10 JAN. 1984

Paper presented at 8th International Conference
on Magnet Technology, Grenoble, September 5-9

TRI-PP-83-90
Sep 1983

MAGNET INSTALLATIONS FOR HIGH RADIATION AREAS AT TRIUMF

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Abstract - Magnets at the exit of the TRIUMF cyclotron and adjacent to meson production targets are subjected to operational radiation levels of 200 Gy/h. When these magnets are serviced or modified residual radiation levels up to 1 Gy/h on contact must be accommodated. Several magnets are described together with the current techniques used to be able to handle magnets in these environments. We utilize quick electrical and water disconnects and a "handling at a distance" approach for removal of the magnets to a warm cell for modification or repair. Finally some preliminary ideas for installations where radiation levels will be one or two orders of magnitude higher will be put forward.

INTRODUCTION

TRIUMF proton beam lines transport 500 MeV protons to meson production targets and a thermal neutron facility. The maximum current is 150 μ A, and because the targets are in series along the beam line several per cent of the beam is spilled into the surroundings. Magnets immediately adjacent to these targets are of a radiation-hard design with no organic insulation. These magnets are buried beneath steel and concrete shielding and are inaccessible. During operation they experience radiation levels of up to 200 Gy (2000 rad/h), and if exposed for maintenance they have residual fields up to 1 Gy/h (100 rad/h). The magnets adjacent to the cyclotron exit ports also experience high radiation levels due to split neutral beams which cause residual fields of 0.4 Gy/h.

MAGNET DESIGNS

TRIUMF radiation-hard magnets are based mainly on Alex Harvey's designs from Los Alamos [1]. We use an indirectly cooled MI conductor for our "Combination magnets" at the cyclotron exit ports. Quadrupole designs adjacent to targets use a directly cooled MI conductor, Fig. 1. A septum magnet is used adjacent to the first meson target as the clearing element in a zero degree take-off pion channel. This magnet uses brazed or ceramic spacers and sprayed alumina insulation [2].

OPERATING EXPERIENCE

TRIUMF has operated for nearly ten years and our operational problems have been relatively few. Our major problems have been:

- 1) The septum magnet has twice developed water leaks and had to be removed for dismantling and repair.
- 2) The directly cooled MI conductor used for quadrupoles has a tendency to plug up with time until the low flow causes an over-temperature trip. The cooling circuit has to be backflushed with a chemical solution for a period of hours to restore the flow.
- 3) A quadrupole triplet (Fig. 4) adjacent to our LAT2 target which was mounted on rails, but not clamped in position, moved breaking the electrical contact fingers so that the magnets could not be energized.

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Fig. 1. Radiation-hard quadrupole magnets 8QN16M/9.

The majority of work on active magnets has been due to planned upgrading, or installation modifications. For this type of work we made a detailed plan with time and personnel requirements for each operation. Then radiation dosages are estimated based on the previous radiation levels and experiences on similar jobs. If estimated doses are too high, then the job procedures are reviewed and modified to minimize radiation exposure to maintenance personnel. The radiation exposures are hard to estimate with accuracy because the surveyors tend to note the highest contact dose levels and the radiation fields are very non-uniform. Also, the elapsed time for a specific job varies with individuals and not all the time is spent in the high radiation area. As our experience grows we hope our predictions of radiation dose will improve. At the completion of each job a review is made of the actual and predicted doses.

REMOTE HANDLING

When TRIUMF was being built we naively assumed that a magnet requiring repair would be removed from the beam line to a hot cell or a shielded area and fixed. We have found that conventional manipulators used in hot cells are of little use because a) they are not powerful enough, b) the magnets are not designed for maintenance using manipulators and so cannot be handled. We designed a walk-up lead shield trolley mounted on wheels which proved to be impractical along the beam lines due to component bases which would not allow the shield to be positioned close enough to the magnet to be repaired. In any case the most radioactive magnets cannot be approached with this shield. The use of a warm cell, local shielding and semi-hands-on repair has been much more successful. The basic remote-handling concept along our beam lines is to use long-handled tools "at a distance" usually vertically above the components. In this way personnel should not have to approach closer than approximately 2.5 m. The magnets are designed to be removed from the beam line and replaced using this concept. No realignment is necessary if the installation is properly designed.

For work on magnets in situ we utilize local lead shielding which is positioned from a distance before approaching the magnet closely. The nature of this shielding depends on the specific job but it may be either 0.6 cm thick plates stacked to the required thickness, lead-shot packed into double walled packets of a convenient size, or 5 x 7.5 x 15 cm lead bricks.

CRITERIA FOR PRESENT INSTALLATIONS

Our experience has led us to establish the following criteria for magnet installations in areas where the radioactivity levels are high:

1. The magnet mounting must be such that the magnet may be removed and replaced within the alignment tolerances, usually ± 0.25 mm without requiring an in-situ optical alignment. This is usually achieved by mounting the magnet on a three-point

support with an adjustment frame which is set and locked during the initial installation. Alternatively, the magnet frame is mounted on rails so that the magnets can be moved horizontally into position against a fixed stop. As the magnets are usually installed in channels between shielding blocks the supports are not visible from above during installation. It is essential to install positioning guides which are long enough to be visible by the crane personnel at all times.

2. Water and electrical connections must be of the quick disconnect type and must either contact automatically when the magnet is positioned or be capable of operation from a distance.

3. Lifting attachments must be such that they can be installed and disconnected and the magnet moved without maintenance personnel approaching closer than 2.5 m.

4. Cooling water circuitry should be such that the direction of water flow may be reversed and connections are provided for backflushing solutions to be circulated. Each magnet must have its own indicating flow meter and adjustable alarm switch which is mounted in an area accessible during maintenance periods.

5. The operating point of temperature switches should take into account the fact that when buried inside close packed shielding the magnets operate 10-15° hotter than when tested in an open laboratory.

Figures 2-4 show magnets at various stages of installation which illustrate some of these features.

INSTALLATIONS FOR HIGHER RADIATION LEVELS

In future years TRIUMF will increase its output current and is planning a kaon factory. If radiation levels increase by an order of magnitude, then maintenance work on active magnets will become much more difficult. It is anticipated that the magnet designs for such installations will have to be modified; already we find that it is preferable to remove an active magnet for storage and install a new non-radioactive one if possible.

The following additional criteria must be considered:

1. The magnets should be conservatively rated to increase reliability. This may make them larger but steel and copper are good shielding materials.
2. The magnets should be designed for ease of fabrication and lowest cost, because they should not be expected to be repairable. Spare magnets should be available to reduce loss of operating time in the event of a failure.

Fig. 2. Partially assembled dipole moved to low radiation area on slide rails.

Fig. 3. Power connections for quadrupole triplet with electrical contact fingers.

Fig. 4. Triplet installation prior to covering with shielding blocks.

3. Magnets should be designed so that they can be removed from the beam line without breaking vacuum connections. This means that they must separate easily into two or more components.
4. Some auxiliary service components now in use will have to be upgraded. For instance we use wiring for thermal switches which is rated at 10^6 Gy and quick disconnect water switches still have an "O" ring seal. Neither of these components will be satisfactory in the future.
5. Means of sensing the coil temperatures should be incorporated into the installation because of the problems of using flow and temperature switches without using redundant circuitry for reliability.

References

1. A. Harvey, Proc. 4th Int. Conf. on Magnet Technology, Brookhaven 1972, BNL CONF-720908, p. 456.
2. T.R. Gathright and P.A. Reeve, IEEE Trans. Magn., Mag-17 (1981) 1714.