Attachment 2.
Procedures and Work Instruction

Moab UMTRA Project Lift Approval Procedure (DOE-EM/GJRAC1803)

“Design Change Control with NQA-1 QA Requirements” (FONQAWI 105)

Moab UMTRA Project Moisture/Density Testing Procedure (DOE-EM/GJRAC1783)

Moab UMTRA Project Standard Practice for Sampling Aggregates Procedure (DOE-EM/GJRAC1933)

Moab UMTRA Project Radon Flux Measurements Procedure (DOE-EM/GJRAC1939)

DOE–EM/GJRAC1803

Office of Environmental Management – Grand Junction

UMTRA Project

Moab UMTRA Project
Lift Approval Procedure

Revision 4

July 2011

U.S. Department of Energy

Office of Environmental Management

Prepared by the Remedial Action Contractor under contract number DE-AT30-07CC00014
for the U.S. Department of Energy Office of Environmental Management, Grand Junction, Colorado.

DOE-EM/GJRAC1803

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Moab UMTRA Project
Lift Approval Procedure

Revision 4

Review and Approval

Beachem Bosh RAC Quality Assurance Representative	7-28-11 Date
Kathy Turvy RAC Quality Assurance Manager	7-28-11 Date
Brent Anderson RAC Operations Manager	7/28/11 Date

Revision History

Revision No.	Date	Reason/Basis for Revision
0	April 16, 2009	Initial issue.
1	April 23, 2009	Revision update includes correction of lift approval percentage.
2	December 2009	Revision updates include machine parameter changes, compactor information, cold weather placement, and surveying methods.
3	November 2010	Revision updates include updated forms, reference to testing in accordance with DOE-EM/GJRAC1783, horizontal lift compaction requirements, and survey documentation requirements.
4	July 2011	Revision updates include new verbiage to section 3.2.4 Lift Survey.

Table of Contents

Section Page
Acronyms and Abbreviations ... iv
1.0 Purpose and Scope ... 1
1.1 Purpose ... 1
1.2 Scope ... 1
2.0 General ... 1
2.1 Definitions ... 1
2.2 Source Documentation ... 2
2.3 Responsibilities ... 2
2.3.1 Quality Assurance Manager ... 2
2.3.2 QA/QC Representative ... 2
2.3.3 Operations Manager ... 2
2.3.4 Equipment Operators ... 2
2.3.5 All Personnel ... 2
2.4 Precautions and Limitations ... 3
2.4.1 Stop Work ... 3
2.4.2 Safety Protocols ... 3
2.4.3 Training and Procedures ... 3
2.5 Records ... 3
3.0 Requirements and Guidance ... 3
3.1 Compliance ... 3
3.1.1 Lift Identification ... 3
3.1.2 Waste Disposal ... 3
3.1.3 Lift Thickness ... 3
3.1.4 Debris ... 4
3.1.5 Machine Properties ... 4
3.2 Procedure ... 4
3.2.1 Moisture Testing ... 4
3.2.2 Debris Inspection ... 4
3.2.3 Visual Inspection ... 4
3.2.4 Lift Surveys ... 4
3.2.5 CAES Terrain Data ... 5
3.2.6 Requirements for Lift Approval ... 5
3.2.7 Reworking of Lifts ... 5
3.2.8 Troxler Gauge Testing ... 5
4.0 References ... 6

Attachments

Attachment 1. Lift Approval Form (QC-F-001)
Attachment 2. Machine Parameters for Machines Weighing 63,300 lb to 94,500 lb
Attachment 3. Machine Parameters for CAT 825H Compactors and Machines Weighing Greater Than or Equal to 94,500 lb
Attachment 4. Field Density Test Form (QC-F-002)

Acronyms and Abbreviations

ASTM	American Society for Testing of Materials
CAES	computer-aided earthmoving system
GPS	global positioning system
IWP	integrated work plan
lb	pound
QA	Quality Assurance
QC	Quality Control
RAIP	Moab UMTRA Project Remedial Action Inspection Plan
RRM	residual radioactive material
RWP	radiological work permit
UMTRA	Uranium Mill Tailings Remedial Action

1.0 Purpose and Scope

1.1 Purpose

The purpose of this procedure is to provide a consistent and practical method for compacting waste material on the Moab Uranium Mill Tailings Remedial Action (UMTRA) Project using a machine equipped with a computer-aided earthmoving system (CAES) and to provide methods for approving waste lifts.

1.2 Scope

This procedure applies to the disposal of waste using a machine equipped with a CAES and the approval of waste lifts.

2.0 General

2.1 Definitions

Computer-aided earthmoving system (CAES) – Machine guidance system that delivers real-time productivity information to machine operators on an in-cab display using satellite navigation technology, machine-mounted components, a radio network, and office management software.

Layer of snow – Blanket of snow that covers working lift areas without any voids in the snow.

Lift Area – Area of the embankment identified for material placement.

Lift Identification – Discrete number that consists of the following:

- Embankment (i.e., U for UMTRA project cell)
- Work Element (i.e., W for residual radioactive material [RRM] placement, I for interim cover placement, R for radon barrier placement, B for biointrusion placement, F for frost protection placement, C for cap rock placement, E for embankment placement)
- Lift Area – (e.g., A1, B1, C1) year, month, and day. (e.g., UWA1090117, UIA1090117, URA1090117, UBA1090117, UFA1090117, UCA1090117)

NOTE: The day the lift area is first tested will be the date used for lift identification.

Machine – Heavy equipment that is greater than or equal to 63,300 pounds (lb) in weight.

Machine pass – Movement of a machine across an area of the lift in any direction that meets compaction criteria calculated by an algorithm in the CAES. Movement of the machine from one side of the lift to the opposite side of the lift (which meets compaction criteria calculated by an algorithm in the CAES) constitutes one pass; the return trip from the opposite side of the lift (which also meets compaction criteria calculated by an algorithm in the compactor’s system) constitutes a second pass.

Wheel pass – Movement of the machine rear or front axle/wheels across an area of the lift that meets compaction criteria calculated by an algorithm in the compactor's system. The CAES reports one wheel pass for each end of the machine (i.e., two wheel passes equals one machine pass).

2.2 Source Documentation

- American Society for Testing of Materials (ASTM) Standard D6938, "Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)"
- ASTM D1556, "Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method"
- ASTM D698, "Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))"
- ASTM D2216, "Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass"
- ASTM D4643, "Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating"

2.3 Responsibilities

2.3.1 Quality Assurance Manager

The Quality Assurance (QA) Manager is responsible for:

- Implementing and directing Quality Control (QC) activities contained within this procedure
- Identifying QC problems
- Initiating, recommending, and/or providing QC solutions

2.3.2 QA/QC Representative

The QA/QC Representative or designee is responsible for the proper implementation of this procedure and for approving lifts in accordance with this procedure.

2.3.3 Operations Manager

The Operations Manager or designee is responsible for issuing directives to equipment operators.

2.3.4 Equipment Operators

Equipment operators are responsible for compacting lifts with the compaction machine in accordance with this procedure.

2.3.5 All Personnel

When involved in compacting waste using the compaction machine, all employees are responsible for identifying any safety hazards and complying with the applicable Radiological Work Permits (RWPs) and Integrated Work Plans (IWPs).

2.4 Precautions and Limitations

2.4.1 Stop Work
Work shall be immediately terminated by any personnel who feel the activity in progress is unsafe and/or may create an unsafe condition. Work will be resumed when the condition is corrected.

2.4.2 Safety Protocols
All personnel shall remain clear of any operating equipment and maintain good communication with the equipment operator.

Personnel observing compaction using the compaction machine shall always be in visual view of the operator and shall be in front of the machine and never behind the machine working area while machine is in operation.

2.4.3 Training and Procedures
All personnel using the Troxler Nuclear Density Gauge shall attend 8 hours of Nuclear Moisture/Density Gauge training and shall perform all testing in accordance with project procedures.

2.5 Records

The compactor screen printout and the calculations of the exported terrain data shall be attached to the Lift Approval Form (QC-F-001) (see Attachment 1).

Following QA/QC approval of the QC documents, copies shall be made to be maintained on site as a reference file and the original documentation transmitted to Records Management in accordance with the *Moab UMTRA Project Records Management Manual* (DOE-EM/GJ1545).

3.0 Requirements and Guidance

3.1 Compliance

3.1.1 Lift Identification
Each lift shall be given a discrete lift identification number. The lift identification number shall be used to identify all documentation for that lift.

3.1.2 Waste Disposal
No waste material shall be disposed on a lift until the prior lift is approved, with the exception of management of stockpile material.

3.1.3 Lift Thickness
Lift thickness shall not exceed an average uncompacted thickness of 12 inches.

3.1.4 Debris

In accordance with this procedure, debris placement shall be in a single layer, shall be distributed across the lift, and shall comply with the debris size requirements found in Addendum E, *Remedial Action Inspection Plan (RAIP),* of the *Moab UMTRA Project Remedial Action Plan* (DOE-EM/GJ1547).

3.1.5 Machine Properties

The machine properties (see Attachments 2 and 3) under the machine parameters tab for the machines shall be as follows:

- Number of levels (the number of machine passes) shall be set at three or four depending on machine weight. Four machine passes are required for machines weighing between 63,300 lb and 94,500 lb. Three machine passes are required for 825H Caterpillar compactors and machines weighing greater than or equal to 94,500 lb.
- Lift height shall be set at 12 inches.
- Thick lift threshold shall be set at 2 feet.

3.2 Procedure

3.2.1 Moisture Testing

The QC Technician (or qualified personnel) shall perform a moisture test in accordance with applicable ASTM standards for each day that material is placed. Test results shall be documented on the Field Density Test Form (QC-F-002) (see Attachment 4).

3.2.2 Debris Inspection

When performing moisture testing, the sample location shall be from material placed that day. The QC Technician (or qualified personnel) shall inspect the debris once it is spread out across the lift. The debris shall be spread out uniformly across the lift in a manner to minimize void spaces and shall not exceed debris size requirements. The debris inspection shall be documented on the Lift Approval Form (QC-F-001) (see Attachment 1).

3.2.3 Visual Inspection

The QC Technician (or qualified personnel) shall visually inspect the lift areas for frozen material, frost, and snow prior to placement of RRM. No material that is frozen, has frost, or is under a layer of snow shall be approved or placed on. The inspection shall be documented on the Lift Approval Form (QC-F-001) (see Attachment 1) under the comment section.

3.2.4 Lift Surveys

Each lift shall be surveyed using a hand-held global positioning system (GPS) or CAES. When determining the lift thickness of a lift area less than 3,000 square feet, one survey point should be performed for every 15 feet. When determining the lift thickness of a lift area greater than or equal to 3,000 square feet, the survey for each lift shall have a minimum of 10 points. The lift thickness will be determined by comparing the current lift elevations to the previous lift elevations located on the same northing and easting locations. When calculating the loose lift thickness no survey point shall be <1.3’, as long as the average loose thickness is ≤ 1.0’. QC shall perform a visual inspection to ensure lift is placed uniformly thick. Surveys shall be documented on the appropriate form and attached to the Lift Approval Form (QC-F-001) (see Attachment 1).

3.2.5 CAES Terrain Data

Each lift shall be compacted by a minimum of three or four machine passes depending on weight and type of machine used. To ensure the lift area meets the three or four machine pass requirement, print the compaction screen and identify the lift, and export the terrain data for the lift using the CAES.

NOTE: See the CAES Office User Guide for more information on exporting terrain data.

The terrain data results shall be copied into a spreadsheet, and the percentage of pixels that have greater than or equal to three or four machine passes shall be calculated. A copy of the calculations and the compaction screen printout shall be attached to the Lift Approval Form (QC-F-001) (see Attachment 1).

3.2.6 Requirements for Lift Approval

Lifts that meet the following requirements shall be approved:

- Seventy percent of the pixels have greater than or equal to three or four machine passes depending on weight of machine (green pixels) when placing material on slopes.
- Eighty percent of the pixels have greater than or equal to three or four machine passes depending on weight of machine (green pixels) when placing material on approximately horizontal lifts.
- The average lift thickness is less than or equal to 12 inches with no white pixels on the compactor screen printout.
- The compactor screen print out shows uniform compaction over the entire lift area.

3.2.7 Reworking of Lifts

Lifts shall be reworked (e.g., adding additional compaction, cutting the lift, adding more fill) that do not meet the requirements in Section 3.2.

3.2.8 Troxler Gauge Testing

The QC Technician (or qualified personnel) shall perform in-place density tests every 6 months in accordance with ASTM D6938 and ASTM D1556 to verify the CAES is working correctly.

If the CAES is not used to verify compaction and the lift thickness, then the lift shall be tested in accordance with *Moab UMTRA Project Moisture/Density Testing Procedure* (DOE-EM/GJRAC1783). The testing frequency, inspections, and required reporting shall comply with the RAIP and surveying shall be performed using a hand-held GPS or a level survey.

4.0 References

ASTM (American Society for Testing of Materials) Standard D6938, “Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).”

ASTM (American Society for Testing of Materials) Standard D1556, “Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.”

ASTM (American Society for Testing of Materials) Standard D698, “Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).”

ASTM (American Society for Testing of Materials) Standard D2216, “Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.”

ASTM (American Society for Testing of Materials) Standard D4643, “Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating.”

CAES Office User Guide.

DOE (U.S. Department of Energy) *Moab UMTRA Project Moisture/Density Testing Procedure* (DOE-EM/GJRAC1783), February 2009.

DOE (U.S. Department of Energy) *Moab UMTRA Project Records Management Manual* (DOE-EM/GJ1545), April 2008.

DOE (U.S. Department of Energy) *Moab UMTRA Project Remedial Action Plan* (DOE-EM/GJ1547), July 2008.

Attachment 1.
Lift Approval Form (QC-F-001)

Attachment 1. Lift Approval Form (QC-F-001)

LIFT APPROVAL FORM

PROJECT: ____ **OTHER** ____

NW CORNER **DATE:** ____

	P 1 ____
	EW: ____ X ____ = ____
	NS: ____ X ____ = ____
	P 2 ____
	EW: ____ X ____ = ____
	NS: ____ X ____ = ____
	P 3 ____
	EW: ____ X ____ = ____
	NS: ____ X ____ = ____
	P 4 ____
	EW: ____ X ____ = ____
	NS: ____ X ____ = ____
	P 5 ____
	EW: ____ X ____ = ____
	NS: ____ X ____ = ____
	Page 2 attached: Y N

IDENTIFY LOTS ABOVE

LIFT ID: ____ - ____ NW CORNER: ____

Uncompacted Thickness: ____ Compacted Thickness: ____ Debris Insp. By: ____ Date: ____ Time: ____

NW CORNER of debris placement: ____ EW Dimension ____ NS Dimension ____

Lift Area (ft²): ____ Lift Volume (yd³): ____

Comments:

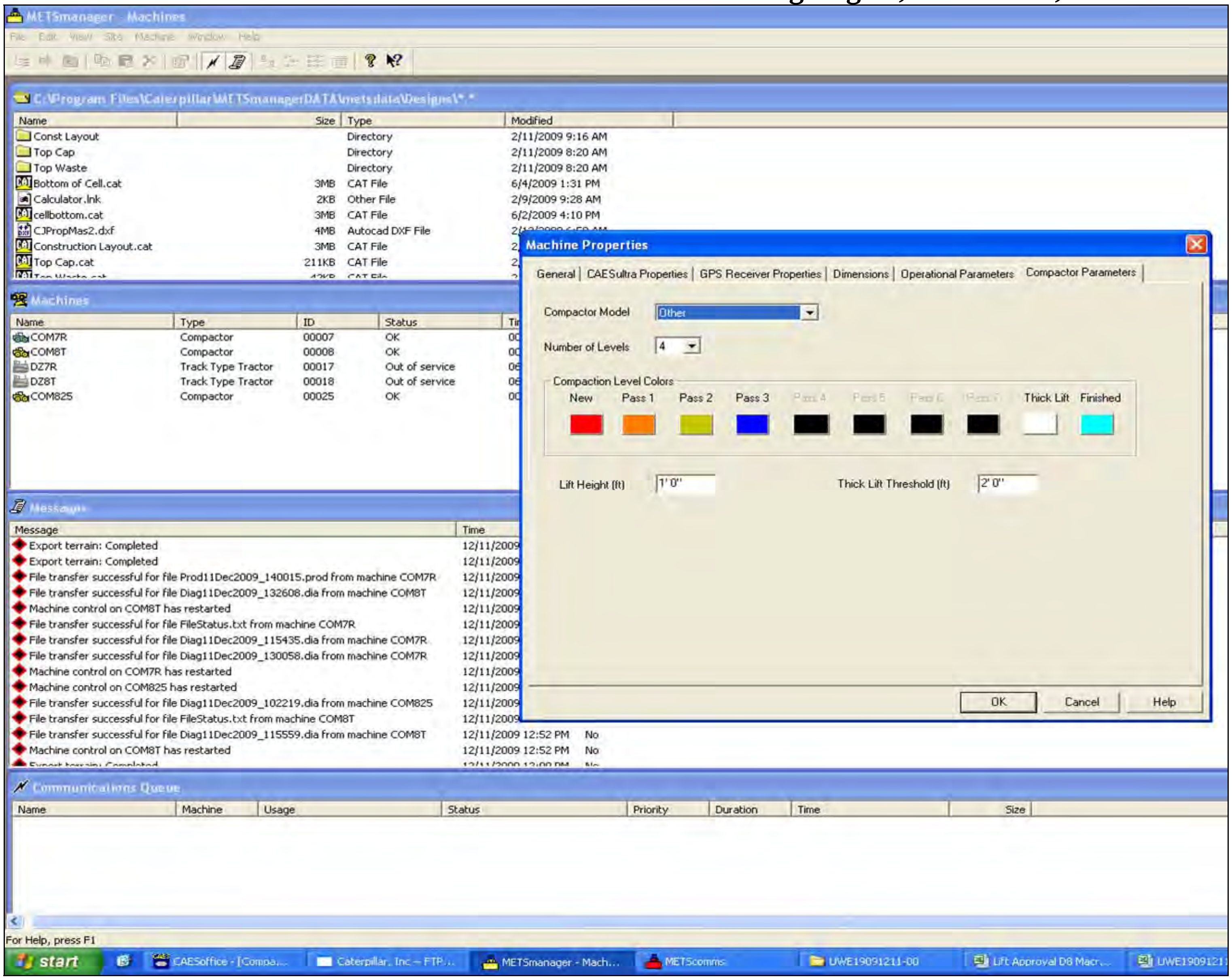
KEYING IN NOTES: N E S W ____ MOISTURE/ DENSITY TESTS ID # (S): ____

LIFT APPROVED BY ____ DATE: ____ TIME: ____

____ QA/QC APPROVAL ____ DATE

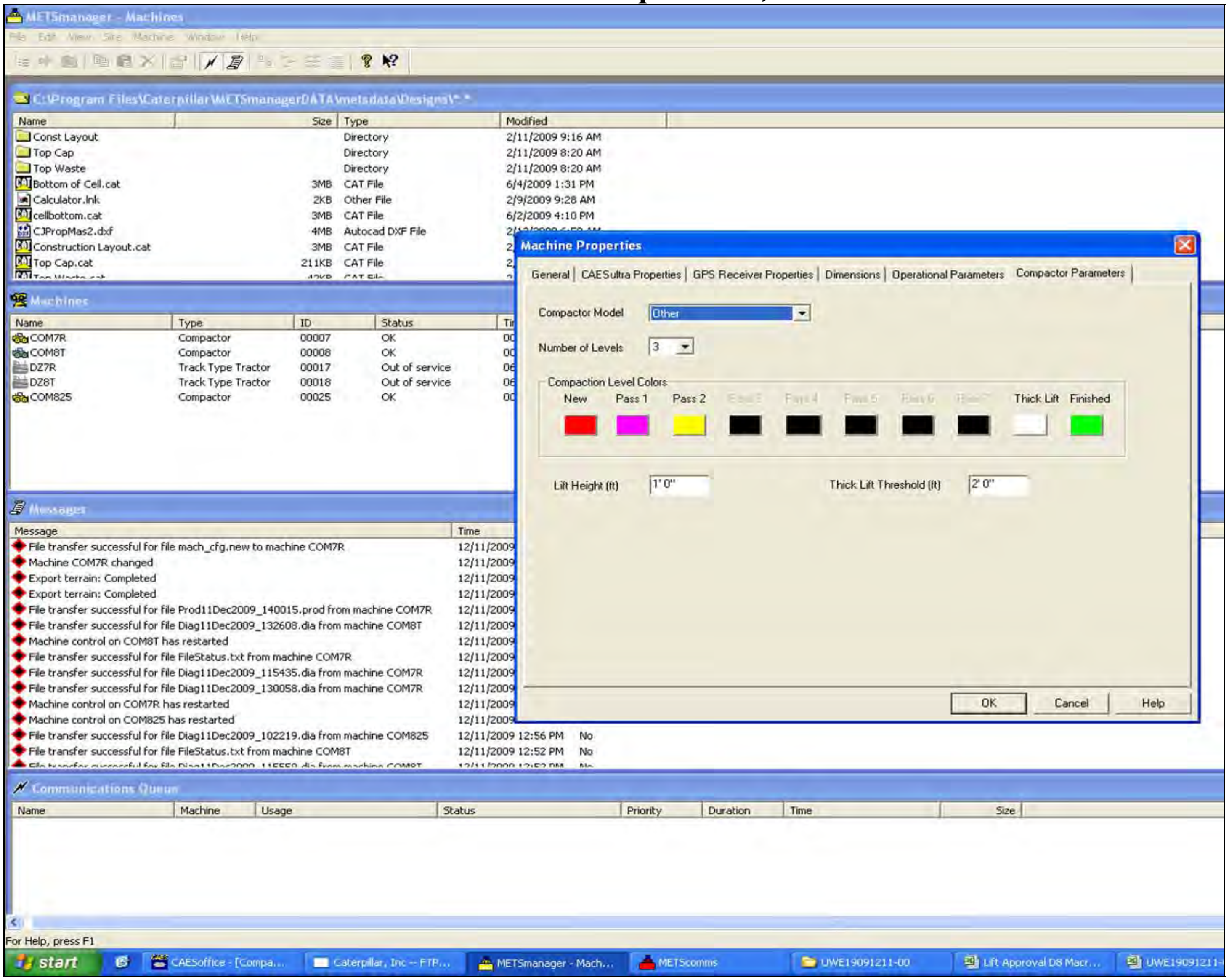
Attachment 2.
Machine Parameters for Machines Weighing 63,300 lb to 94,500 lb

Attachment 2. Machine Parameters for Machines Weighing 63,300 lb to 94,500 lb



Attachment 3.
Machine Parameters for CAT 825H Compactors and Machines Weighing Greater Than or Equal to 94,500 lb

Attachment 3. Machine Parameters for CAT 825H Compactors and Machines Weighing Greater Than or Equal to 94,500 lb



Attachment 4.
Field Density Test Form (QC-F-002)

Attachment 4. Field Density Test Form (QC-F-002)

Moab UMTRA Project

FIELD DENSITY TEST

PROJECT: ______________________ OTHER ____________

LIFT IDENTIFICATION: ______________________ DATE: ____________

TEST ID NUMBER(S): ______________________

TEST LOCATION: ______________________ ____ D1556 ____ D6938

ASTM D6938 (DENSITY DETERMINATION)

Make/Model ________ Gauge Serial # ________

Last Calibration Date: **N/A**

Daily Standard Counts:

Density ________ Moisture ________

____ *Method A (Direct Transmission)* *or* ____ *Method B (Backscatter)*

Depth Setting ____ *(inches)* Count Time ____ *(minutes)*

Moisture Count ________ Density Count ________

Wet Density (ρ_m) ________ (lbs/ft^3) Dry Density ________ (lbs/ft^3)

Moisture Density ________ (lbs/ft^3) Moisture Fraction ________ (%)

MOISTURE DETERMINATION

____ ASTM D2216 @ 110° C or ____ ASTM D4643

Container ID ________

Mass of container & wet specimen (M_{cms})		g
Mass of container & dry specimen (M_{cds})		g
Mass of water (M_w) $M_w = M_{cms} - M_{cds}$		g
Mass of container (M_c)		g
Mass of dry specimen (M_s) $M_s = M_{cds} - M_c$		g
Moisture content (w) $w = (M_w / M_s) \times 100$		%

Dry Density $(\rho_d) = (100 \times \rho_m)/(100 + w)$

$\rho d = (100 \times$ ____ $) / (100 +$ ____ $=$ ____ lbs/ft^3

Note: Wet Density from ASTM D 1556 (ρ_m) takes presidence over ASTM D 6938 (ρ_m)

Percent Compaction = ρ_d / $\gamma_d max \times 100$

____ / ____ x 100 = ________ %

ASTM D1556 (DENSITY DETERMINATION)

Testing Apparatus ____ Calibrated Vol. (lbs/ft^3) ____

Bulk Density of sand (ρ_1) ____ g/cm^3 ____ lbs/ft^3

Mass of Sand to Fill Cone & Plate (M_2) ____ g

Mass of bottle & cone **before** filling cone, plate & hole		g
Mass of bottle & cone **after** filling cone, plate & hole		g
Mass of sand to fill cone, plate, & hole (M_1)		g
Mass of sand to fill hole		g
Mass of wet soil & container		g
Mass of container		g
Mass of wet soil (M_3)		g

Test Hole Volume $V = (M_1 - M_2) / \rho_1$ ____ cm^3

Dry Mass of soil $M_4 = 100\, M_3 / (w + 100)$ ____ g

Wet Denisty $\rho_m = (M_3 / V) \times 62.43$ ____ lbs/ft^3

Dry Denisty $\rho_d = M_4 / V$ ____ g/cm^3

Dry Unit Weight $\gamma_d = \rho_d \times 62.43$ ____ lbs/ft^3

Soil Description: ________

Proctor ID: ________

____ ASTM D698 or ____ ASTM D1557

Maximum Dry Density ($\gamma_d max$) ________ (lbs/ft^3)

Optimum Moisture (w_{opt}) ________ (%)

Required Moisture: ____ % to ____ %

Required Percent Compaction: **90.0** (%)

Comments:

TEST RESULTS:

____ Pass Date: ____

____ Failed Moisture

____ Failed Compaction Time: ____

By: ________ / ________
(print) *(signature)*

QA/QC APPROVAL DATE

JACOBS

<table>
<tr><td colspan="2">Federal Operations
Work Instruction</td><td>Document No:
FONQAWI 105</td><td>Page:
1 of 4</td></tr>
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NQA-1 QA Requirements</td><td>Supersedes:
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05-15-08</td></tr>
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William D. Barton</td><td>Previous Rev. & Issue Date:
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05-20-08</td></tr>
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1.0 PURPOSE

The purpose of this work instruction is to define those activities associated with the identification, registration and communication of design changes perceived to impact project schedule, cost, budget, quality, or basis of design.

2.0 SCOPE OF APPLICATION

This work instruction applies once formal configuration control is involved on a project through the issuance of as-built drawings. This work instruction is applicable to all design changes, irrespective of the source, affecting designs by Federal Operations on projects with NQA-1 quality assurance requirements.

3.0 DEFINITIONS

Design Change	Any revision or alteration of technical requirements defined by approved and issued design output documents and approved and issued changes thereto.
Design Change Notice	A form used to document, review, approve, and issue design changes to an issued design once formal configuration control is invoked on a project.

4.0 METHOD (PROCESS REQUIREMENTS)

This work instruction ensures that design change is controlled and communicated in a consistent manner enabling project cost, budget, schedule, and quality to be achieved. This will be achieved by documentation, coordination and agreement of all design changes on the project, irrespective of their source. This work instruction shall be used in conjunction with FOWI 213-01 Change Management.

The discipline engineer responsible for the design to which the change applies shall ensure that changes to number-revision design documents are captured and reviewed for their effect on design. Also, the discipline engineer shall ensure that the quality level of the structure, system, or component being affected by the change is included in the change control process.

Design changes will be implemented only after the necessary approvals (Ref. FOWI 213-01 Change Management). Areas requiring diligent attention to design change control include:

- Modifications to the project-approved Basis of Design
- Modifications to issued Design P&IDs
- Modifications to issued Process Data Sheets (equipment, instrument, hydraulic)

4.1 RESPONSIBILITIES

It is the responsibility of the Project Manager and each Discipline Lead to ensure that design change is controlled and that all project personnel understand and follow this work instruction.

Dependent upon project size and complexity the Project Manager may assign design change control activities to a Project Engineer or other key member of the project team. Such assignment shall be documented in the Project Execution Plan and shall include maintenance of the Design Change Log and its issuance to all Discipline Leads on a weekly basis.

4.2 SOURCES OF CHANGE

During the design process, changes may originate from numerous sources and occur for a variety of reasons. When engineering personnel identify changes to technical requirements defined by approved and issued design output documents (latest document revision) the engineering personnel shall use best engineering judgment to determine if a change notice is required. If required, a Design Change Notice shall specify both the reason and source of the change.

Typical sources of design change include:

- An instruction from the client that modifies the agreed scope
- Receipt of information from third parties (e.g. regulatory/legislative authorities, suppliers, subcontractors)
- Change of project strategy
- Change to take advantage of superior or more cost efficient design solutions
- Development of design by any engineering discipline

4.3 COMMUNICATION AND CONTROL OF CHANGE

The communication flow associated with a design change is defined in the attached Communication Flowchart (Ref. FONQAWI 105e1).

When engineering personnel have identified a potential change to the approved and issued design output documents they shall review this change with the relevant Discipline Engineer.

The Discipline Engineer will evaluate whether the potential change has an impact on other disciplines, reviewing it as necessary with the Project Engineer and raising it for discussion at the regular Project Coordination Meeting. The Discipline Lead will also assess whether this change should be made to approved and issued design output documents.

Where it is determined that a change to the approved and issued design output documents has occurred or is necessary, the Discipline Engineer of the originating discipline shall initiate and issue a Design Change Notice (Ref. FONQAWI 105f1).

Prior to issuing of the Design Change Notice, the lead of the originating discipline shall, in conjunction with the Project Engineer, establish requirements with respect to HAZOP review and schedule impact, as appropriate.

Upon receipt of the Design Change Notice, the Project Manager or designee will update the Design Change Log (Ref. FONQAWI 105f2).

The Project Manager (or designee) shall review the Design Change Notice and provide the necessary authorization. Thereafter, the Project Engineer shall update and re-issue the Design Change Log.

Discipline Leads shall regularly review the Design Change Log to monitor the status of the design change.

Discipline Leads shall ensure that a change is implemented upon receipt of the Change Notice approved by the Client or Project Manager (Ref. FOWI 213-01 Change Management).

The Design Change Notice conveys the following information to the Project Manager:

- Originating discipline
- Brief description of change

- Source of change
- Initial assessment of other engineering disciplines likely to be affected
- Assessment of Change Notice required

4.4 REGISTRATION OF DESIGN CHANGES

The Design Change Log (Ref. FONQAWI 105f2) is typically constructed as a database; entries can be sorted by Discipline Lead and project management requirements.

Discipline Leads will issue completed Design Change Notices (Ref. FONQAWI 105f1) to the Project Engineer who will enter the details on the Design Change Log. Entries will be completed after receipt of the project authorization from the Project Manager. Design changes will be sequentially numbered. The number, issued by the Project Engineer, will include a suffix indicating the originating discipline, as follows:

- PR Process
- ME Mechanical
- P Piping
- L Instrumentation (Controls Systems)
- EL Electrical
- CS Civil/Structural
- A Architectural
- B Building Services
- R Validation
- EV Environmental
- HC Home Office Construction
- PJ Project
- SC Scheduling
- CT Cost
- ES Estimating
- EX Expediting
- MC Material Control
- DC Document Control
- IN Inspection
- HV HVAC

4.5 APPROVAL/IMPLEMENTATION OF CHANGE

The Project Manager shall approve or reject all Design Change Notices within one week of receipt.

The Project Manager shall review the Design Change Log on a regular basis:

- With the Project Engineer to ensure its accuracy and upkeep a status of design change
- With the Cost Engineer to assess the design change trend
- With design, safety, and validation leads to assess requirements for additional HAZOP Review
- To ensure that required Change Notices are being generated

5.0 RELATED DOCUMENTATION (REFERENCES)

FONQAWI 105e1 Communication Flow Chart

FONQAWI 105f1 Design Change Notice

FONQAWI 105f2 Design Change Log

FOWI 213-01 Change Management

6.0 RECORDS

The Design Change Log and Design Change Notices are records and will be maintained in the Project Central Files.

DOE–EM/GJRAC1783

Office of Environmental Management – Grand Junction

MOAB UTAH

UMTRA Project

Moab UMTRA Project Moisture/Density Testing Procedure

Revision 1

March 2011

U.S. Department of Energy

Office of Environmental Management

Prepared by the Remedial Action Contractor under contract number DE-AT30-07CC00014 for the U.S. Department of Energy Office of Environmental Management, Grand Junction, Colorado.

DOE-EM/GJRAC1783

Moab UMTRA Project
Moisture/Density Testing Procedure

April 2011

Prepared by the Remedial Action Contractor under contract number DE–AT30–07CC00014 for the U.S. Department of Energy Office of Environmental Management, Grand Junction, Colorado.

DOE-EM/GJRAC1783

Moab UMTRA Project
Moisture/Density Testing Procedure

Revision 1

Review and Approval

Beachem Bosh — Date
RAC Quality Assurance/Quality Control Representative

Kathy Turvy — Date
RAC Quality Assurance Manager

William Craig — Date
RAC Radiological Control Manager

Revision History

Revision	Date	Reason for Revision
0	February 2009	Initial issue.
1	April 2011	Added revised lift approval form; added Attachment 4 Emergency Procedure for Troxler gauge damage.

Table of Contents

Section Page

1.0 Purpose and Scope 1
1.1 Purpose 1
1.2 Scope 1
2.0 General 1
2.1 Definitions 1
2.2 Responsibilities 2
2.2.1 Quality Assurance Manager 2
2.2.2 QA/QC Representative 2
2.2.3 QC Technician or Qualified Personnel 2
2.2.4 Radiation Control Technician 2
2.2.5 Equipment Operator 2
2.2.6 Authorized User 2
2.2.7 Radiological Control Manager 2
2.3 Precautions and Limitations 2
2.4 Records 3
3.0 Requirements and Guidance 4
3.1 Compliance 4
3.2 Procedure 5
4.0 References 6

Attachments

Attachment 1. Field Density Test Form QC-F-002
Attachment 2. Lift Approval Form QC-F-001
Attachment 3. Troxler Sign-Out Log Form QC-F-003
Attachment 4. Emergency Procedure for Troxler Gauge Damage

1.0 Purpose and Scope

1.1 Purpose

This procedure provides requirements and methods for the proper moisture/density testing of soils placed at the Moab Uranium Mill Tailings Remedial Action (UMTRA) Project.

1.2 Scope

This procedure applies to the moisture/density testing of all soil materials placed at the Moab UMTRA Project.

2.0 General

2.1 Definitions

Authorized user – One who has met the training requirements in Section 2.3 of this procedure, has the proper thermoluminescent dosimeter (TLD) (or equivalent) with neutron dosimetry, and is authorized to use the Troxler by the Radiological Control Manager.

Compactable soils – Having a bulk density greater than 70 pounds per cubic foot dry weight in accordance with ASTM International (ASTM) D698, "Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))." Graded material that will pass through a 4-inch grizzly. Having soil like properties.

Frozen material – Material that contains frost or ice or cannot meet the compaction requirements because of frozen water inside the material.

Lift area – An area of the embankment, which is identified for waste placement.

Lift identification – A discrete number that consists of the following:

- Embankment (U for UMTRA Project cell)
- Work element (W for waste placement; I for interim cover; R for radon barrier; and E for embankment).
- Lift area (e.g., A1, B1, C1) ,year, month, and day. (e.g., UWA1090117; UI A1090117; UR A1090117)

Lot – A portion of a lift area that shall be tested individually to ensure it meets compaction requirements.

Old/new lift interface – The intersection of the old lift and the new lift.

Random number – A number between 0.001 and 0.999 that is generated from a calculator or computer with random generator function.

Standard count – A measurement of a known reference to ensure accurate gauge readings.

Standard proctor – ASTM D698.

Troxler – A moisture/density gauge that uses radioactive materials to determine in placed moisture and density. Special requirements are employed for use and security maintenance of the Troxler.

2.2 Responsibilities

2.2.1 Quality Assurance Manager

The Quality Assurance (QA) Manager is responsible for:

- Implementing and directing Quality Control (QC) activities contained within this procedure.
- Identifying QC problems.
- Initiating, recommending, or providing QC solutions.

2.2.2 QA/QC Representative

The QA/QC representative is responsible for proper implementation of this procedure.

2.2.3 QC Technician or Qualified Personnel

The QC technician or qualified personnel is responsible for following the testing and disposal process of this procedure.

2.2.4 Radiation Control Technician

The Radiation Control Technician is responsible for:

- Performing necessary surveys to minimize workers' exposure in accordance with the *Moab UMTRA Project ALARA Program* (DOE-EM/GJRAC1922).
- Posting radiation hazards in accordance with *Moab UMTRA Project Radiological Posting and Access Control* (DOE-EM/GJRAC1748).
- Posting requirements for radiation hazards.
- Briefing radiation workers that enter a controlled area under a radiological work permit (RWP).

2.2.5 Equipment Operator

The equipment operator is responsible for handling and placing the waste.

2.2.6 Authorized User

The authorized user is responsible for:

- Maintaining Troxler security.
- Keeping compliance with the requirements of this procedure
- Minimizing any radiation exposures from the Troxler.

2.2.7 Radiological Control Manager

The Radiological Control Manager is responsible for:

- Overseeing the Radiation Protection Program at the UMTRA Moab Project.
- Designate, in writing, personnel authorized to use the nuclear density gauge (i.e., the Troxler).

2.3 Precautions and Limitations

- Work shall be immediately terminated by any personnel who feel the activity in progress is unsafe and/or may cause an unsafe condition. Work will be resumed when the condition is corrected.
- All workers are responsible to ensure they have met the requirement of the appropriate Integrated Work Plan and RWP.
- All personnel shall remain clear of any operating equipment.

- All personnel using the Troxler shall attend the 8-hour Nuclear Moisture/Density Gauge training prior to use.
- New users shall be required to contact the Radiological Control Manager to add their name to the authorized users list.
- Before removing the Troxler from its designated storage location, the responsible authorized user shall ensure the gauge source rod is in the shielded, locked position and then lock the transport case.
- The Troxler gauge shall be kept under constant surveillance by the authorized user for as low as reasonably achievable (ALARA) and security purposes.
- The Troxler gauge shall not be chained to a post, chained in the back of an open bed truck, or secured in a similar manner when not in constant surveillance, transport, or in storage.
- Troxler gauge users are required to use a minimum of two independent physical controls that form tangible barriers to secure portable gauges from unauthorized removal whenever the portable gauges are not under the control and constant surveillance of the licensee (i.e., the Troxler shall be locked in the cab of a vehicle and chained to the steering wheel, locked in a secured box and chained in the back of a truck or locked in the cab of the vehicle inside the restricted area).
- The source rod on the Troxler shall not be touched with fingers, hands, or any part of the body, unless needed maintenance is performed by a trained service technician.
- All personnel shall minimize their exposure from the unshielded source rod. Authorized users shall embrace the ALARA principles of time, distance, and shielding to accomplish this and limit the access of unnecessary personnel to the Troxler. Never look directly under the gauge when lowering the rod into the ground.
- Authorized users shall comply with the *Moab UMTRA Project Radiation Protection Program Manual* (DOE-EM/GJRAC1885).
- Authorized users shall always wear their assigned TLD (or equivalent) when using the Troxler.
- Authorized users shall always return the source to the locked and shielded position after each measurement is taken.
- Troxler gauges shall be stored only in approved storage. Gauges are kept in an approved storage location when not under constant surveillance by an authorized user.
- The *Moab UMTRA Project Emergency Response Plan* (DOE-EM/GJ1520) shall be initiated should the source rod fail to return to the locked position or should the Troxler be damaged in any way that endangers others (a 25-foot area shall be cordoned off around any damaged Troxler gauge).

2.4 Records

All Field Density Test Forms QC-F-002 (Attachment 1) shall be attached to the appropriate Lift Approval Form QC-F-001 (Attachment 2).

Records shall be reviewed and approved before sent to Records Management.

The Troxler Sign-Out Log Form QC-F-003 (Attachment 3) will be reviewed by the QA/QC representative or QA Manager each quarter and transmitted to Records Management each year.

3.0 Requirements and Guidance

3.1 Compliance

- Each lift shall be given a discrete designation (lift identification number) for testing and surveying purposes.
- Each lift shall be tested to meet the specifications.
- Radon barriers shall be compacted to at least 95 percent of a standard proctor (ASTM D698) and have moisture content of ±3 percent of the optimum moisture.
- Waste (residual radioactive material) shall be compacted to at least 90 percent of a standard proctor (ASTM D698) and have a moisture content of ±3 percent of the optimum moisture. Moisture/density testing shall be performed for each waste or fill material in the lift.
- Perimeter embankments shall be compacted to at least 95 percent of a standard proctor (ASTM D698) and have moisture content ±5 percent of the optimum moisture.
- Spoils embankments shall be compacted to at least 90 percent of a standard proctor (ASTM D698) and have moisture content ±5 percent of the optimum moisture.
- Construction projects shall be in accordance with specifications in each project construction plan-associated documentation.
- All soil density and moisture tests shall be performed with a calibrated nuclear moisture/density gauge (ASTM D6938, "Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).") or by the sand-cone method (ASTM D1556, "Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-cone Method.").
- Proficiency testing of the nuclear moisture/density gauge shall be completed by performing a sand-cone density test and an oven or microwave drying test.
- A sand-cone density test (ASTM D1556) shall be performed jointly with 5 percent of all nuclear density tests for waste material.
- An oven or microwave drying test (ASTM D2216, "Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass," or ASTM D4643, "Standard Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating") shall be performed jointly with 10 percent of all nuclear moisture tests.
- A standard count shall be performed and at the start of each day.
- Standard counts must be within the ranges established.

NOTE: If the moisture standard count is not within the indicated range, a moisture dry back shall be performed to determine the moisture of any material tested (ASTM D2216 or ASTM D4643).

- Waste material (residual radioactive material) shall only be placed in cold weather (< 32^{o} F) when the required moisture and compaction requirements can be met.
- Troxler gauge security and accountability is kept through use of the Troxler Sign-Out Log Form QC-F-003 (Attachment 3).
- Lost, damaged, or unaccounted sources require immediate (within 2 hours) notification to the Radiological Control Manager. If the Troxler gauge is damaged, follow the emergency procedure in Attachement 4 for damaged Troxler gauges.
- All applicable U.S. Department of Transportation requirements shall be followed when transporting the Troxler gauge (Title 49 Code of Federal Regulations Part 173.24 [49 CFR 173.24], "Pipeline and Hazardous Materials Safety Administration, Department of

Transportation, General Requirements for Shipments and Packagings," and 49 CFR 173.465, "Pipeline and Hazardous Materials Safety Administration, Department of Transportation, Type A packaging tests.")

- Authorized users shall take precautions to protect gauges from damage from heavy equipment. Ensure there is no heavy equipment operation on a lift during testing. If heavy equipment is being used on an adjacent lift and equipment will be operating close to a Troxler, a flag high enough to be seen shall be posted by the Troxler.

3.2 Procedure

1. Calculate the approximate area of the lift then sketch the lift area. Waste lifts shall be sketched on the Lift Approval Form QC-F-001 (Attachment 2).
2. Divide the lift into lots.
3. Generate random numbers for the in-place moisture/density test coordinates as follows:
   - Generate two random numbers for each lot using a calculator or computer with a random number generator.
   - Multiply one random number by the approximate north-south dimension of the lot and the other random number by the approximate east-west dimension of the lot as measured in feet.
   - Locate the test locations specified by the random numbers.
   - If the sample location is outside the lot, generate two new random numbers.
   - Record this on the Lift Approval Form QC-F-001 (Attachment 2).
4. Prepare the testing site for the nuclear gauge and/or sand-cone test by leveling the area and removing any loose material from the surface.
5. When testing density and moisture with a nuclear gauge, follow the density gauge manual for operation and ASTM D6938 for the proper testing methods. When testing density by the sand-cone method, follow ASTM D1556.

NOTE: The density gauge manual is located in the transport case for the Troxler.

6. When the lift does not meet compaction or moisture requirements, record the results on the Field Density Test Form QC-F-002 (Attachment 1) and notify the equipment operator to re-work the material.
7. After the equipment operator has reworked the material, retest the material.
8. The QC representative or qualified personnel shall approve lots that meet compaction and moisture requirements. Document results on the Field Density Form QC-F-002.

NOTE: Conditional approval can be given in the field from gauge readings if the QC representative is confident that moisture dry-back results will not produce a failing moisture or density.

NOTE: If the QC representative gives conditional approval and the moisture results produce failing moisture or density a condition report shall be written unless the lift had no additional material disposed on that particular lift area.

4.0 References

49 CFR173.24 (Code of Federal Regulations), "Pipeline and Hazardous Materials Safety Administration, Department of Transportation, General Requirements for Shipments and Packagings."

49 CFR 173.465 (Code of Federal Regulations), "Pipeline and Hazardous Materials Safety Administration, Department of Transportation, Type A packaging tests."

ASTM (ASTM International) D698, "Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))."

ASTM (ASTM International) D1556, "Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-cone Method."

ASTM (ASTM International) D2216, "Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass."

ASTM (ASTM International) D4643, "Standard Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating."

ASTM (ASTM International) D6938, "Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)."

DOE (U.S. Department of Energy), *Moab UMTRA Project ALARA Program* (DOE-EM/GJRAC1922), October 2010.

DOE (U.S. Department of Energy), *Moab UMTRA Project Emergency Response Plan* (DOE-EM/GJ1520), November 2009.

DOE (U.S. Department of Energy), *Moab UMTRA Project Radiation Protection Program Manual* (DOE-EM/GJRAC1885), February 2011.

DOE (U.S. Department of Energy), *Moab UMTRA Project Radiological Posting and Access Control* (DOE-EM/GJRAC1748), January 2009.

Attachment 1.
Field Density Test Form QC-F-002

Attachment 1. Field Density Test Form QC-F-002

Moab UMTRA Project

FIELD DENSITY TEST

PROJECT: ____________ OTHER ____________

LIFT IDENTIFICATION: ____________ DATE: ____________

TEST ID NUMBER(S): ____________

TEST LOCATION: ____________ ____ D1556 ____ D6938

ASTM D6938 (DENSITY DETERMINATION)

Make/Model ________ Gauge Serial # ________

Last Calibration Date: N/A

Daily Standard Counts:

Density ________ Moisture ________

____ *Method A (Direct Transmission)* *or* ____ *Method B (Backscatter)*

Depth Setting ____ *(inches)* Count Time ____ *(minutes)*

Moisture Count ________ Density Count ________

Wet Density (ρ_m) ________ *(lbs/ft^3)* Dry Density ________ *(lbs/ft^3)*

Moisture Density ________ *(lbs/ft^3)* Moisture Fraction ________ *(%)*

MOISTURE DETERMINATION

____ ASTM D2216 @ 110° C or ____ ASTM D4643

Container ID ____________

Mass of container & wet specimen (M_{cms})		g
Mass of container & dry specimen (M_{cds})		g
Mass of water (M_w) $M_w = M_{cms} - M_{cds}$		g
Mass of container (M_c)		g
Mass of dry specimen (M_s) $M_s = M_{cds} - M_c$		g
Moisture content (w) $w = (M_w / M_s) \times 100$		%

Dry Density $(\rho_d) = (100 \times \rho_m)/(100 + w)$

ρd = (100 x ______) / (100 + ______ = ______ lbs/ft^3

Note: Wet Density from ASTM D 1556 (ρ_m) takes presidence over ASTM D 6938 (ρ_m)

Percent Compaction = ρ_d / $\gamma_d max$ x 100

______ / ______ x 100 = ______ %

ASTM D1556 (DENSITY DETERMINATION)

Testing Apparatus ______ Calibrated Vol. *(lbs/ft^3)* ______

Bulk Density of sand (ρ_1) ______ g/cm^3 ______ lbs/ft^3

Mass of Sand to Fill Cone & Plate (M_2) ______ g

Mass of bottle & cone **before** filling cone, plate & hole		g
Mass of bottle & cone **after** filling cone, plate & hole		g
Mass of sand to fill cone, plate, & hole (M_1)		g
Mass of sand to fill hole		g
Mass of wet soil & container		g
Mass of container		g
Mass of wet soil (M_3)		g

Test Hole Volume $V = (M_1 - M_2) / \rho_1$ ______ cm^3

Dry Mass of soil $M_4 = 100\ M_3 / (w + 100)$ ______ g

Wet Denisty $\rho_m = (M_3 / V) \times 62.43$ ______ lbs/ft^3

Dry Denisty $\rho_d = M_4 / V$ ______ g/cm^3

Dry Unit Weight $\gamma_d = \rho_d \times 62.43$ ______ lbs/ft^3

Soil Description: ____________

Proctor ID: ____________

____ ASTM D698 or ____ ASTM D1557

Maximum Dry Density (γ_d *max*) ______ (lbs/ft^3)

Optimum Moisture (w_{opt}) ______ (%)

Required Moisture: ______ % to ______ %

Required Percent Compaction: **90.0** (%)

Comments:

TEST RESULTS:

______ Pass Date: ______

______ Failed Moisture

______ Failed Compaction Time: ______

By: ______ / ______
(print) (signature)

______________ QA/QC APPROVAL ______________ DATE

QC-F-002
Rev 2, June 2011

File Code Index No.: ______
Page ____ of ____

Attachment 2.
Lift Approval Form QC-F-001

Attachment 2. Lift Approval Form QC-F-001

LIFT APPROVAL FORM

PROJECT: ____________ **OTHER** ____________

NW CORNER **DATE:** ____________

P 1					
EW:		X		=	
NS:		X		=	
P 2					
EW:		X		=	
NS:		X		=	
P 3					
EW:		X		=	
NS:		X		=	
P 4					
EW:		X		=	
NS:		X		=	
P 5					
EW:		X		=	
NS:		X		=	
Page 2 attached:		Y		N	

IDENTIFY LOTS ABOVE

LIFT ID: ____________ - ____ NW CORNER: ____________

Uncompacted Thickness: ______ Compacted Thickness: ______ Debris Insp. By: ______ Date: ______ Time: ______

NW CORNER of debris placement: ______ EW Dimension ______ NS Dimension ______

Lift Area (ft^2): ______ Lift Volume (yd^3): ______

Comments:
____
____
____
____
____
____
____
____
____
____
____
____
____
____

KEYING IN NOTES: N E S W ______ MOISTURE/ DENSITY TESTS ID # (S): ______

LIFT APPROVED BY: ____________ DATE: ____________ TIME: ______

____________ ______
QA/QC APPROVAL DATE

Attachment 3.
Troxler Sign-Out Log Form QC-F-003

Attachment 3. Troxler Sign-Out Log Form QC-F-003

Moab UMTRA Project
Troxler Sign-out Log

Date	Name of Responsible User	Gauge Serial No.	Location of Where Gauge will be Used	Sign-out *(time & date)*	Sign-in *(time & date)*

QC-F-003
Rev 1, June 2011

File Code Index No.: ________
Page _____ of _____

Attachment 4.
Emergency Procedure for Troxler Gauge Damage

Attachment 4. Emergency Procedure for Troxler Gauge Damage

Emergency Procedure for Troxler Gauge Damage
The following procedures apply when the source fails to return to a shielded position (e.g., as a result of being damaged, source becomes struck below the surface) or if any other emergency or unusual situation arises (e.g., the gauge is struck by a moving vehicle or is in an accident involving a vehicle)

1. Immediately secure the area and keep people at least 25 feet from the gauge in all directions until the situation is assessed and radiation levels are known, notify Radiological Control of situation. However, if any personnel are injured contact site Health and Safety and immediate supervisors.
2. If any heavy equipment is involved, detain the equipment and operator until it is determined there is no contamination present.
3. Gauge users and other potentially contaminated individuals should not leave the scene until emergency assistance arrives.
4. Visually inspect the gauge to determine the position of the source rod practice ALARA and ensure your safety prior to performing inspection (exposed or shielded) and the position of the source shutters (open or closed), and the extent of damage, if any, to the source housing and/or shielding.
5. Notify the following persons listed below, but do not leave the scene to make notifications if needed; get someone to assist:
   - Radiological Controls Manager
   - Construction Manager
   - QA Manager
   - Radiological Controls Supervisor (Nights)
   - Radiological Controls Supervisor (Days)

6. Follow the directions provided by the Radiological Controls Manager.
7. The Radiological Controls Manager must:
   - Arrange for a radiation survey to be conducted as soon as possible by a knowledgeable person using the appropriate radiation detection instrumentation (the person performing the survey must be competent in the use of the survey instrument).
   - Make necessary notifications.

Reports to the U.S. Nuclear Regulatory Commission and/or the U.S. Department of Energy must be made within the reporting timeframes specified in regulations. Reporting requirements are found in 10 CFR 20.220102203 and 10 CFR 30.50.

NOTE: Before shipping a damaged gauge:

- Send close-up photographs of the damaged gauge to Troxler.
- Send leak test sample to Troxler for analysis or send leak test results.
- Obtain returned goods authorization number from Troxler.

DOE–EM/GJRAC1933

Office of Environmental Management – Grand Junction

UMTRA Project

Moab UMTRA Project Standard Practice for Sampling Aggregates Procedure

October 2010

U.S. Department of Energy

Office of Environmental Management

Prepared by the Remedial Action Contractor under contract number DE-AT30-07CC00014 for the U.S. Department of Energy Office of Environmental Management, Grand Junction, Colorado.

DOE-EM/GJRAC1933

Moab UMTRA Project
Standard Practice for Sampling Aggregates Procedure

Revision 0

October 2010

Prepared by the Remedial Action Contractor under contract number DE-AT30-07CC00014
for the U.S. Department of Energy Office of Environmental Management, Grand Junction, Colorado.

DOE-EM/GJRAC1933

Moab UMTRA Project
Standard Practice for Sampling Aggregates Procedure

Revision 0

Review and Approval

10-18-10

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RAC Quality Assurance Representative
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10-18-10

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10-18-10

Mark Greenhalgh
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Date

Revision History

Revision No.	Date	Reason/Basis for Revision
0	October 2010	Initial issue.

Table of Contents

Section Page
1.0 Purpose and Scope 1
1.1 Purpose 1
1.2 Scope 1
2.0 General 1
2.1 Miscellaneous Documentation Referenced 1
2.2 Definitions 1
2.3 Responsibilities 1
2.3.1 Quality Assurance Manager 1
2.3.2 QA/QC Representative 1
2.3.3 QA/QC Technician 1
2.3.4 Project Field Engineer 1
2.3.5 Project Personnel 2
2.3.6 QA Coordinator 2
2.3.7 Records Manager 2
2.4 Precautions and Limitations 2
2.5 Records 2
3.0 Requirements and Guidance 2
3.1 Requirements 2
3.2 Sampling Aggregates in Place 3
3.3 Sampling Aggregates from a Conveyor Belt 3
4.0 References 4

Attachment

Attachment 1. Sampling Log Form (QC-F-011)

1.0 Purpose and Scope

1.1 Purpose

The purpose of this procedure is to provide a standard and consistent method for sampling aggregates for the Moab Uranium Mill Tailings Remedial Action (UMTRA) Project.

1.2 Scope

This procedure covers sampling of aggregates for the acceptance or rejection of materials to be used in construction activities on the Moab UMTRA Project.

2.0 General

2.1 Miscellaneous Documentation Referenced

Reference was made to the following documents during the construction of this procedure:

- U S. Department of Energy (DOE) *Moab UMTRA Project Final Remedial Action Plan* (DOE-EM/GJ1547), Addendum B, "Final Design Specifications," 32-11-23 R1, "Aggregate and Riprap."
- *Final Remedial Action Plan*, Addendum E, "Remedial Action Inspection Plan (RAIP)."

2.2 Definitions

None.

2.3 Responsibilities

2.3.1 Quality Assurance Manager

The Quality Assurance (QA) Manager is responsible for:

- Implementing and directing Quality Control (QC) activities contained within this procedure
- Identifying QC problems
- Initiating, recommending, and/or providing QC solutions

2.3.2 QA/QC Representative

The QA/QC Representative is responsible for proper implementation of this procedure.

2.3.3 QA/QC Technician

The QA/QC Technician, or qualified personnel, is responsible for obtaining aggregate samples to be tested in accordance with this procedure and the American Society for Testing of Materials (ASTM) Standard D75, "Standard Practice for Sampling Aggregates."

2.3.4 Project Field Engineer

The Project Field Engineer is responsible for specifying the use of this procedure for obtaining samples.

2.3.5 Project Personnel

All personnel are responsible to perform work in accordance with applicable Integrated Work Plans (IWPs).

2.3.6 QA Coordinator

The QA Coordinator is responsible for ensuring documents are signed and once signatures are verified, making copies and submitting the original documents to Records Management.

2.3.7 Records Manager

The Records Manager is responsible for maintaining and disposing documentation in accordance with the *Moab UMTRA Project Records Management Manual* (DOE-EM/GJ1545).

2.4 Precautions and Limitations

Work shall be immediately terminated by any personnel who feel the activity in progress is unsafe and/or may create an unsafe condition. Work may be resumed when the condition is corrected.

All work shall be performed in accordance with applicable IWPs.

Proper personal protective equipment (e.g., leather gloves, steel-toe boots) shall be worn while sampling.

2.5 Records

A Sampling Log Form (QC-F-011) (see Attachment 1) shall be kept with the sample, attached to the laboratory test results, and submitted to the QA/QC department for review and approval.

Following QA/QC review and approval, the QA/QC Representative shall submit all documentation to the QA Coordinator.

The QA Coordinator shall ensure all documentation is filled out and signed, make copies of files, and submit the originals to Records Management.

Following QA/QC approval of documents, QA/QC shall make copies of the files to be maintained on site as a reference file. All completed records shall be maintained in accordance with the *Records Management Manual*.

3.0 Requirements and Guidance

3.1 Requirements

Samples taken shall be obtained in accordance with this procedure and ASTM Standard D75.

The sample source and the location of aggregate samples shall be documented on the Sampling Log Form (QC-F-011) (see Attachment 1).

Sample size and quantity needed for acceptance are defined in Table 1 of ASTM Standard D75.

The QA/QC Technician, or qualified personnel, shall use every precaution to obtain samples that show the nature and condition of the materials represented.

The QA/QC Technician, or qualified personnel, shall sample the aggregate in accordance with this procedure and ASTM Standard D75.

Samples shall be taken from the finished product unless specifically authorized by Project management.

Visual inspection shall be used to determine discernible variations in the material.

Operations shall provide suitable equipment for proper inspection and sampling of the material.

All work shall be performed in accordance with the applicable IWPs.

3.2 Sampling Aggregates in Place

1. Prior to beginning the sampling procedure, the size of sample necessary to perform the required tests shall be determined by referring to Table 1 of ASTM Standard D75.
2. A minimum of three random locations for the area that will be tested shall be identified, and verification that the testing area is less than or equal to required testing frequencies as per project specifications shall be made.
3. Samples approximately equal in weight shall be obtained at the random locations generated for the area being tested. Samples shall be taken the full depth of the material being sampled, with care taken to exclude all underlying material. The specific areas from which samples are being removed shall be clearly marked.

   NOTE: A metal frame or plate placed over the sample area is a definite aid in securing approximately equal increment weights.

4. The sample material shall be extracted, protected from contamination by loose or segregated material located around the sampling location, and placed in a suitable container.
5. The minimum number of field samples required is three. More samples may be obtained depending on the criticality of and variation in the properties to be measured.
6. Aggregates shall be transported in bags or other containers constructed to preclude loss or contamination of any part of the sample or damage to the contents from mishandling during shipment.
7. The final sample size shall be no less than that required by ASTM Standard D75.

3.3 Sampling Aggregates from a Conveyor Belt

1. Prior to beginning the sampling procedure, the size of sample necessary to perform the required tests shall be determined by referring to Table 1 of ASTM Standard D75.
2. The units to be sampled shall be randomly selected.
3. Stop and lockout/tagout the conveyor belt while the sample increments are being obtained.

4. A minimum of three samples of approximately equal increments shall be selected and obtained at random from the unit being sampled and combined to form a field sample with a mass equal to or exceeding the required size as per ASTM Standard D75.
5. Two templates, the shapes of which conform to the shape of the conveyor belt, shall be placed in the aggregate stream on the belt and spaced such that the material contained between them will yield an increment of required weight.
6. All material between the templates shall be carefully scooped into a suitable container and the fines on the belt collected with a brush and dust pan and added to the container.
7. Aggregates shall be transported in bags or other containers constructed as to preclude loss or contamination of any part of the sample or damage to the contents from mishandling during shipment.
8. The final sample size shall be no less than that required by ASTM Standard D75.

4.0 References

ASTM (American Society for Testing of Materials) Standard D75, "Standard Practice for Sampling Aggregates," June 2009.

DOE (U.S. Department of Energy) *Moab UMTRA Project Final Remedial Action Plan* (DOE-EM/GJ1547), July 2008.

DOE (U.S. Department of Energy) *Moab UMTRA Project Records Management Manual* (DOE-EM/GJ1545), April 2008.

Attachment 1.
Sampling Log Form (QC-F-011)

Attachment 1. Sampling Log Form (QC-F-011)

SAMPLING LOG

PROJECT:______________________________ OTHER______________

DATE:______________

SAMPLE NUMBER:______________ MATERIAL TYPE: SOIL______ ROCK ______
LOCATION:______________________________

TEST(S) TO BE PERFORMED: SAMPLED BY:______________
PROCTOR:______ CLASSIFICATION:______ LABORATORY PERMEABILITY:______
NA SOUNDNESS:______ LA ABRASION:______ ABSORPTION:______
SPECIFIC GRAVITY:______ GRADATION:______
COMMENTS:______________________________

SAMPLE NUMBER:______________ MATERIAL TYPE: SOIL______ ROCK ______
LOCATION:______________________________

TEST(S) TO BE PERFORMED: SAMPLED BY:______________
PROCTOR:______ CLASSIFICATION:______ LABORATORY PERMEABILITY:______
NA SOUNDNESS:______ LA ABRASION:______ ABSORPTION:______
SPECIFIC GRAVITY:______ GRADATION:______
COMMENTS:______________________________

SAMPLE NUMBER:______________ MATERIAL TYPE: SOIL______ ROCK ______
LOCATION:______________________________

TEST(S) TO BE PERFORMED: SAMPLED BY:______________
PROCTOR:______ CLASSIFICATION:______ LABORATORY PERMEABILITY:______
NA SOUNDNESS:______ LA ABRASION:______ ABSORPTION:______
SPECIFIC GRAVITY:______ GRADATION:______
COMMENTS:______________________________

Sampled by: ______ DATE ______ QA/QC APPROVAL ______ DATE ______

DOE–EM/GJRAC1939

Office of Environmental Management – Grand Junction

UMTRA Project

Moab UMTRA Project
Radon Flux Measurements Procedure

Revision 0

May 2011

U.S. Department of Energy

Office of Environmental Management

Prepared by the Remedial Action Contractor under contract number DE-AT30-07CC00014
for the U.S. Department of Energy Office of Environmental Management, Grand Junction, Colorado.

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Radon Flux Measurements

Revision 0

Review and Approval

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5-6-2011
Date

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Revision History

Revision No.	Date	Reason/Basis for Revision
0	May 2011	Initial issue.

Table of Contents

Section Page

Acronyms and Abbreviations v

1.0 Scope 1

1.1 Purpose 1

1.2 Applicability 1

1.3 Authority 1

1.4 Revisions 1

2.0 Definitions 1

3.0 Requirements 1

3.1 Prerequisites 1

3.2 Tools, Material, Equipment 2

3.2.1 Instruments 2

3.2.2 Charcoal Collection Media 2

3.2.3 Other Required Equipment 2

3.3 Precautions/Limits 2

3.3.1 Weather Conditions 2

3.3.2 Measurement Location Restrictions 2

3.3.3 Radon-222 Emission Standard 3

3.4 Acceptance Criteria 3

4.0 Procedure 3

4.1 Canister Preparation 3

4.1.1 Activated Charcoal Preparation 3

4.1.2 Canister Preparation 3

4.2 Measurement Locations 4

4.3 Canister Placement 4

4.4 Canister Collection 4

4.5 Charcoal Sample Preparation 5

4.6 Counting Charcoal Blanks, Standards, and Samples 5

4.7 Charcoal Standards 5

4.8 Charcoal Blanks (Background) 6

4.9 Charcoal Samples 6

4.10 Radon Flux Calculations 7

4.10.1 Individual Region Flux Measurements 7

4.10.2 MDC Calculations 7

4.10.3 Mean Radon Flux 8

4.11 Quality Control Checks 8

4.12 Action Levels 8

4.13 Final Report 8

5.0 Records/Reports/Notifications 9

6.0 References 9

Attachments

Attachment 1. Radon Flux Measurement Numbering System
Attachment 2. Sample Activated Charcoal Preparation Form
Attachment 3. Sample Canister Placement Log
Attachment 4. Sample 222RN Flux: OCS QC Form
Attachment 5. Sample Radon Flux OCS Log Form
Attachment 6. Sample OCS Instrument Survey Initial Standard Deviation Set

Acronyms and Abbreviations

°C	degrees Centigrade
°F	degrees Fahrenheit
CFR	Code of Federal Regulations
cpm	counts per minute
DOE	U.S. Department of Energy
dpm	disintegrations per minute
dps	disintegrations per second
m^2	square meters
MDC	minimum detectable concentration
OCS	Opposed Crystal System
pCi	picocuries
QA	quality assurance
QC	quality control
Ra-226	radium-226
RAC	Remedial Action Contractor
Rn-222	radon-222
ROI	region of interest
-s	per second
UMTRA	Uranium Mill Tailings Remedial Action

1.0 Scope

1.1 Purpose

This procedure describes the sampling methodology, analysis, calculations, and associated reporting requirements necessary to measure radon flux using insitu charcoal canisters according to Title 40 Code of Federal Regulations Part 61 (40 CFR 61), “National Emission Standards for Hazardous Air Pollutants,” Appendix B, “Test Methods,” Method 115, “Monitoring for Radon-222 Emissions.”

1.2 Applicability

The requirements of this procedure apply to all radon flux measurements made after placement of radon barrier material at the U.S. Department of Energy (DOE) Moab Uranium Mill Tailings Remedial Action (UMTRA) Project at the Crescent Junction disposal site, in accordance with the National Emissions Standard for Hazardous Air Pollutants requirements set forth in 40 CFR 61 Subpart T, “National Emission Standards for Radon Emissions from the Disposal of Uranium Mill Tailings.”

1.3 Authority

40 CFR 61 Subpart T

1.4 Revisions

None.

2.0 Definitions

Charcoal batch – A quantity of charcoal that has been activated at the same time in the same oven.

Charcoal standards – Radioactive sources prepared by mixing a known amount of liquid radium-226 (Ra-226) source material in a container filled with charcoal.

Radon flux – The rate of radioactive radon gas diffusion from the soil into the atmosphere per unit area.

3.0 Requirements

3.1 Prerequisites

The DOE representative shall be notified prior to beginning radon flux measurements.

The measurement locations shall be established prior to radon flux, sampling and approved by the Operations Manager or designee.

3.2 Tools, Material, Equipment

3.2.1 Instruments

An Opposed Crystal System (OCS) shall be assembled, set-up, and checked out in accordance with requirements of applicable health physics procedures, and shall be available for use in counting the exposed charcoal media.

A programmable calculator may be used to perform the radon flux calculations.

The Symphony spreadsheet program, “Moab UMTRA Project Flux Calculations,” may be used to perform the OCS efficiency calculations, the radon flux calculations, and the minimum detectable concentration (MDC) calculations.

3.2.2 Charcoal Collection Media

Activated charcoal from the same batch shall be used for each group of measurements.

Each batch of charcoal used on site shall be kept separate from other batches. Batches shall not be mixed

3.2.3 Other Required Equipment

Other required equipment includes:

- Radon Flux Canisters.
- Oven with a built-in temperature indicator or thermometer that can read 0 to 200 degrees Centigrade (°C) in 1°C increments (if oven does not have a built in temperature indicator).
- Minimum thermometer to record minimum temperatures and validate field measurement data.

3.3 Precautions/Limits

3.3.1 Weather Conditions

Flux measurements shall not be initiated within 24 hours of precipitation.

If rainfall occurs during the 24-hour measurement period, the measurement is invalid if the seal around the lip of the canister has washed away or if the canister is surrounded by standing water.

Radon flux measurements shall not be made if the ambient temperature (i.e., air temperature at the immediate measurement location) is below 35 degrees Fahrenheit (°F) or if the ground is frozen. Measurement results shall be deemed invalid if the ambient temperature drops below 35°F during the measurement period.

3.3.2 Measurement Location Restrictions

All radon flux measurements shall commence after the final lift of radon barrier material has been placed but prior to placement of any other layer (except filter layers). Radon flux measurements will not be made until the radon reaches secular equilibrium with radium. This time delay will depend on the time between lifts and the placement of the final radon barrier. This may require up to a 30 days to be in secular equilibrium. No measurements shall be made on intermediate barrier lifts or tailings material.

No measurement location shall fall within 3 meters of the edge of the barrier or within 3 meters of an intermediate lift or an exposed tailings surface.

Each measurement location shall be free from large rocks, standing water, and vegetation.

3.3.3 Radon-222 Emission Standard

Radon-222 emissions to the ambient air from uranium mill tailings piles that are no longer operational shall not exceed 20 picocuries per square meter per second (pCi/m^2-s) of radon-222 (Rn-222).

3.4 Acceptance Criteria

At least 85 percent of all measurements must yield valid (useable) results.

The radon flux measurements must demonstrate that Rn-222 emissions (the mean radon flux) from the pile do not exceed the standard.

4.0 Procedure

4.1 Canister Preparation

4.1.1 Activated Charcoal Preparation

The charcoal to be used shall be purged of any radon before being used by heating in an oven for 24 hours at 110°C.

1. Fill the required number of OCS cans with charcoal (approximately 400 milliliters each) to within an eighth of an inch from the lip.
2. Fill an additional 5 percent, a minimum of three OCS cans, for blanks from each batch.
3. Label each OCS can from each batch with the batch number and a sequential number (see Radon Flux Measurement Numbering System in Attachment 1).
4. Place the cans of charcoal in the oven and record the batch number, can numbers in the batch, date in, oven temperature, and time in on the Activated Charcoal Preparation Form (Attachment 2).
5. After 24 hours, remove the cans of charcoal from the oven and record the date out, oven temperature, and time removed from the oven. The oven temperature should be measured with a thermometer that can read 0-200°C in 1°C increments or by using the oven's built-in temperature indicator.
6. The charcoal shall then be cooled to room temperature in an area of low background radon concentration.
7. Seal the cans.

4.1.2 Canister Preparation

1. Label canisters (see Attachment 1).
2. Prepare each canister for sampling in the field immediately prior to placement.
3. Turn the canister over on its handle and remove the retainer wire and bottom pad.

4. Open a prepared charcoal can and pour the activated charcoal in the center of the plastic grid. Distribute the charcoal evenly over the grid, ensuring no charcoal is lost outside of the canister.
5. Place pad, screen side toward the charcoal, on the grid.
6. Secure the pad in the canister by inserting the retainer wire in the tabs on the inside of the canister.

4.2 Measurement Locations

1. Measurements shall be made on each 40-acre disposal cell at 100 defined spaced locations over the entire cell.
2. Each location will be as close to the center of an individual measurement region (approximately 1/100 of the cell area) as practical.
3. If monitoring just part of the cell, there must be a sufficient number of samples to meet the total cell requirement.
4. The Operations Manager shall identify the proposed sample locations on a measurement location drawing.
5. The disposal cell surface area shall be determined in m^2. Determination of cell surface area shall be performed by site operations staff.
6. A copy of the measurement location drawing will be provided to the Remedial Action Contractor (RAC) Radiological Control Manager or designee for approval, prior to taking any measurements. A copy will also be provided to the site Quality Assurance/Quality Control (QA/QC) Manager and the Operations Manager or their designees. The drawing must be provided well in advance of flux measurements to allow submittal to the DOE.

4.3 Canister Placement

1. Each charcoal canister shall be placed on a pre-determined location, per Section 4.2, for a period of 22 to 26 hours. When possible, canisters should be placed during the morning.
2. The location surface shall not be penetrated by the lip of the canister.
3. Each canister shall be carefully positioned on a flat surface using radon barrier material to seal around the edge (lip) of the canister.
4. Obtain a bucket of radon barrier material and use it to seal the canister by mounding around its outer edge.
5. Canister placement information shall be recorded on the Canister Placement Log (Attachment 3) at the time of placement and shall include site, batch number, date placed, can number, canister alphanumeric number, time placed, flux point number, flux point coordinates, and a notation on weather conditions 24 hours prior to placement (e.g., “clear,” “no precipitation”).

4.4 Canister Collection

1. After the sample collection time period has elapsed, carefully remove the canister from the measurement location.
2. Carefully unload the charcoal from the canister into a large plastic bag.
3. Disassemble the canister completely and recover all visible charcoal.
4. Seal the bag.

5. Label the bag with sample location point number, date and time collected and record this information on the Canister Placement Log along with a notation regarding weather conditions at the time of collection and the low temperature.
6. Restore the measurement location surface to as near its original condition as possible.
7. If it is apparent that a canister has been moved, disturbed, or tampered with, that canister measurement shall be deemed invalid, a notation shall be made in the Comments Section of the Canister Placement Log, and the location should be re-sampled.
8. If conditions indicate that damage has occurred to the radon barrier itself, immediately notify the site QA/QC Manager. The site QA/QC Manager shall then notify the site Manager
9. Transport the sample bag(s) to a sample preparation area (i.e., an area of low Rn-222 background concentrations) as soon as possible.

4.5 Charcoal Sample Preparation

1. The charcoal in the bags shall be transferred to an OCS sample can so that the quantity of radon on the charcoal can be determined. This activity shall be conducted in a clean work area (i.e., low Rn-222 concentrations and contamination free).
2. Position the plastic bag so that the charcoal collects in one of the bottom corners. Gently tap the side of the bag to dislodge trapped particles.
3. Once the charcoal is collected in a bag corner, place it over an OCS can and cut away the corner funneling the charcoal into the can.
4. If the charcoal is more than ½ inch below the lip, the measurement shall be invalid. This should be noted in the Comment Section of the Canister Placement Log. The canister should be examined for defects and repaired as necessary. The measurement should be repeated.
5. Seal the can and label it with the batch, sample, and location point numbers.
6. Allow a minimum of 4 hours (not to exceed 24 hours) after sample collection, for equilibration of radon and its progeny, before counting.
7. Chain-of-custody on charcoal samples shall be maintained between field personnel and lab personnel by signature on the Canister Placement Log (Attachment 3).

4.6 Counting Charcoal Blanks, Standards, and Samples

1. Prior to counting charcoal standards, backgrounds, or samples on the OCS, it shall be set up according to the appropriate daily checkout procedure for OCS operation.
2. Establish a region of interest around 609 kiloelectron volt peak, typically including channels 320 to 382.
3. Counting time shall be set at 500 seconds and a printout of the region of interest and counts obtained.
4. When using a Series 35 OCS, counting should be performed using Task 1.
5. When using an OCS, the “SAMPLE” job file can be used to obtain the region of interest data, but all information below the “SAMPLE GROSS COUNTS” section at the bottom of the printout is invalid and should be marked out.

4.7 Charcoal Standards

1. Daily, before and after counting charcoal samples, both (approximately 250 and 500 pCi per gram) charcoal standards shall be counted on the OCS for 500 seconds each.

2. The standards shall be leak tested daily prior to counting and the results recorded on the Radon-222 Flux: OCS QC Form (Attachment 4).
3. The integra.1 data for OCS Region of Interest (ROI) #1 shall be used to calculate the counting efficiency for each of the standards. The average of the efficiencies calculated prior to sample counting will be used in the sample calculation. These standards shall be traceable to the National Institute of Standards and Technology. Standard count results shall be recorded on the Radon-222 Flux: OCS QC Form.
4. Both charcoal standards and the background blank, when counted, should yield results within the 95 percent confidence interval (2 sigma) of their respective mean activities (Section 4.11). If count results from this functional test are not within these limits for accuracy, sample counts will be suspended until the Radiological Control Manager or designee investigates the cause, and subsequently approves use of the system.
5. Calculate efficiency for each of the two standards by using the following equation:

$$Eff = \frac{(\text{Standard Counts}/LT) - (\text{Average Background Counts}/LT)}{(\text{Std. pCI}) * 0.037}$$

Where:
LT = Live Time (in seconds)
Eff = efficiency (counts/disintegration)

6. Record the counting efficiency on the ^{222}Rn Flux: OCS QC Form (Attachment 4).

4.8 Charcoal Blanks (Background)

1. One of the batch blanks prepared in Section 4.1.1 shall be designated as a background check blank and counted on the OCS for 500 seconds before and after counting charcoal samples.
2. The background blank must correspond with the batch of-the samples being counted. Record the background blank count results on the ^{222}Rn Flux: OCS QC Form (Attachment 4).
3. The average of all blank counts will be used in the calculation of efficiency, radon flux measurements, and the calculation of MDC.

4.9 Charcoal Samples

1. After the standards and background blank have been counted, each flux measurement sample shall be counted for 500 seconds.
2. Record the flux point, batch number, can number, flux point coordinates, exposure start and stop date and time, exposure time (T1 in seconds), and OCS count start time and date on the Radon Flux OCS Log Form (Attachment 5).
3. When a sample count has been completed, record the counts under ROI #1 in the "Sample Count" column of the Radon Flux OCS Log Form. Determine the net counts for that sample by subtracting the background blank ROI #1 counts from the sample ROI #1 count and record this value.
4. When sample counting is completed, including duplicate counting (Section 4.11) and blank counting, empty all used cans, including the batch blanks, into a container labeled with the appropriate manufacturing batch number.

4.10 Radon Flux Calculations

Once the net counts are obtained (Section 4.6), the following calculation in Section 4.10.1 shall be used to determine the radon flux.

4.10.1 Individual Region Flux Measurements

$$J = \frac{C \quad \lambda^2}{AEK\ [1\text{-}e^{-\lambda T1}\ [e^{-\lambda(T2-Tt)} - e^{-\lambda\ (T3-T1)}]}$$

Where:
J = Radon flux (pCi/m²-s)
C = Net counts in ROI #1
A = Area of the canister, 0.05 m²
E = OCS efficiency (counts per minute/disintegrations per minute [cpm/dpm])
K = Conversion from dps to pCi (0.0.37 disintegrations per second [dps]/pCi)
λ = Radon decay constant 2.097E-6/second
T1 = Exposure time (in seconds)
T2 = Time from canister placement (start of measurement) to start of counting (in seconds)
T3 = Time from canister placement (start of measurement) to end of counting (in seconds)

Record the result on Radon Flux OCS Log Form.

4.10.2 MDC Calculations

The MDC shall be calculated using the following equation:

$$MDC = \frac{(3.0 + 4.65\ \sqrt{BKG})\lambda^2}{AEKT}$$

Where:
BKG = Average Background Counts in ROI #1
MDC = Minimum Detectable Concentration
A = Area of the canister, 0.05 m²
E = OCS efficiency (cpm/dpm)
K = Conversion from dps to pCi (o.0.37 dps/pCi)
λ = Radon decay constant 2.097E-6/second
T = Constant – 1.298E-4 (Assuming minimum exposure time and maximum time between measurement and count)

NOTE: The MDC should only be used in making priori estimate of expected instrument performance and should not be used when evaluating sample data.

The Symphony spreadsheet program, RN_FLUX. WR1, may be used to perform the calculations and can also be substituted for the Radon Flux OCS Log Form.

4.10.3 Mean Radon Flux

The mean radon flux for the total cell or pile area shall be calculated as follows:

$$Jx = \frac{J1\ A1 + ...J100\ A100}{Ax}$$

Where:
Jx = Mean radon flux (pCi/m²-s)
J1 = Radon flux measurement in region 1 (pCi/m²-s)
A1 = Area of region 1 (m²)
Ax = Total Cell Area (m²)

At the completion of radon flux measurements, the pertinent data shall be forwarded to the Radiological Control Manager or designee. The data shall be entered into the database and a program run to check for math errors. The data will then be printed out for use in the site completion report.

4.11 Quality Control Checks

1. Prior to initiating this procedure, both charcoal standards shall be counted 20 times each to establish the 95 percent confidence levels. Results shall be recorded on the OCS Instrument Survey Initial Standard Deviation Set Form (Attachment 6).
2. Ten percent, or a minimum of one per measurement group, of flux measurement samples shall be recounted to document the reproducibility of the counting technique.
3. Record the results on the Radon Flux OCS Log Form and note "Duplicate" in Comments column.
4. In addition to the background blanks, 5 percent of the analyzed samples or a minimum of one per measurement group shall be blank samples. Blank sample results shall be recorded on the Radon Flux OCS Log Form and "Blank" shall be noted in comments column.
5. At least 85 percent of all measurements must yield valid (useable) results.
6. A precision of 10 percent of the mean must be maintained for all duplicate samples above 1.0 pCi/m²-s.
7. The accuracy of all measurements must be ±10 percent
8. All flux measurement calculations shall be verified and reviewed by the site Radiological Control Manager or designee. Calculations shall also be approved by the site Radiological Control Manager or designee by signature.

4.12 Action Levels

The operations Manager shall be notified when any single radon flux measurement result exceeds 10.0 pCi/m²-s or if any criteria in Section 4.11 are not met.

4.13 Final Report

The report shall include the following information:

- The name and location of the facility.
- A list of the piles at the facility.
- A description of the control measures taken to decrease the radon flux from the source and

any actions taken to insure the long term effectiveness of the control measures.

- The results of the testing conducted including the results of each measurement.

5.0 Records/Reports/Notifications

A copy of the measurement location drawing shall be provided to the Radiological Control Manager or designee prior to making any flux measurements (See Section 4.2).

All flux measurement documentation shall be reviewed and signed by the site Radiological Control Manager.

A copy of the Radon Flux Measurement Data Sheets (Attachments 2, 3, 4, and 5) shall be transmitted to the Radiological Control Manager or designee when each group of measurements has been completed. The original site flux measurement location drawing and forms shall be transmitted to the Radiological Control Manager when all measurements have been completed.

The QA department shall be kept apprised of the location of all pertinent records for a period of 5 years. These records must be made available for inspection upon request.

6.0 References

40 CFR 61 (Code of Federal Regulations), "National Emission Standards for Hazardous Air Pollutants," Appendix B, "Test Methods," Method 115, "Monitoring for Radon-222 Emissions."

40 CFR 61 (Code of Federal Regulations), Subpart T, "National Emission Standards for Radon Emissions from the Disposal of Uranium Mill Tailings."

Attachment 1.
Radon Flux Measurement Numbering System

Attachment 1. Radon Flux Measurement Numbering System

RADON FLUX MEASUREMENT NUMBERING SYSTEM

Batch Numbers

Batch number shall be an alphanumeric designator where the .letter indicates the batch and the number indicates the sequential cycle through the oven (e.g., A 1, A2 for batch A, first time through the oven; and batch A, second time through the oven).

Can Numbers

Can numbers shall be sequential numbers (e.g., 1, 2, 3 ..., X) for each batch.

Canister Numbers

Each canister shall be permanently labeled with a unique sequential alphabetic designators (e.g., A, B, C ... , AA~ BB) with doubles as required.

Attachment 2.
Sample Activated Charcoal Preparation Form

Attachment 2. Sample Activated Charcoal Preparation Form

Activated Charcoal Preparation Site - Crescent Junction

Batch #	Can #	Date In Oven	Date Out Oven	Over Temp	Time in Oven	Time Out Oven	Comments

Note: All Cans in this batch were filled to within 1/8th inch of the lip with charcoal.

RCT/QTT Name/Signature:_________________________________ Date: ____________________

Attachment 3.
Sample Canister Placement Log

Attachment 3. Sample Canister Placement Log

Canister Placement Log

Can #	Canister #	Time Places / Time Collected		Flux Point #	Flux Point Coordinates	Comments

RCT/QTT Name/Signature:______________________________________ Date: ______________________

Attachment 4.
Sample 222RN Flux: OCS QC Form

Attachment 4. Sample 222RN Flux: OCS QC Form

^{222}RADON FLUX: OCS QC

SITE ____________ DATE ____________ OCS SN ____________

TECHNICIAN ____________

^{214}Bi Peak Check Using ____________ pCi/g Standard

Time ______ At ______ Set To ______ Time ______ At ______ Set To ______

Background Check Integral ____________ (Before Counting, Used in 2 Sigma Calculation)

Background Check Integral ____________ (After Counting)

Efficiency ____________ (Used in Sample Activity Calculation)

Acceptable Integral Ranges

2 Sigma ______ to ______

$$Integral - 2\sqrt{Integral}$$
$$Integral + 2\sqrt{Integral}$$

$^{226}Ra_1$ _____ pCi Standard Data

Acceptable Integral Ranges

2 Sigma ______ to ______

3 Sigma ______ to ______

Standard Integral ______ (Before Counting)

Standard Integral ______ (After Counting)

Eff_1 ______

Leak Test:

Time______ Pass/Fail (Circle One)

$^{226}Ra_2$ _____ pCi Standard Data

Acceptable Integral Ranges

2 Sigma ______ to ______

3 Sigma ______ to ______

Standard Integral ______ (Before Counting)

Standard Integral ______ (After Counting)

Eff_2 ______

Leak Test:

Time______ Pass/Fail (Circle One)

$$Eff_1 = \frac{(^{226}Ra_1\ Int - Bkg\ Int)/LT}{(std.\ pCi)(0.037)}$$

$$Eff_2 = \frac{(^{226}Ra_2\ Int - Bkg\ Int)/LT}{(std.\ pCi)(0.037)}$$

$$Efficiency = \frac{Eff_1 + Eff_2}{2}$$

Reviewed by ____________ Approved by ____________

Attachment 5.
Sample Radon Flux OCS Log Form

Attachment 5. Sample Radon Flux OCS Log Form

RADON FLUX OCS LOG

SAMPLE IDENTIFICATION		FLUX POINT COORDINATES	EXPOSURE START	TIME STOP	EXT. TIME	OCS COUNT	CALCULATION TIMES	REGION OF INTEREST NUMBER ONE DATA				RADON FLUX pCi/m²-s	COMMENTS
FLUX POINT #	BATCH#	N.	TIME	TIME	T1	TIME	T2	SAMPLE CT.	BKG	NET	EFF		
	CAN #	E.	*DATE	*DATE		*DATE	T3						

* JULIAN DATE   Reviewed ____________________   F5-OP-003-5   Approved ____________________

$$MDC = \frac{(3.0 + 4.65\sqrt{BKG})\lambda^2}{AEKT} = \_\_\_\_\_\_\_\_\_\_$$

Attachment 6.
Sample OCS Instrument Survey Initial Standard Deviation Set

Attachment 6. Sample OCS Instrument Survey Initial Standard Deviation Set

OCS INSTRUMENT SURVEY
INITIAL STANDARD DEVIATION SET (AS RECEIVED)

INSTRUMENT: ____________________
SN: ____________________

SITE: ____________________

NAME: ____________________

DATE: ____________________

500 SEC STD CHECK ROI #1 INTEGRAL		500 SEC STD CHECK ROI #1 INTEGRAL	
1.	________	11.	________
2.	________	12.	________
3.	________	13.	________
4.	________	14.	________
5.	________	15.	________
6.	________	16.	________
7.	________	17.	________
8.	________	18.	________
9.	________	19.	________
10.	________	20.	________

AS RECEIVED AVERAGE = ____________________
AS RECEIVED STANDARD DEVIATION = ____________________
2-SIGMA RANGE = ____________________ TO ____________________
3-SIGMA RANGE = ____________________ TO ____________________

SOURCE: RA-226 S/N ________

SOURCE ACTIVITY: ________ pCi

REVIEWED BY: ____________________ APPROVED BY: ____________________