Appendix A

Operational Exposure Guidance

Operational exposure guidance gives the commander a flexible system of radiation exposure control. OEG procedures aid in the successful employment of a unit on a contaminated battlefield, while keeping the exposure of personnel to a minimum. Radiation exposure must be controlled to the maximum extent possible consistent with the mission. If exposure control is ignored, the results could be disastrous. Establishing and using OEG helps the commander keep radiation exposures to a minimum and still accomplish the mission. OEG is the key for reducing casualties in radioactive fallout areas.

All nuclear radiation, even in small doses, has some harmful effect on the body. It should be avoided whenever possible, without interfering with military operations.

It is not possible to give the commander hard and fast rules on radiation exposure. We cannot say that 20 cGy of radiation will not affect the unit. The unit may have been exposed to radiation previously. If the unit has had previous exposure and receives another 20 cGy of radiation, there may be casualties. This is why RES must be maintained. Establishing OEG must be based on a unit's prior exposure. The commander establishes an OEG for each tactical operation.

Establishing one numerical value or acceptable degree of risk as an OEG for all subordinate units throughout a campaign would be meaningless. An OEG must be established for each unit and each operation. It must be based upon the radiation exposure status of the unit at that time and on the combat situation.

The commander can decide which unit to select for a given mission based on the OEG. Each level of command uses the OEG system to select the best unit to conduct a mission. The commander is assured the troops will receive the least amount of injuries or sickness possible. Commanders put OEG in all operation orders. All command and staff agencies use OEG and RES to accomplish the mission while minimizing radiation exposure.

Based on the OEG, a unit can determine the turn-back dose (D_{tb}) and turn-back dose rate (R_{tb}) for a military operation (such as a radiological survey):

$$D_{tb} = \frac{(OEG) - \text{previous exposure}}{(2)}$$

$$R_{tb} = \frac{2 \times (OEG - \text{previous exposure}) \times \text{speed}}{\text{distance}}.$$

If the dosimeter reading indicates a turnback dose and the dose rate is still increasing, the unit should immediately leave the contaminated area by the same route it used to enter the area. If the dose rate is decreasing, the commander must decide whether to continue through the contaminated area (then return to the unit by a clean route) or immediately leave by the same route used to enter the area. This may conflict with some basic rules of tactics or recon, but it must be done to minimize casualties.

Categories of Exposure

Effective use of radiation exposure records permits rapid determination of a unit's potential to operate in a radiologically contaminated area. Dose criteria has been established in four categories. Radiation Exposure Status-0 (RES-0), Radiation Exposure Status-1 (RES-1), Radiation Exposure Status-2 (RES-2), and Radiation Exposure Status-3 (RES-3). Dose criteria is shown in Tables A-1 and A-3 (page A-5) for each category. This information is based on the best available estimates on predicting the effects of radiation exposure.

Table A-1. Radiation exposure status categories.

RES-0	The unit has not had any radiation exposure.
RES-1	The unit has been exposed to greater than 0 cGy but less than or equal to 70 cGy.
RES-2	The unit has been exposed to greater than 70 cGy but less than or equal to 150 cGy.
RES-3	The unit has been exposed to greater than

Risk Criteria

The degree-of-risk concept helps the commander to establish an OEG for a single operation and minimize the number of radiation casualties. By using the RES categories (Table A-1) of subordinate units and the acceptable degree of risk, the commander establishes an OEG based on the degree of risk (Table A-3, page A-4). There are three degrees of risk-negligible, moderate, and emergency. Each risk can be applied to radiation hazards from enemy or friendly weapons, or both, and from initial nuclear radiation from planned friendly supporting fire.

Degrees of risk are defined in percentages of either casualties or performance degradation. From a radiation standpoint, the effect causing performance degradation (but not casualties) is vomiting. This is commonly called a nuisance effect. Degrees of risk for radiation are discussed in following paragraphs. (See FM 101-31-1 for a complete discussion of degrees of risk, to include blast and thermal effects.)

Before beginning this discussion, let's first look at what a casualty is and what nuisance effects are. A casualty is defined as an individual whose performance effectiveness has dropped by 25% from normal. Specific measures of performance depend upon the task. This, of course, implies that an individual casualty status may depend on the task assigned.

The casualty data presented next is based on a 50% confidence level that the unit is at 75% performance decrement. Nuisance effects can range from vomiting, skin burns, and ear drum rupture to nausea. These symptoms, at low radiation levels, may take hours to develop. Individuals thus exposed should be able to function in the important hours after a nuclear attack and after the first set of symptoms abate. This performance decrement is further explained in Figure A-1, parts 1 and 2 (next page).

Negligible Risk

Negligible risk is the lowest risk category. The dose is 0 to 50 cGy for personnel in RES-0. This dose will not cause any casualties. Troops receiving a negligible risk dose will experience no more than 2.5 percent nuisance effects. Negligible risk is acceptable when the mission requires units to operate in a contaminated area. Negligible risk should not be exceeded unless a significant advantage will be gained.

Moderate Risk

Moderate risk is the second risk category. The dose is 70 cGy for personnel in RES-0. This dose generally will not cause casualties. Troops receiving a moderate risk dose will experience no more than 5 percent incidence of nuisance effects. Moderate risk is usually acceptable in close support operations. Moderate risk must not be exceeded if troops are expected to operate at full efficiency.

Emergency Risk

Emergency risk is the final risk category. The dose is 150 cGy. In this category, not more than 5 percent casualties are expected. Nuisance effects may exceed the 5 percent level. The emergency risk dose is only acceptable in rare situations, termed disaster situations. Only the commander can decide when the risk of the disaster situation outweighs the radiation emergency risk.

To better understand the relationship between the risk categories and the dose rate received, see Table A-2 (pages A-3 & -A4). The table data are not intended for use in determining operational exposure guidance or categories of risk. That information is contained in Table A-3 (page A-4). Table A-3 shows the relationship of the categories of exposure and the degree of risk categories. It also shows the possible exposure criteria for a single operation that will not exceed the dose criteria for a stated degree of risk,

The risk criteria for the RES-1 and RES-2 categories are based on assumed average exposures for units in RES-1 and RES-2 (40 cGy for RES-1, and 110 cGy for RES-2). This criteria should be used only when the numerical value of the total past cumulative dose of a unit is unknown. When the cumulative dose within a category is known, subtract the known dose from the RES-0 criteria for the degree of risk of concern.

For example, if a unit in RES-1 received 30 cGy, it may receive an additional dose of 20, 40, or 120 cGy, respectively, before exceeding the negligible, moderate, or emergency dose.

Radiation Exposure Records

The OEG concept requires that radiation exposure records be maintained by all units. Because platoons are usually located in areas of equal radiation levels, the most realistic unit exposure data are based on readings obtained at the platoon level. Radiation exposure records are maintained at all levels.

Battalion S1, in coordination with the battalion NBC staff, maintains RES records for all assigned and attached units. The records are based on platoon level data received daily or after a mission in a radiologically contaminated area. Unit SOP indicates specific reporting procedures. Monthly records are maintained according to unit SOP.

Figure A-2 (page A-5) shows a suggested way of maintaining RES data for each company within a battalion (companies maintain records by section). A blank radiation exposure chart, DA 1971-6-R, is in Appendix H.

Processing DATA

The data from each platoon-size element are passed to the unit NBC defense team. Readings from tactical dosimeters (IM93s or DT236s) are averaged by the defense team on a daily basis, and an informal record maintained at platoon and company level (Figure A-2 page A-5). The IM93s, which work on the principle of the electrical collection of ions, are recharged after each report is submitted or every three days, whichever occurs first. For the DT236, prior to nuclear operations, each unit will read 10 percent of the total number of DT236 weekly to ensure no leakage has occurred. After nuclear operations have commenced in the theater of operations, one third of the total number of DT236s will be read daily. The DT236s have a response time of 24 hours and ± 30% accuracy. This is due to the process by which the DT236 records radiation levels.

(Text continued on page A-6)

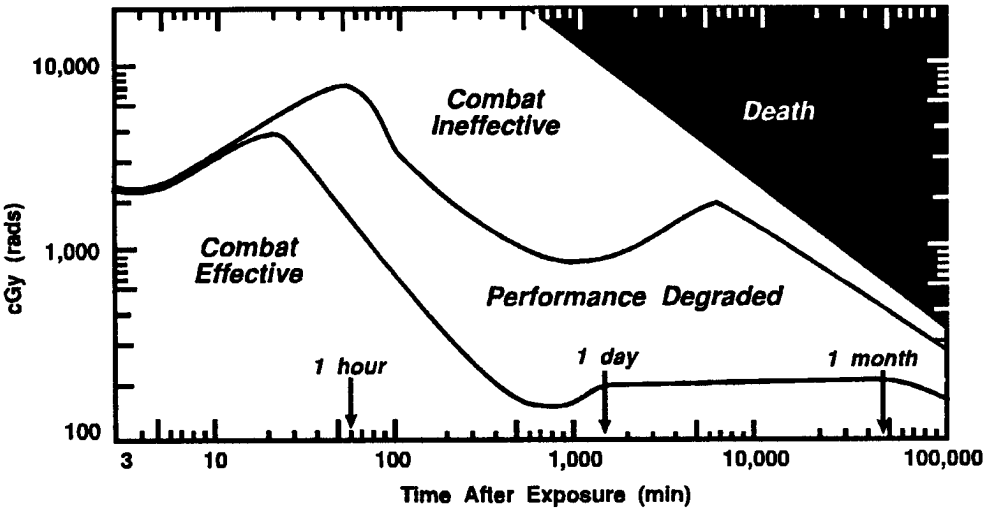

Figure A-1, Part 1. Combat effectiveness for physically demanding tasks after exposure to ionizing radiation.

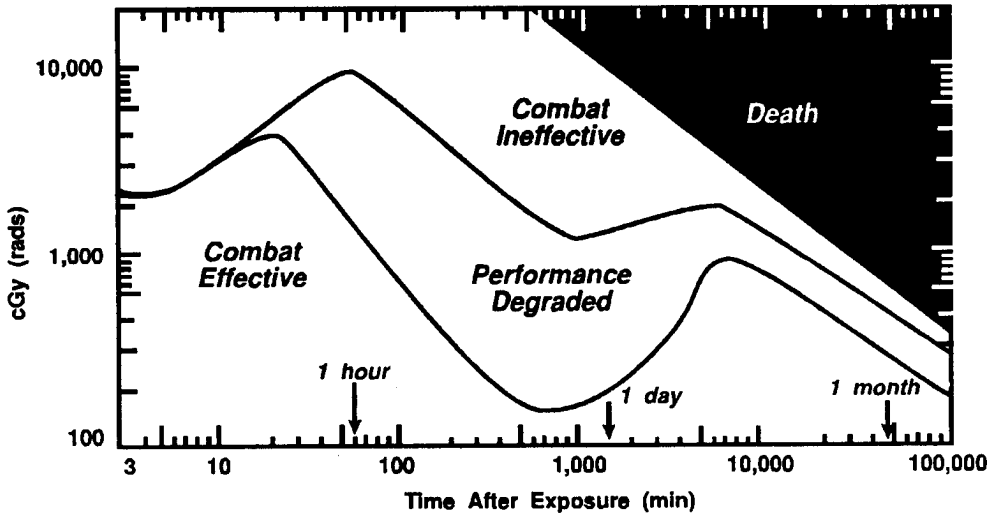

Figure A-1, Part 2. Combat effectiveness for nonphysically demanding tasks after exposure to ionizing radiation.

Table A-2. Effects of radiation exposure on combat personnel.

Dose Range (cGy)	Initial Symptoms	Approx Time of Initial Symptoms (beginning-ending)	Performance Capability (mid-dose range)	Final Disposition
0 to 70	None to slight incidence of transient headache and nausea. Vomiting in up to 5% of personnel in upper range.	6 to 12 hours	Combat effective	Duty
70 to 150	Transient mild nausea vomiting in 5%--30% of personnel. Vomiting in up to 5% of personnel in upper part of range.	2 to 20 hours	Combat effective	Duty: No deaths.
150 to 300	Transient mild to moderate nausea and vomiting in 20%--70% of personnel. Mild to moderate fatigue and weakness in 25%--60% of personnel.	2 hours to 2 days	DT: PD from 4 hours til recovery. UT: PD from 6 hours to 1 day then 6 weeks til recovery.	Duty: Less than 5% deaths at low end of exposure range; death may occur in 10% of personnel.
300 to 500	Transient moderate nausea vomiting in 50%--90% of personnel. Moderate fatigue in 50%--90% of personnel.	2 hours to 3 days	DT: PD from 3 hours to 2 weeks, til death or recovery. UT: PD from 4 hours to 2 weeks or until death or recovery.	Duty at low end of exposure range; less than 10% deaths. At high end of exposure range, death may occur in more than 50% of personnel after 4 weeks.
500 to 800	Moderate to severe nausea and vomiting in 80%--100% of personnel. Moderate to severe fatigue and weakness in 90%--100% of personnel.	Within 1 hour 2 hours to at least 6 weeks	DT: PD from 2 hours to 3 weeks; CI from 3 weeks til death. UT: PD from 2 hours to 2 days then 7 days to 4 weeks.	At low end of exposure range, death may occur in more than 50% of personnel beginning, after 4 weeks. At high end of exposure range, 99%, beginning after 3 weeks.
800 to 1,500	Moderate to severe nausea, vomiting, dizziness, disorientation in 100% of personnel; moderate fluid loss in 80% of personnel.	45 minutes to 2½ days	DT: PD 1 hour to 6 hours then 1½ days to 1 week; CI up to 6 hours then 1½ days to 1 week until death. UT: PD 1½ hours to 8 days; CI 8 days til death.	1,000 cGys—death in 1 to 3 weeks

Continued

LEGEND: DT—demanding task
UT—undemanding task
PD—performance decrement (25%--70% of pre-irradiation performance level)
CI—combat ineffective (less than 25% of preirradiation performance level)

Table A-2 continued.

Dose Range (cGy)	Initial Symptoms	Approx Time of Initial Symptoms (beginning-ending)	Performance Capability (mid-dose range)	Final Disposition
	Severe fatigue and weakness in 100% of personnel.	2 hours til death (1 to 3 weeks).		
1,500 to 3,000	Severe nausea, vomiting, fluid loss, and headache in 100% of personnel. Severe fatigue, weakness, dizziness, disorientation in 100% of personnel.	30 minutes to 3 days 1 hour til death (5 to 12 days)	DT: PD 30 minutes to 2½ hours til death. UT: PD 45 minutes to 5 days; CI 5 hours til death.	2,500 cGy—death in 5 to 12 days
3,000 to 8,000	Severe nausea, vomiting, fatigue, weakness, dizziness, and disorientation, fluid imbalance, and headache.	15 minutes to 5 days	DT/UT: CI 3 minutes to 30 minutes; PD 30 minutes to 90 minutes; CI 90 minutes til death.	4,500 cGy—100% death at 2 to 3 days

LEGEND: DT—demanding task PD—performance decrement (25-70% of preirradiation performance level).
UT—undemanding task CI—combat ineffective (less than 25% of preirradiation performance level).

Table A-3. Nuclear radiation exposure status and degree of risk exposure.

Radiation Status Category[A & B]	Total Past Cumulative Dose[C] (cGy)	Possible Exposure Criteria, for a single operation that will not result in exceeding the dose criteria for the stated degree of risk [D & E] (cGy).
RES-0 Units	No exposure	Negligible risk: ≤ 50 Moderate Risk: ≤ 70 Emergency Risk: ≤ 150
RES-1 Units	More than 0, but less than or equal to 70	Negligible risk: ≤ 10 Moderate Risk: ≤ 30 Emergency Risk: ≤ 110
RES-2 Units	More than 70 but less than or equal to 150	Any further exposure is considered to exceed a negligible or moderate risk. Emergency Risk: ≤ 40
RES-3 Units	More than 150	Any further exposure will exceed the emergency risk.

Notes:
A. Radiation status categories are based on previous exposure to radiation.
B. Reclassification of units from one radiation status category to a less serious one is made by the commander, upon advice of the surgeon, after ample observation of actual state of health of exposed personnel.
C. All exposures to radiation are considered total body and simply additive. No allowance is made for body recovery from radiation injury.
D. Risk levels are graduated within each status category to provide more stringent criteria as the total radiation dose accumulated becomes more serious. The exposure criteria given for RES-1 and RES-2 units should be used only when the numerical value of a unit's total past cumulative dose is unknown.
E. Each of the degrees of risk can be applied to radiation hazards resulting from enemy or friendly weapons, or both, and from initial nuclear radiation resulting from planned friendly supporting fire.

DATE: *23 July 9X*
UNIT: *B/4-14 FA*

Radiation status category	Numerical criteria Total cumulative dose (cGy)
RES - 0	0 = (no exposure)
RES - 1	1 = Greater than 0, but less than or equal to 70
RES - 2	2 = Greater than 70, but less than or equal to 150
RES - 3	3 = Greater than 150

Radiation Exposure Chart

ELEMENT	Previous Exposure	New Exposure	Total Exposure	RES Category
HQ Plt	*25*	*40*	*65*	*1*
1st Plt	*20*	*20*	*40*	*1*
2d Plt	*40*	*40*	*80*	*2*
3d Plt	*10*	*20*	*30*	*1*
Spt Plt	*30*	*10*	*40*	*1*

Radiation status category of company or battalion	Number of platoons in company or number of companies in battalion: 2	3	4	5	6	7
	Sum of RES numbers of all platoons or companies					
RES - 0	0	0-1	0-1	0-2	0-2	0-3
RES - 1	1-2	2-4	2-5	3-7	3-8	4-10
RES - 2	3-4	5-7	6-9	8-12	9-14	11-17
RES - 3	5-6	8-9	10-12	13-15	15-18	18-21

Category Total *6*

Overall Status *1*

Figure A-2. Example of completed radiation exposure chart.

The DT236 uses the process of scintillation, or the conversion of radiation into detectable light, to record gamma; and the process of a solid state semi-conductor for neutron radiation. The solid-state semi-conductor must be heated to obtain a radiation dose reading. Therefore, those DT236s read directly after a nuclear burst will not show the true amount of radiation received. During this response time, readings should be obtained with the IM93 dosimeters and used for planning purposes once the 24 hours has elapsed. The readings from the DT236 will be used for determining unit RES. After recording all platoon information, the company reports platoon and company status to the battalion according to its SOP.

Battalion records and maintains the status on each platoon, company, and attached elements. An overall battalion status is reported to the S3 or placed on the daily briefing chart. Battalion then forwards the company and overall battalion status to brigade.

Brigades maintain records on all company-size elements as well as battalion overall RES. This information generally is collected at the brigade administrative and logistics center (ALOC) with the brigade S1. Brigade NBC personnel must ensure this information is collected, tabulated correctly,

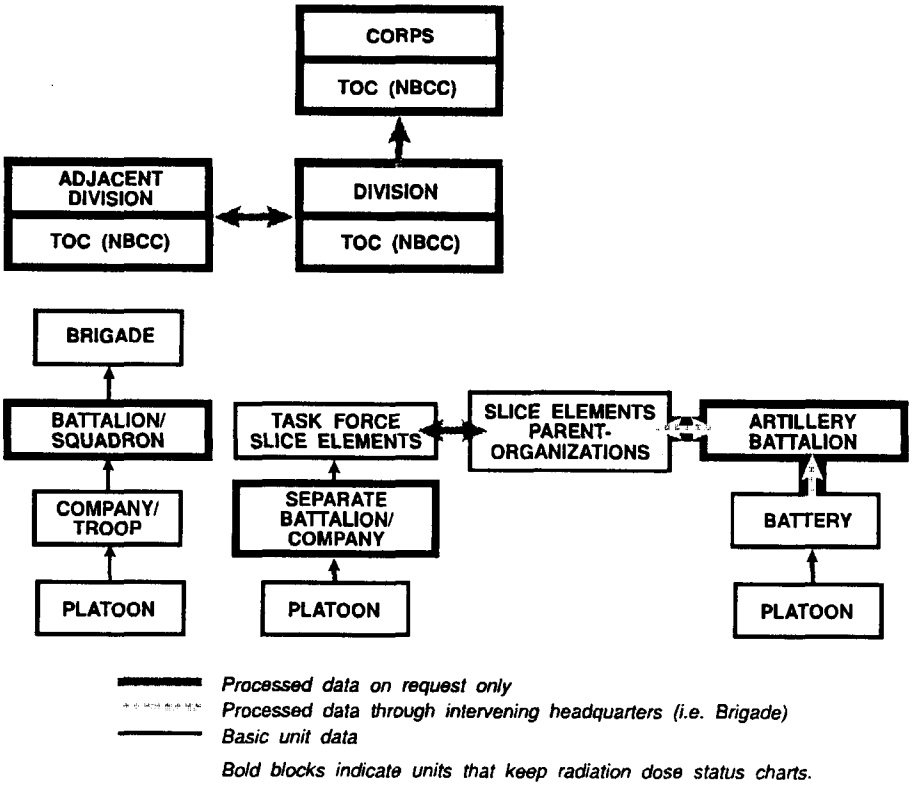

Figure A-3. Typical flow of dosimetry information within a division.

and maintained. Typical flow of dosimetry within a division is shown in Figure A-3.

In the example, total exposure begins with the records of the previous day. The new exposure occurred in the past 24 hours. The RES category for each unit or element is determined from Table A-3. Overall status of the battalion is determined from the same table.

Since the platoon is the lowest level at which radiation exposure records are kept, replacements should be at platoon level. An ineffective platoon is either pulled out of a company, or the personnel are reassigned to different platoons with the same RES. A new platoon is then assigned to the company.

This creates severe management problems for personnel replacement. All levels of command must follow these procedures. It may be difficult, but it keeps personnel from becoming incapacitated due to overexposure to radiation.

Individual Dosimetry

The following information concerns unit dosimetry. As an interim measure until the Army issues the DT236 individual dosimeters to each soldier, the dose of the soldier is assumed to be the same as the platoon or similar size unit to which the soldier is assigned. When reassigned or evacuated through medical or other channels, the soldier's dose will be assumed to be the same as the platoon or similar-size unit to which last assigned. A notation of this status (RES-0, RES-1, RES-2, RES-3) will be made on the soldier's official records for formal record of radiation exposure when the individual is passed on to a gaining unit.

The following is an example of employment of an operation exposure guide:

It is 6 October. The battalion commander plans to commit Company B on 7 October in a radiologically contaminated area. He will accept a moderate risk. The radiation dose status chart (Figure A-4) is checked, and the radiation status of Company B is determined to be RES-1.

The commander notes from Table A-3 that a RES-1 unit may receive a dose less than or equal to 30 cGy and not exceed a moderate risk. Therefore, he establishes an OEG of no more than 30 cGy for Company B in this operation. He then examines the estimate of hazard shown on the contamination chart provided by the division NBCC. If it does not exceed the OEG, he consults with the S3 and the surgeon concerning the potential of B Company's personnel for successful accomplishment of the mission under the conditions contemplated. The steps discussed above usually precede finalization of an operations plan and are accomplished routinely through normal staff action.

DATE: *30 OCT 9X*

UNIT: *B Company*

Radiation status category	Numerical criteria Total cumulative dose (cGy)
RES - 0	0 = (no exposure)
RES - 1	1 = Greater than 0, but less than or equal to 70
RES - 2	2 = Greater than 70, but less than or equal to 150
RES - 3	3 = Greater than 150

Radiation Exposure Chart

ELEMENT	Previous Exposure	New Exposure	Total Exposure	RES Category
B1	*20*	*20*	*40*	*1*
B2	*20*	*20*	*40*	*1*
B3	*0*	*0*	*0*	*0*
B4	*20*	*0*	*20*	*1*

Radiation status category of company or battalion	Number of platoons in company or number of companies in battalion: 2	3	4	5	6	7
	Sum of RES numbers of all platoons or companies					
RES - 0	0	0-1	0-1	0-2	0-2	0-3
RES - 1	1-2	2-4	2-5	3-7	3-8	4-10
RES - 2	3-4	5-7	6-9	8-12	9-14	11-17
RES - 3	5-6	8-9	10-12	13-15	15-18	18-21

Category Total *3*

Overall Status *1*

Figure A-4. Radiation dose status chart, month 10.