Internal Exposure Management
NRC Roles and Responsibilities and Recent Licensee Performance

Ronald L. Nimitz, CHP

A. Role and Responsibility of the NRC.

The Nuclear Regulatory Commission (NRC) was created as an independent agency by the Energy Reorganization Act of 1974. The NRC's mission is to regulate the Nation's use of byproduct, source, and special nuclear materials, to ensure adequate protection of public health and safety, to promote the common defense and security, and to protect the environment. The NRC's scope of responsibilities includes regulation of commercial nuclear power plants; research, test, and training reactors; fuel cycle facilities; medical, academic, and industrial uses of nuclear materials; and the transport, storage, and disposal of nuclear materials and waste.

The NRC fulfils its responsibilities through a system of licensing and regulatory activities that includes among others: licensing the siting, design, construction, operation, and decommissioning of applicable facilities; licensing possession and use of materials; conducting confirmatory research; conducting inspection and enforcement activities; and developing and implementing rules and regulations that govern licensed nuclear activities. The NRC implements its inspection responsibilities, in part, by using personnel to conduct onsite inspections at locations of licensed activities using defined inspection procedures.

The NRC and its licensees share a common responsibility to protect public heath and safety. Federal regulations and the NRC regulatory program are important elements in the protection of the public. NRC licensees, however, have the primary responsibility for the safe use of nuclear materials.

B. Regulations Controlling Occupational Radiation Exposure

The primary NRC regulations controlling occupational and public radiation exposure are contained in Title 10, Code of Federal Regulations, Part 20 (10 CFR 20), "Standards for Protection Against Radiation." 10 CFR 20 establishes standards for protection against ionizing radiation resulting from activities conducted under licenses issued by the NRC including licenses to possess; use; transfer; or dispose of byproduct, source, or special nuclear material or to operate production or utilization facilities under parts 30 through 35, 39, 40, 50, 60, 61, 70 or 72.

10 CFR 20 Subpart C, "Occupational Dose Limits," incorporates recommendations of the International Commission on Radiological Protection (ICRP) (1977) and provides the basic occupational exposure limits (20.1201) for adults. These are an annual limit (whichever is more limiting) of:

- 0.05 sievert (Sv) (5 rem) total effective dose equivalent,
- 0.5 Sv (50 rem) for the sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye, and
- 0.15 Sv (15 rem) eye dose equivalent, and
- 0.50 Sv (50 rem) shallow dose equivalent to the skin or to any extremity.

For internal exposure control and assessment purposes, Appendix C to 10 CFR 20, provides a listing of annual limits of intake (ALIs) and derived air concentrations (DACs) of radionuclides for occupational exposure.

10 CFR 20 provides additional requirements for limiting exposure including requirements for summation of external and internal doses (20.1202), requirements for determination of external dose from airborne radioactive materials (20.1203), and requirements for determination of internal exposures (20.1204). Other subparts provide conditions requiring individual monitoring of external and internal occupational dose, requirements for records and reporting of exposures, and requirements to conduct surveys that may be necessary and reasonable to comply with the regulations in Part 20.

10 CFR 20 also provides requirements for use of respiratory protection equipment and other controls to limit internal exposure in restricted areas. An important aspect of these regulations is that if it is impractical to apply process or other engineering controls to reduce concentrations of radioactive material in air, to values below those that define an airborne radioactivity area, the licensee is required, consistent with maintaining the total effective dose to as low as is reasonably achievable (ALARA), to increase monitoring and limit intakes by, among other controls: control of access, limitation of exposure times, or use of respiratory protection equipment. Also of note is that the NRC has recently revised its requirements for use of respiratory protective equipment to recognize new respiratory protection devices and procedures that have proven effective, adopt new national consensus standards, and conform NRC requirements to new requirements of other US worker protection agencies.

C. Supporting Guidance Documents

Because of the wide variety of licensees under its regulatory purview, and the need to provide standardized guidance to its licensees on acceptable practices and methods for exposure monitoring, measurement and reporting, the NRC has established various documents which provide guidance to licensees on such matters as surveys, personnel monitoring, exposure assessment, and reporting. Foremost among these documents are NRC Regulatory Guides(RGs). RGs are issued to describe and make available to licensees and the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations. The guides, which receive public and industry comment, delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. The RGs reference consensus standards (e.g., American National Standards). The guides are not substitutes for regulations, and compliance with them is not required unless a licensee has specifically committed to a particular RG's use. Methods and solutions different from those set out in guides will be acceptable if they provide a basis for findings requisite to the issuance or continuance of a permit or licensee to the commission. In some instances, RGs have been incorporated by reference into licenses.

Several RGs deal specifically with airborne radioactivity surveys and internal exposure monitoring, assessment, and recording. For example RGs provide guidance on acceptable concepts, models, equations, and assumptions for a bioassay program; guidance on air sampling in the work place and applications of bioassays for fission and activation products; guidance on health physics surveys in uranium mills; guidance on monitoring criteria and methods to calculate occupational radiation doses; instructions for recording and reporting occupational radiation exposure data; and use of respiratory protection equipment.

The NRC has also published other documents which provide useful information for conducting surveys, monitoring, and internal exposure assessment. For example, the NRC issues documents called NUREGs, and like RGs these are available to licensees and the public and cover a wide range of topics. The NUREGs differ from RGs in that they provide very detailed information on a variety of topics including

research topics. For example NUREG/CR-4884, "Interpretation of Bioassay Measurements," is a comprehensive manual (about 800 pages) that describes how to compute intakes of radioactive material from both in-vivo and in vitro bioassay measurements. Another NUREG (1400) provides detailed guidance on air sampling in work places.

The NRC also provides information to its licensees and the public that may be of importance to operations at a particular type of facility. The type of generic correspondence most frequently issued are Information Notices (INs). These notices typically cover an important issue or event and are designed to provide timely information coupled with a brief NRC assessment. Licensees are not required to take action on INs. INs have been issued for such matters as unplanned intakes of radioactive material, unplanned external exposure events, and changes to regulations.

The NRC has other means to provide information to licensees; however, the above-described methods are typically used for matters involving surveys, monitoring, and assessment of personnel exposure to airborne radioactivity.

Finally, the NRC does maintain its own web page (www.nrc.gov). This tool is readily accessible to the public. It provides information on a wide variety of topics, including newly released documents as discussed above. NRC regulations, Regulatory Guides, NUREGs, and Information Notices are available on the web. I invite you to visit www.nrc.gov.

D. Inspections

The NRC conducts inspections at its licensed facilities in accordance with formally approved inspection guidance. These guidance documents describe the type of inspection to be performed, the program attributes to be reviewed, and the inspection frequency. The inspections are tracked and scheduled via computers, which better allows the NRC to effectively manage its resources and provide oversight of its licensees commensurate with the safety significance of licensed activities. The inspections review safety activities and verify compliance with applicable regulatory requirements. In the event of non-conformance, the NRC first checks that to see if the licensee has or will place the finding in its corrective action program. More significant enforcement action may be taken after conduct of appropriate meetings with licensee personnel and review of facts. Enforcement actions are guided by NRC enforcement manuals and guidance also readily available on the web.

Recently, the NRC has implemented a pilot Regulatory Oversight Process. The process provides for risk based reviews of licensee activities in strategic performance areas. For example, in the area of reactors, performance is evaluated in the strategic areas (Reactor Safety, Radiation Safety, and Safeguards) through a combination of NRC inspections and the nuclear power plant operator's use of performance indicators. The process provides for inspections in sub-areas called "Cornerstones." The Cornerstones are initiating events, mitigation systems, barrier integrity, emergency preparedness, public exposure control, occupational exposure control, and physical protection. Inspections are conducted of "inspectable areas" within each cornerstone. Findings from the inspections and outputs from performance indicators are input into a Significance Determination Process which assesses the significance of the finding and prompts further NRC action consistent with an "Action matrix." The new inspection process is expected to be fully implemented at power reactor sites in 2000.

E. Occupational Exposures at NRC Licensed Facilities

NRC licensees are required to assess and report instances of intake of airborne radioactive materials consistent with the requirements of 10 CFR 20. The NRC has, since 1969, been compiling occupational radiation exposure data. The data has been published in publically available NUREGs. In 1994, consistent with major revision to 10 CFR20, the reporting of whole body exposure changed to reporting of Total Effective Dose Equivalent (TEDE). Consequently, reports from 1994 to date report internal exposures in Committed Effective Dose equivalents (CEDE). Maximum Committed Dose Equivalents (CDE) and Total Organ Dose Equivalents (TODEs) are also compiled. The below tabulated data is excerpted from the 1997 volume of NUREG-0713, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities," and the 1998 draft volume, which was under review. The NUREG is a compilation of radiation exposure data maintained in the NRC's Radiation Exposure Information Reporting System (REIRS). The compilation includes information on exposures at nuclear power reactors; industrial radiographers; fuel processors (including uranium enrichment), fabricators; manufactures and distributors of byproduct material; independent spent fuel storage installations; and facilities for land disposal of low level waste. Tables 1, 2 and 3, respectively, provide a summary of collective and average CEDE based on the type of NRC licensee for 1997 and 1998, a summary of maximum occupational internal exposures by category for 1997 and 1998, and a summary of CEDE for each year for the period 1994-1998.

Table 1: Collective and Average Committed Effective Dose Equivalent (CEDE) by Licensee Type

Year >>	1997			1998		
Licensee Type	Num. with measured CEDE	Collective CEDE (person-rem, cSv)	Avg. Meas. CEDE (rem, cSv)	Num. with measured CEDE	Collective CEDE (person-rem, cSv)	Avg. Meas. CEDE (rem, cSv)
Nuclear Pharmacies	22	0.276	0.013	26	0.314	0.012
Manufact/ Distribution	8	0.146	0.018	8	0.164	0.021
Uranium Enrichment	36	0.314	0.009	58	0.242	0.004
Fuel Fabrication	2,639	800.16	0.303	2,462	741.8	0.301
Reactors	1,034	10.99	0.011	943	18.89	0.020

Source: NUREG 0713 (1997 Final, 1998 draft)

Table 2 Maximum Occupational Exposures by Licensee				
Year >>	1997		1998	
Exposure category	Number of Individuals with meas. Dose	Maximum Exposure Reported (rem, cSv)	Number of Individuals with meas. Dose	Maximum Exposure Reported (rem, cSv)
CEDE (Committed Effective Dose Equivalent) (rem)	4,105	2.88	3,907	3.40
CDE (Committed Dose Equivalent) (rem)	3,376	29.65	2,898	28.35
TODE (Total Organ Dose Equivalent) (rem)	62,984	29.65	56,310	28.57
TEDE (Total Effective Dose Equivalent) (rem)	77,094	4.48	67,221	12.92

Source: NUREG 0713(1997 Final, 1998 draft)

There were no exposures in excess of applicable NRC limits in 1997 or 1998 solely attributable to intakes of radioactive material. There were two exposures in excess of the applicable extremity limit in 1997, and four exposures in excess of the TEDE limit due to deep dose equivalent attributable to radiography activities. The maximum CDE exposures occurred at fuel fabrication facilities.

Table 3 Internal Dose - Committed Effective Dose Equivalent - CEDE (1994-1998)			
Year	Total with meas. CEDE	Collective CEDE (person-rem, cSv)	Average meas. CEDE (person-rem, cSv)
1994	3,244	1,024.85	0.316
1995	2,948	709.01	0.241
1996	3,042	722.16	0.237
1997	3,739	811.89	0.217
1998	3,513	766.06	0.218

Source: NUREG 0713(1997 Final, 1998 draft)

F. Case Example

Case Example-Reactor

In November 1996, through information provided by its onsite resident inspector, the NRC became aware of elevated airborne radioactivity within the reactor cavity at a pressurized water reactor nuclear power station undergoing refueling. The NRC staff reviewed airborne radioactivity sample analyses and concluded that the licensee may not have properly monitored or assessed internal exposure of workers. This review prompted a subsequent onsite inspection which confirmed that the licensee had not properly monitored for, or assessed exposure to, airborne transuranic radioactive material. In addition, because of the delay in identifying the presence and potential exposure, the licensee had not initiated timely in-vitro sample analyses. The licensee had conducted exposure assessment for activation products. Subsequent analyses indicated the potential to exceed applicable organ dose limits. The licensee subsequently initiated a comprehensive review of the event and concluded that internal exposure was limited due to the relatively rapid clearance of material from the body and no applicable limit had been exceeded. The NRC performed follow-up assessment and used available internal dosimetry codes to assess the potential intake. The assessment reviewed radionuclide compositions, potential impacts of particle sizes, and individual excretion rates. Although no exposure in excess of applicable limits was identified, the reviews did identified areas for improvement including work control and oversight by radiation protection personnel, failures to follow radiation work permits, inadequate airborne radioactivity sampling and analysis, and weaknesses in dose assessment.

The NRC inspection prompted significant action by the licensee to identify root causes and implement program improvements. To alert the industry to the event, the NRC issued Information Notice 97-36, "Unplanned Intakes By Workers of Transuranic Airborne Radioactive Materials and External Exposure Due to Inadequate Control of Work."

The NRC conducted follow-up inspections to confirm implementation of licensee program enhancements and performed direct oversight of resumption of potential airborne radioactivity producing activities. The referenced Information Notice provides a summary of the event and the airborne radioactivity monitoring and exposure assessment matters identified by the licensee as well as a summary of licensee corrective actions.

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USNRC Region I

Role and Responsibility of the NRC

* **The Nuclear Regulatory Commission (NRC) was created as an independent agency by the Energy Reorganization Act of 1974.**

* **The NRC's mission is to regulate the Nation's use of byproduct, source, and special nuclear materials, to ensure adequate protection of public health and safety, to promote the common defense and security, and to protect the environment.**

* **The NRC's scope of responsibilities includes regulation of commercial nuclear power plants; research, test, and training reactors; fuel cycle facilities; medical, academic, and industrial uses of nuclear materials; and the transport, storage, and disposal of nuclear materials and waste.**

Regulations Controlling Occupational Radiation Exposure

* **10 CFR 20, Standards for Protection Against Radiation, establishes standards for protection against ionizing radiation in the United States resulting from activities conducted under licenses issued by the NRC.**

* **10 CFR 20 incorporates recommendations of the ICRP (1977) and provides the basic annual occupational exposure limits (20.1201) for adults.**

  - **5 rem (0.05 Sv) total effective dose equivalent,**

  - **50 rem (0.5 Sv) for the sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye,**

  - **15 rems (0.15 Sv) eye dose equivalent,**

  - **50 rems (0.50 Sv) shallow dose equivalent to the skin or to any extremity.**

* **10 CFR 20 also provides, in part**

  - **requirements to conduct surveys that may be necessary and reasonable to comply with the the regulations in Part 20**

  - **requirements for summation of external and internal doses; determination of external dose from airborne radioactive materials; and determination of internal exposures**

  - **conditions requiring individual monitoring of external and internal occupational dose and requirements for records and reporting of exposures.**

Regulations Controlling Occupational Radiation Exposure(Contd.)

ALARA Requirements

* **10 CFR 20 provides requirements for use of respiratory protection equipment and other controls to limit internal exposure in restricted areas. If it is impractical to apply process or other engineering controls to control concentrations of radioactive material in air to values below those that define an airborne radioactivity area, the licensee is to, consistent with maintaining the total effective dose ALARA, increase monitoring and limit intakes by, among other controls, control of access, limitation of exposure times, or use of respiratory protection.**

Supporting Guidance Documents

* **NRC Regulatory Guides (RGs) receive public and industry comment and are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants.**

* **RGs reference consensus standards (e.g., American National Standards). And are not substitutes for regulations, and compliance with them is not required.**

* **Regulatory guides provide guidance on (examples):**

  - **acceptable concepts, models, equations, and assumptions for a bioassay program (8.9)**
  - **air sampling in the work place (8.25)**
  - **applications of bioassays for fission and activation products (8.26)**
  - **health physics surveys in uranium mills (8.30)**
  - **monitoring criteria and methods to calculate occupational radiation doses (8.34)**
  - **recording and reporting occupational radiation exposure data (8.7).**
  - **implementing use of respiratory protection (8.15)**

Supporting Guidance Documents(Contd.)

* **The NRC issues NUREGs, which are available to the public and cover a wide range of topics. NUREG /CR-4884, "Interpretation of Bioassay Measurements", is a comprehensive manual (about 800 pages) that describes how to compute intakes of radioactive material from both in-vivo and in vitro bioassay measurements.**

* **The NRC issues Information Notices (INs). These notices typically cover an important issue or event and are designed to provide notice to licensee's in a timely fashion to allow them to become aware of the issue and respond as it sees appropriate. Licensees are not required to take action on INs.**

* **The NRC maintain its own web page (www.nrc.gov) which provides information on different topics including newly released documents as discussed above. NRC regulations, RG and Information Notices are available on the WEB. Availability of NUREGs is also provided on the WEB.**

Inspections

* **To implement its responsibilities, the NRC conducts inspections at its licensed facilities in accordance with formally approved inspection program documents.**

* **Inspection procedures describe the type of inspection to be performed, the program attributes to be reviewed, acceptance criteria, and the inspection frequency. Enforcement is guided by NRC enforcement manuals.**

* **NRC implemented a pilot Regulatory Oversight Process. At reactors, performance is evaluated in strategic areas (Reactor Safety, Radiation Safety, and Safeguards) through a combination of inspection and performance indicators. The process provides for inspections in sub-areas called "Cornerstones". The Cornerstones are initiating events, mitigation systems, barrier integrity, emergency preparedness public exposure control occupational exposure control, and physical protection. Inspections are conducted of "inspectable areas" within each cornerstone. Findings from the inspections and outputs from performance indicators are feed into a Significance Determination Process which assess the significance of the finding and prompts further NRC action consistent with an "Action matrix". The new inspection process is expected to be fully implemented in 2000.**

Occupational Exposures at NRC Licensed Facilities

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* **Exposure Data was excerpted from the 1997 volume of NUREG-0713, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities," and the 1998 draft volume which was under review.**

* **The compilation includes information on exposures at nuclear power reactors; industrial radiographers; fuel processors (including uranium enrichment), fabricators; manufactures and distributors of byproduct material; independent spent fuel storage installations; facilities for land disposal of low level waste.**

Collective and Average CEDE by Licensee

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Reactor Case Example

* In November 1996, through information provided by its onsite resident inspector, the NRC became aware of elevated airborne radioactivity within the reactor cavity at a pressurized water reactor nuclear power station undergoing refueling.

* An onsite inspection confirmed that the licensee had not properly monitored for, or assessed exposure to airborne transuranic radioactive material and an intake in excess of applicable limits had occurred. In addition, because of the delay in identifying the presence and potential exposure, the licensee had not initiated timely in-vitro sample analyses.

* The licensee had conducted exposure assessment for activation products. The licensee subsequently initiated a comprehensive review of the event and concluded that internal exposure was limited due to the relatively rapid clearance of material from the body and no applicable limit had been exceeded.

Reactor Case Example(Contd.)

* The NRC performed confirmatory analysis and used available internal dosimetry codes to assess the potential intake. The assessment reviewed radionuclide compositions, potential impact of particle sizes, and individual excretion rates. Although no exposure in excess of limits was identified, the NRC reviews identified weaknesses in several areas including work control and oversight by radiation protection personnel, failures to follow approved procedures including radiation work permits, inadequate airborne radioactivity sampling and analysis, and weaknesses in dose assessment.

* The NRC inspection prompted significant action by the licensee to identify root causes and implement program improvements.

* To alert the industry to the event, the NRC issued an Information Notice 97-36, Unplanned Intakes By Workers of Transuranic Airborne Radioactive Materials and External Exposure Due to Inadequate Control of Work. The NRC conducted follow-up inspections to confirm implementation of licensee program enhancements and performed direct oversight of resumption of potential airborne radioactivity producing activities. The Information Notice provides a summary of the event and the airborne radioactivity monitoring and exposure assessment matters identified by the licensee as well as a summary of licensee corrective actions.