MICE HYDROGEN SYSTEM

Control System

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V1	5-Mar-09	First Draft
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MICE Hydrogen Control System Specification

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1. THE DESIGN PRINCIPLE

The design principle for the MICE Hydrogen Control System is to separate the control functions from the safety critical functions, with the control functions performed by an Omron CJ1M-CPU13-ETN PLC with a NS8-TV01B-V2 touch screen programmable terminal The PLC is linked to the EPICS[1] control system for monitoring purposes only.

Note:- Omron PLCs are used on ISIS for Hydrogen control.
Also, Omron CJ1M is used on Diamond for Vacuum Control so an EPICS interface exists.

Safety Functions are to be hardwired separately and assessed to IEC 61508.
The following have been identified as Safety Functions:-

- Operation of the ventilation system on detection of a hydrogen leak
- Shut PV20 if there is a pressure rise in the cryostat during operation (to $>10^{-2}$mbar)
- Key Interlock System to control access to the Gas Panel

Intrinsically safe (Ex i).equipment is used as the preferred method of explosion prevention particularly inside the Gas Panel Enclosure (rated ATEX Zone 2) as air is always present.

The mechanical design of the system ensures a 'safe state' exists when all power is removed from the system.

2. LOCATIONS

Equipment will be located in the following locations:

- Hydrogen System Control Room – Adjacent to MICE Local Control Room next to the MICE Hall personnel door
- Hydrogen System Mezzanine (LH2 Mezz) – Inside the MICE Hall on the south side above the cooling channel
- Pump Enclosure - On the MICE Hall Roof on the South side
  Turbo pumps are located in the MICE Hall behind the shield wall at mezzanine level
- Cryostat – In the Muon Beam Cooling Channel in the MICE Hall

3. HYDROGEN SYSTEM CONTROLS CABINET

The Control Cabinet (2200mm high, 800mm wide & 500mm deep) is located in the Hydrogen System Control Room and contains the PLC, touch screen, intrinsically safe barriers, power supplies, flow-meter readout unit and vacuum gauge controllers.
The PLC (including inputs), flow-meter and vacuum gauges will be powered from a UPS to enable control and monitoring functions to be maintained if a mains failure occurs (2 hour back up).

All valve solenoid control signals can be fitted with a key switch to prevent their operation unless the key is present. This is linked out on those valves where a key is not required.

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[1] Experimental Physics and Industrial Control System

The following valves will have key switches:-
HA-PV14 H2 Supply – Permit required for issue of key
HA-PV17 Purging Line – Permit required for issue of key
HA-PV19 Vacuum Line – Permit not required

4. GAS PANEL

All electrical signals in the Gas Panel Enclosure are intrinsically safe (Ex i).
The inside of the Gas Panel Enclosure is rated ATEX Zone 2.

Valves are pneumatic with the air solenoids mounted on the outside of the Gas Panel Enclosure.
Valve limit switches are protected with intrinsically safe barriers mounted in the Control Cabinet which also detect short circuits and broken wires, giving an assurance the valve status is indicated correctly.
Pressure transducers are 4-20mA giving broken wire detection.

The Gas Panel Enclosure will be fitted with a trapped key interlock to ensure:-
The enclosure is closed before a hydrogen fill can take place.
The enclosure cannot be opened if the system contains hydrogen or if a leak is detected.

An override key, issued under a permit, will be provided to allow corrective action to be taken if safe to do so.

5. CRYOSTAT

Electrical signals in the Cryostat are intrinsically safe where possible

Temperature sensors in the Cryostat are intrinsically safe.
Level sensors in the Cryostat are intrinsically safe

The Cryostat heaters cannot be intrinsically safe:
The heater power supply is interlocked by two hardwired vacuum switches to prevent / disable there operation if the cryostat vacuum is not good (i.e. above 10^{-2}mbar).
Heater wiring is separated from other Cryostat wiring by a physical barrier or 50mm.
The heater power supply will be UPS backed (2 hour back-up) to enable liquid hydrogen to be boiled off in the event of a power failure.

6. VENTILATION SYSTEM

To ensure any leaks from the pipe work inside the Gas Panel Enclosure are vented to atmosphere outside the hall, the Gas Panel Enclosure is kept under a negative pressure by a ventilation system run by two inverter controlled 7.5kW fans.

One fan on its own will be capable of providing the flow rate required to deal with a leak. (DSEAR recommendations = 450 air changes per hour).

If a signal is present from the Hydrogen Detection System (HDS) saying no hydrogen has been detected, the fans will be run to give a reduced flow rate (100 air changes per hour).

Normally both fans will be used to achieve the flow rate required.
The loss of one fan will cause the other to speed up to maintain the required flow rate.

Detection of hydrogen or failure of the Hydrogen Detection System will cause the fans to speed up to 450 air changes per hour

Fans are UPS backed (2 hour back up - this is based on a calculated time of 55 minutes for a controlled vent – i.e. the time to boil off all the liquid hydrogen in a full system).
Each fan has its own UPS converter but batteries are shared.

7. HYDROGEN DETECTION SYSTEM

The Hydrogen Detection System is 'stand alone' and will be UPS backed.
All sensors will be in pairs to give redundancy.

The Hydrogen Detection System will be supplied by a specialist contractor and subject to regular maintenance and testing.

Each hydrogen system will have sensors:-
In the top of the Gas Panel Enclosure to detect leaks in the pipe work;
In the vent line to detect relief valve / bursting disc operation.

Note:- Conventional hydrogen sensors require the presence of oxygen to detect hydrogen. The vent line is purged with nitrogen, so infra-red sensors are used to detect hydrogen in the nitrogen purge gas; they react to helium in the same way and cannot distinguish between hydrogen & helium.
However, this is acceptable as the presence of either gas in the vent line signifies the operation of a relief valve or bursting disc.

Sensors common to all systems will be fitted:-
In the exhaust line of the vacuum pumps to detect leaks into the cryostat vacuums (these will also see hydrogen when the pipe work is purged);
In the Vacuum Pump Enclosure;
On the MICE Hall Ceiling as a precautionary measure for the protection of personnel.

Warning beacons are fitted to each Gas Panel Enclosure and to the Vacuum Pump Enclosure, as detailed below.
A traffic light system is to be used– i.e. Green = system purged and safe, Amber = system running, but no leaks detected, Red = leak detected.

8. VACUUM SYSTEM

Rotary pumps for the hydrogen pipe work (HA-VP01) and the cryostat vacuum (HA-VP02B) are located in the Vacuum Pump Enclosure.
These pumps are 415V 3-phase and controlled by a contactor panel located in the Hydrogen System Control Room.
The cryostat vacuum also has a turbo pump (HA-VP02A) located behind the shield wall. This pump is 24V and is controlled from the PLC cabinet.

The PLC provides start / stop signals to pumps; manual control is also available.
Note:- PLC status does not affect pump operation i.e. the pumps do not go off if the PLC does.

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Vacuum gauge controllers are located in the Control Cabinet
One analogue and two set points for all gauge controllers are wired back to the PLC.

The vacuum gauge controller for the hydrogen pipe-work (HA-VG05) is a Leybold CENTER TWO (2 channel - output 0 - 10V and 4 C/O contact)
The vacuum gauge controller for the cryostat vacuum (HA-VG03 & HA-VG06) is a Leybold CENTER THREE (3 channel - output 0 - 10V and 6 C/O contact)

Vacuum Equipment - Leybold

Pumps

HA-VP01	TRIVAC D 25 B - Rotary Vane Vacuum Pump
HA-VP02A	TURBOVAC SL 300 DN 100 ISO-K – Turbo Pump
HA-VP02B	TRIVAC D65B - Rotary Vane Vacuum Pump

Gauges Controllers

HA-VG03	CENTER THREE, Vac Gauge Controller 3 Channel - Output 0 - 10V and 6 C/O Contact
HA-VG05	CENTER TWO, Vac Gauge Controller 2 Channel - Output 0 - 10V and 4 C/O Contact
HA-VG06	CENTER THREE, Vac Gauge Controller 3 Channel - Output 0 - 10V and 6 C/O Contact

Gauges Heads

HA-VG03A	CERAVAC CTR 100 Capacitance Vacuum Gauge, Range 0,001 - 10 Torr
HA-VG03B	CERAVAC CTR 100 Capacitance Vacuum Gauge, Range 0,1 - 1000 Torr
HA-VG03C	PENNING-Transmitter PTR 225 Vacuum Gauge, Range 1E-9 - 1E-2mbar
HA-VG05	CERAVAC CTR 100 Capacitance Vacuum Gauge, Range 0,001 - 10 Torr
HA-VG06A	CERAVAC CTR 100 Capacitance Vacuum Gauge, Range 0,001 - 10 Torr
HA-VG06B	CERAVAC CTR 100 Capacitance Vacuum Gauge, Range 0,1 - 1000 Torr
HA-VG06C	PENNING-Transmitter PTR 225 Vacuum Gauge, Range 1E-9 - 1E-2mbar

9. DRAWINGS

Drawings

204/77501	CABLE BLOCK DIAGRAM
204/77502	GA OF CONTROL CABINET
204/77503	LAYOUT OF EQUIPMENT
204/77504	WIRING DIAGRAM OF CONTROL CABINET
204/77505	WIRING DIAGRAM OF GAS PANEL
204/77506	WIRING DIAGRAM OF CRYOSTAT