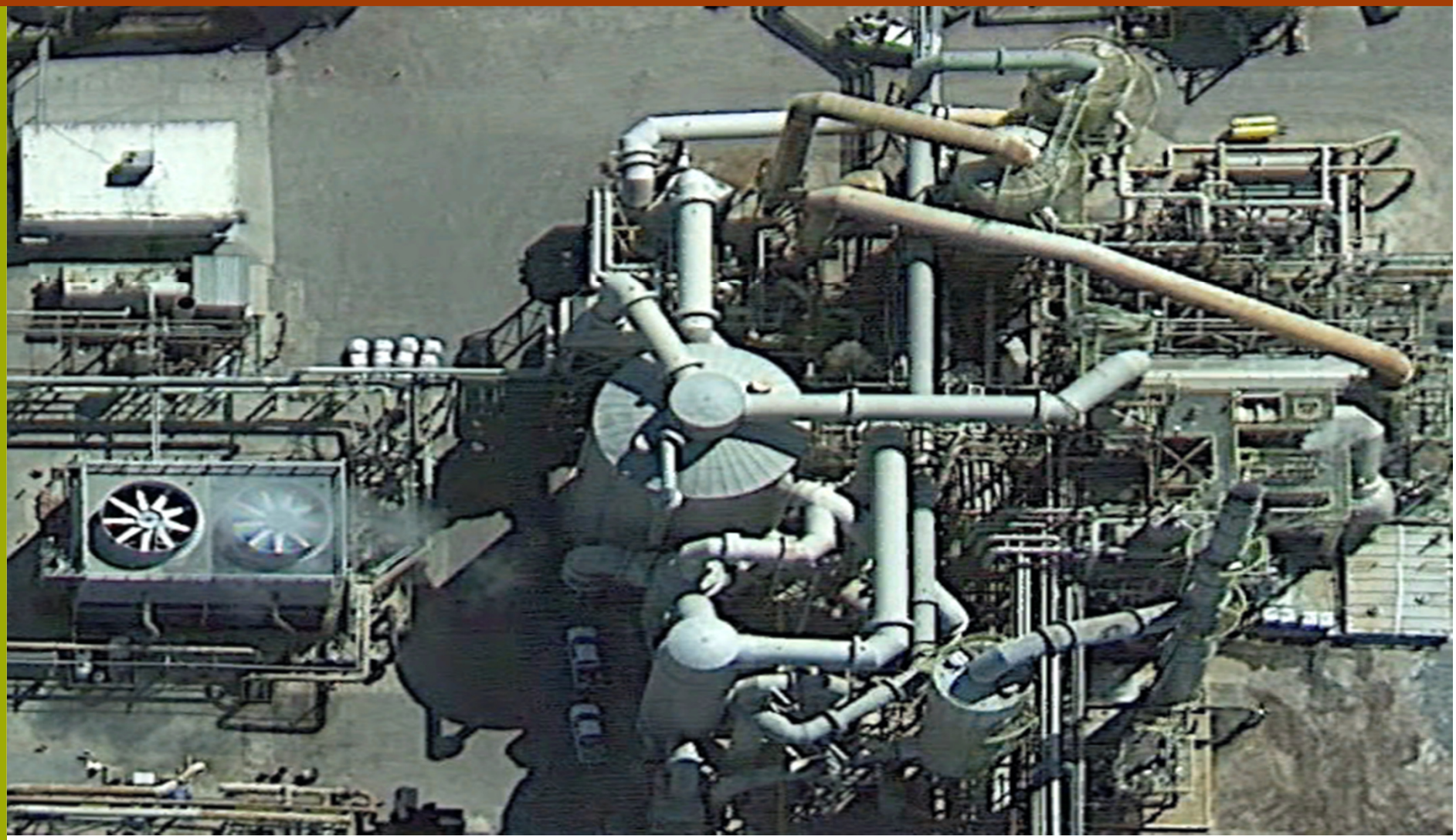
Hydrogen Safety Concerns – Second Failure

Hydrogen Safety Concerns – Second Failure

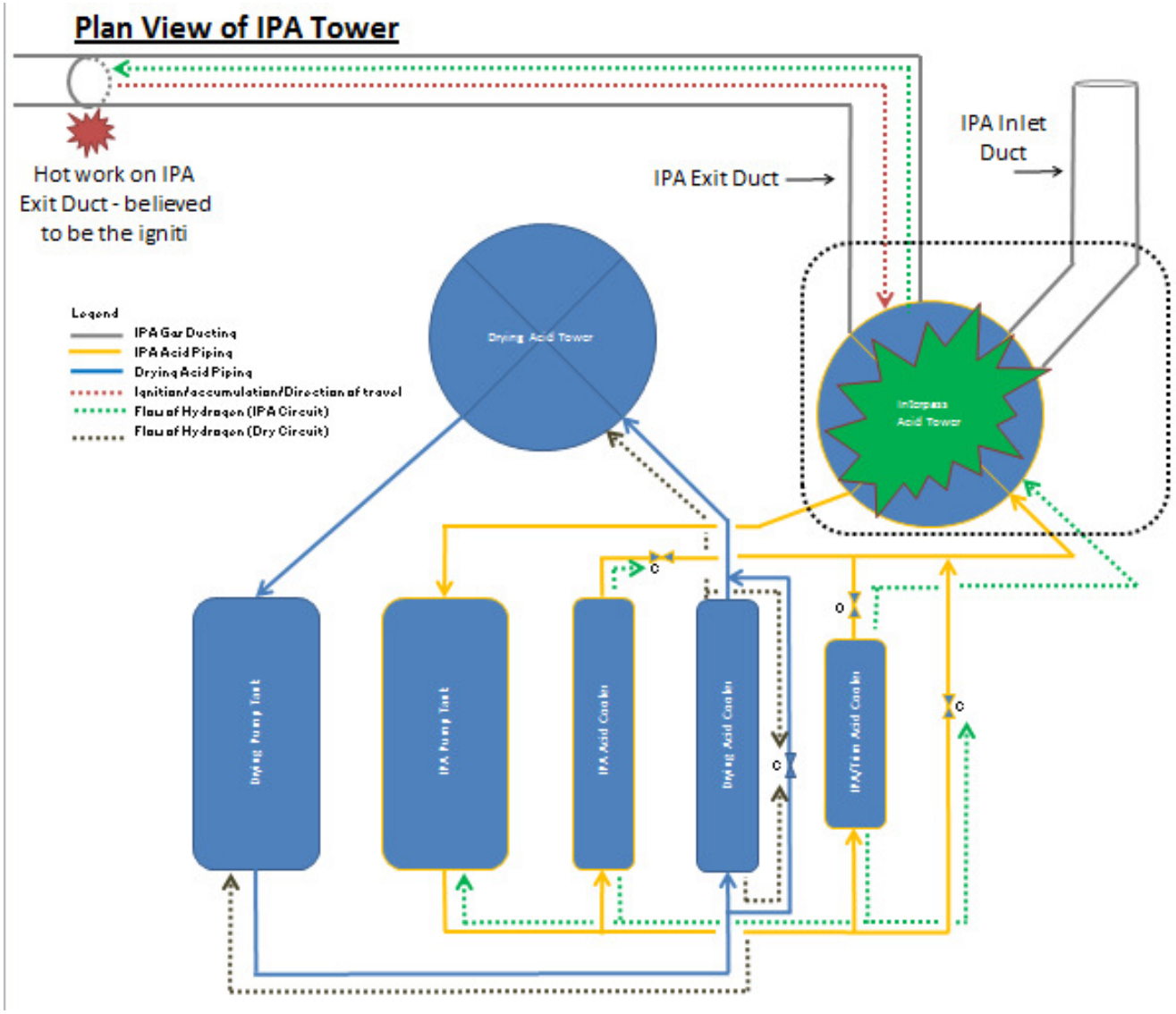
Sulphuric Operating Experience

750 Plant-Years of Sulphuric Acid Operating Experience with no hydrogen explosion incidents!

Aerial View of Plant

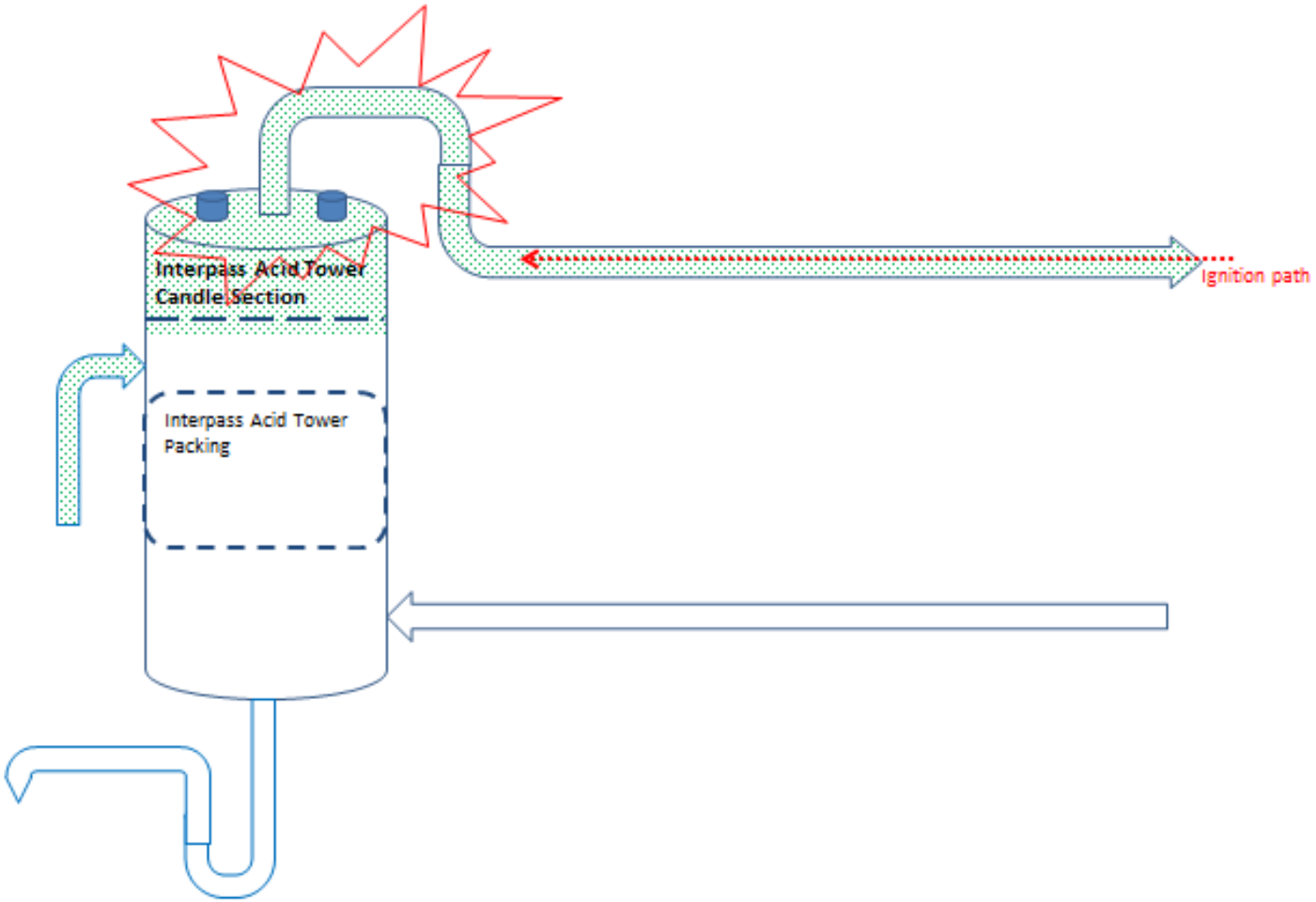


IPA Tower Event



IPA Tower Event

Project View of IPA Tower



IPA Tower Event

Left Picture: shows damage to the candle level of the IPA Tower
Right Picture: shows damage to the DT Exit Duct as the roof of the IPA Tower made contact with it

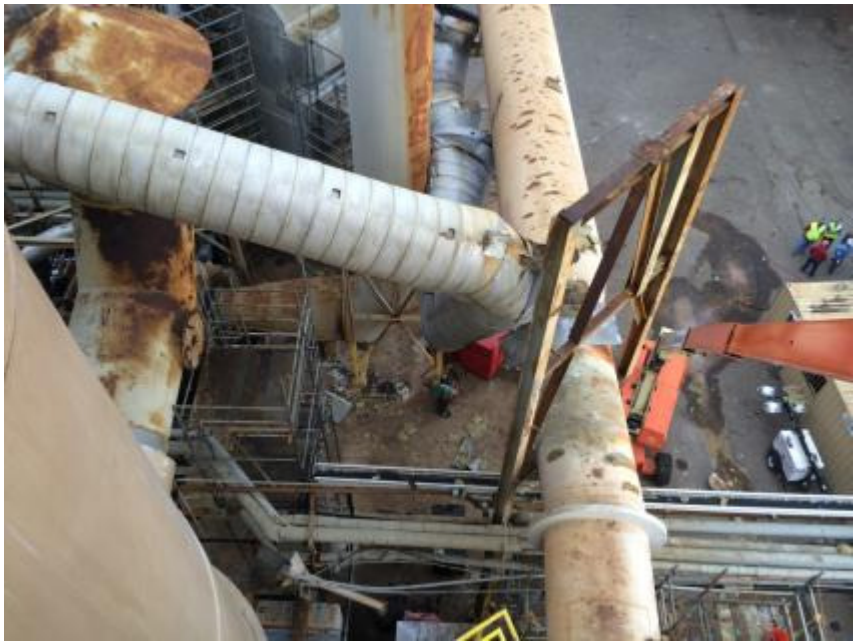
IPA Tower Event

These two pictures show the IPA Exit Duct Support; where it used to be, where it wound up

IPA Tower Event

This is two pictures of the same section of duct. One from above and one from below

IPA Tower Event



Left Picture shows how the duct rotated 180 degrees from South to North
Right Picture shows the roof of the IPA Tower where it landed

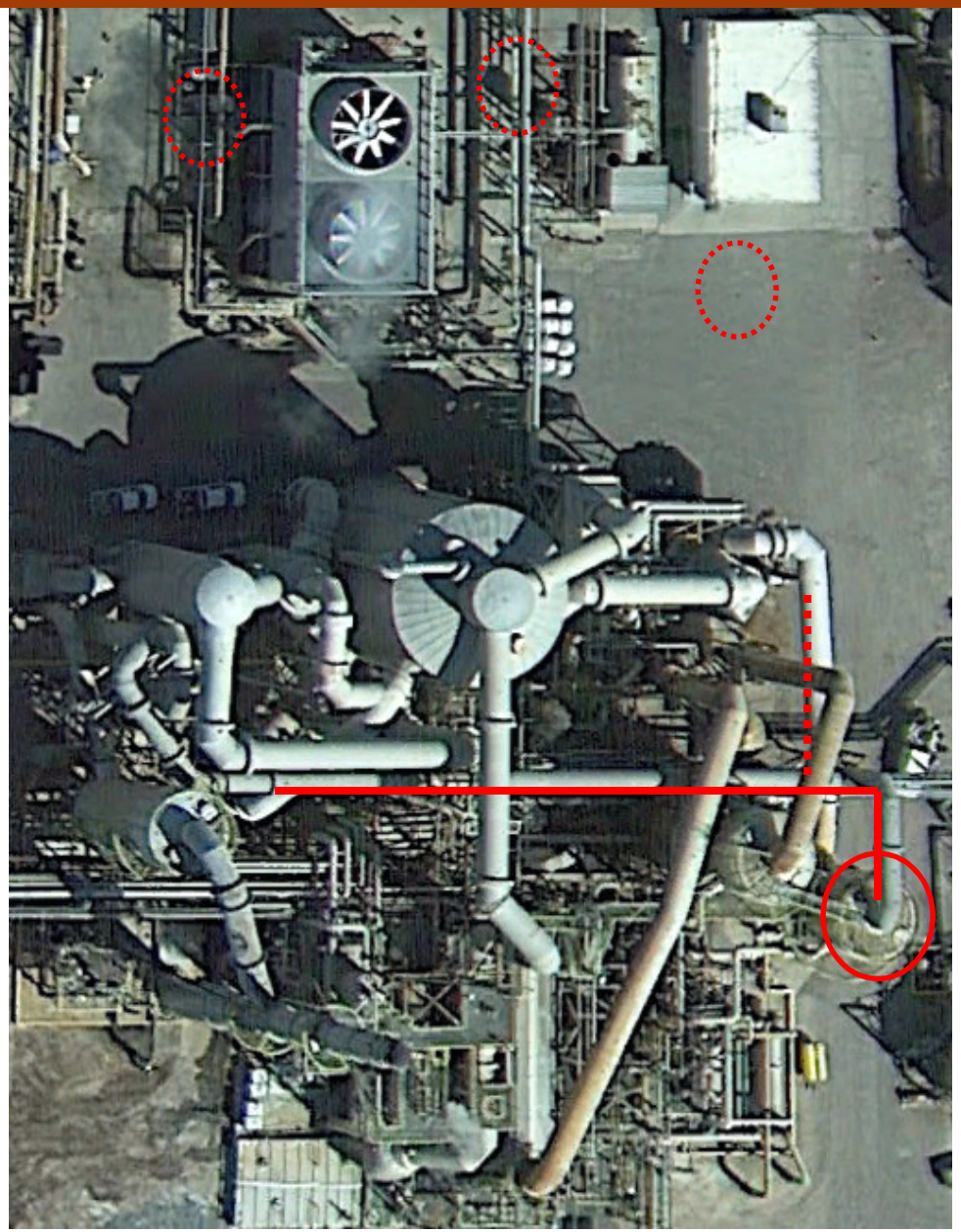
IPA Tower Event

Left Picture shows where the contractor was actively welding the band on the duct
Right picture shows the force of the blast blowing the flashing off the Cold Hex

IPA Tower Event

Misc. debris in the blast radius

IPA Tower Event



Understanding Industrial Accidents

Victim Impact Levels

1st-Party Victims – Directly involved in the Operations

2nd-Party Victims – Non-operating system users

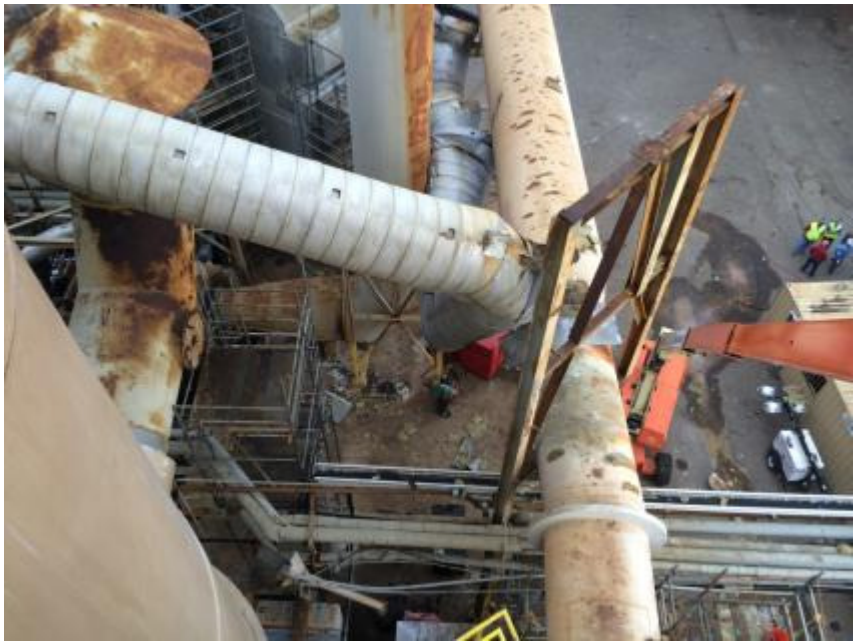
3rd-Party Victims – Innocent bystanders

4th-Party Victims - Future Generations

First Failure – First Indication

Hydrogen Safety Concerns – Second Failure

IPA Tower Event



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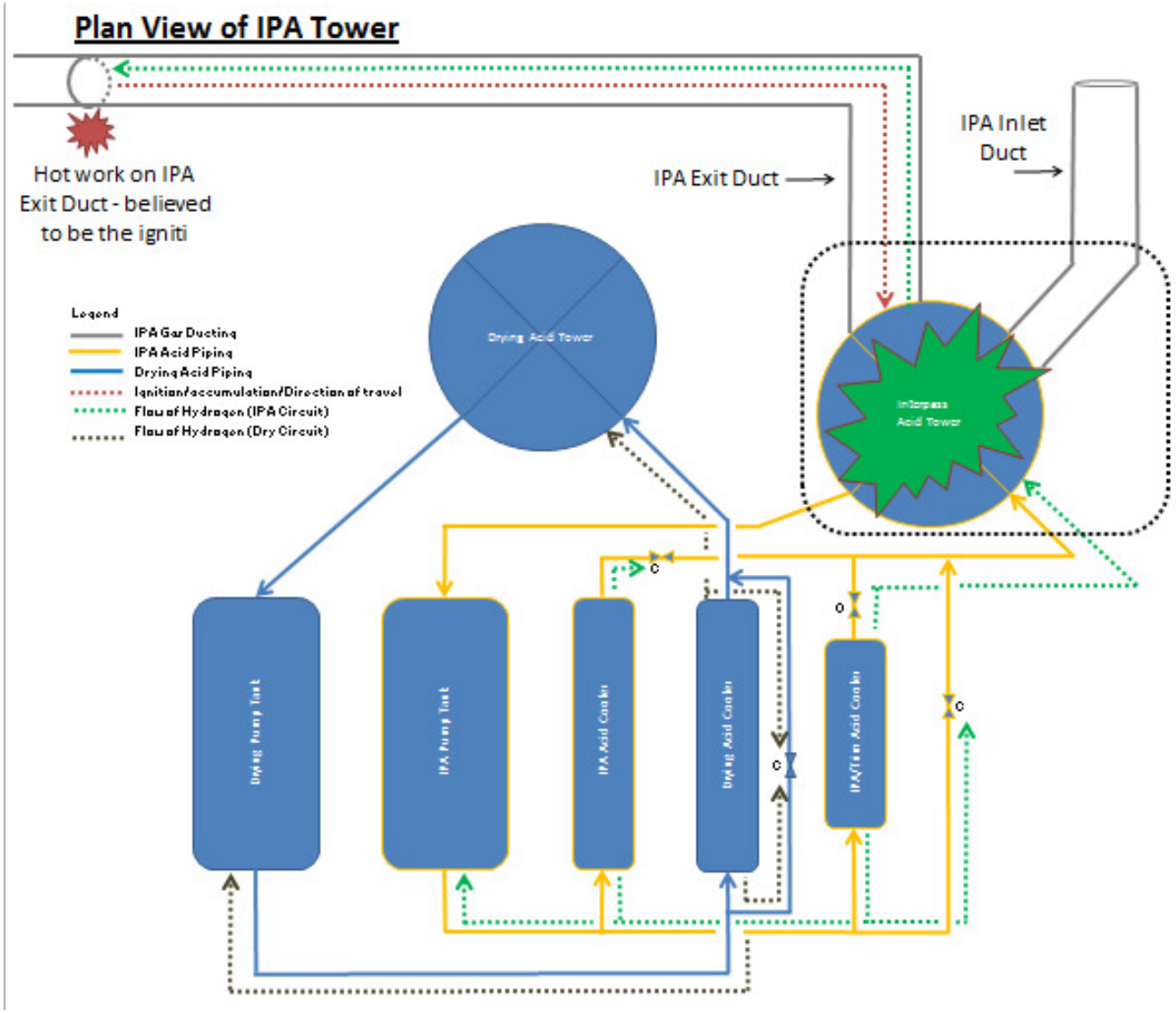
Failure of Imagination

Acid Cooler Neutralization Procedure



Acid Cooler Neutralization Procedure

- **Old Old Procedure –** pump neutralizing solution through coolers one cooler at a time.

- **New Old Procedure –** pump neutralizing solution through the (3) coolers in series.

- **New New Procedure –** pump neutralizing solution through coolers in parallel

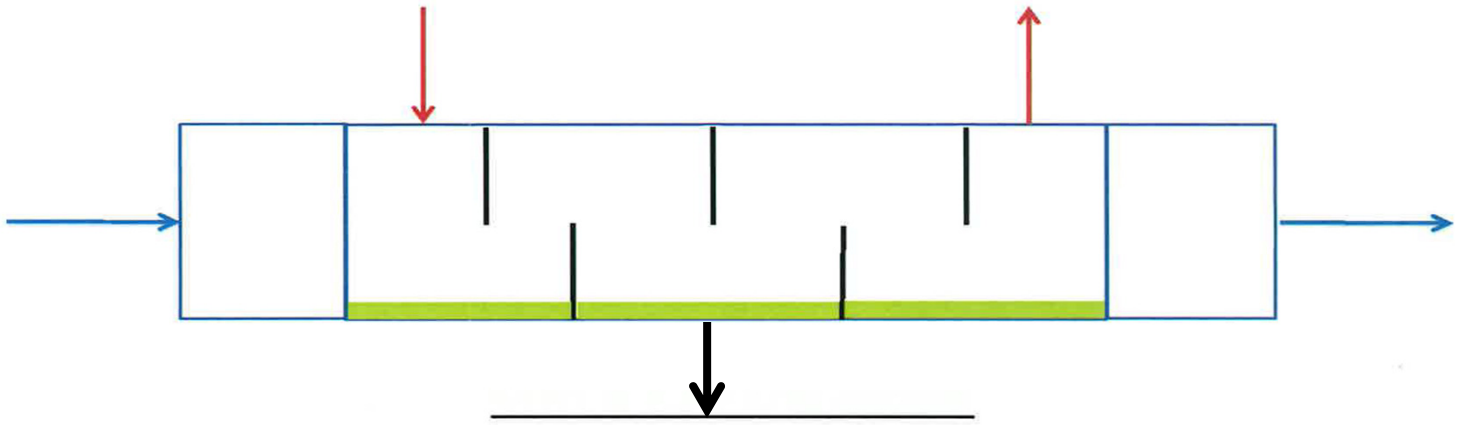
Acid Cooler Neutralization Procedure

- **Plant & Contractor Followed Procedure**
- **Procedure had been “improved” to reduce time & cost**
- **Hot condensate was not available for neutralization**
- **Recirculation pump broke down with no spare on site**

Acid Cooler Neutralization Procedure

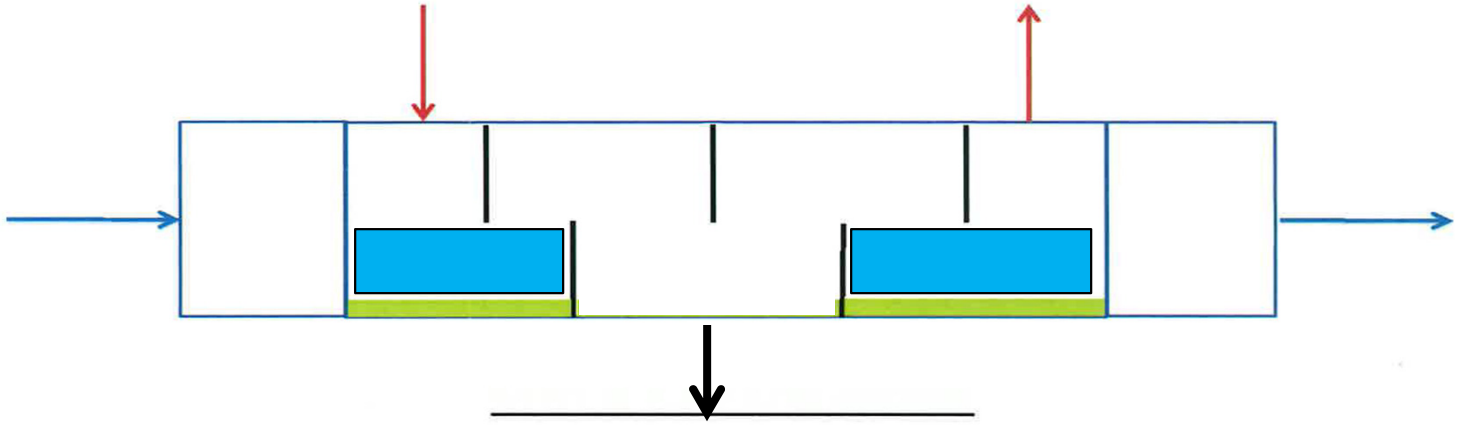
- **Supply of hot condensate for neutralization solution make-up was out of service during the time of the cooler cleaning**
- **Had previously begun using Caustic Soda rather than Soda Ash for neutralization solution**
- **Recirculation pump coupling broke and no spare pump or coupling was on site. Lost 12-hours of neutralization time.**
- **Acid side cooler drains were inspected and approved by three levels of operations management**

Shell and Tube Acid Cooler



Residual Sulfates Plugged off Baffle Drain Notches

Shell and Tube Acid Cooler



- Acid Side only has one drain in center - drain check indicates cooler is empty
- Neutralizing solution is trapped behind baffles

AIChE Center for Chemical Process Safety

Web-seminar titled "*Lessons learned from the Space Shuttle Challenger Disaster*"

An Organization's Culture must:

1. **Maintain a sense of vulnerability about your process**
2. **Combat the acceptance/normalization of deviances**
3. **Establish an imperative for safety**
4. **Perform valid and timely hazard and risk assessments**
5. **Ensure open and frank communications**
6. **Learn and advance the culture**