



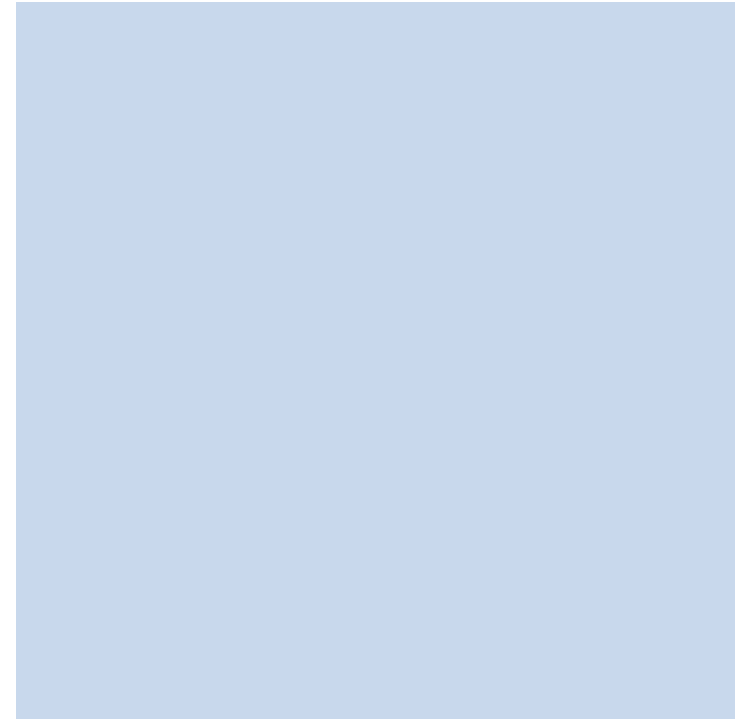
**IRSN**

INSTITUT  
DE RADIOPROTECTION  
ET DE SÛRETÉ NUCLÉAIRE

*Faire avancer la sûreté nucléaire*

# Measurement strategies in coal-fired power plants to meet the demands of French legislation

European ALARA  
Network for NORM  
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**French Ministerial Order of May 25<sup>th</sup>, 2005**

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# French ministerial Order of may 25<sup>Th</sup>, 2005

- Evaluation of occupational exposure
- Evaluation of population exposure
- 10 relevant industrial activities
  - several activities like mining excluded
- Studies carried out under the operator responsibility
- Results addressed to ASN and IRSN

# French ministerial Order of may 25<sup>Th</sup>, 2005

## Mandatory content of survey :

- Description of production site, process and raw material,
- Radiological characterization of raw material, final and by-products, wastes and effluents,
- Identification of workplaces liable to NORM impact,
- Dose assessment for workers.

# IRSN Missions

- Support and technical assistance to the public authorities for civil activities:
  - Synthesis of studies carried out in the framework of French Ministerial Order of May 25<sup>TH</sup>, 2005.
- Contractual studies and measurement services for public and private organizations:
  - NORM studies in the framework of French Ministerial Order of May 25<sup>TH</sup>, 2005.

# Measurement strategies for coal-fired power plants

## Sources and pathways of exposure

- Clinker: external exposure,
- Coal, ashes and soot : external and internal (inhalation, ingestion),
- Wash water and gaseous effluents : potential public exposure,
- Radon : internal exposure.

# Measurement strategies

- Dose rate measurements supplemented by passive dosimetry to assess external exposure,
- Short term potential-alpha energy assessment and 2 month integrating measurements for radon 222,
- In-situ gamma spectrometry with Hp-Ge detector,
- Sampling based on gamma spectrometry results to carry out laboratory analysis.

# Measurement strategies : sampling

- Coal clinker and soot sampled in standardised geometry :
  - SG500 polyethylene bottles,
- Washwater :
  - 3 liters polyethylene bottles,
- Airborne ashes sampled in standardised geometry :
  - B132 filters in cellulose fiber - 1,2 m<sup>3</sup>/h aerosol sampler



# Measurement strategies : Nuclides

## ■ Uranium 238 decay chain :

- $^{238}\text{U}$ ,  $^{226}\text{Ra}$  and  $^{210}\text{Pb}$  if secular equilibrium is reached, +  $^{234}\text{U}$  in water,
- $^{230}\text{Th}$ ,  $^{234}\text{U}$  and  $^{210}\text{Po}$  outside of secular equilibrium.

## ■ Thorium 232 decay chain :

- $^{232}\text{Th}$ ,  $^{228}\text{Ra}$  and  $^{228}\text{Th}$ ,

## ■ Uranium 235 decay chain :

- based on uranium 238 decay chain,

## ■ Potassium 40

# Measurement strategies : Analysis

- Uranium 238 decay chain :
  - gamma spectrometry to quantify  $^{234m}\text{Pa}$ ,  $^{226}\text{Ra}$  and  $^{210}\text{Pb}$ ,
  - Alpha spectrometry for  $^{234}\text{U}$ ,  $^{230}\text{Th}$  and  $^{210}\text{Po}$  if needed(\*).
  
- Thorium 232 decay chain :
  - Gamma spectrometry to quantify  $^{228}\text{Ac}$ ,  $^{212}\text{Pb}$  and  $^{208}\text{Tl}$ ,
  - Alpha spectrometry to quantify  $^{232}\text{Th}$  and  $^{228}\text{Th}$  if needed(\*).
  
- Uranium 235 decay chain :
  - gamma spectrometry to quantify  $^{235}\text{U}$ ,
  
- Gamma spectrometry to quantify  $^{40}\text{K}$

(\*) if equilibrium is not reached or detection threshold is too high

# Results and feedback : analysis (1)

- Radon  $< 40 \text{ Bq.m}^{-3}$  and EAP  $< 10 \text{ }\mu\text{J.m}^{-3}$  in all facilities
- Only gamma spectrometry both in-situ and in laboratory has been carried out
- Ashes and soot

	$^{234\text{m}}\text{Pa}$	$^{226}\text{Ra}$	$^{210}\text{Pb}$	$^{235}\text{U}$	$^{228}\text{Ra}$	$^{208}\text{Tl}$	$^{40}\text{K}$
Activity Bq/kg	$< 130 - 150$	$< 89 - 170$	$71 - 110$	$6 - 7$	$41 - 94$	$12 - 32$	$120 - 210$

# Results and feedback : analysis (2)

Coal originating from Colombia, Venezuela, South Africa, Norway and Island

	$^{234m}\text{Pa}$	$^{226}\text{Ra}$	$^{210}\text{Pb}$	$^{235}\text{U}$	$^{228}\text{Ra}$	$^{208}\text{Tl}$	$^{40}\text{K}$
Activity Bq/kg	< 85	< 50	< 8 - 15	< 4	< 3 - 12	0,85 - 4	12 - 37

Clinker

	$^{234m}\text{Pa}$	$^{226}\text{Ra}$	$^{210}\text{Pb}$	$^{235}\text{U}$	$^{228}\text{Ra}$	$^{208}\text{Tl}$	$^{40}\text{K}$
Activity Bq/kg	< 77 - 120	< 36 - 150	9 - 77	< 4 - 6	< 4 - 100	2 - 36	60 - 170

# Results and feedback : dose assessment

- Hypothesis for internal exposure (inhalation and ingestion)
  - measurement of dusts level in the facility,
  - secular equilibrium + highest specific activity,
  - no protection.
  - quantity of dust ingested = quantity of dust inhaled.
  - accidental exposition : dust level =  $5 \text{ g.m}^{-3}$  and 1 hour exposition

	External exposure in $\mu\text{Sv.y}^{-1}$	Internal exposure in $\mu\text{Sv.y}^{-1}$	Effective dose in $\mu\text{Sv.y}^{-1}$	Accidental exposure in $\mu\text{Sv}$
Boiler operator	1 - 27	16 - 73	18 - 93	48 - 174
Service engineer	4 - 20	4 - 50	18 - 71	

# Feedback

- Dose assessment has been done with penalizing hypothesis :
  - high detection threshold,
  - secular equilibrium based on highest specific activity
- Viable as long as annual effective dose  $\ll 1$  mSv
- Analysis only by gamma spectrometry → quick results and low cost.

# Feedback

- Aerosol analysis by gamma spectrometry : detection threshold leading to doses of several mSv per year  
→ ashes and soot analysis used for dose assessment
- Some nuclides taken into account that might not be in the samples (thorium 232)
- Service engineer : measurement not feasible inside the boiler while in service  
→ uncertainty on external exposure

# Prospects

- In situ radiometry and gamma spectrometry compulsory for a quick penalizing dose assessment
- Collecting aerosol on gravimetric impactor for accurate inhalation dose assessment
- Raw material, products and effluents sampling enabling easy preparation for alpha spectrometry