

22 Luminised Equipment

Scope

1. Luminous articles to which this Chapter applies are those in which the luminous paint or film contains radioactive material. Such paints and films can be found on instrument control panels and switches, scales watches, compasses and dials. Modern equipment (post 1970s) uses tritium (H-3) as the radioactive material. However, in the past other radioactive materials have been used, including promethium-147 (Pm-147) in the 1950s and 1960s and radium-226 (Ra-226) pre-war to the 1950s.
2. This Chapter describes the radiological requirements for keeping, using and disposing of equipment luminised using radioactive materials not including sealed sources incorporating tritium which can be classified as a GTLD, these are addressed in Chapter 19. Summaries of the radiation risk and regulatory requirements for some specific luminised equipments are provided at the Annexes to this Chapter. Summary risk assessments for a range of other in-service luminised equipments not listed in the Annexes are also available from the Dstl RPA Body. Additionally, the RPA is to be consulted where further information regarding the radiological hazards and safety requirements for luminised equipment is required.
3. It should be noted that not all luminous articles are radioactive. Some are luminised using non-radioactive materials.
4. This Chapter does not describe the requirements for the de-luminising and re-luminising of radioactive luminous components. These are specialist activities and must only be undertaken under controlled arrangements determined through consultation with the RPA.

Statutory Requirements and Parallel Arrangements

5. In addition to the general requirements of the Health and Safety at Work etc Act 1974 and the Management of Health and Safety at Work Regulations 1999, the following specific legislation applies directly or is applied indirectly through parallel arrangements designed to achieve equivalent standards:
 - a. Ionising Radiations Regulations 2017 (IRR17) (apply directly);
 - b. Environmental Permitting (England and Wales) Regulations 2016 (as amended) (EPR16) (parallel arrangements);
 - c. Environmental Authorisations (Scotland) Regulations 2018 (EASR18) (parallel arrangements);
 - d. Radioactive Substances Act 1993 (Northern Ireland) (as amended) (RSA93) and associated Exemption Orders (parallel arrangements); and
 - e. Carriage of Dangerous Goods and Transportable Pressure Equipment Regulations 2009 (as amended) (apply directly).

Duties

6. Duties as detailed in Chapter 39 apply.

Keeping and Use of Luminised Articles

Radioactive substances legislation notification / permitting requirements

7. Luminised articles, are defined as unsealed sources made wholly or partly from a luminescent film or paint which contains either Pm-147 or tritium. There is no requirement for a notification for the keeping and use of luminised articles containing tritium or Pm-147 provided the item activity and premises activity limits are below those stated in Table 1.

Table 1 Radioactive material exemption / general binding rules limits

Radionuclide	Maximum activity incorporated in an individual luminised article	Maximum quantity on premises
England, Wales and Northern Ireland		
Promethium-147 (Pm-147)	80 MBq	40 GBq
Tritium (H-3)	4 GBq	200 GBq
Scotland		
Tritium (H-3)	4 GBq	5 000 GBq

8. In Scotland Pm-147 luminised articles that can be classed as sealed sources (such as watches) with and activity below 200 kBq do not require an authorisation; above this a notification to SEPA is required. For unsealed sources the maximum quantity of Pm-147 on the premises with requiring an authorisation is 10 MBq.

9. In respect to any luminised articles containing radium-226 (Ra-226), under EPR16/EASR18/RSA93 a notification / permit may be required, and further advice should be sought from the RPA.

Markings

10. The following markings are sometimes found on luminised equipment.

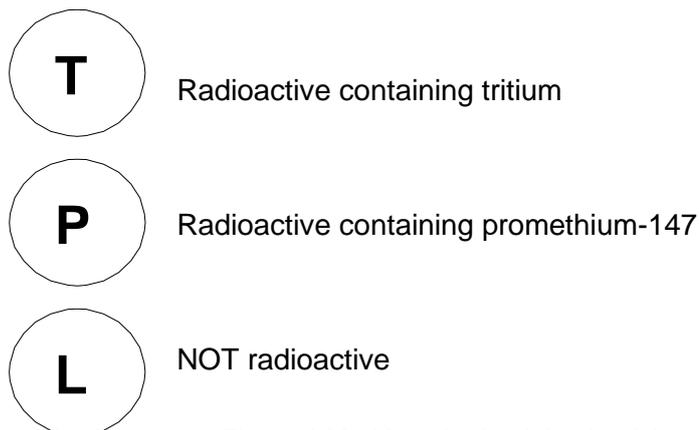


Figure 1 Markings for luminised articles

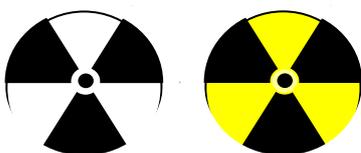


Figure 2 Standard radiation trefoil. Colour of symbol: black on yellow or white background.

Historical Items

11. Promethium-147, which has a radioactive half-life of only 2.6 years, was used until the 1970s as a luminising agent. A few items containing promethium-147 remain in service but the limited activities of promethium-147 that generally remain on any such equipment are such that the radiation emitted is difficult to detect. Furthermore, such items are unlikely to remain luminous. The hazards associated with promethium-147 luminised articles are summarised in Table 2.

12. Radium luminised compounds, unlike other luminised materials, can be identified by the easily measurable gamma radiation emitted. The age of the equipment can also be an indicator of the potential presence of radium. Many items dating from pre-war to the 1950s were luminised with radium-based paint, and the luminous material is now likely to be dirty brown in appearance. As is the case for articles luminised using promethium-147, radium luminised articles are unlikely to remain luminous today. However, much of the original radioactivity will remain as the half life of radium-226 is approximately 1600 years.

13. Where radium luminised equipment is held by museums and in historical collections, such articles are not to be stored, used, handled or placed on display, unless a risk assessment has been completed in consultation with an RPA as there can be external dose rates from the luminised surface. The RPA is to be contacted for further guidance on the use and handling of radium luminised equipment. Radium items other than those held by museums or historical collections are to be removed from service and arrangements put in place to dispose of the items through authorised disposal routes.

14. Equipment containing radium must not be passed for any sale involving members of the public.

Disposal of Luminised Articles

15. Within the UK, the disposal of luminised articles and fragments and associated waste arisings from damaged articles may be undertaken using the normal refuse route. The disposal container is to be securely sealed and not have any visible markings to indicate the presence of radioactive material. Advice should be sought from the DSTL radiation waste advisor (RWA) or radiation protection adviser (RPA).

Radioactive substances legislation notification / permitting requirements

16. Luminised articles can be disposed of locally in normal refuse subject to the limits in Table 2.

Table 2 Radioactive waste exemption / general binding rules limits

Radioactive waste	Maximum activity per 0.1 m ³ of normal refuse	Maximum quantity of waste disposed of per year
England, Wales and Northern Ireland		
Luminised article with no single item containing > 80 MBq of Pm-147 or > 4 GBq of tritium	80 MBq of Pm-147 4 GBq of tritium	2 GBq of PM-147 100 GBq of tritium
Scotland		
A tritium source	No more than one luminised article with an activity in excess of 4 GBq	10 000 GBq (all tritium sources)

17. In Scotland luminised fragments incorporating Pm-147 can be disposed of in normal refuse provided no single item exceed an activity of 40 kBq and the total activity of radioactive substances per 0.1 m³ of normal refuse does not exceed 400 kBq.
18. Details of the material disposed of and the disposal route should be entered on the radioactive source list and the Dstl Annual Holdings Return.
19. These disposal arrangements cover non-routine occurrences and should not be used for situations where a continuous waste stream is being generated. Unless otherwise advised, intact luminised articles should be returned through stores for recycling.
20. The RWA / RPA should be consulted in respect to disposal of radium luminised articles.

Hazards

Beta

21. Low energy beta radiation is emitted by tritium and promethium-147 luminised articles, but the energy of the beta is insufficient to penetrate beyond the instrument casing. Radium-226 luminised articles emit higher energy beta radiation which may not be fully attenuated by the instrument casing.
22. Tritium and promethium-147 can present a hazard internal to the body if taken in by ingestion, inhalation, and absorption through the skin or through cuts in the skin. The beta radiation emitted by radium-226 can give rise to a radiation dose to the skin in the event of skin contamination and will present an internal hazard if the material is ingested, inhaled, or absorbed through cuts in the skin.
23. Low levels of Bremsstrahlung radiation (X-rays) can be emitted from luminised equipment.

For radium-226 luminised articles only

Alpha

24. Radium-226 emits alpha radiation. This radiation will be fully attenuated by the instrument casing but will present an internal hazard if the casing is damaged and the luminising material is inhaled, ingested or contaminates the skin.

Gamma

25. Radium luminised equipment can present an external hazard during use or storage as dose rates of 10-100s µSv/hr could be measured.
26. A leaking source will cause contamination that could lead to an internal hazard if the radioactive material enters the human body.

Tritium Monitoring and Detection

27. Monitoring the radiation dose rate from a tritium luminised article is difficult due to the very low energy beta radiation emitted and will therefore record a level less than 1 $\mu\text{Sv/hr}$. Similarly, it is very difficult to detect tritium contamination without the use of specialised monitoring instrumentation. Tritium surveys are therefore generally carried out by indirect means involving the taking and analysis of smears of the surfaces to be monitored.

Risk Assessments for Luminised Equipment

28. The range of luminised articles in service within MOD is too large to describe in this publication. Similarly, it is not possible to include risk data for all items. However, summary risk assessments for a selection of luminised articles are provided at Annexes A and B of this Chapter. These summary risk assessments can be used to scope the hazard and control requirements for a wider range of luminised equipment and can be used, where appropriate, as input to the risk assessments and local orders required in accordance with Chapters 2 and 16 respectively. Advice on further detail and assessments can be sought from the RPA.

Personal Protective Equipment (PPE)

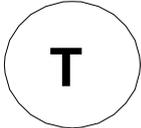
29. PPE is not required for the routine handling of intact luminised equipment.

Breakage of Luminised Equipment

30. Luminised equipment must not to be deliberately damaged or have protective covers removed by unauthorised persons.

31. Broken luminised articles are potentially hazardous because loose radioactive material can enter the body by a variety of means including inhalation of radioactive dust and absorption through cut or damaged skin. Detailed guidance on the procedure for dealing with broken luminised equipment is in Chapter 40.

Wristwatch Divers 300m – Example of a Summary Radiation Risk Assessment

Wristwatch Divers 300M	
Description	<div style="display: flex; align-items: center; justify-content: space-around;">  <div style="text-align: center;">  <p>Watch marking</p> </div> <div style="width: 30%;"> <p>The Divers Watch contains 2.4 MBq of tritium paint, which is used to luminise the hands and numbers, in dark/ dimly lit conditions.</p> </div> </div>
Use	Luminous watch for use underwater
Supplier	Cabot Co Ltd
NSN	0555-99-757-3314
IPT Details	Combat Support
Radionuclide	Tritium (H-3)
Ionising Radiation	Beta
Half Life	12.3 years
Original Activity	2.4 MBq
Hazard	Tritium is the radioactive form of hydrogen and is present within the luminising material on the watch dial. The glass face of the watch is sufficient to attenuate the beta radiation emitted by the tritium. If the watch is destroyed in a fire the tritium is rapidly converted to tritiated water – a more hazardous form of tritium. Tritium and tritiated water emitted during such an event may present a hazard due through inhalation and absorption through the skin.
Risk Assessment	The likelihood of accidental damage to this watch is low, because it would require a strong and directional force to break the glass face of the watch. If broken, and on the basis of an assumption that 10% of the tritium is removed of which 1% is ingested, a committed effective dose of 0.1 µSv could be received. This dose is negligible
Local orders	Details of the required control measures as detailed in this chapter are to be included in the local orders for radiation safety (Chapter 16 refers).
Control measures during use	No protective clothing or special precautions required.
Inspection	Annually as well as during routine maintenance. Check to be made for signs of damage.
Leak Testing	Leak testing is not required for this component.
Accounting	This item is to be accounted for on a Radioactive Source List. Chapter 9 refers. All radioactive material is to be mustered monthly. Any change of location is to be entered in the Source Movement Log together with any change in custodian.
Storage and Labelling	This item is to be stored in a dedicated area for radioactive materials. Chapter 9 refers. The storage area is to have a sign indicating the presence of radioactive material within i.e. a trefoil including the contact name and telephone number of the WPS and stating the nature of the radiological hazard e.g. Items contain radioactive material. No radiation hazard from intact item. Radioactive contamination hazard if item damaged

Contingency Plans	If a breakage occurs the area is to be cordoned off. The broken item can be cleaned up using a breakage kit (Chapter 40 refers). Reporting of loss and certain other incidents are to be carried out in accordance with the procedures described in Chapter 14.
Transport	This item may be transported in an excepted package provided the total package activity does not exceed 40,000 GBq and the surface dose rate of the package is less than 5 μ Sv/hr. The Dangerous Goods Manual refers.
Disposal	Ships, Units and Establishments are to return unbroken items through the Stores Organisation. Broken items are to be disposed of in accordance with Chapter 40.

Chronograph Wristwatch Luminous – Example of a Summary Radiation Risk Assessment

Chronograph Wristwatch Luminous	
Description	<div style="display: flex; align-items: center;">  <div style="text-align: center;">  <p>Watch marking</p> </div> <div style="margin-left: 20px;"> <p>The Chronometer watch contains a total of activity of 2.4 MBq of Promethium-147 in the form of luminised paint. This paint is used to luminise the hands and the numbers of the watch.</p> </div> </div>
Use	Luminous watch
Supplier	Seiko
NSN	6645-99-814-9181
IPT Details	Combat Support
Radionuclide	Promethium-147
Ionising Radiation	Beta
Half Life	2.6 years
Original Activity	2.4 MBq
Hazard	Promethium is present within the luminising material on the watch dial. The glass face of the chronometer watch is sufficient to attenuate the beta radiation.
Risk Assessment	The likelihood of accidental damage to this watch is such a degree that the risk of Pm-147 release is low. A more severe accident, for example, smashing or crushing the watch face, could result in a small dose (0.6 µSv) through ingestion or inhalation of promethium 147
Local orders	Details of the required control measures as detailed in this chapter are to be included in the local orders for radiation safety (Chapter 16 refers).
Control measures during use	No protective clothing or special precautions required.
Inspection	Annually as well as during routine maintenance. Check to be made for signs of damage.
Leak Testing	Leak testing is not required for this component.
Accounting	This item is to be accounted for on a Radioactive Source List. Chapter 9 refers. All radioactive material is to be mustered monthly. Any change of location is to be entered in the Source Movement Log together with any change in custodian.
Storage and Labelling	This item is to be stored in a dedicated area for radioactive materials. Chapter 9 refers. The storage area is to have a sign indicating the presence of radioactive material within i.e. a trefoil including the contact name and telephone number of the RSO or WPS and stating the nature of the radiological hazard e.g. Items contain radioactive material. No radiation hazard from intact item. Radioactive contamination hazard if item damaged.
Contingency Plans	If a breakage occurs the area is to be cordoned off. The broken item can be cleaned up using a breakage kit (Chapter 40 refers). Reporting of loss and certain other incidents are to be carried out in accordance with the procedures described in Chapter 14.
Transport	This item may be transported in an excepted package provided the total package does not exceed 2,000 GBq and the surface dose rate of the package is less than 5 µSv/hr. The Dangerous Goods Manual refers.
Disposal	Ships, Units and Establishments are to return this item, unbroken, through the Stores Organisation. Broken items are to be disposed of in accordance with Chapter 40.