AGS/RHIC

Radiation **S**afety **C**ommittee

Issued: March 17, 2000

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Minutes of Sub-Commitee review of February 7, 2000

The RHIC Permit link/Beam Abort System Review

Present: L. Ahrens, D. Beavis, Asher Etkin, J.W.Glenn , Ed Lessard, Waldo Mackay, Brian Oerter, Robert Olsen, Dejan Trbojevic, Alan Stevens, Johannes van Zeijts

Purpose of the meeting: in part to fulfill requirements set by the RHIC AAR committee, this RSC subcommittee is to review the permit link/abort system. Specifically the RSC Chair requested a description of the system, an explanation of what "configuration control" is in place and/or planned, and some estimate of the consequences of a failure of the system – perhaps due to a weakness in this configuration control.

Trbojevic and Ahrens briefly described the permit link and abort systems, with contributions from Mackay, Oerter, and Stevens. Meeting handouts (covering the descriptions and other issues) are attached to these minutes. The contents of these attachments are not necessarily repeated in these minutes.

The RHIC Permit Link includes a large number of inputs, any one of which can initiate a sequence that results in the RHIC beams being aborted. This process is referred to as "pulling" the permit. The Permit input lines are engineered to be failsafe in the sense that simply disconnecting an input – say cutting its cable – will pull the permit. The inputs to the permit link come in maskable and unmaskable flavors. Setting bits via software commands can remove the ability of a channel to pull the permit. That channel is referred to as being "masked". The unmaskable inputs, which are primarily inputs from the quench link, are nevertheless sometimes disabled by replacing the usual input cable with a fake current source. Applying such a hardware "mask" is not routinely done to the maskable inputs, since the same end can usually be achieved more easily by "clicking" masking for them in a pet page. The software mask status is visible through the software. Since hardware masking is possible, and in fact is routinely used on the Quench Link permit inputs during the prebeam startup, there is concern that hardware masks might be inadvertently left in place when going into a running period and cause the system to fail. There is apparently no way the control system can know if a hardware mask is in place. Configuration control for this aspect of the permit link inputs is required. Several present agreed that the working out of a system to inform workers that such hardware masks were not to be applied – perhaps attaching "do not operate" tags to the permit link input modules – should be created. Someone needing to apply a hardware mask would then be instructed to follow a Procedure before bypassing the "do not operate" tag. Since these hardware modifications are used, a formal system to keep track of changes is probably needed. This is required after commissioning is successfully completed. **(Trbojevic-RHIC-FY2001)** 64

There is at least one set of unmaskable input channels, in 12 o'clock, for inputs from the PASS. When PASS finds it necessary to positively remove the beam from RHIC, which it guarantees by the insertion of the beam shutters, it also pulls the Permit, allowing the (relatively fast) Abort system to cleanly remove the beam. Is some configuration control already in place for these inputs? If not, the above system or another should be in place to cover these inputs – after commissioning of the abort system, perhaps by 1 May 00. **(Etkin-RHIC-FY2000)**. 65

The maskable channels are vulnerable to getting set into an improper state (i.e. masked when they should be active). By the same token because their status is easily changed, the system has the capability to evolve as the commissioning proceeds. For example, we expect to begin running with most if not all of the loss monitor channels masked, and then with understanding, and as the total beam energy increases, to bring the loss monitors into contributing to the magnet protection.

A subset of the maskable channels – including the vacuum valves – have already been identified as deserving special protection so that they will be more difficult to mask, and perhaps easily checked (alarmed on?) to assure that they are not masked. The plan is to group these such that an additional password is needed to modify their mask state, with only a few privileged modifiers – presently seen as Trbojevic and Olsen. It was left open whether changes to the mask states of this group needed special handling – documentation. Presumable the members making up the special group also must be controlled. **(Olsen-RHIC-FY2001)**.

It seemed the consensus that the mask status of input channels not put into this special protection category did not require any specific documentation beyond that provided by the masking program (which I hope provides tools for logging any changes made.)

The Abort/Dump part of the system can also fail, and some modes of failure could be described as a failure in configuration control. It is certainly required that there be correct settings of control variables for this part of the beam removal system including timing, trigger events, voltage references; and monitoring circuitry with permit–pulling capability. There seemed a consensus to not charge the RSC with the requirement to specify in detail the configuration control of this system. However, an experimental check that the system is healthy, on several time scales, is required.

It is anticipated that after any significant shutdown period the permit/dump system would be tested with low intensity beam before high-energy beams would be stored. This at least checks that the basic components are working. However there was a concern that despite this, if we are into a mode of routine beam dumping – perhaps every few minutes during some stages of the commissioning, we might dump the beam in a sloppy fashion. Further this might continue for prolonged periods and not be noticed, due to other pressing concerns. We will need a procedure by which Operations can regularly check that the system is working properly. **(Ahrens-RHIC-2001)**.

The analogy was made by Lessard to the procedures presently (i.e. for proton high intensity fast extraction) governing the surveillance by Operations of the quality of the beam transport to the g-2 target. Each shift a set of measurements are taken which must then fall within a specified range – determined by the cognizant physicist to correspond to acceptable transport. It is likely the beam diagnostics looking at the machine during a routine dump would provide signals that could be used to judge the quality of the dump. In particular, the loss pattern around the machine away from the immediate region of the dump may be an excellent indication of the dump quality. (Some variation of this same measure – perhaps the sum of the losses away from the dump region - may allow a quantitative estimate of the beam escaping from the dump region – and hence of the beam captured in the dump's well-controlled region.) The ratio of the (away from dump) loss to the beam in the machine (or some equivalent measurement) may well allow the control system to directly monitor the quality of every dump. Other diagnostic signals mentioned include the BPM sum signals – providing intensity and location, and the wall gap monitor.

Some relevant comments concerning the systems and experience to be gained (which go beyond configuration control):

Spontaneous firing of the dump kickers may be a problem. The system comprises 10 independent capacitor banks, each charged to 20 – 30 kV, and located under the rings, ready to discharge through the 10 kicker magnets at the trigger to the Thyratron switches. The system must hold this voltage throughout the (10 hour) store. A spontaneous triggering will surely not be synchronized with the "hole" in the beam train, and will probably result in a small messy pulse and a messy abort of the beam i.e. not local to the dump.

Stevens, who did the calculations for the design, notes that at full energy and intensity the dump may be marginal in its ability to contain enough of the beam energy to avoid quenching the next downstream superconducting magnet – Q4. This is something we will learn experimentally.

Another relevant piece of information from Stevens concerns the expected amount of beam loss required to quench RHIC magnets. If a quench occurs at loss levels well below those relevant for radiation on the berm, this at least will be a very visible monitor of losses – should the normal loss monitor system be for one reason or another blind. Alan's prediction is that at full energy and intensity, the loss of less than .1 percent of the beam at a magnet will cause a quench.

Glenn attempts to move the group to quantify what damage will be done to the complex if the permit/abort system fails. This should shed some light on the relevance of these issues specifically to the Radiation Safety Committee, and give him some information relevant to the C-A Systems Safety Committee that he chairs. The particular permit input of interest is generated by an insertable device (vacuum valve, beam shutter, beam scraper) or by nearby loss monitors. The beam should go away if this device senses that it is going into the beam, or if there is unusual beam loss created by the device. If the device is not retracted, that fact is intended to cause the permit to be pulled. These devices typically move into the beam slowly – ms, the abort system works rapidly – in less than .1 ms. The beam shutter devices have thinned edges designed to scatter more than absorb the beam. This results in less heating to the shutter and a less localized beam loss. The vacuum valves have a more complicated shape, but not a beveled edge. The beam loss may be more localized, the heating to the valve greater. Perhaps the worst result for these devices, should the beam not abort, and as far as cost to the program – would be damage making retraction impossible. This would be costly because of time out of the program, and the replacement of the equipment. There are estimates of 2 weeks to swap RHIC magnets. Perhaps this would be a similar delay. And valve costs were estimated to be of order $20 K.

The other feature of this inadvertent interaction with the beam is the production of radiation. The entire beam would be lost. The radiation into a controlled area, but one not posted as a radiation area, could be high enough (>50 mR) to make the event reportable. At least a significant amount of effort would be required to learn what dose had been generated. This connection makes the discussion relevant for the RSC. The related subject of the Operating Safety Limit for the startup and for the later running was also briefly revisited, without conclusive progress. Mackay is point person for working out the procedure, with break points as the intensity and energy increases, for respecting the OSL, which itself will need to be restated as the machine configuration matures.