

EXHIBIT / FOOT NOTE
13

Lithium Nevada

Filterability of LNC Neutralized Clay Slurry v2

Prepared by: Ryan M. Ravenelle

Date: 08/04/2021

Abstract

It is generally known that clay is a relatively difficult material to dewater. This is due to the inherent fine size of clay particles ($< 75\mu\text{m}$) and from rheological and physicochemical properties of the clay itself. Filtration of native clay slurry is notoriously slow and problematic, and Lithium Nevada Corporation (LNC) has even experienced this phenomenon at their local research facility.

In the LNC process flowsheet, there is a filtration step of clay slurry. However, it is of critical importance to highlight that this clay slurry is not native clay, but rather a slurry of clay that has been treated with concentrated sulfuric acid. When clay is exposed to acidic solution, the fundamental nature of the clay changes significantly as does the dewatering behavior.

Extensive filtration test work has been performed by LNC as well as by external vendors on acid treated clay slurry. All data shows the slurry exhibits good filterability while producing dry, competent filter cakes. LNC has extremely high confidence that there will be no challenges to create the same quality filter cake on production scale as observed at the bench and pilot scale.

General Background on Acid Treated Clays

Treating clay with acid causes many changes in the physical characteristics of the native clay structure. For example, acid H^+ can exchange with Al^{3+} , Fe^{3+} and Mg^{2+} located within smectite crystalline structure. This in turn greatly increases surface area and pore volume,^[1] and similar behavior is observed for kaolinitic clay.^[2]

The large surface area and large pore volume of acid-modified clays make them good adsorbents. In fact, acid modified clays are used as adsorbents in various industries to remove undesirable compounds. For example, removing undesirable colors and compounds from edible oils or contaminants in water. In many applications, the acid activated clay is contacted with the solution of interest and then filtered once the clay has adsorbed the contaminant. Thus, filtering of acid modified clays is an accepted process in common industries and practiced worldwide.

Internal Filtration Tests: LNC Research Facility

LNC has a research facility located in Reno, NV that has been working with clay samples from the Thacker Pass proposed pit for over two years. The research facility includes large leach/neutralization batch tanks along with a pilot scale size filter press (Figure 1).

Lithium Nevada



Figure 1: Pilot scale plate and frame filter press

To date, >90 large leach/neutralization batches have been performed (~800 lbs/batch), with each being filtered on the filter press shown in Figure 1. This filter press is known as a “membrane” style press. In these presses, every other filter plate has a chamber that can be filled with pressurized fluid, causing the chambers to squeeze residual liquid out of the slurry to generate low-moisture content filter cakes.

An example of a filter cake directly out of the press is shown in Figure 2 below.



Figure 2: Photos of filter cakes directly out of filter press

As shown in the photo, the cakes are solid in nature, competent, friable, and can easily be broken by hand. Once filter cakes are collected from each batch, composite samples are taken and dried in an oven at 105°C to determine the moisture content. In Figure 3, the results of measured filter cake % solids of 93 samples are shown.

Lithium Nevada

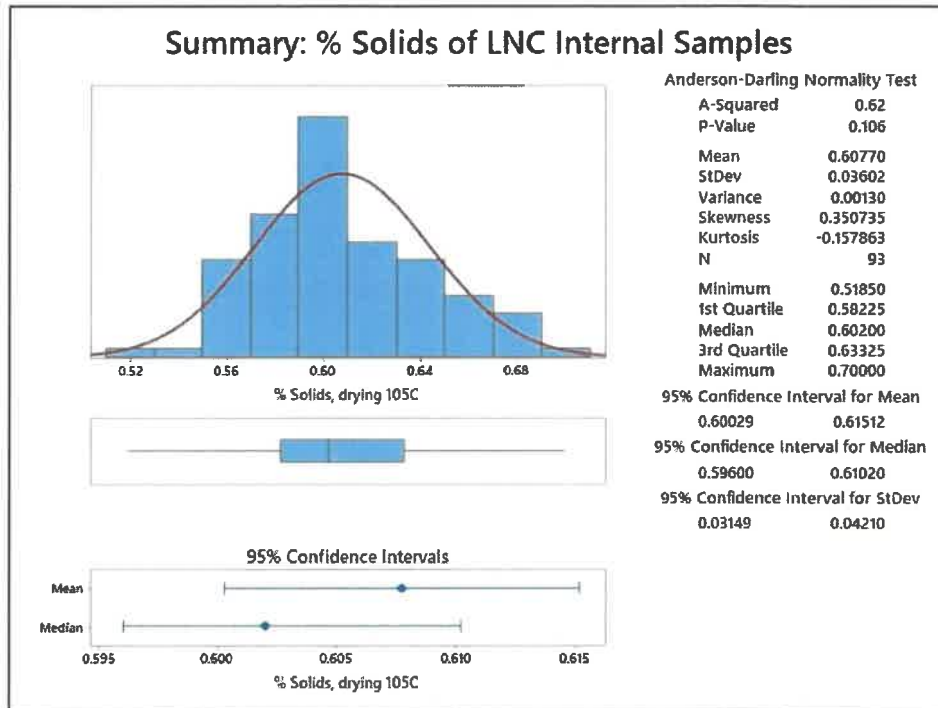


Figure 3: Descriptive statistics for filter cake moisture data, internal LNC data

On average, filter cakes are measured to contain 61% solids, with the 95% confidence interval ranging from 60% to 61.5% solids. Note that the pilot scale filter press operates at a squeeze pressure of 200 psig.

External Filtration Tests: Outside Vendors

LNC has also contracted multiple filtration studies by outside vendors to confirm results obtained internally.

The photos in Figures 4 and 5 show filter cakes collected by two separate vendors on different acid treated process clay slurries. The vendors obtained filter cakes very similar in nature to the filter cakes collected at the LNC research facility.

Note that the vendor who has performed the most filtration tests on the slurry states in their final report that "...the samples demonstrate good filterability, in terms of filling and compaction time, obtaining a well-formed and compact filter cake after squeezing."^[3]

Lithium Nevada



Figure 4: Filter cake from Vendor 1 test



Figure 5: Filter cake from Vendor 2 test

A summary of the filter cake moisture content collected by the two vendors is provided in Figure 6. The average percent solids of the filter cakes determined by each vendor were 62% and 69% solids, respectively. The filter cake moisture was determined by drying at 60°C versus 105°C at the LNC facility. Additionally, vendors were able to achieve higher squeeze pressures in their testing, and both of those variables can result in a higher measured filter cake % solids. For more discussion on drying temperature, see the *External Filter Cake Drying Tests* section.

Lithium Nevada

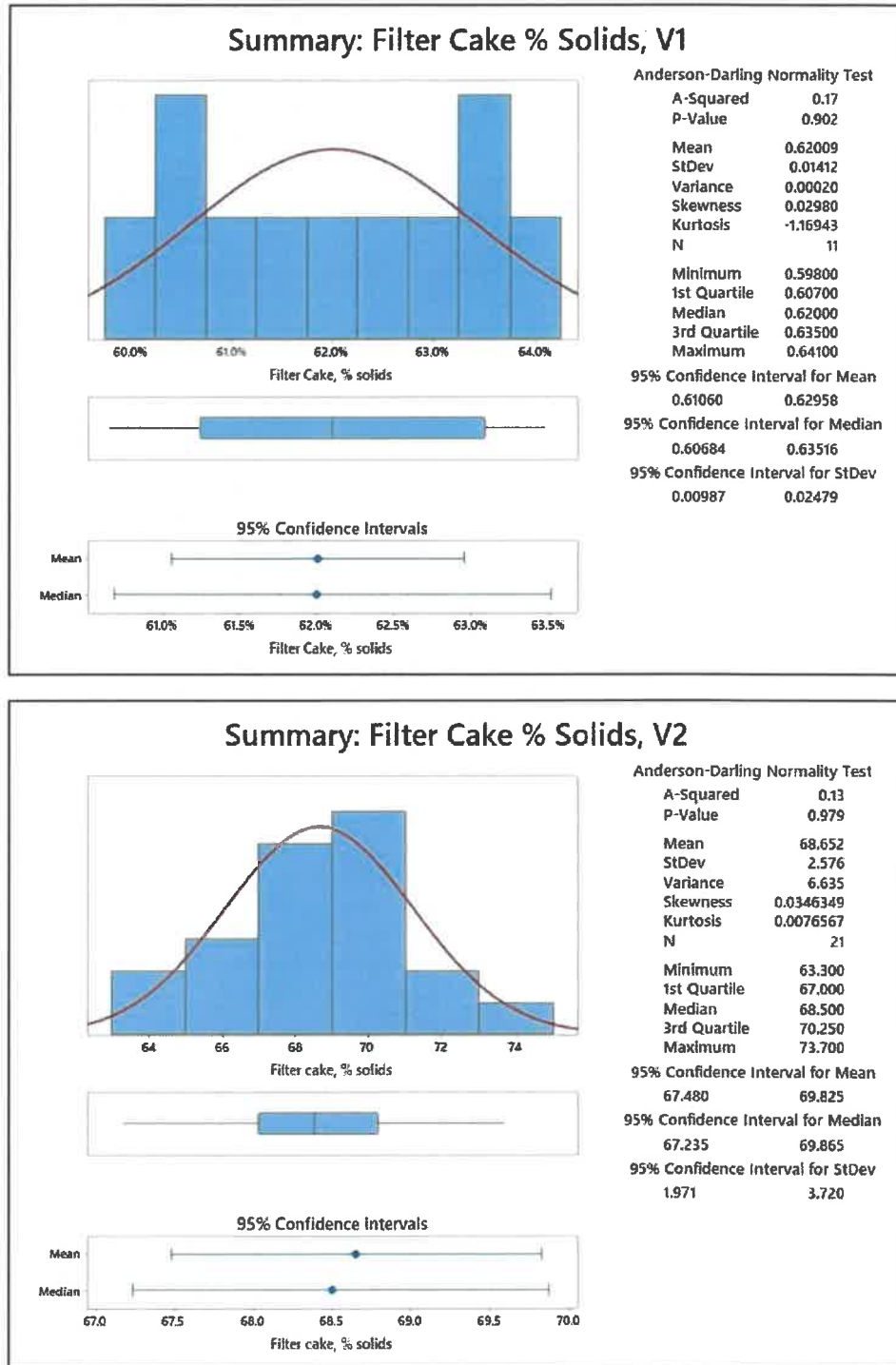


Figure 6: Descriptive statistics for filter cake moisture data, Vendors 1 and 2

Lithium Nevada

External Filter Cake Drying Tests

At the end of 2020, LNC contracted an engineering services company to investigate the moisture content and other characteristics of the filter cake. They collected filter cake samples directly from the filter press in Reno, NV (Figure 7), bucketed the samples “as-is”, and then performed drying tests at multiple temperatures.



Figure 7: Filtered clay tailings directly from press, used for drying tests

It was found that the drying temperature has a large effect on the measured % solids (Figure 8). The hypothesis is that two forms of water are in the clay: structural water which is bound in the crystal structure of the material, and free water which is representative of moisture on particle surfaces and in pores. As drying temperature increases, the structural water is removed, thus resulting in a lower measured % solids (i.e. higher moisture content). It was concluded that 45°C be used as the reference temperature, as it is thought to better represent free water rather than structural water.^[4]

Lithium Nevada

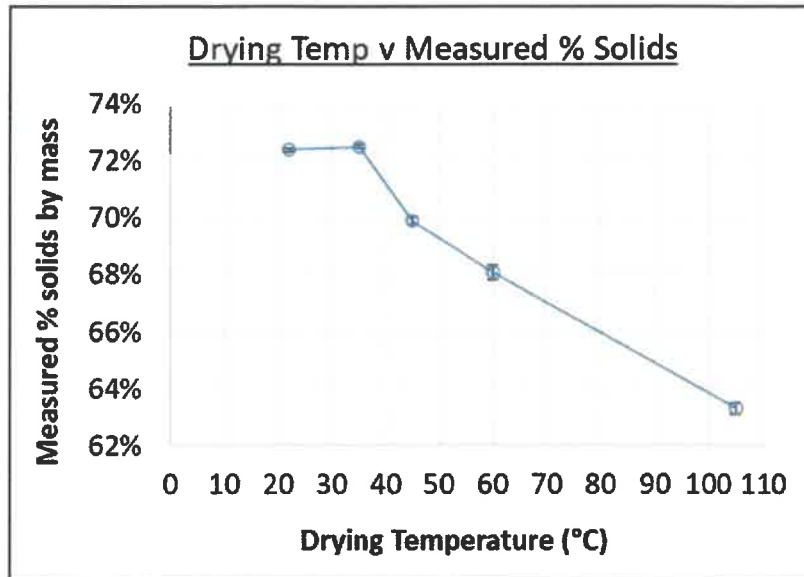


Figure 8: Effect of drying temperature on measured cake % solids

As shown in Figure 8, at 45°C, the measured % solids is ~70% by mass. The samples dried at 105°C were closer to 63% solids, comparable with the results measured at the LNC research facility (Figure 3).

The evaporation rate at 22°C (air-drying, room temperature) on three different samples was also examined (Figure 9).

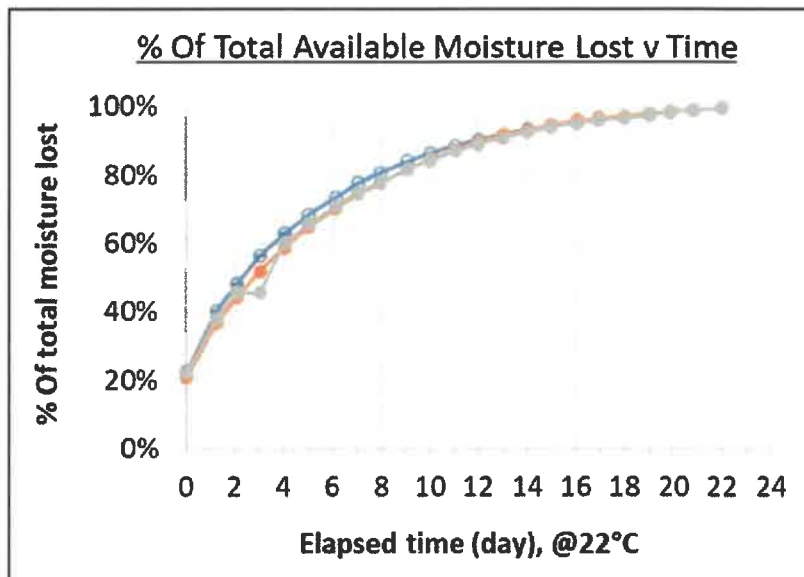


Figure 9: Moisture loss vs time, air drying at room temperature

Lithium Nevada

From Figure 8, the filter cake is measured to contain ~72% solids at 22°C, thus every kilogram of cake contains about 0.28 kg moisture. According to Figure 9 then, after 4 days of air drying at room temperature, it is expected that 60% of that moisture would evaporate, or ~ 0.17 kg moisture. As temperature increases, the evaporation rate also increases as expected.

Conclusions

To date, LNC has been testing filtration of acid treated process clay slurry for about 2 years. Over the course of this time, more than 90 large batches (~800 lbs/each) have been run through a pilot scale filter press with consistently good filtration and final filter cakes at 61% solids on average (determined by drying at 105°C). Filter cakes are dry to touch, competent, friable, and easily broken by hand. Work done by external vendors has validated the data collected by LNC, with filter cakes having similar moisture contents and physical properties.

It is known that the drying temperature of the filter cake can have a large effect on the measured % solids, with higher temperatures resulting in artificially lower reported % solids due to structural water being liberated. Thus, it is likely that the “real” percent solids of filter cakes are closer to 70% solids. The filter cakes will dry when exposed to air at room temperature, with about 60% of the total free moisture evaporated over the course of 4 days.

Considering the results, LNC has very high confidence that filtering the process clay slurry will not be problematic. It has been demonstrated on multiple scales (bench to pilot) and by multiple parties. Throughout the testing campaigns performed by equipment providers, there has never been a concern with scale up of the process.

Addendum: Salt separation

Two major salts are generated in the process that are removed and eventually transferred to the CTFs. The salts are $\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$ and a Na/K sulfate mixture. Salts are produced in crystallizers, forming a slurry that is ~15-20 wt.% solids. Unlike the clay tailings, salts are not removed with filter presses, as that is not the appropriate technology for the application. Instead, the slurry is fed to centrifuges, where the solids salts are removed from liquid by centrifugal force.

The centrifuge contains a basket filter and spins at high speed, forcing the solids to collect on the filter while liquid passes through. This is a common technique for crystallization and is practiced on a large scale around the world. Centrifuges operate continuously, and are well suited for separations of crystals from liquid.

$\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$ salt has been generated by various vendors on representative brines prepared by LNC.^{[6], [7]} Figure 10 shows a picture of magnesium sulfate crystal slurry both before and after centrifuging.

Lithium Nevada



Figure 10: a) $\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$ crystal slurry, b) after centrifuge, crystal separation

As can be seen in the photograph, the crystals were cleanly separated from the slurry. The vendor noted that the centrifuge was “very effective at dewatering the crystals.”^[6]

Another vendor also conducted continuous pilot scale testing to generate $\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$ crystals.^[7] Samples were continuously taken and separated via centrifuge (Figure 11).



Figure 11: $\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$ crystals generated during continuous testing

The crystal sizes were measured for various runs, with the resultant size distribution shown in Figure 12.

Lithium Nevada

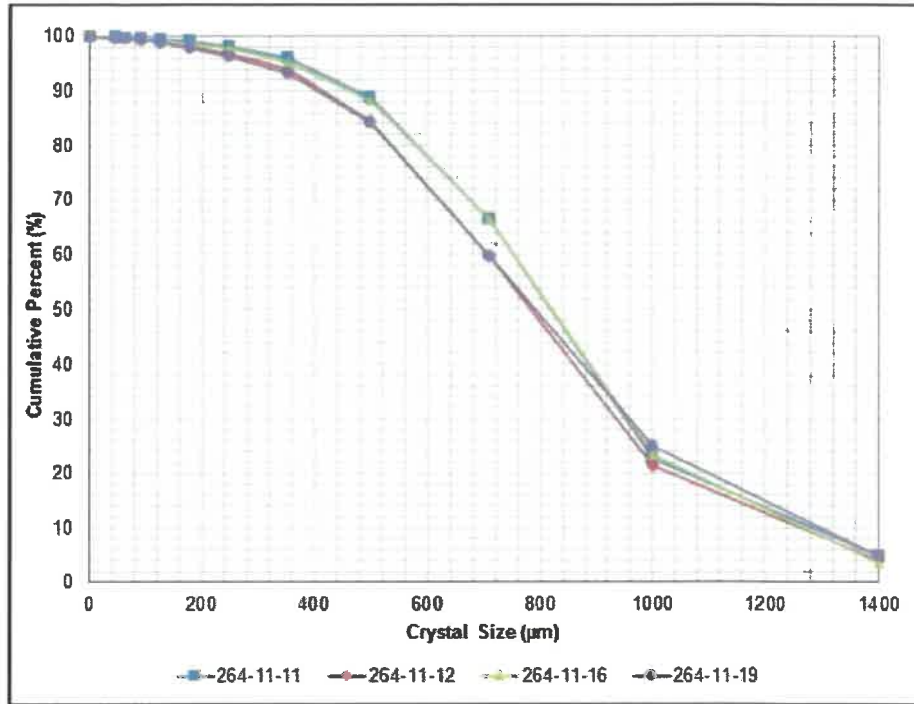


Figure 12: $\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$ crystal size distribution from various continuous tests

The d50 represents the median size of the crystals, and this value was from 780-800 μm . In other words, relatively large crystals that are within the capability of centrifugal separation. This vendor is very familiar with magnesium sulfate crystallization systems and noted that the crystal characteristics were “consistent with previous $\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$ crystals that [they] have produced.” No concerns were raised with the ability to effectively remove crystals from slurry via centrifugation.

The vendor also performed testing to generate Na/K sulfate crystals. Samples were again taken over the course of continuous runs, centrifuged, and the crystal sizes measured (Figure 13). In this case, the d50 ranged from 407-509 μm , again relatively large. The vendor commented that “the large crystal size indicates the solid/liquid separation should be relatively easy” in the process plant.

Lithium Nevada

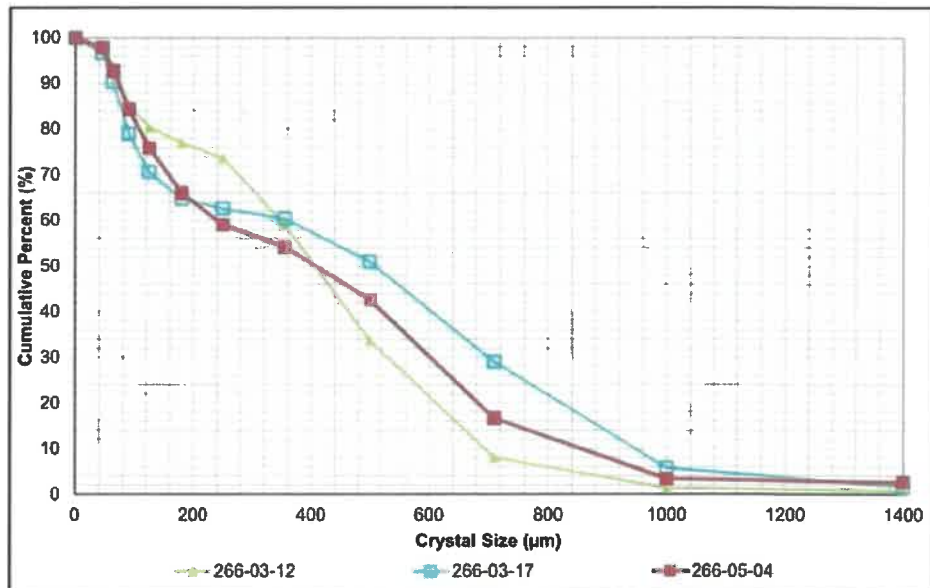


Figure 12: Na/K sulfate crystal size distribution from various continuous tests

Salt separation conclusions

Pilot and continuous scale experiments on both $MgSO_4 \cdot 6H_2O$ and Na/K sulfate salts has been performed by multiple crystallization vendors. In each case, large crystals were produced and efficiently separated by centrifugation. There have been no concerns raised by either vendor about using centrifuges for crystal separation. It should also be noted that especially in the case of $MgSO_4 \cdot 6H_2O$, other operations around the world use a very similar process for crystal removal. Based on the test results and the seasoned experience of the vendors, LNC has very high confidence that separating crystals from the various crystallizers will not be problematic.

References

Lithium Nevada

- [1] Tomić, Z. et. al. Modification of Smectite Structure by Sulfuric Acid and Characteristics of the Modified Smectite. *J. Ag. Sc.*, 56, 1, 25-35. 2011.
- [2] Panda, A.K. et. al. Effect of Sulphuric Acid Treatment on the Physico-chemical Characteristics of Kaolin Clay. *Colloids and Surfaces A: Physicochem. Eng. Aspects* 363(2010) 98-104.
- [3] Grosso-Kaswalder. Confidential Test Report Prepared for LNC, #LAB321011. 05/12/2021.
- [4] Confidential Clay Tailings Filter Stack Design Review Summary Report Prepared for LNC. Project #2074210170, Dec. 2020.
- [5] Thacker Pass Project Engineering Design Report, Clay Tailings Filter Stack, Waste Rock Storage Facilities, Coarse Gangue Stockpile, Mine Facilities & Process Plant Stormwater Management prepared by NewFields for LNC. Project #475.0385.000, April 2, 2020.
- [6] Confidential MgSO₄ Crystallization Pilot Testing, Report Prepared for LNC, Ref. #P30082, 2021.
- [7] Confidential Thacker Pass Project Li₂CO₃ Production, Report Prepared for LNC, Ref. #5300219071, Nov. 2020.