U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Regulatory Inspections

Jason vonEhr
Health Physicist
USNRC Region IV

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Objectives for Regulatory Inspection Presentation

- To provide the basis for NRC's inspection program
- To introduce the guidance and implementing documents
- To review the typical radioactive sources in use
- To identify the challenges and approaches to well logging inspections

NRC Implementing Document

Inspection Manual Chapter 2800

- Materials Inspection Program
- https://www.nrc.gov/reading-rm/doc-collections/insp-manual/manual-chapter/
- Groundwork of the NRC's material inspection program – not limited to well logging
- *Performance-Based Inspections* vs *Compliance-based Inspections*
  - unannounced inspections
  - Observation of licensed activities
  - Reactive vs Routine
  - Field vs Main Office

NRC Guidance

- NRC Guidance for Licensing/Use
  - NUREG-1556, Volume 14, Rev 1: “Consolidated Guidance About Material Licenses, Program Specific Guidance about Well Logging, Tracer, and Field Flood Study Licenses”
- NRC Inspection Manual
  - Inspection Procedure 87123: Well Logging Programs
  - Inspection Procedure 87137: 10 CFR Part 37 Materials Security Programs

Well Logging Operations

Drill-to-Stop - Well logging operation that requires all drilling operations to cease and requires that parts of the drilling apparatus are removed to provide access to the well bore. The well logging tool is then lowered into the well bore to obtain information.

Measurement While Drilling (MWD or LWD) - Well logging operations that occur during the drilling of the well bore and do not require that the drill stem or other equipment be removed from the well. This type of operation requires that the well logging tool contain one or more sealed sources and be located above the drilling stem to obtain information through mud telemetry communications.

Typical “Sealed” Sources in use

- Tools often use one or more of the following:
  - Am-241/Be
  - Cs-137
  - H-3
  - Co-60
- Co-60 is used in pipe collar markers & subsidence or depth control markers
- Depleted uranium (DU) can be used as a weight in sinker bars to pull a logging tool to the bottom of the well

Sources – Radioactive Markers

- Licensed material used for depth determination or direction orientation, such as radioactive collar markers & radioactive iron nails (10 CFR 39.47)
- The quantities shall not exceed § 30.71 (Exempt) & are only subject to § 39.37 (Inventory)

Small Metal Beads or Metal Strips

- Iridium-192 (10 µCi)
- Cobalt-60 (1 µCi)

Other Types of Services

- Tracer studies – unsealed RAM (liquid, gas or solid) is injected into a well bore/underground reservoir to monitor movement of fluids & gases; the logging tool (detector) is lowered down to detect injected isotopes & use the data to analyze the formation
  - The tracer survey uses techniques similar to gamma ray spectroscopy to ID the distribution & placement of the tagged materials
  - Common isotopes: iodine-131, iridium-192, scandium-46, antimony-124
  - Chosen for (relatively) short lived half-lives, distinct gamma spectra, and commercial availability

Examples of Tracer Studies

- Field flood studies & oil and gas recovery studies - performed to investigate direction & flow rate of oil & water; radioisotopes are injected into multiple wells, then oil/gas samples are collected & analyzed
  - Gas (H-3, Kr-85, Br-82, C-14, I-131)
  - Liquid (H-3, C-14, Na-22, S-35, Ca-45, Co-60, Ni-63, Zn-65, Sr-85, Sc-46, Sr-90, Ag-110m, I-125, I-131, La-140, Ir-192)
- Labeled frac sands - Liquid or solid RAM chemically bonded to glass or resin beads are injected into a well in a density-controlled solution; the sands' distribution within the formation's fractures is assessed with a well logging tool (detector) lowered into the geologic formation following injection
  - Ag-110m, Br-82, Ir-192, Sb-124, Sc-46

Tracer Studies Cont'd

Well Logging Tracer Applications Common Isotopes for Tracer Studies	
Gas	H-3, C-14, Kr-85, Br-82, I-131, I-125
Liquid	H-3, C-14, Na-22, S-35, Ca-45, Co-60, Ni-63, Zn-65, Sr-85, Sc-46, Sr-90, Ag-110m, I-125, I-131, La-140, Ir-192, Fe-59, Sb-124, Au-198, Ag-110m
Labeled Frac Sand, Beads, Resin	Sc-46, Br-82, Ag-110m, Sb-124, Ir-192

INSPECTIONS

Prior to Performing an Inspection

- Know the rules/regulations related to well logging.
  - 10 CFR Parts 19, 20, 21, 30, (37), 39, 71, (or Agreement State Equivalent) and 49 CFR
- Understand license authorizations and commitments
- For temporary job sites: have the appropriate Personal Protective Equipment (PPE), radiation instrumentation, and any additional items such as wipes, gloves, etc.
- For previous inspection findings review corrective actions and long term measures implemented to prevent recurrence.
- Understand the licensee's file: previous inspection findings, any license amendments, or pending requests since at least the last inspection

Inspection Planning

- Main Office vs Temporary Job Site
  - Temporary Job Site
    - May be announced through oil/gas operator (client)
    - Preference should always be unannounced (at least with the licensee) when practicable
    - Ensure the inspector is prepared (PPE may include: Steel-toed boots, Nomex, hard hat, safety glasses, ear plugs/hearing protection)
  - Central Office
    - Much easier, but less indicative of the level of radiation safety and security than in the field

Job Site Considerations

- Remote job site locations, sometimes hours or days away from central office
- Job site location access controls; many oilfields require a safety escort
- The lack of appropriate and required PPE may lead to the inspector not being allowed access to the well logging operation (i.e. no steel toe boots)
- Unanticipated adverse weather conditions

Job Site Inspection Protocol

- Oil/gas operator authorization
- Inspector's own PPE: PERSONAL SAFETY IS INSPECTOR'S RESPONSIBILITY
- Extended onsite time
- Oil/gas operator's assistance
- The inspector SHOULD NOT be a nuisance- "stay out of the way"
- If practicable: inspector should be onsite prior to logging rig-up
- Ensure licensee performs proper radiation surveys
- For post-tracer operations: survey above and around well head
- Conduct licensee interviews when time permits (safety culture, field experience, what-if scenarios, etc.)
- Inspection debrief with oil/gas operator (they always want to know the results)

Jobsite Inspection – What to Review First?

- There are many items to review & observe, but they fall basically into three areas:
  - Observation of activities & conducting surveys of the site
    - Emphasis is on *Performance Based Inspection*
  - Interviews with site personnel (licensee & non-licensee)
    - Assess licensee personnel's *training and experience*
  - Reviewing the paperwork (performance based vs. compliance based)

RECORDS REQUIRED AT TEMPORARY JOB SITES BY NRC

- 10 CFR 39.75
  - Operating and Emergency procedures
  - Evidence of radiation survey instrument calibration
  - Radiation survey records
  - Shipping papers
  - Copy of License (State or NRC)

NRC's Oversight Offshore

- NRC Memorandum of Understanding with BSEE – Bureau of Safety and Environmental Enforcement
- BSEE offers logistical support to NRC's oversight of offshore Gulf of Mexico
- For reasons of employee safety and legal restriction (lack of an equivalent memo with BSEE's other regions) the NRC does not conduct inspections offshore in Alaska and Pacific Regions

ACCIDENTS/EVENTS

Factors Contributing to Accidents

Understand why accidents can occur when performing well logging activities

LACK OF USE OF SURVEY METER

LACK OF REGULATORY CONTROL

EQUIPMENT FAILURE

ACCIDENT

POOR OR NO TRAINING

NOT FOLLOWING SAFETY POCEDURES

INADEQUATE OR MISSING SAFETY PROGRAM

Accidents Involving Well Logging

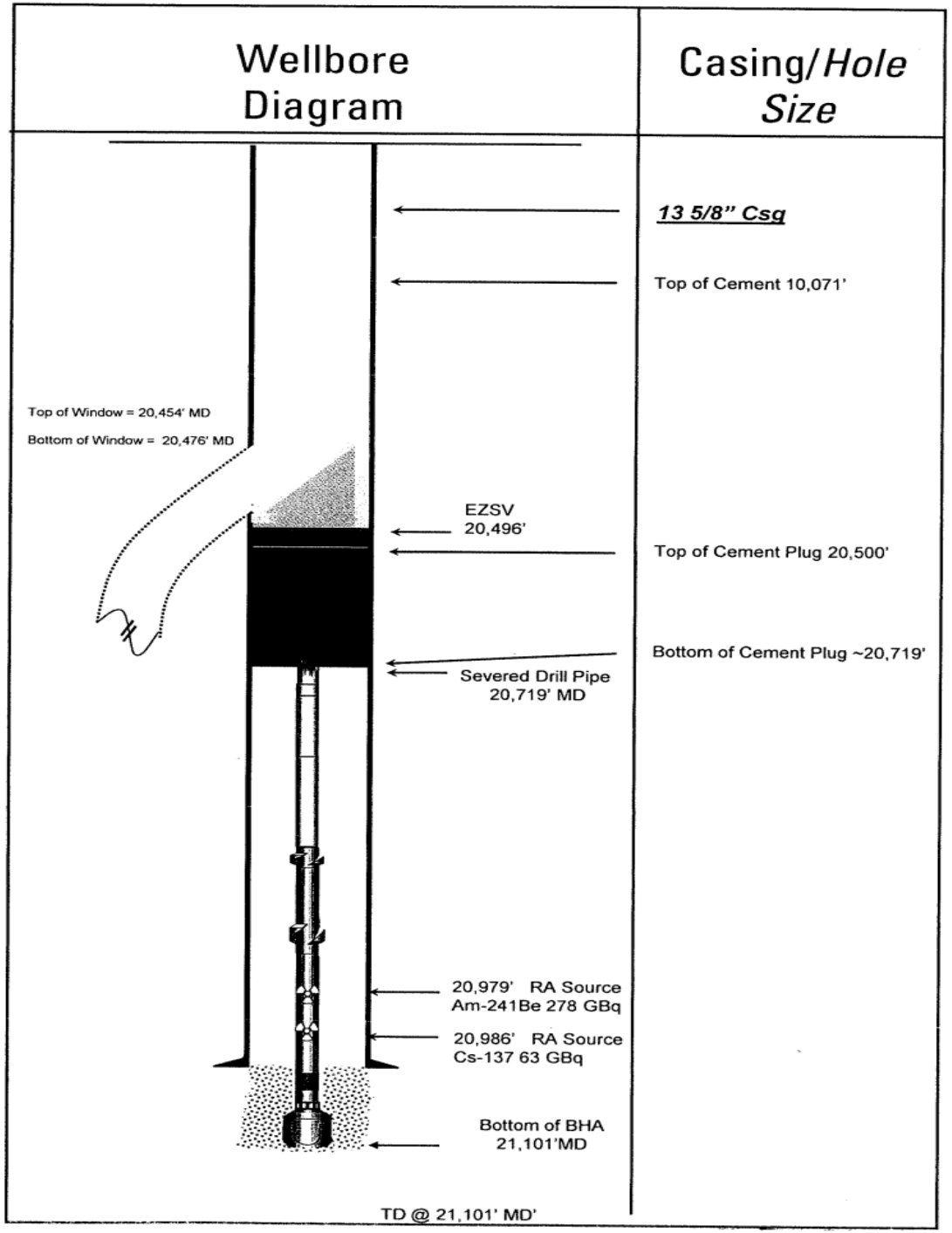
Examples of potential accidents in well logging

- Source stuck down well (common)
- Lost (misplaced) source during/after well logging
- Lost or stolen source (in storage or transport)
- Physical damage (during “fishing” operations)
- Transportation accident
- Suspected exposure of persons
- Leaking source

Source Abandonment Procedures

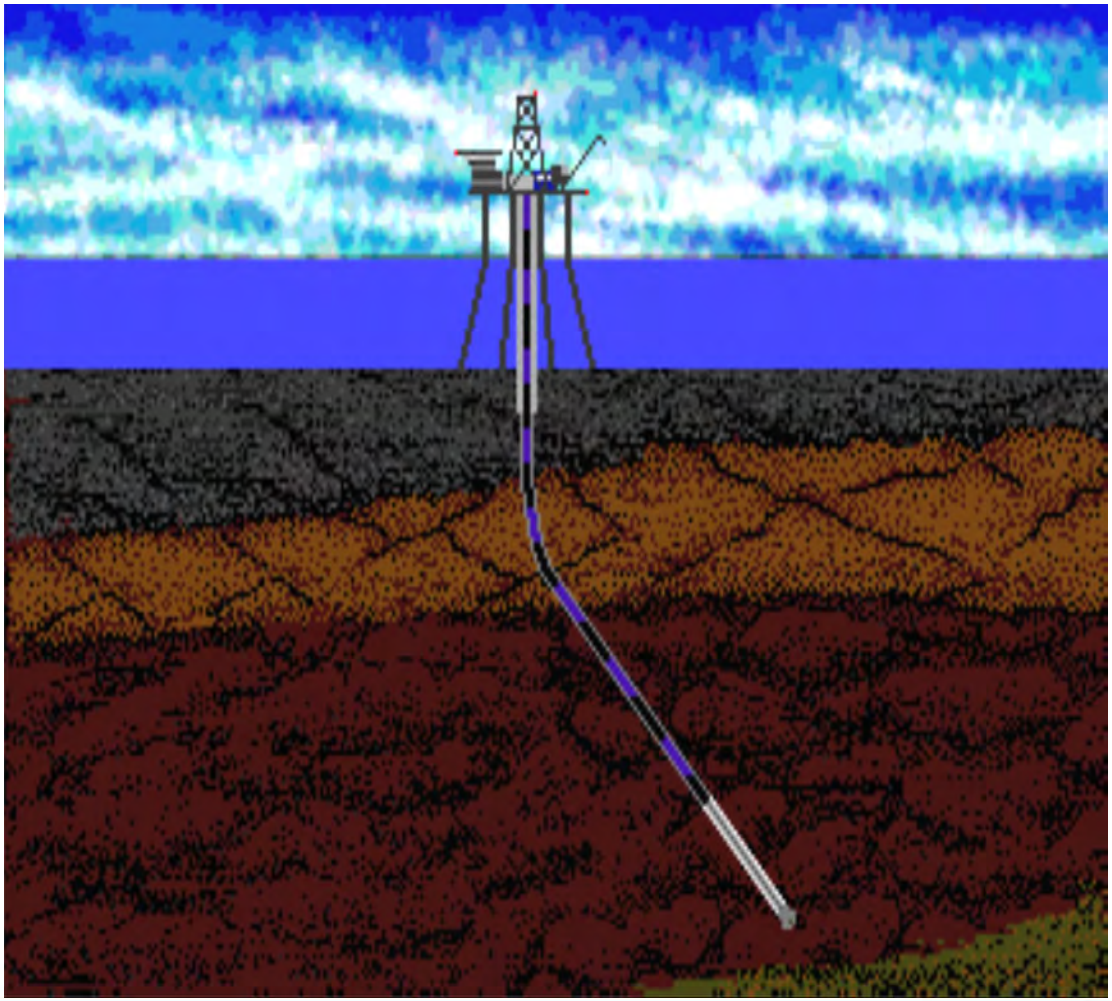
- 10 CFR 39.15(a)(5) or equivalent State regulation requires the following to be implemented within 30 days:
  - Each irretrievable well logging source be immobilized and sealed in place with a cement plug
  - A means shall be in place to prevent inadvertent intrusion on the source (i.e. whipstock or deflection device)
  - A permanent identification plaque must be mounted at the surface of the well which contains the word “CAUTION”, the radiation symbol, date of abandonment, name of well owner and well, radionuclide and activity, depth of source and plug, and a warning to not re-enter the well.

Source Abandonment – Reporting Info



Reporting Challenges for Abandonment

- GPS location of…
  - Well head
  - Site of Drilling equipment (offshore)
  - Geographic location of sources
- True Vertical Depth
- Measured Depth



Abandoned Source Plaque

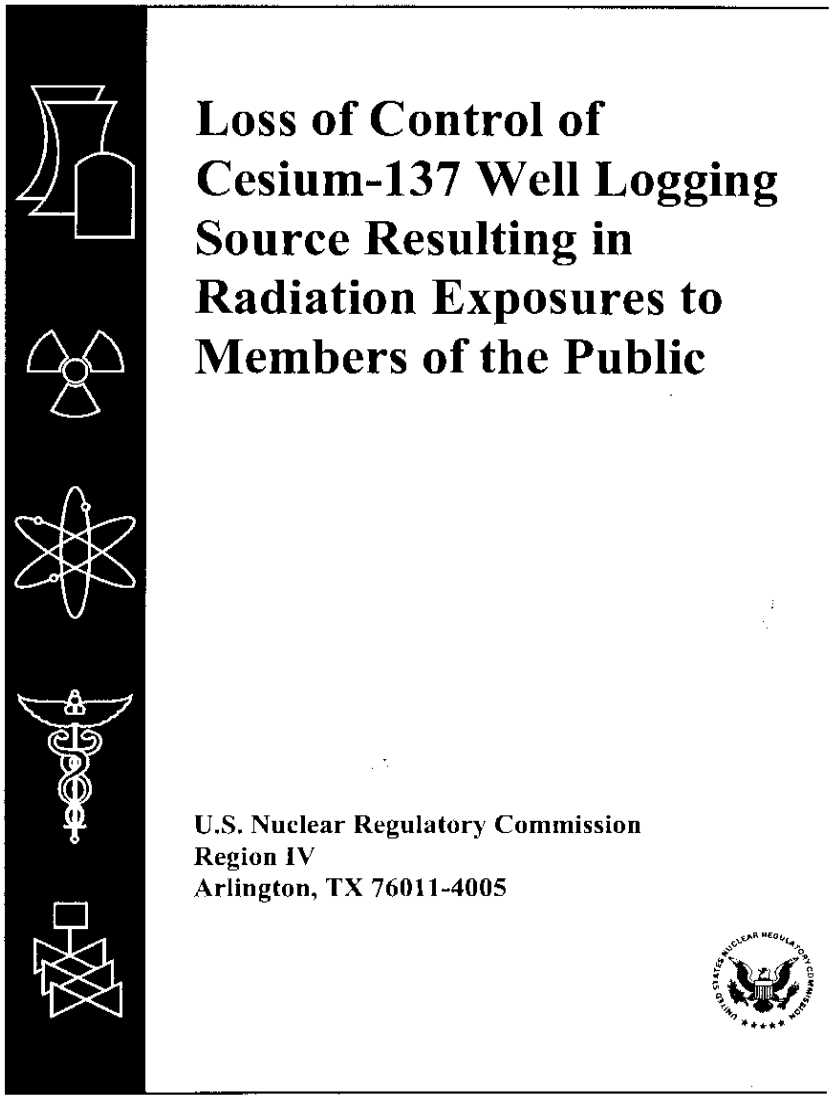
ATTACHMENT 1
Representation of Permanent Warning Plaque

ANADARKO
OCS-G-24194 005 ST01BP00
60-811-40066-01

CAUTION

ONE 15.0 CURIE AM-241BE RADIOACTIVE SOURCE AND ONE 2.0 CURIE CS-137 RADIOACTIVE SOURCE ABANDONED 29 NOVEMBER 2016 AT 29,511 FT. MD / 27,679 FT. TVD AND AT 29,498 FT. MD / 27,670 FT. TVD. PLUG BACK DEPTH 27,811 FT. MD / 26,487 FT. TVD. AVOID BORE BELOW PLUG BACK, AND DO NOT RE-ENTER THIS WELL BELOW PLUG BACK BEFORE CONTACTING THE U.S. NUCLEAR REGULATORY COMMISSION

Accidents Involving Well Logging



NUREG-1794

Loss of Control of Cesium-137 Well Logging Source Resulting in Radiation Exposures to Members of the Public

U.S. Nuclear Regulatory Commission
Region IV
Arlington, TX 76011-4005

2002 Augmented Inspection Team (AIT)

- U.S. NRC NUREG-1794
- Loss of control of 1.3 curie (48 GBq) Cs-137 source (2002) in Montana
- Source lay unshielded on the drill rig floor for 2 days exposing 31 members of the public
- Direct cause: Failure of logging engineer to properly transfer the source to its transport container immediately after removal from tool
- Contributing causes: Failure to perform required radiation surveys; false indication of plug assembly
- Root cause: Failure to adequately investigate precursor events (six similar events occurred from 1987 and 2001, and only the direct, not root cause of each event was addressed)

Oklahoma City Event

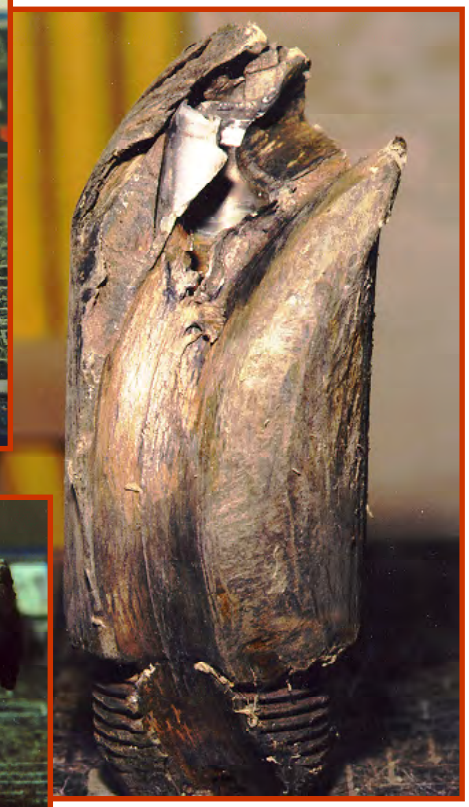
- In February 2007, a logging crew failed to properly transfer cesium source from storage area to the transport container
- A mechanic (member of the public) found the source and put it in his jacket pocket, and wore this jacket for 4 hours, while visiting 5 commercial stores/offices
- The next morning, the logging crew realized that they didn't have their cesium source. They found it still in the mechanic's jacket pocket, which was hanging up in his office.
- The dose estimates to the mechanic were 1 to 5 rem whole body exposure, and 18 Gray (1800 rads) shallow dose equivalent

Oklahoma City Event

- Causes of the event:
  - Radiation surveys of the transport container were not performed after “loading” the source
  - Vehicle surveys were not performed, even though the Shipping Certificate said that they were performed
  - The logging supervisor had not received refresher radiation safety training in 2002, 2003, 2005, and 2006; the logging assistant had not had this training the year prior to the event (2006)

Accidents Involving Well Logging

- Source:
  Am-Be (200 GBq)
- Description:
  Source destroyed during recovery operation



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Event Involving Tagging Ops

- Source:
  Ir-192, Sc-46, Sb-124

- Description:
  - Portal Alarm at landfill – initiates NRC inspection.
  - Logging Client had disposed of drilling cuttings, which included trace quantities of licensed material from tracer operations.
  - Trace occurred at one well between July 27 and August 9, 2014, and a second well on August 17 and September 3, 2014
  - Well completed, and subsequent (attempted) disposal occurred November 7, 2014, and December 16, 2014, respectively
  - 53 additional Vac-boxes generated, 48 of which >10 pCi/gram tracer isotopes, 9 > 100 pCi/g, and 1 containing 842 pCi/g

Event Involving Tagging Ops

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NUREG-1556
Volume 14, Rev. 1

Consolidated Guidance About Materials Licenses

Program-Specific Guidance About Well Logging, Tracer, and Field Flood Study Licenses

Final Report

Manuscript Completed: April 2018
Date Published: April 2018

Prepared by:
K.J. Lambert
S.E. Mack
R.J. Torres
S.L. Wilson

Office of Nuclear Material Safety and Safeguards

Response from Applicant:

- A statement that: "We will not perform frac-tagging operations."

OR

- A statement that: "We will perform frac-tagging operations and have submitted step-by-step operating and emergency procedures that include the following:

  — Receiving, controlling, and handling tracer material during well injections.

  — Handling, controlling and disposing of any unused tracer materials.

  — Securing, maintaining control, and posting of areas involved with frac-tagging operations using radioactive materials.

  — Containment and/or decontamination of a spill or "sandout" (or "fluid reversal") involving tracer material during frac sand operations. The procedure includes, among other items, radiation surveys, licensee contact information, steps to be taken by the licensee and the client in the event that a "sandout" (or "fluid reversal") occurs when the licensee has already left the client's site, and steps to be taken by the licensee and the client to evaluate flowback or production wastes for the presence of tracer material.

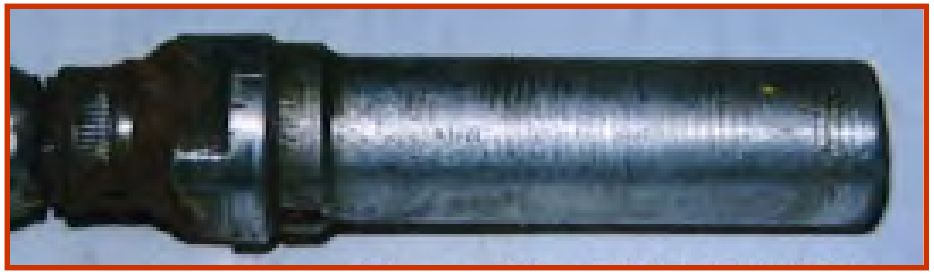
  — Disposal of radioactive materials resulting from frac-tagging operations (such as a sandout, fluid reversal, or flowback) at (i) a licensed low level radioactive waste disposal facility; (ii) decay-in-storage using holding tanks and subsequent unrestricted release; or (iii) a request for alternate waste disposal under 10 CFR 20.2002, "Method for obtaining approval of proposed disposal procedures." The procedure includes a description of who will be responsible for the disposal of radioactive materials resulting from frac-tagging operations occurring at client's facilities, and the method for making a determination of the concentration of licensed material (picocuries/gram) in these operations.

  — Actions to be taken in the event of an explosion, leak and contamination event, and the incapacitation of a lone well logging supervisor."

PHOTO TOUR

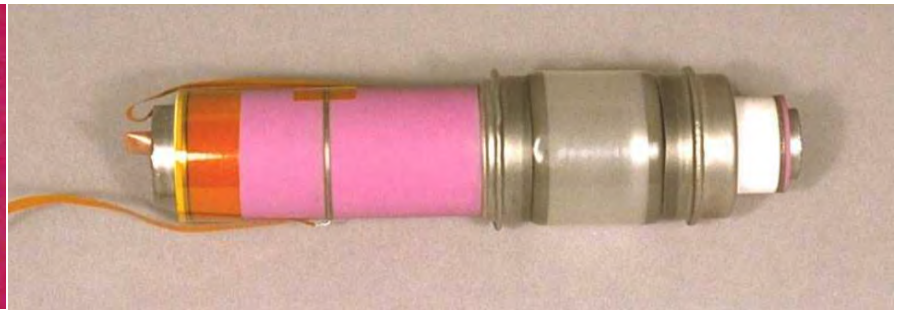
Well Logging
Sealed Sources

Cs-137



Am-241:Be

Neutron Accelerator Tube



Tritium (D-T fusion reaction)

- Can work as neutron activation analysis; neutrons emitted from tube bombard atoms in the formation, which emits gamma rays through activation or inelastic collisions. The gamma rays are detected by logging tool.
- Can work as neutron moderation analysis; neutron emitted are moderated or 'thermalize' (slow down) in the formation, a fraction of which will be captured by the detector. This allows analysis of, among other things, hydrogenous content of the formation (difference between water and oil/natural gas)

Typical well logging truck, Prepping for work at a TJS

The “Olympic Torch” run to the platform

Conventional Tracer Studies

Tracer Transport Container

Tracer Pumps

Radiation Survey Meter at Tracer Distribution Junction before entering Well

Field Flood Studies

Tracer Studies – Frac Site View

Frac Pumps

Missile

Well-head

Missile

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Questions?