Brookhaven National Laboratory

MEMORANDUM

Date: 09/17/96

To: Chris Ceresko, Ali Javid-Far, Jim Mills

From: A.J. Stevens *ajs*

Subj.: Evaluation of the Current Counting House Shielding Design at 8 O'clock

A preliminary version of the shielding was analyzed in a previous memorandum.[1,2] In that version, a single layer of "hybrid" blocks (43 cm. steel and 109 cm. concrete) was proposed. The conclusion of that analysis was that another foot. of light concrete was needed to come within the design criteria (500 mrem) for a local fault at 4 times the design intensity. Also, no analysis of the cracks inherent in a single layer design was made and the design did not include a labyrinth, which is believed required for emergency egress from the tunnel.

For the evaluation given here, the results of the CASIM calculations shown in Ref [1] are extrapolated. The plan view of the current design is shown in Fig. 1. Recall from Ref [1] that the area shown must provide protection for a fault on the DX magnet on the opposite side of the facility hall, and from faults on "local" magnets. Although not shown on the figure, the worst local faults are on the local DX magnet, which is on the left hand side of Fig. 1, and on Q2 which is positioned slightly off the right hand side of the figure. Over most of the wall, 5 ft. of concrete has been added to the shielding originally proposed. This reduces the worst case fault dose to about 20 mrem.[3] The "weak spot" near the left side of the wall in Fig. 1 (which shows pipes entering the main facility hall) has a total of 7 ft., 10 inches of concrete. Even with no credit for the shadowing on either side of this slot the dose scales to 110 mrem. There is thus considerable "overkill" as regards the basic wall thickness.

On the left hand side of Fig. 1 are two arrows representing punch-through from a fault on the DX magnet on the opposite side of the facility hall. The arrow labeled (1) was the position of end wall punch through evaluated in Ref [1]. I have extrapolated Fig. 3 of Ref [1] to the larger transverse radius shown by the arrow labeled (2). The result is 333 mrem at the corner (tip of arrow (2)). This meets the criteria as is, without taking credit for the fact that people are at a greater distance from the fault than evaluated and the effects of the shielding wall separating the hall from the assembly area.

The remainder of this memorandum deals with the labyrinth area. The labyrinth "punch-through" is represented by three arrows shown drawn through (or partially through) the labyrinth entrance. The worst case of the three rays shown passes through a shielding thickness of the equivalent of 8.4 ft of light concrete. If one applies this to the labyrinth entrance dose of 43 rem about 70 mrem is obtained.[4]

The total dose at the exit is the punch-through plus the low energy neutron dose that "bounces" through the labyrinth. Unfortunately, the 15 ft. of available transverse space does not easily allow construction of a classic symmetric multi-leg labyrinth. As a first step in estimating the existing labyrinth I note that is difficult (although not impossible) to draw paths with only one bounce between the entrance and exit. Since most short paths take two or more bounces, the labyrinth probably has effectively 2.5 "legs". The estimate here is obtained by plugging in labyrinth formula using the two legs indicated in the figure. The attenuation formula are:

$$Leg\,1: \quad \frac{1}{1+2.5\sqrt{d}+.17d^{1.7}+.79d^{3}}$$

$$Leg\,2 \quad \frac{1}{1+2.8d(1.57)^{d+2}}$$

where d is the physical length divided by the square root of the cross-sectional area. Now in the case of the first leg, the cross-sectional area is straightforward, namely the 3 ft. width times the vertical opening of 7 ft., 8 inches. The physical length is 7.45 ft. which gives $d = 1.55$, and an attenuation of 0.135. For the cross section of the second leg I have used the area that is encountered immediately after going through the first leg which is 4.3 ft by 11.3 ft. This, in itself, is certainly conservative. For the 12.5 ft. length, $d = 1.79$ which gives a second leg attenuation of .0361. The total attenuation multiplied by the 43 rem incident dose gives 210 mrem. Adding this to the punch through gives about 280 mrem in a worst case fault at 4 times design intensity.

References/Footnotes

1. Memorandum from A.J. Stevens to Chris Ceresko, Jim Mills dated 11/14/95, Subj: "Evaluation of Counting House Shield Design at 8 O'clock."

2. There is a typographical error in Ref [1]. In the third paragraph, reference is made to "...the Q2 magnet (clockwise beam)". This should read "...(counter-clockwise beam)". The orientation described in the first paragraph of the previous memorandum is correct.

3. The point of evaluation is the counting house wall which is 9.75m from the beam center line. This differs from the 6.69m point of evaluation in Ref. [1].

4. This is not really a correct calculation. The rays drawn in Fig. 1 are from the Q2, Q3 area, but the entrance dose quoted is from the DX magnet. The labyrinth entrance is at the extreme right hand side of Fig. 2 of Ref [1]. At this point the dose from Q2 is smaller than that from DX by about 50% because the entrance is "tucked behind" the endwall that shields the entrance from Q2. Furthermore, the 2 ft. concrete block (W 40 in Fig. 1) was not present in the calculation of Ref

[1]. Generally, accurate calculations are not performed for punch-through in geometries like this one. Rays are drawn to verify that no very short paths exist relative to what is needed. In this case, that process led to including both the W 40 block and the small heavy concrete block near the labyrinth exit as a part of the shielding configuration.

cc:

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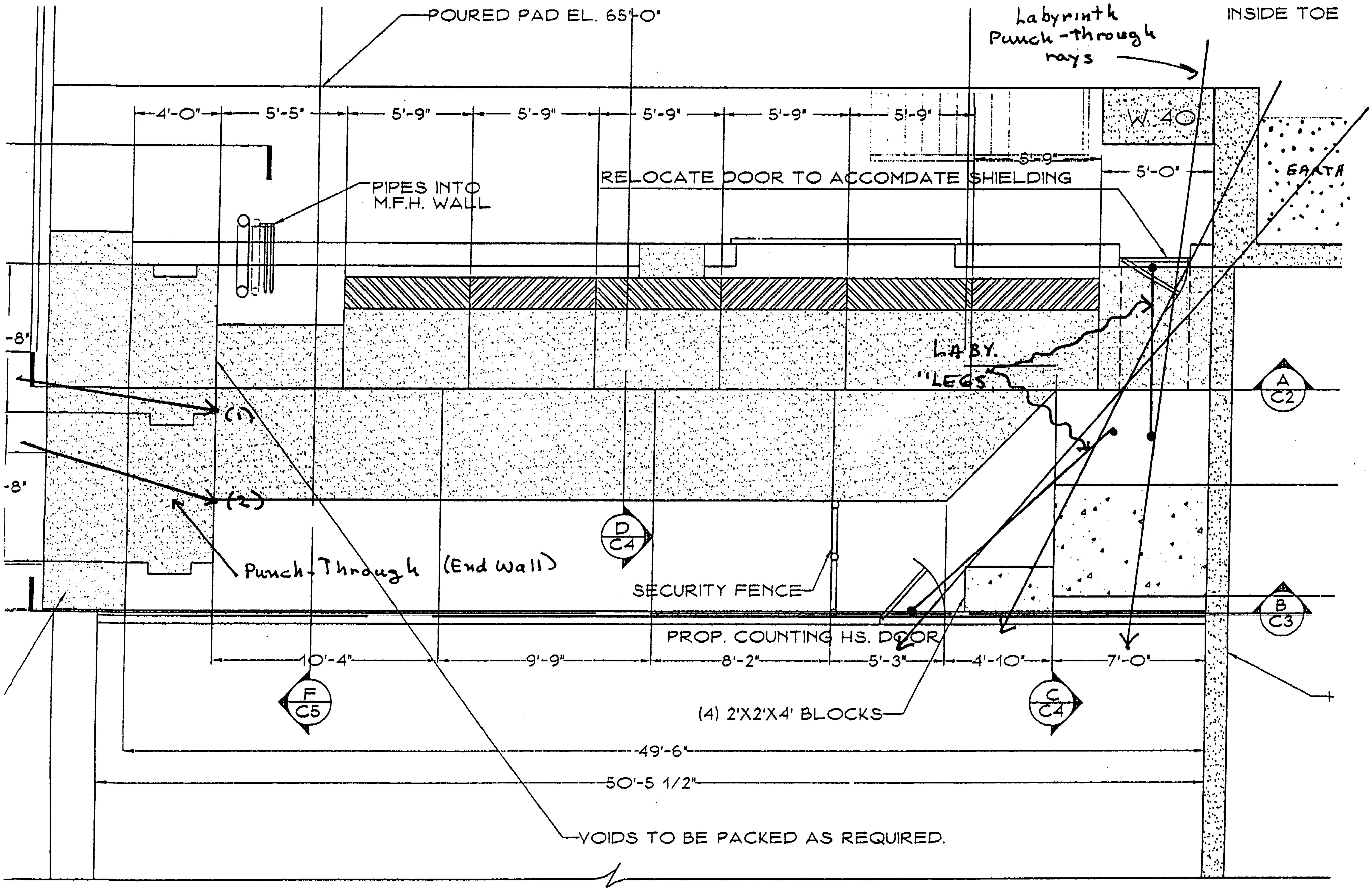

Fig. 1 Plan View of the PHENIX Counting House Shield Design as of 09/17/96.