Training Package
TP 22/17

Recent (2016) Accidents/Incidents in the Gases Industry in Asia

AIGA *Asia Industrial Gases Association*

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Introduction

At the regular Safety Advisory Group (SAG) meetings, members exchange information on accidents / incidents that have occurred. Accident / Incident details discussed at the SAG remain confidential.

The SAG has decided to share the more notable accidents / incidents on a regular basis with the national associations and member companies via the Training Package publications.

The following slides contain the summaries, pictures and other relevant information to highlight the root causes and lessons to be learned from these accidents / incidents .

Further Information:

These Training Packages are posted only on the Members Page and are meant for distribution among Members only.

While the best effort is made to provide sufficient information on the accidents / incidents, please contact the SAG (through the Secretary General) if you need further clarifications.

Agenda

- **Accident / Incident cases,**
  related to:
  - **Transportation** & product decantation,
  - **Cylinder Handling,**
  - **Use on non compatible material** / Parts **not cleaned** for O2 service
  - **Maintenance work, Lifting & working at Height**
- **Lessons learned** from the safety events
- **Main AIGA standards** related to these accidents / incidents

Accidents / Incidents

related to

Transportation & product decantation

Event #1

LIN ISO tanker - roll over

Consequence: 2 Fatalities (contractor truck driver & 3rd party car driver)

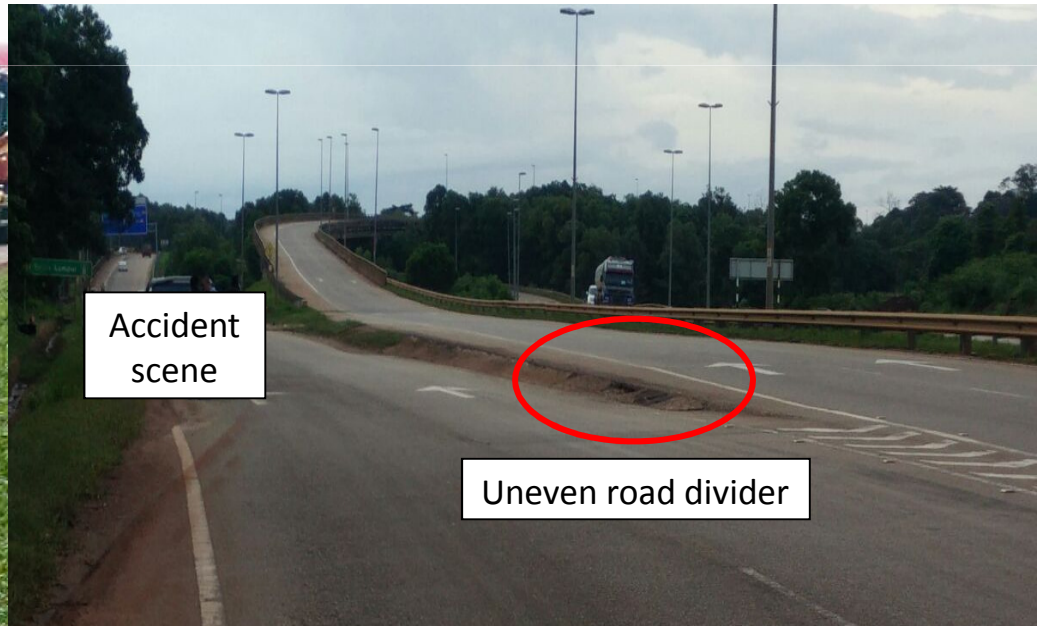
What happened:

At 6:00 am, a full LIN ISO tanker was moving on a straight and wet road when the driver was forced to move right to avoid a slow moving car moving right to avoid a water pool on the road. Doing so, the truck drove its right wheels over an uneven road divider, causing it to go off-balanced, rolled over and crushed the private car it was overtaking. The private car driver died on the scene. The contractor driver was badly injured (neck backbone dislocation) mainly because he was not wearing his seat-belt and passed away 5 days later due to his injuries.
The rollover happened at an estimated speed of 40 to 45 km/h.

Major Cause(s):

- Lack of Defensive Driving
- Not wearing seat belt

Event #1 Pictures



Event #2

Product vehicle roll over due to over speed

Consequences: Driver - First Aid Injury / Co-driver - Recordable Injury

What happened:

A Lox ISO vehicle rolled over at a bend due to over speed (80 Km/h instead of 60 Km/h). The road and weather conditions were good and the incident happened around midday. There was no product spillage.

The accident led to serious damages to the prime mover and fortunately didn't involve any third party. The driver was wearing his seatbelt and thus suffered only first aid injuries. The co-driver was resting at the sleeping berth with safety net. He suffered recordable injury on the back but did not require medical leave.

Major Cause(s):

- Over speed (80 km/h instead of 60 km/h as allowed for the bend).
- Possible sleep inertia; the driver was driving for less than 5 minutes after waking from sleep in the sleeper berth.
- Failure of fifth wheel fixation, leading to prime mover disconnecting from trailer
- High centre of gravity of the ISO vessel

Event #2 Pictures

Event #3

High severity product vehicle accident

Consequences: Recordable injury to driver (cut on nose)

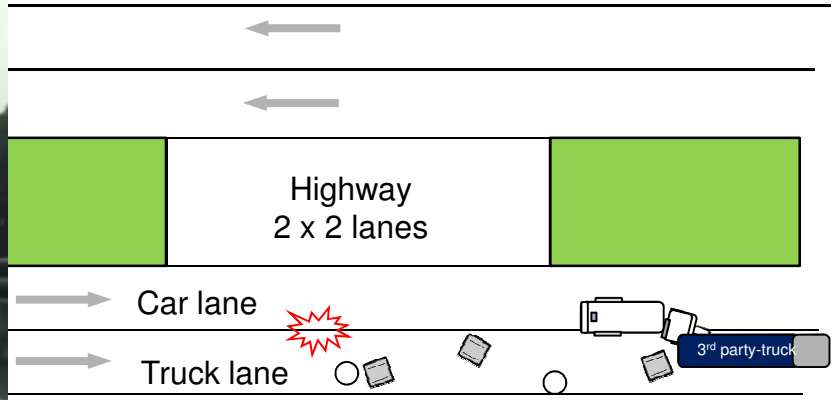
What happened:

At around 4:23 am, a truck accident happened on the highway while ISO Lin tanker was on the way to deliver to customer. The contractor driver was driving at 67 Km/h when he crashed onto a slow-moving truck (40 Km/h) transporting 5 cement pipes which was in front of him on the same lane. The contractor owned prime-mover received extensive damages at the cabin. Third party truck had slight damages in its tail. No damage to the Lin ISO tanker neither any product release. Contractor driver was tired, saw the truck at the last moment and tried to avoid the collision. He was wearing his seatbelt and sustained only minor cut in his nose (Recordable Injury).

Major Cause(s):

- Driver fatigue. Driver saw the slow-moving truck at the last moment.
- Slow signaling by the 3rd party vehicle

Event #3 Pictures



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Event #4

Product vehicle roll over

Consequences: Contractor driver fatality

What happened:

Contractor owned & operated product vehicle while on its way to a customer rolled over by 90 degrees resulting in fatal injury to the seat belted driver (bamboo shrubs pierced the neck and skull). The vehicle cabin had to be cut open to extract the driver. Unfortunately the driver passed away on the way to the hospital

Major Cause(s):

- Aggressive driving (Speed / Driving too close to road edge)
- Lack of practical roll over prevention training ; Route risk mitigation

Event #4 Pictures

Event # 5

Product vehicle roll vver

Consequences: Vehicle damage ; Potential Fatal Event

What happened

Contractor owned liquid nitrogen straight truck, rolled over by 90 degrees at approximately 10 kilometers from plant while on its way to a second customer after delivering to the first customer. The truck was carrying a partial load of 9 MT in tanker. The accident happened on a sharp curved section of the road where the driver lost control. No injuries to anyone and no product release.

Major Cause(s):

- Excessive speed in the curve
- Hard braking

Event # 5 Pictures

Event #6

Product vehicle accident for not applying wheel chocks

Consequences: Contractor Driver Lost Time Injury (LTI)

What Happened:

The driver has completed the LIN unloading process, disconnect the transfer hose/and removed the wheel chocks. He climbed up the truck to drive back to the depot however he noticed the power cable still intact and was not disconnected. He then climbed down from the cab and attempted to disconnect the power cable. While doing that, the truck rolled backward and hit the driver who was standing next to the tanker before the truck went into the drain. The customer employee called local emergency number and injured person was sent to the hospital by ambulance. As a result of the impact, his left middle finger, thigh and ankle were fractured and required to undergo the surgical operation.

Major Cause(s):

- The driver failed to secure the truck before he climbed down from the cab (Parking brake "ON" / Not kept engaged in First gear / Wheel chocks not placed).

Event #6 Pictures

Event #7

Product vehicle pulled away with hose connected

Consequences: Process Safety Event

What Happened:

After loading LIN at a filling station, a the driver went to Weighing Machine room to print the load ticket. During that time the residual liquid in the filling hose remained to flow back into the tank. Driver on return from Weighing Machine control room got busy in some paper work and forgot to disconnect the hose and started the truck which pulled the hose and resulted into damage to pipeline and the check valve.

Major Cause(s):

- Driver did not close the valve box door prior to moving off.
- Truck anti tow-away device appeared to have malfunctioned.

Event #7 Pictures

Event # 8

Product vehicle hitting a Two Wheeler

Consequences: 3rd Party Two wheeler driver fatality

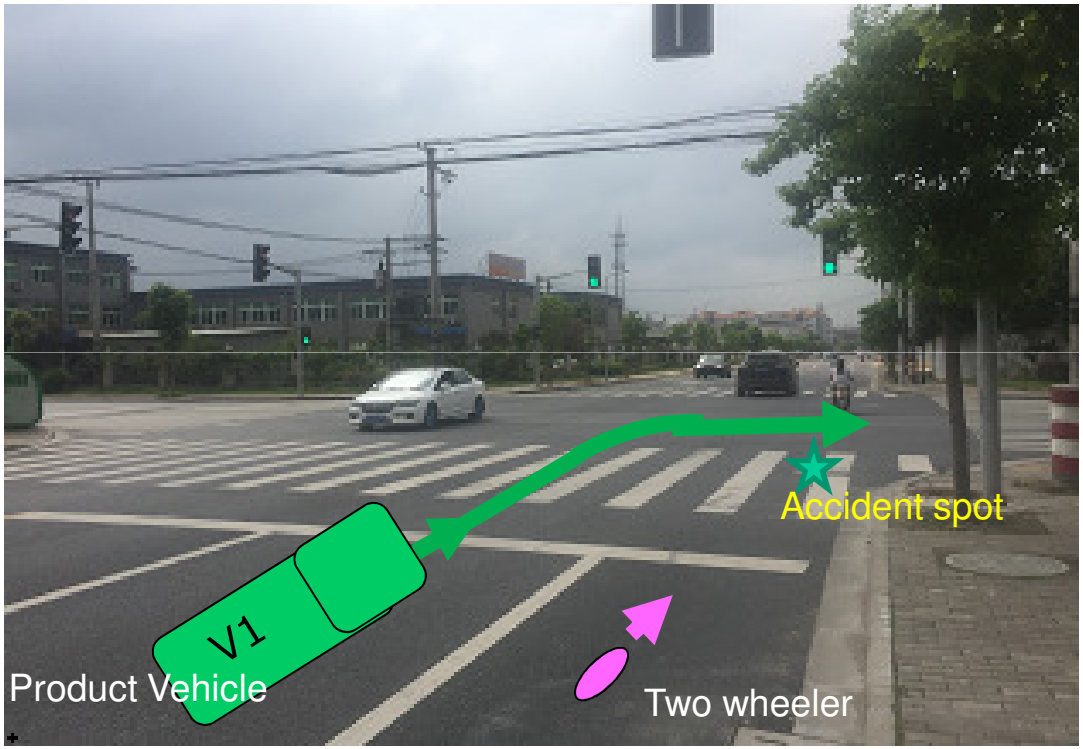
What Happened:

While turning right at the traffic light intersection, the truck hit the scooter who rode next to it. Due to the impact the Rider fell down and hit the ground hard. The rider was sent to the nearby hospital and was pronounced dead by the doctor couple hours later.

Major Cause(s):

- Driver failed to check the right hand side of his truck while travelling along with the scooter.
- Driver failed to check the right side mirror before turning the truck.
- Helper did not assist the driver when turning took place.

Event #8 Pictures



Accidents / Incidents
related to
Cylinder Handling

Event #9

HP hose connector failure

Consequences: Recordable Injury (broken nasal bone)

What happened:

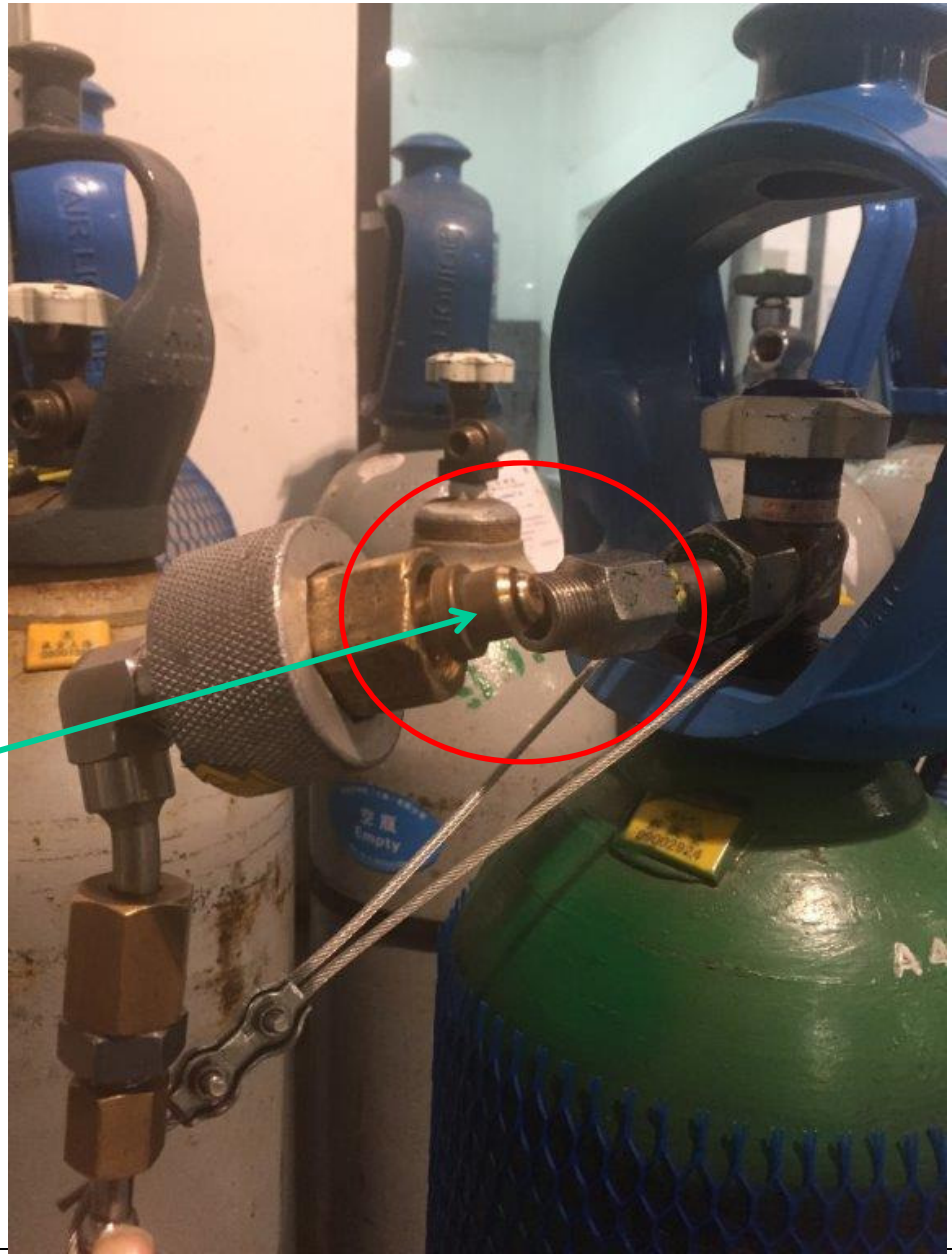
During the routine work of analyzing a gas cylinder and after having connected the hose, installed the safety cable and opened the cylinder valve, the hose connector suddenly disconnect. The flexible hose under-pressure, swung and hit the operator's face. The operator did not sustain major injury thanks to anti-whip cable properly installed and because he was wearing the required PEE (safety glasses).

Major Cause(s):

- Adaptor thread wear & tear
- Lack of checks & maintenance of adaptors

Event #9 Pictures

Failed Connector



Event #10

Valve shearing off due to Argon cylinder fall

Consequences: High Severity Potential Process Safety Event

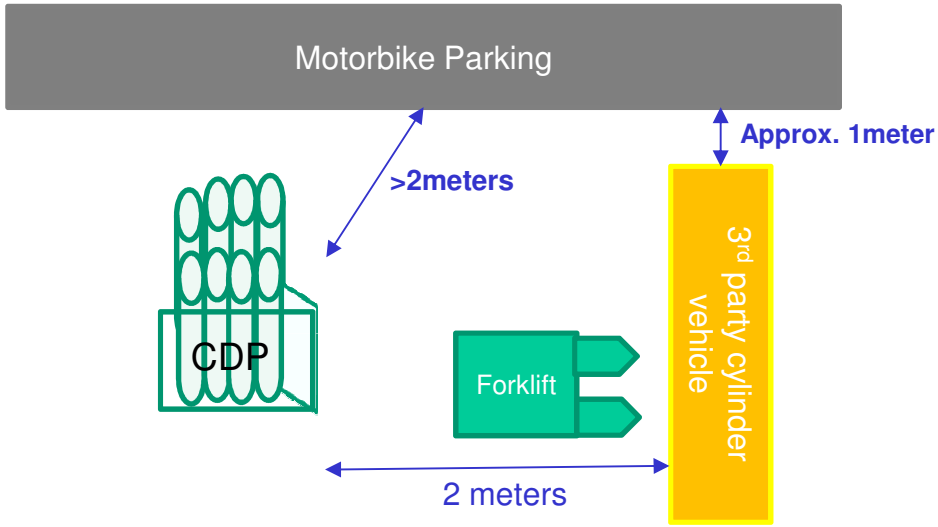
What Happened:

A customer driver removed 6 full Argon cylinders from Cylinder Delivery Pallet (CDP). The cylinders were left free standing next to his truck while waiting for forklift driver to load the cylinders into the truck. While reversing the forklift, he accidentally hit the CDP. As a result, the cylinders in the CDP fell and hit one of the free standing cylinders. The freestanding cylinder's valve sheared off and the cylinder ended underneath the truck with a release of 200bar of product, causing three motorcycles parked within 2 meters vicinity to collapse. There was no damage to the motorcycles and minor damages to the customer truck. No injuries were reported.

Major Cause(s):

- Inadequate compliance with company SOPs and less than adequate risk assessments for unloading/ loading area

Event #10 Pictures



Event #11

Cylinder fall & driver injury

Consequences: Lost Work Injury (LTI) ; Potential Fatal Event

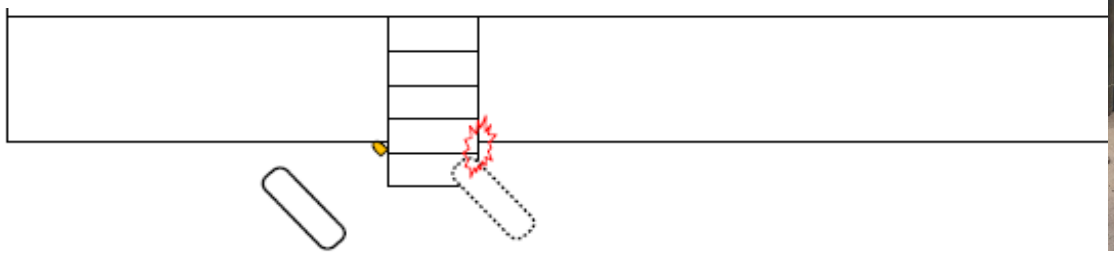
What happened

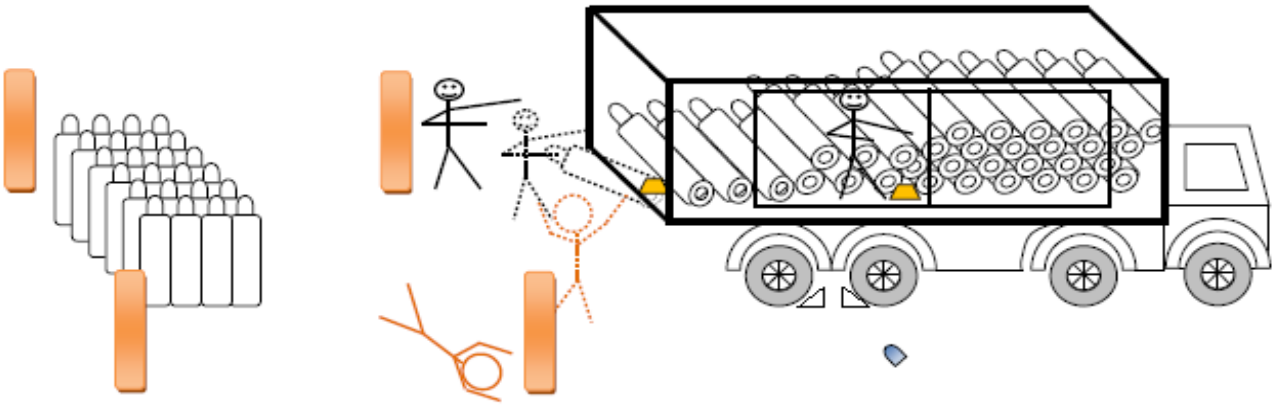
During unloading of empty cylinders from truck to ground, a high pressure Argon cylinder with residual pressure (200 bar) was rolling toward the end of truck compartment floor. Contractor driver attempted to stop the rolling cylinder from falling down the vehicle , failed and panicked leading to tripping and falling on the ground backwards resulting in fracture of the skull and leg. The cylinder fall resulted in the valve shearing off and ejecting the cylinder approximately to18m away. The ejected cylinder / valve cap did not contact any individual.

Major Cause(s):

- Inadequate procedure / implementation for horizontal cylinder handling
- Unreliable cylinder stopper mechanism
- Inadequate Contractor safety management

Event #11 Pictures





Accidents / Incidents

related to

use on non compatible material/ parts

not cleaned for O2 service

Event #12

Pressure gauge burst during cylinder pressure checking

Consequences: Recordable Injury

What happened

An operator was injured when doing a pressure checking for medical oxygen cylinder . The incident took place when the operator tightened the screw, and opened cylinder valve slowly. While doing this , the gauge glass shattered injuring the operator on the right side of the chest. The operator was sent to the hospital immediately for treatment. The gauge that was used was not compatible for oxygen service.

Major Cause(s):

- Non oxygen compatible gauge
- Use of portable gauges for pressure checking

Event #12 Pictures

Event #13

Nickel rupture disc failure of CO cylinder

Consequences: Process Safety Event

What happened

The operator was analyzing the quality of other cylinders in the cylinder warehouse where he heard a sound which something had ruptured and he immediately evacuated from the warehouse. He went back to the warehouse and found that the ruptured disc of one cylinder was broken and all gases had been released. The gas was mixture of CO in balanced N2. There was no gas detector in the warehouse.

Major Cause(s):

- The Nickel material of the ruptured disc reacted with CO gas in the cylinder which made the thickness to decrease & this weakened the rupture disc
- Lack of exact procedure to select valve of appropriate specification
- Lack of knowledge of the workforce about reactivity of Nickel and CO gas

Event #13 Pictures

Picture of Ruptured Disc

Event #14

Customer Oxygen pipeline fire

Consequences: Lost time burn injury

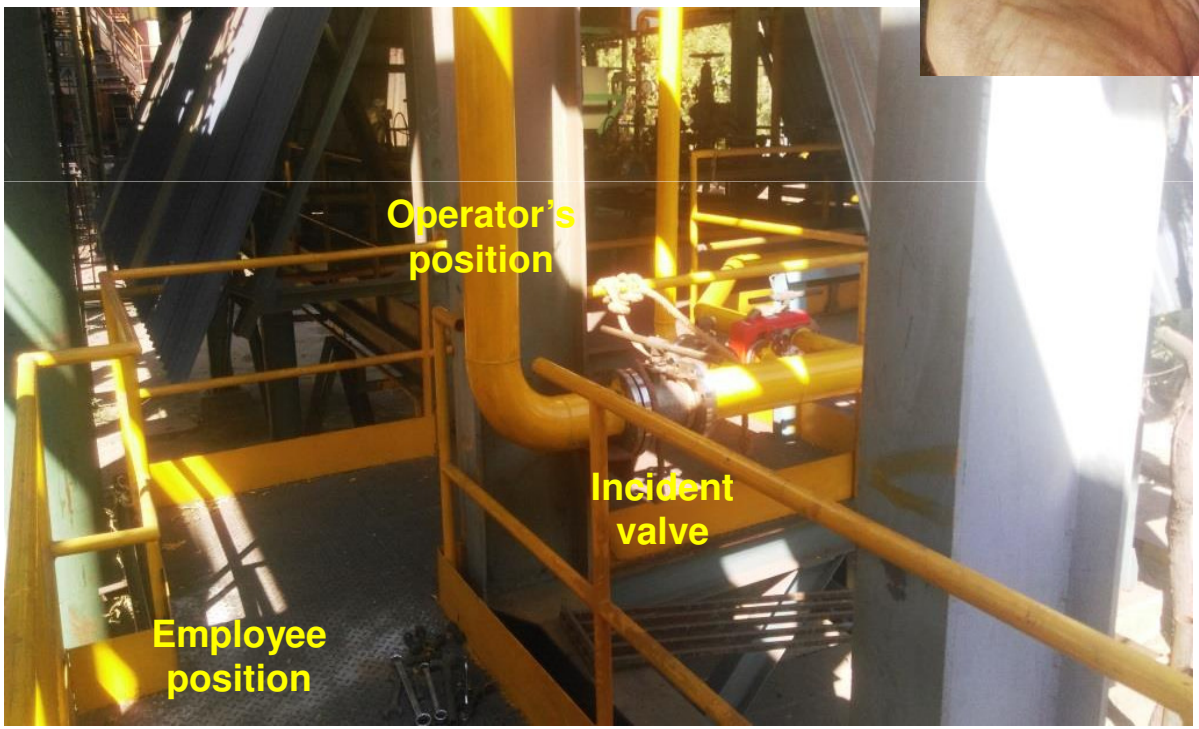
What happened:

Applications Support employee suffered a burn injury to the right forearm when witnessing the opening of a 6 inch ball valve on a customer oxygen pipeline during the commissioning of a stove oxygen enrichment project. The valve was being operated by a customer technician and oxygen was being charged for the first time in the pipeline when the fire occurred from the upstream flange on the valve. The employee was wearing FRC jacket, the arm of which got burnt.

Major Cause(s):

- Customer did not clean valve for oxygen service / Valve oxygen cleaning certificate not requested from customer
- Less than adequate FRC usage awareness / No SOP for charging oxygen for the first time in pipeline

Event #14 Pictures



Accidents / Incidents

related to

Maintenance work, Lifting & working at Height

Event #15

Tyre burst while inflating after on site repair

Consequences: Worker injury on forehead and lips

What happened:

During pre-trip inspection of a vehicle, a driver found one flat tyre. The maintenance team dismantled the tyre and decided to fix it on-site. They found the tube flap nipple broken, which was then replaced with a new one. The mechanic squat on the tyre to hold the tyre inflator and his supervisor sat on the tyre to control the pressure then they started inflating the tyre. They hear a “krek” sound when the pressure reached 60 psi, they continued inflating the tyre and suddenly around 70 psi the tyre burst. Mechanic was thrown up and fell with his forehead touching the ground first, and his helmet got detached. He was injured on his fore head and lips (got 12 stitches), and his supervisor thrown to the side but not injured.

Major Cause(s):

- Driver decided to run the vehicle with flat tire for long time the day before
- Mechanic’s initiative to repair tire on-site
- Wrong method & tools to perform the task

Event #15 Pictures

Injury - forehead & lips
Contractor mechanic has been “ejected” by the explosion.

Truck’s tyre burst after repair, while inflating

Event #16

Painting work in ASU – Oxygen Deficient Atmosphere

Consequences: High Severity Potential event

What happened:

Two contractors were doing anti-corrosive painting on pipe gallery near the ASU workshop (one was painting and the other was on standby). After painting the lower part of the steel structure, the contractor climbed up on the moveable scaffold and started to paint the higher part at about 2m height. When he was standing on the first floor of the movable scaffold, his portable O_2 detector alarm went on and showed that O2 content was 18%. The contractor evacuated immediately and the standby person reported the event to plant management. After inspection, it was found that a N2 storage tank purge outlet was discharging nearby the painting area which led to low oxygen percentage.

Major Cause(s):

- There was no warning sign around the nitrogen purge outlet.
- The risk with N2 purge outlet was identified during the risk assessment of the Safe Work Permit but only requirement of portable oxygen detector was identified
- No initial testing was done to determine ambient O2 content around the purge outlet and the safe work distance was also not defined.

Event #16 Pictures

During investigation the below ambient Oxygen analysis levels were found:

The distance from the horizontal position of nitrogen purge outlet	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m
Environmental oxygen content	12.70%	15.00%	18.00%	20.90%	20.90%

Event #17

Rapid swing of Cold Box while lifting

Consequences: Employee Lost time Injury (LTI)

What happened:

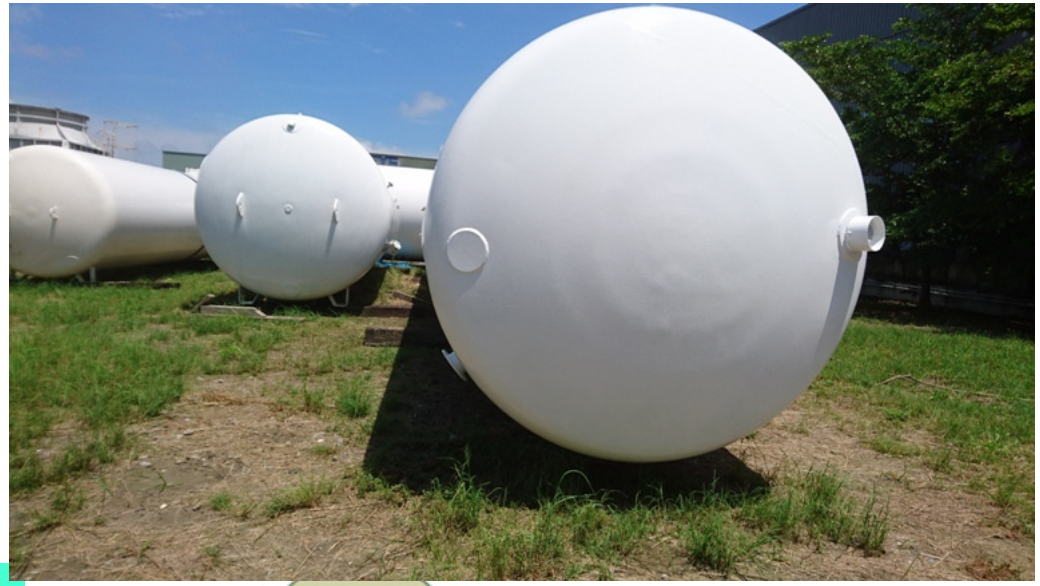
While lifting a N2 generator cold box 30 cm upward in order to re-paint this unit, the cold box swung rapidly towards the employee standing beside. The employee couldn't escape, as he was trapped in a narrow area (0.5 m x 9.5 m) between the cold box and a storage tank. He was hit on his chest, pressed between the cold box and the other tank lying aside.

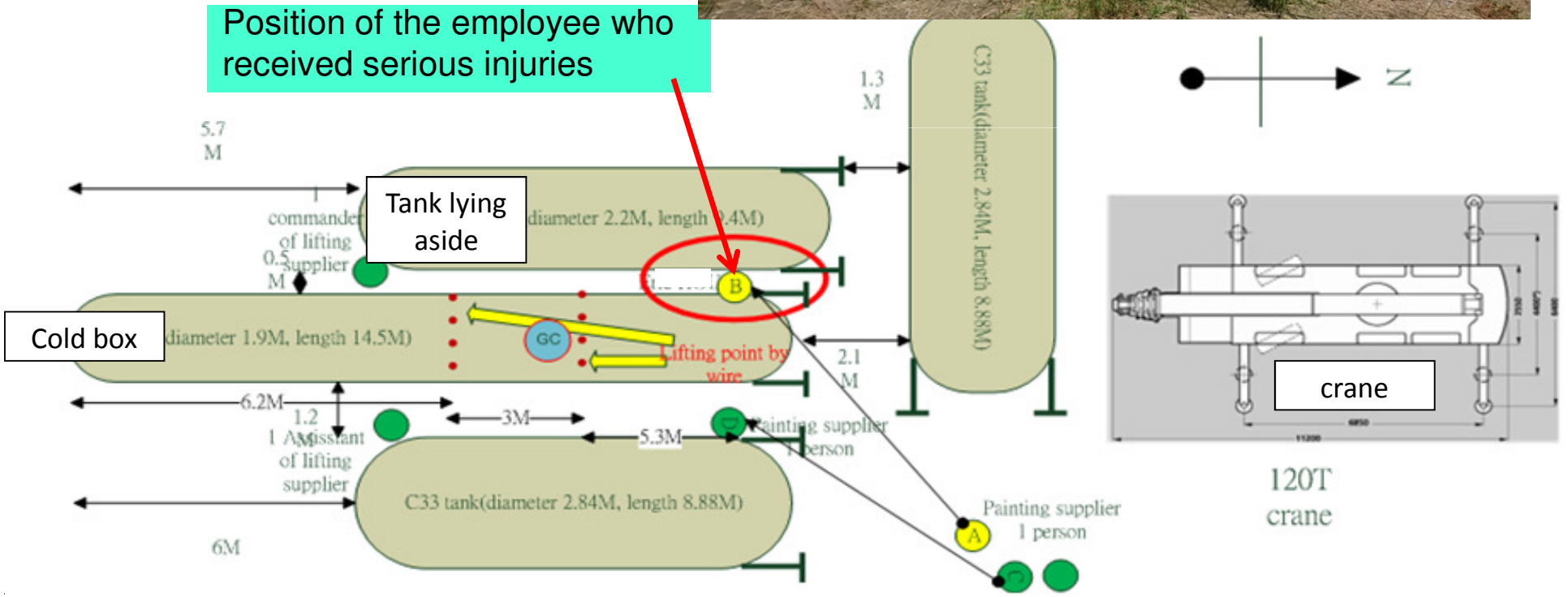
The employee suffered serious multiple injuries and required hospitalization for several weeks.

Major Cause (s):

- The specific risks about this lifting work were not properly assessed.
- A generic lifting plan was used and the injured employee was not involved in the job analysis exercise.

Event #17 Pictures





Event #18

GOX Pipe line breakage due to Cold Embrittlement (CE)

Consequences: Process Safety Event with property damage

What happened:

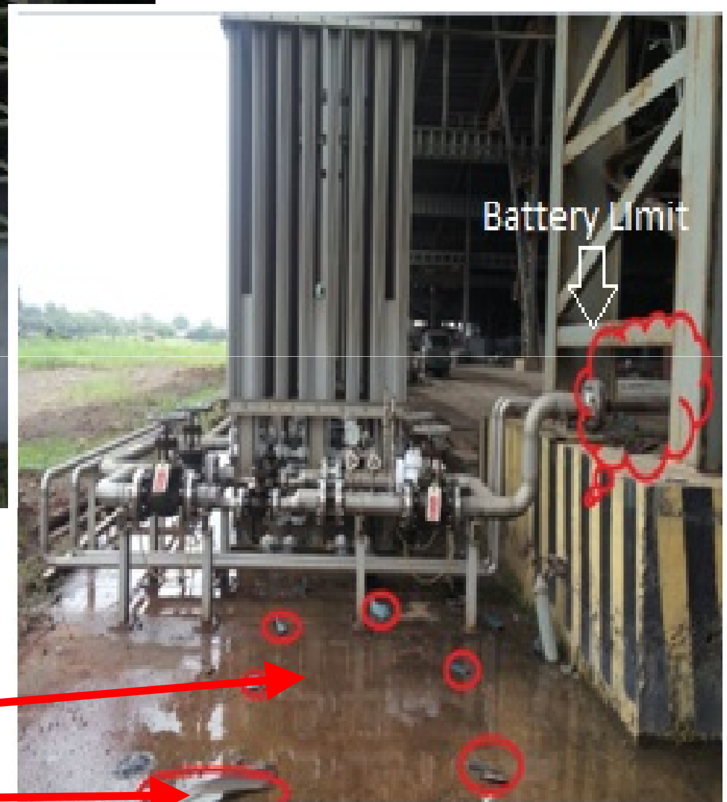
Low temperature alarm downstream of Lox vaporisers got activated at around 8:00 am at a customer Installation which was not noticed/ignored. Temperature of oxygen gas continued to drop and at around 10:30 am cold embrittlement incident happened, this led to bursting of customer's carbon steel pipe *(20m long x 4" diameter)*, interruption of customer's oxygen supply and release of liquid & gaseous O2 for 10 min. Nobody was injured.

- **Note:** 3 days prior the incident, customer informed of a 'temperature low' alarm activation at their Lox tank. Then a service technician visited the site and found the cold embrittlement alarm activated and icing on pipeline downstream of vaporizers up to the pressure reducing station. Increase in O2 consumption what noticed by the technician and he requested the users to reduce the same immediately. The situation was normalised within 30 min.

Main Cause(s):

- Protection design : Insufficient CE protection (only alarm, no shut-off valve)
- Sudden increase of customer's consumption beyond vaporization design capacity
- Previous alarm (3 days prior) not properly escalated to HSE & management

Event #18 Pictures



Scattered pieces
of customer pipe

Event #19

Workman falling from height

Consequences: Injury to worker

What Happened:

At a construction site two contract workers with safety harness & life line, were tasked to dismantle formwork at 7.8 m of cooling tower when the grating which they were standing on tilted, resulting in a sudden jerk on life line. One end of life line eye hook came out from anchor point, and both workers landed on 3.5 m RCC beam with loose life line & harnesses. One of the workers sustained minor cut injury in forehead & both of them had strain in muscle of waist .

There was no property damage.

Major Cause(s):

- Lack of risk assessment for implementation of safe systems of work – working at height

Event #19 Pictures

Event #20

Fall accident during maintenance work at height

Consequences: Lost Time Injury (LTI) of a mechanic

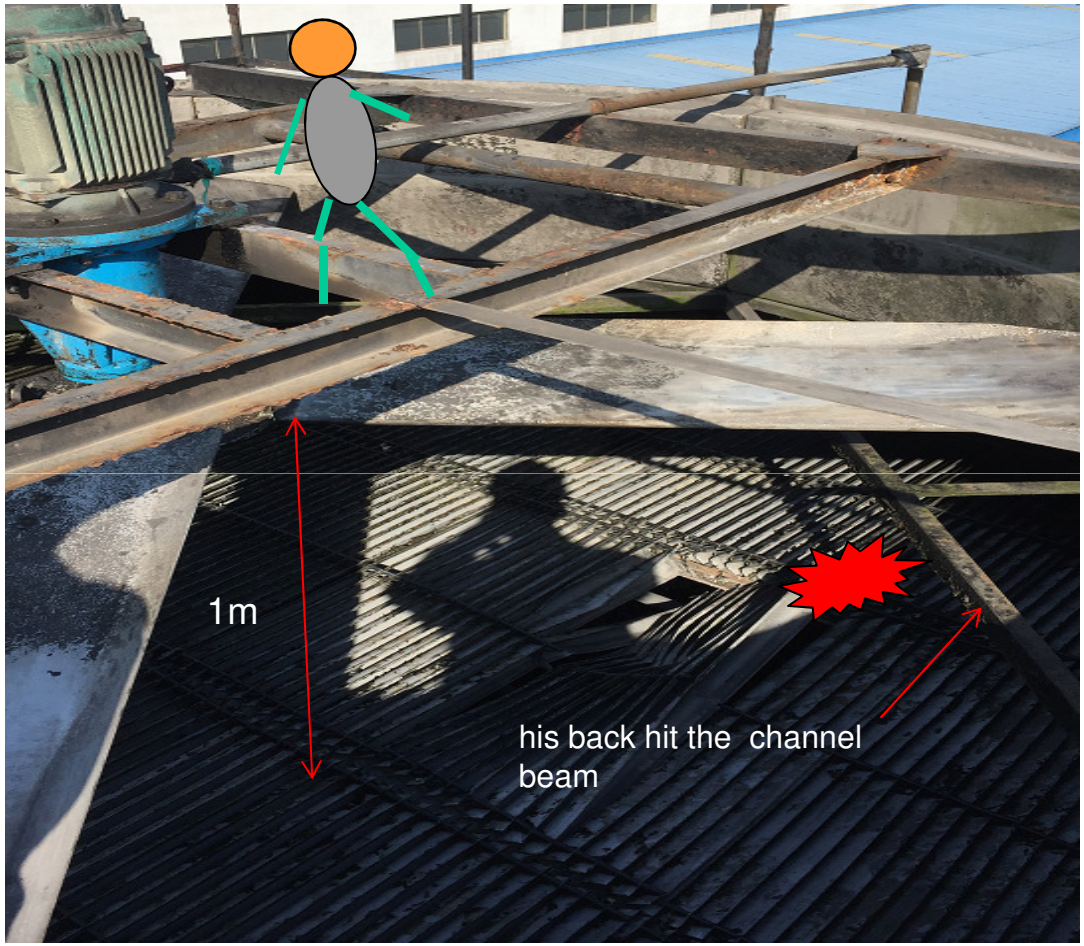
What happened

Around 8:00 am, a maintenance team had finished the repair work on a transmission of a cooling tower fan. While climbing down, one worker slipped on the steel frame which is supporting the fan and fell down (height around 1 meter). His back knocked on the girder and caused a fracture of back rib.

Major Cause(s):

- Lack of fall protection
- The mechanic's unsafe behavior

Event #20 Pictures



LESSONS LEARNED from the safety events

Transportation Safety :

- Road safety and especially **Fatigue management** is critical to avoid severe road accidents.
- Train each driver on Vehicle **Rollover Prevention**, using AIGA Training Package 18/15.
- **In Vehicle Camera** system shall help to significantly improve driving behavior.

Personnel Safety :

- **Discipline** & consistency in the application of safety rules (PPE, anti-whip cable, seatbelt…) are critic al to effectively limit the consequences of accidents.
- **Check for O2 level** & effective ventilation prior to work in potential O2 deficient atmosphere.
- **Safe Work Permit's golden rule:**

  "Always perform a physical site visit just before starting the work"
- Hazardous task & jobs have to be performed by trained & qualified personnel.
- **Lifting job is always an hazardous job** that need to be well prepared and well assessed.

Process Safety :

- **Cold embrittlement is a common & fatal risk of our Gas Industry** that shall be mitigated at all time. Customers must be trained on this risk and on how to react in case of alarm.
- Ensure 100% compliance to **material compatibility** and correct **oxygen cleaning** procedure

Main AIGA standards related to these accidents / incidents

- **AIGA 041/10:** Defensive Driving
- **AIGA 039/16:** Road Transport Emergency Preparedness
- **AIGA 040/15:** Good practice guide for loading & unloading of cryogenic liquid tankers
- **AIGA 008/10:** Safety Training for Employees
- **AIGA 015/15:** Safety Management of Contractors
- **AIGA 010/04:** Management of Change (MOC)
- **AIGA 011/04:** Work Permit System
- **AIGA 005/10:** Fire Hazard of Oxygen Enriched Atmosphere
- **AIGA 012/04:** Cleaning of Equipment for Oxygen Service

Thank you

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