CleanTech
For Cleaning Process Improvement

NEW WRINKLES in Evaluating Ultrasonic Tanks

In a previous article appearing in this publication ("Aluminum Foil Erosion Helps Determine Ultrasonic Damage," *Precision Cleaning*, June 1998, page 19), we described how erosion (weight loss) of aluminum foil can be a measure of cavitation intensity, and presumably cleaning ability, of ultrasonic tanks. The efficacy of this method was tested using household aluminum foil 1.0 mil (0.0010") in thickness. When this test was repeated 1.3 years later on the same seven 40-kHz production tanks, erosion rates surprisingly averaged 62% less. This discrepancy led us to reexamine the test procedure, which was suspect because all of the tanks appeared substandard.

Limitations of the Foil Test

A clue was that foil samples cut by the new analyst looked smoother than usual because he took pains to avoid wrinkles, while the former analyst had handled the foil casually. Therefore, wrinkling was considered a factor. Indeed, it promoted erosion upon further testing in a 40-kHz swept-frequency laboratory tank similar to the production tanks (**Figure 1**). Foil handled normally became more perforated than smooth foil, while foil that had been intentionally crumpled was riddled with pinholes. A possible explanation is that wrinkles serve as foci or "stress-risers" for cavitation (violent collapse of momentary bubbles created by pulses of ultrasonic energy).

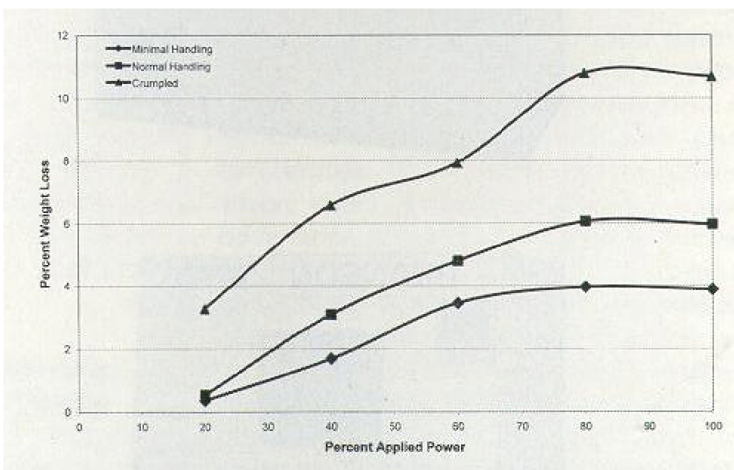

Figure 1. Effect of wrinkling on foil erosion.

When the production tanks were retested with normally handled foil, erosion levels averaged only 18% lower than originally. This reduction might be explained by experimental error or slight degradation of cavitation intensity by factors such as pitting of the tank surface above the transducers (energy transfer decreases with roughness).

Monitoring Method Needed

We believe the aluminum foil test is valid as a rough measure of cavitation energy when performed in a controlled manner with all factors, including the analyst, identical except the tank under test. However, the analyst may necessarily change. In any case, we found this method to be too time-consuming for routine monitoring.

Accordingly, meters were reconsidered. An analog cavitation meter of old design was not very sensitive to changing generator power in the laboratory test, and fluctuation of the needle made reading difficult. Such results had led us to reject meters[1], but a recently commercialized digital ultrasonic energy meter now has come to our attention.

A Meter That Works

In the laboratory tank, the ultrasonic energy meter (ppb Inc, Palo Alto, Calif) proved more sensitive to changes in generator power than the cavitation meter (**Figure 2**). Furthermore, the digital readings were stable, unlike the analog readings of the cavitation meter, and the standard deviation was relatively low, giving confidence in the data. For each applied power level, eight readings were taken at two levels in each quadrant of the tank and averaged.

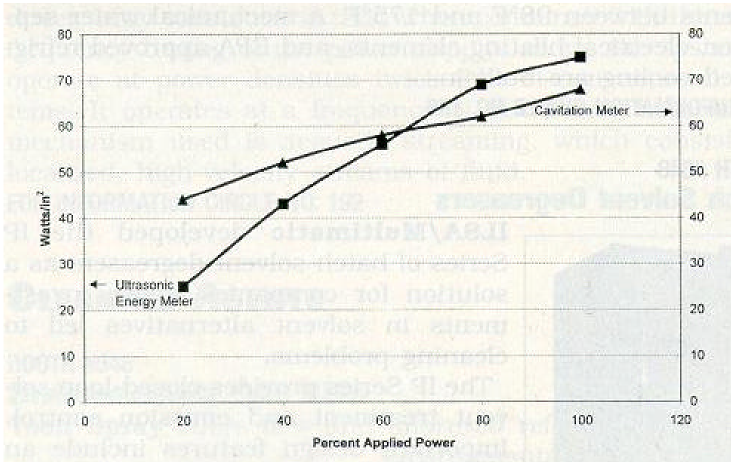

Figure 2. Ultrasonic energy meter vs. cavitation meter.

Foil test data and meter data correlated for a single tank because both erosion and cavitation increased with generator power, but not across the eight different tanks, as seen by the scattered data points in **Figure 3**. Assuming that foil erosion represents cleaning ability, this poor correlation is consistent with the opinion of ultrasonic equipment specialists that the meter is suitable for monitoring a single tank but not for comparing tanks. Since our purpose was monitoring, this caveat didn`t matter.

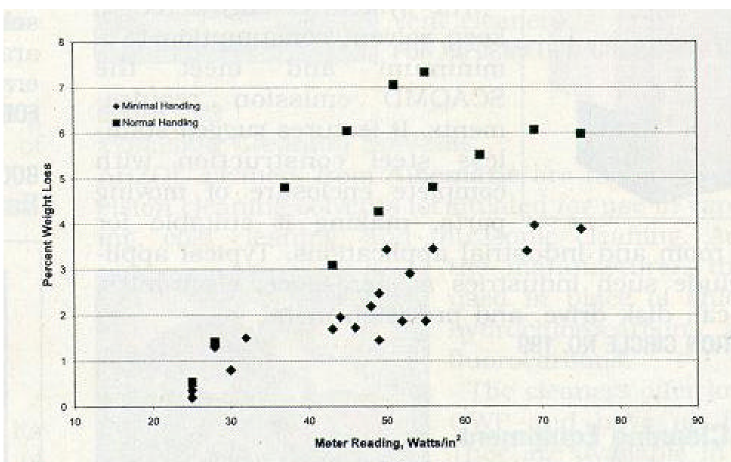

Figure 3. Correlation of meter and foil data, eight tanks.

The ultrasonic energy meter reads energy density in watts per square inch of sensor surface on a rubber-armored or quartz probe. The reading represents intermittent or peak cavitation energy and cannot be related by calculation to the energy (watts) entering a tank from the transducers. Thus, the watts/in^2 value really serves as a relative number, which suffices for monitoring tank performance.

Though cleaning may be influenced by parameters such as small hot spots not reflected in the meter reading, the rule-of-thumb recommended range is 30-80 watts/in^2, while greater than 100 watts/in^2 might damage surfaces[2]. Our seven production tanks fell into the 31-66 watts/in^2 range, which will be maintained.

Wrap-Up

The aluminum foil test has the advantage of representing actual damage to fragile surfaces and presumably dislodgement of contaminant particles from more durable surfaces. Therefore, we will continue using this method, with awareness of the effect of wrinkling, for calibrating new tanks to match old ones.[1] However, the ultrasonic energy meter will take over the task of monitoring tank performance. Advantages of the ultrasonic energy meter over the foil test are summarized in the **Table**.

TABLE: COMPARISON OF TEST METHODS

METHOD	STANDARD DEVIATION (N − 1) AS PERCENT OF THE MEAN	RESULTS INDEPENDENT OF OPERATOR	CALIBRATION FEASIBLE	TIME (MIN) TO CHECK A TANK
Aluminum Foil Erosion	28	No (wrinkling increases corrosion)	No	60
Ultrasonic Energy Meter	2-9	Yes	Yes	5

Convenient features of the meter include automatic averaging of several readings taken quickly at various locations in a tank. The meter stores and retrieves data and can be connected to a computer port. An NIST-traceable calibration certificate is available.

References

1. Kolyer JM, Passchier AA, Tran QM. Aluminum foil erosion helps determine ultrasonic damage. Precision Cleaning. *1998;8(3):19-21.*

2. Telephone conversation on August 23, 1999, with L Azar of ppb Inc.

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