PROTON IMPROVEMENT PLAN II DIVISION DOCUMENT

OPERATIONS

P2DP-OP-0003

PIP2IT CONTROL ROOM ON-THE-JOB TRAINING (OJT)

RESPONSIBLE DEPARTMENT: PIP-II Division

PREPARED BY: Darren J. Crawford, PIP-II Operations Coordinator — DATE: 8/21/2020

REVIEWED BY: Eduard Pozdeyev, PIP-II L3 Commissioning Manager — DATE: 8/21/2020

APPROVED BY: Lia Merminga, PIP-II Division Head — DATE: 8/21/2020

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Revision History

1)

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1.0 PURPOSE AND SCOPE

The following checklist is provided to ensure basic operations training was received prior to operating the Proton Improvement Plan II Injector Test (PIP2IT) accelerator at the Cryomodule Test Facility (CMTF).

2.0 AUTHORIZED PERSONNEL

This training shall be administered by the PIP-II Operations Coordinator and/or PIP2IT Operation experts (see list in section 3.11) with each intended operator. Upon record of completion, the Fermilab employee being trained becomes a PIP2IT qualified accelerator operator (QAO).

3.0 ON-THE-JOB TRAINING (OJT)

3.1 Operating Requirements

_____ Rad Worker training completed.

_____ Read P2DP-OP-0004, P2DP-OP-0005, P2DP-OP-0006, P2DP-OP-0007, and pip2-Docdb-4872.

3.3 PIP2IT Control Room

3.3.1 ACNET pages and applications

_____ PIP2IT operational ACNET pages are primarily P126, P127 and P128

_____ PIP2IT Sequencers are P135 (Ion Source), P136 (RFQ) and P137 (MEBT bunching cavities)

_____ PIP2IT uses several Java applications; For basic operation, only the "PXIE Timing Plot" Java application is recommended to be used and is located in the Application Index main menu

_____ The PIP2IT RFQ's basic functionalities may be controlled from a Synoptic display (PXIE RFQ RF Distribution), which can be found in the PXIE folder of the Synoptic Viewer repository (accessible via the PIP2IT Group website or the AD Controls website)

_____ Monitoring and advanced control of the RFQ employ a Labview application, which resides on CNS71 and CNS72 in the PIP2IT Control Room

_____ Monitoring and advanced control of the MEBT bunching cavities employ 2 Labview applications, which reside on CNS71 and CNS72 in the PIP2IT Control Room (one application for bunching cavity #1 and one application for bunching cavities #2 and #3)

_____ Controls for the cryogenic systems employ a Synoptics interface

_____ Manipulation of the cryogenic systems beyond monitoring a few parameters via ACNET pages or plots is restricted to Cryogenics experts

3.3.2 Sequencer aggregates

_____ When turning ON/OFF the Ion Source, RFQ and bunching cavities with the Sequencers, the order in which the aggregates are run does not matter

_____ All three aggregates must be completed before establishing beam to/through the RFQ

_____ Note that some of the commands may be bypassed and should not be enabled unless directed by a PIP2IT Operation Expert

_____ Understand that bunching cavity #1 (B1) and bunching cavities 2 & 3 (B3 & B3) have different LLRF 'drivers'

_____ B2 and B3 can only run in CW RF mode

_____ B1 can run in both pulsed and CW RF modes but the ***B1 RF mode has to match the RFQ running mode*** (i.e. RFQ and B1 both in pulsed mode, or both in CW mode)

3.4 PIP2IT Sequencer Turn On for Pulsed Operation (P135)

3.4.1 "***PXIE Ion Source Turn ON***" aggregate

_____ Turn on the PIP2IT Ion Source from P135 and understand the main steps and interact with the Sequencer as required

_____ Three (3) default plots are started

_____ Set the beam pulse length (may be bypassed)

_____ Set the gas flow

_____ PIP2IT Critical Device Control reset

_____ Power supplies enabled and values for voltage or current set (***except*** for the bias power supply)

_____ LEBT chopper HV check

_____ Beam pulse length set to 10 μs

_____ Ion Source Filament current ramps up ('fast' rate at the beginning, slower when it gets close to its desired value)

_____ Filament current regulation Finite State Machine (FSM) enabled

_____ Bias power supply enabled and set to 30 kV

_____ Beam current regulation FSM enabled

_____ Alarm lists enabled

3.4.2 "***PXIE RFQ Pulsed RF Turn On***" aggregate

_____ Turn on the PIP2IT RFQ RF in pulsed mode from P136 and understand the main steps

- _____ RFQ power amplifiers reset
- _____ Pulse repetition rate check
- _____ Water valves (for the RFQ wall and vanes) set to 20% (default)
- _____ Bunching cavity #1 set to pulsed mode
  - _____ It does not mean that bunching cavity #1 will turn on (and it does not have to be on)
- _____ RFQ set to pulsed mode
- _____ RFQ RF trip devices reset
- _____ RFQ RF coupler bias power supply turned on (default voltage setting)
- _____ RFQ RF feedforward amplitude parameter set to 0.1 (default)
- _____ RFQ RF feedforward and frequency tracking enabled
- _____ RFQ RF enabled
- _____ RFQ voltage ramps up to nominal value (60 kV)
- _____ RFQ Resonance control enabled
- _____ RFQ RF amplitude and phase set points set to nominal value (60 kV, 0°)
- _____ RFQ RF adaptive beam compensation disabled
- _____ RFQ RF beam compensation phase and amplitude set to default values
  - _____ Only relevant if adaptive beam compensation is enabled

_____ If an error occurs and/or the RFQ voltage readback is not 60 kV, refer to the troubleshooting steps described in the PIP2IT Startup Procedure

3.4.3 "***B1 RF Turn On Pulsed***" aggregate

_____ Turn the MEBT bunching cavity #1 (B1) RF on in pulsed mode from P137 and understand the main steps

- _____ Pulse repetition rate check
- _____ B1 set to pulsed mode
- _____ B1 RF power amplifier turned on

_____ B1 RF trip devices reset

_____ B1 ion pump and water flow devices reset

_____ B1 RF feedforward amplitude parameter set to 0.44 (default)

_____ B1 RF feedforward enabled

_____ B1 RF enabled

_____ B1 RF amplitude set to 60 kV (default) and RF phase set to -90° (default)

_____ B1 Frequency tracking disabled

_____ B1 RF feedback enabled

_____ B1 RF amplitude checked

3.4.4 "***B2 RF Turn On CW***" aggregate

_____ Turn the MEBT bunching cavity #2 (B2) RF on from P137 and understand the main steps (reminder: B2 can only be run in CW mode)

_____ B2 RF set to CW mode

_____ B2 RF power amplifier powered up

_____ B2 RF trip devices reset

_____ B2 ion pump and water flow devices reset

_____ B2 RF power amplifier turned on

_____ B2 RF feedforward amplitude parameter set to 0.44 (default) and phase parameter set to -90° (default)

_____ B2 RF enabled

_____ B2 RF feedforward enabled

_____ B2 RF phase set to -90° (default)

_____ B2 RF voltage set to 50 kV (default)

_____ B2 RF PID loop proportional and integral gains set to default values

_____ B2 RF feedback enabled

3.4.5 "***B3 RF Turn On CW***" aggregate

_____ Turn the MEBT bunching cavity #3 (B3) RF on from P137 and understand the main steps (reminder: B3 can only be run in CW mode)

_____ Although the aggregates for B2 and B3 are very similar, for historical reasons, or peculiarity

of the power amplifiers, they may not be exactly identical

_____ B3 RF power amplifier powered up

_____ B3 RF trip devices reset

_____ B3 ion pump and water flow devices reset

_____ B3 RF power amplifier turned on

_____ B3 RF feedforward amplitude parameter set to 0.44 (default) and phase parameter set to -90° (default)

_____ B3 RF enabled

_____ B3 RF feedforward enabled

_____ B3 RF phase set to -90° (default)

_____ B3 RF voltage set to 50 kV (default)

_____ B3 RF PID loop proportional and integral gains set to default values

_____ B3 RF feedback enabled

_____ B3 RF amplitude checked

3.5 PIP2IT Sequencer Turn off Pulsed Operation (P135)

3.5.1 "***PXIE Ion Source Turn OFF***" aggregate

_____ Turn off the PIP2IT Ion Source from P135 and understand the main steps and interact with the Sequencer as required

_____ Beam current regulation FSM disabled

_____ Extraction and bias voltages set to zero

_____ Bias power supplies disabled

_____ Sequencer files loaded with zero settings

_____ Ion Source Filament current ramps down

_____ Filament current regulation Finite State Machine (FSM) disabled

_____ Gas flow set to 0

_____ Arc current set to default value

_____ Alarm lists disabled

_____ Once the aggregate is complete, restore settings from a D1 save file

3.5.2 "***PXIE RFQ Pulsed RF Turn Off***" aggregate

_____ Turn off the PIP2IT RFQ RF (when ran in pulsed mode) from P136 and understand the main steps

_____ RFQ Resonance control disabled

_____ Beam compensation, RF feedback and RF feedforward disabled

_____ RFQ RF disabled

_____ RFQ RF power amplifiers turned off

_____ RFQ RF coupler bias power supply turned off

3.5.3 "***B1 RF Turn Off Pulsed***" aggregate

_____ Turn the MEBT bunching cavity #1 (B1) RF off (when ran in pulsed mode) from P137 and understand the main steps

_____ B1 RF feedback disabled

_____ B1 RF feedforward disabled

_____ B1 Beam compensation disabled

_____ B1 RF disabled

_____ B1 RF power amplifier turned off

3.5.4 "***B2 RF Turn Off CW***" aggregate

_____ Turn the MEBT bunching cavity #2 (B2) RF off from P137 and understand the main steps

_____ B2 RF feedback disabled

_____ B2 RF feedforward disabled

_____ B2 RF disabled

_____ B2 RF power amplifier turned off

3.5.5 "***B3 RF Turn Off CW***" aggregate

_____ Turn the MEBT bunching cavity #3 (B3) RF off from P137 and understand the main steps

_____ B3 RF feedback disabled

_____ B3 RF feedforward disabled

_____ B3 RF disabled

_____ B3 RF power amplifier turned off

3.7 Systems

3.7.1 Compressed air

_____ Know that vacuum valves use compressed dry air to operate, including the MEBT Fast Acting Valve

_____ Know that compressed dry air flows through the RFQ RF couplers

_____ Alarms are set for the flow meters although the ACNET devices (P:R3AD01, P:R3AD02, P:R3AD03 and P:R3AD04) report their values in "Volts"

_____ Flow rates are set manually and should not change without a system expert

3.7.2 Low-Conductivity Water (LCW)

_____ There are several independent LCW systems/circuits

_____ The Ion Source and LEBT are on a closed-loop circuit with a stand-alone chiller located outside of the PIP2IT enclosure

_____ Note that the water conductivity for this system is not reported into ACNET

_____ The RFQ has a dedicated cooling/regulating skid used to maintain the RFQ on-frequency by varying the RFQ walls and vanes temperatures

_____ The RFQ cooling/regulating skid and the MEBT components are fed from the main LCW cooling skid located near the exit door on the west(?) side of the CMTF building

3.7.3 RF System

_____ Know that there are several RF systems

_____ Understand that the LLRF hardware for the RFQ and Bunching Cavity #1 is different (older version) from the LLRF hardware for Bunching Cavities #2 and #3

_____ Except for phasing of the bunching cavities (semi-automatic procedure), RF devices should not be changed without approval/supervision of a PIP2IT LLRF expert or the PIP2IT Coordinator

3.7.4 Cryogenics

_____ Know that PIP2IT shares the same cryo-plant as CMTS-1

_____ Each cryomodule can be cooled independently from one another

_____ Each SRF system has a cryogenic permit

3.8 Machine Protection System (MPS)

_____ Know that multiple systems are monitored

- _____ Currently, the MPS GUI is in development and, only a minimum of actions should be done from it (such as resetting it)
- _____ Individual trip channels should not be enabled/disabled without authorization from a sub-system expert and/or PIP-II Operations Coordinator
- _____ Some moveable devices
- _____ Beamline vacuum system
  - _____ Note that the MPS vacuum permit is segmented (e.g. Ion Source & LEBT, MEBT 1, MEBT 3)
  - _____ The vacuum valves statuses are also monitored preventing beam to be extracted when closed
- _____ Low Conductivity Water (LCW) System
- _____ RF System
- _____ Differential Pumping Insert (DPI) current and body temperature
- _____ LEBT chopper status
- _____ Various current read backs (from beam impinging onto electrically isolated surfaces) e.g. MEBT kickers' protection electrodes
- _____ Beam loss as defined by the measurement differential between successive current monitoring devices (toroids, Ring Pick Ups, Beam dump)
- _____ Beam macro-pulse length

_____ Understand that the MPS provides a beam permit based on the status of the systems it monitors

- _____ When the beam permit is disabled/tripped, the MPS either prevent the beam from being extracted from the ion source or from being accelerated in the RFQ via a multi-tiers process

_____ If the MPS permit trips, and conditions for resuming operations are not met, contact a PIP2IT Operations expert (See call-in list)

3.9 Manipulating Devices

_____ LEBT solenoids

_____ Magnets

- _____ Ion Source steering dipoles

_____ LEBT steering dipoles

_____ MEBT quadrupoles

_____ MEBT steering dipoles

_____ LEBT chopper

_____ LEBT chopper mode/status

_____ LEBT chopper pulse length

_____ LEBT chopper free run frequency

_____ Instrumentation (Movable Devices)

_____ LEBT scraper

_____ MEBT scrapers

_____ There are 4 sets of 4 scrapers (up, down, right, left) along the MEBT beam line

_____ Understand the dual purpose of these scrapers (beam line components protection, beam size measuring devices), which may depend on the running conditions (e.g. pulse width, duty factor)

_____ Wire scanner

_____ Emittance (Allison) scanner

_____ Bunching cavities RF phases (when used in conjunction with the RF phasing java application)

_____ Contact a PIP2IT Operations Expert and/or PIP2IT Coordinator, or his/her designee, before manipulating:

_____ Vacuum/Gate Valves

_____ Beam current intensity (i.e. Ion Source’s extraction voltage and/or Arc current)

_____ LEBT dipole switching magnet

_____ RF magnitudes (RFQ or bunching cavities)

_____ Timing system (pulse frequency, trigger delays)

_____ The MEBT kickers and MEBT beam absorber should not be manipulated without direct assistance/supervision of the proper experts

_____ PIP2IT Qualified Operators trained with this OJT are not trained to manipulate the cryogenics systems

3.10 Controlled Access

_____ Safety training requirements

_____ Rad Worker II

_____ Oxygen Deficiency Hazard (ODH)

_____ The PIP2IT Cave is classified ODH 2, when either the cryogenic distribution system or any of the cryomodules contains cryogens *and* the PIP2IT enclosure's roof blocks are in place

_____ Controlled Access is to be approved by a PIP2IT Operations Expert or the PIP2IT Coordinator (or his/her designee)

_____ Turn-off the beam

_____ As of the time of this writing, there is no Sequencer aggregate to turn the beam off for a controlled access

_____ Set the Ion Source's Extraction voltage (P:L00IXV) to zero

_____ Set the Ion Source's Bias voltage (P:L00IBV) to zero

_____ For redundancy, disable Bias voltage power supply

_____ On access, the LEBT bending/switching magnet/dipole power supply will be disabled by the Radiological Safety system and the PIP2IT critical device (P:PITCDC) will be tripped

_____ Turn-off other systems as required for the tasks to be accomplished during the Controlled Access

_____ Once the Controlled Access is completed, beam operation is re-established by doing the turn off steps above in the reverse order

_____ IMPORTANT NOTE: At the time of this writing, the PIP2IT components do not get activated when running beam. The Controlled Access procedure may have to be updated should the radiological conditions of the PIP2IT enclosure change.

3.11 Call-in List

_____ PIP2IT Operations Group (Experts)

_____ Bruce Hanna (630) 404-0204

_____ Sasha Shemyakin (630) 670-8123

_____ Lionel Prost (630) 885-6570

_____ Jean-Paul Carneiro (630) 440-6489

_____ Arun Saini (331) 901-1362

4.0 RECORDS

The PIP-II Operations Coordinator will keep originals of the completed OJTs affixed with the name, date and signature of the

trainee. They represent an official record that training to operate PIP2IT was completed.

Get familiar with the accelerator components and main parameters (reference material: http://beamdocs.fnal.gov/AD-public/DocDB/ShowDocument?docid=5370)

Understand personal safety hazards (High Voltage, Ionizing radiation, hydrogen gas, RF radiation, laser, cryogenics)