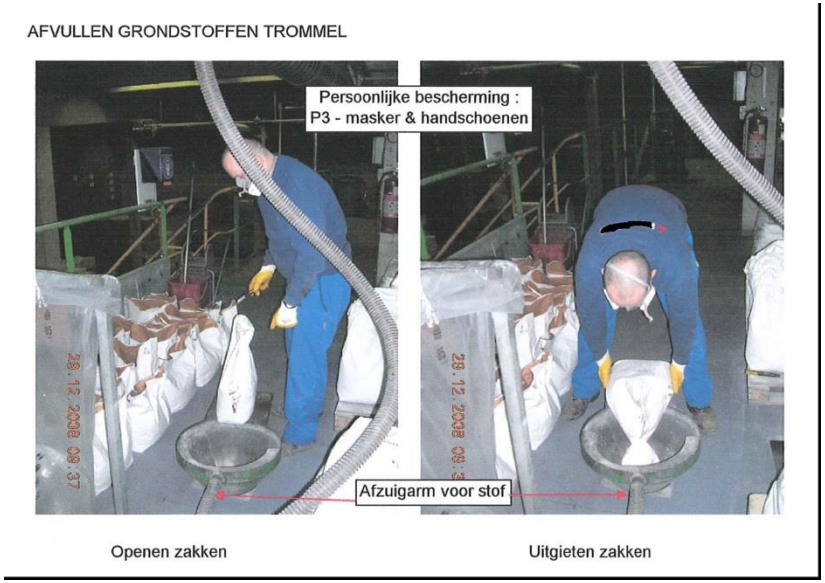
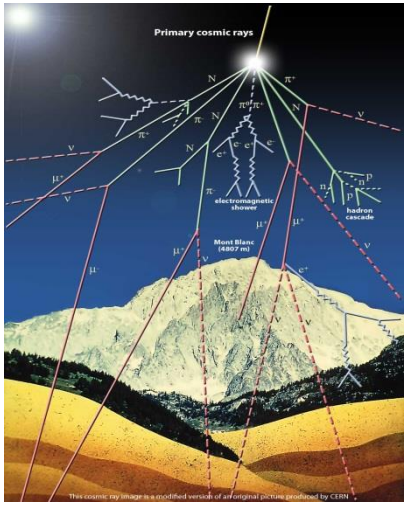
Exposure to natural radiation in industry and aviation





Continuous education afternoon in radiation protection for recognized occupational physicians

"FUTURE PERSPECTIVES IN RADIATION PROTECTION"

FANC – October 14, 2016

FANC AFCN

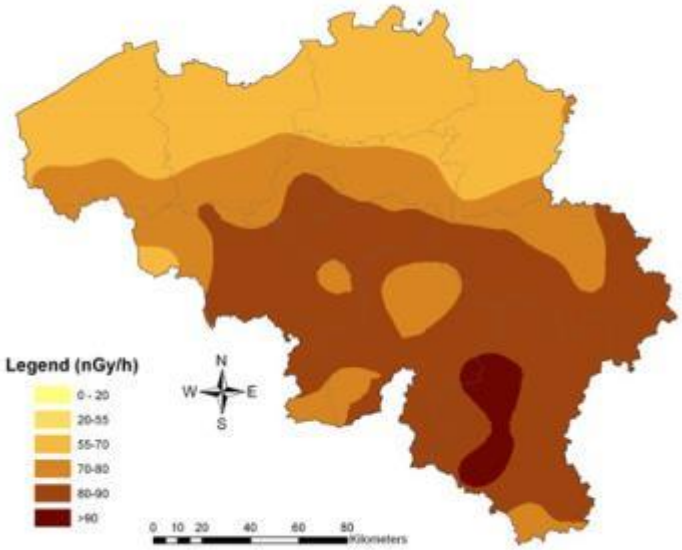
Overview

1. Natural radioactivity
2. Current Belgian NORM industries
3. Belgian NORM regulations
4. Dose-assessment for NORM industries
5. Cosmic radiation

Natural radioactivity

NORM = "*Naturally Occurring Radioactive Material*"

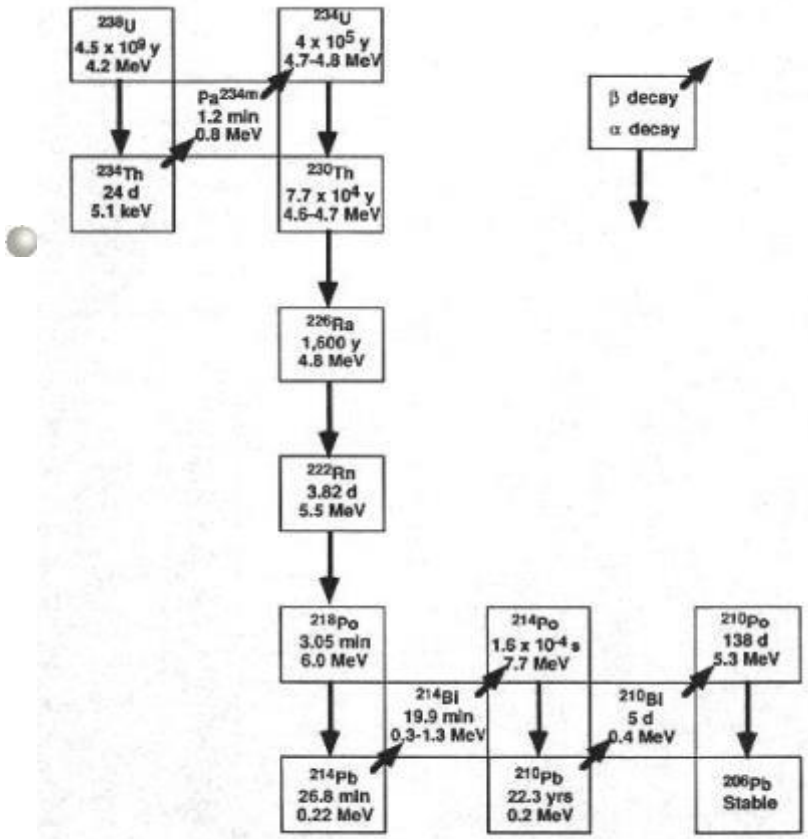
⇒ **uranium and thorium** series **+ potassium-40**
⇒ Background concentrations in Belgian soil: a few ppm uranium/thorium (5 – 50 Bq/kg U-238, Th-232)
⇒ Dose-rate 0,06 – 0,1 µSv/h



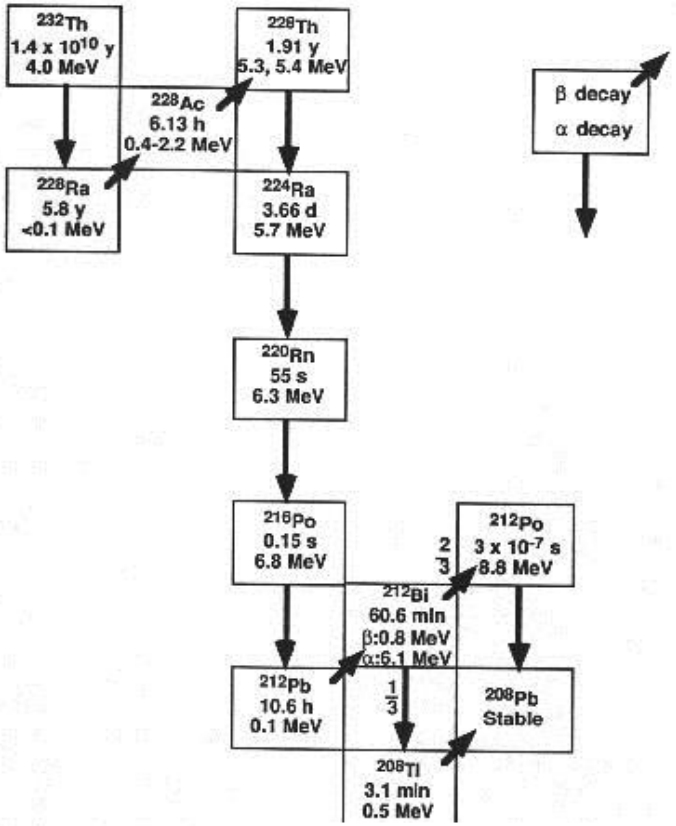
NORM: a “cocktail” of radioactive substances

Uranium, thorium + decay chain: Ra-226, Pb-210, Po-210, Ra-228,…

Uranium serie



Thorium serie



NORM in industries

⇒ some **raw material/mineral** (phosphate, zirconium sand,…) **<u>richer</u>** in uranium and/or thorium

⇒ some **process** lead to an enhanced concentration in **residues or products**

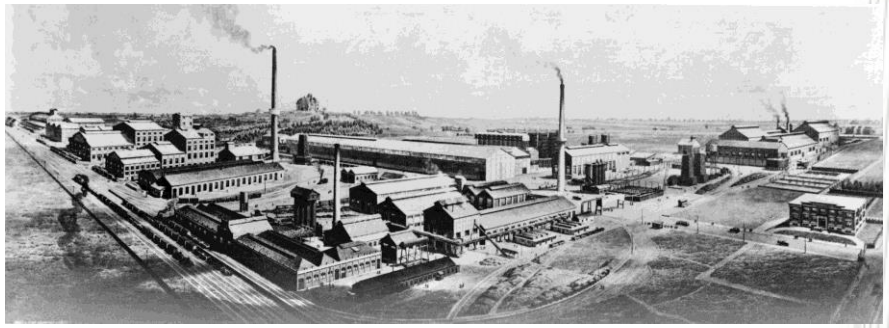
⇒ ~ 100 Bq/kg to 10 000 – 100 000 Bq/kg

2 X to 200 – 2000 X background concentrations in Belgian soil

⇒ **Increased risk of exposure**

Current Belgian NORM industries

"Old" industrial country
Phosphate industry from the 1920s



Titaniumdioxide production

Tin foundry

Groundwater treatment

Belgian NORM regulations

Directive 96/29/EURATOM
Transposed into Royal Decree of July, 20 2001

Art.4 lists "*work activities involving natural radiation sources*"

Art.9: industries are submitted to **declaration**

Objective of declaration: dose-impact assessment (workers + population)

Impact workers + population must be < 1 mSv/a
– if not, **corrective measures** or **licensing.**

NB: directive 96/29/Euratom now replaced by **2013/59/Euratom**
=> More focus on NORM activities

Royal Decree 20/07/2001	2013/59/Euratom
Declaration	Notification
Corrective measures	Registration
Authorization	Licensing

List of work activities

FANC Decrees 01/03/2012 (+ 2013/2016) => extended list of NORM activities

- Storage, handling and processing of **phosphate ores**
- Storage, handling and processing of **zircon and zirconia**
- Decommissioning and recycling of **zircon(ia)-based refractories**
- **Titaniumdioxide** production
- **Groundwater treatment** facilities
- **Coal-fired** power plant
- Production of **non-ferrous metals**
- Primary **iron** production
- Production, storage, use and handling of **thorium-based materials**
- **Oil reffineries**
- Extraction and transport of **natural gas** and **shale-gas**
- **Geothermal energy –** including exploration phase
- Storage, handling and processing of **pyrochlore, columbite, tantalite, ilmenite, rutile, cassiterite, monazite, garnet and silica fumes**
- Distribution of **consumer products** with an activity concentration above RP 122 II
- **processing, valorization and recycling of residues with an activity concentration above RP 122 II**

Current NORM industries

FANC website

Factsheets for each NORM sector

http://www.fanc.fgov.be/nl/page/-norm-problematiek-informatiedossier/363.aspx

NORM in de non-ferro metaalindustrie

Zoals voor de staalindustrie, wordt de *primaire* metaalindustrie, uit ertsen en concentraten, het meest getroffen door de NORM problematiek. De natuurlijke radioactieve stoffen zullen zich in de productiereststoffen accumuleren: slakken (zware elementen zoals uranium, radium of thorium) en filterstof (vluchtige elementen, Pb-210 en Po-210) zoals in de filterkoeken afkomstig van de chemische extractieprocessen.

Sommige reststoffen van de primaire metaalprocessen die een verhoogde concentratie aan radioactieve stoffen bevatten worden in een tweede extractiefase opgewaardeerd. De secondaire metaalindustrie kan dus ook worden getroffen, in functie van de gebruikte grondstoffen.

Te onderzoeken processen :

De stroom van grondstoffen nakijken. Eventuele « risicostromen » identificeren.

Kobaltkoeken, reststoffen van de zinkproductie, kunnen een verhoogde concentratie aan uranium bevatten, tot 13 Bq/g aan U-238. Deze reststoffen kunnen worden hergebruikt om het kobalt te extraheren.

Concentraties van respectievelijk ~ 6 Bq/g en 1-2 Bq/g aan U-238 werden ook al vastgesteld in koperkoeken en in slakken van de primaire koperproductie.

Het gebruik van kalkmelk (calciumhydroxide) in sommige processen (zoals ontzwaveling) kan ook leiden tot radioactieve afzettingen die rond 10 Bq/g aan Ra-226 kunnen bereiken.

Aandachtspunten – stralingsbescherming van de werknemers

Behandeling van de risicogrondstoffen;
Onderhoudsoperaties op elementen van het productieproces.

Aandachtspunten – beheer reststoffen

De afwezigheid van radioactieve afzettingen in het filterstof, de slakken, de filterkoeken nagaan.

Om meer te weten :

- "Werkzaamheden met blootstelling aan natuurlijke stralingsbronnen" - Nederlands Ministerie van Sociale Zaken en Werkgelegenheid (2001).
- "German national report to levels and inventory of TENORM", K. Leopold et al., Universität Essen / GRS (2002).

NORM: risk-assessment of workers exposure

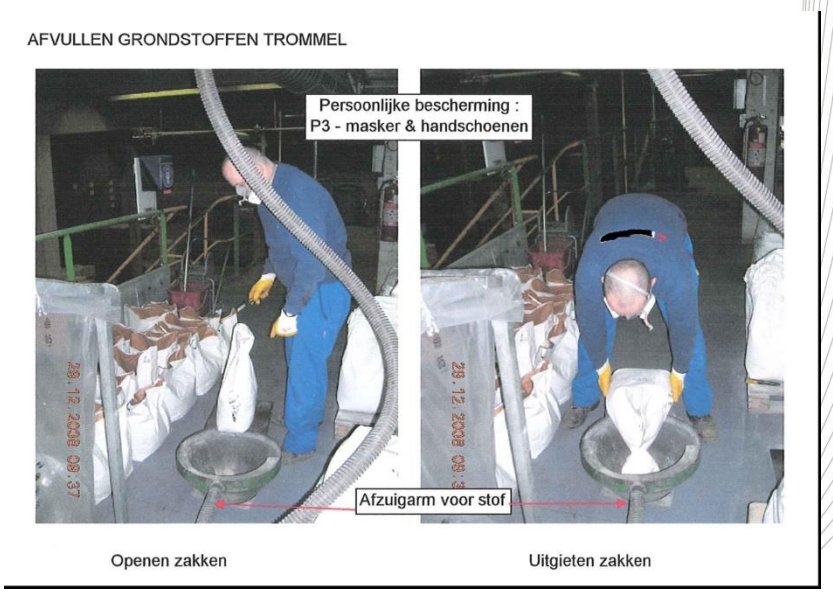
- List **work tasks of concern**;

- Assess relevant **parameters**: time of exposure, dust concentration, …

- **Exposure pathways**:
External radiation, **inhalation** (dust + radon), ingestion

- Check **protection measures**

Critical tasks:
Maintenance / decommissioning operations



Dose-assessment workers: example

Thoriated welding rod

(up to 4% thorium)

tabel 22 Resultaten van de scenarioberekeningen voor gebruik van Th-houdende wolfraam laselektroden (mSv/jaar).

Scenario		Doses (mSv/jaar)			
		Inhalatie	Ingestie	Extern	Totaal
Opslag laselektroden	normaal			0,044	0,04
	ongunstig			0,88	0,9
Slijpen laselektroden	normaal	0,15	0,002		0,15
	ongunstig	1,0	0,063		1,1
WIG lassen	normaal	0,34			0,3
	ongunstig	14			14

Dose-assessment workers: example

Coal-fire power plant

⇒ Pb-210 contaminated scales in boilers

[Pb-210] = 190 Bq/g

⇒ Po-210 not measured – supposed in equilibrium;

⇒ dose-rate in contact 2.5 µSv/h;

⇒ Maintenance operation (clean-up boilers) critical

Dose-assessment workers: example

Dust measurement:

Cleaning operations	Polishing vaporization pipes	Other operations
450 mg/m^3	22 mg/m^3	11,8 mg/m^3

Calculation of inhalation dose:

- $D_{inh} = N \cdot c \cdot b \cdot \Sigma_i a_i \cdot h_i^{inh}$

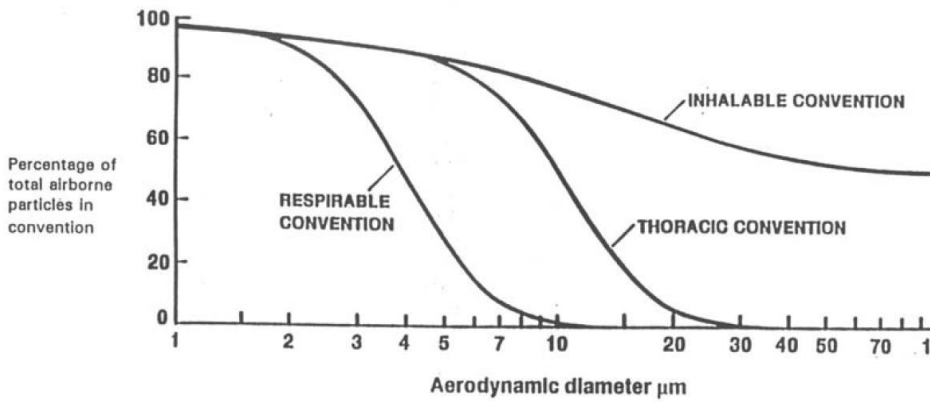
N= exposure time
C = dust concentration
b = respiratory debit (= 1,2 m3/h)
a_i = activity concentration (= 190 Bq/g)
h_i^{inh} = dose conversion coefficient

	Cleaning operations	Polishing vaporization pipes	Other operations
Without respiratory protection			
Inhalation dosis	3,9 µSv/h	17,03 µSv/h	9,13 µSv/h
With respiratory protection			
Inhalation dosis	0,2 µSv/h	0,85 µSv/h	0,46 µSv/h

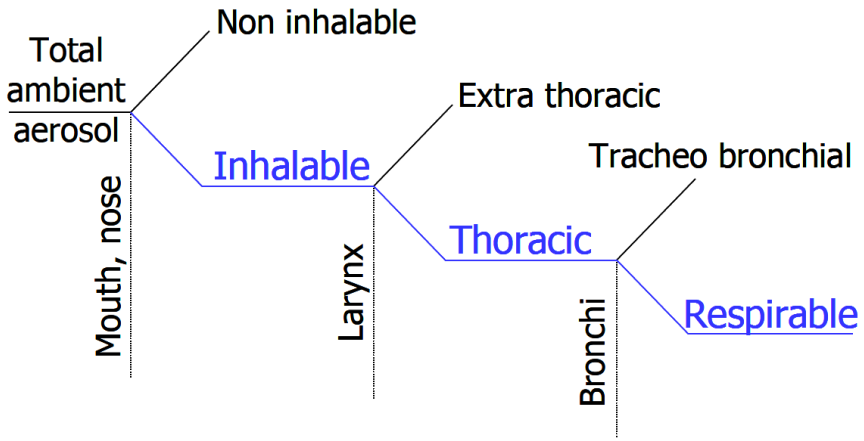
Internal dose may reach up to 8 mSv without respiratory protection

Inhalation dosis

“**Strategies and Methods for Optimisation of Internal Exposures of Workers from Industrial Natural Sources**” (SMOPIE project – report June 2004)



=> Assessment methodology for internal dose-assessment



Link with “classical” work safety

NORM entangled with non-radiological aspects of Health&Safety

Example:

Good Practice Guide on Workers Health Protection through the Good Handling and Use of Crystalline Silica and Products Containing it

http://www.nepsi.eu/good-practice-guide.aspx

2.2.7

This guidance sheet is aimed at employers to help them comply with the requirements of workplace health and safety legislation, by controlling exposure to respirable crystalline silica.

Specifically, this sheet provides advice on the cutting and polishing of refractory materials and glass. Following the key points of this task sheet will help reduce exposure. Depending on the specific circumstances of each case, it may not be necessary to apply all of the control measures identified in this sheet in order to minimize exposure to respirable crystalline silica. i.e. to apply appropriate protection and prevention measures.

This document should also be made available to persons who may be exposed to respirable crystalline silica in the workplace, in order that they may make the best use of the control measures which are implemented.

This sheet forms part of the Good Practices Guide on silica dust prevention, which is aimed specifically at the control of personal exposure to respirable crystalline silica dust in the workplace.

Cutting and Polishing Refractory Materials and Glass

This activity relates to the cutting of refractory materials and glass which may generate large quantities of airborne dust.

Access

- ✓ Restrict access to the work area to authorised personnel only.

Design and equipment

- ✓ Dust control can be achieved by using wet cutting methods, which prevent fine dust from becoming airborne by trapping it in water.
- ✓ Ensure that water supplies are adequate and that they are maintained. Take precautions during cold weather against freezing.
- ✓ Take precautions to ensure the control of legionella and other biological agents. If the water used for wet cutting is re circulated, ensure that it is checked regularly with respect to pH value and contamination with micro organisms.
- ✓ The provision of appropriate drainage systems is essential when using water sprays and hoses.
- ✓ Ensure that electrical systems etc have adequate protection against the hazards present in the working environment, including water and silica dust.
- ✓ Use cutting and polishing tools containing no crystalline silica.

March 2006 – 2.2.7 – Page 1 of 2

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Decommissioning NORM facility

Dose-impact of decommissioning

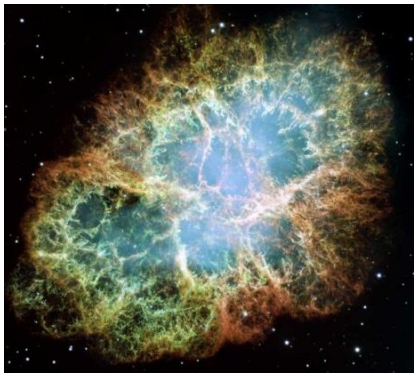
- Follow-up external dose workers (assessment through working time-registration + dosimeter);
- Protection against inhalation/ingestion of dust;

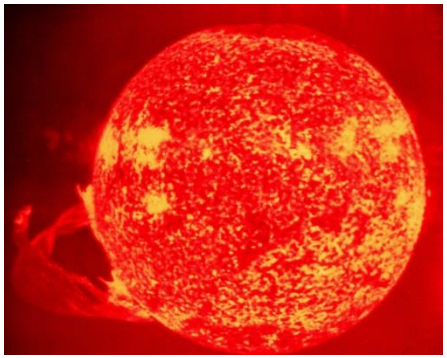
Overview external dose (~ 6 months):

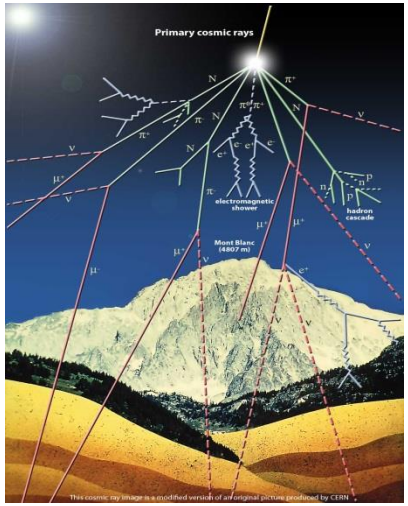
Worker	1	2	3	4	5	6	7	8	9	10	11	12	13
Dose (µSv)	794	1309	1233	1076	223	16	1447	16	636	64	10	549	75
***Measured* dose 28-5 till 30-6**	60	100	0	80	0	0	480	0	0	0	0	0	0
***Calculated* dose 28-5 till 30-6**	93	217	117	185	37	0	200	0	76	6	0	75	10

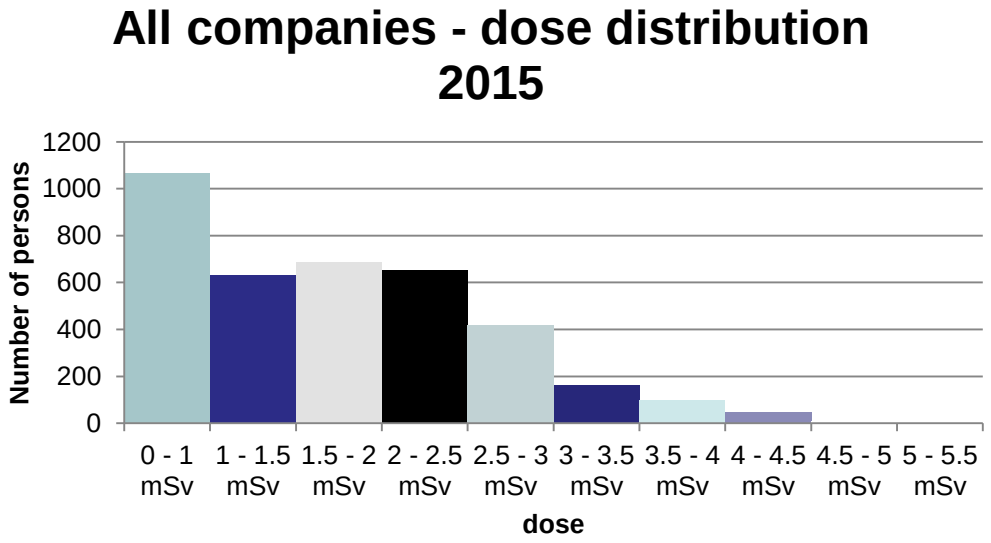
⇨ measured dose < calculated dose **excepted** for worker "7" (team leader)

Cosmic radiation



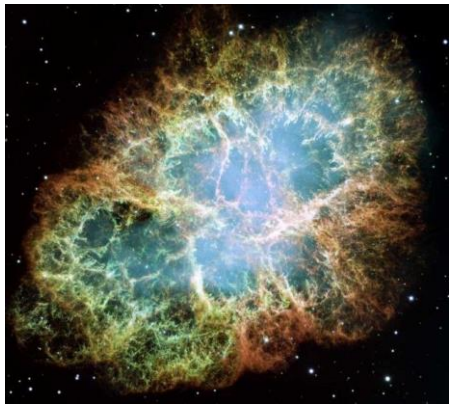




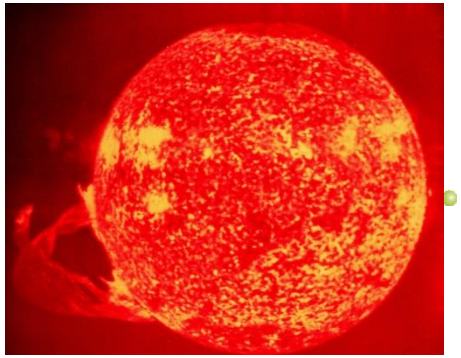


What is cosmic radiation ?

Primary cosmic radiation: high energetic particles from space (mainly hydrogen and helium nuclei)



Galactic component (main component): e.g. supernova explosions,…

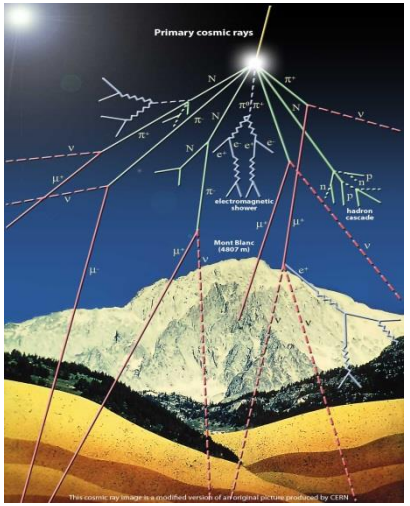


Solary component

(11-years cycle, may be significant in case of solar disturbance event / solar flare – e.g. 1956)

What is cosmic radiation ?

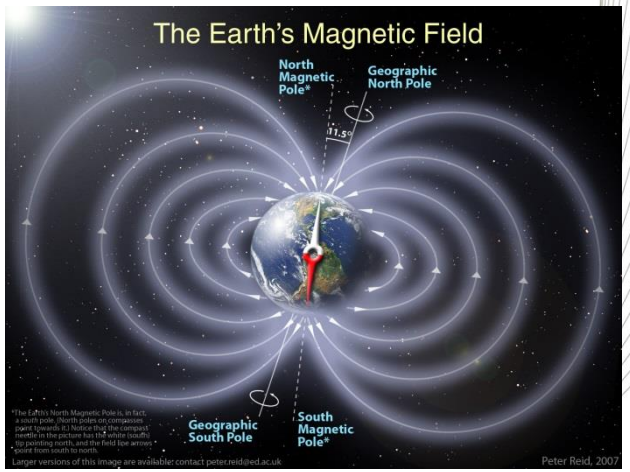
Secondary cosmic radiation - interaction of primary cosmic radiation with earth's atmosphere => secondary particles



2 main factors affecting the flux of cosmic radiation:

- Altitude (absorption by the atmosphere)

- Latitude (protection due to earth's magnetic field decreases with latitude – highest dose near the poles)



Belgian regulatory framework

Art. 9 Royal Decree 20/07/2001:

For aircrew with dose possibly > 1mSv/y:

- assess individual doses
- take into account dose assessments in the working schedules (at least < 6 mSv/y)
- inform the concerned workers (+ company occupational physician)
- limitation of doses during pregnancy (As Low As Reasonably Achievable – in any case < 1 mSv/y)

NB: no legal requirements for “frequent flyers” but advisable to record their flying time and assess their dose

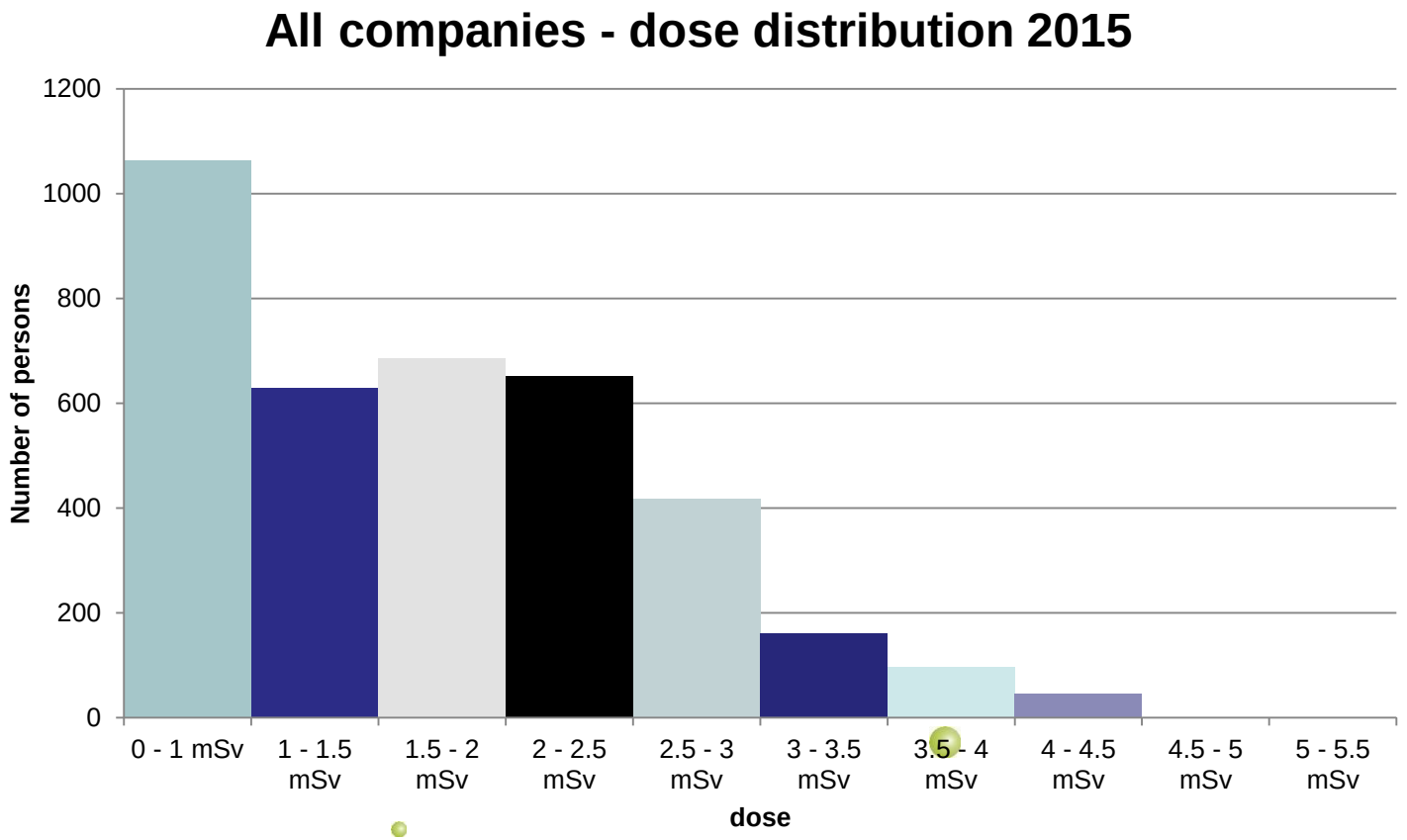
⇒ “Rule of thumb” – 1 hour flying = ~ 5 µSv

Recent public consultation on ICRP draft report “Radiological Protection from Cosmic Radiation in Aviation”

http://www.icrp.org/page.asp?id=242

Dose distribution

2015: average 1.25 mSv – max. 5.04 mSv



Significant # people in the upper range of the distribution

http://www.afcn.be/fr/page/rayonnement-cosmique/1191.aspx