SNS RING AND TRANSPORT SYSTEM MAGNET ACCEPTANCE AND INSTALLATION PREPARATION

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Abstract

Installation of the magnets in the SNS-Ring, or any accelerator, requires quality assurance to minimize problems. The geometry of the ring was frozen and the dipole length was adjusted to reflect the measured dipoles magnetic length to aid the installation process. The approach established here is based on the Magnet Acceptance procedures used for RHIC [1]. The magnets are first measured and checked on the bench for mechanical and electrical characteristics, field strength, multipole strengths, survey, etc. Each group performing these measurements determines whether the magnet is within the design specifications. A magnet that passes is accepted. A magnet that fails may be accepted if the problem can be either repaired or reworked and retested to specifications. Such a magnet is classified as a spare or fixed. Furthermore, once accepted, these magnets are assembled into units such as the full half cell assemblies before being shipped for installation. These assemblies have a checkout list as well.

INTRODUCTION

The process of installing magnets in the SNS-Ring (or any accelerator) requires that any problems be identified and resolved. A system of checking is proposed to identify any problems that may arise. A determination of whether this problem is a show stopper and must be fixed or can be handled by simpler means is then addressed. In this paper we discuss our approach. We start with the geometry of the SNS-Ring, then we describe the method used to identify problems.

RING GEOMETRY

Before installing the SNS-Ring, the geometry must be agreed upon and fixed. The geometry consists of the ring dimensions and the coordinates of the center of the ring. Since the geometry of the HEBT and RTBT lines are already established, the SNS-Ring geometry must not be changed.

Ring Dimensions

When the SNS-Ring was originally designed the dipoles were assumed to be $1.5m$ long. After some dipoles were built and their lengths measured, the magnetic length was somewhat shorter. We agreed to choose the $SD1717$ dipole to be the standard. The magnetic length of this dipole is measured to be $1.4407m$. Replacing these design magnets with the shorter magnets and adjusting the drift spaces to fix the circumference leads to a change in the geometry.

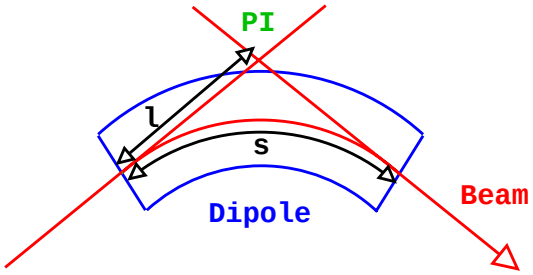

Figure 1: Schematic of the dipole showing the beam direction and the two intersecting tangents (PI). Fixing the PI point freezes the geometry.

To fix the geometry the drift spaces about the dipoles must be adjusted differently. Consider the schematic of the dipole shown in Fig. 1. If the length, s, changes and the PI point (Point of tangent Intersection) stays fixed, then the angle must be the same as:

$$s = \rho\theta \qquad s_0 = \rho_0\theta$$

where s_0 is the length of the design dipole. The length from either end of the dipole to the PI point is:

$$l = \rho\tan(\frac{\theta}{2}) \quad l_0 = \rho_0\tan(\frac{\theta}{2})$$

Thus, the change to the drift space length on both sides of the dipole due to a change in the dipole length leads to:

$$\Delta d = l_0 - l = \frac{s_0 - s}{\theta}\tan(\frac{\theta}{2})$$

When applied to the SNS-Ring the circumference becomes $248.00612m$.

Ring Center

The center for the SNS-Ring is fixed at [2]:

$$North(X) = 10110.611218m$$
$$Vertical(Y) = 2000.000000m$$
$$East(Z) = 20000.000000m$$

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This center is determined by the Linac coordinates, HEBT line and the foil position.

QUALITY CHECKS

Several groups are involved with the quality assurance. The Magnet Division measures the performance of the magnets as well as the multipoles. They also check to see if the mechanical center from the Survey Group matches the field center of the magnet. Furthermore, it may be necessary to trim or shim the magnet. The magnets and assemblies must pass tests for the mechanical and electrical systems. The AP (Accelerator Physics) Group sorts which half cell the magnet should go based on reducing optical errors. We ensure that the Survey and Magnet Divisions must send all their data to SNS. In addition, all applicable data (e.g. magnet, surveys, travelers, inspection and test records) are forwarded to SNS. Assemblies must be checked for vacuum leaks and polarity as well. We start with the Magnet checks.

Magnet Checkoff List

The following table shows the checkoff list to determine if the magnet is acceptable. Here we use 'y/n/yc/c' which means 'Yes/No/Yes with comment/Comment'.

Table 1: Magnet check

Column	Description	Response
Mag_Serial	Magnet serial name	
Mag_Type	Magnet description	
DateTime	Date and time of last data entry	
TF1.0OK	Transfer function at 1.0GeV measured	y/n/yc/c
TF1.3OK	Transfer function at 1.3GeV measured	y/n/yc/c
MulOK	Magnet harmonics	y/n/yc/c
MechOK	Mech. test complete	y/n/yc/c
ElecOK	Elec. test complete	y/n/yc/c
SurveyOK	Survey measurement complete	y/n/yc/c
Shim	Is it shimmed?	y/n/yc/c
Trim	Is there a trim?	y/n/yc/c
Sort	Is it sorted?	y/n/yc/c
MagDataTrans OK	Magnet data transferred to SNS	y/n/yc/c
SurvDataTrans OK	Survey data transferred to SNS	y/n/yc/c
DocOK	Documents complete	y/n/yc/c
HCA	Half-cell assigned	y/n/yc/c
SUMOK	Summary OK for installation	y/n/yc/c

Sometimes a magnet can be accepted but a comment is added such as a particular multipole is greater than 2σ from the average. In this case the magnet can still be accepted, but may be sorted to a region where that multipole is not critical or this magnet could become a spare. If this turns out to be a problem the magnet may be repaired and then retested. Table 3 shows the results for the first half-cell sent to SNS. Note, at this time the magnet data has not been transferred to SNS yet. The $SUMOK$ cannot be given till this is complete

When a set of magnets for making an assembly such as a complete half cell are accepted, the final assembly then undergoes a similar battery of checks.

Assembly Checkoff List

A table for the assembly checkoff list is shown in Table 2. Many of the items are similar to the checkoff items for the magnets. Two differences are the polarity checks and the vacuum checks. The magnet polarity is checked off when the power supply leads produce field directions as defined by [3]. The assembly is checked for vacuum leaks as well.

Table 2: Assembly check

Column	Description	Response
Assemble_Serial	Assembly serial name	
DateTime	Date and time of last data entry	
TypeOK	Verification of the element type and sorting plan	y/n/yc/c
MechOK	Mech. test complete	y/n/yc/c
ElecOK	Elec. test complete	y/n/yc/c
MpolOK	Magnetic polarity checked correctly	y/n/yc/c
SurveyOK	Survey measurement complete	y/n/yc/c
VacuumOK	Vacuum test complete	y/n/yc/c
SurveyDataTrans OK	Survey data transferred to SNS	y/n/yc/c
DocOK	Documents complete	y/n/yc/c
SUMOK	Summary OK for installation	y/n/yc/c

After the assemblies checks out, they are sent to SNS. Table 4 gives an example of the results for the first half-cell sent to SNS.

SUMMARY

Before the SNS-Ring can be installed, the geometry must be defined and frozen. This geometry depends on the injection as well as the extraction lines. Since, the measured dipole length was different from the original design, the drift spaces about the dipole had to be changed in order to recover the original design geometry. A prescription for doing this is presented in the ring geometry section.

Table 3: This table shows an example of the acceptance checkoff list for the magnets in the first half-cell for the SNS-ring. The comment: (1) Magnetic measurement made with non-production measurement system.

Column	**Dipole**	**Quadrupole**	**Sextupole**	**Corrector**
Mag_Serial	13	07	03	004
Mag_Type	17D120	21Q40	21CS26	27CDVM30
DateTime	October 18,2002	October 18,2002	October 18,2002	October 18,2002
TF1.0OK	Y	Y	Y	Y
TF1.3OK	Y	Y	Y	Y
MulOK	Y	Y	Y	YC (1)
MechOK	Y	Y	Y	Y
ElecOK	Y	Y	Y	Y
SurveyOK	Y	Y	Y	Y
Shim	N	N	N	N
Trim	N	N	N	N
Sort	Y	Y	N	N
MagDataTransOK				
SurvDataTransOK	Y	Y	Y	Y
DocOK	Y	Y	Y	Y
HCA	Y	Y	Y	Y
SUMOK				

Table 4: Assembly acceptance example for the first half-cell A1. The comment: (1) Magnet polarity ID for dipole and quadrupole per Tepikian's TN#114

Column	**Result**
Half_cell	A1
Assemble_Serial	RA1-1
DateTime	Nov 1, 02
TypeOK	Y
MechOK	Y
ElecOK	Y
MpolOK	YC (1)
SurveyOK	Y
VacuumOK	Y
SurveyDataTransOK	Y
DocOK	Y
SUMOK	Y

A plan for pre-installation checks of the SNS-Ring is presented for minimizing problems that may arise. This plan calls for checking each magnet that will be installed. These magnets must be tested to produce the magnetic field required for proper operation of SNS. Furthermore, these magnets must be able to operate at the higher energy of $1.3GeV$ protons. Along with the field checks there are other checks for each magnet. These magnets must be checked mechanically and electrically. They must be measured by the Survey Group which may uncover other problems that need to be addressed. Additionally, we record whether the magnet was shimmed, has a trim coil and if the magnet was sorted. This information is required if the magnet ever needs to be replaced by a spare. Finally, all data concerning these magnets, such as magnetic field measurements, survey measurements and all other documentation must be transferred to SNS. When everything is complete then the summary OK for installation is checked.

Besides each individual magnet, the completed assemblies that are shipped to SNS must pass similar kinds of checks with the following differences. The magnets in the assembly must be verified and follow the sorting plan. The power supply connections must be properly labeled so that the magnets are correctly powered during installation. The beam tube must pass the vacuum tests. Finally, all documentation must be transferred to SNS. Similarly, as with the magnets, when an assembly passes all these tests, the summary OK for installation is checked.

ACKNOWLEDGEMENTS

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[2] J. Galambos, private communication.

[3] S. Tepikian, C. J. Gardner, SNS TechNote #114 (July, 2002) and W. J. McGahern, SNS TechNote #119 (November, 2002)