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INSTRUMENTATION FOR THE TEVATRON BEAM DUMP

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Introduction

A graphite core beam dump designed to accept aborted protons from both the Main Ring and the Tevatron has been installed at Fermilab. Instrumentation was designed and constructed to monitor the integrity of the dump, the temperature at various locations about the core, and the position of the beam at the front face of the dump. These devices include calorimeters, temperature sensing devices, and an ionization chamber. Constraints were placed on the choice of materials used due to expected maximum temperatures of 400°C and accumulated doses over 10 years of up to 10^{10} R. Presented in this paper are details of the choice of materials for and the design and construction of the desired instrumentation.

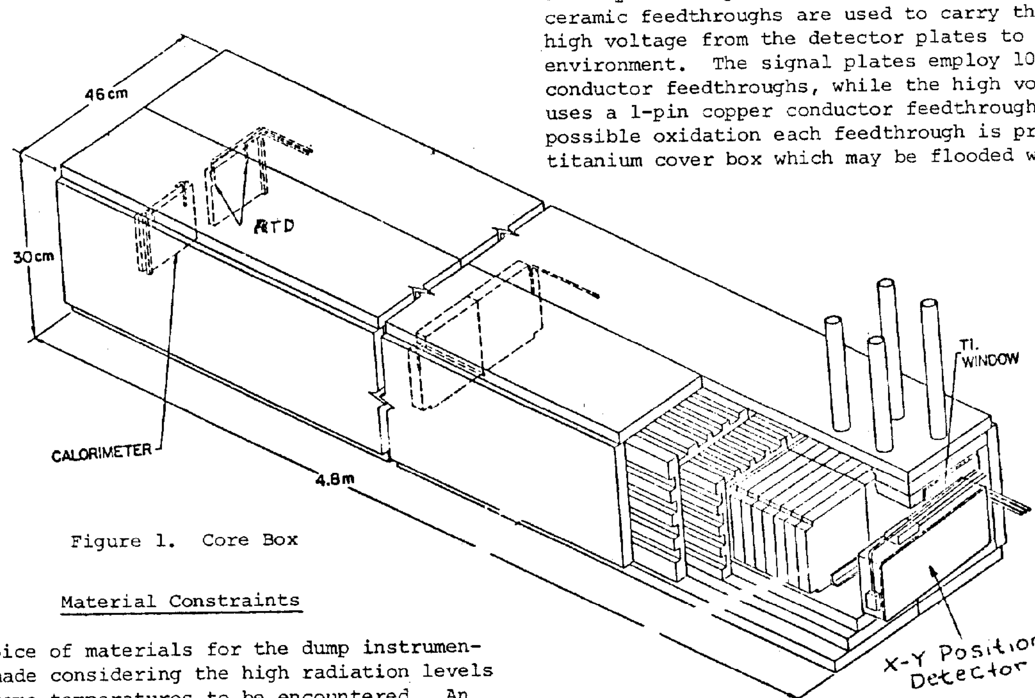

Figure 1. Core Box

Material Constraints

The choice of materials for the dump instrumentation was made considering the high radiation levels and the extreme temperatures to be encountered. An expected beam intensity of 2 x 10^{13} protons per pulse gives an estimated 10 year lifetime absorbed dose of 10^{10} Rads. Another constraint was an estimated temperature in excess of 400°C at the shower maximum. These conditions precluded the use of any organic compounds as insulation material. Ceramics however did meet these criteria and were commercially available. As a result, magnesium oxide was chosen for the cable insulation, and alumina was chosen for the position detector vacuum feedthroughs.

Table 1. Material Data[2,3,4,5]

	Teflon	Alumina	Magnesium Oxide
Radiation dose	5.2×10^{3} Rads	2×10^{19} n cm^{-2}	3.5×10^{18} n cm^{-2}
Melting point in degrees C	400	2000	2700
Radiation effect	res./1000<	none	none

x-y Position Detector

The x-y position detector is a segmented ionization chamber having an effective area of 30.5 cm x 15.2 cm and a resolution of ± 1.3 cm in both planes. The active portion of the detector consists of two planes of titanium strips separated by a titanium high voltage plate which has a thickness of 1.58 mm. The horizontal beam position is measured by twelve equally spaced strips, six for the Main Ring beam and six for the Tevatron beam. Because the Main Ring and Tevatron beams will not be aborted simultaneously, their corresponding strips are jumpered together thus reducing the number of cables needed. The vertical beam position is measured by six equally spaced strips. The aforementioned strips are all 2.00 cm wide and are separated by .635 cm. Commercial high voltage ceramic feedthroughs are used to carry the signals and high voltage from the detector plates to the external environment. The signal plates employ 10-pin nickel conductor feedthroughs, while the high voltage plate uses a 1-pin copper conductor feedthrough. Because of possible oxidation each feedthrough is protected by a titanium cover box which may be flooded with dry argon.

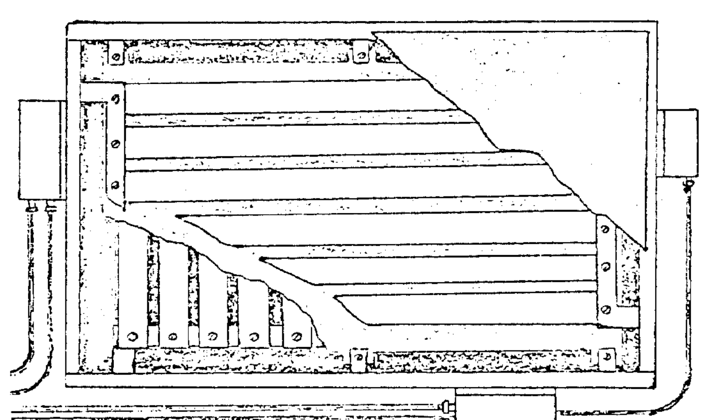

Figure 2. x-y Position Detector

*Operated by Universities Research Association, Inc. under contract with the U.S.Department of Energy.

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Temperature Transducers

The primary instrumentation for the thermal measurements of the abort are platinum element resistance temperature detectors (RTD). These were chosen for their high radiation resistance and measurement accuracy and stability. These devices consist of fine platinum wire wound around an alumina core and encapsulated in a stainless steel sheath. The element comes equipped with three leads making possible balanced bridge measurements. The element leads are then welded to a three constantan conductor cable which was described earlier in this paper.

The electronics required to measure the resistances of the RTDs will reside above ground in a Main Ring service building. The detection circuitry will consist primarily of a constant current source. The resulting measurements will be sent back to the main control room via a computer link.

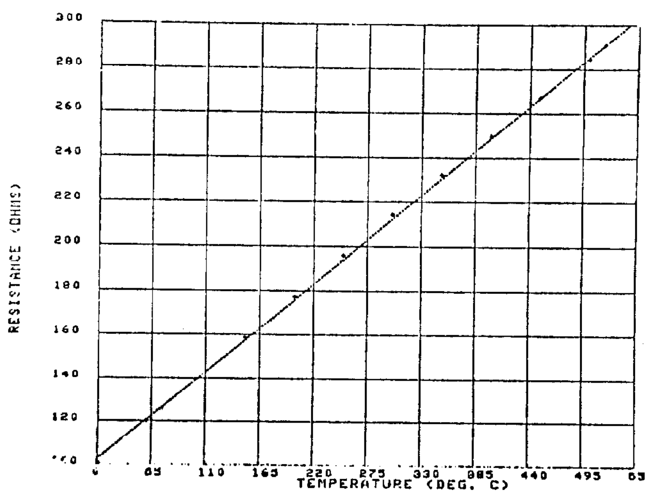

Figure 3. Plot of Resistance vs. Temperature

RTD Specifications:

1.

1.	Element resistance	100 @ 0°C
2.	Resistance per degree	.1
3.	Temperature range	-200°C to 540°C
4.	Measuring current	10 milliamps DC max.
5.	Response time constant	4.5 seconds
6.	Power dissipation	50 milliwatts max.

There are seven RTDs located in the abort. Two are located near T max (z=2.2 m) as calculated by a Monte Carlo nuclear cascade program called MAXIM. The danger of the graphite expanding sufficiently to crack the aluminum shell necessitates temperature monitoring at that location. As a result, attempts will be made to maintain these temperatures below 200°C.

There is another RTD in one of the steel shielding blocks surrounding the aluminum shell. It is located downstream of the secondary particle shower maximum (z=2.4 m) and will provide temperature monitoring of the blocks. The concern here is that the steel may expand sufficiently to crack the surrounding concrete skin. Attempts will be made to maintain temperatures to approximately 50°C. There are four additional RTDs located in the calorimeters, which are described below.

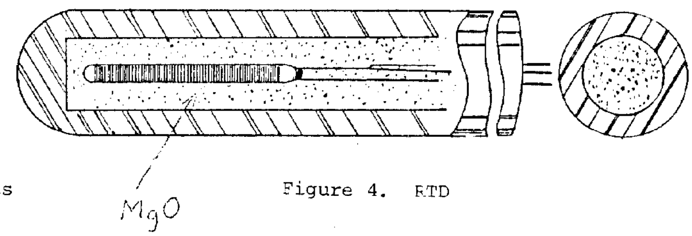

Figure 4. RTD

The Calorimeters

The calorimeters are two aluminum blocks (11.4 cm x 13.3 cm x 1.27 cm) located at the end of the graphite core (see Figure 5). There is one for Main Ring beam and one for Tevatron beam. Each is insulated with asbestos and equipped with two RTDs, one located in the top of the block, the other in the bottom. The base of each calorimeter is welded to the aluminum box so that it will reach thermal equilibrium with the box in about 30 seconds. This time constant is roughly equivalent to the proposed cycle time for the Tevatron. The purpose of the calorimeters is to monitor the integrity of the dump materials by measuring the temperature rise of the calorimeter at each aborted beam pulse. By means of the calorimeters, long-term changes in the temperature rise of the dump per abort, and ultimately the integrity of the dump core material can be noted. A rise in temperature per abort would indicate the possibility of cracked or broken graphite blocks upstream.

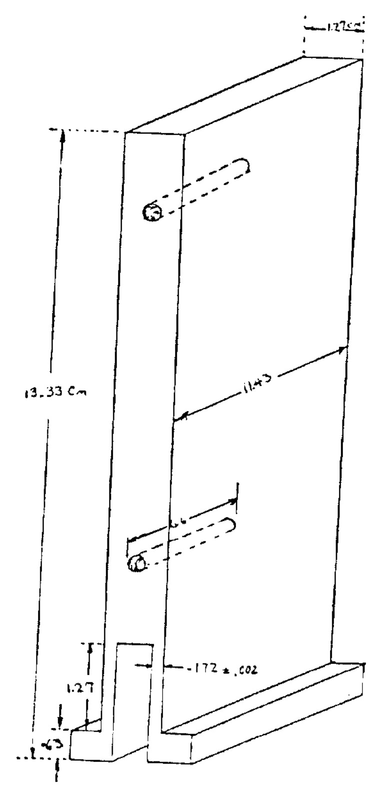

Figure 5. Calorimeter

Acknowledgements

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5. 1 Rad. = $3 \star 10^6$ n cm^{-2}; assume average 1 mev.