MI-0242

Effect of FØ Crossover Shielding Field Change

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A. Introduction

A field change was made during installation of steel shielding which was installed in the berm beneath the crossover which connects the FØ service building to the MI60 service building. The design called for eight 9 inch thick steel plates to be added between the tunnel and the crossover, with the remainder to be filled in with CA6 and concrete. It became evident in the process of stacking the steel that if all eight plates were to be installed, the remaining CA6/concrete layer would be thinner than called for by the design drawings by approximately 2 to 5 inches. The unexpected shortage of space resulted because the large steel plates are not perfectly flat. Small distortions in each layer accumulated to the point where installation of the eighth plate would not leave enough space for the entire 26" layer of CA6/concrete layer. It was eventually decided to install only seven of the eight plates. The purpose of this note is to document the decision to install only seven plates.

B. Discussion

The cross over is an interconnecting passageway between the MI60 service building and the FØ service building. It runs across the top of the MI 60 region of the MI enclosure and the FØ straight section of the Tevatron. For purposes of this note, the affected region is the section of the crossover directly above the FØ straight section of the Tevatron which contains the Tevatron RF section and a portion of the P150 transfer line between MI and Tevatron.

All enclosures associated with the MI including the FØ straight section were designed[5] to be loaded with 26 soil equivalent feet. With few exceptions[6], the required shielding thickness for most of the MI project (including the FØ crossover) is 24. 5 feet. This difference between the shielding design and shielding requirement is intended to act as a buffer in the event more restrictive radiation safety controls or increased beam intensity limitations become necessary.

It was intended[5] that a minimum of three feet of soil or concrete be used following any steel shielding installation to reduce the radiation levels associated with low energy neutrons which are not well attenuated by steel. This is the conventional wisdom at the laboratory and it is documented[4]. However, additional advice regarding the outer layer of concrete shielding suggests that two feet of soil or concrete is sufficient following a thick iron shield[3,7]. The crossover is one instance in the MI shield design in which the latter advice was observed. The total transverse distance between the crossover region and the FØ straight section is 12 feet. The final 26" of crossover was designed to be 14" of CA6 and 12" of concrete. Due to the field change, the as-built final thickness of CA6/concrete increased from a minimum of 28 up to 31 inches. The attenuation factor for 28 and 36 inches of concrete is 0.0115 and 0.0042 respectively[3]. One might expect an increase in dose rate by a factor of about 2.7 if 3 feet of soil equivalent shielding such as concrete is replaced by 28 inches of the same material.

The total soil equivalent transverse shielding in the region of the cross over consists of 7.75 feet of steel and 4.25 feet of CA6, concrete, and sand. As mentioned above, a minimum of 28 inches of CA6 and concrete are in the final layer; the remaining 23 inches of sand and concrete are found between various layers of steel. Since each foot of steel is equivalent to 2.89 feet of soil[1,2], the total soil equivalent thickness of soil in the crossover region is 26.6 feet.

Summary/Conclusion

Prediction of actual effectiveness of shielding in the region is confounded by a number of factors, e.g., the thickness of steel shielding, possible loss mechanisms in the P150 line, and the thickness and placement of non-steel shielding. In addition, the shielding requirement of 24.5 feet is based upon a magnet to tunnel ceiling distance of three feet. In the case of the P150 line, the distance from beam line to tunnel ceiling is approximately 8 feet. This additional distance between the beam and line tunnel should reduce the resulting dose rate in the crossover region. The total soil equivalent shielding exceeds the shielding requirement of 24.5 feet, but it isn't clear how well the final layer of concrete/CA6 will reduce the dose due to low energy neutrons. Shielding calculations involving very thick shields almost always result in poor statistical power in the region of interest. For these reasons, a measurement will be made in the crossover region when sufficiently high beam intensities (approximately 50% beam power) are available for transport through the P150 line. Based upon the advice found in references 3 & 7, and because of the magnet tunnel geometry for this particular case, it is believed the measurement will show that the shielding is sufficient for unlimited occupancy.

The MI60 and FØ service buildings will be posted as Controlled Areas because of the presence of radioactive materials in them. Since the crossover region is between them with no other entry points, it will effectively be posted as a controlled area as well. As a consequence, even if the measurement shows that the design goal of unlimited occupancy was not achieved, there is no impact on the occupancy designation for the crossover region.

References

[1] "Design of Steel Shielding for FØ", Philip Martin and Chandra Bhat, October 25, 1994

[2] "Shielding Requirements Under the Passageway from MI60 to FØ", P. Martin and C. M. Bhat, March 10, 1994

[3] "Concrete Shielding Exterior to Iron", P. Yurista and D. Cossairt, August 1983

[4] "Chapter Eight, Fermilab Radiological Control Manual", January 1998

[5] "Fermilab Main Injector Preliminary Safety Analysis Report", S. D. Holmes, May 5, 1992

[6] "Shielding Requirement for the Main Injector Era," Memo with attachments to Peter Lucas from Mike Gerardi, Dated Aug. 4, 1997.

[7] "Topics in Radiation at Accelerators: Radiation Physics for Personnel and Environmental Protection, Revision 3", J. D. Cossairt, October, 1996