



**RADPROS**

# Nuances of Colorado's TENORM Regulations

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# RAD PROS

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- Environmental contractor – *licensed in* radioactive materials management
- Waste Broker – oilfield, haz and radioactive
- Radiological Surveys, Sampling, Site and Dose Assessments, Dose Modeling
- Remediation/Reclamation
- TENORM Training
- Compliant Packaging, Transport, and Disposal
- Regulatory Consulting & RSO Support
- Radiation Safety Programs & Licensing



# 6 CCR 1007-1 Part 20

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- Interim Guidance published February 2007
- TENORM Rules in place January 21, 2021
- Compliance by July 14, 2022



# DEFINITIONS

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**NORM** – naturally occurring radioactive material

**TENORM** – technologically-enhanced NORM

- Concentration of radioactivity is enhanced by past or present human activities

As simple as:

- Putting a pipe in the ground
- Passing water, oil, or gas through a filter
- Sludge settling in the bottom of a tank
- Radon gas accumulating in buildings/tanks



# Industries Impacted by CO TENORM Rules

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1. Oil & Gas Operations
2. Drinking Water Treatment Plants
3. Mining
4. Wastewater Treatment Plants
5. Manufacturers



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# Impacted Tubing



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# Midstream/Pigging Sludge & Filters

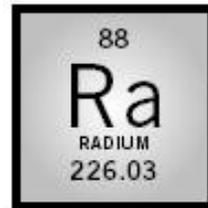


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# Isotopes and Exempt Concentrations

Isotopes of Concern:

- Radium-226 **1620 yrs**
- Radium-228
- Lead-210
- Polonium-210
- Radon



Exempt Concentration

**5 pCi/g** *Above background*

**Pipe – no external dose;  
50 feet long and < 600 dpm/cm<sup>2</sup>**



# Allowable Possession Limits - Registrants

Waste	Isotopes	Registrant Allowable Range (above background)	Dose Rate Survey Needed?	Dose Rate Limit
Produced Fluids	Ra-226, Ra-228, Pb-210, Po-210	5 - 250 pCi/g	No	-
Oily Waste	Ra-226, Ra-228, Pb-210, Po-210	0 - 50 pCi/g	No	-
Pigging Waste	Pb-210, Po-210	0 - 500 pCi/g	No	-
Filter Socks	Ra-226, Ra-228, Pb-210, Po-210	0 - 500 pCi/g	Yes, if > 50 pCi/g	2 millirem/hour
Equipment, Pipe & Scale	Ra-226, Ra-228, Pb-210, Po-210	n/a	Yes	2 millirem/hour
Other Waste	Ra-226, Ra-228, Pb-210, Po-210	0 - 50 pCi/g	No	-
RCRA Hazardous Waste	Ra-226, Ra-228, Pb-210, Po-210	5 - 100 pCi/g	Yes, if > 50 pCi/g and > 10% solids	2 millirem/hour



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# Part 20 Additional Rules

- 100 millirem/year exposure limit
- Included production water as a potential source of TENORM
- Radon monitoring if material  $> 50$  pCi/g and is inside



# Biggest Logistical Issues

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- Ingrowth period of 21- to 28-days for **characterization**
- EPA SW-846 increases likelihood of additional **sampling events**
- Some **labs** don't produce reliable results at very low levels
- Dose-based approach creates opportunities to side-step licensing and expensive protective measures
- Adds lots of complexities, most environmental companies aren't able to navigate – licensing, equipment, expertise
- CDPHE underestimated their support need



# Practical Implications of Part 20

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1. Characterization costs increased – more samples and analytes required
2. Waste profiling is more difficult
3. Profile approval has slowed
4. More waste is exported
5. Training requirements imposed
6. Need specific expertise in radioactivity



# SW-846 Overview/Sampling Requirements

- CDPHE requires 3-6 separate samples for characterization of new waste streams
- Samples results input into SW-846. Determines the upper confidence limit of the data. Establishes if waste stream is exempt or non-exempt based on Part 20

Entity/Company Name: \_\_\_\_\_  
 Site/Facility Name: \_\_\_\_\_

**Calculating Net Concentration Data**

Step 1: Select your Isotope of Concern from the Drop Down  
 Step 2: Enter in Site Specific Background value if applicable  
 Step 3: Enter in your laboratory results in pCi/g  
 Step 4: You may use the values in the appropriate Net Concentration column for your data analysis

Please Note: Site Specific Net concentration values will be in the violet column if used

Isotope of Concern: Ra-226

Sample	Laboratory Results (pCi/g)	Net Concentration (CDPHE Background) (pCi/g)	Net Concentration (Site Specific Background) (pCi/g)
1	2.4	1	2.4
2	3.6	2.2	3.6
3	2.5	1.1	2.5
4	4.1	2.7	4.1
5	1.9	0.5	1.9
6	3.2	1.8	3.2
7	4.2	2.8	4.2
8	0	0	0
9	0	0	0
10	0	0	0
11	0	0	0
12	0	0	0
13	0	0	0
14	0	0	0
15	0	0	0
16	0	0	0
17	0	0	0
18	0	0	0
19	0	0	0
20	0	0	0
21	0	0	0

Isotope	CDPHE Background Value (pCi/g)	Site Specific Background Value (pCi/g)
Pb-210	1.4	
Po-210	1.4	
Ra-226	1.4	
Ra-228	1.3	

Standard Analysis of Data to Determine Adequate Number of Samples and the Upper Limit of the Confidence Interval  
 SW-846 statistical determination of adequate characterization

Entity/Company Name: \_\_\_\_\_  
 Site/Facility Name: \_\_\_\_\_  
 Isotope: Ra-226  
 Concentration Limit or Threshold: 5

Appropriate Number of Samples: 6  
 Is the Material Concentration Lower than the Threshold or Limit? Yes

Estimate  $\bar{X}$  (x bar) sample mean (straight average of previous measurements) estimated 6 calculated 2.967  
 Upper limit of the Confidence Interval (Reportable Value): 3.42 pCi/g

Estimate  $s^2$  variance of sample  $s^2$  1.17466667

Sample Number or Date	X	X <sup>2</sup>	sum of X <sup>2</sup>	sum of X	sum of X <sup>2</sup> /n	n (number of samples)	sum of X <sup>2</sup> /n	sum of X <sup>2</sup> - [sum of X] <sup>2</sup> /n	sum of X <sup>2</sup> - [sum of X] <sup>2</sup> /n-1
1	1.4	1.96	51.8	18.6	275.56	6	45.9266667	5.67333333	1.17466667
2	1.8	3.24							
3	2.5	6.25							
4	3.2	10.24							
5	4.2	17.64							
6	3.6	12.96							
7	0	0							
8	0	0							
9	0	0							
10	0	0							
11	0	0							
12	0	0							
13	0	0							
14	0	0							
15	0	0							
16	0	0							
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21	0	0							
22	0	0							
23	0	0							
24	0	0							
25	0	0							
26	0	0							
27	0	0							
28	0	0							
29	0	0							
30	0	0							
40	0	0							
60	0	0							
100	0	0							
Greater than 100									1.882

TABLE 9-2. TABULATED VALUES OF STUDENT'S T FOR EVALUATING SOLID WASTE

Degrees of Freedom (n-1)	Tabulated "t" Value
1	80%
2	3.078
3	1.885
4	1.638
5	1.476
6	1.440
7	1.415
8	1.397
9	1.383
10	1.372
11	1.363
12	1.356
13	1.350
14	1.345
15	1.341
16	1.337
17	1.333
18	1.330
19	1.328
20	1.326
21	1.325
22	1.324
23	1.323
24	1.323
25	1.322
26	1.322
27	1.321
28	1.321
29	1.321
30	1.320
40	1.320
60	1.320
100	1.320
Greater than 100	1.282

Appropriate number of samples to be collected

$n = RT - X \text{ bar}$   
 $RT = \text{regulatory threshold}$   
 $n = RT - s^2 / d^2$

RT	s	d <sup>2</sup>	n	n <sub>min</sub>	s <sup>2</sup>
5	2.2333	4.98777778	1	476	1.17466667
					0.45304353



# Registration and Licensing Costs

## Registration Requirement (if you generate TENORM)

- **\$200/facility/year**, or
- \$200/township/year, which may cover multiple facilities for the same entity in each township

## Specific License Requirement \$2,790

(if you routinely generate and store TENORM waste at a site that exceeds 50 pCi/g)

- May cover more than one facility if within 1 mile
- Reduced fees for additional facilities under the same license (75% for 2nd, 50% for 3<sup>rd</sup>, and 25% for 4+)
- Additional costs to generator for license preparation



# Complexities of the New Rules

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- Characterization of sludges and liquids can be difficult
- All characterization evaluated on a **dry weight basis**
- Dry weight basis produces more consistent and comparable lab results, but it exaggerates the risk
- CDPHE's answer: Introduce dose rates
  - ✓ Requires more special equipment
  - ✓ Outside expertise - health physicist
- Gaining waste acceptance at the landfill can be difficult
  - ✓ Individual WAC and strict interpretation of guidance
- What about aqueous waste streams?



# Understanding TENORM Units/Conversions

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Waste profiling and TENORM registration requires dry weight concentrations (pCi/g):

- Sample results for a liquid (wash water, produced water, sludges) may be reported in pCi/L.
- Follow the formula below to convert:

$$\text{Concentration in pCi/g} = \frac{\text{Concentration in pCi/L}}{(\text{TDS} + \text{TSS in g/L})}$$

*Where:*

TDS = Total Dissolved Solids

TSS = Total Suspended Solids



# Conversion Examples "Dirty vs. Clean Water"

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## Dirty Water/Liquids:

TSS = 1.32 g/L

TDS = 1.21 g/L

$$1.77 \text{ pCi/g} = \frac{4.49 \text{ pCi/L}}{2.53 \text{ g/L}}$$

## Clean Water/Liquids:

TSS = 0.0108 g/L

TDS = 0.245 g/L

$$17.55 \text{ pCi/g} = \frac{4.49 \text{ pCi/L}}{0.2558 \text{ g/L}}$$

***Unintended consequences!***



# TENORM Rules

## Registrant Obligations

- No purposeful dilution
- Can't abandon TENORM
- Must secure and label TENORM
- Properly package and transport
- Recordkeeping
- Minimize contamination
- **Appoint a responsible individual**
- Maintain ALARA
- **Training**
- Only trained personnel may perform equip maintenance
- Spill reporting



# Registrant Requirements

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## Training Requirements

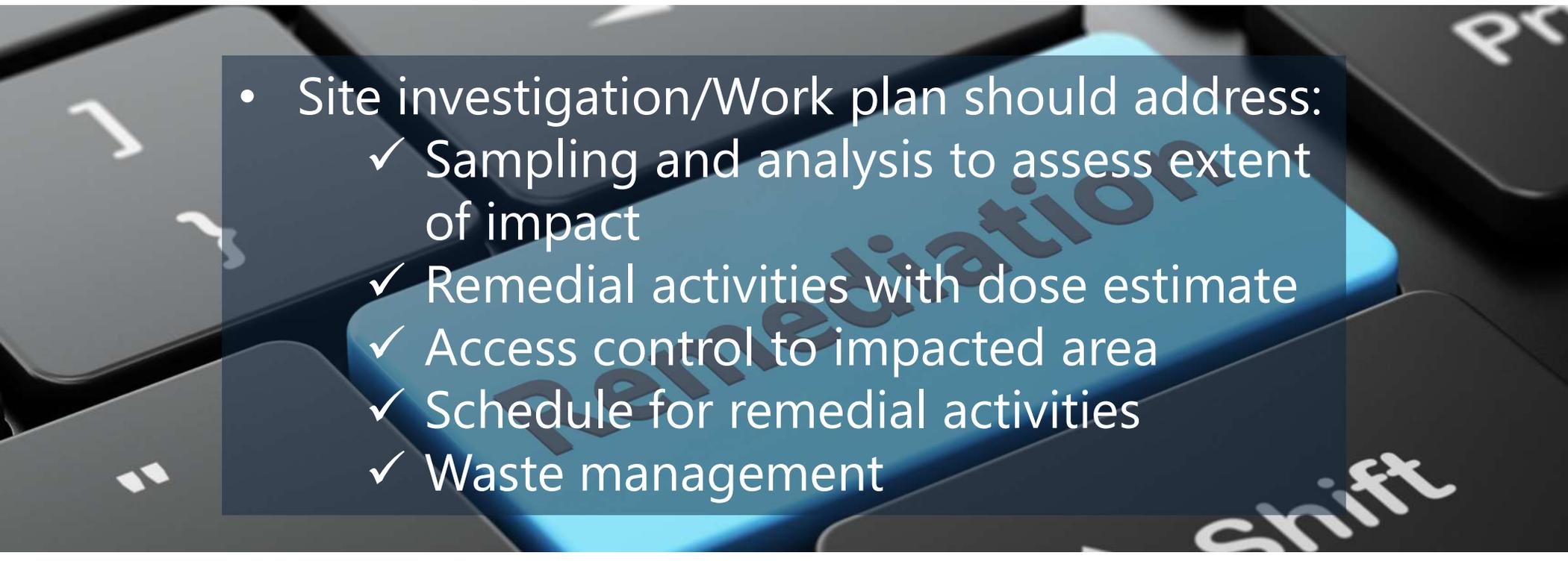
- Initial training that aligns with potential for exposure
- Refresher training every 3 years
- Applies to all registrants
- 40-hour training for designee with a specific license



# Spill Reporting

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- Report **within 24 hours** of reporting to ECMC
- CDPHE may require a:
  - ✓ Site investigation
  - ✓ Groundwater and surface water impacts
  - ✓ Potential for anyone to exceed 100 millirem

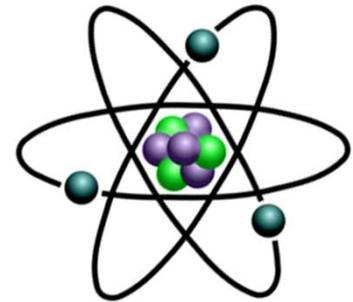
- 
- Site investigation/Work plan should address:
    - ✓ Sampling and analysis to assess extent of impact
    - ✓ Remedial activities with dose estimate
    - ✓ Access control to impacted area
    - ✓ Schedule for remedial activities
    - ✓ Waste management

# More Requirements

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## Monitoring/Surveying Requirements

- Routine periodic area/facility radiation surveys
- Monitoring of occupancy or access
- Detection/monitoring **equipment costs**
- Radon



## DOT and CDPHE Compliance

- Training in compliant TENORM transport
- Effort and costs associated with TENORM Rule compliance



# Licensed Contractor Needed

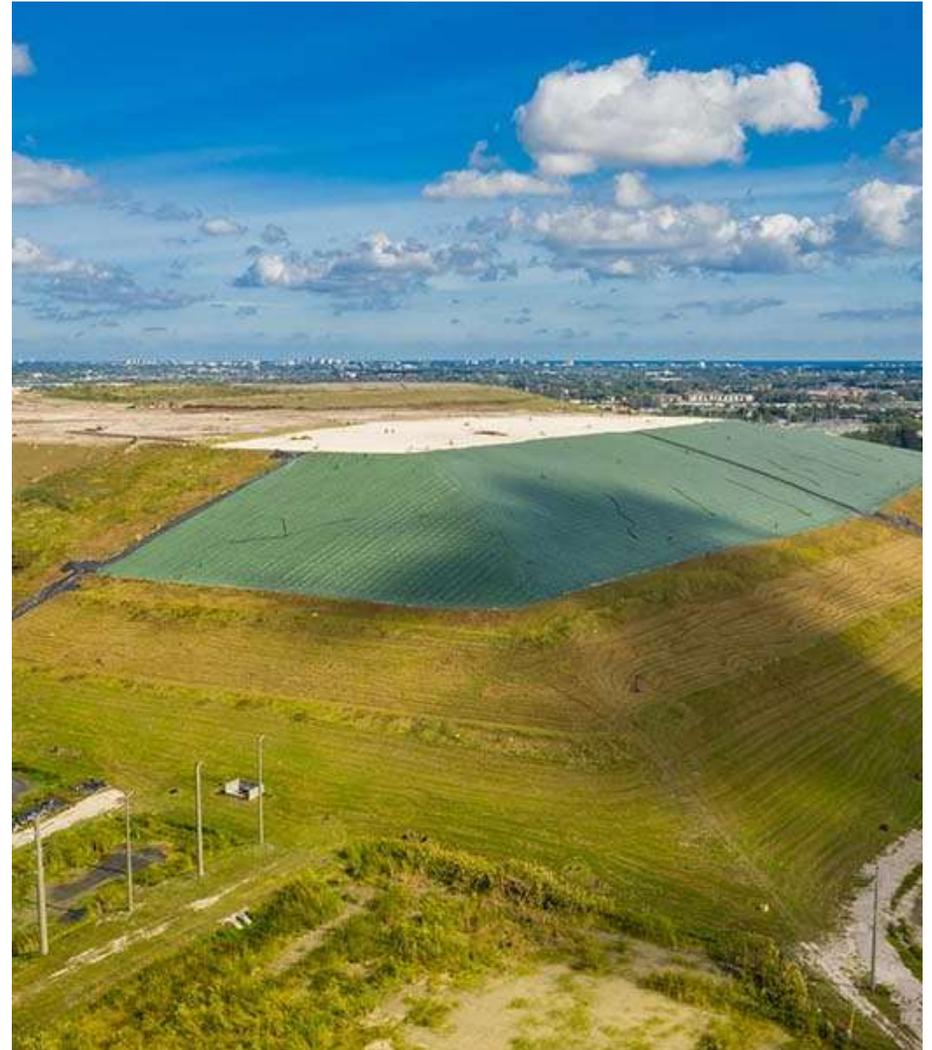
## Services Contracting

- Use of a **licensed** Radioactive Materials Contractor when levels **exceed 50 pCi/g**
- Surveys/Sampling/Site Assessments
- Material handling, transport, and disposal
- Site remediation and demolition
- Decontamination
- Decommissioning
- Free release activities
- Waste brokering



# Landfills

- Landfills may register and accept TENORM up to 50 pCi/g
- Republic – Foothills LF
- WM – N. Weld & Buffalo Ridge
- Pawnee LF
- Clean Harbors/Deer Trail accepts 222 pCi/g
- Out of state > 222 pCi/g with an export permit required



# Nuances of Gas Waste Streams



- Pb-210 - not detectable with a scintillator probe
- Shows as a dusty film or “black rouge” in pipe, CS, MS, gas plants
- Filters show wide variability in levels
- RCRA co-contaminants create big issues for transport and disposal
- Gas waste streams is the biggest predictable issue in Colorado

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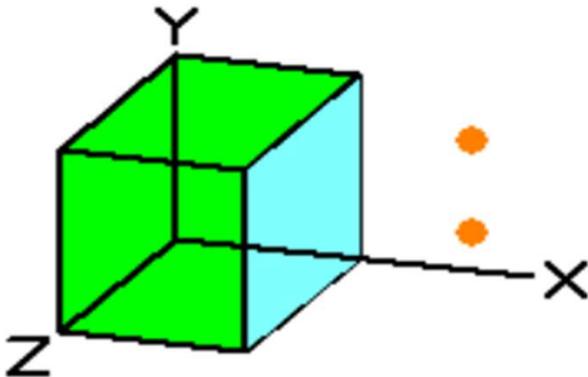


# 6 CCR 1007-1 Part 20 Section 20.9

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- CDPHE's dose-based approach leaves a door open
- Allows non-exempt TENORM to be **registered** instead of **specifically licensed, IF** you can prove the maximum exposed individual (MEI) will not receive total effective dose equivalent (TEDE)  $> 100$  mrem/year
- Allows for additional activities involving TENORM, if you can prove the MEI will not receive a TEDE of  $> 100$  mrem/year

Alternative disposal or handling practices



# Dose Modeling

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**How we prove MEI will not receive TEDE > 100 mrem/year**

- **External Dose** – Deep Dose Equivalent (DDE)
  - Requires specialized software to model the specific situation and calculate external doses
  - Dosimetry
  - Radiation exposure rate surveys
- **Internal dose** – Committed Effective Dose Equiv. (CEDE)
  - Air monitoring
  - Use DAC for each radionuclide to calculate CEDE from air monitoring results
- **TEDE = DDE + CEDE**

**This back door can save a lot of compliance heartache!**



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