Overview of the Hall D LH2 Target Control Logic

cdk 4-26-14

Important ALARMS on: OVC vacuum
Gas pressure (fill & exhaust)
Condenser temperature
Cell temperature (top & bottom)

The alarm settings change according to the Target Status.

We will be able to override these

Three relays will be used to turn off compressor in case of error:

1) Target goes sub-atmospheric (pressure switch on gas panel set to 15 psiA)
2) Condenser heater fails (condenser thermometer < 20 K)
3) Bad OVC vacuum (OVC gauge)

- Three buttons for Hall D personnel to control the target.
- A different set of alarms and heater settings is loaded by each button.

Fill Target w/ LH2

Cools target low enough to fill cell with LH2.

Empty Target

Boils LH2 from cell. Fridge is warmed above condensation point.

Target OFF

Boils LH2 from cell. Compressor turned OFF.

A simple target status is displayed at all times:

"Target is Cooling";
➔ "Target is FULL & Ready for Beam";

"Target is Emptying";
➔ "Target is EMPTY & Ready for Beam";

"Target is OFF and Warming Up"

Fill Target w/ LH2

Check error status
Load cooling alarm settings
Load liquid set point (21K) into condenser control heater PID
Turn Compressor ON

Set status to "Target is Cooling"

When top thermometer in cell is COLD:
Load liquid alarm settings

"Target is FULL & Ready for Beam"

Empty Target

Load gas alarm settings
Load gas set point (25K) into condenser control heater PID
Turn Boiling Heater ON

Set status to "Target is Emptying"

When bottom thermometer in cell is WARM:
Turn Boiling Heater OFF

"Target is EMPTY & Ready for Beam"

Target OFF

Load warm alarm settings
Turn compressor OFF
Condenser control heater OFF
Boiling Heater ON until bottom thermometer is WARM (25K)

Set status to "Target is OFF Warming up"

Fill Target w/ LH2

Check error status
Load cooling alarm settings
Load liquid set point (21K) into condenser control heater PID
Turn Compressor ON

Set status to "Target is Cooling"

When top thermometer in cell is COLD:
Load liquid alarm settings

"Target is FULL & Ready for Beam"

Empty Target

Load gas alarm settings
Load gas set point (25K) into condenser control heater PID
Turn Boiling Heater ON

Set status to "Target is Emptying"

When bottom thermometer in cell is WARM:
Turn Boiling Heater OFF

"Target is EMPTY & Ready for Beam"

Target OFF

Load warm alarm settings
Turn compressor OFF
Condenser control heater OFF
Boiling Heater ON until bottom thermometer is WARM (25K)

Set status to "Target is OFF Warming up"

Fill Target w/ LH2

Check error status
Load cooling alarm settings
Load liquid set point (21K) into condenser control heater PID
Turn Compressor ON

Set status to "Target is Cooling"

When top thermometer in cell is COLD:
Load liquid alarm settings

"Target is FULL & Ready for Beam"

Empty Target

Load gas alarm settings
Load gas set point (25K) into condenser control heater PID
Turn Boiling Heater ON

Set status to "Target is Emptying"

When bottom thermometer in cell is WARM:
Turn Boiling Heater OFF

"Target is EMPTY & Ready for Beam"

Target OFF

Load warm alarm settings
Turn compressor OFF
Condenser control heater OFF
Boiling Heater ON until bottom thermometer is WARM (25K)

Set status to "Target is OFF Warming up"

STATUS: Cooling Target

Target cell is cooling but not yet filled with LH2, as indicated by top and bottom cell thermometers $\gtrsim$ 21 K

Condenser PID Set Point: 21.0 K

Condensation pressure is about 18 psiA

Boiling Heater: OFF

COOLING ALARMS: Require 5 consecutive readings to produce alarm

Sensor	Units	LO	HI
OVC vacuum	Torr	$1 \cdot 10^{-9}$	$5 \cdot 10^{-5}$
P_fill,P_exhaust	psiA	15.5	28.0
T_condenser	K	20.5	300
T_top, T_bot	K	20.5	300

VP Curve of LH2 (freezes ~14K)

P (psia)	T (K)
14.7	20.37
15.0	20.44
16.0	20.66
17.0	20.87
18.0	21.08
19.0	21.27
20.0	21.46
21.0	21.64
22.0	21.82
23.0	21.99
24.0	22.15
25.0	22.31
26.0	22.47
27.0	22.62
28.0	22.77
29.0	22.91
30.0	23.05

STATUS: Liquid Target

Target cell is cold and filled with LH2, as indicated by top and bottom cell thermometers ≲ 22 K

Condenser PID Set Point: 21.0 K

Boiling Heater: OFF

LIQUID ALARMS: Require 5 consecutive readings to produce alarm

Sensor	Units	LO	HI
OVC vacuum	Torr	$1 \cdot 10^{-9}$	$5 \cdot 10^{-5}$
P_fill,P_exhaust	psiA	15.5	28.0
T_condenser	K	20.5	21.0
T_top, T_bot	K	20.5	21.0

VP Curve of LH2 (freezes ~14K)

P (psia)	T (K)
14.7	20.37
15.0	20.44
16.0	20.66
17.0	20.87
18.0	21.08
19.0	21.27
20.0	21.46
21.0	21.64
22.0	21.82
23.0	21.99
24.0	22.15
25.0	22.31
26.0	22.47
27.0	22.62
28.0	22.77
29.0	22.91
30.0	23.05

STATUS: Boiling Target

Heater on target cell is used to boil liquid out of the cell.
Boiling complete when T_top > 23 K

Condenser Set Point: 25.0 K
(keeps condenser cold, but above condensation point)

Boiling heater: 50 W (If T_top < 23 K)
0 W (If T_top > 23 K)

GAS ALARMS: Require 5 consecutive readings to produce alarm

Sensor	Units	LO	HI
OVC vacuum	Torr	$1 \cdot 10^{-9}$	$5 \cdot 10^{-5}$
P_fill,P_exhaust	psiA	15.5	28.0
T_condenser	K	20.5	30.0
T_top, T_bot	K	20.5	300

VP Curve of LH2 (freezes ~14K)

P (psia)	T (K)
14.7	20.37
15.0	20.44
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18.0	21.08
19.0	21.27
20.0	21.46
21.0	21.64
22.0	21.82
23.0	21.99
24.0	22.15
25.0	22.31
26.0	22.47
27.0	22.62
28.0	22.77
29.0	22.91
30.0	23.05

STATUS: Empty/Gas Target

Target is filled with cold H2 gas, as indicated by top and bottom cell temperatures > 23 K. Condenser is cold but above condensation point.

Condenser Set Point: 25.0 K

Boiling heater: 50 W (If T_top < 23 K)
0 W (If T_top > 23 K)

GAS ALARMS: Require 5 consecutive readings to produce alarm

Sensor	Units	LO	HI
OVC vacuum	Torr	$1 \cdot 10^{-9}$	$5 \cdot 10^{-5}$
P_fill,P_exhaust	psiA	15.5	28.0
T_condenser	K	23.0	30.0
T_top, T_bot	K	23.0	300

VP Curve of LH2 (freezes ~14K)

P (psia)	T (K)
14.7	20.37
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22.0	21.82
23.0	21.99
24.0	22.15
25.0	22.31
26.0	22.47
27.0	22.62
28.0	22.77
29.0	22.91
30.0	23.05

STATUS: Target warming up

Compressor is OFF.

Condenser Set Point: OFF

Boiling heater: 50 W (If T_top < 23 K)
0 W (If T_top > 23 K)

WARM ALARMS: Require 5 consecutive readings to produce alarm

Sensor	Units	LO	HI
OVC vacuum	Torr	$1 \cdot 10^{-9}$	$5 \cdot 10^{-5}$
P_fill,P_exhaust	psiA	15.5	28.0
T_condenser	K	20.5	300
T_top, T_bot	K	20.5	300

VP Curve of LH2 (freezes ~14K)

P (psia)	T (K)
14.7	20.37
15.0	20.44
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30.0	23.05