Radiological Emergency Preparedness Handbook

Minnesota Division of Emergency Management
Radiological Emergency Preparedness

LAST REVISION 7/20/01

Forward

The purpose of the Radiological Emergency Preparedness (REP) program is to protect the public and emergency workers from the adverse effects of radiation due to an incident at a commercial nuclear generating plant. Even though there have been no injuries to the public caused by an incident at a commercial nuclear generating plant in the United States, a variety of organizations must be ready with a coordinated response. The Minnesota Emergency Operations Plan per the Governor's Executive Order delegates specific responsibilities to the state agencies that have the expertise to carry out specific actions during an incident at a commercial nuclear generating plant. Counties within a ten-mile planning zone around the nuclear power plant have emergency operations plans and specific procedures that activate and guide various local resources. These plans and procedures are reviewed annually by the Federal Emergency Management Agency (FEMA) to ensure that federal standards are met. Annual training, drills, and exercises ensure that personnel, equipment, and facilities are ready to meet any challenge.

The information in the "Radiological Emergency Preparedness Handbook" is intended to compliment training for responders by enhancing knowledge of the program. This handbook does not supercede instructions or steps found in procedure and plans. Comments and questions may be addressed to:

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NOTE: This handbook has been annotated with recent information about KIO3. The annotated information is clearly shown in brackets [new info] and was added to this handbook in OCTOBER, 2002.

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Table of Contents

Chapter 1

Nuclear Power in Minnesota Page

Nuclear Power Plants in Minnesota 1-1
General Nuclear Power Plant Layout 1-2
Boiling Water Reactors (BWRs) 1-3
Pressurized Water Reactors (PWRs) 1-4
Radioactive Barriers 1-5
Fuel Damage in Relation to Fuel Pin Temperatures 1-6
Offsite Accident Consequences 1-7
Emergency Classification Levels 1-8
Protective Action Recommendations (PAR) 1-11
Emergency Planning Zones (EPZs) 1-12
Emergency Radiological Guidance for the General Public 1-13

Chapter 2

Radiation Basics

Types of Radiation 2-1
Radiation Units 2-2
Unit Prefixes 2-3
Radioactive Decay 2-4
Radiation Doses in Perspective 2-5
Typical Radiation Exposure Levels 2-7
Radiation Protection Methods 2-8
Exposure vs. Contamination 2-8
Radiological Guidance for Emergency Responders 2-9
Radiation and Health Effects 2-10
Acute Effects of Radiation Dose 2-11

Table of Contents (continued)

Chapter 3
Radiological Protection

Instrument Overview	3-1
Self Reading Dosimeter	3-2
Dosimeter Charger	3-3
Thermoluminescent Dosimeter (TLD)	3-4
Potassium Iodide [and Potassium Iodate] (KI and KIO3)	3-5
CD V-700	3-6
CD V-715	3-7
Eberline E-120	3-8

Chapter 4
Government and Utility Roles

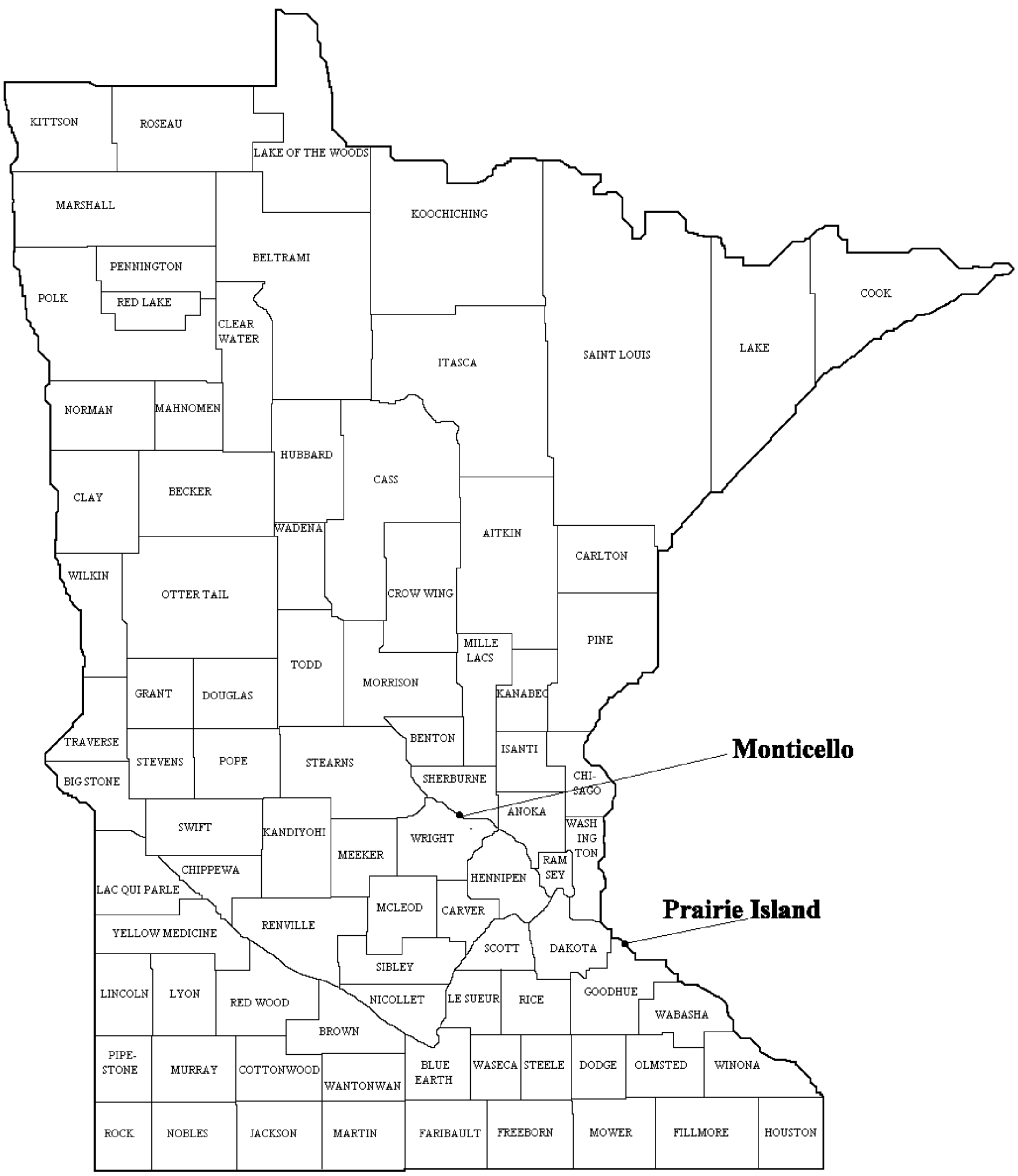
Government and Utility Roles	4-1
Federal Government	4-1
State of Minnesota	4-2
Counties	4-3
Utility	4-4
County Activities by ECL	4-4

Glossary i

Abbreviations Used In Radiological Emergency Preparedness (REP) xii

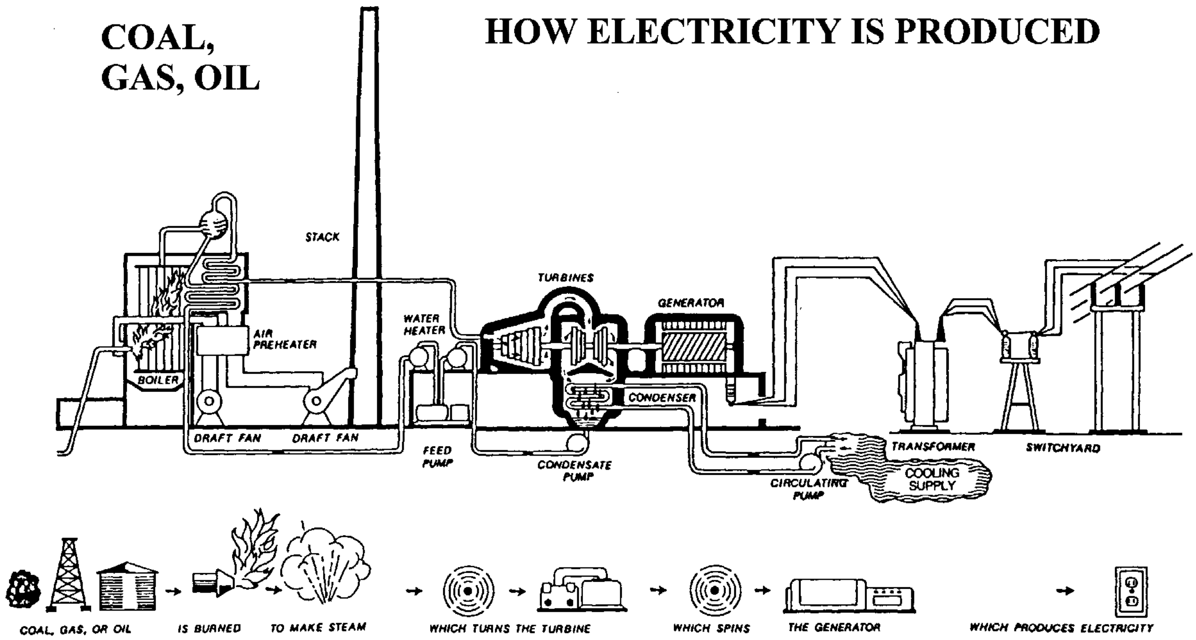
NUCLEAR POWER PLANTS IN MINNESOTA

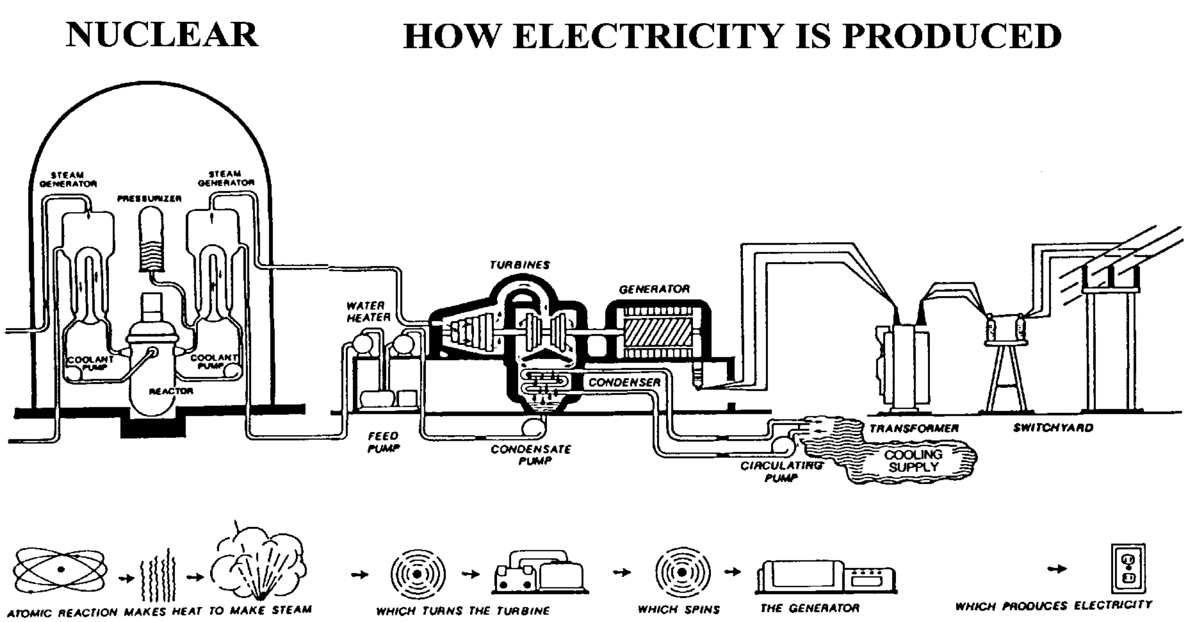
Minnesota has two commercial power plants. They are located in Monticello and Welch (near Red Wing). Both are owned by Xcel Energy (formerly NSP) and operated by the Nuclear Management Company (NMC). The Monticello plant operates a single boiling water reactor (BWR) that produces 569 Mw of electricity and has been online since 1971. The Prairie Island plant operates twin pressurized water reactors (PWR) that produce a combined 1,040 Mw of electricity. Unit 1 has been online since 1973 and unit 2 since 1974.



GENERAL NUCLEAR POWER PLANT LAYOUT

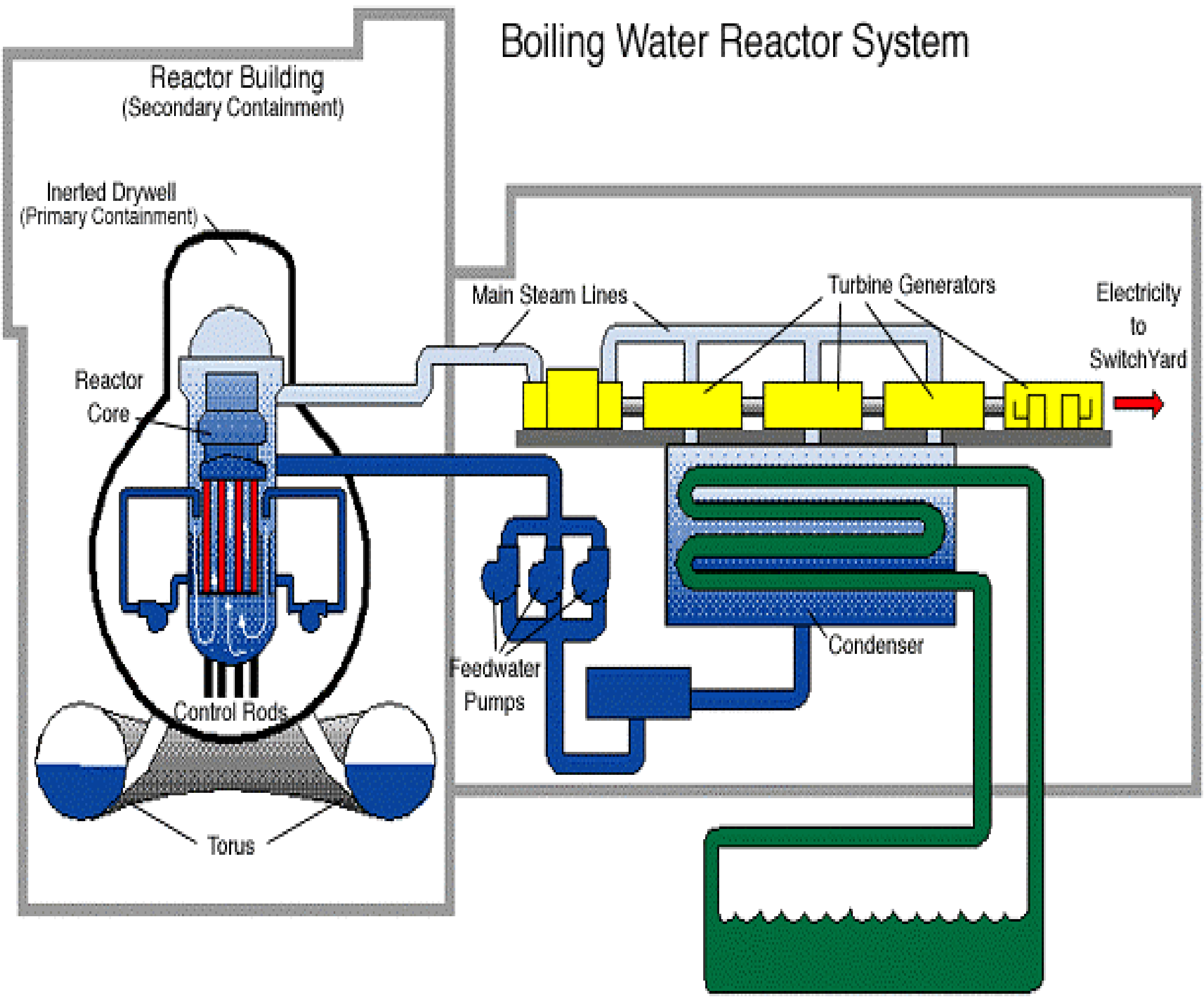
A nuclear power plant is very similar to a fossil fuel power plant. Both use a heat source to boil water. The boiling water creates steam, which spins a turbine. The turbine is connected to an electrical generator, which generates electricity. Nuclear power plants use uranium as the heat source instead of fossil fuels. The uranium atoms are spilt to produce heat. This reaction is call fission. Since this reaction also releases radiation three barriers shield the reactor.





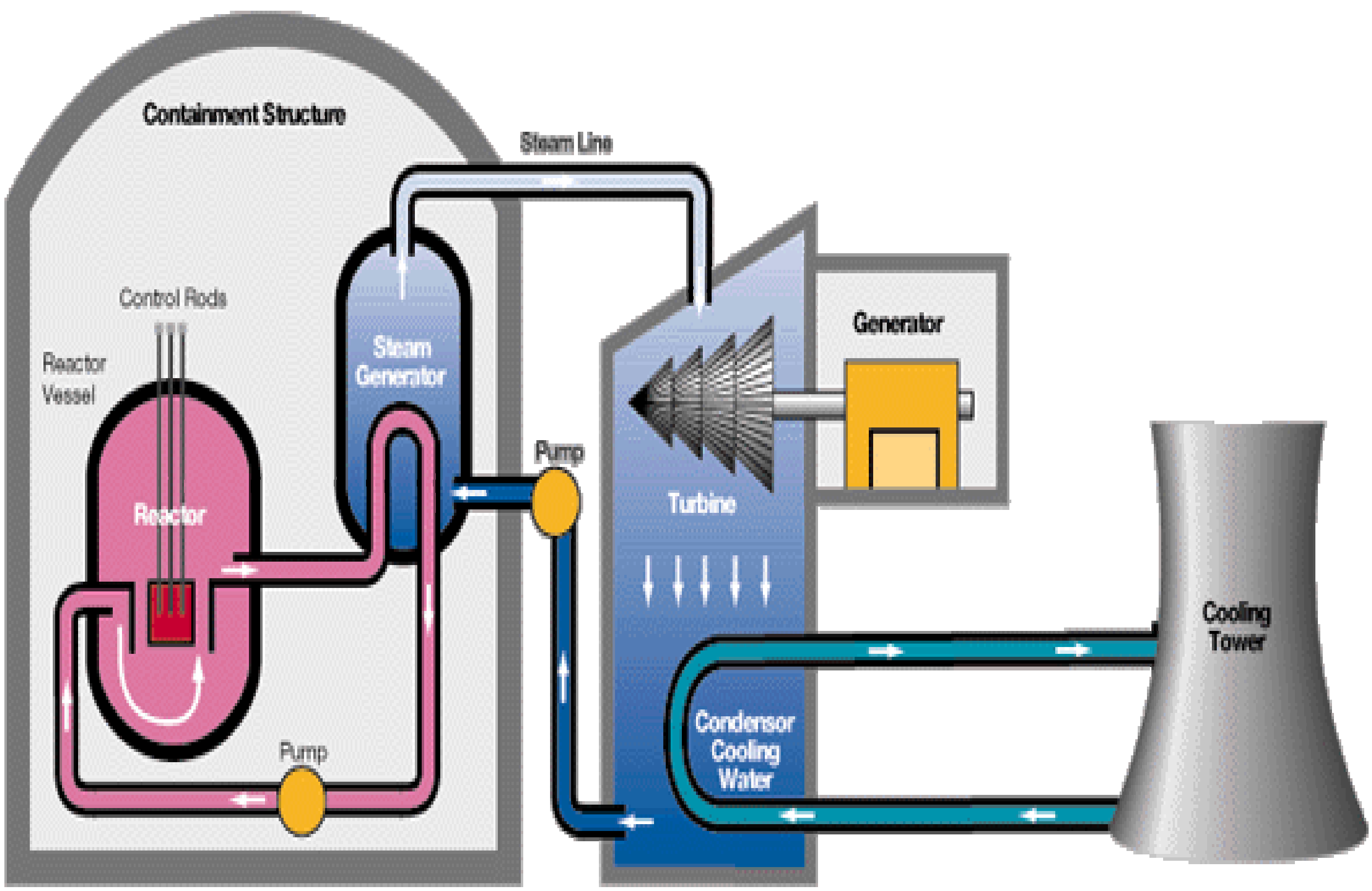
BOILING WATER REACTORS

In the boiling water reactor water is circulated through the reactor core picking up heat as the water passes through the fuel assemblies. When heated sufficiently the water turns to steam and is removed by the steam separators in the upper part of the reactor. The steam then goes through the main steam lines to the turbine-generator where it produces electricity. After this the steam is condensed in the condenser, which is at a vacuum and is cooled by river water. After it has been cooled it is pumped back into the reactor to start the process all over again.



PRESSURIZED WATER REACTORS

The pressurized water reactor (PWR) is made up of three separate cooling systems. In the first system, the reactor heats the water, which is under high pressure (2250psi) and is not allowed to boil. This water is pumped to the steam generator and passes through tubes. In the second cooling system the heat from the first cooling system is transferred to the water and is turned to steam. This steam turns the turbine and generates electricity. Water from the Third cooling system is pumped through the condenser and removes the heat from the second cooling system. In this system only the first cooling system is expected to have radioactivity.



RADIOACTIVE BARRIERS

There are three barriers in nuclear power plants that are designed to prevent a release of radioactive materials to the environment. The first barrier is the fuel cladding/fuel rods. The reactor vessel and primary coolant system piping make up the second barrier. The last barrier is the containment building.

The First Barrier: Fuel Rod-Fuel Pin

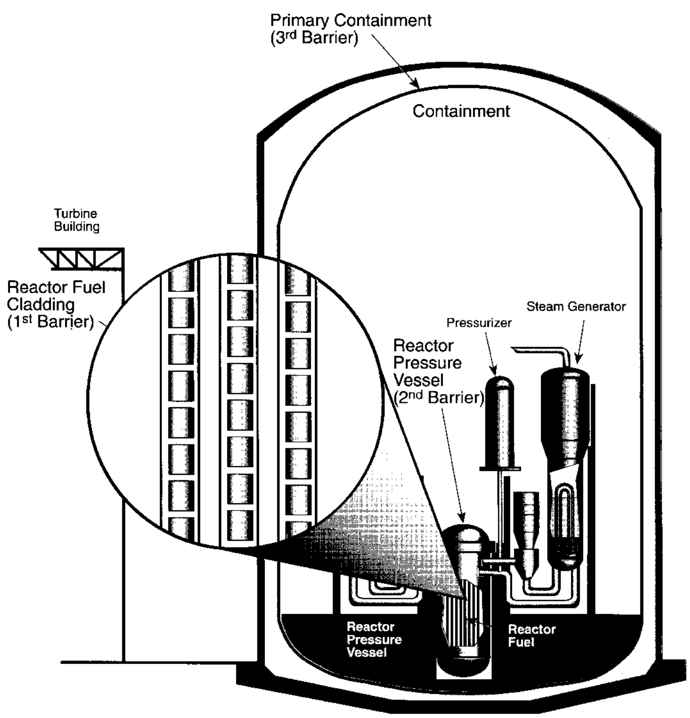
The Fuel pellets are placed inside the fuel rods or fuel pins. The rods or pins are made of zirconium or stainless steel, which act as the first barrier. These fuel rods are assembled into bundles and are contained within the reactor core. With this first barrier there can be no major release without damage to the fuel pin or rod.

The Second Barrier: Primary Coolant System

The reactor vessel and the primary coolant system piping make up the second barrier. The Primary coolant system holds the water that cools the core. This barrier must fail before there is core damage.

The Third Barrier: The Containment Building

The containment building is made up of thick reinforced concrete. It is designed to withstand a break in the primary coolant system. It can reduce the fission product by use of sprays, pools, and filters. Finally it can remove long-term decay heat through sprays, recirculation, and coolers



Fuel Damage In Relation To Fuel Pin Temperature

When the reactor core is uncovered the temperature will begin to rise and begin to cause damage to the fuel rods. If temperatures reach 1400° C the fuel cladding is expected to fail. When this occurs radioactive material will be released from the core to the primary coolant (secondary containment). At Temperatures greater than 1400°C severe core damage is expected.

Fuel damage progression vs. Average fuel pin temperature

Time After Uncovery	Temperature	
45-90 min	3000°C	melting of fuel pellets (UO_2) possible melt through of vessel
	2500°C	Release of all volatile fission products
30-60 min	2300°C	Possible formation of uncoolable core
	2000°C	Formation of "liquefied fuel; fuel dissolves in melted components
20-40 min	1700°C	very rapid release of iodine, cesium, and noble gases
	1400°C	Very rapid steam - zircalloy reaction release of H_2 and failure of fuel cladding
10-20 min	1000°C	Possible cladding burst - release of fission products in fuel gap
	315°C	Normal operating temperature

souce: NRC Reactor Accidents Training Modle I-from EMI accident assessment course -E350

OFFSITE ACCIDENT CONSEQUENSES

The severity of impact to offsite areas will differ based on the severity of the accident. The severity is contingent on two factors: status of the reactor core and status of the reactor containment barriers.

Conditions			Results	
			Distace at which EPA early phase PAGs exceeded	Threshold for acute health effects[a]
Core	Release		Miles	Exceeded
Spikes or no damage	•Lesser coolant release (50 GPM)		None	None
	•Major coolant release (>500 GPM)		<2	None
Gap Release (uncovered 15-30min)	•Design leak in containment		None	None
	•Major leak in containment		<5	None
	•Total failure of containment		>10	Thyroid effects
Melted or severely heated (uncovered >30min)	•Design leak in containment		<2	None
	•Major leak in containment		>10	Thyroid effects
	•Total containment failure > 2hr after release from vessel	mitigated[b] or unmitigated	>10	Radiation sickness
	•Total containment failure < 2hr after release from vessel	Mitigated[b]	>10	Radiation sickness
		Unmitigated	>10	Deaths

[a]Effects from high dose rates delivered over a short period of exposure at the site boundary

[b]Mitigated by sprays, filters and/or through pool. Release with hold-up times > 2hr are assumed to be mitigated by plateout in containment.

Source: RTM-96 p. C-15

EMERGENCY CLASSIFICATION LEVELS

After the incident at Three Mile Island in 1979, the NRC determined that there was a need for a consistent method of classifying incidents. These classification levels are related to existing plant conditions and emergency action levels.

Notification of Unusual Event (NUE):

The NUE is the lowest level of emergency. At this level there is no threat to public safety or release of radioactive material. At this level the power plant provides notification to the offsite agencies (State Duty Officer and the counties surrounding the plant). Neither the offsite agencies nor utility activate their EOC's at this time. Some examples of an NUE are as follows:

- Coolant system leaking at 5-50 GPM.
- Tornado visible from the plant.
- Attempt made to breach plant security.
- Aircraft crash on site with no danger to structures.
- Loss of containment building integrity.
- River levels >918 ft. or <902 ft. for Monticello and >686 ft. or <672.5 ft. for Prairie Island.
- Airborne or liquid radioactive materials released above limits.
- Fire at the plant lasting more than 10 minutes

Alert:

The alert is the next highest classification level. At this level there is still no threat to the public, but there is an actual or potential for degradation of safety to the plant core. Any releases are expected to be limited to a small fraction of the EPA Protective Action Guideline exposure levels. At this level the State, County and utility EOC's will be activated as well as the JPIC. Also the schools in the 10-mile EPZ are notified. The state field teams are activated. The AG field teams and reception centers are put on standby, and the first EAS message is sent out. Some examples of conditions that would classified as an alert are:

- Coolant system leak at a rate of greater than 50 GPM.
- A tornado has struck a plant structure.
- The plant control room has been evacuated.
- An aircraft has crashed within the protective fence.
- River levels >921 ft. or <900 ft. for Monticello and >692 ft. or <669.5 ft. for Prairie Island.
- Airborne or liquid radioactive release at > 10x allowed limits.
- Fire at the plant that may affect the plant safety systems
- Temporary loss of AC or DC power (both off and onsite).
- Toxic or flammable gasses enter the plant site.

Site Area Emergency (SAE):

The SAE is the third level of emergency classification level. At this level there is actual or potential for major failures of plant functions needed for protection of the public. Also a release, if any, is not expected to exceed EPA Protective Action Guideline exposure levels beyond the plant site boundary. At an SAE the schools, if in session, will be evacuated to their designated reception center, which will also be activated at an SAE. Roadblocks will be established, animals will be sheltered, and a precautionary Protective Action Recommendation maybe issued. The State and counties to free up funds for emergency operations may declare a State of Emergency at this level. Examples of plant conditions that would result in a SAE are:

- Coolant system leaking at greater than pump capacity.
- Sustained winds of > 100mph.
- Plant security has been compromised in such a way as to threaten the plant safety systems.
- An aircraft has crashed into the plant and has damaged the plant safety systems while not in a cold shutdown.
- River levels are >930 ft. or <899 ft. for Monticello and >698 ft. and <666.5 ft. for Prairie Island.
- Both AC and DC power (off and onsite) has been lost for more than 15 minutes.
- Offsite radiation doses are projected or measured at greater than 50mR/hr for more than 1/2 hour or 500mR for 2 minutes.

General Emergency (GE):

The General Emergency is the highest classification level. At this level there is actual or imminent substantial core damage or melting with the potential for the loss of containment integrity. Releases, if any, can be expected to exceed EPA Protective Action Guideline exposure outside the plant boundaries. At a GE protective actions will be implemented. The public will be notified of this through the EAS/EBS system, tone alert radio activation, the sounding of sirens, and route alerting. Also at this ECL level congregate care centers will be setup. Examples of plant conditions that would warrant a GE are:

- Coolant leak in excess of pump capacity with significant fuel damage.
- The loss of two out of three fission barriers with the actual/potential loss of the third barrier.
- Loss of AC power and the steam powered feed water system has failed.
- Plant security has been compromised that has resulted in the loss of physical control of the plant.
- Offsite radiation dose rates exceed 1000 mR/hr.

In addition to these ECLs there are two more conditions:

Media Sensitive Events: A media sensitive event is an event that does not meet the criteria for a NUE, but NMC or the NRC deems it to be of interest to the media or public. During a Media Sensitive event NMC will notify the State and counties as well as making the media contacts.

Rapidly Escalating Events: A Rapidly Escalating Event happens when the first call from the power plant to the state and counties is at the General Emergency ECL. If this happens the State duty officer will select and send out the appropriate EAS message. The Duty Officer will also contact the counties to coordinate the siren activation time. If a rapidly escalating event occurs NMC will recommend, at a minimum, 2 miles 360º and 5 miles down wind PAR.

U.S. ECL OCCURANCES

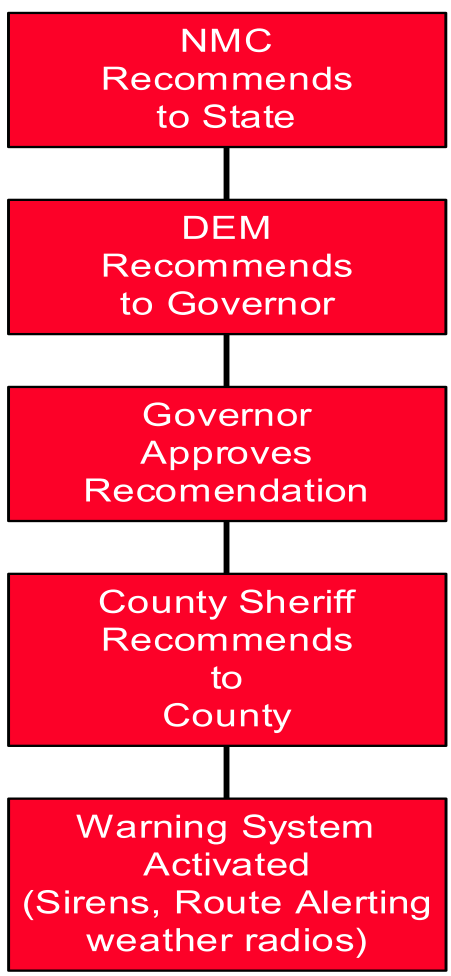
YEAR	NUE	ALERT	SITE AREA	GENERAL
1989	197	13	0	0
1990	151	10	1	0
1991	170	9	2	0
1992	135	20	1	0
1993	103	8	1	0
1994	92	3	0	0
1995	66	8	0	0
1996	63	3	0	0
1997	40	3	0	0
1998	26	4	0	0
1999	34	4	0	0
2000	18	1	0	0

Protective Action Recommendations (PAR)

Protective Actions are activities conducted in response to an incident or potential incident to avoid or reduce the radiation dose to members of the public. If the ECL at the plant escalates to the level of General Emergency, one or more protective actions will be issued. If the event is a Rapidly Escalating Event, a PAR will accompany the first notification from NMC. Some examples of PARs are:

- Evacuation of people in affected areas out to a maximum of 10 miles from the plant.
- Sheltering of people in affected sectors out to a maximum of 10 miles from the plant in unfavorable weather conditions (when evacuation is not practical).
- Sheltering animals in affected areas and place them on stored feed
- Store or process agricultural products to reduce radiation hazard.

PAR Implementation Process



Emergency Planning Zones (EPZs)

The NRC has established two emergency planning zones for planning purposes. To protect the people in these zones the state planning and assessment center in the State EOC may issue a protective action recommendation

They are as follows:

The Plume Exposure EPZ:

This area encompasses a circular area with a ten-mile radius surrounding the power plant. The people in this zone may be directly exposed to radiation during an incident at a power plant. PARs may include:

- Evacuation
- Sheltering in place

The Ingestion Pathway EPZ:

This area encompasses a circular area with a fifty-mile radius surrounding the power plant. The people in this zone may be exposed to radiation by eating or drinking contaminated food, milk, or water. PARs for this EPZ may include:

- Placing farm animals on stored feed and water
- embargoing contaminated foodstuffs
- Store or process agricultural products to reduce radiation hazard

Emergency Radiological Guidance for the General Public

EMEGENCY ACTIONS	STATE OF MINNESOTA	FEDERAL
Monitor Radiation Levels[1]	Above background radiation levels probable	none
Control access to effect areas[2]	Projected doses above 500 mrem	none
Evacuation	1-5 rem (TEDE)[3]	1-5 rem (TEDE)[3]
Administration of Stable Iodine[4]	Not applicable	25 rem (CDE) from radioiodine to the thyroid
Sheltering	Should be considered for doses less than 1 rem or in the case of adverse travel conditions.	Should be considered for doses less than 1 rem or in the case of adverse travel conditions.

[1] Request that the public listen to the media for emergency information
[2] In addition at this stage, evacuation along with details and contingencies should be considered.
[3] Under expected emergency conditions, evacuation should be initiated at a projected dose of 1 rem; under adverse environmental conditions evacuation may be delayed out to 5 rem for the general public and to 10 rem for special groups.
[3] Ibid
[4] The federal guidance states that administering stable iodine to the general public requires the approval of the state medical officer. The State of Minnesota does not plan to do this.

Types of Radiation

Radiation refers to the process of emitting energy either as rays or particles that are generated by disintegrating atoms. Radioactivity refers to the ability to produce this energy. The type of radiation that we are concerned about during a nuclear incident is called " ionizing radiation". It is called ionizing because the atoms have enough energy in the to dislodge electrons from their orbits. When electrons are dislodged ions are produced. The significant types of nuclear radiation produced in a nuclear reactor are alpha, beta, and gamma.

Alpha radiation (α) is the ionized nucleus of a helium atom, containing two protons and two neutrons. Alpha particles are relatively large, heavy, and slow moving compared to the other types of radiation. Due to these factors Alpha Radiation only travels several centimeters in the air. Due to it's relatively large size alpha radiation cannot penetrate skin so is only an internal hazard.

Beta radiation (β) is a particle about the size of an electron emitted from the nucleus of an atom. Beta radiation is small and fast moving and can travel several meters through the air. Due to its size and speed it can penetrate about 1 cm in soft tissue. Therefore beta is both an external and internal hazard.

Gamma radiation (γ) is an electromagnetic wave. Therefore it has no measurable mass or electrical charge. Gamma radiation travels at the speed of light and can travel as far as a mile in air. Gamma radiation can pass through the body and through several inches of lead. Gamma is both an external and internal hazard.

Type of radiation	Range in Air	Average Penetration	Type of Hazard
Alpha	1-2 cm	Superficial	Internal
Beta	1-2 meters	1cm of skin	External & Internal
Gamma	1 mile	Through the body, several inches of lead	External & Internal

RADIATION UNITS

There are four main units used to quantify radiation. The Curie (Ci) is the Unit that is used to describe the strength or activity of radioactive material. It is defined as the quantity of radioactive material in which 37 billion disintegrations per second occur. The Roentgen (R) is the unit of exposure which corresponds to the production of ions by gamma or x-rays in a volume of air. The Rad is the unit of absorbed dose and is the measure of energy deposited in a material by any type of radiation. The Rem is the unit of dose equivalent. The dose equivalent in Rem is numerically equal to the absorbed dose in rad multiplied by a quality factor. The quality factor reflects the ability of a particular type of radiation to cause biological damage. Rem is also called radiation equivalent man or radiation equivalent mammal.

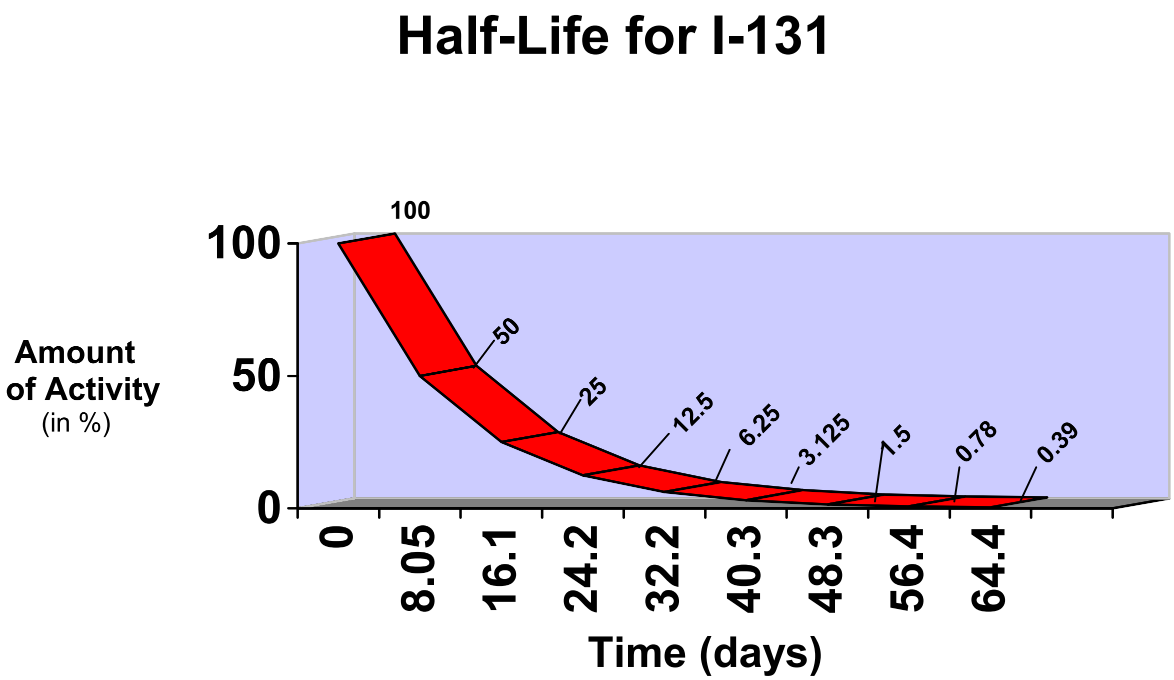
UNIT	SYMBOL	USE
Curie	Ci	Unit of activity
Roentgen	R	Unit of Exposure -only applies to Gamma and X-rays
Rad	rad	unit of dose
Rem	rem	unit of dose equivalent

UNIT PREFIXES

Multiplication factor	Prefix	Symbol
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto	h
10 = 10^{1}	deka	da
1 = 10^{0}	Base unit	
0.1 = 10^{-1}	deci	d
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	μ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p

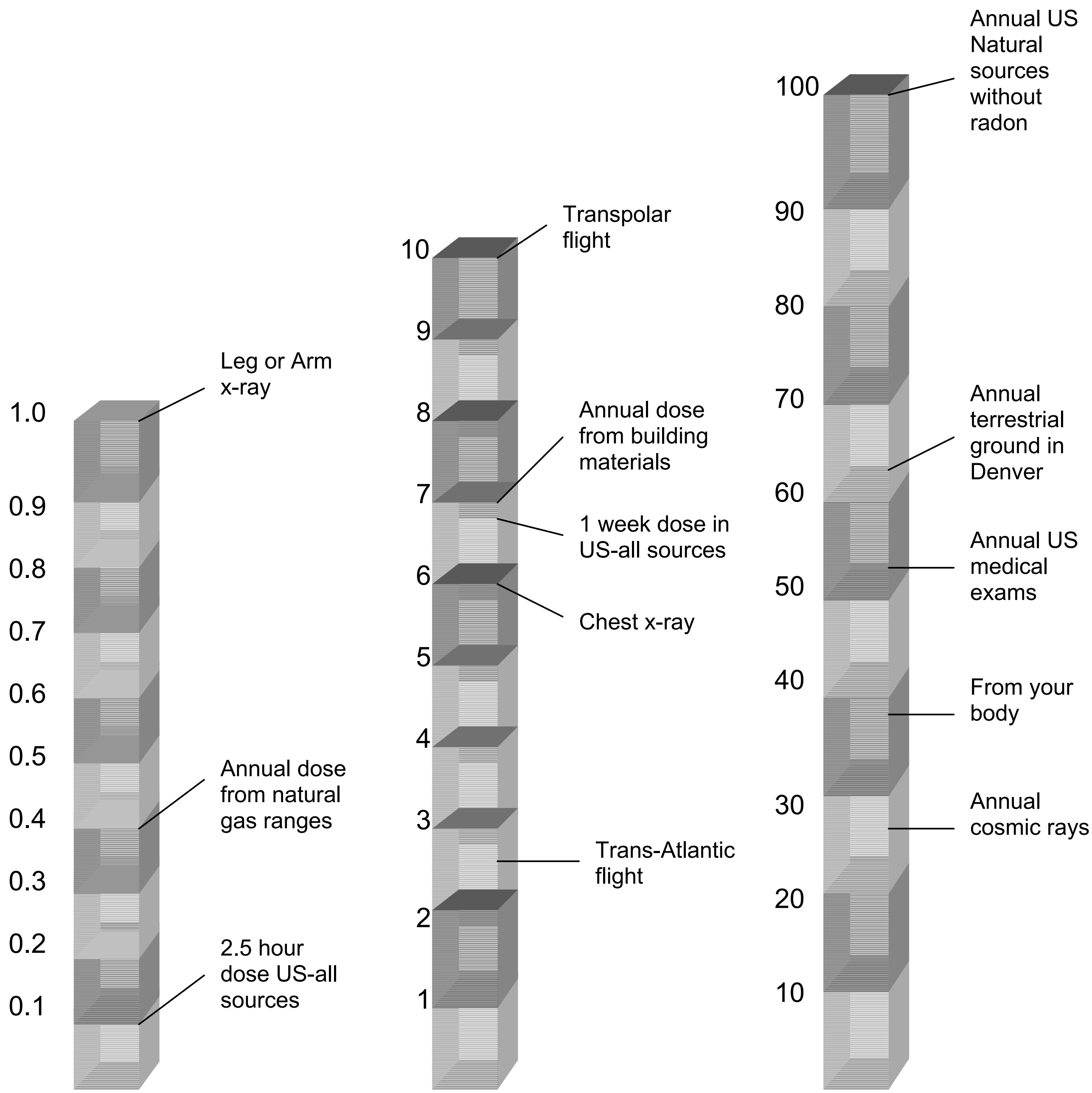
RADIOACTIVE DECAY

Radioactive materials decrease in activity over time. This process is called radioactive decay. In this process the radionuclide is transformed into a more stable form. This process is usually accompanied by the emission of charged particles and gamma rays. The time it takes for half of the atoms to decay to a more stable form is called the half-life.



Radiation Doses in Perspective

In mRem (1rem=1000mRem)



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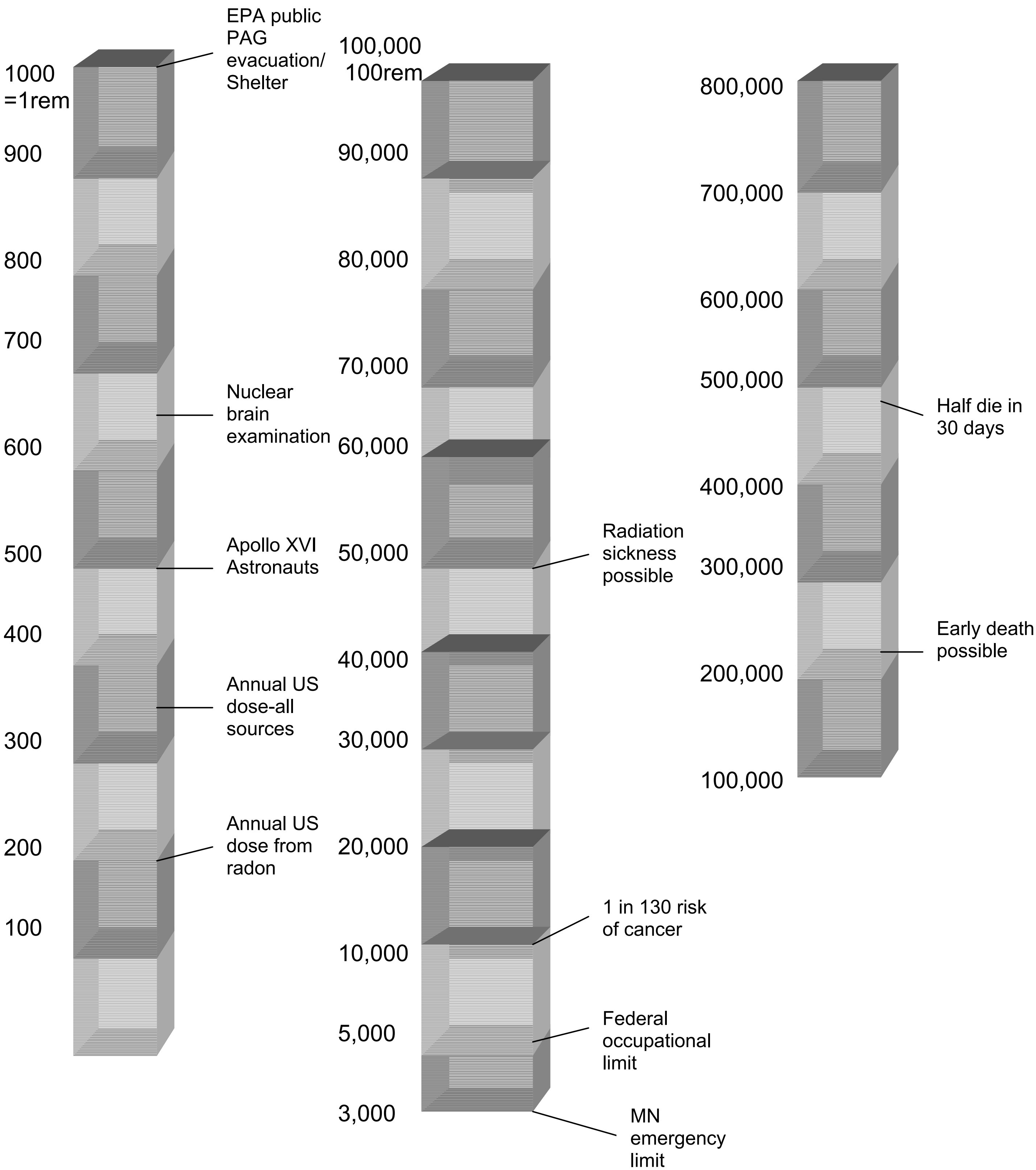

Typical Radiation Exposure Levels

Natural Background Radiation:	***Millirem per year***
Cosmic rays from the sun	26
Radiation from the ground	28
Internal radiation in our bodies	39
Radiation in the air you breathe (radon gas)	201

Man-made Radiation	**Millirem per year**
Medical and dental x-rays	53
Air travel	1
Living within 5 miles of a nuclear plant	0.05
Other (fallout, occupational exposures, etc.)	10
Total Average Exposure	**360**

Other Interesting Sources of Radiation Exposure

- Eating a banana (K-40) — 0.01 mRem [4]
- Smoking a pack of cigarettes a day — 1300 mRem/yr[5]
- Dwelling in the average constructed house — 7 mRem/yr[2]
- Drinking domestic water — 15-90 mRem/yr[2]
- Cooking with natural gas(from radon) — 5 mRem/yr[6]
- Dwelling in a granite building — 100 mRem/yr[7]

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[4] Health Physics Society Newsletter, March 1991
[5] National Council Radiation Protection Report No. 95
[6] National Council Radiation Report No. 56
[7] NSP Emergency Planning Guide.

Radiation Protection Methods

There are three methods to protect yourself or limit your exposure to external radiation TIME, DISTANCE, and SHIELDING.

TIME: By spending the least amount of time in a radioactive area as possible, exposure can be limited. The less time in the area the lower the total radiation exposure.

DISTANCE: The farther you are from a radioactive source, the less the rate of exposure. For a point source, given a distance D from the point source, the exposure rate would be $1/D^2$ times the original exposure rate. For an area source, such as ground contamination, the exposure rate will decrease at a rate of 1/D, for any given distance from the source.

SHIELDING: Shielding is one of the most important methods for radiation protection. It consists of positioning some sort of material between you and the radiation source. The material will absorb radiation thereby reducing your exposure. Shielding is not typically needed for alpha radiation, but is for beta or gamma. The shielding potential is influenced by three factors: where the shielding is, the density of material used, and how thick the material is. To be effective the shielding must be placed between you and the source.

Exposure vs. Contamination

Exposure: refers to the amount of ionization that radiation produces in the air, measured in roentgens. When combined with the element of time, it is called an exposure rate. Exposure occurs when a person is close enough to a radiation source to be hit by the radiation. When the radioactive source is removed the exposure stops. Exposure stops once the source is isolated or removed.

Contamination: refers to radioactive particles (dust like particles) that could be deposited on the ground, areas, people, or objects. Contamination occurs when radioactive materials, which give off radiation, get on or in a person. These particles continue to emit radiation and are an exposure hazard until they are removed. For example, being two feet away from a strong gamma source exposes a person; but tracking through a powdered form of radioactive material contaminates a person.

Radiological Guidance for Emergency Responders

Emergency responders such as firemen, public safety officers, state and county transportation personnel, and monitoring personnel, could possibly be exposed to radiation under emergency conditions. The table below indicates the dose limits for emergency responders. These doses are for the entire duration of the event. Doses should be kept as low as reasonably achievable (ALARA).

EMERGENCY CONSIDERATION	STATE OF MINNESOTA	FEDERAL
Emergency Worker General Dose Limit	3 rem[8] 3,000 mRem	5 rem 5,000 mRem
Dose Limit for Protecting Valuable Property	3 rem 3,000 mRem	10 rem[9] 10,000 mRem
Dose Limit for Life Saving	25 rem 25,000 mRem	25 rem or greater[10] 25,000 mRem
Consider the administration of stable iodine (KI [or KIO3]) to emergency workers[11].	5 rem 5,000 mRem (CDE Thyroid)	Not Applicable
Administration of Stable iodine (KI [or KIO3])[12]	25 rem 25,000 mRem (CDE Thyroid)	25 rem 25,000 mRem (CDE Thyroid)

[8] Doses should be kept as low as reasonably achievable (ALARA). Emergency workers must be informed of the biological risks of radiation exposure. The maximum radiation exposure rate for emergency workers in the field is 100 mR/hr. Personnel encountering rates above this should withdraw to a safer area and notify their supervisor.
[9] Justification of this higher exposure can only be allowed when lower doses are not practical such as during the presence of conditions that prevent the rotation of workers or other commonly used dose reduction methods.
[10] Only on a voluntary basis to persons fully aware of the risks involved. (see footnote two)
[11] Taking stable iodine is voluntary and should not be taken by those allergic to iodine.
[12] The administration of stable iodine is recommended; however, the approval of state medical officers is required.

Radiation and Health Effects

The effects of radiation on health fall into two categories, early (called acute) and late (called chronic).

Early (Acute) health effects are clinically observable within three months after exposure. Acute effects result from large exposures to radiation in a very short time. There are no observable effects below 50 Rem instantaneous exposure and may not be up to 100 Rem instantaneous exposure. See the chart **Acute Effects of Radiation Dose** on the next page for examples of other acute effects.

Late (Chronic) are those effects that show up years after exposure. Chronic effects may be the result of both large amounts of radiation exposure in short periods of time **or** small amounts of radiation exposure over a long period of time. Exposure to ionizing radiation increases the risk of cancer, leukemia, cataracts, and genetic effects.

Chronic effects are statistical in nature. Regardless of the amount of radiation exposure, there is no medical technique available that could tell if a person will have cancer after exposure to radiation. Current statistics are based on studies done on populations exposed to various levels of radiation such as the survivors of Hiroshima and Nagasaki, patients who have undergone medical treatment, and workers who have worked with radiation.

The variables that impact chronic effects are the amount of exposure, duration of exposure, type of radiation, a person's genetic and physical makeup, and portion of the body exposed. There is better correlation between high amounts of radiation exposure received in a short period of time and chronic effects than receiving low amounts of radiation exposure over a long period of time. The following chart may be used to compare the risk of receiving one Rem of radiation to other risks:

Health Risk	Estimated Life Expectancy Lost (Days)	Health Risk	Estimated Life Expectancy Lost (Days)
Cigarette Smoking	2250	Being murdered (homicide)	90
Heart Disease	2100	Legal Drug Misuse	90
Being 30% Overweight	1300	Fire Arms Accidents	11
Cancer	980	Natural Radiation	8
20% Overweight	900	Medical X-Rays	6
Stroke	520	Coffee	6
Dangerous Job – Accidents	300	Oral Contraceptive	5
Motor Vehicle Accidents	207	Accidents to Bicyclists	5
Pneumonia – Influenza	141	All Catastrophes Combined	3.5
Alcohol (US average)	130	Exposure to 1 Rem	1

Source: B. L. Cohen "A Catalog of Risks"; *Health Physics 36*; Pergamon Press, 1979

Acute Effects of Radiation Dose

Acute Effects of Radiation Dose
(Whole Body)[13]

Range	Subclinical Range 0-100rem	Therapeutic Range			Lethal Range	
		100-200 rem	200- 600 rem	600- 1000 rem	1000- 5000 rem	>5000 rem
Vomiting Incidence	none	5-50%	300rem, 100%	100%	100%	100%
Delay Time	n/a	3 hr	2 hr	1 hr	30 min	
Leading Organ	none	bone marrow			GI tract	Central nervous system
Characteristic signs	none	Moderate leukemia	Severe leukemia, hemorrhage, infection, purpura, epilation>300rem		Diarrhea, fever, electrolyte loss	convulsions, tremors, ataxia
Therapy	reassurance	Blood monitoring	blood transfusion antibiotics	marrow transplant & Growth factors	Maintain electrolytes	Sedatives
Prognosis	Excellent	Excellent	Good	Guarded	Hopeless	
% Death	None	None	0-80%	80-90%	90-100%	

13 Source: Basic Radiation Protection Technology P.96

Instrument Overview

Radiological instruments can provide a range of monitoring capabilities. All instruments we use are designed to detect gamma radiation. Some have the additional capability to detect beta radiation, but none of our instruments detect or measure alpha radiation. These instruments can be divided into two separate categories:

Survey meters: Used by monitoring personnel in determining contaminated areas and radiation exposure rates, usually in r/hr or mr/hr.

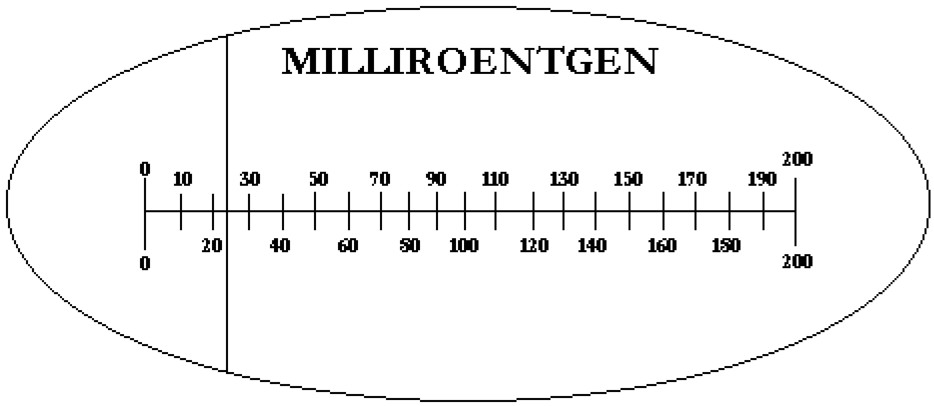
Dosimeters: Used by all emergency workers who might be exposed to radiation. Dosimeters are used to determine your accumulated total exposure dose, usually in r or mr.

Care and use of all instruments:

Batteries: Remove all batteries when not in use. Batteries should be inspected for corrosion. If corrosion appears use new batteries. Dirty contacts should be cleaned before battery installation. Be sure to install the batteries to the correct polarity and turn off the instrument before installing or removing the batteries.

Calibration: Ensure that each instrument is calibrated in accordance to the calibration schedule.

SELF READING DOSIMETER



Self-reading dosimeters are sometimes called pocket dosimeters, direct reading dosimeters, pen dosimeters, etc. They can be read by holding the end with the clip to your eye and pointing the dosimeter towards a light. We use two different ranges, 0-200mR and 0-20 R.

This dosimeter measures total accumulated dose for gamma radiation. For example, if you stood in a radiation field of 50 mR/hr for one hour, your dosimeter would read 50mR.

Dosimeters must be charged or "zeroed" before use. If dropped it can give a false high reading and should be rezeroed. It should be worn on the *outside* of your clothes.

As radiation passes through a dosimeter, ions are created. The ions are collected in an ion chamber where they cause a reduction in the charge the dosimeter holds. As the charge is reduced, a filament will go upscale, indicating the accumulated dose.

This type of dosimeter gives an approximate and temporary record. It can be read by the emergency worker unlike the thermoluminescent dosimeter.
Your supervisor will call every 30 minutes for you to read your dosimeter. Record your reading on your dosimeter-tracking card.

Dosimeter Charger

The dosimeter charger is used to charge or zero self-reading dosimeters. To zero a dosimeter press the dosimeter down on the charging contact, a light should go on so you can read the dosimeter. Then use the knob to move the hairline up or down scale till it reads zero.

THERMOLUMINESCENT DOSIMETER(TLD)

Thermoluminescent Dosimeter (TLD)

Radiological Emergency Preparedness
444 Cedar Street, Suite 223
St. Paul, Minnesota 55101

Not transferable; carry at all times.
W8 6/1/95 Acct number X Participant number
Issue date
ID number Badge type

Thermoluminescent Dosimeters (TLD) measure total accumulated dose of beta, gamma, x-ray, and neutron radiation.

The ones that Minnesota uses are about the size of a driver's license (see above example-not to scale).

Inside the TLD is a material (lithium fluoride) that reacts when radiation passes through it. When these badges are sent to the laboratory, they are heated and give off light. The total amount of light released is proportional to the amount of radiation encountered.

Emergency workers are required to wear a TLD in or near a breast pocket while in a potentially contaminated area.

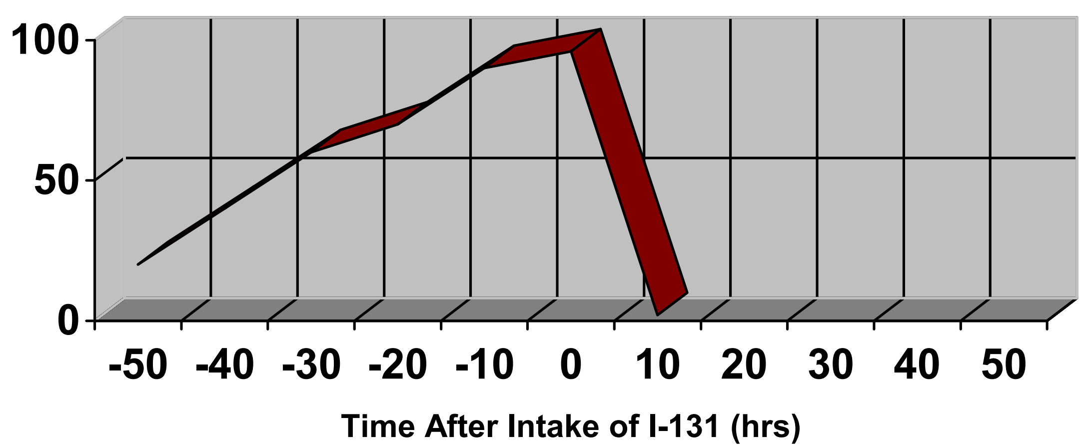
The TLD is very accurate and will be used as a legal record of the dose you received. Therefore never wear anyone else's badge. Never let anyone else wear your badge. If there is a high reading we won't know who was exposed.

POTASSIUM IODIDE (KI) [or POTASSIUM IODATE (KIO3)]

One of the radioactive materials that may be released during a radiological incident is radioactive iodine (Iodine 131). Iodine is used in the human body by the thyroid gland. During a release of iodine 131 it will be taken up by the thyroid gland when inhaled.

Potassium iodide is a thyroid blocking agent and is used to fill up the thyroid gland with non-radioactive iodine, thus reducing the chance that radioactive iodine will enter the thyroid gland. It does not block other types of radiation.

Percent of Thyroid Blocked by 130mg KI [or 170mg KIO3]



WHEN TO TAKE KIO3 OR KI

Take only when instructed by the state technical personnel in the State Emergency Operations Center (EOC), Planning and Assessment Center (PAC). These instructions will be passed through the county EOC.

Do not take KI [or KIO3] if you are allergic to iodine or shellfish. Report any side effects to your supervisor.

If you are on any other medication, you may want to check with your physician or pharmacist for potential interactions.

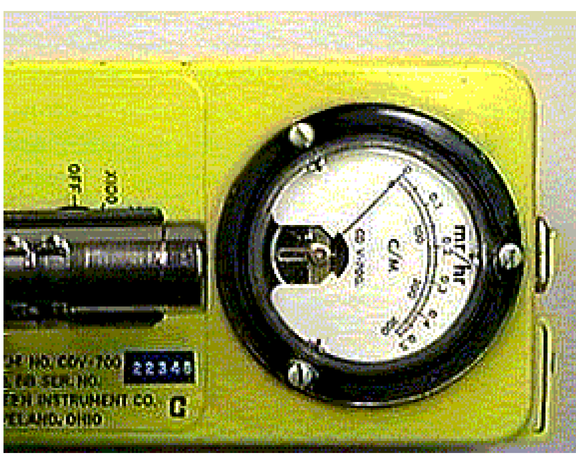
CD V-700

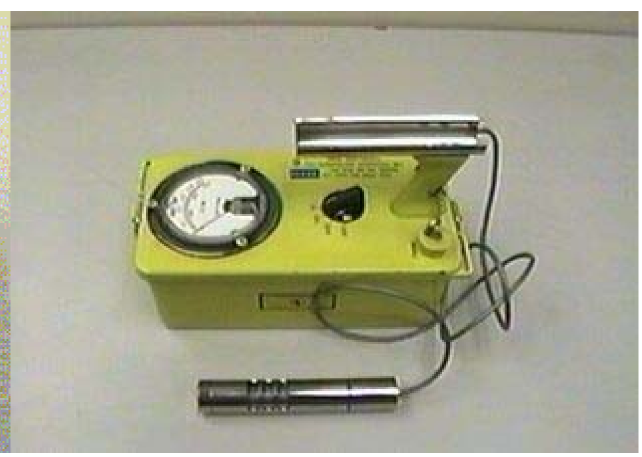
The CD V-700 is a 0-50 mr/hr survey meter. It is a low range meter that measures gamma dose rates and can also detect the presence of beta. It is designed for low level measurements and has limited usefulness in areas of high contamination. In high radiation areas with dose rates from 50 mr/hr - 1 r/hr the meter will show off scale readings. When the dose rates are greater than 1 r/hr, the meter will "saturate". When this occurs it will read zero or less than full scale. If this occurs a higher range instrument is required for monitoring this area.

The CD V-700 has a shield on the probe. When the shield is closed, beta is stopped and only gamma is measured. When the shield is open both gamma and beta are measured. There is only one control knob on this meter. It has four positions; Off, x100, x10, and x1. In the x1 position the dose rate is read directly from the meter. When in the x10 or x100 position the reading must be multiplied by a factor of 10 or 100 to get the correct dose rate.

Before using the CD V-700 an operation check should be done to ensure the meter is working correctly. The operational check should be performed as follows:

- Turn the knob to the x10 scale and allow the meter to warm up for 30 seconds.
- Open the shield on the meter probe all of the way
- Place the probe next to the check source on the side of the meter. It should read between 1.5-2.5 mr/hr. If it does not, the meter needs to be calibrated.





CD V-715

The CD V-715 is a 0-500-r/hr-survey meter. It will measure gamma radiation doses only. It is a high range meter.

There are two knobs on the CD V-715. The first knob has seven settings: Circuit check, Off, Zero, x100, x10, x1, and x0.1. When set to the x1 scale the dose rate is read directly from the instrument. When in the x0.1, x10, or x100 scale, the dose rate is found by multiplying the reading by a actor of 0.1, 10, or 100. The second control is used to adjust the meter to zero when the first knob is set to Zero during the operational check.

As with all survey meters it should be checked before it is used to ensure it is operating properly. The operational check is performed as follows:

- Turn the selector to Zero, allow two minutes for warm up, and adjust the zero control to make the meter read zero.
- Turn the selector to Circuit Check and make sure it reads within the red area marked circuit check.
- Recheck the zero setting as the switch selector is turned to the four scales (x100, x10, x1, and x0.1). When only background radiation is present, the meter should not read more than two scale divisions upscale of any range.


Eberline E-120

The E-120 Survey meter will detect both beta and gamma radiation. As radiation passes through the pancake probe, ions are produced. The ions create an electric current in the probe, which flows through the cable and into the meter, causing the needle to move. This meter measures in units of counts per minute (CPM). The scale runs from 0-5k where k=1,000.

There are five positions that can be selected on the knob: Off, Batt, x10, x1, and x0.1. In the x1 position the reading is as shown on the scale. Multiply times 10 or .1 for the other settings. When the range selector is on Batt, the needle should be up in the area marked "Batt OK".

The RESET button is used to reset the needle back to zero when it has gone off-scale because of a high reading. The range can than be changed to a less sensitive range.

The RESPONSE button determines how fast the needle will go upscale. When turned all the way to the left, the needle response will be slow and when turned to the right, the response will be fast. One could start out with the response button near the center of its range and adjust it faster or slower as desired.

There is also a jack for connecting headphones or a speaker. The headphones will give the quickest indication that contamination is present.

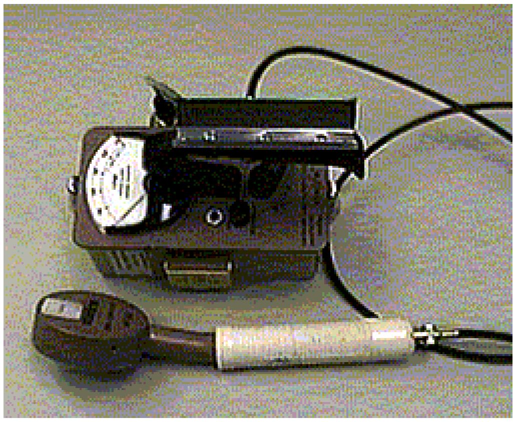
To operationally check this instrument, perform the following:

1. Turn the range selector to Batt and observe the needle fluctuation. It should move to the area marked "BATT OK".
2. Turn the range selector to the range indicated on the calibration sticker and hold the probe over the source on the side of the meter. The needle should go to the area on the face of the meter as indicated on the calibration sticker.

NOTE: Always be sure to Turn Off the speaker and the meter when done using the E-120.

Eberline E-120 Cont.

In Minnesota, Nuclear Management Company calibrates all E120's used for powerplant accidents annually. They are calibrated to an efficiency such that 7500-10,000 CPM equals one mR/Hr.



Government and Utility Roles

In the event that there is a radiological incident at one of the nuclear power plants there will be many different organizations responding. These will come from federal, state, and local governments as well as the utility. This section will cover what each of their role is in an emergency.

Federal Government:

Federal Radiological Emergency Response Plan:

The Federal government will respond according to the Federal Radiological Emergency Response plan or FRERP.

- Provides the Federal Government's concept of operations based on specific authorities.
- Outlines Federal policies and planning considerations on which the concept of operations are based.
- Specifies authorities and responsibilities of each Federal agency

Participating Agencies:

- Dept. of Agriculture (USDA)
- Dept. of Commerce (DOC)
- Dept. of Defense (DOD)
- Dept. of Energy (DOE)
- Dept. of Health and Human Services (HHS)
- Dept. of Housing and Urban Development (HUD)
- Dept. of the Interior (DOI)
- Dept. of Justice (DOJ)
- Dept of State (DOS)
- Dept. of Transportation (DOT)
- Dept. of Veterans Affairs (VA)
- Environmental Protection Agency (EPA)
- Federal Emergency Management Agency (FEMA)
- General Services Administration (GSA)
- National Aeronautics and Space Administration (NASA)
- National Communications System (NCS)
- U.S. Nuclear Regulatory Commission (NRC)

Federal Government (cont.):

Federal Radiological Monitoring and Assessment Center (FRMAC):

The FRMAC is established by DOE for the coordination of Federal radiological monitoring and assessment activities with that of State and local agencies. It will maintain a common set of off-site radiological monitoring data, provide technical assistance to the lead federal agency, state and local agencies. When the emergency phase is over DOE will transfer management of the FRMAC to the EPA.

State of Minnesota:

The State of Minnesota provides direction, coordination, and control in accordance to the Minnesota Emergency Operations Plan (MEOP). The State EOC is made up of the operations group and the planning group.

State Activities by ECL:

A. Notification of Unusual Event
1. Stand-by until verbal close out; or
2. Escalate to a more severe class.

B. Alert
1. Implement staff notification procedures.
2. Dispatch accident assessment team to EOC.
3. Dispatch radiological support liaisons to field.
4. Notify the U.S. DOE at Argonne National Lab of incident.
5. Evaluate off-site radiation monitoring and ingestion pathway dose projections if actual releases exceed technical specification limits.
6. Develop sampling strategy.
7. Maintain alert status until verbal close out.
8. Escalate to a more severe class.

C. Site Area Emergency
1. All of the above.
2. Notify U.S. DOE (Argonne National Lab), and request assistance, if needed.
3. Recommend sheltering - placing milk animals within two miles of the plant on stored feed, and assess need to extend distance.
4. Provide off-site monitoring results to licensee and others, and jointly assess them.
5. Continuously assess information from licensee and off-site monitoring with regard to initiating or changing protective actions and mobilizing evacuation sources.

6. Maintain site emergency status until close-out or reduction of emergency class.
7. Escalate to a general emergency class.

D. General Emergency
1. All of the above.
2. For actual or projected severe core damage accidents or loss of control of the facility, recommend evacuation for 2 mile radius and 5 miles downwind (unless conditions make evacuation dangerous) and assess need to extend distances. Advise remainder of plume EPZ to go indoors and listen to Emergency Alert System (EAS) messages.
3. Maintain general emergency status until close out or reduction of emergency class.

Counties:

If an accident or incident were to occur, the surrounding counties would also respond in accordance with their emergency operations plans. Their main focus would be to maximize the protection of lives and property, ensure that government can survive and continue to provide essential services, and support local units of government. By activating their EOCs they will assure that this is accomplished by exchange of information between county departments and where appropriate, to coordinate operations with other counties, state and federal agencies, as well as Indian communities. All county EOCs will be in direct contact with the state EOC and would be advised of all recommended protective actions.

County Activities by ECL:

NUE:

No activation of facilities. County dispatchers notified by the affected powerplant's SEC. County Emergency Management Director notified by dispatch.

Alert:

Activation of all EOC's. PIO's sent to JPIC. Area schools are notified of situation. County Emergency Worker Decon Centers notified (actual setup may occur later). Transportation companies notified(Busses for school children)

Site Area Emergency:

Schools may be evacuated to there designated reception center. Road bocks are established. County boards declare a state of emergency.

General Emergency:

Protective actions will be taken. Counties will sound their sirens and Deputies will run their routes for evacuation or a shelter in place order is needed.

Utility :

If an accident or incident were to occur, the utility would respond in accordance with their emergency operations plans. They would activate their TSC,OSC, EOF, and HQEC and would coordinate with the state and counties to minimize the risk to the public.

County Activities by ECL:

NUE:

3. Promptly inform state and/or local off-site authorities of nature of unusual condition as soon as discovered.
4. Augment on-shift resources as needed.
5. Assess and respond.
6. Escalate to a more severe class, if appropriate.
   or
7. Close out with verbal summary to off-site authorities, follow by written summary within 24 hours.

Alert:

Promptly inform state and/or local authorities of alert status and reason for alert as soon as discovered. Augment resources by activating on-site Technical Support Center, on-site operational support center, emergency operations facility (EOF), and other key emergency personnel to stand-by status. Assess and respond. Dispatch on-site monitoring teams and associated communications. Provide periodic plant status updates to off-site authorities (at least every 15 minutes.) Provide periodic meteorological assessments to off-site authorities and, if any release are occurring, dose estimates for actual releases. Escalate to a more severe class, if appropriate. Close out or recommend reduction in emergency class by verbal summary to off-site authorities followed by written summary within eight hours of close out or class reduction.

Site Area Emergency:

8. Promptly inform state and/or local off-site authorities of site area emergency status and reason for emergency as soon as discovered.
9. If not already staffed, augment resources by activating on-site Technical Support Center, on-site operational support center and near-site EOF.
10. Assess and respond.
11. Dispatch on-site and off-site monitoring teams and associated communications.
12. Dedicate an individual for plant status updates to off-site authorities and periodic pressure briefings (perhaps joint with off-site authorities.)
13. Make senior technical and management staff on-site available for consultation with NRC and state on a periodic basis.
14. Provide meteorological and dose estimates to off-site authorities for actual releases via a dedicated individual or automated data transmission.
15. Provide release and dose projections based on available plant condition information and foreseeable contingencies.
16. Escalate to general emergency class, if appropriate.
    or
17. Close out or recommend reduction in emergency class by briefing of off-site authorities at EOC and by phone followed by written summary within eight hours of close out or class reduction.

General Emergency:

Promptly inform state and local off-site authorities of general emergency status and reason for emergency as soon as discovered (parallel notification of state/local). If not already staffed, augment resources by activating on-site Technical Support Center, on-site operational support center and near-site EOF. Assess and respond. Dispatch on-site and off-site monitoring teams and associated communications. Dedicate an individual for plant status updates to off-site authorities and periodic press briefings (perhaps joint with off-site authorities.) Make senior technical and management staff on-site available for consultation with NRC and state on a periodic basis. Provide meteorological and dose estimates to off-site authorities for actual releases via a dedicated individual or automated data transmission. Provide release and dose projections based on available plant condition information and foreseeable contingencies. Close out or recommend reduction in emergency class by briefing of off-site authorities at EOF and by phone followed by written summary within eight hours of close out or class reduction

.

GLOSSARY

Absorbed Dose: The energy imparted to matter by ionizing radiation per unit mass matter. The unit of absorbed dose is the radiation absorbed dose (rad).

Activity: The rate of decay of radioactive material, expressed as the average number of nuclear disintegrations per second.

Acute Effect: Somatic effect of radiation which is manifest in relatively short times (in a matter of minutes for extremely high doses, up to about a year for lesser doses).

ALARA: Acronym for keeping radiation exposure "As low as reasonably achievable." Radioactive material users apply this concept in minimizing occupational and public exposure.

Alpha Particle: A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is equal in mass and charge to a helium nucleus and has low-penetrating power and short range. The most energetic alpha particle from radioactive decay will generally fail to penetrate the skin. Alphas are hazardous when an alpha-emitting nuclide is introduced into the body.

Atom: The smallest particle of an element that cannot be divided or broken up by chemical means. It consists of a central core called the nucleus, which contains protons and neutrons. Electrons revolve in orbits in the region surrounding the nucleus.

Background Radiation: The radiation in man's natural environment, including **cosmic rays** and radiation from the naturally radioactive elements, both outside and inside the bodies of men and animals. It is also called natural radiation. Manmade sources of radioactivity contribute to total background radiation levels. Approximately 90 percent of background radiation from man-made sources are related to the use of ionizing radiation in medicine and dentistry.

Becquerel (Bq): The radioactivity unit of the international system of units. One becquerel equals one nuclear disintegration per second.

GLOSSARY

Beta Particle: A small particle ejected spontaneously from a nucleus of a radioactive element. It has the mass of an electron and has a charge of minus one or plus one. It has medium or intermediate penetrating power and a range of up to a few meters in air. Beta particles will penetrate only a fraction of an inch of skin tissue. Symbol ($\beta-$,$\beta+$)

Boiling Water Reactor (BWR): A type of reactor system, which allows water to boil directly in the reactor core to produce steam for the turbine generator.

Buffer Zone: An expanded portion of the restricted zone selected for temporary radiation protection controls until the stability of radioactivity levels in the area is confirmed.

Chronic Exposure: Radiation exposure occurring over long periods of time.

Committed Dose: The radiation dose due to radionuclides in the body over a 50-year period following their inhalation or ingestion.

Committed Effected Dose Equivalent: The sum of the 50-year committed doses to individual organs from inhalation or ingestion of radionuclides, where the individual organ doses have been adjusted so that the associated risk of fatal cancer can be added to the risk of fatal cancer from whole-body dose.

Containment: A structure found at nuclear power plants designed to contain any radioactive materials that may be released from the nuclear reactor fuel and cooling systems.

Contamination, Radioactive: Deposition of radioactive material in any place where it is not desired, particularly where its presence can be harmful.

Control Rod: A rod made of neutron absorbing material which, when inserted into a nuclear reactor, reduces the number of neutrons, which can strike fuel and cooling atoms causing fission.

Controlled Area: An area where entry, activities, and exit are controlled to assure radiation protection and prevent the spread of contamination.

GLOSSARY

Critical: The state of fissile material, e.g., the core of a nuclear reactor, when the chain reaction is exactly self-sustaining.

Curie: The basic measuring unit used to describe the amount of **radioactivity** in a sample of material. One curie is equal to 37 billion disintegrations per second. Symbol: Ci.

Decay, Radioactive: Disintegration of the nucleus of unstable atoms by spontaneous emission of charged particles, electromagnetic radiation, or both.

Decontamination: The operation of removal or reduction of contaminating radioactive material from a structure, area, object, or person.

Deposition: Physical settling or placing of radioactive material onto a surface. Fallout may be deposited on surfaces. Material
ingested or inhaled by an individual may be deposited in the lungs or other organs.

Detector: A material or device that is sensitive to radiation and can produce a response signal suitable for measurement or analysis. A radiation detection instrument.

Division of Emergency Management: The State Division designated to prepare for and deal with any national or statewide emergencies.

Dose Rate: Dose delivered or absorbed per unit time, a rads per second or rem per hour.

Dose: A quantity (total or accumulated) of ionizing radiation received. The term "dose" is often used in the sense of the exposure dose, expressed in roentgens, which is a measure of the total amount of ionization that quantity of radiation could produce in air. This should be distinguished from the absorbed dose, given in rads, that represents the energy absorbed from the radiation in a gram of any material. Furthermore, the biological dose, given in rem, is a measure of the biological damage to living tissue from the radiation exposure.

Dosimeter: A small pocket-sized ionization chamber used for monitoring radiation exposure of personnel. Before use it is given a charge, and the amount of discharge that occurs is a measure of the accumulated radiation exposure.

Drill: A drill is an event involving organizational responses to a simulated accident to develop, test, and maintain specialized emergency skills that constitutes one or more components of an emergency plan.

Electron: A small, negatively charged particle typically found surrounding an atom's nucleus.

Emergency Classification Levels (ECL): The Federal Emergency Management Agency has established four levels of nuclear power plant incident ratings. These levels are:

Notice of an Unusual Event (NUE): This includes any unpredicted activity at the plant, from a small fire in some location other than the containment building to the presence of an unauthorized person on the site. When either plant reports an NUE, NSP notifies the Department of Public Safety's Division of Emergency Management, which then begins to monitor the situation.

1. **Alert:** A power plant emergency is considered to be in the Alert state when a problem with the reactor has developed or is likely to develop imminently. At this stage the Division of Emergency Management begins to notify the Governor's Office (in most cases) and other state agencies that would be involved in evacuation or cleanup; and the State Emergency Operations Center is mobilized. The DNR will mobilize its own Emergency Coordination Center at this time.

2. **Site Area Emergency:** A Site Area Emergency is declared when an outside-uncontrolled release of radioactive material (usually within the containment building) has occurred or is very likely to occur. A Site Area Emergency still affects only the power plant and its workers, but may rapidly change to a General Emergency. At this time the general public will begin to be alerted to the possible danger.

4. **General Emergency:** A General Emergency is declared when an uncontrolled release of radioactive material (usually in the form of a steam "plume") into the surrounding environment has occurred or is very likely to occur immediately. Sirens will sound within the ten-mile radius of the plant and evacuation procedures may begin. The emergency siren will sound a steady tone for 3 minutes, followed by 15 minutes of silence, repeated three times for a total of 39 minutes. All employees within the siren range should turn to the Emergency Broadcast System for their area.

Emergency Coordination Center: The location in the DNR building (6th Floor Training Room) from which the DNR Radiological Emergency Response effort is directed.

Emergency Dose Limit: A level of projected absorbed dose following a nuclear incident above which the total risk to health of an individual is considered excessive.

Emergency Operating Center: The location from which the state (444 Cedar Street, Suite 223) and the county (county courthouse or law enforcement center) emergency response effort is coordinated and directed.

Emergency Planning Zone: A generic area defined about a nuclear facility to facilitate offsite emergency planning and develop a significant response base. It is defined for the plume and ingestion pathways.

Encapsulated Source: A radionuclide sealed in a container such as a tube or needle. Also called a **sealed source.**

Exposure: A measure of the ionization produced in air by x- or gamma radiation. The roentgen (R) is the unit of exposure. The term "dose", sometimes used interchangeably with exposure, actually refers to absorbed ionization of energy.

Fission Product: An atom produced through the splitting (fission) of a larger atom.

Fission: The splitting of an atom resulting in the release of neutrons, energy, and two or more smaller atoms.

GLOSSARY

Footprint: The area that is primarily effected by an uncontrolled radioactive release. This area will be identified by the higher levels of radioactivity occurring within it.

Gamma Rays: Electromagnetic radiation comparable to light. They are similar to x-rays except for their origin. They are emitted with energies characteristic of each nuclide, and many are highly penetrating. Although their intensity decreases exponentially with thickness of the absorbing material, they can travel hundreds of feet in air and penetrate completely through the body.

Geiger Counter, or G-M Meter: An instrument used to detect and measure radiation. The detecting element is a gas filled chamber operated by a voltage whose electrical discharge will spread over the entire anode when triggered by a primary ionizing event.

Gray (Gy): The absorbed radiation dose unit of the international system of units. One gray equals 100 rad.

Half Life: The time required for the decay of one half of a given quantity of a radionuclide.

High Level Radioactive Waste (HLW): Highly radioactive solid, liquid and gaseous materials from nuclear operations (usually spent fuel) for which there is no further use; material that the NRC determines by rule to require permanent isolation.

Ingestion Pathway Zone: A 50- mile zone around a nuclear power plant that includes all food production, processing and marketing facilities; an area where the general public might consume food or drink contaminated with radioactivity released during a nuclear plant accident.

Ingestion: The term used when radioactive materials are taken into the body through the mouth, such as by eating or drinking. Also applies when breathing results in the inhaled materials being swallowed.

Interdiction: A protective action taken to prevent use of contaminated areas or ingestion of contaminated foodstuff.

Internal Radiation: Radiation (including alpha and beta particles and gamma radiation) resulting from radioactive substances within the body.

Inverse square law: The relationship which states that gamma radiation intensity is inversely proportional to the square of the distance from a point source.

Ionization: The separation of a normally electrically neutral atom or molecule into electrically charged components. The term is also employed to describe the degree or extent to which this separation occurs. Ionization is the removal of an electron (a negative charge) from an atom or molecule, either directly or indirectly, leaving a positively charged ion. The separated electron and ion are referred to as an ion pair.

Ionizing radiation: Electromagnetic radiation (**x-ray** and **gamma-ray** photons) or particulate radiation (electrons, positions, protons, neutrons, and heavy particles) capable of producing ions by direct or secondary processes.

Joint Public Information Center: A group established by the Division of Emergency Management and other involved agencies to respond to questions or requests for information from the press and the public.

Latent Effect: Somatic effect (such as cancer) produced by exposure to radiation, which is not manifested until a long time after exposure.

Millirem (mrem): A one-thousandth part of a rem.

Milliroentgen (mR): A one-thousandth part of a roentgen.

Monitoring: Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present for purposes of health protection. Also referred to as "surveying".

MPBB: *M*aximum *p*ermissible *b*ody *b*urden. The maximum amount of a specific radionuclide considered to produce no adverse health effects if deposited inside the body.

Neutron: A small particle possessing no electrical charge typically found within an atom's nucleus. Neutrons released by fission may strike nuclear fuel atoms causing additional fissions.

Neutron: A subatomic particle having zero charge and mass approximately equal to that of a proton. It is emitted in the fission process and control of the neutron population in a nuclear reactor is the method for controlling the reactor.

Nuclear Reactor: A device, in which a fission chain reaction can be initiated, maintained and controlled. Its essential component is a core with fissionable fuel. It usually has a moderator, shielding, coolant and control mechanisms.

Nuclear: Technically, an adjective referring to the atom's nucleus. Commonly, refers to radioactive processes that involve the disintegration of the nucleus, as in nuclear particles and nuclear energy.

Nucleus: That part of an atom where neutrons and protons are located and in which the positive electrical charge and most of its mass is concentrated.

Placard: A standard device or sign attached to the outside of a vehicle to identify the hazards associated with the cargo.

Plume Exposure Pathway: The principal exposure source from this pathway are (a) whole body external exposure to gamma radiation from the plume and from deposited materials and (b) inhalation exposure from the passing radioactive plume. The duration of principal potential exposures could range in length from hours to days.

Plume: The volume of air containing the release from an accident.

Potassium Iodate/Iodide (KIO3/KI): A prophylactic drug that can be used to effectively block the uptake of radioiodine by the thyroid gland.

Pressurized Water Reactor (PWR): A type of reactor system, which maintains cooling water at a very high pressure, which prevents water from boiling in the reactor core during normal operation.

Projected Dose: An estimate of the radiation dose which affected individuals could potentially receive based on estimated or measured initial concentrations of radionclides or exposure rates, or if protective actions are not taken.

Protective Action Guide: Projected absorbed dose to individuals in the general population, which warrants protective action.

Protective Action: An action taken to avoid or reduce a projected dose. (Sometimes referred to as protective measure.)

Protective Clothing: Special clothing worn by a radiation worker to prevent contamination of his/her body or personal clothing.

Proton: A subatomic particle with a positive charge along with the neutron it is the basic building block of atomic nuclei.

Rad: *R*adiation *a*bsorbed *d*ose. A (rad) is the unit of **absorbed dose.** The rad is a measure of the energy imparted to matter by ionizing particles per unit mass of irradiated material at the place of interest. A rad is approximately equal to the absorbed dose in tissue when the exposure in air is one roentgen (R) of medium-voltage x-radiation.

Radiation Sickness: The complex of symptoms resulting from excessive exposure of most of the body to ionizing radiation. The earliest of these symptoms are nausea, fatigue, vomiting, and diarrhea, which may be followed by loss of hair (epilation), hemorrhage, inflammation of the mouth and throat, and general loss of energy. In severe cases, where the radiation exposure has been relatively large, death may occur within two or four weeks. Those who survive six weeks after the receipt of a single large dose of radiation will generally recover.

Radiation Survey Instrument: A portable battery-powered device used to detect and measure the dose rate at the spot where the instrument is held.

Radiation: The energy propagated through space or through a material medium such as waves; for example, energy in the form of electromagnetic waves or of elastic waves. Radiation, or radiant energy, when unqualified, usually refers to electromagnetic radiation; such radiation commonly is classified, according to frequency, a Hertzian, infrared, visible (light), ultraviolet, **x-ray**, and **gamma ray.** Also, particles such as **alpha** and **beta** radiation, or rays of mixed or unknown type--for instance, **cosmic rays--** can be called radiation.

GLOSSARY

Radioactive Decay: The decrease in the amount of any radioactive material with the passage of time due to the spontaneous emission of alpha, beta, or gamma radiation from the nucleus.

Radioactive Material: Any material, which spontaneously emits particulate or electromagnetic ionizing radiation.

Radioactivity: The property of certain nuclides of spontaneously emitting nuclear particles or gamma or x-ray radiation, or of undergoing spontaneous fission.

Radioscope: An unstable isotope of an element that decays or distnegrates spontaneously, emitting radiation. Approximately 5000 natural and artificial isotopes have been identified.

Rem: The unit of dose equivalent in body tissue. It is equal to the absorbed dose (measured in rads) multiplied by the quality factor, which takes into account the effectiveness of different types of radiation, and by other multiplying factors. For beta and gamma radiation the quality factor is 1.

Roentgen: The unit of radiation exposure in air. Roentgens are the units for quantities of x-or gamma radiation measured by detection and survey meters.

Scram: A rapid, non-routine shut down of a reactor.

Sealed source: A radioactive source, sealed in an impervious container, which has sufficient mechanical strength to prevent contact with and dispersion of the radioactive material under the conditions of use and wear for which it was designed. Generally used for radiography or radiation therapy.

Sheltering: The use of a structure for protection from an airborne plume, deposited radioactive materials, or dangerous weather conditions.

Shielding: Any material or barrier that attenuates radiation.

Sievert (Sv): The radiation dose unit of the international system of units. One sievert equals 100 rem.

Somatic: Referring to the human body (as with bodily tissue), as distinguished from genetic tissues and characteristics.

Source Term: A particular type or amount of radionuclide originating or the source of a nuclear incident. In its broadest sense, the source term also describes the conditions and mode of emission.

Survey Meter: A portable instrument used in radiological monitoring to detect and measure ionizing radiation.

Technical Support Center: The emergency response facility located at the plant that will be used by plant management, technical support staff, plant operators and the NRC to manage their response to the accident.

Time, Distance, Shielding: The three main ways to minimize exposure to radiation are to: 1) decrease the time spent in a radiation field, 2) increase the distance from the radiation source, and 3) increase the amount of shielding material between the source and the receptor.

Transport Index: The number placed on a radioactive materials package label that indicates the control required during transport. The transport index is the radiation level, in millirems per hour, at 3 feet from the accessible external package surface; or, for fissile Class II packages, an assigned value based on critical safety requirements for the package contents. Abbreviation: TI. Criticality

Uranium: A type of atom used to fuel nuclear reactors due to its ability to undergo fission with a free neutron creating a nuclear chain reaction and resulting in heat.

Whole Body Counter: A device to identify and measure the radiation in the body (body burden) of human beings and animals; it uses heavy shielding to keep out background radiation and ultrasensitive detectors and electronic equipment.

Whole Body Exposure: Exposure of the major portion of the body to radiation.

X-Rays: Penetrating electromagnetic radiation originating in the electron field of an atom. X rays are similar in wavelength and frequency to gamma rays, which originate in the nucleus of an atom.

ABBREVIATIONS USED IN RADIALOGICAL EMERGENCY PREPAREDNESS (REP)

A

ALARA	AS LOW AS RESONABLY ACHIEVABLE
AMS	AERIAL MONITERING SYSTEM (DOE)
ARCA	AREA REQUIRING CORRECTIVE ACTION
ARFI	AREA RECOMMENDED FOR IMPROVEMENT

B

BWR	BOILING WATER REACTOR (MONTICELLO)

C

CFR	CODE OF FEDERAL REGULATIONS
CPM	COUNTS PER MINUTE, UNIT OF MEASURE ON A SURVEY METER
CURIE	BASIC UNIT OF RADIOACTIVITY

D

DEG	DIVISION OF EMERGENCY GOVERNMENT-WISCONSIN
DEM	DIVISION OF EMERGENCY MANAGEMENT-MINNESOTA
DHS	DEPARTMENT OF HUMAN SERVICES
DOE	DEPARTMENT OF ENERGY
DOT	DEPARTMENT OF TRANSPORTATION

E

EAL	EMERGENCY ACTION LEVEL
EAS	EMERGENCY ALERT SYSTEM
EBS	EMERGENCY BROADCAST SYSTEM
ECL	EMERGENCY CLASSIFICATION LEVEL
ED	EMERGENCY DIRECTOR (PLANT)
EM	EMERGENCY MANAGER (EOF)
EOC	EMERGENCY OPERATION CENTER
EOF	EMERGENCY OPERATION FACILITY
EP	EMERGENCY PLANNING
EPZ	EMERGENCY PLANNING ZONE
EV2	EVACUATION OF SCHOOL CHILDREN

F

FEMA	FEDERAL EMERGENCY MANAGEMENT AGENCY
FRMAC	FEDERAL RADIOLOGICAL MONITORING AND ASSESSMENT CENTER
FRC	FEDERAL RESPONSE CENTER
FRERP	FEDERAL RADIOLOGICAL EMERGENCY RESPONSE PLAN

G

H

I

IPZ	INGESTION PATHWAY ZONE

J

JPIC	JOINT PUBLIC INFORMATION CENTER

K

KI or KIO3	POTASSIUM IODIDE or POTASSIUM IODATE

L

LOCA	LOSS OF COOLANT ACCIDENT

M

MDA	MINNESOTA DEPARTMENT OF AGRICULTURE
MDH	MINNESOTA DEPARTMENT OF HEALTH
mR	MILLI ROENTGEN
mrem	MILLI REM
MS-1	MEDICAL SERVICES FOR CONTAMINATED AND INJURED

N

NAWAS	NATIONAL WARNING SYSTEM
NOAA	NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
NMC	NUCLEAR MANAGEMENT COMPANY
NRC	NUCLEAR REGULATORY COMMISSION
NSP	NORTHERN STATES POWER COMPANY
NUE	NOTIFICATION OF UNUSUAL EVENT
NUREG 0654	FEMA/NRC CRITERIA FOR PREPARING REP PLANS

O

OSC	OPERATIONS SUPPORT CENTER

P

PAG	PROTECTIVE ACTION GUIDE
PANS	PUBLIC ALERT AND NOTIFICATION SYSTEM
PAR	PROTECTIVE ACTION RECOMENDATION
PHN	PUBLIC HEALTH NURSE
P.I.	PRAIRIE ISLAND NUCLEAR POWER PLANT
PIO	PUBLIC INFORMATION OFFICER
PWR	PRESSURIZED WATER REACTOR (PRAIRIE ISLAND)

Q

R

R	ROENTGEN, UNIT OF RADIATION EXPOSURE
RAD	UNIT OF ABSORBED DOSE OF RADIATION OF ANY TYPE
Rem	ROENTGEN EQUIVALENT MAN, UNIT OF ABSORBED RADIATION DOSE. DESCRIBES THE BIOLOGICAL EFFECTIVNESS OF EXPOSURE
REP	RADIOLGICAL EMERGENCY PREPAREDNESS

S

SCRAM	AUTOMATIC SHUTDOWN OF REACTOR WITH CONTROL RODS
SEC	SHIFT EMERGENCY COMMUNICATOR (PLANT)

ABBREVIATIONS USED IN RADIALOGICAL EMERGENCY PREPAREDNESS (REP)

SOP	STANDARD OPERATING PROCEDURE
T	
TLD	THERMOLUMINESCENT DOSIMETER
TMI	THREE MILE ISLAND
TSC	TECHNICAL SUPPORT CENTER (NSP)
U	
USDA	UNITED STATES DEPARTMENT OF AGRICULTURE
V	
W	
X	
Y	
Z	