Procedures for Abnormal LH2 Target Situations

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1. Lost of electrical power – no cooling no monitoring
    a. Short 15-20 min power outage
        i. *The UPS should keep the hydrogen alarm system powered and also PV205 closed for about 15 – 20 min*
        ii. *No action required*
        iii. *Follow target pressure from manual gauges*
        iv. *If pressure climbs over 2 bar open MV128 to reduce pressure in the target*
        v. *Contact senior target operator*

    b. Longer than 20 min power outage
        i. *The UPS keeps the Alarm system and PV205 closed for about 20 min*
        ii. *To prevent the loss of the isolation vacuum close valve MV505 on the Ar/He reservoir. When the battery of the UPS runs out only the gas in the tubing will be released to the vacuum causing a vacuum alarm and a slow boil off of the LH2*
        iii. *Open MV128 to keep pressure low in the target*
        iv. *Try to find out the reason for the lack of power – if it is a breaker trip – follow the lab rules to reactivate the breaker*
        v. *Follow target pressure in P105. Do not do anything, target will vent itself*
        vi. *Contact senior target operator*

2. Lost of one of the cryo coolers
        i. *The target will stay cold with one cryo cooler*
        ii. *Follow target temperatures and pressure*
        iii. *Try to fix the cooler*

iv. *Contact a senior target operator*

3. Lost of one of three heaters
    i. *A consequence is that the target pressure will decrease below ambient pressure which we do not want – we want to operate the target with positive pressure*
    ii. *Try to bring the target temperature with the two working heaters to the level that the target pressure is slightly over the ambient pressure of 11.2 psia (=580 Torr or 0.77 bar)*

4. Lost of PT106
    i. *PT106 is the main pressure gauge to monitor the target pressure*
    ii. *Pump He gas out from gas manifold up to MV126*
    iii. *For the monitoring of the target pressure open MV126 and monitor pressure with PT105*
    iv. *Note that PT106 is connected to the target alarm and warning system*

5. Ice block in exhaust line
    i. *With the ice block we mean an ice block in the exhaust line that fully closes the line and thus separates the target vessel and the relief route creating a hazardous over pressure situation*
    ii. *The ice block can be a consequence of an air leak into the exhaust circuit – probability for this is very small. The thorough leak check is very important*
    iii. *Indications that there is ice formation in the exhaust line, can be an extra heat load but if the leak is small the heat load cannot be recognized. Normally during the formation of the ice there is instability in target temperatures and pressures*
    iv. *Indicator for the ice blockage in the exhaust line that closes the line, is the low pressure in PT106 though the target heaters are on. Note that heaters have set points and it can be that they are not heating since the target temperature is higher that the set points*
    v. *To clear the ice block in the exhaust line do following. These tasks should be performed by a senior target operator:*
        1. *See around if there is an evident reason for a leak*
        2. *Contact a senior target operator and inform about the problem.*
        3. *With the supervision of the senior target operator*
            a. *Add He gas through the gas panel and MV126 to the exhaust line little over ambient pressure. The He gas will prevent more air coming in and also it will start to warm the exhaust line and the ice block.*
            b. *Try to heat the target and see if a pressure increase in the target will increase reading of PT106.*

c. *Find the hydrogen PT- phase diagram – table should be in the target manual folder – and using the diagram bring the target temperature to XYZ K that elevates the pressure in the vessel to 45 psia. This pressure should break the ice block. If not then;*
d. *Use the maximum heat in the heater H4 to help to warm the exhaust line more*
e. *If this doesn't help then connect a pump to the port in MV127 and then flush He gas from the gas panel through MV126 and pump it out through MV129 and MV127. This will warm the pipe more effectively.*

4. *If these actions do not help then the experiment has to inform CCR, EAM, and line management about this potentially serious target condition.*
5. *Note that as long as one of the cryocoolers is functioning, the target is cold and safe.*
6. *More complicated methods to open the blockade can be only performed if approved by lab's Emergency Management*

6. Ice block in the precooler
   a. Ice block in He lines
      i. *Stop Helium flow from the Dewar*
      ii. *Pull out transferline*
      iii. *Feed warm Helium gas to circuit*

   b. Ice block in Hydrogen precooling/ OPC loop
      i. *Stop Helium cooling*
      ii. *Feed warm Helium gas to the Helium loop*
      iii. *Keep Helium pressure on the hydrogen inlet*
      iv. *When the blockage opens, the Hydrogen target needs to be emptied because there is air in the system*

7. He signal in isolation vacuum
   i. *Depending on the size of the signal*
   ii. *Contact senior operator*
   iii. *If the signal is growing, empty the target*

8. Malfunctioning LH2 panic button
   Function of the panic button is in a case of emergencies to spoil the vacuum by opening the PV205 which will allow Ar/He gas mixture to fill the isolation vacuum
   i. *To dump the gas to vacuum the PV205's (normally open valve) control circuit has to be opened. PV205 is interlocked to the*

Hydrogen alarm in the cave or the panic button has been pushed and it opens the control circuit.

ii. *If panic button is not functioning, use the cable cutter attached to the panic button to cut the* cable.

iii. *Panic button should be only used in emergencies such as; fire in ER2 or other long-term ER2 evacuation that would prevent access to ER2 to monitor the LH2 target*

iv. *The target response to an activation of the panic button:*

1. *Isolation vacuum alarm sounds and LED is on*
2. *Helium partial pressure alarm sounds and LED is on*
3. *Hydrogen target pressure warning sounds and LED is on*

9. Hydrogen fire in one of the joints

Note a hydrogen fire is not visible. If hydrogen from a leaking joint starts to burn

i. *Warn coworkers about the fire*
ii. *Remove combustible material out from fire*
iii. *Limit the hydrogen volume by closing proper valves*
iv. *Let the hydrogen burn off*
v. *Contact a senior target operator*
vi. *Inform CCR, EAM, and line management*
vii. *If fire is large, trigger the general fire alarm*
viii. *If possible without any danger, close proper valves*

10. Clear low oxygen alarm in cave

a. *To clear an oxygen alarm in cave check that there is no cave hydrogen alarm*
b. *Open the door*
c. *With the handheld meter, enter cave if safe.*
d. *Reset alarm and check its calibration*