Cleaning Tight Features and Small Lumen Tubing with Vacuum Cycle Nucleation (VCN)

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The PQCW offers practical, hands-on and independent, training in cleaning. More Info shsu.edu/pqcw & pqcw@shsu.edu 1

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Hosts: The Product Quality Cleaning Workshop Team

Barbara and Ed Kanegsberg – "The Cleaning Lady and the Rocket Scientist"

- BFK Solutions - Consultants in Critical Cleaning – established in 1994
- Authors and Editors of the two-volume CRC Handbook for Critical Cleaning
- Independent recommendations for process improvement
- Common sense expertise and industry involvement: JS3 (military), IPC, ASTM, U.S. ISO expert, EPA, FDA
- Co-chairs of the Product Quality Cleaning Workshops
- barbara@bfksolutions.com and ed@bfksolutions.com

Darren Williams – "The Professor"

- Professor of Physical Chemistry at Sam Houston State University
- Leader of the Cleaning Research Group
- Co-chair of the Product Quality Cleaning Workshops
- Performs cleaning trials, material compatibility studies, and models/tests cleaning chemistry formulations
- williams@shsu.edu

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PQCW - Workshops for Terrific Products

- "People with different functions within our company, including Strategic **Sourcing**, Project **Management**, and **Manufacturing Engineering**, attended.

- "We learned a lot; and we have made changes. We are **refining our own cleaning** requirements and putting together training programs.
- "For example, we used the workshop to develop **black light testing and fixtures;** and we have already set up a one-hour **"Parts Washing 101"** training course.
- "The section about **EPA amended TSCA had useful, timely information."**
  - Christian Johnson, Engineer, Yaskawa, participant, PQCW21

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Our Speakers

Dr. Don Gray

- President of Vacuum Processing Systems, LLC (VPS) in Rhode Island
- Professor of chemical engineering for over thirty years
- Upon his recent retirement he and Joe started VPS
- Holder of 12 cleaning related patents.
- Invented the vacuum-to-vacuum solvent cleaning process, which is recognized by the USEPA as being over 95% effective in solvent recovery, and was awarded the US EPA's coveted Environmental Excellence award.

Joe Schuttert

- Sales Director at VPS
- Joe's education includes Biology and Chemistry.
- Retired from a successful career in the pharmaceutical industry
- Sales manager at Serec Corp
- At Serec and VPS Joe analyzed the customer's parts cleaning processes.
- Personally involved in the cleaning of thousands of parts from a wide variety of industries using both aqueous and solvent chemistries.

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VACUUM PROCESSING SYSTEMS (VPS) PRODUCTS

VACUUM VAPOR DEGREASERS:

VACUUM CYCLING NUCLEATION :

FLAMMABLE SOLVENT SYSTEMS:

3D PRINTING SUPPORT MATERIAL REMOVAL:

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VACUUM CYCLING NUCLEATION

when superior performance is a requirement

Vacuum Cycle Nucleation (VCN) is the most exciting advancement in industrial cleaning since the introduction of ultrasonics. VCN provides superior performance in both aqueous and solvent applications.

1. The process is accomplished by applying a vacuum to an enclosed chamber containing a part submerged in a liquid.
2. Reducing the pressure to below the vapor pressure of the liquid results in the formation of vapor bubbles at the solid part's surface where typically nucleation sites for bubble formation can be found in the form of imperfections, crevices, pores, channels or foreign particle material.
3. The growing vapor forces liquid from the part creating fluid agitation throughout the part.
4. The cleaning liquid being forced from the part's internal volume carries contaminant and particles to the bulk fluid.
5. The vacuum is paused to allow fresh cleaning fluid to enter the part and the cycle is repeated until the part is cleaned.
6. A typical cycle time is from 1 to 3 seconds so that a very short time is needed to completely clean a part.

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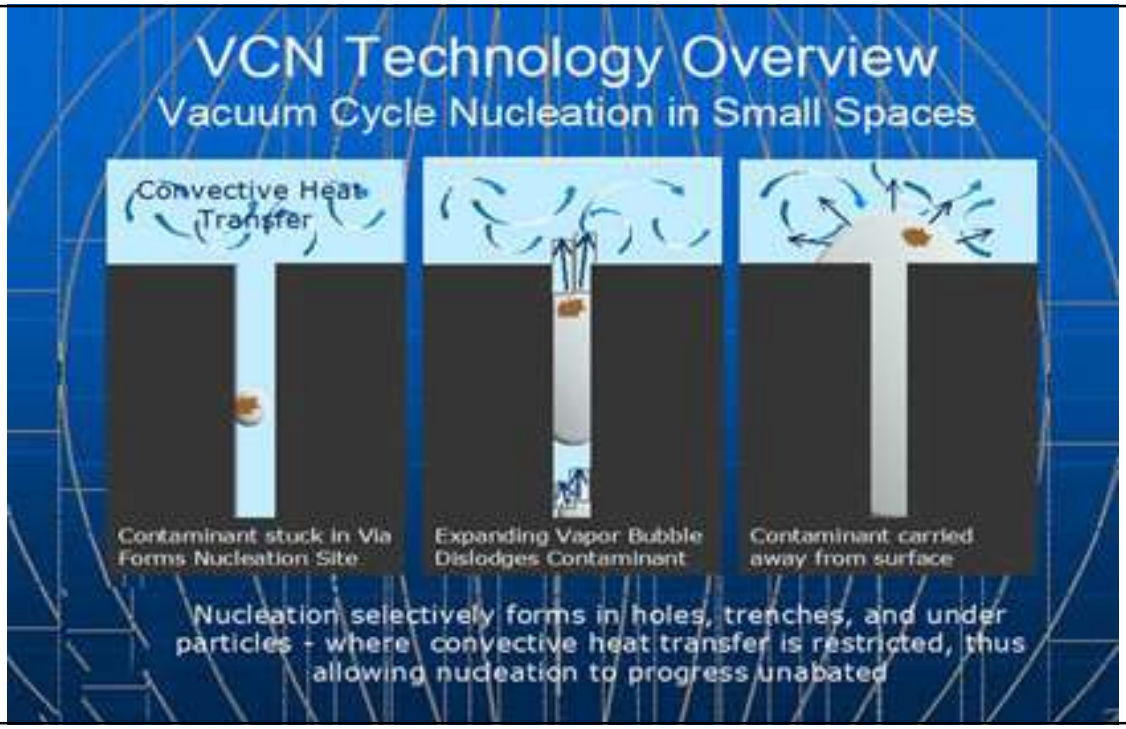
VCN Technology Overview
Vacuum Cycle Nucleation in Small Spaces
Convective Heat Transfer
Contaminant stuck in Via Forms Nucleation Site
Expanding Vapor Bubble Dislodges Contaminant
Contaminant carried away from surface
Nucleation selectively forms in holes, trenches, and under particles - where convective heat transfer is restricted, thus allowing nucleation to progress unabated

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VACUUM VAPOR FORMATION DUE TO NUCLEATION TARGET THE KEY AREAS NEEDING CLEANING

VAPOR FORMATION

Fluid in an enclosed container will exert a pressure equivalent to the fluid's vapor pressure. The space above the liquid level is filled with the fluid's vapor. When a vacuum is pulled on the chamber, vapor is removed from the chamber. The vapor space now needs to be replenished with vapor. The fluid forms vapor bubbles that replenishes the vapor space.

NUCLEATION

Boiling liquids need nucleation points in order to begin vapor formation. Vapor therefore begins forming on parts within the chamber. The best nucleation points are in crevices and tight areas where a high solid surface to liquid volume can be found. The interior of small packed parts is an ideal location for vapor bubble formation. The vapor bubbles begin to form throughout the parts and liquid is forced from the interior creating fluid motion within the matrix of parts. Stopping vacuum reverses the process and fresh fluid enters the packed volume. This process is cycled until the parts are cleaned.

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VCN HAS ADVANTAGES OVER ULTRASONICS

	Ultrasonics	VCN	
Internal Cleaning	No	Yes	Ultrasonics can't penetrate solid surfaces.
Damage to Delicate Parts	Yes	No	Ultrasonic bubbles are small and aggressive to shock contaminant from a surface. VCN bubbles are large and gentle to move fluid throughout a part.
Load Dependent	Yes	No	Solid surfaces adsorb ultrasonic energy. The larger the load, the greater the energy dissipation and the more energy required.
Uniform Treatment	No	Yes	Ultrasonics is adsorbed on the surfaces closest to the transducers. Parts located on the inside of a basket can receive little to no ultrasonic energy.
Targets Contaminant	No	Yes	Vapor needs a solid surface to begin forming. Vapor nucleates in regions of high surface area to fluid volume. VCN likes to create vapor in tight areas.
Chemical Delivery to Surface	No	Yes	When a fluid has been loaded with contaminant, the cleaning process either slows or ceases. VCN replenishes all areas with fresh cleaner in seconds.
Effectiveness With Solvents	Low	High	Ultrasonics likes to operate at temperatures low enough to make sure vapor formed collapses as opposed to evaporating. Solvents are often used at the boiling point.
Concentrations Required	Hi	Low	Since VCN continuously replenishes cleaner at a surface, lower concentrations of surfactant is required to accomplish effective cleaner.
Effective Rinse Method	No	Yes	At the end of cleaning, surfactants are now the contaminant. Using VCN with your rinse water removes surfactants from your surface quickly and efficiently.

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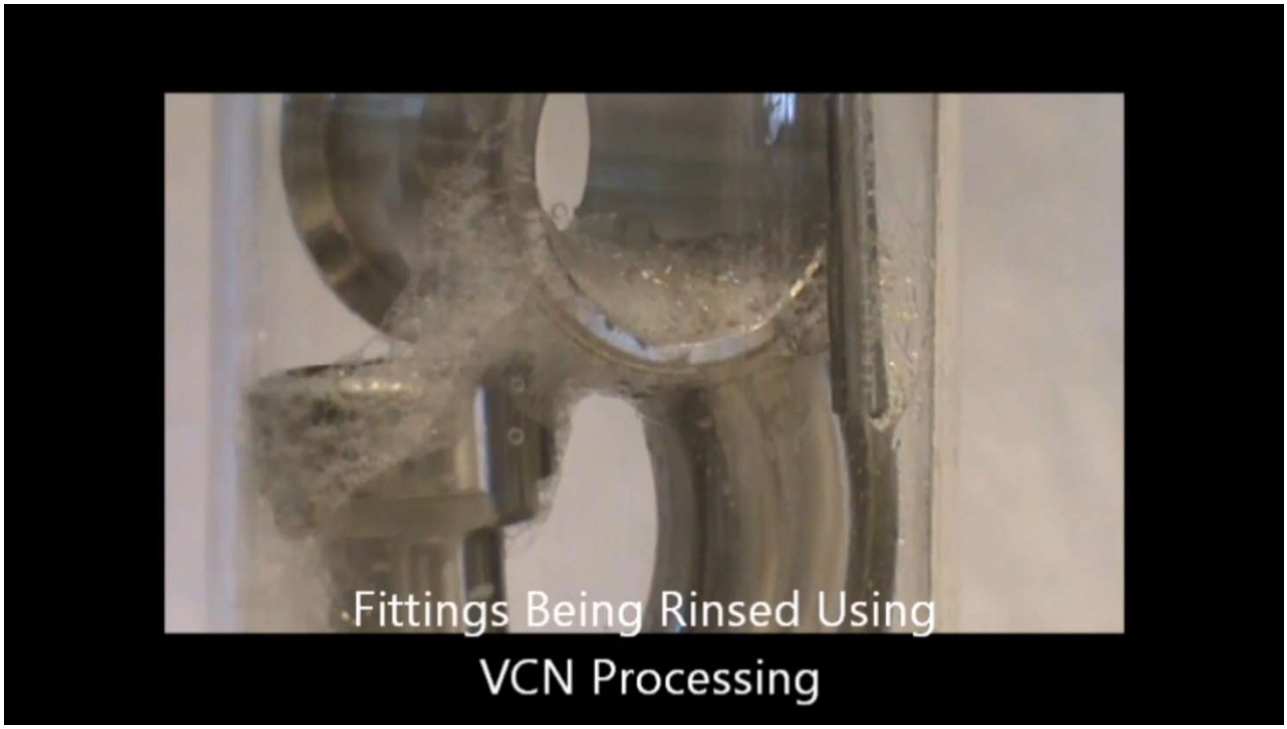

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VCN IS PERFECT FOR DISINFECTING MEDICAL PARTS

Cleaning of Hip Implants

Hip implants were cleaned in the VCN process using off the self hydrogen peroxide concentrations of 3%. The results were acceptable implants well within the required levels for bio burden, toxicity and total carbon.

	PART #1	PART #2	PART #3	ACCEPTABLE LEVELS
BIO BURDEN	8	16	30	<100, PREFERABLY <50
TOXICITY	Non Toxic (grade 0)	Non Toxic (grade 0)	Non Toxic (grade 0)	GRADE 2, MILDLY TOXIC BEFORE CLEANING CYCLE
TOTAL CARBON	191	282	248	<1500 NORMALLY TEST AT 100/500

The video shows vapor bubble formation within an internal porous matrix. The porous part behaves like a sponge during the pulsing VCN process. Fluid is expelled from the part during the vacuum cycle as when squeezing a sponge and then the pores are filled with fresh fluid during the pressure cycle as when a sponge is submerged in a fluid.

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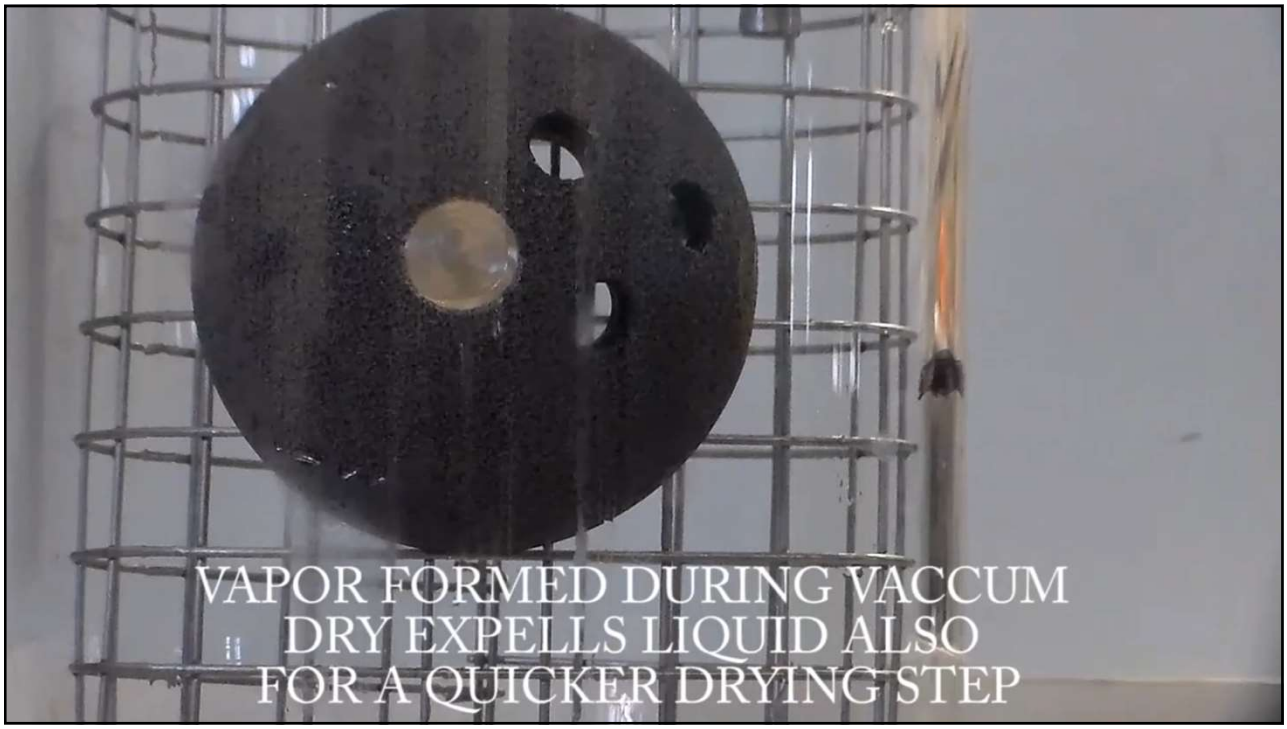

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VCN IS FAST, GENTLE AND EFFECTIVE

Internal Penetration of Parts

Like the initial vapor bubble formation in a boiling pot of water, VCN bubbles like to form in tight areas like the crevices in the pot where water begins to boil. Vapor bubbles expel fluid and contaminant from the area and collapsing bubbles draws in fresh fluid. The cycle is in seconds so that fluid turnover in the part's internal surfaces is rapid. The agitation produced during vapor formation works to remove particles and surface contaminants.

1.Pack your parts. VCN pressure is uniform throughout the chamber even under adjoining surfaces.

2.Clean at lower temperatures if your part has sensitive materials.

3.Clean in a controlled environment. Keep out ambient surroundings.

4.Vacuum dry to prevent spotting. Reduce solvent loss or use lower surfactant concentrations for cost savings.

5.Vacuum distill to concentrate waste and recycle solvent for additional operating cost savings.

Bearing Cleaning Demonstrates the Power of VCN
Video shows how VCN can form vapor bubbles in very small spaces. VCN at low vacuum or low temperature can reveal the primary vapor bubble generation location in a part. A bearing is seen in the video.

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VCN PROCESS IS MADE FOR TUBE CLEANING

SOLVENT TUBE CLEANING

VCN Advantages for Tube Cleaning
1. Uniform internal cleaning
2. VCN bubble action great for particle removal
3. No manifolding necessary
4. VCN performs bulk fluid turnover inside tubes
5. Efficient VCN rinse
6. Solvent cleaning is effective
7. Low solvent usage
8. Multiple processes performed in 1 tank
9. Complete vacuum drying
10. Solvent VCN systems are closed loop

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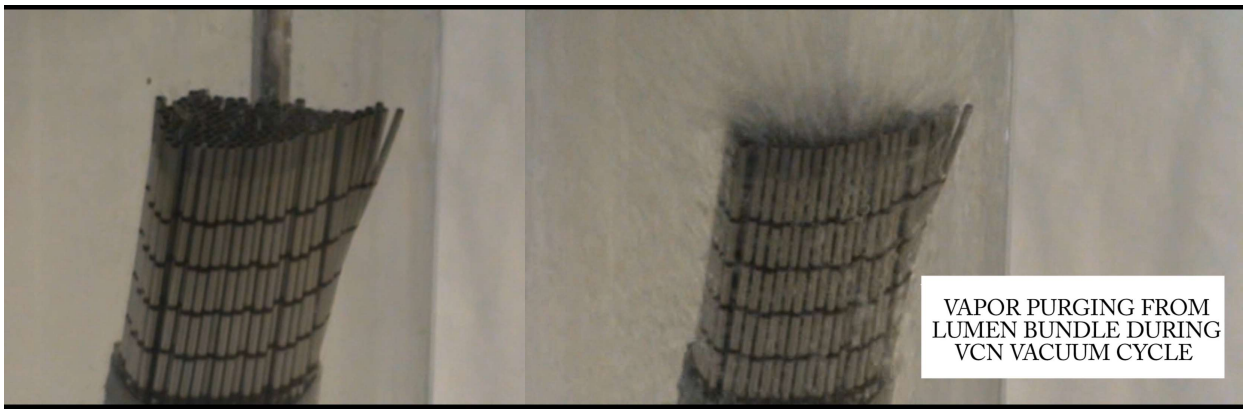

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FLUID MOTION DURING VCN PROCESSING IN A COILED TUBE

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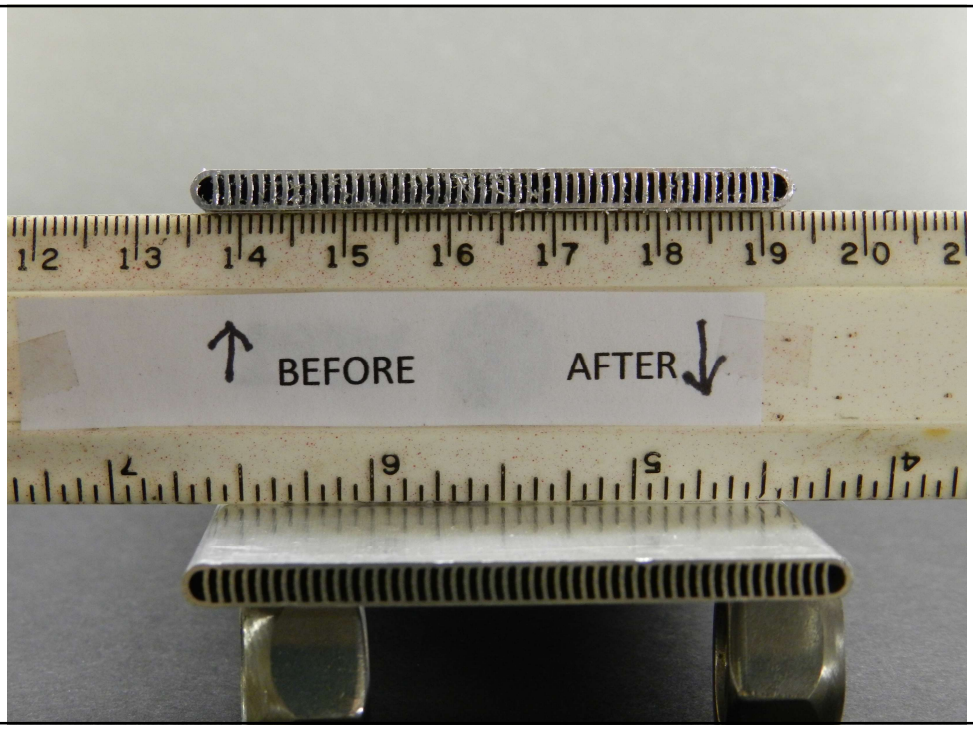

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COMBINE ULTRASONICS with the VCN PROCESS to CLEAN YOUR PARTS INSIDE and OUTSIDE

Up until now we have only been able to use external cleaning methods to clean our parts. When we are challenged with removing oils, grease or other contaminants within pores, dead end holes or tubes, ultrasonics or jet spray are generally our best choice. Ultrasonics, since sonics cannot penetrate solid surfaces, and sprays are line of sight cleaning methods. If we cannot see the contaminant, we usually don't clean it. Treatments following cleaning such as passivation, sterilization and other surface treatment processes are not effective on dirty internal surfaces. When interior cleaning of your part is required, we recommend using the VCN process with our ultrasonic cleaning system.

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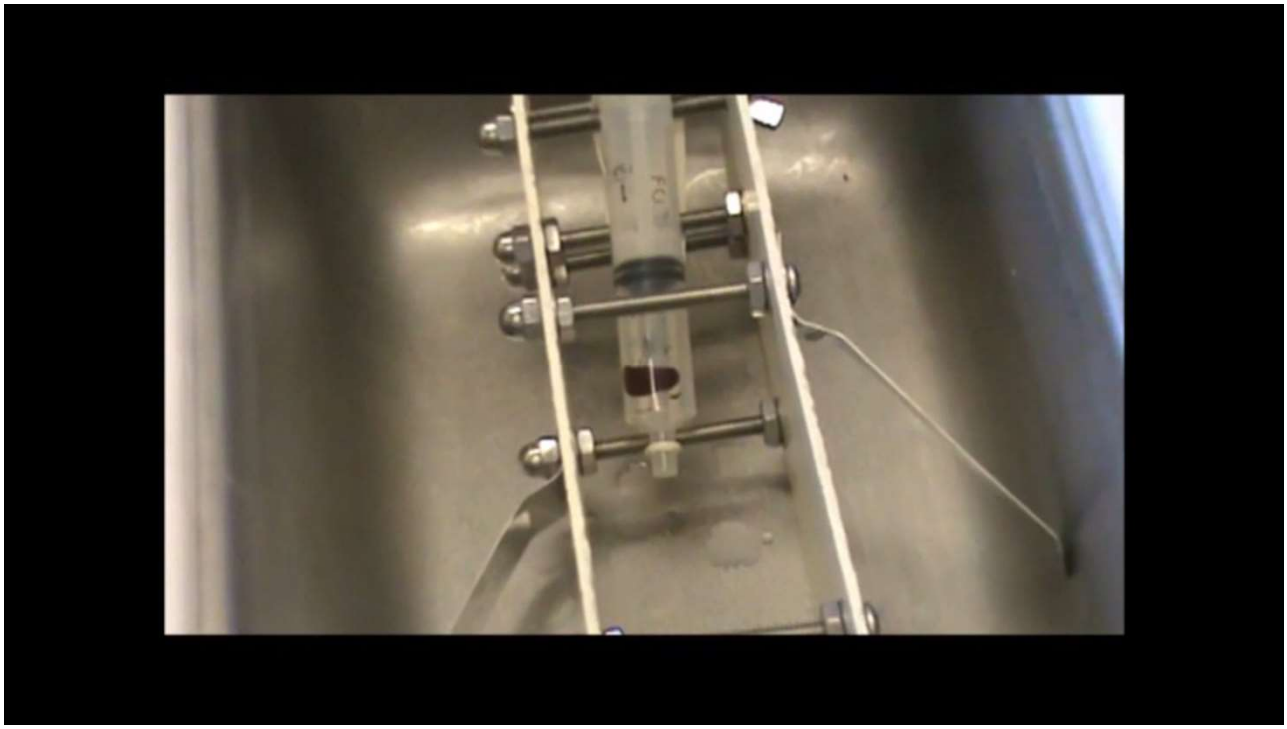

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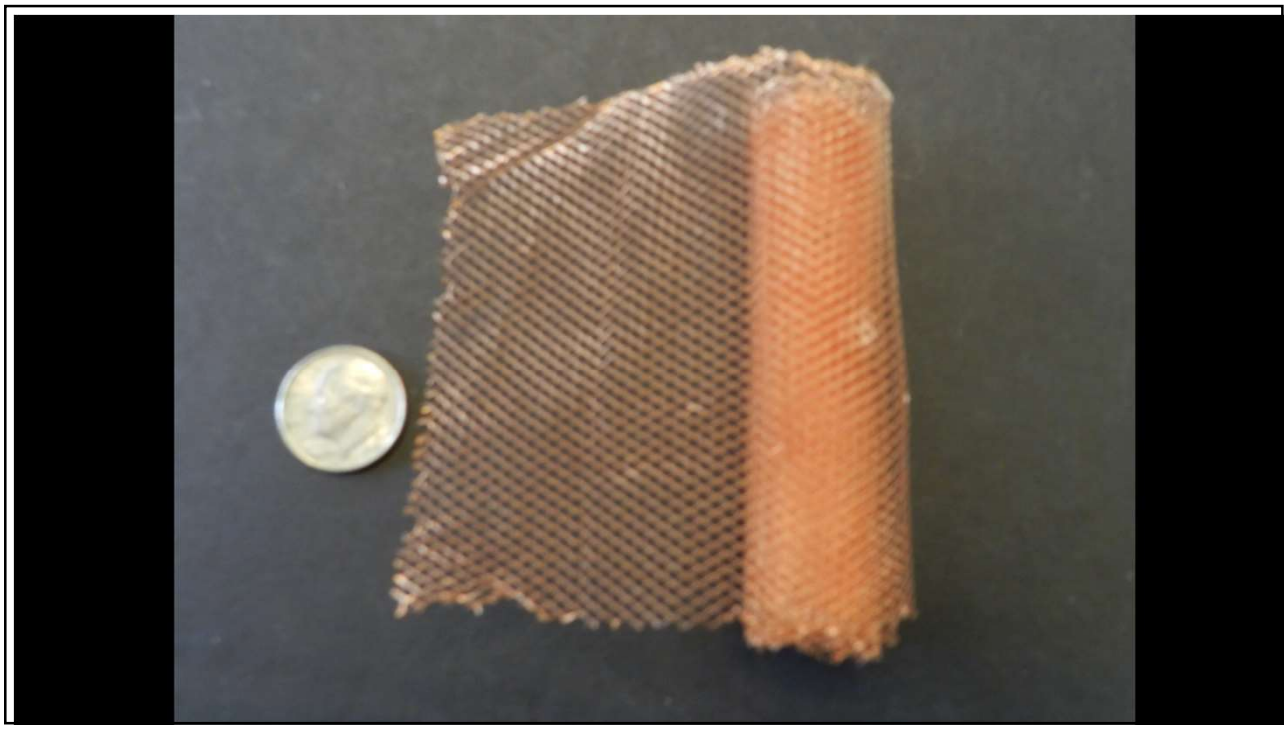

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VCN CAN BE USED FOR CLEANING AND RINSING

Aqueous Cleaning of Stainless-Steel Pipes and Fittings

Pipe fittings can be difficult to clean internally. Oils generally need to be dissolved in solvents or surfactants to assure complete cleaning and even then, pooled solvents when dried can deposit nonvolatile oils back on the fitting. Tumbling is not often an option since parts could be damaged. Aqueous cleaning is now an option using the VCN process. VCN can both clean and rinse your parts thoroughly.

1. Emulsified oils are removed from the internals of a fitting using gentle VCN agitation.
2. Continuous skimming removes contaminant from the cleaning chamber.
3. A thorough rinse is assured using VCN thus preventing water spotting.
4. Vacuum drying produces a dry, cooled part.
5. No more damage from tumbling or ultrasonics.
6. Lower required surfactant concentrations can result in substantial savings.

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Cleaning in Higher Concentrations
Produces More of a Foam Cleaning

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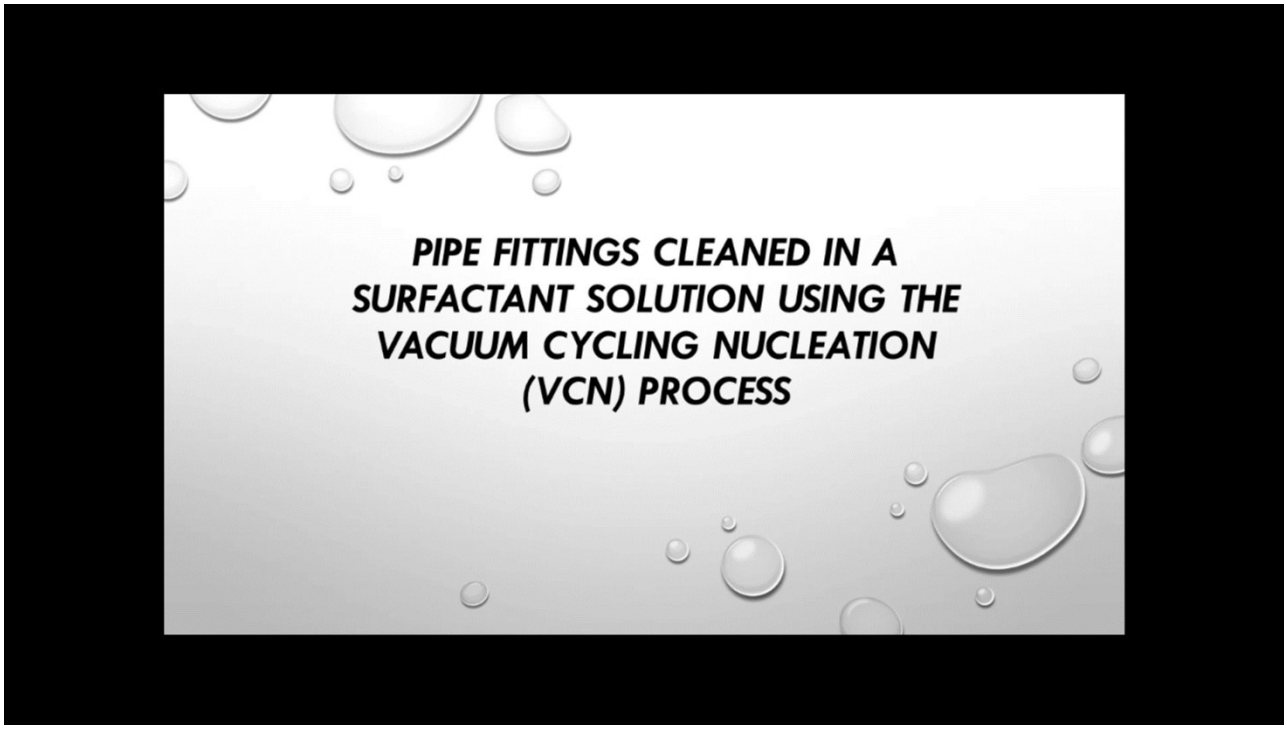
PIPE FITTINGS CLEANED IN A SURFACTANT SOLUTION USING THE VACUUM CYCLING NUCLEATION (VCN) PROCESS

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SOLVENT EXTRACTION OF INTERNAL RESIDUALS USING THE VACUUM CYCLING NUCLEATION (VCN) PROCESS

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product quality cleaning workshops

Thank you for joining us!
What Questions do you have?

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