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ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
Al	aluminum
AP	anterior-posterior
cm	centimeter
DCF	dose conversion factor
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
ESE	entrance skin exposure
GSD	GEOMETRIC Standard Deviation
Gy	gray
HVL	half-value layer
ICRP	International Commission on Radiological Protection
IREP	Interactive RadioEpidemiological Program
in	inch
kV	kilovolt
kVp	kilovolt-peak
LAT	lateral
mA	milliampere
mAs	milliampere-second
mC	millicoulomb
mGy	milligray
mm	millimeter
mR	milliroentgen
NCRP	National Council on Radiation Protection and Measurements
NIOSH	National Institute for Occupational Safety and Health
PA	posterior-anterior
R	roentgen
s	second
SID	source-to-image distance
SPD	site profile document
SSD	source-to-skin distance
TBD	technical basis document
U.S.C.	United States Code
yr	year

3.1 INTRODUCTION

Technical basis documents (TBDs) and Site Profile documents are general working documents that provide guidance concerning the preparation of dose reconstructions at particular sites or categories of sites. They will be revised in the event additional relevant information is obtained about the affected site(s). These documents may be used to assist NIOSH in the completion of the individual work required for each dose reconstruction.

In this document the word “facility” is used as a general term for an area, building, or group of buildings that served a specific purpose at a site. It does not necessarily connote an “atomic weapons employer facility” or a “Department of Energy [DOE] facility” as defined in the Energy Employees Occupational Illness Compensation Program Act [EEOICPA; 42 U.S.C. § 73841(5) and (12)]. EEOICPA defines a DOE facility as “any building, structure, or premise, including the grounds upon which such building, structure, or premise is located … in which operations are, or have been, conducted by, or on behalf of, the Department of Energy (except for buildings, structures, premises, grounds, or operations … pertaining to the Naval Nuclear Propulsion Program)” [42 U.S.C. § 73841(12)]. Accordingly, except for the exclusion for the Naval Nuclear Propulsion Program noted above, any facility that performs or performed DOE operations of any nature whatsoever is a DOE facility encompassed by EEOICPA.

For employees of DOE or its contractors with cancer, the DOE facility definition only determines eligibility for a dose reconstruction, which is a prerequisite to a compensation decision (except for members of the Special Exposure Cohort). The compensation decision for cancer claimants is based on a section of the statute entitled “Exposure in the Performance of Duty.” That provision [42 U.S.C. § 7384n(b)] says that an individual with cancer “shall be determined to have sustained that cancer in the performance of duty for purposes of the compensation program if, and only if, the cancer … was at least as likely as not related to employment at the facility [where the employee worked], as determined in accordance with the [probability of causation] guidelines established under subsection (c) ….” [42 U.S.C. § 7384n(b)]. Neither the statute nor the probability of causation guidelines (nor the dose reconstruction regulation) define “performance of duty” for DOE employees with a covered cancer or restrict the “duty” to nuclear weapons work.

As noted above, the statute includes a definition of a DOE facility that excludes “buildings, structures, premises, grounds, or operations covered by Executive Order No. 12344, dated February 1, 1982 (42 U.S.C. 7158 note), pertaining to the Naval Nuclear Propulsion Program” [42 U.S.C. § 7384l(12)]. While this definition contains an exclusion with respect to the Naval Nuclear Propulsion Program, the section of EEOICPA that deals with the compensation decision for covered employees with cancer [i.e., 42 U.S.C. § 7384n(b), entitled “Exposure in the Performance of Duty”] does not contain such an exclusion. Therefore, the statute requires NIOSH to include all radiation exposures in its dose reconstructions for employees at DOE facilities, including radiation exposures related to the Naval Nuclear Propulsion Program. As a result, all internal and external dosimetry results are considered valid for use in dose reconstruction. No efforts are made to determine the eligibility of any fraction of total measured exposure for inclusion in dose reconstruction.

Diagnostic X-ray procedures contributed to the radiation exposure received by workers from their employment at the Pantex Plant. In general, doses from these medical procedures were not included as part of the occupational recorded dose, although they were clearly related to occupation. NIOSH, in its role to reconstruct occupational dose under the EEOICPA, has classified diagnostic medical X-rays administered in conjunction with routine or special physical examinations required for employment as occupational exposures (NIOSH 2002). This TBD describes recommended options to conduct dose reconstruction for Pantex workers from medical X-rays administered before, during, and at termination of employment as a condition of employment. Background information on X-ray doses can be found in *Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-ray Procedures* (ORAU 2003).

3.2 EXAMINATION TYPES AND FREQUENCIES

Pantex required preemployment and routine physical examinations as part of its occupational health and safety program. The Medical Department maintains a log for each worker of what appears to be all X-ray examinations. An inspection of the logs for selected long-term workers showed that there was not a consistent pattern in the frequency of their examinations. Based on this inspection, practices apparently varied among workers, probably based on occupation and job responsibilities. Table 3-1 summarizes general patterns and default dose reconstruction recommendations.

Table 3-1. Pantex worker x-ray examinations.

Period	Examination	Frequency	Default dose reconstruction recommendation
1952-81	Chest PA	For some workers, on employment and annual	Use log of X-ray examinations to identify occupation-related examinations for chest PA, lumbar spine AP, and lumbar spine LAT examinations. If log is not available in claim documentation, assume preemployment chest PA, lumbar spine AP, and lumber spine LAT examinations and annual chest PA examinations.
	Lumbar spine AP	For some workers, men only, preemployment	
	Lumbar spine LAT	For some workers, men only, preemployment	
1982 - 2004	Chest PA	For some workers, on employment and every 5 years	Use log of X-ray examinations to identify occupation-related chest PA examinations. If log is not available in claim documentation, assume preemployment chest PA and an examination every 5 years.

3.3 EQUIPMENT AND TECHNIQUES

A complete history of Pantex X-ray equipment manufacturers, models, examination techniques, and exposure rates for these techniques has not been identified. Therefore, dose reconstruction must utilize claimant-favorable assumptions described in ORAU (2003). Section 3.6 summarizes the recommended approach for dose reconstructors. The following paragraphs summarize available historical information.

3.3.1 <u>Photofluorography</u>

This TBD analysis examined X-ray film records for long-term Pantex workers who began work in the early 1950s to determine if the Plant used photofluorography techniques for chest X-rays. All the records showed full-size 14- by 17-in. films for all years, including 1952, 1954-1956, 1958-1959, 1962, 1964-1966, 1968, 1970-1979, and 1982. These observations, along with conversations with Pantex employees, led to the conclusion that Pantex never used photofluorography.

3.3.2 <u>X-Ray Machines</u>

Historical records have been obtained for four X-ray machines at Pantex, as follows:

- **General Electric** - The earliest record found of a specific X-ray machine at Pantex involved an inspection using U.S. Department of Health, Education and Welfare, Public Health Service, Form 4495-3 (PHS 1967) of diagnostic X-ray facilities on September 26, 1967. The inspector identified the “Control Panel Manufacturer” and “Tube Head Manufacturer and Model” as “General Electric,” and identified the film as “GAF Supreme” with “RADLIN T” intensifying screens. Another survey of the diagnostic X-ray facilities at Pantex occurred from August 13 to 18, 1970; the inspector found a “General Electric” control panel and a “Profexray Model AZ Type 2” tube head (PHS 1970).

- **Picker** - From approximately July 11, 1972, through 1984, Pantex used a Picker X-Ray Pictronic 500 with a Picker X-Ray Style 2098 tube head.

- **Universal** - A Universal X-Ray, Inc., control panel with a Eureka X-Ray Tube Company Model Sapphire 150 tube head was installed between March 19 and May 25, 1984.

- **Continental -** A Continental TM-50 6626.235 X-ray machine was installed between November 1, 1993, and November 6, 1995. On November 6, 1995, several measurements of x-ray exposure at 30 inches for selected kVps of 60 to 100 in increments of 10 were determined (Huddleston 1995). For chest films, the measured value of 0.913R for 100 MAS at 30 in for 80 KVP was converted to the distance of 62 in for a PA Chest radiography. The calculated value is 0.21 R for 100 MAS and this value is equivalent to 0.02 cGy for the typical 10 MAS PA chest examination. This machine uses *photo-timing*, which measures the incidence on the film directly, during irradiation, to determine the exposure time. This machine was in use as of June 2004.

There is evidence of ongoing Pantex reviews (Gidley 1970; Alexander 1972a,b) of the X-ray equipment and techniques but the information is difficult to evaluate, particularly with regard to the entrance skin exposure (ESE) for the different equipment and techniques.

3.3.3 Specific Technique Charts

A table obtained from the Pantex Medical Department of suggested X-ray techniques in GE 1941 (GE 1941) implies that Pantex probably used a General Electric CRT 1 or CRT 2 X-ray tube operated "on full wave rectification" in the early days, along with "fast" film. A 1967 table of desk instructions (Pantex 1967) of X-ray examination steps shows close similarity to the 1941 table. Measurements of the entrance kerma for the Pantex X-ray equipment and techniques used have not been located prior to those in 1995 for the Continental X-ray machine. There is some kVp and filtration data for Pantex techniques, as listed in Tables 3-2 through 3-4, but not enough to estimate the beam quality. The measured beam output for the Continental system (Huddleston 1995) has been used in Table 3-2 and these values are consistent with NCRP 102, Table B.2 (1989).

Table 3-2. Technique factors for chest PA x-rays.

Period	Total filtration (mm Al)	Half-value layer (mm Al)	Current (mA)	Voltage (kVp)	Exposure time (s)	Entrance kerma cGy
Pre-1967	Unknown	Unknown	Unknown[a]	Unknown[a]	Unknown[a]	0.2[b]
1967-1969	1.5	Unknown	100	Unknown[c]	0.1	0.2[a]
1970-1984	2.5	Unknown	100	Unknown[c]	0.1	0.1[a]
1985-1994	2.5	Unknown	100	Unknown[c]	0.1	0.05[a]
1995-2004	~2.5	Unknown	Unknown	~80	(d)	0.02[e]

a. Expected to have selected values closely similar to 1941 GE X-ray techniques.
b. Default values from ORAU (2003): Pre-1970, 0.2; 1970-85, 0.1; after 1985, 0.05.
c. Operationally selected based on body size.
d. System has photo-timing. Used 0.1 sec and 100 MAS in calculations of entrance kerma.
e. Entrance kerma value calculated, at 80 kVp and 62 in TSD using measured output (Huddleston 1995).

Table 3-3. Technique factors for lumbar spine AP X-rays.

Period	Total filtration (mm Al)	Half-value layer (mm Al)	Current (mA)	Voltage (kVp)	Exposure time (s)	Entrance kerma mrad
Pre-1967	Unknown	Unknown	Unknown[a]	Unknown[a]	Unknown[a]	2,000[b]
1967-1969	1.5	Unknown	100	(c)	1	2,000[a]
1970-1981	2.5	Unknown	100	(c)	1	2,000[a]
1982-2004	Not Performed					

a. Expected to have selected values closely similar to 1941 GE X-ray techniques.
b. Default value from Lincoln and Gupton (1958, Table III, Facility F).
c. Selected based on body size.

Table 3-4. Technique factors for lumbar spine lateral X-rays.

Period	Total filtration (mm Al)	Half-value layer (mm Al)	Current (mA)	Voltage (kVp)	Exposure time (s)	Entrance kerma mrad
Pre-1967	Unknown	Unknown	Unknown[a]	Unknown[a]	Unknown[a]	5,000[b]
1967-1969	1.5	Unknown	200	(c)	3	5,000[a]
1970-1981	2.5	Unknown	200	(c)	3	5,000[a]
1982-2004	Not Performed					

a. Expected to have selected values closely similar to 1941 GE X-ray techniques.
b. Default value from Lincoln and Gupton (1958, Table III, Facility F).
c. Selected based on body size.

3.4 ORGAN DOSE CALCULATIONS

Organ dose calculations for workers at Pantex from 1952 to the present involve three primary diagnostic medical radiographic procedures administered in connection with preemployment and regular medical examinations:

- PA 14- by 17-in. chest film (preemployment and annual through 1981 and approximately every 5 years thereafter)
- AP lumbar spine film (men only; preemployment only)
- Lateral lumbar spine film (men only; preemployment only)

The analysis for this TBD evaluated only doses from these three techniques. Other radiographic examinations of Pantex employees that could have occurred are likely to be nonoccupational in the sense that they were associated with illness or injury and were not part of a routine examination process. There is no indication in the examined records that the occupational medical program routinely administered other diagnostic radiographic examinations. Prior to 1995, the analysis used the default organ dose recommendations for PA chest examinations in ORAU (2003) (i.e., entrance kerma of 0.2 cGy prior to 1970, 0.1 cGy prior to 1985 and 0.05 cGy until 1995) because of the lack of detailed information on measurements of the ESE for the different Pantex X-ray equipment. The analysis used the measurements performed for the Continental X-ray and techniques in 1995 (Huddleston 1995). This analysis assumed that an exposure of 1 R is equivalent to a kerma of 1 rad, to 10 mGy or 1 rem (ORAU 2003). Tables 3-5 through 3-9 summarize organ doses for PA chest examinations for the various periods.

There is no information from ORAU (2003) on an estimate of the organ dose from preemployment AP and LAT lumbar spine examinations performed prior to 1982. The purpose of these examinations was to determine if individuals had preexisting back problems prior to hiring for certain occupations. Little information has been located pertaining to these examinations. For dose reconstruction purposes, and if there is not more specific information on the claim-specific log of worker X-ray examinations,

Table 3-5. Calculated organ dose for Default Entrance Kerma Values for PA chest radiographs before 1967 assuming minimal collimation.

Organ	Dose conversion factor (mGy/Gy air kerma)(beam quality for 2.5 mm Al HVL)[a]	Organ dose (rem)
Thyroid	174	3.48E-02
Eye/brain	32	6.40E-03
Ovaries	168	3.36E-02
Urinary bladder	168	3.36E-02
Colon/rectum	168	3.36E-02
Testes	9.1	1.82E-03
Lungs	451	9.02E-02
Thymus	451	9.02E-02
Esophagus	451	9.02E-02
Stomach	451	9.02E-02
Bone surfaces	451	9.02E-02
Liver/gall bladder/spleen	451	9.02E-02
Remainder	451	9.02E-02
Female breast	49	9.80E-03
Uterus	149	2.98E-02
Bone marrow	92	1.84E-02
Skin[b]		2.72E-01

a. Dose conversion factors from ORAU (2003) and ICRP (1982, Tables A.2 to A.8).
b. Skin dose was determined by multiplying ESE by a backscatter of 1.36 for an HVL of 2.5 mm Al. From NCRP (1989, Table B-8).

Table 3-6. Calculated organ dose for Default Entrance Kerma Values for PA chest radiographs from 1967 through 1969.

Organ	Dose conversion factor (mGy/Gy air kerma)(beam quality for 1.5 mm Al HVL)[a]	Organ dose (rem)
Thyroid	11	2.20E-03
Eye/brain	11	2.20E-03
Ovaries	0.2	4.00E-05
Urinary bladder	0.2	4.00E-05
Colon/rectum	0.2	4.00E-05
Testes	0.01	2.00E-06
Lungs	250	5.00E-02
Thymus	250	5.00E-02
Esophagus	250	5.00E-02
Stomach	250	5.00E-02
Bone surfaces	250	5.00E-02
Liver/gall bladder/spleen	250	5.00E-02
Remainder	250	5.00E-02
Female breast	18	3.60E-03
Uterus	0.3	6.00E-05
Bone marrow	49	9.80E-03
Skin[b]		2.56E-01

a. Dose conversion factors from ORAU (2003) and ICRP (1982, Tables A.2 to A.8).
b. Skin dose was determined by multiplying ESE by a backscatter of 1.28 for an HVL of 1.5 mm Al. From NCRP (1989, Table B-8).

Table 3-7. Calculated organ doses for PA chest radiographs from 1970 through 1984.

Organ	Dose conversion factor (mGy/Gy air kerma)(beam quality for 2.5 mm Al HVL)[a]	Organ dose (rem)
Thyroid	32	3.20E-03
Eye/brain	32	3.20E-03
Ovaries	1	1.00E-04
Urinary bladder	1	1.00E-04
Colon/rectum	1	1.00E-04
Testes	0.01	1.00E-06
Lungs	451	4.51E-02
Thymus	451	4.51E-02
Esophagus	451	4.51E-02
Stomach	451	4.51E-02
Bone surfaces	451	4.51E-02
Liver/gall bladder/spleen	451	4.51E-02
Remainder	451	4.51E-02
Female breast	49	4.90E-03
Uterus	1.3	1.30E-04
Bone marrow	92	9.20E-03
Skin[b]		1.32E-01

a. Dose conversion factors from ORAU (2003) and ICRP (1982, Tables A.2 to A.8).
b. Skin dose was determined by multiplying ESE by a backscatter of 1.32 for an HVL of 2.5 mm Al. From NCRP (1989, Table B-8).

Table 3-8. Calculated organ doses for PA chest radiographs from 1985 through 1994.

Organ	Dose conversion factor (mGy/Gy air kerma)(beam quality for 2.5 mm Al HVL)[a]	Organ dose (rem)
Thyroid	32	1.60E-03
Eye/brain	32	1.60E-03
Ovaries	1	5.00E-05
Urinary bladder	1	5.00E-05
Colon/rectum	1	5.00E-05
Testes	0.01	5.00E-07
Lungs	451	2.26E-02
Thymus	451	2.26E-02
Esophagus	451	2.26E-02
Stomach	451	2.26E-02
Bone surfaces	451	2.26E-02
Liver/gall bladder/spleen	451	2.26E-02
Remainder	451	2.26E-02
Female breast	49	2.45E-03
Uterus	1.3	6.50E-05
Bone marrow	92	4.60E-03
Skin[b]		6.60E-02

a. Dose conversion factors from ORAU (2003) and ICRP (1982, Tables A.2 to A.8).
b. Skin dose was determined by multiplying ESE by a backscatter of 1.32 for an HVL of 2.5 mm Al. From NCRP (1989, Table B-8).

Table 3-9. Calculated organ doses for PA chest radiographs from 1995 through 2004.

Organ	Dose conversion factor (mGy/Gy air kerma)(beam quality for 2.5 mm Al HVL)[a]	Organ dose (rem)
Thyroid	32	6.40E-04
Eye/brain	32	6.40E-04
Ovaries	1	2.00E-05
Urinary bladder	1	2.00E-05
Colon/rectum	1	2.00E-05
Testes	0.01	2.00E-07
Lungs	451	9.02E-03
Thymus	451	9.02E-03
Esophagus	451	9.02E-03
Stomach	451	9.02E-03
Bone surfaces	451	9.02E-03
Liver/gall bladder/spleen	451	9.02E-03
Remainder	451	9.02E-03
Female breast	49	9.80E-04
Uterus	1.3	2.60E-05
Bone marrow	92	1.84E-03
Skin[b]		2.64E-02

a. Dose conversion factors from ORAU (2003) and ICRP (1982, Tables A.2 to A.8).
b. Skin dose was determined by multiplying ESE by a backscatter of 1.32 for an HVL of 2.5 mm Al (maximum value in NCRP, Table B-8).

dose reconstructors should use the assumption that AP and LAT lumbar spine examinations were conducted for each male worker, at preemployment only, employed prior to 1982. The dose to workers from these examinations is based on measurements of exposure by Lincoln and Gupton (1958) for several different X-ray examination techniques at eight Oak Ridge National Laboratory facilities. Exposures were measured using a phantom to simulate the patient, and both filtration and collimation varied by facility, reflecting different procedures employed at each facility at the time. This data was used to calculate (Lopez 2004) probability distributions for each organ of interest in ICRP (1982). Table 3-10 lists the results of these analyses.

3.5 UNCERTAINTY ANALYSIS

The description of error and uncertainty in ORAU (2003) is directly applicable to the evaluation of medical X-ray doses to Pantex workers. Available historical documentation is insufficient to ensure claimant-favorable analysis of the dose. In particular, the apparent unavailability of measurements of the ESE for the specific X-ray equipment and diagnostic techniques used historically at Pantex provides little option but to utilize the default options from ORAU (2003). Dose reconstructors should use the recommendation from ORAU (2003) to assume that errors are all positive (i.e., only +30% be used) for Pantex workers.

Table 3-10. Organ dose estimates for lumbar spine AP and LAT radiographs prior to January 1,1982.[a]

Organ	Organ Dose, rem	
	AP lumbar spine[b]	LAT lumbar spine[b]
Thyroid	5.00E-04 (2.96)	1.00E-04 (1.90)
Eye/brain	5.00E-04 (2.96)	1.00E-04 (1.90)
Ovaries	3.27E-01 (2.56)	2.25E-02 (2.10)
Urinary bladder	3.27E-01 (2.56)	2.25E-02 (2.10)
Colon/rectum	3.27E-01 (2.56)	2.25E-02 (2.10)
Testes[c]	2.55E-02 (3.10)	3.97E-02 (1.51)
Lungs	1.22E-01 (2.53)	6.36E-02 (2.00)
Thymus	1.22E-01 (2.53)	6.36E-02 (2.00)
Esophagus	1.22E-01 (2.53)	6.36E-02 (2.00)
Stomach	1.22E-01 (2.53)	6.36E-02 (2.00)
Bone surfaces	1.22E-01 (2.53)	6.36E-02 (2.00)
Liver/gall bladder/spleen	1.22E-01 (2.53)	6.36E-02 (2.00)
Remainder	1.22E-01 (2.53)	6.36E-02 (2.00)
Uterus	4.36E-01 (2.60)	1.51E-01 (2.10)
Bone marrow	5.75E-02 (2.60)	1.10E-01 (2.10)
Skin[c]	1.79E-00 (2.44)	5.79E-00 (1.84)

a. Doses are geometric means in rem and the values in parentheses are the corresponding geometric standard deviations.
b. Calculated by Lopez (2004) from the information in Lincoln and Gupton (1958).
c. Doses to the skin and testes represent measured (Lincoln and Gupton 1958) rather than calculated doses.

3.6 INSTRUCTION GUIDE FOR DOSE RECONSTRUCTORS

Pantex practice involved maintaining a log of the date and type of medical examination, and a historical record of the associated radiography films. DOE-provided medical X-ray dose information should include a copy or transcription of information from this log. Dose reconstructors should use the list of examinations in this log. In the event that DOE does not provide this log, dose reconstructors should use the default assumptions listed in Table 3-11 to ensure the use of claimant-favorable assumptions.

Table 3-11. Summary of dose reconstruction recommendations.

Examination	Period	Default frequency	Table
PA Chest	Prior to 1/1/1967	Preemployment and annually thereafter	Table 3-5
	1/1/67 through 12/31/69		Table 3-6
	1/1/70 through 12/3181		Table 3-7
	1/1/82 through 12/31/84	Preemployment and every 5 years thereafter	Table 3-7
	1/1/85 through 12/21/94		Table 3-8
	1/1/95 to 2004		Table 3-9
Lumbar spine AP	Prior to 1/1/1982	Preemployment, men only	Table 3-10
Lumbar spine LAT		Preemployment, men only	Table 3-10

For actual dose calculations, dose reconstructors should assume a normal distribution with an uncertainty of ±30% at the 99% confidence interval. However, to select claimant-favorable judgments, dose reconstructors should use only the positive uncertainty and multiply the doses listed in Tables 3-5 through 3-10 by a factor of 1.3 to include uncertainty at the 99% confidence level (ORAU 2003).

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GLOSSARY

absorbed dose

The energy imparted per unit mass by ionizing radiation to matter at a specified point. The International System unit of absorbed dose is joules per kilogram. The special name for this unit is the gray (Gy). The previously used special unit of absorbed dose, rad, is being replaced by the gray (1 rad = 0.01 Gy; 1 Gy = 100 rad).

anterior-posterior (AP)

Irradiation geometry in which the radiation passes from the front of a person to the back.

entrance kerma

Air kerma without backscatter.

entrance skin exposure (ESE)

A value typically measured for various x-ray examinations used to estimate skin dose and to calculate organ doses (for organs that lie in the x-ray path) depending upon such parameters as x-ray unit voltage, current, filtration and collimation. The ESE is measured in units of Roentgen (R) or kerma (Gy).

filtration

Material in the useful beam that usually absorbs preferentially the less penetrating radiation.

fluorography

The production of a photographic record of the image formed on the output phosphor of an image intensifier by the action of X-rays transmitted through the patient.

half-value layer (HVL)

Thickness of a specified substance that, when introduced in the path of a given beam of radiation, reduces the kerma rate by one-half.

kerma

The sum of the kinetic energies of all charged ionizing particles liberated by uncharged ionizing particles per unit mass of a specified material. Kerma is measured in the same units as absorbed dose. The SI unit of kerma is joule per kilogram and its special name is gray (Gy). Kerma can be quoted for any specified material at a point in free space or in an absorbing medium.

lateral (LAT)

Irradiation geometry in which the radiation passes from one side of a person to the other.

posterior-anterior (PA)

Irradiation geometry in which the radiation passes from the back of a person to the front.

radiography

The production of images on film by the action of X-rays transmitted through the patient.

roentgen (R)

The previously used special unit of exposure. An exposure of 1 roentgen will produce 2.58×10^{-4} coulomb per kilogram of air.

rem

Historical unit of dose equivalent. The word derives from roentgen equivalent (in) man.

technique or technic

In diagnostic radiology, the combination of source-to-image distance (SID), accelerating potential (peak kilovoltage), tube current (milliampere), and exposure time (seconds). The last two parameters are often multiplied to yield the electric charge that has crossed the X-ray tube during the exposure, expressed in milliampere-seconds or millicoulomb. Any combination of time and tube current that produces a given product in milliampere-seconds will produce the same exposure for a fixed peak kilovoltage.

x-ray

This refers to (1), scientifically, ionizing electromagnetic radiation of external nuclear origin, or (2) colloquially, an image generated by exposing a detector (e.g., film) to X-rays.