Concept of Operations For the Accelerator Personnel Safety System 0 (PSS0)

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1. INTRODUCTION

1.1. Purpose of the document

The purpose of this document is to describe the concept of operation for Accelerator Personnel Safety System 0 (PSS0). This information is a set of step-by-step instructions for operating procedures of the Personnel Safety System to be installed for the ESS accelerator ISrc and LEBT test stand.

1.2. Definitions, acronyms and abbreviations

Abbreviation	Explanation of the abbreviation
ISrc	Ion Source
LEBT	Low Energy Beam Transport
ICS	Integrated Control System Division
AD	Accelerator Division
PSS	Personnel Safety System
PSS0	Personnel Safety System for ISrc and LEBT Test Stand
HV PS	High Voltage Power Supply
SIF	Safety Instrumented Function
FEB	Front End Building
EMC	Electromagnetic Compatibility
FAT	Factory Acceptance Test
Authorized operator	A trained personnel authorized by ESS management who ensures the safe operation of ISrc and LEBT test stand.
Z0	ISrc Fenced Area, PSS0 controlled area

1.3. References

[1] SS 4364000 Swedish standard; Low-voltage electrical installations - Rules for design and erection of electrical installations.
[2] SS-EN 50110-1:2013 European standard; Operation of electrical installations – Part 1: General requirements.
[3] Accelerator Personnel Safety System and Ion Source Interface Control Document (ESS-0064042).
[4] Ion Source and LEBT Temporary Test Stand (ESS-0118213).
[5] Ion Source High Voltage Protection Cage (ESS-0122281).

2. SYSTEM CHARACTERISTICS

2.1. System purpose

PSS0 aims to mitigate high voltage electrical hazards for personnel arising from operating the ISrc and LEBT test stand. Mitigation against radiation hazards is out of the scope of this document and PSS0.
The system design is chosen to suit the requirements in SS-4364000 which is a Swedish standard for Low-voltage electrical installations - Rules for design and erection of electrical installations [1].
The system operation is chosen to suit the requirements in SS-EN 50110-1:2013, a European standard for operation of electrical installations [2]. It should be noted that, in the context of this document “operation” means all activities including work activities necessary to permit the electrical installation of the ISrc HV PS to function.

2.2. System overview

PSS0 consists of the following equipment:

- A fence around the ISrc HV platform, which provides protection against direct contact to the ISrc HV platform and prevents any access to ISrc fenced area (i.e. PSS0 controlled area; Z0) during operation of the ISrc. Before the ISrc HV platform can be energized by the HV PS, the ISrc fenced area has to undergo a formalised search ensuring evacuation of workers from the PSS0 controlled area and in addition the ISrc fenced area access door must be locked. It should be noted that this fence also provides the required shielding against radiation from the operation of the ISrc.
- Two contactors (in series) on mains incoming power to HV PS ensure that the HV PS is disabled upon access to ISrc fenced area.
- A HV grounding relay that is required to ground the HV PS capacitors and to discharge cable currents.
- A grounding rod to be used by the operator upon access to ISrc fenced area to ensure the operator that the HV PS capacitors and cable discharge currents have been properly grounded. It should be noted that the HV grounding relay has the main function to ensure grounding of the ISrc HV platform, and the grounding rod will be used as an additional layer of protection.
- Key exchange system to provide a predefined mechanical sequence to de-energize the HV PS and provide access to ISrc fenced area.
- amGard pro Fortress proLok to be used for locking of the access door to ISrc fenced area.
- Safety switches to monitor the positon (i.e. open or closed) of the ISrc fenced area access door.
- Mechanical micro-switches to monitor the positon (i.e. open or closed) of the 8 steel doors of the ISrc HV platform.
- Search buttons to be used to carry out a formalised search within ISrc fenced area prior to energizing the HV PS.

- The PSS racks containing the PSS red and blue train CPUs, PSS0 remote I/Os, and PSS contactors for the HV PS, which are installed in G01-FEB level 90.
- Emergency stop button to be installed outside ISrc fenced area, and in the vicinity of the ISrc and LEBT test stand. The main objective of this emergency stop button is to provide means for quick intervention of operator(s) to de-energize the HV PS in the event of an incident that could jeopardize the integrity of the ion source (e.g. Fire, explosion).
- Blue light; as mentioned earlier in this document, mitigating radiation hazards is not in the scope of PSS0, however a blue signal light will be installed outside ISrc fenced area to inform personnel that beam is imminent upon energizing the HV PS.

Figure 1 shows the distribution of PSS0 field devices.
Figure 2 shows an overview of Personnel Safety Systems interfaces with ISrc. The details of Interfaces between PSS0 and ISrc are described in [3].

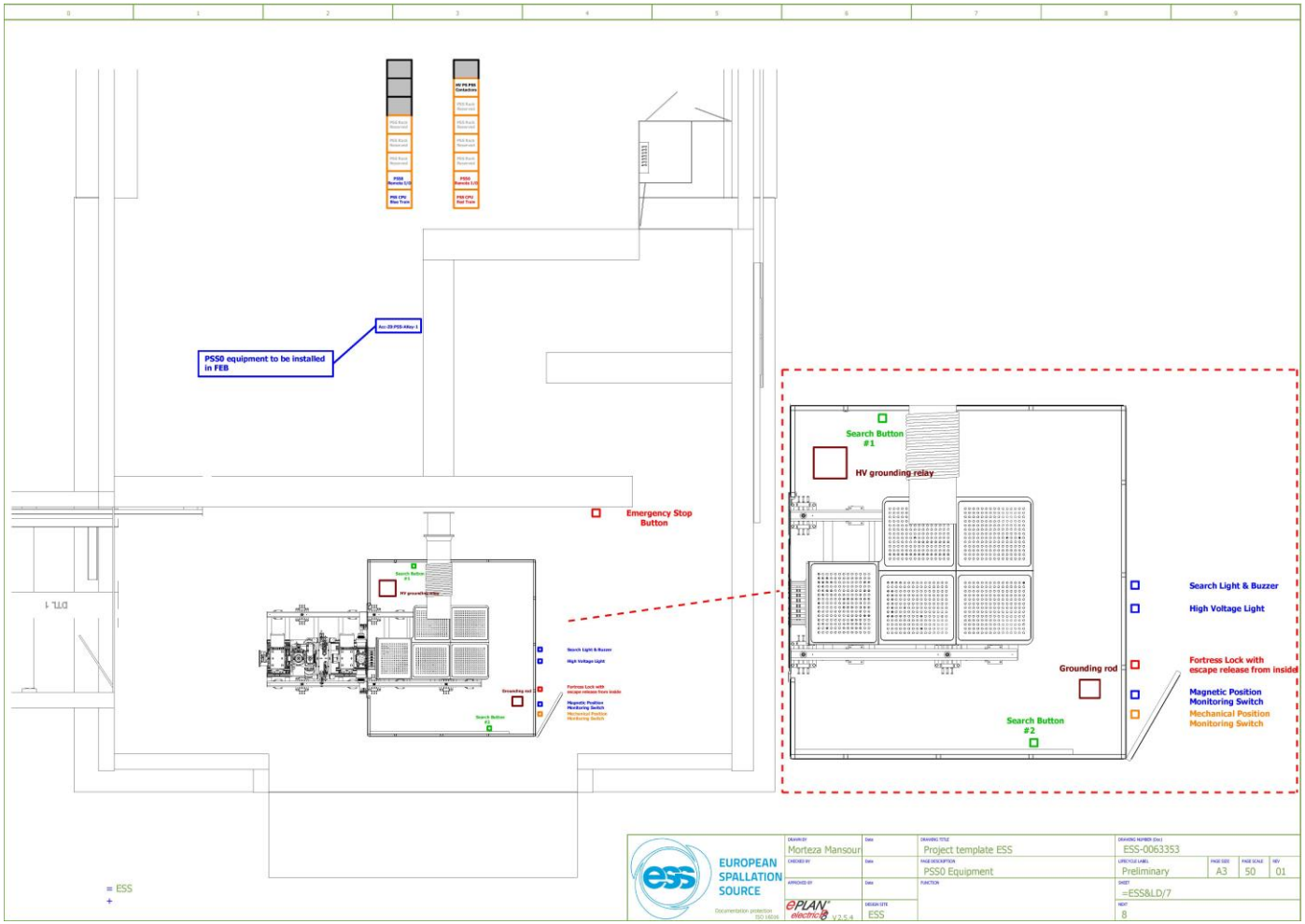

Figure 1:PSS0 field devices

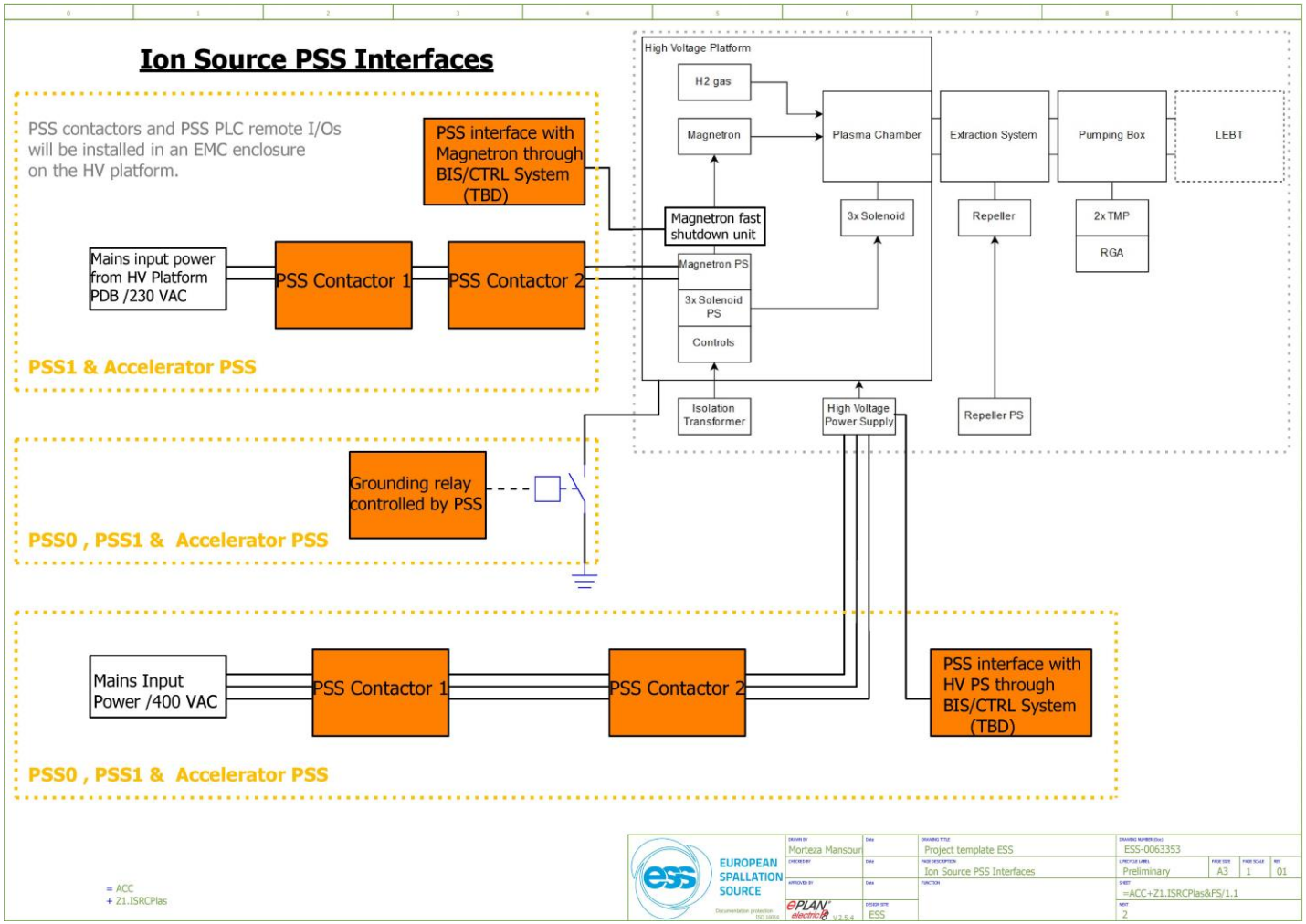

Figure 1: PSS interfaces with ISrc

3. SYSTEM STAKEHOLDERS

3.1. ICS

The protection and safety systems group in ICS is responsible to develop, install, commission, validate and maintain PSS0.

3.2. AD

The Linac group in AD is responsible to develop, install and maintain the ISrc fence, and operate the PSS0 system according to all the procedures described in this document.

4. CONCEPTS OF OPERATION

4.1. Environment

PSS0 will be installed to mitigate against electrical hazards for personnel arising from operating the ISrc and LEBT test stand. The ISrc and LEBT will be installed in Accelerator tunnel (building G01). Figure 3 shows a 3D model of the ion source and LEBT. The ISrc and the racks for control systems I/Os, vacuum, etc. are situated inside a metallic cage, which is called the ISrc HV platform. There are 8 steel doors for the ISrc HV platform. The high voltage platform houses the plasma chamber as well as the controls and power supplies needed for plasma generation. The platform is biased to 75 kV DC to allow extracting of a 75 keV proton beam. The LEBT consist mainly of two solenoids to focus the beam, an iris to reduce the beam current, a chopper to remove the first part of the beam, and diagnostics [4].
It shall be noted that the HV PS maximum output power rating is 100 kV and 150 mA, DC.

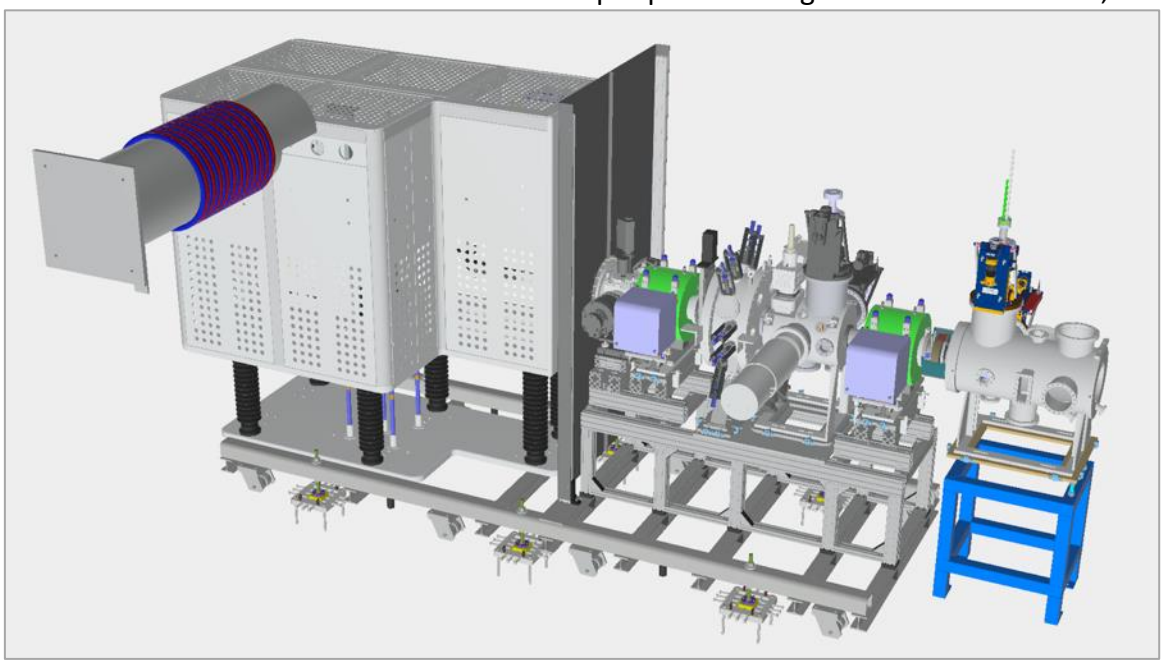

Figure 3: Ion source high voltage platform (left), and LEBT. In place of the RFQ there is a diagnostics tank that will be used only during the commissioning.

The ISrc HV platform will be surrounded by a fence to provide protection against direct contact to ISrc HV platform from any usual direction of access when the HV PS is energized. The fence design conforms to IP 3X and its detailed design is described in [5].
The HV PS is installed in FEB level 090 and the HV cable runs through a dedicated cable route to the ISrc HV platform.

4.2. Operating scenarios

4.2.1. Energizing HV PS

In order to enable ISrc operation, the HV PS needs to be energized.
Following the issue of ISrc operation permit by operation manager, the authorized operator shall carry out all the procedures mentioned below step by step to energize the HV PS:

- The operator makes sure there is nobody inside the platform, and all the steel doors of the ISrc HV platform are closed (the position of these doors are being monitored by the mechanical micro-switch on each steel door, and if any of the platform doors open during the search procedure, the search breaks and need to restart).
- Illuminated search button #1 starts flashing. The operator looks around the area within the ISrc fence to ensure there is no one present there, and presses search button #1.
- The Z0 sounder installed on the ISrc fence (outer side) starts sounding in short pulses.
- 15 seconds after the search button #1 is pressed (timer T1), the Illuminated search button #2 starts flashing.
- The operator looks around the area within ISrc fence to ensure there is no one present there, and presses search button #2.
- The operator will remove the grounding rod from the ISrc HV platform, and will place the grounding rod in its rest place next to the ISrc fenced area access door. (the position of the grounding rod in its rest place is being monitored by the mechanical micro-switches of the grounding rod)
- The operator leaves the ISrc fenced area and closes the door.
- The operator inserts the safety key into the slot #3 on the proLok, this will enable the removal of access key from slot #2 on the proLok.
- The signal to the proLok solenoid is disabled by PSS PLC. The access door is locked. The overall time for searching Z0 shall not exceed 60 seconds (timer T2)
- The Z0 sounder is sounding in long pulse for 5 seconds. The “Area Searched” light on the ISrc fence turns on.
- The HV grounding relay opens (i.e. disconnects the ISrc HV platform from ground potential).
- "High Voltage ON" light installed on the ISrc fence (outer side) turns on.
- The operator returns the access key to slot #1 in the wall-mounted box installed next to HV PS in FEB, and turn it into ON position.
- After 1 second, the PSS contactors interfacing the mains input power to HV PS, are enabled (i.e. closed).
- A signal will be sent from PSS PLC to interlock PLC, issuing the permit to enable the external interlock of the HV PS.
- The interlock PLC sends the enable signal to the external interlock of the HV PS.
- The operator presses the “RESET” button, followed by pressing “ON” button on the HV PS front panel.

- The HV PS is rearmed, and the operator can ramp up the HV PS to 75 kV through CS-Studio in the control room.

Figure 4 shows the flowchart of sequences for energizing the HV PS.

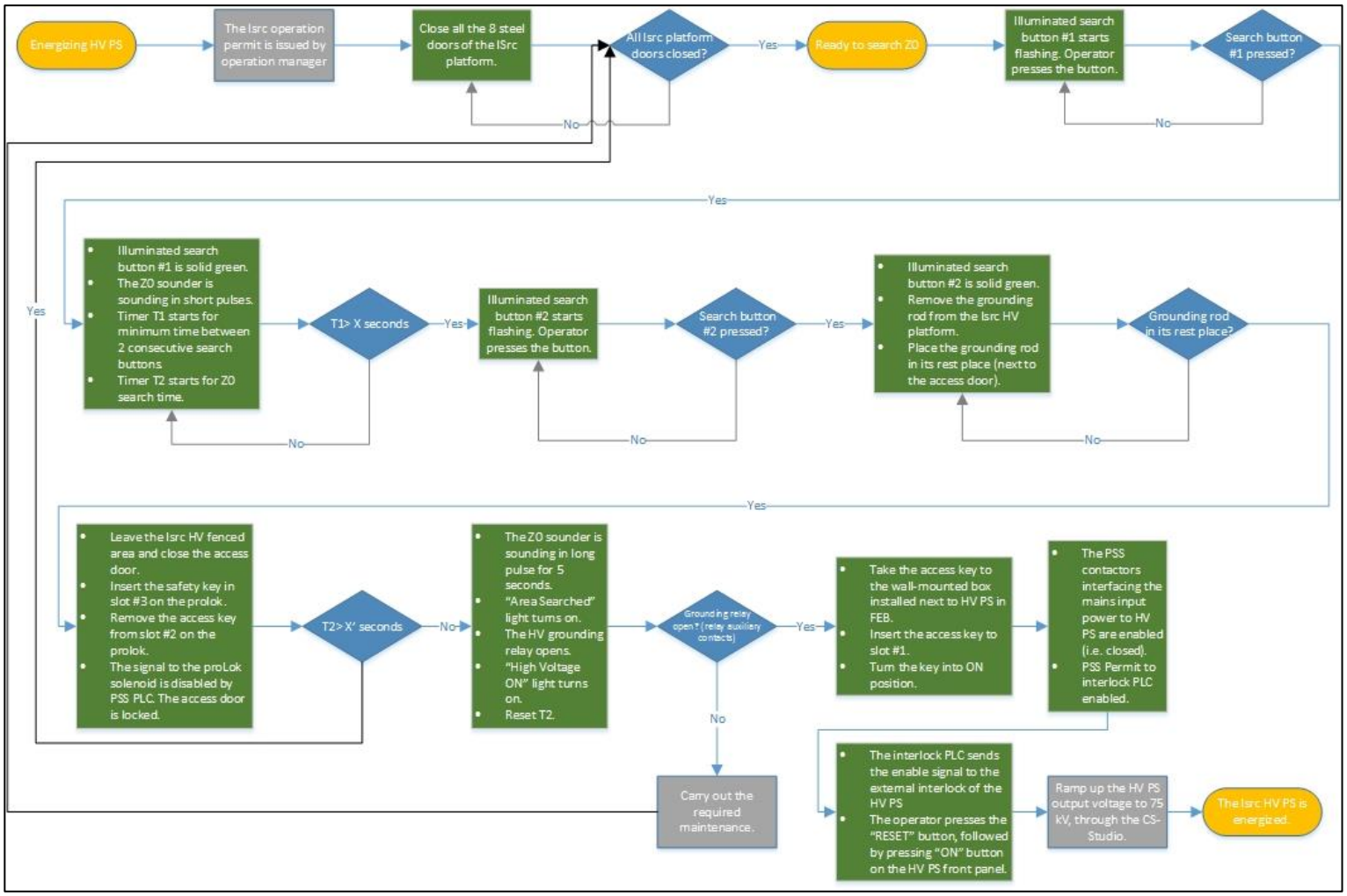

Figure 4: Energizing the HV Power Supply

4.2.2. De-energizing the HV PS and access to ISrc fenced area during normal operation

Following the issue of permit to access ISrc fenced area by operation manager, the authorized operator shall carry out the procedures mentioned below step by step to de-energize the HV PS, and get access to ISrc fenced area.

- The operator in the control room ramps down the HV PS output voltage to zero, through the CS-Studio graphical user interface.
- The operator should obtain the key for the wall-mount box installed next to HV PS which contains the access key to ISrc fenced area.
- The operator goes to FEB, where the HV PS is installed, and removes the access key from slot #1 in the wall-mount box installed next to HV PS.
- The permit signal from PSS PLC to interlock PLC is disabled. Hence, the interlock PLC will disable the permit from HV PS external interlock.
- After 1 second, the PSS contactors interfacing the mains input power to HV PS are disabled (i.e. opened).
- The operator shall verify the absence of high voltage in the output of the HV PS by checking the voltage meter on the front panel of the HV PS.
- After 500 mili seconds (timer T3), the HV grounding relay closes (i.e. connects the ISrc HV platform to ground potential).
- “High Voltage ON” light turns off.
- The operator goes to accelerator tunnel and inserts the access key to slot #2 on the proLok, and removes the safety key from slot #3 on the proLok. The authorized operator shall carry the safety key with him/herself during the access period to ISrc fenced area.
- The signal to the proLok solenoid is enable by PSS PLC. The access door is unlocked.
- “Area Searched” light on the ISrc fence turns off.
- Upon access to ISrc fenced area, the operator will place the grounding rod to the ISrc HV platform. (The grounding rod is installed across the access door to the ISrc fenced area, in order to ensure that operator will always remove it from its rest place and places it on the HV platform.)
- The operator can start work inside the HV fenced area according to the procedures developed by system owner and ES&H for any intervention/maintenance activity.

Figure 5 shows the flowchart of sequences for de-energizing the HV PS and access to ISrc fenced area.

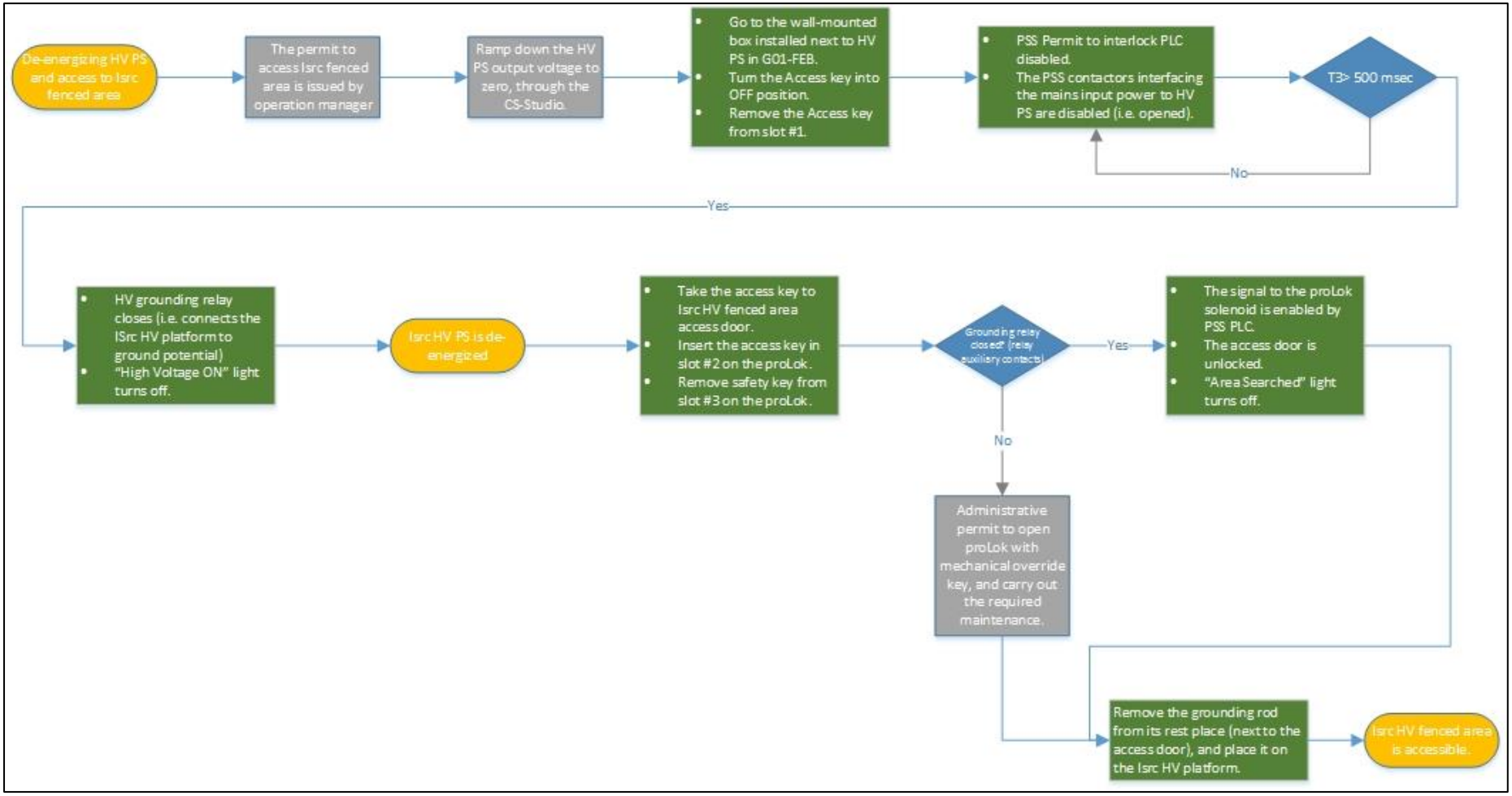

Figure 5: De-energizing the HV PS and access to ISrc fenced area

4.2.3. De-energizing the HV PS and access to ISrc fenced area in case of emergency

For the case of emergency for example fire or risk of explosion in the ISrc and LEBT test stand area, an emergency stop button will be installed outside ISrc fenced area, and in the vicinity of the ISrc and LEBT test stand. The main objective of this emergency stop button is to provide means for quick intervention of operator(s) to de-energize the HV PS in the event of an incident that could jeopardize the integrity of the ion source.

In addition, the authorized operator is in the possession of a mechanical override key, to unlock the access door from outside. This override key shall only be used in case of emergency when quick access to the ISrc fenced area is required. It should be noted that as soon as the access door is open (during either normal access or emergency access), the safety position monitoring switches installed on the access door will trip the HV PS mains incoming power.

4.2.4. Maintenance in ISrc HV platform

The isolation transformer provides low voltage power to the distribution board and equipment on the ISrc HV platform. PSS0 will interface neither the isolation transformer nor the distribution board. Therefore, in order to do any activities within ISrc fenced area such as cleaning, maintaining, and setting up the equipment installed on the ISrc HV platform, procedures such as Lockout Tag-out (LOTO), and covering adjacent low voltage live parts, shall be carried out by the operator(s) involved in those activities. These procedures will be developed by AD.

DOCUMENT REVISION HISTORY

Revision	Reason for and description of change	Author	Date
1	First issue	Morteza Mansouri	2017-10-13