Argonne NATIONAL LABORATORY

Advanced Photon Source Upgrade

Advanced Photon Source Upgrade Project

Preliminary Design Report

September 2017

Chapter 7: Storage Ring Removal and Installation

Document Number : APSU-2.01-RPT-002
ICMS Content ID : APSU_1705610

Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

AC	Alternating Current
APS	Advanced Photon Source
Argonne	Argonne National Laboratory
ASD	Accelerator Systems Division
BTS	Booster-to-Storage Ring
DC	Direct Current
DLM	Doublet L-bend Multiplet
DOE	U.S. Department of Energy
EPS	Equipment Protection System
FY	Fiscal Year
HVAC	Heating, Ventilation, and Air Conditioning
LOTO	Lockout/Tagout
LLW	Low-Level Waste
MBA	Multi-bend Achromat
RF	Radio Frequency
SR	Storage Ring

7 Storage Ring Removal and Installation

7-1 Introduction

The existing Advanced Photon Source (APS) storage ring (SR) tunnel is divided into six zones, A through F, with a total of 40 sectors. Zones A through E (sectors 1 through 35), which provide the X-rays for science experiments, contain magnet girders, insertion devices, and front ends. Zone F (sectors 36 through 40) contains magnet girders, and radio frequency (RF) and injection equipment. The area above the SR is called the mezzanine; this is where power supplies, vacuum, diagnostics, and controls electronics for the storage ring are located. The existing SR and some of the components on the mezzanine will need to be removed so that the new multi-bend achromat lattice configuration can be installed.

The installation period has been defined as the period during which no X-ray beam will be available for APS experimental users and will therefore need to be as short as feasible. The goal is for the duration of this period to be no longer than 12 months. The main installation period tasks will consist of removal, installation, and testing. In order to meet the 12-month overall goal, the removal task goal has been set at 2 months. The installation task goal has been set at 7 months. The preliminary schedule is shown in Figure 7.1.

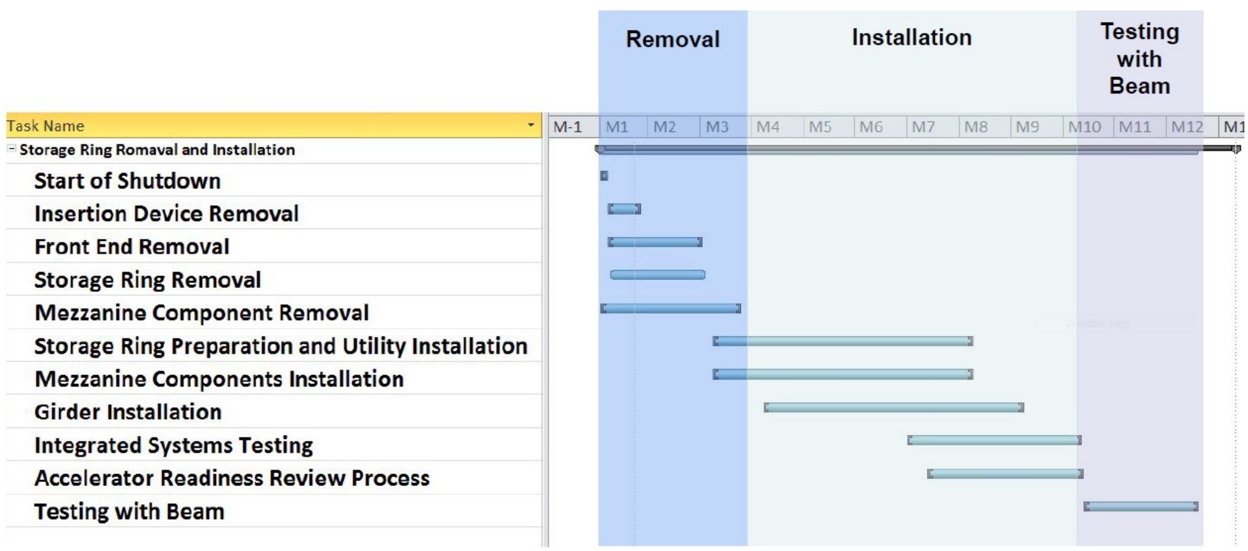

Figure 7.1. Storage ring removal and installation schedule

7-2 Storage Ring and Mezzanine Equipment Removal

This work will require an area for the storage, reuse, or disposal of materials removed from the storage ring and the mezzanine. This area is referred to below as the disposition facility. The facility will need an estimated 5,000 square feet of indoor space for the storage and characterization of radiologically contaminated materials, and an estimated 15,000 square feet of outdoor storage yard for the temporary storage of uncontaminated materials. The project is investigating options for identifying this space, including the use of existing Argonne National Laboratory space or the building of new space on site. There is a possibility that the existing Building 367, shown in Figure 7.2, could fill this need, provided that adjoining outdoor space can be fenced in for storage use. Building 367 can be made available to the project beginning in Fiscal Year (FY) 2017.

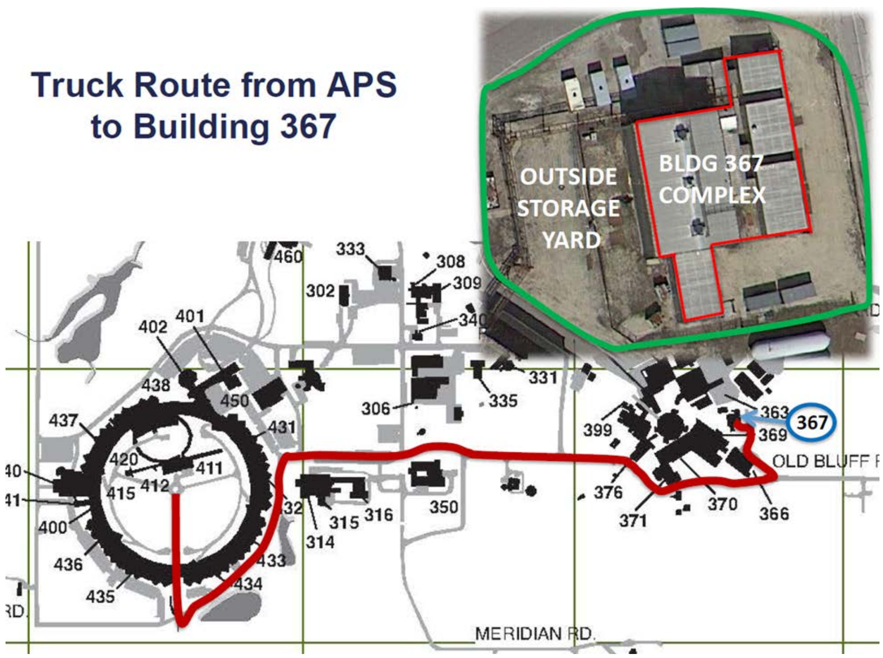

Figure 7.2. Argonne Bldg. 367 used for removed material disposition

When the APS accelerator shuts down to begin the upgrade installation period, the following SR and mezzanine removal sequence can begin immediately, with some tasks occurring in parallel. The in-tunnel SR heating, ventilation, and air conditioning (HVAC) ducting will remain in place and the HVAC system will remain functional throughout the removal and installation phases. Alternating current (AC) wall outlet power and tunnel lighting will also remain functional. Prior to removal, each individual girder will be “gapped” (i.e., isolated from all energized sources and attachments: power, equipment protection system (EPS), diagnostics and control cables, cooling water and compressed air lines). All magnet power converters on the SR mezzanine will be de-energized and lockout/tagout (LOTO) applied at the switchgear circuit breaker panels. Established LOTO procedures and checklists will be used, and the presence of zero voltage will be verified. The SR vacuum systems will be shut down and electrically disconnected, and the power cords to the pumps will be cut. The vacuum chambers will be opened to atmospheric air. Compressed air lines to the vacuum valves will be shut off, bled down, and disconnected at the shutoff valve. The cooling water headers will be drained following established procedures. Cooling hoses to individual components will be

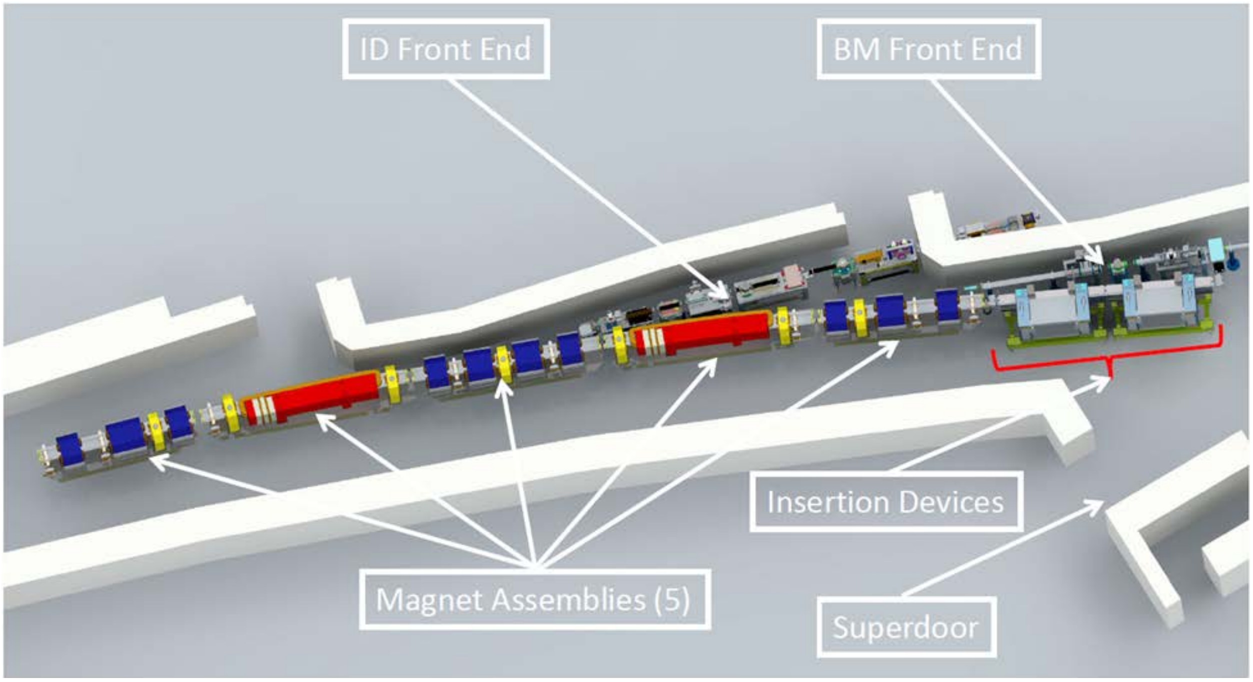

Figure 7.3. One sector of the existing storage ring

cut or disconnected and drained into the tunnel floor drains. Vacuum bellows interconnecting the girders will be removed, vacuum chamber ends radiologically surveyed for contamination, and the vacuum chamber end flanges capped.

A typical single sector of the existing SR is shown in Figure 7.3. Individual girders will be removed using established procedures and transported to the super doors using tugs as shown in Figure 7.4. The girders, and any other SR components in Zones A–E (Sectors 1–35), will be removed from the tunnel through the super doors.

All insertion devices (estimate: 55) will be removed using routine, established procedures and moved out of the SR tunnel through the super door. At that point, they will be transported to the insertion device work area. Insertion devices will be reconfigured for use with the new multi-bend achromat (MBA) lattice before reinstalling.

All front ends (estimate: 60) will be removed through the ratchet doors on the outboard side of the SR tunnel using routine, established procedures. At that point, they will be transported to the front end work area. Removal of the front ends is necessary to prevent damage during the SR removal, and to facilitate reconfiguration for use with the new MBA lattice before front end reinstallation. All SR technical components will be removed from Zone F, with the exception of 12 RF cavities in Sectors 36, 37, and 40 (four per sector), which must be preserved for the new MBA. The remaining 12 cavities will be kept in place and protected from damage during the removal and installation work. The Sector 38 RF cavities and waveguides will be disconnected and removed through the nearby super door. At that point, the components will be handed over to the Accelerator Systems Division (ASD) RF Group for use as spares. On the mezzanine, the associated waveguides and shielding will be disassembled and removed. The remaining penetrations in the floor will be plugged.

Figure 7.4. Moving existing SR girder with tug and dolly

The booster-to-storage ring (BTS) system and accompanying injection equipment will be de-energized with an established LOTO procedure, brought up to atmospheric air, and gapped with respect to power, water, air, vacuum and electronics. The disassembled equipment will be removed through the nearby super door and transported to the disposition facility for waste stream processing.

Remaining power, EPS, diagnostic, and control cables will be pulled down through the tunnel roof labyrinths, cut to manageable lengths, moved out through the super doors and transported to the disposition facility for waste stream processing.

The tunnel floor will be prepared for the installation of the plinths. The tunnel walls will be cleaned and otherwise prepared for painting. The tunnel walls will be painted prior to installation activities if the schedule allows.

A typical single sector of the existing mezzanine is shown in Figure 7.5. On the SR mezzanine (the top of the SR tunnel), magnet power converter cabinets and raw direct current (DC) power supplies will remain in place.

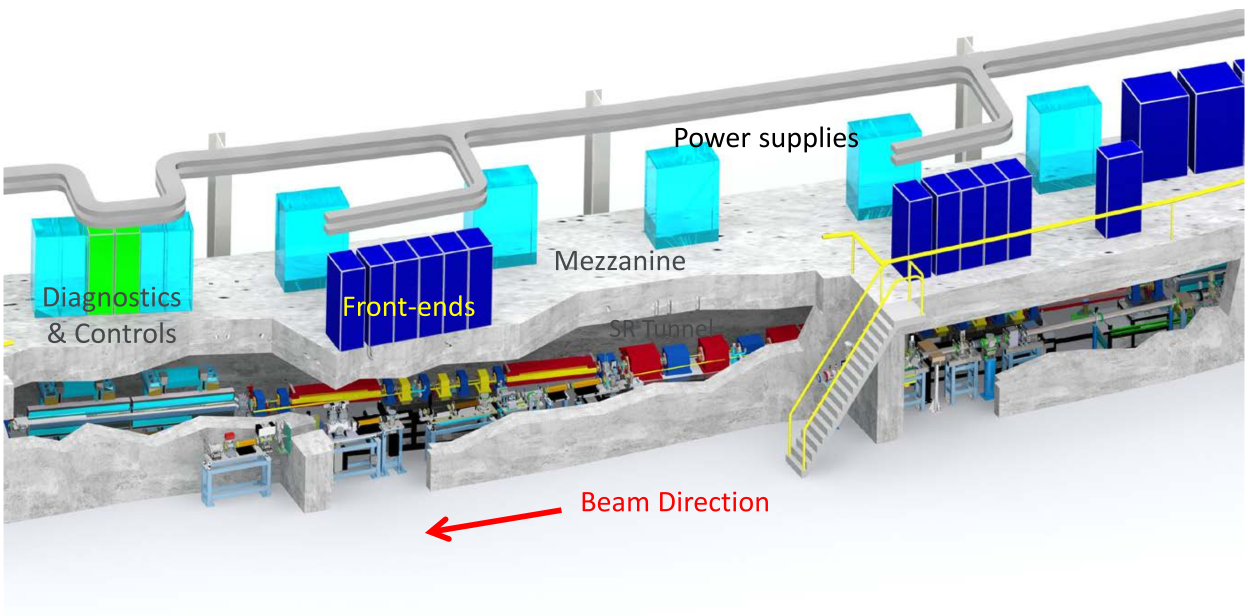

Figure 7.5. One double sector of electronic equipment on the SR mezzanine

All material to be removed from the tunnel will be surveyed. Once girders are removed, more detailed radiological characterization and disposition can be performed as non-critical path work at the disposition facility. Removed material estimates and expected dispositions are listed in Table 7.1. All activated materials will be disposed as low-level waste (LLW). Non-activated metal waste from the SR tunnel will be surveyed and documented per Argonne *Clearance Protocol for Potentially Activated Materials* [1] and DOE *Clearance and Release of Personal Property from Accelerator Facilities* [2]. The disposition path for potentially activated material removed from the storage ring tunnel is shown in Figure 7.6. The current plan is to separate out the non-activated metals such as steel, aluminum, and copper for recycling. Recently, the SLAC upgrade project has removed a full kilometer of its linac, comprised of 699 tons of aluminum alignment pipes, copper accelerator tubes, and a complex maze of cables and electronics, of which about 59% (or 400 tons) of steel, scrap metal, wire, copper, and aluminum has been recycled [3].

Table 7.1. Material for disposal

Item Description	Weight [tons]	Volume [cu-yd]	Type of Waste	Quantity	Type of Containers
Girder assemblies	1811	1449	Low level rad Suspension metals	10 176	B-25 Bin 40 cu-yd dumpster
Power cables	30	20	Suspension metals	4	20 cu-yd dumpster
DC converter cables	46	104	Electronics recycling	5	40 ft semi-trailer
Other electronics	24	88	Electronics recycling	8	40 ft semi-trailer
Totals	1911	1661			

Note: The numbers of bins, dumpsters, and semi-trailers were calculated by volume and adjusted by weight capacity.

Nonmetal waste will be surveyed, documented, and disposed of through the regular clean trash stream, if applicable. Nearly 200 magnet girder assemblies ranging in weight from 6.8 tons to 11.3 tons each will be removed from the tunnel and temporarily stored at the disposition facility. Nearly 1600 cubic yards of waste, weighing a total of almost 1900 tons, will be disposed of.

Removal of the SR and its associated equipment will take five crews working in two shifts; each crew will have one engineer, 10 technicians, and two riggers, and there will also be five general, management, and administrative personnel who are not part of any crew. The flow of equipment into and out of the super doors during a five crew shift is shown schematically in Figure 7.7. The 70 people per shift can complete the task in 36 working days with effort estimated at 40,180 person-hours. Worker density in the tunnel will not be an issue.

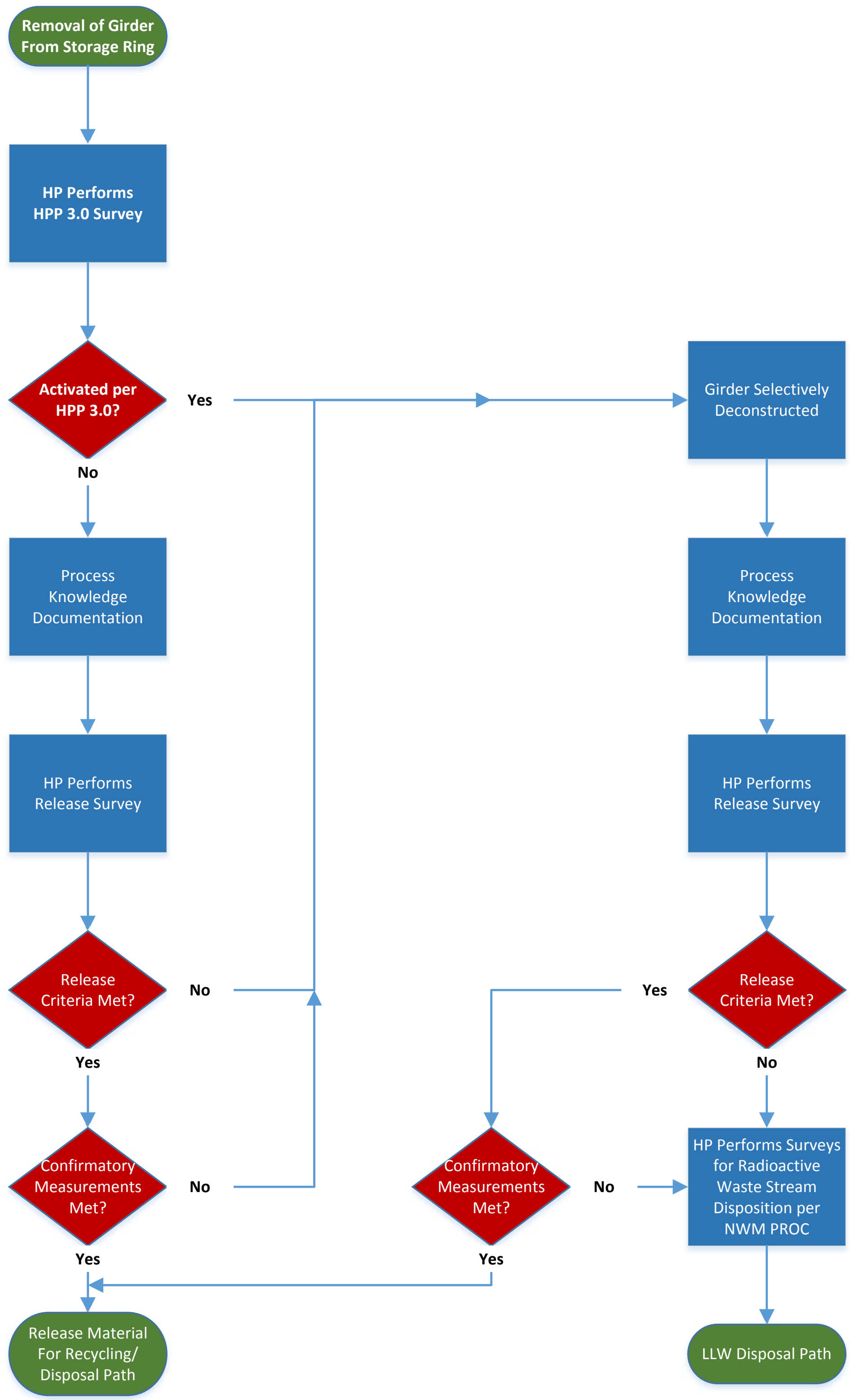

Figure 7.6. Disposition path for potentially activated material removed from storage ring tunnel

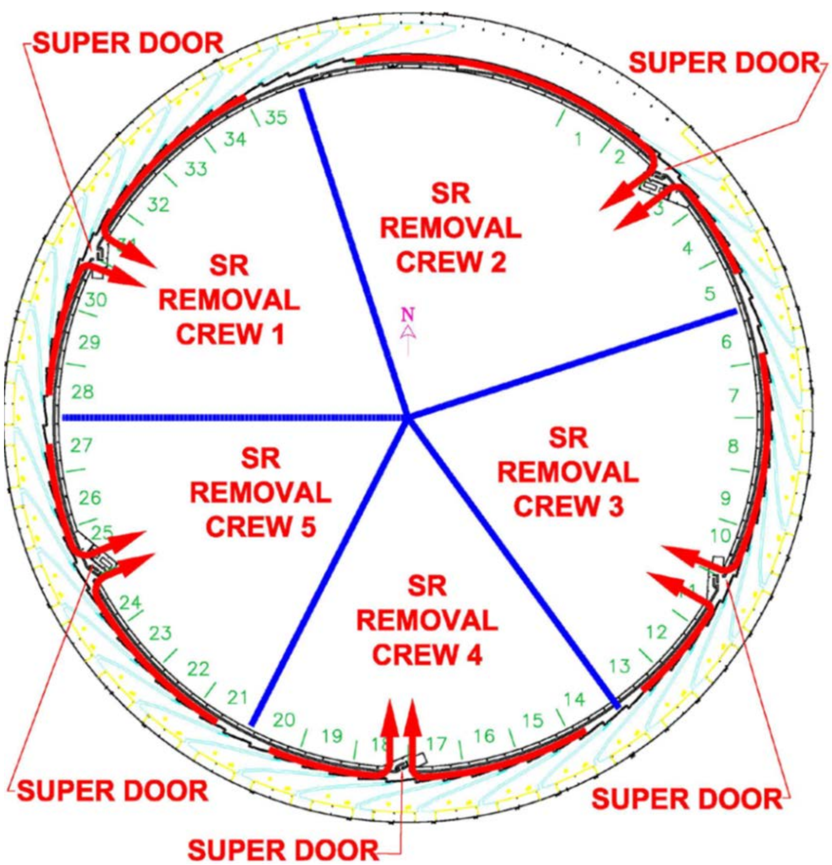

Figure 7.7. Storage ring removal material flow with five crews and two shifts

7-3 Storage Ring and Mezzanine Equipment Installation

The installation period has been defined as the period during which no X-ray beam will be available for APS experimental users and will therefore need to be as short as feasible. The goal is for the duration of this period to be no longer than 12 months. The main installation period tasks will consist of removal, installation, and testing. In order to meet the 12-month overall goal, the installation task goal has been set at 7 months. The preliminary schedule was shown in Figure 7.1.

The staging areas to support the storage ring installation have been previously described in Section 4-3.14.3. Space needs for staging the magnet modules on support plinths, for new and reworked insertion devices, and for reworked front ends have been estimated and possible locations scouted. Transport of the magnet module assemblies from the staging location to the APS infield have been looked at with respect to weather, road weight restrictions, traffic, and congestion within the infield.

Space needs for staging the electronic equipment on the mezzanine have been estimated and locations around the mezzanine have been investigated and found to be adequate. A detailed installation plan is under development and will be a standalone document. The plan will include the following removal activities described in Section 7-2:

- Removal of insertion devices
- Removal of front ends
- Removal of beam transfer line and injection equipment
- Storage ring removal, including all associated vacuum systems, cables, and hoses
- Removal of SR-related electronics on the mezzanine
- Power supply and cable removal
- Health physics activities during equipment removal

The plan will also cover the activities necessary to check and establish the alignment network needed for SR alignment during installation. The plan will also include the following installation activities:

- Survey and alignment activities prior to and during installation
- Front end installation
- Injection-extraction installation
- Vacuum system installation
- Diagnostics installation
- Magnet and support installation
- Power supply and cable installation
- Controls and cable installation
- ID installation

Planning for personnel ramp-up and any outside contracts needed to support the removal and installation will also be included. Prior to the start of installation, all equipment and components needed during the installation period must be tested, staged nearby, and ready for installation. The present preliminary plans are that the magnets will be installed directly onto the magnet support plates and there will be five basic magnet modules as described in the PDR. These are:

- Two L-bend assemblies

- Two Quad Doublet–L–bend–Multiplet (DLM) assemblies
- One FODO assembly

Associated with the five magnet modules are three support plinths. Vacuum chambers, components, and supports are preassembled with the magnet modules to whatever extent possible. Vacuum system assemblies are sectioned to match the length of the magnet modules. The NEG coated copper FODO section is activated and vacuum isolated using gate valves prior to installation into the magnet module. Once the SR is ready to start the installation process, the following installation sequence is assumed:

- Magnet modules (including supports) for a given sector will be transported to the appropriate super door and placed on air casters.
- Powered pallet drivers will be used to move the magnet modules on air pads around the SR. With these air pads, magnet modules can be moved in all directions.
- Alignment jacks will be used to elevate the plinths once in place so that the air pads can be removed.
- The largest magnet modules (FODO) will be the first to be installed for all sectors in a given installation crew's assigned area.
- Once the FODO magnet modules are installed and grouted in place, the remaining magnet modules needed for a given sector of the SR are installed.
- When all magnet modules for a sector are installed, rough aligned, and grouted in place, water, power, controls, and diagnostics for the sector are installed.

The injection/extraction system will be installed following routine, established procedures. A description of the injection/extraction system is in section 4-3.6.

As soon as the first two sectors are completed, the insertion device group will begin to install the insertion devices following routine, established procedures. Examples of typical insertion devices to be installed are shown in Figure 7.8.

As soon as the first FODO and downstream DLM magnet modules are installed, the front end group will begin to install the front ends following routine, established procedures. Examples of the new front ends to be installed are shown in Figure 7.9.

Prior to the start of installation, all equipment and components needed for mezzanine installation during the installation period must be staged, tested, and ready for installation. The mezzanine installation will be happening in parallel to the installation work in the storage ring with the following assumptions:

- Installation is a mix of new equipment in existing cabinets and completely new cabinets
- Five-day-a-week, two-shift operation is assumed
- Work will be performed by two- or three-person teams that are distributed around the mezzanine

The scope of the installation work on the mezzanine is as follows:

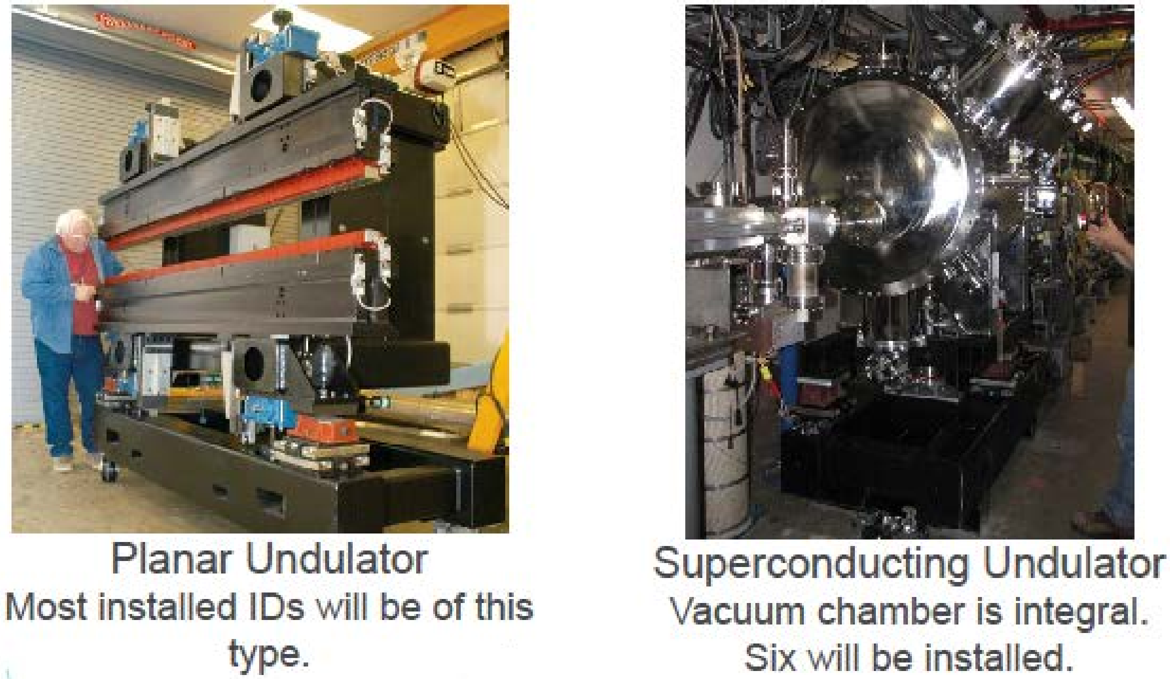

Figure 7.8. Typical insertion devices to be installed

- Install new diagnostics cabinets
- Install new power converter modules into the existing cabinets
- Install new vacuum control equipment into the existing cabinets
- Install new controls and diagnostics electronics (See Figure 7.5, Table 7.2, and Table 7.3 below.)

Installation of the SR and its associated equipment will take seven crews working in two shifts; each crew will have one engineer, 10 technicians, and two riggers, and there will also be five general, management, and administrative personnel who are not part of any crew. The flow of equipment into and out of the super doors during a seven crew shift is shown schematically in Figure 7.10. Worker density in the tunnel will not be an issue.

Table 7.2. Diagnostics installation scope

Item	Qunatity
RF BPM hardline coax installation/sector	570 (sets for 40 sectors)
RF BPM heliax coax installation/sector	570 (sets for 40 sectors)
EMI cabinets installed	40 (1 per sector)
Libera Brilliance plus BPMs installed	570 (sets for 40 sectors)
Hydrostatic level systems	35 sets
Cap det and temperature instrumentation	35 sets
ID x-ray BPM cable installation	90
BM x-ray BPMs cable installation	70
ID x-ray BPM electronics installation	90
BM x-ray BPMs electronics installation	70
High resolution beam size monitors	2
Pinhole lower-resolution beam size monitor	4
Real-time feedback double sector controller	20
Transverse multi-bunch feedback system	2
DCCT current monitor electronics	2
Branch current monitor electronics	1 batch
Loss monitors	80

Table 7.3. Controls installation scope by subsystem

Device	Activity
Vacuum to IOC	Install moxa, RS323 cables, Ethernet to switch Equipment and cable installation Tech system checkout
Power supplies	Ethernet wiring assumes, databases, three circuits Equipment and cable installation Tech system checkout
Machine protection interfaces	16 thermocouple wires, 40 water/vacuum for interlock latch cards Equipment and cable installation Tech system checkout
IOC database debug	Determine that all devices are communicating and the database is correct Equipment and cable installation Tech system checkout
Diagnostics	Install crate and Ethernet BPM wiring Equipment and cable installation Tech system checkout
Timing	EVR install and Ethernet Equipment and cable installation Tech system checkout

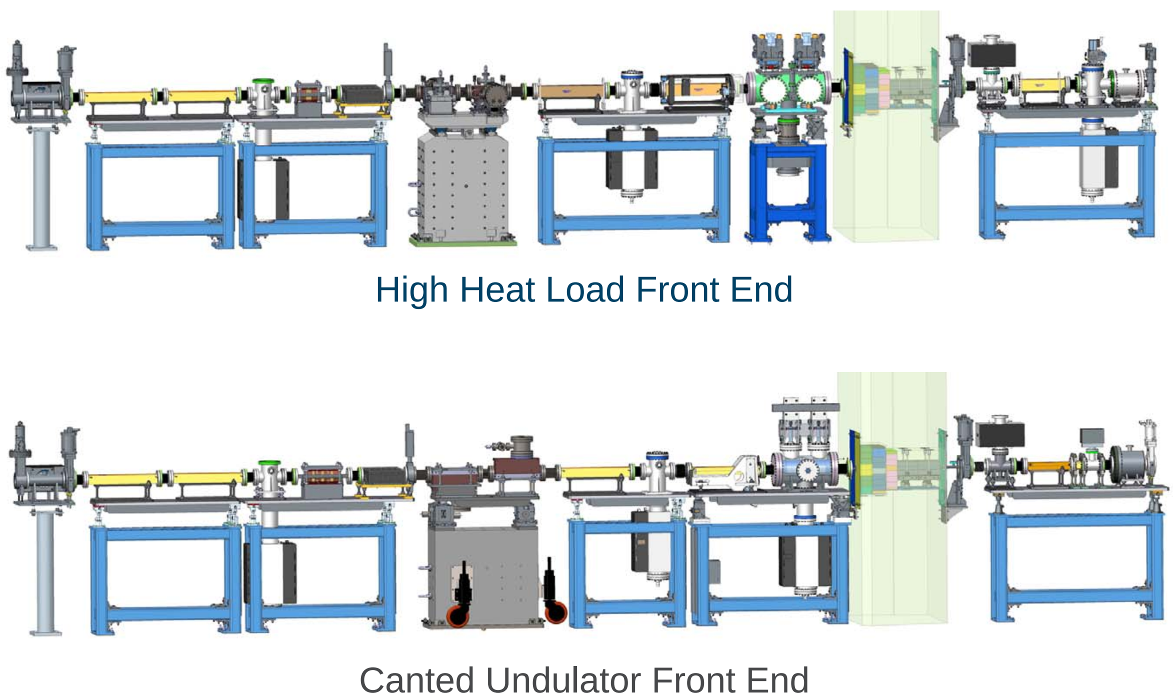

Figure 7.9. New ID front ends to be installed

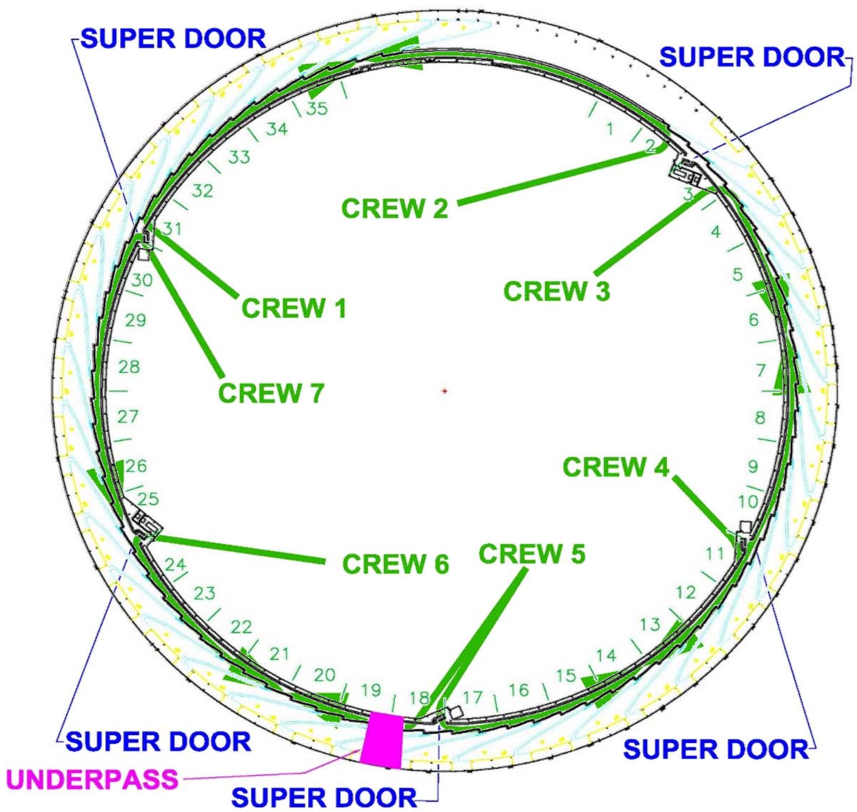

Figure 7.10. Storage ring installation by a seven crew shift

References

[1] Argonne National Laboratory. *RS-TBD-003*. Number Clearance Protocol for Potentially Activated Material - Technical Basis Document. Argonne, IL, 2017.

[2] US Department of Energy. *DOE-STD-6004-2016*. Number Clearance and Release of Personal Property from Accelerator Facilities. Washington, DC, 2016.

[3] SLAC National Accelerator Laboratory. Taking Down a Giant: 699 Tons of SLAC's Accelerator Removed for Upgrade, Jan 2017.