



TVAC Functional Testing in Chamber A: Operational Lessons Learned

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VIPER Rover on the Moon

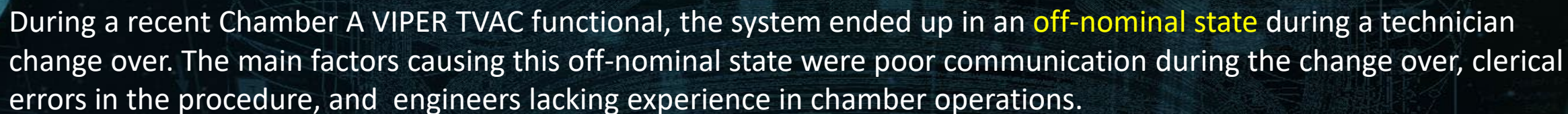
VIPER stands for **Volatiles Investigating Polar Exploration Rover**

Mobile Robot to locate and analyze water/ice on the lunar South Pole

VIPER will be tested by simulating conditions at the lunar pole in a TVAC

JSC's **Chamber A** is a 55 ft diameter x 90 ft high, thermal-vacuum test facility





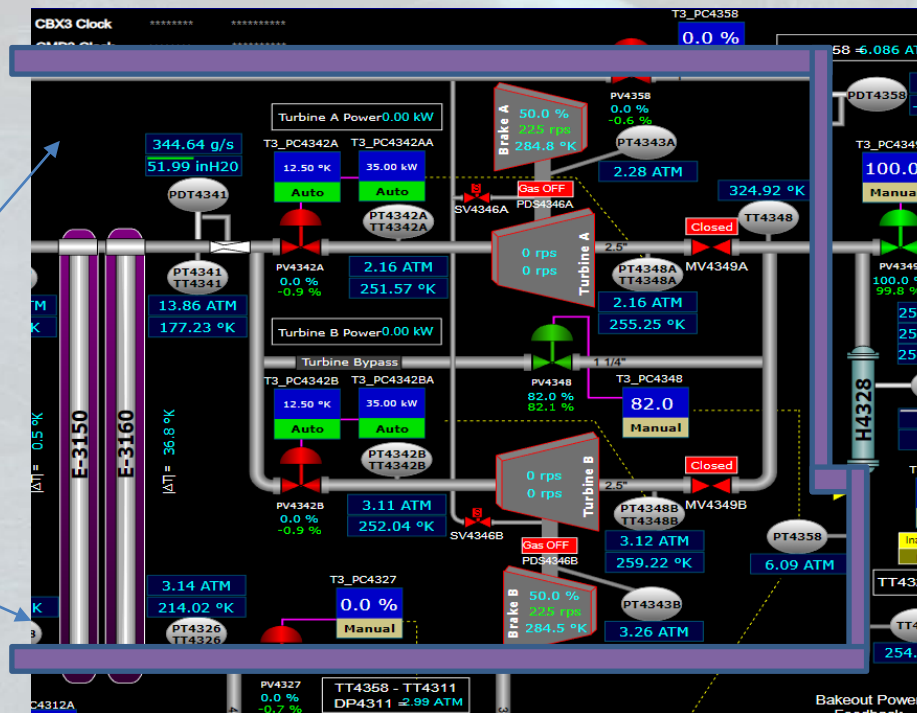
The best steps to recovery from most off-nominal states are to review the procedure and return to the last nominal state and repeat the proper steps. It was not possible in this case as Helium HX was already at 80K. We conjectured that we had an Imbalance Flow.

What we did: We needed to reverse the actions that caused the imbalance flow in the first place so that we could slowly warm the HX back up. When entering the Off-nominal conditions, we had more flow on the inlet of the heat exchanger than the return causing it to cool. To warm the HX back up, we needed more flow on the return than the inlet of the HX. We did this using PC4358 to introduce additional helium bypassing the top of the HX and flowing back across the return.

This was done slowly as the gas coming from PC4358 was at ambient temperature. We focused on the CBX by isolating the chamber.

By passing
HX inlet

Returning
Across HX

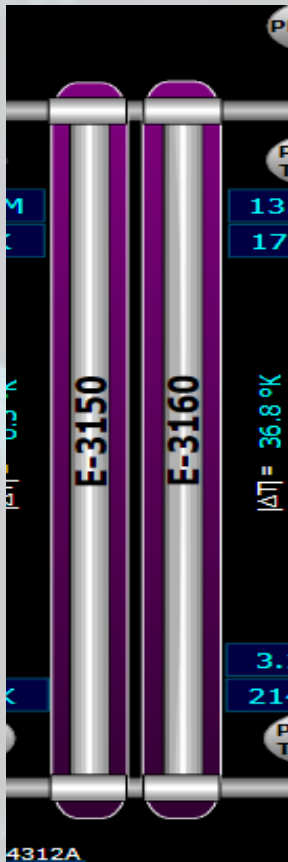


Heat exchangers and how to drive and control them are non-intuitive.

Instinctively, operators may conclude that the temperature differential across the heat exchanger is driving HX changes

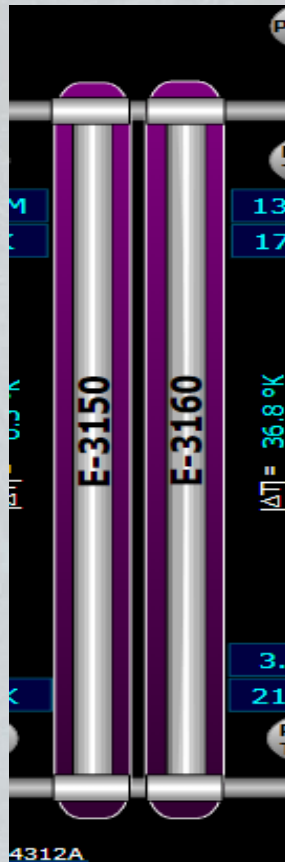
It is much easier though to understand and operate heat exchangers by thinking about flow.

Inlet flow



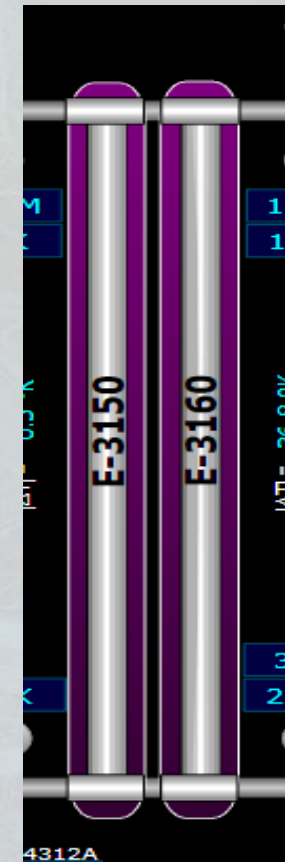
When the flow is greater on the inlet than the outlet. The temperature at the inlet will continuously decrease until it reaches the temperature (80K) of the gas flowing in. The larger the difference in flow the quicker this happens and the larger the delta created

Balanced Flow



When the flow is balanced the temperatures on the heat exchanger will be steady and equalized. There will be no delta across the heat exchanger

Outlet Flow



When the flow is greater on the outlet than the inlet. The temperature at the inlet will continuously increase until the inlet temperature reaches the outlet temperature. Once again, the larger the flow difference the quicker this happens and the larger the delta this creates.

3 scenarios of how the heat exchangers in CBX3 operate



Root Cause

The layout of the procedure caused the Step to close 4311 to be missed during technician changeover as the buyoff for the step was on a different page than the actual action for the step. During the changeover, there was a miscommunication as all the steps on the next page were to be N/A as they were completed earlier during the test. This resulted in an assumption that the step to close 4311 had been worked even though it had not. The engineer working the shift had never run CBX3 before and was unaware that 4311 needed to be closed

Solutions

Communication during changeovers along with proper procedures, and engineering experience are all critical and any of these could have prevented this from occurring.

1. All buy offs need to be on the same page, so it is clear if work has been completed or not.
2. If steps are being run out of order or marked N/A, it needs to be communicated to everyone exactly what steps still need to be completed and assumptions should not be made.
3. Training and experience are vital to identifying off-nominal states before they become bigger problems