Maintenance Report
MCBH Hydrogen Filling Station

Prepared for HNEI
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1 OVERVIEW

The Hawaii Natural Energy Institute (HNEI) operates a Hydrogen fueling station at the Marine Corps Base Hawaii (MCBH) in Kaneohe on the windward side of the island of Oahu. The close proximity to the ocean, trade wind conditions, dust, and high temperatures provide and aggressive environment that is very harsh on the equipment and enclosures. Since operation has been suspended due to a lack of hydrogen vehicles, considerable maintenance work is required in order to preserve the equipment. A variety of variety of maintenance challenges were revealed and are documented in order to support future design considerations for operation in such an environment.

1.1 SYSTEM HISTORY AND TIMELINE

The Hydrogen filling station at the Marine Corps Base Hawaii has not been in use for approximately 2 years, since August 2015 when the GM Equinox fuel cell electric vehicle project was completed. Systems were periodically operated afterwards, but after failure of a pilot valve on the 700bar compressor in September 2015, no 700 bar compression could be performed pending replacement of the valve. Coolers and the electrolyser were exercised and in April 2016, the electrolyser was upgraded with a dew point sensor to meet Toyota technical requirements for fueling the Mirai fuel cell electric vehicle. In August 2016, 4 of the 9 electrolyser's power supply failed and no hydrogen was produced thereafter. About once a month, the electrolyzer was switched on to circulate fresh deionized water through the fuel cell stacks in order to preserve the Proton-Exchange-Membrane (PEM) stacks by keeping them hydrated. Progressive corrosion could be observed as illustrated in Figures 1 to 3. In 2017 a major effort to refurbish the electrolyzer was started.

2 OBSERVATIONS AND ANALYSIS

2.1 GENERAL CORROSION

The high salt concentration in the ambient air is a major concern at MCBH. The electrolyser uses a fan to maintain a positive pressure inside the fluid compartment and dilute any hydrogen leaks that may occur to ensure low concentrations of hydrogen in the enclosure, hence, there is a high volume of air throughput. The corrosion pattern highlighted in picture 4 shows exactly the effects of the airflow from the blower over the brass columns of the hydrogen dryer.


Fig 1: Fluid compartment, May 2014


Fig 2: Fluid compartment, Aug 2016


Fig. 3: Fluid compartment, May 2017

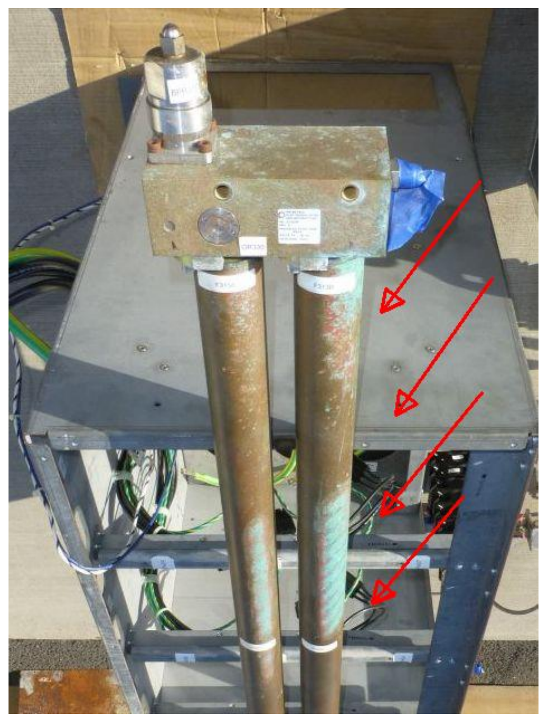
Fig 4: Corrosion by salt air flow

At times when the electrolyser is not running at high power and generating heat, the electrolyzer chiller cools the inside of fluid and electrical compartments below ambient temperature. Due to the high humidity, this leads to condensation of water and droplet formation on metal surfaces. The airflow enriches the water with salt and the metal surface corrodes rapidly as can be see in figures 5 to 7.

Fig 5: Electrolyser ceiling, April 2016

Fig 6: Electrolyser ceiling, August 2016

Fig. 7: Electrolyser ceiling, May 2017

2.2 WIRES AND TERMINALS

Wires and terminals or other connectors are also subject to corrosion and corrosion related failure. The connectors used were very well rated for the application, they are water protected and have specified corrosion resistance.

However, only moulded assemblies are truly IP67 (flood protected) because the problem on mounted connectors still remaining is the cable input. While we did not observe any problem with the mating contacts, we found internal corrosion through cable grommets that did not seal completely, see Figure 8.

Fig 8: Cable Corrosion

Fig 9 Terminal Corrosion

2.3 STAINLESS STEEL

In such environments the use of stainless steel is mandatory. Some assemblies, however included galvanised or other metallic components which are subject to corrosion, even more as metals with different electro-chemical potential are in contact in the presence of an electrolyte (salty water) which triggers accelerated galvanic corrosion. An example of a valve having a stainless steel body and galvanised nut and washer is shown in Figure 10.

Even stainless steel is not a guarantee for corrosion resistance. First there are many different qualities available (304, 316, 316L, etc.) and it is not always specified for every component. During machining with steel tools, tiny particles can be embedded into the surface of the work piece. Over time those particles can start to rust leaving unsightly stains. Only by special (and expensive) treatment of the surface (pacifying) can the tool-steel particles be etched out. This type of corrosion, as shown in Figure 11, however is more a concern for threads and does not severely impact the functionality of the component.

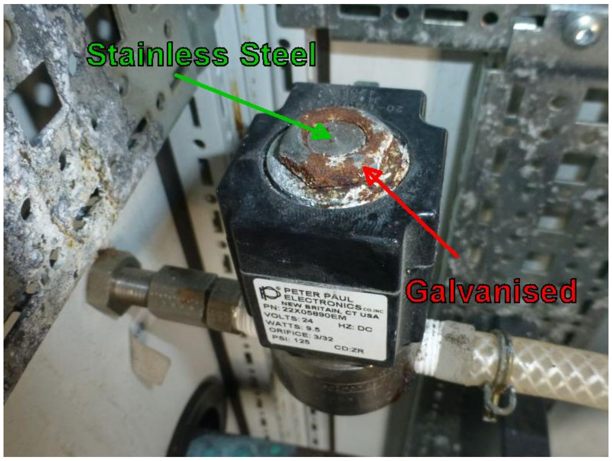

Figure 10: Mixed metals

Figure 11: Stainless Steel corrosion

2.4 ELEVATED TEMPERATURES

Another problem encountered is related to high ambient temperatures, especially in closed containers. Depending on the hazard zoning of the room (explosive atmosphere always/rarely present, etc.) and type of explosion protection (encapsulation, over pressure, dilution, etc.), the container might or might not have ventilation. Unfortunately, the container with 2 large electrical transformers does not have ventilation and ambient temperatures can exceed 40°C. This caused problem with PLC controllers, repeated PC failures and over-heated lead-acid back up batteries, as shown in Figure 12.

Figure 12: Overheated battery

2.5 Other Maintenance Work

Besides those specific technical challenges, maintenance work involved de-rusting and painting of containers and structural components, replacing hardened plastic hoses and identify and repair minor leaks on the hydrogen piping.

3 RECOMMENDATIONS

Periodic operation of major components such as the electrolyzer and compressors is very important for preserving the overall operability of the system. After problems with the fast fill chiller and related power supply failure of the electrolyser, no hydrogen was produced for several months. This also prevented the compressor from being operated which therefore needs special care for restart to prevent damage to the compressor seals.

The following findings were developed from our experience in the operation and maintenance of this station:

- Design the system to meet the challenges of the environmental conditions at the site and consider ample ventilation and filtration of salty or dusty air.

- Only use high quality stainless steel components. While it increases the initial procurement cost, the reduced maintenance and replacement costs will more than pay back the additional upfront cost.

- Operate major components weekly. Sitting in a hot, humid, and corrosive environment reduces life span of the system. Operating the machinery (e.g. compressor, pumps etc.) ensures that bearings remain lubricated and metal parts will not seize up.

- Wash exterior surfaces with fresh water, especially air breathing radiators, and change filters frequently.

- Keep a stock of filters and other consumables to avoid prolonged down time during which operation is not possible.

- Inspect frequently for corrosion and initiate maintenance as soon as problems are discovered to keep them from spreading

- Ensure proper grounding of all metal objects.

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