Incident Summary #II-1253159-2021 (#23971) (FINAL)

SUPPORTING INFORMATION	Incident Date		August 5, 2021
	Location		Delta, BC
	Regulated industry sector		Electrical - Extra low voltage (less than 30V)
	Impact – Injury	Qty injuries	17
		Injury description	17 Workers reported exposure to toxic gas, of which 12 went to hospital for assessment.
		Injury rating	Moderate
	Impact – Damage	Damage description	Toxic gas release from a lead acid battery
		Damage rating	Moderate
	Incident rating		Moderate
	Incident overview		Workers were exposed to toxic gases from the fumes of a continuously charging lead acid battery.
INVESTIGATION CONCLUSIONS	Site, system and components		- The site is a warehouse for storage and distribution of beverages. - The involved equipment was located on the third floor of the bottle tower in an area that is open to the lower levels. The buildings ceiling is directly above the third floor. - Areas on the ground floor where affected personnel were located are near entrance openings where gases could move to the exterior. - Airflow from the third floor air conditioning ducting system issues out downwards from the ceiling. - The Cubiscan 100 (figure 1) is a parcel measuring machine that takes dimensions, weights, and determines storage configurations using computer programs. A 120 volt powered charger (figure 2), a 12 volt battery, and a direct current (DC) to alternating current (AC) inverter (figure 3) comprise the power supply circuit for the Cubiscan as shown in the diagram (figure 4). - The Cubiscan was stored on the top tier of a two tier rolling cart with the battery, inverter and charger on the lower tier. - The lead acid battery (figures 5, 6 and 7) has six cells at 2 Volts each for a total of 12 Volts nominal. The battery converts chemical energy into electrical energy for loads, while conversely converting electrical energy from the charger into chemical energy when replenishing the charge of the battery. - Water loss is a normal condition when charging lead acid batteries as the charge current splits water into oxygen and hydrogen gases that escape through the vents. - Preventative maintenance plans for lead acid batteries typically include keeping the cells filled with water and testing the electrolyte (sulphuric acid) charge levels with a device called a hydrometer (figure 8). - The battery has caps on top of each cell that can be removed to fill its fluids. - Lead acid batteries contain sulphuric acid electrolyte and water. Balancing the amounts of these two fluids according to the hydrometer readings helps to ensure proper function of the battery. - Sulphur dioxide and hydrogen sulphide can be produced when overcharging batteries to the point where the electrolyte levels are depleted.

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	- Manufacturer's requirements include that lead acid batteries are to be charged in ventilated areas. - BC electrical code section 26 includes installation, storage and ventilation requirements for storage batteries including lead acid batteries. - Sulphur dioxide (SO_2) is a very toxic colorless gas with a pungent, irritating sulphur odour. It is corrosive to the respiratory tract, the eyes and the skin. In higher concentrations, it can cause life threatening accumulations of fluid in the lungs. - Hydrogen sulphide (H_2S) is an extremely hazardous, colorless, flammable gas with a "rotten egg" smell. - Exposure to either SO_2 or H_2S over 100 PPM parts per million can be immediately dangerous to life and health (IDHL). - Both SO_2 and H_2S gases are heavier than air and may travel along the ground and collect in low lying areas.
Failure scenario(s)	The Cubiscan parcel measuring machine was stored for three years on the third floor of the bottle tower as it was not in use. Prior to the incident, the charger was plugged in and the battery was left charging. This very likely resulted in four of the six cells, as the fluid levels depleted, emitting toxic gas such as hydrogen sulphide and sulphur dioxide gas into the indoor workspace as the remaining fluids boiled off. The gas was likely drawn to the open entry doors on the ground level where workers were exposed to the gas.

Facts and evidence	- The gas utility technician stated they smelled a sulphur smell as soon as they walked in the building and they are familiar with that being a battery off gassing smell.
	- Facility maintenance personnel stated:
	  - The Cubiscan's battery charger was connected to a power receptacle when they first investigated a very strong sulphur smell.
	  - They observed the battery bubbling, spitting water and its plastic case bowing out from pressure. When they unplugged the charger from the power receptacle, those effects stopped.
	  - The battery was being continuously charged, was likely low on water and overheated from a dry cell.
	  - Batteries in the warehouse are included in a preventative maintenance plan but the Cubiscan battery was not included in that plan as it was not in use and put in storage.
	  - The forklift batteries elsewhere in the building have smart chargers that turn off when the battery fluid levels get too low.
	- The facilities maintenance manager stated:
	  - They recognized the smell of a battery at the time of the incident and figured it was a battery somewhere as the facility has many batteries.
	  - The Cubiscan had been stored on the 3rd floor of the bottle tower for around 3 years but was thought to have been recently reconnected to the charger.
	  - The Cubiscan has a constant charged system and should always be plugged in.
	  - Twelve workers reported to the hospital after the incident.
	  - The facility is 450, 000 square feet and the Cubiscan was stored on the 3rd floor of the bottle tower.
	  - The rooftop hatches were closed at the time of the incident.

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	- Facility workers stated during initial medical assessment:
	  - There were pockets of strong foul smelling odour in the warehouse. They experienced stomach pain, confusion, persistent headache, dizziness and shortness of breath, sore throat, and sensitivity to light. Some stated they worked in the area with the foul smell for over 4 hours.
	  - That the fire department had their gas detectors go off but stated it could be a false positive. That the fire department had stated the smell was likely from a battery off gassing.
	  - That the gas utility had their gas detectors go off but were unable to find the source.
	
	- The gas utility technician ruled out a natural gas leak through on site testing.
	
	- The charger manufacturer's owner's guide states:
	They strongly recommend that you purchase and install the optional Battery Temperature Sensor (BTS) to protect your battery and improve charging accuracy. There was no evidence of a BTS installed on the battery involved in the incident.
	
	- The battery manufacturer's representative examined the battery and stated they found four of six cells empty (figure 6), and that the off-gassing is in line with overcharging and electrolyte burn off. They also confirmed that the battery was manufactured in 2018.
	- The battery manufacturer's tech support representative stated the battery requires fluid top off every 4-6 weeks and should be filled to ½" over the top of the plates inside. The manufacturer's web site confirms these fill requirements. They stated that H_2S can be produced when overcharging. They also stated that battery leaking is an indication of overcharging.
	- The battery manufacturer's safety data sheets for the battery state that the electrolyte may produce toxic gases including SO_2 and H_2S as products of hazardous decomposition (figure 9).

Causes and contributing factors	The incident was very likely caused by the extended overcharging of a lead acid battery without preservation of the battery's minimum fluid levels. The battery's exclusion from the site's maintenance plan was a contributing factor.

Figure 1 – Cubiscan parcel measuring machine (battery was on the bottom left)

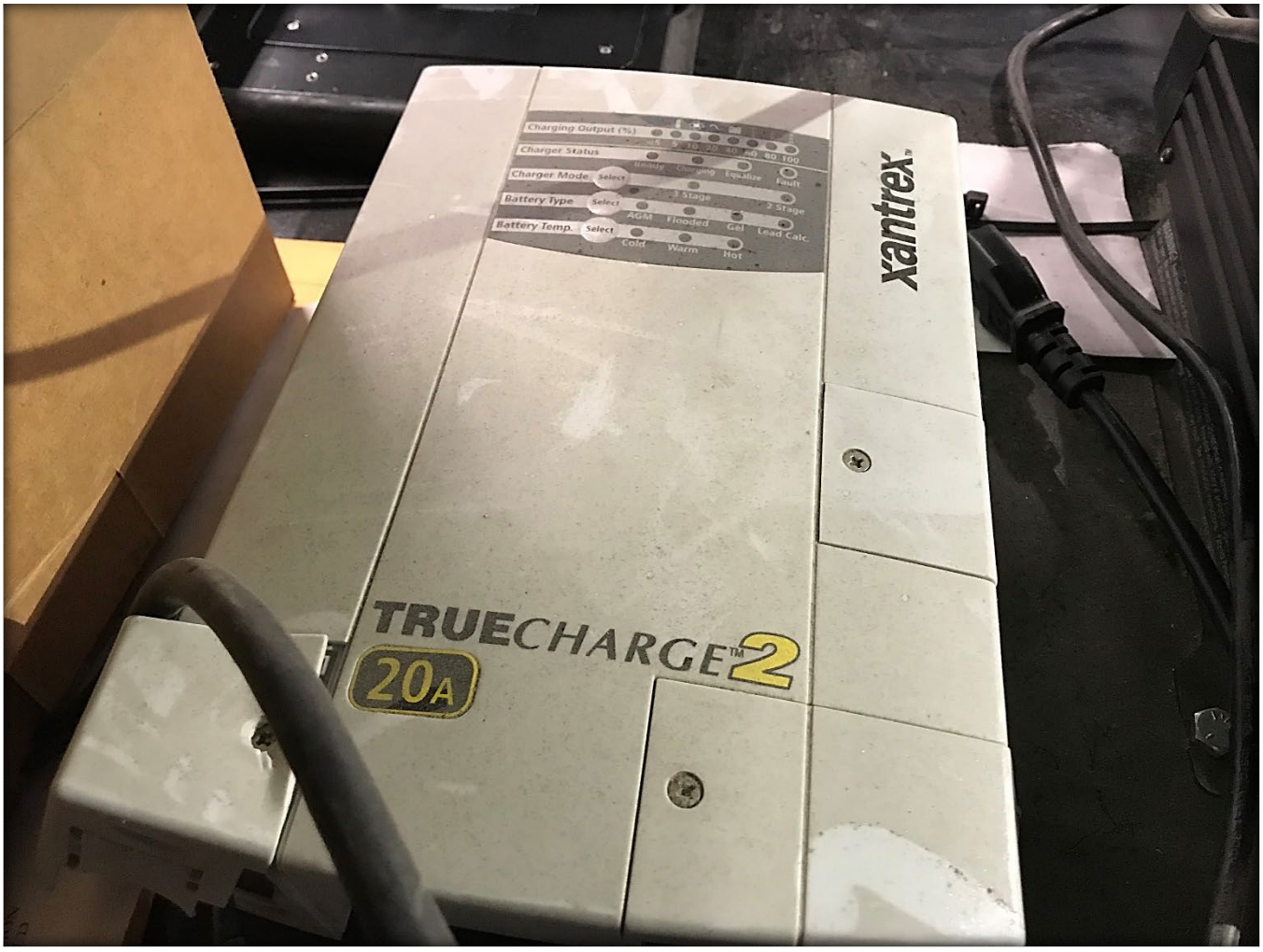

Figure 2 - Battery charger

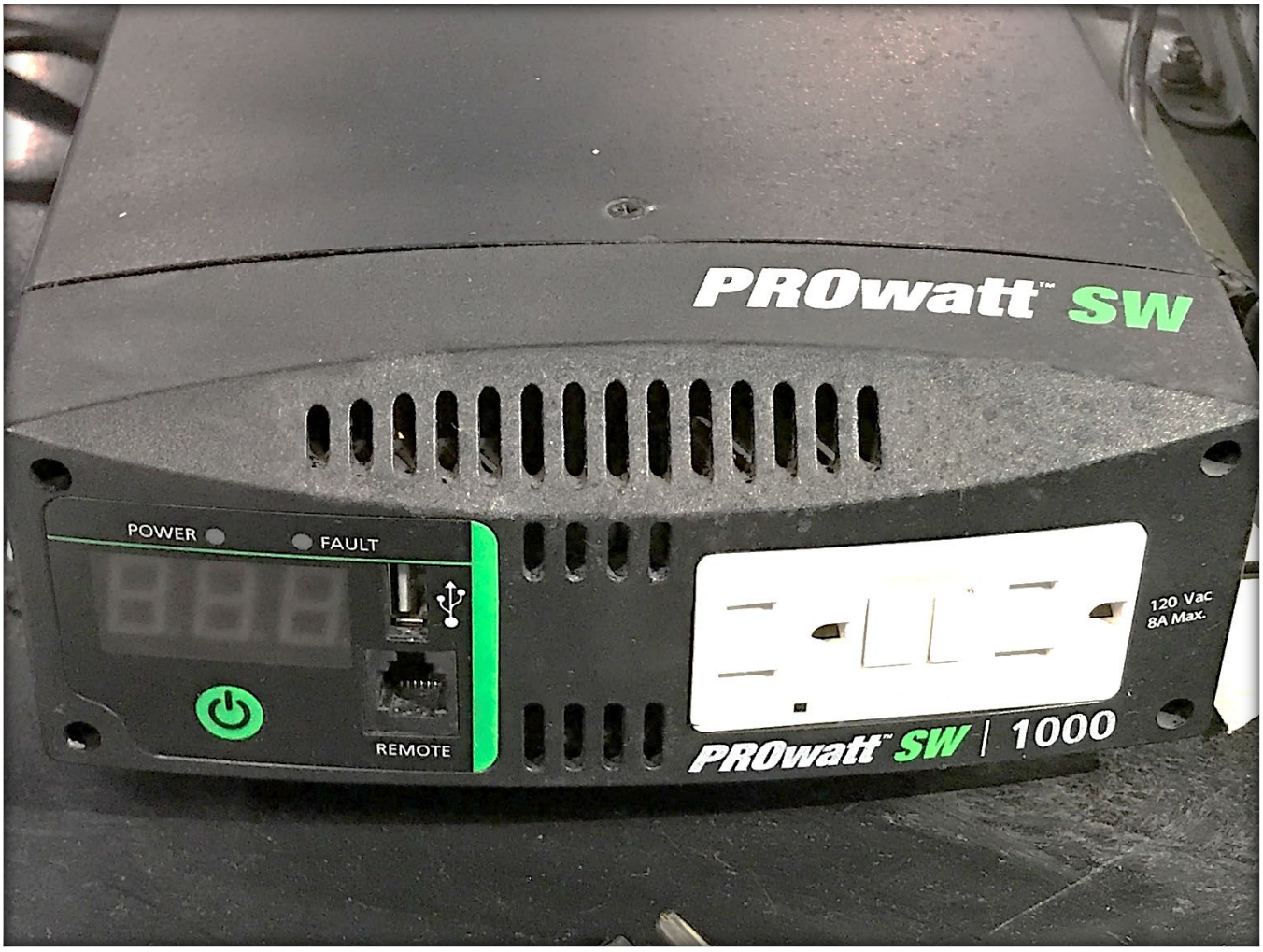

Figure 3 – Inverter that converts DC battery power to AC to power the Cubiscan 100

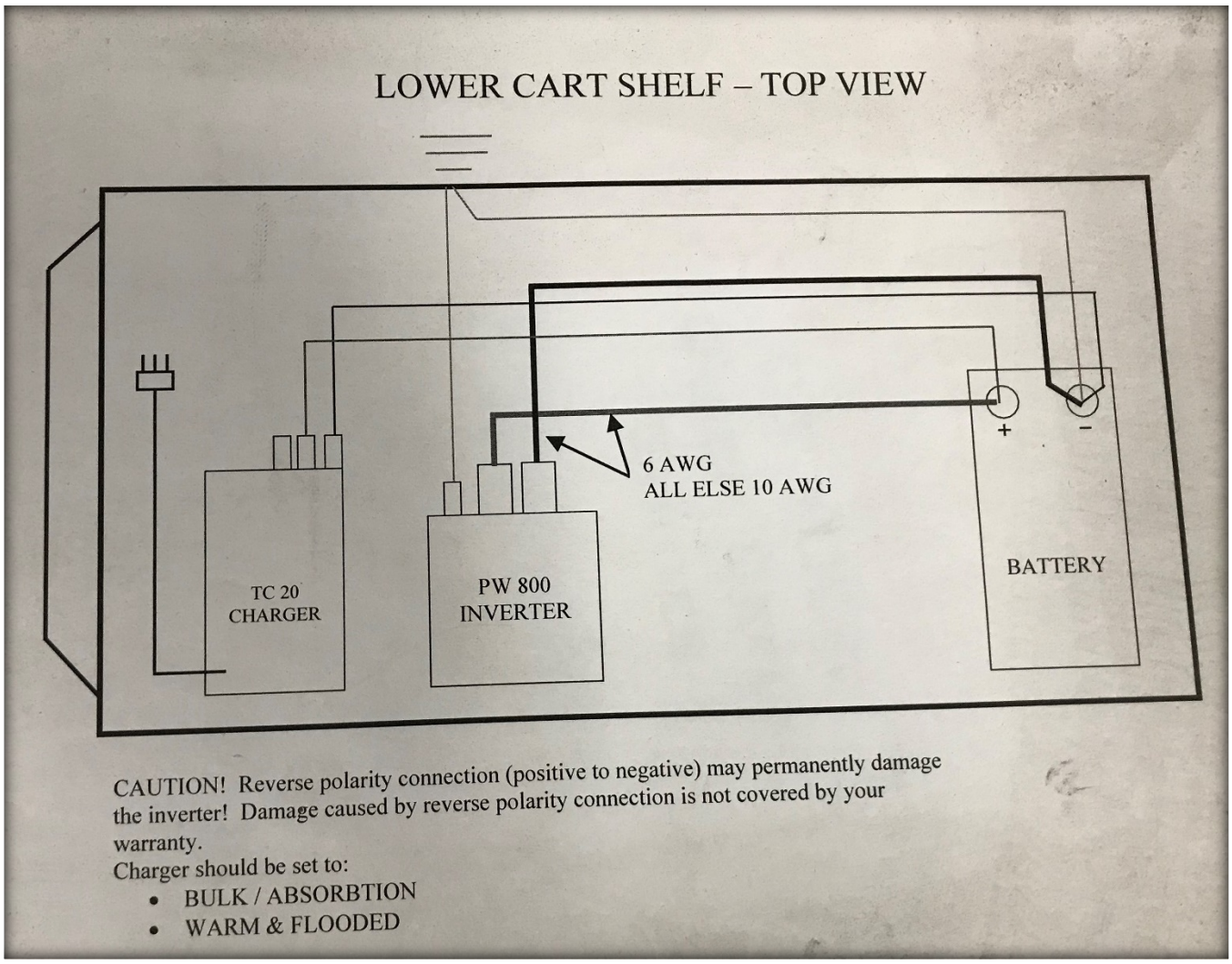

Figure 4 - Power supply system diagram from the Cubiscan 100 manual, charger was set as per the bullets.

Figure 5 - Battery showing signs of electrolyte residue (white powder)

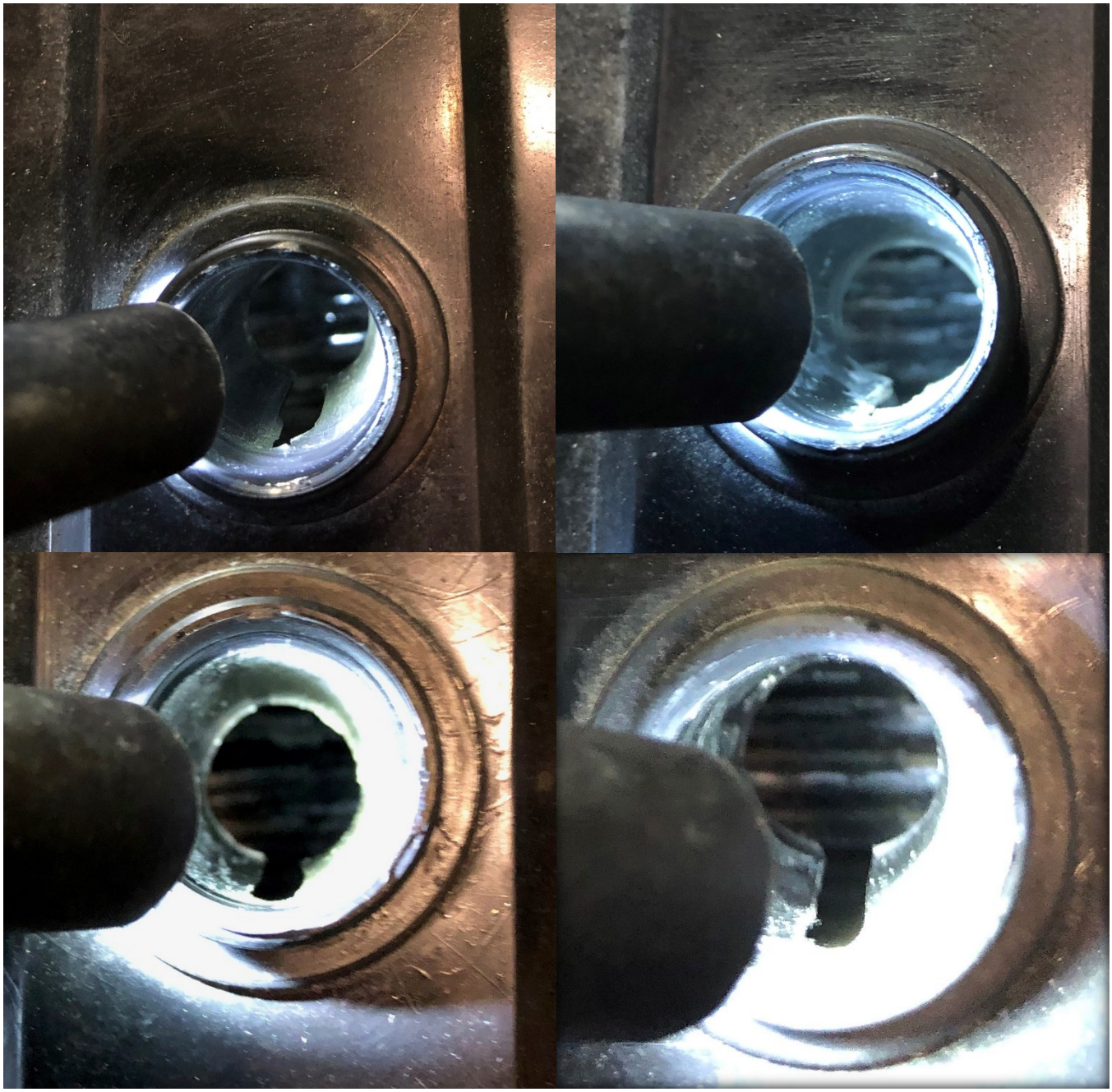

Figure 6 - Of the six cells, four were empty as confirmed by the battery manufacturer’s representative.

Figure 7 - Battery after the incident with fluid accumulations.

Figure 8 - Example battery testing hydrometer

10.6 Hazardous decomposition products

Electrolyte: Sulfur trioxide, carbon monoxide, sulfuric acid mist, sulfur dioxide, hydrogen sulfide.

Lead compounds: Temperatures above the melting point are likely to produce toxic metal fume, vapor, or dust; contact with strong acid or base or presence of nascent hydrogen may generate highly toxic arsine gas.

Figure 9 - Battery manufacturer's safety data sheet for the battery involved with the incident including SO_2 and H_2S as hazardous products of decomposition.