Chapter 7 Appendix 2

AVAILABLE DATA FOR HOUSE SHIELDING ESTIMATES OF JAPANESE ATOMIC BOMB SURVIVORS

William A. Woolson
Science Applications International Corporation

To make intelligent decisions concerning the methods to update the dosimetry assignments for the Japanese atomic bomb survivors, it is necessary to know the available shielding information that exists in uncoded form on paper and in coded form that can be directly accessed by the computer. The objective of this report is to provide a summary of the available shielding data, both in uncoded and coded form. This report is the result of visits to RERF in Hiroshima and Nagasaki in February and November 1983. The special assistance provided by Mr. Hiroaki Yamada at Hiroshima and Mr. Yoshio Okamoto at Nagasaki is acknowledged. They were in charge of the ABCC shielding sections at their respective locations and have been long involved in the RERF shielding program. Their familiarity with the methods, procedures, and data was of invaluable assistance in this work.

The following sections of this report will provide a description of the information that is available in the shielding history files in uncoded form; a brief description of the various shielding methods that were used over the course of time from the T57D system to the present day T65D; and a description of the current coded data bases that can be accessed by computer.

Information Available in the Shielding History Files

A typical shielding history file contains about 5 to 10 pages of information stored in manila folders that can be accessed by the survivor's master file (MF) number. The MF number, a six-digit number, is unique for each survivor in the data base and is the primary

This report was written early in the work on the reassessment, and some of the work described has been superceded by more recent analysis. This report contained a final section about plans on how to use the information described here in the final dosimetry system. That section has been omitted because these topics are covered in Volume 1, Chapter 9.

reference point linking the shielding and health data. Location-dependent data are also referenced by MF number. For example, the files for survivors located in a given neighborhood, at the time of the bomb (ATB), can be found through their MF number. The shielding files for the subjects at Hiroshima and at Nagasaki are stored at the RERF facilities at Hiroshima and Nagasaki, respectively. Microfiles of all the shielding history files have been made and are available at the Oak Ridge National Laboratory.

The shielding histories do not all contain the same information. The explicit data available in the shielding histories varies according to the date at which the original interview was conducted, the location of the survivor (Hiroshima or Nagasaki), and the particular situation or configuration existing for the survivor ATB. The sample history file is fairly typical for survivors inside Japanese houses ATB (see Appendix 7-2a).

All the shielding histories examined have a form called "Radiation Shielding Summary" which contains the information required for the T57D system. The house penetration distance was used to calculate the attenuation factor for survivors in Japanese houses in the T57D system.

In some cases, an earlier version of the radiation shielding summary is also included in the shielding history. The earlier version is usually written in Japanese and contains information concerning the experiences of the survivor during and after the bombing. Most often this part (the experience) has been translated into English and exists as one or two separate typewritten pages. Another form, the master sample questionnaire (MSQ), usually accompanies the shielding history. The MSQ was used to obtain the information required during the interview of the subject. Often, the MSQ was written in Japanese, and in some instances, an English translation is also provided. This form requests information such as the location of the subject, the type of clothing the subject was wearing, and what is remembered of the flash, heat, blast, sound, and the rain following the bomb. A narrative account then follows describing the experience following the bombing and what actions the survivor took to survive.

The information of most interest for the shielding analysis is on three sheets of vellum paper that contain superb drawings of the survivor location, orientation, and surrounding features. Considering the number of shielding histories, the craftsmanship displayed in these detailed drawings is truly remarkable. The first sheet consists of a plan view of the subject's house in the neighborhood housing cluster that shows four or five of the nearest streets and the location of 10 to 20 houses nearest the subject. The type of construction (one-story or two-story houses, factories, etc.) and the location of open spaces (fields, vacant lots, gardens, rivers, etc.) are identified on this sheet. The subject is located in the house and an arrow from the subject points in the direction of the hypocenter. The housing clusters were drawn from information obtained from the survivor and nearby survivors, plus the pre-shot aerial survey photographs. The location of houses containing survivors is identifiable on enlargements of these pre-shot aerial photographs, and plan views in the history file appear to be very accurate renditions of the house clusters.

The second sheet of shielding information contains a detailed plan of the construction immediately surrounding the subject. The scale is usually 1/100 but may be 1/200 for larger houses. This sheet provides the floor plan of the house containing the survivor and the immediate neighboring houses. The floor plan typically lays out the size of the room, in terms of the number of tatami mats, and identifies kitchens, gardens, bathrooms, etc. Second-story plans of importance are included. This sheet gives the orientation of the person by the use of a circle, half of which is shaded. The light portion of the circle indicates the front of the person ATB. The location and orientation of other nearby survivors are also given on this sheet. A line is drawn from the person in the direction of the bomb.

The last sheet in this series is an elevation view of the shielding situation for the survivor that shows all the structure penetrated by the ray from the person to the bomb. The scale is the same as the detailed plan view. It typically shows the location and slope of the roofs and the location of windows and provides a detailed sketch of the orientation of the person from which one can ascertain whether the person was sitting, standing, or prone. The elevation view is constructed in the plane normal to the ground containing the line of sight to the bomb. The heights of second story floors, roof peaks, and roof and veranda slopes are determined from a standard template.

Additional sheets of information may be attached to the shielding history. In some cases, the shielding histories at Nagasaki contain a scale drawing of the material penetrated by the line-of-sight ray from the subject to the bomb on a sheet of graph paper. This was a convenient method to estimate the mass penetration for the early shielding calculations. Various code sheets are in the file for coding various shielding methods into the data base for computer analysis. Examples of these are "code sheet for shielding parameters" for a nine-parameter formula application, "code sheet for the globe operation", and "code sheet for provision of transmission factors (TF) by globe work or by application of air dose." These are discussed in some detail in the next section.

On the assumption that the Japanese houses were constructed with standard materials and to uniform sizes (which, from what can be learned, is a very good assumption), the shielding history contains all of the information required to do state-of-the-art shielding calculations. Additional information, not available in the shielding history, probably could not improve the accuracy of the calculation because the improvement would be less than the inherent uncertainties involved in the calculational procedure. There is sufficient data for the shielding estimates and the question is deciding the most sensitive information and how can it be economically extracted from the shielding history files of the survivors.

Various Shielding Methods in the Shielding History File

There were three distinct methods for calculating the radiation attenuation of Japanese houses for the survivors at Hiroshima and Nagasaki. These three methods are referred to as the mass penetration technique, the house penetration method, and the globe/nine-parameter formula procedure. Some of the shielding histories contain a calculation of the attenuation by all three methods. Those histories compiled at a later date may only have one or two.

The mass penetration method was the first technique employed to estimate the house shielding. It appears to have been used exclusively at Nagasaki. This method calculates the mass penetrated along the line of sight from the survivor to the bomb, and an attenuation factor is provided as a function of this mass penetration. From the shielding history, the thicknesses of the penetration track through materials along the lines of sight are calculated. This calculation is performed with a graphical technique using a scale drawing of the location, materials, walls, roofs, partitions, etc., penetrated by the line-of-sight ray to the bomb. The

Table 1. Shielding Data for Various Materials

Material	Density g/cm³	Thickness cm	g/cm²	Source of Information
Concrete, light	2.027			Measurements of Nagasaki specimens
Concrete, heavy	2.264			As above
Japanese House				
Roof			13.68	Measurements on Nagasaki houses
Warehouse mud roof		9	10.386	
Walls				
Warehouse mud wall & mud fence	1.154	21	24.2	
Standard mud wall	1.154	7.37	8.5	Construction Handbook
One side lath stucco			3.5	As above
One side metal lath & cement			6.5	As above
Clapboard			1.0	As above
Floors				
Tatami			1.150	Measurements on Nagasaki houses
Sugi boards	0.45			Construction Handbook
Fir (hinoki) (Desk top)	0.50		1.0	As above
Pine, Plum (2nd floor)	0.55	1.4	0.77	As above
Asbestos cement				
Corrugated tile			1.52	Measurements on Nagasaki specimens
Glass window			1.14	
Mirrow (1.4 × 4)			5.6	
Iron sheet	7.48	0.05	0.374	
Machine	7.5	13	97.5	
Wooden wall (wooden room, cabinet, shelf, wooden screen)		10-20	0.6	
Ceiling thickness (sugi)	0.45	0.3 mm	0.135	
Wall siding			8.635	
Wooden plank	1.9		0.77	
Brick				
Wooden door			0.27	
Street car ceiling (veneer)	0.75	0.5	0.375	
Street car roof (iron)	7.5	0.16	1.2	
Street car body (iron)	7.5	0.23	1.725	
Street car pillar (keyaki)	0.75	2	1.5	
Earth	1.6			
Granite	2.637			

mass penetration is specified in standard thicknesses of the various house features. Table 1 lists the standard thicknesses for roofs, walls, concrete, etc., that were used in the mass penetration procedure. Thus, for example, if the line of sight penetrated two mud wall thicknesses (elevation angle of 60°) then 17 g/cm² was penetrated.

This procedure may have merit for situations involving bulk shielding. That is, a shielding situation in which the mass penetrated along any line near the line of sight is reasonably uniform. In this particular situation, however, the presence of streaming paths through windows and less shielding in other directions makes the procedure questionable. A statistical analysis of the calculated mass penetrated, however, would be very useful for checking the adequacy of the house cluster models developed for the dosimetry revision.

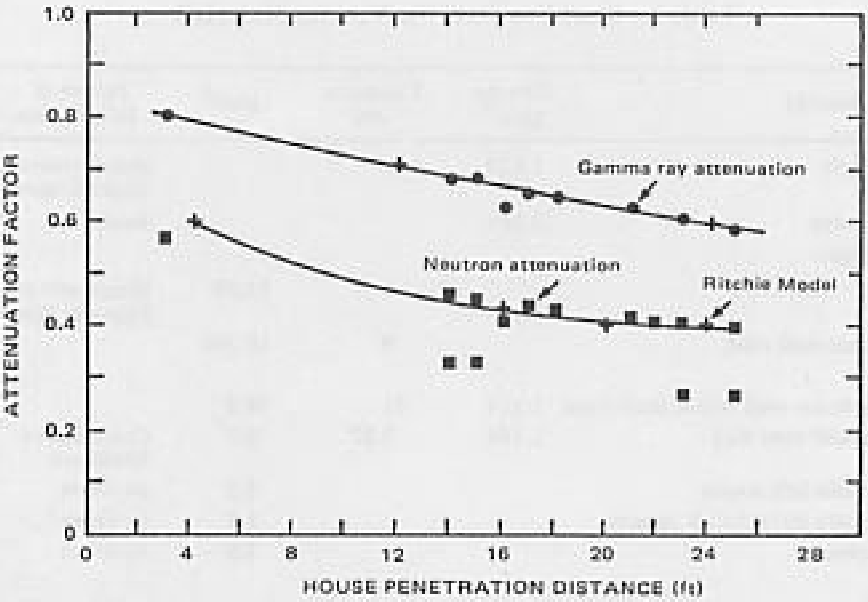

Figure 1. Attenuation factors versus house penetration distance from shielding history files

The next shielding method devised was the house penetration method. This method was developed from Operation Plumbbob measurements of the house TF for a typical Japanese house. An experiment was performed during the Plumbbob test in which a Japanese house was built at the Nevada test site and exposed during the test. An analysis of the TF for the various detectors placed throughout the house was performed by Ritchie and Hurst.[1] Their analysis indicated that the house penetration distance, that is, the distance of the projection on the horizontal of the line of sight from the wall of the house to the survivor was a parameter that could reproduce the test results. Thus, a single parameter easily calculated from the shielding history provided a relationship for the calculation of the house attenuation. This method was used in the T57D dosimetry system and the Radiation Shielding Summary (described later) contains a space for the house penetration distance in feet calculated fróm examination of the shielding history, and this house penetration distance was then used to derive the attenuation factors that were then recorded on the Radiation Shielding Summary (see Appendix 7-2a). My reconstruction of the relationship between attenuation and house penetration distance that was used is summarized in Figure 1. Most of the shielding histories for survivors in Japanese houses at Hiroshima and Nagasaki contain a calculation of the attenuation based on this house penetration method. The problem with this technique is that it does not embody sufficient information about the shielding afforded the survivor. The Plumbbob test consisted of a single, small isolated house and it is not too surprising that in that situation a house penetration parameter could be used to reproduce the TF measurements. In realistic situations, though, where there are one- and two-story houses in closely clustered arrangements, this technique would have little validity.

The third shielding method used was a combination of the globe and nine-parameter methods. The globe procedure was used primarily for survivors who were in the open but shielded by Japanese-type houses. That is, survivors who were in the streets but whose line of sight to the bomb was intercepted by a building. The globe technique was also

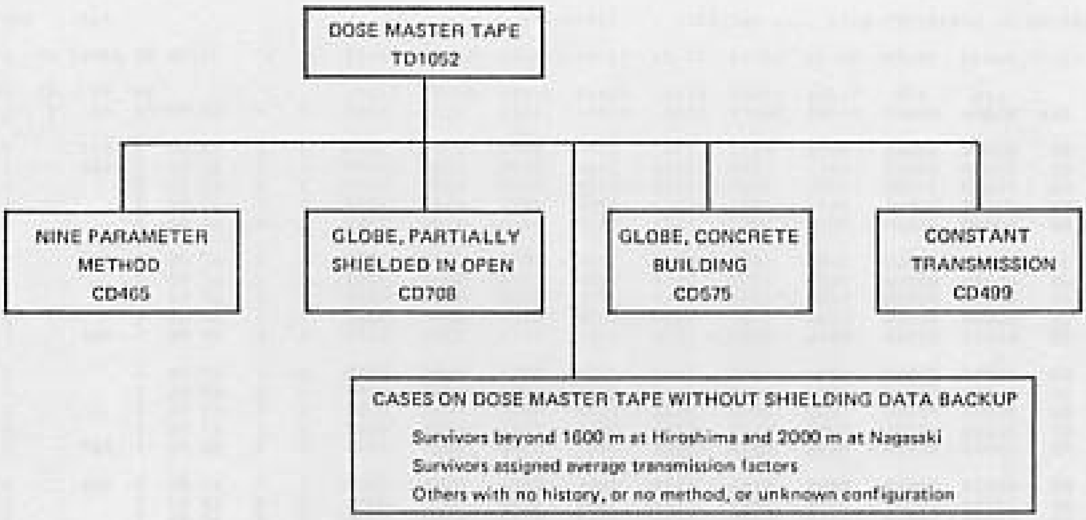

Figure 2. Shielding data bases

used for survivors in the thick, heavily shielded concrete buildings. The nine-parameter formula developed from the BREN house transmission measurements was used for survivors in single-family Japanese houses. Most of the shielding histories that have an assigned attenuation factor have code sheets attached to the history file that contain the data for the nine parameters or for the globe operation. There is another code sheet for TF for those situations for which neither the globe technique or the nine-parameter formula was applied. For example, a survivor in a Nagasaki factory building is normally assigned a TF of around 0.85 without any calculation of his shielding.

This completes the description of the noncoded data available in the shielding history. Next, the information available in the computerized data bases is described.

Available Computer Data Bases for Survivor Shielding

This section describes the data that can be accessed by the computer on the shielding configuration of a survivor. A file called the dose master tape, to be described shortly, summarizes the shielding data and points to the method used for the shielding calculation (if any was performed). Four other files give the detailed information required to reconstruct this shielding calculation. Figure 2 provides the flow diagram for accessing the various types of computer coded shielding information.

The dose master tape summarizes dose and TF data for each survivor. It provides the location; the free-in-air (FIA) gamma-ray and neutron kermas computed by the T65D system; the TF for both gamma rays and neutrons; and the calculated gamma-ray, neutron, and total kerma at the survivor's location. Additional information includes the shielding method applied and the method for analyzing the dose. An example printout of this dose master tape is given in Figure 3. At the top of the list are the columns containing the data on the dose master tape file. A description of the parameters associated with these various columns is given in Figure 4. Important columns to examine are column 57, which gives the method of estimating the dose, and columns 63 to 65, which point to the data file, if available, that contains the detailed shielding information.

The listing in Figure 3 contains a few especially interesting cases in Hiroshima. The first

* LISTING OF DOSIMETRY DATA .... T65 DOSE * HIROSHIMA PAGE: 350

8-11	12-15	16-17	26-30	31-35	36-39	40-43	22-25	18-21	44-47	48-51	52-55	56	57	71-74	82	63-65	62	61	7	4-6
ABSC-ISSA	ORDI-NATE	SEA	AIR GAMMA	AIR NEUTR	TRANS GAMMA	TRANS NEUTR	SLANT DIST.	GRAND DIST.	GAMMA DOSE	NEUTR DOSE	TOTAL DOSE	C	M	YR MO	SH MI	SO ES	SA 2	SA 1	SEX	MF-NO.
4333	5937	00	00000	00000	0916	0375	2371	2300	0000	0000	0000	2	5	66 08	1	465		4	2	237999
4333	5937	00	00000	00000	0916	0361	2371	2300	0000	0000	0000	2	5	66 08	1	465		3	1	238000
4330	5930	00	00000	00000	1000	1000	2439	2370	0000	0000	0000	3	5	67 08	2			3	2	238003
4510	6160	00	00873	00814	9999	9999	0947	0750	9999	9999	9999	4	0	67 08	2			2	1	238004
4330	5930	00	00000	00000	1000	1000	2439	2370	0000	0000	0000	3	5	67 08	2			3	2	238005
4438	5993	00	00012	00005	1000	1000	1718	1618	0012	0005	0017	2	5	67 08	1	499		3	2	238006
4530	6040	00	00020	00009	1000	1000	1615	1506	0020	0009	0029	3	1	67 02	2			3	1	238007
4330	5940	00	00000	00000	1000	1000	2357	2285	0000	0000	0000	3	5	67 08	2			3	2	238008
4330	5930	00	00000	00000	1000	1000	2439	2370	0000	0000	0000	3	5	67 08	2			3	2	238009
4378	6214	00	00031	00016	0914	0387	1538	1426	0028	0006	0034	1	2	66 08	1	465		2	1	238013
4160	6200	00	00000	00000	1000	1000	2537	2471	0000	0000	0000	3	5	67 08	2			3	1	238015
4148	6191	00	00000	00000	1000	1000	2636	2572	0000	0000	0000	3	5	69 05	2			4	1	238017
4657	6165	00	00001	00000	1000	1000	2168	2090	0001	0000	0001	3	5	67 08	2			5	2	238018
4530	6148	00	00329	00258	1000	1000	1111	0949	0329	0258	0587	3	1	67 08	2			5	1	238021
4404	6353	00	00008	00003	0830	0248	1802	1707	0008	0003	0011	2	5	66 08	1	465		3	1	238022
4513	6042	00	00035	00018	0985	0368	1514	1400	0034	0006	0040	1	2	66 08	1	465		2	2	238033
4520	6020	00	00012	00005	1000	1000	1705	1604	0012	0005	0017	3	5	67 02	2			3	2	238034
4150	6210	00	00000	00000	1000	1000	2637	2573	0000	0000	0000	3	5	67 08	2			3	1	238035
4520	6020	00	00012	00005	1000	1000	1705	1604	0012	0005	0017	3	5	67 02	2			3	1	238037
4639	6126	00	00002	00001	1000	1000	2049	1966	0002	0001	0003	3	5	67 08	2			5	2	238038
4640	6119	00	00002	00001	1000	1000	2071	1989	0002	0001	0003	3	5	67 08	2			5	1	238039
4637	6194	00	00003	00001	1000	1000	2004	1919	0003	0001	0004	3	5	67 08	2			5	1	238040
4510	6240	00	00276	00210	0904	0316	1141	0984	0249	0066	0315	3	4	67 08	2			5	1	238041
4480	5680	00	00000	00000	1000	1000	4539	4503	0000	0000	0000	3	5	69 05	2			4	2	238042
4910	5930	00	00000	00000	1000	1000	4952	4918	0000	0000	0000	3	5	69 05	2			4	1	238043
4366	6291	00	00075	00044	0842	0277	1375	1248	0062	0012	0074	1	2	66 08	1	465		2	2	238044
4356	6276	00	00106	00068	0879	0307	1310	1177	0093	0020	0113	1	2	66 08	1	465		2	1	238045
4374	6295	00	00074	00044	0993	0374	1376	1249	0073	0016	0089	1	2	66 08	1	465		2	2	238046
4377	6257	00	00367	00294	0913	0238	1092	0927	0335	0069	0404	1	2	66 08	1	465		2	2	238047
4377	6257	00	00367	00294	0913	0236	1092	0927	0335	0069	0404	1	2	66 08	1	465		2	2	238048
4377	6257	00	00367	00294	0913	0238	1092	0927	0335	0069	0404	1	2	66 08	1	465		2	1	238049
4432	6369	00	00005	00002	1000	1000	1912	1823	0005	0002	0007	3	5	67 08	2			5	1	238051
4432	6369	00	00005	00002	1000	1000	1912	1823	0005	0002	0007	3	5	67 08	2			5	2	238052
4417	6324	00	00033	00017	0804	0250	1528	1415	0026	0004	0030	1	2	66 08	1	465		5	2	238054
4540	5960	00	00001	00000	1000	1000	2247	2172	0001	0000	0001	3	5	67 08	2			3	2	238055
4610	5750	00	00000	00000	1000	1000	4221	4181	0000	0000	0000	3	5	67 08	2			3	2	238059
4180	6230	00	00000	00000	1000	1000	2408	2338	0000	0000	0000	3	5	67 08	2			3	1	238060
4373	6255	00	00361	00288	0980	0392	1095	0931	0353	0112	0465	1	2	66 08	1	465		2	2	238062
4373	6255	00	00361	00288	0924	0337	1095	0931	0333	0097	0430	1	2	66 08	1	465		2	2	238063
4390	6340	00	00013	00006	9999	9999	1698	1597	9999	9999	9999	4	0	67 08	2			3	2	238064

Figure 3. Sample listing of the dose master tape

one of interest is MF238004 (the MF number is given in the right-hand column). For this particular case, the method is classified as zero, which indicates that no method was available to do the shielding calculation, and hence the gamma-ray dose, neutron dose, and the total dose columns are filled with nines. The next interesting case is MF238022. For this case a shielding survey was taken and the nine-parameter TF, both gamma-ray and neutron, were calculated (refer to columns 36 to 43). However, because this person was beyond 1600 m at Hiroshima, he was assigned the FIA kerma at that ground range, which for T65D was 11 rad in total. If, in fact, the TF had been applied, his T65D dose would have been reduced to 7 rad. Complementing this particular instance, MF238034 had no shielding history available and was assigned a T65D FIA dose of 17 rad because his ground range was 1604 m. Another interesting case is MF238041. This particular person was assigned the average TF. He was at 984 m ground range from the bomb, and the average TF applied to the FIA dose of 500 rad reduced it to 315 rad.

Shielding Categories. There are 10 separate shielding categories that were applied to the Hiroshima and Nagasaki survivors. Table 2 lists the shielding categories and the number of subjects in each category as a function of their dose estimation method as outlined in Figure 2. This table is for the high-dose cases called the proximally exposed group, that

Figure 4. Data Format for Dose Master Tape

TD #1041

Dose Master Tape (T-65 Dose)

Item No.	Description of Field and Positions	Columns
1	Master File number	1-6
2	Sex and city of exposure Code 1 Male, Hiroshima 2 Female, Hiroshima 3 Male, Nagasaki 4 Female, Nagasaki	7
3	Coordinates of location ATB Abcissa 8-11 Ordinate 12-15 9999 Unknown Note: 1) Maps used to measure the coordinates are; Army Map Service U.S. Army, Washington, DC Hiroshima - 138449 9-46 1946 and Nagasaki - 138353 8-45 1945 2) There exist the coordinates over 100 in Nagasaki. In this case, ignore hundredth position and code tenth position. For example, 102.54 will be coded as 0254.	8-15
4	Height above sea level of location Code 00 Less than 10 meters : : 09 90-99 meters : : 20 200-209 meters : : 99 Unknown	16-17
5	Exposure distance Ground distance 18-21 Slant distance 22-25 9998 9988 meters and over 9999 Unknown	18-25

Page 1 of 5 pages

Figure 4, continued

TD #1041

Item No.	Description of Field and Positions	Columns
5	Exposure distance (continued)	

Distance is calculated by maching using the following hypocenter and height of burst;

	Hiroshima	Nagasaki
X-Coor.	44.295	93.656
Y-Coor.	61.697	65.960
Height (m)	577	507

Note: When the above estimates concerning the epicenter changes, it should be revised so that the dose estimation derived according to these estimates ties in with Item 12, month and year of dose estimation. Therefore, if the estimates of epicenter may change, the date of revision should be stated.

6	Air dose at this location	26-35

Gamma	26-30
Neutron	31-35

99998 99998 rads and over
99999 Unknown

According to slant distance and by the air dose formula, air dose at a given location of interest is calculated as a 5 digit integer with round off by machine.

7	Transmission factors as decimal fraction	36-43

Gamma	36-39
Neutron	40-43

Code in 4 digit number to three decimals by round off.

9999 Transmission factor unknown

Note: 1) Calculated results from DC Nos. 465 and 708 for 9-parameter code and globe operation are machine transferred.

2) Coded transmission factors by CD #499 is machine transferred.

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Figure 4, continued

TD #1041

Item No.	Description of Field and Positions	Columns
7	Transmission factors as decimal fraction (continued)	36-43

Note: 3) 100% air dose transmission is gang punched for cases who are in open and shielding histories are not obtainable. Necessary information to make this decision is derived from ST-100 Master Tape.

4) Average transmission factors has been derived from the 9-parameter code as follows, and is machine transferred for cases exposed inside Japanese type houses or light constructions for subjects which have no shielding history. Necessary information to make this decision is derived from the ST-100 Master Tape and CD #411 for ST-100 subjects.

		Hiroshima	Nagasaki
Average Values	Gamma	0.904	0.813
" "	Neutron	0.316	0.351

Item No.	Description of Field and Positions	Columns
8	Estimated tentative 1965 dose	44-51

Gamma	44-47
Neutron	48-51

Calculated in 4 digit numbers by multiplication of air dose at this location (Item 6) and transmission factors as decimal fraction (Item 7).

Code	
0000	Less than 1 rad
:	:
9998	9998 rads and over
9999	No information

Item No.	Description of Field and Positions	Columns
9	Total dose	52-55

This is the sum of gamma and neutron dose, and coded the same as mentioned in Item 8.

Item No.	Description of Field and Positions	Columns
10	Class of dose estimation	56

(For additional explanation, see memo of 21 March 1966 by J.S. Chaka and R.C. Milton)

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Figure 4. continued

TD #1041

Item No.	Description of Field and Position	Columns
10	Class of dose estimation (continued) Code 1 Good estimate 2 Fair estimate 3 Rough estimate, no shielding history 4 No estimate, for example, includes some cases exposed inside concrete building, when method of estimating transmission factor is not yet available. In general, heavily shielded cases without method of estimation will remain in this category.	56
11	Method of estimating dose Code 1 By air dose alone 2 By 9-parameter formula 3 By globe application 4 Applied average transmission factor derived from 9-parameter code for cases exposed inside Japanese type house or building of light construction for subjects which have no shielding history 5 By 100% air dose; subjects exposed beyond 1600 m in Hiroshima and beyond 2000 m in Nagasaki who have shielding history and for any type of shielding conditions 0 No method available	57
13	Sample Classification I Code 1 PE-86 2 ME-200 3 ME-Y 4 Others 5 Master sample reserve under 2500 m 6 ME-200-1 7 F_1 Mortality Extension	61
14	Sample Classification II (HE-39 only) Code 1 HE-39	62

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Figure 4, continued

TD #1041

Item No.	Description of Field and Positions	Columns
15	Source Card designs Code 455 CD #465 499 CD #499 708 CD #708 CD #575 bbb Derived from ST-100 Master Tape	63-65
16	Surrounding shielding condition Information derived from CD #708 Card 2, Col. 79 Code 1 Mainly shielded by Japanese type house 3 Solid shield, shielded by terrain 4 Solid shield, other than above b Not applicable, source data is CD #465 and CD #499	66
17	Reserved columns	67-70
18	Year and month of dose estimation Year (71-72) Code 66 1966 67 1967 : : 75 1975 76 1976 : : Month (73-74) Code 01 January 02 February : : 12 December	71-74
19	Original card design number of this tape Code 500	75-77
20	Reserved Columns	78-88

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Table 2. Number of Life Span Study Survivors by Dose Estimation Method, Shielding Category, and City. Survivors in the Distal Group and Survivors Without Data on Acute Symptoms are not Included

Shielding Category	FIA Dose	Dose Estimate Method			
		9-Parameter	Average	Globe	Total
Hiroshima					
1-In open-unshielded	564	2	0	436	1002
2-In open-partially shielded	5	255	0	27	287
3-In open-shielded by terrain	1	1	0	22	24
4-In open-shielded by building	19	10	1	1244	1274
5-Shielded totally by concrete building	3	0	1	189	193
6-Shielded totally by Japanese-type house	82	7077	7	53	7219
7-Shielded totally by factory building	13	3	0	0	16
8-In air raid shelter	0	0	0	23	23
9-Miscellaneous	12	0	1	14	27
Unknown[a]	306	1	2003	0	2310
Total	1005	7349	2013	2008	12375
Nagasaki					
1-In open-unshielded	208	0	0	151	359
2-In open-partially shielded	160	201	0	59	420
3-In open-shielded by terrain	101	220	0	502	823
4-In open-shielded by building	18	0	0	252	270
5-Shielded totally by concrete building	1	1	1	457	460
6-Shielded totally by Japanese-type house	94	2385	2	29	2510
7-Shielded totally by factory building	742	2	0	54	798
8-In air raid shelter	0	0	0	248	248
9-Miscellaneous	7	6	1	14	28
Unknown[a]	61	0	416	2	479
Total	1392	2815	420	1768	6395

[a]These survivors have no shielding histories. Information obtained from mail questionnaires was used to determine their dose estimation method.

is, survivors at ground ranges less than 1600 m at Hiroshima and 2000 m at Nagasaki. As mentioned, the nine-parameter technique (CD465) was used primarily for survivors totally shielded by Japanese-type houses. The globe technique (both CD708 and CD575) was used primarily for subjects in the open who had some shielding along the line of sight and for subjects in the concrete and factory buildings. The FIA dose was applied to a surprisingly large number of subjects at Nagasaki, over half of whom were in factory buildings.

Applications of the Nine Parameter Formula. The nine-parameter formula (CD465) was applied to over half of the subjects in the Life Span Study in the proximally exposed group. As discussed in Chapter 7 Appendix 1, the nine-parameter formula modeled the measured radiation TF from the BREN reactor and ^{60}Co experiments. A regression analysis determined which physical parameters of the given detector location influenced the measured TF for three types of radiation: neutrons from the BREN reactor, gamma rays during the BREN reactor operation, and the ^{60}Co gamma rays. It was determined that nine of these parameters could reproduce the measured data with suitable accuracy. The neutron formula from the BREN reactor data was applied directly at both Hiroshima and Nagasaki. Different combinations of the formulas for reactor gamma rays and ^{60}Co gamma rays were used at Hiroshima and Nagasaki on the basis of the results from the HARDTACK series of weapon test experiments. Assuming the house models used at BREN were reasonable radiation

Table 3. Data Format for CD465, the Nine-parameter File

Item	Description	Number of Columns	Columns Used
Part I: Identification			
1	Master file number	6	1-6
2	Sex and city of exposure	1	7
3	Coordinates as to exact location ATB	8	8-15
Part II: Nine Parameters and Certainty of Coding			
4	FS (Front Shielding)	1	16
5	FSS (Front Shielding Size)	1	17
6	US (Unshielded)	3	18-20
7	LS (Lateral Shielding)	2	21
8	IFW (Internal Frontal Walls)	1	22
9	ILW (Internal Lateral Walls)	1	23
10	HF (Height above Floor)	2	24-25
11	FN (Floor Number)	1	26
12	SP (Slant Penetration)	4	27-30
13	Certainty of coding nine parameters	9	31-39
Part III: Other Pertinent Data			
14	Completeness of shielding drawings prior to coding	1	40
15	Attenuation factor (T57D)	6	41-46
16	Description of Japanese-type house	1	47
17	Treatment of house	1	48
18	Treatment of projection	2	49-50
19	Elevation	1	51
20	Grove	1	52
21	Present coding disposition	1	59
22	Sea level	2	54-55
23	Class of estimating dose	1	56
24	Method of estimating dose	1	57
25	Reserve columns	17	58-74
26	Card design number	3	75-77
27	Reserve columns	3	78-80

analogues of typical Japanese houses, it was concluded previously (Chapter 7 Appendix 1) that these gamma-ray TF are too high by a factor in the range 1.5 to 2. The composition of the materials in the BREN houses was not exactly the same as that in Japanese houses (Chapter 7). Another problem with these formulas is the lack of dependence of the TF on the distance from the bomb. The calculations show significatnt range dependence for houses between 900 and 1600 m ground range. It is caused primarily by the changing proportion of the radiation that goes through the roof and the walls (Chapter 7).

The data that can be computer accessed for the nine-parameter cases is given in Table 3. The nine parameters are the nine variables listed in columns 16 to 30. The code for shielding parameters (see Appendix 7-2b) provides a brief description of how the parameters are coded for a given shielding situation. The shielding analyst examined the shielding history file described above, derived the nine parameters, and placed them on the code sheet. The official procedure for coding the nine parameters was revised several times when it became apparent that many of the shielding situations would not fit neatly into the described procedure.

Several points should be noted about the application of the nine-parameter formula. The frontal shielding (FS) parameter was only coded as present if the distance from the subject to the shielding (i.e., an adjacent house) was less than twice the height of the building. This corresponds to the elevation angle of the BREN house transmission measurements. Thus,

Table 4. Sample of Nine-parameter Data from 21 Cases at Hiroshima (and Some Globe-cases for Comparison)

Value	Frequency	Value	Frequency	Value	Frequency	Value	Frequency
Front Shielding		Front Shielding Size		Unshielded		Lateral Shielding	
0	8	0	8	4	1	0	4
1	8	1	8	5	1	2	4
2	4	2	5	6	1	3	13
5	1			9	1		
				100	17		
Internal Frontal Walls		Internal Lateral Walls		Height Above Floor		Floor Number	
0	2	0	12	<0.3	9	1	10
		1	6	0.3<V<0.7	3	2	9
		2	3	>0.7	9	3	2

	Average Value	Standard Deviation	Average Used in LSS
Slant penetration	3.97	2.73	
Mass penetration (g/cm^2) (12 cases available)	33.7	15.7	
T57D Gamma ray transmission	0.63	0.073	
T57D Neutron transmission	0.38	0.09	
9P attenuation (7 cases available)			
Gamma ray	0.915	0.03	0.904
Neutron	0.315	0.04	0.316
Globe (26 different cases) partially shielded in open			
Gamma ray	0.84	0.11	
Neutron	0.69	0.21	

for practical purposes, if a line of sight from the subject to the bomb did not intercept the wall, it was not included in the shielding description in the nine-parameter formula. Another example is the height above the floor (HF) parameter. Because of the many situations involved in determining this parameter, it cannot be used to determine if the person was prone, sitting, or standing.

Other information, however, can be inferred from examination of the data in CD465. For example, since the T57D gamma-ray and neutron attenuation factors are given, the house penetration distance can apparently be calculated. Other useful information includes the description of the Japanese-type house, column 47, and the treatment of the house, column 48. One of the options was to code the house as a tenement house. There were many survivors at Hiroshima in these tenements, which were of very uniform construction. Their TF may be more precise than for other situations.

During the visit to RERF, Hiroshima, code sheets in the history file for the data associated with CD465 were examined and the information for 21 individual cases in a residential district northwest from the hypocenter was copied out. The data obtained from this small sample are in Table 4. Most of the information is stored as integral data with the exception of the parameter HF and slant penetration (SP). The code sheets did not provide the calculated attenuation factors for the gamma rays and the neutrons from the nine parameters. However, the actual attenuation factors calculated from the nine parameters were obtained for 7 of the 21 cases by examining printouts from the master dose tape. This data for the seven cases is also provided in the table. From the shielding files the mass penetration thicknesses were obtained for 12 of the 21 cases and the results of that analysis are also listed. For completeness of the table, the results of analyzing 26 different cases that had their shielding calculated by the globe technique are also listed (discussed below). All of the 26 cases were for survivors in the open but partially shielded by Japanese houses. It would be a mistake to draw firm conclusions from these limited data; however, the information provided here is reasonably indicative of the general situation. It is interesting to note the disparity between the three sets of radiation TF (the T57D, the T65D nine-parameter, and the T65D globe). Note, for example, the small standard deviation with just seven cases of the nine-parameter data. Also listed in separate columns are the average TF used when the averages are applied to the survivor history without a detailed calculation.

Although the nine-parameter formula is reasonably complex, in practice the attenuation factors calculated with this formula do not differ a great deal. The actual attenuation is dominated by the constant factors in the formula. This is the reason that seven cases of our limited sample came so close to the average over many thousands of cases.

In comparing the nine-parameter formula with the globe data for people partially shielded in the open, the neutron TF is greater than for the globe, but the gamma-ray TF is less. In application of these methods, many people in the open were assigned less gamma-ray dose than people that were totally shielded by a house. There have been noticeable inconsistencies in the radiobiological analysis of health effects for people whose shielding was calculated by the nine-parameter formula compared to those calculated by the globe method that may be due to this disparity.

Shielding Method for Subjects Exposed Inside Concrete Buildings. The globe technique was used to provide the shielding for subjects exposed inside concrete buildings. The application of the globe technique for these people was identified at CD575. About 11% of the subjects at Nagasaki had their attenuation computed by this technique.

In the globe procedure, 4π angular space is divided into small intervals and the shielding present in each of these intervals is calculated for the incident angular distribution. The resulting dose is then the sum over 4π space of the individually attenuated incident radiation in each interval. The line of sight from the exposure location to the bomb defines the polar axis reference. There are a total of 18 polar intervals (or zones) of 10° width. Each polar interval is then divided into 36 azimuthal intervals, called sections in the globe terminology. Each section corresponds to equally spaced azimuthal intervals of 10°.

The basic input data to the globe technique is the normalized polar angular distribution of the neutron radiation with respect to the line of sight from the bomb to the survivor. This distribution was assumed to vary with ground range. Let

$D(\mu)$ = dose per steradian, 2π azimuthally symmetric, in solid angle $d\Omega = 2\pi d\mu$, where $\mu = \cos\beta$ and β is the polar angle of the solid angle with respect to the line of sight.

The total dose is then given by

$$D_T = 2\pi \int_{-1}^{1} D(\mu)\, d\mu \tag{1}$$

and the dose fraction per steradian by

$$f(\mu) = \frac{D(\mu)}{D_T} \quad (2)$$

The solid angle of the polar zones (or latitudes) of the globe is given by

$$\Delta\Omega_i = 2\pi\left(\cos\beta_i - \cos\beta_{i-1}\right) = 2\pi\left(\mu_i - \mu_{i-1}\right) = 2\pi\,\Delta\mu_i \quad (3)$$

where β_i is the polar angle boundary of the zones (every 10°). The percentage of dose received in each zone per steradian is then given by

$$F_i = 100 \times 2\pi \int_{\mu_{i-1}}^{\mu_i} \frac{f(\mu)\,d\mu}{2\pi\Delta\mu_i} \quad (4)$$

This is the value given in the first column of Table 5. Likewise, the percentage of dose received in each zone (second column of Table 5) is

$$P_i = F_i\,2\pi\,\Delta\mu_i \quad (5)$$

Each zone is divided into 36 equally space azimuthal sectors. A portion of these are above and a portion below the horizon, and a few have parts in both. Applying the globe to house models, Ritchie and Hurst[1] found that if they depressed the horizon by 4° and if they assumed the incident radiation per steradian for sectors below the horizon was half of that above the horizon, they got reasonable agreement with Nevada house shielding measurements. It seems the factor of one-half was assumed and the 4° depression found to give the best agreement.

Let N_A^i and N_B^i be the numbers of the 36 zones above (A) and below (B) the depressed horizon for zone i such that

$$N_A^i + N_B^i = 36 \quad (6)$$

Note that N_A and N_B are not required to be integers. The values of N_A and N_B for several elevation angles (α) are given in Table 6.

Because of the assumptions above, the incident radiation was redistributed so that more arrives per steradian from above. Note that the redistribution for any given polar angle is a function of the angle of elevation or ground range. (Current models for synthesizing two-dimensional angular distributions from one-dimensional calculations that are only polar angle dependent do not redistribute but rather only subtract from near and below horizon incidence.) A factor C_A^i is defined as

$$P_i = C_A^i\,(N_A^i + \frac{1}{2}N_B^i) \quad (7)$$

Values of C_A^i are given in Table 5. The value listed as C_B is $C_A/2$ if $N_B = 0$. Thus $C_A^i N_A^i$ is the percentage of radiation arriving in zone i above the depressed horizon and $C_A^i N_B^i/2$

Table 5. Angular Distribution of Neutron Dose Received at a Point 1 m Above the Ground for Horizon Depression $\delta = 4°$

Latitude Zone Z Degrees	Dose Rec'd per Steradian F	Dose Rec'd per Zone P %	Angular Distribution Function C in 36ths of Percent Per Zone: $\alpha=14°$ HCD=2km, Above Horizon C'_A	$\alpha=14°$ HCD=2km, Below Horizon C'_B	$\alpha=18.4°$ HCD=1.5km, Above Horizon C'_A	$\alpha=18.4°$ HCD=1.5km, Below Horizon C'_B	$\alpha=26.5°$ HCD=1km, Above Horizon C'_A	$\alpha=26.5°$ HCD=1km, Below Horizon C'_B	$\alpha=45°$ HCD=0.5km, Above Horizon C'_A	$\alpha=45°$ HCD=0.5km, Below Horizon C'_B
0-10	103.751	9.902	0.2751	0	0.2751	0	0.2751	0	0.2751	0
10-20	34.349	9.738	0.2705	0	0.2705	0	0.2705	0	0.2705	0
20-30	20.593	9.531	0.3028	0.1514	0.2874	0.1437	0.2647	0	0.2647	0
30-40	15.764	9.904	0.3315	0.1657	0.3225	0.1613	0.3020	0.1510	0.2751	0
40-50	12.945	10.025	0.3483	0.1741	0.3387	0.1693	0.3260	0.1630	0.2785	0
50-60	10.663	9.567	0.3354	0.1677	0.3313	0.1657	0.3228	0.1614	0.2942	0.1471
60-70	8.725	8.661	0.3078	0.1539	0.3054	0.1527	0.2950	0.1475	0.2836	0.1418
70-80	7.126	7.539	0.2711	0.1355	0.2697	0.1349	0.2670	0.1335	0.2585	0.1293
80-90	5.813	6.342	0.2303	0.1151	0.2299	0.1149	0.2290	0.1145	0.2259	0.1129
90-100	4.760	5.194	0.1903	0.0951	0.1905	0.0953	0.1910	0.0955	0.1919	0.0959
100-110	3.904	4.130	0.1527	0.0763	0.1534	0.0767	0.1547	0.0773	0.1586	0.0793
110-120	3.201	3.177	0.1186	0.0593	0.1195	0.0597	0.1214	0.0607	0.1276	0.0638
120-130	2.639	2.368	0.0794	0.0397	0.0905	0.0453	0.0928	0.0464	0.1009	0.0505
130-140	2.178	1.687	0.0645	0.0323	0.0657	0.0329	0.0682	0.0341	0.0801	0.0401
140-150	1.807	1.135	0.0442	0.0221	0.0455	0.0227	0.0483	0.0241	0	0.0315
150-160	1.461	0.676	0.0272	0.0136	0.0285	0.0143	0.0325	0.0163	0	0.0188
160-170	1.160	0.328	0.0143	0.0071	0.0167	0.0083	0	0.0091	0	0.0091
170-180	1.006	0.096	0	0.0027	0	0.0027	0	0.0027	0	0.0027
Total		100.00								

$P = 2\pi F(\cos Z_1 - \cos Z_2)$. HCD=Distance from hypocenter for 500 m burst height.

$$C'_A = \frac{P}{N_A + \frac{1}{2}N_B} \;\cdot\; C'_B = \frac{C'_A}{2}$$

Table 6. Number of Ten-degree Sections Above, N_A, and Below, N_B, the Apparent Horizon for Various Hypocenter Distances. Horizon Depression 4°. Burst Height 500 m

Latitude Zone Center Angle (Degrees)	$\alpha=14°$ HCD=2km N_A	$\alpha=14°$ HCD=2km N_B	$\alpha=18.4°$ HCD=1.5km N_A	$\alpha=18.4°$ HCD=1.5km N_B	$\alpha=26.5°$ HCD=1km N_A	$\alpha=26.5°$ HCD=1km N_B	$\alpha=45°$ HCD=0.5km N_A	$\alpha=45°$ HCD=0.5km N_B
5	36	0	36	0	36	0	36	0
15	36	0	36	0	36	0	36	0
25	26.96	9.04	30.51	5.49	36	0	36	0
35	23.75	12.25	25.42	10.58	29.60	6.40	36	0
45	21.56	14.44	23.18	12.82	25.50	10.50	36	0
55	21.04	14.96	21.76	14.24	23.28	12.72	29.03	6.97
65	20.26	15.74	20.73	15.27	21.71	14.29	25.08	10.92
75	19.62	16.38	19.90	16.10	20.47	15.53	22.34	13.66
85	19.07	16.93	19.18	16.82	19.40	16.60	20.15	15.85
95	18.58	17.42	18.51	17.49	18.40	17.60	18.13	17.87
105	18.09	17.91	17.85	18.15	17.39	18.61	16.09	19.91
115	17.58	18.42	17.15	18.85	16.32	19.68	13.81	22.19
125	17.00	19.00	16.35	19.65	15.06	20.94	10.91	25.09
135	16.30	19.70	15.36	20.64	13.43	22.57	6.13	29.87
145	15.33	20.67	13.94	22.06	10.96	25.04	0	36
155	13.72	22.28	11.47	24.53	5.56	30.44	0	36
165	9.85	26.15	3.36	32.64	0	36	0	36
175	0	36	0	36	0	36	0	36

is the percentage arriving below it.

The globe procedures determine the quantities ψ_A^i and ψ_B^i, which are number sectors in zone i that intercept the shield above and below the depressed horizon. If the shield has a TF (f), it produces a dose 1-f of that without the shield present. With this, the globe procedure calculates the dose as

$$D = D_T \left[1 - \frac{1-f}{100} \sum_i C_A^i (\psi_A^i + \frac{1}{2}\psi_B^i) \right] \tag{8}$$

The calculation of the radiation attenuation for subjects exposed inside the concrete buildings used the globe technique in a manner that will be described using an example history. This particular history was for a person in the University Hospital medical ward at Nagasaki located about 700 m from the hypocenter on a hill to the southeast of the hypocenter. Figures 5 and 6 give the physical information obtained during the interview of the subject. This particular subject was located in a hallway of the hospital on the top story ATB. The line-of-sight attenuation calculation, discussed previously, is provided in Figure 7. To calculate the attenuation using the globe technique, a simplified layout of the shielding situation was made as illustrated in Figure 8. The subject was in a long hallway surrounded by rooms to the north and south. The north and east walls of the hallway were considered to be "solid," that is, blocking the incident radiation. To the west of the subject, at a distance of 8.5 m, was another wall and a window. Figure 9 provides additional information required by the shielding analyst. This figure indicates, among other things, that the north and east walls were treated as solid. It indicates that the west wall was 33 cm thick, the south wall was 67 cm thick, and the ceiling was 35 cm thick. This particular subject was located at 700 m from the hypocenter and, thus, the elevation angle to the bomb was 35°. From this model, the globe operation could be performed. The analyst recorded the information obtained from the globe setup on the CD575 working card provided for this subject and shown in Figure 10.

The data that goes on the working cards is reasonably self-explanatory. The notable exception is the treatment of windows. The windows were reduced in size corresponding to the opening, as viewed by the subject, if the thickness of the wall exceeded a certain amount. The thickness criterion was different for gamma rays and neutrons. It is believed that the thickness was 50 cm for gamma rays and 15 cm for neutrons. Thus, the size of the window and the corresponding solid angle for radiation streaming to the subject in the globe calculation may be different for gamma rays and neutrons. This caused a separate specification for neutron and gamma rays for the radiation incident through the windows. The example was in this situation. The first four boxes to the left of the column punched data of the working card (Figure 10) indicates that this describes the globe blockage for the west wall for gamma rays and neutrons. The second group of numbers is for the west wall for window and gamma rays. The next set provides the west wall window neutron data. Following these three cards, the next two cards describe the south wall for gamma rays and neutrons; then, the ceiling for gamma-ray and neutron blockage. The zone number data, starting in column 16 and ending in column 69, are three-digit numbers, which, when divided by 360, provide the fraction of sectors in that particular zone that are blocked. Following this

Figure 5. Sample floor plan of a survivor configuration. Survivor located in a medical ward of the University Hospital, Nagasaki

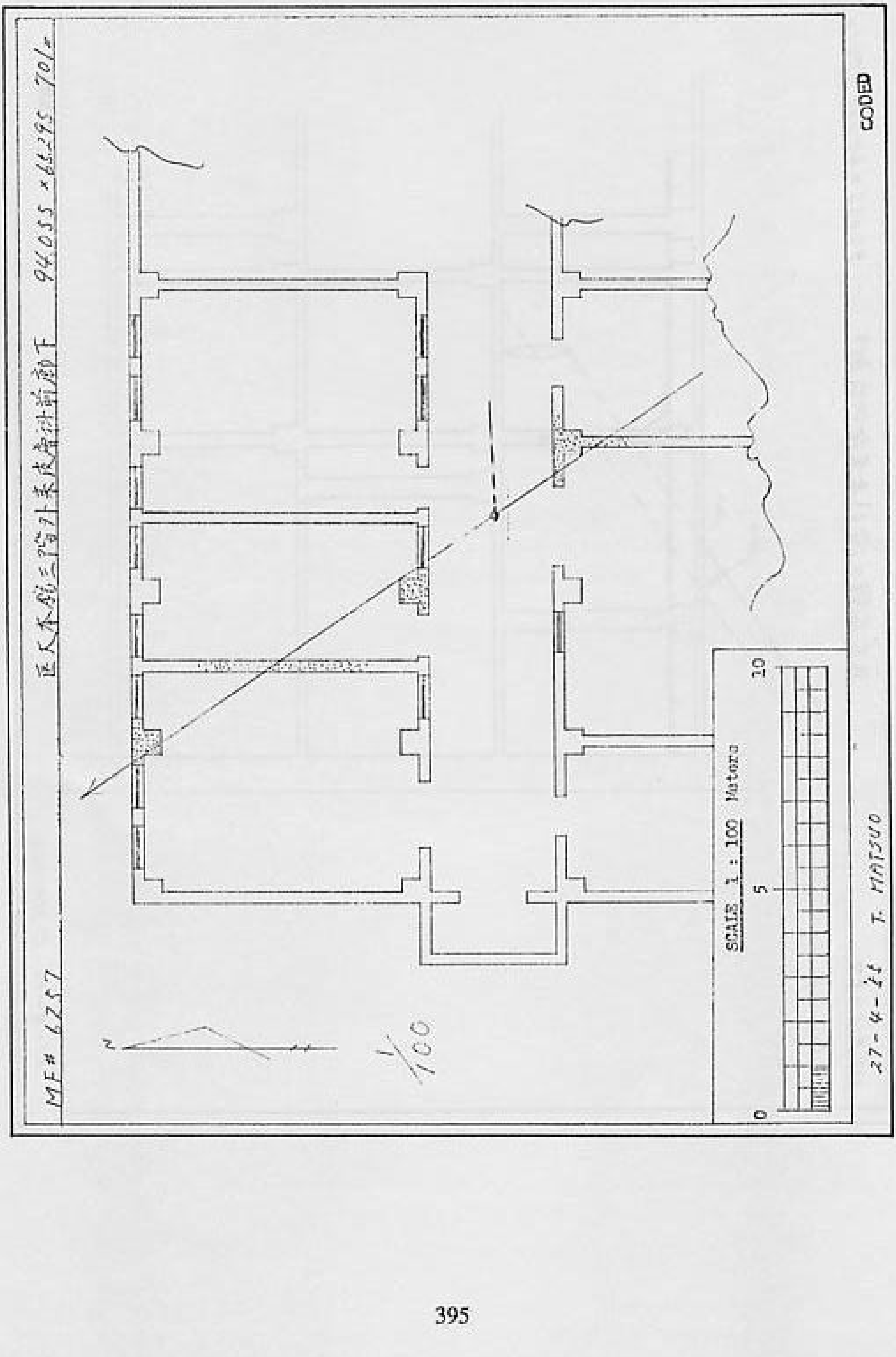

Figure 6. Elevation for the floor plan of the survivor shown in Figure 5

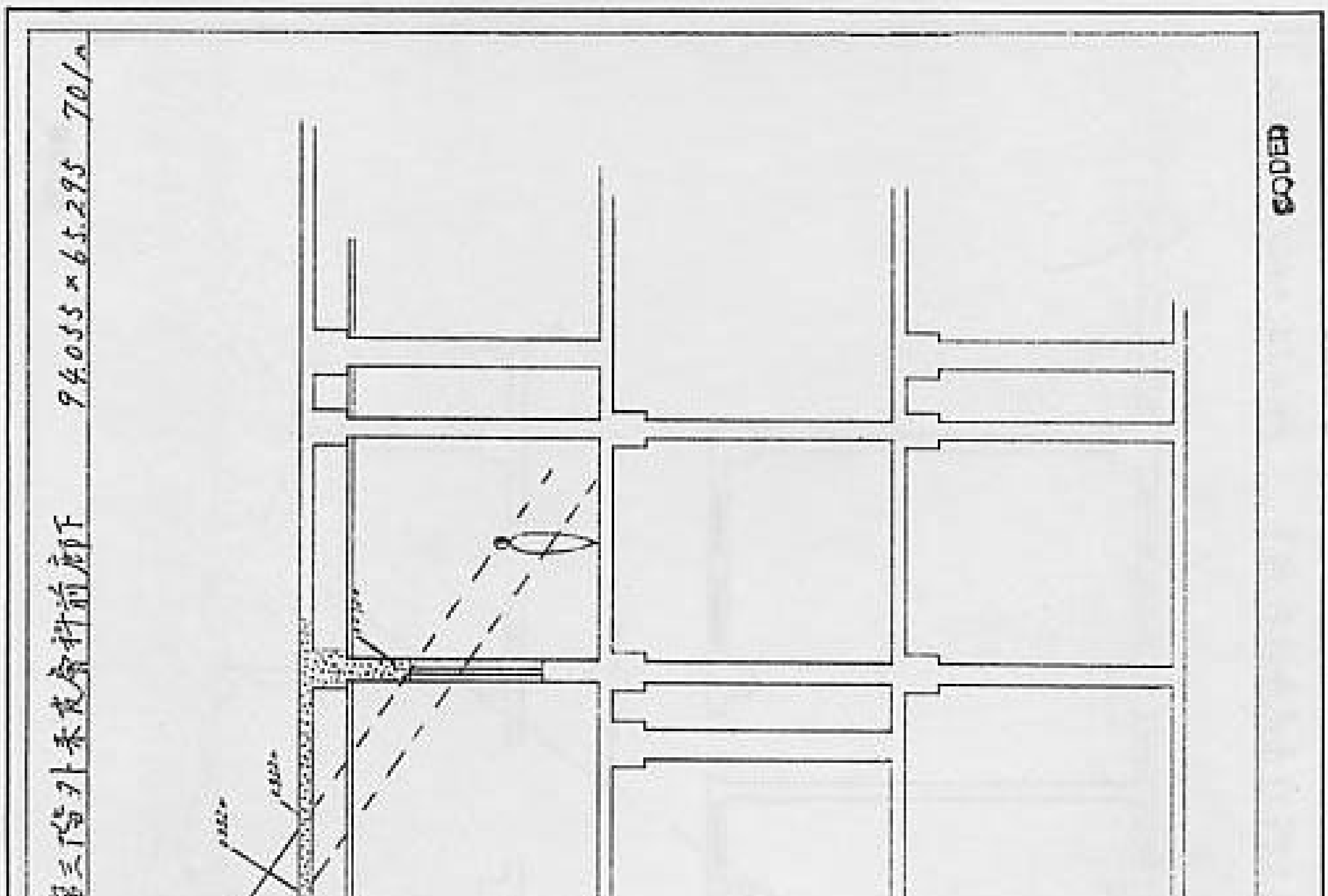

Figure 7. Sample line-of-sight attenuation computation sheet for the survivor shown in Figure 5

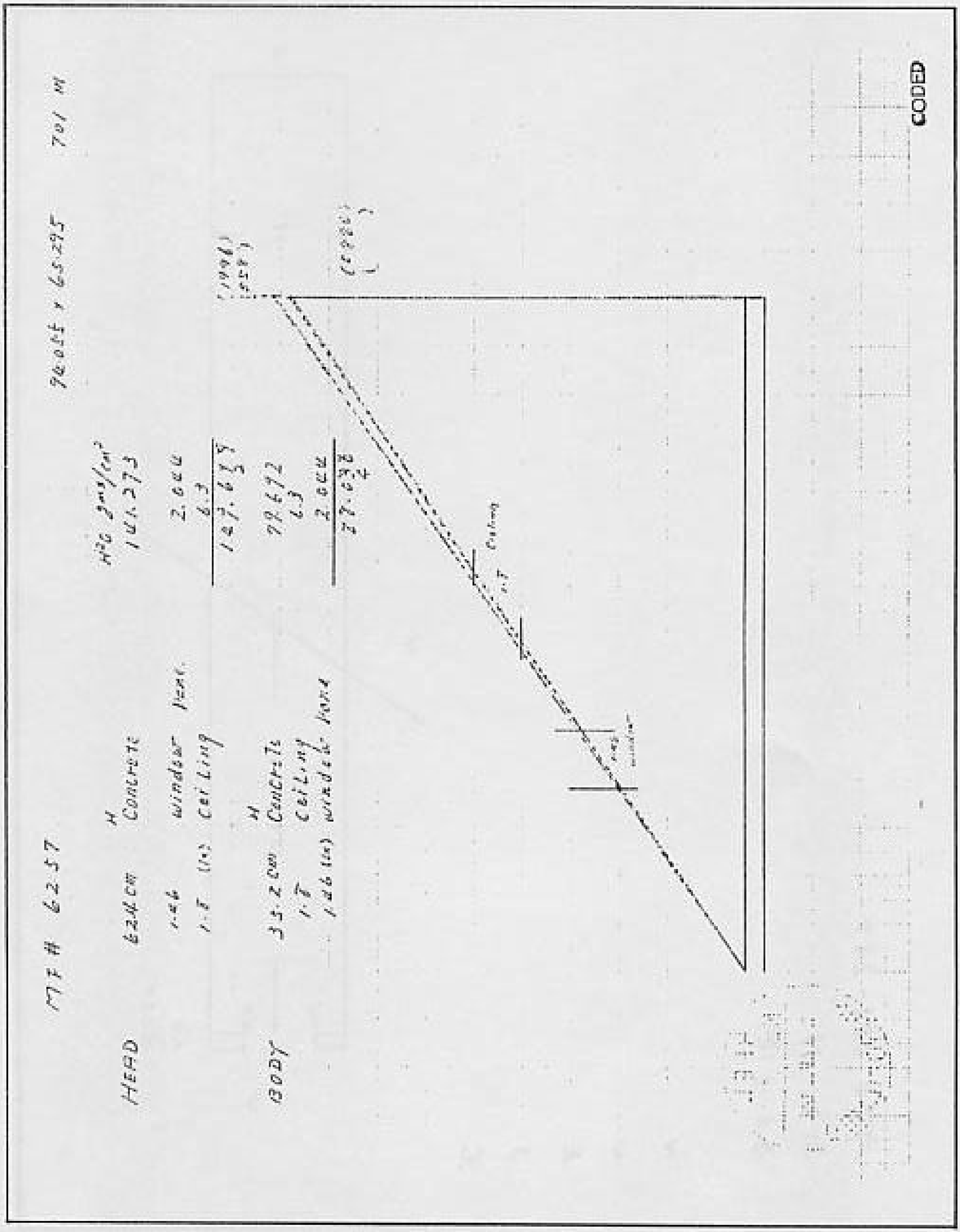

Figure 8. Sample simplified floor plan for application of the globe technique - for the survivor shown in Figure 5

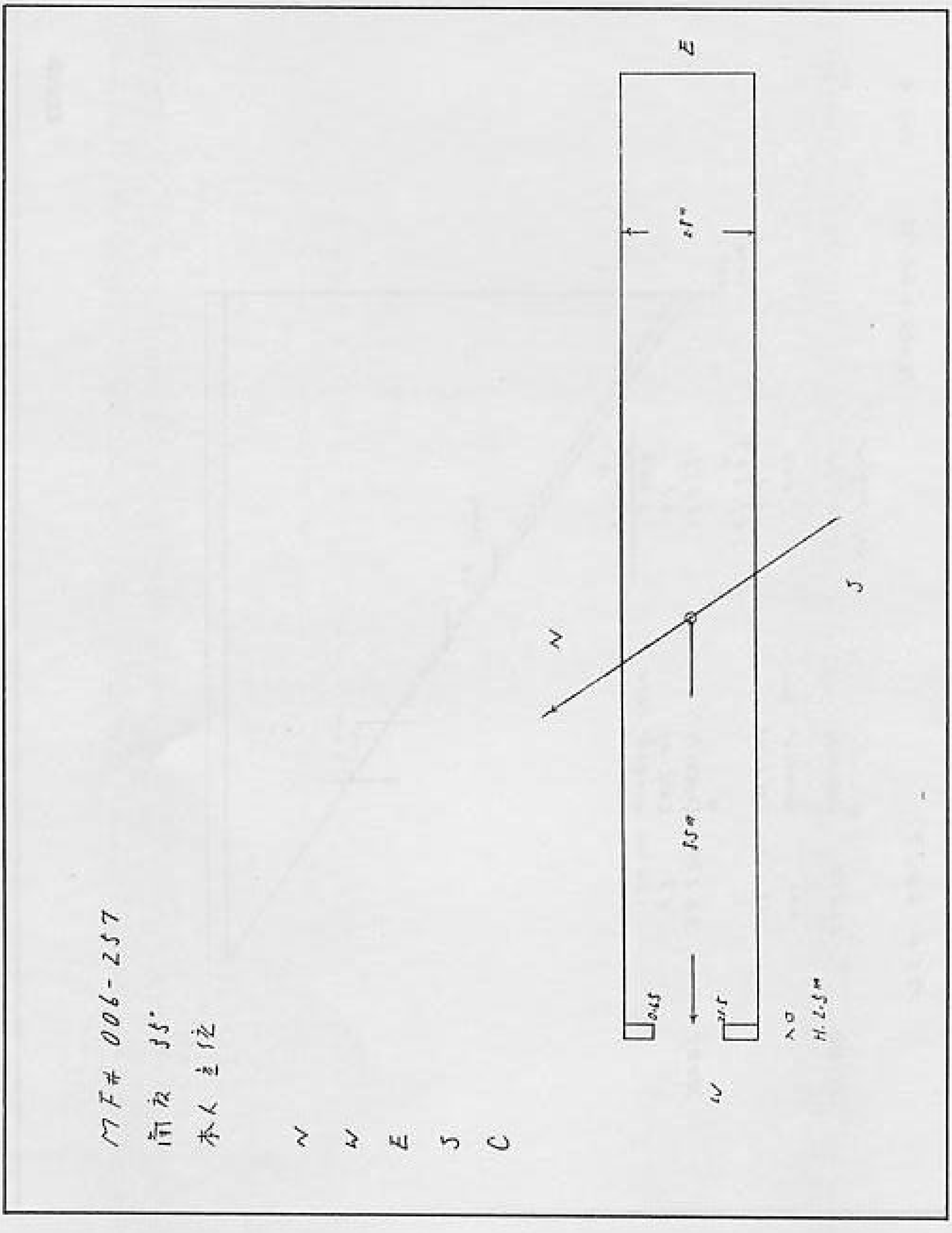

Figure 9. Sample data sheet for the globe study - for the survivor shown in Figure 5

Date [illegible]

コンクリート建内グローブ作業シート

M.P # 666-247

空中線量　ガンマー線 ______ Rad

　　　　　中性子線 ______ Rad

爆心距離 .... ______ meter　90.05 × 65.30

標　　高 .... 20 meter

仰　　角 .... 35 degree

被照射面	開口部の有無	壁体の厚さ	爆心方向	照射の必要性	分割数
北壁	有　(無)	Solid cm	☑	有　(無)	☐
西壁	(有)　無	33 cm	☐	(有)　無	☐
東壁	有　無	Solid cm	☐	有　(無)	☐
南壁	有　(無)	67 cm	☐	(有)　無	☐
天井	—	35 cm	☐	(有)　無	☐

備　考 ______

Date Formed 1 Oct.'69
Field Op.Sect. Nag.

Figure 10. Sample working card sheet for CD575 analysis - for the survivor shown in Figure 5

Figure 11. Sample master card sheet of CD575 analysis - for the survivor shown in Figure 5

Date Coded:

CODE SHEET FOR SUBJECT EXPOSED INSIDE CONCRETE BUILDING, GLOBE OPERATION (CD# 575)

Master Card

M.P. #						Sex City Exp.	Coordinates									Sea Level	
0	0	6	2	5	7	3	9	4	0	5	×	6	5	3	0	0	2
1	2	3	4	5	6	7	8	9	10	11		12	13	14	15	16	17

F.Wall	D.W. 1 rad		Q.Build.	C.E.D.	M.E.D.	No.W.cards		
1	0	5	1	3	3	0	5	2
18	19	20	21	22	23	24	25	26

CD#			C.I.#	
5	7	5	0	0
75	76	77	79	80

電孔済 46.1.-9 計算課

Distance (H.C.)	Distance (E.C.)

	Gamma	Neutron	Remarks
Air Dose			
Transmission Factor			
Received Dose			

Notes: 北及び 東壁は Solid

Date formed: 1 Oct.'69 STAT.DEPT. F.O.S.

Figure 12. Data Format for CD708, the Globe-data File

C.D.#708

17 July 1961
Rev. 21 June 1966
Field Operations Div.
Statistics

Code for Globe Operation on Shielding Work

(C.D.#708)

Item No.	Description of field and positions Card#1			Columns
1.	Master file number			1- 6
2.	Reserved column			7
3.	Number of shielded sections in each spherical zone			8-79

Code number of shielded sections in 18 spherical zone each divided into portions above and below horizon. 0°-90° is the front angle and 90°-180° is the back angle.

Code

Number of section	0°- 10° above the horizon	8- 9
"	" below "	10-11
"	10°- 20° above the horizon	12-13
"	" below "	14-15
"	20°- 30° above the horizon	16-17
"	" below "	18-19
"	30°- 40° above the horizon	20-21
"	" below "	22-23
"	40°- 50° above the horizon	24-25
"	" below "	26-27
"	50°- 60° above the horizon	28-29
"	" below "	30-31
"	60°- 70° above the horizon	32-33
"	" below "	34-35
"	70°- 80° above the horizon	36-37
"	" below "	38-39
"	80°- 90° above the horizon	40-41
"	" below "	42-43
"	90°-100° above "	44-45
"	" below "	46-47
"	100°-110° above the horizon	48-49
"	" below "	50-51
"	110°-120° above the horizon	52-53
"	" below "	54-55
"	120°-130° above the horizon	56-57
"	" below "	58-59
"	130°-140° above the horizon	60-61
"	" below "	62-63
"	140°-150° above the horizon	64-65
"	" below "	66-67
"	150°-160° above the horizon	68-69
"	" below "	70-71
"	160°-170° above the horizon	72-73
"	" below "	74-75
"	170°-180° above the horizon	76-77
"	" below "	78-79

4. Indication of a card number — 80

Code

1 For card number

Page 1 of 3 pages

Figure 12, continued

C.D.#708

17 July 1961
Rev. 21 June 1966
Field Operations Div.
Statistics

Code for Globe Operation on Shielding Work

(C.D.#708)

Item No.	Description of field and positions Card#2		Columns
1.	Master file number		1- 6
2.	Reserved columns		7-42
3.	Sex and city of exposure 1 Male, Hiroshima exposed 2 Female, Hiroshima exposed 3 Male, Nagasaki exposed 4 Female, Nagasaki exposed		43
4.	Coordinates of location ATB		44-51
	Abscissa	44-47	
	Ordinate	48-51	
	Note: Maps used to measure the coordinates are; Army Map Service U.S. Army Washington D.C. Hiroshima - 138449 9-46 1946 and Nagasaki - 138353 8-45 1945		
5.	Height above sea level of location ATB Code height in 10's of meters. 00 Less than 10 m 01 10-19 m 02 20-29 m : : 09 90-99 m : : 20 200-209 m : 90 Unknown		52-53
6.	Quality of shield 1 Transmission (Japanese-type house) 2 Solid (Zero transmission only)		54
7.	Front and back distances for gamma build-up factor		55-60
	Front distance	55-57	
	Back distance	58-60	
	Code distance from subject to nearest object in meters to one decimal. bbb No shield or distance is larger than 2H in front and/or H in back, or exposed beyond 1500 m in Hiroshima and 2000 m in Nagasaki according to the distance recorded on the shielding history. 999 Not applicable because quality of shield is solid.		

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Figure 12, continued

Item No.	Description of field and positions Card #2		Columns
8.	Class of estimating dose		61
	1	Good estimate	
	2	Fair estimate	
	3	Rough estimate; No shielding history	
	4	No estimate; for example, includes some cases exposed inside concrete building, where method of estimating transmission factor is not yet available. In general, heavily shielded cases without method of estimation will remain in this category.	
9.	Method of estimating dose		62
	1	By air dose alone	
	2	By 9-parameter formula	
	3	By globe application	
	4	Applied average transmission factor derived from the 9-parameter code for cases exposed inside of Japanese type of houses or light constructions for subjects which have no shielding history.	
	0	No method available	
10.	Reserved columns		63-74
11.	Card design number		75-77
	708	For card design number	
12.	Reserved column		78
13.	Surrounding shielding condition		79
	1	Mainly shielded by Japanese-type house	
	3	Solid shield, shielded by terrain	
	4	Solid shield, other than above	
14.	Indication of a card number		80
	2	For card number	

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working card is the master card for the CD575 calculation, which is provided in Figure 11.

Because the globe operation for subjects in concrete buildings separated the fraction of the incident radiation streaming through windows, a better model may be developed to calculate the radiation attenuation to these survivors. This model would consist of a nominal concrete building radiation transport analogue. The calculation of the dose to the survivor would then consist of two separate doses, one from the bulk shielding of the concrete building itself and the other from the radiation streaming through the windows. The actual angular distributions calculated in the FIA transport could be used as source terms for both of these calculations. The data on the window sizes would be obtained from the data contained on the CD575 working card.

Method for Survivors in the Open Shielded by Buildings or Terrain. The globe technique was also used to provide TF for survivors who were in the open but shielded by surrounding buildings or terrain (CD708). The shielding by Japanese houses or other configurations had to be substantial (about 60%) for the application of the globe in this category. Only two types of conditions were considered insofar as calculating the TF through the shielded portion of the hemisphere around the survivor. These conditions were either shielded by a Japanese-type house or by "solid" shielding, such as concrete buildings or a terrace. For the solid shielded cases, the incident radiation in the globe zones and sectors was considered to be entirely blocked. There were approximately 3,000 subjects at Hiroshima and 400 at Nagasaki that were in the open but shielded by Japanese-type buildings.

Figure 12 provides the information coded for subjects in CD708. The complete description required two cards. The first card contains mainly the number of sectors in each zone that were shielded. The second card provides additional information such as sex, city of exposure, coordinates of location ATB, height above sea level, whether the shield is solid or of the typical Japanese house, and class and method of estimating dose. One interesting column is the front and back distances for gamma-ray buildup factors. These columns (55 to 60 of card 2) give the distance from the subject to the nearest object in the front and back. This was coded as zero if the distance was larger than twice the height of the shield for front or equal to the height for the back. (On the visit to Nagasaki in June 1984, Mr. Okamoto and Mr. Yamada of RERF reported that zero was coded if nothing was in a radius of 20 m in front or 10 m in back of the subject.)

Reference

1. Ritchie, R. H. and Hurst, G. S., 1959. Penetration of weapons radiation: application to the Hiroshima-Nagasaki studies. Health Physics 1:390-404.