SSG-RS-02-200

12 GeV Upgrade Project

DESIGN CRITERIA DOCUMENT

WBS 643

Personnel Safety Systems

Revision 0

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Technical Custodian: JLab Safety Systems Group

DESIGN CRITERIA DOCUMENT

Personnel Safety System

Approvals

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ACRONYMS

AC	Alternating current
ALARA	As low as reasonably achievable
CEBAF	Continuous Electron Beam Accelerator Facility
DC	Direct Current
DOE	Department of Energy
EHS&Q	Environment, Health, Safety, and Quality
GeV	Giga-electron Volt = Billion electron volts
HPA	High Power Amplifier
JLab	Thomas Jefferson National Accelerator Facility
Linac	Linear accelerator
NFPA	National Fire Protection Association
ODH	Oxygen Deficiency Hazard
PSS	Personnel Safety System
rf/RF	Radio frequency
SRD	System requirements document
SSG	Safety Systems Group
V&V	Verification and Validation

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1 Scope

This report identifies the codes, standards, practices and methods to be used in the design of the Personnel Safety System (PSS) for the Continuous Electron Beam Accelerator Facility (CEBAF) 12 GeV Upgrade Project. In summary, the 12GeV project will involve:

- Adding five new cryomodules and RF HPAs to each linear accelerator (linac).
- Adding a fifth pass dipole electromagnet string (Arc 10) to the West Arc.
- Replacing several electromagnet power supplies to support higher energy beam transport.
- Upgrading experimental equipment in the existing experimental Halls A, B, C.
- Construction of a photon Tagger and experimental Hall D complex.
- Expansion of existing infrastructure, e.g. power, service buildings, conduits, to support doubling the beam energy to 12GeV.

2 System Description and Introduction

The personnel safety systems are engineered access controls, interlocks, and warning devices that protect personnel from hazards uniquely associated with accelerator operation. They work in conjunction with other engineering controls and administrative procedures to reduce the risk of personnel injury from the following hazards:

- Prompt Ionizing Radiation in excess of established JLab standards
- Non-Ionizing Radiation in excess of established JLab standards
- Exposed electrical conductors, e.g. magnet leads, with at least 50VDC
- Exposure to Oxygen Deficiency as defined in the JLab EH&S Manual

The PSS performs the first three objectives by establishing occupied and exclusion areas. JLab beam Containment Policy dictates that personnel shall be kept away from prompt radiation and prompt radiation shall be kept away from people. The latter is condition monitored by safety systems. Low oxygen triggers area alarms, warning personnel within an area to evacuate and warning personnel outside an ODH area to keep out.

3 References & Standards

This section contains a number of references, regulations, and standards implemented fully or in part at JLab. The responsible engineer determines the extent to which each of these industrial standards is applied. In the event of a conflict between Industrial and Laboratory standards, the Laboratory standard supersedes the Industrial standard.

3.1 IEC (International Electro-technical Commission)

3.1.1 IEC 61508 Parts 1-3 Functional Safety of electrical/electronic/programmable electronic safety-related systems
3.1.2 IEC 61511 Part 1 Functional safety – Safety instrumented systems for the process industry sector
3.1.3 IEC 62061 Safety of machinery - Functional safety - Electrical, electronic and programmable electronic control systems

3.2 U.S. Department of Energy Orders

3.2.1 DOE Accelerator Safety Order 420.2b
3.2.2 DOE Accelerator Safety Order 420.2b Guidance

3.3 Federal Regulations

3.3.1 10CFR835 Occupational Radiation Protection
3.3.2 10CFR851 Worker Health and Safety Program

3.4 National Council on Radiation Protection (NCRP)

3.4.1 NCRP Report 88: Radiation Alarms and Access Control Systems
3.4.2 NCRP Report 144: Radiation Protection for Particle Accelerator Facilities

3.5 International Atomic Energy Agency (IAEA)

3.5.1 IAEA Report 188: Radiological Safety Aspects for the Operation of Electron Linear Accelerators
3.5.2 IAEA Report 283: Radiological Safety Aspects of the Operation of Proton Accelerators

3.6 National Fire Protection Association (NFPA)

3.6.1 NFPA 70E Standard for Electrical Safety in the Workplace, 2004 Edition
3.6.2 NFPA 79 Electrical Standard for Industrial Machinery, 2007 Edition
3.6.3 NFPA 101 Life Safety Code, 2006 Edition

3.7 International Society for Automation (ISA)

3.7.1 ANSI/ISA RP92.2 Operation and Maintenance of Oxygen Monitoring Systems

3.8 Jefferson Laboratory requirements, Standards, and Guidelines

3.8.1 Jefferson Lab EH&S Manual

3.8.1.1 Appendix 2410-T2 TJNAF Work Smart Standards Set

3.8.1.2 Chapter 3210 Hazard Identification and Characterization

3.8.1.3 Chapter 6200 Jefferson Lab's Electrical safety program

3.8.1.4 Chapter 6310 Ionizing Radiation Protection

3.8.1.5 Appendix 6310-T2 Prompt Radiation Control Policy

3.8.2 Jefferson Lab Personnel Safety System 12GeV Systems Requirement Document

3.8.3 Jefferson Lab Quality Assurance Plan

3.9 Jefferson Lab Reports and Notes

3.9.1 Hall D Beam Containment Proposal
3.9.2 S01-001 Personnel Safety System Configuration Control Policy
3.9.3 SSG-UG-01-100 SSG Documentation Numbering Guidelines
3.9.4 CEBAF PSS Users' Manual
3.9.5 Safety Systems Documentation Numbering Guidelines
3.9.6 CEBAF-TN-85-015 Radiation and safety assessment documentation
3.9.7 CEBAF-TN-86-058 Workshop on radiation safety
3.9.8 CEBAF-TN-88-073 Proposal for a safety and interlock system for CEBAF
3.9.9 CEBAF-TN-89-172 Configuration of the switchyard and beamlines for ensuring safety of beams
3.9.10 CEBAF-TN-89-188 Overview of the accelerator Personnel Safety System
3.9.11 CEBAF-TN-90-233 Workshop on personnel safety interlocks
3.9.12 CEBAF-TN-90-228 CEBAF personnel access and safety system – access control system
3.9.13 CEBAF-TN-90-253 CEBAF Personnel Safety System PLC failure modes and effects analysis
3.9.14 CEBAF-TN-93-012 Personnel Safety System: Proposal for segmentation of the accelerator tunnel and its interlock systems
3.9.15 TN-95-028 Description of the CEBAF Personnel Safety System

4 Design Requirements and Standards

4.1 Lifecycle Management

The JLab 12GeV upgrade PSS systems shall be managed under a lifecycle model or similar criteria as described in IEC61508 part 1. Under this standard hazards shall be addressed, safety functions allocated, and risk reduction targets for PSS functions assigned a safety integrity level (SIL). The PSS shall then be designed to meet or exceed the target SIL.

4.2 Drawing and Document Numbering

PSS documents shall be uniquely numbered using the existing JLAB document numbering requirements. All PSS drawings, specifications, requirements, and user documentation shall fall under JLab configuration control. Drawing numbers are based on the JLAB standard documentation numbering guidelines. All PSS drawings uniquely start with the letter 'S' and are numbered sequentially. The first four digits identify each drawing. The fifth character denotes the original drawing size, e.g. ANSI A, B, C, D. The final two characters denote the drawing level such as "assembly" and "schematic diagram." An example of a complete drawing number is: S0046D01

The drawing title hierarchically describes the following:

Title Level	Example
Major System	Personnel Safety System
Area or Major Assembly	Hall D
Subsystem	Oxygen Monitoring System
Drawing Type	Site Layout

Table 1: JLab PSS Drawing Number Scheme

Where ever practical, existing PSS drawings shall be modified to reflect changes associated with the addition of the 12GeV PSS system. This is to avoid duplication of functions among several drawings.

Documents other than drawings that form the design basis of the Personnel Safety Systems shall be managed under the JLab Safety System Group design guidelines.

4.3 Principal Design Tools

Several design tools are used in the design, modeling, and development of the Personnel Safety Systems. The primary tools are:

4.3.1 AutoCad version 2006 or later (Autodesk): All drawings other than electrical circuits
4.3.2 Intellution iFix version 4.0 or later (GE Fanuc): HMI interface
4.3.3 PCAD version 2006 or later: Printed Circuit design, simulation, and layout
4.3.4 ProWorx32 (Schneider Automation): Schneider PLC configuration and programming
4.3.5 Step 7 version 5.4 or later (Siemens): Siemens PLC configuration, networking, and programming
4.3.6 Excel (Microsoft) version 2003 or later: Calculation of reliability, risk, and SIL

5 Quality Assurance and Testing

The 12GeV Personnel Safety Systems shall be designed, developed, and managed under the JLab Quality Assurance Plan. This plan, based on ISO-9000-2000, identifies key requirements pertaining to work processes and output.

Personnel involved in the management and design of the 12GeV PSS upgrade shall be qualified to do so as evidenced by a combination of education and experience. Likewise, personnel performing the installation and maintenance of PSS systems shall also be trained and qualified to do so.

Due to the critical nature of safety systems, the PSS design and development shall follow a Verification and Validation (V&V) model. Under this model test criteria are developed for hardware subassemblies, software functions, and integrated subsystems. Each safety function shall be independently tested and verified as correct. The final commissioning shall fully validate the design as defined in the latest version of the Systems Requirement Document. In addition, all safety systems shall be independently revalidated (certified) before hazardous devices are operated. Per standard SSG procedure, a written procedure and checklist shall be used to record the test results.

Where practical to do so, equipment performing critical safety functions shall be certified for use in safety applications by an independent testing laboratory. The programmable logic controllers used for the Tagger and Hall D areas shall be certified for use in SIL 3 applications.