



## *DoubleSShot*

pH and Sieve Analysis of *Skylighter* KNO<sub>3</sub>

Rev. 2011/03/24

## **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  $20\text{ }^\circ\text{C} \pm 1\text{ }^\circ\text{C}$  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 of 6.0 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.

Something of note is a very strong smell, similar to rubber cement, emanating from the oxidizer. This smell diminished with time when the propellant was left in the open air for several hours.

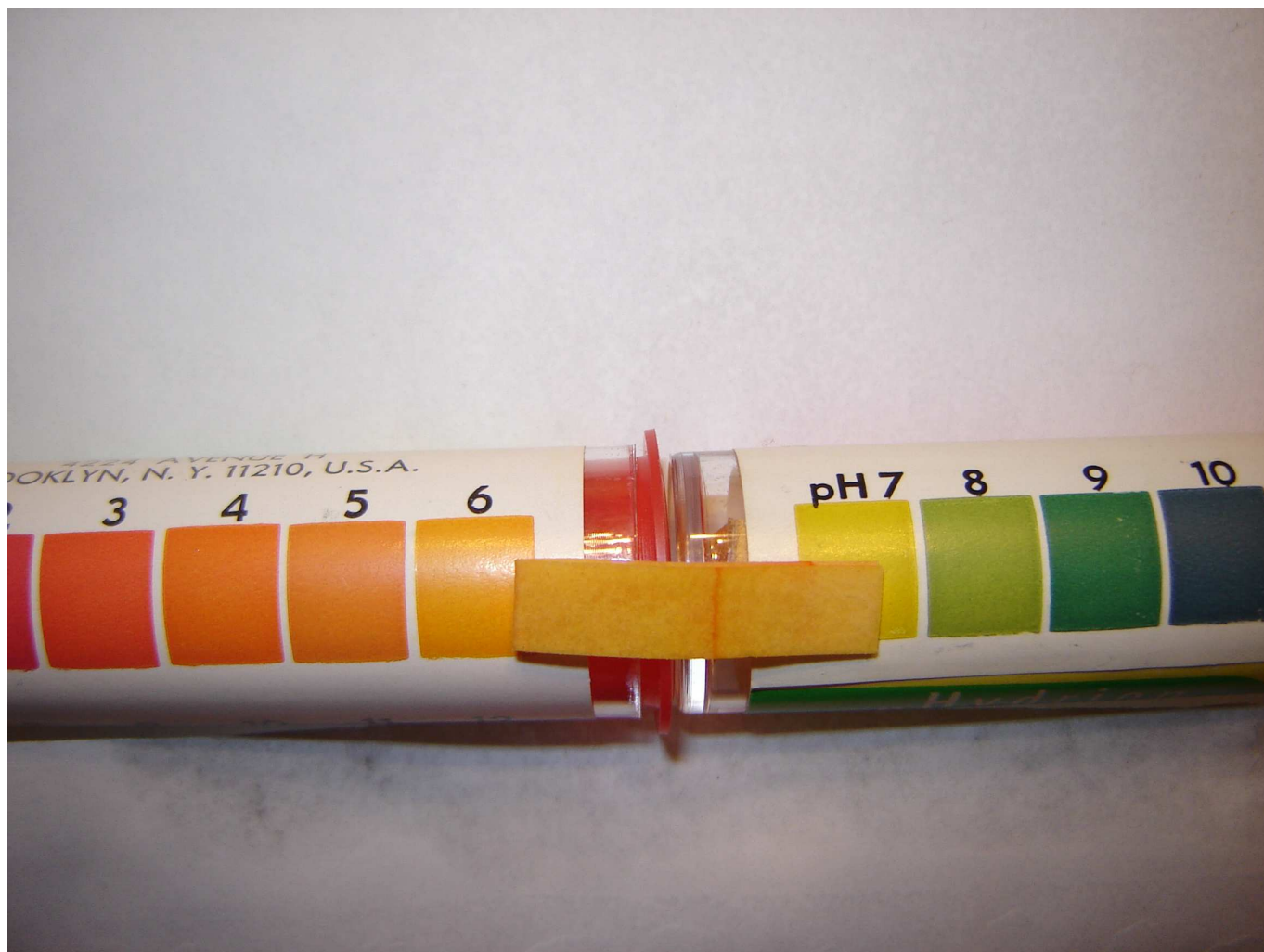


Figure 1 pH test strip dipped both ends in sample solution for comparison.

## **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. Five sieve sizes were used, US Standard #10, 35, 60, 120, and 230 from Hubbard Scientific. Size #10 was used to help break up any clumps though very little was seen in the sample.

The sieves were cleaned, washed, and thoroughly dried for twenty four hours in twenty-eight 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 #10 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	55.26	55.26	0.00	0.00	0.00
10	2,000	167.56	167.57	0.01	< 0.01	< 0.01*
35	500	158.51	158.78	0.27	1.35	1.35
60	250	152.85	154.39	1.54	7.70	9.05
120	125	143.37	146.44	3.07	15.35	24.40
230	63	139.70	142.65	2.95	14.75	39.15
pan	< 63	127.29	139.45	12.16	60.80	99.95

Table 1 Skylighter  $\text{KNO}_3$  particle size distribution

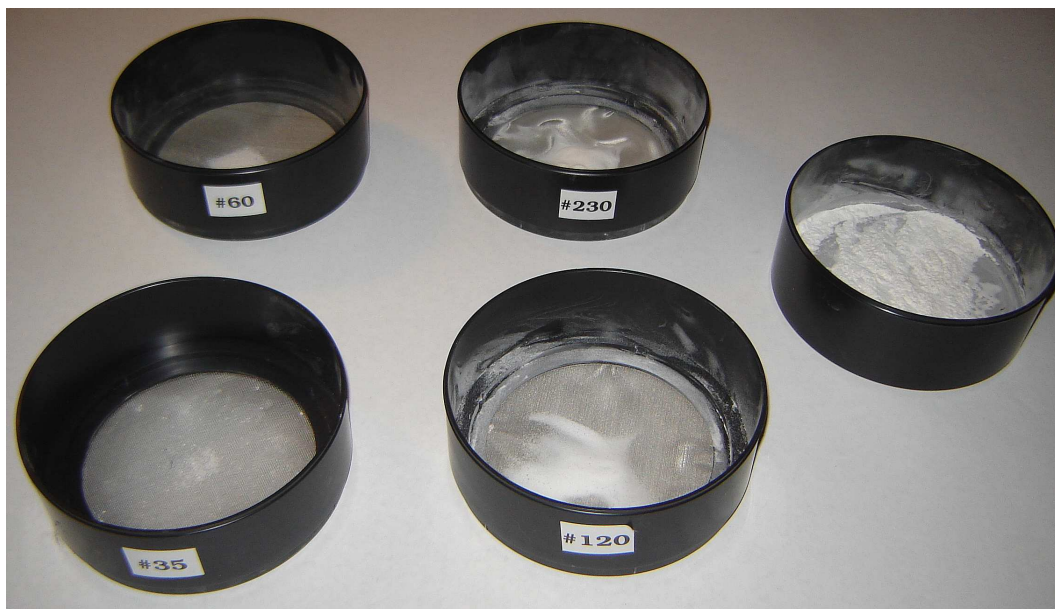


Figure 2 Sieves and pan with  $\text{KNO}_3$  retained.

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 below sand size and could be characterized as a powder. As such, this  $\text{KNO}_3$  particle size distribution should cause an unacceptable increase in propellant casting viscosity.

To test this, a sample of 635 grams of Skylighter  $\text{KNO}_3$  was added to 342 grams of sorbitol, mixed for one hour in a rotating tumbler and the heated to 275 °F. The result was unpourable “slurry” with consistency of mash potatoes. See photo.



Figure 3 Propellant made of Skylighter  $\text{KNO}_3$  and sorbitol.

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## Conclusion

This analysis has shown  $\text{KNO}_3$  obtained from Skylighter has an acceptable pH but has a particle size distribution too small for the current method of propellant grain manufacture. This was verified by the attempt to mix, heat, and pour a grain using the chemicals provided. While the fine milling of the  $\text{KNO}_3$  may be optimal for use in the manufacture of fireworks, it is not for our present needs in the Sugar Shot to Space project.

We wish to thank Skylighter for the samples of  $\text{KNO}_3$  and sorbitol provided for this analysis.

## Additional information provided on Skylighter sample

Technical grade with 0.05% TAG anti-cake. Oxidizer used in black powder, primes, and glitter and spark-producing formulations.

Assay: 99.5% purity minimum.

Impurities:

Cl: 0.06% max.

Na: 0.2% max.

Moisture: 0.1% max.

Water Insolubles 0.01% max.



Figure 4 Skylighter provided  $\text{KNO}_3$  and sorbitol used in this report.