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APPROVED BY: (SUPERVISOR) R.L.Ashley *	PROGRAM HNPF	TWR 8200
OTHER S. Berger *	PROJECT Handling of Fuel and Core Components	DATE December 15, 1959
		PAGE 1 OF 14

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Include Figures 6 and 7 with all copies

SUBJECT: Analysis of Radiation from HNPF Cold Traps and Primary Sodium Pumps During Removal and Shipping

CONTENTS:

I STATEMENT OF PROBLEM

Determine the expected maximum contamination of the cold traps and primary sodium pumps. Determine the maximum dose rates from these components during removal and shipping. Specify suitable shielding for casks to be used in the removal operation and for shipping these components away from the reactor site.

II SUMMARY OF RESULTS AND RECOMMENDATIONS

A. Cold Trap

Access to an unshielded cold trap is limited by high dose rates, i.e., 100 mr/hr at 120 ft, after 180 days decay time. (This dose rate does not depend upon the length of time the cold trap has been in use.) A handling cask providing a radial shield of 3" of lead will provide adequate personnel protection for the removal operation, if 180 days decay time is allowed before the trap is removed. As shown by Figure 7, dose rates from the cask body, before it is lifted from the floor, would be 10 mr/hr at 20 ft.

An additional 2.4" of lead is required for off-site shipment of the cask. This additional shielding can be added after the trap has been removed from the reactor building.

Dose rates from the cold trap after the shield plug has been removed from the access hole are shown in Figure 6. If direct line-of-sight exposure is avoided, dose rates to personnel will be below 100 mr/hr at any position, and below 10 mr/hr at distances greater than 20 ft from the access hole.

Dose rates from the cask during its travel away from the hole, shown in Figure 7, will be below 100 mr/hr at distances from the cask greater than 10 ft and below 10 mr/hr at 35 ft, if the cask is raised no more than 3" from the floor during its travel.

B. Primary Sodium Pump

Remote, unshielded handling of a primary sodium pump is feasible, since dose rates would be 100 mr/hr at 28 ft and 10 mr/hr at 90 ft, after ten years of operation, and providing that 14 days decay time is allowed to eliminate activity from the Na^{24} film clinging to the pump. Dose rates after only one year of operation would be a factor of 4 lower than those quoted above.

The cold trap handling cask, described in part A, can also be used for sodium pump removal. Additional shielding of 1" of lead is required for off-site shipment of the pump.

Dose rates from the cask during pump handling will be well below those during handling of the cold trap, and thus will present no serious difficulty.

III METHOD USED

A. Dose Rate Calculations

Calculations of handling and shipping cask requirements were made, using the methods and equations developed in Reference 1. The methods and equations for calculating dose rates from the cold trap after the shield plug is removed, and during the travel of the cask over the floor, are developed in Reference 2.

B. Cold Trap

1. Contamination:

The dominant contamination of the cold trap after the decay of Na^{24}, is expected to result from fission products which have been released from the core into the sodium coolant and deposited in the cold trap. Based on Reference 10, the amount of fission products released from the core is estimated as 0.01% of the total core fission product inventory after 1 year of operation at 254 Mw(t).

The activity of this quantity of fission products was calculated from Reference 4. The resultant values are as follows:

TABLE I: Fission Product Contamination of Cold Trap (Gamma Curies*)

	Total	0 - 0.8 Mev	1.4 - 1.6 Mev	2.0 - 2.2 Mev
After 60 Days Decay Time	2,616	2,534	72	9.5
After 180 Days Decay Time	805	799	-	6.2

The above values include the volatile components which may and may not deposit in the cold trap. However, the volatiles comprise no more than about 20% of the total at the decay times indicated. It is assumed that this maximum contamination is essentially independent of the operating lifetime of the cold trap.

The deposits in the cold trap are expected to be somewhat localized in the top portion.(5) For dose rate calculations, two assumptions are made; first, that the activity is localized in the top 2 ft of the active length of the trap, and second, that the activity is unformly distributed along the 6 ft of active length. (The true situation will, of course, lie between these extremes.) The assumption which gives the higher dose rate in a particular situation is used.

2. Unshielded Access:

Using the methods of Reference 1, and assuming a ½" steel shell for the cold trap, and that it is filled with steel wool of density about 24 lb/ft^3,(5) the dose rates from an unshielded cold trap were calculated and presented in Figure 1.

3. Handling Cask:

Using the same method as above, and assuming a 3" lead radial shield to be provided by the handling cask, the dose rates at the cask surface are presented in Figure 2, for the case of 180 days decay. Dose rates at 60 days decay would be a factor of 6 higher. Therefore, a decay time of 180 days is preferable.

* 1 Gamma Curie = 3.7×10^{10} photons/sec

4. Shipping Cask:

The additional shield required to reduce the dose rate to 10 mr/hr at 1 meter is shown in Figure 3 to be 2.4" of lead. Figure 4 shows, as a matter of interest, dose rates from the top and bottom ends of the cask as a function of shield thickness. Figure 5 gives a means of estimating the amount of lead shield for which 1" of several different materials can be substituted. Figure 5 is not exact, but provides a convenient estimate.

5. Dose Rates from Open Access Hole:

Dose rates in the reactor room, after the shield plug is removed from the access hole, arise from direct radiation, scattering from the side of the access hole, and from scattering from the roof. (The last contribution is relatively insignificant.) These dose rates are calculated by the methods developed in Reference 2, and are shown in Figure 6.

6. Dose Rates Near the Handling Cask During Travel Across Floor:

By adding the dose rates from photons penetrating the handling cask to those from photons scattered from the floor, Figure 7 was prepared, showing total dose rates near the handling cask during its travel across the floor. The dose rates are not high enough to present any serious difficulty.

C. Primary Sodium Pump

1. Contamination:

Contamination due to retention of solid sodium, in the freeze seal design pump, is treated thoroughly in Reference 6. The present free surface design pump will, however, drain essentially free of sodium.[7] Thus, other sources of contamination must be investigated. The principal source of contamination, after 14 days decay time to eliminate Na^{24} activity, will be from mass transfer activity on the lower surfaces which are in contact with the primary coolant.

The contaminated surface area is estimated as 65,000 cm^2. The extent of contamination is extrapolated from the data of References 8 and 9, which is given in terms of dose rate at the surface of a 16" pipe;

TABLE II: Mass Transfer Surface Contamination[(2)(3)]

	Years Operation	Co^{60}	Mn^{54}
Dose Rate at the Surface of a Drained 16" Sodium Pipe	1	-	1.8 r/hr
	10	4 r/hr	3.3 r/hr
Surface Contamination	1	-	60 uc/cm^2
	10	46 uc/cm^2	100 uc/cm^2
Total Contamination of a Sodium Pump	1	-	3.9 curies
	10	3 curies	6.5 curies

The pump, itself, will absorb about half of the radiation, giving a suitable safety factor to calculations using this data. The activity is approximately uniformly distributed along the lower 63" of the pump.

2. Unshielded Access:

From the contamination values of Table II, dose rates from an unshielded sodium pump were computed and shown in Figure 1.

3. Handling and Shipping Casks:

Using the methods of Reference 1, Figure 8 was prepared. From this, the dose rates for the handling cask with a 3" lead wall are shown to be 85 mr/hr at the surface and 42 mr/hr at 1 meter. An additional 1" of lead is required for off-site shipment.

Since the pump contamination is considerably lower than the cold trap contamination, dose rates from scattered radiation will be considerably lower, as can be seen from Figure 1. Thus, scattered radiation will not present any serious exposure problems during handling of the sodium pump.

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IV REFERENCES

1. W. A. Rhoades, "Shielding Requirements for HNPF Shipping Casks", TDR 4473, October 16, 1959.

2. G. L. Wegmann, "Remote Removal of HNPF Moderator Cans", TDR 4487, October 20, 1959.

3. IOL, J. P. Hale to J. F. Stolz, "Design Criteria for Removal of a Primary Cold Trap - HNPF", November 22, 1958.

4. P. Spiegler, "Energy Release from the Decay of Fission Products", TDR 4128, July 31, 1959.

5. Personal Communication, W. M. Hoschouer, Design Engineering Group, Atomics International.

6. W. P. Kunkel, "Radiological Hazards Associated with Removal of the Primary Sodium Pump", TDR 2640, April 3, 1958.

7. Personal Communication, L. E. Manners, Design Engineering Group, Atomics International.

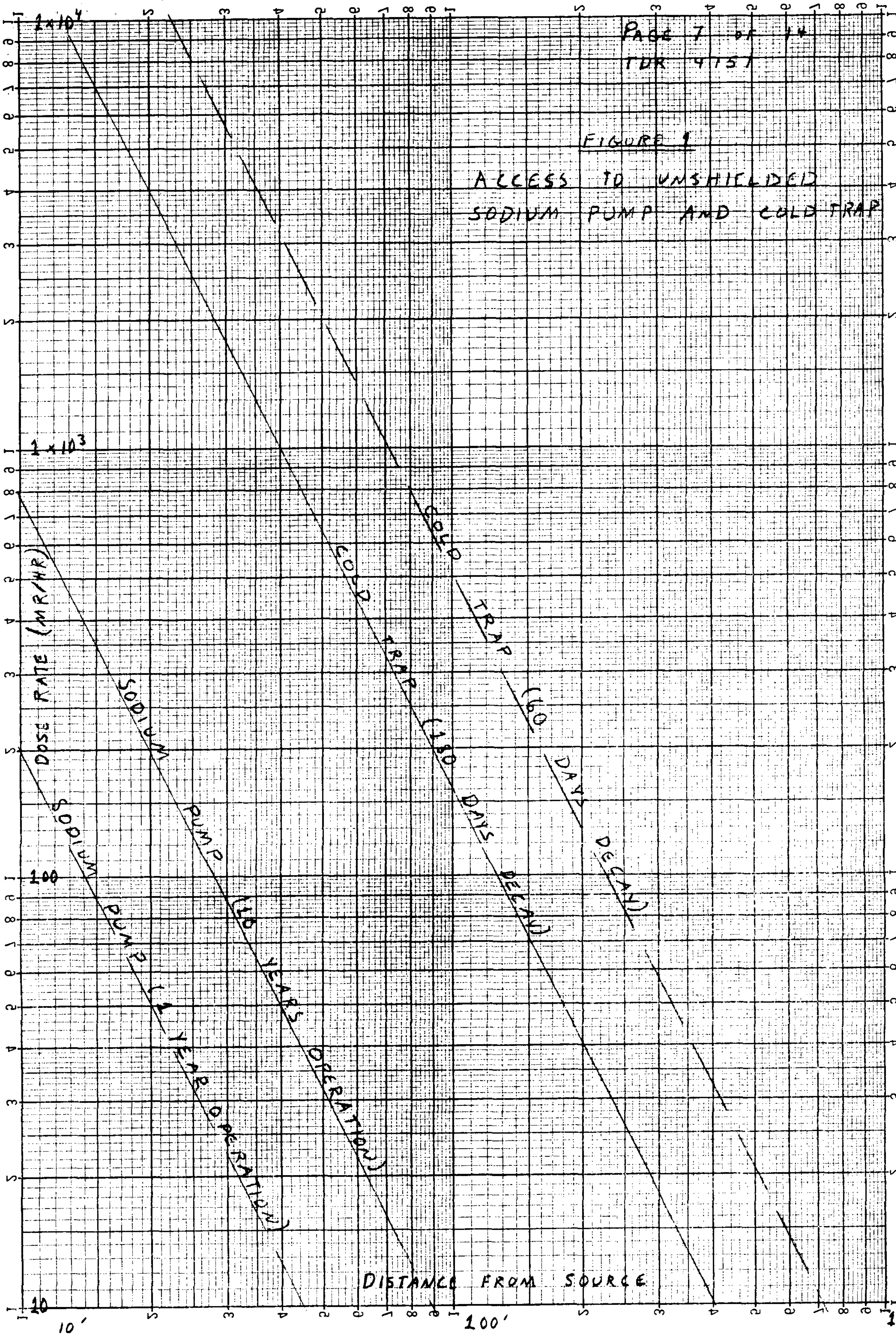
8. Personal Communication, F. D. Anderson, Component Power Plant Group, Atomics International.

9. F. D. Anderson, "Summary of Accessibility Studies for the Hallam Nuclear Power Facility", (Secret R.D.), NAA-SR-3389, December 1958.

10. Theodore L. Gershun, ed., "Preliminary Safeguards Report Based on U-Mo Fuel for the HNPF", NAA-SR-3379.

FIGURE 1

ACCESS TO UNSHIELDED SODIUM PUMP AND COLD TRAP



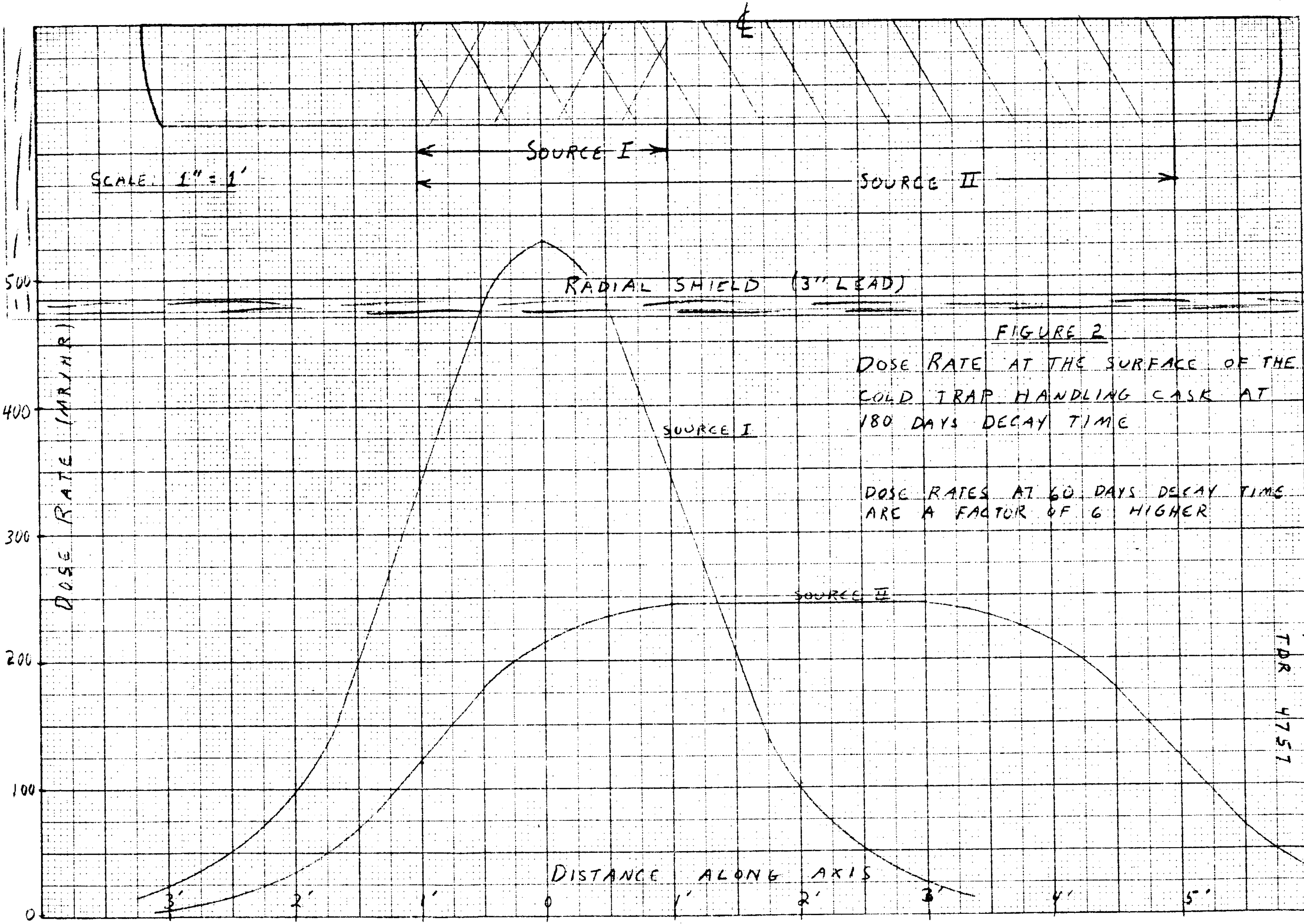
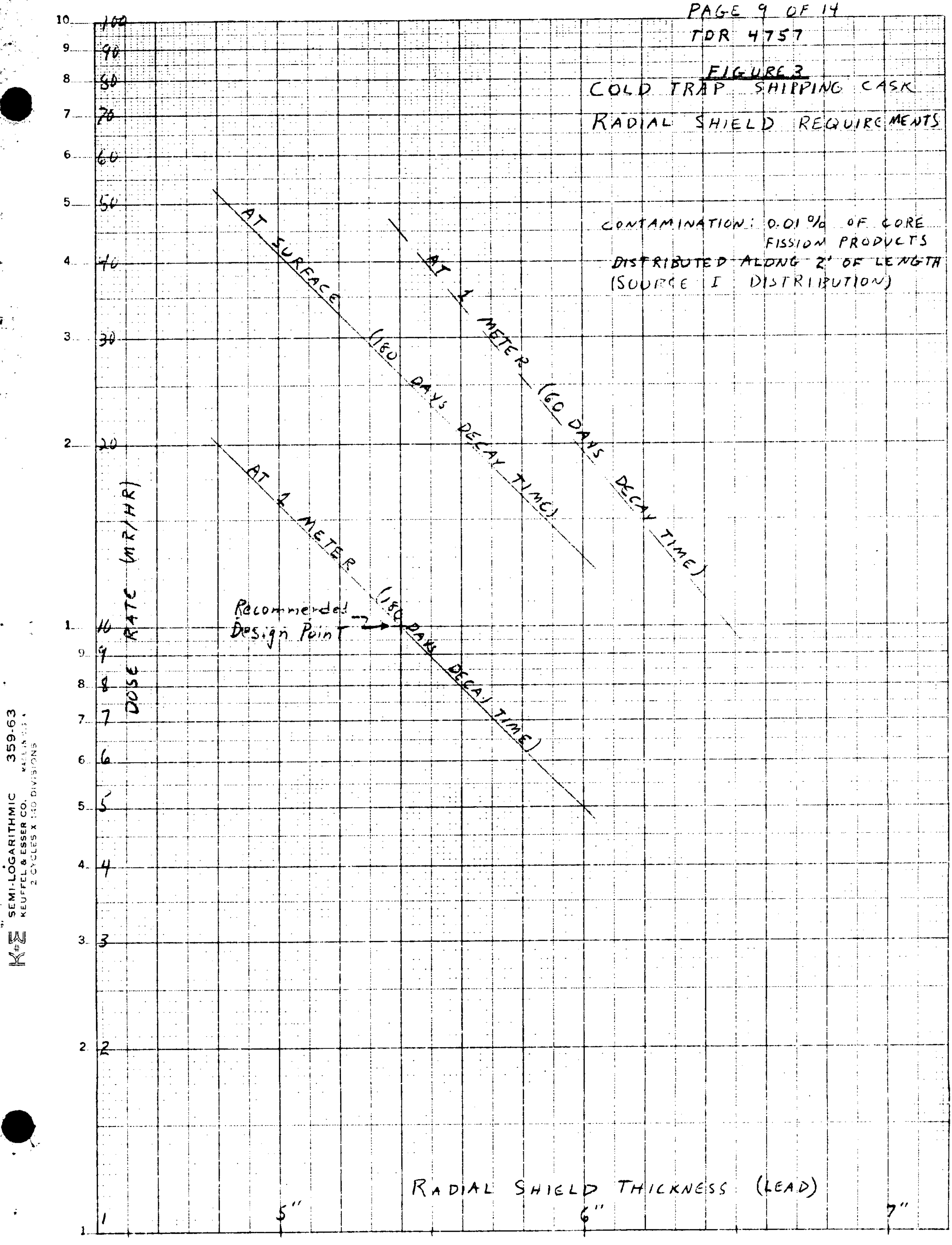


FIGURE 2

DOSE RATE AT THE SURFACE OF THE COLD TRAP HANDLING CASK AT 180 DAYS DECAY TIME

DOSE RATES AT 60 DAYS DECAY TIME ARE A FACTOR OF 6 HIGHER

FIGURE 3
COLD TRAP SHIPPING CASK
RADIAL SHIELD REQUIREMENTS



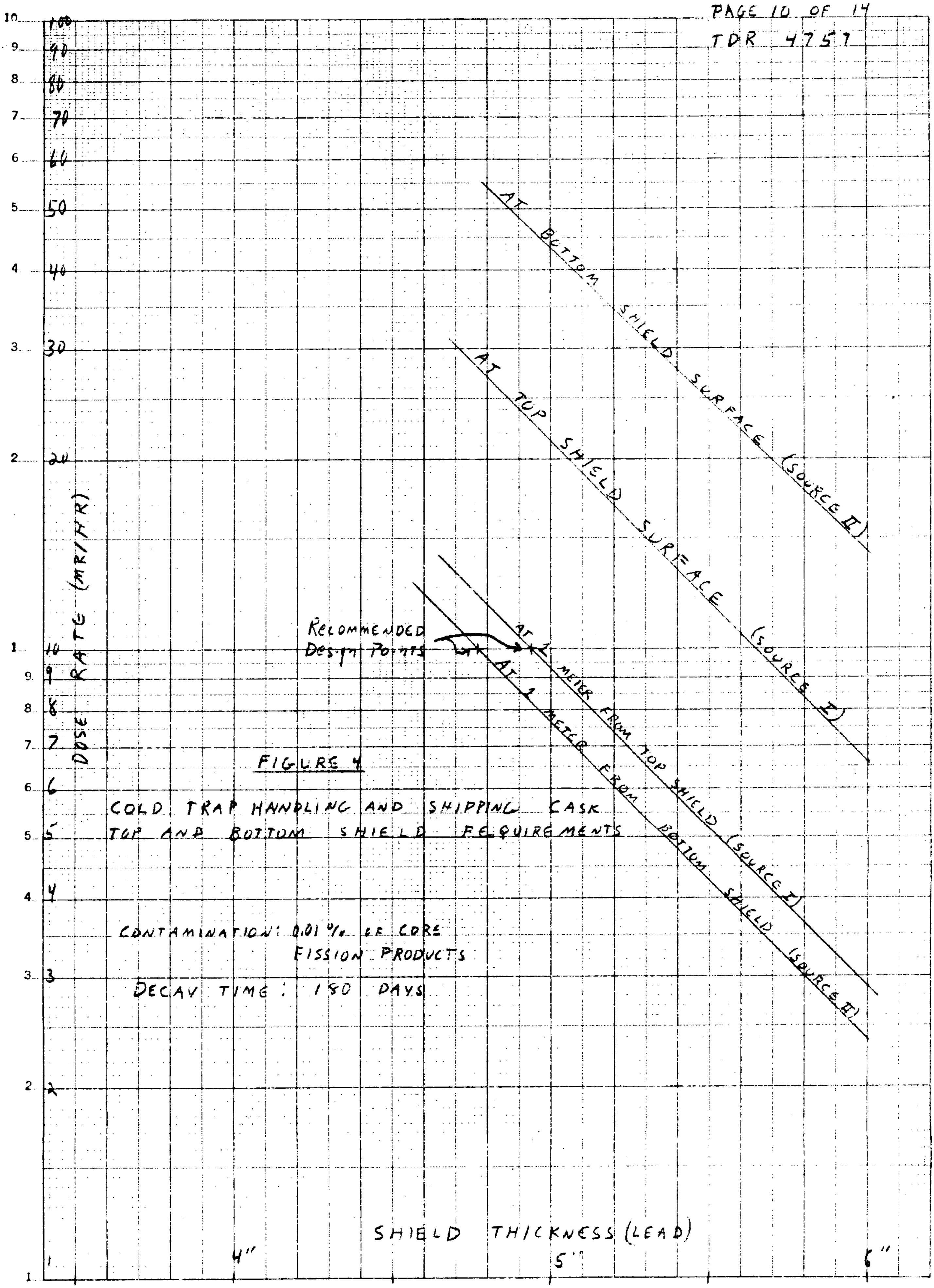


FIGURE 4

COLD TRAP HANDLING AND SHIPPING CASK TOP AND BOTTOM SHIELD REQUIREMENTS

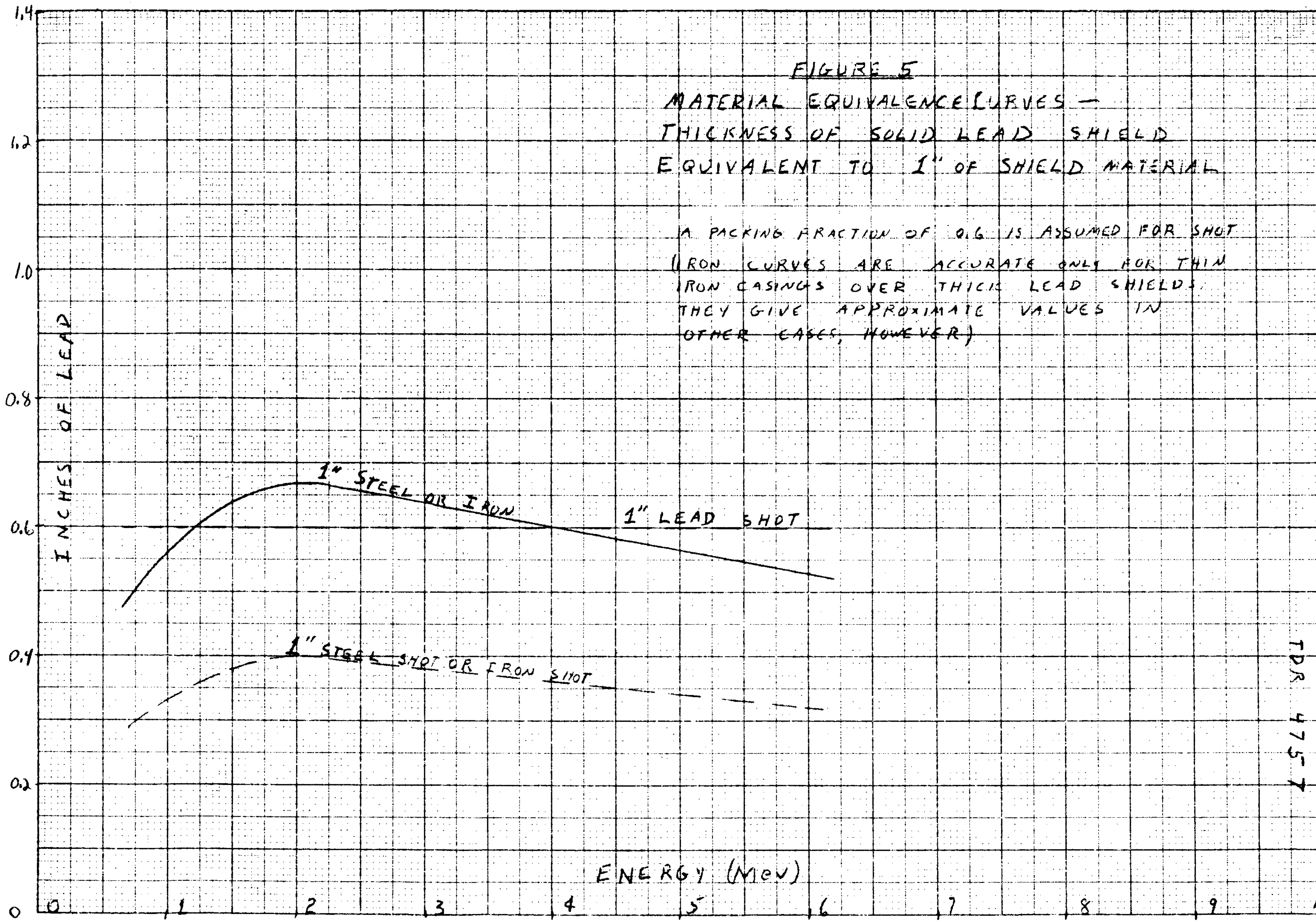


FIGURE 5
MATERIAL EQUIVALENCE CURVES —
THICKNESS OF SOLID LEAD SHIELD
EQUIVALENT TO 1" OF SHIELD MATERIAL
A PACKING FRACTION OF 0.6 IS ASSUMED FOR SHOT
(IRON CURVES ARE ACCURATE ONLY FOR THIN
IRON CASINGS OVER THICK LEAD SHIELDS.
THEY GIVE APPROXIMATE VALUES IN
OTHER CASES, HOWEVER)
1" STEEL OR IRON
1" LEAD SHOT
1" STEEL SHOT OR IRON SHOT
INCHES OF LEAD
ENERGY (Mev)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
7
8
9
10

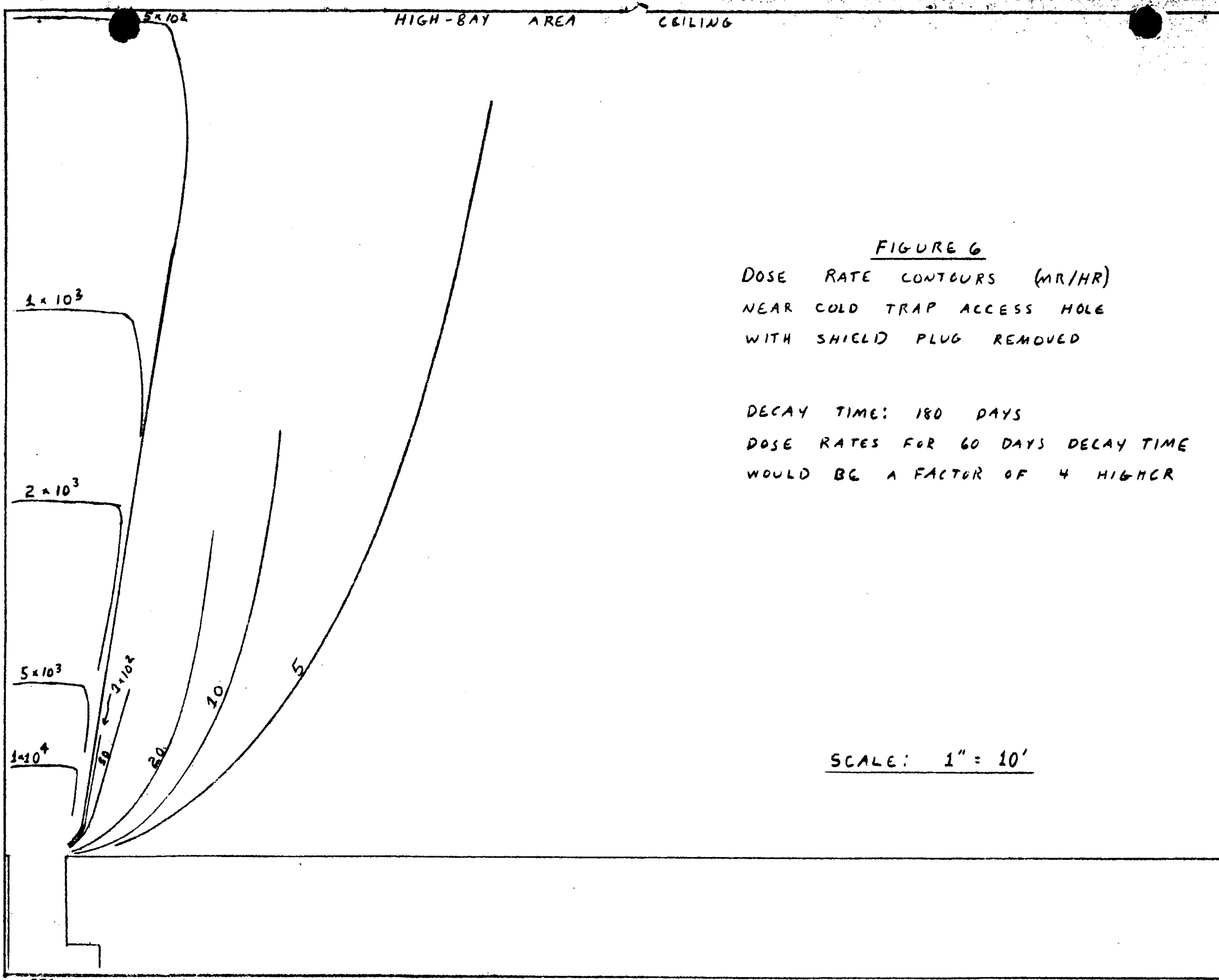


FIGURE 6

DOSE RATE CONTOURS (MR/HR) NEAR COLD TRAP ACCESS HOLE WITH SHIELD PLUG REMOVED

DECAY TIME: 180 DAYS

DOSE RATES FOR 60 DAYS DECAY TIME WOULD BE A FACTOR OF 4 HIGHER

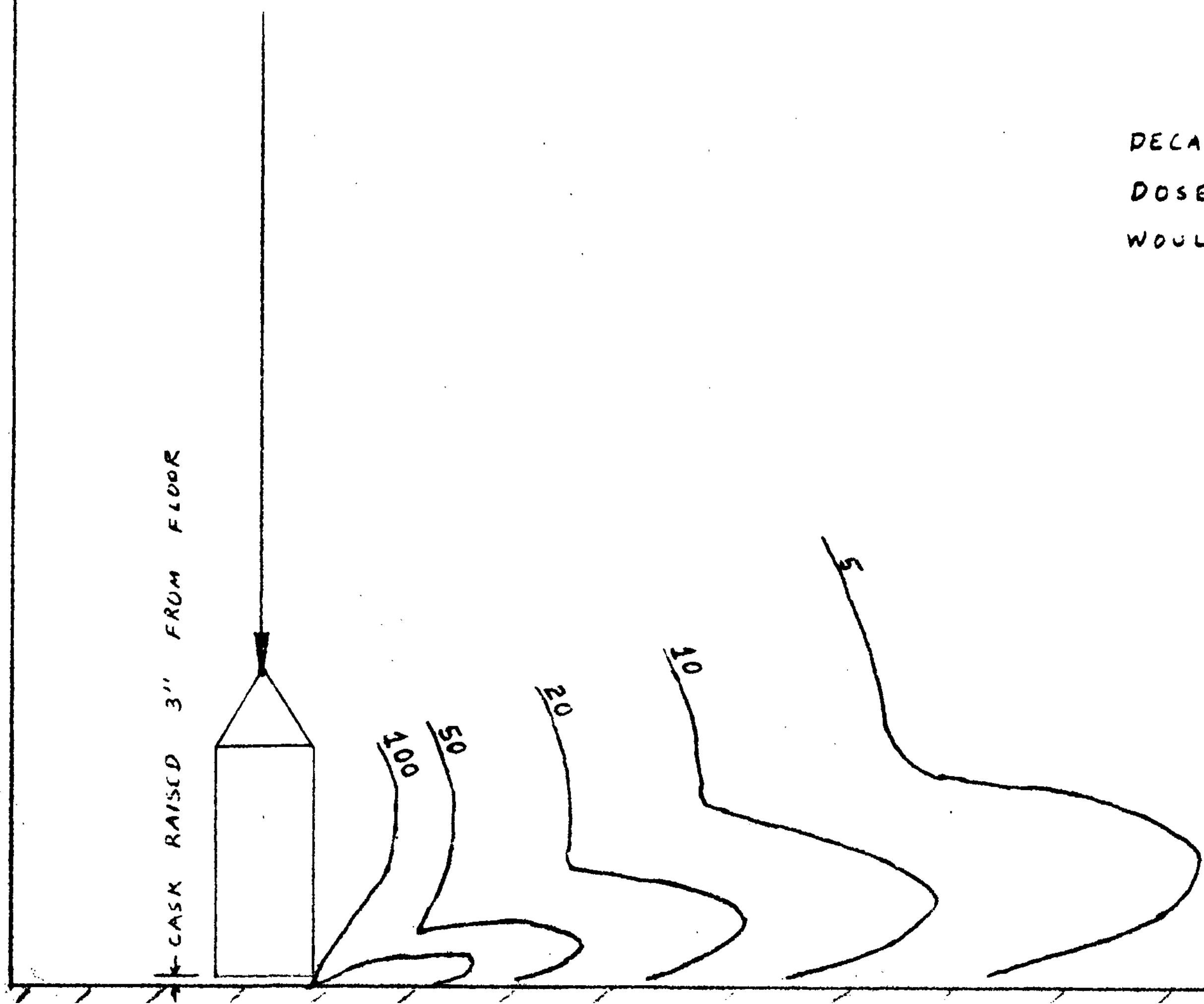
SCALE: 1" = 10'

FIGURE 7

DOSE RATE CONTOURS (MR/HR)
NEAR COLD TRAP HANDLING CASK
RAISED 3" FROM FLOOR

DECAY TIME: 180 DAYS
DOSE RATES FOR 60 DAYS DECAY TIME
WOULD BE A FACTOR OF 4-6 HIGHER

SCALE: 1" : 10'



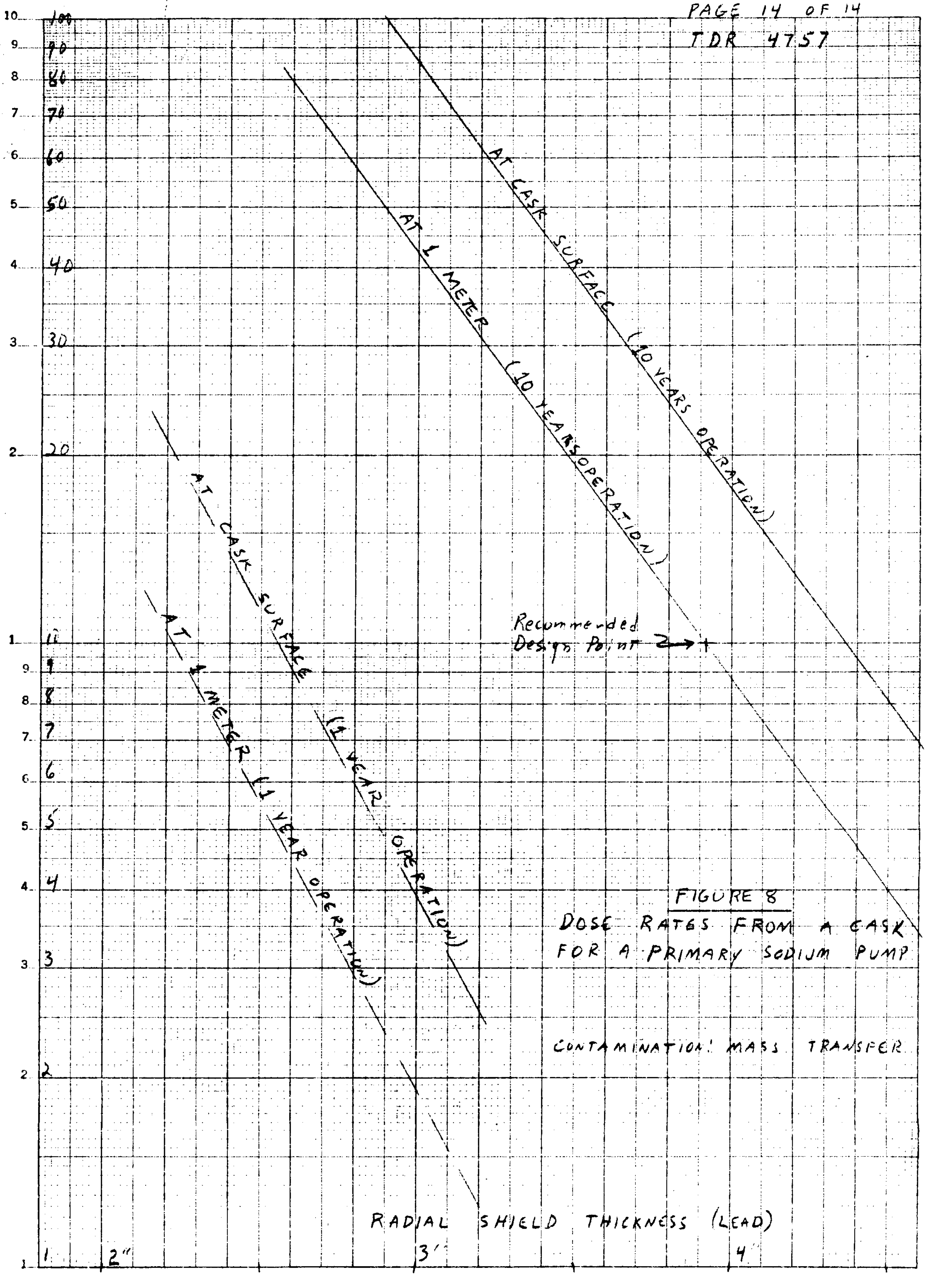


FIGURE 8

DOSE RATES FROM A CASK FOR A PRIMARY SODIUM PUMP

CONTAMINATION: MASS TRANSFER