



Australian Government

Australian Radiation Protection
and Nuclear Safety Agency

TECHNICAL REPORT

Results of the Quality Assurance Testing Program for Radiopharmaceuticals (2009)

Z Ivanov

TECHNICAL REPORT SERIES No. 153



Australian Government

**Australian Radiation Protection
and Nuclear Safety Agency**

**Results of the Quality Assurance Testing
Program for Radiopharmaceuticals 2009**



This document is issued in
accordance with NATA's
accreditation requirements.

Accredited for compliance
with ISO/IEC 17025

Accreditation Number: 14442

Version: 4

Issue Date: September 2010

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ABSTRACT

This report tabulates results obtained during 2009 for the Radiopharmaceutical Quality Assurance Test Program conducted by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA).

CONTENTS

COPYRIGHT NOTICE AND DISCLAIMER	2
ABSTRACT	3
INTRODUCTION	5
RESULTS	5
ACKNOWLEDGEMENTS	8
ABBREVIATIONS	9
CHROMIUM [⁵¹ Cr] EDETATE INJECTION	10
SODIUM CHROMATE [⁵¹ Cr] SOLUTION	11
GALLIUM [⁶⁷ Ga] CITRATE INJECTION	12
⁹⁹ Mo/ ^{99m} Tc CHROMATOGRAPHIC GENERATOR	13
SODIUM PERTECHNETATE [^{99m} Tc] INJECTION (FISSION)	14
INDIUM OXINE [¹¹¹ In] SOLUTION	15
IOBENGUANE [¹²³ I] INJECTION	16
SODIUM IODIDE [¹³¹ I] CAPSULES (THERAPY)	17
THALLOUS [²⁰¹ Tl] CHLORIDE INJECTION	18
KIT FOR THE PREPARATION OF TECHNETIUM [99mTc] ALBUMIN AGGREGATED INJECTION (PULMOLITE)	19
KIT FOR THE PREPARATION OF TECHNETIUM [^{99m} Tc] BICISATE INJECTION (NEUROLITE)	20
KIT FOR THE PREPARATION OF TECHNETIUM [^{99m} Tc] CALCIUM PHYTATE INJECTION (COLLOID)	21
KIT FOR THE PREPARATION OF TECHNETIUM [^{99m} Tc] DISOFENIN INJECTION (HEPATOLITE)	22
KIT FOR THE PREPARATION OF TECHNETIUM [^{99m} Tc] EXAMETAZIME INJECTION (CERETEC)	23
KIT FOR THE PREPARATION OF TECHNETIUM [^{99m} Tc] MEDRONATE INJECTION (MDP)	24
KIT FOR THE PREPARATION OF TECHNETIUM [^{99m} Tc] MERTIATIDE INJECTION (MAG3)	25
KIT FOR THE PREPARATION OF TECHNETIUM [^{99m} Tc] OXIDRONATE INJECTION (HDP)	26
KIT FOR THE PREPARATION OF TECHNETIUM [^{99m} Tc] PENTETATE INJECTION (DTPA)	27
KIT FOR THE PREPARATION OF TECHNETIUM [^{99m} Tc] SESTAMIBI INJECTION (CARDIOLITE)	28
KIT FOR THE PREPARATION OF TECHNETIUM [^{99m} Tc] SUCCIMER INJECTION (DMSA)	29
KIT FOR THE PREPARATION OF TECHNETIUM [^{99m} Tc] TETROFOSMIN (MYOVUE)	30
KIT FOR THE PREPARATION OF TECHNETIUM [^{99m} Tc] TIN PYROPHOSPHATE INJECTION (PYP)	31
KIT FOR THE PREPARATION OF TECHNETIUM [^{99m} Tc] TIN PYROPHOSPHATE INJECTION (PYP)	32

INTRODUCTION

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) conducts a Radiopharmaceutical Quality Assurance (QA) Test Program under a Memorandum of Understanding (MOU) between ARPANSA and the Therapeutic Goods Administration (TGA). As part of this MOU radiopharmaceuticals used in nuclear medicine in Australia are tested for compliance with specifications. Where the radiopharmaceutical is the subject of a monograph in the British Pharmacopoeia or the European Pharmacopoeia, then the specifications given in these Pharmacopoeias are adopted. Where a monograph is only available in the US Pharmacopoeia, then this specification is generally adopted. Unless stated otherwise, these specifications listed apply at all times up to the date of product expiry. Radionuclidic purity has been determined up to the expiry time.

For Thallous [^{201}Tl] Chloride Injection and Sodium Pertechnetate [$^{99\text{m}}\text{Tc}$] Injection, radionuclidic purity is determined and the impurity levels at both the time of calibration and expiry are quoted.

Samples for testing were obtained through commercial channels according to the schedule set at the beginning of the test period as described in *Quality Assurance of Radiopharmaceuticals including Cold Kits: MR-RPQA-SOP-0000*. All technetium-99m cold kits were reconstituted using Sodium Pertechnetate [$^{99\text{m}}\text{Tc}$] Injection according to the directions supplied in the package insert. Pharmacopoeia methods are used for testing, together with some additional methods described in the ARPANSA Quality System: Radiopharmaceuticals Quality Assurance Testing Program (MR-RPQA-WI-0060A).

RESULTS

The results of testing during 2009 are summarised in the following tables. Overall, 37 batches of 22 different types of radiopharmaceuticals were tested.

In the case of Iobenguane [^{123}I] Injection, the radionuclidic content could not be determined accurately. A certified reference standard for Iodine-123 is still not available therefore the correction for the effect of the absorption of the abundant low energy X-ray emission by the container and the sample is unknown. Thus, measurement in the original sample glass vial (and using the dose calibrator manufacturer's setting for ^{123}I) gave an apparent 73 % of the stated radioactivity at the calibration date

and time when measured using two different dose calibrators. Measurements with the Iobenguane [¹²³I] Injection in Livingstone plastic 1 mL syringes gave the value of 133 % of the stated radioactivity at the calibration date and time on the basis of the MBq/mL activity concentration. The manufacturers of dose calibrators advise that for the measurement of ¹²³I a 10 - 20% syringe correction may be required.

For Sodium Iodide [¹³¹I] Capsules (Therapy) the BP does not require a “Uniformity of Content” test. The measurement of radioactivity content of 3 capsules of this batch showed that the radioactivity of no capsule differed by more than 8.9 % from the average value, with a relative standard deviation of 7.74 % and for another batch of 10 capsules showed that the radioactivity of no capsule differed by more than 7.3 % from the average value, with a relative standard deviation of 5.68 %.

Due to the shortage of supply and impending discontinuation of the manufacture of Instant Thin Layer Chromatography-Silica Gel (ITLC-SG) media, ARPANSA has conducted comparison tests on alternative media that may be suitable for the measurement of the radiochemical purity of some commonly used technetium-99m radiopharmaceuticals.

Radiopharmaceuticals used in this study were:

Technetium [^{99m}Tc] Pentetate Injection (DTPA),
Technetium [^{99m}Tc] Succimer Injection (DMSA),
Technetium [^{99m}Tc] Oxidronate Injection (HDP),
Technetium [^{99m}Tc] Tin Pyrophosphate Injection (PYP),
Technetium [^{99m}Tc] Calcium Phytate Injection (Colloid),
Technetium [^{99m}Tc] Medronate Injection (MDP),
Technetium [^{99m}Tc] Exametazime (Ceretek), and
Technetium [^{99m}Tc] Tetrofosmin (Myoview).

In conclusion, the Varian SA (not heat activated) and Whatman 3MM papers were found to be typically good substitutes for ITLC-SG, showing similar R_f values, similar radiochemical purity, and only slightly longer run times. It is important to note that these results are only indicative replacements for ITLC-SG and that individual practices that reconstitute ^{99m}Tc-radiopharmaceuticals will have to validate any new procedures in their laboratory as part of their Quality Control Program.

Comparison of the results, obtained with different chromatographic media, were presented at the 40th Annual Scientific Meeting of the Australia and New Zealand Society of Nuclear Medicine (ANZSNM).in Auckland, New Zealand.

The BP and USP do not require a test for benzyl alcohol used as an antimicrobial preservative in some “ready to use” radiopharmaceuticals. ARPANSA, however performs this test using an in-house method.

According to the current BP, labelling of the radiopharmaceutical preparations complies with the relevant national and European legislation. In accordance with the “*General Requirements for Labels for Medicines*” of the Therapeutic Goods Act 1989, TGA Order No. 69, 3(2) (b), (c), the label or labels must include the name(s) and quantity or proportion of all active ingredients in the goods. For small volume injections the label on the primary pack must include the name and quantity of each excipient.

In the case of one type of “cold kit” radiopharmaceutical, the kit from an Australian manufacturer met the TGA approved manufacturer’s specification for pH after reconstitution (pH = 4.5 – 6.0) and for other three batches from the overseas manufacturer met the value given in USP (pH = 4.0 – 7.5), which is outside the BP specification (pH = 6.0 – 7.0), but has been approved by the TGA.

Non-compliance of the vial/package label was observed in one batch. Vial/label non-compliance consisted of absence of a statement as to the presence or absence of a microbiological preservative and the absence of the name and quantity of each component. Only the names of the components were listed in the delivery note but not the quantity of each.

In 2009, ARPANSA participated in the ANZSNM Radionuclide Dose Calibrator Accuracy Testing survey conducted by Lantheus Medical Imaging, Australia. The survey included the measurement of ANSTO/ARI standards for ^{99m}Tc , ^{67}Ga , ^{201}Tl , ^{131}I diagnostic and ^{131}I therapy in two ARPANSA dose calibrators. The ARPANSA results were in excellent agreement with the standard source values, except for ^{201}Tl , where the deviations from the standard were -1.90 and 2.3%. As noted in last years’ technical report, difficulties remain to be resolved in the radionuclidic content measurement of ^{201}Tl , as the presence of small amounts of ^{200}Tl and ^{202}Tl impurities can significantly affect the measurement value to radiation decay resulting in varying levels of these radionuclidic impurities, in particular an increase with time of the percentage content of the longer lived ^{202}Tl ($t_{1/2} = 12.23$ days).

Due to staff and resource reductions, ARPANSA is no longer able to perform animal testing as part of the ARPANSA Quality Assurance Test Program. The Biological Distribution specifications have been retained in the Report for the sake of completeness only.

ACKNOWLEDGEMENTS

The testing of the radiopharmaceuticals and cold kits was performed by Ilonka Bokor and Zlata Ivanov with Robert Guilfoyle assisted with comparison tests on alternative media that may be suitable for the measurement of the radiochemical purity of some commonly used technetium-99m radiopharmaceuticals listed above.

ABBREVIATIONS

The following abbreviations are used in the tables –

ARI	- ANSTO Radiopharmaceuticals and Industrials, Lucas Heights, Sydney, Australia
CIS BIO	- CIS Bio International, Gif Sur Yvette, France
GE Healthcare	- GE Healthcare Limited, formerly Amersham Health Pty. Ltd., UK
Lantheus (AUST)	- Lantheus Medical Imaging, formerly Bristol-Myers Squibb Medical Imaging (BMS) Tullamarine, VIC, Australia
Lantheus (USA)	- Lantheus Medical Imaging, formerly Bristol-Myers Squibb Medical Imaging North Billerica, MA, USA
RADPH	- Radpharm Scientific, Belconnen, ACT, Australia
RADPH/EDM	- Edmonton Radiopharmaceutical Centre, Edmonton, Alberta
Tyco/Mall	- TYCO Healthcare, Lane Cove, NSW Australia; Mallinckrodt Medical B.V., Petten, Netherlands
CALIB. DATE	- Calibration Date
EXP.	- Expiry testing
INT.	- Initial testing
MAX	- Maximum
MIN	- Minimum
N.A.	- Not applicable (not required by BP/USP)
N.D.	- Not detected
No.	- Number
p	- Page
reconst.	- reconstitute
TBD	- To be done
†	- Not determined

CHROMIUM [⁵¹Cr] EDETATE INJECTION

Current edition of BP

SPECIFICATIONS		SUPPLIER	ARI
		LOT/BATCH No.	118704-001
		CALIB. DATE	01/05/09
		EXPIRY DATE	01/06/09
Appearance	A clear, violet solution		Pass
Particulate matter	None visible		Pass
Identification	Gamma spectrum does not differ significantly from that of a standardised chromium-51 solution		Pass
Radionuclidic content	90-110% of stated value		106.5 ± 0.1*
Radionuclidic purity	Gamma spectrum does not differ significantly from that of a standardised chromium-51 solution		Pass
pH	3.5 – 6.5		4.5
Radiochemical purity			
1) Chromic ion	as %	INT.	0.7 ± 0.2
2) Chromate ion	as %		2.0 ± 0.3
3) Cr-edetate	≥ 95% as ⁵¹ Cr-edetate		97.3 ± 0.5
		EXP.	0.3 ± 0.01
			0.7 ± 0.1
			99.0 ± 0.1
Chromium (Cr)	≤ 1mg/mL		0.2
Benzyl Alcohol	90 – 110 % of stated value		N.A
Vial/Package Label	Complies		Complies

* Two vials from the same batch.

SODIUM CHROMATE [⁵¹Cr] SOLUTION

Current edition of BP

SPECIFICATIONS		SUPPLIER	GE Healthcare
		LOT/BATCH No.	1138
		CALIB. DATE	21/10/09
		EXPIRY DATE	16/12/09
Appearance	A clear, colourless or slightly yellow solution		Pass
Particulate matter	None visible		Pass
Identification	Gamma spectrum does not differ significantly from that of a standardised chromium-51 solution		Pass
Radionuclidic content	90-110% of stated value		104
Radionuclidic purity	Gamma spectrum does not differ significantly from that of a standardised chromium-51 solution		Pass
pH	6.0 - 8.5		6.1
Radiochemical purity	≥ 90% as chromate ion	INT.	97.4 ± 0.1
		EXP.	96.4 ± 0.1
Total chromate	≤ 2.7 µg of chromate ion (CrO ₄ ²⁻) per MBq		0.02
Benzyl Alcohol	90 – 110 % of stated value		N.A
Vial/Package Label	Complies		Complies

GALLIUM [⁶⁷Ga] CITRATE INJECTION

Current edition of BP

		SUPPLIER	ARI	Lantheus (USA)	Tyco/Mall
		LOT/BATCH No	118947-004	G134911S	75294
		CALIB. DATE	08/05/09	22/05/09	20/05/09
SPECIFICATIONS		EXPIRY DATE	13/05/09	29/05/09	01/06/09
Appearance	A clear, colourless solution		Pass	Pass	Pass
Particulate matter	None visible		Pass	Pass	Pass
Identification	Gamma spectrum does not differ significantly from that of a standardised gallium-67 solution		Pass	Pass	Pass
Citrate presence	A yellow colour develops in the test solution only		Pass	Pass	Pass
Radionuclidic content	90-110% of stated value		103	97	97
Radionuclidic purity	≤ 0.2% ⁶⁶ Ga		N.D.	N.D.	N.D.
pH	5.0 - 8.0		7.1	5.5	6.1
Radiochemical purity	≥ 97% as Ga Citrate	INT.	99.1 ± 0.1	99.8 ± 0.1	99.7 ± 0.08
		EXP.	99.4 ± 0.2	99.5 ± 0.2	99.8 ± 0.01
Zinc limit test	≤ 5 µg/mL		< 5	< 5	< 5
Benzyl Alcohol	90 – 110 % of stated value		108	100	99
Vial/Package Label	Complies		Complies	Complies	Fails

⁹⁹Mo/^{99m}Tc CHROMATOGRAPHIC GENERATOR

Current edition of BP (Sodium Pertechnetate [^{99m}Tc] Injection (Fission) and MR-RPQA-WI-0060A

		SUPPLIER	ARI	
		LOT/BATCH No.	120997-054	
		CALIB. DATE	30/11/09	
SPECIFICATIONS		EXPIRY DATE	14/12/09	
Maximum surface radiation dose rate	< 2000 µSv/h		106 µSv/h	
Dose rate at 1 metre	< 100 µSv/h		2.8 µSv/h	
Appearance (after milking)	A clear, colourless solution		Pass	
Particulate matter	None visible		Pass	
Identification	Gamma spectrum does not differ significantly from that of a standardised technetium-99m solution		Pass	
			MIN	MAX
			Elution	Expiry
Radionuclidic purity	≤ 0.1% ⁹⁹ Mo		0.0	0.0
	≤ 5 x 10 ⁻³ % ¹³¹ I		16	N.D.
	≤ 5 x 10 ⁻³ % ¹⁰³ Ru		N.D.	N.D.
	≤ 6 x 10 ⁻⁵ % ⁸⁹ Sr		†	†
	≤ 6 x 10 ⁻⁶ % ⁹⁰ Sr		†	†
	≤ 1 x 10 ⁻⁷ % alpha-emitting impurities		†	†
	≤ 1 x 10 ⁻² % all other gamma-emitting impurities		N.D.	N.D.
pH	4.0 - 8.0		5.5	5.5
Radiochemical purity	≥ 95% as pertechnetate ion (^{99m} TcO ₄) ⁻	INT.	99.8 ± 0.04	99.9 ± 0.01
		EXP.	99.9 ± 0.02	99.9 ± 0.01
Aluminium	≤ 5µg/mL		0.4 µg/mL	0.4 µg/mL
Milking efficiency	None (for information only)		89	94
Moly assay (⁹⁹ Mo breakthrough)	≤ 0.1 % ⁹⁹ Mo at expiry		N.D.	4E-4
Vial/Package Label	Complies		Complies	

SODIUM PERTECHNETATE [^{99m}Tc] INJECTION (FISSION)

Current edition of BP

SPECIFICATIONS		SUPPLIER	Lantheus (AUS)
		LOT/BATCH No.	277793
		CALIB. DATE	05/03/09 @ 09:00 h
		EXPIRY DATE	05/03/09 @ 17:00 h
Appearance	A clear, colourless solution		Pass
Particulate matter	None visible		Pass
Identification	Gamma spectrum does not differ significantly from that of a standardised technetium-99m solution		Pass
Radionuclidic content	90-110% of stated value		101
			INT. EXP.
Radionuclidic purity	≤ 0.1% ⁹⁹ Mo		N.D. N.D.
	≤ 5 x 10 ⁻³ % ¹³¹ I		N.D. N.D.
	≤ 5 x 10 ⁻³ % ¹⁰³ Ru		N.D. N.D.
	≤ 6 x 10 ⁻⁵ % ⁸⁹ Sr		† †
	≤ 6 x 10 ⁻⁶ % ⁹⁰ Sr		† †
	≤ 1 x 10 ⁻⁷ % alpha-emitting impurities		† †
	≤ 1 x 10 ⁻² % all other gamma-emitting impurities		N.D. N.D.
pH	4.0 - 8.0		5.0
Radiochemical purity	≥ 95% as pertechnetate ion (^{99m} TcO ₄ ⁻)		99.95 ± 0.003 99.95 ± 0.005
Aluminium (Al)	≤ 5 µg /mL		†*
Vial/Package Label	Complies		N.A.

*Insufficient sample size

INDIUM OXINE [¹¹¹In] SOLUTION

Current edition of BP

SPECIFICATIONS		SUPPLIER	GE Healthcare
		LOT/BATCH No.	5544
		CALIB. DATE	07/10/09
		EXPIRY DATE	12/10/09
Appearance	A clear, colourless solution		Pass
Particulate matter	None visible		Pass
Identification	Gamma spectrum does not differ significantly from that of a standardised indium-111 solution, apart from any difference due to the presence of indium-114m		Pass
Radionuclidic content	90-110% of stated value		108
Radionuclidic purity	Gamma spectrum does not differ significantly from that of a standardised indium-111 solution, apart from any difference due to the presence of indium-114m		Pass
	≤ 0.25% of the total radioactivity is due to radionuclides other than indium-111 at all times up to expiry		Pass
pH	6.0 – 7.5		6.5
Radiochemical purity	≥ 90% of activity as ¹¹¹ In-Oxine	INT.	90.5 ± 0.5
		EXP.	90.8 ± 0.9
Vial/Package Label	Complies		Complies

IOBENGUANE [¹²³I] INJECTION

Current edition of BP

		SUPPLIER	ARI	
		LOT/BATCH No.	120838-009	
		CALIB. DATE	10/11/09	
SPECIFICATIONS		EXPIRY TIME	11/11/09	
Appearance	A clear, colourless or slightly yellow solution		Pass	
Particulate matter	None visible		Pass	
Identification	Gamma spectrum does not differ significantly from that of a standardised iodine-123 solution apart from any differences attributed to the presence of iodine-125, tellurium-121 and other radionuclidic impurities		Pass	
Radionuclidic content	90-110% of stated value		73 ± 0.7* 133**	
Radionuclidic purity	≤ 0.35 % of the total radioactivity is due to radionuclides other than iodine-123		N.D.	
pH	3.5 – 8.0		5.0	
			INT.	EXP.
Radiochemical purity	≥95% of activity as iobenguane		97.7 ± 0.4	98.3 ± 0.1
	≤4 % of activity as iodide		1.9 ± 0.01	1.7 ± 0.1
	≤1% of activity in other peaks		1.0 ± 0.04	N.D.
Vial/Package Label	Complies		Complies	

* Measurements performed in the glass vial, supplied by the manufacturer in two different dose calibrators (Capintec).

** Measurements performed in a Livingstone plastic 1 mL syringe

Note: No reference standard is available and no adjustment was made to the Capintec setting. For details refer to p 5 of this report.

SODIUM IODIDE [¹³¹I] CAPSULES (THERAPY)

Current edition of BP

		SUPPLIER	ARI	ARI
		LOT/BATCH No.	117597-025	120766-050
		CALIB. DATE	22/12/08	09/11/09
SPECIFICATIONS		EXPIRY DATE	05/01/09	23/11/09
Appearance	Gelatine capsule		Pass	Pass
Identification	Gamma spectrum does not differ significantly from that of a standardised iodine-131 solution		Pass	Pass
Radionuclidic content	90-110% of stated value		97 ± 7.5*	96 ± 5.5**
Radionuclidic purity	≥ 99.9% as ¹³¹ I,		Pass	Pass
	≤ 0.1% of the total radioactivity is due to ¹³⁰ I, ¹³³ I, ¹³⁵ I and other radionuclidic impurities		N.D.	N.D.
Radiochemical purity	≥ 95% of activity as iodide	INIT.	98.9 ± 0.2	98.7 ± 0.04
		EXP.	98.1 ± 0.05	99.5 ± 0.03
Disintegration	The shell and its contents dissolve completely within 15 min.		Pass	Pass
Vial/Package Label	Complies		Complies	Complies

* 3 capsules measured.

**10 capsules measured.

Note: The BP does not require a Uniformity of Content test for Sodium Iodide [¹³¹I] Capsules (Therapy). For details refer to p 6 of this report.

THALLOUS [²⁰¹Tl] CHLORIDE INJECTION**Current edition of BP**

		SUPPLIER	ARI	MALL		
		LOT/BATCH No.	118956-002	75360		
		CALIB. DATE	07/05/09	21/05/09		
SPECIFICATIONS		EXPIRY DATE	12/05/09	28/05/09		
Appearance	A clear colourless solution		Pass	Pass		
Particulate matter	None visible		Pass	Pass		
Identification	Gamma spectrum does not differ significantly from that of a standardised thallium-201 solution		Pass	Pass		
Radionuclidic content	90-110% of stated value		96	95		
Radionuclidic purity	At all times up to expiry		At calibration	At expiry	At calibration	At expiry
	²⁰¹ Tl ≥ 97 %		99.1	99.5	99.6	98.8
	²⁰² Tl ≤ 2.0 %		0.1	0.4	0.4	1.2
	²⁰⁰ Tl %		0.8	0.1	0.1	0.005
	²⁰¹ Pb %		N.D.	N.D.	N.D.	N.D.
	²⁰³ Pb %		N.D.	N.D.	N.D.	N.D.
pH	4.0 - 7.0		4.5	5.0		
Radiochemical purity	≥ 95% of the activity is present as Thallous ion	INT.	99.9 ± 0.02	99.7 ± 0.02		
		EXP.	99.4 ± 0.4	99.2 ± 0.03		
Thallium	≤ 10 µg/mL		Pass	Pass		
Benzyl Alcohol	90 – 100 % of stated value		†	N.A.		
Vial/Package Label	Complies		Complies	Complies		

KIT FOR THE PREPARATION OF TECHNETIUM [^{99m}Tc] ALBUMIN AGGREGATED INJECTION (PULMOLITE)

Current edition of USP/BP

SPECIFICATIONS		SUPPLIER	RADPH/EDM	
		LOT/BATCH No.	9D399	
		EXPIRY DATE	Sept 2011	
			INT.	EXP.
Appearance before reconstitution	Freeze-dried solid with no evidence of moisture		Pass	TBD
Appearance after reconstitution	A white suspension which may separate on standing		Pass	TBD
Check for vacuum	Vacuum present. If no vacuum is found, the vial should be discarded.		N.A.	TBD
pH	3.8 -7.5 after reconstitution		5.0	TBD
Radiochemical purity	1) ≥ 90.0 % in aggregated albumin (by chromatography)		99.2 ± 0.1	TBD
	2) ≤ 10 % as soluble and dispersed radiochemical impurities (by centrifugation)		1.6 ± 0.04	TBD
Particle size	$\geq 90\%$ of the observed aggregated particles (not less than 100) have a diameter between 10 μm and 90 μm		Pass	TBD
	No particle having a maximum diameter $> 150 \mu\text{m}$ is present		Pass	TBD
Non filterable radioactivity*	The radioactivity remaining on the membrane is $\geq 90\%$		98.5 ± 0.02	TBD
Biological distribution	$\geq 80\%$ in the lungs		†	
	$\leq 5\%$ in the liver + spleen		†	
Vial/Package Label	Complies		Complies	

* Current edition of BP.

KIT FOR THE PREPARATION OF TECHNETIUM [^{99m}Tc] BICISATE INJECTION (NEUROLITE)

Current edition of USP

		SUPPLIER	Lantheus (USA)		Lantheus (USA)	
		LOT/BATCH No.	0182A		0192A	
SPECIFICATIONS		EXPIRY DATE	01/05/09		01/07/10	
		INT.	EXP.	INT.	EXP.	
Appearance before reconstitution	Freeze-dried solid	Pass	Pass	Pass	TBD	
Appearance after reconstitution	A clear, colourless solution	Pass	Pass	Pass	TBD	
pH	6.3 - 7.6* after reconstitution 6.5 – 7.5** after reconstitution	7.0	7.1	7.0	TBD	
Radiochemical purity	≥ 90.0 % as ^{99m} Tc-Bicisate (chromatography system A)	94.0 ± 0.2	95.7 ± 0.1	92.5 ± 0.3	TBD	
	≤ 10.0 % as impurities (colloidal, ^{99m} TcO ₄ ⁻ & ^{99m} Tc-EDTA) (chromatography system B)	6.0 ± 0.2	4.3 ± 0.1	7.5 ± 0.3	TBD	
Tin content	12 - 72 µg SnCl ₂ .2H ₂ O*	N.A.		N.A.		
Vial/Package Label	Complies	Complies		Complies		

* Manufacturer's approved specification.

** Current edition of BP specification.

KIT FOR THE PREPARATION OF TECHNETIUM [^{99m}Tc] CALCIUM PHYTATE INJECTION (COLLOID)

Current edition of BP (Technetium [^{99m}Tc] Colloidal Tin Injection)

SPECIFICATIONS		SUPPLIER	RADPH
		LOT/BATCH No.	2547
		EXPIRY DATE	31/05/09
		INT.	EXP.
Appearance before reconstitution	Freeze-dried solid with no evidence of moisture	Pass	Pass
Appearance after reconstitution	A clear, colourless or slightly yellow solution, free of any visible particulate matter	Pass	Pass
Check for vacuum	If a vacuum is not observed when the vial is pierced, the vial should be discarded	Pass	Pass
pH	4.0 - 7.0 after reconstitution	5.0	
Radiochemical purity	≥ 95.0 % as ^{99m} Tc-colloid	96.3 ± 1.5	97.3 ± 0.4
Tin content	≤ 1.0 mg SnCl ₂	Pass	
Vial/Package Label	Complies	Complies	

KIT FOR THE PREPARATION OF TECHNETIUM [^{99m}Tc] DISOFENIN INJECTION (HEPATOLITE)

Current edition of USP

		SUPPLIER	RADPH/EDM	
		LOT/BATCH No.	9D399	
SPECIFICATIONS		EXPIRY DATE	23/04/10	
			INT.	EXP.
Appearance before reconstitution	Freeze-dried solid with no evidence of moisture		Pass	Pass
Appearance after reconstitution	A clear, colourless or slightly yellow solution, free of any visible particulate matter		Pass	Pass
pH	4.0 - 5.0 after reconstitution		4.7	4.6
Radiochemical purity	1) $\geq 90.0\%$ as ^{99m} Tc-disofenin		97.3	98.8
	2) hydrolysed ^{99m} Tc + tin colloid (chromatography system A)		0.15 ± 0.01	0.20 ± 0.01
	3) free pertechnetate (chromatography system B)		2.51 ± 0.41	1.0 ± 0.1
	2) + 3) $\leq 10\%$		2.66	1.2
Tin content	0.24 - 0.6 mg SnCl ₂ *		N.A.	
Biological distribution	$\geq 70\%$ in gallbladder + intestines		†	
	$\leq 10\%$ in the liver		†	
	$\leq 10\%$ in the kidneys		†	
	$\leq 3\%$ in the stomach		†	
	$\leq 3\%$ in the blood		†	
Vial/Package Label	Complies		Complies	

* Value given in label/product information.

KIT FOR THE PREPARATION OF TECHNETIUM [^{99m}Tc] EXAMETAZIME INJECTION (CERETEC)

Current edition of USP

		SUPPLIER	GE Healthcare		GE Healthcare	
		LOT/BATCH No.	1276		1280	
SPECIFICATIONS		EXPIRY	29/10/09		24/12/09	
			INT.	EXP.	INT.	EXP.
Appearance before reconstitution	Freeze-dried solid with no evidence of moisture		Pass	Pass	Pass	Pass
Appearance after reconstitution	A clear, colourless solution, free of any visible particulate matter		Pass	Pass	Pass	Pass
pH	9.0 – 9.8 after reconstitution		9.2		9.4	
Radiochemical purity	≥ 80.0 % as ^{99m} Tc-Exametazime		94.8	95.5	95.3	90.3
	% as free pertechnetate		1.1 ± 0.2	0.90 ± 0.03	1.4 ± 0.1	1.5 ± 0.3
	% as hydrolysed reduced ^{99m} Tc		2.5 ± 0.1	1.3 ± 0.1	2.9 ± 0.3	1.8 ± 0.1
	% as ^{99m} Tc secondary exametazime complex		1.7	2.3	0.4	6.4
Tin content	7.6 µg SnCl ₂ .2H ₂ O/vial*		N.A.		N.A.	
Biological distributor	≥ 1.5 % in the brain		†		†	
	≤ 20 % in the intestines		†		†	
	≤ 15 % in the liver		†		†	
Vial/Package Label	Complies		Complies		Complies	

* Value given in label/product information.

KIT FOR THE PREPARATION OF TECHNETIUM [^{99m}Tc] MEDRONATE INJECTION (MDP)

Current edition of BP

		SUPPLIER	RADPH		RADPH	
		LOT/BATCH No.	2608		2628	
SPECIFICATIONS		EXPIRY DATE	October 2009		December 2009	
			INT.	EXP.	INT.	EXP.
Appearance before reconstitution	Freeze-dried solid with no evidence of moisture		Pass	Pass	Pass	Pass
Appearance after reconstitution	A clear, colourless solution		Pass	Pass	Pass	Pass
pH	3.5 – 7.5 after reconstitution		5.0	5.0	4..5	4.5
Radiochemical purity	1) ≥ 95.0 % as ^{99m} Tc-MDP		99.8	99.5	99.3	99.7
	2) ≤ 2.0 % as ^{99m} TcO ₄ ⁻		0.06 ± 0.02	0.06 ± 0.03	0.1 ± 0.03	0.1 ± 0.01
	3) as colloidal ^{99m} Tc		0.17 ± 0.01	0.4 ± 0.1	0.6 ± 0.08	0.2 ± 0.02
	2) + 3) ≤ 5.0 %		0.2	0.5	0.7	0.3
Tin content	≤ 3 mg/mL		Pass		Pass	
Biological distribution	≥ 1.5% attached to femur		†		†	
	≤ 1.0% in the liver		†		†	
	≤ 0.05 %/g in the blood		†		†	
Vial/Package Label	Complies		Complies		Complies	

KIT FOR THE PREPARATION OF TECHNETIUM [^{99m}Tc] MERTIATIDE INJECTION (MAG3)

Current edition of BP

		SUPPLIER	TYCO/MALL		TYCO/MALL		TYCO/MALL	
		LOT/BATCH No.	0948004		0968005		0969003	
SPECIFICATIONS		EXPIRY DATE	01/02/09		24/4/09		01/07/10	
			INT.	EXP.	INT.	EXP.	INT.	EXP.
Appearance before reconstitution	Freeze-dried solid with no evidence of moisture		Pass	Pass	Pass	Pass	Pass	TBD
Appearance after reconstitution	A clear, colourless solution		Pass	Pass	Pass	Pass	Pass	TBD
pH	5.0 - 7.5 after reconstitution		5.5	5.5	5.5	5.5	5.7	TBD
Radiochemical purity	≥ 94.0 % as ^{99m} Tc-MAG3*		99.7	99.7	99.7	99.7	99.8	TBD
	% as hydrophilic impurities*		0.1 ± 0.01	0.2 ± 0.01	0.16 ± 0.02	0.14 ± 0.01	0.15 ± 0.01	TBD
	% as non-elutable impurities*		0.13 ± 0.2	0.12 ± 0.1	0.13 ± 0.2	0.12 ± 0.1	0.07 ± 0.04	TBD
	≤ 2% as reduced-hydrolysed technetium (by chromatography)		0.06 ± 0.00	0.06 ± 0.003	0.06 ± 0.001	0.06 ± 0.003	0.04 ± 0.003	TBD
Tin content	≥ 50 µg SnCl ₂ .2H ₂ O/vial**		N.A.		N.A.		N.A.	
Vial/Package Label	Complies		Complies		Complies		Complies	

* Tested by the method recommended by the manufacturer.

** Value given in label/product information.

KIT FOR THE PREPARATION OF TECHNETIUM [^{99m}Tc] OXIDRONATE INJECTION (HDP)

Current edition of USP

		SUPPLIER	TYCO/MALL	
		LOT/BATCH No.	0918014	
SPECIFICATIONS		EXPIRY DATE	11/05/09	
			INT.	EXP.
Appearance before reconstitution	Freeze-dried solid with no evidence of moisture		Pass	Pass
Appearance after reconstitution	A clear, colourless solution		Pass	Pass
pH	2.5 – 7.0 after reconstitution		4.5	5.0
Radiochemical purity*	1) ≥ 90.0 % as ^{99m} Tc-oxidronate		99.5	99.8
	2) % as free pertechnetate		0.3 ± 0.1	0.1 ± 0.02
	3) % as colloidal ^{99m} Tc		0.2 ± 0.04	0.1 ± 0.0
	2) + 3) ≤ 10 %		0.5	0.2
Tin content	0.258 - 0.342 mg SnCl ₂ .2H ₂ O**		0.27 mg	
Biological distribution	≥ 1.0% attached to one femur		†	
	≤ 5.0% in the liver		†	
	≤ 5.0% in the kidneys		†	
Vial/Package Label	Complies		Complies	

* Current edition of BP for Technetium [^{99m}Tc] Tin Pyrophosphate Injection.

** Value given in label/product information

KIT FOR THE PREPARATION OF TECHNETIUM [^{99m}Tc] PENTETATE INJECTION (DTPA)

Current edition of BP

		SUPPLIER	ARI		ARI		RADPH	
		LOT/BATCH No.	2562		2610		2665	
SPECIFICATIONS		March 2009		November 2009		May 2010		
		INT.	EXP.	INT.	EXP.	INT.	EXP.	
Appearance before reconstitution	Freeze-dried solid with no evidence of moisture	Pass	Pass	Pass	Pass	Pass	Pass	
Appearance after reconstitution	A clear, colourless or slightly yellow solution	Pass	Pass	Pass	Pass	Pass	Pass	
Check for vacuum	If a vacuum is not observed when the vial is pierced, the vial should be discarded	Pass	Pass	Pass	Pass	Pass	Pass	
pH	4.0 – 7.5 after reconstitution	4.4	4.5	4.5	4.7	5.5	5.5	
Radiochemical purity	1) $\geq 95.0\%$ as ^{99m} Tc-DTPA	99.7	99.5	99.2	99.75	99.4	99.6	
	2) Colloidal ^{99m} Tc impurity (chromatography system A)	0.1 ± 0.03	0.2 ± 0.011	0.4 ± 0.1	0.2 ± 0.02	0.1 ± 0.0	0.1 ± 0.003	
	3) Free pertechnetate ^{99m} Tc (chromatography system B)	0.2 ± 0.06	0.3 ± 0.023	0.4 ± 0.1	0.05 ± 0.002	0.5 ± 0.03	0.3 ± 0.02	
	2) + 3) $\leq 5.0\%$	0.30	0.5	0.8	0.3	0.6	0.4	
Tin content	≤ 1 mg/mL	Pass		0.3		0.3		
Vial/Package Label	Complies	Complies		Complies		Complies		

KIT FOR THE PREPARATION OF TECHNETIUM [^{99m}Tc] SESTAMIBI INJECTION (CARDIOLITE)

Current edition of USP

SPECIFICATIONS		SUPPLIER	Lantheus	Lantheus		
		LOT/BATCH No.	3945 SKA	3970KA		
		EXPIRY DATE	01/08/2009	01/11/10		
			INT.	EXP.	INT.	EXP.
Appearance before reconstitution	Freeze dried solid with no evidence of moisture		Pass	Pass	Pass	TBA
Appearance after reconstitution	A clear, colourless solution		Pass	Pass	Pass	TBA
pH	5.0 - 6.0 after reconstitution		5.1	5.3	5.2	TBA
Radiochemical purity	≥ 90.0 % as ^{99m} Tc-Sestamibi		98.6	98.6	98.2	TBA
	≤ 10.0 % ^{99m} Tc impurities		1.4 ± 0.1	1.4 ± 0.1	1.8 ± 0.1	TBA
Tin content	0.075 mg SnCl ₂ *		N.A.		N.A.	
Vial/Package Label	Complies		Complies		Complies	

* Value given in label/product information.

KIT FOR THE PREPARATION OF TECHNETIUM [^{99m}Tc] SUCCIMER INJECTION (DMSA)

Current edition of BP

		SUPPLIER	RADPH	
		LOT/BATCH No.	2659	
SPECIFICATIONS		EXPIRY DATE	April 2010	
			INT.	EXP.
Appearance before reconstitution	Freeze dried solid		Pass	Pass
Appearance after reconstitution	A clear, colourless solution		Pass	Pass
Check for vacuum	If a vacuum is not observed when the vial is pierced, the vial should be discarded		Pass	Pass
pH	2.3 - 3.5 after reconstitution		2.8	3.0
Radiochemical purity	≥ 95.0 % as ^{99m} Tc-DMSA		98.25 ± 0.2	99.20 ± 0.04
	≤ 2.0 % as ^{99m} TcO ₄ ⁻		1.75 ± 0.2	0.80 ± 0.04
Tin content	≤ 1 mg/mL		0.3 mg/mL	
Biological distribution	≥ 40% in the kidneys		†	
	≤ 10% in the liver		†	
	≤ 2% in the stomach		†	
	≤ 5% in the lungs		†	
Vial/Package Label	Complies		Complies	

KIT FOR THE PREPARATION OF TECHNETIUM [^{99m}Tc] TETROFOSMIN (MYOVIEW)

Current edition of USP

SPECIFICATIONS		SUPPLIER	GE Healthcare	
		LOT/BATCH No.	1678	
		EXPIRY DATE	12/01/10	
			INT.	EXP.
Appearance before reconstitution	Freeze-dried solid with no evidence of moisture		Pass	Pass
Appearance after reconstitution	A clear, colourless solution, free of any visible particulate matter		Pass	Pass
pH	8.3 - 9.1 after reconstitution		8.4	
Radiochemical purity	1) $\geq 90.0\%$ as ^{99m} Tc-Tetrofosmin		97.1 \pm 0.1	97.1 \pm 0.1
	2) Reduced hydrolysed & hydrophilic impurities		2.8 \pm 0.1	2.5 \pm 0.1
	3) Unbound pertechnetate		0.1 \pm 0.01	0.4 \pm 0.1
	2) + 3) $\leq 10\%$		2.9	2.9
Tin content	0.03 mg/vial SnCl ₂ .2H ₂ O*		†	
Vial/Package Label	Complies		Complies	

* Value given in label/product information.

KIT FOR THE PREPARATION OF TECHNETIUM [^{99m}Tc] TIN PYROPHOSPHATE INJECTION (PYP)

Current edition of BP

		SUPPLIER	TYCO/MALL	TYCO/MALL	
		LOT/BATCH No	0948004	0949004	
SPECIFICATIONS		EXPIRY DATE	01/02/09	27/10/09	
		INT.	EXP.	INT.	EXP.
Appearance before reconstitution	Freeze-dried solid with no evidence of moisture	Pass	Pass	Pass	Pass
Appearance after reconstitution	A clear, colourless or slightly yellow solution, free of any visible particulate matter	Pass	Pass	Pass	Pass
Check for vacuum	If a vacuum is not observed when the vial is pierced, the vial should be discarded	N.A.	N.A.	N.A.	N.A.
pH	6.0 – 7.0 after reconstitution* 4.5 – 6.0 after reconstitution** 4.0 - 7.5 after reconstitution***	5.5	5.5	5.0	5.0
Radiochemical purity	1) ≥ 90.0 % as ^{99m} Tc-PYP	98.6	98.1	97.4	98.1
	2) as free pertechnetate (chromatography system A)	0.6 ± 0.1	0.4 ± 0.1	0.2 ± 0.02	0.2 ± 0.02
	3) as colloidal [^{99m} Tc] (chromatography system B)	0.8 ± 0.2	1.5 ± 0.3	2.4 ± 0.3	1.7 ± 0.1
	2) + 3) ≤ 10 %	1.4	1.9	2.6	1.9
Sodium pyrophosphate	1-50 mg/mL sodium pyrophosphate on reconstitution	†		†	
Tin content	≤ 3 mg/mL	< 3		< 3	
Vial/Package Label	Complies	Complies		Complies	

* Value given in BP.

** Manufacturer specification.

*** Value given in USP.

KIT FOR THE PREPARATION OF TECHNETIUM [^{99m}Tc] TIN PYROPHOSPHATE INJECTION (PYP)

Current edition of BP

		SUPPLIER	CIS BIO		RADPH	
		LOT/BATCH No.	9001BA		2652	
SPECIFICATIONS		EXPIRY DATE	23/01/10		March 2010	
			INT.	EXP.	INT.	EXP.
Appearance before reconstitution	Freeze-dried solid with no evidence of moisture		Pass	Pass	Pass	Pass
Appearance after reconstitution	A clear, colourless or slightly yellow solution, free of any visible particulate matter		Pass	Pass	Pass	Pass
Check for vacuum	If a vacuum is not observed when the vial is p the vial should be discarded		N.A.	N.A.	Pass	Pass
pH	6.0 – 7.0 after reconstitution*				4.5	4.5
	4.5 – 6.0 after reconstitution**					
	4.0 - 7.5 after reconstitution***		5.3	5.3		
Radiochemical purity	1) ≥ 90.0 % as ^{99m} Tc-PYP		98.3	98.8	98.2	98.2
	2) as free pertechnetate (chromatography system A)		0.4 ± 0.1	0.1 ± 0.02	0.6 ± 0.2	0.3 ± 0.2
	3) as colloidal [^{99m} Tc] (chromatography system B)		1.3 ± 0.7	1.1 ± 0.1	1.2 ± 0.2	1.5 ± 0.1
	2) + 3) ≤ 10 %		1.7	1.2	1.8	1.8
Sodium pyrophosphate	1-50 mg/mL sodium pyrophosphate on reconstitution		†		†	
Tin content	≤ 3 mg/mL		†		†	
Vial/Package Label	Complies		Complies		Complies	

* Value given in BP.

** Manufacturer specification.

*** Value given in USP.