CLAS 12
DC GAS
OPERATORS
MANUAL

George Jacobs

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I Introduction

The CLAS 12 Drift Chamber Gas System, DC GAS, supplies high purity gas mixtures to the detectors. The gas is mixed, stored, and a metered delivery is supplied. The system also maintains a constant differential pressure between the atmosphere and detectors by pumping the gas out of the detectors.

Gas is supplied via the boil off from liquid argon and liquid CO2. The liquid argon bulk supply tank is located on the concrete pad next to the gas shed. The liquid CO2 dewars are staged alongside the outside wall. Pressure is reduced to 160psig at the supply panel in the gas shed. It is then split into 2 identical circuits, each capable of supplying 350 slm of mixed gas.

Gas is mixed in each of the circuits by metering flow using Mass Flow Controllers, MFCs. The thermal conductivity of the mixed gas is constantly monitored using the Panametrics Thermal Conductivity Units (TCUs). Once the proper ratio of gases has been obtained by adjusting the mixture to produce the proper thermal conductivity, the MFCs are setup to operate in a master/slave mode. The Argon gas flow is the master and the CO2 is the slave, maintain the correct ratio for varying flows.

The mixed gas flows to the supply buffer tanks. The supply buffer tanks have a combined volume of 50,000 liters. Gas is stored in these tanks at ~60-100psig. The tanks can supply gas for a period of time in case of a problem with the bulk supply or the mixing equipment.

The supply buffer tanks supply gas to the DC metering panels. Gas flows out of the tanks, pressure is reduced by a pressure regulator. A small portion of the gas is diverted to sensors, which measure the oxygen and moisture content to assure mixture purity. Gas is then metered to the hall by MFCs, Mass Flow Controllers.

Gas flows down several hundred feet of piping to the solenoid valve panel in the Hall. Here solenoid valves direct flow to the detectors during normal operation or bypass the gas flow to the exhaust piping in case of a control system fault. Pressure transducers monitor the pressures at the chamber exhaust manifolds. If this pressure exceeds the setpoint, relays open to de-energize the solenoids and isolate the detectors from the gas system.

During normal operation the gas flows to the supply manifolds where it is split up to supply each of the 6 detectors. The gas exits the individual detectors and enters the exhaust manifold. Pressure in the exhaust manifold is monitored by a capacitance manometer, which sends a control signal to a cRio PID controller which operates a control valve on the inlet of the gas return vacuum pumps. This controls gas flow out of the detectors in order to maintain a constant differential pressure between the atmosphere and chambers. In case of equipment failure, power loss, or extraordinary transient the detectors are protected by oil filled bubblers which will vent the gas to atmosphere or break vacuum which exceeds 0.125 inch water column.

Gas exhausted from the return is exhausted to the atmosphere while a portion of the return gas is diverted to oxygen and moisture sensors to monitor contaminants. Contaminant levels indicate the leak levels in the system.

All parameters monitored are input to EPICS and the Alarm Handler. This allows for remote monitoring and alarm functions.

II Controls Overview

The DC gas system consists of 2 identical mixing systems, 3 individual supply, and 2 pressure control systems. Each of these subsystems has its own controls, monitoring, and protection system.

Controls can be broken down as follows:

<u>GAS MIXING AND STORAGE</u>
Mix #1 Argon MFC
Mix #1 CO2 MFC
Mix #1 ratio - TCU #1
Mix #1 Pressure – Absolute Baratron
Mix #2 Argon MFC
Mix #2 CO2 MFC
Mix #2 ratio - TCU #2
Mix #2 Pressure – Absolute Baratron

<u>DETECTOR GAS SUPPLY</u>
R1 gas flow to detector – R1 Supply MFC
R2 gas flow to detector – R2 Supply MFC
R3 gas flow to detector – R3 Supply MFC
O2 Level
H2O Level

<u>DETECTOR PRESSURE CONTROL</u>
R1-R2 control pressure – cRIO
R1-R2 Differential Pressure - MKS 223B Baratron
R3 control pressure - cRIO
R3 Differential Pressure – MKS 223B Baratron

<u>DETECTOR GAS RETURN</u>
R1-2 gas return flow - R1-2 return flow MFT
R1-2 return O2 Level
R1-2 return H2O Level
R3 gas return flow - R3 return flow MFT
R3 return O2 Level
R3 return H2O Level

<u>PROTECTION CIRCUIT</u>
R1-2 differential pressure – R1-2 OMEGA DP25
R1-2 differential pressure transducer - Magnahelic
R1-2 under pressure relay – R1-2 OMEGA DP25 Relay 1
R1-2 over pressure relay - R1-2 OMEGA DP25 Relay 2
R3 differential pressure – R3 OMEGA DP25
R3 differential pressure transducer - Magnahelic
R3 under pressure relay – R3 OMEGA DP25 Relay 1
R3 over pressure relay - OMEGA DP25 Relay 2

III Operator Training

The DC gas system uses high pressure gas and cryogenic liquids. The Control system uses complex specialty electronics and instruments. There are personnel and equipment hazards associated with improper operation of this equipment. Because of this, only properly trained and authorized persons are permitted to operate this equipment. Only the Hall B Engineer can appoint an authorize operator.

The prospective operator must accomplish the following 3 steps
1) Operators must complete the proscribed training program
2) Operators must pass a final checkout with the SME
3) The Hall B Lead Engineer must certify the operator

IV System Operation

Gas Supply

The DC Gas supply manifold is on the outside wall of the Hall B Gas Shed, Bldg. 96B. Argon and Nitrogen gases are supplied from bulk tanks which are filled by the vendor. The vendor monitors the bulk tank levels via a land line and schedules tankers to fill them. In an emergency or for maintenance purposes, portable dewars can be used to supply these gases under direct supervision of a system expert. CO_2 gas is supplied from high pressure dewars, the operator must monitor the dewars and change them out before they go dry. Experience with these containers allows one to determine if it is almost empty by it's tilt weight. Also note that the CO_2 dewar supply pressure range is 150-175psig. This means that the supply should never exceed 175 psig and that it should never fall below 150psig. Therefore, the on line dewar must deliver CO_2 at pressure above that of the backup dewar, but well below the 200psig relief valve setpoint. Similarly, the backup dewar must deliver CO_2 at pressure above 150psig, but below that of the on line dewar. The reasoning behind this is that in case the on line dewar goes empty, the backup dewar will be capable of supplying the system for normal ops. In theory, the backup dewar will never be needed because the operator will change out the on line dewar prior to it "going dry" .

CO2 Dewar Operation

The CO_2 dewars must be ordered through the JLAB ecommerce system. At least 4 dewars should be on hand at all times. Dewars should be ordered on a 1-1 basis, as soon as one is removed from the manifold a replacement should be ordered. Extra dewars should be ordered ahead of time prior to holidays such that they are on hand when required. There is a 7 day delay between ordering and delivery. For example, if an order is placed on a Friday, delivery may not happen until the following Friday.

The CO_2 dewars must be monitored as necessary from the time they are delivered by the vendor. The pressure buildup circuits must be adjusted as required to produce an internal pressure >200psig and <350psig. **Frequent monitoring of pressure and levels in the dewars is required in order to insure a dependable gas supply.**

There are heaters installed between the dewar and the pressure regulators. These heaters prevent the pressure regulators from freezing up. CO_2 flow to the mixing system will be disrupted if the regulator freezes. These heaters should be operated from the period of late Fall to early Spring.

Care must be taken when attaching the supply line to the dewar such that only the gas supply connection is used. Connecting the regulator to the liquid supply connection will cause a disruption in the CO_2 gas supply and may cause equipment damage.

Improper CO2 pressure is one of the most common issues an operator must resolve. This issue can always be traced back to either operator error or CO_2 dewar problem. **Common operator errors are; improper pressure regulator setting, failure to open the dewar supply valve, failure to open the supply hose valve, failure to replace empty dewars, and improper operation of the dewar pressure buildup circuit. Common CO2 dewar problems are; dewar pressure is too low, dewar empties due to excessive venting, and improper pressure buildup circuit operation.**

CO_2 Dewar Change Out

Liquid CO_2 Dewar Characteristics

CO_2 is delivered in standard 180 liter dewars.
A full dewar contains 400 lbs (182 kg) of liquid CO_2.
The gross weight of a full CO_2 dewar is ~730 lbs (331 kg).
The pressure relief on the dewar is set at 350 psi.
A dewar will vent gas out the relief valve as it warms up.
Excessive gas venting from the relief valve is not uncommon during the summer months.

Procedure

1) Close the gas supply valve on the dewar you are going to remove from service.

2) Close the supply hose valve for that same dewar.

3) Remove the supply hose from that dewar using a wrench.

4) Move the empty dewar to the designated part of the concrete pad.

5) Move a full dewar to the place the one you removed was.

6) Connect to the gas line to the dewar after verifying the gasket is in place.

7) Open the gas supply valve on that dewar.

8) Open the supply line valve.

9) Adjust the pressure regulator to 150 psig on the backup supply dewar.

10) Adjust the pressure regulator to 175 psig on the main supply dewar.

Detector pressure protection solenoid Valves

Solenoid valves are installed in the system to isolate the drift chambers from the gas system in case of a component failure or power outage. A Dwyer Magnahelic indicating differential pressure transmitter monitors pressure at the exhaust manifold of each region. The 4-20ma signal sent by the transmitter is received by an Omega DP25-E process controller with dual alarm relays and analog output in the Hall B Gas Shed.

The DP25-E unit has a digital display that reads out directly in inches of water column. The relays are controlled by set points programmed into the controller by the expert. All relays are normally open (NO); under fault conditions the relays open, and are active between the high pressure limit and the low pressure or negative pressure limit. These relays control the safety solenoid valves in the hall via the solenoid valve control unit, DC GAS Master Control box, in the gas shed. The DC GAS Master Control box permits either automatic or manual control of the solenoid valves. Manual control is sometimes needed to recover the system from an over or under protection isolation.

Isolating the Gas system from the high pressure gas supply

Preliminary Discussion

The bulk gas supply tanks, the supply buffer tanks, and/or supply dewars, hold a large supply of gas at high pressure. It is possible that a failure could occur resulting in the uncontrolled escape of gas. It would be dangerous to enter the gas shed if such a failure had occurred. All high pressure supplies of gas would have to be secured from outside the gas shed.

Procedure for Isolating the HP Gas Supply

1) Close DC005, DC006, DC007, and DC008 at the valve panel on the outside wall of the gas shed.

2) Close the inlet and outlet valves on each of the 4 gas supply buffer tanks located between the gas shed and Hall C. This is a total of 8 valves. DC028, DC029, DC030, DC031, DC032, DC033, DC034, and DC035

3) Close DC061 and DC063 to isolate the detector supply mass flow controllers.

4) Inform the DC gas system expert.

5) Inform the Run Coordinator.

Normal Operating Parameters

The gas system can be seen as a number of components connected together in series. If any one component fails or malfunctions the system will not perform its function. Parameters such as pressure and flow are used to describe the inputs and outputs of these components. A fault anywhere in system can be located by checking these parameters.

Gas Supply
Argon bulk storage tank supply pressure 160-175 psig
CO2 dewar supply pressure 150-175 psig
Nitrogen supply pressure 30-40 psig

Gas Mixing
Argon supply - 140-150 psig
CO2 supply - 140-150 psig
#1 conductivity meter - 10% set to match reference calibration gas
#2 conductivity meter - 10% set to match reference calibration gas
Storage Buffer Tanks - All 4 tanks – 60-100 psig

Gas Metering
Region 1 metering supply 15 psig
Region 2 metering supply 15 psig
Region 3 metering supply 15 psig

Pressure Control Setpoints
R1-2 PID Loop Pressure Setpoint – 0.075”wc
R3 PID Loop Pressure Setpoint – 0.075”wc

Pressure Safety Interlock Setpoints
Pressure Safety Interlocks Low Pressure Trip -0.010”wc
Pressure Safety Interlocks High Pressure Trip 0.150”wc

Responding to problems indicated by EPICS

The EPICS alarm handler monitors the analog outputs of system sensors and transducers. These controls and instruments provide inputs to EPICS for use as a remote monitoring and warning system. EPICS cannot be used for control of any component in the gas system.

There are multiple components between the alarm handler's computer screen and the analog input signal coming out of the instrument being monitored. The first step in responding to an alarm is to verify the actual operating condition of the system.

System troubleshooting must be documented. Take notes of what the conditions are, actions taken, and the results of those actions.

There are only a few conditions that require immediate action. The following procedures are designed to prevent equipment damage and data loss.

General Procedures

1) Check actual system operating parameters to verify the problem. If the problem is real continue. If the problem only shows up on the alarm handler, it is an EPICS or IOC problem. No further action is needed.

2) If detector pressure is out of the normal operating band and the system did not automatically go to bypass, manually switch to bypass.

3) If the mixing ratio is incorrect, check the gas supply pressures. If the CO_2 pressure is low, change out the supply dewar.

5) If an automatic bypass condition has occurred, determine the reason for this failure prior to returning to normal operations.

6) Refer to the appropriate section of the DC GAS System Operators manual for further guidance.

Responding to a low CO2 pressure alarm

The CO2 gas supply pressure is monitored by a pressure transducer. Pressure is maintained 150-175 psig to the mixing system. If the CO2 pressure is too low, the mix ratio of the gas will be incorrect. The CO2 concentration will be too low. Maintaining CO2 gas pressure within the proper range is a daily activity. The CO2 Low Pressure alarm setpoint is 100 psi.

Procedures

1) Check that the CO2 supply pressure at the CO2 pressure regulator outlet pressure gauge on the outside wall of the gas shed matches the alarm value.

2) Check the CO2 gas supply valves are open on the connected dewars, flex lines, and pressure regulator outlet valves

3) Check individual CO2 dewar pressures - carefully adjust the pressure buildup valve to increase CO2 supply pressure (This takes several hours to come to an equilibrium)

4) Replace empty CO2 dewars

5) Verify the CO2 pressure regulators on the gas shed wall are set properly.

Equipment Operation

Refer to the DC Gas section of the Hall B Gas System Controls Operating Procedures

Operating the OMEGA DP25-E Process Controllers

These units have a menu system. All functions can be setup using the controls on the front panel. The operators manual should be used as a guide to operations.

These units are the heart of the Pressure Safety Interlock System for the detectors.

Each unit has 2 relays.
----The under pressure protection relay is configured to be active, closed, above the setpoint.
----The over pressure protection relay is configured to be active, closed, below the setpoint.

Both relays must be active in order for the bypass control solenoids to be energized. If either relay trips, the solenoids will be de-energized and the chambers will be bypassed.

(SEE NORMAL OPERATING PARAMETERS)

WARNING

Improper use could cause gas system malfunction and detector damage. Only properly trained and authorized personnel are permitted to operate these controllers.

Calibrating the Panametrics TCUs

The Panametrics TCUs tend to slowly drift over time and are temperature sensitive. We use the units to maintain a 10.0% mixture of CO_2 in Argon. These units use a reference leg of Argon to compare to the mixed leg. The gas flow through each leg must be equal. There is a large piping volume which must be purged through the unit before an equilibrium reading can be obtained from the unit. A 10-12 minute time lag to equilibrium in unit readout is typical.

The following procedure is used to perform the Weekly calibration checks.

Preliminary Discussion

This procedure compares the 10% calibration standard to the mix. This procedure must be performed prior to any adjustment to the mix.

Procedure

1) Switch the TCU selector valve to calibration gas 10%
2) After a 10-12 minute window record the TCU outputs.
3) Switch the TCU selector to the mix
4) Adjust the mix to match the 10% standard
5) Switch to calibration gas buffer 1 and compare the result to the calibration value
6) Switch to calibration gas buffer 2 and compare the result to the calibration value
7) Repeat the above steps as necessary

Adjusting the Argon CO2 Gas Mixture Ratio

The gas mixture composition directly effects detector operation. The gas mix is controlled to maintain a 10% +/-0.2% drift of CO2 in Ar gas mixture. The Ar-CO2 mix ratio is controlled by varying the CO2 flow rate. The CO2 MFC operates in slave mode to the Ar MFC. The CO2 MFC will adjust CO2 flow to maintain a set ratio of flows.

The Panametrics TCU is used to maintain the proper gas mix. The Panametrics TCU has a 4-20ma output. This is read out on an Omega process controller. The reading units are ma (milli-amps). Weekly calibrations are performed. Calibration gas is flowed through the TCU. The mixture of the gas is then adjusted to match the calibration gas immediately following the calibration procedure.

PROCEDURE

Refer to the DC Gas section of the Hall B Gas System Controls Operating Procedures to Make these Adjustments

--To increase the percentage of CO2 in the mix, the current output signal must be increased. To increase the current output signal, the CO2 MFC must be adjusted to flow more gas.
--To decrease the percentage of CO2 in the mix, the current output signal must be decreased. To decrease the current output signal, the CO2 MFC must be adjusted to flow less gas.
--Small incremental adjustments work best. A 5% change in CO2 flow will change the mix by ~ 0.5%. That is a large change. A very good estimate of the change required can be easily calculated as follows. The difference between the calibration gas TCU reading and that of the mixed gas determine the change required. After each adjustment, 20-40 minutes should be allowed for the TCU to stabilize. Then the mix can be adjusted again in a similar manner. This process is repeated until the mix is exactly 10% CO2 in Ar as indicated by the Panametrics TCU.

Maintaining Buffer Tank Pressure

The detector gas supply mass flow controllers meter gas from the supply buffer tanks to the detectors. If the mixing supply input to the buffers exactly matches the output flow, the pressure in the buffer is constant. Whenever the output from the buffers to the detectors is changed, the input to the buffers from the mixing system must also be changed in order to maintain buffer pressure. The Ar-CO2 ratio is manually controlled to match a reference value determined by a calibration gas. The total flow into the buffer must equal the total flow out over time or the pressure will either increase or decrease outside of the normal operational range.

One purpose of the supply buffer tanks is to average out any fluctuation in the mix over time and to minimize the effect of any short term error in the mix. If detector flow is increased without also increasing the mixing flow, pressure in the buffers will begin to decrease. As the pressure decreases, the amount of gas in the buffers is reduced, and the efficiency of the buffer to buffer out fluctuations in the mix is reduced. At some point the pressure will decrease below that required to maintain flow to the detectors.

The solution is to program the cRIO to automatically control buffer tank pressure by varying the gas mixing flow at the high, 100 psi, and low, 80 psi, buffer tank pressure setpoints.

For Buffer #1 (R1-R3), The cRio is programmed to mix gas as follows;
R1 supply flow + R3 supply flow = R1-3 Current Flow
@ 80 psi mixed gas flow rate = 1.1 x Current Flow
@ 100 psi mixed gas flow = 0.9 x Current Flow

For Buffer #2 (R2), The cRio is programmed to mix gas as follows;
R2 supply flow = R2 Current Flow
@ 80 psi mixed gas flow rate = 1.1 x Current Flow
@ 100 psi mixed gas flow = 0.9 x Current Flow

Refer to the DC Gas section of the Hall B Gas System Controls Operating Procedures to Make These Adjustments

CAUTION

IMPROPER OPERATION OF THIS SYSTEM CAN RESULT IN CATASTROPHIC DAMAGE TO THE DETECTOR.

ONLY PROPERLY TRAINED AND AUTHORIZED INDIVIDUALS ARE PERMITTED TO OPERATE DC GAS FLOW AND PRESSURE CONTROL SYSTEMS.

Adjusting gas Flow to the Detectors

Each of the 3 DC Regions is supplied by it's own MFC.
R1 MFC
R2 MFC
R3 MFC

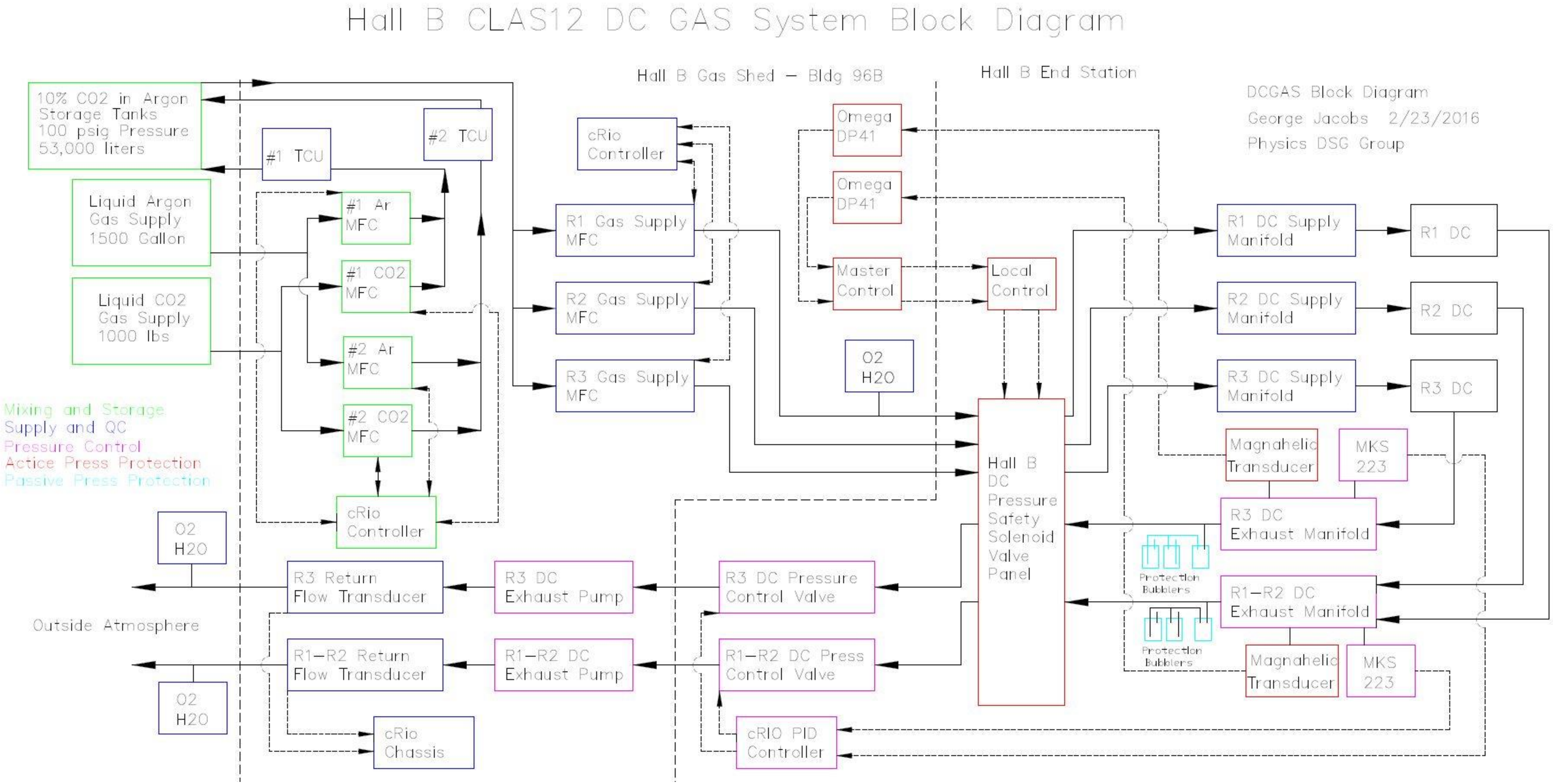
Gas Flow must be increased for DC operation with beam.

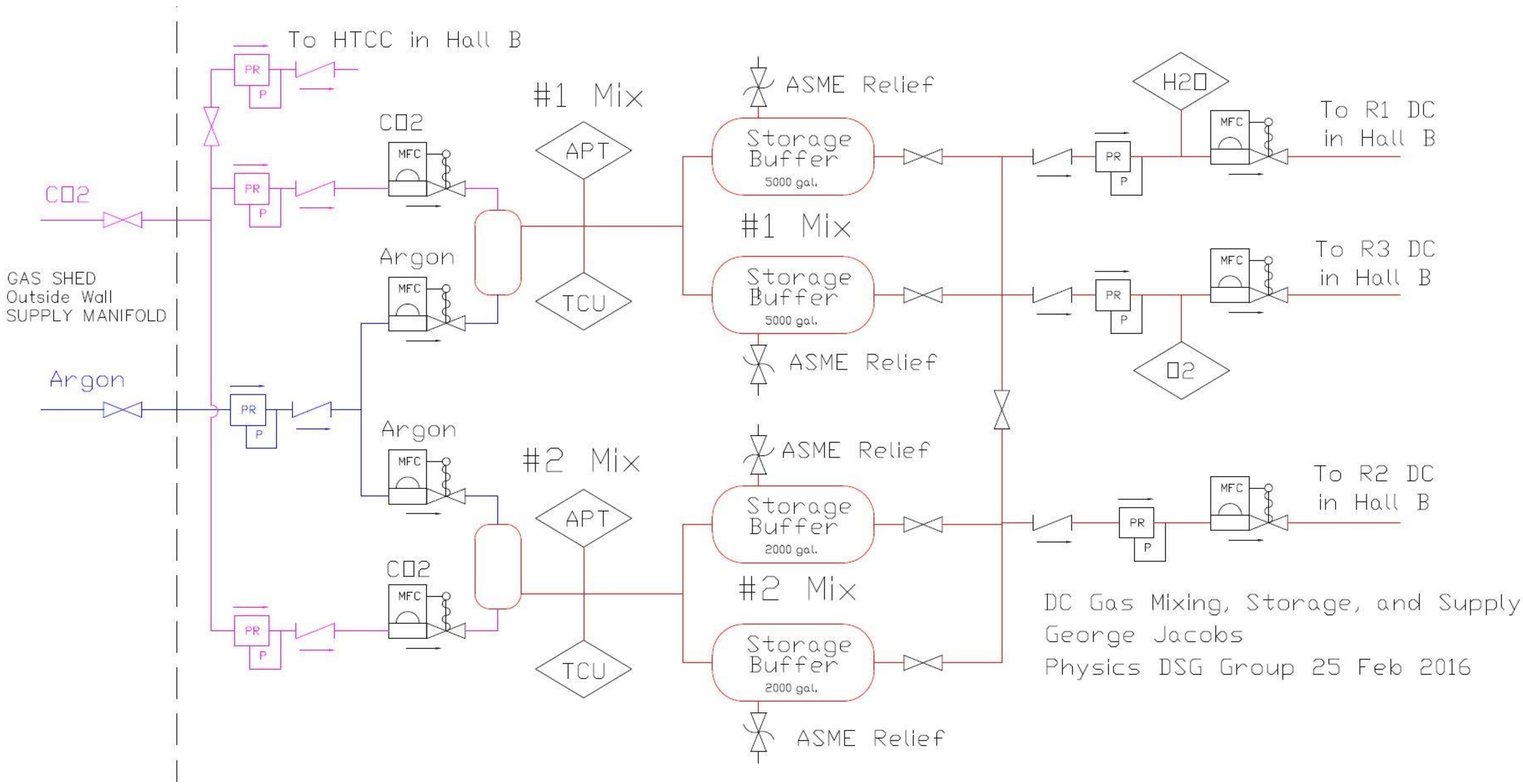
Gas Flow must be decreased during non beam operation in order to conserve gas.

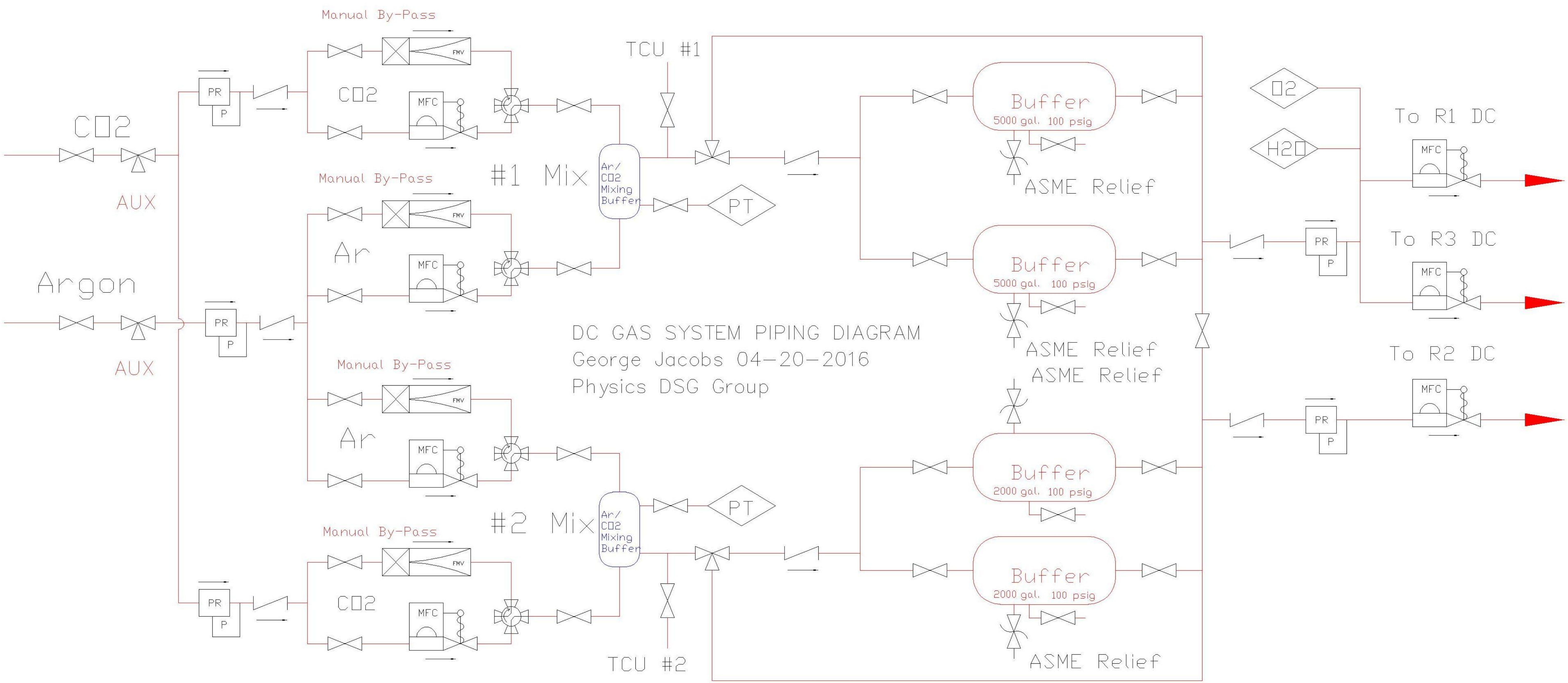
(SEE NORMAL OPERATING PARAMETERS)

Refer to the DC Gas section of the Hall B Gas System Controls Operating Procedures to Increase or Decrease Gas Flow

VI – List of Appendixes


Hall B CLAS12 DC GAS System Block Diagram
Hall B Gas Shed – Bldg 96B
Hall B End Station
DCGAS Block Diagram
George Jacobs 2/23/2016
Physics DSG Group
10% CO2 in Argon Storage Tanks 100 psig Pressure 53,000 liters
#1 TCU
#2 TCU
Liquid Argon Gas Supply 1500 Gallon
Liquid CO2 Gas Supply 1000 lbs
#1 Ar MFC
#1 CO2 MFC
#2 Ar MFC
#2 CO2 MFC
cRio Controller
cRio Controller
R1 Gas Supply MFC
R2 Gas Supply MFC
R3 Gas Supply MFC
Omega DP41
Omega DP41
Master Control
Local Control
O2 H2O
Hall B DC Pressure Safety Solenoid Valve Panel
R1 DC Supply Manifold
R2 DC Supply Manifold
R3 DC Supply Manifold
R1 DC
R2 DC
R3 DC
Magnahelic Transducer
MKS 223
R3 DC Exhaust Manifold
R1–R2 DC Exhaust Manifold
Protection Bubblers
Protection Bubblers
Magnahelic Transducer
MKS 223
Mixing and Storage
Supply and QC
Pressure Control
Actice Press Protection
Passive Press Protection
O2 H2O
R3 Return Flow Transducer
R3 DC Exhaust Pump
R3 DC Pressure Control Valve
Outside Atmosphere
R1–R2 Return Flow Transducer
R1–R2 DC Exhaust Pump
R1–R2 DC Press Control Valve
O2 H2O
cRio Chassis
cRIO PID Controller


To HTCC in Hall B
PR
P
#1 Mix
CO2
MFC
APT
ASME Relief
Storage Buffer
5000 gal.
H2O
To R1 DC in Hall B
CO2
GAS SHED Outside Wall SUPPLY MANIFOLD
Argon
TCU
#1 Mix
Storage Buffer
5000 gal.
To R3 DC in Hall B
ASME Relief
O2
Argon
Argon
#2 Mix
APT
ASME Relief
Storage Buffer
2000 gal.
To R2 DC in Hall B
CO2
#2 Mix
Storage Buffer
2000 gal.
TCU
ASME Relief
DC Gas Mixing, Storage, and Supply
George Jacobs
Physics DSG Group 25 Feb 2016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TCU #1
CO2
PR
P
MFC
FMV
CO2
AUX
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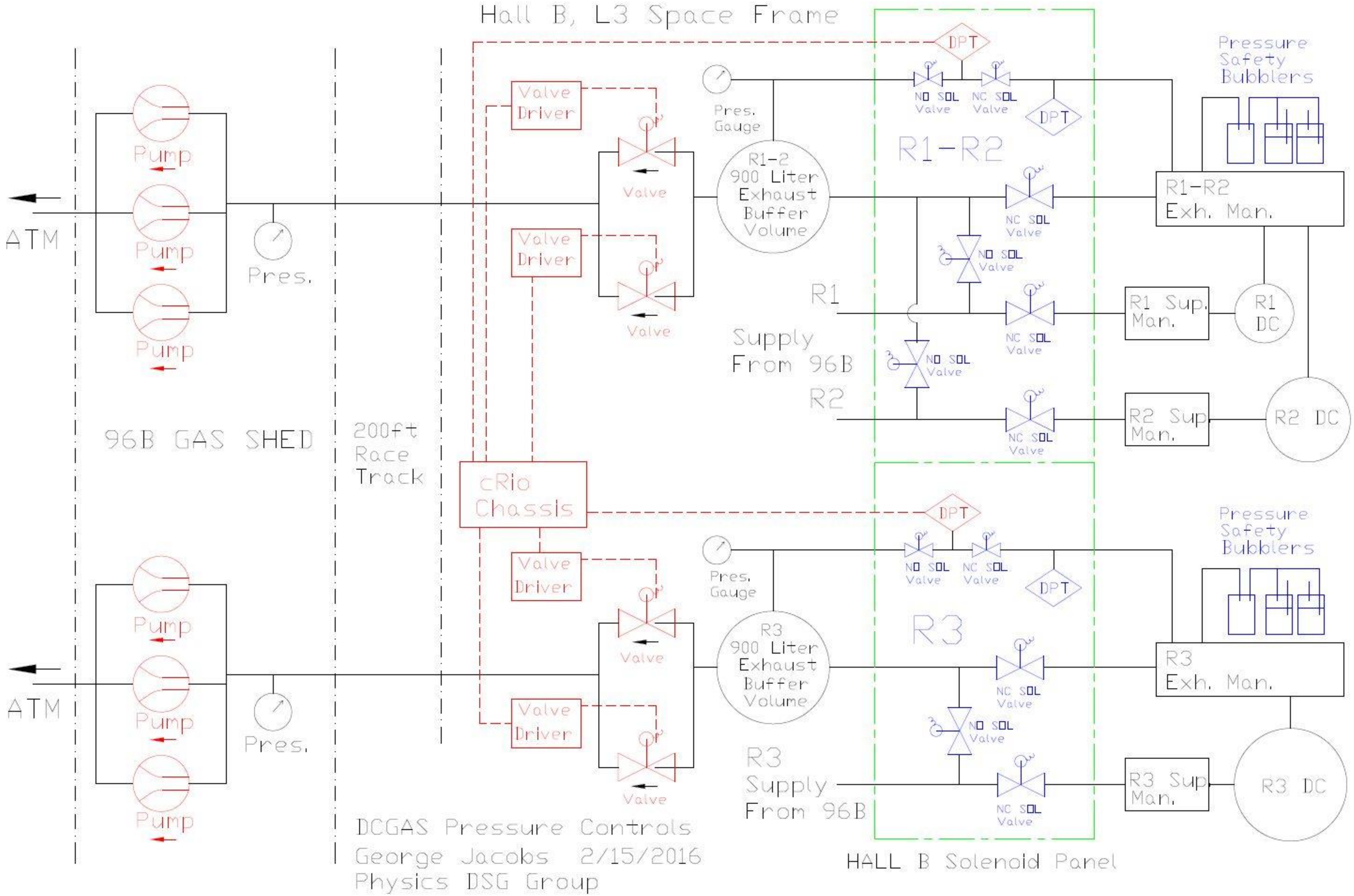
Argon
AUX
Buffer
5000 gal. 100 psig
ASME Relief
Buffer
5000 gal. 100 psig
ASME Relief
ASME Relief
O2
H2O
To R1 DC
To R3 DC
To R2 DC
Manual By-Pass
Ar
DC GAS SYSTEM PIPING DIAGRAM
George Jacobs 04-20-2016
Physics DSG Group
Manual By-Pass
#2 Mix
Ar/ CO2 Mixing Buffer
PT
CO2
TCU #2
Buffer
2000 gal. 100 psig
Buffer
2000 gal. 100 psig
ASME Relief


Hall B, L3 Space Frame
Pressure Safety Bubblers
DPT
NO SOL Valve
NC SOL Valve
Valve Driver
Valve
Pres. Gauge
R1-2 900 Liter Exhaust Buffer Volume
R1-R2
R1-R2 Exh. Man.
Pump
ATM
Pres.
R1
R1 Sup. Man.
R1 DC
Supply From 96B
R2
R2 Sup. Man.
R2 DC
96B GAS SHED
200ft Race Track
cRio Chassis
R3 900 Liter Exhaust Buffer Volume
R3
R3 Exh. Man.
R3 Supply From 96B
R3 Sup. Man.
R3 DC
DCGAS Pressure Controls
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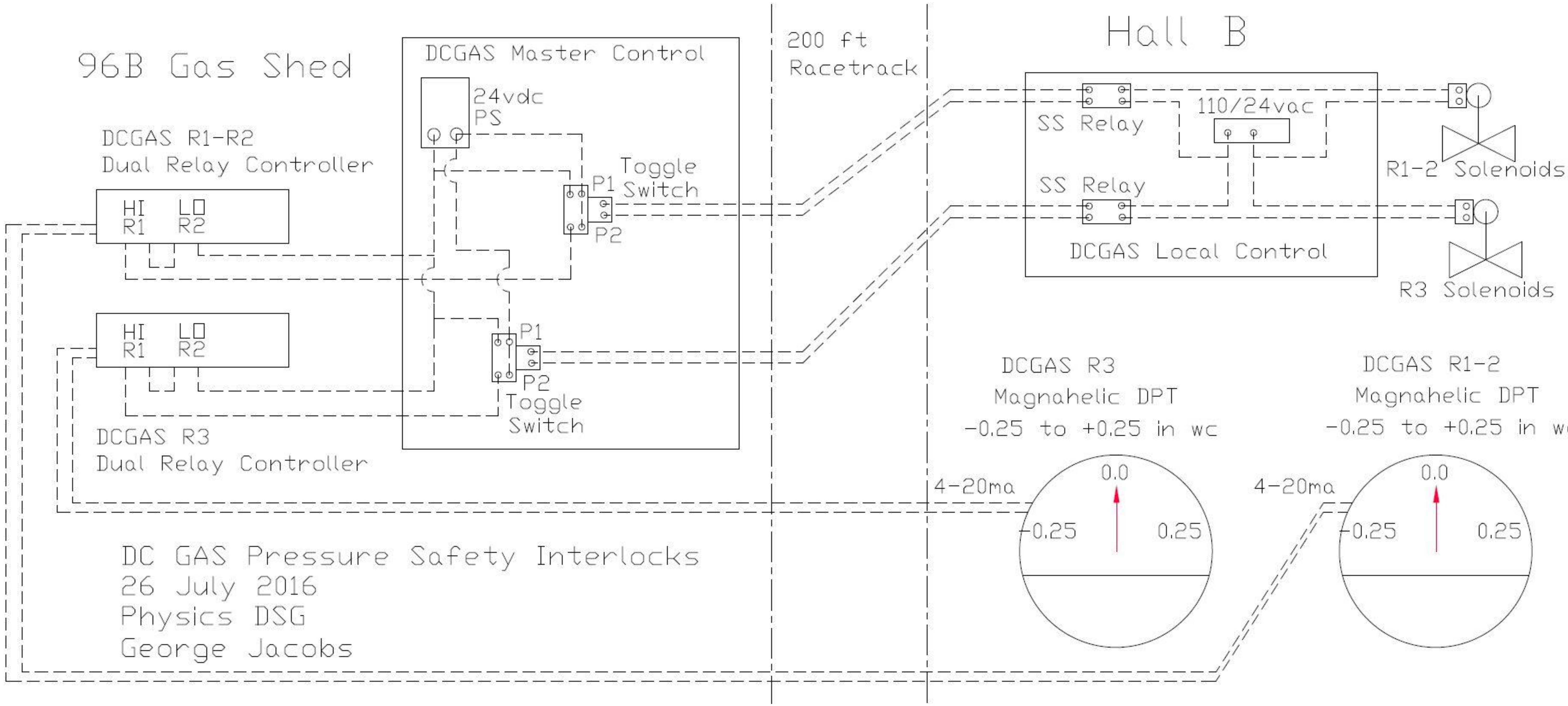
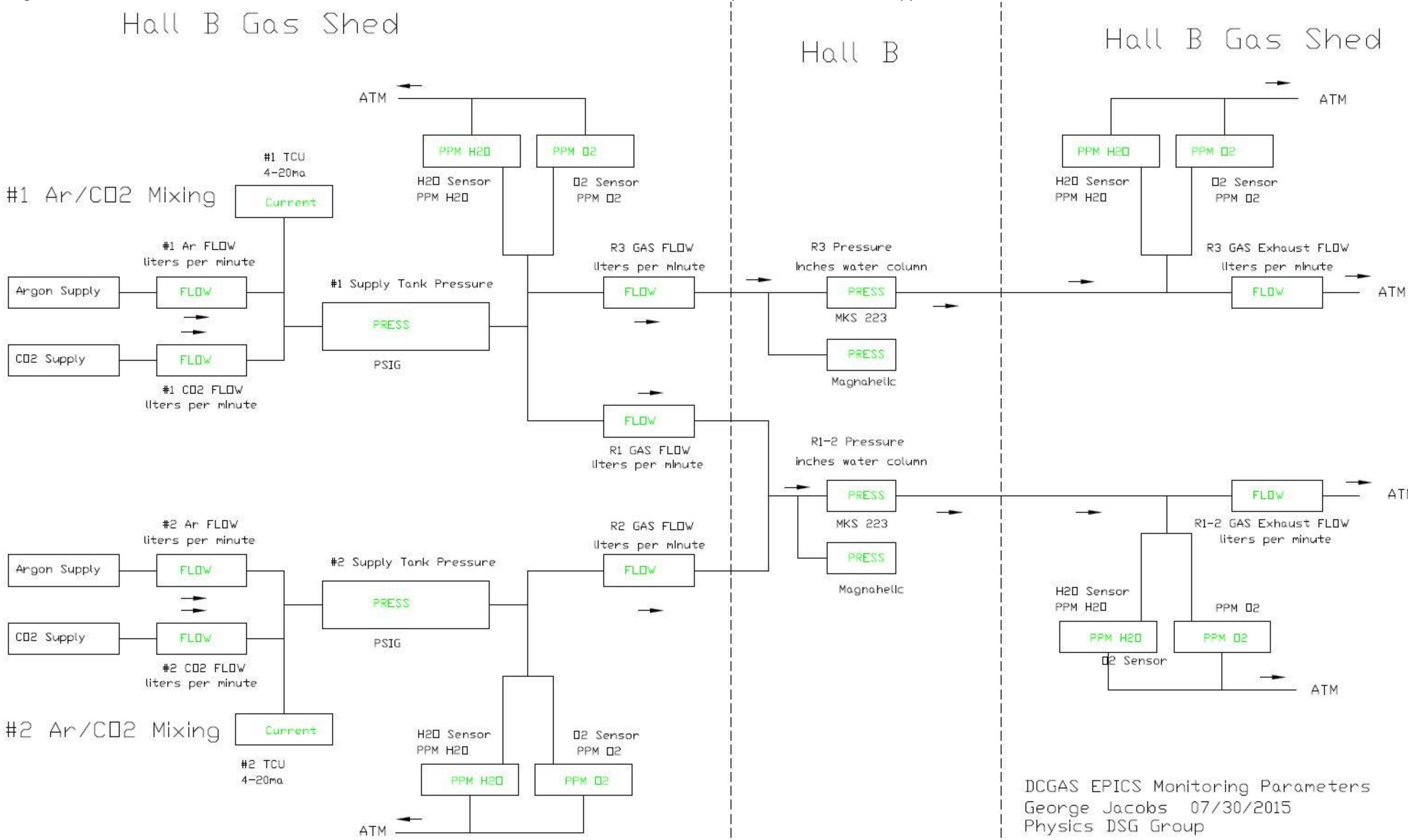
HALL B Solenoid Panel


96B Gas Shed
DCGAS Master Control
200 ft
Racetrack
Hall B
24vdc
PS
DCGAS R1-R2
Dual Relay Controller
HI LO
R1 R2
Toggle
Switch
P1
P2
SS Relay
110/24vac
SS Relay
DCGAS Local Control
R1-2 Solenoids
R3 Solenoids
HI LO
R1 R2
P1
P2
Toggle
Switch
DCGAS R3
Dual Relay Controller
DCGAS R3
Magnahelic DPT
-0.25 to +0.25 in wc
DCGAS R1-2
Magnahelic DPT
-0.25 to +0.25 in wc
4-20ma
0.0
-0.25
0.25
4-20ma
0.0
-0.25
0.25
DC GAS Pressure Safety Interlocks
26 July 2016
Physics DSG
George Jacobs


Hall B Gas Shed
Hall B
Hall B Gas Shed
ATM
PPM H2O
PPM O2
H2O Sensor
PPM H2O
O2 Sensor
PPM O2
#1 TCU
4-20ma
#1 Ar/CO2 Mixing
Current
#1 Ar FLOW
liters per minute
Argon Supply
FLOW
#1 Supply Tank Pressure
PRESS
PSIG
CO2 Supply
FLOW
#1 CO2 FLOW
liters per minute
R3 GAS FLOW
liters per minute
FLOW
R3 Pressure
inches water column
PRESS
MKS 223
PRESS
Magnahelic
R3 GAS Exhaust FLOW
liters per minute
FLOW
ATM
FLOW
R1 GAS FLOW
liters per minute
R1-2 Pressure
inches water column
PRESS
MKS 223
PRESS
Magnahelic
FLOW
ATM
R1-2 GAS Exhaust FLOW
liters per minute
#2 Ar FLOW
liters per minute
Argon Supply
FLOW
#2 Supply Tank Pressure
PRESS
PSIG
CO2 Supply
FLOW
#2 CO2 FLOW
liters per minute
R2 GAS FLOW
liters per minute
FLOW
H2O Sensor
PPM H2O
PPM O2
PPM H2O
PPM O2
O2 Sensor
ATM
#2 Ar/CO2 Mixing
Current
#2 TCU
4-20ma
H2O Sensor
PPM H2O
O2 Sensor
PPM O2
PPM H2O
PPM O2
ATM
DCGAS EPICS Monitoring Parameters
George Jacobs 07/30/2015
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