Canadian Association of Provincial Cancer Agencies

Standards for Quality Control at Canadian Radiation Treatment Centres

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Brachytherapy Remote Afterloaders

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Developed, revised and submitted for approval by THE CANADIAN ORGANIZATION OF MEDICAL PHYSICISTS and THE CANADIAN COLLEGE OF PHYSICISTS IN MEDICINE

Source Document: **Rob Barnett (Kitchener)**
Joanna Cygler (Ottawa)

External Reviewers: **Jeff Bews (Winnipeg), Luc Beaulieu (Quebec City), Ian Kay (Calgary)**

Primary Task Group Reviewers: **Clément Arsenault (Moncton)**

Secondary Task Group Reviewer: **Peter Dunscombe (Calgary)**

Task Group Members: **Clément Arsenault, Jean-Pierre Bissonnette, Peter Dunscombe (Chair), Harry Johnson, George Mawko, Jan Seuntjens**

Document development and review process: The quality control documents in this series originated from one of two sources. Some of the source documents were commissioned by CAPCA specifically for the purpose of developing national standards. Others had been previously developed for provincial use by the Physics Professional Affairs Committee of Cancer Care Ontario (formerly the Ontario Cancer Treatment and Research Foundation). The source documents were developed over an extended period of time from 1989 to 2001. Each source document was reviewed in 2003 by one or more independent Canadian medical physicists and the reviews accepted by the task group as they became available. The primary and secondary task group reviewers then examined the source document, the external review(s) and any appropriate published literature to propose quality control standards, objectives and criteria to the full task group. The full task group met in November 2003 and, by a consensus approach, developed the present document. The task group gratefully acknowledges the effort contributed by the author(s) of the source document and the reviewer(s) whose work forms the basis of this document. Extensive review, updating and reformatting have been performed and, for any errors or omissions introduced in this process, the task group takes full responsibility.

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Acronyms, Synonyms and Definitions

AAPM	American Association of Physicists in Medicine
ADCL	Accredited Dosimetry Calibration Laboratory
Al	Aluminum
ANSI	American National Standards Institute
BSF	Back scatter factor
CAPCA	Canadian Association of Provincial Cancer Agencies
CCO	CancerCare Ontario
CCPM	Canadian College of Physicists in Medicine
CNSC	Canadian Nuclear Safety Commission (Successor to the Atomic Energy Control Board - AECB)
COMP	Canadian Organization of Medical Physics
CSA	Canadian Standards Association
CTV	Clinical target volume
Cu	Copper
EPI(D)	Electronic Portal Imaging (Device)
HVL	Half value layer
IAEA	International Atomic Energy Agency
ICRU	International Commission on Radiation Units and Measurements
IEC	International Electrotechnical Commission (Geneva, Switzerland)
IMRT	Intensity Modulated Radiation Therapy
INMS-NRCC	Institute for National Measurement Standards of the National Research Council of Canada
IPEM	Institution of Physics and Engineering in Medicine
IPSM	Institute of Physical Sciences in Medicine
ISO	International Organization for Standardization
Isocentre	The intersection of the axes of collimator and gantry rotation
Linac	Electron linear accelerator
MLC	Multileaf Collimator
MPPAC	Medical Physics Professional Advisory Committee
MU	Monitor unit

NCRP	National Council on Radiation Protection and Measurements
NIST	National Institute of Standards and Technology
NRCC	National Research Council of Canada
NTD	Normal treatment distance
ODI	Optical distance indicator
PMMA	Polymethyl methacrylate
PDD	Percentage depth dose
PTV	Planning target volume
QA	Quality assurance (the program)
QC	Quality Control (specific tasks)
SSD	Source-to-surface distance
STP	Standard temperature and pressure
TBI	Total body irradiation
TG-	Publications of various AAPM Quality Assurance Task Groups
TLD	Thermoluminescence dosimeter
U	air-kerma strength (μGy m^2/h)
WHO	World Health Organization
σ	Standard deviation
ε_T	Timer/(monitor) end error

Frequencies:

Daily:	Once during every treatment day and separated by at least 12 hours.
Weekly:	On average once every 7 days and at intervals of between 5 and 9 days
Monthly:	On average once every four weeks and at intervals of between 3 and 5 weeks
Annually	On average once every 12 months and at intervals of between 10 and 14 months.

Output:

Output constancy check: a daily instrument reading (corrected for temperature and pressure) taken under reproducible geometrical conditions designed to check that the radiation output (e.g. cGy/MU) values in clinical use are not grossly in error.

Output Measurement: a determination of the absorbed dose to water (cGy) at a reference point in the photon beam for a chosen field size and beam quality.

Introduction

Patients receiving treatment in a Canadian cancer centre have a reasonable expectation that the quality of their treatment is independent of their geographic location or the centre they are attending. Insofar as medical physicists contribute to treatment quality, this expectation will be more closely met through the harmonisation of quality control standards across the country. The Canadian Association of Provincial Cancer Agencies (CAPCA) has initiated the process of standardisation of treatment quality in Canada through its draft document "Standards for Quality Assurance at Canadian Radiation Treatment Centres". This present document is an appendix to the CAPCA document and is concerned with quality control standards for use with brachytherapy remote afterloaders. It is based on a report originally prepared for the Medical Physics Professional Advisory Committee of Cancer Care Ontario.

A quality control program on equipment used for radiotherapy in a Canadian cancer centre must be carried out by, or under the direct supervision of, a qualified medical physicist. Here, a qualified medical physicist is a physicist who is certified in Radiation Oncology Physics by the Canadian College of Physicists in Medicine or who holds equivalent certification. This individual, known as the supervising physicist, is responsible for ensuring compliance with the local quality control protocol, appropriate documentation, appropriate remedial actions and communication with other relevant parties on the operational state of the equipment. Depending on local circumstances and organisational structure, one physicist may supervise quality control on all equipment or the responsibilities may be dispersed. However, the supervising physicist for a particular piece of equipment must have a direct line of communication to the Quality Assurance Committee for the Radiation Treatment Program.

This document contains specific objectives and criteria that the equipment should meet in order to assure an acceptable level of treatment quality. However, it does not recommend how the tests should be carried out. It is the responsibility of the supervising physicist to ensure that the locally available equipment and procedures are sufficiently sensitive to establish compliance or otherwise with the objectives and criteria specified here. There are many other publications dealing with the performance, specifications and quality control of brachytherapy equipment (AAPM 1994; AAPM 1997; IPEM 1999). Many of these publications have extensive reference lists. Some have detailed descriptions of how to conduct the various quality control tests.

Radiation safety activities are beyond the scope of this report. However, such activities may be integrated into routine quality control programs of equipment.

A successful quality assurance program is critically dependent upon adequately trained staff and a culture of continuous quality improvement. Educational opportunities to be offered to quality control staff must include new staff orientation, in-house continuous education, conference participation and manufacturer's courses as appropriate. All such educational activities must be documented as part of the quality assurance program.

Continuous quality improvement embodies the concepts of documentation, monitoring, review and feedback.

The standards promoted in this document are based on the experience of the authors and reviewers and are broadly consistent with recommendations from other jurisdictions (AAPM 1994; AAPM 1997; IPEM 1999). Although this document has undergone extensive review it is possible that errors and inaccuracies remain. It is hoped that the users of these standards will contribute to their further development through the identification of shortcomings and advances in knowledge that could be incorporated in future versions.

Performance Objectives and Criteria

Objectives and criteria for the evaluation of the performance of radiotherapy equipment fall into several categories.

1. Functionality. Systems for which the criterion of performance is "Functional" are either working correctly or not. Such systems are commonly associated with the safety features of the equipment or installation. Operating a facility, which has failed a test of functionality, has the potential to expose patients and staff to hazardous conditions.

2. Reproducibility. The results of routine quality control tests, for which reproducibility is the criterion, are assessed against the results obtained at installation from the accepted unit. Tolerances and action levels may be set for parameters that can be quantified. An example is the transit dose (i.e. dose due to the transit of the source from one dwell position to the next).

3. Accuracy. Accuracy is the deviation of the measured value of a parameter from its expected or defined value. Examples are source positional accuracy and source strength calibration (U).

4. Characterisation and documentation. In some cases it is necessary to make measurements to characterise the performance of a piece of equipment before it can be used clinically. An example is the measurement of the ion collection efficiency of an ionisation chamber.

5. Completeness. The use of this term is restricted to the periodic review of quality control procedures, analysis and documentation.

For quantities that can be measured, tolerance and action levels may be defined.

i. Tolerance Level. For a performance parameter that can be measured, a tolerance level is defined. If the difference between the measured value and its expected or defined value is at or below the stated tolerance level then no further action is required as regards that performance parameter.

ii Action Level. If the difference between the measured value and its expected or defined value exceeds the action level then a response is required immediately. The ideal response is to bring the system back to a state of functioning, which meets all tolerance levels. If this is not immediately possible, then the use of the equipment must be restricted to clinical situations in which the identified inadequate performance is of no or acceptable and understood clinical significance. The decision on the most appropriate response is made by the supervising physicist in conjunction with the users of the equipment and others as appropriate. If the difference between the measured value and its expected or defined value lies between the tolerance and action levels, several courses of

action are open. For a problem that is easily and quickly rectifiable, remedial action should be taken at once. An alternative course of action is to delay remedial intervention until the next scheduled maintenance period. Finally, the decision may be made to monitor the performance of the parameter in question over a period of time and to postpone a decision until the behaviour of the parameter is confirmed. Once again, this will be a decision made by the supervising physicist in consultation with the users of the equipment and others as appropriate.

Documentation of equipment performance is essential and is discussed later. However, at the conclusion of a series of quality control tests it is essential to inform the users of the equipment of its status. If performance is within tolerance verbal communication with the users is sufficient. If one or more parameters fails to meet Action Level criteria, and immediate remedial action is not possible, then the users of the equipment must be informed in writing of the conditions under which the equipment may be used. Compliance with Action Levels but failure to meet Tolerance Levels for one or more parameters may be communicated verbally or in writing depending on the parameters and personnel involved. The judgement of those involved will be required to make this decision.

System Description

Brachytherapy is the placement of encapsulated radioisotopes in, or adjacent to, tissue to treat cancer. This practice offers unique advantages to the management of several treatment sites and has been used to complement external beam radiation therapy since the onset of radiation oncology.

Remote afterloading equipment was developed to reduce and, in many cases, eliminate the radiation exposure to members of the staff. With remote afterloading systems the user does not directly handle the radioactive source and the patient is irradiated in a shielded room with staff monitoring the process remotely.

LDR remote afterloaders contain radioactive source pellets, non-radioactive pellets or dummies, a source storage unit, a pellet transfer mechanism, a mechanism to distinguish active and non-active pellets, and several selectable channels for the pellets to travel to an applicator. A typical device contains 10 to 20 small radioactive sources of Cesium-137. For LDR treatments, dose rates vary between 20 to 100 cGy/ h and typical source (air-kerma) strengths are on the order of ~60 U (activity of ~700 MBq). The pellet sequence and time of treatment for each channel are user selectable and the entire process is under microprocessor control. The pellets are moved pneumatically from the storage safe, through the transport tubes to the treatment applicator and back to the safe when treatment is interrupted or completed. There is a series of interlocks for the various systems used in the afterloader. Typical LDR treatments for cancer of the cervix will take 48-72 hours of continuous irradiation.

High-Dose Rate (HDR) refers to treatment dose rates of 10-100 cGy/minute. These remote afterloaders are similar in appearance to the LDR units but obviously have increased internal shielding requirements. For most HDR remote afterloaders, one single and small radioactive source (Iridium-192), laser-welded to a stainless-steel cable, is moved out of the safe by a motor-drive mechanism to step along the prescribed positions (dwell positions) with different irradiation times (dwell times). The user can preselect source positions and dwell times at each of those positions, in a series of up to 24 applicator lines. The source strength is approximately 40000 U (activity of ~370 GBq) on installation of a new Ir-192 source. Because of the relatively short half-life of Ir-192 (73.83 days), these sources are usually replaced every three months. Some older HDR remote afterloaders use a pneumatic mechanism similar to the LDR remote afterloaders. These units typically use Cobalt-60 pellets with source strengths of ~3000 U (activity of ~10 GBq). Arranged radioactive and dummy seeds are sent to the applicator together similar to the LDR unit. Typical HDR irradiation times are 5-10 minutes and a treatment course may consist of several fractions.

Another form of HDR treatment is Pulsed Dose Rate (PDR) treatment. With a PDR device irradiations are given in short “pulses” with the total treatment being given in a time comparable to that required for LDR treatments. The mechanism for PDR units is very similar to that used in HDR units. PDR remote afterloaders also use a single Iridium-192 source attached to a cable. However, the source strength for these units is typically only 10% of the source strength of an Ir-192 HDR unit.

Acceptance Testing and Commissioning

Brachytherapy remote afterloaders that are newly acquired or substantially upgraded require acceptance testing before being put into clinical service. Acceptance tests have three purposes:

- to ensure that the unit meets stated specifications,
- to establish baseline parameters for the future quality control program,
- to familiarize the customer with operation of the unit.

In addition acceptance testing of the equipment and facility will include establishing compliance with applicable radiation safety codes. These are included in federal regulations and it is the supervising physicist or designate's responsibility to be familiar with these requirements and to demonstrate compliance. Decommissioning of brachytherapy equipment and facilities may also be regulated by provincial and/or federal authorities.

Acceptance tests are customarily described in a document prepared by the vendor, although the purchaser may wish to specify additional tests. The document is signed by the purchaser upon satisfactory completion of testing, before which formal purchase of the unit should not be completed.

The standards for acceptance testing of brachytherapy remote afterloaders should be consistent with routine quality control objectives and criteria. In particular, there is no reason why a new or upgraded remote afterloader, and its associated safety systems, should not meet the Tolerance Levels detailed later in this document (Tables 1a, b and c). Tests on all components of the equipment must be included. These tests should be performed by, or under the supervision of, a qualified medical physicist.

Adherence to these standards (Tables 1a, b and c) must be demonstrated and documented, in or outside of the vendor's acceptance testing protocol, before a new remote afterloader or major upgrade is accepted, and put into clinical service. Also, an appropriate subset of acceptance tests must be performed after any repair or preventive maintenance interventions on the equipment. The extent of testing required must be judged by a qualified medical physicist.

Commissioning generally refers to the acquisition of additional measured data from a unit after most acceptance testing is completed, with two purposes:

- for subsequent calculations, for example, involving radiation dose,
- to establish baseline parameters for the future quality control program.

Clearly all the tests listed in Tables 1a, b and c must be performed at this time with the intended local test equipment and protocols if meaningful baselines are to be established.

Quality Control of Equipment

The purpose of a quality control program is to assure that operational standards for a unit that were considered acceptable at time of purchase continue to be maintained, as closely as possible, over the life of the unit. Thus, quality control tests typically are periodic repetitions, partial or full, of acceptance and commissioning tests. For remote afterloaders, tests are required for mechanical, radiological and safety systems.

The standards for remote afterloader quality control are listed in Tables 1a, b and c. These minimum standards consist of tests to be performed, along with their minimum frequency. The tests are derived from the published literature and, in particular, the standards laid out in the AAPM documents, TG-56 (AAPM, 1997) and TG-40 (AAPM, 1994), and the IPEM document, Report 81 (IPEM, 1999). The Tolerance Level is typically set at 50-75% of the Action Level.

The tests should be performed by a qualified medical physicist, or a suitably trained individual working under the supervision of a qualified medical physicist. Independent verification of the results of quality control tests is an essential component of any quality control program. To ensure redundancy and adequate monitoring, a second qualified medical physicist must independently verify the implementation, analysis and interpretation of the quality control tests at least annually. This independent check must be documented.

Daily tests must be scheduled at the beginning of each treatment day. For LDR or PDR remote afterloaders where treatments may last several days, daily tests should be performed prior to the initiation of the treatment. For other tests, testing at less than the minimum frequency is permissible only if experience has established that the parameters of interest are highly stable. Documentary evidence supporting this decision is essential. It is unlikely that a frequency of less than half that specified here could be justified.

In the event that the equipment does not meet the stated performance objectives and criteria, an adjustment or repair should be effected. If it is not immediately possible to restore the equipment to full performance, then the use of the equipment must be restricted to clinical situations in which the identified inadequate performance is of no or acceptable and understood clinical significance. The decision on the most appropriate response is made by the supervising physicist in conjunction with the users of the equipment and others as appropriate.

Preventive maintenance schedules and interventions are recommended by the manufacturer of the equipment and should be adhered to diligently. Following preventive maintenance or repair, the appropriate quality control tests selected from those listed in Tables 1a, b and c must be performed before the unit is returned to clinical service. The extent of testing required must be judged by a qualified medical physicist. Frequently, machine repairs and quality control testing are performed by different persons. In such cases, good communication and reporting between the various staff involved are essential.

As pointed out previously, radiation safety activities are beyond the scope of this report. However, certain activities must be integrated into routine quality control programs of equipment, e.g. room surveys after source replacement.

Documentation

Appropriate documentation is an essential component of a quality assurance program. All documents associated with the program should contain, as a minimum, the following information:

1. the name of the institution
2. the name of the originating department
3. the name of the developer of the document
4. the name of the individual or group who approved the document for clinical use
5. the date of first issue
6. the number and date of the current revision

Further guidelines on the design of appropriate documentation may be found elsewhere (ISO 1994, Quality 2000)

Documents for use in a quality control program may be conveniently separated into two major categories: protocols and records. The protocols must be included in the Policy and Procedure Manual of the Radiation Treatment Quality Assurance Committee.

The quality control protocol contains the standards, or performance objectives and criteria, to be applied to the piece of equipment. Such standards are based on documents such as this. In addition to the specification of standards, the protocol should provide sufficient detail on the test equipment and procedures to be followed that there can be no residual ambiguity in the interpretation of the test results.

The quality control record contains the results of the tests, the date(s) on which they were performed and the signatures and qualifications of the tester and the supervising physicist. When the number of tests to be performed on a particular occasion is limited and the test procedure is simple it may be advantageous to combine the protocol and record into a single document.

In addition to the protocol and record, it is essential to have a means of documenting any corrective action that takes place together with any subsequent tests. Deviations from the locally approved protocol, such as those resulting from clinical pressure to access the equipment, must, of course, also be documented.

Finally, all documentation related to the quality control program must be retained for at least ten years.

Table 1a: Quality Control Tests - HDR Remote Afterloaders

Designator	Test	Performance	
		Tolerance	**Action**
Daily			
DHRA1	Door interlock/last person out	Functional	
DHRA2	Treatment interrupt	Functional	
DHRA3	Emergency off (console)	Functional	
DHRA4	Room radiation monitor	Functional	
DHRA5	Console displays (treatment status indicator, date, time, source strength)	Functional	
DHRA6	Printer operation, Paper supply	Functional	
DHRA7	Data transfer from Planning Computer	Functional	
DHRA8	Audio/Visual communication system	Functional	
DHRA9	Source positional accuracy	1	2
DHRA10	Dwell time accuracy	1%	2%
Quarterly (or at source replacement)			
QHRA1	Mechanical integrity of applicators, guide tubes, connectors	Functional	
QHRA2	Emergency off (in room)	Functional	
QHRA3	Power failure recovery	Functional	
QHRA4	Source strength calibration	3%	5%
QHRA5	Source positional accuracy	1	2
QHRA6	Dwell time accuracy	1%	2%
QHRA7	Timer linearity	1%	2%
QHRA8	Records	Complete	
Annually			
AHRA1	Transit dose reproducibility	1%	2%
AHRA2	X-ray marker positional accuracy	1	2
AHRA3	Review emergency response procedures	Complete	
AHRA4	Independent quality control review	Complete	

Tolerances and action levels are specified in millimetres unless otherwise stated

N.B.: RADIATION SAFETY RELATED TESTS HAVE NOT BEEN INCLUDED IN THIS LIST BUT MUST BE PART OF A COMPREHENSIVE QA PROGRAM. SPECIFIC LICENSE REQUIREMENTS AND APPLICABLE SAFETY CODES MUST BE FOLLOWED.

Notes

Daily Tests

DHRA1-8 The configuration of these tests will depend on the design of the facility and equipment. Safety is the concern and tests should be designed accordingly. As a minimum, manufacturer's recommendations and applicable regulations must be followed.

DHRA9 Accuracy of source drive mechanism to be verified using autoradiographs, ion-chamber measurements or visual checks with in-room cameras.

DHRA10 Comparison of dwell time accuracy with external standard such as a stopwatch. The dwell time used should be sufficiently long such that errors in the measurement of the time (e.g. reaction time of the observer) are less than 1%.

Quarterly Tests

QHRA1 Verification of damage (excessive wear, kinks, etc.) to applicators, guide tubes, connectors.

QHRA2 The configuration of this test will depend on the design of the facility and equipment. Safety is the concern and tests should be designed accordingly. The objective of this test is to confirm that the appropriate warnings and interlocks appear on the console when the in-room emergency off buttons are depressed. This test can be performed without exposing the source.

QHRA3 The configuration of these tests will depend on the design of the facility and equipment. Safety is the concern and tests should be designed accordingly. The objective of this test is to verify that the equipment safely terminates and resumes a treatment after a power failure.

QHRA4 Comparison of measured source strength with manufacturer's supplied value. On installation of a new source, source strength must be measured using an ADCL-calibrated re-entrant chamber. Measured source strength should be used for planning and treatment purposes. Discrepancies greater than 5% between the measured and the manufacturer's supplied source strengths must be investigated. Stability of re-entrant chamber should be verified prior to use.

QHRA5 Accuracy of source drive mechanism to be verified using autoradiographs, ion-chamber measurements or visual checks with in-room cameras.

QHRA6 Comparison of dwell time accuracy with an external standard such as a stopwatch. The dwell time used should be sufficiently long such that errors in the measurement of the time (e.g. reaction time of the observer) are less than 1%.

QHRA7 Verification of the linearity of the timer over a clinically relevant range.

QHRA8 Documentation relating to the daily quality control checks, preventive maintenance, service calls and subsequent checks must be complete, legible and the operator identified.

Annual tests

AHRA1 Reproducibility of transit dose or source speed between dwell positions. Can be verified using autoradiographs, ion-chamber measurements or visual checks with in-room cameras.

AHRA2 Autoradiograph of source positions superimposed on to radiograph of applicator with x-ray markers. The mechanical integrity and spacing of the

x-ray markers should be checked prior to performing the autoradiograph. To be performed for each type of applicator used.

AHRA3 The configuration of these tests will depend on the design of the facility and equipment. Review of the emergency procedures when a source fails to retract properly and is still exposed in the room.

AHRA4 To ensure redundancy and adequate monitoring, a second qualified medical physicist must independently verify the implementation, analysis and interpretation of the quality control tests at least annually.

Table 1b: Quality Control Tests - PDR Remote Afterloaders

Designator	Test	Performance	
		Tolerance	**Action**
Daily			
DPRA1	Door interlock/last person out	Functional	
DPRA2	Treatment interrupt	Functional	
DPRA3	Emergency off (console)	Functional	
DPRA4	Room radiation monitor	Functional	
DPRA5	Console displays (treatment status indicator, date, time, source strength)	Functional	
DPRA6	Printer operation, Paper supply	Functional	
DPRA7	Data transfer from Planning Computer	Functional	
DPRA8	PDR sequencing	Functional	
DPRA9	Audio/Visual communication system	Functional	
DPRA10	Source positional accuracy	1	2
DPRA11	Dwell time accuracy	1%	2%
Quarterly (or at source replacement)			
QPRA1	Mechanical integrity of applicators, guide tubes, connectors	Functional	
QPRA2	Emergency off (in room)	Functional	
QPRA3	Power failure recovery	Functional	
QPRA4	Source strength calibration	3%	5%
QPRA5	Source positional accuracy	1	2
QPRA6	Dwell time accuracy	1%	2%
QPRA7	Timer linearity	1%	2%
QPRA8	Records	Complete	
Annually			
APRA1	Transit dose reproducibility	1%	2%
APRA2	X-ray marker positional accuracy	1	2
APRA3	Review emergency response procedures	Complete	
APRA4	Independent quality control review	Complete	

Tolerances and action levels are specified in millimetres unless otherwise stated

N.B.: RADIATION SAFETY RELATED TESTS HAVE NOT BEEN INCLUDED IN THIS LIST BUT MUST BE PART OF A COMPREHENSIVE QA PROGRAM. SPECIFIC LICENSE REQUIREMENTS AND APPLICABLE SAFETY CODES MUST BE FOLLOWED.

Notes

Daily Tests

DPRA1-9 The configuration of these tests will depend on the design of the facility and equipment. Safety is the concern and tests should be designed

accordingly. As a minimum, manufacturer's recommendations and applicable regulations must be followed.

DPRA10 Accuracy of source drive mechanism to be verified using autoradiographs, ion-chamber measurements or visual checks with in-room cameras.

DPRA11 Comparison of dwell time accuracy with external standard such as a stopwatch. The dwell time used should be sufficiently long such that errors in the measurement of the time (e.g. reaction time of the observer) are less than 1%.

Quarterly Tests

QPRA1 Verification of damage (excessive wear, kinks, etc.) to applicators, guide tubes, connectors.

QPRA2 The configuration of these tests will depend on the design of the facility and equipment. Safety is the concern and tests should be designed accordingly. The objective of this test is to confirm that the appropriate warnings and interlocks appear on the console when the in-room emergency off buttons are depressed. This test can be performed without exposing the source.

QPRA3 The configuration of these tests will depend on the design of the facility and equipment. Safety is the concern and tests should be designed accordingly. The objective of this test is to verify that the equipment safely terminates and resumes a treatment after a power failure.

QPRA4 Comparison of measured source strength with manufacturer's supplied value. On installation of a new source, source strength must be measured using an ADCL-calibrated re-entrant chamber. Measured source strength should be used for planning and treatment purposes. Discrepancies greater than 5% between the measured and the manufacturer's supplied source strengths must be investigated. Stability of re-entrant chamber should be verified prior to use.

QPRA5 Accuracy of source drive mechanism to be verified using autoradiographs, ion-chamber measurements or visual checks with in-room cameras.

QPRA6 Comparison of dwell time accuracy with external standard such as a stopwatch. The dwell time used should be sufficiently long such that errors in the measurement of the time (e.g. reaction time of the observer) are less than 1%.

QPRA7 Verification of the linearity of the timer over a clinically relevant range.

QPRA8 Documentation relating to the daily quality control checks, preventive maintenance, service calls and subsequent checks must be complete, legible and the operator identified.

Annual tests

APRA1 Reproducibility of transit dose or source speed between dwell positions. Can be verified using autoradiographs, ion-chamber measurements or visual checks with in-room cameras.

APRA2 Autoradiograph of source positions superimposed on to radiograph of applicator with x-ray markers. The mechanical integrity and spacing of the x-ray markers should be checked prior to performing the autoradiograph. To be performed for each type of applicator used.

APRA3 The configuration of these tests will depend on the design of the facility and equipment. Review of the emergency procedures when a source fails to retract properly and is still exposed in the room.

APRA4 To ensure redundancy and adequate monitoring, a second qualified medical physicist must independently verify the implementation, analysis and interpretation of the quality control tests at least annually.

Table 1c: Quality Control Tests - LDR Remote Afterloaders

Designator	Test	Performance	
		Tolerance	**Action**
Daily			
DLRA1	Door interlock/last person out	Functional	
DLRA2	Treatment interrupt	Functional	
DLRA3	Room radiation monitor	Functional	
DLRA4	Console displays (treatment status indicator, date, time)	Functional	
DLRA5	Printer operation, Paper supply	Functional	
DLRA6	Audio/Visual communication system	Functional	
DLRA7	Active source position verification	1	2
Annually			
ALRA1	Mechanical integrity of applicators, guide tubes, connectors	Functional	
ALRA2	Power failure recovery	Functional	
ALRA3	Source strength calibration	1%	2%
ALRA4	Timer accuracy	1%	2%
ALRA5	Timer linearity	1%	2%
ALRA6	X-ray marker positional accuracy	1	2
ALRA7	Source inventory	Document	
ALRA8	Records	Complete	
ALRA9	Review emergency response procedures	Complete	
ALRA10	Independent quality control review	Complete	

Tolerances and action levels are specified in millimetres unless otherwise stated

N.B.: RADIATION SAFETY RELATED TESTS HAVE NOT BEEN INCLUDED IN THIS LIST BUT MUST BE PART OF A COMPREHENSIVE QA PROGRAM. SPECIFIC LICENSE REQUIREMENTS AND APPLICABLE SAFETY CODES MUST BE FOLLOWED.

Notes

Daily Tests

DLRA1-6 The configuration of these tests will depend on the design of the facility and equipment. Safety is the concern and tests should be designed accordingly. As a minimum, manufacturer's recommendations and applicable regulations must be followed.

DLRA7 Using an autoradiograph jig, programmed source positions must be verified with respect to planned source positions.

Annual tests

ALRA1	Verification of damage (excessive wear, kinks,...) to applicators, guide tubes, connectors.
ALRA2	The configuration of these tests will depend on the design of the facility and equipment. Safety is the concern and tests should be designed accordingly. The objective of this test is to verify that the equipment safely terminates and resumes a treatment after a power failure.
ALRA3	Yearly or on installation of new sources, source strength must be measured using an ADCL-calibrated re-entrant chamber. Measured source strength should be used for planning and treatment purposes. Discrepancies greater than 5% between the measured and the manufacturer's supplied source strengths must be investigated. Chamber response should be checked prior to use to ensure that its calibration factor has not changed since its last use.
ALRA4	Comparison of dwell time with external standard such as a stopwatch. The dwell time used should be sufficiently long such that errors in the measurement of the time (e.g. reaction time of the observer) are less than 1%.
ALRA5	Verification of the linearity of the timer over a clinically relevant range.
ALRA6	Autoradiograph of source positions superimposed on to radiograph of applicator with x-ray markers. The mechanical integrity and spacing of the x-ray markers should be checked prior to performing the autoradiograph. To be performed for each type of applicator used.
ALRA7	The total source inventory within the remote afterloader should be documented by programming all sources and using autoradiography.
ALRA8	Documentation relating to the daily quality control checks, preventive maintenance, service calls and subsequent checks must be complete, legible and the operator identified
ALRA9	The configuration of these tests will depend on the design of the facility and equipment. Review of the emergency procedures when a source fails to retract properly and is still exposed in the room.
ALRA10	To ensure redundancy and adequate monitoring, a second qualified medical physicist must independently verify the implementation, analysis and interpretation of the quality control tests at least annually.

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