Incident Title	**Hydrogen Trailer Transfill Facility Explosion**	
Incident Type	Explosion and Fire	
Date	1st June 2019	
Country	USA	
Location	Santa Clara, CA	
Fatalities	**Injuries**	**Cost**
0	2	Unknown

Incident Description

Credit: Air Products via H_2 Safety Panel

The Santa Clara transfill facility supplies gaseous hydrogen (GH_2) at 517 barg (7500 psig) and near-ambient temperature to high pressure tube trailers for delivery to retail fuelling stations. It comprises a liquid hydrogen (LH_2) storage tank, cryogenic pumps, ambient air product vapourisers, 5 parallel un/loading bays, an elevated vent stack and multiple hose connections. Bay #1 is used by LH_2 delivery tankers for filling the LH_2 storage tank. Bays #2 - #5 are used for filling GH_2 tube trailers. At the time of the incident, Bays #1 - #4 were occupied. In Bay #3, a dual-module tube trailer with a total GH_2 capacity of 500 kg (1102 lb) was being filled by 2 drivers (a trainer and a trainee). Both modules were being filled simultaneously using the automated fill system.

When both modules were almost full, the trainee noticed a GH_2 leak near the front module fill line isolation valve and reported it to the trainer who instructed the trainee to stop filling that module. However, the trainee stopped the filling process for both modules and did not uncouple the trailer from the fill system. The trainer then isolated the front module fill line, depressured the fill manifold, and removed a pipe spool. He soon realised he did not have all the required materials so instructed the trainee to shut off the GH_2 supply. The trainee misunderstood and pressed a "Purge/Enable Trailer" button which opened all pneumatic valves on the trailer, inadvertently restarting the fill process. GH_2 escaped from the open-ended pipe spool. The GH_2/air mixture ignited within 3 secs, causing a deflagration explosion followed by a jet fire. The trainer immediately pressed the emergency stop button. All pneumatic valves on the trailer closed either by this action or by plastic air supply lines melting. The explosion and jet fire caused additional leaks which escalated the fire.

Incident Analysis

Basic cause was a short duration release of high pressure GH_2 due to a cracked O-ring or leaking cone and thread fitting on the fill line isolation valve.

Critical factors included: 1) The 25-cylinder tube cluster in each module was partially enclosed in an open-top container (reduced leaking GH_2 dispersal rate and increased explosion overpressure), 2) Proximity of other tube trailers and cabs in adjacent loading bays (impacted by jet fires), 3) Brass pressure relief devices (PRDs) failed due to extreme heat from the fires.

Root causes included: 1) Inadequate training (leak repair), 2) Violation of Lock out/Tag out (LOTO) procedure (while attempting unauthorised repair), 3) Miscommunication (ambiguous control button labelling caused trainee to inadvertently initiate flow to open-ended pipe), 4) Inappropriate plant layout (un/loading bay spacing), 5) Inappropriate construction material (brass PRDs)

Lessons Learned

1) LH_2/GH_2 delivery drivers should all be trained on safe isolation of leaks.
2) LH_2/GH_2 system leaks require prompt (double) isolation of the leak source, depressuring to a vent stack and purging with inert gas (typically nitrogen).
3) GH_2 tube trailer module walls help contain internal jet flames and protect cylinders from external fire (but confinement can increase explosion hazard).
4) Flow-limiting devices (e.g. excess flow valves) can minimise leak rate in the event of an accidental release through an open or ruptured pipe.
5) Automatic water sprays can help mitigate escalation by cooling LH_2 tanks and LH_2/GH_2 trailers (but water ingress to vent may freeze and restrict flow).

More Information

1) "Report on the June 2019 Hydrogen Explosion and Fire Incident in Santa Clara, California", Hydrogen Safety Panel, Report No. PNNL-310150-1 (2021)

Industry Sector	Process Type	Incident Type
Industrial Gases	Gaseous Hydrogen Transfill	Explosion & Fire
Equipment Category	**Equipment Class**	**Equipment Type**
Mechanical	Piping	Fittings (Threaded Connections)

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