FIRE SERVICES EXAMINATIONS BOARD

STUDY NOTE

EXAMINATION	STATION OFFICERS' EXAMINATION
PAPER	OPERATIONS
SUBJECT	FIREFIGHTING & RESCUE INCIDENTS
ITEM	INCIDENTS IN PREMISES INVOLVING RADIOACTIVE SUBSTANCES
STUDY NOTE No.	3102

INTRODUCTION TO THE STUDY NOTE

This study note has been prepared as the basis of study in connection with the qualifying examinations for promotion.

Candidates will be expected to demonstrate knowledge of the information contained in the study note and understand how it should be applied:

The 'References' made at the end of the Study Note are included for information only and candidates will not be expected to study these as part of the bibliography.

INCIDENTS IN PREMISES INVOLVING RADIOACTIVE SUBSTANCES

1. Introduction

Radioactive materials are in use in industry, hospitals and scientific establishments as well as for military and energy generation purposes. The possibility of incidents involving them has grown over the years.

There are no inherent fire hazards associated with radioactive substances as such. Some are themselves flammable or combustible in varying degrees and, to this extent, they have a fire hazard attached to them, but this hazard is no greater because of their radioactive properties.

Radiation cannot be perceived by the senses and its effects can be delayed. The hazard that does arise is that there is a danger of radioactivity being radiated. This can cause biological, chemical and physical changes, which may be harmful. It can also have a genetic effect, which will be apparent in any future offspring of the person affected and if the substance is volatilised, the danger is greater in that the radioactive vapours could be ingested with more serious consequences.

The method of fighting a fire involving radioactive substances is no different because of the radioactivity. However, because of the consequences of radioactivity causing contamination that can be a danger to health, rigid control procedure for dealing with incidents involving, or likely to involve, radioactive substances are necessary.

2. General

Where premises house radioactive materials in hazardous quantities special precautions are taken, the same is true when radioactive materials are being transported in bulk.

In both cases there are special procedures arranged between the authorities concerned, the police, and other interested bodies, to deal with incidents when they do occur. Ordinarily, however, the radioactive sources involved in incidents will probably be small and there is little risk of firefighters being seriously affected. To ensure their safety, however, there must be provision for effective command and control at such incidents and thorough decontamination of personnel and equipment at the incident's conclusion.

3. Protection from Radiation Effects

(a) Dose Limitation

Planning for operational incidents should eliminate the need for a firefighter to handle radioactive materials as a normal part of his/her operational duties.

The essence of UK legislation is that Fire Authorities and, therefore, brigade planners will be aware of risks within the authority's area and can, therefore, ensure appropriate arrangements to maximise safety, limit effective doses, secure the provision of effective arrangements and the provision of specialised instruments.

The overriding consideration of any plan is the requirement to ensure that firefighters are not needlessly exposed to ionising radiations.

The principle that should be applied is that which is known as ALARP. This means that all firefighters should only be exposed to doses, which are "As Low As Reasonably Practicable".

This can be achieved by providing suitable support resources, both in personnel and in the provision of personal protective equipment eg dosemeter.

There is a need for limiting exposure and this is agreed as follows:

(i) *Male Firefighters*

For foreseeable incidents a male firefighter should not be exposed to more than 50mSv for the whole body.

The Ionising Radiation Regulations 1985 (The Regulations) indicate the need to ensure that if an effective dose equivalent exceeds 50mSv in any one calendar year, then the Fire Authority shall ensure an immediate investigation and that the Employment Medical Adviser (HSE) or the Brigade Medical Adviser implements the medical surveillance system.

If a firefighter has been exposed to an effective dose of 50mSv in any one calendar year, the firefighter should not be exposed to ionising radiation for a minimum of 2 years. The Officer-in-Charge must be made aware of any firefighter who is within the scope of their authority and responsibility who is subject to this limitation.

The National Radiological Protection Board (NRPB) advised that for any foreseeable incident in the UK it should be possible to limit exposure to less than 15mSv, this excludes Licensed Sites.

An investigation is required if the exposure at any one incident is more than 15mSv and, in the event of a cumulative dose, in excess of 75mSv in any consecutive five-year period.

(ii) *Female Firefighters*

The dose limit for a female of reproductive capacity shall be 13mSv in any consecutive three-month interval; the dose limit for the abdomen for a pregnant female is 10mSv during a declared term of pregnancy.

The exposure figures for a female during a time of a declared pregnancy at an incident have become largely irrelevant, since guidance was issued to Fire Authorities which should ensure that female firefighters will be excluded from firefighting duties, during a term of declared pregnancy.

Females who do not fall within the definition of a woman of reproductive capacity shall have the same figures applied as those which apply to males.

Clearly, from the above it can be seen that there is no scope to include female firefighters of reproductive capacity in a Fire Brigade plan for dealing with incidents, which may involve the risk of exposure to more than 13mSv whole body dose.

(b) Time, Distance and Shielding

Protection from external radiation is to be found in a combination of three factors:

- TIME;
- DISTANCE; and
- SHIELDING.

(i) Time

The duration of exposure is of critical importance - the shorter the exposure, the smaller the dose received. It is, therefore, extremely important that at any incident which involves radiation the objective to restrict dose levels to "as low as reasonably practicable" (ALARP) should be followed.

(ii) Distance

The intensity of radiation decreases as the distance from the source increases. It is said to follow the inverse square law. This means that, if the distance away from the source is doubled, the intensity of the radiation (dose rate) is reduced to one quarter of its former value - example for a 200GBq source, eg:

Dose rate (mSv/hr)	Distance (metres)
400	.5
100	1.0
25	2.0
6.25	4.0
1.56	8.0

However, consideration must always be given to wind direction and watercourses (including the flow of water used for firefighting) when assessing safe distances, due to the possibility of airborne or water dispersion.

(iii) Shielding

Protection can also be obtained by placing some form of shielding between the source and the person exposed. All radioactive sources capable of creating an external radiation hazard are normally shielded according to the strength of the source and the nature of the radiation. The object of the shielding is to block the emitted particles and absorb the radiation so that it is either diminished or cannot reach and harm people nearby. In an emergency, radioactive sources may lose their shielding and, in these circumstances, it will be necessary to make use of materials which may be available. The effectiveness of a shield is dependent on its thickness and density; for example, the following materials will reduce to approximately a quarter of the gamma radiation from radioactive cobalt.

Material	Thickness
Lead	25mm
Steel	40mm
Concrete	150mm
Earth or Brick	190mm
Water	330mm
Hardwood	500mm

Examples of the hazards from the various types of isotopes and shielding effects are shown in the grid below:

Isotope Emitting	Can be stopped by:	External Hazard	Internal Hazard
Alpha particle	Sheet of paper	None	Very serious
Beta particle	Clothing	To skin & eyes	Serious
Gamma radiations	Dense material	To whole body & internal body organs	Serious
Neutron radiations	Dense material	To whole body and internal organs	Very Serious

(c) Instrumentation

It is important to recognise that the recommended and generally available contamination instruments possessed by Brigades will not detect all radioactive hazards, let alone accurately measure them.

It is important to recognise also that dose rate meters generally possessed by most Brigades only detect radiation sources of certain activities and that specialised instruments operated by a competent person may be necessary in certain foreseeable incidents. For example, Fire Authorities need not possess, but firefighters should be aware of, the existence of instruments capable of detecting the presence of electron capture nuclides, emitted neutrons and high levels of gamma radiation.

Firefighters must be aware of the difficulties of measuring surface contamination. The detection efficiencies of such instruments vary from 0% to 30% according to the radionuclide present, the instrument available and prevailing conditions. At best, the surface contamination meters generally available to Brigades can only indicate whether radioactive substance(s) might be present. Accordingly, training programmes must acknowledge this fact when explaining the capacities of instrumentation provided by Brigades or outside agencies.

(d) Protective Equipment

(i) The Objective of Personal Protective Equipment (PPE)

PPE is required to provide a level of protection appropriate to the degree of risk that the firefighter may be exposed to. To this end, it is possible to provide a high level of protection to personnel by covering all areas of the skin. In addition, it is necessary to protect against inhalation of airborne particles and this can be achieved by the use of breathing apparatus. To facilitate decontamination, many Brigades use Chemical Protection Suits (CPS) which allow the contamination to be washed off using the wet decontamination method.

(ii) How PPE Protects

PPE protects the firefighter by shielding the wearer against alpha and beta particles.

Alpha particles only travel short distances and cannot penetrate the outer dead layer of the skin. If they were to enter the body through a small cut or by ingestion, then the risk of harmful effects greatly increases. Provision of whole body protection will ensure that any small cuts that the wearer may have, and that he/she may be unaware of, will be covered.

Beta particles can travel up to a few metres and may penetrate the skin but will be stopped by the barrier provided by PPE as these particles cannot penetrate more than 1cm of plastic. In addition to the hazards to the skin, there is also a hazard to the lens of the eye and the provision of breathing apparatus will provide adequate protection to this area.

Gamma and neutron radiations pose different problems for the firefighter than either alpha or beta particles because of their energetic nature. These radiations are penetrative, therefore, PPE is unlikely to provide the protection required. The need for suitable monitoring and the application of ALARP are of paramount importance when faced with this particular risk.

4. National Arrangements for Incidents Involving Radioactivity (NAIR)

The NAIR Scheme is designed to provide advice and assistance to the police and can be activated by them in the event of unforeseen incidents involving radioactivity which might constitute a danger to the public.

The Scheme assumes that the police will normally be the first to be notified of an incident. Chief Fire Officers and Firemasters are required to arrange for the police to be notified if the fire service is informed first.

Under the NAIR Scheme, police forces are allotted sources of expert advice and assistance (drawn mainly from hospitals and the major nuclear operators) in two stages.

Stage One provides for the attendance of a radiation expert. It is the function of the Stage One expert to assess the situation and to advise the police what further action, if any, is necessary. If follow-up action is required, he/she will normally recommend that the Stage Two team be called. The Stage Two team is able to deploy greater resources and will normally arrive in its own transport with the necessary additional equipment. The Stage Two team will normally be able to deal with an incident. If not, it should be able to advise on further measures to be taken to clear the hazard.

All fire brigade pre-planning for incidents involving radiation hazards will include the triggering of technical support and advisors via the NAIR scheme.

5. Initial action at an Incident

(a) On being mobilised, Brigade Control must inform all Officers-in-Charge of appliances that radioactive material is in use at the premises, or involved at the location to which they are responding.

(b) If that information is not known, it is imperative that an informative message "RADIATION SUSPECTED" be sent back immediately from any incident in which the presence of radioactive materials is suspected, to permit the appropriate mobilisation for a radiation incident.

(c) If a competent person is in attendance, this should be stated in the message.

(d) Brigade Control must be informed if it is subsequently found that radioactive materials are involved - ie "RADIATION CONFIRMED" in order that subsequent appliances/mobiles can be advised accordingly and any other standing arrangements can be implemented.

(e) It is imperative that the Officer-in-Charge of the first attendance ascertains the form, strength and location of any source that may be involved in accordance with planning arrangements.

(f) Effective liaison must be established at an early stage of the incident and maintained as an integral part of operational procedures.

(g) For pre-determined risks, the functional elements of the pre-determined operational plan should be implemented.

(h) In addition to seeking advice, there should be an adequate number of suitable dose rate meters on the pre-determined attendance.

(i) Suitable and sufficient instrumentation should be requested via fire control if the above is not apparent.

(j) Firefighters must not be committed to areas where radioactive materials might be present unless a dose rate meter is available or where it has been identified through the risk assessment that it is permissible to do so.

(k) When firefighters are committed to an area where radiation may be present, it is imperative that a dose rate meter is used to ensure a safe location for each team, and those personnel remain in the area for the minimum time necessary.

(l) All personnel entering a restricted area must be protected by suitable PPE and equipment with a personal dosemeter.

(m) Exposure to ionising radiations must be restricted, so far as is reasonably practicable (ALARP) and all necessary steps must be taken to ensure this.

(n) The Officer-in-Charge should endeavor to determine the location of the source, and plan a route to the fire, which will involve the least exposure to firefighters. For predetermined risks, this requirement may be detailed in the pre-determined operational plan.

(o) Only the minimum number of essential personnel should be employed on any duty involving radiation.

(p) Those so employed should be removed from the hazard zone as soon as possible.

(q) Operations must be conducted as far as possible from behind any available cover, which may provide shielding from radiation.

(r) The BA Entry Control Officer (BAECO) should be made responsible for recording dosemeter readings on entry and exit, and ensuring that firefighters do not enter the restricted area unless they are wearing suitable PPE and are equipped with a personal dosemeter.

(s) All other personnel should be kept upwind away from the hazard zone.

(t) Appliances should also be parked on the upwind side.

(u) Reinforcements must be FULLY briefed at the incident before being committed to operational duties.

This brief should include type and strength of source, information on hazard zone, the requirement for PPE, meteorological information and precise instructions as to allocated duties at the incident.

6. Establishment of a Restricted Area

(a) If a radioactive source becomes involved in fire, or a source has been broken up or damaged by fire or accident, then the Officer-in-Charge should consider declaring a restricted area.

(b) To decide whether this is necessary, the form of the source is of importance. Some major sources may be used in a certain fixed position, or they may be movable and normally kept in a special store. Minor sources may be kept fixed in one position all the time, either sealed or unsealed, or there might be several sources distributed throughout the premises.

(c) When a restricted area is declared, movement into or out of the area must be strictly controlled. This can be achieved by utilising barrier tape marked: RESTRICTED AREA.

(d) In the early stages, the boundaries of the restricted area may be based on an estimate of the maximum external radiation dose rate, and should be verified as soon as possible by checking with a dose rate meter.

(e) It may be necessary to adjust the boundaries after this and subsequent checks and the advice of any competent staff who may be in attendance should be sought. This is particularly important where contamination is confirmed over a wider area. Fire appliances and fire brigade personnel not operationally involved should be kept outside the zone (upwind of the incident, if possible).

(f) "Cooling down" operations should similarly be conducted with care to avoid the undue disturbance of debris until any radioactive source has been identified.

"Turning over", body recovery or salvage work must not be permitted in the restricted area until sources have been removed/made safe and the area/body declared to be uncontaminated or otherwise protected.

7. Hazmats Officer

(a) A Hazmats Officer mobilised to the incident should assume responsibility for specific functions as determined in the pre-determined operational plan and/in brigade procedures.

(b) These functions will require contact with external agents, and should be designed to support the senior fire brigade officer in attendance with regard to decision-making.

(c) In particular, this will probably include information gathering on radiation monitoring, briefing and debriefing of BAECO and the confirmation and control of the decontamination procedure.

(d) The Hazmats Officer may also be appointed as the focal officer for all documentation related to dose recording, consistent with local brigade procedures.

(e) All relevant information gleaned by the Hazmats Officer must be passed to the senior fire brigade officer in attendance for appropriate action.

(f) The Hazmats Officer will also be responsible for liaison with the appropriate competent person in considering the arrangements for disposal of contaminated fire brigade equipment and clothing etc.

8. Breathing Apparatus Entry Control Officer (BAECO)

(a) The BAECO must ensure that all personnel are fully briefed on entering the hazard zone, and fully debriefed, if appropriate, on exit.

(b) He/she must also record dosemeter readings in/out on BA tallies and transfer dose exposure readings to the Hazmats Officer who shall provide further direction, if required.

(c) If the Hazmats Officer is not in attendance, then the Officer-in-Charge must be informed direct.

(d) The BAECO must ensure that all personnel who are being committed in BA are provided with the relevant PPE.

(e) Once cleared by the competent person, the BAECO is responsible for taking a second reading of the dosemeter to check the original outgoing reading given by the firefighter.

9. Environmental Pollution

(a) Subject to operational and safety considerations, all reasonably practicable measures should be taken to prevent water used for firefighting or decontamination from entering water courses, drainage or sewage systems.

(b) The environmental pollution can also be limited by the use of water spray to limit disturbance of burning materials.

(c) In the event that polluted water cannot be contained by reasonable measures, the fire authority should secure the arrangements to notify the appropriate agency.

(d) This applies similarly in the case of emissions to the atmosphere. Environmental pollution is generally the responsibility of the employer but under some circumstances will come within the scope of the NAIR Scheme.

10. General

(a) Officers-in-Charge of each appliance must ensure that the appropriate documentation is completed and submitted in line with relevant brigade policy.

(b) Where radioactive materials are involved in an incident, the police should be notified immediately, as should any available source of technical advice. It may also be necessary to alert local hospitals.

(c) Irrespective of what decontamination measures are implemented, if and when it is suspected or there is evidence (such as a dosemeter reading) that a firefighter has been exposed to excessive radiation, the Officer-in-Charge should see that the firefighter attends hospital for examination.

(d) Anyone who receives an open wound during operations should withdraw from the incident and must be given priority in the decontamination process to permit medical treatment at a hospital at the earliest stage.

(e) Anyone who feels unwell during or immediately after the incident should also attend hospital.

(f) Details of exposure to radiation should be entered on the firefighters personal record. The Brigades Medical Advisor and the Brigades Health and Safety Advisor should be informed and the information kept available for reference.

(g) Particular care should be taken that a firefighter is not, by the cumulative effect of radiation on different occasions, subjected to more than the maximum permissible dose as promulgated to Brigades and laid down in Brigade orders or operational notes.

11. Decontamination Process

The provision of contamination checks is a function that cannot be properly carried out by a Fire Authority as this will require a person competent for this action.

It is the responsibility however of the Fire Authority to implement First Aid Decontamination procedures for brigade personnel. At all incidents, the advice of the competent person for the employer should be sought or if appropriate the competent person responding under NAIR, or within brigade contingency arrangements.

If the incident involves a pre-determined risk, then the pre-determined operational plan will include decontamination requirements (including resources). These typically are as follows:

(a) Where contamination is suspected, a decontamination officer should be appointed and a decontamination zone established.

(b) Decontamination should consist principally of cleaning and removing contaminated clothing of firefighters.

(c) Contaminated clothing and equipment should be placed in plastic bags, and further advice sought.

(d) It is not the responsibility of the Fire Authority to decontaminate persons, premises and vehicles etc outside fire brigade control. Where it is decided necessary to provide this assistance, this must be under the supervision of a competent person.

(e) It should be noted that disposal of the radioactive source is not the responsibility of the Fire Authority and it should not, therefore, be necessary for a firefighter to handle the radioactive materials.

12. Personal Protective Measures During Decontamination

(a) Firefighters awaiting examination before entering a clean holding zone prior to decontamination must not eat, smoke, drink, scratch or bring their hands into contact with their mouth, nostrils or eyes.

(b) Firefighters with exposed open wounds must not enter any restricted area or form part of the decontamination process. Instead they must withdraw and be given priority in the decontamination process to permit medical treatment at the earliest stage.

(c) Firefighters must retain their personal dosemeter throughout the decontamination process to allow a second independent reading by the BAECO.

(d) If the firefighter is proceeding to a clean holding zone, the dosemeter should be bagged and retained by the firefighter until cleared by the competent person.

(e) If a dosemeter is dropped or suffers similar shock during operations in the restricted area the firefighter must withdraw. The reading on the dosemeter must be recorded in the usual way but must not be regarded as a reliable measurement of dose. His/her partner's reading will be a useful guide but as it is the personal dose, which is the mandatory requirement, the firefighter must advise the person responsible for recording doses at the scene of the circumstances to allow competent calculation to be made.

(f) If the firefighter cannot read the dosemeter, he/she should withdraw. Re-entry will only be permitted if a dose rate meter subject to normal entry control requirements supports him/her.

Note: This study note does not deal with incidents involving transported radioactive materials.

References

Manual of Firemanship Book 1.
Manual of Firemanship Book 12.
Technical Bulletin 2/1993