



IONISING RADIATION AUDIT CHECKLISTS

PURPOSE OF THESE CHECKLISTS

These checklists were developed based on the requirements specified in the following standards and codes of practice:

- Australian Standard AS 2243.4 (Safety in laboratories, Part 4: Ionising radiations)
- Code of practice for protection against ionising radiation emitted from X-ray analysis equipment (1984)
- The Code of Radiation Protection Requirements for Industrial Radiography (2018)

Compliance with these standards and codes of practice is a condition of the Source Licence issued by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) to the Australian National University under the Australian Radiation Protection and Nuclear Safety Act 1998.

The purpose of these checklists is to identify any issues of non-compliance with the ARPANSA Source Licence conditions. Each checklist relates to a different aspect of ionising radiation safety and protection. A different combination of checklists is to be used for different laboratories.

HOW TO USE THESE CHECKLISTS

1. Carefully read the summary page (following page) to identify the relevant checklists to be completed.
2. Complete each relevant checklist by placing a tick in the appropriate box next to each checklist item (**C=Compliant**, **NC=Not Compliant**, **NA=Not Applicable**).
3. Sign and date the summary page.
4. Forward a copy of each completed checklist and the summary page to the Radiation Safety Officer.
5. Forward a copy of each completed checklist and the summary page to Safety and Wellbeing.

SUMMARY

College or Division: _____	Research School or Department: _____
Building Number: _____	Room Number: _____
Radiation Safety Officer: _____	

The laboratory contains the following source(s) of ionising radiation:

	Sealed radioactive substance(s) → Complete checklists 1, 2, 3, 4, 5 and 6
	Unsealed radioactive substance(s) → Complete checklists 1, 2, 3, 4, 5, 7 and 8. For medium-level radioisotope laboratories, also complete checklist 9.
	X-ray analysis unit(s) other than industrial radiography X-ray unit(s) → Complete checklists 1, 2, 3, 4 and 10.
	Industrial radiography X-ray unit(s) → Complete checklists 1, 2, 3, 4, and 11.
	pXRF → Complete checklists 1, 2, 3, and 12.

After completing the relevant checklists, this summary page must be signed and dated in the spaces provided below.

Print Name: _____

Signature: _____

Date: _____

CHECKLIST 1: GENERAL ARRANGEMENTS FOR IONISING RADIATION PROTECTION

Item	C	NC	NA	Comment
Only authorised personnel shall have access to radiation sources.				
A radiation safety officer shall be appointed to supervise radiation safety activities.				
The radiation safety officer shall be kept informed of the nature of the radiation work being done in the laboratory.				
A register shall be kept of the receipt, location, use, transfer and disposal of radiation sources.				
A radiation warning sign shall be displayed at the entrances to the designated radiation area. The warning sign shall show the radiation trefoil symbol in black against a yellow background. Suitable wording shall be chosen to give adequate warning of the hazard concerned.				
Precautions shall be taken to protect occupationally exposed and non-occupationally exposed persons from direct and scattered ionising radiations. This may include time, distance and shielding considerations, and/or personal and area monitoring.				
The designated radiation area and areas likely to have an ionising radiation hazard shall be monitored with appropriate instruments at regular intervals and the results shall be recorded.				
Radioactive substances shall be used and stored so that they do not present a hazard to persons in the vicinity and are secure against theft or unauthorized tampering.				

X-ray analysis units and industrial radiography X-ray units shall be fitted with appropriate interlocks to prevent personnel from accessing the primary X-ray beam.				
Personnel working with radiation sources shall receive training and instruction on the radiation hazards associated with their work and the safe working procedures to be employed to avoid or minimize the hazard.				

CHECKLIST 2: PROCEDURES, TRAINING AND INSTRUCTION

Item	C	NC	NA	Comment
Rules of safe working procedures for dealing with potential hazards shall be displayed in the laboratory.				
Emergency procedures for dealing with potential accidents and incidents shall be displayed in the laboratory.				
Personnel shall receive training and instruction on the radiation hazards associated with their work.				
Personnel shall receive training and instruction on safe working methods and techniques.				
Personnel shall receive training and instruction on precautions to be taken and reasons for taking them.				
Personnel shall receive training and instruction on emergency procedures.				
Personnel shall receive training and instruction on reporting any incident relevant to the health and safety of people and the protection of the environment.				
Personnel shall receive training and instruction on any regulatory requirements relating to the particular radiation source.				
Training records shall be maintained by the user, supervisor, radiation safety officer or a responsible person.				

CHECKLIST 3: PERSONAL MONITORING

Item	C	NC	NA	Comment
All persons who are occupationally exposed to ionising radiation shall be issued with a personal dosimeter device.				
Precautions shall be taken to ensure that personal dosimeter devices are exposed only to those ionising radiations that impact on the wearer during the normal course of work.				
Personal dosimeter devices shall be processed at regular intervals by an accredited service provider.				
Records of all occupational radiation doses received by occupationally exposed persons shall be maintained by the radiation safety officer or a responsible person.				
Radiation dose records shall be periodically reviewed by the radiation safety officer.				
The radiation safety officer shall inform occupationally exposed persons of any excessive doses or unusual monitoring results.				
Records of all occupational radiation doses received by an occupationally exposed person shall be made available to that person on request.				
Personal radiation dose records shall be kept during the working lifetime of the person and afterwards for not less than 30 years after the last dose assessment and at least until the person reaches or has reached the age of 75 years.				

CHECKLIST 4: RADIATION MONITORS

Item	C	NC	NA	Comment
Personnel in laboratories where sources of ionising radiation are used shall have ready access to radiation monitoring equipment.				
If high activity sources (sealed or unsealed), or irradiating apparatus could give rise to an external radiation hazard, a dose-rate monitor shall be available.				
All monitoring instruments shall be calibrated when first taken into use and following major repairs or service.				
Dose-rate monitors shall be calibrated at annual intervals. The calibration should be traceable to a national standard for ionising radiation.				
Count-rate monitors shall be calibrated at five-year intervals. The calibration should be traceable to a national standard for ionising radiation.				
The efficiency of count-rate monitors shall be tested against a standard check source at annual intervals.				
Records shall be maintained of the date and results of all monitor calibrations and efficiency tests.				

CHECKLIST 5: STORAGE OF RADIOACTIVE SUBSTANCES

Item	C	NC	NA	Comment
Radioactive substances shall be stored separately from non-radioactive substances.				
The store shall be kept locked except when radioactive substances are being transferred into or out of the store.				
The store shall be sited to minimize the risk of flooding and other natural or man-made hazards. If there is any possibility of accidental flooding, provision shall be made for all substances to be stored above floor level, and for water to be drained.				
The store shall be constructed of durable, fire-resistant materials.				
The store's interior surfaces shall be constructed of materials which can be decontaminated easily.				
The store shall be adequately shielded to ensure that radiation levels outside the store at locations that are accessible to occupationally exposed persons shall not exceed 20 µSv/h.				
A radiation warning sign shall be displayed at the entrance to the store. (The warning sign shall show the radiation trefoil symbol in black against a yellow background. Suitable wording shall be chosen to give adequate warning of the hazard concerned).				
The store shall be provided with spillage trays on which the containers of liquid radioactive substances shall be placed. Each tray shall have sufficient volume to retain the whole of the contents of the containers on the tray and enable their recovery.				

CHECKLIST 5 (CONTINUED).

Item	C	NC	NA	Comment
The store shall be provided with an air extraction system if any radioactive gases or vapour are emitted from the substances held in the store.				
All containers of radioactive substances (including waste) shall be labelled with the following details: radionuclide(s), activity, description of contents, physical form, chemical form and encapsulating material.				
Consideration shall be given to any other physical, chemical or biological storage requirements of the substance.				

CHECKLIST 6: SEALED RADIOACTIVE SUBSTANCES

Item	C	NC	NA	Comment
When not in use, sealed sources shall be stored in a secure and adequately shielded containment, which shall bear the radiation trefoil symbol.				
Each sealed source or its containment shall be clearly labelled to show the source activity and nature and shall be serially numbered or otherwise identified to distinguish it from others in the same laboratory.				
A record for each sealed source shall be kept by a responsible person, and these records shall be reviewed at least annually or when changes are made. The record shall include the following: (a) The serial number or other identification of each source. (b) The physical nature of the source, the radionuclide, date of receipt and activity upon receipt. (c) All movements or transfers of the source. (d) The date and manner of disposal of the source.				
The radiation safety officer or person responsible shall be satisfied that each sealed source is satisfactorily accounted for by means of a periodic audit, and a record of the audit shall be kept.				
Each sealed source or its housing shall be examined for contamination and the integrity of its sealing, i.e. by wipe or smear testing each source or its housing at annual intervals.				

Leak testing shall be performed at 10-year intervals and whenever leakage is suspected. Leak testing shall be done in accordance with the standard ISO 9978.				
Sealed sources shall be manipulated by remote means such as forceps, long tongs, drive cables or similar devices.				

CHECKLIST 7: UNSEALED RADIOACTIVE SUBSTANCES

Item	C	NC	NA	Comment
No unauthorized person shall be permitted to enter a radioisotope laboratory.				
Records of all stocks of radioactive substances shall be maintained. The records shall include: (a) The nature and activity of each substance. (b) The date of receipt. (c) The place of storage or use. (d) The date and manner of disposal.				
All work with unsealed radioactive substances shall be segregated from other work.				
Eating, drinking, smoking and the application of cosmetics shall not take place in the laboratory.				
No food, drink, utensils or cutlery shall be allowed in the laboratory.				
Food and drink for normal consumption shall not be stored with radioactive substances.				
Techniques shall be well thought out and understood before work with unsealed radioactive substances is undertaken.				
Working procedures and a contingency plan for radiation spills shall be displayed within the laboratory.				
A high standard of cleanliness shall be maintained in the radioisotope laboratory.				

At least one appropriate contamination monitor shall be available in the radioisotope laboratory.				
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CHECKLIST 7 (CONTINUED).

Item	C	NC	NA	Comment
Radiation and contamination surveys shall be carried out with suitable monitoring equipment at regular intervals, and a record of each survey kept.				
Protective clothing reserved specifically for radioactive work, shall be worn at all times in the laboratory, even for very low levels of activity.				
For work in low-level laboratories, a laboratory coat or overall shall be worn.				
For work in medium-level laboratories, the laboratory coat shall have elasticized sleeve cuffs and a crossover front with high neck fastened with hook and loop fastening fabric.				
Suitable gloves shall be worn for all work with unsealed radioactive substances.				
All protective clothing worn in radioisotope laboratories shall be removed before leaving, and left in, or immediately outside, the laboratory.				
No mouth operations (e.g. pipetting by mouth) shall be carried out in the laboratory.				
All reagents, tools and, where possible, apparatus used in the designated radiation area shall be clearly labelled and normally remain in the area.				
All work benches where unsealed radioactive substances are handled, and all flushing sinks where low level liquid waste is disposed of, shall display a radiation trefoil symbol.				
All radioactive preparations shall be clearly marked with the radiation trefoil symbol and details of the chemical compound, radionuclide, activity, date and name of responsible user.				

All work with unsealed liquid sources shall be carried out in a double container or a large tray (made from, e.g., stainless steel or plastics) lined with absorbent paper to restrict the spread of any spilt liquid.				
Operations that can produce vapour, spray, dust or radioactive gas shall be carried out in a fume cupboard or glove box.				
Appropriate waste receptacles for solid active materials (e.g. filter papers, gloves, paper tissues, disposable pipette tips, emptied disposable analysis tubes, and similar material) shall be provided in the laboratory.				
Filled waste receptacles shall be sealed and labelled with the following details: department/laboratory, radionuclide(s), activity, description of contents, date, signature, and name.				
Suitably marked (and if necessary, shielded) containers shall be provided for liquid waste of high specific activity.				
When leaving the designated radiation area, all workers shall wash their hands thoroughly.				
Cleaning of radioisotope laboratories shall be carried out by suitably trained persons.				

CHECKLIST 8: LOW-LEVEL RADIOISOTOPE LABORATORY DESIGN

Item	C	NC	NA	Comment
Joints shall be sealed and made waterproof and be located away from sources of contamination (e.g., not near sinks or under edges of benches). Seamless PVC flooring is recommended. Painted or carpeted surfaces are not acceptable.				
Walls should be smooth and reasonably free of exposed electrical conduits, and water and gas pipes. These surfaces should be finished with washable high gloss or semi-gloss paint.				
Bench tops shall have a smooth waterproof, chemically resistant covering which is easy to clean (Melamine, seamless vinyl, cast epoxy resin and stainless steel are recommended. Painted surfaces are not acceptable).				
Drainage shall be arranged so that other building areas cannot become contaminated if the drainage system becomes blocked.				
Secure storage facilities shall be provided for stocks of radionuclide. Refrigerator storage or freezer storage, or both, may be required in medical and biological radioisotope laboratories.				
A flushing sink, preferably with knee operated or automatic actuator, should be provided for the sewer disposal of aqueous liquid waste to permit rapid dilution of the effluent within the laboratory drainage system and to help keep this drainage system clean.				
A hand washbasin with automated action, or knee- or foot-operated taps should be provided, preferably immediately adjacent to the entrance doorway.				

A hand-held shower on a flexible hose and an eye wash facility should be provided to assist decontamination of personnel.				
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CHECKLIST 9: MEDIUM-LEVEL RADIOISOTOPE LABORATORY DESIGN

Item	C	NC	NA	Comment
A medium-level radioisotope laboratory shall meet all design requirements for a low-level radioisotope laboratory.				
The floor shall be strong enough to support the weight of any shielding while maintaining its smooth decontaminate continuous surface.				
The floor covering shall be covered up to and be sealed to walls and vertical surfaces to aid cleaning.				
Benches shall be strong enough to support the weight of any shielding likely to be used. The front and side edges of the bench top should be slightly raised and the back covered up to the wall or reagent shelf, so that the bench top acts as a shallow tray to help contain spills.				
Joints between bench surfaces shall be designed and constructed so that they do not leak or trap contamination.				
A hand washbasin shall be provided, and the taps shall be operated automatically or be operated by knee or foot.				
All drainage systems shall be continuous and be appropriately labelled at accessible locations.				
If glove boxes are to be used, each shall have its own exhaust air filter.				
The laboratory shall be maintained at a negative pressure with respect to adjacent spaces. An alarm system which is automatically activated in the event of failure of the ventilation system shall be installed.				

CHECKLIST 10: X-RAY ANALYSIS UNITS

Item	C	NC	NA	Comment
Each X-ray analysis unit shall be clearly labelled to indicate whether it is a fully enclosed unit, or a partially enclosed unit.				
Each room, cubicle or area in which an X-ray analysis unit is operated shall have a sign at each entrance stating that an X-ray analysis unit is in that room, cubicle or area.				
Each room, cubicle or area in which a unit, other than a fully enclosed unit, is operated shall have at each entrance an illuminated sign or sign combined with a light which is activated only when the X-ray tube is energised, and which then indicates that the X-ray tube is operating.				
Fail-safe warning lights or illuminated signs, or both, shall be fitted to each X-ray analysis unit and interlocked to show, unambiguously, when an X-ray tube is operating.				
X-ray tubes shall be mounted in a protective and electrically shockproof housing made from material that is not readily deformed.				
Each aperture in the X-ray tube housing shall be covered by a shutter or a completely shielded enclosure.				
Each shutter shall be fitted with a positive closing device which, in the absence of an applied force, keeps the shutter closed.				
Each shutter shall be so constructed that it is impossible to remove the shutter and its operating mechanism without the use of tools.				

Each shutter shall be so constructed that the shutter and its operating mechanism is interlocked with the tube housing so that their removal de-energizes the X-ray tube.				
Each shutter shall be interlocked with an illuminated sign or light which is illuminated only when that shutter is open and indicates without ambiguity which shutter is open.				
All illuminated warnings shall be readily discernable on the unit and be duplicated where necessary.				
Effective beam stops shall be provided to absorb the useful X-ray beam after it has passed through the sample and the analysing components.				
Housings, shutters, shielded enclosures and beam stops shall be so constructed that the integrated dose rate at any accessible point 5 cm from their surfaces does not exceed 100 µSv in any one hour for all practical operating conditions of the X-ray tube.				
Interlocking devices shall be provided to prevent the generation of X-rays when the shutter or an aperture in the enclosure is open without the analysing components and beam stops being in position.				
Interlocking devices shall be provided to prevent the generation of X-rays when either the housing is removed from the X-ray tube, or the X-ray tube is removed from the housing.				
Interlocking devices shall be provided to prevent the generation of X-rays when an enclosure is detached from the housing.				

Interlocking devices shall be provided to prevent the generation of X-rays when a beam stop is removed.				
X-ray fluorescence analysers shall be fully enclosed and fitted with interlocks to prevent access to the interior of the enclosure during an irradiation.				
Radiation shields shall be made of lead backed by supporting material having greater resistance to distortion than lead, or of dense materials not readily distorted, e.g. steel, brass or lead glass.				
Each person working in the vicinity of an X-ray analysis unit should wear a suitable personal monitoring device on the chest throughout all exposures made with the unit.				
Periodic radiation surveys of each X-ray analysis unit shall be carried out to detect unintended radiation emissions and the results of each survey recorded.				
A list of working rules shall be drawn up for each X-ray analysis unit to ensure safety.				
When the X-ray tube is energized, access of non-essential personnel to the room containing the unit shall be prevented by physical barriers. A sign warning of the operations in progress shall be placed at each entrance to the room containing the unit.				
For large enclosures, personnel shall be prevented from entering the enclosure during an irradiation by the provision of interlocks.				
For large enclosures, a warning alarm shall sound automatically for a period of at least 20 s before irradiation begins.				

Any person accidentally shut in a large enclosure shall be able either to leave by a suitable exit or be able to enter an adequately shielded refuge without delay.				
Where an irradiation takes place in a large enclosure it shall be capable of being stopped or quickly interrupted from within the enclosure.				

CHECKLIST 11: INDUSTRIAL RADIOGRAPHY X-RAY UNITS

Item	C	NC	NA	Comment
The X-ray tube shall be contained in a housing that provides shielding from radiation in all directions other than beam direction.				
A key switch shall be fitted to the X-ray control panel to prevent unauthorised use. The key shall be removable only when the switch is in the off position. The function of the key switch and its on and off positions shall be clearly marked on the control panel.				
X-ray on and off controls shall be physically separate from the key switch. Their function, and the on and off positions, shall be clearly marked on the control panel.				
A red or amber indicator lamp shall be provided on the control panel and shall be automatically illuminated when the X-ray tube is energised. This lamp shall be duplicated on the X-ray tube housing and operate in parallel with its counterpart on the control panel.				
An interlock shall be provided such that if either of the 'beam on' indicator lamps fail, the X-ray tube cannot be energised, and replacement of the lamp will not automatically re-energise the X-ray tube.				
The control panel shall be equipped with a device or devices indicating the X-ray beam energy and output in terms of the X-ray tube potential difference (kV(peak)) and current (mA) or electron energy and dose rate, as appropriate.				

X-ray equipment that is used for direct-viewing fluoroscopy shall be shielded such that at no time during exposure can the dose rate at any accessible position exceed 25 μ Sv/h.				
Fluoroscopic imaging devices shall be positioned such that the primary X-ray beam is totally intercepted, and the exposure configuration shall be arranged such that it is not possible for any part of the body of any person to be inserted into the beam.				
Industrial radiography X-ray units shall be inspected at regular intervals and tested to ensure that all interlocks, shutters and control mechanisms operate effectively and that no components are unacceptably worn or damaged.				
A record shall be maintained with all inspection reports and details of any repairs to the unit.				
Personnel appointed to operate industrial radiography X-ray units shall receive adequate training and have appropriate knowledge of the hazards associated with the equipment.				
Film badge dosimeters or thermo luminescent dosimeters (TLDs) shall be used for determination of personal radiation exposure.				
A radiation monitor, of appropriate energy response, shall be used to monitor the radiation levels in the vicinity of an industrial radiography X-ray unit whenever the unit is energised.				
The radiation monitor shall have sufficient measurement range to measure radiation levels at least throughout the ranges of 1 μ Sv/h or its equivalent to 10 mSv/h or its equivalent.				

X-radiography sites shall be clearly identified as either fully or partially enclosed through the use of warning notices at the perimeter and at access points. A warning light shall be provided which is illuminated during exposure and which is clearly visible from outside the enclosure.				
A fully enclosed X-radiography site shall be so constructed that, with access doors or ports closed, the walls, floor and ceiling surrounding the site form a complete shielding enclosure.				
A fully enclosed X-radiography site shall be provided with visible and audible warning devices inside the enclosure which shall be activated during exposure.				
A partially enclosed X-radiography site shall be constructed with walls at least 2.1 m high.				
A partially enclosed X-radiography site shall be provided with visible and audible warning devices which shall be activated during exposure, and which can be seen and heard from both inside and outside the enclosure.				
A partially enclosed X-radiography site shall be provided with a suitable means of exit to enable any person who is accidentally shut in to leave the enclosure without delay.				
The shielding associated with a fully or partially enclosed X-radiography site shall be sufficient to ensure that at no time during exposure does the dose rate outside the enclosure exceed 20 $\mu\text{Sv/h}$ measured 5 cm from any accessible surface.				

The shielding and location of a fully or partially enclosed X-radiography site shall be such that no member of the public will receive an effective dose equivalent in excess of 1 mSv per year from exposures carried out within it.				
Doors and panels covering access apertures into a fully or partially enclosed X-radiography site shall overlap those apertures by a sufficient margin to prevent leakage of scattered radiation from the enclosure.				
Conducts for feeding cabling, electrical power or other services through the walls of a fully or partially enclosed X-radiography site, shall incorporate a dogleg or baffle that leaves no line-of-sight aperture through the walls to the radiation source, so that the radiation shielding integrity of the walls is not impaired.				
Interlocks shall be fitted to all access points to activate a visible and audible alarm if any interlock is opened during exposure. The opening of an interlock during exposure shall automatically cause the interruption of the power supply to the X-ray equipment or X-ray tube, and subsequent closing of this interlock shall not automatically re-energize the X-ray tube.				

CHECKLIST 12: Portable XRF (pXRF)

Item	C	NC	NA	Comment
The radiation apparatus must be constructed of material of sufficient strength and thickness to ensure that it cannot be fractured or deformed by normal use, accidental impact or misuse.				
The radiation apparatus must be fitted with a clearly distinguishable light that provides a warning to the operator whenever the X-ray tube is energised.				
The radiation apparatus must incorporate an exposure control that is always provided and requires: • continuous actuation (e.g. a trigger), or • a pre-set time interval. Emission of X-rays must not be possible after the timer has expired, or the trigger is released.				
The radiation apparatus must incorporate a proximity sensor so that the radiation apparatus will not continue to emit X-rays if the apparatus is not in the 'measurement' position (e.g. in direct contact with the sample being analysed). (If the proximity sensor can be disabled by the operator, it must not be able to remain in a disabled condition when the apparatus is de-energised, then re-energised, i.e. it must be a conscious act by the user to de-activate the proximity sensor for each measurement session). For radiation apparatus which allows a proximity sensor to be disabled, the radiation apparatus must not continue to emit X-rays if the detector experiences a low count rate.				

This clause does not apply when a pXRF apparatus is used in a local enclosure.				
The radiation apparatus housing must be shielded, so that when the X-ray tube is energised, and operating at its maximum output, the radiation dose rate must not exceed 10 $\mu\text{Gy.h}^{-1}$ at any accessible point 5 cm from any external surface when measured against a steel target.				
Radiation dose rate measurement inspections of the pXRF apparatus are to be undertaken and recorded every six (6) months to detect unintended radiation emissions from the pXRF apparatus.				
pXRF apparatus must be in good working order, free of damage and structurally sound, i.e. no cracks in housing, damage to trigger, proximity sensor and interlocks.				
pXRF must be taken out of service if they are believed to be damaged or if any of the safety features are not working as required.				
Good operating practice to minimise radiation exposure is always ensured, as per manufacturer's specifications. Strictly no pointing at persons – including keeping operator's hand away.				
pXRF apparatus safety features are checked and maintained in accordance with manufacturer's guidelines.				
pXRF is only to be repaired/maintained by a competent person.				
Logbooks (hardcopy or electronic) are maintained to ensure pXRF apparatus records are kept and maintained for all operational, safety and maintenance checks (both minor and major service) undertaken.				

The pXRF must be securely stored. For example, stored in a secure room or locked cabinet or lockable transport case.				
Appropriate disposal of pXRF apparatus is undertaken if the apparatus is damaged and incapable of operation.				
Incidents or hazards involving pXRF are recorded in ANU hazard/incident reporting system (Figtree).				