EUROMET PROJECT
FINAL REPORT

1. Ref. No: 634 (please leave blank)	2. Subject Field: Ionizing radiation

3. Type of collaboration:
comparison

4A: Partners:
(institutions) ČMI, BEV, SMÚ

5. Participating countries:
Czech Republic, Austria, Slovak Republic

6. Title:
Common calibration of ionizing chambers

7. Progress:

All devices (4 ionization chambers) were brought to the Czech Metrology Institute and calibrated in a week 18 to 21 September 2001.

At the same week there were provided and prepared standards with radionuclides ^{18}F, ^{67}Ga, ^{99m}Tc, ^{201}Tl, ^{123}I, ^{131}I in the form of 5 or 4 ml water solution in the usually two P6-like ampoules. The standards of ^{133}Xe and ^{85}Kr were prepared in the gas ampoules. The ^{137}Cs was in the form of gel. Specific activity of the solutions and gases were measured either by calibrated spectrometer or calibrated ionization chamber. The ^{131}I was standardized by absolute method and sent to S.I.R

Troubles were found in the calibration of ^{123}I and ^{201}Tl.

The more details are described in the technical final report which is an attachment of this final report.

8. Coordinator's name:
Address: Pavel Dryak, ČMI - IIZ Praha, Radiová 1, Czech Republic

Telephone +420 2 66020497 Fax: +420 2 66020466
e-mail: pdryak@cmi.cz

9. Completion Date: 29 March 2002	10. Coordinator's signature:

Technical Final Report of the EUROMET Project E634

The aim of the project was a calibration of the secondary chambers especially by short living radionuclides.
If the secondary chambers were calibrated by the producer, the resulting activities from producer's calibration were compared to the CMI standards.

Table 1: Participants, persons and devices

laboratory	Responsible persons	Calibrated devices
Czech Metrology Institute – Inspectorate for Ionizing Radiation Czech Republic	Pavel Dryák, Veronika Olšovcová	1. NPL-CRC No. 400001 2. BQM 4 No. 33
Slovak Metrology Institute Slovak Republic	Anton Švec	VacuTec 70 129 No.98012 with steel liner 2,2 mm connected to Electrometer Keithley 6517A No.0695463
Bundesamt fuer Eich- und Vermessungswessen, Austria	Petra Jachs, Michael Kreuziger	ISOCAL IV, model 286/SA/102

All devices were brought to the Czech Metrology Institute and calibrated by responsible persons, given in Table 1, in the week from 18th to 21st September 2001.

During the same week there were provided and prepared standards with radionuclides ^{18}F, ^{67}Ga, ^{99m}Tc, ^{201}Tl, ^{123}I and ^{131}I in the form of 5 or 4 ml water solution in the usual two P6-like ampoules. While the standards of ^{133}Xe and ^{85}Kr were prepared in the gas ampoules, the ^{137}Cs was in the form of gel. Specific activities of solutions and gases were measured either by calibrated spectrometer or calibrated 4π-γ ionization chamber. The ^{131}I was standardized by absolute method and sent to S.I.R. Details of the standards used are in the following Table 2.

Table 2: Standards prepared for E634

Radionuclide Vial number	Activity [MBq] (σ)	Reference time Day, hour, min	Volume [ml]	Weight [g]	Chemical composition	Impurities at reference time	Remark
^{137}Cs 591-15	11,682(105)	18.9.2001 12:00	5 ml	5,0720	gel	^{134}Cs 0,09 % ± 10%	1)
^{137}Cs 591-16	11,903(107)	18.9.2001 12:00	5 ml	5,0394	gel		
^{137}Cs 591-17	11,566(104)	18.9.2001 12:00	5 ml	5,0250	gel		
^{137}Cs 591-18	12,070(109)	18.9.2001 12:00	5 ml	5,0338	gel		
^{137}Cs 591-19	11,828(106)	18.9.2001 12:00	5 ml	5,0029	gel		
^{131}I 799-01	19,870(199)	18.9.2001 12:00	5 ml	5,0783	NaI in H_2O	^{126}I < 0,05%	2)
^{131}I 799-02	19,448(194)	18.9.2001 12:00	5 ml	5,0545	NaI in H_2O		
^{18}F 800-002	52,494(787)	18.9.2001 13:00	4 ml	4,0727	KF + $Na_2S_2O_3$ +Na_2CO_3	< 0,1%	3)
^{18}F 800-003	52,091(781)	18.9.2001 13:00	4 ml	4,0473			
^{123}I 801-002	91,00(109)	18.9.2001 15:00	5 ml	4,9991	KI + $Na_2S_2O_3$	^{124}I 0,004% ^{126}I 0,01% ^{131}I 0,007%	3)
^{123}I 801-003	91,45(110)	18.9.2001 15:00	5 ml	5,0136			
^{67}Ga 802-001	103,32(155)	19.9.2001 10:00	5 ml	5,0261	$GaCl_3$ + HCl	^{66}Ga < 0.015%	3)
^{67}Ga 802-002	101,34(152)	19.9.2001 10:00	5 ml	5,0214			
^{201}Tl 803-001	74,571(820)	19.9.2001 12:00	5 ml	5,0083	KCl + Tl_2SO_4 +HNO_3	^{200}Tl 0,113% ^{202}Tl 0,251%	3)
^{201}Tl 803-002	73,993(814)	19.9.2001 12:00	5 ml	4,9949			
^{201}Tl 803-003	75,289(828)	19.9.2001 12:00	4 ml	4,0173			
^{99m}Tc 804-002	96,510(965)	19.9.2001 13:00	5 ml	5,0031	NaCl + NH_4OH	^{99}Mo 9.10^{-5} % ^{131}I < 3.10^{-6} %	3)
^{99m}Tc 804-003	97,637(976)	19.9.2001 13:00	5 ml	5,0160			
^{133}Xe	188,6(70)	19.9.2001 12:00	33 ml		nitrogen	^{131m}Xe < 0,66 %	4)
^{85}Kr	2437(120)	20.9.2001 12:00	33 ml		nitrogen	None gamma	5)

Remarks

1) The solution was standardized by absolute method. The composition of the gel is similar to water, with density 1 $g.cm^{-3}$.
2) The solution was standardized by absolute method. It was sent to S.I.R.. The difference from the last four records (NIST, OMH, NPL, LNMRI) was 0,5%.
3) The solutions were standardized by calibrated CMI ionization chamber which was calibrated by CMI standard solutions .
4) The activity of gas in the 33 ml glass ampoule (length 55 mm, int. diam. 27 mm, glass wall 1,5 mm) was standardized by calibrated HpGe spectrometer. The calibration factor is valid for 33 ml glass ampoule.
5) The activity of gas in the 7 ml glass ampoule (length 5 cm, int. diam. 1,3 cm, glass wall 1 mm) was standardized by calibrated HpGe spectrometer. The calibration factor is valid for 7 ml glass ampoule.

The calibration factors given by producers and used in the comparison are listed in the following Table 3.

The comparison of the CMI values and response of the devices is given in the Table 4.

Table 3: The producers' calibration factors

	NPL-CRC (pA/MBq)	BQM* (pA/MBq)	VacuTec** (pA/MBq)	ISOCAL IV*** (pA/Bq)
^{137}Cs	5,751	5,102	6,812	5,751
^{131}I	3,999	3,984	7,347	3,999
^{18}F	10,35	9,524	13,947	10,35
^{123}I	1,685	4,000	10,83	1,685
^{67}Ga	1,547	2,849	10,52	1,547
^{201}Tl	0,8557	4,762	10,89	0,8557
^{99m}Tc	1,227	2,146	12,58	1,227
^{133}Xe	Not given	3,610	4,878	Not given
^{85}Kr	0,0320	0,613	0,376	0,0320

* recalculated from the original calibration factors which were given as kBq/pA
** recalculated from the original calibration factors which were given as MBq/pA
*** equivalent to NPL-CRC calibration

Table 4: CMI activity values and responses of the NPL-CRC, BQM, VacuTec and ISOCAL IV secondary chambers. In case of NPL-CRC secondary chamber the uncertainty of the calibration factors were not given, type A uncertainty is less than 0,5%.

Radionuclide Vial number	CMI activity, A MBq	NPL response, A_r	$(A_r - A)/A$ %	BQM response, A_1	$(A_1 - A)/A$ %	VacuTec response, A_2	$(A_2 - A)/A$ %	ISOCAL IV response, A_3	$(A_3 - A)/A$ %
137Cs 591-15	11,682(105)	11,509***	-1,48	11,47(31)	-1,82	11,82(12)	+1,2	11,51(25)***	-1,44
137Cs 591-16	11,903(107)	11,729***	-1,46	11,79(31)	-0,96	12,06(12)	+1,3	11,73(25)***	-1,44
137Cs 591-17	11,566(104)	11,389***	-1,53	11,35(31)	-1,88	11,69(12)	+1,1	11,39(25)***	-1,50
137Cs 591-18	12,070(109)	11,889***	-1,50	11,89(31)	-1,50	12,21(12)	+1,1	11,89(25)***	-1,48
137Cs 591-19	11,828(106)	11,669***	-1,34	11,63(31)	-1,68	11,98(12)	+1,2	11,65(25)***	-1,50
131I 799-01	19,870(199)	20,025	+0,78	19,30(58)	-2,86	20,52(30)	+3,3	19,99(15)	+0,62
131I 799-02	19,448(194)	19,587	+0,71	18,91(58)	-2,78	20,11(30)	+3,4	19,56(15)	+0,58
18F 800-02	52,494(787)	53,14	+1,23	50,0(20)	-4,78	54,96(82)	+4,7	52,93(107)	+0,82
18F 800-03	52,091(781)	52,857	+1,47	49,6(20)	-4,88	54,28(82)	+4,2	52,52(107)	+0,82
123I 801-02	91,00(109)	96,554	+6,10	96,74	+6,31	97,5(1,5)	+7,1	95,8(21)	+5,27
123I 801-03	91,45(110)	97,025	+6,10	97,16	+6,25	98,0(1,5)	+7,1	96,3(21)	+5,31
67Ga 802-01	103,32(155)	103,827	+0,49	94,3(47)	-8,70	102,1(1,5)	-1,2	103,0(28)	-0,32
67Ga 802-02	101,34(152)	101,665	+0,32	92,4(47)	-8,80	100,2(1,5)	-1,1	100,9(27)	-0,42
201Tl 803-01	74,571(820)	83,78*	+12,3	72,82*	-2,4	80,0(1,2)*	+7,3	84,33(89)*	+13,1
201Tl 803-02	73,993(814)	83,76*	+13,2	72,16*	-2,5	79,3(1,2)*	+7,2	83,77(89)*	+13,2
201Tl 803-03	75,289(828)	84,14*	+11,7	72,82*	-3,4	**		84,23(89)*	+10,6
99mTc 804-02	96,510(965)	98,171	+1,72	97,7(29)	+1,25	98,9(1,5)	+2,4	97,34(165)	+0,86
99mTc 804-03	97,637(976)	99,288	+1,69	98,8(29)	+1,16	100,0(1,5)	+2,4	98,49(167)	+0,88
133Xe	188,6(70)	**		189(9)	+0,4	202,1	+7,1	**	
85Kr	2437(120)	**		**		2569	+5,4	**	

* corrected to impurities

** not measured

*** gel compound; provided calibration factor for liquid solution only

From the data presented in Table 4 it is clear that there is some problem in the calibration of the CMI chamber for ^{123}I and ^{201}Tl.

When the activity measured with NPL-CRC chamber is taken as the reference activity of ^{123}I and ^{201}Tl, the resulting activities and deviations from the NPL-CRC reference value for BQM, VacuTec and ISOCAL are shown in the following Table 5.

Table 5: Activities of ^{123}I and ^{201}Tl measured by BQM, VacuTec, ISOCAL when compared with NPL-CRC chamber results.

Radionuclide Vial number	NPL-CRC activity, A_r MBq	BQM response, A_1	$(A_1-A_r)/A_r$ %	VacuTec response, A_2	$(A_2-A_r)/A_r$ %	ISOCAL IV response, A_3	$(A_3-A_r)/A_r$ %
123I 801-02	96,554	96,74	+0,19	97,5	+0,98	95,801	-0,78
123I 801-03	97,025	97,16	+0,14	98,0	+1,0	96,301	-0,75
201Tl 803-01	83,78	72,82	-13	80,0	-4,5	84,333	+0,66
201Tl 803-02	83,76	72,16	-14	79,3	-5,3	83,768	+0,01
201Tl 803-03	84,14	72,82	-13			84,234	+0,11

Comment

The calibration of ^{137}Cs, ^{131}I, ^{18}F, ^{67}Ga and ^{99m}Tc is acceptable. The individual deviation can be used for the new calibration of chambers.
The calibration of ^{133}Xe and ^{85}Kr was possible only for BQM and VacuTec, due to the dimensions of well of chambers. However, results are not comparable due to different calibration conditions. It is generally acceptable for both chambers.
The real problem is in the calibration of CMI chamber for ^{123}I and ^{201}Tl. The calibration was done 5 years ago by commercially available material. This knowledge leads to necessity of recalibration of CMI chamber for the above-mentioned radionuclides. Then a new comparison of activity measurements of these radionuclides would be advisable.