INSTALLATION AND INTEGRATION OF INDUS-2

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Abstract

The Synchrotron Radiation Sources consists of a large number of components of varying nature. Some components are light but highly delicate whereas some are big and heavy. However all components need a careful handling during their installation. Unit-cell mock-up assembly and virtual simulation of the installation process using software tools contributed significantly in visualizing various handling schemes, checking interferences and defining the assembly sequences. We have recently completed the installation and integration of 2.5 GeV Synchrotron Radiation Source, Indus-2, by adopting a set procedures of installation and pre-defined sequences. This paper presents an overview of procedures, sequences of assembly, equipments and toolings used for material handling and safety precautions taken during the whole task of installation and assembly.

INTRODUCTION

Indus-2 is a 2.5 GeV, 300mA electron storage ring designed for production of hard x-rays. It consists of 8 unit cells (or super periods) with a total circumference of 172.474 meter Each unit cell has two 22.5° bending magnets, a triplet of quadrupoles in the achromat section, two quadrupole in the long straight sections and four sextupoles in the achromat section..

Table 1: Components details for installation

Components	Approx. size (meter), Weight (kg)	
Dipole (16 Nos.)	2.2x1.35x0.88, 10000 kg	
Dipole vacuum chamber (16 Nos)	3.57x0.65x0.1, 300 kg	
Support Girders	Short straight section (8 Nos.)	6.5x0.92x0.37, 1500 kg
	Long straight section (16 Nos.)	3.25x0.92x0.3 7 1000 kg
	Dipole girder (16 Nos.)	1.83x0.84x0.4 7 1500 kg
	TL-3 Support (20 Nos)	3.0x0.58x0.8, 1000 kg
Quadrupole (72 Nos.)	0.56x0.86x0.8, 1500 kg	
Sextupole (32 Nos.)	0.78x0.3x0.75, 1000 kg	
Septum Magnets	1.3x0.6x0.6, ~1000 kg	

A total 27 number of beam lines are planned to tap the synchrotron radiation from Indus-2 for various purposes. (Ref.1). The electron beam from booster synchrotron is injected into Indus-2 through 65 meter long Transport line-3, which consists of 3 dipoles, 18 quadrupoles and 24 independent steering magnets (12 horizontal + 12 vertical). Major components for installation in Indus-2 with their critical features are given in Table 1.

The task of Installation of Indus-2 was much more complex due to narrow circular ring tunnel and severe restrictions on availability of space. The installation work started after the construction of the civil building (12000 Sq m) and was accomplished in stages (fig 3).

SEQUENCE OF INSTALLATION

Machine Component Installation

Installation of Indus-2 and Transport line-3 components can be broadly divided in two groups i.e. magnet and vacuum components. R.C.C. foundation is specially designed and constructed for this purpose with passive isolation of sensitive magnetic lattice from rest of the floor by using a sand blanket. Embedded Plate (MS) of 250 mm X 250 mm are provided in the ring floor to bear the large static loads of magnets and other components. After completion of the construction work, concrete floor adjacent to EPs was leveled to ensure uniform load distribution.

Installation of Support Girders & Alignment jacks

Threaded holes were drilled on the Floor Embedded plates (120 Nos.) for fixing the dipole girders and straight sections girder-jacks to make the machine foundation ready for installation. The positions of these holes were controlled by a combination of specially made template and theodolite equipped with distance meter. Afterward all dipole girders and straight section jacks were installed and anchored with these holes. Subsequently the straight section girders were installed on their jacks. References for drilling holes, for fixing of Transport line–3 support structures (20 nos.), were taken from the footprint marked as per designed location of TL-3. All support structures were first anchored to TL-3 RCC foundation.

Installation of Magnetic Components

Dipole magnets were the heaviest component for installation in the tunnel ring (fig 1). These magnets were transported by a truck in the Indus-2 building and there unloaded by 10 MT fixed hoist over a suitably designed transit trolley, used for transporting the magnets inside tunnel area. In the tunnel area they were transported to their designed locations by 10 MT EOT crane. A special fixture for handling and storing of multipoles was

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designed and fabricated. All the magnets were transported to tunnel area as per the procedure. Six-strut support

Figure 1: Installation of ring dipole at location.

system used for supporting multipoles were first doweled and bolted on straight section girders and afterward magnets were carefully fastened over them.

After installation of magnets, the machine was ready for pre-alignment. Dipoles were aligned with in their specified tolerances, whereas multipoles were aligned within 1 mm accuracy before opening the upper halves for installing vacuum chambers.

Maximum weight of the component in TL-3 was of dipole magnet (~1 MT) the installation was done using a single point hoist and hydraulic pallet.

Installation of Vacuum Components:

Ultra High Vacuum (UHV) components were installed in the ring and TL-3 subsequent to positioning & first alignment of magnets and beam diagnostic components. Major UHV components installed in the INDUS-2 ring are: dipole chambers, straight section chambers, pumps, and gauges. Aluminium alloy dipole chambers were filled with dry nitrogen gas before shifting to the ring. These dipole chambers are the heaviest & delicate components of UHV envelope and require high degree of safety in handling & transportation (fig.2). In order to install these large dipole chambers within available clearance of 3-4 mm in magnet pole gap, an adjustable placement trolley was designed & fabricated. This trolley has the necessary features of leveling, clamping & pushing the dipole chambers inside the dipole magnets. Straight Section chambers lighter in weight & were shifted manually and installed on pre-placed fixed and floating Aluminium supports at regular intervals in the ring. These chambers were also filled with Nitrogen gas & assembled with TSP bodies. Sputter Ion Pumps were installed manually due to limitation of space in the ring. Gauges & RGAs were last components to be installed before start of evacuation. Turbo molecular pumps for roughing were mounted on trolleys for their movement & installation.

RF-shielded SS316 bellows are used for compensating the misalignments during installation of the chambers, valves etc. and also to take care of the thermal expansion during bake-out and ring operation.

Final assembly and testing

After assembly of vacuum system, upper halves of the multipoles were positioned and machine was ready for precise alignment. A companion paper in these Proceedings gives details of the Alignment of Indus-2 machine. Assembly of ring (except injection system) and TL-3 assembly up to beam dump was completed by March 2005. Power and signal cabling was done and tested. Radiation system was installed. Final assembly & testing of other sub-systems with TL-3 was completed by July 2005. Trail experiment to store beam in Indus-2 started on August 14, 2005. Major milestones of installation are given in table2:

INSTALLATION CONSIDERATIONS

Component Design:

Lifting systems for the Indus-2 components has been designed as per relevant standards & specifications. Proper selection of lifting points with respect to C.G was also critical to avoid tilt less than 5º during installation. A proper support & transport system ensured the component and personnel safety.

Installation Process:

It is important to select efficient Installation process for the component installation Computer simulation contributed significantly in visualizing various handling schemes, checking and verifying interferences that helped in safe installation Footprint marking of the ring components helped in interference checking of various sub-systems before actual installation.

During Component Installation:

Sagging of the components due to self-weigh was minimized during handling by suitably supporting the components at suitable interval and other handling procedures. To prevent damage of the components due to sudden impact during handling & transportation, linear velocity was controlled.

RADIATION SHIELDING AND GENERAL SERVICES

A beam bump constitutes interlocking lead bricks (100mm Sq X 40mm thk) and Labyrinth made out of concrete blocks (300mmX300mmX 200mm) was installed at the end of TL-3.All the 27 Beam line holes are plugged with circular concrete plugs for biological shielding. These blocks are replaced by two part fabricated shielding to accommodated beam-lines.

For carrying cables of varying ratings like high current/low voltage for magnet power supplies, high voltage for power cables, signal, diagnostic and other instrumentation, a large cable tray system of more than 7 Km length was designed and installed in the Indus-2 building. At inner side of the ring, a separate four-tier cable tray system has been provided to feed the power to different magnets with separate rack for control cables.

Table 2: Major Milestones of Indus-2 Installation

Period	Activity
Dec 2003	First marking in ring begin
Jan-Feb 2004	Unit cell Mock up assembly
Feb-June 2004	Fixing of Jacks & girders
June-Nov 2004	Installation of ring magnets
1st Nov 2004	Last ring dipole magnet roll in
Nov 04- March 05	Installation of ring & Tl-3 vacuum components
March 05	TL-3 assembled & completed up to beam dump. Shielding maze assembled.
4th May, 2005	450 MeV beam was transported through TL-3 upto beam dump
6th June 2005	Last major installation for Indus-2 ring (Septum & Kicker magnet P/S)
Aug 26, 2005	Beam went first turn on Indus-2 ring

Access and crossover steel structures were designed and installed for quick access in ring and Transport line areas.

SAFETY DURING INSTALLATION

Ensuring safety during various phases of installation is always a difficult task. Strict safety guidelines (Ref. 2) and regulations are thus mandatory and their implementation need supervision and control. The building is provided with all the necessary material handling systems tested as per relevant codes to ensure personnel and component safety. Special care was taken in the handling of the vacuum components with dissimilar transition joint.

A Work Permit system was implemented for better coordination among the user group. This system also helped in monitoring the machine related activities and safe working culture.

Figure 2: Dipole Vacuum Chamber assembly with supports.

Figure 3: Beginning and completion of assembly.

CONCLUSIONS

The experience in installation and integration of Indus-2 components has shown that with a very systematic and careful approach in sequencing of the activities, planning, better coordination among sub-systems groups, the big challenge like this could be successfully met

Designing the support & transport system, mock-up trials, computer simulation of the installation process, checking and verifying interferences that helped in safe installation of the sub-system components in confined tunnel and other machine areas of the with severe restrictions on availability of space. A dedicated team coordinated the activities with a view to solve all interferences and to insure a smooth installation, which is the key to success.

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