SNO-STR-90-120

SUDBURY NEUTRINO OBSERVATORY

Grounding and Shielding of SNO Electronics

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1. Introduction

Signal levels in the few millivolt range are produced at the output of the PMTs and considerable care is required to prevent interference from various sources in the neutrino observatory and elsewhere in the mine. It is proposed to enclose the PMTs and the front end electronics inside an electromagnetic shield which would float isolated from the mine ground. Power for the electronics and other systems that must operate inside the shielded region would be obtained from an uninterruptable power supply (UPS). The mine ground, the proposed arrangement for the electromagnetic shield and considerations for obtaining effective isolation are discussed in section 2. A list of components that will operate inside the shielded region and require detailed consideration is given in section 3. Some comments on the notes prepared by S. Nilakantan on the Design Coordination Meeting of 21 June, 1990 are included in section 4.

2. Shielding and Isolation of Detector Electronics

The ground in the mine is provided by a heavy copper wire which runs down the shaft and is grounded at the surface. The rock at the 6800' level is dry and does not act as an effective ground. There is substantial noise on the mine ground and it is essential that the sensitive detector electronics be well isolated from it. The utilities such as pumps, fans, lights etc and the electronics located in the control room such as computers for data collection and control and monitoring of the detector systems should not require isolation.

The proposed electromagnetic shield would enclose the detector cavity and the electronics corridor. The shielding in the cavity would be provided by the stainless steel liner and the wire mesh installed as part of the ground control in the area above the deck. The wire mesh on the walls and back of the electronics corridor would serve as part of the shield for the electronics corridor. It would be completed by mesh placed in the concrete floor and across the block wall separating the electronics corridor from corridor no. 1. The steel fire door set in this wall would form part of the shield. To make the shield effective the sections of screen should be connected together at frequent intervals (approximately 2') to provide electrical continuity. The no. 4 mesh used for ground control

comes in 5′ x 11′ sheets and Inco standards call for it to be overlapped by a minimum of 6". This overlap should be adequate for shielding purposes. A minimum of 2 connections along the 5′ side and 3 along the 11′ side of a sheet should be adequate. The connections must provide good electrical contact that will remain effective over the life of the laboratory. Tack welding or suitable crimping techniques may be used that will not suffer from corrosion over time. The stainless steel liner will probably be connected to the liner at the deck. To maintain isolation a gap is required between the mesh surrounding the electronics corridor and that in corridor no. 1. The best location for the gap would be just outside the block wall described above. A narrow gap is all that is required, 6" would be enough to ensure that unwanted contact does not occur. Pipe and ventilation ducting will require insulating sections at the point of entry into the shielded area.

In the first paragraph the electromagnetic shield is described as floating and not connected to the mine ground. What is really required is the flexibility to float the shield completely isolated from the mine ground or to connect it in some way to the ground. It is impossible to predict where the connection should be made to obtain minimum interference. The grounding connection would then the made by a explicit connection to be located as necessary.

The electrical systems that operate inside the shielded area require clean power and would be supplied from one or more UPS units. These may include the high voltage supplies for the PMTs, the front end electronics, computers, the earth's field compensation power supplies, lights, ventilation fans, monitoring and control systems that must operate in this area when data is being collected. Systems operating in the shielded area should be free of electrical noise. Thus incandescent lighting is strongly preferred over fluorescent lighting. Independent fluorescent lighting circuits could be installed if it is felt that light levels that would be expensive to obtain with incandescent units are required when installation and maintenance work is carried out. Solid state starters should be used for ventilation fans.

The grounding of the front end electronics to the local floating ground of the shield will require careful design. Return currents should be carried in a neutral line, grounds which should be massive should carry no current. Ground loops are to be avoided and flexibility in the grounding arrangements is desirable so that connections can be varied in light of experience.

Systems located in the shielded region that are only used during construction or in the operation phase when data is not being collected,(eg. for monitoring or servicing) need not be supplied from the UPS clean power source. They can be supplied from a normal power source which would be disconnected (by

unplugging) at the point where the power line enters the shielded region. This would be most useful for large load items such as cranes, pumps and welding supply lines if the latter are a permanent installation.

The operation of the detector will require that a number of sensors and controls be located in or near the detector inside the shielded region. There will be communication between these sensors and controls and systems located in the control room. It is essential these links not introduce ground loops and noise into the shielded region. One solution to this problem is to provide the links through a single fiber optic link between a Modicon (or other suitable computer) in the electronics corridor and a corresponding unit in the control room. Alternatively careful consideration of isolation and grounding may allow individual sensors to be connected directly to units in the control room and the utility room. Individual components requiring consideration are listed in the next section.

The possibility of providing an isolated shielded enclosure around one or more of the spare rooms is under discussion. If it is decided this should be done then the requirements would be the same as described above for the electronics corridor and cavity. It is recommended that each spare room be a separate isolated enclosure surrounded by screening which floats with respect to the mine ground and that each room be supplied by a separate UPS. The precautions discussed above for isolating the communication lines to the shielded region should be observed.

3. Systems Operating in the Shielded Region

The components located in the shielded region that use electrical power and/or communicate with systems outside the shielded region require careful consideration to avoid the introduction of noise into the low level detector signals. This section contains a list of such components. Reference is given to the work breakdown structure used in PSD-TM-12 revision P2 where details of the various components are discussed.

Ground Water Drainage 4.2470, 4.3400, 4.4340
The water detection sensors will be located between the SS liner and the screening in the cavity. Pumps may be located on the deck.

Clean Room Services 4.2560, 4.3600, 4.4360, 4.5400
A clean room has been proposed for the area of the deck enclosing the access to the acrylic vessel. It would contain the systems used for calibration of the detector.

Cranes 4.2600
Cranes will be installed in the cavity for use during construction. One or more of these may remain for intermittent use during the operating phase.

H2O Systems 4.3100, 4.4310
Sensors used for monitoring and control of the water level, temperature and flow rates during recirculation may be located inside the SS liner or on the deck.

D2O Systems 4.3200, 4.4320
Sensors used for monitoring and control of the heavy water level and flow rates during recirculation may be located inside the SS liner or on the deck.

Cover Gas 4.3320, 4.4330, 4.6200
Pressure and flow controls for the inert cover gas will be located in the cavity.

Lighting and Power Outlets 4.4221
Lighting, emergency lighting and power outlets are required above the deck and in the electronics corridor.

Communications 4.4222
Telephone links will be required between the shielded and the non shielded regions of the observatory.

HVAC Controls 4.4223, 4.6210, 4.6220
Local circulation fans, thermostats and alarms may be located in the shielded region.

Vessel Monitoring 4.4350
A system of ultrasonic sensors may be used to monitor distortion of the acrylic vessel. They would be mounted in the H2O inside the SS liner.

Magnetic Field Compensation Coils 4.4400
The earth's field compensation coils and power supplies will be located in the shielded region. The coils will be installed between the stainless steel liner and the ground control screening in the cavity. The possible need of connecting together all the screening sections below the deck should be considered.

Safety Systems 4.4521, 4.4523.
Smoke detectors, door interlocks and possible other safety systems will be required in the shielded area.

Rock Monitors 4.4600
The behaviour of the rock will be monitored over the life of the observatory. At present the proposed monitoring system lies entirely outside the shielded region. If any rock monitoring systems are proposed for locations inside the shielded region the maintenance of isolation will require consideration.

Controls and Alarms 4.4710
Isolation of sensors for controls and alarms located in the shielded region is required.

Detector Systems 4.5000
The isolation of the detector is discussed in section 2 above.

4. Comments on Notes Prepared by S. Nilakantan

Item No 4
Could the hoist not be supplied by a power line that could be disconnected or unplugged at the point where it enters the shielded region?

Item No. 10
An earlier estimate of power for the electronics and computer located in electronics corridor was 25 to 30 kVA.

Item No. 12
Incandescent lighting is strongly preferred.

Item No. 14
Return currents should be carried in a separate neutral line, there should be no current in the ground bus.

Item No. 16
The duplicate sensors would be in the electronics racks in the electronics corridor.

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