

**STANDARD OPERATING PROCEDURE NO. 61**  
**MEASUREMENTS WITH NUCLEAR RADIATION GAUGE**

<b>REVISION LOG</b>		
Revision Number	Description	Date
61.0	Original SOP (R. van Dame, V. T. McLemore)	06/16/04
61.1	Addition of Appendix 2 (PJP)	7/8/2004
61.2	Comments/additions by VTM	9/5/04
61.3	Corrections/additions by PJP	9/15/04
61.4	Minor comments by JRM, approved VTM	12/12/2005
61v4	Changes accepted, printed for binders project, sent to Jack for posting on website	8/18/05
61v4	Finalized by LMK for posting on Molycorp project website and to send to George Robinson for lab audit. LMK did not edit this SOP.	4/3/07
61v5	Editorial by SKA	10/27/08

## **1.0 PURPOSE AND SCOPE**

This Standard Operating Procedure (SOP) serves as a supplement to the Quality Assurance Project Plan (QAPP) and provides technical guidance and methods that will be used for taking field measurements with nuclear radiation gauge (i.e. nuclear densitometer or nuclear densometer) equipment at the Molycorp Site.

The nuclear densitometer contains radioactive material, which can be dangerous if not handled properly. In order to keep operation of this equipment safe for the operator(s) and others it is important to follow strict operating procedures set by the manufacturer (see manual, Appendix 2) and that comply with regulatory requirements.

A nuclear densitometer is used to measure bulk density and moisture content of soils. A nuclear densitometer consists of two radioactive sources or emitters; namely, a gamma source for measuring density and a neutron source for measuring moisture content. The direct transmission mode of operation, which requires insertion of the source rod into the soil profile, is/was used in this study for measuring density. The density reading recorded by the nuclear densitometer is an average value for the material between the surface and the source at the end of rod. The source rod may be inserted into the soil profile at different increments, up to a maximum depth of 300 mm (12in). The neutron source is located in the gauge itself, which uses a backscatter technique to measure the average moisture content of approximately the top 10 cm of material beneath the gauge. The nuclear densitometer complies with the ASTM standards for density and water content measurements by the nuclear method (D2922-96 and D3017-96, respectively).

The main advantage of the nuclear densitometer over other methods is its speed of data collection. The main disadvantage of the method is that data can be highly variable in heterogeneous materials as a result of the averaging process. Large diameter sand-cone density test results are generally considered more reliable than nuclear densitometer test results. A comparison of dry density values from mine soils reveals that measurements obtained by the sand-cone density method are consistently higher than results obtained by nuclear densitometer by approximately 7%.

Gravimetric moisture contents obtained from drying physical samples (ASTM standard D4718-87) are generally higher than the moisture contents determined with the nuclear densitometer. The moisture content measurement difference between the two methods, however, is not considered to be significant.

## **2.0 RESPONSIBILITIES AND QUALIFICATIONS**

The MolyCorp contractor appointed staff has the overall responsibility for implementing this SOP. They will be responsible for assigning appropriate environmental staff to implement this SOP and for ensuring that the procedures are followed by all personnel.

All personnel performing these procedures are required to have the appropriate health and safety training. In addition, all personnel are required to have a complete understanding of the procedures described within this SOP and receive specific training regarding these procedures. Finally, all personnel are required to have received specific training regarding radiation safety and nuclear gauge operation.

A state certification that complies with the federal Nuclear Radiation Commission (NRC) is required for operation.

All environmental staff and assay laboratory staff are responsible for reporting deviations from this SOP to the RI Project Manager or Field Manager.

### **3.0 RELATED STANDARD OPERATING PROCEDURES**

Related SOPs include:

- SOP 1 Data management (including verification and validation)
- SOP 3 Surveying
- SOP 9 Test pits

### **4.0 EQUIPMENT LIST**

The following materials and equipment listed will be needed for nuclear gauge measurements:

- field map
- GPS
- Bound field book with field sample forms
- Nuclear gauge
- Hammer and tube for holes

Other materials and equipment may be needed based on field conditions.

### **5.0 PROCEDURES**

See attached field manual in Appendix 2.

### **6.0 DOCUMENTATION**

Documentation of observations and data acquired in the field will provide information on the activities concluded and also provide a permanent record of field activities. The observations and data will be recorded with waterproof ink in a permanently bound field logbook with consecutively numbered pages, and on field data sheets.

Project and subcontractor staff are responsible for documenting logging activities. Field notes will be kept during logging activities. The following information will be recorded in a bound field log book:

- Names of personnel
- Weather conditions
- Date, time and location of logging
- Description of survey set-up and data collection
- Times that procedures and measurements are completed
- Summary of data reduction and preliminary interpretations

- Documentation of all problems encountered
- Calibration information
- Other applicable information

## **7.0 FIELD NOTES**

Note the (test pit) location, probe depth, probe orientation, identification number(s) of associated field sample(s), and qualitative description (e.g., color, grain size) of the material at each measurement location.