

Clay Liner Quality Control and Construction at the NOEF

1.0 PURPOSE

Due to design specification of the North Overburden Emplacement Facility (NOEF), testing is required to ensure that no long term seepage occurs from the Potentially Acid Forming (PAF) rock into the ground water. This seepage is controlled by a clay liner. The clay liner has a relatively low permeability and thus the seepage is effectively controlled. It is important that accurate control testing of the clay liner in order to control the effective permeability of the clay.

2.0 SCOPE

A construction quality control system is used to directly monitor and control the quality of the dump construction. Construction quality control is normally performed by a Geotechnical engineer, earthworks superintendent and operators.

A construction specification is required for quality control of:

- Material Evaluation – USC (Unified Soil Classification)
- Construction Methods – type of equipment used
- Compaction Specification – Modified vs. Standard Proctor Density, lift thickness and number of passes.
- Testing requirements – Particle Size Distribution, Atterberg Limits, Density test (nuclear or lab) and hydraulic conductivity.

3.0 AUTHORITY

The Mine Manager authorises changes to this procedure.

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4.0 DEFINITIONS

MRM: McArthur River Mine

Shall: Indicates that a statement is mandatory.

Should: Indicates a recommendation.

5.0 HORSEPLAY

Horseplay of any kind will not be tolerated, as it poses an immediate risk of harm to workers. Personnel are not to initiate, encourage or participate in horseplay and shall report all incidents of horseplay to their Supervisor immediately.

6.0 CONSTRUCTION SPECIFICATION

6.1 Material Evaluation

- Soil must be a Unified Soil Classification of (ML, CL, CI, or MH)
- Soil must contain a minimum of 50% by weight which passes 0.075mm AS1152 sieve
- Soil must have a clay content of 25% (less than or equal to 0.005mm AS1152 sieve) by weight or greater
- Soil must have a plasticity index of 10 or greater
- Soil must have a hydraulic conductivity of not more than 1×10^{-7} cm/sec
- Soil compaction is required to have a relative compaction of 98% (standard proctor) and moisture content between Optimum Moisture Content to 2% above.

Hydraulic conductivity testing can generally be conducted either insitu or via a laboratory.

Appropriate methods include:

- Sealed double-ring infiltrometer (SDRI)
- Boutwell borehole test (minimum of 5)

- Shelby Tube (carved block) test using a 30cm tube with a minimum of 3 tests
- Other tests are to be approved by the site Geotechnical Engineer

A set of at least three quotes for laboratory testing is required every couple of months in order to ensure that cost controls are kept.

6.2 Preparation of Foundation

- Strip and excavate all soft, organic, permeable and other desirable materials. Proof-rolling with heavy equipment as needed to detect soft areas which may cause settlement.
- Filling of fractures, depressions and any areas where undesirable material has been removed. Backfill material must then be recompact as required by the material in order to form an appropriate surface for the clay liner.
- The foundation surface may also be scoured to a depth of 30 to 50 cm and recompact as needed to provide a good contact between foundation material and the clay liner.
- Upon completion of foundation construction, the entire base and side wall should be compacted with a roller or smooth drum, seal rolled to prevent puddles or ponds on the foundation surface.
- A final proof rolling is also recommended.

6.3 Clay Liner Installation

- The liner is to be placed in a series of lifts
- Lift thickness is usually a function of:
 - Soil Characteristics
 - Size and type of compaction equipment
 - Required compactive effortGenerally the lift thickness is approximately 10 to 30 cm thick, loose lift only.
- The liner material is generally placed with a truck and then distributed with a dozer or grader.
- The following is a list of equipment which is to be used for compaction of clay liner, depending upon type of soil being compacted:
 - Sheepsfoot or clubfoot roller
 - Pad foot roller

- Vibrating sheep foot roller

At least **5 to 15 equipment passes** with a compactor over a given point is usually recommended to achieve necessary remould and compaction of clay liner.

An equipment pass is defined as one pass of compaction equipment or one pass of a drum over a given area of clay.

Compaction equipment weighing **18 tonnes** or more is recommended. On a side slope, lighter equipment is adequate with additional passes.

Caterpillar 815, 825 and 826 are also effectively utilized for the compaction of clay liners.

- After each lift segment is installed, it is bevelled or step cut with grading equipment to ensure proper keying into the next or previous segment. This will eliminate pathways for seepage along the liner along the boundary
- Particular attention should be paid to clumps of dirt size reduction as this can have a significant effect on the hydraulic conductivity of the liner:
 - Clumps of dirt sizes reduction is usually accomplished using proper compaction techniques.
- Moisture should also be applied prior and during construction of the liner, and the moisture should be uniformly applied and distributed by water cart. Adequate equilibration time after moisture addition is critical to ensure uniform moisture to the materials. Moisture content can be monitored using either field compaction tests or the Standard Proctor or Modified Proctor test.

6.4 Keying in Liner Segment

Scarification / bonding between lifts is considered essential to bonding clay lifts together during compaction activities in order to achieve desired hydraulic conductivity, this can have an effect on horizontal hydraulic conductivity and thus the effective seepage control. This is done by scarifying the previous lifts if required by a sheep foot roller. The control of moisture throughout the lifts is essential.

6.5 Quality Control Measures

- Clay material should be compacted on the wet side of optimum (0 to 5%)
- Desiccation should be considered and waste compatibility should be kept in mind.
 - Liner material will be tested for liquid, plastic and shrinkage limits.

- If Desiccation cracking is noticed, Geotechnical Staff are to be notified.
- Percentage Standard Compaction testing is required. A minimum of ninety-five percent (95%) standard proctor density has been recommended for adequate compaction. Soil placement of a density of 93% of standard proctor density will be considered to not pass. No more than five percent of density values can be below 95% as long as the failures are not concentrated in one area.

No.	Item	Testing	Frequency
1	Pre-construction Activities Material Evaluation	<ul style="list-style-type: none"> • Particle Size Distribution • Moisture • Atterberg Limit • Moisture-Density Curve • Lab Hydraulic Conductivity 	Every 4000 cubic metres or Soil Material change Every 4000 cubic metres or Soil Material change Every 4000 cubic metres or Soil Material change Every 5000 cubic metres or Soil Material change Every 8000 cubic metres or Soil Material change
2	Off-site Clay Borrow Source Testing	<ul style="list-style-type: none"> • Particle Size Distribution • Moisture • Atterberg Limit • Moisture-Density Curve • Lab Hydraulic Conductivity 	Every 1000 cubic metres Every 1000 cubic metres Every 5000 cubic metres Every 5000 cubic metres or Soil Material change

No.	Item	Testing	Frequency
			Every 10000 cubic metres
3	Clay Liner Testing Database during construction	<ul style="list-style-type: none"> • Particle Size Distribution (to 0.002m sieve) • Moisture Content • Dry Density • Atterberg Limit (LL+PL) • Undisturbed Hydraulic Conductivity • Moisture-Density Curve (as per clay borrow pit requirements) • Density (nuclear or sand cone) 	<p>1 test per 5000 square metres per lift</p> <p>5 tests per 5000 square metres per lift evenly distributed</p> <p>5 test per 5000 square metres per lift</p> <p>1 test per 5000 square metres per lift</p> <p>1 test per 5000 square metres per lift</p> <p>Every 5000 cubic metres or Soil Material change</p> <p>5 tests per 4000 square metres per lift evenly distributed</p>
4	Granular Drainage Blankets	<ul style="list-style-type: none"> • Particle Size Distribution (to 0.075mm sieve) • Hydraulic Conductivity Test 	<p>1 test per 1200 cubic meters or 2200 tonnes</p> <p>1 test per 2300 cubic meters or 4500 tonnes</p>

No.	Item	Testing	Frequency
5	Bedding Material around perforated collection pipes	<ul style="list-style-type: none"> Particle Size Distribution (to 0.075mm sieve) <p><i>Note: 85% of backfill materials shall have a diameter greater than the diameter of pipe perforation</i></p>	<p>1 test per 1200 cubic meters or 2200 tonnes or minimum of 3 tests.</p> <p>1 test per 2300 cubic meters or 4500 tonnes or minimum of 3 tests</p>
All testing and sampling is to be performed in accordance with Australian Standards			

6.6 Post Installation Activities

- Upon completion of liner, it shall be rolled smooth to seal surface so precipitation can run off freely. It is recommended that erosion protection in the form of rock is placed.
- The completed liner must be surveyed as per the NOEF As Built Review and sign off procedure (MIN-TEC-PRO-1000_0025).
- The liner must not remain uncovered for long periods of time, in order to prevent desiccation prior to installation of the next layer of material. The liner may be required to be covered with rock in order to prevent desiccation.
- All test results will be kept in G:\Mining\Mining Technical Services\Geotechnical\MRM\North OEF\Laboratory Test Results\TestingDatabase.rev01.xlsx.

7.0 RESPONSIBILITY

7.1 Mine Manager

- Authorises changes to this procedure.

7.2 Technical Services Superintendent

- Shall ensure the implementation of this procedure to all Technical Services personnel
- Shall ensure compliance by Technical Services personnel

7.3 Geotechnical Engineer

- Shall ensure clay liner sampling is conducted as required.

7.4 Survey

- Shall ensure all samples taken are picked up by the Survey Department

8.0 REFERENCES

- AS1141: Methods of Sampling and Testing Aggregates
- AS1289: Methods of Testing Soils for Engineering Purposes
- McArthur River Mine Overburden Emplacement Facility (OEF) Design Report, URS, 2008
- Bowles, J.E. (1996). Foundation Analysis and Design, 5th Edition. McGraw-Hill.

9.0 REVISION HISTORY

Issue No	Revision No	Section	Brief Description	Initials