



## *DoubleSShot*

pH and Sieve Analysis of *KBH<sub>3</sub> Chemical Supply Company* KNO<sub>3</sub>

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## **Objective**

The purpose of this analysis is to determine the  $\text{KNO}_3$  pH and particle size distribution. The pH of the oxidizer appears to have an effect on the caramelizing of the sugar propellant when heat/melting in the casting process. The particle size distribution of the oxidizer, in this case  $\text{KNO}_3$ , effects the slurry viscosity during the heating and pouring of the propellant into the grain casting tubes. Any reduction of the slurry viscosity that does not affect cure time and burn rate is advantageous to the casting process. Slurry viscosity, propellant caramelizing, cures time, burn rate and fracture toughness are all important for the Sugar Shot to Space project. The pH result and data obtained from this grain size distribution is used to determine suitability of the  $\text{KNO}_3$  sample for propellant grain casting that requires the propellant to be “pourable” and respond to vibration table settling technique presently used to reduce voids and increase propellant density.

## **Testing**

Two properties are being tested in this analysis; pH and particle size distribution. The pH of the sample was tested and a particle size determination of the relative proportions of grain sizes.

## **Apparatus Required**

- pH strips or pH meter
- 100 ml graduated cylinder
- Thermometer
- Glass cup
- Distilled water
- Stack of five screen sieves including pan and cover
- Digital scale (300 gram capacity with 0.01 gram resolution)
- Mortar and Pestle ( for crushing the sample if lumped)
- Timing device

### **Additional materials**

- Gloves
- Safety glasses
- Camera or video recorder

**Notice:** The balance should be sensitive to 0.1% of total weight of sample taken.

## **Procedure**

### **PART ONE pH**

The potassium nitrate ( $\text{KNO}_3$ ) needs to have a nearly neutral or slightly acidic pH. The pH test is done by dissolving a 10.0 gram sample of the oxidizer into 50.0 ml of distilled water. The solution needs to be at a temperature of 20 °C prior to the pH testing. This can be done with a pH meter or suitable pH testing strips. The testing strips used in this investigation were *pHydrion* 1-12 pH paper strips.

### **Results**

The pH paper strips indicated a pH very close to 7.0 as illustrated in the following picture. This pH is within the required range of 5.5 – 7.0 and is within the acceptable range with regards to the required pH.



Figure 1 pHydrion pH strip test of “KBH<sub>3</sub> Chemical Supply Company” KNO<sub>3</sub>

## **Procedure**

### **PART TWO particle size**

The only current requirement for grain size is that it be “granular”. This may need to be looked into at a further date when our automated casting system is completed and tests conducted for the required size of particle. Four sieve sizes were used, US Standard #35, 60, 120, and 230 from Hubbard Scientific. Size #10 was not used to help break up any clumps in this analysis because no clumps or large particle sizes were seen in the sample.

The sieves were cleaned, washed, and thoroughly dried for twenty four hours in thirty-two percent humidity air. The sieves were then weighed with the weights recorded. A 20.00 gram dried sample of  $\text{KNO}_3$  was measured and placed in the #35 sieve of the stack and covered. The stacked sieves were then roto-tapped for a period of five minutes.

Each sieve, cover and pan was then carefully weighed including the amount of  $\text{KNO}_3$  retained.

## **Results**

The cover showed no signs of  $\text{KNO}_3$  but was weighed. Visually, the pan showed the most  $\text{KNO}_3$  collected with varying amounts retained by the sieves. See data table.

| Sieve # | Sieve size micron | Mass of sieve grams | Mass of sieve and sample retained grams | Mass of sample Retained grams | Percentage On each sieve | Cumulative % retained |
|---------|-------------------|---------------------|---|-------------------------------|--------------------------|-----------------------|
| cover   | NA                | 55.24               | 55.26                                   | 0.00                          | 0.00                     | 0.00                  |
| 10      | NA                | -                   | -                                       | -                             | -                        | -                     |
| 35      | 500               | 158.48              | 159.17                                  | 0.69                          | 3.45                     | 3.45                  |
| 60      | 250               | 152.80              | 159.43                                  | 6.63                          | 33.15                    | 36.6                  |
| 120     | 125               | 143.34              | 151.66                                  | 8.32                          | 41.61                    | 78.21                 |
| 230     | 63                | 139.64              | 142.47                                  | 2.83                          | 14.15                    | 92.36                 |
| pan     | < 63              | 127.23              | 128.75                                  | 1.52                          | 7.60                     | 99.96                 |

Table 1 “ $\text{KBH}_3$  Chemical Supply Company”  $\text{KNO}_3$  particle size distribution



Figure 2 Sieves and pan with  $\text{KNO}_3$  retained.

| sieve # | size range    | Wentworth range   | Wentworth name   | other names |
|---------|---------------|-------------------|------------------|-------------|
|         | 256-∞ mm      | 10.1-∞ in         | boulder          | boulder     |
|         | 64-256 mm     | 2.5-10.1 in       | cobble           | cobble      |
|         | 32-64 mm      | 1.26-2.5 in       | pebble           | gravel      |
|         | 16-32 mm      | 0.63-1.26 in      | pebble           | gravel      |
|         | 8-16 mm       | 0.31-0.63 in      | pebble           | gravel      |
|         | 4-8 mm        | 0.157-0.31 in     | pebble           | gravel      |
| 5       | 2-4 mm        | 0.079-0.157 in    | granule          | gravel      |
| 10      | 1-2 mm        | 0.039-0.079 in    | very coarse sand | sand        |
| 35      | 0.5-1 mm      | 0.020-0.039 in    | coarse sand      | sand        |
| 60      | 0.25-0.5 mm   | 0.010-0.020 in    | medium sand      | sand        |
| 120     | 125-250 μm    | 0.0049-0.010 in   | fine sand        | sand        |
| 230     | 62.5-125 μm   | 0.0025-0.0049 in  | very fine sand   | sand        |
|         | 31.25-62.5 μm | 0.00015-0.0025 in | silt             | mud         |
|         | 1/∞-3.9 μm    | 1/∞-0.00015 in    | clay             | mud         |
|         | 1/∞-0.97 μm   | 1/∞-0.000039 in   | colloid          | mud         |

Chart 1 Wentworth Scale (adapted from Wikipedia)

The majority of the particles are -35/+120 sieve size or between 125-500 micron and could be characterized as sand like. As such, this KNO<sub>3</sub> particle size distribution should be acceptable in regards to propellant casting viscosity.

## **Conclusion**

The sample of KNO<sub>3</sub> obtained from ebay seller “KBH<sub>3</sub> Chemical Supply Company” in North Carolina was found to have a pH that is acceptable for our propellant casting process without the need of additives. It was also found that the particle distribution size is suitable for the Sugar Shot to Space project though no specifications with regard to grain size distribution currently exists for KNO<sub>3</sub>. The particle size is somewhat smaller than the currently used “pkunlimited” KNO<sub>3</sub> but since 15% of the “pkunlimited” KNO<sub>3</sub> has been “ground in a coffee grinder” before casting, the “KBH<sub>3</sub> Chemical Supply Company” may eliminate some or all of this KNO<sub>3</sub> grinding. This may be an area where a study could be undertaken to determine the optimal particle size for a viscosity needed to be “pourable” and for other desirable characteristics such as Isp, cure time, burn rate, and fracture toughness as needed for Sugar Shot to Space.

The twenty-five pound sample was obtained at a cost of \$60.00 from KBH<sub>3</sub> Chemical Supply Company. Larger quantities can be purchased for \$2.00 a pound.