

Instruction Manual

Ultrasonic Cavitation Intensity Meter Model CM-3-100

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PREFACE

To obtain the best and most meaningful results from your Cavitation Meter, you should at least have a basic understanding of what cavitation is, and how it is operated to provide effective cleaning in your ultrasonic cleaning system.

This manual attempts to provide the user with this basic understanding of cavitation, as well as an introduction to the operation of Alexy's Cavitation Intensity Meter, Model CM-3100. We have been using our meter design for over 25 years for calibration field service and lab work. We have found our meter to be dependable and trouble free. The stainless steel probe is virtually indestructible.

Many factors must be considered before accepting any given cavitation reading as a direct indication of cleaning efficiency. This manual discusses the most important of these factors. The CM-3-100 is not designed to compare cleaning ability of different frequencies, makes or designs of ultrasonic cleaning equipment. One make or type of equipment that is excellent for a given cleaning task may be quite unsuitable for a different cleaning application. Some operating frequencies are better for certain applications than others, which will be explained later.

The CM-3-100 meter is best used for periodic reading of cavitation intensity in an ultrasonic cleaner or cleaning line to determine if the cavitation intensity has dropped over a period of time. It is best to take readings on a weekly basis and keep a record of readings.

Another important use is to check the effect of workbaskets, fixtures, and workloads, on the ultrasonic energy in a cleaning tank.

SECTION I - INTRODUCTION

I. Cavitation

Ultrasonic cleaning employs high frequency sound waves, which are above the range of human hearing. These ultra high or "silent" sound waves, when introduced into a cleaning solution, cause microscopic gas bubbles in the cleaning solution to expand to their limit. At this point, enlarged gas bubbles suddenly collapse or implode, giving off tiny but powerful pressure waves. This process is cavitation and the waves emitted by cavitation generate an erosive action. Together with the cleaning solvent, this action creates the desired cleaning effect. Cavitation has been described as countless tiny scrubbers that force dirt and grease from parts immersed in the cleaning liquid.

Therefore, the purpose of introducing ultrasound into a cleaning solution is solely to provide an intense scrubbing action on the part to be cleaned. It will accelerate the chemical cleaning action of the cleaning solution, making it more effective on soluble soils, and it will break loose tenacious insoluble soils or particulate matter which is ordinarily not removed by chemical action alone. Cavitation exists throughout the entire volume of an ultrasonic cleaning tank, but primarily on the surfaces of the parts to be cleaned. The scrubbing action of the cavitation is carried into all recesses and minute openings of the parts being cleaned wherever capillary action will take the cleaning solution. If cavitation is not occurring as expected, the engineers at Alexy Associates are available to help you with your problem.

II. Factors Effecting Cavitation

Factors include; the frequency and amplitude of the vibrational energy introduced into the liquid, the temperature of the liquid, the kind of liquid used, the gaseous condition of the liquid, and many other factors.

a. Frequency and Amplitude of Vibrational Energy

The amplitude of the vibrational energy must be above a minimum threshold level required to initiate cavitation in the particular cleaning solution used. The frequency of

the vibrational energy is also a very important factor. In general, for a given amount of energy applied to a cleaning tank, there will be more intense cavitation at the lower frequencies. This is because at the microscopes gaseous bubbles in the liquid will grow to a much larger size before they collapse and can thus produce a much stronger shock wave.

At the higher frequencies, however, the microscopic bubbles will grow to a collapsible size at a more rapid rate and although each collapsing bubble is a smaller implosion, there can be many times the number of implosions per unit time. Thus, the amount of cavitational energy might be the same at two widely different frequencies with different effects in a cleaning solution.

This explains why cavitation generated at sonic and very low ultrasonic frequencies is somewhat like scrubbing with a very coarse bristle brush and cavitation generated at higher ultrasonic frequencies (e.g., 40,000 cycles-per-second) is comparable to using a softer brush with many more bristles. This also explains why cavitation generated at a very low ultrasonic frequencies can be damaging to delicate parts whereas cavitation generated by using higher ultrasonic frequencies will provide excellent cleaning without damage. In general, ultrasonic frequencies in the range from 20 to 120 KHz are used for ultrasonic cleaning applications.

b. Temperature of Liquid

The temperature of a cleaning liquid has various effects upon a cleaning system. Maximum cavitation intensity occurs at a temperature considerably below boiling and approaches zero as the temperature of the liquid approaches boiling.

Heating helps to degas (see the next section - Gaseous Condition of the Liquid) the liquid, thereby increasing cavitation. Heating also helps to increase the chemical action of the liquid. Because of the plus and minus affects that temperature has upon an ultrasonic cleaning system, the optimum compromise had to be ascertained to provide the most practical results. It was learned that a temperature of about 130 degrees F. to 140 degrees

F. is, generally optimum for aqueous systems. This temperature range provides the most effective compromise of chemical activity and cavitation for most ultrasonic cleaning systems.

c. Gaseous Condition of Liquid

When a cleaning liquid contains a large amount of dissolved gas, it tends to dampen cavitation intensity. In contradiction, however, a cleaning liquid must have some dissolved gas in order to cavitate. It is the microscopic bubbles of dissolved gas that grow and implode creating the scrubbing action.

The proper combination of temperature and gaseous condition of the liquid helps to achieve the best cavitation and over-all cleaning action.

d. The Kind of Liquid Used

The two broad classifications of ultrasonic cleaning solutions, aqueous and solvent, greatly differ in their effects upon cavitation intensity. Aqueous solutions normally produce a much more intense cavitation effect than do solvent liquids; yet, the cleaning action in the solvent liquid may be much greater than in the aqueous solution for the same type of cleaning job required. The type of soil to be removed determines the type of liquid to be used. Aqueous systems are best for inorganic soils, however, by adding a detergent to the liquid many light greases and oils can be removed. Where heavy organic grease, oil or waxy soils are present, an organic solvent may best do the job.

Because of the nature of organic solvents, cavitation intensity is frequently less than intensity in aqueous solutions; yet the solvent action appears to make up for the lower scrubbing activity. For example, if you put a bit of grease in detergent water and stir briskly, the grease will dissolve slowly and perhaps not even completely. But, drop a similar bit of grease into an organic solvent such as kerosene and with just light stirring the grease will quickly thin out and dissolve. However, with no stirring in either case, the grease would remain in either liquid for some time before dissolving completely, if at all.

Therefore, cavitation provides the mechanical effect of stirring, which increases the activity of the cleaning liquid.

It should be noted, however, that cavitation does not necessarily increase the activity of the solvent chemically per se. It merely stirs up and breaks the soil into finer particles, which then can be acted upon more readily by the chemical action of the cleaning liquid. It should also be noted that cavitation is also not directly effected by the chemical action of the liquid, but only by the proneness to cavitate the liquid itself. The proneness to liquid and not necessarily by its chemical reactive properties.

The major factors that have effects on cavitation intensity are:

- (1) The size and shape of the tank.
- (2) The depth of the liquid in the tank.
- (3) The amount of dissolved soil or suspended particulate matter in the liquid.
- (4) The inserts or baskets used to contain the parts being cleaned.
- (5) The number, size and shape of parts to be cleaned.
- (6) The density and composition of parts to be cleaned.
- (7) The liquid being used.
- (8) The temperature of liquid being used.
- (9) The position of larger and/or odd shaped parts while immersed in the cleaning liquid.
- (10) The operating efficiency of the system and its associated transducers.

The cavitation meter lets you know that cavitation energy exists in the tank. It allows you to compare readings from one time to another and to determine optimum leads and positions in a given tank. In this way, you can keep a running record on the efficiency of your systems. The cavitation meter is not a diagnostic tool in the sense that it will tell you directly what is wrong with your system. It lets you know that cavitation is or is not occurring and, if so, to what relative intensity.

III. Cavitation Intensity in "CAVINS"

The model CM-3-100 is calibrated in units named "CAVIN" (for CAVitation INtensity). The CAVIN is based on the results of exhaustive tests with the Model CM-3-100 on many and varying ultrasonic cleaning systems in actual use and in the laboratory. Based on these tests, the Model CM-3-100 is calibrated from 0 to 1000 CAVINS. The 1000 CAVIN level is an arbitrarily assigned value for the highest intensity generally encountered in present typical high-intensity aqueous cleaning systems - adjusted for optimum performance without any work load of parts in the cleaning tank.

Although aqueous systems will generally give typical readings between 10 and 1000 CAVINS, some liquid will generally give readings much lower. For this reason, the Model CM-3-100 meter is provided with two range scales; 0 to 100 CAVINS and 0 to 1000 CAVINS.

The Model CM-3-100 is actually a monitor of cavitation and is most useful when used to monitor a system in which standards have been previously established for the system under optimum conditions.

The Cavitation Meter can be used beneficially and can provide meaningful, reasonably accurate results when used with some degree of common sense.

SECTION II - DESCRIPTION

I. Physical Description

The Cavitation Intensity Meter is designed for ease of operation. It is lightweight, self-powered and completely portable.

a. Dimensions & Weight

Height: 6.5" (without probe)

Depth: 3"

Width: 4.13"

Probe length standard: 16" (optional 24" 36" or remote probe).

b. Hanging Bracket

A hanging bracket is furnished so you may store the meter near your ultrasonic cleaning equipment.

c. Case Construction

The Model CM-3-100 case is constructed of flame retardant ABS and is finished in blue wrinkle.

d. Meter

The 3-1/2" meter provided with the Model CM-3-100 is analog type with glass window to avoid chemical crazing.

e. Controls

The Sensitivity Select Control provides X1 range and a X10 range for measuring cavitation in your system.

f. Test Range & Scale Divisions

The test range of the Model CM-3-100 is 0 to 1000 CAVINS, which covers the entire range of cavitation intensity of all known ultrasonic cleaning systems in operation today. On the X1 scale, the increments are in CAVIN units and the range is 0 to 100 CAVINS. On the X10 scale, the increments are in 10 CAVIN units and the range is 0 to 1000 CAVINS.

g. Probe

The standard probe is 18" long, and permanently attached to the meter. The active element of the field probe is a cylindrical transducer which picks up energy enables the meter to read an integrated signal based on the total intensity in the cleaning tank in the immediate vicinity of the probe. This makes the meter insensitive to the angle at which the probe is held. However, moving the probe within the tank will change the meter reading according to the energy levels in the various locations in the tank.

II. Electrical Characteristics

The Model CM-3-100 operates on power generated by the probe. There are no batteries in the unit.

SECTION III - OPERATION

I. General

The Alexy Cavitation Intensity Meter, Model CM-3-100 requires no preparation before it is ready for use. Because of its all solid-state circuitry, the Model CM-3-100 requires no warm-up time. Its operation is easy for even non-technical personnel and the results are read directly from the meter with no need for formulas or other interpretive calculations.

II. Testing Cavitation Intensity

Just as in any other type of measurement, standards must be established in order to obtain meaningful results. In ultrasonic cleaning, however, each tank or tank type is an entity unto itself. A tank first must be tested under optimum conditions; that is, turned on with a fresh supply of cleaning liquid and heated to its proper operating temperature.

Note - When taking readings, the probe should be moved through the liquid in slow, easy movements. Never use quick or jerky movements, for this will affect the accuracy of the readings.

a. Aqueous Systems

In aqueous systems, the peak intensity should be between 10 and 1000 CAVINS, depending upon the type of solution used and the operating efficiency of the tank. You know how effectively your tank has been cleaning. If it has been doing the job at least as expected, then the reading obtained under optimum conditions can be used as a good starting point for comparison.

(1) To establish standards to which future readings will be compared, readings should first be made and recorded at various levels and parts of the tank under optimum conditions.

(2) Next, place standard inserts holders, baskets, etc.) into the tank without parts and record new readings.

(3) Loads of varying sizes should be lowered into tank and more comparative readings recorded. This should be continued until cleaning efficiency begins to drop off.

Note - Each time a new load is immersed, the cleaning solution should be changed if a gross amount of contamination is encountered. This is to be done to be sure

contaminated cleaning liquid is not affecting cavitation intensity that would throw off comparative readings. Each time the liquid is changed it should be brought to operating temperature and pre-checked for intensity to be sure it matches within 10% the intensity recorded under previously optimum conditions. Readings should be made while probe is held in recesses between and around the immersed parts. Once optimum cleaning is noted, the cleaning solution, itself, can be altered in stages until a new optimum cleaning point is obtained. All conditions and resultant readings should be recorded for future comparison.

(4) When the parts to be cleaned are large and can be submerged a few a time, orientation of part/s in the tank should be altered until peak cavitation intensity near or at the surfaces of the parts is noted on the meter.

Note - As a general rule, large parts should be reoriented in the liquid on a regular schedule to allow thorough cleaning of all surfaces. This is true because cavitation intensity varies at different levels of a single tank. Re-orienting or turning parts on a schedule assures that all surfaces of a part are exposed to the highest cavitation intensity levels in the tank.

(5) Because of the many types of tanks and varying transducer configurations to be found, the exact levels of peak intensity will also vary. The Cavitation Intensity Meter will help you determine more precisely where these levels exist in your particular system so that you will be able to properly orient your workloads.

SECTION IV - MAINTENANCE

The design of your CM-3-100 probe eliminates the need for elaborate preventative maintenance procedures. The only recommendation is to keep the unit clean. The probe should be rinsed after each use and the meter should be kept clean and dry.

If any problems should occur, please contact Alexy Associates. Field adjustments, calibration or repairs can not be made unless the unit is sent to us or instruction is given by phone.

GLOSSARY

AMPLITUDE- The distance from the high peak or point of a cycle to its lowest point or trough. Opposed to frequency which refers to the number of vertical peaks and valleys or waves in a given horizontal distance or time lapse, amplitude is the vertical distance from each peak to its corresponding valley. Intensity is proportional to the square of the amplitude.

AQUEOUS- This term pertains to water or anything resembling or consisting of water. An aqueous solution is a solution of any substance or substances in water.

CAVIN- A term proposed by Branson Instruments in 1966 to represent one unit of cavitation intensity. One CAVIN represents 1/1000 of the peak cavitation observed in tests of many typical aqueous ultrasonic cleaning tanks performed under optimum conditions.

CAVITATION- The expansion and rapid implosion of microscopic gas or vapor bubbles produced when high-intensity ultrasonic waves are directed into a liquid.

DAMPING- The extent to which a wave, process or activity is diminished, restrained or checked.

FREQUENCY- The rate of vibration or the number of complete cycles of a signal which pass a given point in a second. The greater the number of cycles or peaks and valleys of a signal per second, the higher the frequency. In audible sound the frequency is also referred to as the pitch.

HARMONIC (Also OVERTONE)- is a vibration frequency which is an integral, or whole, multiple of the fundamental frequency.

WHITE NOISE- The spectrum of sonic and ultrasonic harmonics produced by the imploding bubbles during cavitation. This spectrum extends well into the mega-cycle range. The intensity of these harmonics can be detected and relate directly to cavitation intensity.