A COMPREHENSIVE NATIONAL NETWORK FOR HANDLING EMERGENCIES INVOLVING RADIOACTIVE SHIPMENTS

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ABSTRACT

A comprehensive Transport Emergency Management System (TEMS) has been evolved in India for handling emergencies involving radioactive shipments. The vital elements of the TEMS are (1) a comprehensive emergency response action plan manual (2) Network of Emergency Response Facilities (ERF) situated in various parts of India (3) a Centralized Emergency Communication Room (ECR) and (4) TREMCARD accompanying the shipment. It is mandatory that the transport documents for each radioactive consignment include a TRansport Emergency CARD (TREMCARD). It prescribes the immediate countermeasures and provides contact details of the consignor and of the ECR established by the National Emergency Response Agency (NERA). The ECR operator requests the response laboratory nearest to the accident site to despatch the response team to the site. The physical distribution of these laboratories is such that should a transport emergency occur anywhere, response personnel from the nearest laboratory would be able to reach the affected site within 6 hours. This paper makes an effort aimed at optimisation of resources and recommends a graded approach, on the basis of estimated collective dose following an accident, to the establishment of a comprehensive national network for emergency response.

INTRODUCTION

Radioactive material is transported in connection with nuclear power production and also in connection with application of radioisotopes in Medicine, Industry, Agriculture and Research. Such materials are transported in packages designed to prescribed safety standards. Packages may, during transport operations, encounter accident situations. While Type B packagings are designed to withstand accident conditions of transport, packages of other types are not. In addition there being 14 nuclear power plants and the related facilities forming part of nuclear fuel cycle, there are nearly 250 telegamma therapy, 150 brachytherapy, 1100 industrial radiography and 7500 nucleonic gauge installations in India. Further, there are over a dozen gamma irradiator facilities, 100 gamma chambers, 600 nuclear medicine laboratories and over a 500 research institutions handling radiation sources. All these activities warrant many shipments of radioactive materials in India.

NEED FOR EMERGENCY PROCEDURES

The important difference between an emergency occurring in a nuclear or a radiation facility and one involving a radioactive consignment is that, whereas expertise and equipment would be available in a nuclear plant, such help is not always readily available on the route where a radioactive consignment meets with an accident.

All packages used for transport of radioactive material are designed to appropriate safety standards prescribed by the national competent authority [(1)]. These standards are generally based on the IAEA Transport Regulations [(2)]. The Code which is undergoing extensive revision would be in conformity with IAEA Regulations, 2000 [(3)]. The packages are assessed for their ability to withstand tests simulating accident conditions of transport. Yet, as a measure of additional caution, emergency response procedures for accidents involving radioactive shipments have been developed.

ELEMENTS OF EMERGENCY PROCEDURES

The major elements of the emergency response system for accidents involving radioactive shipments which have been established by the NERA are –

- Preparation of an emergency response manual specifying action plans
- Identification of a nation-wide emergency response network
- Creation of an Emergency Control Room (ECR) at the office of the NERA
- TRansport Emergency CARD (TREMCARD) to accompany the shipment
- Alerting all persons who have a role to play in an emergency
- Training of all response persons
- Mock drills

The persons at the accident site, such as vehicle crew and public functionaries implement the response actions in the initial phase of an accident following the instructions specified in the TREMCARD which is required to be included in the transport documents. However, in certain cases, such as transport of large radioactive sources, additional help may be required to be sent to the site.

EMERGENCY ACTION PLANS FOR LARGE RADIOACTIVE SHIPMENTS

All radioactive consignments are required to be accompanied by TREMCARDs. Emergencies involving small packages are easily handled by following the instructions specified in the TREMCARD. The response action to be taken in the event of an emergency involving large radioactive shipments is complicated.

The action plan to be implemented by the person on the scene would, in general, include the following measures:

* Monitor the cask
* Cordon off area (which is specified in the TREMCARD)
* Seek necessary help from district officials such as police and fire brigade
* Notify NERA and seek help, e.g., emergency response team (ERT)
* Assist the ERT
* Arrange for crane, if needed
* provide extra shielding material, if required
* decontaminate the affected area
* Seek NERA clearance for termination of emergency
* Resume shipment

EMERGENCY COMMUNICATION ROOM (ECR)

The NERA has established an Emergency Communication Room (ECR) at its headquarters. The ECR is equipped with various types of communication facilities such as two telephone lines linked to different telephone exchanges, wireless sets with a back-up, a fax machine and a personal computer with internet connectivity. The ECR is operated round the clock all round the year. Another ECR with the same equipment and personnel support has been established at a different location as a back-up facility. The contact details of all the emergency response facilities in the country are available with the ECR.

NETWORK OF EMERGENCY RESPONSE FACILITIES

An emergency response facility (ERF) is required to have all the necessary equipment necessary for handling an emergency involving a radioactive shipment. A list of equipment including radiation monitoring instruments, personal protective gear and source handling facilities has been prepared by the NERA. Each ERF has the necessary connectivity so that they may be contacted in an emergency. Personnel with expertise and experience in handling radiation emergencies are available at each ERF. These personnel are in a state of readiness to leave immediately upon receipt of intimation regarding a radiological emergency. Such intimation may be received either directly from the affected site or from the ECR.

Several ERFs have been identified all over the country. The contact details of each ERF are available with the ECR. The TREMCARD which is always included in the transport documents provides the contact details of the ECR. The ECR operator, on receipt of the emergency message would determine the ERF that is nearest to the affected site. Then the operator would send all necessary particulars to the appropriate ERF who would proceed to the site. The ERFs have been so identified that it is estimated that normally the response personnel from an ERF could reach the affected site within 6 hours of receipt of information.

GRADED EMERGENCY RESPONSE FOR OPTIMAL UTILIZATION OF RESOURCES

The present set up has the disadvantage that. It requires each ERF to be capable of handling emergencies any severity. The resources, in terms of equipment and expertise needed for handling a major emergency would be much greater than that for handling a minor emergency. Since resources are limited, the number of ERF which can handle major emergencies will have to be limited. Emergencies can be graded with reference to their radiological consequences. Each ERF can then be assigned a grade according to the grade of emergency that it is equipped to handle. This approach would enable optimal utilization of resources.

For this purpose, an analysis was undertaken. The purpose of the analysis was to determine the optimum number of ERFs and also the equipment required at various each ERF. These quantities would depend upon the radiological consequence of transport accidents. Therefore, the dose resulting from accident conditions of transport was calculated for a variety of radioactive shipments. In order to optimize resources to be used for handling transport emergencies an estimate of the radiation exposure was made prior to determining the network of ERFs in India. The evaluation was based on Probabilistic Safety Assessment (PSA) methods. The computer code, INTRETRAN2 was used for making the evaluation. This code which is an updated version of the IAEA's earlier computer code, INTERTRAN (4) is based on RADTRAN IV developed by the Sandia National Laboratories (5).

In computing the dose received under accident conditions of transport, the Code makes use of Probabilistic Safety Assessment (PSA) techniques. That is, if f_j is the fraction of activity released in an accident of severity category, j, (this being an assessed characteristic of the package of the specific design), given that a package of that design contains a radioactive material of activity q Bq, the exposure resulting from the released activity weighted by the probability of occurrence of the train of events leading to the release. The resulting collective dose would be given by:

S_E (i,j,k) = N(i) q(k) n(k) D(k) p(i,j) RF(j) l (i) person Sv

Where,

D(k) = dose resulting from unit release of activity of the specific radionuclide,k, $SvBq^{-1}$

P(i,j) = the probability that an accident of severity, j, occurs in population zone,i km^{-1} y^{-1}

l (i) = total distance traversed by the shipment through zone, i km

RF(j) = Release fraction of activity due to an accident of severity,j

N(i) = affected population in zone, i, along the entire route.

N(k) = number of packages transporting radionuclide, k

q(k) = activity of radionuclide, k contained in a package

The code considers three population zones, viz., rural, semi-urban and urban.

The code can handle twenty accident severities. For making these calculations, from the accident data published by government sources, the probability values for accidents were obtained. On the basis of the consequences of accidents, they were classified according to a scale of severity. From the data about the nature of accidents, twelve categories of severity of accident were derived [6].

The estimated dose resulting from an accident depends upon the severity of the accident, the post-accident condition of the package, and the nature and activity of the contents. In the present study, the dose under accidents occurring in rural, semi-urban and urban environments involving one of 11 different types of radioactive shipments, described below, was calculated. The types of packages, the activities of the radionucldes and the types of radioactive material are described in Table 1. The calculated vales of probability-weighted collective dose to the public under accident conditions of transport calculations show that accidents formed into four groups viz., $\leq 10^{-2}$ person Sv, $> 10^{-2}$ person Sv, ≤ 1 personSv > 1 person Sv, ≤ 10 person Sv and > 10 person Sv. Thus the accident situations could be classified into four levels on the basis of the dose values as given in the Table 2. It can be seen that the collective dose resulting an accident involving a given radioactive consignment depends upon the population zone where the accident occurred.

OPTIMIZATION OF RESOURCES IN RESPONSE NETWORK

The number and distribution of ERFs can now be determined on the basis of their utility. The ERFs may be of four grades, viz., grade 1 to 4. ERF G-1 can handle only level 1 emergencies. ERF G-4 can handle all four levels of emergencies. The resource requirements of ERF G-1 would be much less than that of ERF G-4. The network may include many ERFs of grade 1 and 2 because, in any population zone, the accidents of low severity would be about 100 times more[6] than those of higher severity which would warrant an ERF G-4. Hence, in any transport emergency, the ERF G-1 nearest to the accident site can rush to the spot in the initial phase and determine the grade of response required and keep the situation under surveillance till the arrival of the ERT of appropriate ERF grade, ERF G-4 which may require a long period, say, even 24 hours to reach the spot. The men and material requirements can be utilised in an optimal way.

CONCLUSION

With this classification, a scheme of graded response with optimal utilization of resources commensurate with the demands of the emergency can be devised. The scheme is characterised by a comprehensive network of ERFs of different grades. The ERFs will have to be situated at optimally selected locations. Even if the ERF located nearest to the site of emergency is not equipped to handle the emergency it can handle at least the initial phase of response thereby allowing time for the nearest ERF of appropriate grade to reach the site, if required.

TREMCARD
(TRansport EMergency CARD)

Cargo	:	Brachytherapy Source
Nature of Hazard	:	Radioactive . Potential external hazard
Emergency Action	:	1. Rescue the injured, if any 2. In case of fire, fight fire from a distance. 3. Inspect package visually. If it is intact, continue the shipment. 4. If damage to package is suspected, cordon 5 m area around the package. 5. Notify the authorities listed below.
First Aid	:	1. Obtain medical assistance, if needed. 2. Obtain the names and addresses of persons, if any, involved in the incident and convey the particulars to the authorities listed below
Notification	:	NERA – ECR Consignor

TABLE 1

EXAMPLES OF RADIOACTIVE MATERIALS FOR WHICH ACCIDENT DOSE ESTIMATES WERE MADE

Radionuclde	Type of radioactive material	Activity TBq	Type of package
^{60}Co	Teletherapy	222	Type B(U)
	Brachytherapy	1.85	Type A
	Gamma irradiator sources	3700	Type B(U)
^{192}Ir	Industrial radiography sources	3.7	Type B(U)
^{232}Th	Low Specific Activity thorium compounds	0.023	IP-1
^{99}Mo	Radiopharmaceutical	0.007	Type A
^{131}I	Radiopharmaceutical	0.007	Type A

TABLE 2

LEVELS OF EMERGENCY DERIVED ON THE BASIS OF ASSESSED COLLECTIVE DOSE VALUES DUE TO TRANSPORT ACCIDENTS

Level of Emergency	Estimated dose range (personSv), S_E	Shipment details	
1	$S_E \leq 10^{-2}$	^{60}Co (BT)	R,S
		^{192}Ir (IR)	R,S
2	$10^{-2} < S_E \leq 1$	^{60}Co (TT)	R,S,U
		^{60}Co (GI)	R,S
		^{60}Co (BT)	U
		^{192}Ir (IR)	U
3	$1 < S_E \leq 10$	^{232}Th (LSA)	R,S
		^{99}Mo (RP)	U
4	$10 < S_E$	^{232}Th (LSA)	U
		^{60}Co (GI)	U

Note 1. BT: Brachytherapy source TT: Teletherapy source RP: Radiopharmaceutical GI: Gamma Irradiator source IR: Industrial Radiography source

Note 2. The collective dose from a consignment depends upon the population zone where the accident occurs. The zones and the corresponding range of calculated dose values are identified in the table. R:Rural S:Suburban U:Urban

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