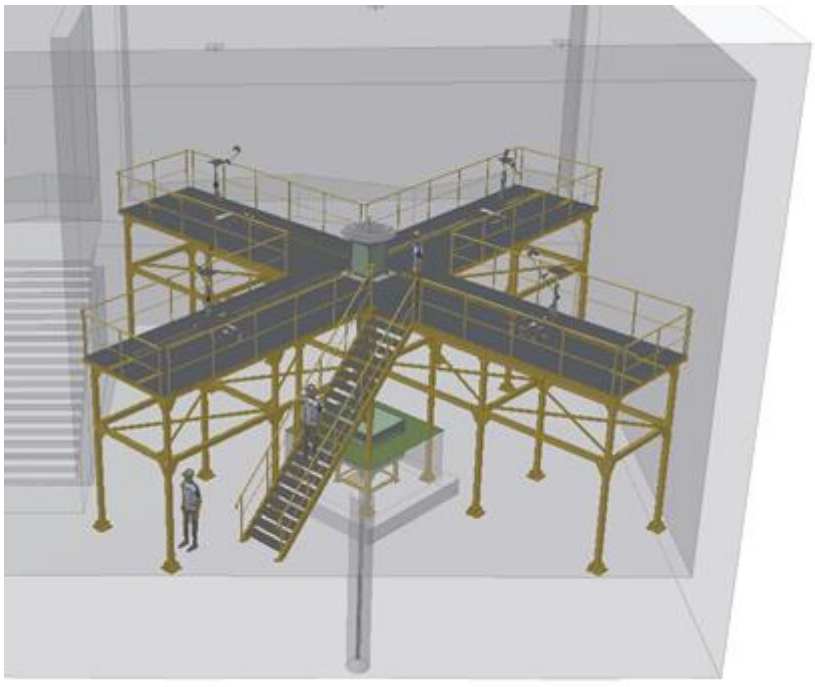
# Neutron Calibration Laboratory



**Thanks to its unique design, the utilised technology and the wide range of optional accessories, the neutron calibration laboratory enables fast and safe calibration of detectors and dosimeters in the field of neutron radiation.**

## Purpose

The neutron calibration laboratory is a comprehensive workplace that enables convenient and safe calibration of detectors and dosimeters in the field of neutron radiation. Thanks to its unique design, the utilised technology and the wide range of optional accessories it makes the calibration process easier and faster.

The specific spatial arrangement and equipment of the workplace can be adjusted according to the customer's requirements and is detailed in design specifications.

## Description

When implementing the neutron calibration laboratory, the following elements are defined and installed:

- An irradiation room (dimensions, provisions for installation of irradiator)
- An irradiator with ionizing radiation sources (number of sources, ejection height, shielding)
- A positioning system, quantity and type of calibration benches, a platform for the placement of the calibration benches
- A safety system to prevent impermissible exposure of personnel
- Irradiation control room and an operator workstation
- Radiation monitoring system
- Software for the calibration process control and data processing
- Electric and data distribution and other optional equipment

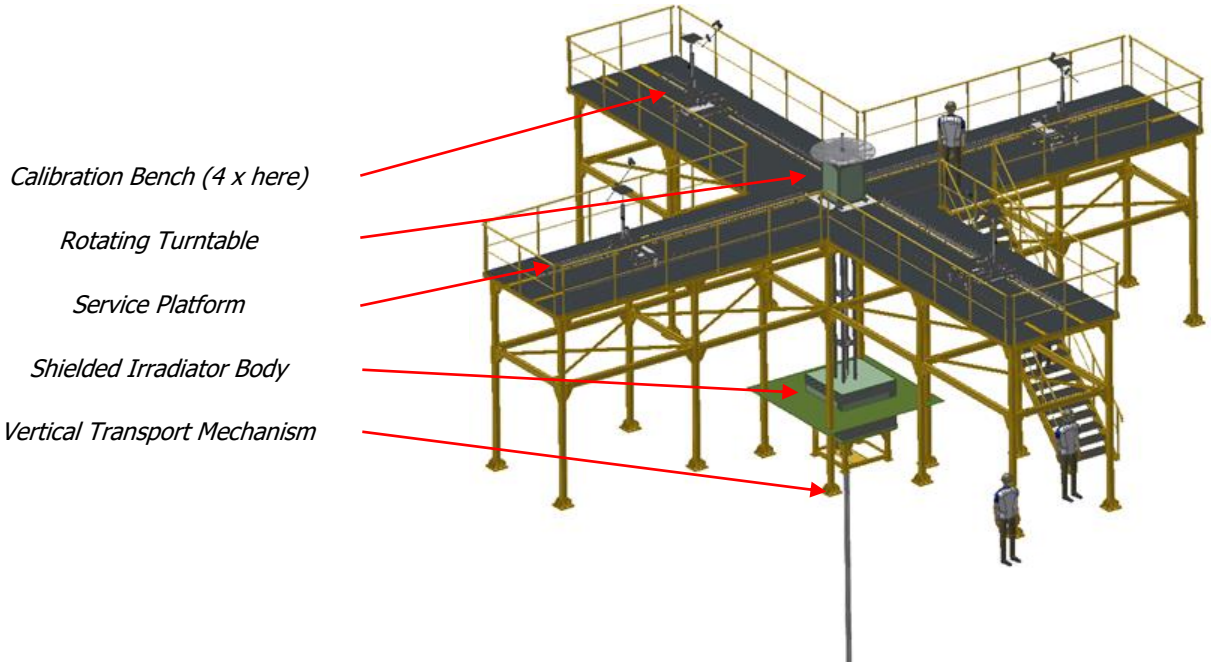
## Main Advantages

- Modular system which can be optimized to specific clients' needs
- The possibility to establish a metrological traceability and to use it as a secondary dosimetric standard
- Can be accredited according to ISO 17025
- Sturdy safety interlocks
- Irradiator for up to 7 sources, the possibility of inserting also gamma sources in the neutron irradiator
- Low dose rate on the irradiator's surface
- Fully automatic or semi-automatic calibration bench with various customizable holders
- Fully automated operation of the laboratory, software applications completely manage the calibration process, data processing and archiving
- The neutron, gamma and beta calibration laboratory can be controlled from one central workstation
- Possibility of a connection to external information systems via LAN.

## Irradiation Room

In the connection with the calibration laboratory supply VF provides its long-term experience with design, construction, and operation of such facilities. The project can be designed and implemented on a turn-key basis and customized to meet specific customers' needs and expectations. An integrated calibration facility with neutron calibration laboratory and other calibration laboratories (such as gamma, panoramic gamma, and/or beta) can be designed and supplied as well.

The **key part of the neutron calibration laboratory** is the irradiation room. The ISO 8529 standard recommends a room with the dimensions of up to 15 x 15 x 15 metres to ensure proper calibration of the neutron detectors (to reduce the effect of neutron scattering). Smaller rooms are permissible but these are associated with greater radiation scattering on the walls. In the room there is an elevated service platform for one or more calibration benches.




The shielding of the irradiation room is designed and constructed to take into account the expected activity of the sources that will be used in the irradiation room. The main shielding is formed by the building materials of the room (concrete, masonry) which are, when required, subsequently given additional shielding made of other suitable materials e.g. polyethylene. The room is air-conditioned to ensure satisfactory conditions for calibration. The interior elements of the irradiation room are preferentially made of light-weight materials to minimize neutron scattering.

## Environmental Parameters

In the calibration laboratory it is usual to install a system that measures the working conditions: temperature, pressure, and relative humidity. It is placed directly in the irradiation room. All measured values are forwarded to the host system, which checks that the environmental conditions are within the acceptable limits. Values are registered in measurement protocols.

## NI-08 Neutron Irradiator

The NI-08 panoramic irradiator is the main part of the neutron calibration laboratory. In standard form it consists of the following parts:

- Horizontal carousel holder with 8 slots for inserting sealed neutron sources (optionally also gamma sources)
- A mechanism for rotating the carousel with the sources to the required position
- A vertical transport mechanism for the sources
- Shielding of the irradiator body against neutron and gamma radiation

Various neutron sources are usually inserted. The $^{241}$Am/Be and $^{252}$Cf are recommended. Carrousel can be equipped with auxiliary gamma radiation sources ($^{137}$Cs, $^{60}$Co, etc.) that are used to measure the response of the neutron detectors in the gamma radiation field.

*Shielded body of the irradiator*

*Carousel holder with the sealed sources*

Each of the sealed radionuclide sources is fixed inside a special holder designed for being used with the NI-08 irradiator. The holders are made of stainless steel.

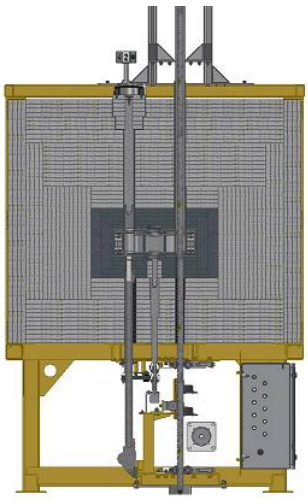
The radiation sources for the irradiator are usually loaded in a hot cell.

The source is moved into the exposure position electromechanically, in two steps. The chosen source arrives in the working position by carousel rotation and then is electromechanically ejected through a vertical transport pipe to the exposure position, typically in the middle of the room. The electromechanical ejection of sources designed and used by VF provides increased reliability and safety when compared to compressed air systems.

The source that is ejected into the exposure position can be identified using control software (through sensors) as well as independently using a mechanical indicator and a camera system installed in the upper part of the irradiator.

The operation of the NI-08 irradiator is controlled by the PLC, placed in the local control switchboard cabinet. Communication between the cabinet and the host system is ensured via Ethernet or RS-485 serial interface.

The irradiator can be modified according to requirements, typically provided with optimized shielding for a specific set of sources.



*Irradiator - cross section through the body*

## NI-08 Specifications

| | |
|---|---|
| Number of sources | up to 7 |
| Total inserted activity, max. as standard | 1.85 TBq (50 Ci) of $^{241}$Am/Be |
| Dose rate on the irradiator body surface | max. ≤ 10 µS/h (1 mrem), usually ≤ 1 µS/h (0.1 mrem) |
| Source ejection height | up to 5 m (10½ ft) as standard |
| Communication interface | Ethernet, RS-485 |
| Maximum source dimension (Ø x L) | diam. 40 x 80 mm (1.57 x 3.15 in) as standard |
| Irradiator body dimensions (W x H x D), without stand | approx. 1.4 x 1.2 (min.) x 1.4 m (55 x 47 x 55 in) |
| Weight of irradiator body, without stand | approx. 3400 kg (7500 lb) |

## Calibration Bench

The calibrated detectors are positioned on the working table of the calibration bench as standard. The calibration bench CB-50 is intended for the precise positioning of the meter within the ionizing radiation field during calibration. A trolley, a key part of the bench, moves on rails. It is used to position the tested instrument at the desired distance from the source.

The bench makes it possible to change the distances of the tested instrument from the source automatically in a range from app. 0.7 m to 10 metres (2¼ to 32½ ft) as standard. The adjustment of the moveable trolley along X axis, i.e. the detector-source distance, is controlled by a power unit that secures its smooth start and stop.

A mechanical scale attached to one rail and camera are used for independent verification of the bench position. The working table can be moved in both vertical and transverse directions. Rotational movement is optional.

*CB-50 Calibration Bench (fully motorized design)*

The range of motion of the motorized/manually operated feed, length of the rails, clamps and tools for detectors, etc. are adapted to the customer's requirements. The motorized motions of the calibration bench can also be remote controlled from the operator's workplace or even directly controlled from the irradiation room using a manual controller with a screen.

The calibration bench controller is installed in a switchboard fixed to the trolley.

If required, the irradiation room can be supplied with multiple calibration benches (up to four) to enable simultaneous calibrations to achieve higher throughput in the workplace.

## CB-50 Specifications

| | |
|---|---|
| Standard detector-source distance | 0.7 4 10 m (2¼ 4 32½ ft) |
| Horizontal adaptation of the working table | ± 300 mm (12 in) as standard |
| Vertical adaptation of the working table | mechanic ± 150 mm (6 in)<br>electro mechanic ± 300 mm (12 in) |
| Repeatability of position adjustment | < ±1 mm (0.04 in) |
| Trolley weight | 70 kg (154 lb) |
| Maximum load of the working table<br>(weight of the detector with accessories) | 10/70* kg (22/154* lb)<br>** with motorized axes Y and Z* |
| Trolley speed | 0 4 200 mm/s (0 48 in/s) |
| Working table dimensions | 300 x 300 mm (12 x 12 in) |
| Communication interface | Ethernet, RS-485 |

**CB-50 Optional Accessories:**

- Custom made holders and jigs for calibrated meters
- Digital measuring system for automated data acquisition


*Measuring panel: input-output connectors*

## Measuring and Power Supply Systems

The Measuring System reads the data from the meters during the calibration (test) process. The power supply system provides for the meters being tested.

The measuring system can receive the readouts in two ways:

- Optically through a camera and a video monitor
- Digitally (option) through measuring panel with integrated rate meters and/or digital interfaces directly to the host system (RS-232, RS-485, Ethernet, etc.)

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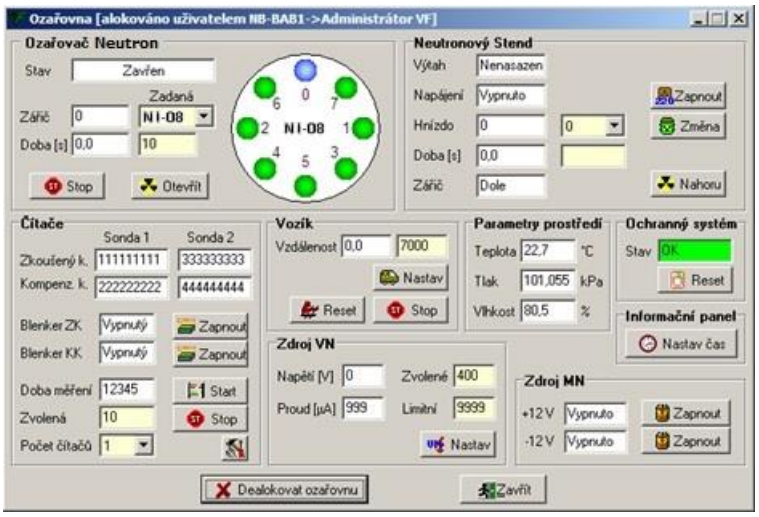
## Control of the Irradiation Room

The Basic Control Software is provided as standard to enable remote control of the laboratory technology. Optionally, a Data and Control System (DaRS), which manages completely the calibration laboratory operation, its accessories and calibrated instruments, can be supplied.

The Basic Control Software provides the user interface for the laboratory technology control from the operator's room. The application can run on the different Microsoft Windows operating systems.

The operator first of all selects the source that is to be ejected into the exposure position, defines the irradiation time and the required distance of the calibration bench trolley. Commands are forwarded to the control PLC technology through the RS-485 interface or Ethernet. Once ejected, the selected source stays in the exposure position for a selected period of time and then returns to the basic shielded position. The irradiation process may be interrupted at the operator's command.

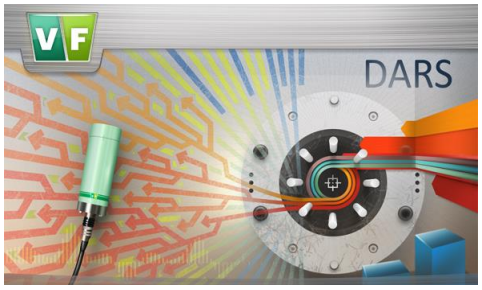
The signals of the safety system are superior to the operational commands of the control software.



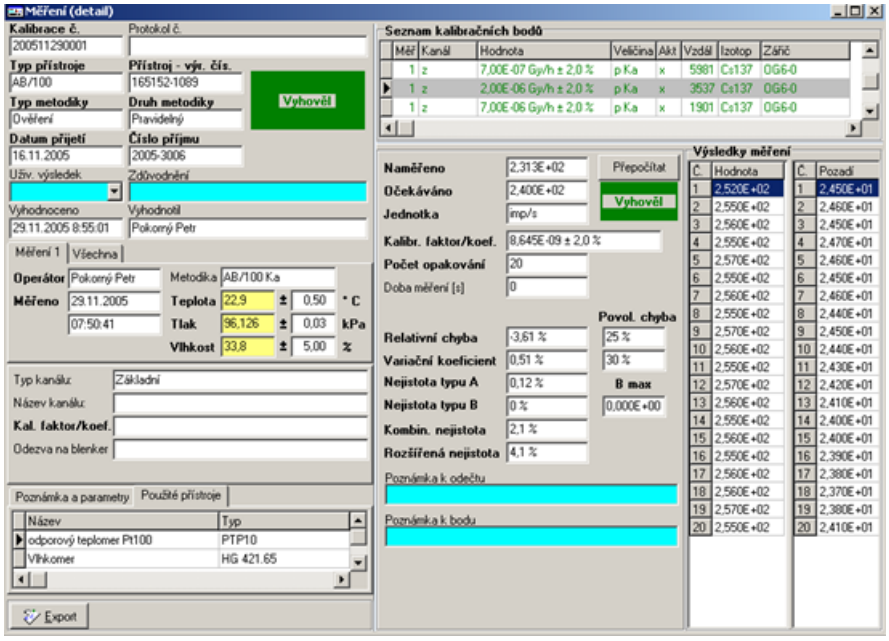

*Screen of NI-08 control*

DaRS, a **Data And Control System**, which enables comprehensive control and administration of calibration laboratory, its aceessories and calibrated instruments, can be supplied as an option. Additional applications or databases are not required. One DaRS can be used for several irradiaton rooms (gamma, beta). DaRS software is a modular based system which consists of several dependent and several independent modules. The modules control individual parts of the system which operates using the SQL database running on a server.

*For more information please see DaRS data sheet.*




*DaRS, a Data and Control System*




*< DaRS:*
*A screen with the results of the automated calibration procedure*

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## Safety System

The purpose of the safety system is to prevent any unacceptable exposure of the personnel. The technical components of the safety system are installed inside the irradiation room and in the operator's control room as well.

All components are hardwired i.e. the signals have higher priority than any signal from control PC.

*Entry door opening button with a key lock and Emergency breaker*

The following **technical means** are usually integrated into the safety system:

- An electromagnetic door lock installed on the entry door to the irradiation room
- A passive open/close entry door sensor
- An entry door opening push button with a key lock
- A set of active motion sensors (PIR) inside the irradiation room
- A camera which views the entire irradiation room status
- A visual and acoustic signalization unit placed at the entry door
- Set of emergency breakers for equipment

*Visual and acoustic signalization unit*

**Basic functions of the safety system:**

- Prevents starting the irradiation procedure if the entry door to the irradiation room is opened
- Prevents the opening the entry door to the irradiation room if irradiation process is in progress
- Moves the source into the irradiator shielding if the entry door to the irradiation room is opened during irradiation
- Moves the source into the irradiator shielding if any person is moving in the irradiation room
- Moves the source into the irradiator shielding after pressing anyone of emergency push-buttons
- Moves the source into the irradiator shielding in case of power failure
- Controls the visual and acoustic signalization – when starting the exposure, a short acoustic warning signal is provided and the light on the signalization unit goes red. The visual warning is constant throughout the exposure.

## Radiation Monitoring System

Radiation monitoring system ensures radiation safety in both the operator's and irradiation room. Its basic version consists of two MDN-01 type smart dose rate probes and one LZJ-22 local display unit. For larger calibration laboratories, it can feature bigger amount of dose rate probes and/or neutron probes, alarm slave units and/or can be connected to a host Radiation Monitoring System.

When the specified alarm levels are exceeded, an acoustic and optical alarm is produced by the LZJ-22 which, as an additional option, can also be produced by the external ASU-50.

*MDN-01 Neutron Dose Rate Meter*

*ASU-50 Alarm Slave Unit*

*LZJ-22 Local Display Unit in the operator's workplace. On the left is the MDG-07 monitor to measure the gamma dose rate.*

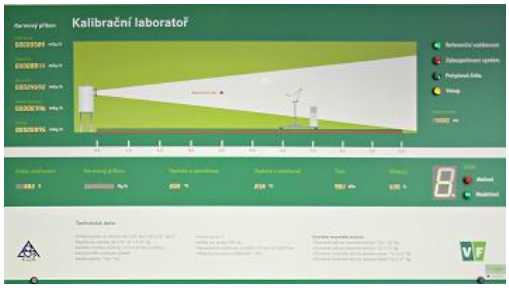
## Other Accessories

A **Shadow Cone**, made up by two materials that conform to ISO 8529, is used to calculate a correction polynomial of the dose rate and to regularly perform quality control of the laboratory. It is used to determine the proportion of directly captured and reflected neutrons.

A **Circular Turntable** with supporting rings for the placement of dosimeters can be installed on the platform above the ejection mechanism as an option. It is primarily used for the precise placement of larger amounts of calibrated personal dosimeters in the radiation field.

The table comes with a 1.2 m diameter and a motorized rotary drive as standard.

A **Heavy Water Moderating Sphere** (with $D_2O$) is intended to slow down fast neutrons to achieve the energy of thermal neutrons. The sphere has a diameter of 300 mm, is filled with deuterium (heavy water - $D_2O$) and has a well at the bottom to enable ejection of the source. The moderation sphere is placed above the source so that the neutron source is ejected into its centre.




The **General Information Panel** providing the overall status of the calibration laboratory with source indicator, calibration bench position, ambient conditions, dose rate values etc. can optionally be supplied and installed in the operator's room.

The **Electronic Personal Dosimetry System** SEOD-MP is designed for operative monitoring of persons and for assessment of their personal doses by means of electronic personal dosimeters. It allows dose record-keeping in accordance with legislative requirements.

The user-friendly and compact **Electronic Dosimeters Terminal** is part of the Electronic Personal Dosimetry System SEOD-MP. It allows acquiring information on persons and their personal doses from electronic personal dosimeters of various types.

## Standards and Certification

- **ISO 8529 Reference neutron radiations:** Part 1: Characteristics and methods of production; Part 2: Calibration fundamentals of radiation protection devices related to the basic quantities characterizing the radiation field; Part 3: Calibration of area and personal dosimeters and determination of response as a function of energy and angle of incidence
- **ICRU Report 57** Conversion Coefficients for use in Radiological Protection against External Radiation
- The neutron irradiator can be **traceable** to the primary (national) or secondary standard.
- The calibration laboratory system fulfils the requirements for **accreditation in compliance with ISO/IEC 17025** for test and calibration laboratories.

## Models and Accessories

| Model | Description |
|---|---|
| **K1418** | NI-08 Neutron Irradiator |
| **K0124** | CB-50 Calibration Bench<br>(electrically driven distance setting, remote control) |
| **K0542** | CB-13 Calibration Bench (manual setting of the distance) |
| **S0201-02** | Basic Control Software |
| **Optional Accessories** | |
| **S1111** | DaRS Data and Control System |
| **-** | Neutron sources ($^{241}$Am/Be, $^{252}$Cf, etc.) |
| **-** | Custom made tools for calibrated items: jigs, standardized phantoms |
| **K1297-51** | Rotating Turntable (for personal dosimeters calibration) |
| **K1297-50** | Shadow Cone |
| **K1297-52** | MS-01 Heavy Water Moderating Sphere |
| **K1483** | MPX-01 Measuring Panel<br>(for digital readout of the data from the meters during the calibration) |
| **K1482** | GIP-01 General Information Panel |
| **Related Products** | |
| **K1353** | IN-02 Neutron Irradiator |
| **S0803** | RMS Radiation monitoring system |
| **K0743** | LZJ-22 Local Display Unit |
| **K0917** | MDN-01 Neutron Dose Rate Meter |
| **K1354** | PNM-01 Portable Neutron Meter |
| **S1112** | SEOD-MP Electronic Personal Dosimetry System |
| **K0043** | TED-MP Electronic Dosimeters Terminal |

*Calibration Bench (a type with one axe motorized movement)*

*PNM-01 Portable Neutron Meter (SND-01 Smart Neutron Detector and Radcount-2S Display Unit)*

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