# Radioactive Contamination of Aircraft and Engines

3rd edition
June 2002

Association of European Airlines

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**RADIOACTIVE CONTAMINATION OF AIRCRAFT AND ENGINES**
**3rd Edition 25 June 2002**

This is the 3rd edition of the AEA booklet "Radioactive Contamination of Aircraft and Engines", which was initially introduced in 1992.

The purpose of the revision was to update the contact details in Appendix 1.

**PRELIMINARY NOTE**
The content of this document shall be considered as guidelines only. The airlines are requested to ensure that they comply with their national legislation, in particular with respect to national authorities involvement in contaminated aircraft and the handling of damaged cargo containing radioactive isotopes.

National legislations may require that national authorities be involved, where contamination levels are below those stated in the booklet. It is recommended that each airline incorporates any national deviation into its own manuals.

Kind regards.

Hanna Tiainen
Assistant Technical Affairs

# TABLE OF CONTENTS

INTRODUCTION

All world radiation experts agree on one issue and that is that the Chernobyl accident should not occur again. The Chernobyl accident illustrated two important points:

(i) Industry, during the critical days was snowed under by a lot of expert supplied information about the levels of radioactive contamination,
(ii) The conclusions about the actual danger to the European population were in total disagreement.

During the days that followed the Chernobyl accident, the European airlines exchanged a lot of information concerning the levels of radioactivity at different European airports and on different aircraft. It was found that the measurements were made using different methods and units and, therefore, it was very difficult to get a clear picture about how the fall-out affected the different European countries and consequently there was unrest and confusion among the workers of the European airlines. For this reason the AEA Engineering & Maintenance Sub-Committee encouraged the establishment of a European Airlines Committee on Material Technology (EACMT) Working Group on the Monitoring and Safe Handling of Radioactive Contamination on Aircraft and Engines. The goal of the Working Group was defined as follows:

- To cover all radioactive contamination problems (excluding medical aspects) occurring on aircraft and engines, whether the problem is caused by an external reason (nuclear accident of international dimension) or an internal reason within the airline (parcel failure or balance weight corrosion problem).

In particular, the Working Group was to perform the following tasks:

1. To define the relations and contacts to be made between the European airlines themselves and between the European airlines and the National and International Authorities in the case of an environmental accident by radioactive contamination.
2. To establish maximum contamination levels above which action should be taken by the European airlines.
3. To define acceptable monitoring procedures to be used by the European airlines.
4. To define suitable cleaning methods in case of aircraft or engine contamination.

The Working Group was established on 18th November 1986 with the following participants:

AZ - Mr. Sergio Solazzi
LH - Mr. Gerhardt Jaeger
SK - Mr. Carl Bonde
SN - Mr. Marc Van Averbeke (Chairman)
SR - Mr. Peter Mueller

The final document was issued by the AEA in August 1992.

The Working Group was reactivated on 2nd January 1997 with the following participants:

KL - Mr O Geleyns
SK - Mr M Mejer
SN - Mr M Van Averbeke (Chairman)

The EACMT Steering Group decided to update the Appendix 1 – contact details of the AEA member airlines in May 2002, and the third edition was published on 25 June 2002.

**PRELIMINARY NOTE**

The content of this document shall be considered as guidelines only. The airlines are requested to ensure that they comply with their national legislation, in particular with respect to national authorities involvement in contaminated aircraft and the handling of damaged cargo containing radioactive isotopes.

## I AEA ALERT SYSTEM

It has been decided to set up a European system of communication between the members of the AEA aimed at informing and assisting each individual airline in the case of an abnormal situation caused by radioactive contamination of aircraft. This communication system will be called the AEA Alert System.

The Alert System will enter into operation in the following cases:
1. If any nuclear accident is openly announced through the usual media.
2. If any European airline discovers an abnormal situation on its aircraft (see definition of abnormal situation under III).

The addresses of AEA Airline Departments to be contacted in case of such incidental matters are given in Appendix 1.

## II UNITS

In order to avoid the use of different units during the information exchanges between the European airlines, it was decided to select one standard unit for measurements of radioactive contamination.

The best-suited unit of measurement for radioactive contamination associated with radioactive dust scattered on the ground or on aircraft surfaces is the *Becquerel per square centimetre (Bq/cm$^2$)*. This unit corresponds to one radionuclide disintegration per second per square centimetre of contaminated area. Nevertheless, most equipments used for low levels of activity are calibrated in COUNTS PER SECOND (CPS) or MINUTE (CPM). The count rating is not an absolute measurement because it depends upon the type of equipment used.

Factors affecting the count rating are:
- The size, thickness and material of the probe window.
- The sensitivity of the probe.
- The type of isotope to be measured.

In order to obtain measurements to be used for the communication between AEA airlines, which should be expressed in Bq/cm$^2$, it is recommended to establish for each equipment and for a given isotope the transformation factor which would allow for the transformation of the count rate into Bq/cm$^2$.

If the transformation factor is not at hand, it may be established by a National Nuclear Agency (please see Appendix 2). Dose rates expressed in *milliGray per hour (mGy/h)*, *milliSievert per hour (mSv/h)* or *milliRontgen per hour (mR/h)* are, of course, the most suitable units for the measurement of ionising radiations,

but they are not adequate for contamination measurements (please see also Appendix 3).

## III ALERT LEVELS

**NOTE:**
National legislations may require that national authorities be involved, where contamination levels are below those stated in the booklet. It is recommended that each airline incorporates any national deviation into its own manuals.

Three types of alert levels should be considered:

ALERT LEVEL I
4 Bq/cm$^2$
Alert level for the airline expert in radiological protection to be involved.

ALERT LEVEL II
10 Bq/cm$^2$
Alert level for the AEA communication system to be started.

ALERT LEVEL III
40 Bq/cm$^2$
Alert level for national authorities to be involved. Maintenance workers will need legal health protection.

Actions to be taken when radioactive contamination is detected are as follows:

1. Below ALERT LEVEL I - 4 Bq/cm$^2$

Below this value it is considered that the radioactive contamination may be completely neglected, regardless of the type of isotope or the degree of looseness of the contamination.

2. Between ALERT LEVELS I and II - 4 to 10 Bq/cm$^2$

The airline expert in radiological protection must be in charge of the problem. He/she must establish the type and extent of radioactive contamination and decide, within the airline and according to the national legislation in the matter, how maintenance work may be performed on aircraft and engines.

3. Between ALERT LEVELS II and III - 10 to 40 Bq/cm$^2$

The radioactive contamination becomes sufficiently important that the AEA communication system should be started. Again, the airline expert in radiological protection must decide, within his/her airline, whether maintenance work can be

performed on aircraft and engines and with what precautions. No strict rule can be established.

4. Above LEVEL III - 40 Bq/cm$^2$
Above this value a system of professional radiological protection must be set up. Work areas with contamination levels of above 40 Bq/cm$^2$ must be considered as supervised areas where only maintenance workers under legal health protection are allowed to work.

## IV TEST LOCATION

Testing the aircraft for radioactive contamination may be performed at different locations. Again, it is advisable that for information exchange the same location be chosen by all European airlines. Experience has shown that the most probable area to find radioactive contamination is in the engine air inlet area where the dust collects and embeds itself into the metallic structure.

The recommendation of the EACMT W/G is to perform the contamination monitoring measurement at the engine air intake by scanning the whole area just in front of the fan blades and keeping the measuring probe at a constant distance of 1 cm from the surface. When other areas of the aircraft are scanned, the exact location should always be mentioned in the circular exchange of information.

## V ADDITIONAL TESTING

The responsibility of the airlines is to ensure that its employees are not exposed to radioactive contamination above what is laid down in the national legislation.

Any additional research work about this radioactive contamination normally pertains to the national health organisations. For instance, smear tests followed by the determination of the Isotope Composition Determination of Radioactive Dust should be performed by specialised laboratories. If smear tests are to be performed on the aircraft fuselage, we recommend standardising the scanned area to a square of 100 cm$^2$. Also, in some cases, special attention should be paid to possible radioactive contamination by beta emitters. This also pertains to the action field of specialized laboratories.

If the results of such tests are available to one of the AEA airlines, they should be shared with the other European airlines through the AEA Information Exchange Programme.

## VI EQUIPMENT

The world market presents a large variety of different measuring equipment for the measurement of radioactivity levels. Moreover, each year new equipment is being introduced into the market. Therefore, it is not our intention to perform any market study to compare the equipment and to evaluate its price/efficiency ratio. Trade names will obviously be avoided. We shall only establish the main characteristics, which should be present in the equipment so that it can be used efficiently for radioactive contamination measurements.

### 1. MEASUREMENT METHODS

*The Geiger-Muller Counter*

This is basically an ionisation chamber where the ionisation caused by the Beta or Gamma radiation is amplified by a cascade effect. Based on the consideration of price/efficiency ratio, the Geiger- Muller counter is the instrument, which is recommended by the EACMT W/G for the purpose of measuring radioactive contamination on aircraft according to these guidelines.

### 2. WINDOW CHARACTERISTICS

The window should be permeable to Beta and Gamma radiation.

It is recommended to use window dimensions of between 10 and 100 $cm^2$. A minimum of 10 $cm^2$ is necessary in order to have a minimum sensitivity. A maximum of 100 $cm^2$ is recommended in order to have good portable equipment, not too fragile in handling and not too expensive.

### 3. DIALS/DISPLAYS

Displays must be calibrated: in $Bq/cm^2$, or in counts per second (or minutes). Displays calibrated in mR/h or mSv/h are usually intended for radiation measurement and are not suitable for radioactive contamination measurements.

### 4. AUDIO SIGNALS

A mechanism, which releases a buzzing sound above a predetermined alert level, is not really necessary for radioactive contamination measurements. Nevertheless, we recommend the use of a clicker, which gives an audible signal proportional to the radioactive environment.

### 5. CALIBRATION

It is recommended that all measuring equipment for radiation level should be calibrated once a year.

The calibration may be performed within the airline by using a calibrated radioactive source or it may be performed through a National Authorised Institute.

All the calibration results should be filed and left for at least 5 years.

## VII CLEANING AND SAFE HANDLING OF RADIOACTIVE CONTAMINATION ON AIRCRAFT STRUCTURES AND ENGINES ON-WING

### 1. MONITORING BEFORE WORK

Before any kind of work may be performed on an aircraft subject to radioactive contamination, monitoring of the aircraft must be performed under the supervision of an expert in radiological protection.

If the contamination is 4 $Bq/cm^2$ or more in areas where personnel and/or passengers may be contaminated, immediate decontamination under the supervision of an expert in radiological protection is needed.

If the contamination is 4 $Bq/cm^2$ or more in areas where it will not contaminate personnel and/or passengers, the aircraft need not be decontaminated until work is planned. Nevertheless, a monitoring programme should be started with an appropriate recording of the measurements performed. Notification to the company line stations should be performed accordingly.

### 2. DECONTAMINATION

The key consideration is whether or not the contamination detected is ‘fixed’ or ‘loose’:

| | |
|---|---|
| Fixed contamination | Contamination, which is attached to a surface so firmly that there is negligible risk of its leaving the surface and entering the human body. |
| Loose Contamination | Contamination, which is not fixed and can be removed from a surface by the handling process to which that surface is normally subjected. |

#### 2.1 Loose contamination

Loose contamination should be removed using wet cleaning methods. Remove as much contamination as possible by using damp mops and rags and, if necessary, finish with a water spray with detergent.

The contaminated mops and rags should be collected into a plastic bag. If it is practical, the contaminated water should also be collected into a container. The disposal of radioactive waste (plastic bags and contaminated water) will be

performed in accordance with local rules. The cleaning personnel will be protected by gloves, coveralls and, if necessary, by masks.

2.2 Fixed Contamination
Fixed contamination should be removed by scrubbing, under damp cleaning conditions. The help of mild cleaning pastes may be considered. Avoid as much as possible dust raising operations. For the disposal of radioactive waste, tools, clothes and for the protection of personnel, see 2.1 above.

2.3 Contamination in Liquid Form
This kind of contamination may occur if radioactive liquid has spilled out in the cargo area, for instance, after the accidental failure of the internal packaging. The procedure to be used is the same as that used for the removal of other non-radioactive dangerous chemicals by using absorbing material, such as Vermiculite.

Again, for the disposal of wastes, tools, clothes and for the protection of personnel, see 2.1.

3. MONITORING AFTER WORK
After contamination removal, additional monitoring of the contaminated area should be performed. Contamination levels should be less than 4 Bq/cm$^2$. Otherwise resume decontamination operations.

## VIII CLEANING AND SAFE HANDLING OF CONTAMINATED ENGINES IN THE OVERHAUL SHOP

This chapter covers the recommendations on how to treat an engine entering the overhaul shop, if it is suspected of being contaminated with radioactive dust.

1. MONITORING BEFORE WORK
The engine areas which are the most prone to radioactive contamination should first be monitored. If the contamination is locally found equal or above 4 Bq/cm$^2$, decontamination should be performed before engine disassembly, under the supervision of an expert in radiological protection, taking all the necessary precautions for the personnel involved.

If the decontamination is successful and no accessible area discloses any contamination above 4 Bq/cm$^2$, the disassembly of the engine may proceed under the normal conditions.

**Caution**: Additional checks should be performed during disassembly in order to be sure that no internal engine area has a contamination level above 4 Bq/cm$^2$.

If it is not possible to decontaminate the engine before disassembly, then the engine disassembly will proceed under the supervision of an expert in radiological protection (see paragraph 2).

**NOTE:** A record of all contamination readings will be attached to the work documents.

2. DECONTAMINATION DURING ENGINE DISASSEMBLY

If it has not been possible to clean a contaminated engine before its disassembly, the engine disassembly work will be performed concurrently with the engine decontamination under the supervision of an expert in radiological protection. This also means that all disassembly work shall be performed by personnel wearing coveralls and gloves.

All contaminated parts shall be cleaned individually, either by rag cleaning or by tank cleaning, whichever is the preferred method. The individual readings on each contaminated part will be recorded on the work documents.

3. MONITORING AFTER WORK

After contamination removal, an additional monitoring of the contaminated parts will be performed. If the radioactive contamination is still above 4 $Bq/cm^2$, the cleaning of the part will be resumed. If the radioactive contamination is below 4 $Bq/cm^2$, the part may proceed to its normal inspection and rework. The successful decontamination will be recorded on the work document.

4. DISPOSAL OF CONTAMINATED CLEANING SOLUTIONS

The disposal of contaminated cleaning solutions and sludge will be performed according to the local rules in this matter.

## IX AIRCRAFT COMPONENTS CONTAINING RADIOACTIVE ISOTOPES

**Note:** Refer also to respective chapters in the aircraft maintenance manuals.

Some aircraft may have internal sources for radioactive contamination, such as smoke and ice detectors signs and indicators. Also, the balance weights of the rudder and elevators are sometimes fabricated from depleted uranium. Depleted uranium is natural uranium, which has been stripped of nearly 100% of its radioactive isotope, U235. Depleted uranium is still radioactive to some degree and also presents a high toxic risk if ingested.

In order to reduce the possibility of direct contact by the maintenance staff, the balance weights are nickel-plated, cadmium plated and painted. Nevertheless,

balance weights may become a source of radioactive contamination if the protective coatings have been locally destroyed and the uranium surface is being touched accidentally by maintenance workers. The reason for the destruction of the balance weights' protective coatings may be the presence of deep scratches or the development of corrosion.

Damaged balance weights have to be treated as follows:

1. BALANCE WEIGHTS WITH FLAKED PAINT

The balance weight must be carefully maintained in order to establish that the flaking of the paint does not penetrate into the protective nickel and cadmium plating. If the flaking does not penetrate into the protective coatings, the balance weight may be cleaned with a white spirit type solvent and repainted locally in-site.

An additional protection with a corrosion preventive compound MIL-L-16173 grade 1 may be performed.

2. BALANCE WEIGHTS WITH FLAKED PLATING

If the corrosion has destroyed the protective plating of the balance weight, there will be an increased potential towards the formation of uranium oxide. This black powder-like material could be transferred to the hands of maintenance workers and later to the mouth and the ingestion system. For this reason it is not advisable to try to clean and repaint such balance weights.

These corroded balance weights should be removed from the aircraft and wrapped in sealed bags under the supervision of an expert in radiological protection. Maintenance people handling these balance weights should wear masks, cloth coveralls, gloves and shoe covers. Thereafter, the balance weights will be stored in special containers and sent for destruction or refurbishment to an approved agency.

## X RADIOACTIVE CONTAMINATION CAUSED BY DAMAGE TO RADIOACTIVE CARGO MATERIAL

In normal circumstances the radioactive cargo material, which is packed and transported according to the rules of the IATA and the ICAO, does not present any contamination, or radiation danger. Danger may arise if there is any accidental damage caused to such radioactive packaging.

The first danger of a damaged radioactive package is radiation. Radiation cannot be stopped by any method, but may be restored back to an acceptable level by keeping the ionising source at a distance or by surrounding the source with shielding material. This aspect is outside the scope of these recommendations.

The second danger of a damaged radioactive package is radioactive contamination. All the recommendations mentioned above for the measurement and removal of radioactive contamination caused by an exterior source of radioactivity may also be used in case of damage to radioactive cargo material. Nevertheless, whenever the freight department comes across an incident with radioactive cargo material, some particular items should be taken into account:

1. If the package is labelled 'Radioactive Material', either from Category I, II or III, a measurement of the radiation level shall be performed at 1 meter from the package.

1.1 If the radiation is above the indicated transport index of the package, an expert in radiological protection should be called. This indicates that the interior receptacle may have been broken.

1.2 If the radiation is close to the indicated index of the package, authorized personnel should have a look at the exterior packaging (and, if possible, the inner receptacle) to check for absence of any possible leak. If any leak is discovered, an expert in radiological protection should be called.

2. If the package is not labelled 'Radioactive Material', but is found on the Air Waybill to be an exempted Radioactive Material package, authorised personnel should have a look at the package to check for the absence of any possible leak. If any leak is discovered, an expert in radiological protection should be called for.

3. The expert will have to check that no radioactive contamination is present on any of the surrounding material or equipment - other freight material, aircraft bilge floor, loading equipment, freight carts. In particular, he will have to ascertain that no cargo handling personnel has been contaminated. If this should be the case, the contaminated person should be sent to the medical department.

4. Any damaged package should wrapped in watertight material and put aside from the remaining freight.

5. The disposal of contaminated material should be made according to the local rules.

## XI SAFETY RULES FOR PERSONNEL

Personnel involved in the cleaning of a contaminated aircraft on the apron or of an engine in the workshop, will have to work under the supervision of an expert in radiological protection. This expert is a person specifically assigned by the company or by a governmental agency and which will fulfil the following tasks:

- Supervise the contamination monitoring before and after the decontamination of aircraft and engine.
- Check if the national regulations about safety are followed.
- Specify the type of protective equipment to be used by cleaning personnel, i.e. the possible need for dosimeters and the use of barriers around the contaminated aircraft and engines with a notice prohibiting entry to non-approved personnel.
- Check the decontamination of clothes, shoes and tooling used during the decontamination of aircraft and/or engines.

## XII NOTIFICATION OF RADIOACTIVE INCIDENTS WITHIN THE COMPANY

Notification of radioactive incidents to the responsible department of an AEA airline may occur either through the channel of the AEA alert system or through the channel of internal information within the company or through information from national authorities. Once the AEA member airline's responsible department has been made aware of the radioactive incident, it will have to decide if the information needs to be transmitted on to other responsible departments within the company.

If the incident is considered serious, the information about the incident should then be transmitted to a group of responsible persons within the company, including at least:

- top management representatives;
- the manager in charge of health and technical safety;
- the manager in charge of company security;
- the expert or consultant in radiological protection;
- the medical department (if injuries or medical problems may be expected).

This group will have to decide on the following items:

- necessity to create any kind of emergency coordination group;
- necessity to alert or not the other AEA airlines;
- necessity and way to inform the following authorities:
    - managers of main and line stations;

- managers of the different departments involved;
- personnel representatives;
- all personnel members;
- airport authorities;
- national authorities.

No definite rule can be established, as this will vary somewhat from country to country and airline to airline. The most important recommendation is that the group should take the right decisions, which warrant the workers and passenger security without over-emphasising the danger by creating unnecessary panic among workers and among the international media.

# APPENDIX 1 MONITORING AND SAFE HANDLING OF RADIOACTIVE CONTAMINATION ON AIRCRAFT AND ENGINES

## AEA AIRLINES

The following departments are responsible for incidental matters and alertness situations in connection with radioactive contamination (25th June 2002):

**AIR FRANCE**
Alertness situation:
DG.DT - Roissy CDG
Phone: +33-1-4156 8071
Fax: +33-1-4156 8029
Sita: HDODTAF

Non alertness situation:
ME.UX - Roissy CDG
Phone: +33-1-4864 9977
Fax +33-1-4864 0796
Sita: CDGUXAF
e-mail: makindel@airfrance.fr

**AUSTRIAN AIRLINES**
Alertness situation:
Maintenance Control
Phone: +43-1-7007 62566
Fax: +43-1-7007 63766
Sita: VIEMCOS
e-mail: Maintenance.control@aua.com

Non-alertness situation:
Maintenance Organisation - Material Testing
Phone: +43-1-7007 62546
Fax: +43-1-7007 63539
Sita: VIETROS
e-mail: roman.wottle@aua.com

**CSA**
CSA - General Inspector
Phone: +420-2-2011 2514
Fax: +420-2-316 2208
E-Mail: Vacin.Pavel@csa.cz
Sita: PRGDPOK

**FINNAIR**
Aircraft Line Maintenance MH/31 or
Engineering EN/28
Phone: +358-9-822 125
Fax: +358-9-818 6622
Sita: HELMHAY
E-mail: pekka.manninen@finnair.com

**IBERIA**
DM/Subdirección Ingeniería
Phone: +34-91-587 5792
Fax: +34-91-329 0543
e-mail: pcifuentes@iberia.es

**KLM**
Alertness situation
Senior Operations Controller
Phone: +31-20-640 3020
Fax: +31-20-304 1519
Sita: OCCLMKL

Non alertness situation
Radiation safety officer
Phone: +31-20-648 6412
Fax: +31-20-648 8167
(Sita: SPLYNKL not preferable)
e-mail: olav.geleyns@klm.com

**SAS**
Control Centre
Phone: +45-32-32 22 71 (day/night) or
+45-32-32 33 83 (night)
Fax: +45 32 32 22 78
SITA CPHYYSK

**SWISS**
Materials- & Process Technology TEMZ
Phone +41-1-812 6752
Fax +41-1-893 1570
E-Mail Rene.Klieber@SRTechnics.com

**TAP AIR PORTUGAL**
Quality engineering
Phone: +351-218-415 883
Fax: +351-218-415 678
email: snascimento@tap.pt

**AEA SECRETARIAT**
e-mail: toc@aea.be
Phone: +32-2-6398 989
Fax: +32-2-6398 999

## APPENDIX 2 NUCLEAR AGENCIES AND ORGANISATIONS

**Europe**

Belgium AVN - www.avn.be, FANC - www.fanc.fgov.be
Croatia HZZZ - www.hzzz.hr
Czech Republic SUJB - www.sujb.cz, NRI - www.nri.cz
Denmark BRS - www.brs.dk, SIS - www.sis.dk
Estonia Eesti Kiirguskeskus - www.envir.ee/ekk
Finland STUK – www.stuk.fi/english
France ASN - www.asn.gouv.fr, OPRI - www.opri.fr
Germany BMU - www.bmu.de, BMI - www.bmi.bund.de
Hungary HAEA - www.haea.gov.hu
Iceland GR - www.gr.is
Ireland - www.irlgov.ie/tec/energy/nuclear, RPII - www.rpii.ie
Italy ANPA - www.mirrorsinanet.anpa.it/RifiutiRadio/seconda.asp
Latvia - www.varam.gov.lv/Latvian/Radiation/radiacij.htm
Lithuania VATESI - www.vatesi.lt, ministery- www.gamta.lt, RSC - www.rsc.lt
Norway NRPA - www.nrpa.no
Slovakia UJD - www.ujd.gov.sk
Slovenia SNSA - www.gov.si/ursjv
Spain CSN - www.csn.es
Sweden SSI - www.ssi.se, SKI - www.ski.se
Switzerland HSK - www.hsk.psi.ch
Turkey TAEK - www.taek.gov.tr
United Kingdom HSE/NII - www.hse.gov.uk/nsd/nsdhome.htm

**Other countries**

Argentina ARN - www.arn.gov.ar
Canada Health Canada - www.hc-sc.gc.ca, CNSC - www.nuclearsafety.gc.ca
Korea KINS - www.kins.re.kr, MOST - www.most.go.kr
Mexico CNSNS - www.cnsns.gob.mx
Russia GAN - www.gan.ru, Minatom - www.minatom.ru
USA NRC - www.nrc.gov, CDRH, Center For Devices And Radiological Health - www.fda.gov/cdrh, NCRP - www.ncrp.com

**International organisations**

EURATOM - europa.eu.int/comm/euratom/index_en.html
European Commission / Nuclear issues - europa.eu.int/comm/energy/nuclear/index_en.html
International Commission on Radiological Commission - www.icrp.org
OECD Nuclear Energy Agency - www.nea.fr
World Nuclear Association - ww.world-nuclear.org

## APPENDIX 3 THE UNITS

Two types of units are used for radiation

- units of activity, which quantify the amount of radiation emitted by a given radiation source and
- units of exposure (dose), which quantify the amount of radiation absorbed or deposited in a specific material by a radiation source.

### Units of activity

**Becquerel (Bq) =** SI-unit used to measure radioactivity. 1 Bq = one disintegration per second.

**Curie (Ci)** = an amount of radioactive material emitting 2.22 x $10^{12}$ disintegrations (particles or photons) per minute (DPM).

### Units of exposure

**Gray (Gy)** = SI-unit for absorbed dose, which is sometimes replaced by RAD (Radiation Absorbed Dose) corresponding to 1/100 Gy (1 Gy=100 RAD). Prognosis is related to the absorbed dose:

- absorbed dose over 5-6 Gy - survival impossible
- absorbed dose between 2 and 4,5 Gy - survival possible
- absorbed dose between 1 and 2 Gy - survival likely
- absorbed dose below 1 Gy - survival virtually certain

**Rontgen (R)** = the unit of measure for exposure, which is sometimes replaced by Coulomb/Kg of air (C/Kg): 1 C/Kg=3876 R.

**Sievert (Sv)** = SI-unit for equivalent dose - taking into account the biological effectiveness of different types of radiation, also used to express ambient dose equivalent, directional dose equivalent, personal dose equivalent and organ equivalent dose.


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AUSTRIAN AIRLINES


MALEV


BRITISH AIRWAYS


Meridiana


british midland
bmi


OLYMPIC
AIRWAYS


cargolux


SAS
Scandinavian Airlines


CROATIA AIRLINES


Spanair


ČSA
CZECH AIRLINES


SWISS
Swiss International Air Lines


CYPRUS AIRWAYS


tap
AIR PORTUGAL


FINNAIR


TAROM


IBERIA


TURKISH AIRLINES