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Radiation Safety and Radiologic Technology Pack

Units, dose rates, dose comparisons, nuclear medicine decay and radiography formulas in one printable PDF

For: Radiologic technology and health physics students, radiographers, nuclear medicine and radiation safety staff

allunitconversions.com/radiation-conversion
By Miguel Coelho · Edition 2.0
9 November 2026

Five reference sheets for the department, classroom or survey kit: SI and traditional radiation units with weighting factors, dose-rate conversions with yearly totals, typical doses from imaging and everyday sources, mCi ↔ MBq tables with decay factors for common radionuclides, and radiography formulas with dose limits compared. Each sheet is also available on its own.

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Conversion values in this pack are generated by the AllUnitConversions conversion library and automatically checked against exact definitions (NIST SP 811, BIPM SI Brochure, 1959 International Yard and Pound Agreement) before the PDF is produced. Reference data taken from standards and regulations is cited to its source on each sheet. Free to print, copy and share with attribution (CC BY 4.0).

Printing tip: print double-sided and staple at the top left, or print single sheets from each chart's own page.

Radiation Units Conversion Chart

Exposure, air kerma, absorbed, equivalent and effective dose, and activity in SI and traditional units

For: Radiologic technologists and students, health physicists, nuclear medicine and radiation safety staff

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EXACT DEFINITION	FORMULA	REVERSE	WORKED EXAMPLE
1 Sv = 100 rem; 1 Gy = 100 rad; 1 Ci = 3.7×10^{10} Bq; 1 R = 2.58×10^{-4} C/kg (all exact)	mrem = mSv × 100; MBq = mCi × 37	mSv = mrem ÷ 100; mCi = MBq ÷ 37	2.4 mSv (world average yearly background) = 240 mrem; 10 mCi = 370 MBq

Values use 4 significant figures. Equivalent dose (Sv) = absorbed dose (Gy) × radiation weighting factor.

Which quantity is which

Quantity	SI unit	Traditional unit	Conversion	What it measures
Exposure	coulomb per kilogram (C/kg)	roentgen (R)	1 R = 2.58×10^{-4} C/kg (exact)	Ionisation produced in air by X-rays or gamma rays
Air kerma	gray (Gy)	measured as exposure (R)	1 R ≈ 8.76 mGy	Energy transferred to air; X-ray tube output and calibration
Absorbed dose	gray (Gy = J/kg)	rad	1 Gy = 100 rad; 1 cGy = 1 rad	Energy absorbed per kilogram of any material
Equivalent dose	sievert (Sv)	rem	1 Sv = 100 rem	Absorbed dose in an organ × radiation weighting factor
Effective dose	sievert (Sv)	rem	1 Sv = 100 rem	Whole-body sum of equivalent doses × tissue weighting factors
Activity	becquerel (Bq = 1 decay/s)	curie (Ci)	1 Ci = 3.7×10^{10} Bq (exact)	Decays per second in a radioactive source

Equivalent and effective dose: millisieverts to millirem

Millisieverts (mSv)	Millirem (mrem)	Microsieverts (µSv)
0.001	0.1	1
0.005	0.5	5
0.01	1	10
0.02	2	20
0.05	5	50
0.1	10	100
0.2	20	200
0.5	50	500
1	100	1,000
2	200	2,000

Millisieverts (mSv)	Millirem (mrem)	Microsieverts (µSv)
2.4	240	2,400
3	300	3,000
5	500	5,000
10	1,000	10,000
20	2,000	20,000
50	5,000	50,000
100	10,000	100,000
250	25,000	250,000
500	50,000	500,000
1,000	100,000	1×10^6

Millirem and rem to millisieverts

Millirem (mrem)	Millisieverts (mSv)	Rem (rem)
1	0.01	0.001
5	0.05	0.005
10	0.1	0.01
25	0.25	0.025
50	0.5	0.05

Millirem (mrem)	Millisieverts (mSv)	Rem (rem)
500	5	0.5
1,000	10	1
2,000	20	2
5,000	50	5
10,000	100	10

Millirem (mrem)	Millisieverts (mSv)	Rem (rem)
100	1	0.1
200	2	0.2
300	3	0.3

Millirem (mrem)	Millisieverts (mSv)	Rem (rem)
25,000	250	25
100,000	1,000	100

Absorbed dose: gray to rad

Radiotherapy often uses centigray: 1 cGy = 1 rad.

Gray (Gy)	Rad (rad)	Milligray (mGy)
0.001	0.1	1
0.01	1	10
0.05	5	50
0.1	10	100
0.5	50	500
1	100	1,000

Gray (Gy)	Rad (rad)	Milligray (mGy)
2	200	2,000
5	500	5,000
10	1,000	10,000
20	2,000	20,000
50	5,000	50,000
70	7,000	70,000

Exposure: milliroentgen to C/kg and air kerma

Exposure (mR)	µC/kg	Air kerma (mGy)
1	0.258	0.008764
10	2.58	0.08764
50	12.9	0.4382
100	25.8	0.8764
500	129	4.382
1,000	258	8.764
2,000	516	17.53
5,000	1,290	43.82
10,000	2,580	87.64

Activity: millicuries to megabecquerels

Millicuries (mCi)	Megabecquerels (MBq)	Becquerels (Bq)
0.001	0.037	37,000
0.01	0.37	370,000
0.1	3.7	3.7×10^{6}
0.5	18.5	1.85×10^{7}
1	37	3.7×10^{7}
5	185	1.85×10^{8}
10	370	3.7×10^{8}

Millicuries (mCi)	Megabecquerels (MBq)	Becquerels (Bq)
20	740	7.4×10^{8}
25	925	9.25×10^{8}
30	1,110	1.11×10^{9}
50	1,850	1.85×10^{9}
100	3,700	3.7×10^{9}
200	7,400	7.4×10^{9}

Activity and exposure factors

From	To	Multiply by
Curies (Ci)	Becquerels (Bq)	3.7×10^{10}
Microcuries (µCi)	Becquerels (Bq)	37,000
Becquerels (Bq)	Microcuries (µCi)	2.702703×10^{-5}
Roentgen (R)	Coulombs per kilogram (C/kg)	2.58×10^{-4}
Coulombs per kilogram (C/kg)	Roentgen (R)	3,875.969

Radiation weighting factors (ICRP 103)

Radiation type	Weighting factor wR
Photons (X-rays and gamma rays)	1
Electrons and muons (beta)	1
Protons and charged pions	2
Alpha particles, fission fragments, heavy ions	20
Neutrons	2.5 to 20, a continuous function of neutron energy

When are R, rad and rem about equal?

Radiation	Relationship
X-rays and gamma rays	1 R gives ≈ 0.876 rad in air, and wR = 1 makes 1 rad = 1 rem, so "1 R ≈ 1 rad ≈ 1 rem" is a common approximation
Beta particles	wR = 1: 1 rad of absorbed dose = 1 rem of equivalent dose
Alpha particles	wR = 20: 1 rad (10 mGy) of absorbed dose = 20 rem (200 mSv) of equivalent dose
Neutrons	wR between 2.5 and 20 depending on energy; never assume 1 rad = 1 rem

Sources and method

- **BIPM SI Brochure, 9th edition** — Definitions of the SI units, including the kelvin (www.bipm.org/en/publications/si-brochure)
- **NIST Special Publication 811** — Guide for the Use of the International System of Units (www.nist.gov/pml/special-publication-811)
- **ICRP Publication 103 (2007)** — Radiation weighting factors and dose limits; lens of the eye per ICRP Publication 118 (2011) (www.icrp.org/publication.asp?id=ICRP%20Publication%20103)
- **ICRU Report 90 (2016)** — W(air)/e = 33.97 J/C, so 1 R = 8.764 mGy air kerma

Unit conversions are generated by the AllUnitConversions conversion library and checked against the exact definitions above; MBq and air-kerma columns are calculated from the defining constants; weighting factors are from ICRP 103. Interactive version, corrections and more charts: **allunitconversions.com/radiation-conversion-chart**

Radiation Dose Rate Chart

µSv/h, mrem/h and mR/h with yearly totals, time to 1 mSv and reference levels

For: Radiation safety staff, survey-meter and Geiger counter users, students and travellers

allunitconversions.com/radiation-dose-rate-chart
By Miguel Coelho · Edition 2.0
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EXACT DEFINITION	FORMULA	REVERSE	WORKED EXAMPLE
1 µSv/h = 0.1 mrem/h = 100 µrem/h (exact)	mSv per year = µSv/h × 8.766 (continuous exposure)	µSv/h = mrem/h × 10	0.2 µSv/h for a whole year = 0.2 × 8.766 = 1.75 mSv

Values use 4 significant figures (time to 1 mSv: 3). A year is taken as 8,766 hours (365.25 days).

Microsieverts per hour to mrem/h, yearly dose and time to 1 mSv

Dose rate (µSv/h)	mrem/h (≈ mR/h for gamma)	mSv per year (continuous)	Hours to receive 1 mSv
0.01	0.001	0.08766	100,000
0.05	0.005	0.4383	20,000
0.1	0.01	0.8766	10,000
0.15	0.015	1.315	6,670
0.2	0.02	1.753	5,000
0.3	0.03	2.63	3,330
0.5	0.05	4.383	2,000
1	0.1	8.766	1,000
2	0.2	17.53	500
3	0.3	26.3	333
5	0.5	43.83	200
10	1	87.66	100
20	2	175.3	50
50	5	438.3	20
100	10	876.6	10
250	25	2,192	4
500	50	4,383	2
1,000	100	8,766	1
10,000	1,000	87,660	0.1

mrem/h (or mR/h for gamma) to µSv/h

Dose rate (mrem/h)	µSv/h	mSv/h
0.001	0.01	1×10^{-5}
0.002	0.02	2×10^{-5}
0.005	0.05	5×10^{-5}
0.01	0.1	1×10^{-4}
0.02	0.2	2×10^{-4}
0.05	0.5	5×10^{-4}
0.1	1	0.001
0.2	2	0.002
0.5	5	0.005

Dose rate (mrem/h)	µSv/h	mSv/h
1	10	0.01
2	20	0.02
5	50	0.05
10	100	0.1
25	250	0.25
50	500	0.5
100	1,000	1
1,000	10,000	10

Dose units for rate readings

From	To	Multiply by
Microsieverts (µSv)	Millirem (mrem)	0.1
Millirem (mrem)	Microsieverts (µSv)	10
Millisieverts (mSv)	Millirem (mrem)	100
Rem (rem)	Millisieverts (mSv)	10

Reference doses as average dose rates

Reference	Dose	Average rate
Public dose limit, planned exposures (ICRP 103)	1 mSv per year	0.114 µSv/h, continuous
World average natural background (UNSCEAR 2008)	2.4 mSv per year	0.27 µSv/h averaged over a year
UK average, all sources (UKHSA)	2.6 mSv per year	0.30 µSv/h averaged over a year
US average, including medical (NCRP 160)	6.2 mSv per year	0.71 µSv/h averaged over a year
Occupational limit (ICRP 103)	20 mSv per year	10 µSv/h over 2,000 working hours

Reading a survey meter or Geiger counter

Point	What to know
Counts per minute (CPM)	CPM is not a dose rate. The conversion depends on the tube and the isotope; use the factor in your meter's manual.
µR/h and µSv/h	For gamma rays, 1 µR/h ≈ 0.01 µSv/h is a common approximation (1 R = 8.76 mGy air kerma).
Background readings	Averages above include radon breathed in, which a gamma meter does not detect, so typical meter readings are lower.
Dose from a rate	Dose (µSv) = dose rate (µSv/h) × time (h).
Distance	From a small source, the dose rate falls with the square of distance: twice as far gives a quarter of the rate.

Sources and method

- **NIST Special Publication 811** — Guide for the Use of the International System of Units (www.nist.gov/pml/special-publication-811)
- **ICRP Publication 103 (2007)** — Radiation weighting factors and dose limits; lens of the eye per ICRP Publication 118 (2011) (www.icrp.org/publication.asp?id=ICRP%20Publication%20103)
- **UNSCEAR 2008 Report, Volume I** — World average natural background 2.4 mSv per year (www.unscear.org/unscear/en/publications/2008_1.html)
- **UKHSA, Ionising radiation: dose comparisons (updated 28 September 2026)** — Contains public sector information licensed under the Open Government Licence v3.0 (www.gov.uk/government/publications/ionising-radiation-dose-comparisons/ionising-radiation-dose-comparisons)
- **NCRP Report No. 160 (2009)** — US average annual exposure 6.2 mSv, including medical
- **ICRU Report 90 (2016)** — W(air)/e = 33.97 J/C, so 1 R = 8.764 mGy air kerma

Rate conversions follow from 1 Sv = 100 rem exactly; yearly totals use 8,766 hours; reference doses are quoted from the sources listed and converted to average rates. Interactive version, corrections and more charts: **allunitconversions.com/radiation-dose-rate-chart**

Radiation Dose Chart

Typical doses from X-rays, CT, mammography, nuclear medicine and everyday sources, in mSv and mrem

For: Patients, students, radiographers, teachers and anyone comparing radiation doses

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EXACT DEFINITION	FORMULA	REVERSE	WORKED EXAMPLE
1 mSv = 100 mrem. Effective dose lets exposures of different body parts be compared on one scale	Comparable background time = dose ÷ yearly natural background dose	Dose = background dose per year × time	CT chest 6.1 mSv ÷ 3 mSv per year ≈ 2 years of US natural background

Typical adult values from the cited sources. Real doses vary with body size, equipment and protocol; children differ from adults.

Medical imaging: typical adult effective doses (RadiologyInfo, US)

Background time uses 3 mSv per year and chest X-ray equivalents use 0.1 mSv, the basis of this source.

Exam	Effective dose	mrem	Comparable natural background	Chest X-ray equivalents
Extremity X-ray (hand, foot)	< 0.001 mSv	< 0.1	< 3 hours	< 0.01
Bone densitometry (DEXA)	0.001 mSv	0.1	3 hours	0.01
Dental X-ray (intraoral)	0.005 mSv	0.5	15 hours	0.05
Panoramic dental X-ray	0.025 mSv	2.5	3 days	0.25
Chest X-ray	0.1 mSv	10	12 days	1
Dental cone beam CT	0.18 mSv	18	22 days	1.8
Screening digital mammography	0.28 mSv	28	34 days	2.8
Breast tomosynthesis (3D mammogram)	0.34 mSv	34	41 days	3.4
CT head and neck	1.2 mSv	120	4.8 months	12
Lumbar spine X-ray	1.4 mSv	140	5.6 months	14
CT lung cancer screening	1.5 mSv	150	6 months	15
CT brain	1.6 mSv	160	6.4 months	16
Cardiac CT for calcium scoring	1.7 mSv	170	6.8 months	17
Intravenous urography (IVU)	3 mSv	300	1 year	30
CT brain, with and without contrast	3.2 mSv	320	1.1 years	32
Non-cardiac CT angiography	5.1 mSv	510	1.7 years	51
CT colonography	6 mSv	600	2 years	60
Barium enema (lower GI X-ray)	6 mSv	600	2 years	60
Upper GI study with barium	6 mSv	600	2 years	60
CT chest	6.1 mSv	610	2 years	61
CT abdomen and pelvis	7.7 mSv	770	2.6 years	77
Coronary CT angiography	8.7 mSv	870	2.9 years	87
CT spine	8.8 mSv	880	2.9 years	88
CT abdomen and pelvis, with and without contrast	15.4 mSv	1,540	5.1 years	150
PET/CT, whole body	22.7 mSv	2,270	7.6 years	230

Everyday sources and reference doses (UKHSA, UK)

Background time uses the UK average of 2.6 mSv per year; chest X-ray equivalents use 0.014 mSv, the UKHSA figure.

Source of exposure	Dose	mrem	Equivalent UK background	Chest X-ray equivalents
Dental X-ray	0.005 mSv	0.5	17 hours	0.36
100 g of Brazil nuts	0.01 mSv	1	1.4 days	0.71
Chest X-ray	0.014 mSv	1.4	2 days	1
Transatlantic flight	0.08 mSv	8	11 days	5.7
Nuclear power station worker, average annual occupational dose (2010)	0.18 mSv	18	25 days	13
UK annual average radon dose	1.3 mSv	130	6 months	93
CT scan of the head	1.4 mSv	140	6.5 months	100
UK average annual radiation dose	2.6 mSv	260	1 year	190
USA average annual radiation dose	6.2 mSv	620	2.4 years	440
CT scan of the chest	6.6 mSv	660	2.5 years	470
Average annual radon dose to people in Cornwall	6.9 mSv	690	2.7 years	490
CT scan of the whole spine	10 mSv	1,000	3.8 years	710
Annual exposure limit for nuclear industry employees	20 mSv	2,000	7.7 years	1,400
Level at which changes in blood cells can be readily observed	100 mSv	10,000	—	—
Acute radiation effects, including nausea and a reduced white blood cell count	1,000 mSv	100,000	—	—
Dose that would kill about half of those receiving it within a month	5,000 mSv	500,000	—	—

Reading these numbers

Point	Why it matters
Compare within one table	Published typical doses differ between countries and sources (a chest X-ray is 0.1 mSv in the US table and 0.014 mSv in the UK table). Compare exams using the same table.
Effective dose	A radiation-protection quantity for comparing exposures, not an exact measure of one person's risk.
Children and pregnancy	Doses for children differ from adult values. Tell the radiographer if you are or may be pregnant.
Your own exam	This chart is for education, not medical advice. Ask your doctor or radiographer about the benefit and dose of a specific exam.

Sources and method

- **RadiologyInfo.org (ACR and RSNA), Radiation Dose in X-Ray and CT Exams (reviewed 15 April 2025)** — Typical adult effective doses; comparable background based on about 3 mSv per year (www.radiologyinfo.org/en/info/safety-xray)
- **UKHSA, Ionising radiation: dose comparisons (updated 28 September 2026)** — Contains public sector information licensed under the Open Government Licence v3.0 (www.gov.uk/government/publications/ionising-radiation-dose-comparisons/ionising-radiation-dose-comparisons)
- **ICRP Publication 103 (2007)** — Radiation weighting factors and dose limits; lens of the eye per ICRP Publication 118 (2011) (www.icrp.org/publication.asp?id=ICRP%20Publication%20103)

Doses are transcribed from the sources listed; the mrem, background-time and chest X-ray columns are calculated from them on the basis stated above each table. Interactive version, corrections and more charts: **allunitconversions.com/radiation-dose-chart**

Nuclear Medicine Decay and Activity Chart

mCi ↔ MBq tables and decay factors for Tc-99m, F-18, Ga-68, I-123, I-131 and Lu-177

For: Nuclear medicine technologists and students, radiopharmacists and medical physicists

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EXACT DEFINITION	FORMULA	REVERSE	WORKED EXAMPLE
1 mCi = 37 MBq exactly (1 Ci = 3.7×10^{10} Bq)	$A = A_0 \times 2^{(-t \div T½)}$	$t = T½ \times \log_2(A_0 \div A)$	Tc-99m: after 3 h, $2^{(-3 \div 6.0072)} = 0.7074$, so 70.7% remains

Decay fractions to 4 decimal places. Half-lives from the IAEA Live Chart of Nuclides (ENSDF).

Half-lives of common medical radionuclides

Nuclide	Half-life	Decay constant λ	Typical use
F-18	109.77 min	0.3789 per hour	PET imaging (FDG and other tracers)
Ga-68	67.71 min	0.6142 per hour	PET imaging (PSMA, somatostatin receptors)
Tc-99m	6.0072 h	0.1154 per hour	SPECT and planar imaging (bone, cardiac, renal, thyroid)
I-123	13.2230 h	0.05242 per hour	Thyroid imaging and uptake
Y-90	64.05 h	0.01082 per hour	Liver radioembolisation
In-111	2.8047 d	0.0103 per hour	SPECT (labelled white cells, octreotide)
Tl-201	3.0420 d	0.009494 per hour	Myocardial perfusion (legacy)
Ga-67	3.2617 d	0.008855 per hour	Infection and lymphoma imaging
Xe-133	5.2475 d	0.005504 per hour	Lung ventilation imaging
Lu-177	6.6443 d	0.004347 per hour	Radionuclide therapy (PSMA, somatostatin receptors)
I-131	8.0252 d	0.003599 per hour	Thyroid therapy and imaging

Millicuries to megabecquerels

Millicuries (mCi)	Megabecquerels (MBq)	Gigabecquerels (GBq)
0.1	3.7	0.0037
0.25	9.25	0.0093
0.5	18.5	0.0185
1	37	0.037
2	74	0.074
3	111	0.111
4	148	0.148
5	185	0.185
6	222	0.222
8	296	0.296

Millicuries (mCi)	Megabecquerels (MBq)	Gigabecquerels (GBq)
10	370	0.37
12	444	0.444
15	555	0.555
20	740	0.74
25	925	0.925
30	1,110	1.11
40	1,480	1.48
50	1,850	1.85
100	3,700	3.7
200	7,400	7.4

Megabecquerels to millicuries

Megabecquerels (MBq)	Millicuries (mCi)
1	0.027
10	0.27
37	1
50	1.351

Megabecquerels (MBq)	Millicuries (mCi)
370	10
400	10.811
500	13.514
555	15

Megabecquerels (MBq)	Millicuries (mCi)
74	2
100	2.703
150	4.054
185	5
200	5.405
250	6.757

Megabecquerels (MBq)	Millicuries (mCi)
740	20
925	25
1,000	27.027
1,110	30
3,700	100
7,400	200

Tc-99m decay (half-life 6.0072 h)

Hours elapsed	Fraction remaining	Percent remaining
0	1.0000	100.0
0.5	0.9439	94.4
1	0.8910	89.1
1.5	0.8411	84.1
2	0.7939	79.4
2.5	0.7494	74.9
3	0.7074	70.7
3.5	0.6677	66.8
4	0.6303	63.0
4.5	0.5950	59.5
5	0.5616	56.2
5.5	0.5301	53.0
6	0.5004	50.0
6.5	0.4724	47.2
7	0.4459	44.6
7.5	0.4209	42.1
8	0.3973	39.7

Hours elapsed	Fraction remaining	Percent remaining
8.5	0.3750	37.5
9	0.3540	35.4
9.5	0.3341	33.4
10	0.3154	31.5
10.5	0.2977	29.8
11	0.2810	28.1
11.5	0.2653	26.5
12	0.2504	25.0
12.5	0.2364	23.6
13	0.2231	22.3
13.5	0.2106	21.1
14	0.1988	19.9
14.5	0.1877	18.8
15	0.1771	17.7
15.5	0.1672	16.7
16	0.1578	15.8
16.5	0.1490	14.9

Hours elapsed	Fraction remaining	Percent remaining
17	0.1406	14.1
17.5	0.1328	13.3
18	0.1253	12.5
18.5	0.1183	11.8
19	0.1117	11.2
19.5	0.1054	10.5
20	0.0995	9.9
20.5	0.0939	9.4
21	0.0886	8.9
21.5	0.0837	8.4
22	0.0790	7.9
22.5	0.0746	7.5
23	0.0704	7.0
23.5	0.0664	6.6
24	0.0627	6.3

F-18 decay (half-life 109.77 min)

Minutes elapsed	Fraction remaining	Percent remaining
0	1.0000	100.0
10	0.9388	93.9
20	0.8814	88.1
30	0.8274	82.7
40	0.7768	77.7
50	0.7293	72.9
60	0.6846	68.5
70	0.6427	64.3
80	0.6034	60.3
90	0.5665	56.6
100	0.5318	53.2
110	0.4993	49.9
120	0.4687	46.9
130	0.4400	44.0
140	0.4131	41.3

Minutes elapsed	Fraction remaining	Percent remaining
160	0.3641	36.4
170	0.3418	34.2
180	0.3209	32.1
190	0.3013	30.1
200	0.2828	28.3
210	0.2655	26.6
220	0.2493	24.9
230	0.2340	23.4
240	0.2197	22.0
250	0.2063	20.6
260	0.1936	19.4
270	0.1818	18.2
280	0.1707	17.1
290	0.1602	16.0
300	0.1504	15.0

Minutes elapsed	Fraction remaining	Percent remaining
150	0.3878	38.8

Ga-68 decay (half-life 67.71 min)

Minutes elapsed	Fraction remaining	Percent remaining
0	1.0000	100.0
10	0.9027	90.3
20	0.8149	81.5
30	0.7356	73.6
40	0.6640	66.4
50	0.5994	59.9
60	0.5411	54.1
70	0.4884	48.8
80	0.4409	44.1
90	0.3980	39.8
100	0.3593	35.9
110	0.3243	32.4
120	0.2927	29.3

Minutes elapsed	Fraction remaining	Percent remaining
130	0.2643	26.4
140	0.2385	23.9
150	0.2153	21.5
160	0.1944	19.4
170	0.1755	17.5
180	0.1584	15.8
190	0.1430	14.3
200	0.1291	12.9
210	0.1165	11.7
220	0.1052	10.5
230	0.0949	9.5
240	0.0857	8.6

I-123 decay (half-life 13.2230 h)

Hours elapsed	Fraction remaining	Percent remaining
0	1.0000	100.0
2	0.9005	90.0
4	0.8108	81.1
6	0.7301	73.0
8	0.6575	65.7
10	0.5920	59.2
12	0.5331	53.3
14	0.4800	48.0
16	0.4323	43.2
18	0.3892	38.9
20	0.3505	35.0
22	0.3156	31.6
24	0.2842	28.4

Hours elapsed	Fraction remaining	Percent remaining
26	0.2559	25.6
28	0.2304	23.0
30	0.2075	20.8
32	0.1869	18.7
34	0.1683	16.8
36	0.1515	15.2
38	0.1364	13.6
40	0.1228	12.3
42	0.1106	11.1
44	0.0996	10.0
46	0.0897	9.0
48	0.0808	8.1

I-131 decay (half-life 8.0252 d)

Days elapsed	Fraction remaining	Percent remaining
0	1.0000	100.0
2	0.8414	84.1
4	0.7079	70.8
6	0.5956	59.6
8	0.5011	50.1
10	0.4216	42.2
12	0.3547	35.5
14	0.2984	29.8
16	0.2511	25.1

Days elapsed	Fraction remaining	Percent remaining
30	0.0749	7.5
32	0.0630	6.3
34	0.0530	5.3
36	0.0446	4.5
38	0.0375	3.8
40	0.0316	3.2
42	0.0266	2.7
44	0.0224	2.2
46	0.0188	1.9

Days elapsed	Fraction remaining	Percent remaining
18	0.2113	21.1
20	0.1777	17.8
22	0.1495	15.0
24	0.1258	12.6
26	0.1059	10.6
28	0.0891	8.9
48	0.0158	1.6
50	0.0133	1.3
52	0.0112	1.1
54	0.0094	0.9
56	0.0079	0.8

Lu-177 decay (half-life 6.6443 d)

Days elapsed	Fraction remaining	Percent remaining
0	1.0000	100.0
2	0.8117	81.2
4	0.6588	65.9
6	0.5348	53.5
8	0.4341	43.4
10	0.3523	35.2
12	0.2860	28.6
14	0.2321	23.2
16	0.1884	18.8
18	0.1529	15.3
20	0.1241	12.4
22	0.1008	10.1
24	0.0818	8.2
26	0.0664	6.6
28	0.0539	5.4
30	0.0437	4.4
32	0.0355	3.5
34	0.0288	2.9
36	0.0234	2.3
38	0.0190	1.9
40	0.0154	1.5
42	0.0125	1.3

Effective dose from an administered activity

Step	Detail
Formula	Effective dose (mSv) = administered activity (MBq) × dose coefficient (mSv/MBq)
Coefficients	ICRP Publication 128 tabulates dose coefficients by radiopharmaceutical for adults and children.
Worked example	370 MBq of F-18 FDG × 0.019 mSv/MBq (adult) = 7.0 mSv
Clinical use	For reference and teaching. Prescribe and verify activities with local protocols and a calibrated dose calibrator.

Sources and method

- **IAEA Live Chart of Nuclides (ENSDF evaluations, retrieved 9 November 2026)** — Half-lives of the radionuclides listed (www-nds.iaea.org/relnsd/vcharthtml/VChartHTML.html)
- **NIST Special Publication 811** — Guide for the Use of the International System of Units (www.nist.gov/pml/special-publication-811)
- **ICRP Publication 128 (2015)** — Radiation dose to patients from radiopharmaceuticals (dose coefficients)

Decay factors are calculated as 2^(−t ÷ T½) from the half-lives listed; mCi ↔ MBq uses 1 mCi = 37 MBq exactly. Interactive version, corrections and more charts: **allunitconversions.com/nuclear-medicine-decay-chart**

Radiography Formulas and Dose Limits Chart

Inverse square law, exposure formulas, grid factors, half-value layers and dose limits compared

For: Radiologic technology students, radiographers and radiation safety officers

allunitconversions.com/radiography-formulas-chart
By Miguel Coelho · Edition 2.0
9 November 2026

EXACT DEFINITION	FORMULA	REVERSE	WORKED EXAMPLE
From a point source, intensity is proportional to 1 ÷ distance^2	$I_2 = I_1 \times (d_1 \div d_2)^2$	$mAs_2 = mAs_1 \times (d_2 \div d_1)^2$ (to keep the same image exposure)	Moving from 1 m to 2 m cuts the dose rate to ¼; keeping image exposure at the longer SID needs 4 × the mAs

Factors to 4 significant figures. The 15% rule and grid factors are standard approximations.

Inverse square law factors

Distance ratio $d_2 \div d_1$	Dose rate factor $(d_1 \div d_2)^2$	mAs factor to keep exposure	Distance ratio $d_2 \div d_1$	Dose rate factor $(d_1 \div d_2)^2$	mAs factor to keep exposure
0.25	16	0.0625	**1.8**	0.3086	3.24
0.5	4	0.25	**2**	0.25	4
0.75	1.778	0.5625	**2.5**	0.16	6.25
1	1	1	**3**	0.1111	9
1.25	0.64	1.563	**4**	0.0625	16
1.5	0.4444	2.25	**5**	0.04	25
1.75	0.3265	3.063	**10**	0.01	100

Exposure and geometry formulas

Relationship	Formula	Worked example
mAs	mAs = mA × exposure time (s)	200 mA × 0.1 s = 20 mAs
Exposure maintenance	$mAs_2 = mAs_1 \times (SID_2 \div SID_1)^2$	10 mAs at 100 cm → 32.4 mAs at 180 cm
15% rule	+15% kVp ≈ doubles exposure to the image receptor; −15% kVp ≈ halves it	70 kVp + 15% = 80.5 kVp with half the mAs
Grid conversion	$mAs_2 = mAs_1 \times (GCF_2 \div GCF_1)$	5 mAs with no grid → 25 mAs with a 12:1 grid (GCF 5)
Magnification factor	MF = SID ÷ SOD	SID 100 cm, SOD 80 cm → MF 1.25
Object size	Object size = image size ÷ MF	50 mm image ÷ 1.25 = 40 mm
Heat units	HU = kVp × mA × s × c (c = 1 single-phase, 1.35 three-phase, 1.4 high-frequency)	80 kVp × 200 mA × 0.1 s × 1.4 = 2,240 HU

Grid conversion factors (GCF)

Grid ratio	GCF
No grid	1
5:1	2
6:1	3
8:1	4
12:1	5
16:1	6

Half-value layers: fraction transmitted

One tenth-value layer ≈ 3.32 half-value layers.

Number of HVLs	Fraction transmitted	Percent transmitted	Number of HVLs	Fraction transmitted	Percent transmitted
0	1	100	**5**	0.03125	3.13
1	0.5	50	**6**	0.01563	1.56
2	0.25	25	**7**	0.007813	0.781
3	0.125	12.5	**8**	0.003906	0.391
4	0.0625	6.25	**10**	9.766×10^{-4}	0.0977

Dose limits compared

Limit (per year unless stated)	ICRP 103 (international)	US NRC 10 CFR 20	NCRP Report 116 (US guidance)
Occupational, effective dose	20 mSv averaged over 5 years; at most 50 mSv in any year	50 mSv (5 rem)	50 mSv; cumulative 10 mSv × age in years
Lens of the eye	20 mSv averaged over 5 years; at most 50 mSv in any year (ICRP 118)	150 mSv (15 rem)	150 mSv
Skin, hands and feet	500 mSv	500 mSv (50 rem)	500 mSv
Public, effective dose	1 mSv	1 mSv (0.1 rem)	1 mSv continuous; 5 mSv infrequent
Embryo or fetus (declared pregnancy)	1 mSv for the rest of the pregnancy	5 mSv (0.5 rem) over the whole pregnancy	0.5 mSv per month

ALARA: time, distance, shielding

Principle	Rule of thumb
Time	Dose = dose rate × time: halve the time, halve the dose.
Distance	Inverse square law: double the distance, a quarter of the dose rate.
Shielding	Each half-value layer halves the intensity; n HVLs transmit $(½)^n$.

Sources and method

- **Standard radiographic technique relationships** — As taught in radiologic technology programmes (e.g. Bushong, Radiologic Science for Technologists)
- **ICRP Publication 103 (2007)** — Radiation weighting factors and dose limits; lens of the eye per ICRP Publication 118 (2011) (www.icrp.org/publication.asp?id=ICRP%20Publication%20103)
- **US NRC, 10 CFR Part 20** — Occupational (20.1201), embryo/fetus (20.1208) and public (20.1301) dose limits (www.nrc.gov/reading-rm/doc-collections/cfr/part020/full-text.html)
- **NCRP Report No. 116 (1993)** — Limitation of exposure to ionizing radiation (US guidance)

Inverse-square and half-value-layer factors are calculated exactly; formulas and grid factors are standard radiographic relationships; dose limits are quoted from the documents listed. Interactive version, corrections and more charts: **allunitconversions.com/radiography-formulas-chart**