SPALLATION NEUTRON SOURCE
ACCELERATOR SYSTEMS DIVISION
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One of the comments made at the “close-out” of the Accelerator Systems Advisory Committee (ASAC) meeting held recently (specifically from G. Rees),
[“. . . that we should make use of the available expertise and knowledge in other high intensity proton beam facilities regarding maintenance, operation, design, component use, material use, etc.” (ref. N. Holtkamp].

In response to this comment, the SNS/ASD Division Director (N. Holtkamp) appointed a small committee (L. Kravchuk, G. Murdoch, K. Reece, J. Stovall) to both look at the manner in which these concerns have been addressed by the SNS Project and also to contact several colleagues at other high-intensity proton laboratories with a set of questions. These questions were two-fold; first to identify those items/issues the other laboratories have in-place as “mitigation factors” and also which items/issues would they very strongly consider necessary were they to start construction once again. It would be safe to state that many of these concerns dealt either directly or indirectly with the facilities ALARA (As Low As Reasonably Achievable) goals and, in general, reducing dose to both personnel and in-tunnel devices (therefore, hopefully, increasing the device lifetime and improve its functionality).

Those laboratories contacted and by whom were, LANSCE/PSR (Mike Borden)-Stovall, TRIUMF (Clive Mark)-Kravchuk, FNAL(Paul Czarapata)-Reece, BNL (Al Pendzick, Charlie Pearson)-Reece & Murdoch, ISIS (John Hurst)-Murdoch, PSI (Eyke Wagner)-Kravchuk, INR (Mikael Grachev)-Kravchuk, ORNL remote handling facility-Murdoch.

Items this committee felt were appropriate to ask both ourselves (SNS/ASD) and the other laboratories included locations we considered to be of importance from either a residual activity perspective and/or “lead-time” to replace (=> spares); all of which impacts reliability and ALARA. The list is also not exhaustive.

First, questions/concerns we asked of ourselves, and then of others included items #1-16.

1. in many of the SNS accelerator designs, concepts, etc, we (SNS/ASD) have been working with high-intensity laboratories as members of the collaboration and have (where practical) incorporated ALARA considerations into the facility design.
2. gas stripping (=> radiation) from "less than desired" vacuum pressure at low energy.
3.portable shield(s) (some configurable and others with simply Pb glass) to enable workers access to activated areas.
4. crane: both to enable workers to place portable shield(s) from a distance (1/r**2) (this is an important asset to keep workers further from the "hot" regions.
5. injection chicane (4 magnets (DC))
6. injection dump beamline septum.
7. 1st arc dipole in the Ring.
8. injection foil drive mechanism (~24 foil assembly).
9. vacuum isolation windows are being designed at SNS/ASD but will be activated.
10. SNS accelerator has many collimators (high residual activity) - 2 in HEBT, 1 in HEBT arc, 3 in Ring and 2 in RTBT. This will localize the losses and permit the remainder of the SNS Accelerator Facility to maintain relatively low residual activity.

11. the Linac dump, HEBT arc collimator (dump), Ring injection dump and RTBT extraction dump all have HARP's (residual activity). These beam dumps are also reentrant such that the residual activity should be of concern only at 180 degrees from the beam direction.
12. a beamstop at the interstitial space between the CCL and the SRF (residual activity).
13. the SNS accelerator facility has (in many places throughout the lattice) sufficient aperture.
14. SNS/ASD has tried to locate water manifold, electrical connections in the beam enclosure away from high activation areas.
15. the last two quadrupole doublets in RTBT (downstream) have radiation resistant coils.
16. there is a concrete shield between these two doublet assemblies to minimize the back streaming neutrons from the Target.

The following questions were directed to the other institutions.

17. what concepts etc. have these institutions use to address these issues.
18. what concepts, etc. would these institutions have done differently to address these questions.
19. how do they decide their "special process" (long-lead time) spares?
20. how do they handle spares in general?
21. which devices should have either quick-disconnect or remote handled vacuum flanges?
22. have other facilities developed proven quick-disconnect vacuum flanges?
23. have other facilities developed proven remote handling tools and techniques?
24. are there other devices that are given "special handling/attention" at other facilities? (is our list exhaustive?)
25. how are X-ray sources treated at other facilities?
26. are quick-disconnect (water, electrical) technologies employed at other facilities?
27. is pre-alignment of "in tunnel" devices/assemblies considered/used to reduce alignment time in the beam enclosure?
28. are "self-aligning" techniques used to install the device/ assemblies?
29. how much reliance upon mitigation (as in the SNS/Machine Protection System(s) - MPS) do other facilities employ to minimize residual activity and therefore extend device lifetime?
30. In all these items, is the integral dose reduction properly accounted for, (ALARA)

From within the responses received from our peer laboratories, this committee chose to select several (but not all) common issues to address in a tabular form (below) and make comparisons with the SNS as presently configured. It is worthy to note that most of the accelerators included in this brief survey have comparable “lists of good practices” they strive to achieve today; even though when they first began operation, consideration of ALARA practices, device reliability and device lifetime may not have been “forefront issues” due to their original lower intensity. In nearly every case, the present modes of “high intensity” at the SNS and the other accelerators have now forced both the SNS to consider these factors in early design stages of devices and the Facility, and also has become somewhat standard practice at other facilities for new projects, retro-fits of existing equipment/systems and simply a re-assessment of operating techniques as beam intensity increases.

Attention to detail (reliability, serviceability, integration, etc.) of not only the “in-beam” devices, but also the associated support equipment are now part of nearly every design review, acceptance testing and nominal operating specifications for the SNS accelerator facility.

	RAL/ISIS	LANL	AGS	INR	TRIUMF	PSI	SNS
Kinematic mounts and/or pre-alignment	Nearly all "beam" Devices have both kinematic mounts and pre-alignment technique	LANSCE & PSR – (older machines; retrofit devices- Yes)	As older devices are retro-fit; both these are incorporated with the "in-beam" devices.	Linac – Yes, (no remote control)	Not special	Not special	Kinematic mounts – yes in many cases. Ring MM – No (welded to girder). Although ½ cell assemblies may be replaced as a unit.
Remote (not robotic) handling	Vacuum valves, etc. RAL has "long handled" tooling developed	Few if any in LANSCE. Target has some.	Old devices – No. Retro-fit & new devices - Yes	Yes – some devices	Yes	Yes	Accelerator – Not yet. Target – Yes (many types).
Cranes	Yes - "could not live without them".	Linac – Yes; PSR – limited coverage	Booster – No; AGS & Experimental areas - Yes	Yes – 2 monorails & crane in Ring and HEBT	Yes	Yes	Linac – No; HEBT, Ring, RTBT - Yes
Portable shields	Several; including Pb Glass ports for viewing.	Yes	Yes – a few.	Yes	Yes	Yes	Yes – one configurable; No– Pb glass view shields.
Quick connect & dis-connect	Yes – most utilities	Few utilities in Accel.	Retrofit – Yes, most utilities	Yes – for vacuum valves.	Yes – for water, air and some electrical	Yes – for most utilities	Few vacuum flanges; some other utilities.
Spares	~ 10% + others based upon MTBF, safety and (ALARA)	Very few to date (LANSCE)	~ 10% + some "special process spares"	~ 10% of focusing and transport system; also vacuum equip.	Very few	Very few.	~ 10% + some "special process spares.

Conclusions;

From conversations and e-mails with colleagues at other high intensity proton laboratories, in addition to the Table (above), Work-Planning, attention to ALARA (both for “in-beam” devices and personnel) and minimization of beam loss are high priorities. Many of these Facilities are “older” and are presently operating at intensities much greater than originally anticipated. Almost every laboratory has become aware of the need to reduce residual activation and therefore reduce the annual dose received by trained facility workers. These (and other) contacts with experienced and responsible staff at other laboratories will continue to be consulted as to their ALARA practices and the method(s) used to achieve them. Although many of the SNS collaboration device/system design reviews included SNS staff, SNS/ASD now has more experienced staff to continue to review and suggest design alternatives that will lead to reduced device activation, better remote handling, quick-disconnect designs and worker annual dose. As at other facilities, this process will continue throughout SNS Construction and Operation.

It is the opinion of this committee that the SNS Accelerator Facility has been (in many areas) designed with these principles in mind. A few examples are 1) radiation resistant magnet coils to improve the device lifetime, 2) specifying quick disconnect vacuum flanges at locations where higher residual activity is expected and probably most importantly, 3) continuing re-visits of present designs for additional design changes that will lead to improved device lifetime and lower worker exposure (such as lifting fixture configurations on Ring half-cell and collimator assemblies) and 4) additional locations where changes in design (i.e. type of vacuum flanges used and location of utility connections) will significantly reduce worker exposure.

From experience at some other high intensity proton linacs (LANSCE, AGS linac) there should be no significant residual activity requiring special handling in the SNS Linac. However, as with most proton accelerators and/or accumulators, some devices/areas are expected to require special handling due to activation (which may well imply design modifications). These include;

1) Ring injection region (chicane magnets, Lambertson septa, foil changer mechanism, injection dump beamline septum).
2) Ring extraction region (Lambertson septum).
3) Collimators (HEBT has 2, HEBT arc has 1, Ring has 3 plus 4 scraper assemblies, RTBT has 2) the methods of removing these collimators (3-sections each) with remote handled lifting fixtures is important).
4) The beam dump vacuum windows will require special handling.
5) Lifting fixtures (in general) have not been designed with ALARA in mind.

With the use of the Machine Protection System(s) (MPS) at the SNS Facility and careful/detailed training of our personnel, the SNS Accelerator should (and likely will) both operate safely at very high intensities and meet strict ALARA goals/guidelines we will set for our staff. As detailed in the SNS Beam Loss Policy, the SNS accelerator will be operated in a loss-limited mode (reducing machine intensity, diagnosing the source of the radiation, correcting that device(s) and then returning to nominal operation).

The SNS/ASD Division has and will maintain contact with our “peer” laboratories to further reduce (and meet) the ALARA goals set each year while improving our beam transport and acceleration techniques.

Lastly, it is the recommendation of this committee that a small group of SNS/ASD engineers and physicists continue to identify areas of expected higher residual activity and suggest device and/or procedural changes that will reduce personnel dose and improve device lifetime.