COOL® CLEAN TECHNOLOGIES

Company and Technology Overview

Since 2001,

We Were Clean Before It Was Cool

COOL® CLEAN TECHNOLOGIES

Who is Cool Clean Technologies?

- **Founded:** 2001 | **HQ:** Eagan, MN
- **Focus:** Sustainable alternatives to traditional manufacturing & assembly methods
- **A company that uses CO_2 in all phases:** Cleaning, surface preparation, cooling, extraction, and more
- **Benefits from our processes:** Effectively dry, zero to trace byproducts, no touch, solvent-free, lower energy costs, and environmentally friendly
- **Industries Served:** Automotive, Aerospace, Medical, Electronics, Fire Service & more

- **Global Presence:**
  - **Manufacturing/Sourcing:** USA, Asia, Europe
  - **Sales & Distribution:** USA, South America, Canada, Mexico, Asia, Europe
  - **Sales & Service Support:** North & South America, Canada, Europe, and key Asian markets (China, India, Vietnam, Malaysia, Korea, Singapore, Thailand, Philippines, Taiwan)

Mission Statement

To apply our innovative CO_2 technologies to complex precision cleaning, extraction & cooling applications in order to improve productivity, quality & safety in an environmentally friendly way.

Environmentally friendly
and
cost effective solutions!

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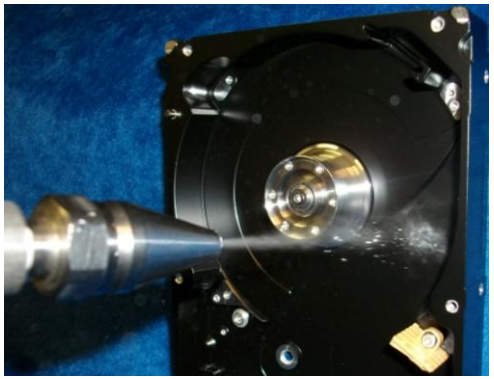
Core Competencies

- **CO_2 Spray Cleaning**
  - Particle Removal (Down to 0.3 microns)
  - Surface Preparation prior to Painting/Coating
  - Residue Removal (Soot, Solder Flux, Oils)
  - Plastics Deburring
- **Machine Tool Cooling and Lubrication**
  - Dry Machining (Milling, Grinding, Turning)
  - Through Tool Drilling (CFRP-Ti, composites)
- **Liquid CO_2 Cleaning, Extraction, and Sterilization**
  - Silicone Extraction
  - Elastomer Outgassing
  - Degreasing
  - Porous Metal and Additive Manufacturing
  - Oil Extraction (Hemp, coffee, spices)
  - Medical Devices and Garments

Spray Cleaning



Liquid CO_2 Cleaning and Extraction

Machine Tool Cooling and Lubrication

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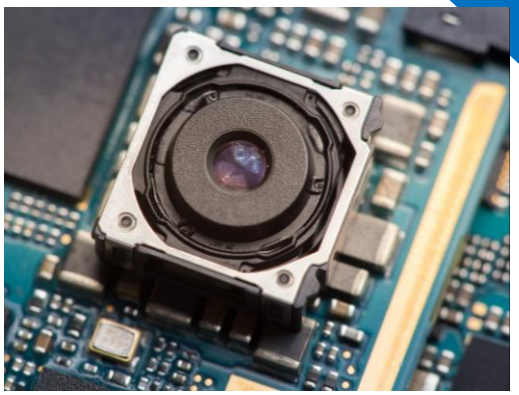
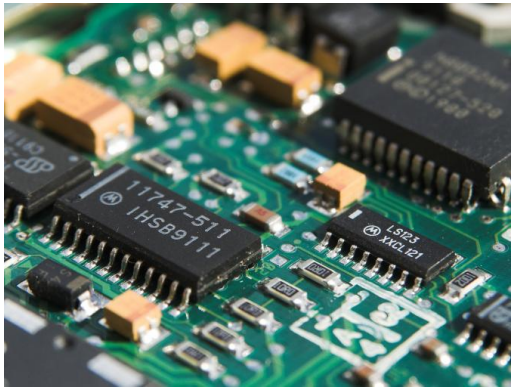
Markets We Serve

Automotive

Medical



Optics & Lens



Electronics

Aerospace

Fire Service

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Why CO_2 Based Technology?

- **Sustainable Process**
  - Cool Clean is a User NOT a Producer of CO_2
  - Utilize recycled CO_2, which is obtained from capturing CO_2 that is produced as a byproduct of natural and industrial processes before reaching the environment
  - Same beverage grade CO_2 used by Coke and Pepsi
- **EPA has named our technology a SNAP (significant new alternative process) technology because it is at worst "environmentally neutral"**
- **When replacing solvents, water waste or a drying process, we become environmentally positive**
- **No reporting requirements for using our system as you are not increasing a carbon footprint**

- **Other common CO_2 uses:**
  - Carbonated beverages
  - Refrigeration and storage
  - Aerosol cans
  - Welding gas
  - Fire extinguishers

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CO_2 Spray Cleaning

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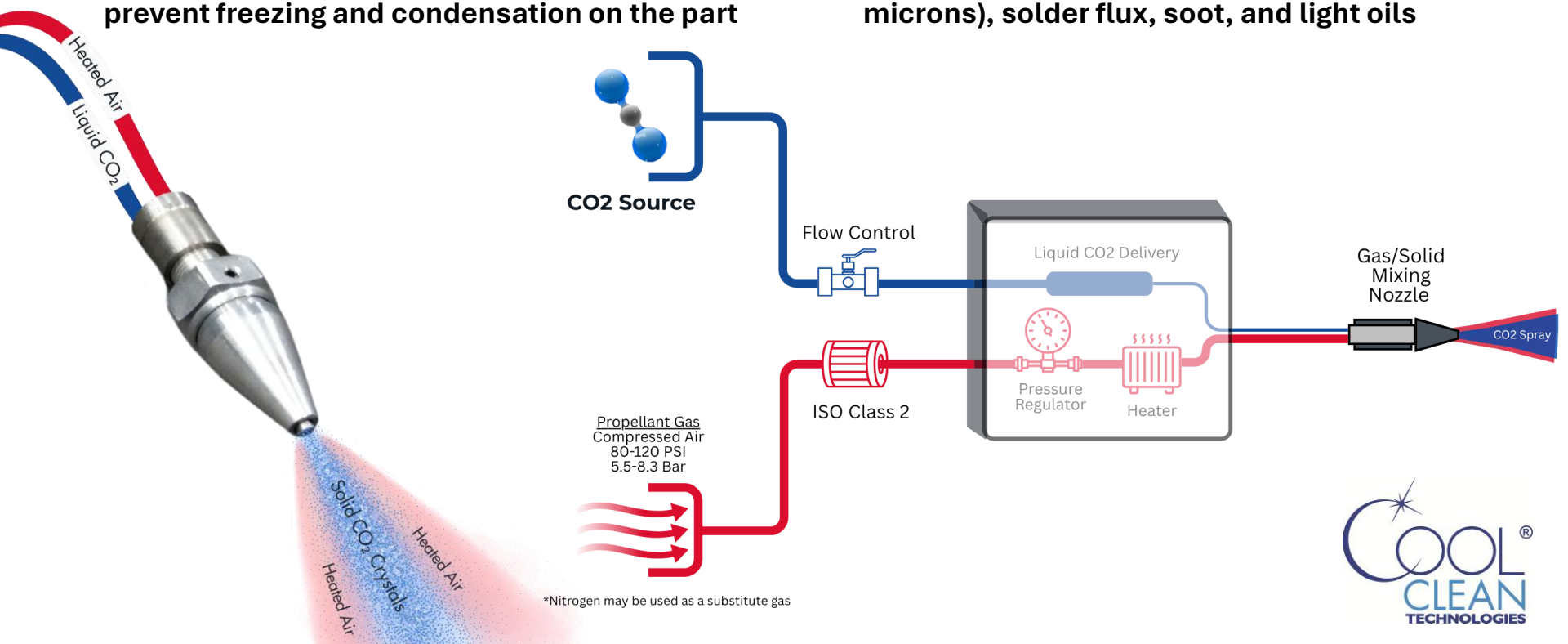
CO_2 Spray Technology

- CO_2 spray is created at the nozzle by condensing liquid CO_2 to create solid CO_2 crystals
- Patented CO_2 spray technology heats the compressed air surrounding the CO_2 crystals to prevent freezing and condensation on the part
- Adjustable CO_2 particle size, density, and cleaning energy adapt to a wide range of applications
- Removes particulates (down to 0.3 microns), solder flux, soot, and light oils



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CO_2 Spray Nozzle Offerings

Coaxial

Standard spray configuration

Soft / small CO2 particles

Working Distance:
10 – 25 mm

Coanda

Long range nozzle system

Large, high momentum CO2 particles

Working Distance:
50 – 300 mm

FLEX Design Available for Larger Spray Configurations

HEN
(High Energy Nozzle)

Concentrated spray particles

Very high momentum, large CO2 particles

Working Distance:
25 - 250 mm

SW-HEN

Wider spray pattern than HEN

High momentum CO2 particles

Working Distance:
10 – 100 mm

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FLEX Desing

- Instant on/off
- Simplified nozzle configuration
- One hose for easy robot management
- Variable spray width

Coanda FLEX

*8 nozzle configuration shown

Large, high momentum CO2 particles

Long range nozzle system

Induces ambience into cleaning jet

Working Distance:
50-300 mm

HEN FLEX

*9 nozzle configuration shown

Long range nozzle system

High momentum CO2 particles

Working Distance:
50 – 100 mm

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Hard Disk Drive Component Cleaning

Cleaning Cost Comparison

DI/US Immersion

- Deionized water (immersion/drying)
- Best for complex surfaces “Ionic Cleanliness”
- Cleans disassembled devices
- $0.12-$0.13/part

CO_2 Spray

- CO_2 spray (customized nozzles)
- Best for semi-planar surfaces “Non-Ionic Cleanliness”
- Cleans partially assembled devices
- $0.015-$0.06/part

Automated HDD Cleaning Video

90% of all HDDs are being cleaned using CO_2 based cleaning

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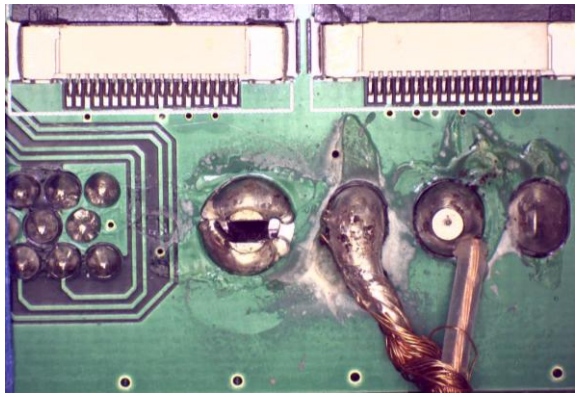
CO_2 Cleaning for Electronics

- **Waterless and solvent free cleaning**
- **Automated to improve accuracy and efficiency**
- **Cleaning removes solder flux, soot, submicron particles, oils, and other debris**
- **Non-abrasive to delicate components on board**
- **Leaves behind no residue post cleaning**
- **Surface preparation prior to soldering and welding**
- **Precision spot cleaning to avoid problem areas**

Solder Flux Removal Video

Flux Residue Removal

Before



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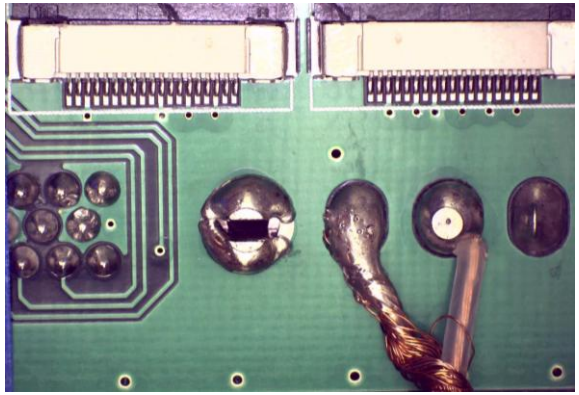

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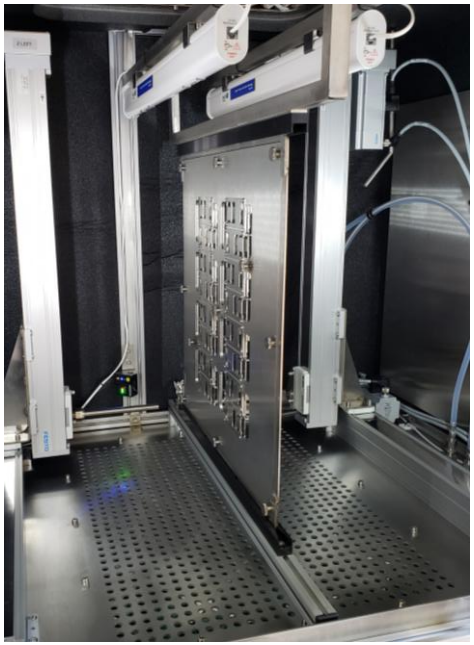
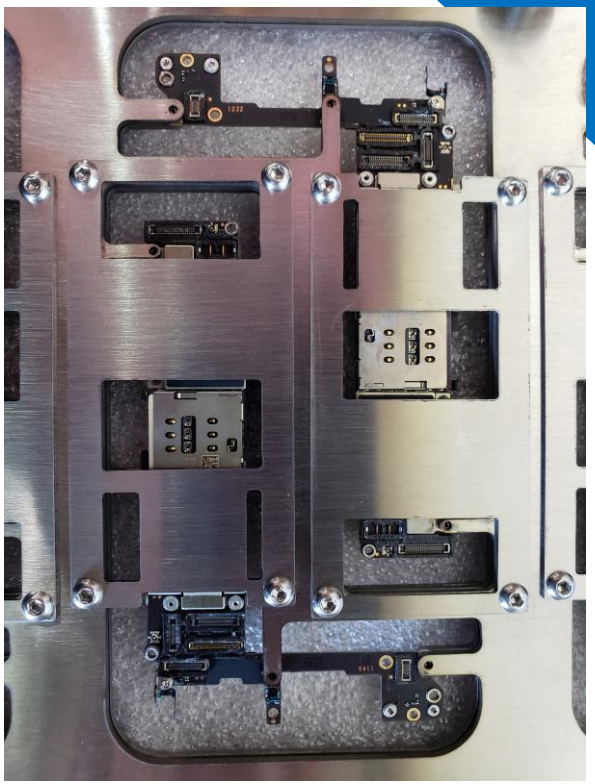
Automated Cleaning Cell for Phone Boards



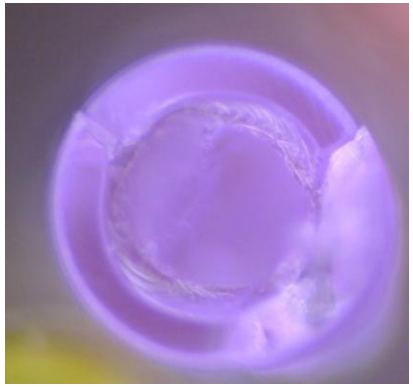


[Automated Clean Cell for Electronics & PCBs Video]

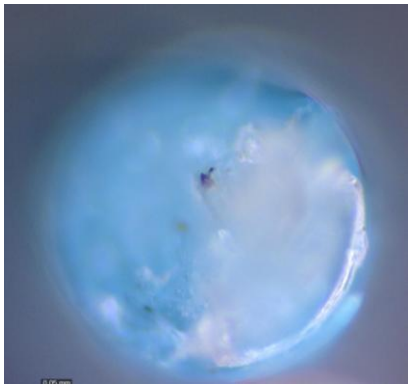
Fiber Optics Connector Cleaning

Before

After



Before



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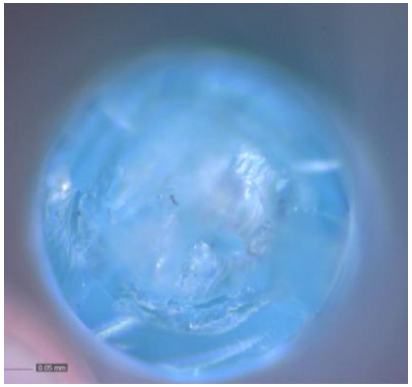

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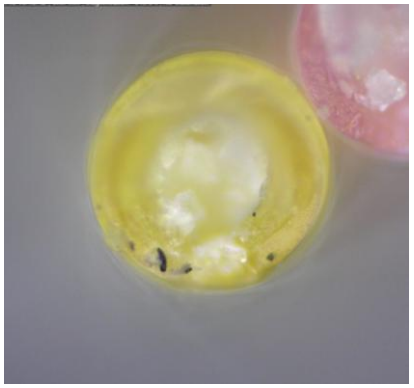

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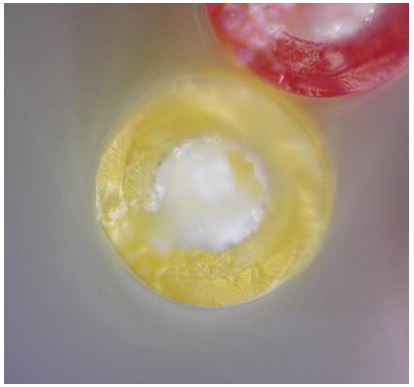

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Optics ands Lens Cleaning

CO_2 cleaning removes debris and oily contamination optical components, such as fiber optic connectors, and camera modules

Before

After

Camera Module CO_2 Cleaning Video

Automotive Parts Cleaning

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CO_2 Used to Clean Various Automotive Components

CO_2 spray cleaning is used to clean various exterior and interior automotive trim components for all vehicles

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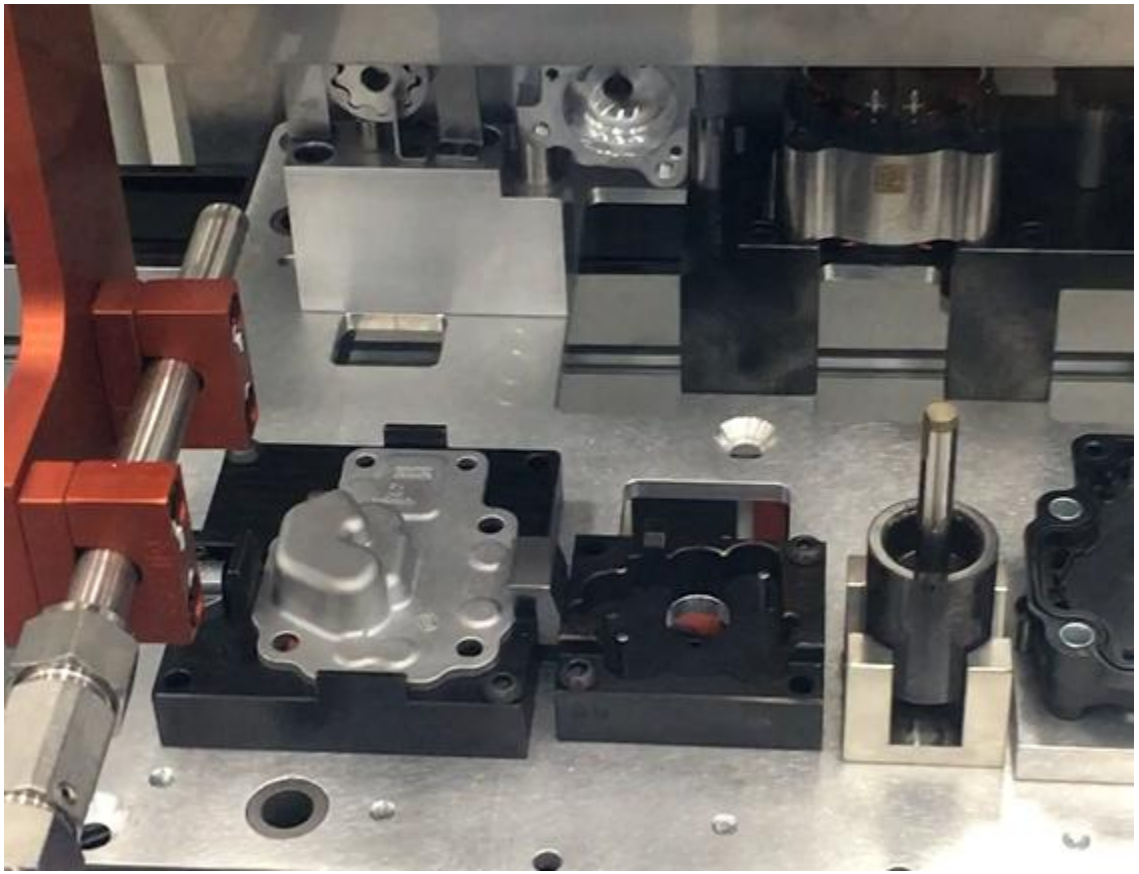
Integrated CO_2 Spray Cleaning for Automotive Transmission Components



Automotive Transmission Component Cleaning Video

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EV Battery Divider Plate

PROBLEM :

- Cleaning residues from divider plate
- Reduce labor costs
- Need a waterless solution

ACTION :

- Implemented CO_2 cleaning after the laser ablation and before the application
- Automated in line process for 3 EV Battery assembly lines

RESULT :

- Nonabrasive cleaning for components
- Cost-effective and efficient
- Minimized defect rate
- Lower manufacturing costs
- Reduced cleaning time

- **TA Systems and PA Solutions partnered to design, manufacture, and install EV battery divider plate assembly systems**
  - Each system produces a part in 6.1 seconds and occupies less than 450 square feet
  - The workflow includes robotic loading, laser ablation, CO_2 cleaning, foam application, hi-pot testing, automated barcode application, and robotic unloading

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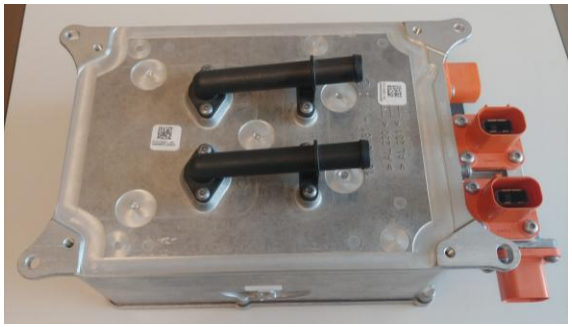
Electronic Components/Systems

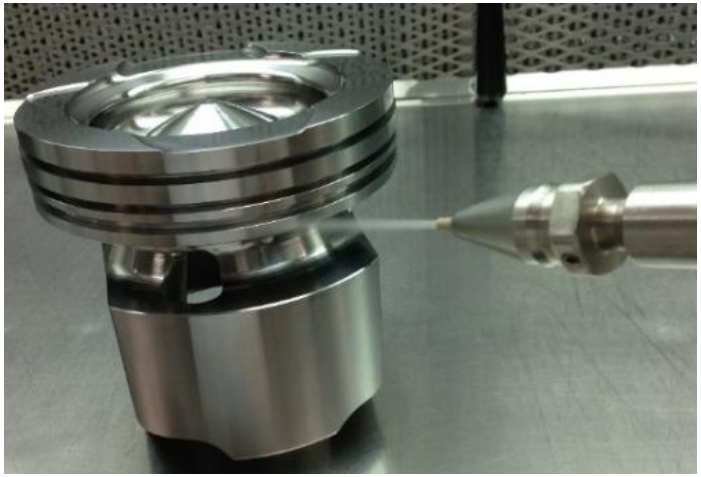
- **Residue Removal**
  - Removing particulate and metal residue that could create an arc during assembly and validation testing in power supply
- **Waterless/solventless cleaning solution**
- **Removing particulate and residue throughout the assembly process**
- **Reduced cooling time after stir friction welding/sealing of unit**

EV Battery Housing



Cleaning Truck Pistons Prior to Inspection

- **Removes machining coolants, particulate, and metal chips from precision pistons for sizing**
- **Self contained system that interfaces with production line, 6 axis robot, and automatic sizing tool**



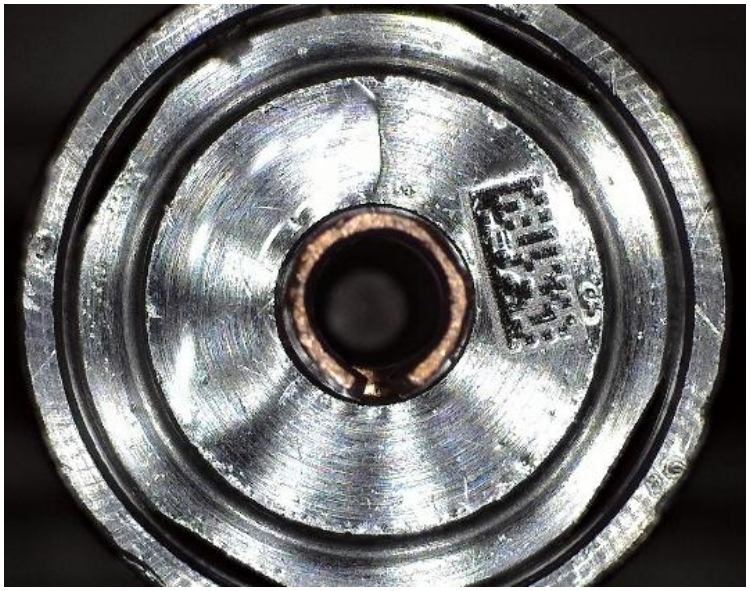
Machining Coolant Removal Video

COOL® CLEAN TECHNOLOGIES

Fuel Injector Part Cleaning with Automation

Laser weld soot and oil-based contamination removal

Before



After

Fuel Injector Cleaning Video

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Jeep Grill Cleaning

Grill Cleaning Video

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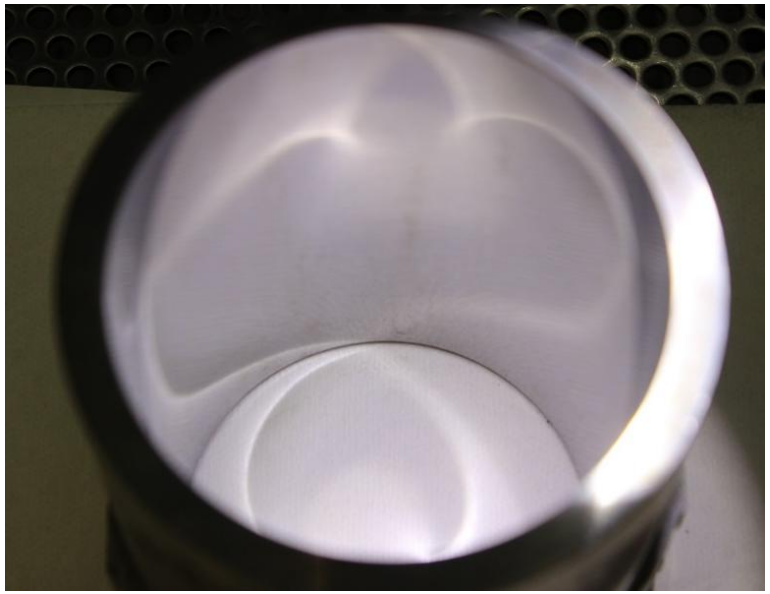
Entire Car Body Cleaning

Automated CO2 Cleaning for Car Body

Automotive Cylinder Wall Cleaning

Before

After



Cylinder Wall Cleaning with Radial Nozzle Video

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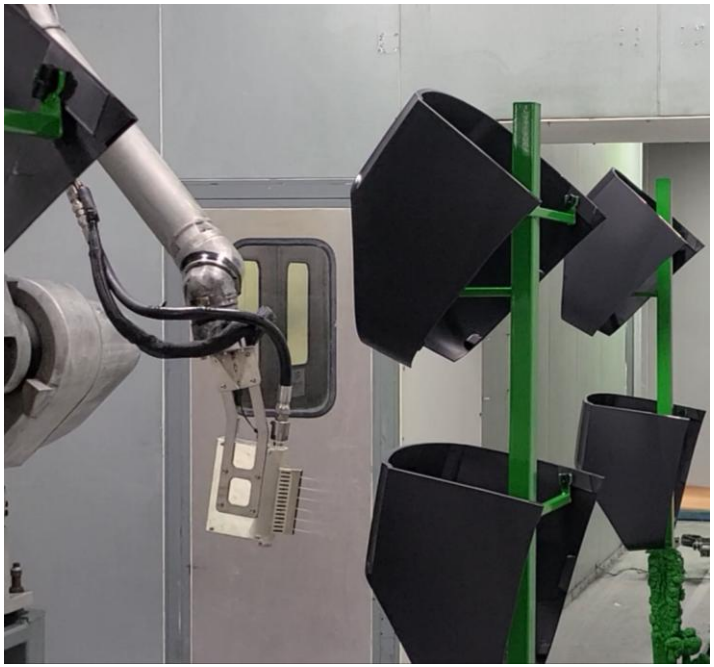
Automotive Plastic Parts Cleaning

Automated Inline Cleaning Video



Omega™ FLEX CO_2 Spray Cleaning Video

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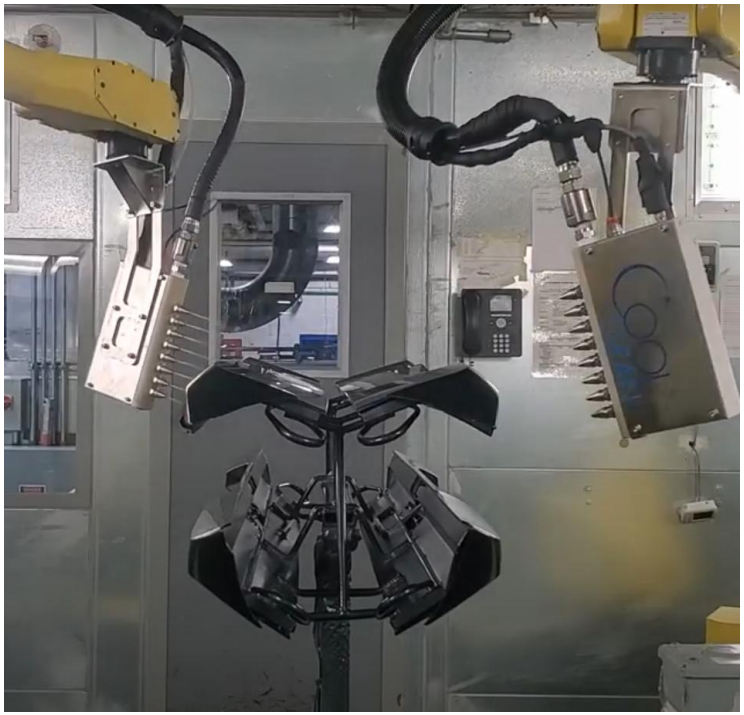
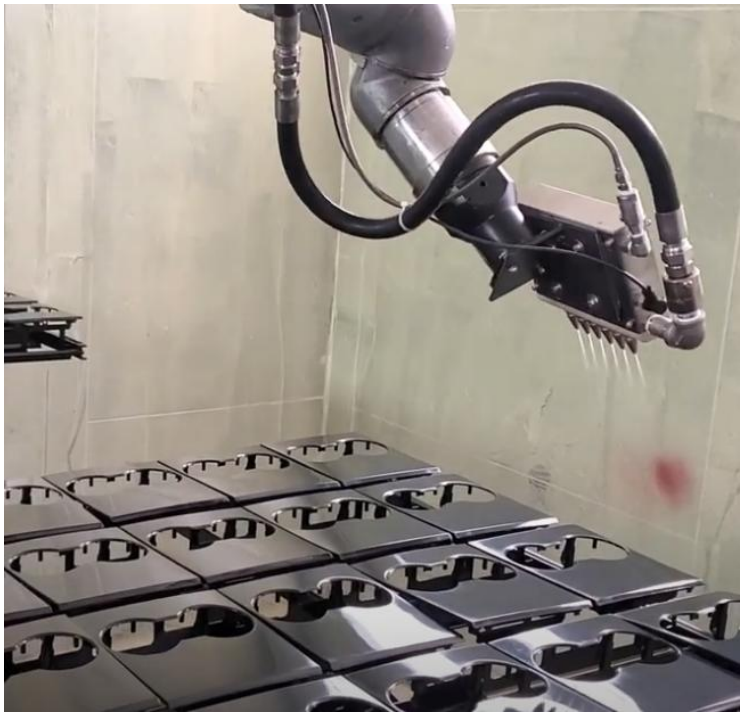
Automotive Plastic Parts Cleaning





Omega™ FLEX Automated CO_2 Spray Cleaning Video

Cupholder Cleaning Video

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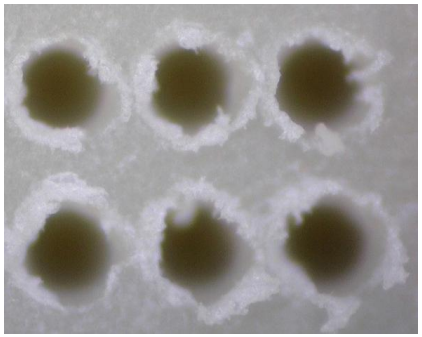
Plastic Deburring/Deflashing

- **Application**
  - Miscellaneous Peek Orthopedic Parts
- **Original Deburring Method**
  - Manual Knife Deburring
- **CO_2 Omega™ with high impact spray**
- **Economic Benefit**
  - Elimination 6-10 minutes per parts

PEEK Deburring Video

Before



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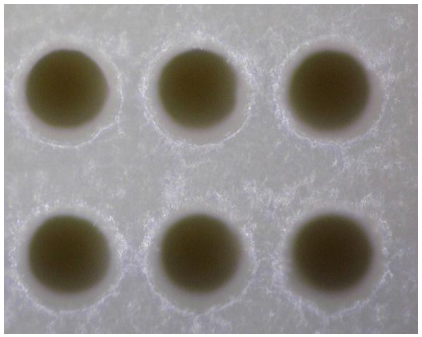

Before

After

COOL® CLEAN TECHNOLOGIES

Machine Tool Cooling and Lubrication

COOL® CLEAN TECHNOLOGIES

CO_2 Cooling Delivery Methods

External Nozzle

Through Tool/Spindle

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Why CO_2 Coolant?

- **Readily Available and Inexpensive**
- **Universal, Renewable, Recyclable and Green**
- **Excellent Cooling Properties**
- **Easy to Control**
- **Inert to Most Material, such as CFRP**
- **Solid CO_2 Crystals Penetrates Boundary Layer**
- **Significant Cooling by Sublimation of CO_2 Crystals**
- **No Post Process Cleaning Needed**
- **No Waiting for Part To Cool**
- **Better Surface Finish Requires Little or No Polishing**

Advantages of CO_2 Coolant

- **"Dry" Machining**
  - Machining Without Water or Oil,
  - Everything Dry, Ideal for Composite Material
- **"Clean" Machining**
  - Cools without producing a coolant agent waste
  - (spent coolant – oil - water, filters)
- **"Green" Pollution Prevention (P2)**
  - Reduces environmental waste at the source
  - (energy savings, no water pumps, liquid wastes)

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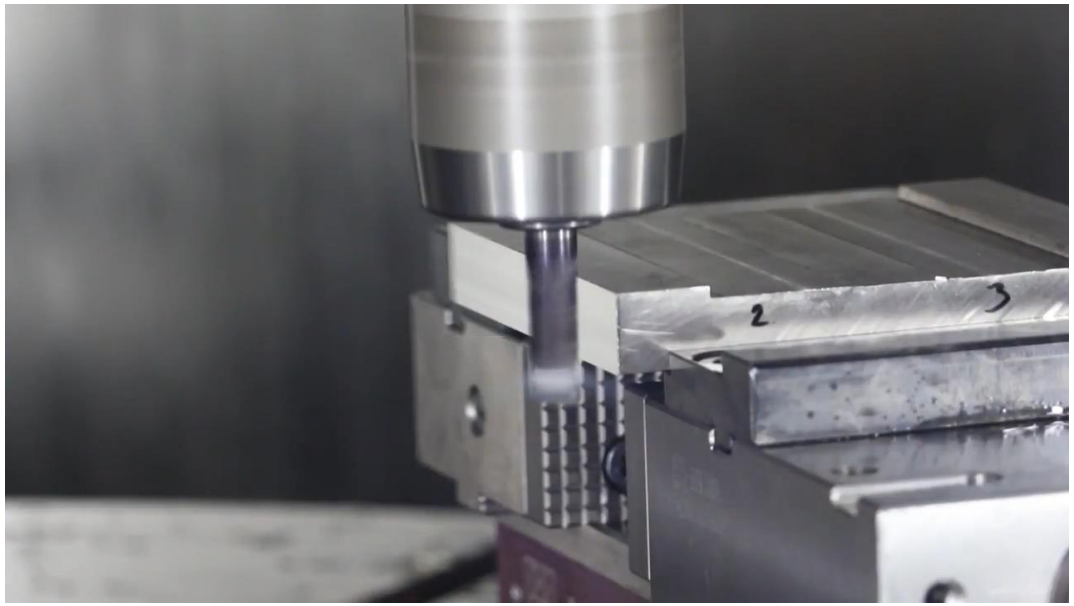
CO_2 Cooling at Research Facility



NUCLEAR AMRC
ADVANCED MANUFACTURING RESEARCH CENTRE

CO_2 Cooling - Through Tool & External Video

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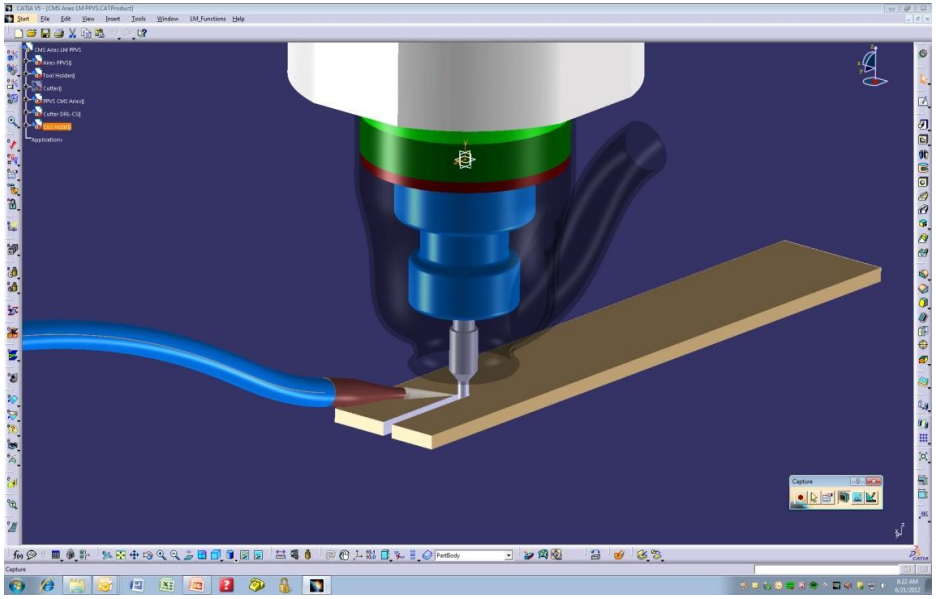
Composite Milling/Trimming

- External spray cooling on workpiece for composite trimming
- Decrease in cutter wear due to heat reduction in the cutting tools
- Feed rate increased by 30%



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Drilling Composite Titanium Stackups

Drilling CFRP Titanium Stackup with CO_2 Coolant Video

COOL® CLEAN TECHNOLOGIES

Liquid CO_2 Cleaning, Extraction, and Sterilization

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Liquid CO_2 Solutions

Applications:

- LCO_2 & $SCCO_2$ extraction for aerospace materials
- Automotive component degreasing systems
- Sterilization of medical devices
- Commercial CO_2 garment cleaning systems
- Bio-based jet fuel from algae via US Air Force
- High-capacity cannabis extraction systems
- Decontamination of fire and rescue gear

Standard Capacities:

- 450 liters
- 610 liters
- 1200 liters

COOL® CLEAN TECHNOLOGIES

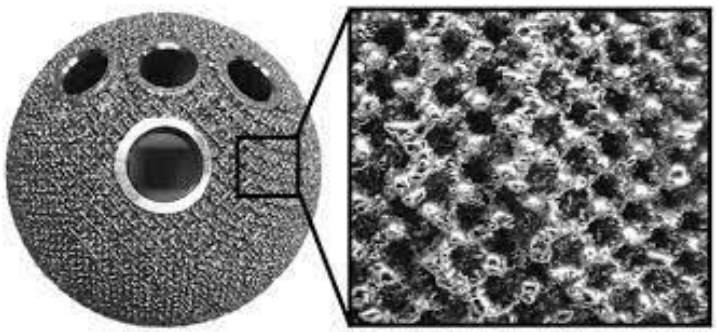
Key Features and Benefits

- Easy to operate "push button" system
- Lowest operating cost process
- Non-toxic, non-flammable, non-corrosive, odorless, chemically stable, and recycled (non-emitting)
- Simple material loading and unloading
- 99% recovery of CO_2 to be reused for additional cycles
- Modular system that requires much less space compared to traditional CO_2 "super critical" machines
- Closed Loop Cleaning System Recycles Fluids for Reuse
- No Residual Contamination
- No Costly Drying Required
- Optional Non-VOC Solvent Package & Ultrasonics

COOL® CLEAN TECHNOLOGIES

Orthopedic Implants – Hip Cup Cleaning

- **Original Cleaning Method**
  - 3 Stage Aqueous Washer
  - Chem-Crest Detergent
- **Enertia™ System Specification**
  - Enertia™ GFx
  - Custom Fixturing for 200 Hip Cups per Cycle
  - Multiple Ultrasonic Modules
  - PLC Programming for FDA Documentation
- **Economic and Environmental Benefit**
  - Better Cleaning than Aqueous
  - No Waste Water Disposal
  - Small Footprint



Orthopedic Medical Device Cleaning with LCO_2 Video

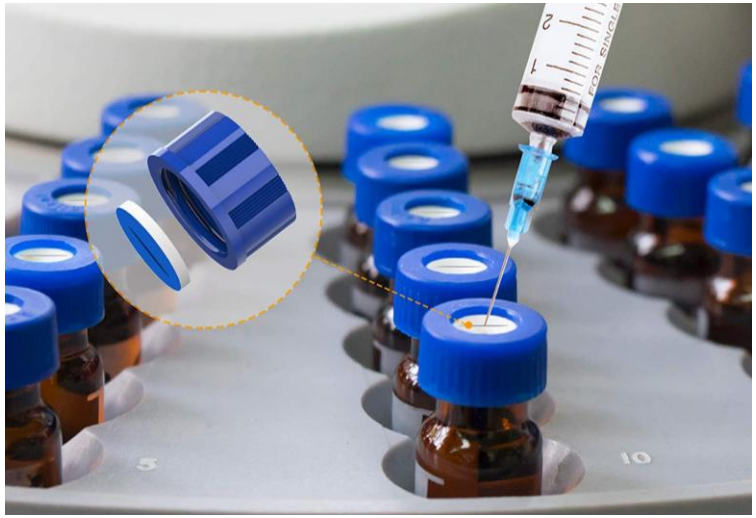
COOL® CLEAN TECHNOLOGIES

Silicone Implants – FDA Approved Process

- **Application**
  - Breast Implant Silicone Oil Extraction
- **Original Cleaning Method**
  - IPA wash system
  - Vacuum Bake Out Oven
  - 16 Hour Cycle time
- **Enertia™ System Specification**
  - Enertia™ GFx
  - 12 Cubic Foot Cleaning Vessel
- **Economic and Environmental Benefit**
  - Replaced IPA wash system
  - Payback by less than 18 months

Silicone Extraction from Septa Discs/Bottle Caps

- **Original Cleaning Method**
  - Vacuum Bake Out Oven
- **30 Hour Cycle time**
- **Enertia™ System Specification**
  - Enertia™ GFx
  - 12 Cubic Foot Cleaning Vessel
- **Economic and Environmental Benefit**
  - Saved Over 50% on Every Cycle on Utilities
  - Short Cycle Time (70% Reduction)
  - Better Extraction Results



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Medical Textiles – Liquid and $SCCO_2$

CO_2 cleaning equipment used to clean medical textiles

Actual textile before and after LCO2 Cleaning

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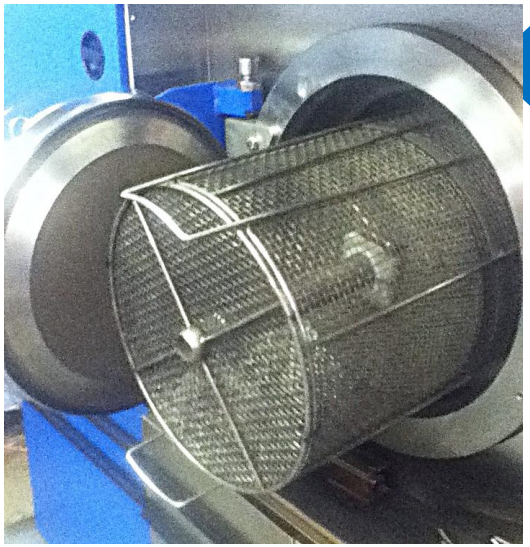
Degreasing Metal Parts

- **Removal of machining contaminates from metal parts**
  - Machining Coolant, Stamping Oil, Drawing Compounds, Grease, Particles, and other organic and nonorganic substances
- **Liquid CO_2 penetrates small crevices**
- **Batch cleaning process for multiple parts in a single load**
- **Parts removed clean and dry**
- **Liquid CO_2 used for degreasing is distilled and reused for subsequent loads**



COOL® CLEAN TECHNOLOGIES

Garment Cleaning/Sterilization

- Non-toxic cleaning agents
- Short cycle time
- No load separation required
- Simple one-button operation
- No stain setting
- Prolonged clothing life
- Less machine maintenance
- No post drying required

COOL® CLEAN TECHNOLOGIES

Firefighter Turnout Cleaning

- Liquid CO_2 cleaning and decontamination of toxins from turnout gear and PPE worn by firefighters
- Equipment being used by Emergency Technical Decon for decontamination and cleaning services of firefighter turnout gear and PPE
- Proven to remove over 99% of harmful toxins and extending the life of the gear

Before

After

EMERGENCY
TECHNICAL DECON

COOL® CLEAN TECHNOLOGIES

Cannabis Oil Extraction

Cold CO_2 Extraction™ for separating cannabinoids from plant material

- Less Post Processing
- Large Volume Extraction Capacity
- Simple Loading & Unloading
- Automatic Dispensing of Extracted Oil
- Retains Terpenes
- Little to No Winterization
- Recovers 99% CO_2 for Reuse

[Cold CO_2 Extraction™ - Terpene and Cannabinoid Cut Video]

For Further Information . . .

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