Lessons Learned Entry 4056 KATHLEEN O BRADY video text

Michael: So Kathleen, can you tell me how you found this problem on the orbiter with the fuel cells?

Kathleen: Sure, the way the problem occurred is you actually have to have a little background on the fuel cells in the beginning. So, the orbiter has three fuel cells that provide all the power to the vehicle while it is on orbit. They provide DC power to the associated main busses, which then distribute it to the systems throughout the orbiter. We also have some equipment on the orbiter that is rotary equipment. Three phase AC equipment, so that DC power is then converted into AC power through three AC inverters in order to utilize the other equipment. It then, provides power back to the fuel cell in order to operate the fuel cells cooling pumps. Just like any other power system, it needs to keep its thermal condition set. So, on orbit it's a great operation and everything goes flawlessly because they are all interdependent on each other. Now, on the ground, what happen was we had two instances where the fuel cell was not actually connected to the main bus, and the main bus didn't have power, but now the main bus doesn't have power, and the AC bus didn't have power so the coolant pumps on the fuel cell did not have power. So, the fuel cell normally operates around 180 degrees and while it's on load it keeps its temperature pretty well, but once the main bus load is removed the fuel cell will start to cool. Once the fuel cell starts to cool, the fuel cell has a parasitic sustaining heater that will turn on in order to keep the fuel cell at the correct operating temperature. Well, what happened on this occasion is the coolant was not flowing any longer just because the AC power is completely removed from the bus, now we have localized heating within the fuel cells so now the coolant is stuck in this heater, it can't move, the heater turn-off point is up stream of that, so with the coolant not flowing the heater never knows when to turn off, so the heater just stays on. And now you have localized heating within the fuel cell and then you resulted in overheating the coolant within the fuel cell. So, it was kind of a big problem and we didn't realize we had it until it occurred the first time. And didn't realize the scenario was possible and then we thought we had put all the precautions in place to prevent this from happening again, and then we had something as simple as an inadvertent switch throw that removed the fuel cell, the wrong fuel cell from the bus and voila, we had the same incident happen again.

Michael: So Kathleen , why is this an important part of the shuttle?

Kathleen: Well, the important part of this incident, I mean the fuel cells do provide all the power while on orbit, so you want highly reliable equipment. Each fuel cell is certified to run for 2600 hours currently. So, you don't want to remove a fuel cell prematurely. On the second occasion that this happened we actually had to remove the fuel cell after only one mission, which is about 200-300 hours and the other really bad part about this is when the coolant that is inside the fuel cell overheats it breaks down into some really nasty stuff, like phosgene gas and hydrogen chloride, which is extremely acidic and corrosive to what is inside the fuel cell, so we had, in both instances we had to remove the fuel cell prematurely.

Michael: So, what would you recommend to new vehicles, future designs, should we avoid this?

Kathleen: Having passive thermal control mechanism within the fuel cell so instead of having active cooling pumps within the fuel cell, have some sort of passive method of cooling; like a heat pipe or something along those lines. Or, if you're going to have another piece of rotary equipment, utilize the power that is being produced by the fuel cell, whether that being having a parasitic AC inverter that can convert it, and run your pumps or some other way so that whenever the fuel cells operating it's not relying on an external source in order to power its cooling mechanisms and maintain its thermal temperatures.

Michael: So can you tell me is there anything interesting how you found this problem?

Kathleen: The original time we found this problem was actually out at Dryden, and we were both these times, both these occurrences were on landing and it was in the established, it when you go from landing from transfer from fuel cell power since the orbiter has been powered by the fuel cell the entire time, to ground power . And in this instance they brought ground power up on the bus, they removed the fuel cell from the bus and an inadvertent switch throw. Something as simple as flipping the wrong switch. Instead of flipping fuel cell one, they flipped fuel cell two, and that removed all the power from that buss.

Michael: Well, great, Kathleen thank you for sharing your knowledge on this Lessons Learned.

Kathleen: Thank you.