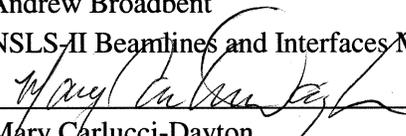
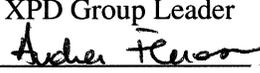
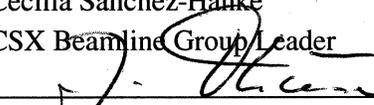
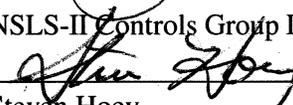
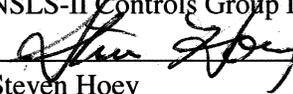
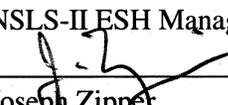


## STANDARD TECHNICAL SPECIFICATIONS for NSLS-II Beamline Components

Approvals:

 Andrew Broadbent NSLS-II Beamlines and Interfaces Manager	Date 19 MAY 2011
 Mary Carlucci-Dayton NSLS-II Beamline Engineering Group Leader	5/19/11
 Yong Cai IXS Beamline Group Leader	5/23/11
 Yong Chu HXN Beamline Group Leader	5/20/11
 Eric Dooryhee XPD Group Leader	05/19/11
 Andrei Fluerasu CHX Beamline Group Leader	May 15, 2011
N/A Cecilia Sánchez-Hanke CSX Beamline Group Leader	19 May 2011
 Juergen Thieme SRX Beamline Group Leader	5/20/11
 Qun Shen NSLS-II Experimental Facilities Division Director	5/20/2011
 Bob Dalesio NSLS-II Controls Group Leader	5/19/11
 Steven Hoey NSLS-II ESH Manager	5/20/11
 Joseph Zipper NSLS-II Quality Assurance Engineer	

**NATIONAL SYNCHROTRON LIGHT SOURCE II**  
 BROOKHAVEN NATIONAL LABORATORY  
 BROOKHAVEN SCIENCE ASSOCIATES  
 UPTON, LONG ISLAND, N.Y. 11973

PROJECT:

**Standard Technical Specifications for NSLS-II Beamline Components**

	LT-C-XFD-SPC-COM-001	4 May 11	1
	SPECIFICATION NUMBER	DATE	VERSION

## VERSION HISTORY

VERSION	DESCRIPTION	DATE	WRITTEN BY	APPROVED BY
<b>A</b>	First draft	18April2011	A. Broadbent	NA
<b>1</b>	First release	19May2011	A. Broadbent	See cover

# Contents

1	INTRODUCTION .....	5
1.1	Definitions/Acronyms .....	5
1.2	Documentation .....	6
2	SCOPE .....	6
2.1	General Information .....	6
2.2	Precedence .....	6
3	GENERAL TECHNICAL REQUIREMENTS .....	7
3.1	Design Life .....	7
3.2	Scope of Supply Exclusions .....	7
3.3	Materials .....	7
	High Heat Load Components .....	8
3.4	Beam Entry and Exit Points for Hutches .....	8
3.5	Fasteners .....	8
3.6	General Fabrication Requirements .....	8
3.7	Coordinate Systems .....	9
4	FACILITY AND INFRASTRUCTURE .....	10
4.1	Floor Layout and Constraints .....	10
4.2	Local Environment .....	10
4.2.1	EMI and RFI .....	10
4.2.2	Acoustic Noise .....	10
4.2.3	Heat Sources .....	11
4.2.4	Vibration .....	11
4.2.5	Hutch Access Dimensions .....	12
4.3	Provision of Utilities .....	12
4.3.1	Electrical Power .....	13
4.3.2	Electrical Grounding System .....	13
4.3.3	De-ionized Water Distribution .....	13
4.3.4	Chilled Water .....	13
4.3.5	Liquid Nitrogen Distribution .....	13
4.3.6	Compressed Nitrogen Gas .....	13
4.3.7	Compressed Air .....	13
4.3.8	Experimental Gasses .....	14
4.3.9	Ambient Temperature Sensors .....	14

4.3.10	Oxygen Depletion Sensor .....	14
4.3.11	Communications Connections .....	14
4.3.12	Cabling and Piping Support Structures .....	14
4.3.13	Gas Exhaust System .....	14
4.3.14	Air Exchange System .....	14
5	EQUIPMENT MECHANICAL INTERFACES .....	15
5.1	Requirements for Survey and Alignment .....	15
5.2	Support Structures, Attachment Points, Feet, and Lifting Eyes .....	16
5.3	Utility Interface to the De-Ionized (DI) Water System .....	16
5.4	Cryocooler Interfaces .....	17
6	EQUIPMENT VACUUM SYSTEMS .....	17
6.1	Standard Sub-Components .....	17
6.1.1	Vacuum Pumps and Controllers .....	17
6.1.2	Vacuum Gauges and Controllers .....	17
6.1.3	Vacuum Valves .....	17
6.1.4	Front End Vacuum Valves and Associated Gauges .....	18
6.1.5	Beamline Fast Valve Sensor .....	18
6.1.6	Residual Gas Analyzer .....	18
6.1.7	Diagnostic Chamber .....	18
6.2	Vacuum Flanges .....	18
6.3	Feed-throughs .....	19
6.4	Vacuum Specifications .....	19
6.5	In-Vacuum Fixings .....	19
6.6	Vacuum Bake-out Heaters .....	19
7	CONTROLS SPECIFICATIONS AND ELECTRICAL INTERFACES .....	20
7.1	Controls and Electrical Interfacing Standards .....	20
7.2	Controls Standards .....	20
7.2	Cryocooler Controls Interface .....	20
8	EQUIPMENT AND FACILITIES FOR INSTALLATION .....	21

# 1 INTRODUCTION

The National Synchrotron Light Source II (NSLS-II) is a state-of-the-art synchrotron light source facility presently being built at Brookhaven National Laboratory (BNL). The overall NSLS-II scientific research facility project includes design, construction, installation, and commissioning of accelerator systems and scientific equipment, and civil construction of the central facilities required to produce a new synchrotron light source. NSLS-II will utilize a highly optimized 3GeV electron storage ring, full-energy injector, state-of-the-art experimental beamlines and optics, and appropriate support equipment. When completed in 2014, NSLS-II will be ~800m in ring circumference and will produce extremely bright short-wavelength light at the specific frequencies needed to enable scientists to clearly resolve molecular and atomic scale structures.

The beamlines will take the x-rays produced by an Insertion Devices (ID) such as an In-Vacuum Undulator (IVU), an Elliptically Polarizing Undulator (EPU), or a Damping Wiggler (DW), or from a Three Pole Wiggler (TPW), or a Bending Magnet (BM) in the synchrotron storage ring and then filter the spectrum to give the energies of interest, and focus the beam to meet the experimental requirements. The detailed requirements are described in the relevant NSLS-II Beamline Preliminary Design Report and the detailed Specification document.

## 1.1 Definitions/Acronyms

BM	Bending Magnet	IVU	In-vacuum Undulator
BNL	Brookhaven National Laboratory	LAN	Local Area Network
BSA	Brookhaven Science Associates	LOB	Lab Office Building
CFM	Cubic Feet per Minute	MPa	Mega Pascal
DAQ	Data Acquisition	NEC	National Electric Code
DCM	Double Crystal Monochromator	NSLS	National Synchrotron Light Source
DI	De-Ionized	NSLS-II	National Synchrotron Light Source II
DW	Damping Wiggler	PDR	Preliminary Design Report
EPS	Equipment Protection System	PLC	Programmable Logic Controllers
EPU	Elliptically Polarizing Undulator	PPS	Personnel Protection System
FDR	Final Design Review	RGA	Residual Gas Analyzer
FE	Front End	RMS	Root Mean Squared
FOE	First Optical Enclosure	SOW	Statement of Work
fMLL	Flat Multilayer Laue Lens	SR	Storage Ring
GeV	Giga (billion) electron Volts	TPW	Three Pole Wiggler
GPM	Gallons Per Minute	UHV	Ultra-High Vacuum
HXN	Hard X-ray Nanoprobe	VC	Vibration Criteria
ID	Insertion Device		

## 1.2 Documentation

Document Number	Document Title
LT-C-XFD-SPC-CO-IIS-001	Beamline Systems Instrumentation Interfacing Standard
LT-C-XFD-RSI-CO-001	Experimental Facilities Requirements, Specifications and Interfaces for the Controls and DAQ System
LT-C-XFD-STD-BL-COORD-001	NSLS-II Beamline Coordinate System Standards
LT-ESHDES-08-003-rev001	Guidelines for NSLS-II Beamlines and Front End Radiation Shielding Design
NSLS-II Tech Note 00020	Bremsstrahlung Ray Tracing Guidelines for NSLS-II Beamlines and Front Ends
NSLS-II Tech Note 0040	Revised Shielding Estimates for the NSLS-II Beamlines at 3.0 GeV Beam Energy
PD-FAC-LAY-1002	Beamlines Floor Plan showing access points, panel set-down areas, beamline positions, etc.
LT-ENG-RSI-SR-VA-002	Requirements for the Design and Fabrication of Components for NSLS-II UHV Systems
LT-C-XFD-RSI 1.04.06	Beamline Front ends RSI document

## 2 SCOPE

### 2.1 General Information

This specification defines the general technical requirements for the NSLS-II beamline components. It must be read in conjunction with the Specification for individual beamline components or packages of components.

### 2.2 Precedence

Precedence of contract documentation is defined in the Contract. This document is a part of, and shall be subservient to, the Specification for the equipment.

### 3 GENERAL TECHNICAL REQUIREMENTS

#### 3.1 Design Life

The synchrotron facility is designed to operate continuously 24 hours per day, 7 days per week ( $\geq 5,000$  User Beam Hours per year). The design life of all beamline components (excluding electronics and BSA replaceable items such as bearings) shall be a minimum of 25 years.

#### 3.2 Scope of Supply Exclusions

The detailed scope of supply (in the form of a components listing) is defined in the Specification document for the equipment. However, the following are excluded from the scope of supply, unless stated otherwise in the specification document for the equipment:

- Insertion Device (ID)
- Front End (FE)
- Radiation shielding enclosures (hutches)
- Equipment Protection System (EPS) including vacuum interlocks, vacuum pump controllers, and vacuum gauge controllers, and any interlocks for such components as white beam filters
- Personnel Protection System (PPS)
- Surveying features (monuments and network coordinates) in the walls and floor of the synchrotron facility
- Beamline utilities, on and inside the radiation enclosures as defined in Section 4.3 Provision of Utilities, including support structures, cable trays, fluid valves and gauges
- End station experimental equipment, including detectors

#### 3.3 Materials

All materials used to build the Equipment shall be capable of withstanding prolonged exposure to an x-radiation environment. Additionally all components in the scope of supply shall be fully UHV compliant. The BSA requirements for UHV equipment are listed in the document LT-ENG-RSI-SR-VA-002 “Requirements for Design and Fabrication of components for NSLS-II UHV Systems,” dated 12/18/2008, Rev A.

<b>NATIONAL SYNCHROTRON LIGHT SOURCE II</b> BROOKHAVEN NATIONAL LABORATORY BROOKHAVEN SCIENCE ASSOCIATES UPTON, LONG ISLAND, N.Y. 11973	PROJECT:		
	Standard Technical Specifications for NSLS-II Beamline Components		
	Page 7 of 21	<b>LT-C-XFD-SPC-COM-001</b>	<b>19 May 11</b>
	Specification Number	Date	Version

High heat load components made of Glidcop Al-15 must satisfy the following design criteria.

**High Heat Load Components**

Peak temperature of inner surface	Critical components: < 300°C
	Noncritical components with fatigue life of <10,000 cycles: < 400°C
Thermal stresses (classified as secondary stresses, per ASME Boiler and Pressure Vessel Code)	< 2xYield Strength of Glidcop Al-15 (room temperature yield strength of Glidcop ~ 300 MPa)
Heat flux across the cooling channel wall	< Critical heat flux value for water (~5-7 W/mm <sup>2</sup> for synchrotron components)
Maximum cooling channel wall temperature	< Saturation temperature of water at the specified pressure
Maximum outside surface temperature	Not to exceed 60°C

**3.4 Beam Entry and Exit Points for Hutches**

Beam transport pipe will pass through a hole in the downstream wall of the FOE – the “beam pipe penetration.” Interfacing of the shielded transport pipe to the hole and guillotine are outside the scope of this contract.

The beam centerline will be at approximately 1400 mm above the experimental floor level where it exits from the storage ring tunnel.

**3.5 Fasteners**

No re-used or suspect/counterfeit fasteners may be used. All fasteners must be purchased new. A list of suspect/counterfeit fasteners is available from the Quality Management Office at BNL.

Stainless steel fasteners are required. Other materials with equivalent corrosion resistance may be considered with written approval from BSA.

NSLS-II has a general preference for metric fasteners on beamline equipment, and especially when these are custom or specialized, and in-vacuum (e.g., vented bolts, silver plated, etc). The provision of spare fasteners is defined in the SOW.

**3.6 General Fabrication Requirements**

The Contractor shall endeavor to design, manufacture, and install equipment that is “visibly appealing” and are the best examples of the highest quality workmanship that can be produced. Attention to detail and long-lasting, aesthetically-pleasing results are required in all aspects of design, manufacturing, and installation.

All parts shall be free of burrs and sharp edges, dents, gouges, and scratches.

The parts shall be clean and free of dirt, corrosion, oil, and grease, with the exception of the appropriate lubrication on moving bearing surfaces.

<p><b>NATIONAL SYNCHROTRON LIGHT SOURCE II</b>          BROOKHAVEN NATIONAL LABORATORY          BROOKHAVEN SCIENCE ASSOCIATES          UPTON, LONG ISLAND, N.Y. 11973</p>	PROJECT:		
	<p><b>Standard Technical Specifications for NSLS-II Beamline Components</b></p>		
	Page 8 of 21	<b>LT-C-XFD-SPC-COM-001</b>	<b>19 May 11</b>
	Specification Number	Date	Version

Bearing surfaces (e.g., door hinges and slides) shall be lubricated as required, preferably with molybdenum disulfide or other stable lubricant that is compatible both with the materials used, and for use in an ionizing radiation environment.

All assembly requirements for alignment marks, keying, or pinning specified on the appropriate assembly or sub-tier drawing shall be done after verification that the assembly meets the dimensional requirements of the drawing.

All fasteners on moving devices shall be locked by means of wires, jam nuts, set screws, spring washers, or similar locking devices to prevent loosening.

Equipment shall be designed for easy access during maintenance, particularly, screws shall not be obscured and the minimum of disassembly shall be needed to access sub-assemblies.

Design of equipment shall include minimization of ground (earth) loops. Earth bonding points shall be provided on all pieces of equipment in compliance with the NEC code, and protected from corrosion.

All safety critical components (e.g., white beam masks and stops, bremsstrahlung collimators and stops, and beam shutters) shall be secured in position after commissioning with anti-tamper, or locking devices. These locks shall be subject to review and approval by BSA at the FDR.

All lead shall be covered, or painted, to avoid exposed surfaces.

Any optical or electronic components shall be located off the beamline orbit plane and shielded wherever possible to prevent radiation damage. Viewports shall use non-blackening quartz glass.

### 3.7 Coordinate Systems

The coordinate systems to be used for NSLS-II beamlines is defined in the document LT-C-XFD-STD-BL-COORD-001, "NSLS-II Beamline Coordinate System Standards."

Where the coordinate system is defined in the Specification document for the equipment, the definition in the equipment specification document shall prevail over the definition given in the NSLS-II Beamline Coordinate System document referenced above.

## 4 FACILITY AND INFRASTRUCTURE

### 4.1 Floor Layout and Constraints

The floor layout varies with location in the facility, and depends on such factors as:

- Low-beta or high-beta straights, or BM / TPW sources all have differing source to ratchet wall distances
- Some floor sectors have extended floor space, where LOBs are immediately adjacent to the experimental floor, or where a bypass corridor is used around the periphery of the facility.
- A number of beamlines have provisions to extend outside the building.

The floor space available, and all constraints are described in the Specification document.

### 4.2 Local Environment

The experimental hall environment is as follows.

Normal ambient conditions within the facility	
Temperature	75±1.8 °F (24±1.0 °C), and 75±0.9 °F (24±0.5 °C) over a 1 hour period.
Relative humidity	50% ±10% in summer, and, 30% ±10% in winter.
Equipment to be capable of operation in the following adverse ambient conditions	
Temperature	50 °F to 100 °F (10–38 °C)
Relative humidity	20% to 80%.

The hutch thermal environment is as follows.

Normal ambient conditions within the hutch	
Temperature	75±0.5 °F (24±0.3 °C), and 75±0.25 °F (24±0.15 °C) over a 1 hour period.

#### 4.2.1 EMI and RFI

Careful consideration shall be made in the specification of any equipment for the minimization of Electromagnetic Interference and Radio Frequency Interference. Sensitive measurements will be made at the synchrotron and these are easily degraded by such interference.

#### 4.2.2 Acoustic Noise

All possible measures should be taken to keep the acoustic noise levels to a minimum. This is important for two reasons: maintaining a pleasant and safe working environment for the users, and reducing vibrations levels for sensitive equipment (particularly on infra-red or nanofocusing beamlines). Noise typically comes from a range of sources:

- Power supply and computer fans
- Water flow in pipes
- Air flow in ducts
- Rotary pumps (generally discouraged except for initial roughing and leak detection).

The noise level with the accelerator running, but without any contribution from the beamlines equipment, is specified at <55 dBA. The following requirements are established to minimize noise produced by the beamlines:

- Careful specification of processors and video cards in stand-alone computers for minimum power consumption, heat generation, and therefore fan cooling
- Use of chilled water for the cooling of enclosed electronics racks (keeping fans to a minimum, and fully enclosed)
- Water flows must be designed to be a maximum of 2 m/s (6.5 ft/sec) except inside components where demanded by the specific design of such a component. All internal bends shall have large radii relative to the pipe diameter; 90 degree bends are not permitted.
- Careful specification of other equipment, e.g., chillers, compressors etc. and inclusion of sound damping materials
- Whisper-type fans must be used.
- Inclusion of noise performance criteria in the specifications for all noise-generating components

#### 4.2.3 Heat Sources

Careful consideration shall be made in the specification of any equipment for the minimization of heat generation or local temperature gradient, in order to achieve quick thermal equilibrium and to achieve high temperature stability within the hutch. The following requirements are established to minimize the heat source:

- Careful specification of all heat sources
- Use of the lowest power components possible
- Use of water-cooling
- Implement methods to turn power off remotely
- Implement high gear-ratios for motion system, so that the power can be turned off without causing displacement for the stepper motors
- Removal of electronics from hutches wherever possible

#### 4.2.4 Vibration

The primary vibration criteria governing the experimental floor and the beamline end-stations are based on broadband floor velocity spectra expressed by the Vibration Criteria curves (VC) that are widely used in vibration sensitive facilities. According to these wideband spectral velocity criteria, in which the spectral value is based on 1/3 octave band intervals of the frequency range, the

spectral velocity amplitude on the experimental floor shall adhere to the VC-E curve characterized by the RMS threshold value of 3.12  $\mu\text{m/s}$  for the entire frequency range.

For the HXN beamline endstation supported on a separate slab outside the perimeter of the experimental floor the governing wideband vibration criteria are those expressed by the VC-F curve which is characterized by a threshold RMS spectral floor velocity value of 1.56  $\mu\text{m/s}$  for the entire frequency range.

In addition, for the experimental floor and based on complimentary narrow-band vibration criteria where the tonal vibrations in the floor spectrum are identified, integrated floor displacements of < 25 nm RMS are anticipated for the frequency range above 4 Hz.

Experiment support systems shall be designed based on the VC-E and VC-F wideband criteria for the experimental floor and the HXN end-station respectively whilst also taking into consideration the narrow-band spectral characteristics of the respective floor vibration in order to meet the performance requirements set out in the Specification document.

No individual component or collection of components supported by the Technical Equipment Floor Slab shall transmit vibration (measured on the floor of the respective end-station) that exceeds:

- 100 nm of RMS integrated displacement based on narrow-band spectral measurements in all three directions and for the frequency range of 1 to 4 Hz, and
- 25 nm RMS integrated displacements for frequencies >4 Hz

The floor slab beneath the Technical Equipment Floor will be approximately 380 mm (15 in.) thick.

The end-station floor in the satellite building of the HXN beamline is 1 m thick.

#### 4.2.5 Hutch Access Dimensions

The walkway width inside the hutch shall be 710 mm (28 in) or greater. Occasional hardware protrusions into this space are acceptable but the aisle cannot be restricted to less than 480 mm (19in) at any point. The layout of components and egress width shall be reviewed at the PDR and FDR.

Drawings of the egress aisles, doorways etc will be made available on request.

### 4.3 Provision of Utilities

The provision of utilities along the beamline in the FOE, the end station and in all user areas is the responsibility of BSA. Standard utility specifications, relevant to beamline components, are listed below, and requests for variations must be made in writing to BSA before the PDR meeting. If more detailed information is required then a copy of the NSLS-II document “Requirements, Specifications and Interfaces for the Experimental Facilities Utilities” is available on request. Layouts of the planned installation are shown in drawings to be included with the equipment specification document.

<b>NATIONAL SYNCHROTRON LIGHT SOURCE II</b> BROOKHAVEN NATIONAL LABORATORY BROOKHAVEN SCIENCE ASSOCIATES UPTON, LONG ISLAND, N.Y. 11973	PROJECT:		
	Standard Technical Specifications for NSLS-II Beamline Components		
	Page 12 of 21	<b>LT-C-XFD-SPC-COM-001</b>	<b>19 May 11</b>
	Specification Number	Date	Version

#### 4.3.1 Electrical Power

Electrical power distribution at 120V (single phase) and 208V (three phase), and 100A will be available for beamline equipment for both sensitive (30kVA) and non-sensitive power (30kVA). The equipment to be installed under the separate utilities contract shall include sub-panel distribution boards with appropriate and properly labeled circuit breakers at each enclosure or experiment area, cable trays, all the electrical outlets in the enclosures and along the beamline and wiring to light fixtures, fans, hoists, etc. inside the enclosures. It also includes electrical power outlets in the hutch, cabin and user area. 480VAC mains will not be provided to beamlines as standard.

#### 4.3.2 Electrical Grounding System

An electrical grounding system with busbar distribution will be provided inside the hutches, close to the floor and along the inboard wall.

#### 4.3.3 De-ionized Water Distribution

De-ionized (process) water distribution at 46 l/min (12 gpm) (average), 57 l/min (15 gpm) (maximum) at 85F+0.2F (29.5C+0.1C) and 1 MPa (150 psi) max design pressure at 38 C (100 F) and ~0.7 MPa (~100 psi) typical working pressure for beamline components needing cooling due to photon heatloads. Typically a maximum of 10 independent cooling circuits is expected with a flow rate of 6 l/min (1.5 gpm) at a minimum differential pressure of 0.4 MPa (60 psi).

#### 4.3.4 Chilled Water

Chilled water at 12°C (53°F) and typically 12 l/min (3 gpm) (24 l/min (6 gpm) maximum) distribution to all equipment racks and some items of end station equipment such as furnaces, compressors, etc. The velocity in pipe not to exceed 2 m/sec (6.5 ft/sec). With ~11°C (~20°F) temperature rise this assumes the removal of ~60% of the 30 kVA per beamline average electrical load with a 24 l/min (6 gallon/minute) flow rate. Typical working pressure 0.7 MPa (100 psi). The minimum differential pressure shall be 0.17 MPa (25 psi).

#### 4.3.5 Liquid Nitrogen Distribution

Liquid nitrogen distribution from the local interface point on the SR tunnel roof for use with pumped liquid nitrogen cooled heat exchangers (cryocoolers). The system is sized for a flow rate of 150 l/hour (40 gpm) with 50% of beamlines taking this flow with a supply pressure of 0.2 –0.3 MPa (30–45 psi).

#### 4.3.6 Compressed Nitrogen Gas

Compressed nitrogen gas is available for beamline use with a flow rate up to 10 l/sec (20 cfm) at STP, with a nominal working pressure of 0.2 MPa (30 psi) and a maximum pressure of 0.85 MPa (125 psi).

#### 4.3.7 Compressed Air

Facility compressed gas (compressed air) is provided at 0.5 MPa (75 psi) nominal with maximum pressure of 0.85 MPa (125 psi) and 5 l/sec (10 cfm) flow rate for 5 seconds with 30 second recuperation.

#### 4.3.8 Experimental Gasses

Experimental gases distribution from gas cylinders will be made available inside hutches as required.

#### 4.3.9 Ambient Temperature Sensors

Ambient temperature sensors will be installed inside the enclosures (hutches) for monitoring purposes.

#### 4.3.10 Oxygen Depletion Sensor

An oxygen depletion sensor will be installed where required; these are outside the scope of any beamline component or optics package.

#### 4.3.11 Communications Connections

Communications connections are included, including: Beamline LAN with switches and racks (including Ethernet outlets in the hutches, cabin or user area), and telephone lines (two per beamline).

#### 4.3.12 Cabling and Piping Support Structures

Cabling and piping support structures will be installed as part of the utilities contract, including necessary pylons and roof supports for cable trays, for all utilities as well as EPS and PPS cables.

#### 4.3.13 Gas Exhaust System

A gas-exhaust system for the ventilation of fume hoods, etc. is provided from the user area or from within enclosures to a common exhaust manifold.

#### 4.3.14 Air Exchange System

An air exchange system will be fitted to hutches for forcing filtered experimental hall air into the hutch (this will then leak out via labyrinths and custom air outlets). The fans are mounted on the hutch roofs and air passes in through a vent labyrinth.

## 5 EQUIPMENT MECHANICAL INTERFACES

### 5.1 Requirements for Survey and Alignment

The Contractor is required to provide sufficient survey features to define each component's 3-dimensional spatial location in a manner consistent with the alignment procedures employed by BSA for survey and alignment. The location of the fiducial points shall be made so that from any observer's point (e.g., laser tracker or theodolite) position, at least three fiducial points can be observed from within the FOE.

Survey monuments of known location, with respect to the source, in the form of 1.5" diameter spherical sockets on floor and walls will be supplied by BSA. Drawings of the monument locations shall be provided by BSA, upon request. The uncertainty in position of the survey monuments will be better than  $\pm 0.25$  mm  $1\sigma$ .

BSA will supply floor markings indicating beam path (for indication only) and a 500 mm offset line from the beam path (accuracy of  $\pm 1$  mm) on the access (outboard) side of the beamline and 5.0 m markers along this line.

BSA will provide access to the site survey network database where the native form of survey data is Spatial Analyzer software files. Text files of monument locations can be provided if required.

All equipment that requires precise alignment shall be fitted with fiducials comprising reference flats with reamed H7 0.250" dowel holes accommodating pinned target nests for 1.5" or 0.5" spheres.

The beamline shall be designed such that adequate line of sight is provided in the fully assembled condition for survey and alignment; where required, any custom target extensions shall be supplied by the Contractor.

Fiducial points shall be provided on any optical substrate holder or bending mechanism, to survey and align the mirrors into the correct position in the x-ray beam.

Fiducial points shall be provided on the base plate (internally), as well as externally, with a known relation to the mirror position and orientation, for all optical elements for the purpose of surveying and aligning the vessel and substrate in the beamline.

All custom designed tooling required to survey and align the Beamline shall become the property of BSA.

A database of the equipment fiducial positions with respect to appropriate points within the device shall be provided by the Contractor with instructions enabling the alignment of the equipment without breaking vacuum.

The equipment fiducial shall be shown to have uncertainties of location in three axes of less than 100  $\mu$ m relative to the aperture, surface, etc. This shall be demonstrated by design, or by measurement.

If the Supplier requires crosshair type theodolite targets within the radiation enclosures, these should be listed in the PDR and FDR reports and installed by the Supplier during installation.

## 5.2 Support Structures, Attachment Points, Feet, and Lifting Eyes

All support structures shall be made of steel and shall include sufficient range of travel to permit easy installation and any motions required for beam steering etc.

Thermal stability of floor stands is extremely important, design verifications shall be provided at the Final Design Review (FDR) stage to ensure that thermal drifts do not cause drifts in energy and / or position.

Ion pump supports shall be an integral part of the Beamline support system. Free standing 'posts' shall not be used to support ion pumps.

Unpainted steel reference surfaces shall be treated to prevent corrosion by a method that shall not affect the accuracy or function of the surface.

All structural steel parts and weldments shall be cleaned, primed and painted with a Polyurethane Enamel Paint, powder coating or equivalent heavy duty, solvent-based paint that is rust inhibitive and chip-resistant. All reference surfaces shall be masked as appropriate. The Contractor's color selection shall be approved by BSA at the PDR.

The Beamline support system for all optical and all high stability components shall be anchored to the floor using grouted floor plates and floor studs installed by the Supplier. The floor studs shall be designed to meet vibration and stability requirements. The floor plates may be surveyed into an accurate position to minimize the height adjustment range of the equipment.

The beamline support system shall be designed to accommodate a variation in the height of the Technical Equipment Floor of  $\pm 20$  mm ( $\pm 3/4$  in.).

Sufficient lifting eyes, either permanent or removable, shall be present on each vessel or stand. All lifting devices shall be appropriately certified for use as described in the accompanying SOW.

## 5.3 Utility Interface to the De-Ionized (DI) Water System

All beamline equipment within the FOE, and optical elements further downstream, requiring water cooling shall be equipped with a stand mounted manifold at the back of the equipment (facing the ratchet wall), to which all of the equipment cooling circuits are attached and factory tested by the Contractor.

BSA staff will make the connection from this manifold to the NSLS-II beamline DI water system, via flexible hoses.

The connectors to be included on the manifold shall be Swagelok 8mm or 12mm compression fittings.

## 5.4 Cryocooler Interfaces

Many beamlines will include a cryocooler system for circulating sub-cooled liquid nitrogen through a monochromator crystal or mount. Where the cryocooler is included in the Contract scope, the system shall include the following.

- A heating system on the nitrogen gas vent exhaust to prevent icing or water accumulation or dripping during operation at normal ambient operating conditions of up to 50% humidity and 25C
- A spring loaded relief valve on the overpressure protection system to minimize possible replacement of the burst disk. This shall allow the system to recover from a small overpressure event and not vent the entire cryocooler. The burst disc is required to meet vacuum vessel code, see SOW section on Pressure Safety.

# 6 EQUIPMENT VACUUM SYSTEMS

## 6.1 Standard Sub-Components

### 6.1.1 Vacuum Pumps and Controllers

Ion pumps (diode type with heaters) shall be supplied as part of the equipment, and shall be a standard product from the range manufactured by Gamma Vacuum, or equivalent replacement. The ion pumps shall be of sufficient capacity to meet the vacuum requirements.

Ion pump controllers shall be Varian (now Agilent) Duo type, or equivalent replacement; these are NOT part of the scope of supply for beamline components and optics packages.

Cables are not required, but the feed-through mating connector shall be supplied with the pump.

### 6.1.2 Vacuum Gauges and Controllers

Vacuum controllers shall be MKS 937B model, or equivalent, with a model 421 Cold Cathode (part number 104220036) and a Pirani gauge model 317 (part number 103170044SH).

The controllers and cables are NOT part of the scope of supply for beamline components and optics packages, but the feed-through mating connector shall be supplied with the vacuum gauge heads.

All cold cathode and Pirani gauges should be mounted on 90° elbows, or similar, to prevent false pressure signals induced by photo-electrons from x-ray photons striking metal surfaces in the beamline.

### 6.1.3 Vacuum Valves

Gate valves shall be standard VAT models, or equivalent, and angle vales shall be Agilent, or equivalent. Normally 2<sup>3</sup>/<sub>4</sub>" diameter angle valves shall be fitted.

### 6.1.4 Front End Vacuum Valves and Associated Gauges

The gate valve at the downstream end of the FE (in the FOE, after the ratchet wall) includes a 2¾” port which is oriented in the direction of the beamline components. Great care needs to be taken to ensure that space conflicts do not occur; this port will be used for vacuum monitoring, typically a “T” piece with Cold Cathode and Pirani gauges will be attached. This sensor will be used as an input to the FE vacuum PLC. Should it not be possible to accommodate the “T” piece and sensors then the sensors may be re-located to a position within ~1m of the start of the beamline, and within the same vacuum section. A solid model is available from BSA on request.

A second (redundant) vacuum pressure sensing device is required on the beamline. This will be implemented by utilizing the relay contacts on the vacuum pump controller (supplied by BSA) for the first ion pump on the beamline. This requires no action on the part of the Contractor responsible for the beamline components.

### 6.1.5 Beamline Fast Valve Sensor

The Front End contains Fast Valve (VAT series 77) located just upstream of the Safety Shutter, The primary sensor is also located in the FE. A second sensor, provided by BSA, shall be positioned in the beamline. Therefore, a 2¾” port for this VAT fast valve sensor shall be provided on the first optical element, or similar location, to be reviewed and approved at the PDR.

### 6.1.6 Residual Gas Analyzer

Each beamline shall be fitted with a 2¾” port for an RGA with ~16” space outboard for the sensor head and electronics. The RGA shall be fitted by BSA after installation of the components. This port shall be positioned downstream of the FE gate valve. There are no other restrictions on placement or orientation.

### 6.1.7 Diagnostic Chamber

Diagnostic chambers included in the beamline shall comprise a standard 6-way cross of 6” or 8” flanges. The diagnostic element may be inserted vertically through the top flange, or horizontally through the side flange.

## 6.2 Vacuum Flanges

Flanges used for connection of adjacent beamline components should have flanges as follows:

Rotatable flanges	Downstream and below components
Non-rotatable flanges	Upstream and above components

#### Exclusions and comments:-

Any gate valve (or other component) with tapped holes in a fixed flange at each end may be followed by a component with a rotatable flange at the upstream end.

Rotatable flanges mounted face to face are not permitted.

Connecting Bellows shall include one rotatable flange at the downstream end.

Flanges underneath components for ion pumps may be fixed at the discretion of the Supplier.

Vacuum flanges and seals shall comply with the requirements of LT-ENG-RSI-SR-VA-002, “Requirements for the Design and Fabrication of Components for NSLS-II UHV Systems.”

### 6.3 Feed-throughs

- All vacuum chambers, for optical components, shall include at least one spare blank port (2<sup>3</sup>/<sub>4</sub>" or 4" CF flange) which may be fitted with an electrical feed-through by BSA. The location shall be agreed at the PDR.
- Separate electrical feed-throughs shall be used for low current / voltage signals, limit switches / high current power to the motors, and high voltages.
- Equipment requiring connections to the beamline EPS shall have dedicated electrical connectors allocated for this purpose.
- Fluid feed-throughs for gases or coolants shall be indicated separately, and the location agreed at the PDR.

### 6.4 Vacuum Specifications

Vacuum levels in components used on the beamline shall be in accordance with the following table.

	Soft x-ray beamlines (working at <1 keV)	Hard x-ray beamlines
Without beam	5 x 10E <sup>-10</sup> mbar	1 x 10E <sup>-9</sup> mbar
With x-ray beam within 1 month of initial commissioning	1 x 10E <sup>-9</sup> mbar	5 x 10E <sup>-9</sup> mbar 2 x 10E <sup>-8</sup> mbar for DCM and monochromatic beam components in the FOE.

Additional requirements for leak testing, out-gassing rate, RGA and bakeout are included in section 4.7 of the document "Requirements for Fabrication of components for NSLS-II UHV Systems."

Bake-out temperatures shall be defined by the Contractor, and will depend on the materials used within each vessel or sub-system.

### 6.5 In-Vacuum Fixings

All bolts used in vacuum shall be metric, vented and silver plated, 300 series stainless steel.

### 6.6 Vacuum Bake-out Heaters

Permanently installed vacuum bake-out heaters shall be included on all vessels used for soft x-ray Beamlines with an operating energy of <2 keV, and any component to be installed within the front end. These shall comprise metal capillary type heaters fixed to the outer surface with tack welded brackets. The temperature monitoring and controller shall be the responsibility of BSA.

# 7 CONTROLS SPECIFICATIONS AND ELECTRICAL INTERFACES

## 7.1 Controls and Electrical Interfacing Standards

All wiring shall comply with the requirements listed in the document “NSLS-II Beamline Systems Instrumentation Interfacing Standard,” LT-C-XFD-SPC-CO-IIS-001.

## 7.2 Controls Standards

All controls provided for beamline equipment shall comply with the requirements listed in the document “Experimental Facilities Requirements, Specifications and Interfaces for the Controls and DAQ System,” LT-C-XFD-RSI-CO-001.

## 7.2 Cryocooler Controls Interface

The cryocooler (where applicable) needs to integrate with the beamline control system and the beamline EPS.

- An output from the cryocooler to the EPS shall signal that the cryocooler is operational. This output shall provide fail-safe logic (i.e., it shall be closed when the cryocooler is in the operational state, and shall open to indicate a fault condition).
- The cryocooler control system shall accept a signal from the beamline EPS to inhibit the delivery of cryogen to the optical component. This signal will be closed to permit cryogen delivery, and open to inhibit delivery. This signal will be in the form of a volt-free dry contact, rated to 48 VDC.
- The Contractor shall provide an EPICS interface to the cryocooler to allow remote monitoring of all operational parameters and remote control of all operations. This EPICS interface shall comprise a minimum of:
  - Device support to allow communication to the cryocooler controller
  - EPICS database for all parameters
  - Source code for an example IOC including startup script, and user interface screens
- The Contractor shall provide BSA with all source code for the cryocooler control system application, including any PLC code.

## 8 EQUIPMENT AND FACILITIES FOR INSTALLATION

BSA will provide the following items for installation purposes:

- Shared clean assembly room for work during installation
- Storage space on the experimental floor for equipment from the time of delivery to the start of installation
- Shared use of two 65 l/s turbo molecular vacuum roughing carts, one with RGA
- Shared use of one helium leak detector
- On-site shared office space
- Source and Front End information and specifications for detailed design of the power loads; available upon request
- Lifting equipment, and operator, as defined in the Statement of Work for the equipment