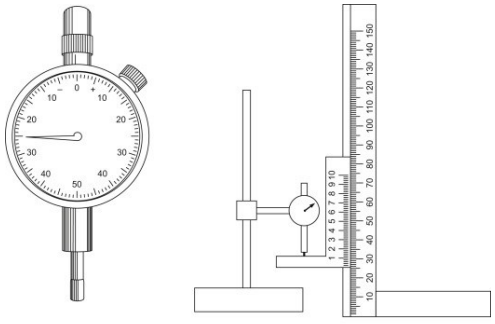
GRANITE VESSEL ANALYSIS

OCTOBER 1, 2023

Plate Layout Inspection

Scope

- *Plate Layout Inspection on Granite Surface Plate*
- *Precision Rotary Table ("rotab") with mechanical rotation*
- *Dial Test Indicators measure deviation in concentricity and roundness*
- *6 Granite Vessels considered early dynastic or pre-dynastic Egyptian*
- *1 Marble Control Vessel - machined circa 1995*



OVERVIEW

This supplemental study is a hands-on approach to stone vessel analysis in an applied setting and intended to be more easily understood by readers without a background in engineering or metrology.

Each vessel was selected due to its granite composition and high-precision craftsmanship. Structured Light scanning and CT (X-ray) scanning have also been performed on each object, allowing for rigorous, precise, and repeatable analysis.

The plate layout inspection is performed on standard rotary table ("rotab") attached to a granite surface plate, which when rotated revealed <= 0.001 inch runout on the outer diameter and <= 0.001 runout on the top surface.

A perpendicular line coaxial with the center of rotation is defined as the Z axis. Depending on the object's geometry, three (3) or four (4) individual points along the Z axis of the body of the vessel are selected to locate the tips of each dial indicator (figure 1) held securely in height stands (figure 2). The tips are deflected and tested to ensure that they have free +/- movement. The distance from the tip to the top surface of the rotab is measured and recorded. The surface variance between lug handles is also measured as this continuity is of primary interest.

Concentricity, Roundness and continuity are measured as the rotab turns 360 degrees, allowing each mounted dial indicator to measure surface deviations down to less than one half thousandth (0.0005) of an inch. The surface variance between lug handles, which interrupt the continuity, is also measured as the continuity is of primary interest.

Where possible, the wall thickness is measured with Dyer Dial thickness gages placed at four (4) approximate equidistant points around Area C. (see figure 3)

A control variable is also introduced: a black and white marble vase manufactured in the mid 1990s using modern lathe machinery. Notably, no modern machined vessels with lug handles could be located. Though marble is considerably softer than granite, we encourage readers to acknowledge the precision in construction as it relates to the ancient granite vessels that have traditionally been considered to be entirely hand-made.

Contents

ACKNOWLEDGEMENTS

A special thank you to the team at Danville Metal Stamping for opening up the inspection shop on a Sunday morning and welcoming us into their world of high precision manufacturing and quality control.

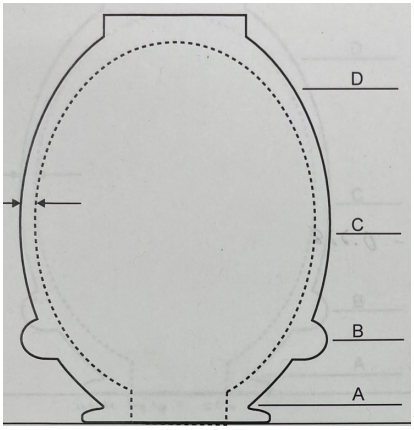
We would not be here if it were not for the perseverance and diligence of Christopher Dunn, who continues to inspire and influence generations of followers.

PROCEDURE

As the precision rotary table is fixed to a granite surface plate, the four (4) dial indicators are positioned independently and in a manner to accommodate each vessel's unique geometric characteristics.

Each vessel is centered on the rotary table. The vessel is free standing and not restrained, but contained in position by magnets.

Over several 360 degree rotations, the variability ("runout") is measured and documented.



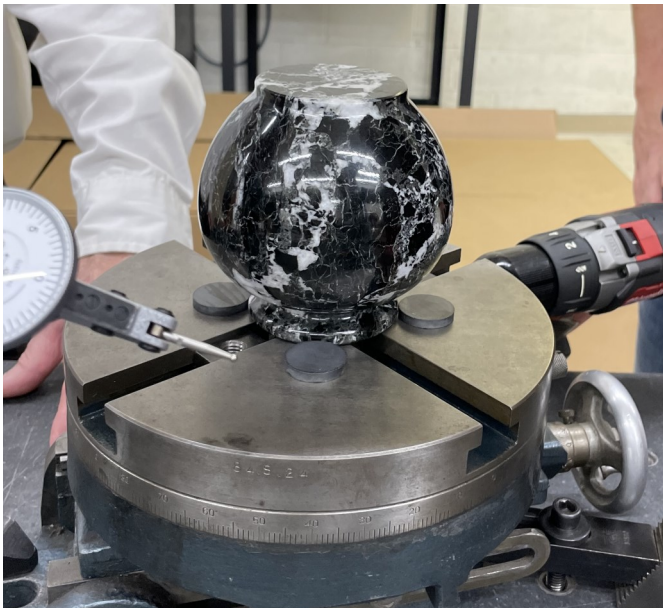
Accordingly, the relative location of focal points A, B, C, and D may vary from vessel to vessel. The height of each focal point is identified in the accompanying charts for reference.

Certain vessels featured lug handles, while others did not; a feature identified separately. The concentricity of the lug handles is measured, as is the continuity of the exterior points *between* the lug handles.

At focal point C, the wall thickness was measured at four (4) equidistant points.

CONTROL VESSEL

A polished marble stone vessel was introduced as a control element. This vessel, manufactured in Fish Creek, Wisconsin in the early 1990's, features a highly polished exterior with a rough, unfinished interior.



Because no suitable granite control vessels were used in the study, it is worth noting that the hardness of marble is significantly less than that of granite, making the control subject less than ideal. Nonetheless, the absolute precision exhibited in both ancient and modern construction can be observed.

Height: 4.15"
Maximum Diameter: 4.11"

SAMPLE GROUP

A sample group of six (6) vessels were analyzed. Each was selected for the following properties:

- Composition: Granite with high levels of quartz or other mineral inclusions
- Age: Traditionally dated to early dynastic or pre-dynastic Egypt
- Provenance: Documented to have been exported from Egypt within the last 150 years

Out of the vessels displayed, several were excluded due to damage which made proper mounting and centering difficult.

VESSEL 1

Red Granite Amphora Jar

Granite with Potassium-rich Feldspar

Height: 4.75”
Maximum Diameter: 3.36”

VESSEL 2

Vase V03

Granite with Potassium-rich Feldspar

Height: 3.00”
Maximum Diameter: 4.41”

VESSEL 3

Vase V05

Granite with Potassium-rich Feldspar

Height: 4.96”
Maximum Diameter: 4.02”

VESSEL 4

Vase V06

Granite

Height: 4.34”
Maximum Diameter: 3.61”

VESSEL 5

Vase V01

Granite

Height: 5.73”
Maximum Diameter: 4.58”

VESSEL 6

Red Granite Lotus Vessel

Granite

Height: 4.475”
Maximum Diameter: 2.880”

CONCENTRICITY AND ROUNDNESS

		Dial Indicator Location								
		A		B		C		D		Between Lug Handles
Vessel	**Orientation**	Height	Var	Height	Var	Height	Var	Height	Var	Var
Red Granite Amphora Jar	Upside Down	0.2460	0.0050	1.5000	0.0005	2.8350	0.0020	4.0430	0.0015	0.009
V03	Upside Down	n/a	n/a	0.6415	0.0020	1.6295	0.0040	2.6900	0.0035	0.005
V05	Right Side Up	4.8230	0.0090	3.9785	0.0100	2.6650	0.0045	1.2320	0.0030	0.009
V06	Upside Down	0.2150	0.0040	1.3190	0.0095	1.7310	0.0050	3.4810	0.0100	n/a
V01	Right Side Up	5.2180	0.0090	4.0780	large	3.0360	0.0150	1.1260	0.0110	0.015
Red Granite Lotus Vase	Upside Down	0.3250	0.0080	1.5090	0.0065	2.5710	0.0060	3.3510	0.0060	n/a
CONTROL Marble Vase	Upside Down	2.1000	0.0050							

all measurements in inches

Height: distance from rotary table surface
Var: Variance or Runout between maximum and minimum measurements

WALL THICKNESS

	Caliper Location				
Vessel	0°	90°	180°	270°	Var
Red Granite Amphora Jar	0.353	0.354	0.352	0.354	0.002
V03	0.280	0.278	0.279	0.278	0.002
V05	0.083	0.083	0.081	0.083	0.002
V06	0.125	0.131	0.135	0.131	0.010
V01	0.480	0.483	0.481	0.479	0.004
Red Granite Lotus Vase	0.125	0.124	0.120	0.122	0.005
CONTROL Marble Vase	0.476	0.492	0.501	0.490	0.025

all measurements in inches

CONCLUSIONS

Based on the plate layout inspection performed, we recognize that the manufacturing precision of the six ancient granite vessels is comparable in accuracy to modern processes such as CNC lathe turning, exhibited in the modern control vessel. In terms of concentricity, roundness, and continuity, we believe such results are typically achieved using high-precision modern machinery.

To address the question of whether or not such manufacturing accuracy is possible *by hand*, we will need to expand the analysis to include both modern and ancient objects that are known to have been hand-made. To this end, we are developing a study to focus on this very subject.

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