

STANDARD OPERATING PROCEDURE NO. 70

DENSITY AND VOLUMETRIC WATER CONTENT BY THE SAND REPLACEMENT METHOD

REVISION LOG		
Revision Number	Description	Date
70.0	Original SOP (Joe Marcoline)	10/19/2004
70.1	Comments-GMLR, corrections VTM	12/31/04, 1/31/05
70v2	Final Edits by LMK	1/31/05
	Posted on Granite FTP 1/31/05 , sent to Jack Hamilton to post on Utah website 1/31/05	
70v3	Modified lab procedures KMD	2/12/2007
70v3	Edited procedural changes LMK and removed “waste rock” from text, could not find ASTM method to insert it. Finalized by LMK for posting on Molycorp project website and to send to George Robinson for lab audit.	4/4/07
70v4	Editorial by SKA	10/28/08

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 one of the three methods that will be used for the direct determination of mine soil density and volumetric water content on the Molycorp Rock Pile Stability Study site.

Generally, in a direct measurement method, the volumetric water content of a soil sample is evaluated on the basis of three measured quantities: (1) W_w , the wet weight of the soil sample; (2) W_d , the oven-dried weight of the sample; (3) V_b , the field volume or the total volume of the sample, where ρ_w is the bulk density of water. With these measured quantities available, the volume of the liquid phase (water), V_b , in the sample can then be

calculated

as

$$V_l = \frac{(W_w - W_d)}{\rho_w} , \quad (6.6)$$

and the volumetric water content (Θ) can then be determined.

$$\Theta = \frac{V_l}{V_t} = \frac{W_w - W_d}{V_t \rho_w} , \quad (6.7)$$

Volumetric water content (Θ) measurement methods were modeled after guidelines established by American Society for Testing and Materials (ASTM) Method D1556-90. The ASTM guideline specifically states it is not intended for materials containing particles greater than 1.5 inches. Rock pile material can be that coarse and in that case an alternative method should be used to determine density and water content.

Summary of method

A smooth horizontal surface is created at the sample location of interest. A hole is hand excavated in the smooth rock pile face and all material removed is saved in a sealed container. The test hole volume is determined by filling it with a dry, free-flowing, sieved sand of known density. The water content of the removed rock pile material is determined and the bulk density of the rock pile material is calculated using the water content and volume of the hole.

2.0 RESPONSIBILITIES AND QUALIFICATIONS

The PI, Project Manager, or Field Manager has the overall responsibility for implementing this SOP. He/she will be responsible for assigning appropriate environmental staff to implement this SOP and for ensuring that all personnel follow the procedures accurately.

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 to receive specific training regarding these procedures, if necessary.

All environmental staff and field staff are responsible for reporting deviations from this SOP to the PI, Project Manager, or Field Manager.

3.0 DATA QUALITY OBJECTIVES

This SOP addresses objectives 1 and 7 in the data quality objectives outlined for the "Geological and Hydrological Characterization at the MolyCorp Questa Mine, Taos

County, New Mexico”. The determination of rock pile material water content and density will be used to help to:

- Determine how the hydrogeochemistry and water balance dynamics influence rock pile weathering and stability.
- Determine if pyrite oxidation, moisture content, and microbe populations affect rock pile weathering and stability.

4.0 RELATED STANDARD OPERATING PROCEDURES

Related SOPs include:

- SOP 1 Data management (including verification and validation)
- SOP 9 Test pits
- SOP 22 Analytical data validation
- SOP 40 Gravimetric moisture content

5.0 EQUIPMENT LIST

The following materials and equipment listed will be needed for the sand replacement method:

- Plastic bags
- Scale
- Known-density sand
- Pick and shovel
- Plastic buckets
- Moisture tins
- Field book/database forms
- Indelible pens and weatherproof labels

5.0 PROCEDURES

- 1 Select a location representative of the staked sample location. Begin by creating a smooth face on the horizontal portion of the pile.
- 2 Excavate a hole with a small trowel or pick. Take great care not only to collect all material removed, but also to excavate a smooth round hole. The hole should be as large as possible without the removed volume exceeding the volume of a 5 gallon bucket. The test can reliably be performed on as little as 500-1000 grams of mine soil.

- 3 Once the material has been excavated and placed into the bucket, weigh the sample. Collect a gravimetric water content sample from the material removed from the hole and reweigh the bucket.
- 4 Place the gravimetric sample in an insulated cooler following SOP 40.
- 5 Line the hole with a thin plastic bag, the mass of the bag should be weighed. For large samples, the bag mass is insignificant in the calculation and can be ignored. Determine the mass of sand that fills the hole by pouring free flowing sand of a known density into the remaining excavation.
- 6 Carefully remove the full bag and weigh the mass of the bag. Convert the mass to a volume using the sand density. Empty the bag of sand and repeat this procedure for a total of three volume measurements. The volume is acceptable only if the three measurements vary by less than 10%.
- 7 As a final check, the sand from the final test can be placed in the excavation without the bag. This step is not necessary, but will give confidence that the volume of sand is equal to the volume of the test hole.
- 8 In the laboratory weigh the sample. If it is in a bucket note in lab book the sample weight plus the weight of the bucket after the sample has been removed. If in a sample bag weigh the sample in the bag not in a bucket.
- 9 Dry the sample in a clean oven-safe pan over night or until the sample is completely dry throughout.
- 10 If the sample was collected in a bucket place the sample in the bag into the bucket and weigh both together. If the sample was in a sample bag, place the sample into the bag and weigh both together. Record in log book.

6.0 CALCULATIONS

Calculate the volume of the test hole according to the following equation:

$$V = \frac{(M_1 - M_2)}{\rho_1}$$

where:

V = volume of the test hole, cm³,

M_1 = bulk mass of the sand used to fill the test hole, grams,

M_2 = mass of the empty bag, grams,

ρ_1 = bulk density of the sand, g/cm³.

Calculate the bulk density of the removed rock pile material according to the following equation:

$$\rho_b = M_3 / V$$

where:

ρ_b = rock pile material bulk density, g/cm³,

M_3 = wet mass of the removed rock pile material, grams,

V = volume of the removed rock pile material, cm³.

Calculate the gravimetric water content of the rock pile material excavated from the test hole according to the following equation:

$$W = \frac{(M_3 - M_4)}{M_4}$$

where:

W = gravimetric water content of the rock pile material removed from the test hole,

M_3 = wet bulk mass of the removed rock pile material, grams,

M_4 = dry bulk mass of the removed rock pile material, grams.

Calculate the volumetric water content (theta) of the rock pile material according to the following equation:

$$\theta = W * \rho_b$$

where:

θ = volumetric water content of removed rock pile material,

W = gravimetric water content of removed rock pile material,

ρ_b = bulk density of the removed rock pile material, g/ cm³.

7.0 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

weatherproof field logbook with consecutively numbered pages, and on field data sheets. The data will then be entered into the database in the proper form (Appendix 1).

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

- Names of personnel
- Weather conditions
- Date, time and location of borehole
- Description of installation and setup
- Documentation of all problems encountered
- Calibration information
- Other applicable information

APPENDIX I. Example Form

VOLUMETRIC MOISTURE CONTENT AND BULK DENSITY BY SAND REPLACEMENT METHOD			
Field_id	GHN-JRM-0031	Date_measured	
Comments			
SOP_number	70	Deviation_SOP	
Mass_contain	920.0		
Mass wet soil + container (g)	13,260.0	Average masssand (g)	10,453.0
Bulk density sand (g/cm3)	1.54	Volume of hole (cm3)	6,788.00
Mass sand fill hole trial 1	10,760.0	Bulk density soil (g/cm3)	1.82
Mass sand fill hole trial 2	10,220.0	Gravimetric moisture content %	9.24
Mass sand fill hole trial 3	10,380.0	Volumetric moisture content %	0.168