Guidelines for triage and monitoring of people exposed to radiation after a malevolent act

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Abstract. After an incident involving the malevolent use of radiation or radioactive material, the exposure could range from very low to substantial, possibly combined with conventional injuries. The European Commission through the Euratom 6th Framework Programme is co-sponsoring the specific targeted research project TMT Handbook, aimed at producing the practicable tools needed for an adequate response to such incidents. There is a wide range of published documents giving guidance. However, most of these documents give generic guidance that could be difficult to implement readily at the time of an incident. TMT Handbook will present practicable, concise advice in the form of a step-by-step guide for the effective and timely triage, monitoring and treatment of people exposed to radiation following a malevolent act. The handbook is divided into modules for various aspects of the response. One of the modules gives guidelines for best practice of triage and monitoring. Development of this triage and monitoring module is drawing on the internationally agreed practical guidance on the subject along with expertise from the project consortium and where appropriate, is making use of current practice in EU countries and existing IAEA and WHO publications. The module defines the monitoring procedures required to confirm a radiation emergency, describes procedures for defining the geographical area within which people may be affected, explains the initial triage and monitoring required for this affected population (including those with trauma injuries), describes how to define a monitoring strategy, and presents information on monitoring and dose assessment techniques. The draft of the handbook will be distributed to national emergency authorities and agencies for comments and they have been invited to test the modules in national emergency response exercises. The interaction with the end users on the practical application of the Handbook through the exercise programme will enable lessons to be learnt regarding implementation.

KEYWORDS: malevolent use of radiation, triage, monitoring, dose assessment.

1. Introduction

After an incident involving the malevolent use of radiation or radioactive material, the exposure could range from very low to substantial, possibly combined with conventional injuries. The European Commission through the Euratom 6th Framework Programme is co-sponsoring the specific targeted research project TMT Handbook, aimed at producing the practicable tools needed for an adequate response to such incidents. There is a wide range of published documents giving guidance. However, most of these documents give generic guidance that could be difficult to implement readily at the time

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of an incident. The module in the TMT Handbook giving guidelines on actions to be taken presents practicable, concise advice in the form of a step-by-step guide for the effective and timely triage and monitoring of people exposed to radiation following a malevolent act.

The triage and monitoring module is drawing on the internationally agreed practical guidance on the subject along with expertise from the project consortium and where appropriate, is making use of current practice in EU countries and existing IAEA and WHO publications.

The module defines the monitoring procedures required to confirm a radiation emergency, describes procedures for defining the geographical area within which people may be affected, explains the initial triage and monitoring required for this affected population (including those with trauma injuries), describes how to define a monitoring strategy, and presents information on monitoring and dose assessment techniques. This presentation is based on the draft version of the module which will be finalised in 2009.

2. Response actions

In the initial stages of the response, there will be little time to carry our detailed planning of the response, and minimal information on which to base such plans. Initial actions to be taken at the scene can be implemented automatically without the need to develop detailed plans that are specific to the incident.

After these initial actions are under way, there will be time to develop a monitoring strategy. This will take into account the specific characteristics of the incident, and of the information received as a result of the initial stages of triage and monitoring.

2.1 Triage

“Triage” is the use of simple procedures for rapidly sorting people into groups based on (a) their degree of physical injury and (b) on actual or potential effects on health, and the allocation of care to these people so as to expedite treatment and maximise the effective use of resources.

Triage is a fundamental part of the response to accidents (such as road traffic accidents) or natural disasters (floods, earthquakes, etc.). In such incidents, triage is designed to allocate medical treatment according to the urgency of the need of patients for care. The process is intended to maximise the number of survivors and can be termed “trauma triage”.

Trauma triage may be required following incidents involving the malevolent use of radiation or radioactive material in a public place. However, the scope of triage is broader for such incidents and includes a group of actions that can be termed “radiological triage”. These actions are intended to sort people rapidly into groups depending on actual or potential effects on their health resulting from radiation exposure.

Triage carried out following an incident involving the malevolent use of radiation of radioactive material is a multi-stage process that would be carried out over an extended period of time. A major problem will be to differentiate those needing care from the potentially large numbers of people who require only information and reassurance often known as the “worried well”. In the early stages, triage decisions will have to be based on limited information, and will concentrate on the identification of those with an urgent need for treatment. In the later stages, more information (such as the results of initial monitoring) will be available, and triage will extend to the identification of groups requiring “low intervention” care.

In the Handbook the process of field triage in the event of an incident involving the malevolent use of radiation or radioactive material is described. Its scope includes all of the triage decisions made from the commencement of the incident up until the time when all people are correctly categorised for triage purposes (assumed to be about 6 days following the incident), or up to the admission of a
particular individual to hospital or other medical facility. The various stages and typical time periods in the field triage process are described in Table 1.

**Table 1**: The various stages in the field triage process

<table>
<thead>
<tr>
<th>Triage Stage</th>
<th>Typical time period when triage decisions will be made</th>
<th>Information available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trauma</td>
<td>0-12 h</td>
<td>Severity of physical injuries to individuals</td>
</tr>
<tr>
<td></td>
<td>2-36 h</td>
<td>Location, etc., at time of incident</td>
</tr>
<tr>
<td></td>
<td>0 h – 6 days</td>
<td>Clinical signs and symptoms, and in the later stages, the results of complete blood counts</td>
</tr>
<tr>
<td>Radiological</td>
<td>6-72 h</td>
<td>Results of initial screening measurements made at incident location</td>
</tr>
<tr>
<td></td>
<td>12 h – 6 d</td>
<td>Results of measurements made with transportable <em>in vivo</em> monitoring facilities close to incident location</td>
</tr>
<tr>
<td></td>
<td>24 h – 6 d</td>
<td>Results of laboratory <em>in vivo</em> monitoring measurements</td>
</tr>
<tr>
<td></td>
<td>72 h – 6 d</td>
<td>Results of laboratory <em>in vitro</em> measurements of biological samples (e.g. radionuclides in urine, cytogenetic measurements of blood, etc.)</td>
</tr>
</tbody>
</table>

### 2.2 Monitoring

The term “monitoring” describes the measurement of radiation dose or contamination, for reasons related to the assessment or control of exposure to radiation or radioactive material, and the interpretation of the results. The monitoring carried out in response to an incident involving the malevolent use of radiation or radioactive material in a public place may be subdivided into source monitoring, environmental monitoring and individual monitoring. The TMT Handbook is mainly concerned with individual monitoring, but the other forms of monitoring also come within the scope of the Handbook.

*Source monitoring* is the measurement of activity in radioactive material released to the environment, or of external dose rates in the localised area around a source. In the present context, its main objective are to indentify and locate the source, and evaluate its potential for exposing people to radiation or radioactive material.

*Environmental monitoring* is the measurement of external dose rates arising from a source in the environment, or of radionuclide concentrations in environmental media. In the present context, its main objective is to determine the geographic distributions of dose rates and/or levels of contamination.
Individual monitoring is monitoring using measurements of quantities of radioactive material in or on the body of the individual, or measurements made by equipment worn by individual workers. It includes the assessment of radiation doses to the individual from the results of measurements.

2.2.1 Monitoring to confirm a radiation emergency

It has to be established whether or not the incident involves the use of radiation of radioactive material, to establish whether radioactive material has been dispersed through the environment and to establish approximately those areas where dose rates or levels of contamination are highest.

Priorities and actions will differ according to the scenario. In the module the following scenarios are considered:
- irradiation (irradiation incident)
- environmental contamination (contamination incident)
- contamination of food/water

2.2.2 Environmental Contamination (Contamination) and External Irradiation (Irradiation) Incidents

For these types of incidents monitoring teams should be established. These teams are likely be made up from staff from first responder organisations (e.g. fire service) or of specialist radiation protection staff. It is unlikely that emergency services will have the equipment or experience to monitor for all types of radiation. Emergency services staff required to do emergency monitoring must, as a minimum, be able to identify elevated gamma dose rates. If only gamma-dose rate monitoring is available then it must be assumed there is widespread contamination of the environment, until contamination monitoring has been carried out.

2.2.3 Monitoring Instruments

The following is a list of instrument types which may be useful for confirming the presence of specific radiation types or to identity the radionuclide(s) present:
- alpha contamination monitors
- beta dose rate monitors
- beta contamination monitors
- X-ray and low energy gamma contamination monitors
- Gamma dose rate monitor
- portable gamma-spectrometry equipment.
- Neutron dose rate monitor

3. Zones and Reception Centres

Zones are established around the scene of an incident to protect and control the public, protect and control members of the emergency services, facilitate the operations of all agencies, guard the scene and prevent unauthorised interference with evidence or property. The Red Zone is the potentially hazardous area immediately surrounding the incident where extreme caution and safety measures is required. The cordon surrounding this zone is called the ‘Safety Perimeter’. The Yellow Zone surrounds the Red Zone and provides a safe and secure working environment for personnel and members of the public being processed for clearance from the incident. The cordon surrounding this zone is called the ‘Security Perimeter’.

A reception centre is set up where people not requiring urgent medical treatment following an emergency can be sent for shelter, rest and medical treatment. There information from affected individuals can be collected, they can be informed and counselled. It is expected that people evacuated
from within the security cordon should be directed to the Reception Centre. People returning having left the scene would also be directed to the Reception Centre.

**Figure 1:** Generic layout of zone boundaries

3.1 Radiation Monitoring Unit

Associated with the reception centre a radiation monitoring unit may be established. This may be located in the same building as the reception centre or located in a separate nearby building. People should be monitored at the radiation monitoring unit and if necessary decontaminated, before entering the Reception Centre.

The radiation monitoring unit should have a segregated area for people waiting for decontamination, an area for external contamination measurements, an area for decontamination of people and an area for internal contamination monitoring (if available). Also available should be storage for replacement clothing, storage for contaminated clothing and other contaminated items, an area for recording and reporting information with communications equipment and an area for counselling concerned individuals.

3.2 Individual Monitoring Methods

The primary monitoring method is the method that is expected to provide the most reliable assessment of internal dose. The measurement is likely to be carried out in a laboratory. For most radionuclides, more rapid measurements can be carried out in the field, although these will in general be less accurate. Such measurements are of most use for triage purposes, and are referred to as rapid screening methods. The initial survey can be done with hand held scintillation probes or dose rate monitors without any knowledge of the radionuclides involved. Portable or transportable body monitors are useful for body counting as demonstrated in figures 1 and 2. If in vivo monitoring facilities are not available or the radionuclide(s) cannot be detected directly from outside the body, indirect methods can be employed. Samples of urine, faeces, blood, nasal swabs, saliva can be used.
In an accident situation it is often not possible to reconstruct reasonably the absorbed dose on the basis of physical dosimetry, and biodosimetry might be the only option to characterise the casualty exposure. In table 2 some rapid screening and primary monitoring methods for a number of radionuclides.

**Figure 2:** Thyroid measurement with NaI(Tl) detector

![Thyroid measurement with NaI(Tl) detector](image)

**Figure 3:** Gammaspectrometric body measurement in lap geometry

![Gammaspectrometric body measurement in lap geometry](image)
### Table 2: Rapid screening and primary monitoring methods for some radionuclides.

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Radiation type</th>
<th>Rapid screening method</th>
<th>Primary monitoring method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt-60 60Co</td>
<td>β, γ</td>
<td>Whole body (rapid)</td>
<td>Lung</td>
</tr>
<tr>
<td>Strontium-90 90Sr</td>
<td>β</td>
<td>Nose blow</td>
<td>Urine</td>
</tr>
<tr>
<td>Barium-133 133Ba</td>
<td></td>
<td>Whole body (rapid)</td>
<td>Whole body</td>
</tr>
<tr>
<td>Caesium-137 137Cs</td>
<td>β, γ</td>
<td>Whole body (rapid)</td>
<td>Whole body</td>
</tr>
<tr>
<td>Polonium-210 210Po</td>
<td>-</td>
<td></td>
<td>Urine</td>
</tr>
<tr>
<td>Radium-226 226Ra</td>
<td></td>
<td>Nose blow</td>
<td>Lung, Urine</td>
</tr>
<tr>
<td>Plutonium-238 238Pu</td>
<td></td>
<td>Nose blow</td>
<td>Urine, Faeces (Lung)</td>
</tr>
<tr>
<td>Americium-241 241Am</td>
<td>γ</td>
<td>-</td>
<td>Lung</td>
</tr>
</tbody>
</table>

The purpose of the initial screening, with field survey equipment, is to classify people according to their levels of internal contamination, as a guide to decisions on further action. The preliminary screening and classification should be performed in an area appropriate to the potential demand, and large enough to permit adequate separation between people awaiting initial monitoring, those being monitored, those awaiting transfer for further assessment and space for temporary collections of contaminated clothing. Public facilities such as sports centres and arenas are likely to be suitable for large groups of people.

### 4. Registration of people and recording and reporting of results

Registration of people involved in incidents should give unambiguous identification of the person monitored or of samples collected. The purpose of record keeping, the nature and scope of the records, and the extent of record keeping systems depend on national requirements. The records should include the results of individual monitoring for internal contamination from both direct and indirect measurements. Models for emergency registration forms are included in the TMT Handbook.

After an incident the first report is needed as soon as possible (within 24 hours) to be used by the “emergency preparedness authorities” for decision making. At the stage the dose assessment might be very preliminary.

The report should include information on type of measurement (environmental, direct or indirect on persons), dose rates, in case of sample type and time of collection, analysis method and results obtained. Within a week a more reliable report will be needed to be used by health and other authorities for further decision making.

The procedures and levels to be used for reporting individual monitoring results should be clearly specified by the management or regulatory authorities. Information reported should be clearly identifiable and understandable. If only final results are reported results which fall below the MDA or derived recording level may be reported as such. (However, the actual result, along with its
uncertainty, should be retained in the records.) Because of privacy considerations, reports should be safeguarded and the persons identity protected, as for medical records.

5. Summary

The handbook contains both general information and detailed proposals for actions to be taken at the scene and in the hospitals by specialized teams in radiation protection, monitoring and medical treatment. It is intended to be used during the response to an incident as a source of practicable guidance. It is believed that this Handbook will help Emergency Response Organisations to prepare for response in case of malevolent use of ionising radiation. The above presentation is a short overview of one of the modules in the Handbook. In addition to the contents in the modules more information is collected into annexes most useful for planning of emergency response.

6. Acknowledgements

This work was partially supported by the EC under the 6th EURATOM Contract Number FP6-036497.

REFERENCES