FIRE SERVICES EXAMINATIONS BOARD

STUDY NOTE

EXAMINATION	LEADING FIREFIGHTERS EXAMINATION
PAPER	OPERATIONS
SUBJECT	FIREFIGHTING & RESCUE INCIDENTS
ITEM	INCIDENTS IN PREMISES INVOLVING RADIOACTIVE SUBSTANCES
STUDY NOTE No.	1108

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 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.

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.

These are the dose limits recognised for the guidance of Fire Authorities for male firefighters.

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.

Other limits are permissible but are outside the scope of this study note and that of Junior Officers.

(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 not recorded as being 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 being included 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. In addition to the call-out arrangements, the handbook includes advice on NAIR participants and details of hospitals, which can accept contaminated casualties of persons suffering from excessive exposure to radiation.

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 plan should be implemented.

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