

# Packed Bed Tower Scrubbers



- for gaseous emissions - NO<sub>x</sub>, Cl<sub>2</sub>, SO<sub>2</sub>, others
- acid fumes, including H<sub>2</sub>SO<sub>4</sub>, HCl, HNO<sub>3</sub>, and HF
- odor control – single and multi-stage units
- combination systems for hot and cold gases
- Systems can incorporate particulate control, gas quench, venturis, cartridge filters, and carbon systems



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# Design Criteria: V/F Series

Tri-Mer packed bed scrubbers are versatile, reliable systems that serve the widest variety of processes. They are used and specified worldwide.

Tri-Mer packed scrubbers are highly recommended for the efficient removal of inorganic gases, odors and fumes, and are particularly appropriate where gas streams have extreme pH. They are well-suited for use as primary or secondary systems in conjunction with thermal oxidizers, and are also used in a series where there are multiple-contaminant gas streams.

Optimum system performance is achieved with systems that combine intimate gas/liquid mixing and low pressure drop.

## CFM

Air flow through the scrubber, based on cubic ft/min. This is determined by the process to be handled by the scrubber, through information provided by customer and Tri-Mer analysis. System capacities of heavy service V/F systems range to 100,000 cfm and above.

## Configuration

Internal vs. external recirculation system, fan location in relation to tower, duct sizes, inlet and outlet plus location of pump systems, tower access service ports, service platform requirement.

## Materials of Construction

Determined by application because most contaminants involve corrosive gases and fumes, material must be able to withstand continuous contact with high and low pH gases and scrubbing solutions.

Standard construction materials include polypropylene, PVC and fiberglass. Optional materials include high alloy metals such as stainless and Hastelloy®. Dual-laminate structures incorporating FRP over PVC, PP, PVDF and Teflon® liners are also available.



External recirculation tank form.



Dual fan set-up prior to installation of duct.

## Operational Efficiency

Removal efficiency of scrubber: inlet vs. outlet requirement, based on mass emission in lbs/hr. **in** vs. lbs/hr **out**.

Factors to consider in calculating removal efficiency are:

1. **contaminant flow composition**
2. **contaminant solubility**
3. **chemistry that will react with contaminants**
4. **reaction speed**
5. **HTU (height transfer unit) factors required for specified removal efficiency**
6. **liquid-to-gas ratio**
7. **velocity**
8. **gas temperature – up to 2000°F with Q-Scrub quench option**

*Packed column with redundant pump and fans incorporating breach-fitted stack assembly.*



Tri-Mer's Q-Scrub interfaces directly with hot gas sources up to 2000°F and provides efficient evaporative water cooling of the gas stream. Materials of construction for the quench section include Hastelloy® C276 and 316L to 304 stainless steel. Custom engineered for gas inputs between 500 cfm to more than 100,000 cfm, Q-Scrub is a reliable solution for efficient quenching.

## System Design

Using the information gathered under the efficiency requirement section above, and other factors specific to the site, Tri-Mer engineers determine the optimum tower diameter, packing depth, recirculation flow rate, and mist eliminator requirement in microns. These calculations form the basis for a layout similar to the illustration on the facing page.



- (A) Scrubber body, manufactured standard in 6" intervals, from 12" through 16' diameter
- (B) Outlet from the scrubber (*Note: can also exhaust vertically*)
- (C) Mist eliminator
- (D) Mist eliminator access door
- (E) Recirculation liquid distribution nozzle system
- (F) Recirculation piping system
- (G) Recirculation pumps: single or redundant, as shown. ANSI style pump shown is standard; vertical sump design is also available
- (H) (Optional) recirculation system basket strainer for prevention of pump damage and nozzle plugging. Y-strainers recommended with smaller units; basket strainers for systems above 8,000 cfm
- (I) Liquid flow meter. Meter can be line-mounted for smaller units; self-powered for larger systems  
*Electrically-powered units also available*
- (J) Packing media. Tri-Packs 2" diameter is recommended for most applications; other options are available
- (K) Packing support grid
- (L) Scrubber inlet (*round or rectangular*)
- (M) Recirculation tank. Illustrations show internal recirculation sump; external recirculation sumps can be recommended for applications such as multi-stage scrubbers incorporating NO<sub>x</sub> control and other applications  
Liquid sump should hold (at minimum) a 1.5x recirculation flow rate
- (N) Recirculation sump level control system
- (O) Clear packing removal portal
- (P) Clear packing fill door



Standard construction materials include polypropylene, fiberglass and PVC. Optional materials include high alloy metals such as stainless and Hastelloy®. Dual-laminate structures incorporating FRP over PVC, PP, PVDF and Teflon® liners are also available.

# V/F Series Capacities

Model Number	Maximum CFM	Tower Diameter Feet and Inches	Standard Recirculation*	Approximate Height**
V/F 12	390	1'-0"	4 – 7	10'-6"
V/F 18	880	1'-6"	9 – 15	11'-0"
V/F 24	1,570	2'-0"	16 – 25	11'-6"
V/F 30	2,450	2'-6"	25 – 40	11'-6"
V/F 36	3,530	3'-0"	35 – 58	13'-0"
V/F 42	4,810	3'-6"	48 – 78	14'-0"
V/F 48	6,280	4'-0"	62 – 100	14'-6"
V/F 54	7,950	4'-6"	80 – 128	15'-6"
V/F 60	9,815	5'-0"	98 – 158	15'-6"
V/F 66	11,880	5'-6"	118 – 190	16'-0"
V/F 72	14,135	6'-0"	140 – 226	17'-0"
V/F 78	16,590	6'-6"	166 – 265	17'-0"
V/F 84	19,240	7'-0"	192 – 307	17'-6"
V/F 90	22,090	7'-6"	220 – 354	17'-0"
V/F 96	25,130	8'-0"	252 – 402	18'-0"
V/F 102	28,370	8'-6"	284 – 454	18'-0"
V/F 108	31,808	9'-0"	318 – 508	19'-0"
V/F 114	35,440	9'-6"	354 – 568	19'-0"
V/F 120	39,270	10'-0"	392 – 628	19'-0"
V/F 126	43,300	10'-6"	432 – 692	19'-6"
V/F 132	47,516	11'-0"	475 – 760	19'-6"
V/F 138	39,270	11'-6"	519 – 830	20'-0"
V/F 144	43,300	12'-0"	565 – 904	21'-0"
V/F 150	47,516	12'-6"	614 – 982	22'-0"
V/F 156	66,366	13'-0"	664 – 1060	22'-6"
V/F 162	71,570	13'-6"	716 – 1145	23'-0"
V/F 168	76,970	14'-0"	770 – 1232	23'-0"
V/F 174	82,565	14'-6"	825 – 1320	25'-0"
V/F 180	88,360	15'-0"	884 – 1412	26'-0"
V/F 186	94,345	15'-6"	944 – 1509	27'-0"
V/F 192	100,530	16'-0"	1005 – 1608	28'-0"

Elevation estimates incorporate a minimum recirculation sump capacity of 1.5x the recirculation flow rate indicated. Elevation assumes a rectangular inlet configuration for gas dispersion, and a round outlet for external fan location. Maximum cfm capacity must be confirmed by manufacturer. Efficiency requirement may dictate a lower cfm than indicated.

\*Standard recirculation flow range in gals/min. Consult Tri-Mer for exact flow requirement based on application.

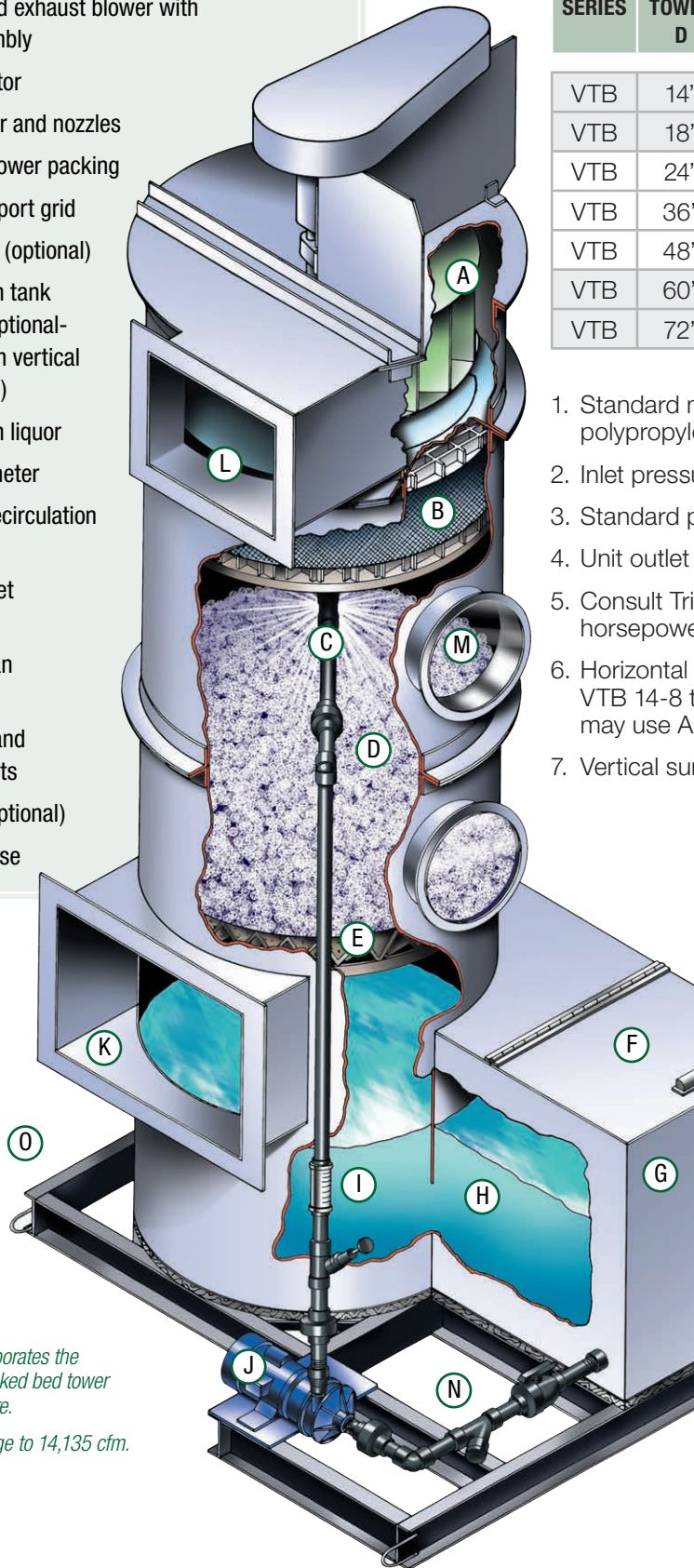
\*\*Approximate height with standard recirculation and 5'-0" packing. All dimensions are for reference only for construction.



# Tri-Mer's VTB Series Packed Bed Scrubbers

## Light Duty Integrated Fan System

- (A) Top-mounted exhaust blower with motor assembly
- (B) Mist eliminator
- (C) Spray header and nozzles
- (D) Tri-Packs® tower packing
- (E) Packing support grid
- (F) Tank access (optional)
- (G) Recirculation tank extension (optional - required with vertical pump option)
- (H) Recirculation liquor
- (I) Liquid flowmeter
- (J) Horizontal recirculation pump
- (K) Scrubber inlet connection
- (L) Horizontal fan discharge
- (M) Packing fill and cleanout ports
- (N) Y strainer (optional)
- (O) Steel sub base



SERIES	TOWER D	FAN SIZE	STD FAN HP	CFM MAX.	STD. RECIRC. RATE/GPM
VTB	14"	8	½	550	6
VTB	18"	10	2	880	9
VTB	24"	12	3	1,570	16
VTB	36"	18	7 ½	3,530	35
VTB	48"	22	10	6,280	62
VTB	60"	27	15	9,815	98
VTB	72"	33	20	14,135	140

1. Standard material of construction – PVC or polypropylene
2. Inlet pressure typically limited to 3" w.g.
3. Standard packing depth 3'-0"
4. Unit outlet integrated with top-mounted blower
5. Consult Tri-Mer Corporation for exact fan and pump horsepower
6. Horizontal magnetic pump standard with model VTB 14-8 thru VTB 48-22. VTB 60-27 and 72-33; may use ANSI style
7. Vertical sump style pumps are also available

*This compact system incorporates the exhaust blower into the packed bed tower as a unified vertical structure.*

*VTB series applications range to 14,135 cfm.*



*8,000 cfm VTB units constructed of black polypropylene ready to ship.*

# Design Criteria: V/F and VTB Series

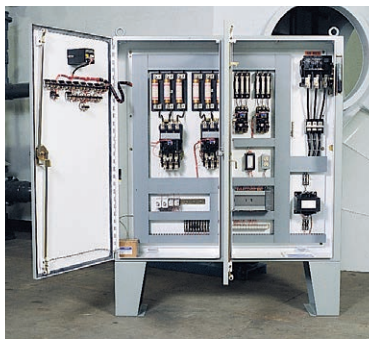
## Control Panels

All Tri-Mer scrubber packages are available with electrical control panels, which can incorporate the following features:

- Panel-mounted flowmeters, pH controls, flow indicators, ORP conductivity controls, alarms and auxiliaries.
- **PLC options.** Most customers specify a dedicated PLC control interface for scrubber operation. Auxiliary loop tie-ins can be made to specific plant processes, so that system chemistry is activated automatically. This provides the user with maximum control and flexibility.

## HMI

The operator interface depicts system status in full detail, in a form most useful to plant personnel. Valve positions, liquid and air flow conditions, pH, reduction or oxidation potential and other required parameters are available at-a-glance. System alarms and other process interrupt functions are detailed through the HMI.



*UL stamped panel assemblies are available from Tri-Mer.*

## Pre-wiring

Skid-mounted: Tri-Mer electrical systems are available completely pre-wired prior to shipment.

Larger systems: available pre-wired to terminal boxes specific to each piece of equipment. This greatly simplifies field wiring.



*Multi-stage scrubber pump room.*

## Piping

Piping connecting the recirculation tank, pumping system and spray header assemblies is part of the Tri-Mer package. These piping assemblies have been thoroughly tested at Tri-Mer.

## Materials of Construction

Standard alternatives include polypropylene, fiberglass and PVC.

## Capacities

Capacities range from 100 cfm to over 100,000 cfm in various models.

## Catwalk Access

V/F and VTB Series Packed Bed Systems are available with optional catwalk access platforms.

## Recirculation Tank

V/F and VTB series units have recirculation tanks which incorporate a horizontal or vertical-style pump. Piping between the spray header assembly and pump is included in the package.



**V/F series scrubbers** are specified for heavy duty applications such as steel pickling, plating, anodizing and other metal finishing operations generating corrosive fumes and gases. They are most effective for applications involving inorganic compounds with high solubility or chemically reactive characteristics. V/F units are used throughout the semiconductor industry.

**The V/F series** is a design incorporating the recirculating tank, inlet transition, packed bed section, mist eliminator and a remote mounted exhaust blower.

V/F units occupy a modest foot print and can be easily used as a scrubber for single or multiple tank chemical processes.

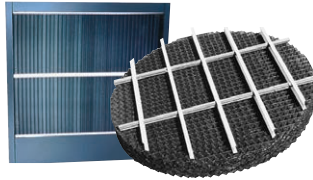


## Packing

The standard random dump section of the wet scrubber system incorporates ultra-high efficiency Tri-Packs® tower packing, originally engineered for use with Tri-Mer's Tri-NOx® Multi-Chem system.

## Mist Eliminator Efficiency

Mist eliminator systems are available in rigid chevron blade style and/or layered pad designs. Selection depends on the efficiency required and scrubber size. Typical mist eliminator efficiencies are based on 99% on



15 micron size droplets. Lower or higher efficiency rates are possible and will be recommended by Tri-Mer engineering, where applicable.

## Inlet Vs. Outlet Performance

It is critical, when calculating the efficiency of the V/F or VTB series scrubber, to know the inlet load of the contaminant being removed. This data should be provided to Tri-Mer in the form of a mass emission number, relating to lbs per hour of contaminant to be removed. Tri-Mer engineers will use HTU (height transfer unit) and NTU factors to calculate the necessary packing depth. Also using the inlet load information, engineering will calculate the liquid-to-gas ratio for optimum pump sizing for recirculation rates.

Tri-Mer Corp. uses conservative calculations in the design of systems to assure reliable, long-term performance under a wide range of operating conditions. Many competitive systems are designed to operate with velocities more than 20% higher than a Tri-Mer system, and recirculation flow rates less than 50%. Use of these under-sized systems on industrial applications often results in failure to meet operating permit requirements.



*Multi-stage scrubber system (Tri-NOx) constructed of polypropylene and fiberglass, with catwalk access.*

For the system owner, this means the choice will be to significantly modify, or replace, the equipment. Tri-Mer's conservative engineering approach serves our customers predictably and well, because systems meet stack efficiency and other operational requirements from the first day they're online.



*Dual stage HCl scrubber with fiberglass columns and catwalks.*



*Multi-stage external recirculation system.*



*Dual pump back-up on multi-stage system. ANSI design.*

## Pumps

Pumps for the V/F series scrubber systems are offered in two categories:

1. ANSI horizontal units
2. Vertical submerged head units



*Blowers are available in belt-driven and direct drive versions.*

## Exhaust Blowers

In the Tri-Mer standard design, materials of construction include polypropylene, PVC or FRP. The inlet cone is laminar flow-molded; its bell-shaped design insures smooth air entry, with minimal system effect loss.

The impeller design is backwardly inclined, flat blade (or air foil wheel). Wheels are available in Class 2, 3, or 4 categories, depending on pressure requirements. Materials of construction for fan impellers are mild steel with FRP coating, stainless steel, and special alloys such as Hastelloy®.

Standard arrangements include one and nine. Vibration isolation is available for the inlet and outlet duct; spring isolation is available for the fan base. The fan discharge depends on stack requirements and fan position. The fan package is then mated to the appropriate scrubber and tested.

# Design Options

## Single-Stage Vertical Flow

These Units are applied to inorganic scrubbing applications requiring between 3 and 16 ft. of packing. This includes a multitude of chemical processes, metal finishing and semiconductor applications. This also includes certain odor control systems (such as light inputs of ammonia or sulfur-based compounds) that are accommodated with a single-stage process.

## Two-Stage Vertical Flow

These systems use two independent columns, operating in series. Columns can operate with identical chemistry, or more typically, use two different chemical processes. An example is ammonia combined with other acids, which requires one stage for primary removal using sulfuric acid, and a second stage operating as a caustic scrubber. The design can be used in many other applications that require dual chemistries to destroy contaminants, and is common throughout Tri-Mer's design portfolio.

## Multi-Stage Scrubbers (NO<sub>x</sub>)

In this equipment design, Tri-Mer incorporates three or more scrubber stages. The best known application for this design is the Tri-NO<sub>x</sub><sup>®</sup> Multi-Chem process, which handles NO<sub>x</sub>, (NO+NO<sub>2</sub>) in any ratio. The primary application of the Tri-NO<sub>x</sub> Multi-Chem process is the removal of NO<sub>x</sub> from gas streams where other contaminants co-mingle with NO<sub>x</sub>. This situation makes other types of NO<sub>x</sub> removal technology impractical, because they use catalytic devices to remove the NO<sub>x</sub>, and gas streams containing particulate or other inorganic/organic matter can readily poison the catalyst and destroy the system.

In contrast, the Tri-NO<sub>x</sub> Multi-Chem system is not vulnerable to catalytic poisoning. This feature makes the Tri-NO<sub>x</sub> Multi-Chem system an excellent system for processes such as hazardous waste incinerators, calcinators, and rotary kilns; also for a wide variety of chemical nitrations and metal finishing operations which emit inorganic and organic material in concert with NO<sub>x</sub>.



*Single stage V/F series packed scrubber with dual pumps and containment pan constructed of UV-stabilized polypropylene.*



*Fiberglass-constructed, 2-stage HCl scrubber with dual fans and catwalk assembly.*



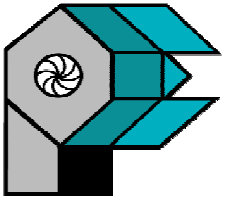
*Tri-NO<sub>x</sub> Multi-Chem plant constructed of black, UV-stabilized polypropylene with external recirculation systems and catwalk access assembly.*



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1400 Monroe St. • P.O. Box 730 • Owosso, MI 48867-0730  
Phone (989) 723-7838 • FAX (989) 723-7844  
Email: [salesdpt@tri-mer.com](mailto:salesdpt@tri-mer.com)

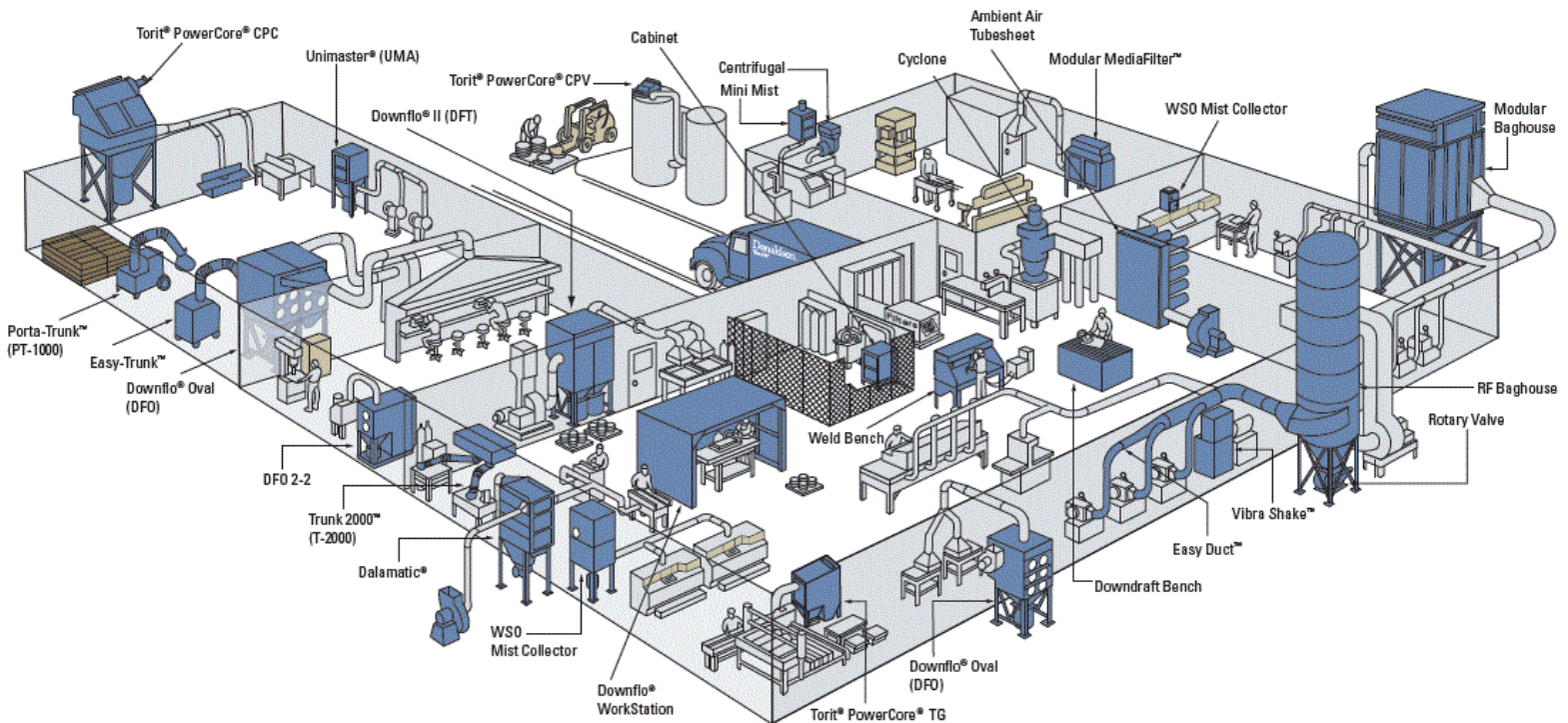




# PROCESS ENVIRONMENTS

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**406 Newport Blvd. League City, TX 77573-3560**

**Phone: (281) 316-2500 Toll Free: (800) 495-2249 Fax: (281) 526-2501**

**Website: [www.processenvironments.com](http://www.processenvironments.com) E-mail: [peimail@processenvironments.com](mailto:peimail@processenvironments.com)**