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**Technical Summary
of the
CO₂ Blast Cleaning Process**

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GENERAL DESCRIPTION OF CARBON DIOXIDE BLASTING

Liquid carbon dioxide (CO₂) is converted to a pellet state for cleaning and decontamination, refer to Illustration 1. Liquid CO₂ is stored in a storage tank at 200-300 PSIG, then transported to the pelletizing chamber within the pelletizer. A rapid expansion of the liquid within the chamber reduces the pressure dramatically and converts the CO₂ to a solid state in the form of dry ice or snow. The snow is compressed and extruded through a ring die into small pellets. The pellets are then transported through a hose at 40 PSIG to the blasting nozzle or gun.

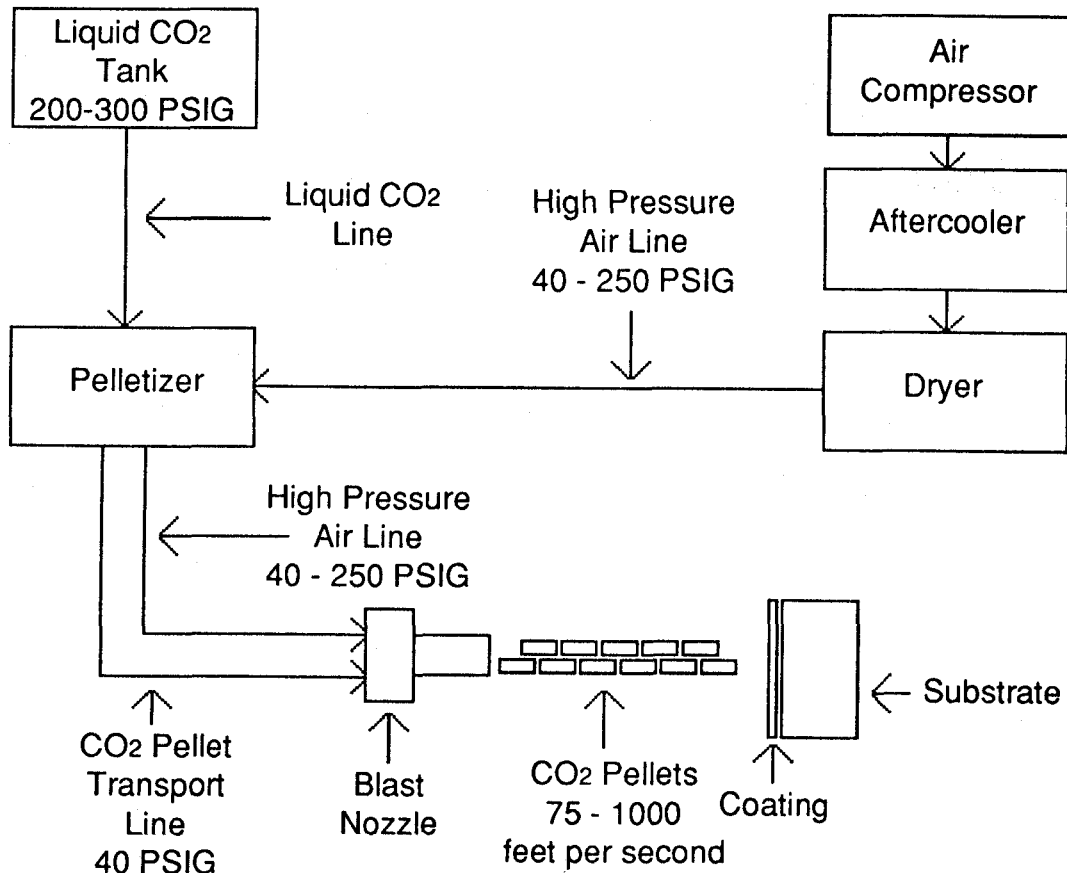
In a separate process, air is compressed, cooled, and dried. The air is then transported to

the pelletizer. An air hose from the pelletizer carries air at 40-250 PSIG, depending on the application.

At the gun, the pellets are entrained into the high pressure air by way of a venturi effect, and are propelled from the nozzle at a velocity of 75-1,000 feet per second. Pellet velocity is a function of the air pressure selected for the application being performed. The pellets are projected onto the surface being cleaned in a manner similar to sand or grit blasting, but the cleaning dynamics at the surface differ dramatically.

Illustration 1

The CO₂ Pellet System



CLEANING DYNAMICS

During impact upon a surface, a particle such as grit or a CO₂ pellet undergoes a deformation phase, caused by the impact, and restitution phase, the response to the deformation, during which the particle attains its next stable state.

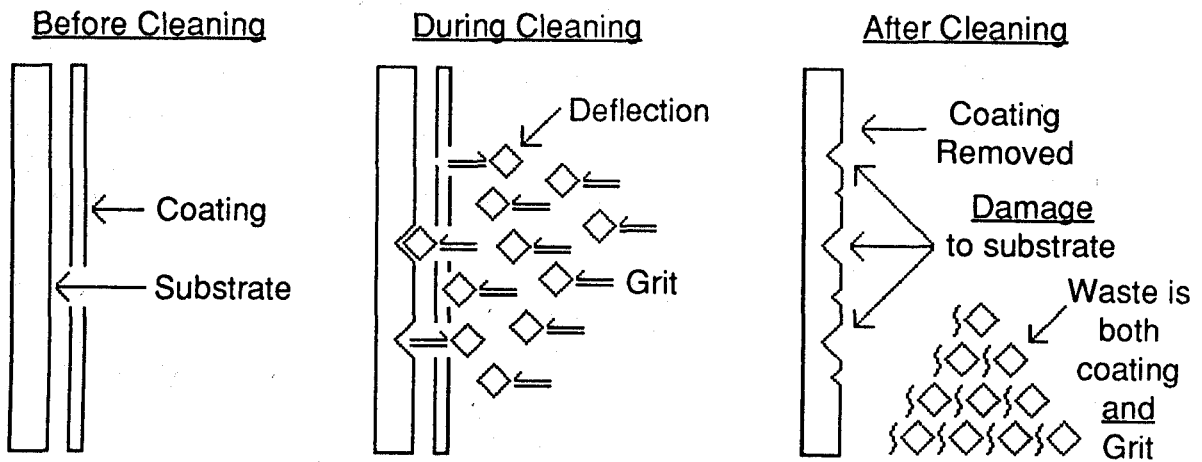
The Cleaning Dynamics of Grit

Conventional grit blasting uses a chiseling action, as shown in Illustration 2. Removal of the coating or contaminates on the surface being cleaned occurs by a chiseling effect as the

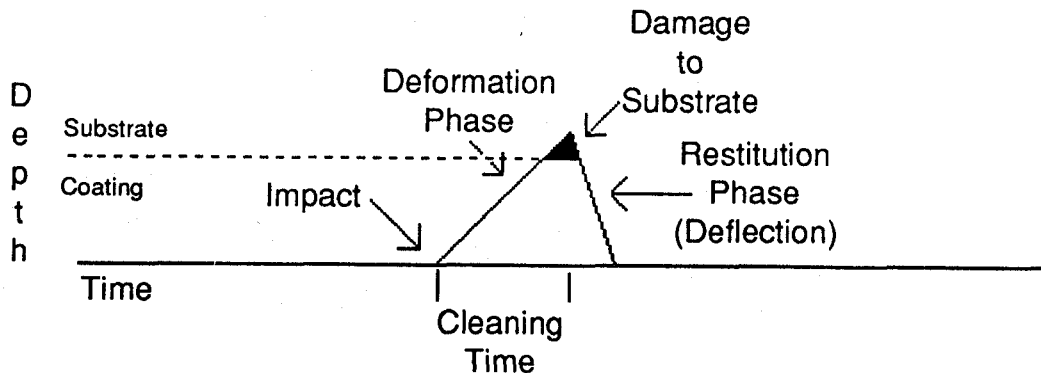
grit particle strikes the target material. The deformation phase of grit blasting consists of the grit particle striking the surface and cleaning. Cleaning occurs only during this phase. Because the grit particle contacts the surface at high pressure and does not change to a different state, the grit particle causes damage to the substrate during the deformation phase. The restitution phase occurs as the particle bounces off the surface, becoming additional contaminated waste to be disposed of or processed.

Illustration 2

The Cleaning Action of Grit



Impact Depth and Cleaning Time of Grit



The Cleaning Dynamics of CO₂

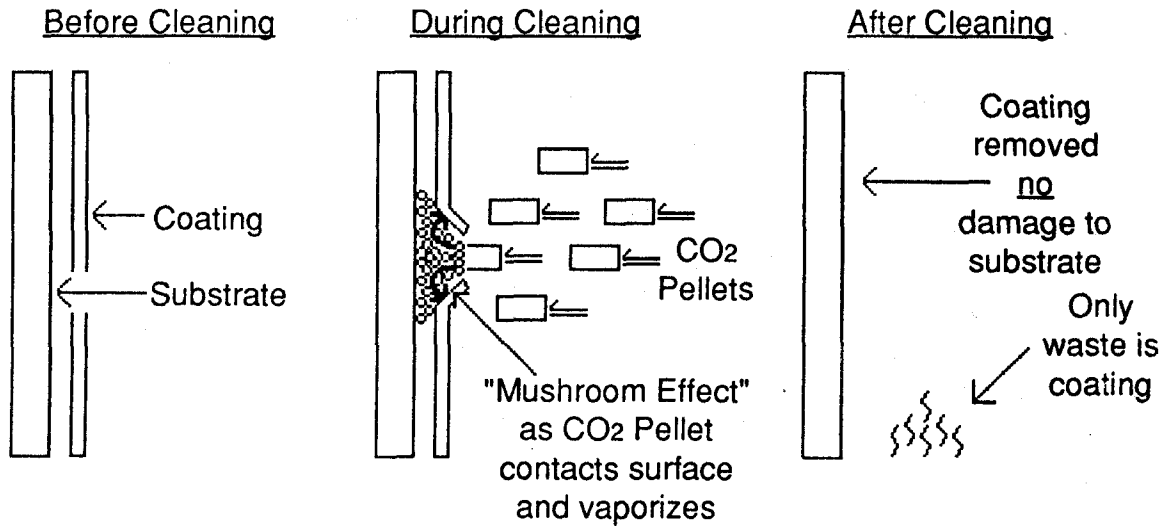
CO₂ blasting, compared to grit blasting, has a much longer cleaning time, refer to Illustration 3. During the deformation phase, a CO₂ pellet strikes the surface and penetrates the coating, removing the coating. Upon impact, the CO₂ pellet begins its restitution phase, and transforms into vapor. Because the volume per pound of a gas is much greater than that of a solid, the CO₂ pellet "mushrooms" under the

adjacent coating, providing additional cleaning action.

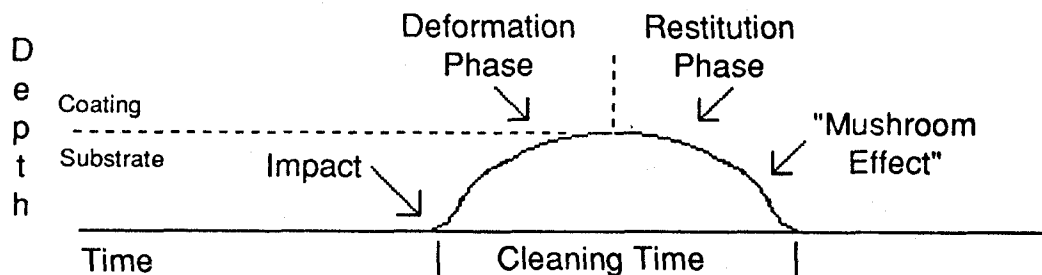
CO₂ pellets impact the surface at a far lower pressure than grit particles. Rather than damaging the substrate, a CO₂ pellet sublimates, turning to vapor. These two factors result in a longer cleaning time when compared to grit and no damage to the substrate. The CO₂ pellet returns to its natural state as a gas, leaving only the coating as waste.

Illustration 3

The Cleaning Action of CO₂



Impact Depth and Cleaning Time of CO₂



ADVANTAGES OF CO₂ BLASTING OVER GRIT BLASTING

The cleaning effect of the CO₂ is superior to grit blasting in the following ways:

FLUSHING ACTION

The CO₂ pellet strikes the surface and mushrooms under the coating, lifting the coated surface from the substrate rather than chiseling it away. This action expands the coverage of each pellet and creates a more efficient cleaning process.

CLEANING TIME

Unlike grit, which cleans only during the deformation phase, CO₂ cleans throughout the deformation and restitution phases. The result is that each CO₂ particle is actually involved in the cleaning process for a significantly longer time than grit particles.

EXPANSION EFFECT

Since the volume per pound of a gas is

many times greater than that of a solid, an additional lifting or "mushroom effect" is created as the CO₂ pellet sublimates beneath the coating and expands to its gaseous state. This expansion removes the adjacent coating, providing greater cleaning efficiency.

NO DAMAGE TO THE SUBSTRATE

For a given particle velocity, compared to grit blasting, the CO₂ pellet does not create as high an impact pressure, so there is no damage to the substrate.

NO RESIDUAL WASTE

In addition to being a superior cleaning technique, CO₂ blasting has the important advantage over other cleaning methods. The absence of residual waste from the cleaning process. The only waste generated is that amount of waste material(s) removed from the surface.

CO₂ BLASTING VERSUS OTHER CLEANING TECHNIQUES

WATER

CO₂ can replace water (hydro-lasing) as a cleaning medium. The most significant advantage CO₂ has over water is that CO₂ produces no residual waste that must be processed. CO₂ removes the need to incorporate costly water processing and filtering in a cleaning program. Also, because CO₂ is a dry medium, it is safe around electrical equipment.

CHEMICALS

CO₂ can replace chemicals as a cleaning medium. CO₂ produces no hazardous mixed waste at job completion, and thus eliminates costly processing and/or disposal. CO₂ also leaves no residue on the surface, unlike chemical methods.

SUMMARY ADVANTAGES OF CO₂ BLASTING

CO₂ blasting has the following advantages over grit blasting and other conventional cleaning methods in the following areas:

1. Environmentally Safe

- a. CO₂ blasting can serve as a substitute for many hazardous solvents.
- b. Waste is minimized; clean-up is confined to removed coatings only.
- c. No mixed waste is generated, as with Freon cleaning.
- d. Disposal costs are drastically reduced.
- e. No resin is generated, as would be produced by water processing following hydro-lasing.
- f. CO₂ is non-corrosive and non-reactive.

2. Enhanced Cleaning Performance

- a. CO₂ provides a superior clean: there is

- no residue left on the surface.
- b. There is no risk of sedimentation or grit entrapment.
- c. There is no risk of change in surface dimensions of the cleaned substrate.
- d. CO₂ has complete mobility.
- e. CO₂ blasting is a dry process and safe around electrical equipment.

3. CO₂ blasting can be effectively used in cleaning and/or decontaminating the following materials without damage:

Plastics	Wood
Aluminum	Carbon Steel
Rubber	Concrete
Copper	Composites
Fiberglass	Stainless Steel
Ceramic Tile	

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Environmental Alternatives, Inc. is leading the way in a technology transfer from traditional cleaning methods to environmentally safe CO₂ blasting.

By using Environmental Alternatives to CO₂ blast clean materials on site, the customer achieves the following benefits:

- a. Decontamination/cleaning is accomplished at the customer's discretion.
- b. Smearable and fixed contaminants (nuclear) can be removed effectively.
- c. No additional mixed waste inventory.
- d. No mixed wastes are generated during cleaning.
- e. Cost for shipping waste containers is drastically reduced or eliminated.
- f. Reduced labor costs for handling shipping of waste.

- g. Significantly reduced burial site tipping charges.
- h. A portable unit can be used to clean in-plant items, such as reactor head studs (nuclear) or production equipment (general industrial).

For more information, write to Environmental Alternatives at:

Environmental Alternatives, Inc.
P.O. Box 338
West Chesterfield, NH 03466

- or call -

603-357-8814

CO2 Blast Cleaning

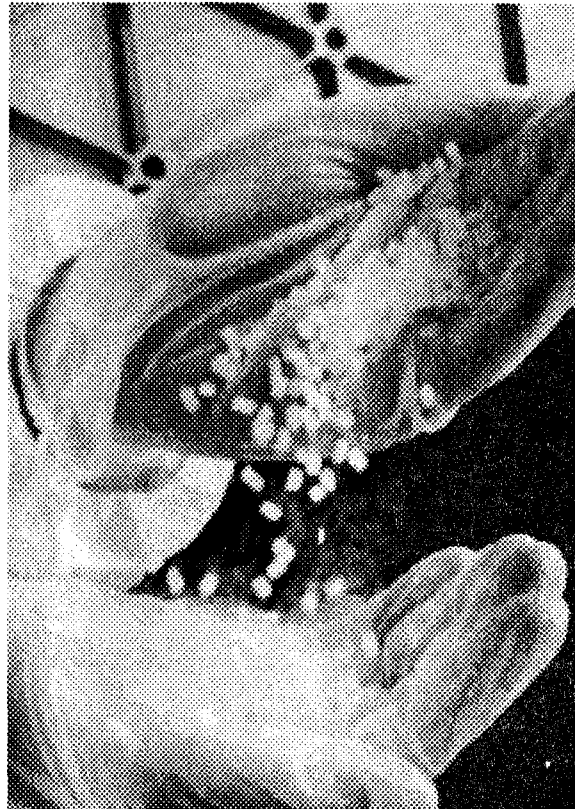
Carbon Dioxide (CO₂) Blast Cleaning, or simply CO₂ pellet cleaning, is the revolutionary cleaning process which:

- ▲ creates no secondary waste
- ▲ cleans without substrate damage
- ▲ is 100% environmentally acceptable

CO₂ Blast Cleaning begins with the conversion of liquid CO₂ into solid CO₂ pellets. These pellets are then propelled onto a surface using compressed air or compressed gasses. Cleaning occurs as the pellets impact the surface and sublime, returning to their natural state in the environment as a gas. The expansion of the gas as the pellets sublime flushes the surface and lifts the contaminants away from a surface (see diagram below).

The results of CO₂ Blast Cleaning are unlike any other cleaning process. After cleaning there is no film or residue on the surface. The only waste to be disposed of is the material that was removed. Cleaning is accomplished faster and more effectively than using other cleaning processes.

Applications for the CO₂ Blast Cleaning process range from the most basic cleaning functions, such as facilities and plant equipment, to the most advanced including the



These CO₂ pellets clean with no surface damage, create no secondary waste and are safe for the environment.

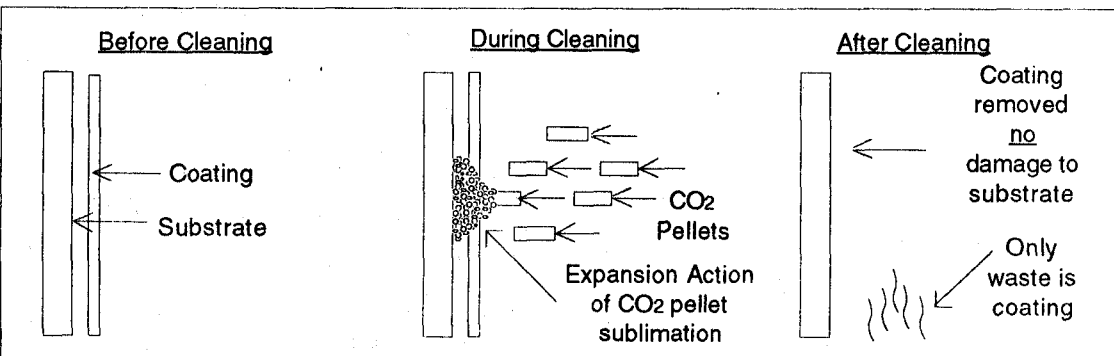
cleaning of electronics and aerospace components. Generally speaking, CO₂ Blast Cleaning is effective if the cleaning need meets one or more of the following criteria:

- ▲ there is a high cost for downtime
- ▲ items to be cleaned are large or have complex geometries
- ▲ waste disposal costs are high
- ▲ the item to be cleaned requires special treatment
- ▲ substrate damage can not be tolerated



CO₂ Blast Cleaning can be performed manually (as shown on the left), robotically, or automated for use in a wide variety of production line applications.

Is CO₂ Blast Cleaning the solution for your cleaning problem? Call Environmental Alternatives at (603) 357-8814 and speak to the non-destructive surface cleaning and waste minimization specialists. EAI offers a complete range of CO₂ Blast Cleaning services ranging from contract cleaning to process engineering & development. Put the experience of Environmental Alternatives to work for you.



The 3 stage diagram on the left shows the cleaning action of the CO₂ Blast Cleaning process. As the pellets strike the surface they sublime under the coating- lifting the contamination away from the surface and flushing the surface clean.



Environmental Alternatives Nuclear Operations

A CO₂ Blast Cleaning Technician performs CO₂ decon on a plant component. The CO₂ process can be used manually (as pictured on right) or used in conjunction with remote manipulators and remote operated vehicles.



In 1989, a company introduced to the nuclear industry a process which revolutionized decontamination and waste minimization. The process is Carbon Dioxide (CO₂) Blast Cleaning. The company is Environmental Alternatives, Inc. (EAI).

CO₂ Blast Cleaning is a decontamination process which uses solid dry ice (CO₂) pellets as a cleaning media. The pellets are propelled onto a surface by compressed air or other compressed gasses. As the pellets impact the surface, they sublime, returning to their natural state in the atmosphere as a gas. Cleaning occurs as the turbulence caused by the sublimation flushes the surface and lifts contaminants away. The CO₂ gas and contaminants are then entrained in an airstream and captured in a HEPA filter. The CO₂ gas is filtered and released.

The CO₂ Blast Cleaning process is the only method of decontamination which creates no secondary waste.

Compared with other decontamination processes, CO₂ Blast Cleaning:

- ▲ Cleans and decontaminates with no secondary waste
- ▲ Is 100% environmentally acceptable
- ▲ Causes no substrate damage
- ▲ Reduces radwaste volume & costs

The CO₂ Blast Cleaning process can be used to decontaminate a variety of plant tools and equipment. Simple tools like hammers and wrenches are decontaminated to free release levels in minutes. Complex surface areas such as chainfalls and motors are cleaned with ease. Even sensitive equipment such as monitors, meters and electric hand tools can be decontaminated quickly and easily- with no damage.

With the experience of Environmental Alternatives, CO₂ Blast Cleaning can be used for a variety of applications ranging from routine in-plant tool decon to specialized facility decontamination using robotics.

Why Environmental Alternatives? Only EAI can service you with complete stationary and portable CO₂ Blast Cleaning systems, offer you the most CO₂ decon experience, and give you the most experience in the industry. From commercial nuclear power and Department of Energy facilities to aerospace and industrial applications, EAI is the non-destructive surface cleaning and waste minimization solution. Need more information? Call us at (603) 357-8814 for a review of your decontamination needs.



From on-site tool decontamination to facility decontamination no one else offers the experience, strength and reliability of Environmental Alternatives.

Shown on left, EAI Technicians complete the decontamination of a hot cell. The cell, along with five others, were free released by Environmental Alternatives.



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Superheater Cleaning Using CO₂ Blast Cleaning

Traditional boiler tube cleaning methods involve the use of high pressure water. This process creates extensive secondary waste and requires significant clean-up.

The tube bundles pictured below are from the superheater of a waste recovery facility Keeler mass burn boiler. The superheater sections (both primary and secondary sections) were cleaned by EAI using the CO₂ Blast Cleaning process.

Compared to high pressure water blasting, the CO₂ Blast Cleaning process cleaned the tube bundles:

- faster
- more efficiently
- more effectively
- with less mess
- with no clean-up

After CO₂ cleaning, the bundles were ready for immediate inspection- no additional cleaning was necessary.

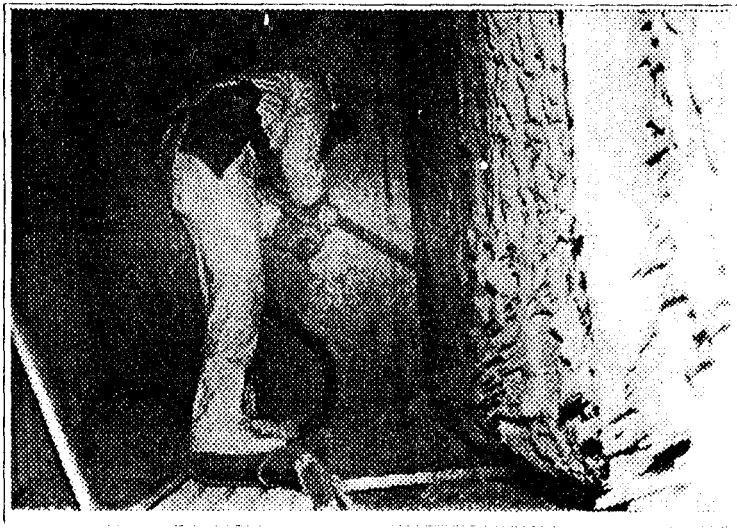
Environmental Alternatives provides a complete line of CO₂ Blast Cleaning services for all applications including on-site cleaning services, cleaning services at our facility, system design, sale and installation. EAI provides you with the most experienced CO₂ team in the industry.

If your current superheater cleaning process is leaving you with barrels of waste water and hours of after cleaning clean-up, call (603) 357-8814 and ask to speak with the EAI technical representative in your area. You may find your cleaning would be better if left to Environmental Alternatives- the non-destructive surface cleaning and waste minimization specialists.



**Environmental
Alternatives
Incorporated**

Before cleaning, the tube bundles of this Keeler mass burn boiler were completely covered with fly ash. Note the heavy build-up of ash on the tube bundle.



After CO₂ cleaning, the tubes are ready for inspection and refiring. No sludge clean-up or wipe down is required prior to inspection.



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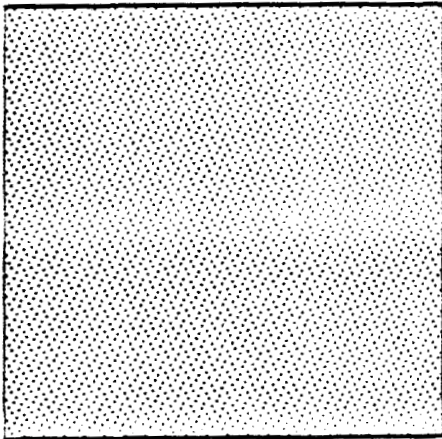
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The AIM Decontamination Process

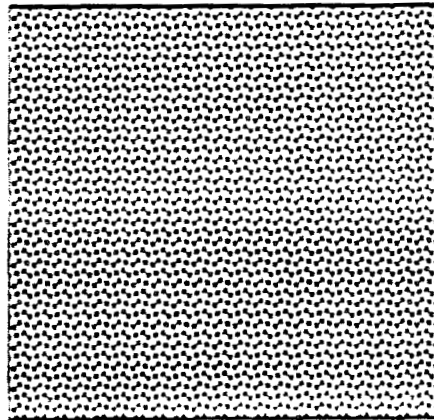
AIM Media Samples

AIM: Absorbent, Impregnated Media, a urethane based, reusable media capable of delicate *and* aggressive cleaning and decontamination. The media can be used on surfaces ranging from glass to steel and concrete. Controls for operating pressures and media flow, and different media grades allow for complete cleaning control, from cleaning without profiling glass to profiling steel.



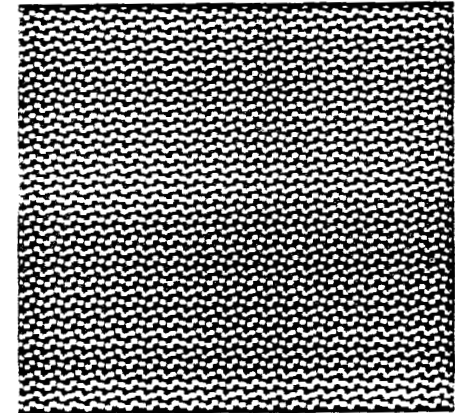
Green Media

- Absorbent
- Non-abrasive
- 10 to 15 uses
- For absorbency, non-profiling applications



Brown Media

- Absorbent
- Mildly-abrasive
- 10 to 15 uses
- For absorbency, mildly-profiling applications



Yellow Media

- Absorbent
- Abrasive
- 10 to 15 uses
- For absorbency and profiling applications

Environmental Alternatives, Inc.

The AIM Decontamination Process

THE AIM (ABSORBENT, IMPREGNATED MEDIA) PROCESS

What is it?

- Utilizes a recyclable urethane in lieu of solvents or media blasting
- Replaces conventional cleaning methods
- Environmental acceptance

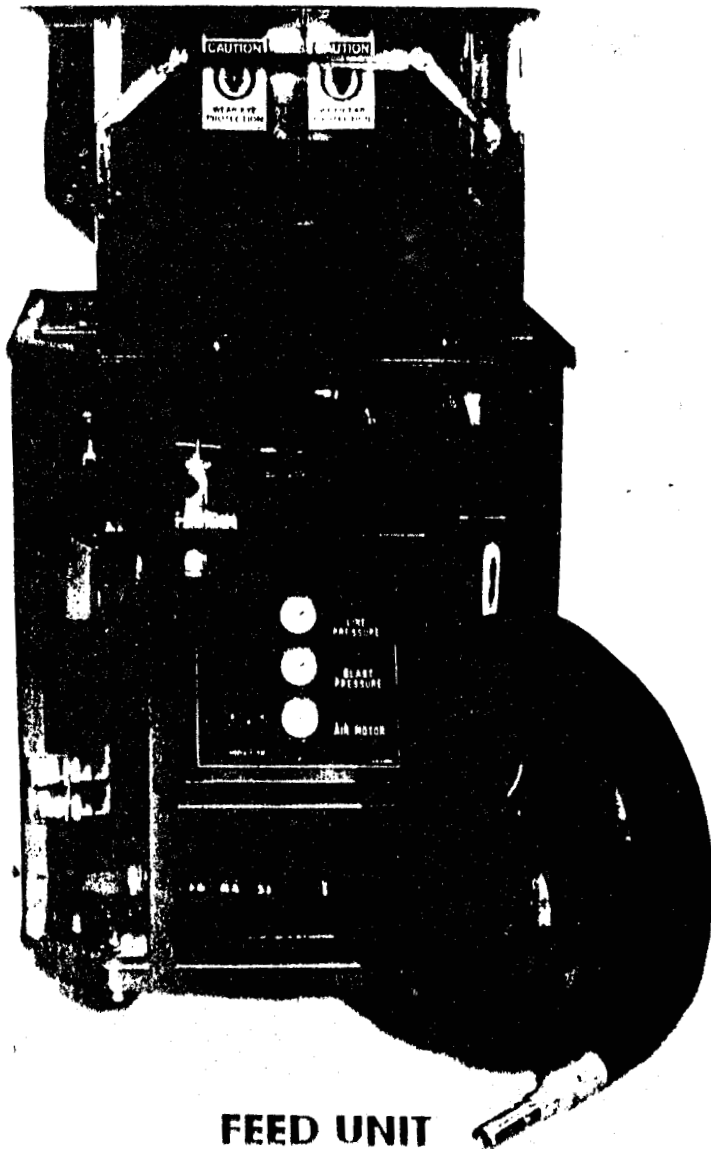
How it works

- AIM media is propelled by compressed air
- As impact occurs, contaminants are absorbed into the media
- As impact occurs, impregnated media profiles the surface
- Media & velocity parameters are controlled and adjustable for each application
- Waste is minimized as the media is recycled up to 15 times

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Streeter Hill Road P.O. Box 338 West Chesterfield, OH 43086

FEED UNIT



FEED UNIT

SPECIFICATIONS

- ▶ Height: 56"
- ▶ Width: 30"
- ▶ Length: 37"
- ▶ Weight: 300 lbs.

REQUIREMENTS

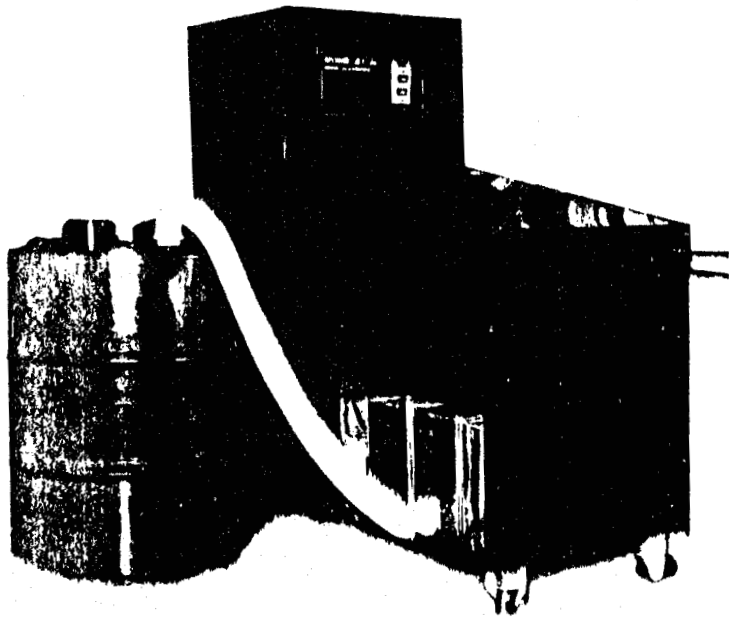
- ▶ 250 cfm compressor delivering 110 to 120 PSI
- ▶ 1-1/4" compressor to Feed Unit air hose
- ▶ Clean and dry air (refer to ASTM D4285-83)

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SIFTER (Media Classifier)

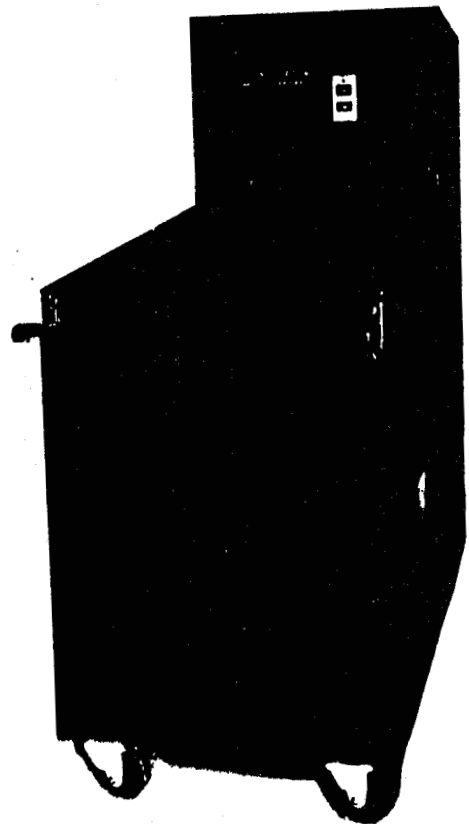


SPECIFICATIONS

- ▶ Height: 61"
- ▶ Width: 23 $\frac{3}{4}$ "
- ▶ Length: 72"
- ▶ Weight: 300 lbs.

REQUIREMENTS

- ▶ 110 volts, single phase,
30 amp.



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The **Feed Unit** is a pneumatically powered device for propelling the foam cleaning media against surfaces to be cleaned or otherwise prepared. The Feed Unit is portable and produced in several sizes to accommodate the needs of a variety of end users. A hopper, mounted atop the unit holds the foam cleaning media. The media is fed by an auger device into a metering chamber which mixes the foam cleaning media with compressed air. The foam cleaning media / air mixture is conducted using standard abrasive blasting hose through a standard abrasive blasting nozzle to the surface to be cleaned or prepared. By varying the Feed Unit air pressure and type of foam cleaning media used, the system can be used in a range from removing soot from wallpaper to removal of fully-cured high-performance protective coatings from steel and concrete surfaces.

The **Sifter Unit** is used to mechanically remove large debris and powdery residues from the foam cleaning media after each use. The used foam cleaning media is swept up or otherwise collected in the work area and placed into the electrically-powered Sifter. This unit vibrates and causes the used foam cleaning media to pass vertically downward through a series of progressively finer screens. Any coarse materials, such as paint flakes, rust particles, etc. are collected in the first, coarsest screen. Next the reusable foam cleaning media particles are collected in next, finer screen, and finally, any fine dust particles fall to the bottom of the sifter for proper disposal.

After sifting, the reclaimed foam cleaning media can be immediately reused in the Feed Unit. After between three to five media cycles, the foam cleaning media should be laundered in the **Wash Unit**. The wash unit is a portable, closed-cycle device which centrifugally launders the foam cleaning media. The contaminated wash water is collected, filtered and reused within the Wash Unit.

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The foam cleaning media is absorptive and can be used either dry or wetted with various cleaning agents and surfactants to capture, absorb and remove a variety of surface contaminants such as oils, greases, lead compounds, chemicals and radionuclides. The capability of using the foam cleaning media wetted also provides for dust control without excess dampening of the surface being cleaning.

Two basic types of foam cleaning media

1. A non-aggressive grade of foam cleaning media, which is used for surface cleaning purposes on sensitive or otherwise critical surfaces.
2. The aggressive grades of foam cleaning media, which are used not only to remove surface contaminants but also are capable of removing tightly-adherent materials such as paints, protective coatings and rust and to roughen concrete and metallic surfaces if desired.

Many currently used cleaning and surface preparation systems, such as abrasive blasting using sand or other hard particles, water washing/blasting, chemical cleaning and even hand techniques (scrubbing, scraping, etc.) have been shown to produce unhealthy environmental conditions for workers and non workers alike. As a result, environmental legislation has been recently enacted at both state and local levels designed to:

- Minimize wastes generated in surface cleaning and preparation activities.
- Capture, absorb and remove contaminants.
- Minimize the adverse affects of surface cleaning and preparation activities on the environment.
- Provide increased worker and public safety.

Innovative Practice

Cleaning with air-propelled foam media

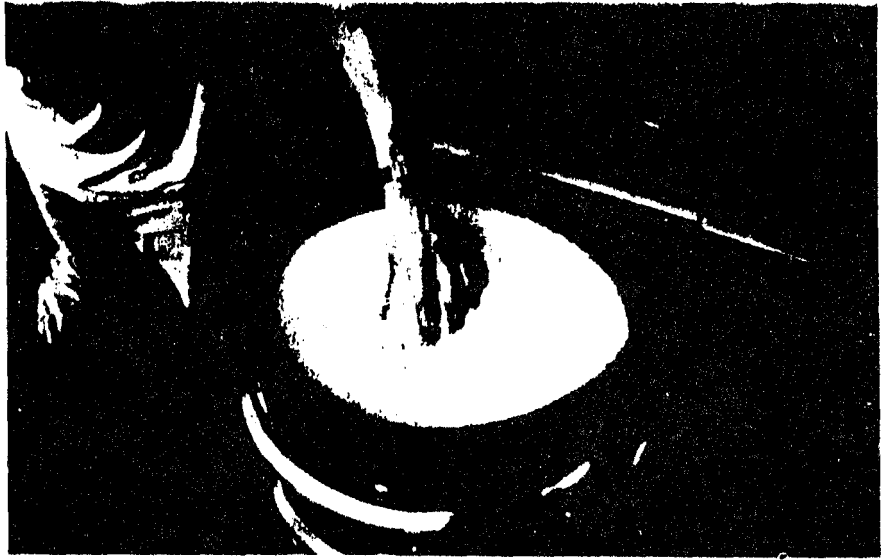
A newly developed method of cleaning is based on use of high density air-propelled foam media. These foam cleaning media is absorptive and can be used either dry or wetted with various cleaning agents and surfactants.

The water-based foam cleaning media can be used to capture and absorb a variety of surface contaminants, such as oil, grease, lead compounds, chemicals, and radionuclides. As such, the process can reduce many hazards associated with traditional surface preparation techniques. Because they are recyclable, foam cleaning media may help minimize waste generated during surface cleaning. When dampened, they can provide dust control without unduly wetting the surface being cleaned.

Several types of foam cleaning media are available, all of which have been ground into particulate form:

- A nonaggressive grade of media can be used to clean delicate substrates such as electrical motors, transformers, or hydraulic oil lines.
- Aggressive grades of media contain particles of various abrasive types encapsulated in foam. Aggressive-grade media remove tightly adherent surface contaminants such as paint and rust.

To make use of this technology, a special pneumatically powered feed unit is used that propels the foam cleaning media against the surface being cleaned. A hopper holding the media sits atop an auger device that meters the media into a chamber where they are mixed with compressed air. The air/media mixture is then



conveyed via a standard abrasive blasting hose and nozzle to the surface. Other pieces of specialized equipment include a sifter, wash unit, and portable evaporator to concentrate liquid waste.

By varying the air pressure and type of foam media, this method of

surface preparation can be used to perform a variety of jobs, including removing soot from wallpaper and high performance coatings from steel and concrete.

