PTB project "Support of the Quality Infrastructure in Serbia"

Report

Fact Finding Mission to Vinča Institute of Nuclear Sciences, Department of Radiation and Environmental Protection, Belgrade:

Support to the international recognition of measurement capabilities

carried out by Dr. Rolf Behrens and Stefan Wallerath

01.-03.12.2014

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1. Introductory remarks

A first PTB project “Support of the Quality Infrastructure in Serbia” started in October 2011. This project consists in three fields of intervention: (i) metrology, (ii) accreditation, and (iii) national quality policy. Support at the meso level of the quality infrastructure (QI)-institutions was focused on the topics of accreditation and metrology. During this phase, European directives, like Prepackage-Directive, Measurement Instrument Directive (MID) and Non-automatic Weighing Instrument (NAWI) Directive have been transposed into National law. The Accreditation Body ATS was capacitated to accredit conformity assessment bodies (CABs) for the EU Pressure equipment and Lifts directives. At the macro-level a draft national quality strategy has been developed but it is still subject to finalisation and approval on the Serbian side.

In January 2014 a new project phase under the same title “Support of the Quality Infrastructure in Serbia” has been approved in order to consolidate the results already achieved and to achieve new results in additional fields of intervention.

The overall aim of the project is to assure that selected services in Metrology and Accreditation are offered in compatibility to EU requirements. Amongst others, the Serbian national metrology institute DMDM shall be prepared to comply with the requirements for accreditation as notified body for MID and NAWI and ATS shall be qualified to accredit (CABs) as notified bodies for selected EU directives.

Within the framework of the PTB project, a first fact finding mission to Vinča Institute of Nuclear Sciences, Department of Radiation and Environmental Protection (Vinča REPD) was carried out from 01.-03.12.2014, with the aim to identify required capacity building support in order to achieve international recognition as a Designated Institute (DI) for Ionizing Radiation. In July 2013 a general agreement between Vinča and DMDM was signed regarding their future cooperation. On September 29, 2014 the Vinča Institute has been recognised as DI by EURAMET.

2. Key persons & institutions involved

During the 3 day visit to Vinča Institute following persons were met:

Dr. Borislav Grubor, director general, Vinča Institute of Nuclear Sciences (1 h on 03.12.)

Dr. Bojan Radak, deputy director general, Vinča Institute of Nuclear Sciences (1 h on 03.12.)

Dr. Đorđe Lazarević, director, Vinča Institute of Nuclear Sciences, Radiation and Environmental Protection Department (Vinča REPD)

Dr. Olivera Ciraj-Bjelac, Vinča REPD

Dr. Gordana Pantelić, Quality Manager, Vinča REPD

Milos Zivanovic, Senior metrologist, Vinča REPD

Sandra Ceklic, metrologist, Vinča REPD

Katarina Karadžić, in education, Vinča REPD

Srboljub J. Stanković, Vinča REPD

Nikola Škundrić – DMDM (on 02.12.)

Additionally, the debriefing meeting (on 03.12.) was attended by following persons:

Boris Lastro – DMDM Vice Director

Dr. Wolfgang Schmid – EURAMET Head of Secretariat

Dr Tanasko Tasić – EURAMET Capacity Building and Members' Support Officer

3. Aims and contents of mission

Terms of Reference for the mission were as follows:

- Fact-finding regarding the role of Vinča Institute of Nuclear Sciences, Radiation and Environmental Protection Department (Vinča REPD) and the status of its measurement capabilities in the field of ionizing radiation, in cooperation with the Serbian National Metrology Institute DMDM
- Estimation of the Technical capabilities, QM-system, participation in international fora / TCs of RMO, participation in laboratory intercomparisons, future CMC claims of Vinča Institute
- Informing Vinča REPD on the requirements and mechanisms of CMC claims for international recognition of measurement capabilities in Appendix C of the BIPM KCDB (in cooperation with DMDM)
- Identification of most relevant measurands for potential future CMC claims
- Identification of gaps and capacity building needs, in order to prepare for the submission of first CMC claims
- Discussing the way-forward as regards potential support from the PTB project side in cooperation with DMDM and Vinča REPD

4. Achievements, difficulties and observations

Introduction:

The Secondary Standard Dosimetry Laboratory (SSDL) of Vinča Institute of Nuclear Sciences, Radiation and Environmental Protection Department is a member of IAEA/WHO network of SSDL and provides the calibrations of dosimeters in radiotherapy and radiation protection and partially in the field of diagnostic radiology. It is a unique laboratory of this type in the country. The service of the Laboratory was significantly improved through the IAEA TC project SRB6003 (2007/2008) when the equipment for calibrations in the fields of radiotherapy and radiation protection was obtained. One of the outcomes of this project was accreditation according to ISO 17025. With this equipment, the calibration service for external beam radiotherapy and radiation protection is covered. However, the calibrations for brachytherapy and nuclear medicine are still not possible, while the calibrations in the area of diagnostic radiology and orthovoltage radiotherapy are not adequate as results from comparison measurements revealed problems below about 70 kV high voltage.

The laboratory is located in Belgrade, capital city of Serbia, on the premises of Vinča Institute of Nuclear Sciences. Such location provides low external environmental disturbances and the possibility of facility extension. At present, it provides calibration services for radiotherapy and radiation protection, it is accredited according to ISO 17025 (http://www.registar.ats.rs/predmet/655/) and as the only laboratory for metrology of ionising radiation in Serbia.

Calibration activities are exclusively performed on the laboratory premises. Separate rooms are provided for radiation sources (Co-60, Cs-137 and X-ray unit). Structural shielding is designed according to radiation protection standards. Control area is located next to the calibration rooms. A mechanical and electronic workshop is available.

Following irradiation equipment is available: a tele therapy unit with Co-60 source, a well collimated multiple source radiation unit with Co-60 and Cs-137 sources for radiation protection calibration and an X-ray generator Philips MG 320. Standard ionizing chambers and electrometers (traceable to the SI): UNIDOS T10002-20756 with ionisation chamber TW 30012-0172, UNIDOS T10002-20767 with ionisation chamber TW 32002-0311, UNIDOS T10002-20767 with ionisation chamber TW 32002-0310, UNIDOS T10002-20767 with ionisation chamber MAGNA A650, Diavolt universal T43014, PTW, check sources, and several working standards. The laboratory is equipped with calibration bench and trolleys with laser positioning (telescope for radiotherapy) system and a monitor chamber. There is a camera with in-room monitor which is coupled to a display in the control room.

The laboratory has four full-time appointed physicists and engineers, one part time physicist and two technicians. One of them is the head of the laboratory. This staff level is sufficient to support complete SSDL activities (establishment and performance) in the field of diagnostic radiology, radiotherapy and radiation protection.

The laboratory regularly participates in the intercomparisons organized by International Atomic Energy Agency (IAEA) in the field of radiation therapy and radiation protection, mainly with TLDs.

Findings:
The Vinča REPD is well equipped and well organised in terms of staff structure, facilities, and working materials. A thorough quality management systems (QMS) is implemented since 2010 including annual internal audits and detailed educations plans for new laboratory workers. The QMS contains both management aspects as well as technical working descriptions including uncertainty budgets for the measurements performed. During the visit uncertainty budgets were investigated in depth and only a few possible minor improvements were identified and indicated to the laboratory. Calibration certificates of the laboratories' measuring instruments were presented whenever asked for. Thus, traceability is generally assumed to be present. Protocols of regular checks including the history of the measuring instruments were also presented whenever asked for. Several aspects regarding the calibration and irradiation practices were discussed and some hints regarding the true values of the operational dose quantities were given to the laboratory.

The laboratory plans to apply for the following CMC entries in the near future:

- Air kerma, K_{a}, and air kerma rate, $\dot{K}_{\mathrm{a}}$, in the radiation protection level using different ^{137}Cs- and ^{60}Co-radiation sources and
- Absorbed dose to water, D_{w}, and absorbed dose rate to water, $\dot{D}_{\mathrm{w}}$, in the radiation therapy level using a ^{60}Co-radiation source.

Several comparison measurements supporting the planned CMC entries have been performed with different institutes over the past years:

- Comparisons with the International Atomic Energy Agency (IAEA) utilising thermoluminescence detectors (TLDs) from the IAEA which were irradiated by Vinča REPD and evaluated by the IAEA. The IAEA maintains CMC entries in the considered area.
- A comparison with the Belgian Nuclear Research Centre (SCK•CEN) utilising a Farmer type ionisation chamber (IC) calibrated in terms of irradiated dose per measured electric charge. The SCK•CEN is traceable to VSL (Netherlands) maintaining CMCs in the considered area.
- A comparison with the IAEA utilising a Farmer type IC calibrated in terms of irradiated dose per measured electric charge. The IAEA maintains CMC entries in the considered area.

The following table contains the comparisons supporting the potential future CMC entries. The underlying documentation was shown during the visit. The uncertainties are given for a confidence level of 95 % (*k* = 2):

Date of measure-ment	Quantity ; Radiat. Quality	Dose rate	Measuring instrument	Partner	Result of partner	Result of Vinča REPD
09-2008	K_a ; ^{137}Cs	no influence	TLDs from IAEA	IAEA	(5.24 ± 0.19) Gy	(5.00 ± 0.09) Gy
05-2009	D_w ; ^{60}Co	no influence	TLDs from IAEA	IAEA	(1.97 ± 0.07) Gy	(2.000 ± 0.024) Gy
05-2011	D_w ; ^{60}Co	no influence	TLDs from IAEA	IAEA	(1.99 ± 0.07) Gy	(2.000 ± 0.024) Gy
05-2013	D_w ; ^{60}Co	no influence	TLDs from IAEA	IAEA	(2.01 ± 0.07) Gy	(2.000 ± 0.024) Gy
12-2013	K_a ; ^{137}Cs	no influence	TLDs from IAEA	IAEA	(5.10 ± 0.18) Gy	(5.00 ± 0.09) Gy
5-2014	$\dot{D}_w$; ^{60}Co	(10 .. 20) Gy/h	Farmer type IC	SCK•CEN	(45.25 ± 0.59) Gy/mC	(45.49± 0.54) Gy/mC
5-2014	$\dot{K}_a$; ^{60}Co	(10 .. 20) Gy/h	Farmer type IC	SCK•CEN	(41.32 ± 0.45) Gy/mC	(41.57 ± 0.45) Gy/mC
10-2014	$\dot{K}_a$; ^{137}Cs	Not yet available.	1 litre IC	SCK•CEN	Results not yet available.	
10-2014	$\dot{K}_a$; ^{60}Co		1 litre IC	SCK•CEN		
11-2014	$\dot{D}_w$; ^{60}Co	10 Gy/h	Farmer type IC	IAEA	Up to now no results available; ongoing with further participants	
11-2014	$\dot{K}_a$; ^{60}Co	10 Gy/h	Farmer type IC	IAEA	Up to now no results available; ongoing with further participants	

Results of further comparison measurements using X-ray qualities were shown during the visit. Only in the low energy region, i.e. below about 70 kV tube voltage, some unsatisfactory results were identified. Possible reasons and potential improvements were discussed.

5. Recommendations and suggestions for further action

Due to the mostly positive findings described above it is recommended to consider the future application for CMC entries mentioned above benevolently (entries based on radiation qualities utilising ^{137}Cs and ^{60}Co).

The laboratory was encouraged to publish the results of the comparison with SCK•CEN in a peer reviewed journal, e.g. in the technical supplement of Metrologia. Nevertheless, the laboratory should take part in future BIPM or supplementary EURAMET comparisons.

In case the laboratory needs additional registered intercomparisons on short notice in order to underpin future CMC claims, the PTB project shall investigate the possibility of financially facilitating bilateral intercomparisons with institutes linked to BIPM or EURAMET key- or supplementary comparisons in the respective measurands.

As the laboratory workers are well educated only horizon widening measures are recommended for both experienced as well as new staff members. For example, a short term visit in a national metrology institute (NMI) maintaining both primary standards as well as CMC entries for the quantities and radiation qualities covered by the Vinča REPDs' accreditation.

Finally, the laboratory should investigate the reasons for the unsatisfactory comparison results in the areas of diagnostic radiology and orthovoltage radiotherapy in the energy range below about 70 kV high voltage.

Minor suggestions for further improvements:

- Measurement results of the regular checks are compared to the previous year. It was suggested to compared them to the first measurements using the instrument.
- Inhomogeneities of the radiation fields should be considered during irradiation of large objects, e.g. large detectors or the ISO water slab phantom (in personal dosimetry).

Annex 1 Presentation of the Vinča Institute of Nuclear Sciences, Department of Radiation and Environmental Protection

VINS SSDL
Belgrade, Serbia

Olivera Ciraj-Bjelac
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E: ociraj@vinca.rs

Vinca Institute of Nuclear Sciences
Radiation and Environmental Protection Laboratory
www.vinca.rs

Vinca Institute of Nucelar Sciences

- Established in 1948
- 800 employees
- Multidisciplinary Institute with 13 department in the field of:
  - Physics, Physical Chemistry, Radiation Chemistry, Biology and Medicine, Energy and Nuclear Engenering, Radiation and Environmental Protection, Radioisotopes, Electronics, Materials, Computing, Thermal science,...

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Radiation and Environmental Protection Laboratory

- Established in 1958
- RADIOECOLOGY AND ENVIRONMENTAL PROTECTION
- RADIATION DOSIMETRY
  - Individual monitoring
  - Ionizing radiation metrology laboratory
  - Non-ionizing radiation
  - X-ray equipment testing
- RADIATION PROTECTION AND SAFETY
  - Radiation risk assessment and safety analysis
  - Emergency planning and preparedness
  - Radiation protection of medical and industrial application of radiation sources
  - Shielding design…

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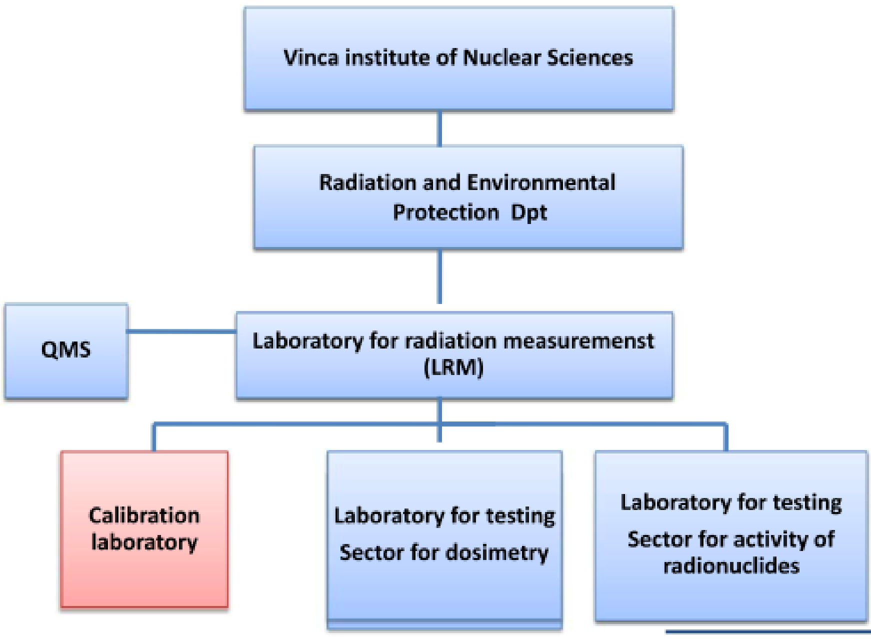
Vinca Institute of Nuclear Sciences



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VINS SSDL

- Member of the WHO/IAEA network of SSDLs since 1978
- Traceability
- Intercomparisons
- Calibration service in the fields of:
  - *Radiotherapy*
  - *Radiation protection*
  - *Diagnostic radiology*
- NMI initiated designation process in September 2014

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Radiotherapy level

- Air kerma, N_k
- Absorbed dose in water, $N_{D,W}$
- Irradiation units and beam qualities
  - *Cirus, Co-60*
  - *X-rays*
- Reference dosimeters
  - PTW 0.6 cc, Farmer type
  - PTW Unidos
  - Working standards
- Traceability: IAEA

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Radiation protection level

- Air kerma
- H*(10)
- Hp(10), Hp(0.07)
- Irradiation units and beam qualities
  - *ISO 4037: S-Cs, S-Co*
  - *Philips MG 320, ISO*
  - *ISO: N and W series*
- Reference dosimeters
  - PTW 32002 1 l
  - PTW 32003 10 l
  - PTW Unidos
  - Working standards
- Trecability: IAEA

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Diagnostic radiology level

- Air kerma
- PPV
- (Kerma-area product)
- (Kerma length product)
- Irradiation units and beam qualities
  - *Philips MG 320 X-ray generator: 30-320 kV*
  - *IEC: RQR and RQM*
- Reference dosimeters
  - PTW Magna A 650 3 cc
  - PTW Unidos
  - PTW Diavolt
- Traceability: IAEA, PTB

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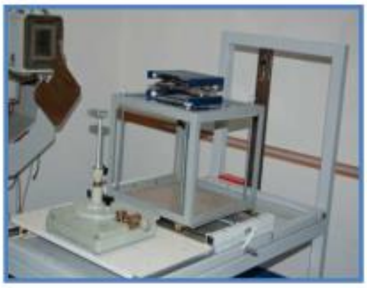
Auxiliary equipment

- Calibration bench
- Calibration trolleys
- Phantoms
- Laser and telescope positioning systems
- Camera with in-room monitor
- Thermometers
- Barometers
- Radiation safety and security systems
- Workshop…



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Quality Management System

- SRPS ISO 17025
- Accreditation board of Serbia (member of EA and ILAC)

ATC
02-036
АКРЕДИТОВАНА
ЛАБОРАТОРИЈА
ЗА ЕТАЛОНИРАЊЕ
SRPS ISO/IEC 17025:2006

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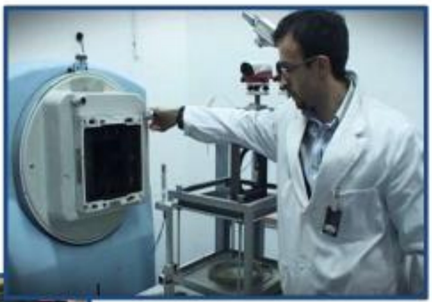
		Range		Uncertainty*	Method
1.	Air kerma (rate)				
	Dosemeters in radiotherpy	7 Gy/h-16 Gy/h	^{60}Co	± 1.1 %	IAEA TRS 277
		0.7Gy/h do 7 Gy/h	X zračenje 100kV do 250kV	± 2.1 %	IAEA TRS 277
	Dosemetra in radiation protection	2.2 µGy/h-20 Gy/h	^{60}Co	± 1.8 %	IAEA SRS 16
		12 µGy/h-6 mGy/h	^{137}Cs	± 1.8 %	
		50 µGy/h-50 mGy/h	X zračenje 40kV do 250kV	± 1.8 %	
	Diagnostic radiology dosemeters	120 mGy/h-3 Gy/h	X zračenje 50kV do 150kV	± 2.2 %	IAEA TRS 457
2.	H*(10)				
	Dosemetra in radiation protection	2.5 µSv/h-20 Sv/h	^{60}Co	± 4.4 %	IAEA SRS 16
		15 µSv/h-7 mSv/h	^{137}Cs	± 4.4 %	
		90 µSv/h-80 mSv/h	X zračenje 40kV do 250kV	± 4.4 %	
3.	Hp(10)				
	EPD	2.5 µSv/h-20 Sv/h	^{60}Co	± 4.4 %	IAEA SRS 16
		15 µSv/h-7 mSv/h	^{137}Cs	± 4.4 %	
		90 µSv/h-80 mSv/h	X zračenje 40kV do 250kV	± 4.4 %	
	Personal dosemeters	2.5 µSv/h-20 Sv/h	^{60}Co	± 4.4 %	IAEA SRS 16
		15 µSv/h-7 mSv/h	^{137}Cs	± 4.4 %	
		90 µSv/h-80 mSv/h	X zračenje 40kV do 250kV	± 4.4 %	
4.	Absormed dose (rate)				
	Dosemetra in radiotherapy	7 Gy/h-16 Gy/h	^{60}Co	± 1.2 %	IAEA TRS 398
5.	X-ray tube voltage				
	Non invasive tube voltage measuring devices	50 kV do 120 kV		± 2 %	IAEA TRS 457:

Uncertainty of calibration factor corresponds to the double standard deviation (k=2).

Staffing level

- 2.5 seniors scientist
- 2 juniors scientist
- 2.5 technicians



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Activities, workload, problems & future plans

- Service to customers in radiotherapy, radiation protection and diagnostic radiology
- Good results in intercomparisons (IAEA, bilateral…)
- Small number of calibrations to customers (~10 in RT, ~1000 in RP and only few in DR)
- Large QMS structure, paperwork
- Not all areas of metrology of IR are covered
- Need for technical improvements (radiation sources and dosimetry equipment) and more staff

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from the doorstep of VINS SSDL in different seasons
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Annex 2 ATS Accreditation Certificate

In red: Translations provided by Vinča REPD; In blue: CMC entries shall be applied for the entries surrounded in blue (dose rate ranges) and corresponding dose ranges

АКРЕДИТАЦИОНО ТЕЛО СРБИЈЕ
АТС

Акредитациони број/*Accreditation No*:
02-036

Датум прве акредитације/
Date of initial accreditation: 05.11.2010.

Ознака предмета/*File Ref. No.*:
2-02-168
Важи од/
Valid from:
05.11.2014.
Замењује Обим од:
Replaces Scope dated:
31.01.2013.

ОБИМ АКРЕДИТАЦИЈЕ

Scope of Accreditation

Акредитовано тело за оцењивање усаглашености/ *Accredited conformity assessment body*

Институт за нуклеарне науке „Винча“
Лабораторија за заштиту од зрачења и заштиту животне средине – „Заштита“
Лабораторија за радијациона мерења
Београд, Винча, Михајла Петровића Аласа 12-14

Стандард / *Standard:*

SRPS ISO/IEC 17025:2006

(ISO/IEC 17025:2005)

Скраћени обим акредитације / *Short description of the scope*

- Еталонирање: дозиметара у радиотерапији, дозиметара у области заштите од зрачења, дозиметара за примену у дијагностичкој радиологији, електронских персоналних дозиметара, личних дозиметара, мерила напона рендгенске цеви неинвазивном методом / Calibration of: dosimeters in radiotherapy, dosimeters in the field of radiation protection, dosimeters in diagnostic radiology, electronic personal dosimeters, personal dosimeters, non-invasive x-ray tube voltage measuring instruments.

АТС-ПР15-О02 Издање/Измена: 3/4 Страна:1/3

ATC

Акредитациони број/ Accreditation No	**02-036**
Важи од/*Valid from*:	05.11.2014.
Замењује Обим од / *Replaces Scope dated:*	31.01.2013.

Детаљан обим акредитације ***Detailed description of the scope***

Област еталонирања/ предмет еталонирања	Опсег Range	Могућност мерења[1)] (CMC)	Метода еталонирања (стандард, опрема или интерна метода)
E-12: Јонизујуће зрачење и радиоактивност			
Керма и јачина керме у ваздуху Kerma and kerma rate			
Дозиметри у радиотерапији (Dosemeters in radiotherapy)	7 Gy/h до 16 Gy/h за мерне услове: ^{60}Co	±1.1%	IAEA TRS 277:1987
	0.7 Gy/ h до 7 Gy/ h за мерне услове: X зрачење од 100 kV до 250 kV	±2.1%	
Дозиметри у области заштите од зрачења (Dosemeters in radiation protection)	2,2 µGy/h до 20 Gy/h за мерне услове: ^{60}Co	±1.8%	IAEA SRS 16:2000
	12 µGy/h до 6 mGy/h за мерне услове: ^{137}Cs	±1.8%	
	50 µGy/h до 50 mGy/h за мерне услове: X зрачење од 40 kV до 250 kV	±1.8%	
Дозиметри за примену у дијагностичкој радиологији (Dosemeters in diagnostic radiology)	120 mGy/h до 3 Gy/h за мерне услове: X зрачење од 50kV до 150kV	±2.2%	IAEA TRS 457:2007
Амбијентална еквивалентна доза и јачина амбијенталне еквивалентне дозе (H*(10))			
Дозиметри у области заштите од зрачења (Dosemeters in radiation protection)	2,5 µSv/h до 20 Sv/h за мерне услове: ^{60}Co	±4.4%	IAEA SRS 16:2000
	15 µSv/h до 7 mSv/h за мерне услове: ^{137}Cs	±4.4%	
	90 µSv/h до 80 mSv/h за мерне услове: X зрачење од 40 kV до 250 kV	±4.4%	
Лични дозни еквивалент и јачина личног дозног еквивалента (Hp(10))			
Електронски персонални дозиметри (Electronic personal dosemeters)	2,5 µSv/h до 20 Sv/h за мерне услове: ^{60}Co	±4.4%	IAEA SRS 16:2000
	15 µSv/h до 7 mSv/h за мерне услове: ^{137}Cs	±4.4%	
Лични дозиметри (Personal dosemeters)	90 µSv/h до 80 mSv/h за мерне услове: X зрачење од 40 kV до 250 kV	±4.4%	

АТС-ПР15-О02 Издање/Измена: 3/4 Страна:2/3

ATC

Акредитациони број/ Accreditation No **02-036**
Важи од/*Valid from*: 05.11.2014.
Замењује Обим од / *Replaces Scope dated:* 31.01.2013.

Област еталонирања/ предмет еталонирања		Опсег Range	Могућност мерења[1] (CMC)	Метода еталонирања (стандард, опрема или интерна метода)
Апсорбована доза у води и јачина апсорбоване дозе у води Absorbed dose to water and absorbed dose rate to water				
Dosemeters in radiotherapy	Дозиметри у радиотерапији	7 Gy/h до 16 Gy/h за мерне услове: ^{60}Co	±1.2%	IAEA TRS 398:2000
Напон рендгенске цеви X-ray tube voltage				
Non-invasive kVp measuring devices	Мерила напона рендгенске цеви неинвазивном методом	50 kV до 120 kV	±2%	IAEA TRS 457:2007

[1] Могућност мерења је изражена као проширена мерна несигурност за фактор обухвата k =2 и ниво поверења приближно 95%

* место еталонирања: на терену
**место еталонирања: у лабораторији и на терену

Овај обим важи само уз Сертификат о акредитацији са акредитационим бројем **02-036**/
This Scope of accreditation is valid only with Accreditation Certificate No. 02-036

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в.д. ДИРЕКТОРА

Милица Лукешевић

АТС-ПР15-О02 Издање/Измена: 3/4 Страна:3/3

Annex 3 List of QM documents maintained by the Laboratory of Radiation and Environmental Protection

LRM	**VINCA INSTITUTE OF NUCLEAR SCIENCES LABORATORY FOR RADIATION PROTECTION AND ENVIRONMENTAL MONITORING 11000 BELGRADE, p.p.522**	*Index: QM.1.100.0c* *Applied from: 26.08.14.* *Copy number: 1*
	Phone. (011)3443307, fax: (011)8066438	*Page*: **1 to 4**

THE LIST OF MANAGEMENT SYSTEM DOCUMENTS

	Date:	Name and surname	Position	Signature
Prepared:	26.08.2014.	Gordana Pantelić	Quality manager	
Approved:	26.08.2014.	Olivera Ciraj Bjelac	LRM Manager	

Index: ***QM.1.100.0c***	**THE LIST OF MANAGEMENT SYSTEM DOCUMENTS**	*Page: 2 to 4*

Quality manual and annexes

No.	Document's index	Title of document	Version	Date of issue
1.	*QM.1.100.00*	Quality manual of LRM	7.0	13.10.14.
2.	*QM.1.100.0a*	Scope of accreditaion of calibration laboratory	5.0	22.01.14.
3.	*QM.1.100.0b*	Scope of accreditaion of testing laboratory	6.0	22.01.14.
4.	*QM.1.100.0c*	The list of documents of quality sistem	-	26.08.14.
5.	*QM.1.100.0d*	The list of staff in LRM	8.0	30.04.14.
6.	*QM.1.100.0e*	Room arrangement with equipment and devices	4.0	09.07.12.
7.	*QM.1.100.0g*	The list of standards and measuring equipment	8.0	25.07.14.

The procedure of management system

No	Document's index	Title of document	Version	Date of issue
1.	*QP.2.100.01*	Managing system management documents	4.0	26.08.14.
2.	*QP.2.100.02*	Arranging of calibration/testing	3.0	27.09.13.
3.	*QP.2.100.03*	Measurement uncertainty budget	4.0	22.01.14.
4.	*QP.2.100.04*	Purchasing and reception of measuring and test equipment	4.0	13.10.14.
5.	*QP.2.100.05*	Purchasing and storage supplies	4.0	13.10.14.
6.	*QP.2.100.06*	Control of nonconforming calibration/testing	3.0	22.01.14.
7.	*QP.2.100.07*	Corrective and preventive actions	3.1	22.01.14.
8.	*QP.2.100.08*	Internal audits of management system	3.0	24.12.13.
9.	*QP.2.100.09*	Reviewing of service quality	2.0	01.09.11.
10.	*QP.2.100.10*	Test methods and procedures	3.0	22.01.14.
11.	*QP.2.100.11*	Procedure of calibration/testing	3.0	22.01.14.
12.	*QP.2.100.12*	Maintenance of measuring and test equipment	4.0	24.12.13.
13.	*QP.2.100.13*	Training and education of staff	3.0	24.12.13.
14.	*QP.2.100.14*	Reporting of calibration/testing	3.0	21.02.13.
15.	*QP.2.100.15*	Resolving user's complaints	2.0	01.09.11.
16.	*QP.2.100.16*	Control of records	3.0	13.02.13.
17.	*QP.2.100.17*	Subcontracting of tests and calibrations	3.0	13.10.14.
18.	*QP.2.100.18*	Participation in interlaboratory comparisons	2.0	24.12.13.

Working instructions/management system instructions

No	Document's index	Title of document	Version	Date of issue
1	2	3	4	5
1.	*QU.3.100.01*	MANUAL FOR PREPARING MANAGAMENT SYSTEM DOCUMENTS	2.0	01.09.11.
2.	*QU.3.100.02*	MANUAL FOR MAINTAINING WORK ENVIRONMENT	2.0	15.08.11.
3.	*QU.3.100.03*	MANUAL FOR IDENTIFICATION, RECEPTION AND STORAGE OF MEASURES /SAMPLES FOR CALIBRATION/TESTING	2.0	01.09.11.
4.	*QU.3.100.04*	MANUAL FOR WORK WITH IONIZING RADIATION SOURCES	2.0	15.08.11.
5.	*QU.3.100.05*	MANUAL FOR OPERATION AND MAINTENANCE OF COMPUTER NETWORK	2.0	15.08.11.
6.	*QU.3.100.06*	MANUAL FOR PREPARATION OF CERTIFICATES/ REPORTS OF CALIBRATION/TESTING	2.0	01.09.11.
7.	*QU.3.100.07*	MANUAL ON ENTRY AND STAY IN WORKING ROOMS	2.0	01.09.11.
8.	*QU.3.100.08*	BOOK OF TEST METHODS AND PROCEDURES	2.0	01.09.11.
9.	*QU.3.100.09*	MANUAL FOR CHECKING THE STABILITY OF STANDARD	4.0	23.05.14.
10.	*QU.3.100.10*	MANUAL FOR OPERATION WITH MEASURING EQUIPMENT	2.0	21.02.12.
11.	*QU.3.100.11*	MANUAL FOR TESTING X-RAY DEVICES	2.0	22.08.12.
12.	*QU.3.100.12*	MANUAL FOR MEASURING AMBIENT DOSE EQUIVALENT	1.0	22.08.11.
13.	*QU.3.100. 20*	MANUAL FOR USING HIGH PURITY SEMICONDUCTOR GAMMASPECTROMETER (HPGe DETECTORS)	2.0	20.02.14.
14.	*QU.3.100. 21*	MANUAL FOR USING THE PROPORTIONAL ALFA BETA COUNTER	2.0	20.02.14.
15.	*QU.3.100. 22*	MANUAL FOR GAMMASPECTROMETRY TESTING OF FOOD, HERBS AND CONSUMER PRODUCTS	2.0	20.02.14.
16.	*QU.3.100. 23*	MANUAL FOR GAMMASPECTROMETRY TESTING OF MINERAL PRODUCTS, BUILDING MATERIALS, WASTE, MINING, ASH, SOILS	2.0	20.02.14.
17.	*QU.3.100. 24*	MANUAL FOR GAMMASPECTROMETRY TESTING OF WATER	2.0	20.02.14.
18.	*QU.3.100. 25*	MANUAL FOR TESTING GROSS ALPHA AND BETA ACTIVITY IN FOOD AND HERBS	2.0	20.02.14.
19.	*QU.3.100. 26*	MANUAL FOR TESTING GROSS ALPHA AND BETA ACTIVITY IN MINERAL PRODUCTS, ASH AND SOILS	2.0	20.02.14.
20.	*QU.3.100. 27*	MANUAL FOR TESTING GROSS ALPHA AND BETA ACTIVITY IN WATER	2.0	20.02.14.

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1	2	3	4	6
21.	*QU.3.100. 28*	MANUAL FOR TESTING CONTENT OF ^{90}Sr IN FOOD AND HERBS SAMPLES	2.0	20.02.14.
22.	*QU.3.100. 29*	MANUAL FOR TESTING CONTENT OF ^{90}Sr IN SOIL SAMPLES	2.0	20.02.14.
23.	*QU.3.100. 30*	MANUAL FOR TESTING CONTENT OF ^{90}Sr IN WATER SAMPLES	2.0	20.02.14.
24.	*QU.3.100. 31*	MANUAL FOR WASHING DISHES	1.0	15.08.11.
25.	*QU.3.100. 32*	MANUAL FOR USING CHEMICALS	1.0	15.08.11.
26.	*QU.3.100. 33*	MANUAL FOR USING THE SCALE	1.0	15.08.11.
27.	*QU.3.100. 34*	MANUAL FOR PREPARING CONTROL CHARTS	1.0	15.08.11.
28.	*QU.3.100. 35*	MANUAL FOR VALIDATION OF METHODS	1.0	1.09.11.
29.	*QU.3.100. 36*	MANUAL FOR RADON CONCENTRATION TESTING	1.0	28.05.12.
30.	*QU.3.100. 37*	MANUAL FOR TESTING PROTECTIVE MATERIAL PROPERTIES	1.0	12.06.2014.
31.	*QU.3.100. 38*	MANUAL FOR TESTING DOSEMETERS FOR ENVIRONMENTAL MONITORING	1.0	12.06.2014.
32.	*QU.3.100. 40*	MANUAL FOR WORKING WITH TLD READER	2.0	22.01.13.
33.	*QU.3.100. 41*	TESTING THE LEVEL OF EXPOSURE OF PERSONS OCCUPATIONALLY EXPOSED	1.0	22.08.11.
34.	*QU.3.100. 42*	TESTING THE LEVEL OF AMBIENT DOSE EQUIVALENT	1.0	22.08.11.
35.	*QU.3.100. 43*	MANUAL FOR CALIBRATION IN KERMA	1.0	15.03.13.
36.	*QU.3.100. 44*	MANUAL FOR CALIBRATION OF DOSEMETERS IN KERMA IN RADIOTHERAPY	1.0	15.03.13.
37.	*QU.3.100. 45*	MANUAL FOR CALIBRATION OF DOSEMETERS IN X RADIATION FIELD	1.0	15.03.13.
38.	*QU.3.100. 46*	MANUAL FOR CALIBRATION IN AMBIENT DOSE EQUIVALENT	1.0	15.03.13.
39.	*QU.3.100. 47*	MANUAL FOR CALIBRATION OF DOSEMETERS IN PERSONAL DOSE EQUIVALENT	1.0	15.03.13.
40.	*QU.3.100. 48*	MANUAL FOR CALIBRATION IN ABSORBED DOSE IN WATER	1.0	15.03.13.
41.	*QU.3.100. 49*	MANUAL FOR CALIBRATION OF NON-INVASIVE X RAY TUBE VOLTAGE MEASURING SYSTEM	1.0	15.03.13.
42.	*QU.3.100. 50*	MANUAL FOR THE PROGRAMME KM 2.1	1.0	15.03.13.

Annex 4 List of standards and measuring equipment maintained by the Laboratory of Radiation and Environmental Protection

	VINCA INSTITUTE OF NUCLEAR SCIENCES LABORATORY FOR RADIATION PROTECTION AND ENVIRONMENTAL MONITORING 11000 BELGRADE, p.p.522	***Index:*** *QM.1.100.0g* ***Version:*** *8.2* ***Applied from:*** *2.12.14.* ***Copy number: 1***
	Phone. (011)3443307, fax: (011)8066438	*Page*: 1 to 8

THE LIST OF STANDARDS AND MEASURING EQUIPMENT

	Date:	Name and surname	Signature
Prepared:	2.12.14.	Gordana Pantelić	
Approved:	2.12.14.	Olivera Ciraj Bjelac	

THE LIST OF MEASURING AND TESTING EQUIPMENT

1. The list of secondary standards

No.	TITLE and index of standard	Range or value measuring	Range or value energy	Measurement uncertainty	Number of card
1	2	3	4	5	7
1	UNIDOS T10002-20756 with ionization chamber TW 30012-0172	0.6 mGy/min to 2800 Gy/min	^{60}Co	± 0.8 %	161
2	UNIDOS T10002-20767 with ionization chamber TW 32002-0311	18 μGy/h to 90 Gy/h	^{60}Co ^{137}Cs	± 0.8 %	160
3	UNIDOS T10002-20767 with ionization chamber TW 32002-0310	18 μGy/h to 90 Gy/h	X radiation	± 1.2 %	159
4	UNIDOS T10002-20767 with ionization chamber TW 32003-0126	2.2 μGy/h to 10 Gy/h	^{60}Co ^{137}Cs	± 1.2 %	163
5	UNIDOS T10002-20767 with ionization chamber Extradin MAGNA A650	0.1 mGy/min to 1000 Gy/min	X radiation	± 1.1 %	164
6	X ray tube voltage measuring system, Diavolt universal T43014, PTW, s/n 01242	X ray tube voltage kV	22 kV to 150 kV	± 2%	187

2. The list of working standards

No.	TITLE and index of standard	Range or value		Measurement uncertainty	Number of card
		measuring	energy		
1	2	3	4	5	7
1.	Ion. cham. for exp. dose PTW M 23331 ser.num. 331	from 8.4 μC/kgs to 8.4 cm/kgs	100 keV-^{60}Co	± 1.1 %	66
2.	Ion. cham. for exp. dose PTW M 23361, ser.num. 127	from 84 nC/kgs to 8.4 μC/kgs	100 keV-^{60}Co	± 1.8 %	67
3.	Ion. cham. for exp. dose PTW M 2337, ser.num. 075	from 20 pC/kgs to 8.4 μC/kgs	100 keV-^{60}Co	± 1.8 %	68
4.	Ion. cham. for abs. dose IBK M 01, ser.num. 88006	from 100 μGy/s to 500 mGy/s	50keV-3MeV	± 1.1 %	70
5.	Ion. cham. for abs. dose IBK M 30, ser.num. 88004	from 5 μGy/s to 500 μGy/s	50keV-3MeV	± 1.8 %	71
6.	Ion. cham. for abs. dose IBK M 1000, ser.num. 88001	from 1 nGy/s to 10 μGy/kgs	50keV-3MeV	± 1.8 %	72
7.	Ion. cham. for exp. dose PTW M 30012, ser.num. 201	0.6 mGy/min to 2800 Gy/min	^{60}Co	± 1.1 %	162
8.	Ion. cham. for exp. dose PTW M 23344, ser.num.057	0.1 mGy/min to 200Gy/min	7.5 kV do 100 kV	± 2 %	69
9.	X ray generator, MG-320, Philips, ser.num. 32234	from 50 nC/kgs to 100 μC/kgs	30 kV-320kV	± 2 %	73
10.	Generator of gamma radiation, IRPIK-A	from 7 pC/kg s to 3 μC/kgs	^{60}Co ^{137}Cs	± 2 %	74
11.	Generator of gamma radiation, IRPIK-B	from 3 μC/kg s to 100 μC/kg s	^{60}Co	± 2 %	75
12.	Ion. cham. for exp. dose PTW M 23342, ser.num. 155	from 10 μC/kg s to 1000 μC/kg s		± 2 %	90
13.	Generator of gamma radiation IRPIK-C	from 60 mGy/h to 7 Gy/h		± 2 %	115
14.	Ionization chamber NE Technology, ser.num. 2571	from 1 to 10 Gy		± 1.8 %	208
15.	Mass weight 1 g OIML E2	1 g		± 0.001 %	218
16.	Mass weight 100 g OIML E1	100 g		± 0.00016 %	219

3. The list of equipments

No.	Title and serial number of equipment	Measured quantity	Range of measurement	Measurement uncertainty	Number of card
1	2	3	4	5	7
1.	Current integrator NP 2000, ser.num. 82001	Current intesity	from 1 pA to 10 pA	± 1%	7
		Current intesity	from 10 pA to 10 μA	± 0.5 %	
2.	Electrometer Keithley 610 C, ser.num.144791	Voltage	from 0.001 V to 100 V	± 1 %	10
3.	Capacitor for NP 2000, ser.num. 82001-1	Capacitance	101.2 pF	± 0.1%	12
4.	Capacitor for NP 2000, ser.num. 82001-2	Capacitance	1.0009 nF	± 0.1%	13
5.	Capacitor for NP 2000, ser.num. 82001-3	Capacitance	10.018 nF	± 0.1%	14
6.	Capacitor for NP 2000, ser.num. 82001-4	Capacitance	100.72 nF	±0.1 %	15
7.	Capacitor for IQ4, Philips, ser.num. 059	Capacitance	1.00 nF	± 0.1%	16
8.	Capacitor for IQ4, Philips, ser.num. 061	Capacitance	9.86 nF	± 0.1%	17
9.	Capacitor for IQ4, Philips, ser.num. 062	Capacitance	92.1 nF	± 0.1%	18
10.	Thermohygrograph W. Lambrecht type 252, ser.num. 3811360	Temperature Humidity	from 0^{o}C to 40^{o}C from 100% to 0%		28
13.	Power supply, MA4170, ser.num.501145	Voltage Current intesity	50V 1.5 A		43
14.	Dosemeter AD6 ser.num. 109066	Dose rate	0.001 mSv to 9999mSv	± 10%	128
15.	Dosemeter AD6 ser.num. 109113	Dose rate	0.001 mSv to 9999 mSv	± 10%	129
16.	Mercury thermometer TLOS,414030	Temperature	0^{0} C to 50^{0} C	± 0.1%	113
17.	Mercury thermometer TWG,414020	Temperature	10^{0} C to 50^{0} C	± 0.1%	112
18.	Thermometer Keithley, 1227693	Temperature	to 200 ^{o}C	± 0.05%	166
19.	Aneroid barometer	Air pressure	920 mbar to 1050 mbara	± 1.5 %	167
20.	Ionization chamber, 451-P, s/n 1807	Dose rate, H*(10)	0-50 μSv/h	± 10%	170
		Dose, H*(10)	0-500 μSv	± 10%	

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1	2	3	4	5	7
21.	Detector, Barracuda MPD, s/n 08070167	X ray unit voltage, kV	18 kV to 155 kV	±1.5%	181
		Kerma in air in radiography	0.1 μGy-2000 Gy	± 5%	
		Time of exposure	0.1 ms -2000 s	± 1%	
22.	Detector, Barracuda MPD, s/n 02090058	X ray unit voltage, kV	18 kV to 155 kV	±1.5%	168
		Kerma in air in radiography	0.1 μGy-2000 Gy	± 5%	
		Time of exposure	0.1 ms -2000 s	± 1%	
23.	Dosemeter Barracuda R100B, s/n 0801048	Kerma in air	2 nGy - 10 kGy	± 5%	182
24.	Fotometar L100B-M, s/n 0708089	Brightness	0.03-72000 cd/m^2	± 5%	183
25.	Photometer L100B-L, s/n 0708089	Luminosity	0.01-24000 lx	± 5%	184
26.	KAPmetet Diamentor E2 PTW	Kerma area product	0.01 μGym^2 - 20 Gym^2	± 8%	169
31.	Gamma spectrometer, model GC 2018-7500, Canberra	Activity of radionuclide	60 keV to 2000 keV		195
32.	Gamma spectrometer, model 7229-7500-1818, Canbera	Activity of radionuclide	60 keV to 2000 keV		196
33.	Gamma spectrometer, model GC 5019, Canberra	Activity of radionuclide	60 keV to 2000 keV		197
34.	Lowphonic α/β proportional counter, Thermo Eberline FHT770T	Activity of radionuclide			198
35.	Thermoluminescent dosimeter readerHarshaw model 6600	Personal dose	10 μSv to 100 Sv		199
36.	Scale „Mettler“ AE 160	Mass	0.05 g to 160 g		200
38.	Furnace, Instrumentaria II, Zagreb, type LP -08	Temperature	0-1200^{0}C		202
39.	Furnace, Instrumentaria I, Zagreb, type LP -08	Temperature	0-1200^{0}C		203
40.	Furnace, Banja Koviljača, type Elektron 1	Temperature	0-1200^{0}C		204
41.	Piston pipettes, eppendorf, ser.num. 3761424	Volume	2-20 μl		205
42.	Electromechanical scale, manufacturer Mettler, type PJ 3000	Mass	0 g to 3000 g		206
43.	Thermo-hygrometer	Temperature and humidity	Od 1 ^{0}C to 50 ^{0}C Od 10 % to 90 %		207

Index: ***QM.1.100.0g***	The list of standards and measuring equipment in LRM	*Page: 6 to 8*

1	2	3	4	5	7
44.	Ionization chamber, 451-P, s/n 635	Dose rate H*(10)	0-50 µSv/h	±10%	171
		Dose, H*(10)	0-500 µSv	±10%	
45.	Automess AD6 with scintillation probe ADb, s/n 109281	Dose rate H*(10)	10 nSv/h-100 µSv/h	±7%	209
		Dose, H*(10)	0.01-999.9 µSv	±7%	
46.	Automess AD6 with scintillation probe ADb, s/n 109282	Dose rate H*(10)	10 nSv/h-100 µSv/h	±7%	210
		Dose, H*(10)	0.01-999.9 µSv	±7%	
47.	Detector, Barracuda MPD, s/n 12110025	X ray unit voltage, kV	18 kV to 155 kV	±1.5%	211
		Kerma in air in radiography	0.1 µGy-2000 Gy	± 5%	
		Time of exposure	0.1 ms -2000 s	± 1%	
48.	Stopwatch Hanhart STOPSTAR 2	Time	0-10 h		212
51.	Dryer, Instrumentaria st-05, num. 2543	Temperature	50-200^{0}C		215
52.	RaySafe ThinX RAD	X ray tube voltage, kVp	45 kV to 150 kV	± 3%	216
53.	NaI detector 2"x2"	Activity of radionuclide	100 keV to 900 keV		217
54.	Furnace, Banja Koviljaca, type Elektron	Temperature	0-1800^{0}C		218
55.	Nonius	Length	0-150 mm		220
56.	Meter tape, 07 0522	Length	0-7.5 m		221
57.	Meter tape, 07 1225	Length	0-7.5 m		222
58.	Meter tape, 07 1226	Length	0-7.5 m		223
59.	Ionization chamber, 451P-DE-SI-RYR	Dose rate H*(10)	0-50 mSv/h	±10%	224
		Dose, H*(10)	0-1000 mSv	±10%	

4. The list of other equipment

	The title of equipment	Properties	Number of card
1	TOR MAS, sn 000472	Measurement of contrast and resolution in mammography	180
2	CD MAM, tzpe 3.4, s/n 1579	Determination of contrast-detail in mammography	179
3	Test Tool ETR1, s/n 88-3206	Determination of geometry, contact film-amplifying, resolution, contrast in radiography	175
4	Body 32 phantom	Dosimetry phantom for computed tomography	177
5	Head 16 cm phantom	Dosimetry phantom for computed tomography	176
6	Beam alignment test tool 162 A, s/n 800423-9038	Measuring the position of the central axis	178
7	Focal spot test tool 112B, s/n 800428-5044	Measuring size of the focus	174
8	RMI Stepwedge, s/n 800414-2880	Measuring the characteristic curve of the image receiver in radiography	172
9	VS4, Egde test object, s/n 20	Determination of the sensitivity of the diagnostic system	173
10	SW4, grey scale test object, s/n 20	Determination of the properties of the monitor	173
11	FSG4, matrix test object, s/n 20	Determination of the geometry of diagnostic images	173
12	Type 18, Huttner tets objects, s/n 20	Measuring size of the focus and resolution limit	173
13	SSM4, wire mash, s/n	Determination of uniformity of diagnostic images	173
14	LCD4, Nosie test object, s/n 20	Measurement of low contrast resolution	173
15	TCD4, CD test object, s/n 20	Measurement of contrast resolution for fluoroscopy	173
16	X-rite densitometer	Measurement of the optical density of the film	206

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5. **The list of standards and referent materials**

Number:	Type (description):	Manufacturer:	Certificate no:	Activity/ reference date
1.	Liquid standard, radionuclide mixtures, mass 2.128 g	Czech Metrological Institute	9031-OL-116/08	3.03.2008.god.
2.	Marineli beaker, radionuclide mixtures, volume 500 cm^3, density 0.985 g/cm^3	Czech Metrological Institute	9031-OL-208/08	15.04.2008. god.
3.	Ba-133, instilled in the center of the disk (the point source)	Czech Metrological Institute	9031-OL-318/11	271.5 kBq, 1.08.2011.
4.	Co-60, instilled in the center of the disk (the point source)	Czech Metrological Institute	9031-OL-317/11	732.9 kBq, 1.08.2011.
5.	Am-241, radioactive substance uniformly deposited on the metal disc dimensions 48.5 x 48.5 x 1.0 mm	Czech Metrological Institute	9031-OL-334/11	224.0 Bq, 1.08.2011.
6.	Sr-90, radioactive substance uniformly deposited on the metal disc dimensions 48.5 x 48.5 x 1.0 mm	Czech Metrological Institute	9031-OL-335/11	189.4 Bq, 1.08.2011.
7.	Marineli beaker, radionuclide mixtures, volume 450 cm^3, density 0.985 g/cm^3	Czech Metrological Institute	9031-OL-419/12	41.203 kBq 31.08.2012. god.
8.	Marineli beaker, radionuclide mixtures, volume 500 cm^3, density 0.985 g/cm^3	Czech Metrological Institute	9031-OL-420/12	41.48 kBq 31.08.2012. god.
9.	Liquid standard, radionuclide mixtures, mass 5.3109 g, volume 4.987 cm^3	Czech Metrological Institute	9031-OL-427/12	72.40 kBq 31.08.2012.god.
10.	Marineli beaker, radionuclide mixtures, volume 500 cm^3, density 0.985 g/cm^3	Czech Metrological Institute	9031-OL-020/08	40.23 kBq 20.01.2008.god.

Annex 5 List of publications discussed during the meeting

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