Technical Specification (Abbreviated Version)

for the

HEX Superconducting Wiggler

Contents

1 Introduction 1
1.1 Overview 1
1.2 Applicable Documents 1
2 Scope 2
2.1 General Information 2
2.2 Scope of HEX-SCW Contract 2
2.3 BSA Scope Responsibility 2
3 Technical Requirements 2
3.1 Design Parameters 2
3.1.1 Reference Coordinate System 2
3.1.2 SCW Magnetic Requirement 3
3.4 Cryogenic System 3
3.4.1 General 3
3.4.2 Cryostat System Design 3
3.4.9 Current Leads 4
3.5 Vacuum System 4
3.5.1 Design Responsibility 4
3.5.2 Vacuum Equipment 4
3.5.3 Electron Beam Chamber (EBC) Design Parameters 4
3.5.4 Cryostat Vacuum 4
3.6 Electrical 4
3.6.1 Power Supplies and Quench Protection 4
3.6.3 Interlocking 4
3.7 Controls 4
3.7.1 Overall Requirements 4
3.7.2 Local Control Console 5
3.8 Maintenance and Reliability 5
3.9 Design for Safety 5
3.9.1 Mechanical System Safety 5
3.9.2 Transport 5
3.9.3 Lifting 5
3.9.4 Acoustic Noise 5
3.9.5 Overpressure Protection and Recovery 5
3.9.6 Safety Valves 5
3.9.7 Internal Piping 5
3.9.8 Cryogenic Hazard 5

DRAFT

3.9.9 Ring-Resident Equipment Protection System 5
3.10 Survey 5
4 ACCEPTANCE TESTS 5

DRAFT

Acronyms and Abbreviations

ATP	Acceptance Test Procedure
BNL	Brookhaven National Laboratory
BOY	Best Operator Yet
BSA	Brookhaven Science Associates
CSS	Control System Studio
DOE	Department Of Energy
EPICS	Experimental Physics and Industrial Control System
EPS	Equipment Protection System
ESH	Environment, Safety, and Health
GHe	Gaseous Helium
GUI	Graphic User Interface
Gy	Gray
HEX	High Energy X-ray Diffraction
ID	Insertion Device
IOC	Input/Output Controller
LHe	Liquid Helium
LN2	Liquid Nitrogen
MLI	Multi-Layer Insulation for Heat Shields
MAWP	Maximum Allowable Working Pressure
NSLS-II	National Synchrotron Light Source II
OFHC	Oxygen Free High Conductivity
PDR	Preliminary Design Review
SCW	Superconducting HEX-Wiggler
WTC	Warm Bore-to-Cold Bore

DRAFT

1 INTRODUCTION

1.1 Overview

The High Energy X-ray Diffraction Superconducting Wiggler (hereafter referred to as "HEX SCW") described herein will be used as a hard X-ray source of the HEX beamline.

1.2 Applicable Documents

The documents listed below are an integral part of this specification. The applicable revision level will be the latest that is in effect at the time of contract award.

Document Number	Document Title
IEC 60332	Tests on Electric and Optical Fiber Cables under Fire Conditions Part 1-2: Test for Vertical Flame Propagation for a Single Insulated Wire or Cable Procedure for 1 kW Pre-Mixed Flame
IEC 60754-1	Test on Gases Evolved During Combustion of Materials from Cables, Part 1: Determination of the Amount of Halogen Acid Gas
IEEE 1202	Standard for Flame-Propagation Testing of Wire and Cable
ID-ML-5000	Measurement Lab ID Magnet Measurement Area Layout
LT-ENG-RSI-STD-002	NSLS-II Nomenclature Standard
LT-ENG-RSI-SR-VA-002	Requirements for Design and Fabrication of Components for NSLS-II UHV Systems
10CFR851	Worker Safety and Health Program
NX-C-HEX-SCW-001	HEX-SCW Reference Design
NX-C-HEX-SOW-SCW-001	HEX-SCW Statement of Work
SR-ID-HEX-SCW-1000	Storage Ring, ID, HEX-SCW Interface Control Drawing
TIA-422-B	Electrical Characteristics Of Balanced Voltage Digital Interface Circuits
BNL-81715-2008-IR	Vacuum Systems Consensus Guidelines for DOE Accelerator Laboratories
ASME BPVC Section VIII	Rules for Construction of Pressure Vessels -> Division 1 (2015)
ASME B31.3	Process Piping (2014)

DRAFT

2 SCOPE

2.1 General Information

The specifications herein define the technical requirements for the HEX-SCW for the NSLS-II HEX beamline.

2.2 Scope of HEX-SCW Contract

- HEX-SCW, A fully functioning 4.3 T superconducting multipole of 1.2m magnetic length with associated controls, power supplies, vacuum equipment and cryogenic equipment. Mechanical fasteners, supports and fiducial points are included, as well as field integral correction coils.

  Persistent mode switch and demountable current leads are not required.
- Controls System, including, , PLC, control software implemented under the EPICS
- Test cables
- Local Control Console
- Feeding line, Liquid helium transfer line (for LHe autofilling).
- Vacuum system, Vacuum vessels, chambers and ports in 1.7 m between both edge flanges.

2.3 BSA Scope Responsibility

The following items are not part of the scope supply:

- Power supplies and quench protection
- Computer server
- Control racks
- Installation cables

3 TECHNICAL REQUIREMENTS

This section defines the required features and describes the performance specifications of HEX-SCW. The HEX-SCW's operating life shall be longer than 20 years.

3.1 Design Parameters

3.1.1 Reference Coordinate System

The NSLS-II HEX-SCW shall employ "the right handed coordinate system." The thumb of a right hand corresponds to the negative X direction, the index finger to the positive Y direction, and the middle finger (positive Z) to the direction of the electron beam. The coordinate S, as distinguished from Z, indicates the curvilinear system that moves with a reference electron.

DRAFT

3.1.2 SCW Magnetic Requirement

The HEX-SCW design shall meet the requirements in Table 1.

Table 1: Standard NSLS-II EPU Magnet Array Parameters

Item		Parameter
Magnet Array length		≤1200 mm
Period Length		70.0 mm
Maximum peak field (Bz) on axis		4.3T
Number of pole pairs @ full field		29
Number of pole pairs @ ¾ field		2
Number of pole pairs @ ¼ field		2
Vacuum chamber full vertical aperture		10mm
Vacuum chamber full horizontal aperture		60mm
Field stability ΔBz / Bz over two weeks		$< 10^{-4}$
Max. Stray field on axis at each end of the cryostat		10 G
Ramping time, 0 to 4.5 T up or down		≤ 5 minutes
Liquid Helium consumption per quench		<10 liter
Maximum amount of LHe stored in the device		
Maximum temperature of magnet coil during quench		< 50 K
$\int_{-\infty}^{\infty} By(x,y,z)dz$	Requirement for the Absolute Value of 1st and 2nd Field Integral Error (|x|<10mm, y=0mm), (mingap ≤gap ≤maxgap) (without correction coils)	≤50 G.cm
$\int_{-\infty}^{\infty} Bx(x,y,z)dz$		≤30 G.cm
$\int_{-\infty}^{\infty}\int_{-\infty}^{z} By(x,y,z')dz'dz$		≤10,000 G.cm.cm
$\int_{-\infty}^{\infty}\int_{-\infty}^{z} Bx(x,y,z')dz'dz$		≤5,000 G.cm.cm
Requirement for the Absolute Value of On-axis Electron Trajectory for E=3GeV at any longitudinal position		|x|<60 μm, |y|<5 μm and |y'|<10 μrad
Requirement for the Absolute Value of Integrated Multipole (|x|<10 mm, y = 0 mm), (mingap ≤gap ≤maxgap)		Definition of Multipole Expansion about ($x = x_0$, $y = 0$)*
		$\int_{-\infty}^{\infty} dz(B_y + iB_x) \equiv \sum_{n=0}^{\infty}(b_n(x_0) + ia_n(x_0))(x - x_0 + iy)^n$
Normal quadrupole (b1(x0))		50 G
Skew quadrupole (a1(x0))		50 G
Normal sextupole (b2(x0))		50 G/cm
Skew sextupole (a2(x0))		50 G/cm

*The reference points (x_0, 0) shall be chosen less than 5.0 mm apart, for example; x_0=-6.0mm, -3.0 mm, 0 mm, 3.0mm, 6.0 mm

3.4 Cryogenic System

3.4.1 General

HEX-SCW shall be cooled using cryocoolers incorporated into a LHe bath cryostat, which is supplied with LHe obtained from storage dewars with a hold time of >18 days.

3.4.2 Cryostat System Design

The details of the requirement are shown in "Vacuum Systems Consensus Guidelines for DOE Accelerator Laboratories" document.

DRAFT

3.4.9 Current Leads

The Contractor shall propose a design for the currents leads which imposes an acceptable heat load and uses proven technology.

3.5 Vacuum System

3.5.1 Design Responsibility

The detailed design of the vacuum systems is the responsibility of the Contractor. However, certain aspects of the design are mandatory, as detailed below.

3.5.2 Vacuum Equipment

Vacuum equipment shall be selected from the standard types used by NSLS-II. No other types of equipment may be used without the prior written agreement of BSA.

3.5.3 Electron Beam Chamber (EBC) Design Parameters

Ultrahigh vacuum of $<1x10^{-9}$ Torr is required to minimize the beam-residual gas interaction and resulting bremsstrahlung radiation. The Contractor shall demonstrate that the EBC assembly with associated pumping and tapered transitions achieves static vacuum of $<2x10^{-10}$ Torr, after in-situ baking, degassing, and pump activation. The EBC assembly shall have a total allowable leak rate of less than 2x10-10 std.cc/sec He and shall be free of any hydrocarbon contamination.

3.5.4 Cryostat Vacuum

The insulating vacuum shall be designed for a vacuum of 1.0E-6 Torr or better. For any components that need to be pumped continuously, isolation valves are required between the pumps and the pumped items.

3.6 Electrical

3.6.1 Power Supplies and Quench Protection

Current power supplies will be provided by BSA. The Contractor must indicate in his/her proposal the quantity and current and voltage rating required for each type of power supplies and quench protection. The Contractor must supply the requirements for any external Quench Protection devices. These could include energy extraction systems, quench detection systems, quench heater systems, etc.

3.6.3 Interlocking

The Contractor is to define signals and logic which will be used as interlocks to ensure correct and safe operation of the device. These shall be realized in a PLC based subsystem or other hardware and not in the IOC. The PLC must be capable of interfacing with the BNL designed and built EPS system for monitoring of critical operational parameters: coil current, pressure, temperature. The Contractor shall supply the EPS as part of a PLC system. BSA will specify the type of the PLC.

3.7 Controls

3.7.1 Overall Requirements

3.7.1.1 The device shall be designed to operate as a turn-key EPICS system. Devices with existing EPICS support shall be provided.

DRAFT

3.7.2 Local Control Console

Remote Control of the HEX-SCW shall be provided in the form of a graphical user interface, implemented with the EPICS-client software,

3.8 Maintenance and Reliability

All components shall be demonstrated by analyses, test, and/or experience (with existing hardware operating in a similar environment) to be capable of meeting the criteria of this specification over the full service life of the HEX-SCW.

3.9 Design for Safety

3.9.1 Mechanical System Safety

3.9.2 Transport

3.9.3 Lifting

3.9.4 Acoustic Noise

The level of acoustic noise for the equipment shall not exceed 60 dBA at 1m.

3.9.5 Overpressure Protection and Recovery

3.9.6 Safety Valves

3.9.7 Internal Piping

3.9.8 Cryogenic Hazard

3.9.9 Ring-Resident Equipment Protection System

3.10 Survey

A survey scheme shall be provided that allows an accurate positioning of the overall device and its magnetic axis to within tolerances.

4 ACCEPTANCE TESTS

The details of the acceptance tests for Factory Acceptance Test, Site Acceptance Test and Final Acceptance Teat.

- End -

DRAFT