MAGNET & SURVEY DATABASE FOR THE SNS ACCUMULATOR RING*

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Abstract

The Magnet and Survey database of the Spallation Neutron Source (SNS) Ring is designed for production-magnet quality assurance, field and alignment error impact analysis, multi-element assembly assistance, and ring installation assistance. The database consists of tables designed to store magnet field property and field quality measurement data, alignment measurements data, quality assurance checklists, and installation information. As part of the controls system, this database will be integrated with EPICS database to play an essential role in future machine commissioning and operations. The database structure can be extended to include magnet data from Linac, HEBT and RTBT. Magnet database has been designed based on the requirements from Magnet Measurement group, physicists responsible for Ring, RTBT, HEBT and Survey group.

1 INTRODUCTION

The Spallation Neutron Source (SNS) accelerator complex [1] currently under construction at the Oak Ridge National Laboratory (ORNL) comprises a front end, a linac, an accumulator ring and its transfer lines. With a circumference of 248 meters, the accumulator ring compresses the proton beam into 0.6 ms pulses of 2×10^{14} particles, and delivers them at a rate of 60 Hz to a liquid mercury target for spallation neutron production.

The SNS project is participated by six institutions including the Argonne National Laboratory, the Brookhaven National Laboratory, the Jefferson Laboratory, the Lawrence Berkeley Laboratory, the Los Alamos National Laboratory, and the ORNL. In such a multi-laboratory collaboration, it is necessary to unify measurement and application conventions, and to establish a database structure commonly accepted by all participating institutions.

The SNS accumulator ring and its transport lines connecting the linac and the two proposed target stations contains more than 300 dipole, quadrupole, sextupole, and multipole correction magnets. The Magnet and Survey database is designed for production-magnet quality assurance, field and alignment error impact analysis, multi-element assembly assistance, and ring installation assistance. The database consists of tables to store magnet field measurement data, alignment measurements data, quality assurance checklists, and installation information. As part of the controls system, this database will be integrated with EPICS database to play an essential role in future machine commissioning and operations.

Design of Magnet and Survey database is based on the requirements from the Accelerator Physics group, the Magnet Measurement group, the Survey group, and the Installation Group. The database is based on the existing structures used for the US part of the Large Hadron Collider (US-LHC) and the Relativistic Heavy Ion Collider (RHIC) developed mainly at the Brookhaven National Laboratory [2].

2 FUNCTIONS AND DATAFLOW

Fig. 1 shows the function of the Magnet and Survey database during production, at installation and after commissioning. After individual magnet elements are constructed and measured, field quality data (integral transfer function, center offset and field angle relative to mechanical fiducials, field harmonics etc.) and alignment data (fiducial positions, magnetic center etc.) are collected. After processing (analyzing measurement conditions and statistics, correcting calibration and other systematic errors, etc.), a minimum set of representative data is transferred to the database. Based on these stored data, computer tracking and simulation is performed to assess the impact of errors; statistical and trend analysis is performed to monitor field quality and to assist in magnet acceptance; information of magnetic center and field angle can be used for alignment sorting before cryostat assembly; and mul-

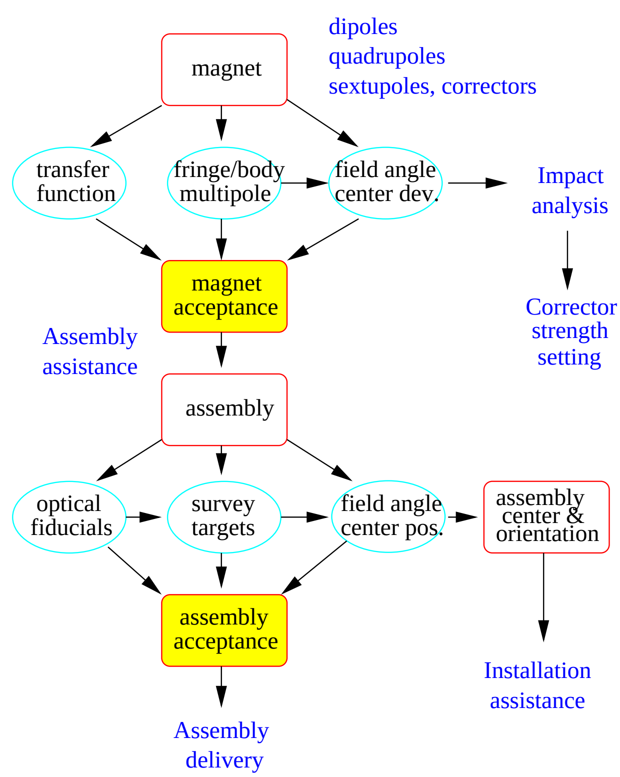

Figure 1: Dataflow for SNS ring magnet field and alignment quality analysis

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tipoles with signs defined according to the convention are used for future machine operation and magnet correction.

During cryostat assembly, survey and alignment data are extracted and stored in the database. Sufficient information is contained to provide the center and field angle of the assembly relative to the fiducials. Along with the completed assembly, this information will be delivered to ORNL to assist in ring installation.

3 MEASUREMENT CONVENTIONS

We adopt conventions established among BNL, CERN and FNAL defining the reference measurement coordinates [3]. Magnetic multipoles are defined in the reference system illustrated in Fig. 2. The description is 2-dimensional with x-y axes chosen such that the skew (or normal) component in the main field of a normal (or skew) magnet is zero. The reference frame is defined with respect to the lead end of the element.

Both the magnitude and sign of measured multipole errors are important for error analysis and for local correction. Fig. 3 shows the change of magnet multipole sign from their measured value for a beam circulating counter-clockwise. In general, rules for multipole transformation under 180° rotation around vertical (y) axis (orientation flip), longitudinal (z) axis (upside-down change) and radial (x) axis are summarized in Table 1.

4 DATABASE STRUCTURE

Magnet and Survey database has been designed using Oracle Designer tool and implemented in the Oracle Server. The database usage procedure has been described using Oracle Designer Process diagram as in Fig. 4. The process diagram helps in understanding who is responsible for what processes. It also describes which process saves information in the database. The process diagram in general gives the highest-level overview of the magnet database usage. Using Designer tool, the Entity Relationship Diagram (ERD) representing the conceptual design has been drawn.

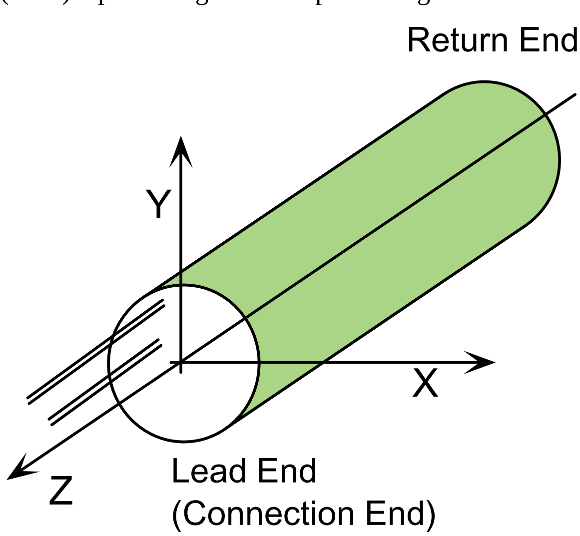

Figure 2: Reference frame for the measurement of magnetic multipoles

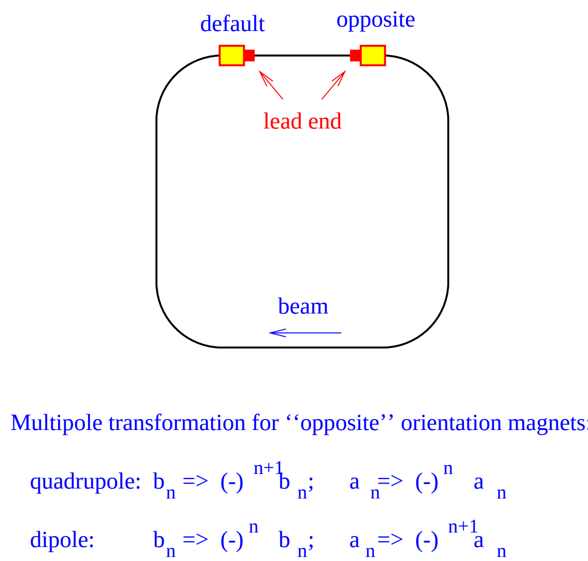

Figure 3: Change of sign of magnet multipoles from their reference measurement value for a beam circulating counter-clockwise

Main entities taking part in the design are identified and their attributes are well defined and documented. The relationship between the entities is also identified and drawn. The diagrammatic representation of the physical design is then generated based on this ERD. The physical design is used to create the table definitions, constraint definitions etc. in the server.

5 DATABASE USAGE

The magnet group receives the magnets from the companies that make the magnets. After receiving the magnets, magnet group members record the magnet information in the database. Magnet group assembles the magnets if required and then makes measurements on them. This data is also recorded in the database. A physicist is responsible for a set of magnets used in the Ring, Linac or transfer lines. They provide the installation instructions to the magnet installers. Physicists record these instructions in this

Table 1: Transformation rule for magnet multipoles. It is assumed that the magnet polarity is adjusted, if necessary, so that the fundamental term remains positive. $N = 1$ is for quadrupole magnet, while $n = 1$ is for quadrupole order.

Item	Normal magnet of order N	Skew magnet of order N
Orientation:		
b_n	$(-)^{n+N+1} b_n$	$(-)^{n+N} b_n$
a_n	$(-)^{n+N} a_n$	$(-)^{n+N+1} a_n$
Upside-down:		
b_n	$(-)^{n+N+1} b_n$	$(-)^{n+N+1} b_n$
a_n	$(-)^{n+N+1} a_n$	$(-)^{n+N+1} a_n$
180° about x:		
b_n	b_n	$-b_n$
a_n	$-a_n$	a_n

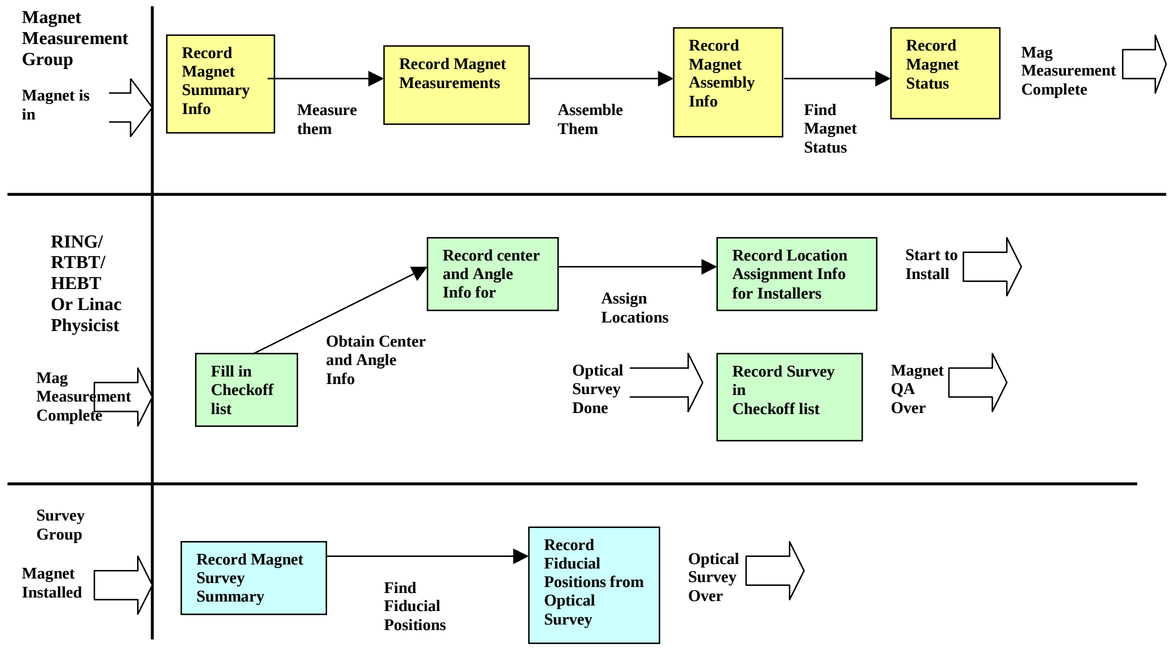

Figure 4: Process Diagram

database. They are also responsible for making sure that various aspects of the magnets such as electrical, cog engineering, survey etc. are performed and are OK.

After various tests are over, the physicists fill in the "check off" list for the respective magnets or for an assembly. These check off list tables are provided in the Magnet database. Physicists record the comments for each of the magnets or an assembly at various times in the process of testing. Survey group is responsible for surveying the magnets and recording the fiducial positions from the optical survey.

Presently the database contains 19 tables as listed in Table 2. The first 5 are intended for field quality of individual magnets, while the next 6 tables are intended for survey and alignment data. The next set contains the tables for recording the magnet status and check off lists to be signed off in the end.

6 SUMMARY

Along with the magnet assembly delivered for installation at ORNL, magnet measurement data containing tables of performance history, field quality, alignment and survey data will be transferred to ORNL. This information is essential both for ring installation and for future machine operation including magnet corrections. SNS Magnet database has been designed to fulfill such tasks, and it will also benefit production stage quality assurance, error impact analysis, and assembly assistance including sorting.

Table 2: Summary of SNS Ring Magnet database tables.

Name	Content
Magnets	summary, magnet name & parameters
Assembly	combined element assembly info.
Integral	int. trans. func. & geometric multipoles
LocalHarm	multipoles measured at one position
Hysteresis	magnetization multipoles
FidMagInfo	summary of magnet survey data
FidOpt	fiducial positions from optical survey
CenterMag	magnet center w.r.t. external ref.
AngleMag	magnet field angle w.r.t. external ref.
Ideal_Built	ideal fiducial position in global coor.
As_Built	actual surveyed fid. pos. in global coor.
MagRingCheck	check-off list for ring magnets
MagHEBTCheck	check-off list for HEBT magnets
MagRTBTCheck	check-off list for RTBT magnets
MagLinacCheck	check-off list for Linac magnets
MagnetStatus	magnet status and history
MagComment	comment number for magnets
CommentList	contents of comment

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