Oxygen Related Accidents/ Incidents in Gas Industry – Learnings

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Background and Intent

Content in the following slides is from the presentation made at the **2018 Oxygen Safety Seminar** held in September 2018 in Taipei, Taiwan.

Seminar was jointly sponsored by OSHA Taiwan, THPGIA, AIGA and NTUT (listed below).

Material shared herein is from AIGA and its members.

Occupational Safety and Health Administration, Ministry of Labor

Taiwan High Pressure Gas Industrial Association

Asia Industrial Gases Association

National Taipei University of Technology

Oxygen Incidents & Accidents

Objective: Prevent Oxygen related accidents and incidents

- Sad truth – Oxygen related accidents continue to happen; hurt people; loss of life and property

Oxygen Incidents' & Accidents' Prevention Requires

- Understanding of Oxygen properties & behaviors under different conditions
- Good engineering design practices
- Following right protocols during construction, installation, commissioning and start-up
- Operational Discipline - Operations and Maintenance practices
- Learnings from Incidents … by sharing information across industry
- AIGA (Asia), EIGA (EU), CGA (North America) help in learning through sharing and developing standards/ guidelines/ training packages etc.

Oxygen Incidents & Accidents … where do they happen?

- Production (Process/ Design induced) – ASUs/ Fill Plants
- Commissioning & Start-up
- Operations – filling of cylinders, delivery of products (Cylinders, Dewars, liquid products through Trailers, Pipelines)
- Maintenance & Modification of Equipment/Plants

Oxygen Incidents & Accidents … Info Sharing

- In next few slides, we will go over accidents/ incidents information
- What is important is to acknowledge that they do happen and to learn their causes and ensure we incorporate learnings at our sites to improve Safety
- What is NOT important is in what country they happened; what company was involved; what customer was involved; etc.

ASU Flat Bottom Tank (FBT) Incident Aftermath - 1978

- LIN Flat Bottom Tank over pressured
- Inner vessel separated from foundation; lifted out from outer tank and fell to grade
- Breaking liquid outlet line on adjacent LOX flat-bottomed tank
- Resulted in LOX spill (800 T)
- 5 off-site fatalities

LOX Tank Fire - 1981

- Resulted in several fatalities
- Vertical LOX storage tank ignited and burned through the bottom and top
- Tank had an aluminum inner vessel and a carbon steel outer vessel.
- Likely cause: friction from an aluminum internal tube (dip tube) rubbing against an aluminum support caused the ignition.
- Company has prohibited the use of aluminum inner vessels in LOX tanks since this incident.

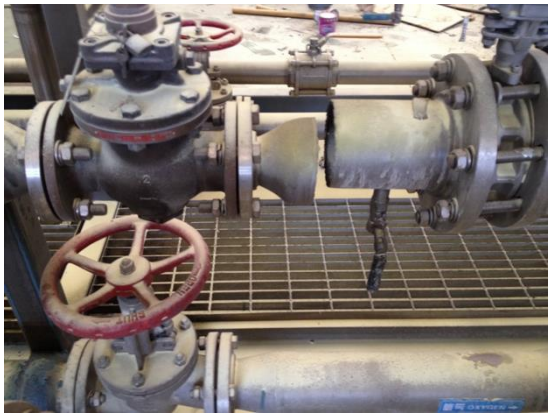
ASU Plant Explosion - 1997

- ASU reboiler explosion led to fire
- Hydrocarbon Accumulation >> Combustion >> Aluminum burning/explosion

Oxygen Energy Release

- Oxygen Energy released during commissioning of pressure control manifold.
- Eight people severely injured (burns) - one subsequently died.
- Highlights need for oxygen piping design expertise, oxygen cleanliness, adequate Hazard Review and Operational Readiness Inspection and safety precautions during commissioning.

Oxygen Fire – Oxy-Combustion Skid

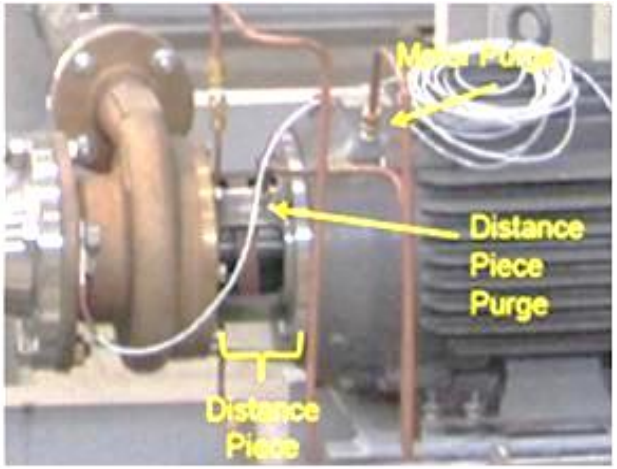


- Flame erupted from an oxy-combustion skid being commissioned at customer location
- Multiple burn injuries to personnel who were present there to get trained
- Likely ignited by rust/particles in a strongly oxidized hydrocarbon mixture (HC solvent introduced by customer for pipe cleaning) carried from upstream pipe
- Flame released out of poor quality weld on the oxygen piping skid.

N2 Compressor Fire (O2 Migrated via cross tie-in)

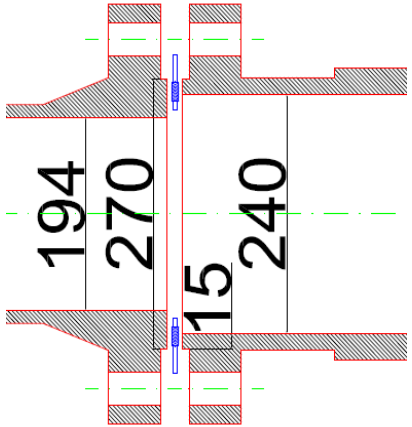
- 2nd GAN compressor was added for reliability of supply (locally) with cross tie-in so that both ASU1 and ASU2 can feed into either of the GAN compressors
- On day of incident, ASU 1 tripped and was being restarted. N2 with high O2 (during ASU restart) was fed to the compressor (manual valve in cross-tie not fully closed) – led to fire in compressor

LOX Loading Pump Motor Energy Release



- Oxygen: Pump seal leak, O2 migrated from pump to motor through the tunnel created by ice ball over the distance piece
- Combustible Material: Electric motor components are not O2 compatible
- Ignition Source: Not exactly known. Probably by heat generated from normal motor friction.

GOX Gasket Failure

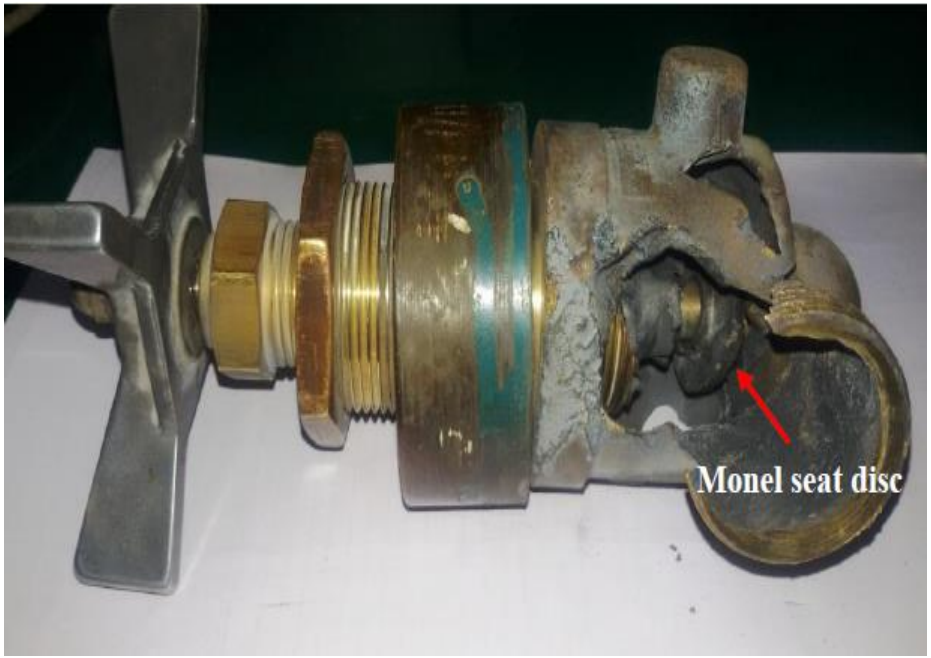


- The mismatch of flange seal surfaces resulted from wrongly designed and manufactured outlet flange, with wrong ID dimension. Error made by vendor designer.
- Error not caught during drawing review and approval.
- Wrong gasket installed (150# was installed instead of 600#)

GOX Compressor Fire - 2002

- Fire initiated in compressor; molten slag and metal flowed to the piping, ignited it and caused the breach.
- The fire lasted 5 seconds.
- As a safety precaution all oxidizer compressors are barricaded. Barricade contained the fire preventing injury.
- Likely the fire was initiated by frictional rub; rub likely caused by fatigue failure of an internal part (impellor cover or blade)
- Rubs possible in compressors; cause friction … ignition … combustion. Practice is to barricade oxidizer compressors and to allow personnel access to the compressor only during outages.

Energy Release – O2 Cylinder Fill Panel Valve



- Fire occurred at the back of inlet valve located on manifold panel which was being opened to change over.
- Maintenance (including degreasing) was done on valve two days prior to incident to fix leak in the valve.
- O2 Cleaning procedure not strictly adhered to during maintenance event.

Pressure Gauge Burst During Cylinder Pressure Check

- Operator was doing pressure check for medical oxygen cylinder.
- Incident happened when operator tightened the screw, and opened cylinder valve slowly.
- The gauge glass shattered injuring the operator on the right side of the chest.
- The gauge that was used was not compatible for oxygen service.

Oxygen Pipeline Fire at Customer Site During First Fill

- Employee suffered burn injury when O2 was charged for the first time into the pipeline
- fire occurred at the upstream flange of the valve.
- Valve was not cleaned for oxygen service
- Less than adequate PPE
- No SOP for charging oxygen for the first time in pipeline

Major Fire & Explosion At Oxygen Pipeline Pressure Reducing Station

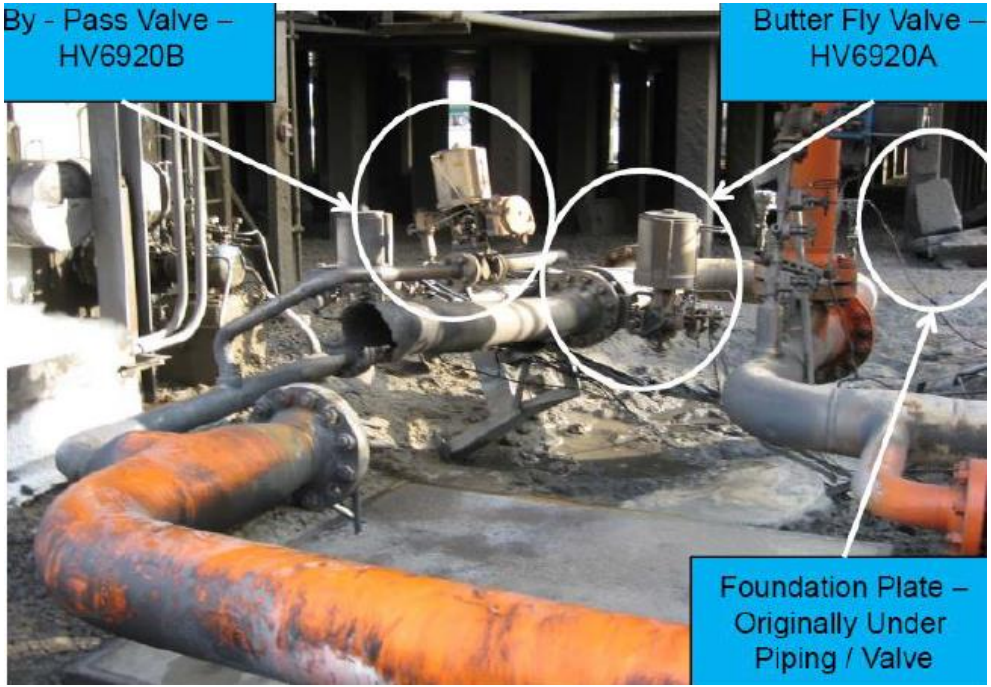
Destroyed Control Room

- Fire and explosion at pressure reducing station on new O2 supply pipeline during commissioning
- Large number of people (~50) present at the control room at the time.
- Fire destroyed the control room and 19 people died.
- Trapped particles in the filter at PRS (after the fire) showed that particle impingement on the steel pipeline in the filter area could have occurred that resulted in ignition.
- Design practices to prevent excess oxygen velocity might not have been properly followed.

Oxygen Pipeline Fire At Conical Filter Flange

- 6-inch O2 line – 3m section “consumed”
- Incident happened after upstream O2 tripped and was re-started
- Particle impingement/ high O2 velocity

Oxygen Pipeline Fire - Newly Modified Piping During Commissioning



- Deficiencies in O2 System Design expertise
- Inadequate Management of Change (MOC) approval process

Oxygen Incidents & Accidents - Conclusion

- KNOWLEDGE IS POWER – ensure systems are designed by people with expertise
- Majority of accidents (with significant impact) happen during commissioning (first fill) – have robust procedures and protocols
- Maintenance done on any part of O2 system should be well planned and done by knowledgeable people.
- Good operating practices are key – it is all about details.

More about AIGA …

AIGA is a technical and safety oriented organization with the purpose of promoting safety, health, environmental awareness and security in the production, distribution and use of industrial gases.

AIGA is registered as a non-profit society based in Singapore. It aims to foster the exchange of technical information among its members in the safe handling and use of industrial, medical and carbon dioxide gases, and to have close liaison with national authorities, in order to work towards the highest level of safety and environmental care across Asian countries.

Content included in this presentation are from AIGA and member companies; and are intended for sharing and learning purposes only – to enhance Oxygen Safety.

Additional Resources from AIGA

- AIGA 005/10: Fire Hazard of Oxygen Enriched Atmosphere
- AIGA 021/12: Oxygen Pipeline and Piping Systems
- AIGA 012/04: Cleaning of Equipment for Oxygen Service
- AIGA 010/04: Management of Change
- AIGA 008/10: Safety Training for Employees
- AIGA 015/15: Safety Management of Contractors

Thank you.