How to correctly choose the list of relevant radionuclides to assess dose uptake by workers?

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TRACTEBEL

ENGIE

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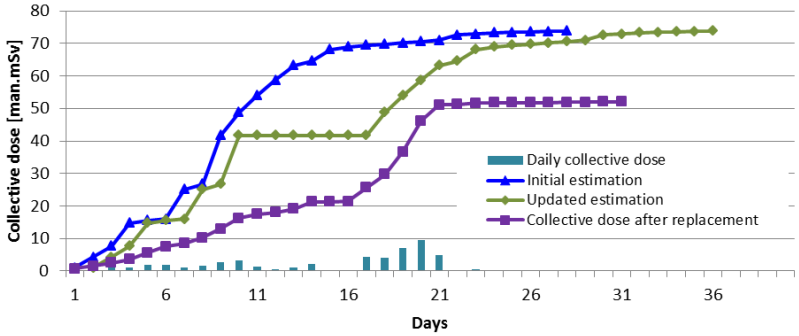
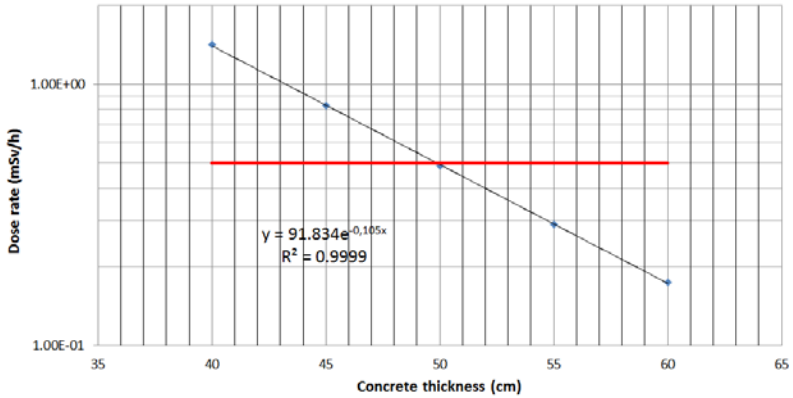
01 Introduction

Introduction



Source term



Introduction
The source term

- Needed for dose uptake/integrated dose/dose rate calculations
- Activity level for a list of radionuclides
- Not known for post-accident assessment
- Not known at design stage
- May include more than 1000 radionuclides

→ Need to reduce to a manageable number

→ Tractebel developed a suitable and reproducible methodology

RN	Activity (Bq)
I-131	5.7E+07
I-133	7.6E+07
I-135	5.7E+07
Kr-85	1.0E+08
Xe-133	6.9E+07
…	…

02 Methodology

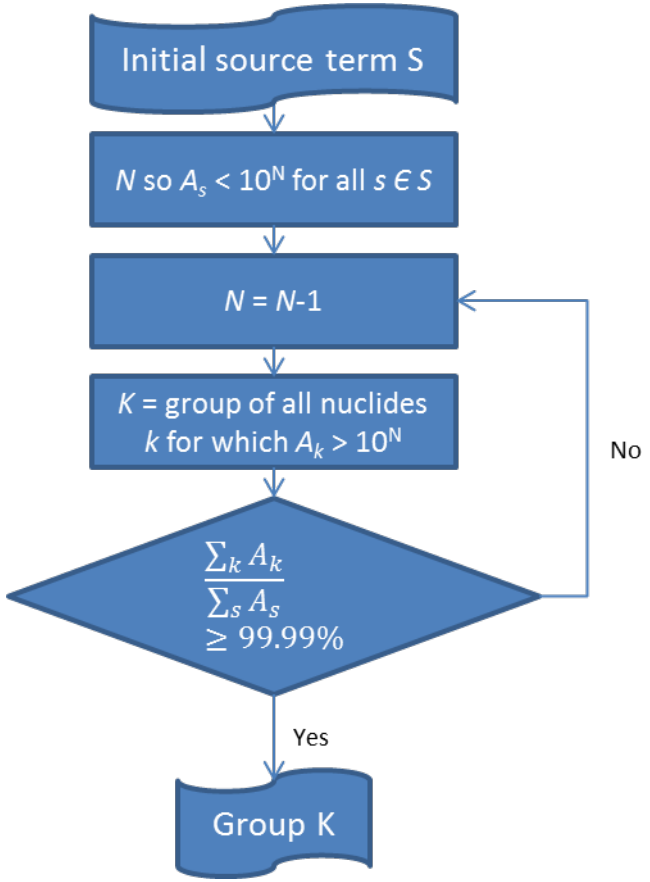
Methodology
Description

- Three screening steps
  - Activity levels
  - Gamma ray energies contribution
  - Influence of higher gamma rays
- Some data needed
  - Gamma lines for each radionuclide obtained after the first screening
  - Branching factor for each gamma line

  → from relevant libraries (ICRP-107, JANIS…)

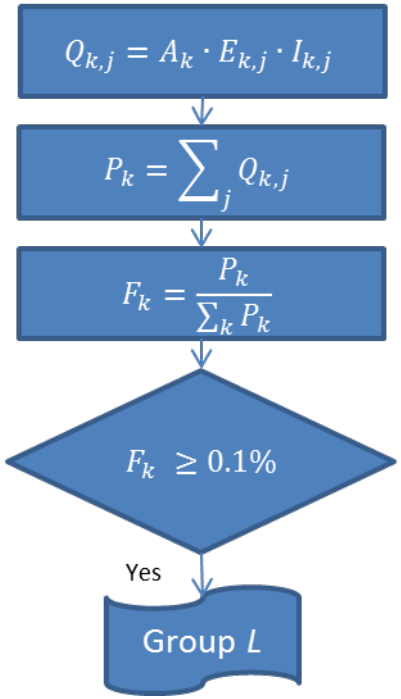
Methodology
Screening 1

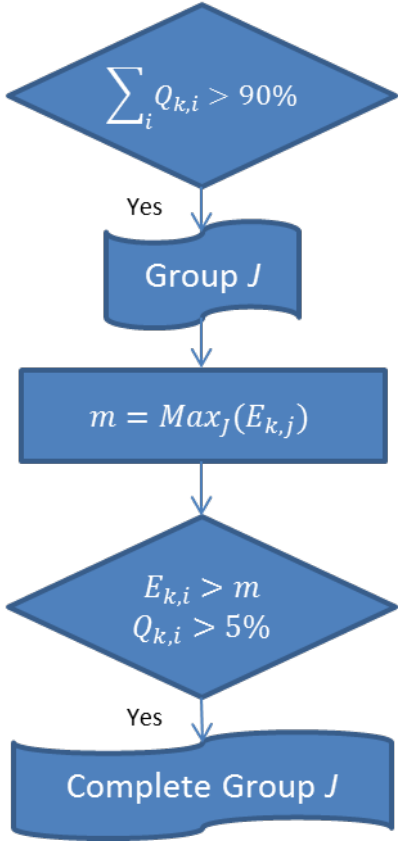
- Based on the relative activity of radionuclides
- Only radionuclides with sufficiently high activities contribute to the dose uptake/dose rate
- Based on the order of activity magnitude
- Activity : generic term
  - Absolute activity (Bq)
  - Volume activity (Bq/m³)
  - Mass activity (Bq/g)
  - …



Methodology
Screening 2

- Based on the relative weight of radionuclides
- Weight P_k : contribution to the dose rate without shielding
- Selection of energies for each radionuclide
  - Most impacting ones (at least 90% of the cumulated energy weight) → Group J
  - Energies with energy weight > 5% if higher than the highest energy of Group *J*

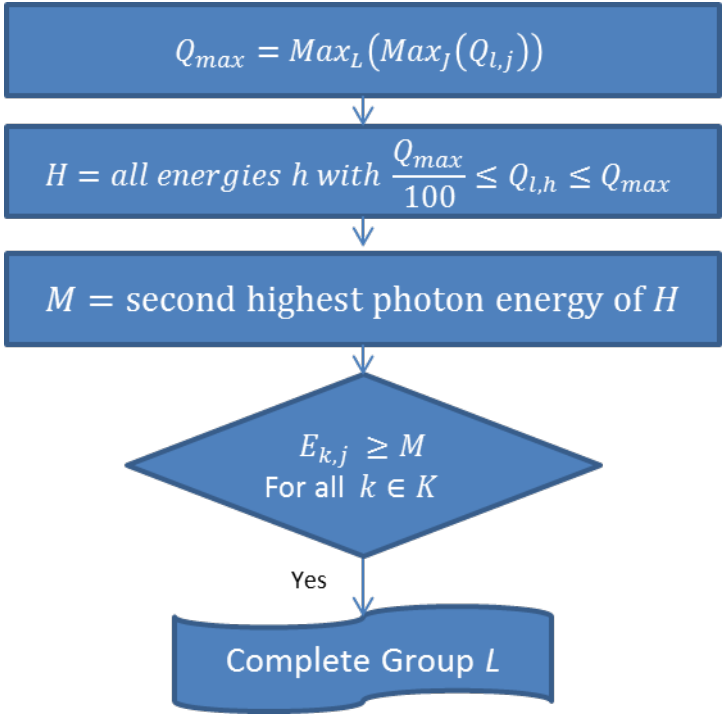




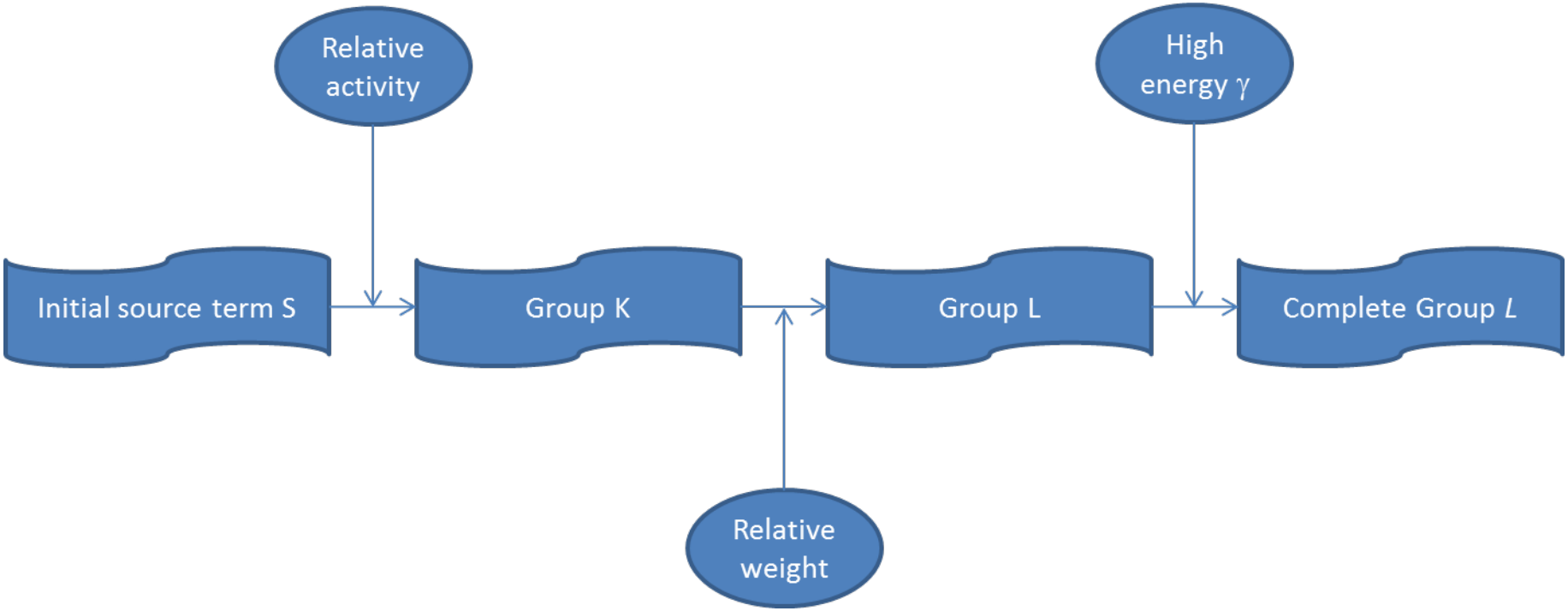
Methodology
Screening 3

- Importance of high gamma ray energy
- $Q_{l,j}$: Energy weight for energy line *j* of radionuclide *l* (as defined before)
- Add neglected radionuclides with relatively high energy gamma rays

  → Might be relevant in case of shielding layers which could affect the relative weight of isotopes



Methodology
Summary



03 Applications

Applications
Containment Filtered Venting System (CFVS)

- CFVS to be installed in all Belgian NPP units

  → To reduce the pressure in the reactor building in post-accident conditions

- Gallery for the venting line between Reactor Building and CFVS
- Manual intervention in the gallery

  → Study to size concrete shielding to limit the dose to the workers (ALARA)

- Initial source term
  - Conservative accident source term computed by severe accident modelling codes MELCOR and IODE
  - 1038 radionuclides for 8 venting periods
  - Activity levels in Bq/m^3 for each radionuclide

Applications
Containment Filtered Venting System (CFVS)

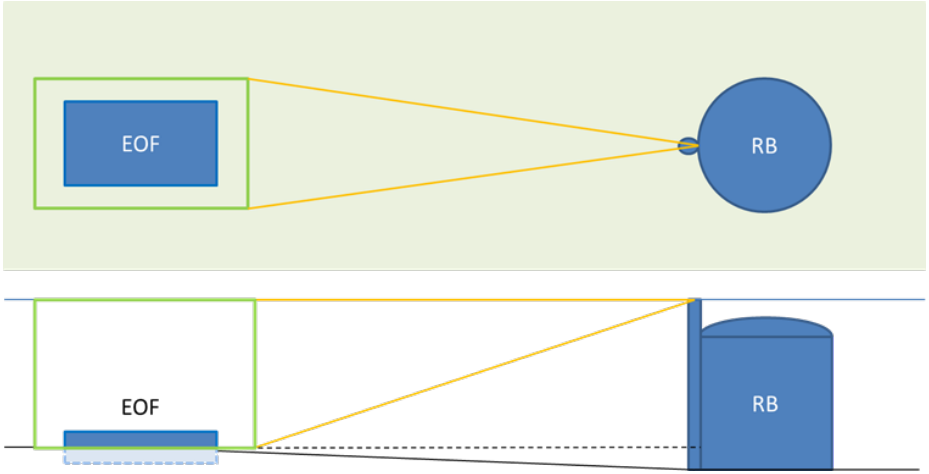
- Screening 1: 60 and 28 radionuclides for Doel and Tihange NPPs, respectively
  - Impact of a smaller order of magnitude (*N-1*): dose rate increase of 0.018% (Tihange NPP case)
- Screening 2: 23 and 15 radionuclides for Doel and Tihange NPPs, respectively
- Screening 3: No additional radionuclide
  - Impact of the 13 excluded radionuclides (Tihange NPP case): dose rate contribution of 0.7%
- Combination of both sites source terms → 31 radionuclides (3%)

Applications
Emergency Operating Facility (EOF)

- A new EOF to be built on Tihange NPP site
- Atmospheric contamination as radioactive source to be considered in the vicinity of and inside the building
  - — Irradiation through external walls
  - — Irradiation from the HVAC filters
  - → Potential irradiation of workers
  - → Need to design suitable shielding (external + internal walls)

Applications
Emergency Operating Facility (EOF)

- Initial source term
  - Output of the filtered vent
  - Uniform dispersion in the volume between Reactor Building and EOF
  - 1038 radionuclides for a 3 minutes integration
  - Activity levels in Bq/m³ for each radionuclide
- Screening 1: 26 radionuclides
- Screening 2: 8 radionuclides
- Screening 3: 3 added → 11 radionuclides (1.1%)



04 Conclusions

Conclusions

- Tractebel has developed a methodology to limit the source term to a manageable number of radionuclides
- No significant influence on the calculated dose (rate) from the screenings
- Conservatism of calculation is kept (if any)
- Otherwise: fairly good results provided + small conservative factor advised
- Con → New screening needed when source term evolves
- Pro → Methodology applicable for all source terms