Technical Bulletin

X-RAY Safety:

- Frequently Asked Questions

- Health and Safety Instructions

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Frequently Asked Questions

Will I be exposed to Radiation if I stand near the machine?

The X-ray machine is designed so that the radiation is contained within the system. All Cassel X-ray machines are built to ensure that they comply with strict current and future radiation exposure levels.

Emission (Radiation) of X-Rays is nearly zero. It is less than 1/3 of the natural Background Radiation (refer page 11, BACKGROUND RADIATION).

Is it safe for a pregnant woman to work near the machine?

Yes. The system is designed to be completely safe for pregnant women to work around.

http://rpop.iaea.org/RPoP/RPoP/Content/SpecialGroups/1_PregnantWomen/PregnancyAndRadiology.htm#Table1

How is the radiation generated?

The radiation is generated is X-rays, which are generated by using electricity.

Is this safer than a Radiation source?

Yes. By turning off the electricity all X-ray generation is stopped. With a radiation source radiation is always being generated. No Cassel machine uses a radiation source.

How do I check the machine for radiation?

A radiation meter is supplied with all Cassel X-ray machines. It is recommended that a radiation survey is conducted at least once a week.

Is this the same as Irradiated Food?

Irradiated food is where food is exposed to extremely high levels of Radiation (1,000,000 RAD). The design of the Cassel X-ray system ensures that the food being inspected is exposed to very low levels of radiation (0.01 RAD).

Will the food become 'Radioactive'?

No. It is impossible for food to become Radioactive by passing through the system. Inspected food absorps about 100.000x less radiation than a human during x-ray of his teeth.

Do I need to declare that the food has been X-rayed?

No. This is only required for Irradiated food.

Health and Safety Instructions

The Cassel X-ray Inspection Systems have been designed to meet current relevant safety regulations.

It is important to ensure the safe operation of the equipment that it is correctly installed and regularly serviced by a properly trained engineer.

DO NOT ATTEMPT TO INSTALL OR OPERATE THIS EQUIPMENT UNLESS YOU HAVE BEEN TRAINED TO DO SO.

Safe operation of the equipment will be ensured if you observe the following rules:

DO NOT TAMPER WITH OR MODIFY ANY OF THE SYSTEM WIRING OR INTERLOCKS.

DO NOT REMOVE OR ATTEMPT TO OPERATE THE SYSTEM WITH ANY PARTS OR PANELS REMOVED--HIGH VOLTAGES AND RADIATION HAZARDS ARE PRESENT.

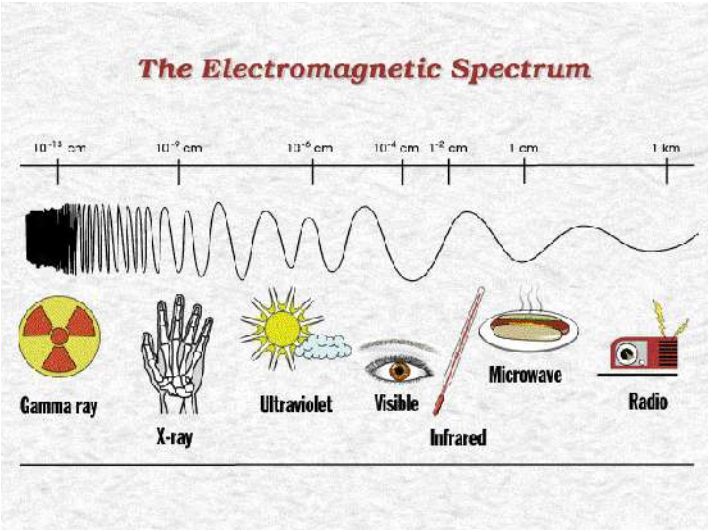
DO NOT USE THE EQUIPMENT IF IT HAS BEEN SUBJECTED TO PHYSICAL DAMAGE.

DO NOT PLACE THE SYSTEM ADJACENT TO A HIGH EMC SOURCE.

CASSEL GERMANY

Radiation and Life

Radiation is energy travelling through space. Sunshine is one of the most familiar forms of radiation. It delivers light, heat and suntans. We control its effect on us with sunglasses, shade, air conditioners, hats, clothes and sunscreen.



There would be no life on earth without lots of sunlight, but we have increasingly recognised that too much of it on our persons is not a good thing. In fact it may be dangerous, so we control our exposure to it.

Sunshine consists of radiation in a range of wavelengths from long-wave infra-red to shorter wavelength ultraviolet.

Beyond ultraviolet are higher energy kinds of radiation which are used in medicine and which we all get in low doses from space, from the air, and from the earth. Collectively we can refer to these kinds of radiation as ionising radiation. It can cause damage to matter, particularly living tissue. At high levels it is therefore dangerous, so it is necessary to control our exposure.

Living things have evolved in an environment which has significant levels of ionising radiation. Furthermore, many of us owe our lives and health to such radiation produced artificially. Medical and dental X-rays discern hidden problems. Other radiation is used to diagnose ailments and some people are treated with radiation to cure disease. We all benefit from a multitude of products and services made possible by the careful use of radioactive materials.

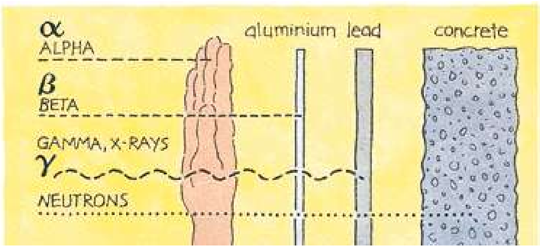
Background radiation is that which is naturally and inevitably present in our environment. Levels of this can vary greatly. People living in granite areas or on mineralised sands receive more terrestrial radiation than others, while people living or working at high altitudes receive more cosmic radiation. A lot of our natural exposure is due to radon, a gas which seeps from the earth's crust and is present in the air we breathe.

X-Ray Safety

Ionising Radiation

Ionising Radiation occurs in two forms - rays and particles, at the high frequency end of the energy spectrum. Ionising radiation produces electrically-charged particles called ions in the materials it strikes. This process is called ionisation. lonising radiation has the ability to affect the large chemical molecules of which all living things are made and so cause changes which are biologically important.

There are several types of ionising radiation:



X-rays and gamma rays, like light, represent energy transmitted in a wave without the movement of material, just as heat and light from a fire or the sun travels through space. X-rays and gamma rays are virtually identical except that X-rays do not come from the atomic nucleus. Unlike light, they both have great penetrating power and can pass through the human body. Thick barriers of concrete, lead or water are used as protection from them.

Alpha particles have a positive electrical charge and are emitted from naturally occurring heavy elements such as uranium and radium, as well as from some man-made elements. Because of their relatively large size, alpha particles collide readily with matter and lose their energy quickly. They therefore have little penetrating power and can be stopped by the first layer of skin or a sheet of paper.

However, if they are taken into the body, for example by breathing or swallowing, alpha particles can affect the body's cells. Inside the body, because they give up their energy over a relatively short distance, alpha particles can inflict more biological damage than other radiations.

Beta particles are fast-moving electrons ejected from the nuclei of atoms. These particles are much smaller than alpha particles and can penetrate up to 1 to 2 centimetres of water or human flesh. Beta particles are emitted from many radioactive elements. They can be stopped by a sheet of aluminium a few millimetres thick.

Cosmic radiations consist of a variety of very energetic particles including protons which bombard the earth from outer space. They are more intense at higher altitudes than at sea level where the earth's atmosphere is most dense and gives the greatest protection.

Radiation and Life

Neutrons are particles which are also very penetrating. On earth, they mostly come from the splitting, or fissioning, of certain atoms inside a nuclear reactor. Water and concrete are the most commonly used shields against neutron radiation from the core of the nuclear reactor.

It is important to understand that ionising radiation does not cause the body to become radioactive.

Calculated cosmic ray doses to a person flying in subsonic under normal solar condition

Route	Subsonic flight at 36,000 ft (11 km)			
	Flight duration (hrs)	Dose per round trip		
		(mrad)	(μGy)	(μSV)
Los Angeles-Paris	11.1	4.8	48	48
Chicago-Paris	8.3	3.6	36	36
New York-Paris	7.4	3.1	31	31
New York-London	7.0	2.9	29	29
Los Angeles-New York	5.2	1.9	19	19
Sydney-Acapulco	17.4	4.4	44	44

Common Units - USA

These are the common units used in the United States in health physics.

Roentgen (R)

The Roentgen is a unit used to measure a quantity called exposure. This can only be used to describe an amount of gamma and X-rays, and only in air. One Roentgen is equal depositing to 2.58 x 10^{-4} coulombs per kg of dry air. It is a measure of the ionizations of the molecules in a mass of air. The main advantage of this unit is that it is easy to measure directly, but it is limited because it is only for deposition in air, and only for gamma and x rays.

RAD (Radiation Absorbed Dose)

The RAD is a unit used to measure a quantity called absorbed dose. This relates to the amount of energy actually absorbed in some material, and is used for any of radiation and any material. One RAD is defined as the absorption of 100 ergs per gram of material. The unit RAD can be used for any of radiation, but it does not describe the biological effects of the different radiations.

REM (Roentgen Equivalent Man)

The rem is a unit used to derive a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Equivalent dose is often expressed in terms of thousandths of a rem, or millirem. To determine equivalent dose (rem), you multiply absorbed dose (RAD) by a quality factor (Q) that is unique to the of incident radiation.

Curie (Ci)

The curie is a unit used to measure a radioactivity. One curie is the amount of radioactivity in one gram of the element first discovered by Madame Curie, Radium. It is also the quantity of a radioactive material that will have 37,000,000,000 transformations in one second. Often radioactivity is expressed in smaller units like: thousandths (mCi), one millionths (uCi) or even billionths (nCi) of a curie. The relationship between Becquerel and curie is: 3.7 x 10^{10} Bq in one curie.

Common Units – SI International Standard

Note: These are the common units used throughout the world in health physics.

Gray (Gy)

The gray is a unit used to measure a quantity called absorbed dose. This relates to the amount of energy actually absorbed in some material, and is used for any of radiation and any material. One gray is equal to one joule of energy deposited in one kg of a material. The unit gray can be used for any of radiation, but it does not describe the biological effects of the different radiations. Absorbed dose is often expressed in terms of hundredths of a gray, or centi-grays. One gray is equivalent to 100 RAD.

Sievert (Sv)

The Sievert is a unit used to derive a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Equivalent dose is often expressed in terms of millionths of a Sievert, or micro-Sievert. To determine equivalent dose (Sv), you multiply absorbed dose (Gy) by a quality factor (Q) that is unique to the of incident radiation. One Sievert is equivalent to 100 rem.

Becquerel (Bq)

The Becquerel is a unit used to measure a radioactivity. One Becquerel is that quantity of a radioactive material that will have 1 transformation in one second. Often radioactivity is expressed in larger units like: thousands (kBq), millions (MBq) or even billions (GBq) of a Becquerel. As a result of having one Becquerel being equal to one transformation per second, there are 3.7 x 10^{10} Bq in one curie.

SI Prefixes

Many units are broken down into smaller units or expressed as multiples, using standard metric prefixes. As examples, a kilobecquerel (kBq) is 1000 Becquerel, a millirad (mrad) is 10^{-3} RAD, a microrem (μrem) is 10^{-6} rem, a nanogram is 10^{-9} grams, and a picocurie is a 10^{-12} curies.

SI Prefixes						
Factor	Prefix	Symbols		Factor	Prefix	Symbols
10^{18}	exa	E		10^{-1}	deci	d
10^{15}	peta	P		10^{-2}	centi	c
10^{12}	tera	T		10^{-3}	milli	m
10^{9}	giga	G		10^{-6}	micro	μ
10^{6}	mega	M		10^{-9}	nano	n
10^{3}	kilo	k		10^{-12}	pico	p
10^{2}	hecto	h		10^{-15}	femto	f
10^{1}	deka	da		10^{-18}	atto	a

X-Ray Safety

HOW MUCH IONISING RADIATION IS DANGEROUS?

A scale of radiation levels

The following table gives an indication of the likely effects and implications of a range of radiation doses and dose rates to the whole body:

10,000 mSv (10 sieverts) in a short-term dose would cause immediate illness and subsequent death within a few weeks. Between 2 and 10 sieverts in a short-term dose would cause severe radiation sickness with increasing liklihood that this would be fatal.

1,000 mSv (1 sievert) in a short term dose would probably cause (temporary) illness such as nausea and decreased white blood cell count, but not death. Above this, severity of illness increases with dose. As a dose accumulated over some time, 1000 mSv would probably cause a fatal cancer many years later in 5 of every 100 persons exposed to it (ie. if the normal incidence of fatal cancer were 25%, this dose would increase it to 30%).

50 mSv/yr is, conservatively, the lowest dose rate where there is any evidence of cancer being caused. It is also the dose rate which arisies from natural background levels in several places. Above this, the probability of cancer occurrence (rather than the severity) increases with dose.

20 mSv/yr averaged over 5 years is the limit for nuclear industry employees and uranium or mineral sands miners, who are closely monitored.

10 mSv/yr is about the maximum actual dose rate received by any Australian uranium miner.

3-5 mSv/yr is the typical dose rate (above background) received by uranium miners in Australia and Canada.

3 mSv/yr (approx) is the normal background radiation from natural sources in North America, including an average of almost 2 mSv/yr from radon in air.

2 mSv/yr (approx) is the normal background radiation from natural sources, including an average of 0.7 mSv/yr from radon in air. (1.5 mSv/yr average in Australia is close to the minimum dose received by all humans on earth.)

0.3-0.6 mSv/yr is a typical range of dose rates from artificial sources of radiation, mostly medical.

0.05 mSv/yr, a fraction of natural background radiation, is the design target for maximum radiation at the perimeter fence of a nuclear electricity generating station. In practice the actual dose is much less.

HOW MUCH IONISING RADIATION IS DANGEROUS?

Biological effects of radiation levels

For low levels of radiation exposure the biological effects are so small they cannot be detected. Radiation protection standards assume however that the effect is directly proportional to the dose, even at low levels. According to this 'linear' theory of radiation effects, if the dose is halved the effect, or the risk of any effect, is halved.

Higher accumulated doses of radiation, while not immediately fatal, may produce a cancer which would only be observed several years after the radiation exposure.

The body has defence mechanisms against damage induced by radiation as well as by chemical carcinogens. However, typically the body has to deal only with a relatively tiny amount of damage at any one time, as opposed to having to deal with a very large amount at once, as was the case for the atomic bomb survivors in 1945. Some allowance has been made for this effect in setting occupational risk estimates, but the degree of protection for low-level radiation exposure may well be greater than these estimates cautiously allow.

Tens of thousands of people in each technically advanced country work in environments where they may be exposed to radiation above background levels. Accordingly they wear monitoring 'badges' while at work, and their exposure is carefully monitored.

HOW MUCH IONISING RADIATION IS DANGEROUS?

BACKGROUND (Natural) RADIATION

Naturally occurring background levels of radiation can typically range from 1.5 to 3.5 millisieverts a year and in some places can be much higher. The highest known level of background radiation affecting a substantial population is in Kerala and Madras States in India where some 140,000 people receive an annual dose rate which averages over 15 millisieverts per year from gamma, plus a similar amount from radon.

Comparable levels ocur in Brazil, Iran and Sudan, with average exposures up to 38 mSv/yr. Four places are known in India and Europe where natural background radiation gives dose rates of more than 50 mSv per year. No adverse health effects have been discerned from doses arising from these high natural levels.

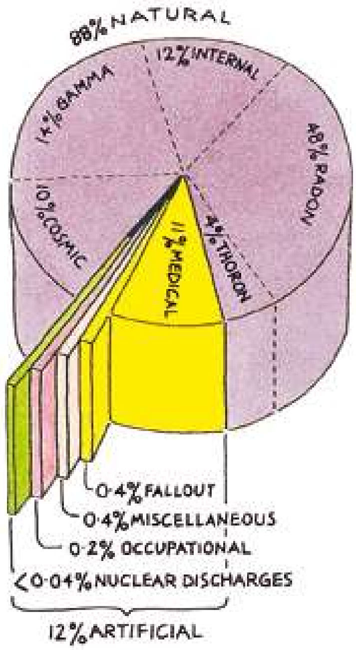
Emission (Radiation) of X-Rays nearly zero. It is less than 1/3 of the natural Background Radiation.

X-Ray Safety

MAN-MADE (Artificial) RADIATION

Ionising radiation is also generated in a range of medical, commercial and industrial activities. The most familiar and, in national terms, the largest of these sources of exposure is medical X-rays. A typical breakdown between natural background and artificial sources of radiation is shown in the pie chart. Natural radiation contributes about 88% of the annual dose to the population and medical procedures most of the remaining 12%. Natural and artificial radiations are not different in kind or effect.

Inspected food absorps about 100.000x less radiation than a human during x-ray of his teeth.



X-Ray Safety

As a manufacturer Cassel is committed to highest standards of quality. For more than ten years our goal has been to ensure the quality of your products. Our reputation has been earned by protecting yours. We supply customers in different industries worldwide such as Foods, Plastics, Pharmaceuticals, Textile, Timber and Mining. Our headquarters and state of the art manufacturing facility are located near Hannover in the heart of Germany. Each year we manufacture and deliver over 1000 Metal Detection and X-Ray systems. Approximately 80% of the production is heading for export markets. To ensure you get the very best of service and support wherever on the globe you are using our metal detectors, we have a worldwide network of partner agents.

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