OPERATING PROCEDURE NO. 82
IN-SITU DIRECT SHEAR TESTS

REVISION LOG

Revision Number	Description	Date
82v0	Original SOP by RDL	6/22/2006
82v1	corrections by VTM after comments from AF, DF, DVZ, GWW	8/28/06
82v2	Corrections by VTM after comments from AF, LK; Figure 1 and 2 re-drawn by LMK	8/31/06
82v3	LMK inserted modified in-situ field test set-up diagram	3/29/07
82v3	Finalized by LMK for posting to Molycorp project website and to send to George Robinson for lab audit; LMK did not edit this SOP.	4/3/07
82v4	Editorial by SKA	10/28/08

1.0 PURPOSE AND SCOPE

This Standard Operating Procedure (SOP) provides technical guidance and methods that will be used to test rock pile materials during environmental investigations at the Molycorp, Inc. (hereafter referred to as Molycorp) mine. This SOP is a supplement to the site-wide and investigation-area specific work plans and field sampling plans (FSPs), and should be used in conjunction with the other SOPs in this volume.

2.0 RESPONSIBILITIES AND QUALIFICATIONS

The Project Manager, Field Manager and Safety Officer will have the overall responsibility for implementing this SOP. They will be responsible for assigning appropriate staff to implement this SOP and for ensuring that the procedures are followed 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 field and laboratory staff are responsible for reporting deviations from this SOP to the Field Manager.

3.0 DATA QUALITY OBJECTIVES

The characterization portion of this research project has identified nine DQOs (Data Quality Objectives), described in the QAPP (Quality Assurance Procedure Plan), that must be addressed in order to solve this problem. The field testing plan specifically addresses three of these DQOs, which are listed below:

- Determine how much cohesion exists in the rock pile material, alteration scars and debris flows and attempt to determine friction angle of in-situ samples.

- Perform direct shear test of in-situ samples under loads representing the natural overburden to determine the effects on cohesion, shear strength and displacement as well as properties such as cohesion and angle of internal friction.

- Determine the influence of weathering on the shear strength properties of the material such as cohesion and friction angle.

4.0 RELATED STANDARD OPERATING PROCEDURES

The procedures set forth in this SOP are intended for use with the following SOPs:

- SOP 1 Data management (including verification and validation)
- SOP 2 Sample management (including chain of custody)
- SOP 3 Surveying (GPS) and coordinate systems
- SOP 4 Taking photographs
- SOP 5 Sampling Outcrops, Rock Piles, and Drill Core (Solid)
- SOP 7 Decontamination of sampling equipment
- SOP 8 Sample preparation (solids)
- SOP 9 Test pit excavation, logging, and sampling (solid)
- SOP 33 Particle Size Analysis
- SOP 36 Sample preservation, storage, and shipment
- SOP 50 Direct Shear Test
- SOP 54 Atterberg Limits
- SOP 75 Specific Gravity
- Any other SOPs dealing with solid sample collection and sampling for complete geological characterization

5.0 TYPE OF SAMPLES TO BE TESTED

The following samples are to be tested for this project and for which testing procedures are described in this SOP.

- Undisturbed soil samples (blocks)

The test described in this SOP will be done in-situ. Representative samples will be collected for particle size analysis (SOP 33), laboratory direct shear test on disturbed samples (SOP 50), Atterberg Limits (SOP 54) and specific gravity (SOP 75). Collection of samples for these tests are covered by SOP 5.

6.0 EQUIPMENT LIST

- Shovel
- Pick
- Direct Shear Box with top smooth plate and roller plate
- Two Hydraulic Jacks with gauges
- Rock Hammer, putty knives, shovels, picks, hoes for digging
- Vertical and horizontal displacement dial gauges (3)
- Tensiometers
- Backhoe,excavator, or front end loader
- Pieces of wood of various sizes and lengths
- 6"x 8" (15 cm x 20 cm) piece of wood of sufficient length to support the backhoe bucket
- Nail Board
- 6" (15cm) nails
- 5 gallon plastic buckets with lids, ziploc bags
- Health and Safety equipment as outlined in the Site-Specific Health and Safety Plan
- Bound field logbook and field sample data sheets
- permanent markers
- GPS unit (SOP No. 3) set to correct coordinate system
- Decontamination Equipment (SOP 7)
- Digital Camera
- Leather Gloves
- Drinking Water for workers

7.0 IN-SITU DIRECT SHEAR TEST PROCEDURES

1. **For safety reasons, no personnel will be located in the trench during the test. Use of heavy-weight leather gloves to protect hands during trench excavation is required. Any time the backhoe/excavator/front end loader is in operation, all other personnel must remain clear of the area. All personnel will wear safety vests while equipment is in operation.**
2. If precipitation begins during the in-situ direct shear test, if possible, the block being sheared will be covered with plastic.
3. An area will be excavated near an access road or in a trench using shovels and picks. The initial excavation, if possible, will be perpendicular to the slope so that individual layers can be examined in the rock pile.
4. The in-situ direct shear test will be conducted within a material constituting a specific material or layer to measure cohesion of that layer. The layer selected should contain a high percentage of fine grained material. Measurements of matric suction (SOP 43) and soil temperature (SOP 40), and samples for density (SOP 70) and moisture content (SOP 40) will be taken from the layer selected for in-situ direct shear testing as soon as possible after opening the trench.
5. The largest particle size in the location chosen for testing should be no greater than 1/7 the width of the shear box. For example, if a 12" (31cm) shear box is

being used the largest particle size within the test block cannot exceed 1.7 inches (4.4 cm). If a cobble or boulder is found on the edge of the shear block during excavation, an attempt can be made to remove it. However, if it is determined that removing the cobble or boulder has disturbed the shear block, another test location must be chosen.

6. After a specific layer is chosen for testing, place the nail board over the area to be tested. Drive the nails through the holes around the nail board. Make sure the board is level. The nail cage will protect the shear block during excavation. Excavate carefully, using hand tools, so the shear block is not disturbed (Fig. 1). After the shear block has been excavated to the proper depth, remove the nails and gently lift the nail board from the top of the shear block. Continue to trim the block by hand until the shear block is the proper size to fit within the shear box.
7. Photograph the block.
8. Place shear box over block and make sure shear box is level. Fill gaps between the block and shear box with sand or fine material being tested. Level the top surface. Place top plate onto block and make sure the top plate is level. If a bucket is used, place the roller plate onto the top plate. Record weights of the top plate and roller plate in bound field book.
9. Bucket samples will be taken from the shear plane level for moisture content (SOP 40), particle size analysis (SOP 33), disturbed laboratory direct shear test (SOP 50), Atterberg Limits (SOP 54), specific gravity (SOP 75), density (SOP 70), and chemistry and mineralogy (SOP 28, 27, 24). Tensiometers will be used to measure matric suction (SOP 43) of the sheared plane surface.
10. A dead weight using plates and lead weights will be used if a backhoe/excavator/front end loader is not available. A steel cuff will be attached to the bucket of the backhoe/excavator/front end loader for placement of the normal load jack one of the hydraulic jacks. This jack is then attached to the steel cover plate of the direct shear box using the ball bearing system. A normal load of 20 kPa will be applied to the shear block. One of the hydraulic jacks will be used to apply the normal load by jacking against the backhoe bucket that provides a static reactive load. The hydraulic jack will be jacked against the roller plate which will rest on the smooth cover plate of the shear box (Fig. 2). The hydraulic gauge on the jack will be utilized to verify that a constant normal load is maintained throughout the direct shear test. The backhoe bucket will be supported by wood or dirt for safety reasons.
11. Place the second hydraulic jack against the steel push plate of the shear box and use pieces of wood to fill the gap between the jack and the trench wall. The shear force should be applied as close as possible to the bottom of the shear box. Make sure both the steel push plate and the jack are level.
12. Supports for the shear dial gauge and normal gauges are placed adjacent to the shear box. Dial gauges are placed after the bucket or dead weights are in position.
13. Photograph the completed setup.

14. Apply pressure to the jacks slowly. Record the initial normal and shear jack pressure.
15. The shear box will be displaced a predetermined amount (20/1000 inches or 0.5 mm) and allowed to settle for approximately 30 seconds before taking a reading from the hydraulic gauge on the jack. This data should be entered into a bound field book and entered into the database to create a graph of shear stress vs. displacement (Fig. 3). This step will be repeated until the peak shear stress has been exceeded and, if possible, the residual shear strength has been established. The test continues for a shear displacement of 3 inches, if possible.
16. Upon completion of the test, the normal load, hydraulic jacks and all gauges should be carefully removed before the dead weights or bucket are removed.
17. Photograph the shear plane and block. Tensiometers will be used to measure matric suction (SOP 43) of the sheared plane surfaces.
18. Bucket samples will be taken from the sheared plane for particle size analysis, if possible (SOP 33).
19. Density sample (SOP 70) is collected at shear plane level.
20. The top of the smooth plate should be inspected for indentations created by the spheres on the roller plate and noted in the bound field book.
21. The test will be repeated, if possible for 2-3 additional layers beneath the first run or on horizontal adjacent blocks of the same material using different normal loads that are less than the in situ normal stress.
22. Upon completion of the in-situ direct shear test, fill the trench with the material removed during excavation to prevent trip and fall hazards.

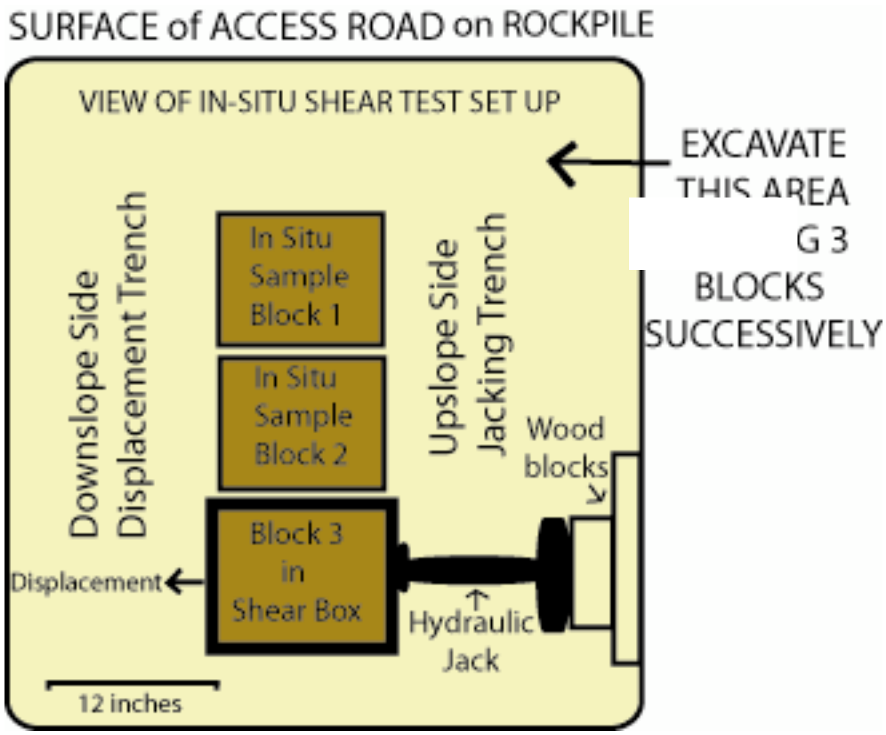


FIGURE 1. Conceptual plan view of the trenches and shear blocks for the in-situ direct shear test. Layers with the highest percentage of fine-grained material will be used for testing. **At no time shall any personnel be in the trench during testing except to adjust the gauges as needed!**

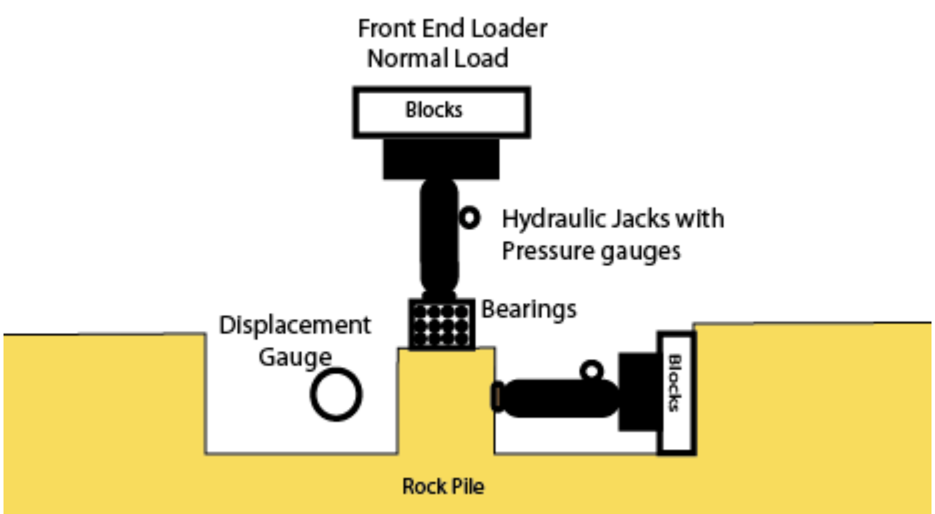


FIGURE 2. Diagram showing location of wood used for mounting horizontal displacement and vertical strain gauges showing the placement of the normal force, hydraulic jack, and bearing assembly above the shear block with the displacing jack in the jacking trench and displacement gauge in the displacement trench on either side of the shear block.

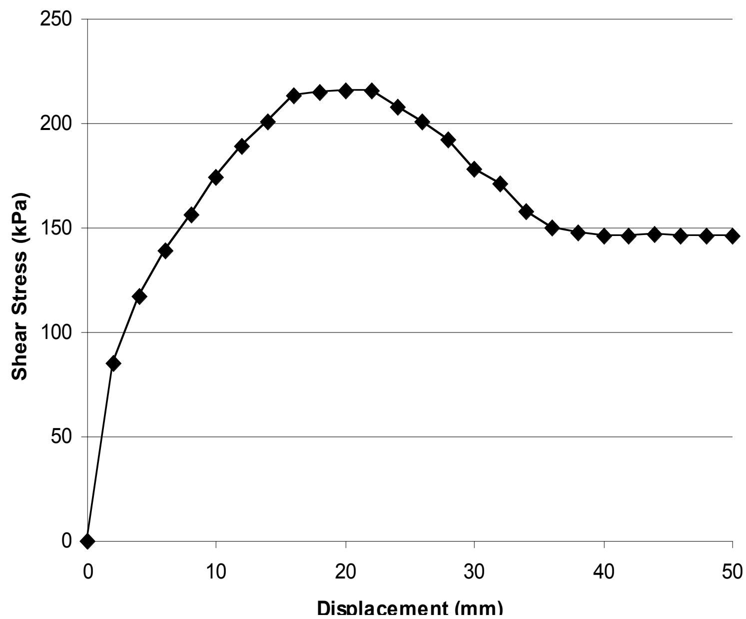


FIGURE 3. Example of a shear stress graph resulting from the in-situ direct shear test.

8.0 DECONTAMINATION OF TESTING EQUIPMENT

Equipment must be brushed and wiped clean after each test (see SOP 7 Equipment decontamination).

9.0 FIELD QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES AND SAMPLES

QA/QC samples are designed to help identify potential sources of sample contamination, and to evaluate any potential error introduced by sample collection and handling. All QA/QC samples will be labeled and sent with the other samples to the laboratory for analysis. The type and number of QA/QC samples are defined in SOP 2, Sample Management. Tests will be conducted using similar normal weights on similar blocks to demonstrate repeatability of the in situ tests.

10.0 SAMPLE MANAGEMENT

Each sample is assigned a unique field identification number. A chain of custody form will be completed and sent with each sample batch. Each in situ site tested will be identified by a sample number and a run number as indicated in the database.

The field identification (ID) number for samples will consist of three components separated by dashes, for example SSW-HRS-0001, as described below.

Field Identification Number (Field id)

Component 1	Component 2	Component 3
Three letter abbreviation for the mine feature, for example SSW for Sugar Shack West.	Three letter initials of the sample collector, for example HRS for Heather R. Shannon.	Sequential four number designation, for example 0001.

Any deviations from this sampling numbering system will be documented and reported to the Field Manager and Principle Investigators.

11.0 DOCUMENTATION

Documentation of observations and data acquired in the field will provide information on the acquisition of samples and also provide a permanent record of field activities. The observations and data will be recorded on field sample forms (Appendix 1) and field logbooks and consequently entered into the database. All information on field forms must be completed.

If samples are held for an extended period of time (i.e., inadvertently missed Fed-Ex pick up), field personnel will document all sample handling and custody on field sample and COC forms and enter this information into the database.

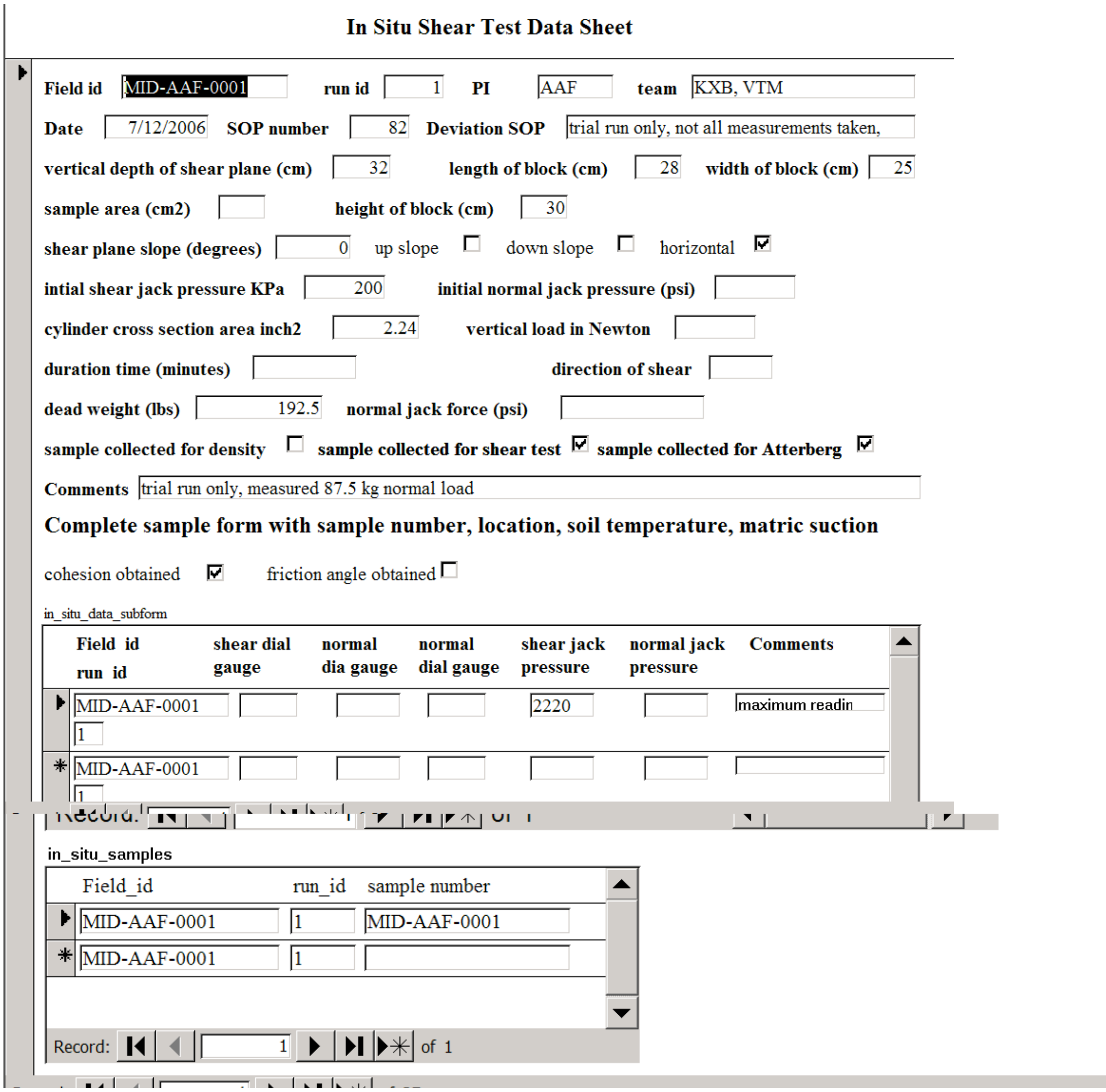
12.0 REFERENCES

Fakhimi, A., Salehi, D. and Mojtabai, N., 2004, Numerical Back Analysis for Estimation of Soil Parameters in the Resalat Tunnel Project, Tunnelling and Underground Space Technology, 19, 57-67

APPENDIX 1 FORMS

See Molycorp project database for current versions of forms.

- Sample_field form
- Sample_anal_request_form
- Sample_preparation form
- In_situ form (see below)



In Situ Shear Test Data Sheet

Field id: MID-AAF-0001 — run id: 1 — PI: AAF — team: KXB, VTM

Date: 7/12/2006 — SOP number: 82 — Deviation SOP: trial run only, not all measurements taken,

vertical depth of shear plane (cm): 32 — length of block (cm): 28 — width of block (cm): 25

sample area (cm2): — height of block (cm): 30

shear plane slope (degrees): 0 — up slope ☐ — down slope ☐ — horizontal ☑

intial shear jack pressure KPa: 200 — initial normal jack pressure (psi):

cylinder cross section area inch2: 2.24 — vertical load in Newton:

duration time (minutes): — direction of shear:

dead weight (lbs): 192.5 — normal jack force (psi):

sample collected for density ☐ — sample collected for shear test ☑ — sample collected for Atterberg ☑

Comments: trial run only, measured 87.5 kg normal load

Complete sample form with sample number, location, soil temperature, matric suction

cohesion obtained ☑ — friction angle obtained ☐

in_situ_data_subform

Field id / run id	shear dial gauge	normal dia gauge	normal dial gauge	shear jack pressure	normal jack pressure	Comments
MID-AAF-0001 / 1				2220		maximum readin
MID-AAF-0001 / 1						

in_situ_samples

Field_id	run_id	sample number
MID-AAF-0001	1	MID-AAF-0001
MID-AAF-0001	1	

Record: 1 of 1

In situ form.

APPENDIX II. CRITERIA FOR SELECTION OF SITES FOR IN-SITU TESTING

1. near roads, safest, easiest to test (ability to get equipment to test site)
2. near the top of the rock piles where finer grained material is most likely to occur
3. use chemistry, paste pH maps from legacy data (Wagner, URS, Norwest) and remote sensing maps, simple field weathering index (1-5) to get a variation in surface paste pH and other soil parameters related to weathering