Digital transformation at the Laboratory for Nuclear Calibrations (LNK) of SCK CEN

BIPM-CCRI Webinar on Digital Transformation in Ionizing Radiation: The example of SCK CEN
• Introduction

• Evolution of LNK since ~1985

• Digital workflow

• Integrated Management System applied to LNK

• What can we do next?
Digitisation, digitalisation or digital transformation?

- Digitisation is the process of converting analog data into digital format and it focuses on data conversion – end goal: “paperless” laboratory and more data easily accessible.

- Digitalisation is about improving processes with digital solutions, is the act of taking analog processes and making them digital – end goal: higher efficiency, less risk of errors.

- Digital transformation is using technology for a general organizational upgrade. Digital transformation is digitalisation-plus, a complete change of strategy – end goal: much higher efficiency, nicely integrated apps, user friendly...

Where is LNK? Digital transformation or just digitalisation?
SCK CEN

Belgian Nuclear Research Centre: a **foundation of public utility** and global leader in the field of nuclear research, services and education.

**mission & vision:** Driven by our passion for science. Boosted by our unique infrastructure. We expand our knowledge in various nuclear areas and develop innovative applications for society.

- location: Mol, B-2400, Boeretang 200, Belgium.
- created in 1952
- ~900 staff, >1/3 with academic degree + ~ 70 PhD

**LNK (Laboratory for Nuclear Calibrations)**

- 3 staff members
- part of the RDC (Radiation Protection Dosimetry and Calibrations group)
- DI for metrology of ionizing radiation in Belgium
Why we need dosimetry calibrations?

There are many places where ionizing radiation is used:

- nuclear power plants,
- research centers
- hospitals: radiotherapy, radiology (X-ray, CT, PET) and nuclear medicine,
- mines and ore industry

- Exposure of workers to radioactivity needs to be monitored with dosemeters (personal or ambient dosemeters).
- Uncertainties on delivered doses are linked to the success of the treatment in RT and NM.

Dosemeters need a traceable calibration (metrology of ionizing radiation)
Example of dosemeters

A device that measures the charge deposited by the radiation in a medium -> the reading is converted to units of dose (Joule/kg = Gy or Sv)

- ionisation chambers + electrometers (the readers):

- ambient dosemeters:

- personal dosemeters:
Evolution of LNK


- 2 irradiation room (access to bunker via room of horizontal irradiator)

2009–2020 – KAL building Mol + Univ. Ghent:
- radiotherapy calibrations not on same site.
- old and manual irradiators
- no more spare parts
- no data acquisition software, no databases ...

2021 -> 2055+ – new LNK (Mol):
- 6 independent irradiation rooms in one place
- modern irradiators
- latest safety and security requirements
- significant automation
New building and irradiators for LNK since 2021

Green field project Oct. 2018 – May 2020:

- 6 independent irradiation rooms with control room in the center.
- Stat-of-art safety system and modern irradiators.
- Located on main SCK CEN site from Boeretang 200, B-2400, Mol.
- All type of dosimetry calibrations in one laboratory (Cs-137/Co-60, neutrons, X-ray, Co-60 radiotherapy, α/β contamination sources.
- Secondary and primary standards used as reference.
Radiotherapy calibrations of ionization chambers at LNK (G-100 Hopewell Designs Inc. irradiator):

- free in air
- inside a water phantom ~“human body”

Ionization chambers are the reference dosemeters for radiotherapy departments of hospitals.
X-ray dual tube generator

- 10-300 kV tube potential
- Xstrahl generators + Hopewell Designs Inc. LPS
- tungsten target
- N-series, RQR-series, H-250 beam qualities (ISO 4037) matched & characterized using HPGe spectrometry (L.C. Mihailescu, 2023 JINST 18 P09037)
- typical dose rates ~200mGy/h (exception few Gy/h for N-250)
- Intensively used for irradiations of biological samples
252Cf/Am-Be neutron irradiator

- Hopewell Designs Inc. N-40 irradiator model
- 1 Cf-252 source -> range: 100 μGy/h- 5 mGy/h
- 1 Am-Be source -> range: 5 μGy/h-150 μGy/h
- large room of 10 m x 10 m x 5 m is needed to reduce scattering of neutrons
- measurement with and without a shadow cone is needed --> 2 irradiations

reference date (2021-05-18)
Digital workflow and challenges?

• The data acquisition system was fully customized for the LNK workflow:
  • workflow and procedure are fixed – all steps must be followed (leakage, multiple readings...).

  - Register the device in LNK database: type, serial nbr. --> unique predefined certificate number
  - Perform irradiations: one record line for each irradiation
  - Export all record lines linked to one certificate number to an Excel template (text file)
  - Operator selects the type of calibration needed from a list of 14 options.
  - Invoicing + logbook + statistics
  - Verify results and print pdf file using macros
  - Verify pdf, sign and send it to customer by e-mail.

• Challenges:
  • Diversity of dosemeters on the market
  • Diversity of methods in one common database (template):
    • about 11 calibration methods / CMC’s (neutrons, X-ray, γ-rays, beta particles...)
    • 5 quantities ($K_{air}$, $H_p(10)$, $H^*(10)$),
    • 2 units (Gy, Sv)
    • 5 “phantoms” (slab, cylinder, pillar, rod, free in air)
    • automate, but still remain flexible.
Digital workflow

- Hopewell GC-60 irradiator (\(^{137}\text{Cs},\ 60\text{Co}\) sources)
- 20° conical collimator
- Detector (sealed ionisation chamber)
- Rotary table (plug & play)
- LPS table (automated x,y,z-axis)
- PTH sensors
- Electrometer
Digital workflow

Utilities based on LabView:
- Registration,
- Irradiator Control,
- Report,
- Irradiator Calibration,
- Rotary table.
Digital workflow

Two independent databases:

- **Irradiation database**: source, quantity, time, beam size, phantom, Monitor Chamber – (1 record=1 irradiation)

- **PTH database**:
  - saves every minute
  - PTH used by Irradiator Control Utility for real time corrections
  - start and stop PTH during irradiation are saved also on Irradiation database.
Digital workflow

Reporting:

- Report Utility as a text field exported to an Excel template,
- Excel templates with macros for analysis,
- Acrobat Reader macro to create a pdf ready for signatures,
- Signed and locked pdf file sent by e-mail.
Excel template for data analysis and *pdf* generation:

- Selection of calibration type: photon, neutron, active detector or passive, calibration v.s. (just) irradiation,
- Language selection (NL, FR, EN),
- PTH correction or ISO 17025 accreditation logo....
Digital workflow and challenges?

• Digital reading from electrometers:
  • presently only 1 type of electrometer is fully implemented,
  • not all electrometers on the market can be easily implemented (from a total of 4-6 types we typically get from customers).

• Manual reading is always needed and it may not be easily replaced:
  • digital screens are available but no possibility to connect to the dosemeter,
  • digital screens are in bad condition (old models, broken, light reflection...),
  • analog devices with a needle.

• All method (re-)validation measurements are performed automatically:
  • digital electrometers with RS-232 connection
  • fully automated LPS with automated calibration procedures defined in the Hopewell data acquisition system.

• Raw data from 3 CMC remain outside the databases->only Excel templates:
  • Radionuclide calibrators for nuclear medicine
  • Surface contamination monitors
  • Beta calibrations
Document storage

**Document storage solution “Alexandria”:**

- + cloud based
- + predefined folder structure for 2 levels
- + daily centralized back-up
- + multiple versions stored.

- - not well suited for large amount of data or uncommon data files (raw measurement data, binary files, executables,...)
- - interface with data acquisition software is difficult
QA documents – IMS applied at LNK

• IMS: quality, safety, security, economics and environmental impact

• All LNK activities are grouped as one IMS process:
  • Online portal for easy access to all procedures
  • **ProReact** app for complaints and NCR’s registrations and follow up
  • **LabTool** app for calibration calendar and reminders
  • 1 validation file and 1 work instruction for each CMC/installation of LNK
  • **Connect** app for Human Capital Management based on SAP SuccessFactor
QA documents – IMS applied at LNK

Work instruction, validation files, templates and forms:

- 1 validation file and 1 work instruction for each CMS/installation of LNK.
- Automated versioning – major and minor update/change.
- All approved versions are locked and cannot be deleted.
- *Pdf* is generated automatically from MSWord after approval.
- Description of the change and list of approvers are automatically included in the *pdf.*
What can we do next?

- Photos taken at start of each irradiation and their storage place linked to the certificate number.
- Automated reading of the screens.
- Web interface for ordering the calibrations, follow up, communication with customer and delivery of certificates. Customer’s feedback can be implemented as well.
- QR codes printed on the calibration labels with direct link to the calibration certificate on the server of LNK.
- User accessible calibration factors for ambient sensors (p, T, H).

- Automate as much as possible but still be flexible ...
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