Nucleonica Software Package: An innovative professional and technical resource for knowledge creation and competence building in nuclear field.

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Nucleonica: Web-based Software Tools for Simulation and Analysis

Nucleonica Overview

- Nuclear Data Resources in Nucleonica
- Nuclear Science Applications & Tools
- Education & Training with Nucleonica
- Knowledge Management with Nucleonica

Nucleonica Case Study

- Characterisation of an irradiated fuel sample (UOX) from a PWR
What is Nucleonica?

- Nucleonica provides you with user friendly access to the latest reference data from internationally evaluated nuclear data.

- A unique feature is the wide range of validated web-based nuclear science applications for decay calculations, dosimetry & shielding, gamma spectrometry, etc.

- In addition Nucleonica offers a range of introductory and advanced training courses.
Nucleonica Architecture & Logical Structure…

The NUCLEONICA Structure

Applications

Databases
(nuclear data)

Web page

Wiki
(explicit AND implicit knowledge)

Forum, Blog
News, Calendar
Main Nucleonica database JEFF3.1 contains decay data on 3852 nuclide.

New: ENSDF/B-VII.1
Nuclear Data Resources in Nucleonica:

Nuclide Datasheets++:

User friendly access to internationally evaluated nuclear data

New: ENSDF/B-VII.1
Validated Nuclear Science Applications & Tools

Radioactive decay calculations with Decay Engine++
Validated Nuclear Science Applications & Tools

Dosimetry & Shielding++
Validated Nuclear Science Applications & Tools

Range & Stopping Power++
low energy photons (energy 100 keV) are attenuated with a thick (15 cm) water shield. This combination of low energies and thick shields give rise to multiple scattering of the radiation.

The red particles (3 MeV positrons) are blocked by a lead shield (green). When the positrons collide with the shield, they combine with electrons (blue) to create gamma radiation (white). Only a few gamma photons pass through the shield material.

Electron-positron pairs are created using 10 MeV photons on lead. By “switching off” energy loss mechanisms, the charged particles are seen to spiral in the applied magnetic field.
Validated Nuclear Science Applications & Tools

Gamma Spectrum Generator

$\gamma$-spectrum simulated for $^{60}$Co 100 kBq source and NaI (3" × 3") detector:

$\gamma$-spectrum simulated for $^{152}$Eu 100 kBq source and HPGe detector.

Fukushima: Gamma spectrum of contamination at the Daiichi plant. Contamination is almost entirely to cesium-137 and cesium-134.
Modelling of $\gamma$-Spectra from Volume / Shielded sources in Nucleonica
Validated Nuclear Science Applications & Tools

webKORIGEN
fuel depletion calculations
& neutron activation

webKORIGEN was developed from the Oak Ridge Isotope Generation and Depletion code ORIGEN. Starting with a given initial reactor fuel or a single target nuclide, it calculates the time evolution of nuclide densities changing due to decays and neutron-induced reactions, and determines derived nuclear properties such as masses, radioactivities, heat releases, radionuclides, emission of radiation, etc.
Validated Nuclear Science Applications & Tools

e-Ship++: package classification for radioactive transports

Joint collaboration between CERN and Nucleonica
Mass Activity Converter

Decay Engine++

Dosimetry & Shielding++

Gamma Spectrum Generator

Nuclide Mixtures
Nuclide Mixtures: Nucleonica's trump card!

Neutron Activation

Gamma Spectrum Generator

e-Ship++

Neutron Activation
Education & Training with Nucleonica

Nucleonica for Smartphones: and Tablet PCs: M-Learning
Education & Training with Nucleonica

Karlsruhe Nuclide Chart

- Fold-out Chart
- Wall-Chart
- Auditorium Chart
- Nuclide Carpet
- Roll Chart
- Karlsruhe Nuclide Chart Online (KNCO)

Nuclide “carpet“
1m x 6.5m
In this slide, the Nucleonica web portal is considered from a knowledge management perspective. Nonaka and Takeuchi have proposed the “knowledge spiral” (shown) in which there are four modes of knowledge conversion: socialization, externalization, combination and internalization (SECI model).

**Socialisation:** conversion of tacit knowledge to tacit knowledge e.g. an apprentice who works with tutor and learns from observing and imitating the tutor's actions. **Externalization:** conversion of tacit to explicit knowledge. **Combination** is the conversion of explicit to explicit knowledge. The process of systemizing already explicit knowledge into a knowledge system. **Internalization** is the conversion from explicit to tacit, which is closely related to “learning by doing”. At the end of the spiral process, one or more individuals in the organisation have acquired new tacit knowledge.

**Socialisation**: conversion of tacit knowledge to tacit knowledge

**Externalization**: conversion of tacit to explicit knowledge

**Combination**: systemizing explicit knowledge

**Internalization**: conversion from explicit to tacit, triggered through “Learning by Doing”.

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Knowledge Management with Nucleonica
Case Study:

Characterisation of an irradiated fuel sample (UOX) from a PWR
Case Study: Characterisation of an Irradiated fuel sample (UOX) from a PWR

A: Calculate the activities of actinide and fission products in the sample (webKORIGEN)

B: Create a nuclide mixture of the 10 nuclides with highest activities (Nuclide Mixtures)

C: Estimate the gamma dose rate from this material – both unshielded and shielded (Dosimetry & Shielding)

D: Generate the gamma spectrum for a HPGe detector (Gamma Spectrum Generator) and identify the main lines.

E: Generate a transport report to determine which type of packaging is required to transport this sample (e-Ship)

F: Use the Decay Engine++ to see how the activity of the sample decreases over 5000 y.
1. Open browser and go to www.nucleonica.com

2. Enter your username and password (iss*) e.g. iss16
3. You will then enter the Networking page…

4. Now go to the Nuclear Science page
5. Here are the applications we are going to use:
A: Calculate the activities of actinide and fission products in the sample. (webKORIGEN)

1. Start the webKORIGEN application
2. Select mode 3: Reactor irradiation and decay
3. Use a fuel mass of 1g. Take a cooling time of 36 years. Otherwise default values
4. Run the application (go to tab 3)
5. Select activities of the main nuclides (Total activity is 10.6 GBq)

6. Plot the activities over the 36 y cooling period

7. Check the top 10 activities and create a nuclide mixture based on these nuclides. Rename the nuclide mixture.
B: Create a nuclide mixture of the 10 nuclides with highest activities (Nuclide Mixtures)

1. Rename the mixture to...
   1g UOX spent fuel & save
C: Estimate the gamma dose rate from this material – both unshielded and shielded (Dosimetry & Shielding)
D: Generate the gamma spectrum for a HPGe detector (Gamma Spectrum Generator) and identify the main lines.
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Results…
E: Generate a transport report to determine which type of packaging is required to transport this sample (e-Ship++)

1. Start the e-Ship application

2. Set the package characteristics (Material, Other form, Solid)

3. Generate the Transport report
F: Use the Decay Engine++ to see how the activity of the sample decreases over 5000 y.
F: Use the Decay Engine++ to see how the activity of the sample decreases over 5000 y.

Activity decreases by factor 100 in 1140 y.
Ingestion radiotoxicity (Sv per ton spent fuel)

- Total
- actinides
- fission products
- ref. 7.83 t U in equilibrium
- with P&T

results based on ICRP72

- 1000 y [99% Pu, 98% (Am+Cm) removal]
- 500 y [99.5% Pu, 99% (Am+Cm) removal]

time (y)
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• Characterisation of an irradiated fuel sample (UOX) from a PWR
Participants at the 6th International Summer School 2014: Operational Issues in Radioactive Waste Management and Nuclear Decommissioning

Trial access to Nucleonica:

Register for Nucleonica (www.nucleonica.com) & get free Premium access for 1 month