



**55th Canadian Chemical Engineering Conference
Process Safety and Loss Management**

Lessons Learned from an Unusual Hydrogen Reformer Furnace Failure

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QUICK FACTS

- **Syncrude Canada Ltd is a joint venture partnership which converts Athabasca Oilsands into a Light Sweet Blend Crude Oil**
- **The facility is an integrated mining, extraction and upgrading operation supported by a common power utility**
- **Current capacity is 250,000 barrels/day of final product which is shipped via pipeline to southern markets**
- **The Upgrading plant is similar to an oil refinery with two separate operating trains each including a crude unit, fluid coker and hydrotreaters**





QUICK FACTS

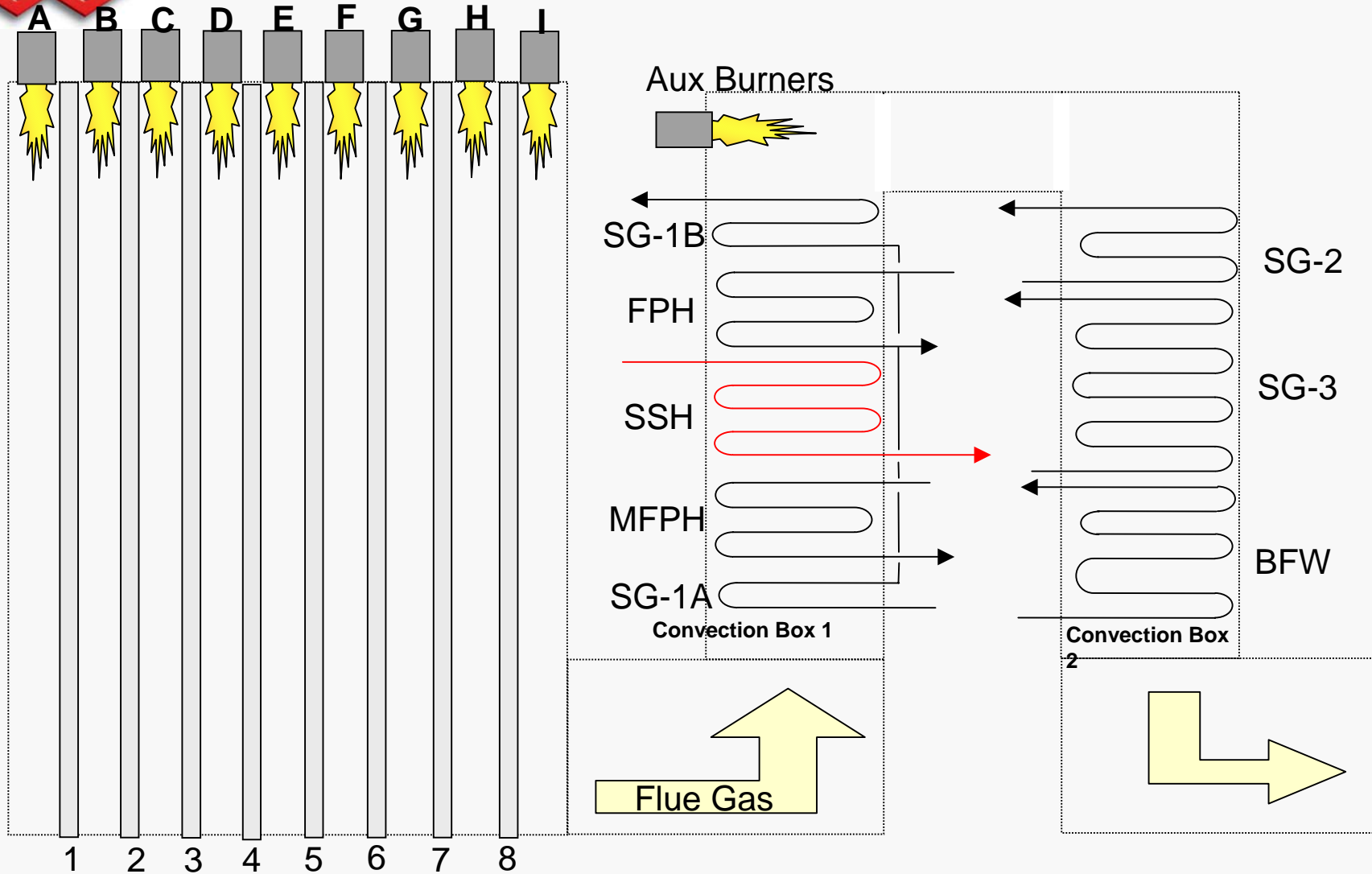
- Within the Upgrading plant 300 MSCFD of hydrogen in three steam/ methane reformers is produced
- The incident occurred in the reformer furnace of unit 3

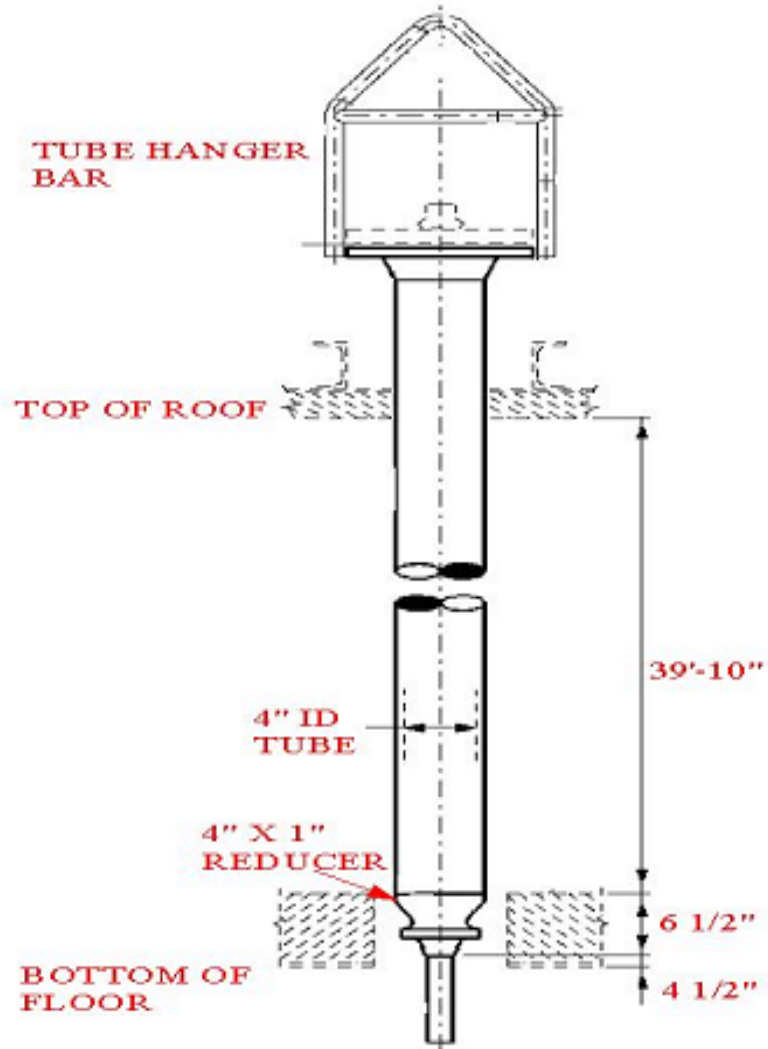
Furnace Facts

- Hydrogen output 81 MSCFD built in 1987 and operational in 1988
- The radiant section of the furnace contains eight (8) parallel rows of. Each row contains forty-six (46) tubes for a total of 368 tubes composed of spun cast HP-45 Niobium Modified Alloy with a design wall tube temperature of 935°C.
- Each tube has a 4" ID by 39'10"
- 108 burners arranged in 9 rows



General Furnace Arrangement





General Tube Arrangement



SUMMARY

THE INCIDENT

- **At 22:39 Sunday January 30, 2005 a rapid sudden high energy pressure impulse occurred within several radiant tubes in the unit 3 reformer furnace**
- **The furnace was in a startup mode on steam without hydrocarbon feed**
- **This impulse caused the simultaneous rupture of 5 tubes with sufficient force to eject portions of the tubes out through the roof of the furnace**



SUMMARY...

- **41 more tubes were destroyed as a result of impacts by tube segments and the subsequent shock wave**
- **All of the flue gas tunnels suffered extensive damage**
- **Fire box sustained impact damage from shrapnel hits**
- **One Operator sustained serious injuries when he was hit by one of the ejected tube assemblies**
- **The entire reformer section was condemned necessitating replacement**



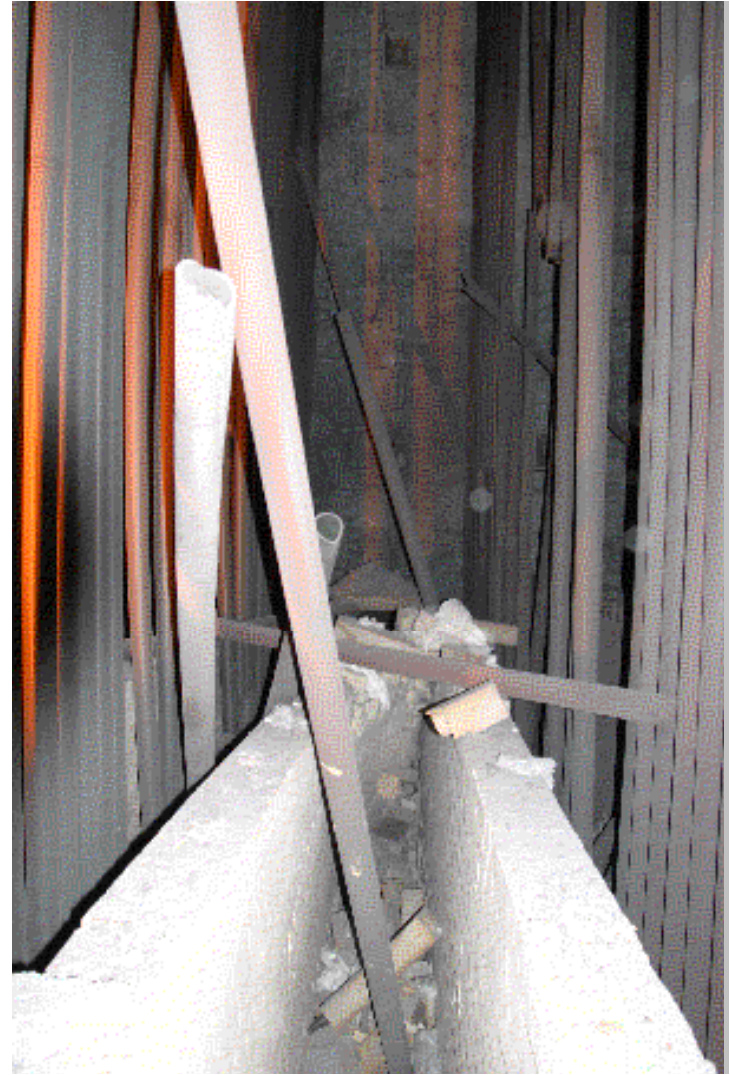
**Pre Incident General Radiant
Tube External Arrangement**



Post Incident External Damage



**Tube 161 lifted approximately
16 ft (view looking up)**

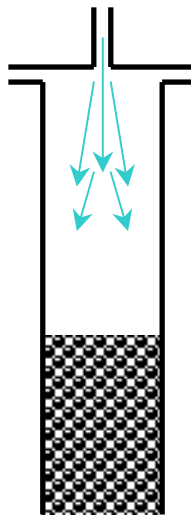


Internal condition of radiant section

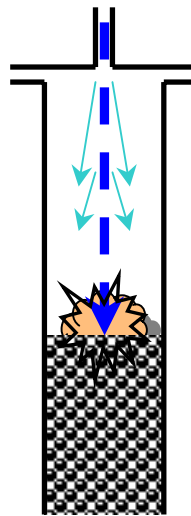


FAILURE MECHANISM

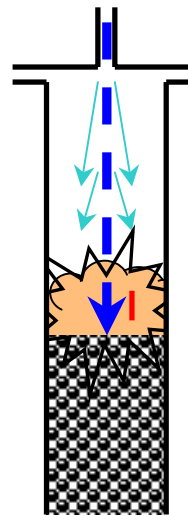
- **Prior to start-up water was present in the feed system upstream of the radiant tube section**
- **As the Process Steam flow was ramped up per the startup procedure (increased mass and velocity) it picked up water and carried it into the radiant tubes**
- **Water introduced into tubes underwent an rapid phase change generating an extreme local pressure impulse and shock wave. The wave initiated longitudinal cracking**
 - **Entrained water impinged on hot (350°C) catalyst and possibly the pipe wall, "instantly flashing"**



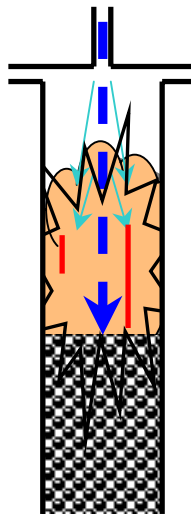
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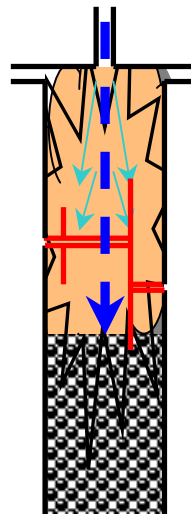
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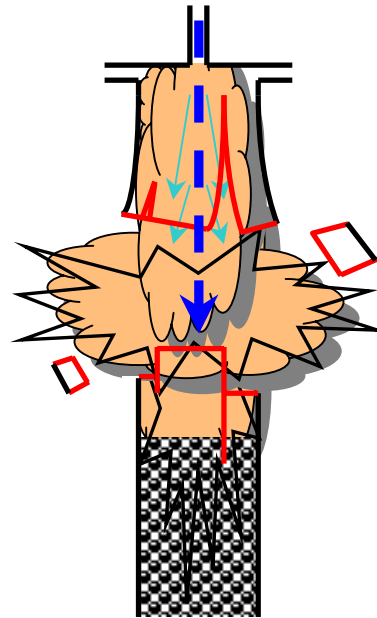
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ROOT CAUSE

- **Accumulated water was not removed upstream of the radiant section prior to introducing steam**
- **The Mixed Feed Preheat Coil is the most probable location where water was pooled prior to the event because:**
 - **Steam could have collapsed into water in the system after shutting down or from passing valves**
 - **Inlet header is not self draining**
 - **The outlet header is the low point**



LESSONS LEARNED

- **Inadequate Safeguards:**
 - Insufficient size and location of drains to ensure all remnant water is removed
- **Inadequate Procedure:**
 - The startup procedure did not account for a startup of a cold furnace with no hold points
 - Insufficient information for operators to detect a wet system
- **Lack of MOC**
 - The startup procedure has two hold points for refractory dry out and new catalyst reduction, during the heat up phase prior to introducing the 600psig startup steam.
 - These hold points were not utilized since the neither was required



LESSONS LEARNED...

- **Non-essential Personnel**
 - At the time of the incident seven people were on the furnace structure
Only the operations personnel were essential