Advantages of Solvent vs. Aqueous Cleaning

Introduction

In the early 1990s, the Montreal Protocol forced many users of conventional vapor degreasers to switch to aqueous cleaning systems, due to the phaseout of ozone-depleting solvents (ODS) such as CFC-113, HCFC-141b, and 1,1,1-trichloroethane that were commonly in use at the time.

Because they are non-emissive and use relatively low-cost detergents as cleaning agents, aqueous systems offered an immediate solution to the problem posed by the elimination of ozone-depleting solvents. However, aqueous systems are by necessity larger, more complex and more labor-intensive than solvent-based systems. They also use copious amounts of water, which can be a hidden cost. Water must typically be processed with deionization or reverse osmosis equipment prior to use. Water consumption may also be limited by local municipalities or other government agencies. Fortunately, recent technical advances may make solvent cleaning a more cost-effective solution than aqueous cleaning in certain critical applications.

New technology spurs return to the proven performance of vapor degreasing

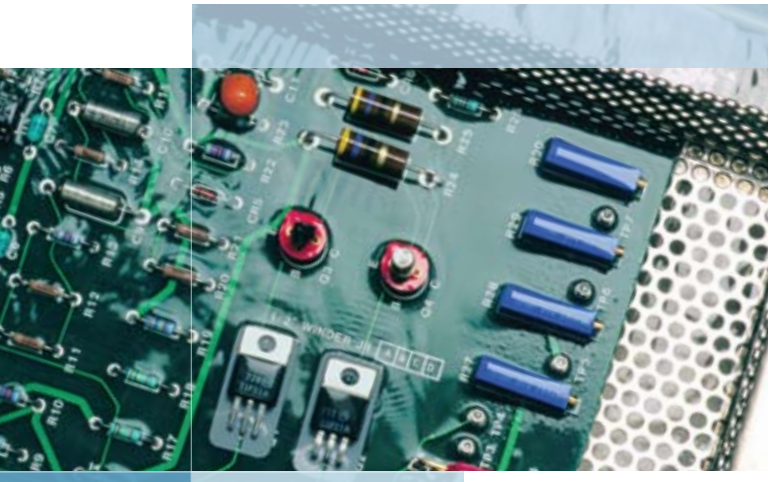
In recent years, improved equipment designs, combined with the advent of advanced, non ozone-depleting solvents, have spurred a resurgence in the use of vapor degreasing cleaning systems. In addition, the rise of cell manufacturing, in which workers are arranged in semi-autonomous teams rather than long production lines, has made the use of low-volume/small-footprint vapor degreasers a more attractive option than large centrally-located aqueous cleaning systems.

Among the most successful of the new generation of precision cleaning solvents for vapor degreasing are 3M™ Novec™ Engineered Fluids – a complete line of nonflammable, non-ODS solvents that exhibit a unique balance of environmental, safety and performance properties.

Novec fluids are ideal for many cleaning applications where high purity and low contamination levels on finished parts are critical. Novec fluids can clean a wide range of soils, demonstrate excellent materials compatibility and have proven successful in vapor degreasing, spray cleaning and hand wipe operations.

The extremely low surface tension of Novec fluids makes them excellent for the removal of particulate contamination and also aids cleaning by allowing better penetration of tight clearances in complex parts. The low heat of vaporization of Novec fluids ensures faster drying. The combination of a high molecular weight fluid and a low heat of vaporization has been shown to be beneficial in controlling fluid losses, making Novec fluids economical to use in vapor degreasing operations. Unlike most aqueous cleaning processes, Novec fluids offer faster cleaning and quick drying with lower energy consumption. Unlike some chlorinated solvents and many hydrocarbon solvents, Novec fluids are not hazardous air pollutants (HAPs).

Novec fluids offer users a high margin of safety in their intended application. They are low in toxicity, which is reflected in high exposure guidelines. In addition, Novec fluids are non-flammable for easier storage and handling. (See Material Safety Data Sheets for precautions and handling recommendations).



Solvent Cleaning vs. Aqueous Cleaning

Comparing the true "cost-of-ownership"

In many applications requiring high purity and low contaminant levels on finished parts, such as electronic components, aerospace materials and medical devices, solvent systems can offer a number of important cost and performance advantages over aqueous systems. In this example, we have illustrated the various steps required to clean a titanium hip joint in an aqueous and a solvent system of roughly equal capacities.

Requires fewer steps than aqueous cleaning – typically 1 wash, 1 rinse, 1 vapor dry

Single solvent system effective on most soils

Vertical process results in smaller footprint – ideal for cell manufacturing systems

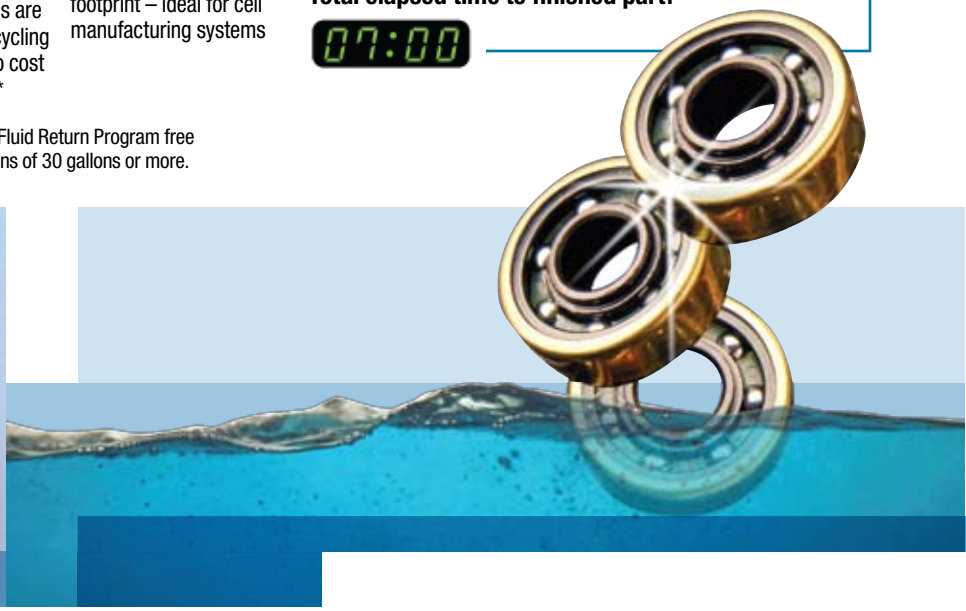
Used Novec fluids are picked up for recycling or disposal, at no cost to the customer.*

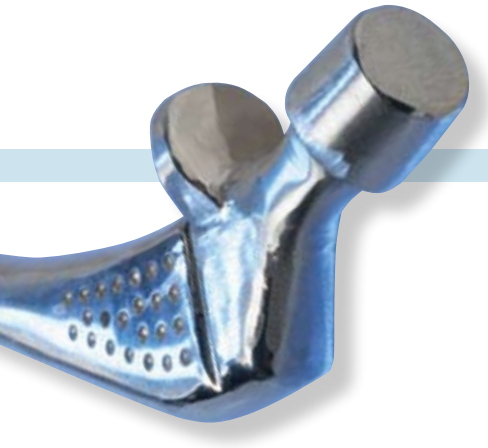
* 3M offers a Used Fluid Return Program free of charge for returns of 30 gallons or more.

Solvent Cleaning with 3M™ Novec™ Engineered Fluids

Process Steps**

1. Part is lowered into immersion sump with ultrasonic agitation and cleaned for 5 minutes. If equipped with an open boil sump, the parts are held in the vapor above the boiling solvent for a minute for an initial rinse. This keeps the ultrasonic tank cleaner.
   Elapsed time: 05:00
2. Part is raised into vapor zone, and held for 1 minute.
   Elapsed time: 06:00
3. Part moves to freeboard zone, allowing solvent to evaporate and return to sump.
   Elapsed time: 07:00
4. Part emerges clean and completely dry.
   Total elapsed time to finished part: 07:00





Aqueous Cleaning

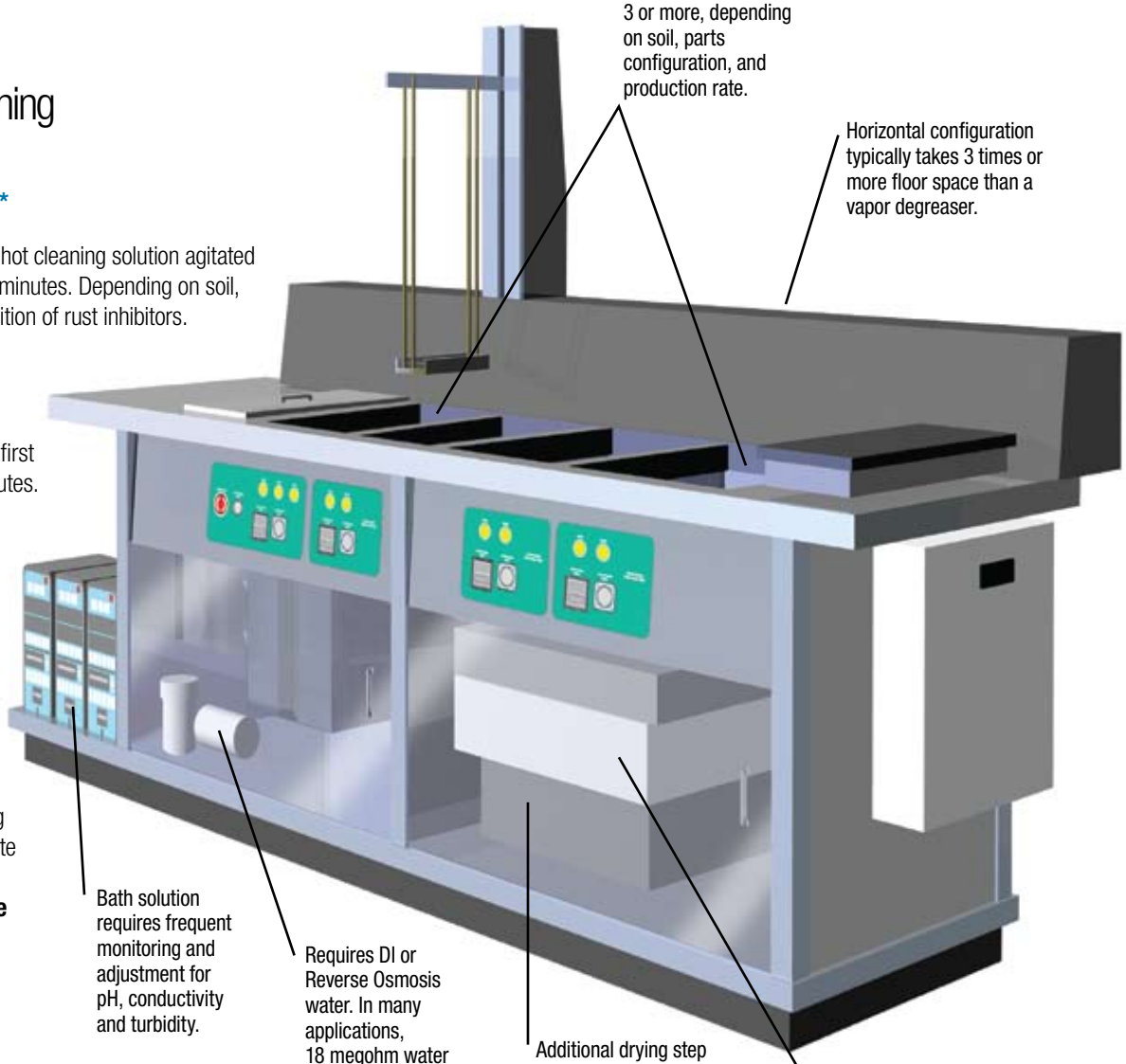
Process Steps**

1. Part is immersed in hot cleaning solution agitated by ultrasonics for 5 minutes. Depending on soil, may require the addition of rust inhibitors.
Elapsed time:

2. Part is immersed in first rinse tank for 3 minutes.
Elapsed time:

3. Part is immersed in second rinse tank for 3 minutes.
Elapsed time:

4. Part is held in drying chamber to evaporate water for 5 minutes.
Total elapsed time to finished part:



**Times required for cleaning and drying operations vary and depends on a variety of factors. General range for solvent cleaning is 1-7 minutes, while aqueous cleaning can take anywhere from 7 minutes to an hour or more.

Cost Comparison Example

The example below is based on a number of assumptions, as noted[1].
Contact your 3M Representative for a specific comparison based on your process.

	Solvent	Aqueous
Startup Cost		
Cleaning equipment	$25,000.00	$35,000.00
Reverse osmosis system[2]	—	$10,000.00
Space cost[3]	$3,750.00	$8,250.00
Initial fill	$750.00[4]	—
Total startup cost	**$29,500.00**	**$53,250.00**
Consumables Cost per Day		
Energy Usage	4 kw	9 kw
Energy Cost	$8.75	$19.68
Fluid Usage[6]	$15.00	—
Water Consumption[7]	—	$10.00
Waste Disposal Cost	Free[8]	?*
Total Cost per Day	**$23.75**	**$29.68**

* Waste disposal costs vary greatly.

[1] Data based on information gathered from industry experts as to typical expected costs in relation to both solvent and aqueous equipment. 5-day work week, 8 hours per day, 250 days per year.

[2] Kyzen reverse osmosis system, 6-20 gal. capacity.

[3] Equipment square footage times three to allow for working space needed; assumes $125/sq. ft.

[4] $15/lb avg x 10 lbs/gal x 5 gal fill

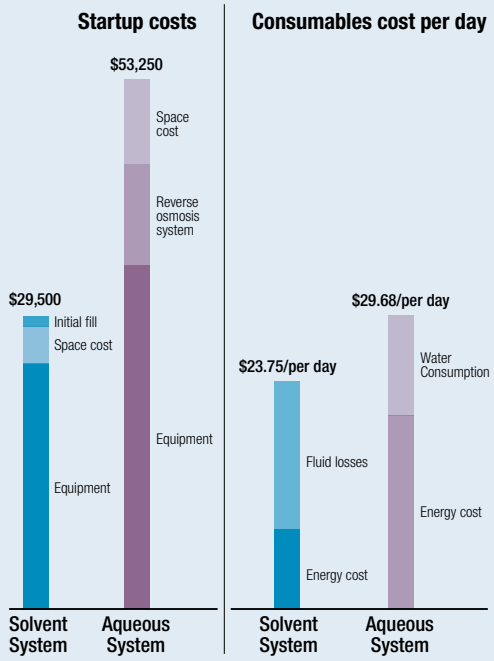
[5] Cost of energy and water/solvent consumption. Does not include equipment depreciation cost or labor/salaries.

[6] Loss rate of 1.5 liters/week and boil down every 2 months with a loss of 3 liters; see Fluid Consumption chart.

[7] Based on water consumption of 60 gals/hr. Water consumption can vary greatly (from 15 gal/hr to as much as 150 gal/hr) depending on cleanliness needed; see Fluid Consumption chart. Assumes cost per gallon for operation of DI water reverse osmosis system of 2 cents per gallon.

[8] 3M offers a Used Fluid Return Program free of charge for returns of 30 gallons or more.

Compare the Total Cost of Ownership of Solvent and Aqueous Cleaning



Fluid Consumption

Solvent System	Aqueous System
1-2 liters/week	600-6,000 gallons/week

The Bottom Line:

3M™ Novec™ Engineered Fluids can save you time and money over aqueous cleaning

- Less floor space
- Lower energy usage
- No waste disposal costs[8]
- Quick drying
- Improved cleaning of parts with complex geometries
- Conserves water

3M™ Novec™ Engineered Fluids Product Selection Guide
Precision Cleaning Applications

	Novec 7100	Novec 7200	Novec 71IPA	Novec 71DE	Novec 71DA	Novec 72DE	Novec 72DA	Novec 7200 Bi-solvent
Soils	Fluoro lubes, light oils, particulate	Fluoro lubes, light oils, particulate	Ionic soils, particulate, fluoro-grease	Oils, silicone, fluorosilicone, fluoro-grease	Flux, oils, silicone, fluorosilicone	Grease, oil, wax, silicone	Flux, ionic soils, silicone, grease, oil wax	Wax, pitch, grease, flux
Class of soils	Light	Light	Light	Medium	Medium	Medium/heavy	Medium/heavy	All
Solvent strength	Mild	Mild	Mild	Strong	Strong	Very strong	Very strong	Variable
Electronics								
Circuit boards	•	•			•		•	•
Hybrid			•		•		•	
Assemblies			•	•	•	•	•	•
Hard drive	•	•	•					
Fiber optics	•		•					
Components			•	•	•	•	•	•
Flex circuits		•	•			•	•	•
Aerospace								
Instruments				•	•	•	•	•
Oxygen systems	•	•		•				
Engines			•			•		•
Maintenance						•		•
Seals, gaskets			•			•		
Hydraulic tubes				•		•		
Gauges	•			•				
Medical								
Orthopedic			•		•	•	•	•
Dental implants						•	•	•
Spinal implants						•	•	•
Cardiac			•			•		
Needles				•	•	•	•	
Surgical staples						•	•	
Surgical blades						•		
Catheters			•					
Plastics			•					•
Silicone tubes			•	•		•		
Surgical tools			•	•		•		
Industrial								
Bearings						•		•
Mechanical						•		•
Metal forming						•	•	
Specialty Cleaning								
Optics						•	•	•
Film cleaning		Novec 8200						•
Piezo electrics						•		

Materials Compatibility

When selecting a cleaning solvent, materials compatibility is as important as the solvent's cleaning ability. Novec fluids are compatible with a wide range of substrates used in aerospace materials, medical devices, optical components, electronics and other parts requiring very clean, spot-free finishes. Independent laboratory compatibility test results of 3M™ Novec™ Engineered 7100, 71DE, 72DA, 72DE and 7200 Fluids are listed below.

Test Description	ASTM#	Novec 7100	Novec 71DE	Novec 7200	Novec 72DA	Novec 72DE
Sandwich Corrosion Test	F1110	Conforms	Conforms	Conforms	Conforms	Conforms
Acrylic Stress Crazing	F484	Conforms	Doesn't conform*	Conforms	Doesn't conform*	Doesn't conform*
Paint Softening Test	F502	Conforms	Conforms	Conforms	Conforms	Conforms
Hydrogen Embrittlement	F519-77	Conforms	Conforms	Conforms	Conforms	Conforms
Hydrogen Embrittlement	F519,1C	Conforms	Conforms	Conforms	Conforms	Conforms
Residue Test	F485	Conforms	Conforms	Conforms	Conforms	Conforms
Immersion Corrosion Test	F483	Conforms	Conforms	Conforms	Conforms	Conforms
Cadmium Removal Test	F483	Conforms	Conforms	Conforms	Conforms	Conforms
Low Embrittling Cadmium Plate	F111	Conforms	Conforms	Conforms	Conforms	Conforms
Flash Point	D56	Conforms	Conforms	Conforms	Conforms	Conforms

* Novec fluids 71DE, 72DA, and 72DE caused visible stress crazing of the acrylic plastics. Testing performed by Scientific Materials, Inc.

3M™ Novec™ Engineered Fluids have been approved in a number of high-value applications within the government and military markets. Please contact your 3M representative for more information.

Resources

3M™ Novec™ Engineered Fluids are supported by global sales, technical and customer service resources, with fully-staffed technical service laboratories in the U.S., Europe, Japan, Latin America and Southeast Asia. Users benefit from 3M's broad technology base and continuing attention to product development, performance, safety and environmental issues.

For additional technical information on 3M™ Novec™ Engineered Fluids in the United States, call 3M Customer Service, **800 810 8513**.

For information on additional 3M fluids, coatings and other materials for the electronics industry, visit our web site at: **www.3M.com/electronics**.

The 3M™ Novec™ Brand Family

The Novec brand is the hallmark for a variety of patented 3M compounds. Although each has its own unique formula and performance properties, all Novec products are designed to address the need for safe, effective, sustainable solutions in industry-specific applications. These include precision and electronics cleaning, heat transfer, fire protection, lubricant deposition and several specialty chemical applications.

3M™ Novec™ Engineered Fluids ▪ 3M™ Novec™ Aerosol Cleaners ▪ 3M™ Novec™ 1230 Fire Protection Fluid ▪ 3M™ Novec™ Electronic Coatings ▪ 3M™ Novec™ Electronic Surfactants

United States
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Taiwan
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Electronics Markets Materials Division
3M Center, Building 224-3N-11
St. Paul, MN 55144-1000
www.3M.com/electronics
1-800-810-8513

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