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Radiological Issues at ISR Facilities

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December 17, 2009

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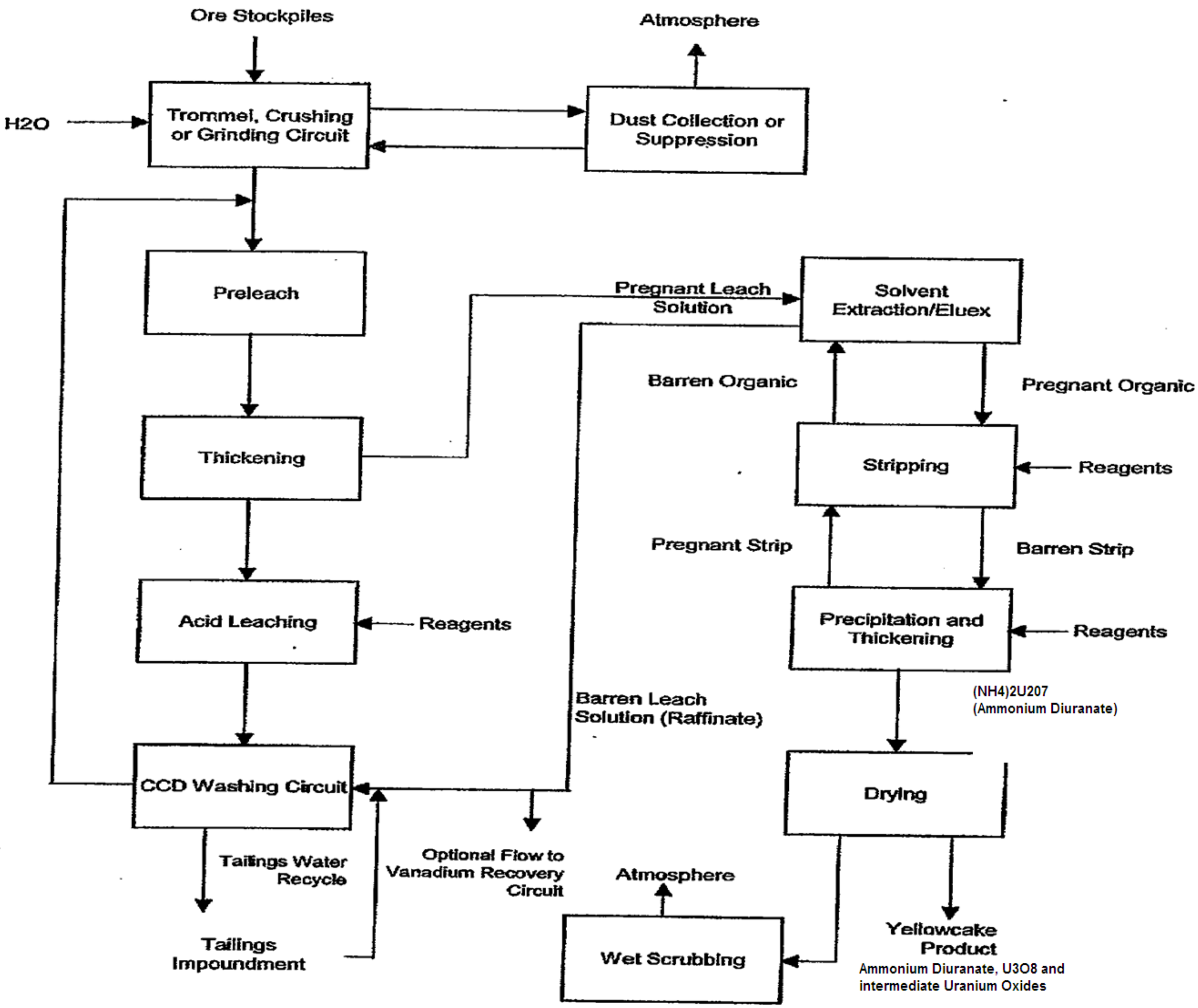
Topics

- Internal Dosimetry
  - Inhalation Classification for Hydrogen Peroxide Precipitated Yellowcake
  - Mixture Rule
- Acceptable Contamination Control Limits
  - Release of Materials for Unrestricted Use
  - Personnel Monitoring
- Coming Soon…
  - Restricted area contamination levels
  - Reporting radon results

Internal Dosimetry

Q. Which translocation classification (D, W, or Y) should be used for uranium at an ISR facility?

A. As with any compound, this is determined by the chemical form. For yellowcake production, this will depend on precipitating conditions, drying temperatures, and location in plant.



Ore Stockpiles
Atmosphere
H2O
Trommel, Crushing or Grinding Circuit
Dust Collection or Suppression
Preleach
Pregnant Leach Solution
Solvent Extraction/Eluex
Barren Organic
Pregnant Organic
Thickening
Stripping
Reagents
Pregnant Strip
Barren Strip
Acid Leaching
Reagents
Precipitation and Thickening
Reagents
(NH4)2U207
(Ammonium Diuranate)
Barren Leach Solution (Raffinate)
CCD Washing Circuit
Drying
Tailings Water Recycle
Optional Flow to Vanadium Recovery Circuit
Atmosphere
Tailings Impoundment
Wet Scrubbing
Yellowcake Product
Ammonium Diuranate, U3O8 and intermediate Uranium Oxides

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Terminology:

What is yellowcake?

Various definitions –

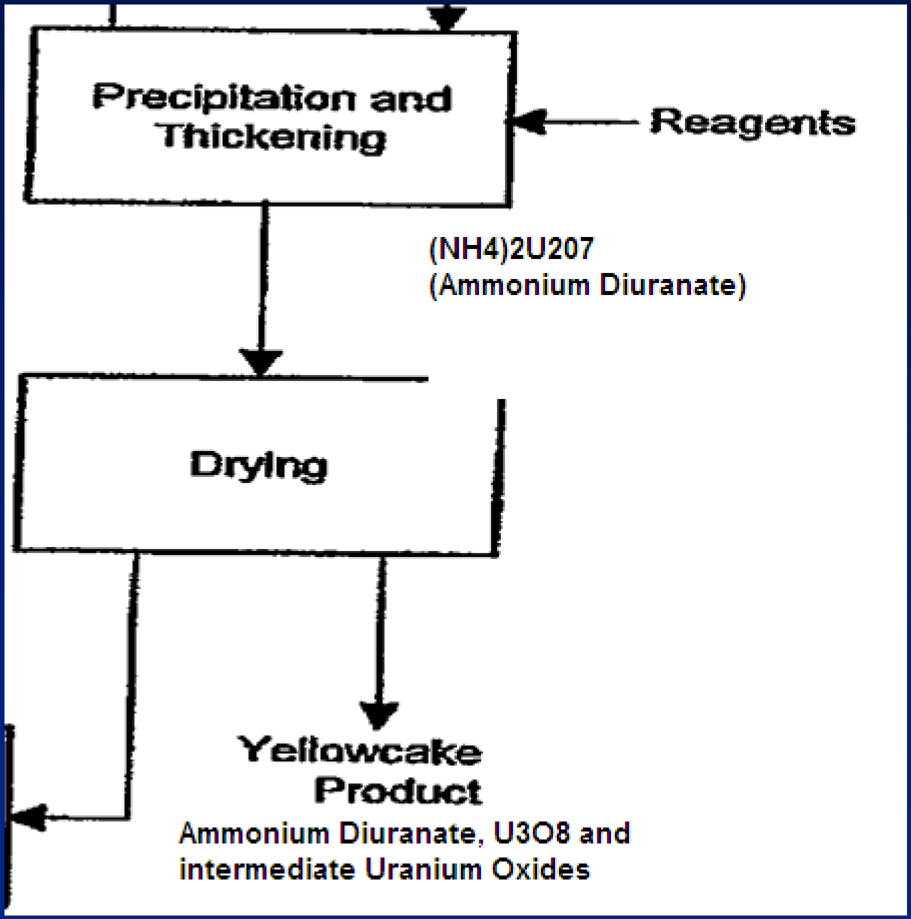
1. A natural uranium concentrate that takes its name from its color and texture. Yellowcake typically contains 70 to 90 percent U3O8 (uranium oxide) by weight. (US DOE/EIA Form 851A)

Yellowcake Definitions, cont'd

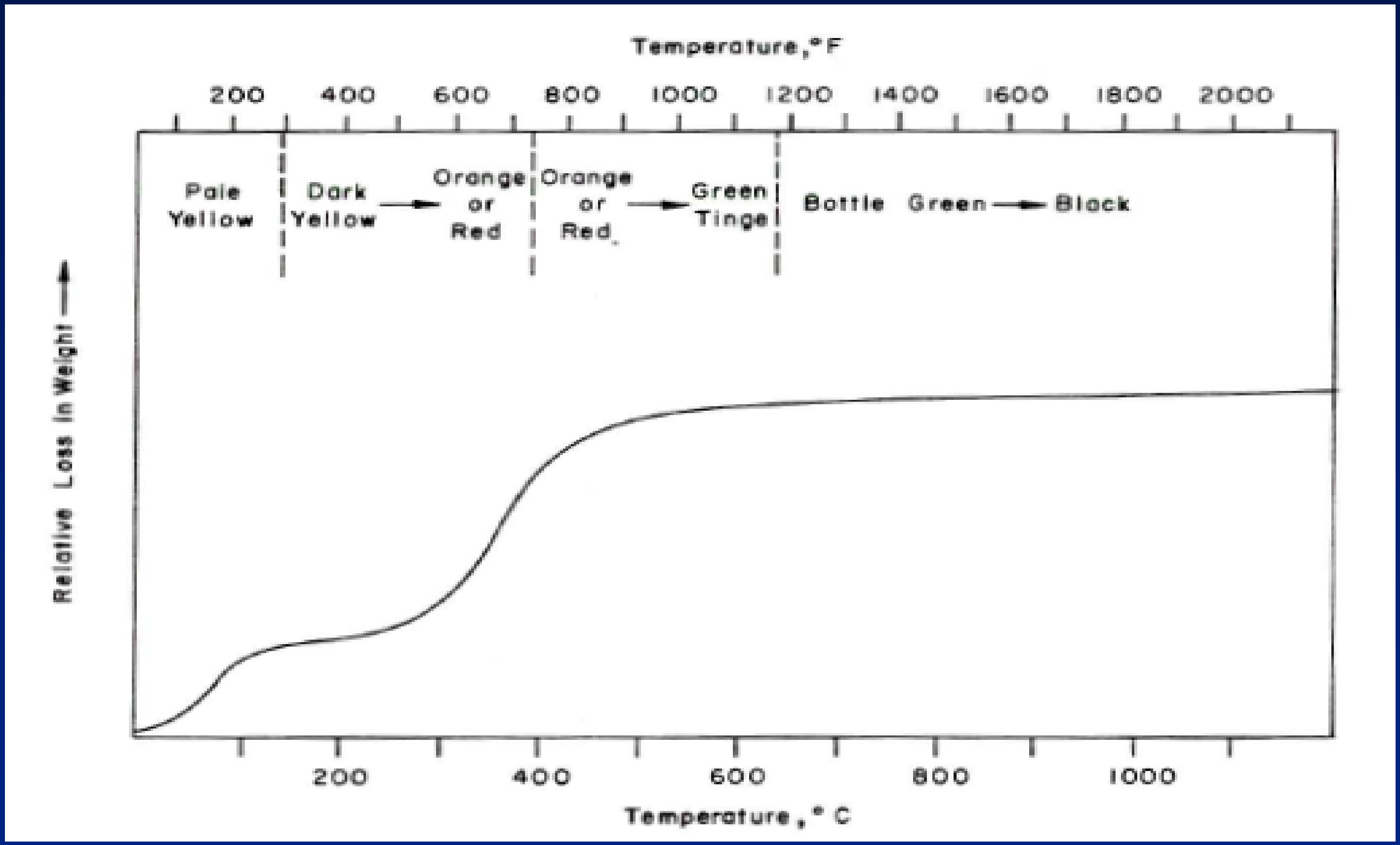
2. The solid form of mixed uranium oxide, which is produced from uranium ore in the uranium recovery (milling) process. Its properties depend on the temperature at which the material is dried. Yellowcake is commonly referred to as U_3O_8, because that chemical compound comprises approximately 85 percent of the yellowcake produced by uranium recovery facilities. (U.S. NRC online glossary)

3. The final precipitate formed in the milling process…the composition is variable and depends on the precipitating conditions. (U.S. DOI, A Dictionary of Mining, Mineral, and Related Terms, 1968)

Conventional milling product:



Effect of calcining temperature on the decomposition of ammonium diuranate:



(Source: Merritt, R.C., The Extractive Metallurgy of Uranium, 1971)

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How NRC has historically classified yellowcake for internal dosimetry

- Prior to 1991, 10 CFR 20 radiation protection standards were based on ICRP-2 (1959)
- The ICRP-2 clearance model depended on the "solubility" of the material. The material was either "soluble" or "insoluble".
- These solubility terms were not defined.

Yellowcake classification, cont'd

- 1966: ICRP Task Group on Lung Dynamics published their report *Deposition and Retention Models for Internal Dosimetry of the Human Respiratory Tract.*
  - Recommendations included the D, W and Y inhalation classification. Declared "solubility" as "confusing and inappropriate" for the lung model.
  - Example: Industry refers to the solubility of uranium in the lixiviant as a technical justification for Class D inhalation class.
- 1977: ICRP Publication 26 incorporated the Task Group's recommendations.

Yellowcake classification, cont'd

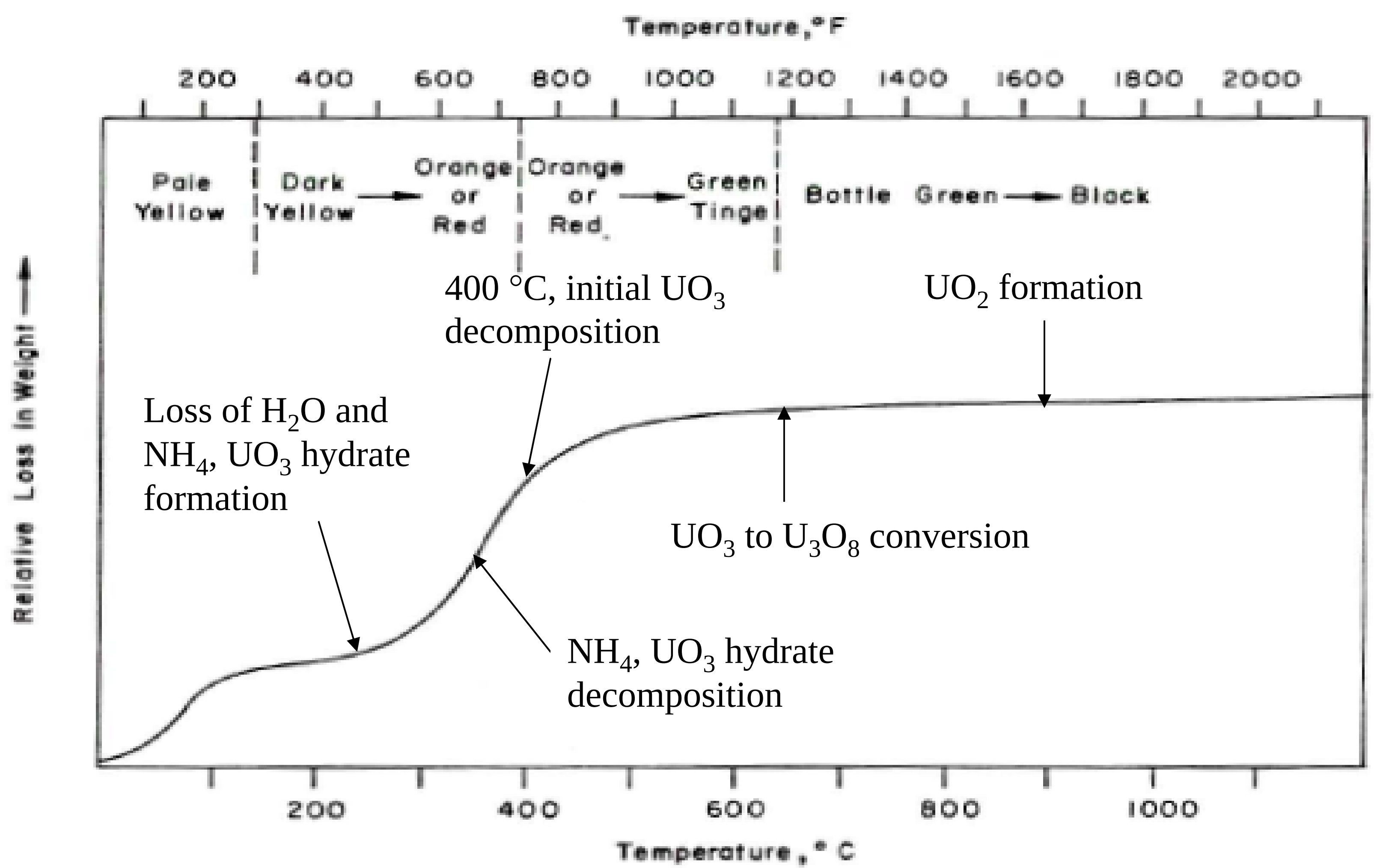
- 1983: NRC published Regulatory Guide 8.30, *Health Physics Surveys in Uranium Mills.*
- 5 references cited as technical justification for yellowcake solubility recommendations.
- Note: Uranium ore dust had its own specified concentration limits that could be used (1960 Federal Register).

Yellowcake classification, cont'd

- 4 of these references related directly to dissolution in simulated lung fluid. The other reference (Merritt) was a general technical reference on uranium extraction.
- 3 of these references evaluated yellowcake from conventional mills.
- 1 reference (Steckel and West) evaluated an intake at Y-12.

Yellowcake classification, cont'd

- Dependence of yellowcake (from conventional mills) solubility on temperature based on references discussed above.
- Dryer temperature < 400°C, yellowcake classified as "soluble" due to predominance of ammonium diuranate.
- Dryer temperature 400°C and higher, yellowcake classified as "insoluble" due to predominance of uranium oxides



Temperature, °F
200
400
600
800
1000
1200
1400
1600
1800
2000
Pale Yellow
Dark Yellow
Orange or Red
Orange or Red
Green Tinge
Bottle Green → Black
400 °C, initial UO_3 decomposition
UO_2 formation
Loss of H_2O and NH_4, UO_3 hydrate formation
UO_3 to U_3O_8 conversion
NH_4, UO_3 hydrate decomposition
Relative Loss in Weight
200
400
600
800
1000
Temperature, ° C

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Yellowcake classification, cont'd

- 1991: NRC incorporates ICRP Publication 26 recommendations into 10 CFR 20, Standards for Protection Against Radiation.
- 2002: Regulatory Guide 8.30 revised. Now titled *Health Physics Surveys in Uranium Mills.*
- Intent was to incorporate 1991 revision to 10 CFR 20 and include in situ recovery technology.

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Yellowcake classification, cont'd

- Recommendations did not update terminology consistent with current version of 10 CFR 20.
- Generic terms "soluble" and "insoluble" remain.
- Uranyl peroxide is mentioned. However, no new references cited for solubility recommendations for this compound.
- No evaluation of uranium in the carbonate or peroxide form in the yellowcake studies referenced.

Yellowcake classification, cont'd

Analysis:

1) Current recommendations for surveys for airborne yellowcake remain based on conventional mill products.

2) Current recommendations do not incorporate current 10 CFR 20 requirements.

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Next Steps

- Efforts to revise Regulatory Guide 8.30 have begun.
- This is a long process (min. 18 months).
- NRC staff recognizes that industry needs guidance now.

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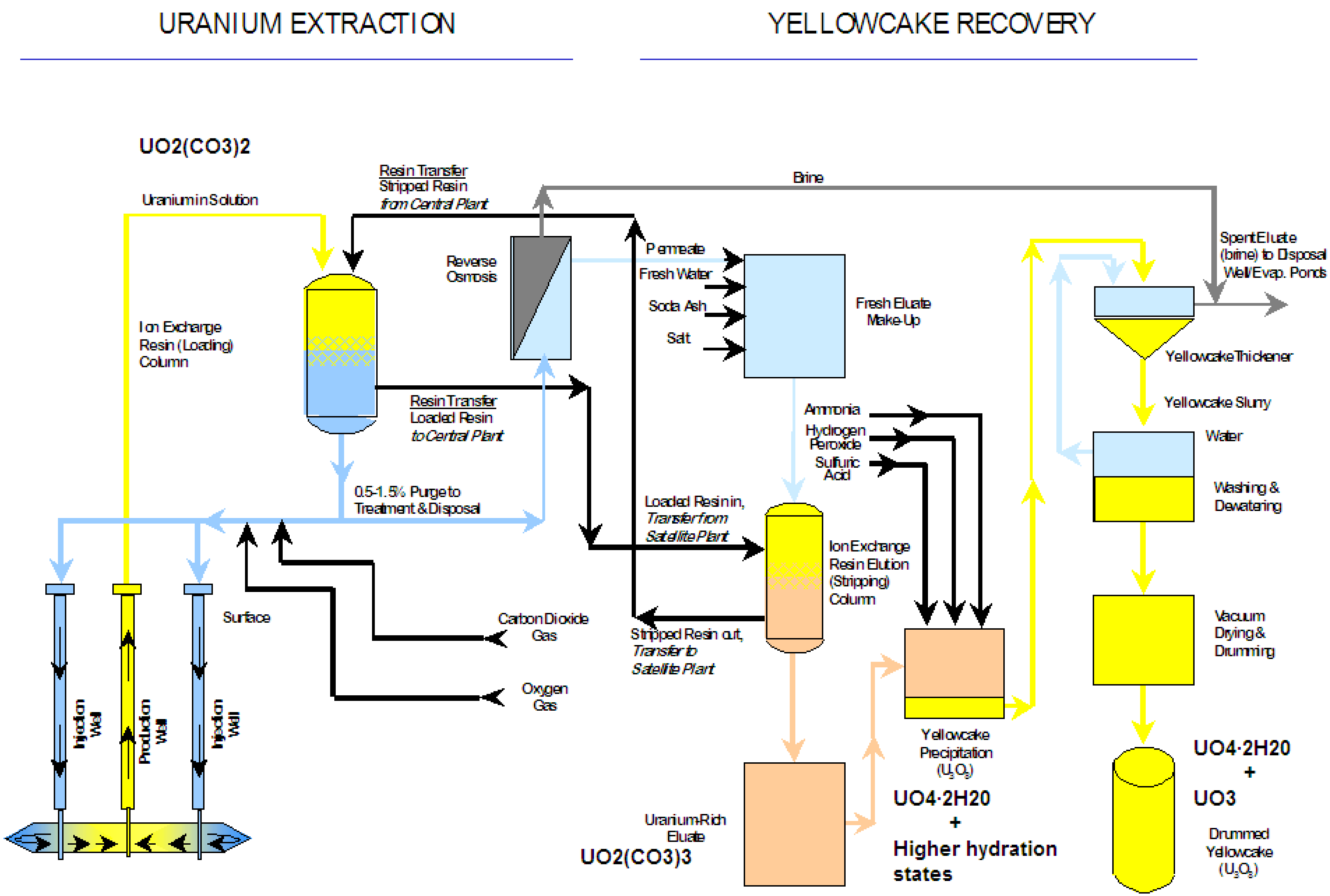
How can industry proceed?

- We have provided a general approach through the licensing process (RAIs).
- The next few slides will provide a technical justification for this approach.

Source: NUREG/CR-6733

FLOW PROCESS SCHEMATIC



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Hydrogen peroxide precipitated yellowcake product prior to drying

$$UO_2^{2+} + 3\,H_2O_2 = UO_8H_4 + 2H^+$$

$$UO_8H_4 + 2\,UO_2^{2+} + xH_2O = UO_8(UO_2)_2 \cdot xH_2O + 4H^+$$

The dihydrate ($UO_4 \cdot 2H_20$) forms at approximately 100^{o}C

Source: Guptka, C.K., Harvinderpal, S, Uranium Resource Processing Secondary Resources, 2003.

What are the transition temperature and chemical products of interest?

- According to Leininger, et. al., $UO_4 \cdot 2\ H_2O$ (uranyl peroxide) is quantitatively converted to UO_3 at T = 150°C and p = 0.2 atm.

- Values consistent with data presented by Katz and Rabinowitch, The Chemistry of Uranium, Part 1, The Element, Its Binary and Related Compounds, 1951

- UO_3 decomposition to lower oxides ~ 400°C (See previous slide from Merritt)

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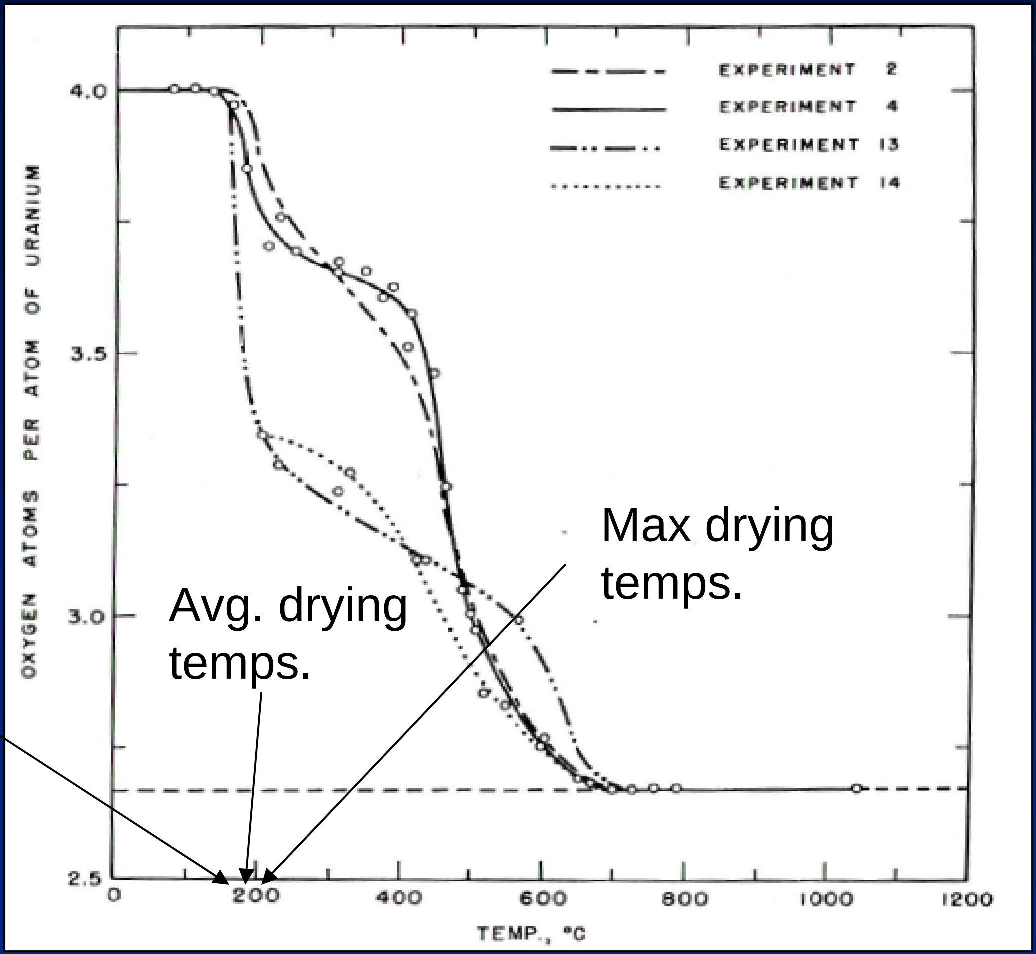
UO_4
Conversion to
UO_3



Thermal decomposition of uranyl peroxide as a result of ignition for 1 ¼ hr.

(Source: Leininger, R.F., et. al., Composition and Thermal Decomposition of Uranyl Peroxide, Chemistry of Uranium collected papers, 1958)

What does this tell us?

- We have uranium compounds (peroxides and carbonates) not specifically addressed by 10 CFR 20 (or ICRP-26) for inhalation classification.

92	Uranium-230	D, UF_6, UO_2F_2, $UO_2(NO_3)_2$
		W, UO_3, UF_4, UCl_4
		Y, UO_2, U_3O_8

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Scarcity of operational data to draw conclusions from.

- One ISR study conducted and reported in the literature. Metzger, et. al. tested uranium at Cogema's Irigaray plant.
- Results indicated their yellowcake was 97% Class D/ 3% Class W
- Based on additional data, actual DAC implemented was 85% D/ 15% W

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Operational data, cont'd

- This is one data point, not a scientific body of evidence.
- Majority of relevant literature suggests Class W or Y for uranium peroxide.
- Data mostly nonexistent for uranium carbonates.

Table 4. Suggested solubility classification for some common uranium compounds.*

Compound	Solubility Class
UF_6 (uranium hexafluoride)	D
$UO_2(NO_3)_2$ (uranyl nitrate)	D
$UO_2(CH_2H_2O_2)$ (uranyl acetate)	D
UO_3 (uranium trioxide)	D
UO_2Cl_2 (uranyl chloride)	D
UO_2SO_4 (uranyl sulfate)	D
$(NH_4)_2U_2O_7$ (ammonium diuranate)	D, W
UO_2F_2 (uranyl fluoride)	D
UO_4 (uranium peroxide)	W

Source: *Biokinetics and Analysis of Uranium in Man*, United States Uranium Registry, USUR-05 HEHF-47, 1984

Literature examples ,cont'd.

The toxicity of uranium varies according to its chemical form and route of exposure. On the basis of the toxicity of different uranium compounds in animals, it was concluded that the relatively more water-soluble compounds (uranyl nitrate hexahydrate, uranium hexafluoride, uranyl fluoride, uranium tetrachloride, uranium pentachloride) were the most potent renal toxicants. The less water-soluble compounds (sodium diuranate, ammonium diuranate) were of moderate-to-low renal toxicity, and the insoluble compounds (uranium tetrafluoride, uranium trioxide, uranium dioxide, uranium peroxide, triuranium octaoxide) had little potential to cause renal toxicity but could cause pulmonary toxicity when exposure was by inhalation.

Source: ***Toxicological Profile for Uranium*, U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, Public Health Service, Agency for Toxic Substances and Disease Registry, September 1999**

Note: **Much of this data from older sources that could only evaluate relative effects (i.e., prior to the TGLD report)**

Table 2-11. Inhalation Classification for Some Uranium Compounds

Uranium Compound	Chemical Name	Material Type
Uranium hexafluoride	UF_6	Type "F"
Uranyl fluoride	UO_2F_2	Type "F"
Uranyl nitrate	$UO_2(NO_3)_2$	Type "F"
Uranyl acetate	$UO_2(C_2H_3O_2)_2$	Type "F"
Uranyl chloride	UO_2Cl_2	Type "F"
Uranyl sulfate	UO_2SO_4	Type "F"
Uranium trioxide	UO_3	Type "M"
Uranium tetrafluoride	UF_4	Type "M"
Uranium oxide	U_3O_8	Type "S" (b)
Uranium dioxide	UO_2	Type "S" (b)
Uranium tetroxide	UO_4	Type "M"
Ammonium diuranate	$(NH_4)_2 + U_2O_7$	Type "M" (a)
Uranium aluminide	UAl_x	Type "S"
Uranium carbide	UC_2	Type "S"
Uranium-zirconium alloy	UZr	Type "S"
High-fired uranium dioxide	UO_2	Type "S" (b)

(a) Ammonium diuranate is known to contain uranium as UO_3, and should not be assigned to a single inhalation class.

(b) The solubility of uranium oxides is very dependent on heat treatment. The rate of oxidation may also affect the solubility. It is recommended that solubility studies be performed to characterize the actual materials present.

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NRC Staff DAC Recommendations:

- 400°C remains a valid transition temperature between inhalation classes (based on UO_3 decomposition).
- Lacking site specific data, hydrogen peroxide precipitated yellowcake, dried at < 400°C, should be considered a Class W compound for radiation protection purposes.
- Lacking site specific data, hydrogen peroxide precipitated yellowcake, dried at 400°C and higher, should be considered a Class Y compound for radiation protection purposes.

NRC Staff DAC Recommendations, cont'd.

- Notwithstanding these recommendations, licensees must also demonstrate compliance with 10 CFR 20.1201(e).
- Without site specific data, the 10 mg weekly limit should be based on 100 % Class D uranium.
- NRC staff will reconsider these recommendations when additional data on hydrogen peroxide precipitated yellowcake becomes available.

Questions?

10 CFR 20.1204(e)(f)(g): Determining DAC for Radionuclides in a Mixture

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10 CFR 20.1204(e)(f)(g): Determining DAC for Radionuclides in a Mixture

Current practice is to rely on gross alpha counting of all airborne surveys in the plant.

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DAC for mixtures, cont'd.

- NRC staff has determined that the potential exists for uranium daughters to be present in air.
  - Paper by S. Brown recommends "airborne monitoring for long-lived alpha emitters (U, Th) in appropriate process areas…" (Brown, S, *The New Generation of Uranium In Situ Recovery Facilities: Design Improvements Should Reduce Radiological Impacts Relative to First Generation Uranium Solution Mining Plants*, Paper #8414, WM 08 Conference, February 25 – March 1, 2008, Phoenix, AZ)

DAC for mixtures, cont'd.

- This includes alpha- and beta-emitting daughters.
- All aspects of operations and maintenance need to be assessed, not just the end product.

DAC for mixtures, cont'd.

Knowledge Gaps:

- NRC staff is unaware of studies addressing the radioisotopic composition of hydrogen peroxide precipitated yellowcake, similar to NUREG/CR-1216 for conventional mills.
- NRC staff is unaware of site specific survey data fully characterizing contamination in work areas (more in next topic discussion).
- NRC staff is unaware of site specific survey data fully characterizing air samples at ISR facilities.

DAC for mixtures, cont'd.

Analysis:

- Current survey practices do not allow for the determination of all potential radiological hazards consistent with 10 CFR 20.1501.

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NRC Staff Recommendations:

- Applicants and licensees are required to demonstrate compliance with 10 CFR 20.1501 and 10 CFR 20.1204(e), (f), and (g) with respect to air sampling programs.

- Regulatory Guide 8.30 will address these issues when it is revised.

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Questions?

Acceptable Contamination Control Limits

- Release of Materials for Unrestricted Use
- Personnel Monitoring

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Release of Materials for Unrestricted Use

Q. What are the correct values of surface contamination levels for releasing equipment and other materials for unrestricted use during ISR operations?

A. Good question!

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Release of Materials for Unrestricted Use

Two issues have been raised over the last year with the ISR industry regarding the release of equipment and materials for unrestricted use. These issues were described by the Wyoming Mining Association in their letter dated July 23, 2009, to the NRC staff.

1. The source of release criteria for ISR facilities (i.e., from what document is release criteria derived?).
2. How these criteria should be applied at ISR facilities.

Historical development of release limits used by NRC

- Prior to 1974: U.S. Atomic Energy Commission document dated April 22, 1970 used for reactor and material licensees.
  - *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material* (Accession # 9006010010, 54023:193-196).
  - The term "associated decay products" is used in conjunction with the U-nat release group, but not defined.

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1970 Guidelines:

ISOTOPE[2]	TABLE I		TABLE II	
	TOTAL[3]	REMOVABLE[3] [4]	TOTAL[3]	REMOVABLE[3] [4]
U-nat, U-235, U-238, Th-nat, Th-232, and associated decay products	10,000 dpm α/100 cm^2	1,000 dpm α/100 cm^2	Average[6] 5,000 dpm α/100 cm^2 Maximum 25,000 dpm α/100 cm^2	1,000 dpm α/100 cm
Other isotopes which decay by alpha emission or by spontaneous fission	1,000 dpm α/100 cm^2	100 dpm α/100 cm^2	Average[6] 500 dpm α/100 cm^2 Maximum 2,500 dpm α/100 cm^2	100 dpm α/100
Beta-gamma emitters (isotopes with decay modes other than alpha emission or spontaneous fission)	0.4 mrad/hr at 1 cm[5]	1,000 dpm β-γ/100 cm^2	Average[6] 0.2 mrad/hr at 1 cm[5] Maximum 1.0 mrad/hr at 1 cm[5]	1,000 dpm β-γ/100^2

- 1974: Regulatory Guide 1.86 published for use by Part 50 licensees only.
  - Some changes from the 1970 Guidelines document (limits, categories).
  - The term “associated decay products” remains with U-nat group but still not defined.

Release of Materials for Unrestricted Use

- 1976: Revised Guidelines now an NRC document.
  - Table values identical to Regulatory Guide 1.86.
  - Retains exposure rate limits for beta-gamma emitters from 1970 Guidelines, not part of Regulatory Guide 1.86.
  - Accession # 8009180453, 06573:307-334.

- 1981: NRC issued Inspection and Enforcement Circular No. 81-07, *Control of Radioactively Contaminated Material*.
  - Addressed to nuclear power reactor facilities.
  - Resulted from radioactive material released to unrestricted areas (trash disposal and sale of scrap material).
  - Provided guidance on contamination detection programs including the need for detection capability at 100 dpm/100 cm^2 fixed and 20 dpm/100 cm^2 removable if alpha contamination suspected.

Release of Materials for Unrestricted Use

- 1983

1. NRC issued Policy and Guidance Directive FC 83-23: Termination of Byproduct, Source and Special Nuclear Material Licenses (ADAMS accession # ML030650166).
   a. Contains Enclosure 2 Guidelines (July 1982) with release limits in Table 1 of this enclosure.
   b. No technical changes noted from 1976 Guidelines.

2. NRC issued Regulatory Guide 8.30 *Health Physics Surveys in Uranium Mills*.
   a. The term "associated decay products" replaced with "uranium and daughters" with no explanation.
   b. References 1976 version of Guidelines. This version looks the same as RG 1.86.
   c. Also references RG 1.86 although it is not applicable.

Release of Materials for Unrestricted Use

- 1990: NRC publishes “below regulatory concern” policy statement (BRC).
  - Quantitative standards for license termination.
  - Unrestricted release of materials.
  - Very controversial.
- 1992: BRC revoked by Energy Policy Act

Release of Materials for Unrestricted Use

- 1994: NRC begins a more focused effort to establish specific requirements for the release of solid materials.
  - This would result in dose-based release criteria.
  - Many studies conducted to relate FC 83-23 release criteria to dose.
  - This effort continued through 2005.

Release of Materials for Unrestricted Use

- 1998: 63 FR 64132 provides supplemental information on the License Termination Rule
  - FC 83-23 as decommissioning criteria (i.e., release of land and facilities) superseded.
  - Clarified that until dose-based release criteria for equipment and materials having residual radioactivity are developed, licensees may continue to use FC 83-23 to the extent authorized by their license.

Release of Materials for Unrestricted Use

- 2002: Regulatory Guide 8.30 revised.
  - Release table re-titled to include ISR facilities.
  - References include the 1987 Guidelines (even though 1993 version is available).
  - Release values remain the same.

Release of Materials for Unrestricted Use

- 2005: Commission unanimously disapproves proposed rule for radiological criteria (i.e., a dose-based approach) for disposition of solid materials.
  - References to National Academies of Science study (2002) that indicated that current approach is protective.
  - Chairman Diaz suggested resubmitting in 2007.

Analysis:

- FC 83-23 release criteria remains the NRC-approved criteria for releasing equipment and material for unrestricted use from ISR facilities during operations.
- Guidelines have been republished several times over the years to reflect changes in the responsible NRC Office.
  - No technical changes to release criteria.
  - Current version is dated April 1993 (ML003745526) (See NRC memo dated 12/27/02 (ML030020591)).

How have the FC 83-23 release criteria been applied at ISR facilities?

Release of Materials for Unrestricted Use

- Current Regulatory 8.30 guidance:

TABLE 2

Surface Contamination Levels for Uranium and Daughters on Equipment To Be Released for Unrestricted Use, on Clothing, and on Nonoperating Areas of UR Facilities*

Average**	5,000 dpm alpha per 100 cm^2	Average over no more than $1 m^2$
Maximum**	15,000 dpm alpha per 100 cm^2	Applies to an area of not more than 100 cm^2
Removable	1,000 dpm alpha per 100 cm^2	Determined by smearing with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the smear

* These values are taken from Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors" (Ref. 23), and from "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct Source. or Special Nuclear Material," Division of Fuel Cycle and Material Safety, USNRC, Washington, DC 20555, August 1987 (Ref. 24). Available in NRC Public Document Room for inspection and copying for a fee.

** The value includes both fixed and removable contamination.

(The contamination levels in Table 2 are given in units of dpm/100 cm^2 because this is the minimum area typically surveyed. When performing a smear or wipe test, the area should roughly approximate 100 cm^2. However, there is no need to be precise about the area to be smeared.)

Observations:

- These recommendations do not address the equilibrium status of uranium and daughters.
- The Table 2 values have been and are currently used without regard to the equilibrium status of uranium and daughters.

How should FC 83-23 release criteria be applied at ISR facilities?

Guidelines release limits:

TABLE 1

ACCEPTABLE SURFACE CONTAMINATION LEVELS

NUCLIDES[a]	AVERAGE[b c f]	MAXIMUM[b d f]	REMOVABLE[b e f]
U-nat, U-235, U-238, and associated decay products	5,000 dpm α/100 cm^2	15,000 dpm α/100 cm^2	1,000 dpm α/100 cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm/100 cm^2	3,000 dpm/100 cm^2	200 dpm/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000 dpm $\beta\gamma$/100 cm^2	15,000 dpm $\beta\gamma$/100 cm^2	1,000 dpm $\beta\gamma$/100 cm^2

Observations:

- As indicated earlier, FC 83-23 Guidelines use the term “associated decay products” not “uranium and daughters”.

- No indication that purpose of Regulatory Guide 8.30 was to change the language or intent of FC 83-23.

What radionuclides are included in the "U-nat and associated decay products" group?

- Definitions for natural uranium in 10 CFR 20 existed from 1957 until 1974 (timeframe during which release criteria were developed).
- NRC has no current regulatory definition for natural uranium.

- NRC online glossary:

  "Uranium containing the relative concentrations of isotopes found in nature (0.7 percent uranium-235, 99.3 percent uranium-238, and a trace amount of uranium-234 by mass). In terms of radioactivity, however, natural uranium contains approximately 2.2 percent uranium-235, 48.6 percent uranium-238, and 49.2 percent uranium-234. Natural uranium can be used as fuel in nuclear reactors."

- 49 CFR 173.403 (US DOT):

  "Chemically separated uranium containing the naturally occurring distribution of uranium isotopes (approximately 99.28 % uranium-238 and 0.72 % uranium-235 by mass)."

- DOE-STD-1136-2009:

  "In processed uranium (natural, enriched, or depleted) all decay products below U^{234} and U^{235} are removed. Because of the long half-lives of U^{235} and Pa^{231} the radionuclides that follow these two nuclides are generally ignored."

- Health Physics Society Ask the Experts website (Question #8456, answered by Eric Abelquist):

“Table 1 of RG 1.86 lists acceptable surface contamination levels for four groupings of radionuclides. The first radionuclide grouping is listed as "U-nat, U-235, U-238, and associated decay products." This grouping refers to processed uranium, i.e., uranium that has been separated from its longer half-life decay products by extraction of the uranium from the naturally occurring ore state. So U-nat is composed of uranium-238, uranium-235, and uranium-234 at relative natural activity ratios of roughly 1.0/0.05/1.0, and contains the short half-life progeny of uranium-238, i.e., thorium-234, protactinium-234, and protactinium-234m, in secular equilibrium with the uranium-238.”

How do these definitions apply to ISR operations?

- ISR process is highly selective in removing uranium from the ore body.
- Because of the half-lives involved, no appreciable buildup of alpha emitting daughters after extracting uranium from ore.
- Any radium or thorium present are not considered associated decay products. They are considered to be contaminants.

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Is equilibrium status relevant for surface contamination levels for the listed isotopes, mixtures, and groups in the Guidelines?

Release of Materials for Unrestricted Use

- No official generic guidance found for uranium group in the Guidelines.

- April 1994 response to Technical Assistance Request from HQ to Region I regarding depleted uranium (DU).
  - Copper sheets contaminated with DU

  - Dose calculations performed specifying daughter ingrowth (consistent with DOE Standard and Health Physics Society response).

Release of Materials for Unrestricted Use

- Guidance for natural thorium limits
  - 1992 guidance memo to Region II from HQ explains that since daughters will grow back in 30-40 years, natural thorium is always associated with its daughter products for purposes of decontamination and release for unrestricted use.

    Note: This requires an analysis by licensee to ensure that release limit is not exceeded at some point in the future.

How has equilibrium status been addressed with other 10 CFR Part 40 industries?

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MOLYCORP York Site decommissioning plan (2000)

- Rare earth facility with raw materials containing Th and U.
- Complete site characterization performed.
- Settling pond residue containing Th-232, Ra-226, and U-238.

Molycorp, cont'd

- Equilibrium status of uranium series analyzed by NRC and PA state regulators.
- FC 83-23 Guidelines used for release criteria.
- Request for additional information addressed disequilibrium and gross alpha surveys.
- As a result, where a mixture of radionuclides existed and gross alpha measurements performed, most restrictive limit (20 dpm/100 cm^2) was used.

Licensing Examples with Decommissioning Thorium Facilities:

- DOW Thorad Project (2000)
  - Th-232 equilibrium status analyzed.
  - Average Th-230 to Th-232 ratio calculated.
  - Sum of fractions methods used to derive surface contamination release criteria based on the FC 83-23 Guidelines.

Examples, cont'd

- Kaiser Aluminum and Chemical Corporation (1999)
  - Th-232 equilibrium status analyzed.
  - Site characterization data used to calculate average Th-230 to Th-232 ratio.
  - Sum of fractions methods used to derive surface contamination release criteria based on the FC 83-23 Guidelines.

DOE UMTRA Project Environmental, Health, and Safety Plan (1988)

- Surface Contamination Limits based on the following:
  - Uranium daughters not in equilibrium with U-238 parent.
  - Th-230, Ra-226, and Pb-210 have lower limits than natural uranium, therefore the U-nat limit is not appropriate.
  - Unless area specific surveys demonstrated otherwise, release criteria were based on the most restrictive radionuclide (20 dpm/100 cm^2).

ANSI Standard N13.12, *Surface and Volume Radioactivity Standards for Clearance* (1999).

- Although not endorsed by the NRC, the approach is consistent with previous examples.
- Natural uranium is defined.
- No qualifiers for progeny assigned to the uranium group.

Conclusion

- Equilibrium status is relevant in assessing release criteria for isotopes, mixtures, and groups listed in the FC 83-23 Guidelines.

NRC Staff Recommendations (answers to previous questions):

1. Criteria for releasing materials and equipment for unrestricted use originate from Policy and Guidance Directive FC 83-23 (ML030650166) for materials licensees, including ISR facilities.

2. The Guidelines listing the release criteria have been updated to reflect changes in the responsible office. The current version is dated April 1993 (ML003745526). Criteria have not changed.

3. Equilibrium status is relevant. Release criteria for natural uranium in the Guidelines does not include radium or thorium.

Recommendations, cont'd.

4. Surfaces with the potential for contamination with beta-gamma emitters (e.g., uranium daughters) must be evaluated separately for these radionuclides. Limits for alpha- and beta-gamma-emitting radionuclides apply independently (Footnote a of the Guidelines).

5. The Guidelines contain a provision for the licensee to make a reasonable effort to eliminate residual contamination.

Recommendations, cont'd.

6. Regulatory Guide 8.30, Health Physics Surveys in Uranium Recovery Facilities, will be revised to incorporate these recommendations.

7. Consistent with 63 FR 64132, it is anticipated that the Guidelines will be incorporated by license condition for ISR facilities.

Questions?

Personnel Monitoring

Regulatory Guide 8.30 provides guidance on surveys for contamination of skin and personal clothing. NRC staff evaluation of this guidance has resulted in the following conclusions:

1. Guidance is not consistent with NRC guidance for other licensees.

2. Guidance is not based on relevant technical data (i.e., ICRP-2 vs. ICRP-30 methodology).

3. Guidance is not based on the ALARA concept.

Loose Surface Contamination Limits (dpm/100 cm²)_

	RG 8.21	RG 8.23	RG 8.24 (U only)	US Navy Ra Sites[1]	DOE (2009, 2008)	RG 8.30
Skin	ALARA (No detectable)	220 (Decon if detectable)	0	No detectable	No detectable (Decon if detectable)	1000
Personal Clothing	22	220	200	No detectable	No detectable	1000 (5000 for soles of shoes)
Restricted Area Surfaces	U-nat: 220,000, Ra-226: 22,000 **NOTE:** These values are for use with protective clothing	220	5000			220,000
Unrestricted Area Surfaces	U-nat: 22 Ra-226: 22	22	200			1000

NRC Staff Recommendations:

1. Align Regulatory Guide 8.30 guidance on surveys for contamination of skin and personal clothing to be consistent with other industries.

2. Surveys implementing the personnel contamination limits should be developed from basic principles using the radiation survey instrument capability (i.e., scan Minimum Detectable Concentration (MDC)) and ALARA.

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NRC Staff Recommendations, cont'd.

3. The determination of the scan MDC should use MARSSIM (NRC 2000), NUREG-1507 (NRC 1998), Abelquist (2001), or similar methodology.

References:

- NRC, NUREG-1575, Rev. 1, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), August 2000
- NRC, NUREG-1507, Maximum Detectable Concentrations with Typical Survey Instruments for Various Radionuclides and Field Conditions, June 1998
- Abelquist, E.W., Decommissioning Health Physics: A Handbook for MARSSIM Users, 2001

NRC Staff Recommendations, cont'd.

4. Available radiological characterization should be provided for the specific uranium recovery operation(s) with the technical basis for the applicant's or licensee's personnel contamination limits.

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Questions?

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Coming Soon to Uranium Recovery…

NRC staff is evaluating current guidance and practices in the following areas:

- Restricted Area Contamination Levels
- Reporting Radon Monitoring Results

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Restricted Area Contamination Levels

NRC regulations do not specify limits for surface contamination levels in restricted areas.

- Regulatory Guide 8.30 provides recommendations.

Loose Surface Contamination Limits (dpm/100 cm²)_

	RG 8.21	RG 8.23	RG 8.24 (U only)	US Navy Ra Sites[1]	DOE (2009, 2008)	RG 8.30
Skin	ALARA (No detectable)	220 (Decon if detectable)	0	No detectable	No detectable (Decon if detectable)	1000
Personal Clothing	22	220	200	No detectable	No detectable	1000 (5000 for soles of shoes)
Restricted Area Surfaces	U-nat: 220,000, Ra-226: 22,000 **NOTE:** These values are for use with protective clothing	220	5000			220,000
Unrestricted Area Surfaces	U-nat: 22 Ra-226: 22	22	200			1000

NRC staff has reviewed the technical bases for this recommendation and have the following observations:

1. Recommended limits are significantly higher than guidance for other industries.
2. Current (2002) recommendations have not changed from the 1983 recommendations.

Restricted Area Contamination Levels

3. Current (2002) recommendations are still based upon ICRP-2 (IAEA Safety Series No. 43, 1976).
4. Limits derived from data from the UK National Radiological Protection Board (NRPB).
5. Confusion between “active” and “inactive” areas (defined by UK NRPB) and trying to relate this to “restricted” area has resulted in a non-conservative recommendation.

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6. “Active” areas necessitate the wearing of protective clothing. This is the basis for RG 8.21 recommendation.
7. “Inactive” areas include where members of the public visit occasionally.
8. The UK NRPB basis document referenced in RG 8.30 contains recommendations updated with ICRP-26 dosimetry.

Restricted Area Contamination Levels

9. Using the same UK NRPB basis document, the limit for U-nat = 1800 dpm/100 cm^2 when no protective clothing worn (inactive area).
10. If protective clothing worn, the limit for U-nat = 180,000 dpm/100 cm^2, when contaminated area < 1 m^2 and 18,000 dpm/100 cm^2 when contaminated area > 1 m^2.
11. If Th-230 present, limits are one tenth of those in #10 above.

Conclusions

- The current recommendation of 220,000 dpm/100 cm^2 is based on outdated dosimetry and does not address the situation for which it was intended (active Vs. inactive areas).
- NRC staff will review this issue when Regulatory Guide 8.30 is revised.

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Conclusions, cont'd.

- Applicants/Licensees should review their contamination control program to ensure that they are ALARA consistent with the observations noted above.

Questions?

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Radon Effluent

NRC staff has observed that licensees use different 10 CFR 20 Appendix B, Table 2, limits for Rn-222 when reporting in accordance with 10 CFR 40.65.

Reporting the correct value is necessary to estimate the maximum potential annual doses to the public resulting from effluent releases.

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Radon Effluent

10 CFR 20.1302, cont'd.

(a) "The licensee shall make or cause to be made, as appropriate, surveys of radiation levels in unrestricted and controlled areas and radioactive materials in effluents release to unrestricted and controlled areas to demonstrate compliance with the dose limits for individual members of the public in § 20.1301."

Radon Effluent

10 CFR 20.1302, cont'd.

(b) "A licensee shall show compliance with the annual dose limit in § 20.1301 by

(1) Demonstrating by measurement or calculation that the total effective dose equivalent to the individual likely to receive the highest dose from the licensed operation does not exceed the annual dose limit; or

10 CFR 20.1302, cont'd.

(2) "Demonstrating that-

(i) The annual average concentrations of radioactive material released in gaseous and liquid effluents at the boundary of the unrestricted area do not exceed the values specified in Table 2 of Appendix B; and

(ii) If an individual were continuously present in an unrestricted area, the dose from external sources would not exceed 2 mrem in an hour and 50 mrem in a year."

10 CFR 20.1302, cont'd.

(c) "Upon approval from the Commission, the licensee may adjust the effluent concentration values in Appendix B, Table 2, for members of the public, to take into account the actual physical and chemical characteristics of the effluents (e.g. aerosol size distribution, solubility, density, radioactive decay equilibrium, chemical form)."

Radon Effluent

10 CFR 20 Appendix B, Table 2

Rn-222 (with daughters removed) 1.0 E -08 uCi/ml

Rn-222 (with daughters present) 1.0 E -10 uCi/ml

NRC Observations

- Some licensees use the “Rn-222 with daughters removed” effluent concentration value in the 10 CFR 40.65 report to assess compliance and this effluent concentration value does not consider the radiation dose from radon progeny.
- Other licensees use the “Rn-222 with daughters present” to assess compliance and this value considers the dose from the radon progeny.

Radon Effluent

Observations, cont'd.

- 10 CFR 20, Appendix B values represent potential radionuclide exposure conditions, not measurement conditions or methods.

Conclusions

- Applicant/Licensee must identify and select a Rn-222 limit.
- Applicant/Licensee must provide a technical basis for selecting that limit, including an evaluation of radon progeny.
- This information is necessary to determine maximum potential public dose as specified in 10 CFR 40.65.
- 56 FR 23375 provides a discussion on uranium mills and ISR facilities related to radon-222 limits.
- NRC staff is developing guidance to address this issue.

Radon Effluent

Questions?