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Engineering Note

Date: 04/05/2001 **Rev Date:** 06/11/2001
Project: Dzero Magnets
Doc. No: H010405A (D0 Eng Note 3823.111-EN-555)
Subject: Toroid Energization - Operating Procedures

1 Purpose

This procedure is used when it is necessary to operate the toroid energization, controls, and interlock system. Included are procedures to prepare for operation, ramp up and down, change polarity, and secure after operation. Only the D0 Control Room Operators or the Project Electrical Engineer are qualified to execute this procedure or operate the toroid system.

2 Prerequisites

This procedure assumes that the operator is familiar with using the Distributed Manufacturing Automation and Control Software (DMACS). DMACS terminals are located in the Dzero Control Room, the Dzero Cryo Control Room, and several other locations around the site -- including some offices. Anyone logged in as a "PUBLIC" user may view the toroid control information on a DMACS terminal. However, In order to control the toroid system, the user must have security privileges for "D0 Sol DC". These privileges are assigned by the DMACS NT SERVER administrator (Dan Markley as of this writing). The operator should also have at least an understanding of the overall toroid energization system as described in the attachments.

3 Procedures

Note that the toroid operation is not nearly as automated as the solenoid operation. Although the computer interface appears at first to be nearly identical to the solenoid interface, much of the operation and interpretation of conditions must be done manually. The following sub-procedures will provide complete guidance in each operation.

3.1 Prior to Operation

3.1.1 Preliminary Physical Inspection

A preliminary inspection must be made to ensure that no obvious hazards to operation exist. This inspection is detailed in the following sub-sections.

- ❑ Verify that the central toroid is in the CLOSED position.

3.1.1.1 Inspect The Power Bus

This step is necessary only if work has been done on or in the vicinity of the toroid energization system since the system was previously operated. This is normally done by the Project Electrical Engineer or his designee at the end of an open or supervised access to the collision hall. Consult with the Project Electrical Engineer.

Visually inspect the entire DC bus beginning at the power supply + and - flags located in the northwest corner of the detector pit. Continue the inspection at all stations described below and then all the way back to the toroid power supply in room 503 on the north side of the detector building. If any problems are found, then notify the Project Electrical Engineer before continuing. Inspect each station as described below:

- ❑ North West corner of collision hall pit. Power supply + and - flags.
  - The flexible cable connections shall be neatly insulated with silicon material. There should be a common mode noise filter connected between each flag and the detector track with a heavy, braided, bare ground strap. The area around the flags shall be free of trash, abandoned tools and etc.
  - LCW valves supplying water to the toroids must be in "on" position.
- ❑ North West gap between the north toroid (EFN) and the central toroid (CF).
  - The flexible cable connections on the EFN flags and the CF flags shall be tight and neatly insulated with silicon material.
  - Coil interconnections on the vertical face of EFN and the vertical & horizontal face of CF appear secure and are free of dangling cables or other potential short circuits.
  - Interlock terminal strip TBEFN on EFN above flags appears neat and secure
- ❑ South West gap between the south toroid (EFS) and CF.
  - The flexible cable connections on the EFS flags shall be tight and neatly insulated with silicon material.
  - Coil interconnections on the vertical face of EFS appear secure and free of dangling cables or other potential short circuits.
  - Horizontal bus run across the bottom face of the EF is free of loose metallic materials that may cause ground faults.
  - Interlock terminal strip TBEFS on EFS above flags appears neat and secure

- ❑ South East gap between EFS and CF.
  - Coil interconnections on the vertical face of EFS appear secure and free of dangling cables or other potential short circuits.
  - Horizontal bus run across the bottom face of the EF is free of loose metallic materials that may cause ground faults.
- ❑ North East gap between EFN and CF.
  - The flexible cable connections on the EFN flags and the CF flags shall be tight and neatly insulated with silicon material.
  - Coil interconnections on the vertical face of EF and the vertical & horizontal faces of CF appear secure and are free of dangling cables or other potential short circuits.
  - Interlock terminal strip TBCFE on CF above the flags appears neat and secure
- ❑ North platform in collision hall pit.
  - The main magnet interlock box located on the wall facing the north platform racks must have the interlock cables from the platform attached. Cables must be secure and in good condition.
  - The "flow chassis" in rack PN06 shows "normal" flow and pressure as defined and indicated on the meters.
- ❑ Locked cage in assembly hall pit north side.
  - There should be a capacitive common mode noise filter connected between each flag and the detector track with a heavy, braided, bare ground strap. The area around the flags shall be free of trash, and etc.
- ❑ Locked cage in room 503 behind power supply.
  - Cables should be secure & the appropriate water valves turned on.

3.1.1.2 Cooling Water System

The low conductivity water (LCW) cooling system must be started well in advance of operations in order to reduce the conductivity to less than 3.0 megOhm/cm. The building manager is responsible for the LCW system. Verify that the system is ready for operations by examining the following items.

- ❑ The manual LCW supply & return valves located above the power supply in room 503 are in the "On" position.
- ❑ The LCW supply pressure gauge above the power supply inside Room 503 reads at least 90 psi.
- ❑ There are no obvious water LCW leaks around the power supply or in the cage behind it.
- ❑ The conductivity meter in DAB 6th floor west mechanical room must read greater than 3.0 megOhms/cm.

3.1.2 Implement Safety Precautions

Skip this section for normal operation under "Area Secured" conditions. However, if the toroid is going to be operated when people may approach during operation, then ropes, signs, and flashing lights must be posted. Implement or verify the following precautions:

- ❑ Block the access to the north end of the east and west EF/CF gaps with yellow rope, flashing lights, and "Caution, Magnet Energized, Authorized Personnel Only" signs.
- ❑ Block the access to the south end of the east and west EF/CF gaps with yellow rope, flashing lights, and "Caution, Magnet Energized, Authorized Personnel Only" signs.
- ❑ Make an announcement over the PA system at 30 minutes and 15 minutes to clear the magnet area before the toroid is about to be energized.
- ❑ Physically inspect the areas adjacent to the toroid for personnel and loose equipment prior to energizing.

3.2 Operation

3.2.1 Megger the Toroid System

This step may be skipped if there has been no access to the collision hall or the power supply cage in room 503 since last operation i.e. if there is valid reason to believe the circuit has not been disturbed.

1) Turn off ground fault detector
2) Unseat power supply regulator module
3) Verify that no personnel or equipment is in contact with the bus at any point.
4) Measure resistance to ground from a power supply DC connection. The normal reading should be approximately 10kΩ @ 250V. Consult with the project engineer is less than 8kΩ.
5) Turn on ground fault detector
6) Reseat power supply regulator module.

3.2.2 Engage Circuit Breaker To Power Supply

The AC circuit breaker for the power supply is located in the 3rd floor utility entry room. The circuit breaker is clearly marked as to its function (C8 in DHP-D0-2 labeled Transrex Supply Main Magnet). When the toroid is not operating, the circuit breaker is normally kept in the "OFF" position.

- ❑ Engage the circuit breaker to the "ON" position.

3.2.3 Verify Power Supply Configuration

The power supply must be configured for operation by manipulating several controls on the front panel. Set the controls as indicated in the following steps. For more details about the purpose of these controls, see the "Power Supply Front Panel Controls & Status" section of this manual.

- ❑ On the "Reference module", set the reference selector switch to "EXT"
- ❑ On the "Reference module", set reference potentiometer to "0".
- ❑ On the "Regulator module", set the mode selector switch to "Current".
- ❑ On the "Power Supply Panel", set the Control Power switch to "On".

3.2.3.1 Energize Power Supply

The power supply "Main" switch is normally kept padlocked in the off position with a configuration control lock maintained by the Dzero control room personnel.

- ❑ Remove the padlock and engage the Power Supply "Main" switch on the power supply front panel to the "ON" position.

3.2.4 Verify External and Internal Interlocks

The power supply will not operate unless all "interlocks" are OK. Interlocks are checked in two places, the "Magnet Interlock Chassis" in the controls rack in room 503, and the "Functions" and "Faults" panels on the power supply in room 503. The procedure to check each of these systems is described below. For more details about the origin and purpose of each of the interlocks being verified, see the "Controls Rack" and "Power Supply" in the "Illustrations" section of this procedure document.

3.2.4.1 Magnet Interlock Chassis

The following items refer to the magnet interlock chassis in the rack adjacent to the toroid power supply in DAB room 503.. If any item is not successful, then refer to the section on "Interlock Troubleshooting".

- ❑ Press & release the RESET button in the upper right corner of the chassis.
- ❑ Verify that "Accel Permit" in the upper left corner is illuminated.
- ❑ Verify that "LCW Permit" in the upper left corner is illuminated.
- ❑ Verify that the indicator for each associated labeled interlock on the panel is illuminated. The "Magnet Interlock Chassis" section of this manual contains an illustration of this panel and a description of each labeled interlock for informational purposes.

3.2.4.2 Power Supply Front Panel

The following items refer to the Power Supply Functions and Faults status panels on the front of the toroid power supply located in room 503. If any item does not verify, then refer to the section on "Interlock Troubleshooting".

- ❑ Press & release the RESET button on the front of the power supply.
- ❑ In the "Functions" panel, verify that "AC On", "24Vdc On", and "Intlks Complete" indicators are illuminated.
- ❑ In the "Functions" panel, verify that the Ground Detector "On" indicator is illuminated.
- ❑ In the "Faults" panel, verify that all indicators are illuminated.

3.2.5 Turn on Power Supply and Charge Toroid

Accomplish the following steps from the DMACs console in the control room. The operator must have security privileges of "D0 Sol DC" in order to execute any of these control functions. The interlock system is progressive and thus the steps must be executed in the order indicated. If any step is missed, just back up and proceed forward from the missed step.

- ❑ Verify that the power supply status is as follows (power supply screen):
  Local/Remote Status = Remote >
  PS Regulation Mode = Current > If not correct, these conditions must be manually set at power supply
  PS Reference = Ext >
- ❑ Reset the Power Supply (power supply control screen)
- ❑ Verify that the Interlocks indicate "OK" (OK status should appear on interlock block) - see the "Troubleshooting Interlocks" section if "Not OK"
- ❑ Set the Power Supply On (power supply control screen).
- ❑ Set the Target Amps to desired current (power supply control screen). Normal setting is 1495 Amps.
- ❑ Select "Proceed to Target" (power supply control screen). Note that the toroid will charge slowly due to a protective hardware rate limiter feature. Charging will require ≅ 8 minutes.

3.2.6 Discharge Toroid Normally and Turn Off Power Supply

- ❑ Set the Target Amps to 0 (power supply control screen).
- ❑ Select "Proceed to Target" (power supply control screen) (note that the toroid will discharge slowly due to a protective hardware rate limiter feature).
- ❑ Wait for the toroid current to decrease to less than 100 Amps. Discharging will require ≅ 8 minutes.
- ❑ Set the Power Supply Off (power supply control screen).

3.2.7 Discharge Toroid FAST and Turn Off Power Supply

The quickest way to perform a FAST discharge is by turning off the power supply. This disables the power supply and forces the toroid to discharge into the resistance of the dc bus system. A FAST discharge stresses the system with resistive heating, mechanical forces, and high voltages. The stresses are well within design parameters. Discharge will require ≅ 10 seconds

- ❑ Set the Power Supply "Off" (power supply control screen).

3.2.8 Change Polarity

Although the power supply may be controlled and monitored either manually or via the DMACS control screen, the polarity switch for the toroid magnet is manually controlled only. The operator must physically go to room 503 to operate the polarity switch. The toroid system must be fully discharged before the polarity can be changed. Hardware interlocks provide protection from attempts to change polarity while current is flowing. Discharge, polarity switch, and recharge will require ≅ 30 minutes.

- ❑ Set the Target Amps to 0 (enter Toroid Target Amps = 0 on power supply control screen).
- ❑ Select "Proceed to Target" (select "Proceed to Target" on power supply control screen).
- ❑ Verify that current in the toroid is decreasing toward 0.
- ❑ Physically go to the power supply location in room 503 and set the switch on the reversing switch controller to the desired polarity. The "Timer Running" lamp will illuminate on the controller; but nothing will happen for 8 minutes. During that time, the controller will clamp the output of the power supply to 0 to ensure that the system discharges before the polarity change executes. After 8 minutes, the reversing switch will change states.
- ❑ Return to the control room and wait for the Polarity Switch to change to the desired state as indicated on the console.
- ❑ Follow the "Turn on Power Supply and Charge Toroid" procedure to re-energize the Toroid.

3.3 Lock Down for Maintenance

The power supply should be locked off with an operator's configuration padlock when not in operation. In addition, anyone working on the power supply itself will want to lock out and tag (LOTO) the main circuit breaker that feeds the 480V to the power supply. There are no multiple energy source components in the system once it is discharged thus standard LOTO procedures apply. Follow the procedures below to lock off the power supply and/or the main circuit breaker.

3.3.1 De-energize and Lock Off Power Supply

The main AC switch for the power supply is located on the front of the power supply. The switch is clearly marked as to its function. When the toroid is not being operated, the switch should be padlocked in the "OFF" position by a configuration lock that is managed by the control room operators.

- ❑ Move switch handle to the off position.
- ❑ Apply operator's configuration padlock.

3.3.2 Disengage the Main Circuit Breaker

The AC circuit breaker for the power supply is located in the 3rd floor utility entry room. The circuit breaker is clearly marked as to its function (C8 in DHP-D0-2 labeled Transrex Supply Main Magnet). When the toroid is not operating, the circuit breaker is normally kept in the "OFF" position.

- ❑ Disengage the circuit breaker to the "OFF" position.
- ❑ If performing maintenance on the power supply, then follow LOTO procedures to secure the circuit breaker in the off position with a lock and tag.

3.4 Troubleshooting Interlocks

The DMACs control screen for the toroid system does not provide assistance in identifying interlock problems. The operator must go physically to room 503 and examine the "Magnet Interlock Chassis" and the "Power Supply Fault Panel" on the Power Supply. The Magnet Interlock Chassis and the Power Supply Fault panel provide a labeled lamp for each required interlock. Illustrations of the Magnet Interlock Chassis and the Power Supply Fault panel are contained in this document along with descriptions of each interlock. In addition, the interlocks are described below. The toroid power supply system will not energize unless all interlocks illuminate after you do a "RESET" on the Magnet Interlock Chassis and the Power Supply. Use the following information to investigate interlock problems.

3.4.1 Magnet Interlock Chassis

This interlocks in the Magnet Interlock Chassis are described below. They are listed in alphabetical order rather than by their position on the Magnet Interlock Chassis to assist in locating them in the list.

3.4.1.1 Accel Permit

Accelerator Permit - This circuit consists of a relay contact controlled by the Accelerator Interlock System. It allows the toroid to operate if the main ring door interlock system is intact, no keys are missing from the key tree, and the key tree door is closed. The contact is located in box titled "D0 Collision Hall #96 Power Supply Interlock Unit". This box is located in rack F10923 located in the Dzero Control Room. The Beams Division personnel responsible for accelerator interlocks are Howard Casebolt and John E. Anderson. If this interlock can not be reset, then check the following:

- Main Ring Interlocks (call Main Control Room for status)
- D0 Collision Hall #96 Power Supply Interlock Unit described above (call John E. Anderson or Howard Casebolt)
- Cable from "D0 Collision Hall #96 Power Supply Interlock Unit" to end rack in room 503
- Defective Magnet Interlock Chassis in room 503.

3.4.1.2 BAL

Balance Detector – Not used - jumpered out - Balance Detector Chassis in control rack.

3.4.1.3 EDS

Emergency Dump Switch. This circuit consists of one crash button that controls the toroid and the solenoid. If this interlock can not be reset, then check the following:

- Crash button depressed in collision hall labyrinth
- Cable from crash button in collision hall labyrinth to controls end rack in room 503 via cable cross connect in SW corner of control room.

3.4.1.4 FS1

40 GPM water flow switch on SW platform. Processed thru flow chassis on north platform.

3.4.1.5 FS2

40 GPM water flow switch on NW platform. Processed thru flow chassis on north platform.

3.4.1.6 FS3

100 GPM water flow switch on NE platform. Processed thru flow chassis on north platform.

3.4.1.7 FS4

100 GPM water flow switch on NW platform. Processed thru flow chassis on north platform.

3.4.1.8 KBUS

Klixons on bus above capacitor tree on 5th floor room 503 inside Cage.

3.4.1.9 KCH

Klixon on choke inside power supply cage on 5th floor room 503.

3.4.1.10 KEB

Klixon on CF, NE end, side bus, KB4 (just above 1st coil).

3.4.1.11 KED

Klixons on CF, NE end, bottom coils, K33 thru K36.

3.4.1.12 KEJ

Historical - Klixon on CF, NE end, jumper (Not Used - Always Enabled), KJ4 - east side jumper to EF-N, KJ5 - east center, jumper to west center.

3.4.1.13 KES

Klixons on CF, NE end, side coils K23 thru K32.

3.4.1.14 KEU

Klixons on CF, NE end, top coils K17 thru K22.

3.4.1.15 KJP

Historical - Klixons on jumpers, Discontinued when water cooled jumpers were removed - Not Used - Always Enabled.

KJ1 - EFN supply jumper at wall
KJ10 - EFS supply jumper at wall
KJ11 - CFW jumper to bus to EFS
KJ12 - EFS jumper to bus
KJ13 - KJ14 Unknown

3.4.1.16 KNB

Klixons on EF North bus,

KB1 - West supply bus
KB2 - West return bus
KB3 - East supply bus

3.4.1.17 KNE

Klixons on EF NE, side coils, K9 thru K16.

3.4.1.18 KNJ

Historical - Klixons on EF North jumpers, Not Used - Always Enabled,

KJ2 - Magnet side of jumper to wall
KJ3 - EF side of jumper to CF east

3.4.1.19 KNW

Klixons on EF NW, side coils, K1 thru K8

3.4.1.20 KRS

Klixon on Reversing Switch - 5th floor room 503, inside cage - In box.

3.4.1.21 KSB

Klixons on EF South, bus,

KB6 - west side supply bus
KB7 - west side return bus
KB8 - west bottom supply bus

3.4.1.22 KSE

Klixons on EF South, east side coils, K65 thru K72.

3.4.1.23 KSJ

Historical - Klixon on EF South, jumper, not used – always enabled.

KJ9 - west side jumper to wall
KJ8 - west side jumper to CF-N

3.4.1.24 KSW

Klixons on EF South, west side coils, K57 thru K64.

3.4.1.25 KWB

Klixon on CF, NW end, side bus, KB5.

3.4.1.26 KWD

Klixons on CF, NW end, bottom coils, K37 thru K40

3.4.1.27 KWJ

Klixons on CF, NW end, side jumper,

KJ6 - west center, jumper to east center
KJ7 - west side jumper to EF-S

3.4.1.28 KWS

Klixons on CF, NW end, side coils, K41 thru K50.

3.4.1.29 KWU

Klixons on CF, NW end, top coils, K51 thru K56

3.4.1.30 LCW Permit

LCW pumps P5 & P6 - 6th floor room 604 west wall. This circuit consists of auxiliary contacts in the motor starters for the LCW water pumps. There are redundant pumps labeled P5 & P6 with the controllers located on the west wall of room 604. This interlock comes from the P6 motor starter cabinet and is internally in parallel with the P5 motor starter. Thus, as long as either of these pumps are running, the interlock is OK. If this interlock can not be reset, then check the following:

- Either P5 or P6 pumps in room 604 must be running.
- Cable from the P6 motor starter to the controls end rack in room 503.

3.4.1.31 PS1-4

Historical – Steel position switches - Not Used

3.4.1.32 PS5-8

Historical – Steel position switches - Not Used

3.4.1.33 PSFS

Flow Switch on LCW supply line to Power Supply, Inside Cage - 5th floor.

3.4.1.34 PX1

NW platform water pressure transducer, Processed thru flow chassis on north platform.

3.4.1.35 RSFS

Flow Switch on LCW supply line to Reversing Switch Inside Cage - 5th floor.

3.4.1.36 WS-1

NW Platform water pressure switch, On water line at NW corner.

3.4.2 Power Supply Fault Panel

If the power supply refuses to operate due to an internal or external interlock opening, then the "Faults" display will indicate the cause. Do not RESET the power supply until the reason for the fault has been noted and recorded. The normal condition of these lamps after a RESET is all illuminated. A fault exists if a lamp is extinguished.

3.4.2.1 AC Imbalance

If not illuminated, is supposed to indicate that current in one of the 3 AC input phases is out of balance. However, normally indicates a failure in the AC balance detector circuit.

3.4.2.2 Condensation Control

If not illuminated, indicates that the power supply has been disabled by the "Condensation Control Chassis" in the power supply controls rack.

3.4.2.3 DC Overcurrent

If not illuminated, indicates that the power supply output current has exceeded the limit set manually on the DC output current meter.

3.4.2.4 Door Interlock

If not illuminated, indicates that the front or rear doors of the power supply are not closed and secured.

3.4.2.5 Emergency S/D

If not illuminated, indicates that the power supply has been disabled by the "Toroid/Solenoid Enable/Disable" switch (shutdown) in the control room or 4^{th} floor lobby.

3.4.2.6 Ground

If not illuminated, indicates that a ground fault has occurred in the toroid bus system.

3.4.2.7 Magnet Interlock Chassis

If not illuminated, indicates that the power supply has been disabled by the "Magnet Interlock Chassis" in the power supply controls rack.

3.4.2.8 SCR Failure

If not illuminated, indicates a failure in the power supply rectifier circuits.

3.4.2.9 SCR Overtemp

If not illuminated, indicates that the power supply rectifiers are above the safe operating temperature limit.

3.4.2.10 Water Overtemp

If not illuminated, indicates that the power supply cooling system water is above the safe operating temperature limit.

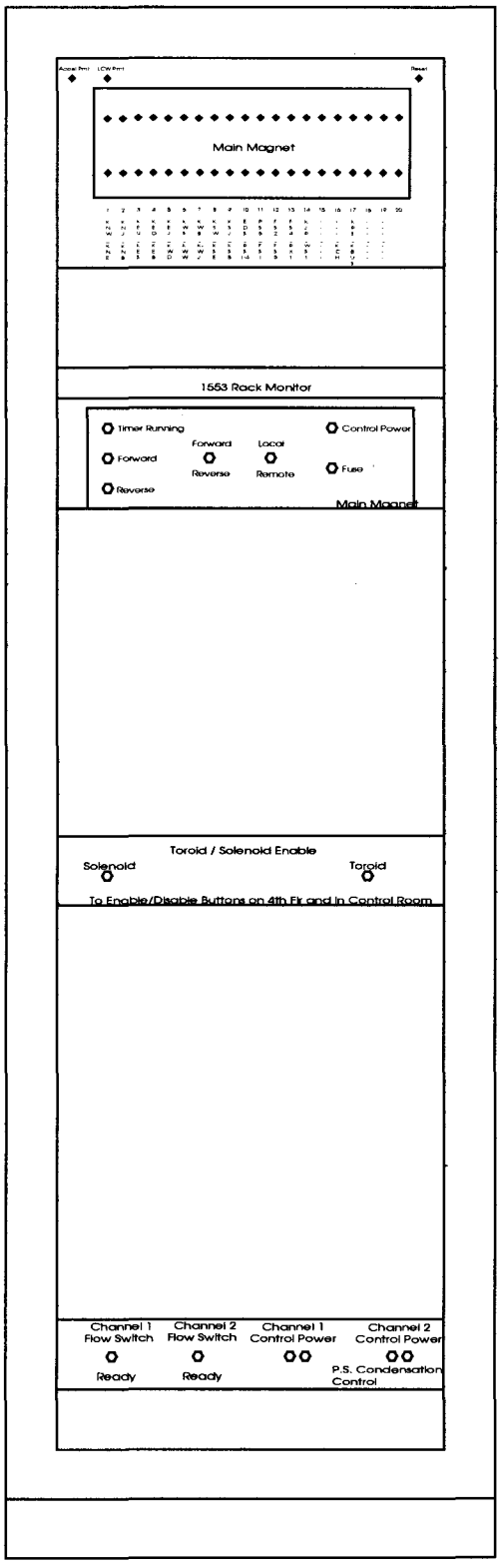
4 Documentation

Maintenance documents, including detailed specifications, schematics and wiring assignments are kept available and up-to-date in the office of the project engineer (Rick Hance).

Full schematics are available for copying in the Dzero flat files. The drawing number is #3740-524-EE-23583 "Detector Platform EF & CF Coils, Cooling Water System, Temp. Sensors, Wiring Diagram"

5 Illustrations

5.1 Power Supply Controls Rack



Magnet Interlock Chassis

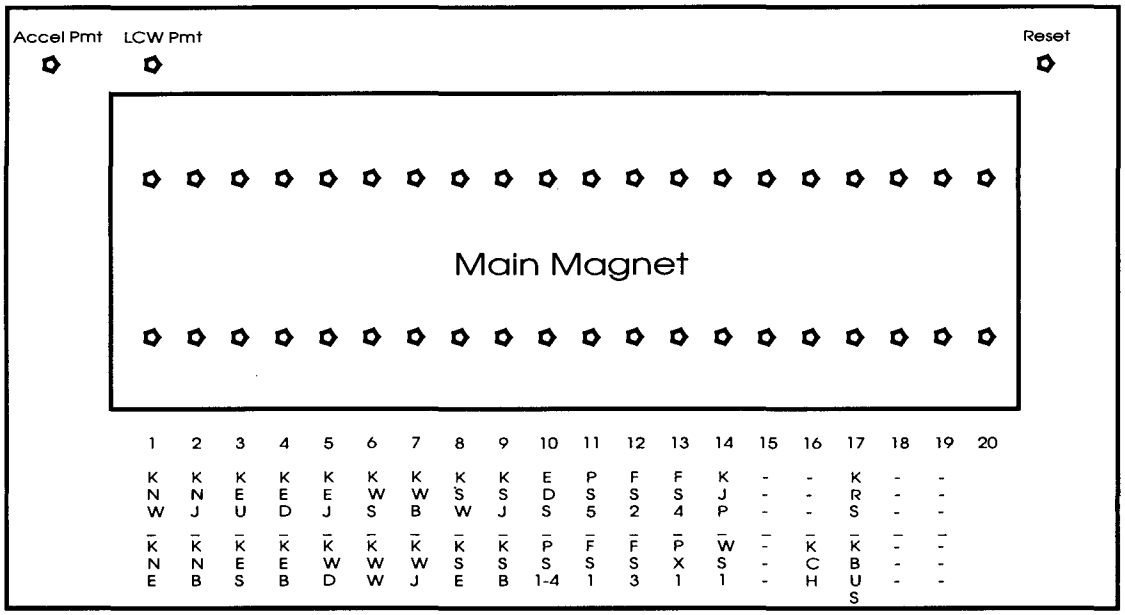
Rack Monitor

Polarity Switch Controller

Enable/Disable Interface

Condensation Controller

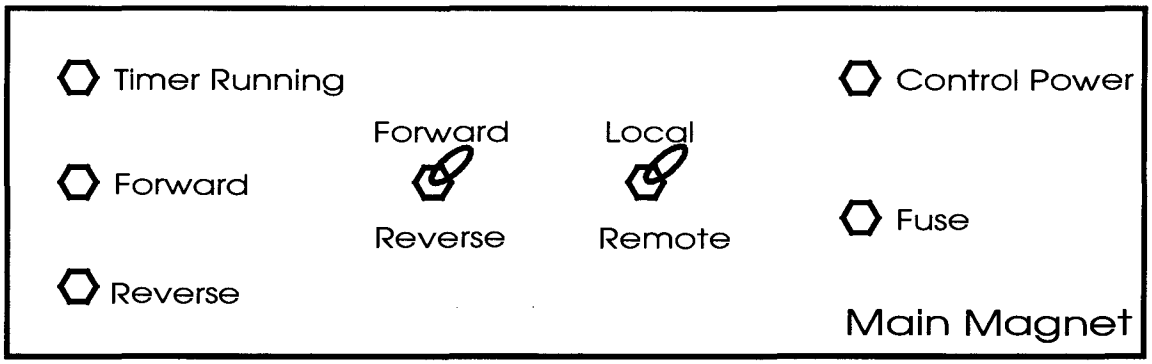
5.1.1 Magnet Interlock Chassis



5.1.1.1 Chassis Interlock Descriptions

Light	Description of Interlock	Device Designator
Accel Permit	Accelerator Permit	Interlock chassis in control room
LCW Permit	P5 & P6 pump motor starter aux contact (parallel)	P5 & P6 motor starter in room 604
KNW	Klixons on EF NW, side coils	K1 thru K8
KNE	Klixons on EF NE, side coils	K9 thru K16
KNJ	Historical - Klixons on EF North jumpers (Not Used - Always Enabled)	KJ2 - Magnet side of jumper to wall KJ3 - EF side of jumper to CF east
KNB	Klixons on EF North bus	KB1 - West supply bus KB2 - West return bus KB3 - East supply bus
KEU	Klixons on CF, NE end, top coils	K17 thru K22
KES	Klixons on CF, NE end, side coils	K23 thru K32
KED	Klixons on CF, NE end, bottom coils	K33 thru K36
KEB	Klixon on CF, NE end, side bus	KB4 (just above 1st coil)
KEJ	Historical - Klixon on CF, NE end, jumper (Not Used - Always Enabled)	KJ4 - east side jumper to EF-N KJ5 - east center, jumper to west center
KWD	Klixons on CF, NW end, bottom coils	K37 thru K40
KWS	Klixons on CF, NW end, side coils	K41 thru K50
KWU	Klixons on CF, NW end, top coils	K51 thru K56
KWB	Klixon on CF, NW end, side bus	KB5
KWJ	Klixons on CF, NW end, side jumper	KJ6 - west center, jumper to east center KJ7 - west side jumper to EF-S
KSW	Klixons on EF South, west side coils	K57 thru K64
KSE	Klixons on EF South, east side coils	K65 thru K72
KSJ	Historical - Klixon on EF South, jumper (Not Used - Always Enabled)	KJ9 - west side jumper to wall KJ8 - west side jumper to CF-N
KSB	Klixons on EF South, bus	KB6 - west side supply bus KB7 - west side return bus KB8 - west bottom supply bus
EDS	Emergency Dump Switch	Inside control room door
PS1-4	Historical - Position Switches - Not Used	
PS5-8	Historical - Position Switches - Not Used	
FS1	Water flow switch on plat - SW-40 gpm	Processed thru flow chassis - north plat
FS2	Water flow switch on plat - NW-40 gpm	Processed thru flow chassis - north plat
FS3	Water flow switch on plat - NE -100gpm	Processed thru flow chassis - north plat
FS4	Water flow switch on plat - NW-100gpm	Processed thru flow chassis - north plat
PX1	Water pressure transducer - NW corner	Processed thru flow chassis - north plat
KJP	Historical - Klixons on jumpers (Discontinued when water cooled jumpers were removed - Not Used - Always Enabled)	KJ1 - EFN supply jumper at wall KJ10 - EFS supply jumper at wall KJ11 - CFW jumper to bus to EFS KJ12 - EFS jumper to bus KJ13 - KJ14 Unknown
WS-1	Water pressure switch on plat - NW	On water line at NW corner
KCH	Klixon on choke - 5th flr	Inside Cage
KRS	Klixon on Reversing Switch - 5th flr	Inside Cage - In Box
KBUS	Klixons on bus above cap tree on 5th flr	Inside Cage - 5th flr
RSFS	Flow Switch on line to Reversing Switch	Inside Cage - 5th flr
PSFS	Flow Switch on line to Power Supply	Inside Cage - 5th flr
BAL	Balance Detector - Jumpered out	Balance Detector Chassis on 5th flr.

5.1.2 Polarity Switch Controller



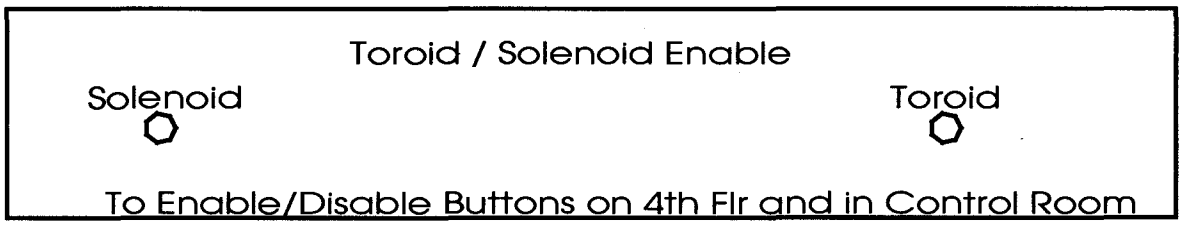
This chassis serves as the controller for the toroid magnet polarity switch. This device is not presently computer controlled and thus must be operated manually. Proper procedure is to set the toroid power supply to 0 Amps either manually or by computer before using the forward/reverse selector switch to change the polarity.

When the selector switch is toggled, this controller will clamp the toroid power supply to 0 Amps as a safety precaution and then wait 8 minutes to ensure that the toroid current has actually reached zero before cycling the switch. During the 8 minutes, the "Timer Running" indicator will illuminate. After the 8 minute delay, the switch will go to its new position. The change will be indicated on the Forward and Reverse indicator lamps.

This device is relatively trouble-free. If it fails to operate, check the obvious before calling in an expert:

- No control power indicator – check the fuse.
- Time delay in progress – wait 8 minutes to see if it cycles.

5.1.3 Enable / Disable Interface Chassis



This chassis serves as a mechanism whereby "Enable/Disable" switches located in the Dzero Control Room, and the 4th floor lobby can disable and discharge both the Toroid and the Solenoid.

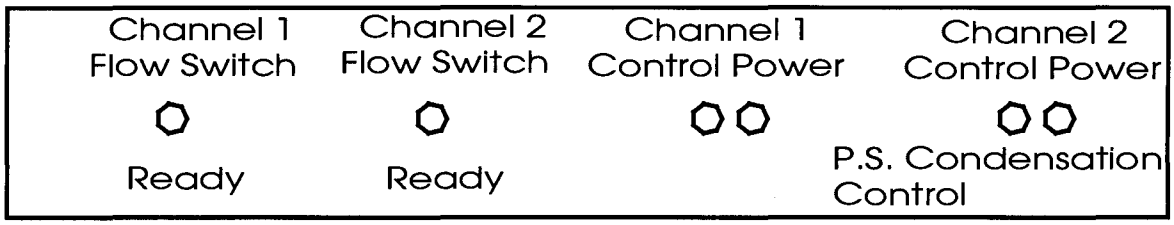
A toggle switch on the emergency console in the control room, and another one on the emergency console in the 4th floor lobby is labeled "Toroid and Solenoid Enable/Disable". These toggle switches connect to this box and hence to the Toroid and Solenoid power supplies as an interlock (Emergency S/D Fault). Lights on this chassis indicate the condition of this interlock. If the light is illuminated, then the toggle switch is enabled, and the interlock is "OK".

If either toggle switch in the control room or 4th floor lobby is set to "Disable Toroid and Solenoid", then the indicator lights on this chassis will not be illuminated. Also, the "Emergency S/D Fault" indicator light on the toroid power supply will not be illuminated, and the power supply will not be allowed to operate.

The most common sources of trouble with this chassis is a follows:

- The Toroid and Solenoid Enable/Disable toggle switch is set to "disabled" either in the control room or the 4th floor lobby - (set the toggle switches to the "enabled" position).
- There is trouble with the control power circuits for this chassis in the control room emergency control panel (contact John Foglesong).

5.1.4 Condensation Controller Chassis



This chassis serves to prevent condensation from forming inside the power supply. It does this by disabling cooling water to the power supply when the power supply is not "on". When the power supply is "on" , it will generate heat which will keep the dew point of the cooling lines high enough to prevent condensation.

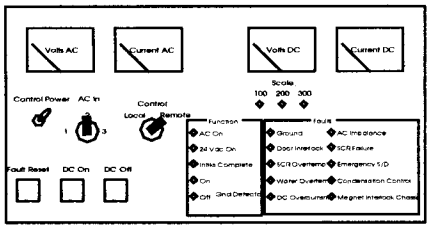
Only channel 2 is used for Run II. Channel 1 was for the SAMUS magnet of Run I. When the power supply is turned "on", a time delay relay in this chassis enables the energizes a solenoid that allows cooling water to begin flowing within the power supply. Within the delay time of the relay, which is about 3 seconds, a flow switch within the power supply cooling system must sense that cooling water is in fact flowing. If cooling water IS flowing, then the "condensation control" interlock remains OK, the solenoid remains energized, and the water continues to flow. If not, then the "Condensation Control" interlock is failed and the cooling water solenoid is deenergized.

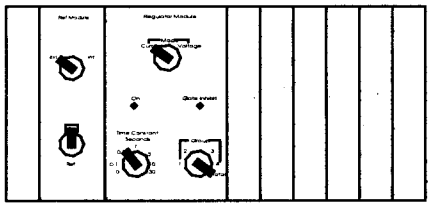
The most common causes of trouble with this devices is:

- No power to the chassis (check line cord).
- Water valves not turned on above power supply (locate and turn on supply & return water valves).
- Bad water solenoid (contact expert).
- Bad flow switch (contact expert – note switch may be stuck and might respond to LIGHT tapping to free it).
- Bad time delay relay in this chassis.

5.2 Power Supply

PEI - 500





AC Power

Off On

5.2.1.1 Analog Meters

These analog meters are intended to display the basic analog input and output information about the toroid power supply. They are highly unreliable and inaccurate; but may be used as "ball-park" indicators.

Current AC	Displays the AC input current to the power supply. At the normal toroid operating level of 1500 Amps DC, the AC input should be approximately _____ Amps AC.
Current DC	Displays the toroid DC current. Should be approximately 1500 Amps DC for Run II. Has a somewhat inaccurate manual pointer that can be set by the operator for maximum allowable current.
Volts AC	Displays the AC input voltage to the power supply. Should be 480V. Multiply the meter reading by the scale factor indicated by lamps below the meter.
Volts DC	Displays the DC output voltage of the power supply. At the normal toroid operating level of 1500 Amps DC, the DC output voltage should be approximately _____ Volts DC.

5.2.1.2 Functions Display

These lamps indicate the readiness of the power supply to operate.

24Vdc On	When illuminated, indicates that the control power is on (see control power switch).
AC On	When illuminated, indicates that the main AC power switch is on.
Gnd Detector	When illuminated, indicates that the power supply ground fault detector is enabled and operating.
Intlks Complete	When illuminated, indicates that all interlocks are complete (no "Faults" are indicated) and the supply is ready to operate.

5.2.1.3 Faults Display

If the power supply quits operating due to an internal or external interlock opening, then the "Faults" display will indicate the cause. Do not RESET the power supply until the reason for the fault has been noted and recorded. The normal condition of these lamps after a RESET is all illuminated. A fault exists if a lamp is extinguished.

AC Imbalance	If extinguished, is supposed to indicate that current in one of the 3 AC input phases is out of balance. However, normally indicates a failure in the AC balance detector circuit.
Condensation Controller	If extinguished, indicates that the power supply has been disabled by the "Condensation Control Chassis" in the power supply controls rack.
DC Overcurrent	If extinguished, indicates that the power supply output current has exceeded the limit set manually on the DC output current meter.
Door Interlock	If extinguished, indicates that the front or rear doors of the power supply are not closed and secured.
Emergency S/D	If extinguished, indicates that the power supply has been disabled by the "Toroid/Solenoid Enable/Disable" switch (shutdown) in the control room or 4th floor lobby.
Ground	If extinguished, indicates that a ground fault has occurred in the toroid bus system.
Magnet Interlock Chassis	If extinguished, indicates that the power supply has been disabled by the "Magnet Interlock Chassis" in the power supply controls rack.
SCR Failure	If extinguished, indicates a failure in the power supply rectifier circuits.
SCR Overtemp	If extinguished, indicates that the power supply rectifiers are above the safe operating temperature limit.
Water Overtemp	If extinguished, indicates that the power supply cooling system water is above the safe operating temperature limit.

5.2.1.4 Controls

AC Input	Selects the most appropriate tap setting to match the AC input voltage. Should be set at 2
AC Power Off/On	Main switch that supplies AC power to the supply. Should be locked and tagged off when not in use.
Control - Local/Remote	Selects whether the power supply is controlled locally at the front panel, or remotely by computer.
Control Power	Enables control power to the power supply causing lights and controls to function.
Current BNC	BNC connection for viewing the current feedback signal on an oscilloscope for maintenance.
DC Off	Engages main contactor in supply allowing DC current to be produced.
DC On	Disengages main contactor in supply disabling DC current production.
Ext / Int	Selects source of reference voltage that programs power supply. Must be set to Ext for computer control, Int for local control.
Fault Reset	Resets Fault panel and clears interlocks if possible.
Gate Inhibit Indicator	When illuminated, indicates that rectifiers are inhibited from operating by the reversing switch timer.
Group Selector	Selects the SCR group whose gate signals will be connected to the test point for oscilloscope evaluation for maintenance.
Group Selector BNC	BNC connection for viewing the selected SCR group firing signals on an oscilloscope for maintenance.
Int. Reference	Potentiometer used to adjust the programming voltage internally when the "Ext/Int" reference switch is set to Int.
Mode – Current / Voltage	Selects the regulation mode of the power supply. Normal mode is **"Current"**.
On Indicator	When illuminated, indicates that rectifiers are not externally inhibited by the reversing switch timer.
Time Constant Selector	Selects the regulation loop time constant. Must be set to **0.3 Seconds**.
Voltage BNC	BNC connection for viewing the voltage feedback signal on an oscilloscope for maintenance.