



**DZERO SILICON COOLING SYSTEM
MOISTURE INJECTION SYSTEM
CONTROL SYSTEM**

**ENGINEERING NOTE
3823.112-EN-583**

Fermilab
Dan Markley
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I Abstract

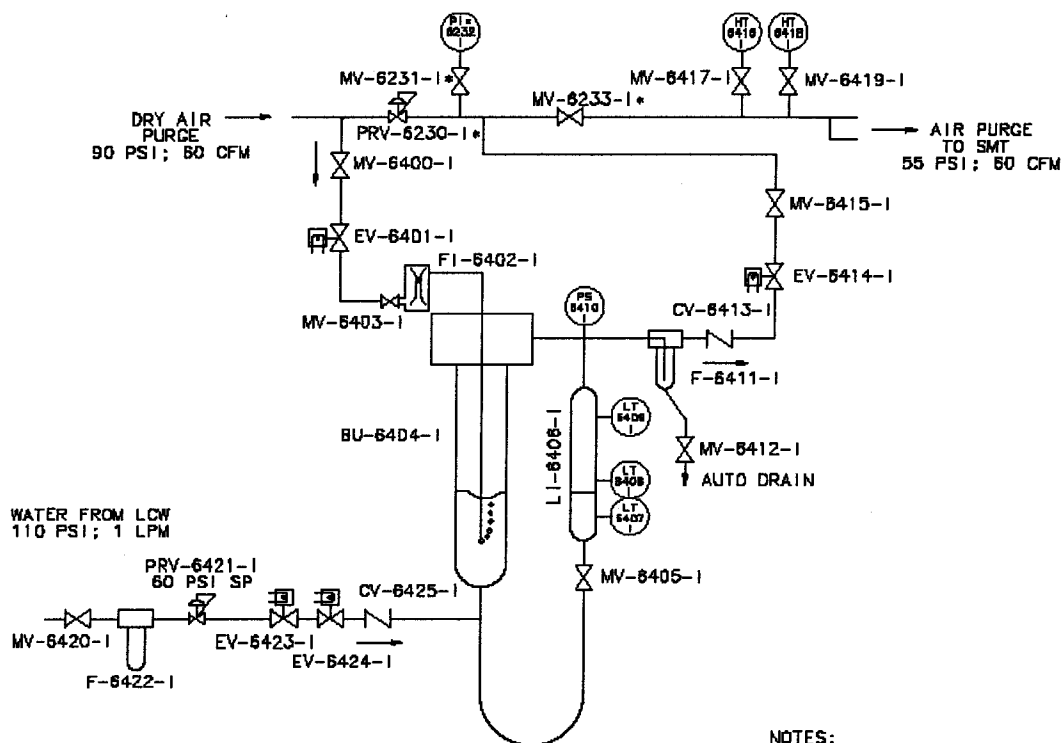
This engineering note describes the Monitoring, Controls, Interlock, and Alarm systems used to operate the Dzero Silicon Moisture Injection System that injects moisture into the Silicon Dry Air Purge System. The actual software programming is not included in this document, but the programming actions and interactions are included.

II Introduction

The Dzero Silicon system was installed in 2000 and commissioned in the spring of 2001. The Monitoring, Controls, Interlock, and Alarm systems of the Silicon cooling system and the dry air purge system are described in engineering note 3823.112-EN-548. The Silicon dry air purge system typically delivers -80°C dry air to the Silicon Detector that keeps the detector in a -50°C air envelope.

Dzero wants to explore whether raising the Silicon purge air dew point by 10°C to 20°C may improve the physics performance of the Silicon detector. The method chosen for raising the air dew point is bypassing about 10% of the purge air through a bubbler system then merging the two air streams back together before reaching the Silicon detector. The injection system equipment is located in room 215 on the South side of the Dzero assembly hall.

III Moisture Injection Flow Diagram



NOTES:
COMPONENTS MARKED WITH (*) ARE PARTS
OF EXISTING PURGE SYSTEM;
PRV-6231-I IS SET TO 55 PSI

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IV Interlocks

The following seven interlocks are hardwired into the moisture injection interlock system. These seven interlock items must all be normal to allow the moisture injector to function. If any one of the seven interlocks are tripped, then EV-6423-I, EV-6424-I, EV-6401-I, and EV-6414-I will all close, forcing all air flow through the main air supply header.

External Interlocks

There are seven external interlock strings.

1. Silicon Cooling System refrigeration Permit. External to Moisture Injection System.
This is an existing Silicon system interlock which will be used in the moisture injection interlock system. This interlock is designed to protect the Silicon detector from high dew points and low purge flows which could cause condensation and even frost inside the detector. The hardware interlock inputs are Purge Air Dew Pt High, S. Silicon Purge Flow(on platform), N. Silicon Purge Flow(on platform), PLC SUM(sum of the Software interlocks). The Software inputs to the interlock are Operator Command, The ten sample dew-points around the detector < -20°C.
2. Silicon System Emergency Warm-up. External to Moisture Injection System.
This is an existing Silicon system interlock which will be used in the moisture injection interlock system. This interlock is designed to protect the Silicon Detector in the event of a cooling system failure or a purge air failure. When this interlock is tripped, it currently shutdown any chiller pumps that may be running. This interlock string was developed separately from the pump interlock in the event more actions were needed, such as a forced warm-up.
There are no hardware inputs for this interlock string. The software inputs are: The ten sample dew-points around the detector < -20°C, S. Silicon Purge Flow(on platform), N. Silicon Purge Flow(on platform), Low coolant temperature, and High Coolant Temperature.
3. HT-6416-I. Internal to Moisture Injection System.
HT-6416-I is a Vaisala Dew point transmitter with an alarm contact. The dewpoint is transmitted to the control system for alarming and historical data collection. The trip point is configured through the transmitter key pad.
4. HT-6418-I. Internal to Moisture Injection System.
HT-6418-I is a Vaisala Dew point transmitter with an alarm contact. The dewpoint is transmitted to the control system for alarming and historical data collection. The trip point is configured through the transmitter key pad.
5. LT-6409-I H2O Level. Internal to Moisture Injection System.
The water level hi intlk is detected by a level switch positioned on the bubbler sight glass.
6. PLC Permit. External to Moisture Injection System from Cryo PLC.
This is controlled by an operator button on one of the computer control pictures. The PLC permit does not currently have any interlocks programmed into it. It is provided for future needs, should the injector operation need them.
7. PS-6410-I Air Pressure. Internal to Moisture Injection System.
Air pressure switch PS1 will assure that the container and it's plumbing are intact. If the sight glass were to break for example, the air system would blow down and the water would continually be added to try and makeup the water level. The pressure switch is expected to be set at 40 Psig. Any pressure less than 40 Psig would shutdown the moisture injection system via the interlock. The bubbler pressure can be recharged once below the air pressure trip point by holding in the reset button. The reset button disables the pressure trip while pressed, but all other interlocks must be clear in order for injection system to be placed back in the run mode.

V Bubbler Water Level Control

The bubbler container will have an external sight glass for water level. The level switches will be mounted to this sight glass. Experimenting has shown that the level switches are too sensitive to mount directly to the bubbler container. Since the air is injected at the bottom of the bubbler, the boiling interferes with the operation of the level switches when mounted on bubbler container. The external sight glass solves this boiling issue with the level switches. There will be an extra dip in the lower leg of the sight glass to help keep bubbles out of sight glass.

EV-6423-I, EV-6424-I, EV-6401-I, and EV-6414-I are all normally closed valves, energized to open. All four valves will close whenever the interlock sum is tripped.

The bubbler water level will be controlled by the opening and closing of EV-6424-I. There is relay logic hardwired such that LT-6407-I locks on EV-6424-I and LT-6408-I releases EV-6424-I. This sets up a control loop that maintains the water level between LT-6407-I and LT-6408-I. LT-6409-I is wired to trip the interlock sum should the water level reach the high level that LT-6409-I is set at.

VI Systems Electrical Power

Dzero has backup electrical power provided by a diesel generator that starts automatically upon commercial power loss. The Silicon purge air compressors, the Silicon chiller cabinets, and the U.P.S. that supplies power to the Silicon cooling system control system are all on backup power. The Silicon cooling system monitoring and interlock system are powered by a U.P.S., which prevents power interruption to these control system. The moisture injection system will also be powered by UPS power.

VII Monitoring

The Dzero Cryogenic PLC control system that monitors the Silicon cooling system will be expanded slightly to accommodate a few inputs and outputs related to the moisture injection system.

An 8 channel analog input module will be added in slot 3 of the PLC base located in the silicon cooling cage. WX represents an analog input channel. Y represents a discrete output channel. X represents a discrete input channel. The following I/O will be added to Dzero Cryogenic PLC control system to accommodate the silicon moisture injection system.

| | |
|--------|--|
| WX1297 | PLC Analog Input: HT-6416-I Dew Point Range = -60°C to 20°C=4-20mA |
| WX1298 | PLC Analog Input: HT-6416-I Temperature Range = 0°C to 80°C |
| WX1299 | PLC Analog Input: HT-6418-I Dew Point Range = -60°C to 20°C=4-20mA |
| WX1300 | PLC Analog Input: HT-6418-I Temperature Range = 0°C to 80°C |
| Y1321 | PLC Discrete Output: PLC Permit |
| X1383 | PLC Discrete Input: Moisture Injection INTLK Sum Status |
| X1384 | PLC Discrete Input: Water Fill Valve Status |

These inputs and outputs will be incorporated on the Silicon Graphics computer pages. Each item can be alarmed on status and historically collected for viewing data with normal historical tools.

VIII Alarms

The Dzero Cryogenic PLC control system that monitors the Silicon cooling system has two general types of alarms. Computer alarms and Auto Dialer alarms. These alarms notify the operations team of current and impending problems with many systems.

The silicon moisture injection alarms will be added to this general system. Operations will be notified of silicon moisture injection system interlock trips and parameters out of normal range, such as dew point.

Computer Alarms.

1. HT-6416-I Dewpoint Hi
2. HT-6416-I Dewpoint Low
3. HT-6418-I Dewpoint Hi
4. HT-6418-I Dewpoint Low
5. Moisture Injection System Interlock Tripped.
6. Water Fill on too long.

AutoDialer Alarms.

1. HT-6416-I Dewpoint HiHi
2. HT-6416-I Dewpoint LOLO
3. Moisture Injection System Interlock Tripped.
4. Water Fill on too long.

IX Security

Physical security of the injection system is maintained through the Dzero assembly building restricted access implementing key and ID access control. There will be some local signage located at the equipment in room 215 noting settings and restricted adjustment of key equipment.

Moisture injection system computer controls will use the iFIX security settings that already exist for the Silicon system users. The iFIX silicon security area settings will simply be duplicated in the database blocks for all Moisture injection system database blocks.

HT-6416-I and HT-6418-I trip set points are electronically set using the keypad on the local chassis. Once HT-6416-I and HT-6418-I are configured the keypads will be locked using a PIN number for restricted access. Only Silicon experts will know this PIN number, currently, Dan Markley, Bill Cooper, Jim Fagan, Mike Sarychev, and Russ Rucinski.

X What If Analysis of the Silicon Moisture Injection System

Revised July 27, 2009.

| Component | Failure | Consequences | Comments |
|--------------------------|--|--------------|---|
| EV-6423-I (H2O Intlk) | What if EV-6423-I Fails to Close? | None | EV-6424-I will close on interlock as well. |
| | What if EV-6423-I Fails to Open? | None | Water level will go down until HT-6416-I and HT-6418-I sensors alarm on low Dew Point. |
| EV-6424-I (H2O Level) | What if EV-6424-I Fails to Close? | None | Hi level interlock will close EV-6423-I |
| | What if EV-6424-I Fails to Open? | None | Water level will go down until HT-6416-I and HT-6418-I sensors alarm on low Dew Point. |
| EV-6414-I (Air Valve) | What if EV-6414-I Fails to Close? | None | EV-6401-I will close also and block air flow |
| | What if EV-6414-I Fails to Open? | None | HT-6416-I and HT-6418-I will fall until in alarm. |
| EV-6401-I (Air Valve) | What if EV-6401-I Fails to Close? | None | EV-6414-I will close also and block air flow |
| | What if EV-6401-I Fails to Open? | None | HT-6416-I and HT-6418-I will fall until in alarm. |
| LT-6407-I (Low Switch) | What if LT-6407-I Fails to Close? | None | Water level will go down until HT-6416-I and HT-6418-I sensors alarm on low Dew Point. |
| | What if LT-6407-I Fails to Open? | None | Hi level interlock will close EV-6423-I and EV-6424-I |
| LT-6408-I (Upper Switch) | What if LT-6408-I Fails to Close? | None | Water level will go down until HT-6416-I and HT-6418-I sensors alarm on low Dew Point. |
| | What if LT-6408-I Fails to Open? | None | Hi level interlock will close EV-6423-I and EV-6424-I |
| LT-6409-I (Hi Intlk) | What if LT-6409-I Fails to Close? | None | HT-6416-I and HT-6418-I hi Dew Point will close EV-6423-I and EV-6424-I |
| | What if LT-6409-I Fails to Open? | None | Hi Level Interlock will not clear. Dew Point could fall |
| PS-6410-I | What if PS-6410-I Fails to detect low pressure | None | Check valve prevents air system from blowing down. Water on time alarm will notify operator of problem. |
| | What if PS-6410-I Fails to detect Hi pressure | None | Interlock will not reset until PS-6410-I is repaired |

| | | | |
|-------------------------|--|--|--|
| Dew Point #1(HT-6416-I) | What if HT-6416-I Fails to detect Hi Dew Point | None | HT-6418-I will trigger an moisture injection shutdown Intlk. |
| | What if HT-6416-I Fails to detect Lo Dew Point | None | HT-6418-I will alarm on Low Dew Point |
| Dew Point #2(HT-6418-I) | What if HT-6418-I Fails to detect Hi Dew Point | None | HT-6416-I will trigger an moisture injection shutdown Intlk. |
| | What if HT-6418-I Fails to detect Lo Dew Point | None | HT-6416-I will alarm on Low Dew Point |
| MV-6400-I | Gets closed | None | Moisture probes will indicate dryer air – trigger computer alarm |
| MV-6415-I | Gets closed | None | Moisture probes will indicate dryer air – trigger computer alarm |
| MV-6403-I | Increase or decrease flow | None | Increased/decreased water content – alarm and/or interlock. |
| LI-6406-I | Sight glass breakage | Air pressure drops. Water spill | Interlock on signal from PS-6410. All solenoid valves close. |
| MV-6405-I | Accidentally closed | Water level not seen by pressure transmitters. Overflow | Handle removed and “Caution-do not close” tag applied |
| MV-6412-I | Fails to Open | Water in purge air in case of overflow | Moisture analyzers will trip interlock on water content. Clear housing will show water inside. |
| MV-6417-I | Closed | None | Impossible – this is a feed through for moisture probe |
| MV-6419-I | Closed | None | Impossible – this is a feed through for moisture probe |
| MV-6420-I | Gets closed | None | Moisture probes will indicate dryer air – trigger computer alarm |
| PRV-6421-I | Fails | None | Water make-up will increase from 1 L/min to 3.3 L/min |
| CV-6425-I | Gets stuck | None | Moisture probes will indicate dryer air – trigger computer alarm |
| CV-6425-I | Gets stuck | None | Moisture probes will indicate dryer air – trigger computer alarm |

