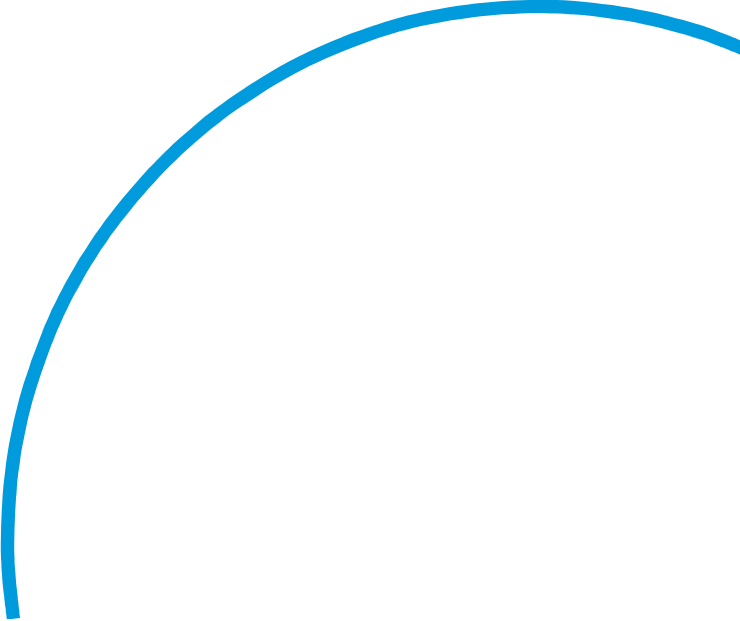


Hydrogen Safety in Sulfuric Acid Plant

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Hydrogen Explosion Incidents

- Australia
- Brazil
- Holland
- Italy
- UK
- US
- ????



Causes of Hydrogen Generation

- Acid Cooler leak
- Boiler leak
- Economizer leak
- Superheater leak
- Tower/pump tank acid strength out of control



Explosion triangle

- Sources of Ignition- temperature, reaction, and others
- Oxidant-oxygen
- Flammable material-Hydrogen

















Temperature effect on Hydrogen Flammability

Temperature °C	LEL % volume	UEL % volume	Limiting Air Concentration % volume	LOC % volume
20	4.1	75.6	20.4	4.3
100	3.4	77.6	19.1	4.0
200	2.9	81.3	15.0	3.2
300	2.0	83.9	10.9	2.3
400	1.4	87.6	6.2	1.3



Risk Mitigation Strategy

- Prevention
- Early detection
- Mitigation



Prevention

- **Equipment**
 - design and lay-out (minimize hydrogen accumulation in the equipment)
 - material of construction
 - flow direction
 - vent and drain (location for the vent –where hydrogen likely to accumulate)
 - Process and safety Interlocks
- **Proper operation**
 - proper operating procedure
 - operating parameters
 - monitoring data
- **Mechanical Integrity**
 - NDT inspection
 - Visual inspection
 - proper maintenance procedure
 - PM program



Early Detection

1. Acid Cooler Leaks

cooling tower water pH and conductivity

2. Steam and Water Leaks

dew point

opacity

flowrate deviation

temperature deviation

3. Tower Acid Out of Control

Acid strength deviation

opacity

flowrate deviation

Temperature deviation

dew point



Mitigation

- 1. proper purge and shutdown procedures
- 2. draining and venting procedure



Forum

- 1. Sharing/dissemination incident information
- 2. Industry Standard Practice