Design Criteria Document

Spallation Neutron Source
Experimental Facilities
Instrument Systems

Shared Design Activities
Optical Elements
WBS 1.7.3.6

Standard Core Vessel
Inserts And Plugs

May 2002

A U.S. Department of Energy Multilaboratory Project

SPALLATION NEUTRON SOURCE

Argonne National Laboratory • Brookhaven National Laboratory • Thomas Jefferson National Accelerator Facility • Lawrence Berkeley National Laboratory • Los Alamos National Laboratory • Oak Ridge National Laboratory

SNS

DESIGN CRITERIA DOCUMENT

Standard Core Vessel Inserts And Plugs

Spallation Neutron Source
Experimental Facilities Division

Prepared by

R Summers

Date Published: May 2002

Prepared for the
U.S. Department of Energy
Office of Science

UT-BATTELLE, LLC
managing the
Error! Unknown document property name. Activities at the

Argonne National Laboratory	Brookhaven National Laboratory
Thomas Jefferson National Accelerator Facility	Lawrence Berkeley National Laboratory
Los Alamos National Laboratory	Oak Ridge National Laboratory

under contract DE-AC05-00OR22725
for the
U.S. DEPARTMENT OF ENERGY

DESIGN CRITERIA DOCUMENT

Standard Core Vessel Inserts And Plugs

WBS 1.7.3.6

May 2002

Instrumentation Systems Senior Team Leader	______________________
SNS Systems Integration	______________________
Instrumentation Systems Lead Engineer	______________________
Instrumentation Lead Physicist	______________________

Standard Core Vessel Inserts and Plugs
WBS 1.7.3.6

Table of Contents

1.0 SCOPE

Neutron research is a unique and powerful tool for studying the structure and dynamics of materials at the atomic, molecular, and macromolecular levels. The SNS is a one-of-a-kind facility in Oak Ridge, Tennessee, that will provide the most intense pulsed neutron beams in the world for scientific research and industrial development. Construction of the $1.4 billion facility began in 1999 and is scheduled for completion in 2006. The eighteen neutron beams in the SNS Target Building are shown in Figure 1.

Figure 1 SNS Target Building with Instruments on Radial Beam Lines from the Target Station

2.0 APPLICABLE DOCUMENTS

2.1 INTERFACE CONTROL DOCUMENTS

100000000-IC0001-R02	1.6 Target Systems with 1.7 Neutron Scattering Instruments

2.2 DESIGN ANALYSES AND CALCULATIONS

107030600-DA0002-R00 Updated Beam-Tube Energy-Deposition Studies

3.0 REQUIRMENTS

3.1 ITEM DEFINITION

A Core Vessel Insert is the upstream end of each instrument. The insert directs the neutron beam toward the downstream sample and detector. The insert has several configurations depending on its elevation (lower or upper), its shape (multi or single) and its internal contents (guide or no guide). Initially, the SNS will not have instruments on all 18 beam lines. Therefore, Core Vessel Plugs will be installed to block the neutron beam. The initial configuration will be a mixture of inserts and plugs. The insert will have the following features:

- The structural capacity to support the total installed weight of the core vessel insert and a portion of the installed weight of the shutter insert and transfer those loads to the Core Vessel flange.
- Alignment features to guide the shutter insert into its proper position.
- Space for an internal Guide and its alignment devices that position an that will be assembled at final installation.
- Sealing features on the mounting flange to match the seal between the Insert flange and the Core Vessel flange.
- Active water-cooling to remove neutron energy deposition in the insert.
- Process line to provide the helium for an internal volume.
- Hot off gas line from the internal volume.
- Helium pressurization to the seal.
- Ten configurations that may be used “as furnished” or modified for all 18 neutron beam lines.

3.2 CHARACTERISTICS

3.2.1 Performance

Table 1 Standard Core Vessel Inserts and Plugs Performance Characteristics

Feature	Nominal Value	Accuracy
STRUCTURAL		
Total steady state load due to Shutter Insert weight	3200 lb (13.2 kN)	
Total transient load due to seismic event according to ?	Maintain upstream window seal and core vessel flange seal for a PC-2 category.	
Reaction load path	Alignment pins and tightened stud nuts on core vessel flange	
THERMAL		
Energy deposition with respect to beam path due to 2 MW proton beam power	"Energy Deposition and Damage Calculations in Core-Vessel Inserts at the Spallation Neutron Source", Brian D. Murphy, 107030600-DA0001.	
Cooling configuration	The insert shall be cooled symmetrically, i.e. cooling on all four sides in regions of active cooling.	
Maximum metal temperature	200º F (94° C)	
Cooling water inlet temperature	82° F (28° C)	
Cooling water outlet temperature	100 ° F (38° C)	
Cooling water flow rate		
Single insert	.47 gpm (29.7μm^3/sec)	
Multi insert	1.88 gpm (119 μm^3/sec)	

Feature	Nominal Value	Accuracy
PRESSURE		
Cooling channels		
Cooling water inlet pressure	22 psig (152 kPa)	
Cooling water pressure drop, maximum	5 psig (34.5 kPa)	
Process Gas channels (supply channel at upstream and hot off-gas at flange)		
Helium inlet pressure	2.0 psig (13.8 kPa)	
Internal volume between windows		
Maximum internal pressure	14.7 psig	
Minimum internal pressure	-14.7 psig	
Maximum upstream external pressure	14.7 psig	
Minimum upstream external pressure	-14.7 psig	
Downstream external pressure	0 psig	
Upstream window leak rate	$\leq 1.0\times10^{-6}$ std atm cc per sec helium	
Downstream window leak rate	$\leq 1.0\times10^{-4}$ std atm cc per sec helium	

3.2.2 Physical

Table 2 PHYSICAL CHARACTERISTICS

Feature	Nominal Value	Accuracy
Insert and Plug ConfigurationOptical Elementss		
Multi Shape Insert		
Elevation and internal contents	Upper elevation No guide 3.94 in wide x 4.72 in high opening only (100 mm x 120 mm)	
Elevation and internal contents	Lower elevation No guide 3.94 in wide x 4.72 in high opening only (100 mm x 120 mm)	
Multi Shape Plug		
Elevation and internal contents	Upper elevation No opening or guide	
Elevation and internal contents	Lower elevation No opening or guide	
Single Shape Insert		
Elevation and internal contents	Upper elevation No guide 3.94 in wide x 4.72 in high opening only (100 mm x 120 mm)	
Elevation and internal contents	Lower elevation No guide 3.94 in wide x 4.72 in high opening only (100 mm x 120 mm)	
Elevation and internal contents	Upper elevation Installed guide 3.94 in wide x 4.72 in high opening only (100 mm x 120 mm)	
Elevation and internal contents	Lower elevation Installed guide 3.94 in wide x 4.72 in high opening only (100 mm x 120 mm)	
Single Shape Plug		
Elevation and internal contents	Upper elevation No opening or guide	

Feature	Nominal Value	Accuracy
Elevation and internal contents	Lower elevation No opening or guide	
Thickness from super mirror surface to outside of guide		
Thin glass	.28 in (7 mm)	
Thick glass	.50 in (13 mm)	
Thin glass on metal substrate	.50 in (13 mm)	
Allowance for adjusting guide	± .25 in (6 mm)	
Allowance for guide adjusting device	.38 in (9.5 mm)	
Allowable streaming clearance around outside of internal guide	.02 in (0.5 mm)	
Beam Path LocationOptical Elements		
Maximum length of insert upstream of the core vessel flange	See Table 3	
Centerline of beam path below top alignment pin in core vessel tube block	9.00 in[1] (229 mm)	
Shutter Gate and Shutter Insert ConfigurationOptical Elements		
Shutter gate alignment and movement	0.625 in (16 mm)	
Gap between core vessel insert and shutter insert	≤ 1 in (26 mm)	
Repeatable alignment of Core Vessel Insert Guide with Shutter Guide	0.00 in (0 mm)	± .040 in (1 mm)
Thermal analysis geometry		
Insert geometry	Multi Core Vessel Insert 107030600M8E8700A107-1	
Thickness of cadmium coating for decoupling	*0.040 in* *(1 mm)*[2]	

•

1 This is true only for the Standard Core Vessel Insert. See the Interface Control Document, paragraph 2.1, to determine the centerline modifications needed for beam lines located on specific moderators.

Feature	Nominal Value	Accuracy
Service Connections		
Diameter of Insert passages	.38 in (9.5 mm)	
Cooling water supply	0.50 in OD x .38 in ID (12.7 mm OD x 9.5 mm ID)	
Cooling water return		
Insert vacuum		
Seal helium supply		
Seal evacuation		

Table 3 Maximum Insertion Lengths
All Ports

Beam Line ID	Allowable Length Inside Core Vessel Flange	Limiting Criteria
Multi Channel and Tall Multi-Channel		
01	32.982	Thermal
04	35.976	Thermal
08	38.952	Plug Removal
11	38.952	Plug Removal
14	35.042	Thermal
16	34.427	Thermal
Single Channel		
02	34.341	Thermal
03	35.174	Thermal
05	35.881	Thermal
06	35.178	Thermal
07	39.116	Thermal
09	39.239	Remote Handling Tool

[2] The italic font is used to indicate the value is a design estimate or a design goal. The value needs to be verified.

Beam Line ID	Allowable Length Inside Core Vessel Flange	Limiting Criteria
10	39.239	Remote Handling Tool
12	39.079	Thermal
13	35.129	Thermal
15	36.603	Thermal
17	34.347	Thermal
18	33.740	Thermal

3.2.3 Reliability

1. Inserts shall be designed for a lifetime of 20 years.

3.2.4 Maintainability

1. Initial installation of the Inserts can be accomplished “hands-on”. After first beam operation, the facility equipment will become activated to a level that precludes further hands-on.
2. The Inserts are designed as replaceable units and will not be designed for in-situ repair.
3. Inserts shall be designed to facilitate remote handling.
4. Inserts shall be replaceable within a 30-day shutdown.

3.3 DESIGN AND CONSTRUCTION

3.3.1 Materials, Processes and Parts

1. The structural material for all structural components shall be 316L or 304L austenitic stainless steel or 6061 aluminum.
2. The Inserts will be equipped with aluminum windows.
3. The Core Vessel Inserts shall provide decouple material around the neutron beam paths over their full length.
4. Minimal clearance (0.25”) allowed between vessel tube blocks and Core Vessel to reduce streaming.

5. Minimal clearance (0.50”) allowed between Shutter Gate and Shutter Insert to reduce streaming.

6. A secondary function is to provide radiation shielding adjacent to the beam. In some cases this helps to eliminate line of sight.

7. CV Insert will be equipped with 3 thermocouples to measure temperature within the Core Vessel Inserts. Thermocouples will be type J [iron (+) versus copper-45% nickel (constantan) (-)] with 2-pin terminators in the Drip Pan area.

8. Flow Switch in Cooling Return Lines - Alarm

9. Thermal Indicator Switch in Cooling Return Lines - Alarm