

Thermoluminescence Dosimetry for Gamma Rays

Table 9. Adjustments made to the measurements of Ichikawa et al. (1966) for this analysis vs. the authors' original adjustments

[The background values shown were subtracted and the authors' correction for induced activation was added back in to the measurement.]

Place	(Gross) "Equivalent gamma doses," R ^a	Gross TL dose, Gy(SiO ₂)	DS02 estimated total annual background dose rate, Gy(SiO ₂)			Age since firing, y			DS02 calculated total back- ground dose, Gy(SiO ₂)	Net in situ dose to quartz, Gy(SiO ₂)	1966	1966
			±	±	±	±	±	estimated dose due to induced activation, R ^{ab}			estimated dose due to induced activation, Gy(SiO ₂) ^b	
Hiroshima												
Zaimokucho, Dempukuji	6600	57.42	0.0033	0.001	400	100	1.32	0.519	56.1		1270	11.049
Zaimokucho, Seiganji	3900	33.93	0.0033	0.001	400	100	1.32	0.519	32.61		1160	10.092
Zaimokucho, Seiganji	3570 ^c	31.059	0.0033	0.001	400	100	1.32	0.519	29.7		(1160) ^c	(10.092)
Zaimokucho, Ninomaru, Hiroshima Castle	4100 1100	35.67 9.57	0.0033 0.0033	0.001 0.001	400 400	100 100	1.32 1.32	0.519 0.519	34.4 8.25		1100 230	9.57 2.001
Ninomaru, Hiroshima Castle	1150	10.005	0.0033	0.001	400	100	1.32	0.519	8.69		230	2.001
Nishishinmachi	930	8.091	0.0033	0.001	150	50	0.495	0.223	7.60		163	1.4181
Nishiteramachi, Koenji	650	5.655	0.0033	0.001	150	50	0.495	0.223	5.16		60	0.522
Nishiteramachi, Shouzenji	530	4.611	0.0033	0.001	150	50	0.495	0.223	4.12		58	0.5046
Honmaru, Hiroshima Castle	620	5.394	0.0033	0.001	400	100	1.32	0.519	4.07		56	0.4872
Honmaru, Hiroshima Castle	410	3.567	0.0033	0.001	400	100	1.32	0.519	2.25		56	0.4872
Honmaru, Hiroshima Castle	400	3.48	0.0033	0.001	400	100	1.32	0.519	2.16		56	0.4872
Nagasaki												
Matsuyamacho	22500	195.75	0.0033	0.001	150	50	0.495	0.223	195		110	0.957
Okamachi	18500	160.95	0.0033	0.001	150	50	0.495	0.223	160		85	0.7395
Okamachi	18200	158.34	0.0033	0.001	150	50	0.495	0.223	158		85	0.7395
Yamazatocho	15600	135.72	0.0033	0.001	150	50	0.495	0.223	135		63	0.5481
Yamazatocho	14200	123.54	0.0033	0.001	150	50	0.495	0.223	123		63	0.5481
Yamazatocho	12400	107.88	0.0033	0.001	150	50	0.495	0.223	107		63	0.5481
Shiroyama ele- mentary school	7840	68.208	0.0033	0.001	36 ⁵	10	0.1188	0.049	68.1		60	0.522
Shiroyamacho	5600	48.72	0.0033	0.001	150	50	0.495	0.223	48.2		48	0.4176
Shiroyamacho	3900	33.93	0.0033	0.001	150	50	0.495	0.223	33.4		22	0.1914
Uenocho	3630	31.581	0.0033	0.001	150	50	0.495	0.223	31.1		14	0.1218
Shiroyamacho	2300	20.01	0.0033	0.001	150	50	0.495	0.223	19.5		8	0.0696
Sakamotocho	1410	12.267	0.0033	0.001	150	50	0.495	0.223	11.8		7	0.0609
Uragamicho	870	7.569	0.0033	0.001	150	50	0.495	0.223	7.07		2	0.0174

^aTaken directly from Ichikawa et al. (1966).

^bNot used in this work.

^cBecause only the "Corrected gamma dose" is given for this entry, the "Equivalent gamma dose" was back-calculated by taking the "Corrected gamma dose," dividing by the noted energy response factor of 1.05 and the shielding factor of 1.09, and adding back an "induced activity" of 1,160 R, which was assumed the same as that reported for the other sample at Seiganji.

Other Corrections and Units Conversions

In the case of the results reported by Hashizume et al. (1967), a correction applied by the authors for angle of incidence, ranging from 1.09 to 1.31, has been removed. It is of course replaced by the implicit modeling of the DS86 calculations. Kaul et al. (1987) had also removed it from the measurements given in Table 10 of Appendix 11. As Hashizume et al. also did not subtract a background estimate from their reported measured values, an estimated background of 0.165 Gy has been subtracted from the measurements, somewhat less than the background of 0.199 Gy subtracted from these same measurements by the authors of Appendix 11. The background estimate used here was obtained by averaging all of the separate measured values for background annual dose rate that are discussed in the section on TLD background of this work, and multiplying by the estimated age of the samples.

No other adjustments were applied, apart from a unit conversion to relate exposure in air (Roentgens) to dose, or dose in one medium to that in another. Unit conversions were applied as was done in Appendix 11 of the DS86 Report.

Results

The calculated building gamma kerma and the calculated total *in situ* dose to quartz are shown for both DS86 and DS02 in Tables 10 and 11, along with the DS02 ground distance that was determined for each sample by map evaluation using GIS. Tables 12 and 13 give 1) the measured values in units of dose to tissue as reported by the authors or as converted from the units reported by using the conversion factors given above, and 2) corrected to a free-in-air-equivalent value at 1 m above ground at the same location, along with 3) measured/calculated ratios. The free-in-air-equivalent measured values are shown in relation to DS86 and DS02 free-in-air calculated values in Figures 17 and 18. The plotted measurements are classified according to the four historical classifications that differentiate the methods used in this section to calculate the *in situ* dose to quartz:

- measurements reported by Ichikawa et al. (1966),
- measurements reported by Hashizume et al. (1967),
- measurements reported in DS86, and
- measurements made since DS86.

It is important to note that these four categories differ markedly in regard to measurement uncertainty. This is particularly true of the 1966 measurements, and to a lesser extent the 1967 measurements, which were made with older methods and are subject to considerably larger errors in the independent variable (distance) than the DS86 and later measurements. These measurements are included here, and extensive efforts have been made to portray them realistically in relation to calculated values, because of the unfortunate lack of DS86 and later measurements at proximal distances, especially in Nagasaki, but they must be regarded with caution.

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Table 10. Sample ground distance and sample-specific calculated dose values for this work: Hiroshima

Lab	Place name	Sample ID#	RERF list No.	DS02 GR (m)	Building gamma		Total dose to quartz at sample height (Gy)	
					DS86	DS02	DS86	DS02
JNIRS	A-bomb Dome			128	16.9	11.7	101	93.0
JNIRS	Togiya-cho Shojun-ji			337	25.6	10.3	65.2	49.4
JNIRS	Nenryo Kaikan (Fuel Authority Bldg)			158	23.3	17.5	66.3	55.8
NUE	Zaimoku cho, Dempuku ji	H-1		410		4.91		32.9
NUE	Zaimoku cho, Seigan ji	H-2		401		5.13		34.1
NUE	Zaimoku cho, Seigan ji	H-2'		401		5.13		34.1
JNIRS	Fukuro-machi East Orthopedic Surgical Hospital			421	7.68	5.78	40.1	35.7
NUE	Zaimoku cho,	H-3		424		4.56		31.1
JNIRS	Naka Telephone Office	3	1-01	521	2.45	1.94	36.2	34.5
JNIRS	Naka Telephone Office	2	1-19	537	2.94	2.35	26.9	25.4
NUE	Naka Telephone Office	203-3	1-04	537	2.59	2.07	32.3	30.7
NUE	Naka Telephone Office	204-2	1-04	537	2.59	2.07	32.3	30.7
NUE	Naka Telephone Office	204-3	1-04	537	2.59	2.07	32.3	30.7
JNIRS	Tate-machi Sanin Godo Bank			624	1.79	1.57	17.2	17.0
JNIRS	Sanin Bank		12-02	630	1.39	1.21	19.1	19.0
JNIRS	Chugoku Elec Co		2_01	670	0.858	0.793	9.04	9.25
JNIRS	Chugoku Elec Co	2	2-03	694	0.857	0.813	9.30	9.64
NUE	Chugoku Electric Co.	3-1-3	2-03	694	0.761	0.722	8.95	9.29
NUE	Chugoku Electric Co.	3-1-3	2-03	694	0.761	0.722	8.95	9.29
NUE	Chugoku Electric Co.	3-2-2	2-03	694	0.761	0.722	8.95	9.29
NUE	Chugoku Electric Co.	3-2-2	2-03	694	0.761	0.722	8.95	9.29
NUE	Chugoku Electric Co.	3-2-3	2-03	694	0.761	0.722	8.95	9.29
JNIRS	Nobori-machi Elementary School			716	0.872	0.821	11.5	11.6
NUE	Hiroshima Castle, ninomaru	H-4		739		0.688		12.6
NUE	Hiroshima Castle, ninomaru	H-4'		739		0.688		12.6
NUE	Nishishin machi ^a	H-5						
NUE	Nishitera machi, koen ji	H-6		977		0.135		4.36
NUE	Hiroshima Castle, honmaru	H-8		1000		0.114		3.96
NUE	Hiroshima Castle, honmaru	H-8'		1000		0.114		3.96
NUE	Hiroshima Castle, honmaru	H-8"		1000		0.114		3.96
JNIRS	City Hall			988	0.096	0.107	3.47	3.57
NUE	Nishitera machi, Shozen ji	H-7		1017		0.101		3.66
NUE	Japanese House (Nobori-cho)		145	1145	0.031	0.033	2.18	2.23
NUE	H.U.P.S. (Hiro. Univ.)	H-1	4-08	1279	0.012	0.014	1.14	1.19
NUE	HUFS "I" Bldg	H1	4-08	1279	0.012	0.014	1.14	1.19
NUE	HUFS "I"	"HP1"		1279		0.015		1.19
NUE	H.U.P.S. (Hiro. Univ.)	H-2	4-07	1290	0.012	0.014	1.11	1.16
NUE	H.U.P.S. (Hiro. Univ.)	H-3	4-09	1305	0.011	0.013	1.03	1.08
NUE	H.U.P.S. (Hiro. Univ.)	H-4	4-01	1324	0.009	0.010	0.962	1.01
NUE	H.U.P.S. (Hiro. Univ.)	H-5	4-03	1346	0.008	0.009	0.848	0.895
NUE	H.U.P.S. (Hiro. Univ.)	H-5B	4-03 horizontal	1346	0.008	0.009	0.761	0.803
NUE	H.U.P.S. (Hiro. Univ.)	H-5B	4-03 vertical	1346	0.008	0.009	0.761	0.803

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Table 10. Continued

Lab	Place name	Sample ID#	RERF list No.	DS02 GR (m)	Building gamma		Total dose to quartz at sample height (Gy)	
					DS86	DS02	DS86	DS02
NUE	H.U.P.S. (Hiro. Univ.)	H-5B	4-03 vertical	1346	0.008	0.009	0.761	0.803
NUE	HUFS "I"	"HP2"		1346		0.009		0.801
JNIRS	H.U.F.S. (Hiro. Univ.)	7	3-07	1385	0.007	0.008	0.743	0.779
NUE	HUFS "E" Bldg	HP1	3-08	1386	0.007	0.008	0.729	0.765
NUE	HUFS "E"	"HP3"		1386		0.006		0.753
JNIRS	H.U.F.S. (Hiro. Univ.)	10	3-10	1395	0.005	0.006	0.688	0.723
NUE	H.U.F.S. (Hiro. Univ.)	H-6-1	3-20	1396	0.005	0.006	0.639	0.671
NUE	H.U.F.S. (Hiro. Univ.)	H-6-2	3-20	1396	0.005	0.006	0.639	0.671
NUE	H.U.F.S. (Hiro. Univ.)	H-6-3	3-20	1396	0.005	0.006	0.639	0.671
NUE	HUFS "E" Bldg	HP2	3-11	1396	0.005	0.006	0.686	0.721
NUE	HUFS "E" Bldg	HP3	(3-11)	1396	0.005	0.006	0.686	0.721
NUE	HUFS "E"	"HP4"		1396		0.006		0.711
NUE	HUFS "E"	"HP5"		1401		0.006		0.729
U of U	H.U.F.S. (Hiro. Univ.)	UHFSO3	3-23	1401	0.005	0.006	0.694	0.728
NUE	H.U.F.S. (Hiro. Univ.)	H-7	3-36	1401	0.005	0.006	0.676	0.709
U of U	H.U.F.S. (Hiro. Univ.)	UHFSO2	3-22	1405	0.005	0.006	0.666	0.699
NUE	H.U.F.S. (Hiro. Univ.)	H-8	3-18	1430	0.004	0.005	0.555	0.583
JNIRS	H.U.F.S. (Hiro. Univ.)	I	3-29	1433	0.004	0.005	0.596	0.626
JNIRS	H.U.F.S. (Hiro. Univ.)	IV	3-31	1434	0.004	0.005	0.581	0.610
NUE	H.U.F.S. (Hiro. Univ.)	H-9	3-17	1436	0.004	0.005	0.527	0.554
JNIRS	Red Cross Hospital		5-01	1456	0.004	0.005	0.509	0.540
NUE	Red Cross Hospital	"HP6"		1456		0.004		0.537
JNIRS	Red Cross Hospital			1456		0.004		0.539
JNIRS	Red Cross Hospital			1456		0.004		0.539
JNIRS	Red Cross Hospital			1456		0.004		0.539
JNIRS	Red Cross Hospital			1456		0.004		0.539
JNIRS	Red Cross Hospital			1456		0.004		0.539
NUE	Red Cross Hospital	HP4	5_01	1457	0.004	0.005	0.530	0.560
JNIRS	H.U.F.S. (Hiro. Univ.)	R1	3-35	1457	0.004	0.005	0.496	0.519
DUR	H.U.F.S. (Hiro. Univ.)	UHFSFT02	3-35	1457	0.004	0.005	0.498	0.521
DUR	H.U.F.S. (Hiro. Univ.)	UHFSFT02	3-35	1457	0.004	0.005	0.498	0.521
OXF	H.U.F.S. (Hiro. Univ.)	UHFSFT03	3-35	1457	0.004	0.005	0.498	0.521
OXF	H.U.F.S. (Hiro. Univ.)	UHFSFT03	3-35	1457	0.004	0.005	0.498	0.521
OXF	H.U.F.S. (Hiro. Univ.)	UHFSFT03	3-35	1457	0.004	0.005	0.498	0.521
U of U	H.U.F.S. (Hiro. Univ.)	UHFSFT02	3-35	1457	0.004	0.005	0.498	0.521
U of U	H.U.F.S. (Hiro. Univ.)	UHFSFT03	3-35	1457	0.004	0.005	0.498	0.521
NUE	H.U.F.S. (Hiro. Univ.)	H-10-1	3-15	1458	0.004	0.005	0.502	0.525
NUE	H.U.F.S. (Hiro. Univ.)	H-10-2	3-15	1458	0.004	0.005	0.502	0.525
NUE	H.U.F.S. (Hiro. Univ.)	H-10-3	3-15	1458	0.004	0.005	0.502	0.525
NUE	H.U.F.S. (Hiro. Univ.)	H-10-4	3-15	1458	0.004	0.005	0.502	0.525
U of U	H.U.F.S. (Hiro. Univ.)	UHFS04	3-24	1464	0.003	0.003	0.520	0.544
U of U	H.U.F.S. (Hiro. Univ.)	UHFS07	3-27	1465	0.003	0.003	0.512	0.536
NUE	H.U.F.S. (Hiro. Univ.)	H-11	3-16	1469	0.003	0.003	0.440	0.460
JNIRS	Hiroshima University Radioisotope Facility			1470		0.003		0.443

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Table 10. Continued

Lab	Place name	Sample ID#	RERF list No.	DS02 GR (m)	Building gamma		Total dose to quartz at sample height (Gy)	
					DS86	DS02	DS86	DS02
JNIRS	Hiroshima University Radioisotope Facility			1475		0.003		0.434
JNIRS	Hiroshima University Radioisotope Facility			1477		0.003		0.430
JNIRS	Red Cross Hospital			1501		0.003		0.446
JNIRS	Red Cross Hospital			1501		0.003		0.446
JNIRS	Red Cross Hospital			1501		0.003		0.446
JNIRS	Red Cross Hospital			1501		0.003		0.446
JNIRS	Red Cross Hospital			1501		0.003		0.446
NUE	Postal Savings (Chokin Kyoku)	A		1596		0.001		0.306
NUE	Chokin-Kyoku (Postal Savings)		6-04	1608	0.001	0.001	0.201	0.212
NUE	Postal Savings (Chokin Kyoku)	B		1607		0.001		0.316
JNIRS	Chokin-Kyoku		6-00	1607	0.001	0.001	0.261	0.279
NUE	Postal Savings (Chokin Kyoku)	D		1619		0.001		0.278
NUE	Postal Savings (Chokin Kyoku)	E		1637		0.001		0.258
NUE	JEMIC	HP7		1788		0.000		0.160
NUE	Myosen-ji "oni-gawara" top	Me-1		1915		0.000		0.077
NUE	Myosen-ji "oni-gawara" bottom	Me-2		1915		0.000		0.077
NUE	Myosen-ji "oni-gawara" top	A-1		1915		0.000		0.077
NUE	Myosen-ji "oni-gawara" bottom	A-2		1915		0.000		0.077
NUE	HUFE clay wall tile	C-1		2050		0.000		0.059
NUE	HUFE clay wall tile	C-2		2050		0.000		0.059
NUE	HUFE clay wall tile	C-3		2050		0.000		0.059
NUE	HUFE	HP5	8-01	2056	<0.001	0.000	0.053	0.057
NUE	HUFE	HP8		2056		0.000		0.057
NUE	Hiramoto "oni-gawara" bottom	Hr-1		2067		0.000		0.045
NUE	Hiramoto "Oni-gawara"	B		2067		0.000		0.045
NUE	Hiramoto Oni-gawara	A1-1		2067		0.000		0.045
NUE	Hiramoto Oni-gawara	A1-2		2067		0.000		0.045
NUE	Hiramoto Oni-gawara	A1-3		2067		0.000		0.045
NUE	Hiramoto Oni-gawara	A2		2067		0.000		0.045
NUE	Hiramoto Oni-gawara	A3		2067		0.000		0.045
NUE	Hiramoto Oni-gawara	A4-1		2067		0.000		0.045
NUE	Hiramoto Oni-gawara	A4-2		2067		0.000		0.045
NUE	Hiramoto Oni-gawara	A5		2067		0.000		0.045

^aCould not be analyzed due to conflicting map information.