# Engineered Systems Group

Total Engineering and System Supply Services

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# Verantis Locations

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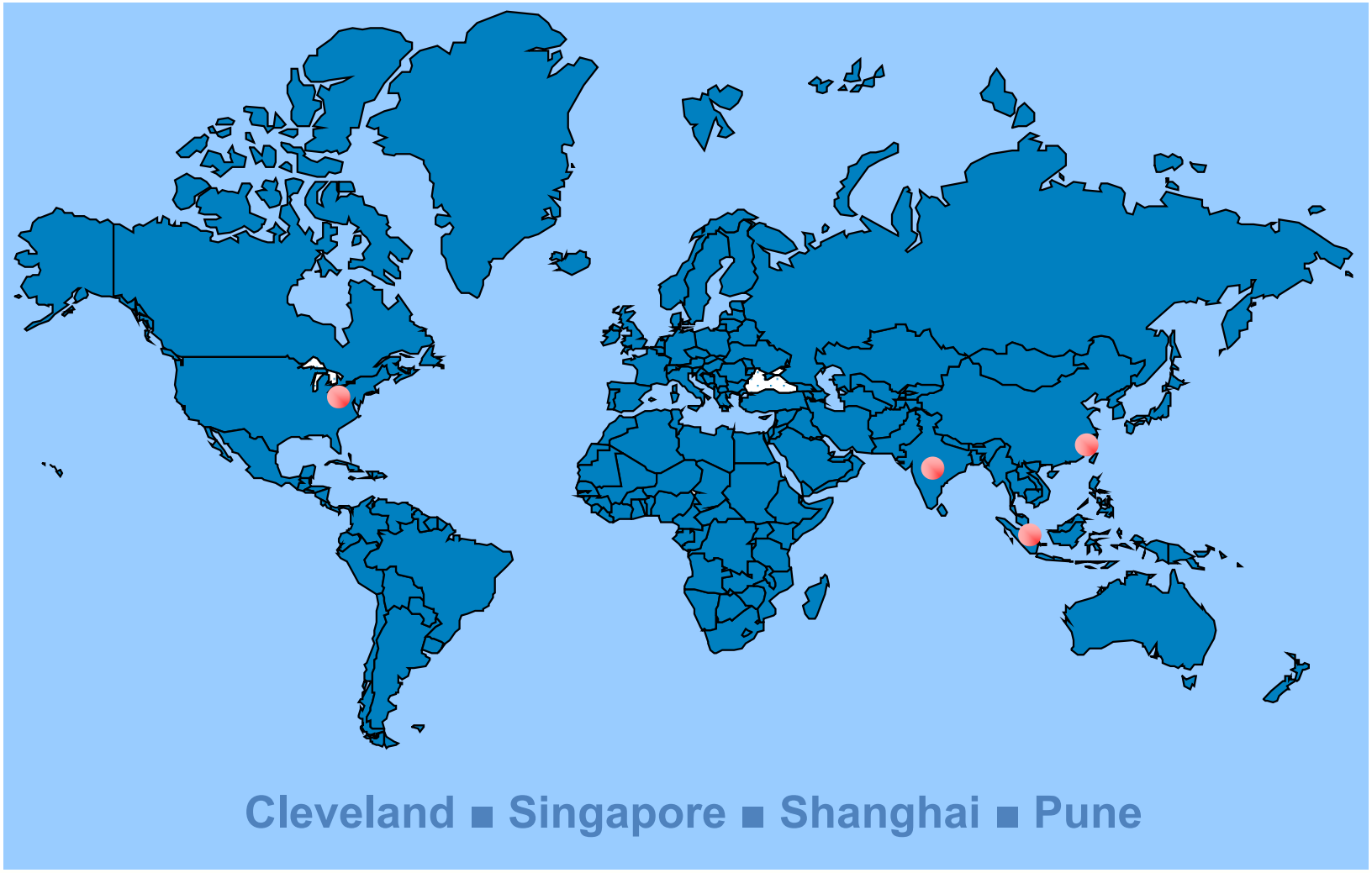

**Factory Assembled**
Systems, Custom Designed Systems and Retrofits

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# Standard Packages

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**Pre-Engineered Units**

- MS Series Miniscrubbers
- G-Series Packed Towers

# Pre-Engineered-Units
# MS Series Miniscrubbers

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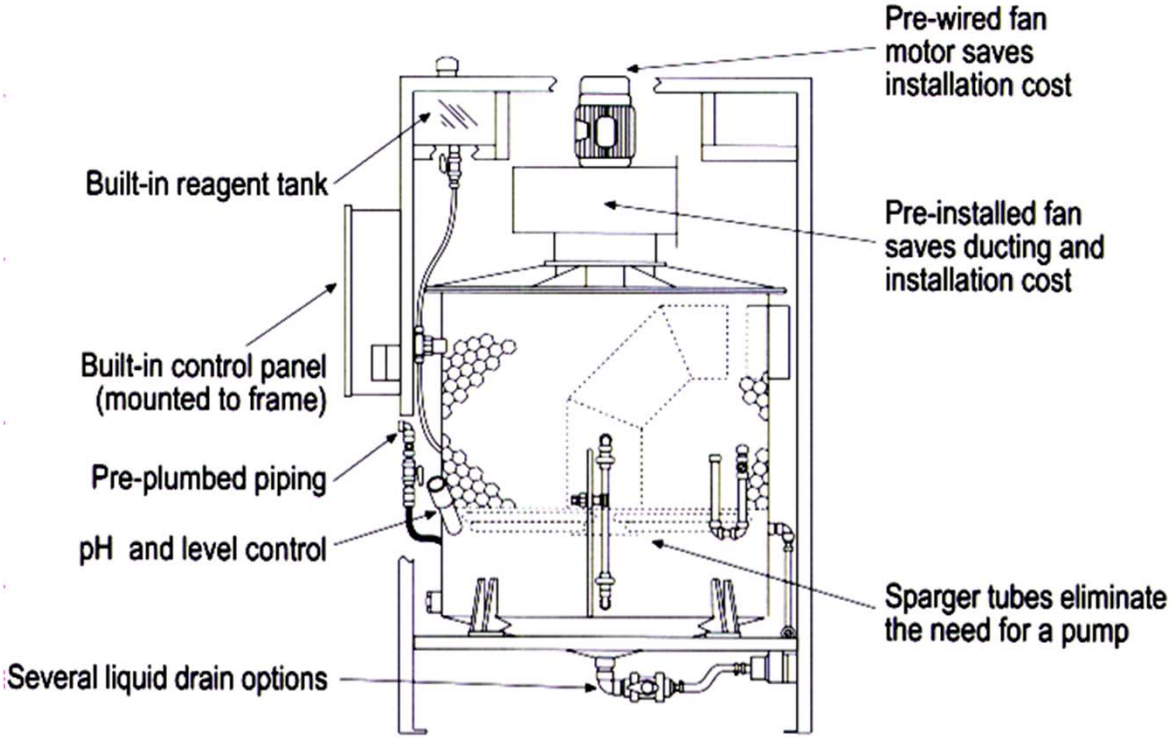

# Pre-Engineered Units
# G Series Scrubbers

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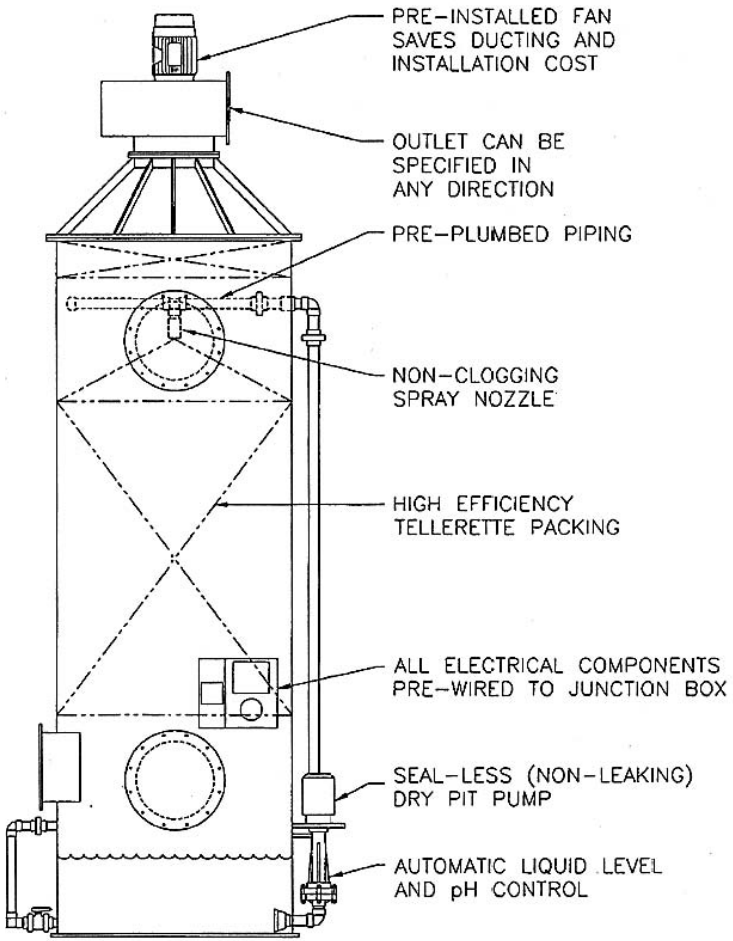

# Custom Designed

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- Typically used for “more complex” process applications or special customer requirements.
- Utilize single or combinations of various scrubber technologies based on application.
- Single or multiple skid-mounted designs.
- All ancillary components selected based customer specifications/preference.
- Pre-assembled piping and prewired to minimize installation time and cost.
- Small systems shipped fully assembled.
- Larger systems preassembled and then broken down for shipment.

# **Gas** Absorption

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# Gas Scrubbing

## Common Control Technologies

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| Stream | | Control Technology |
|---|---|---|
| Acid Exhaust | → | Wet Scrubbing with alkaline solution |
| Alkaline Exhaust | → | Wet Scrubbing with acid solution |
| Soluble VOC's | → | Wet Scrubbing with once through water |
| Insoluble VOC's | → | Thermal Oxidization |
| Alternative Scrubbing Liquids | → | Special Fluids |

# Packed Towers

## (SPT Series)

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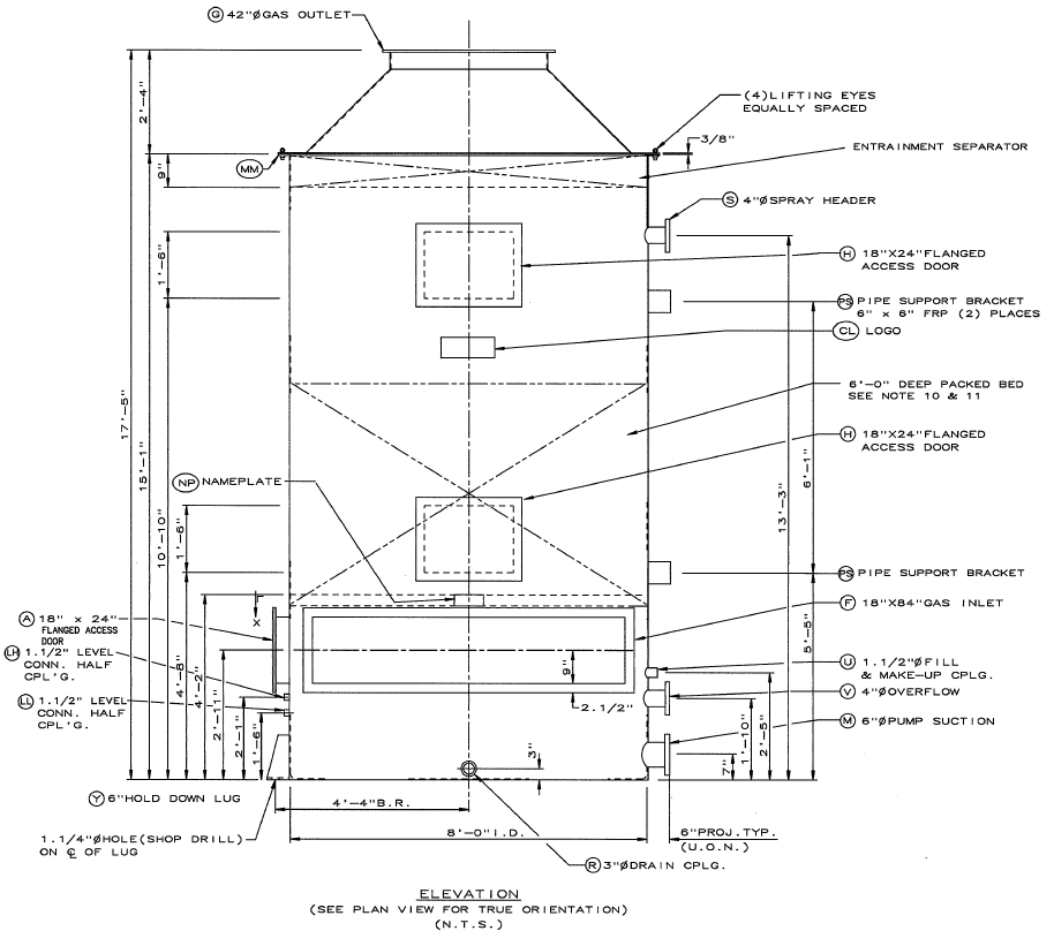


ELEVATION
(SEE PLAN VIEW FOR TRUE ORIENTATION)
(N.T.S.)

# Cross Flow Scrubber

## (HRP Series)

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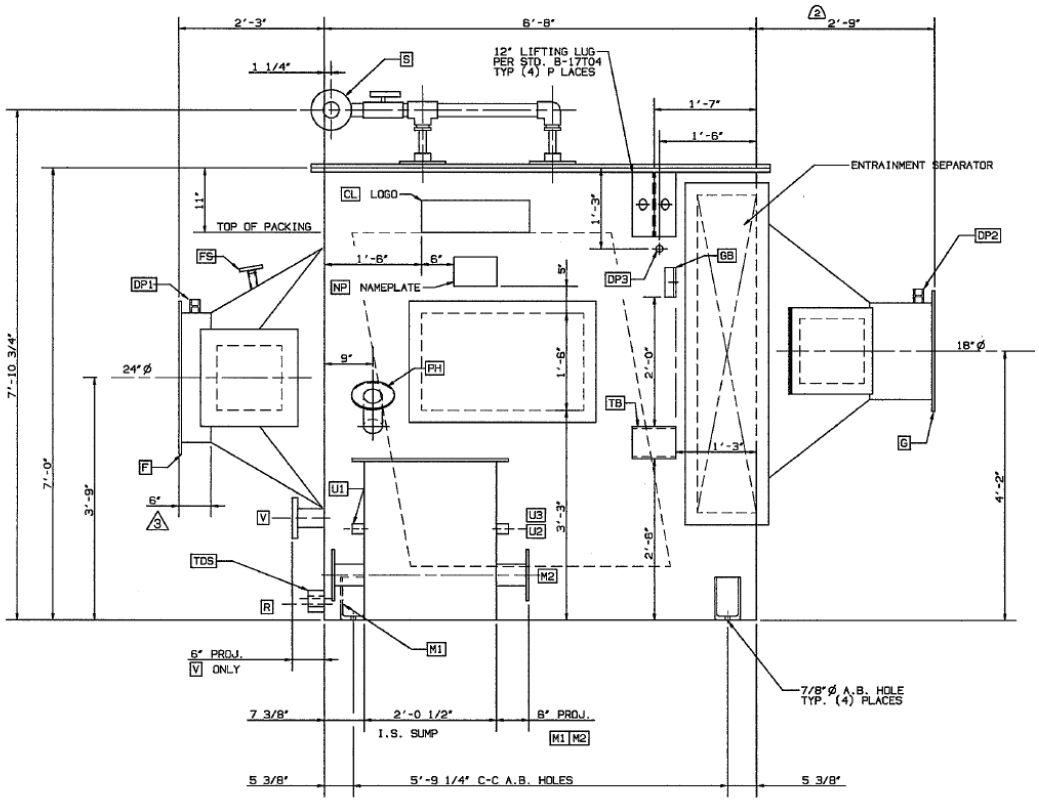

# Sieve Tray Scrubber

## (VTS Series)

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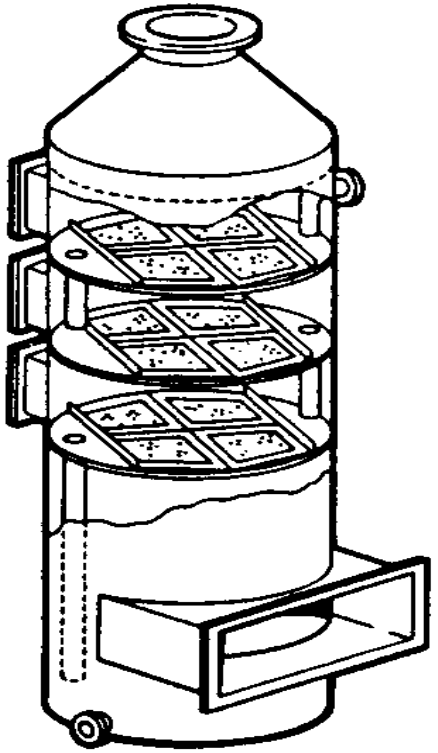

# **Particulate** Removal Technologies

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# Technology Overview

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- Standard Fixed Throat Venturis (VSV Series)
- Multi-Throat (Rod-Throat) Venturis (MTV Series)
- Variable-Throat Venturis (VTV Series)
- Eductor Venturis (EVS Series)
- Fluidized Bed Scrubbers (FBS Series)
- High Efficiency Air Filters (HEAF® Series)
- Ionizing Wet Scrubbers (IWS® Series)

# Particle Size / Technology

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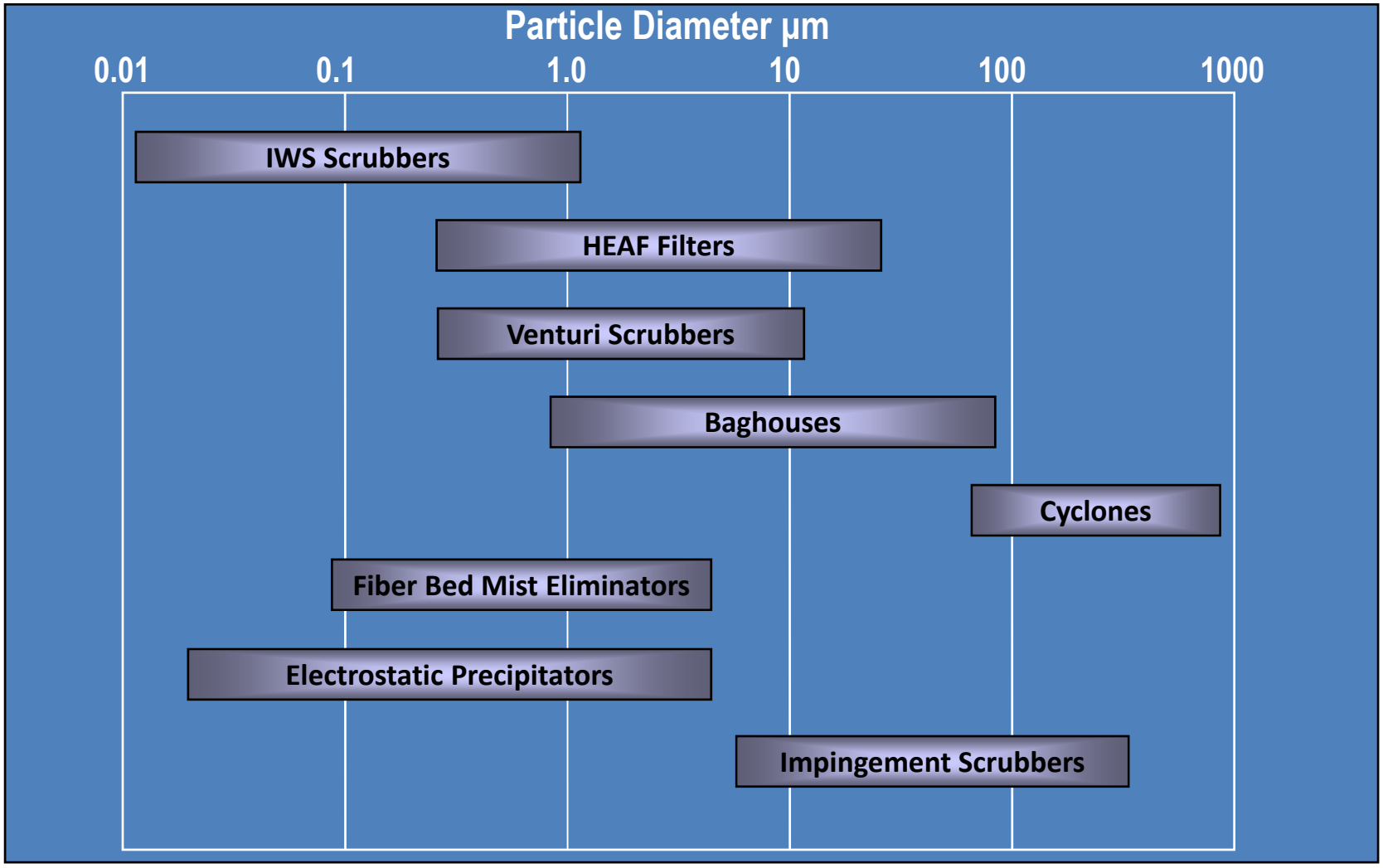

# Venturi Scrubbers

## (VSV, VTV, MTV Series)

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| Specifications | Performance | Applications |
|---|---|---|
| Gas Rates: 100-100,000 CFM | Solid particulate removal: 99.9%+ removal of particulate pending DP design selection | Fixed Throat (VSV):<br>• 100-80,000 CFM<br>• Consistent gas flow<br>• Particles typ 10 to < 1 µm dia<br>• Low to moderate loading<br><br>Variable Throat (VTV):<br>• 1,000-80,000 CFM<br>• Variable gas flow<br>• Particles typ 10 to < 1 µm dia<br>• Low to moderate loading<br><br>Multi-Throat (MTV):<br>• 5,000-100,000 CFM<br>• Consistent gas flow<br>• Particles typ 100 to 1 µm dia<br>• High loading<br>• Low ceiling |
| Fully Engineered for the Customer's specific application | Gas Absorption: 75-90%+ for most soluble / reactive contaminants is attainable | |
| Pressure drop designs from 6 to 100+ in-wc | Mist / Aerosol particulate removal: See solids removal | |
| Fixed throat (VSV), Variable throat (VTV), Multi-throat (MTV) designs | Heat Transfer: Not viable for cooling beyond adiabatic saturation (co-current operation) | |
| Mist eliminator: Verantis Chevron, or Mesh Pad Style | Quenching: Can serves as high temp quench with simultaneous particulate scrubbing | |
| Recirculated or once-through water rates of 5-10 gpm/1,000 cfm | | |
| MOC's - FRP, steel, alloy | | |
| | | |

# Eductor Venturi Scrubbers
## (EVS Series)

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| Specifications | Performance | Applications |
|---|---|---|
| Gas Rates: 5-65,000 CFM | Solid particulate removal: 98-99% removal of particulate to 3μm dia | Emergency scrubbers (HCl, chlorosilanes, $Cl_2$, phosgene, etc.) |
| Fully Engineered for the Customer's specific application | Gas Absorption: 75-90%+ for most soluble / reactive contaminants is attainable | Tank and process vents |
| Provides induced draft from 0 to 10 in-wc (multi-stage for additional SP) | Mist / Aerosol particulate removal: See solid particulate removal | Kettle exhaust |
| EVS Model designation | Heat Transfer: Not viable for cooling beyond adiabatic saturation (co-current operation) | Lower flow applications with induced draft required |
| Mist eliminator: Verantis Chevron or downstream scrubbing stages | Quenching: Can serves as high temp quench with simultaneous particulate scrubbing | Low to high flow applications with high $\Delta$Hr or particle load |
| Recirculated or once-through water up to 400 gpm/1,000 cfm | Can be arranged with multi-stages in series for increased SP induction or gas removal efficiency | Hydrolysis reacting contaminants ($HSiCl_3$, $SiF_4$, etc.) |
| MOC's - FRP, steel, alloy | SP induction depends on water circulation and nozzle pressure at given gas volume | |
| Often paired with downstream packed tower with EVS acting as ID driver and pre-scrubber | Often paired with downstream packed tower | |

# Fluidized Bed Scrubbers

## (FBS Series)

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| Specifications | Performance | Applications |
|---|---|---|
| Gas Rates: 1,000 to 30,000 CFM | Solid particulate removal: 99.9% removal of particulate to < 2μm dia | Gas streams combining moderate to high particle load with contaminant gases |
| Fully Engineered for the Customer's specific application | Gas Absorption: 99.9%+ for most soluble / reactive contaminants is attainable | Tank and process vents |
| 10-15 in-wc pressure drop | Mist / Aerosol particulate removal: See solid particulate removal | Pill coating operations (pharmaceutical) |
| FBS Model designation | Heat Transfer: Can be used for cool / condensing of the gas stream(counter-current operation) | Metal coating processes |
| Mist eliminator: Verantis Chevron or mesh pad | Gas flow must be maintained at a consistent rate for proper operation | |
| Recirculated water at approximately 100 gpm / 1,000 cfm | | |
| MOC's - FRP, alloy | | |
| | | |

# Alternative Technologies

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# Dry/Wet Systems
## (DSB)

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| Specifications | Performance | Applications |
|---|---|---|
| Gas Rates: 10,000 to 100,000 CFM | Solid particulate removal: 99.9% removal of particulate to < 0.5μm dia | Gas streams combining moderate to high particle load with contaminant gases |
| Fully Engineered for the Customer's specific application | Gas Absorption: 99.9%+ for most soluble / reactive contaminants is attainable | Applications requiring a high efficiencies for a combination of particulate and gaseous components |
| 10-12 in-wc pressure drop | Provides for Dioxin/Furan and metals control and removal | Thermal treatment processes |
| Dry sorbent injection (lime/activated carbon) followed by Packed Tower system | Dry sorbent injection reduces liquid chemical consumption | |
| Combines of gas/solid and gas/liquid kinetics from a reagent usage standpoint | | |
| MOC's - Carbon Steel and FRP | | |
| | | |

# Zero Liquid Discharge (ZLD)

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| Specifications | Performance | Applications |
|---|---|---|
| Multiple systems for eliminating liquid blowdown/effluent streams | Ability to remove contaminants from liquid stream (primarily salts and solids) | Facilities with limited or no wastewater treatment capabilities |
| Multistage blowdown flashing system | Flash/evaporator system uses multiple stages, each at a lower pressure to maximize efficiencies | Locations with limited process water capabilities or expensive process water alternatives such as desalination |
| Evaporative quench technologies | Resulting liquid effluent from flash evaporator system can be recycled back as feed water to the scrubbing system or used as process water in the plant. | |
| All systems custom designed to client requirements | | |
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# Zero Liquid Discharge
## (ZLD)

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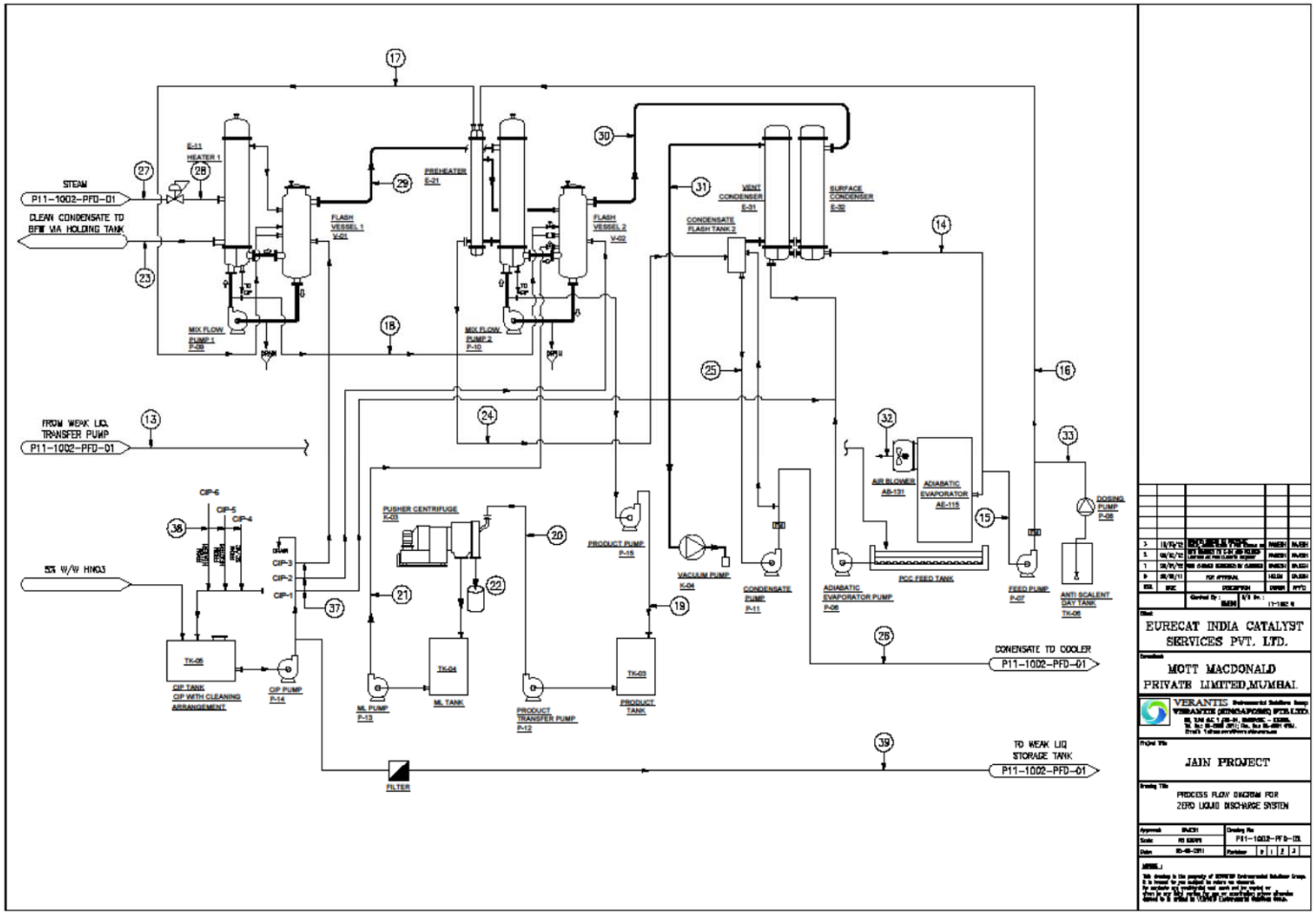

# Product Recovery

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| Specifications | Performance | Applications |
|---|---|---|
| Multiple systems for recovering solids and liquids from thermal processes | Conventional absorption systems for recovery/concentration of liquids such as HCl to 8-15% (wt.) | Primarily thermal treatment processes processing highly chlorinated materials or silane related waste streams (gas and liquids) |
| Primary systems center around recovering liquids such as HCl | Combination pressure/vacuum system for concentration of HCl up to 30%+ (wt.) | |
| System provides for recovery of HCl in the range of 30% (wt.) | Fabric filter baghouse systems for solid product recovery | |
| Also have relatively conventional product recovery for solids such as $SiO^2$ | | |
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# Product Recovery-HCl

## (Vacuum System)

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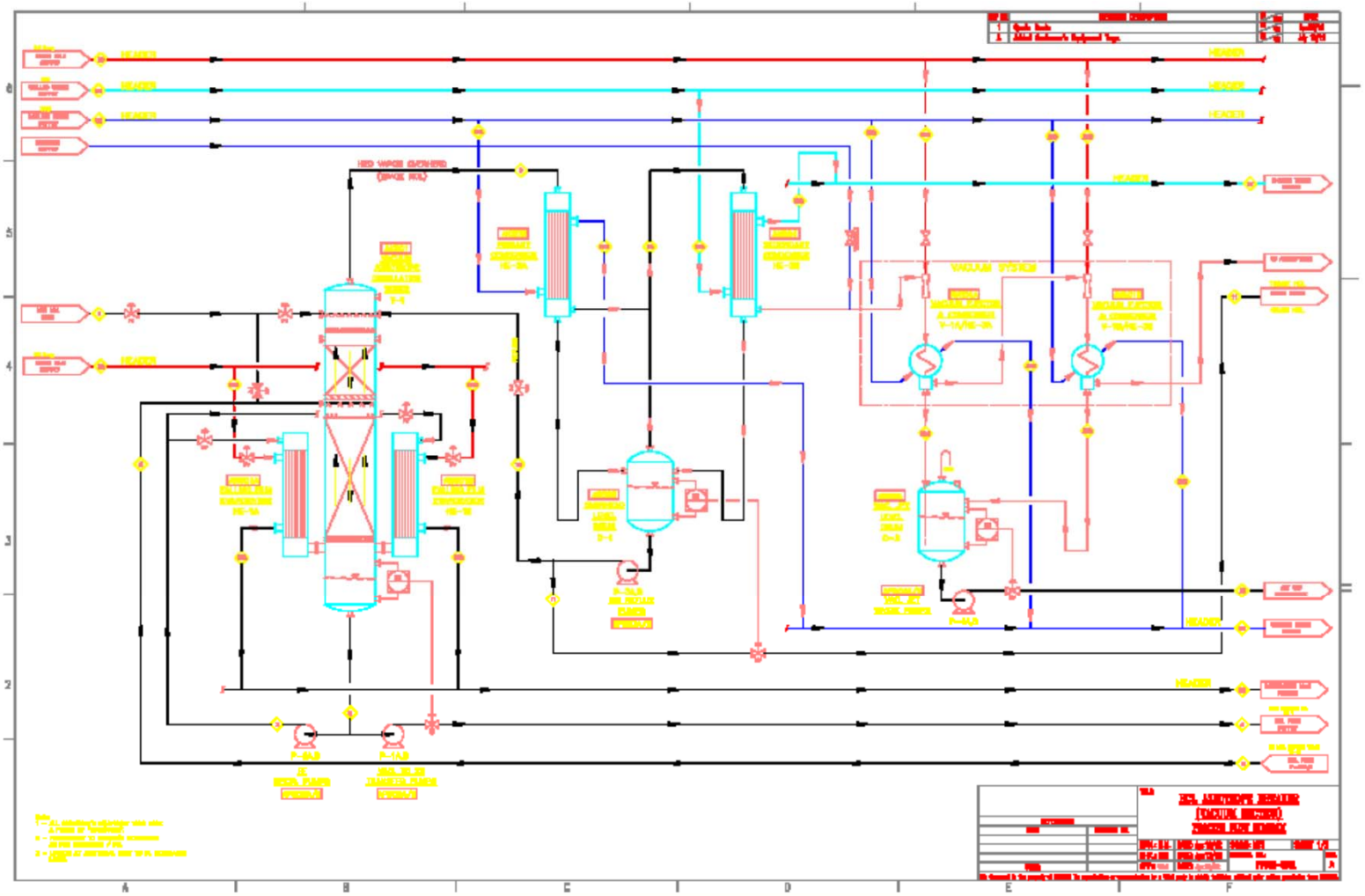

# Product Recovery-HCl

## (Pressure System)

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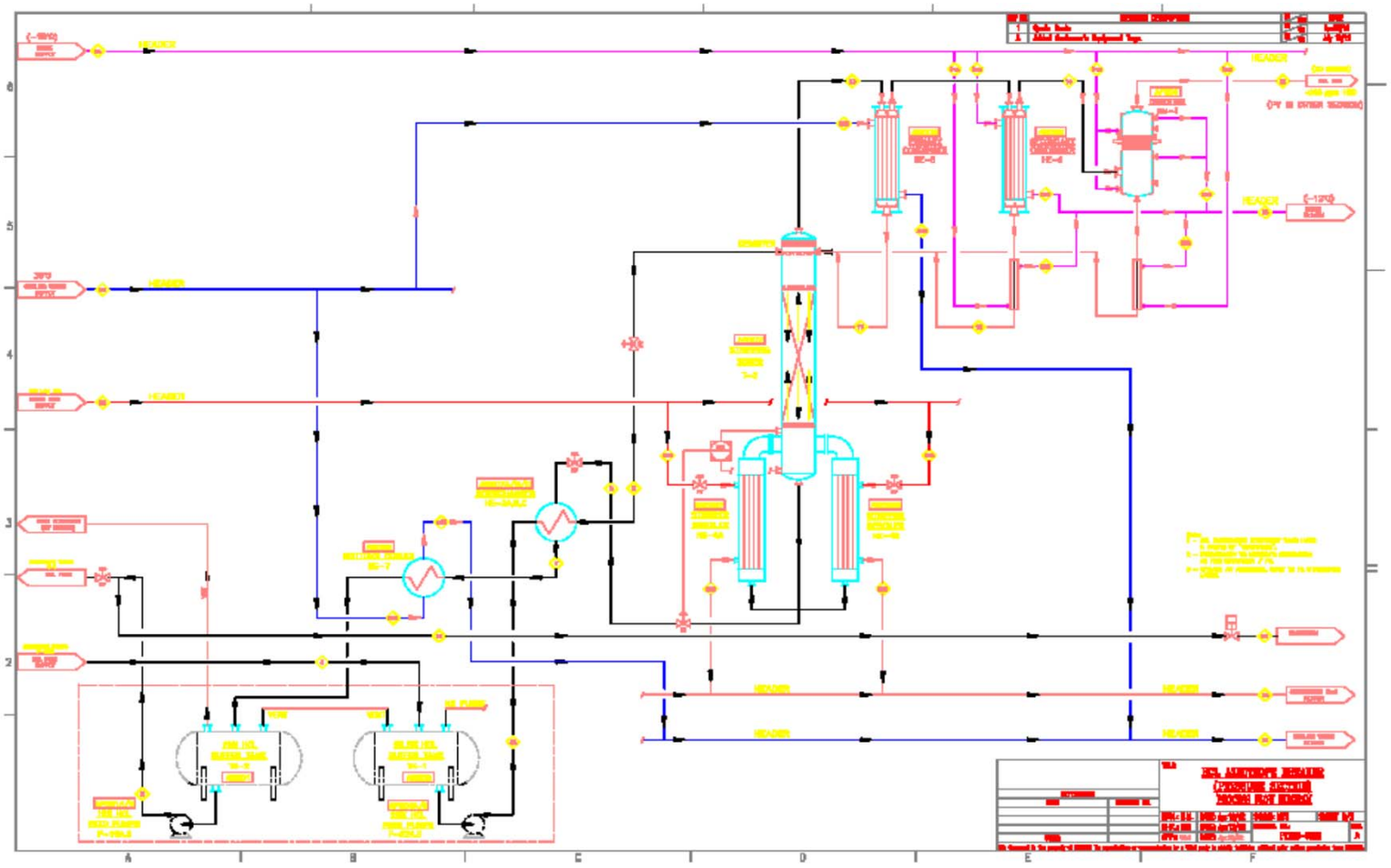

# Alternative Scrubbing Fluids

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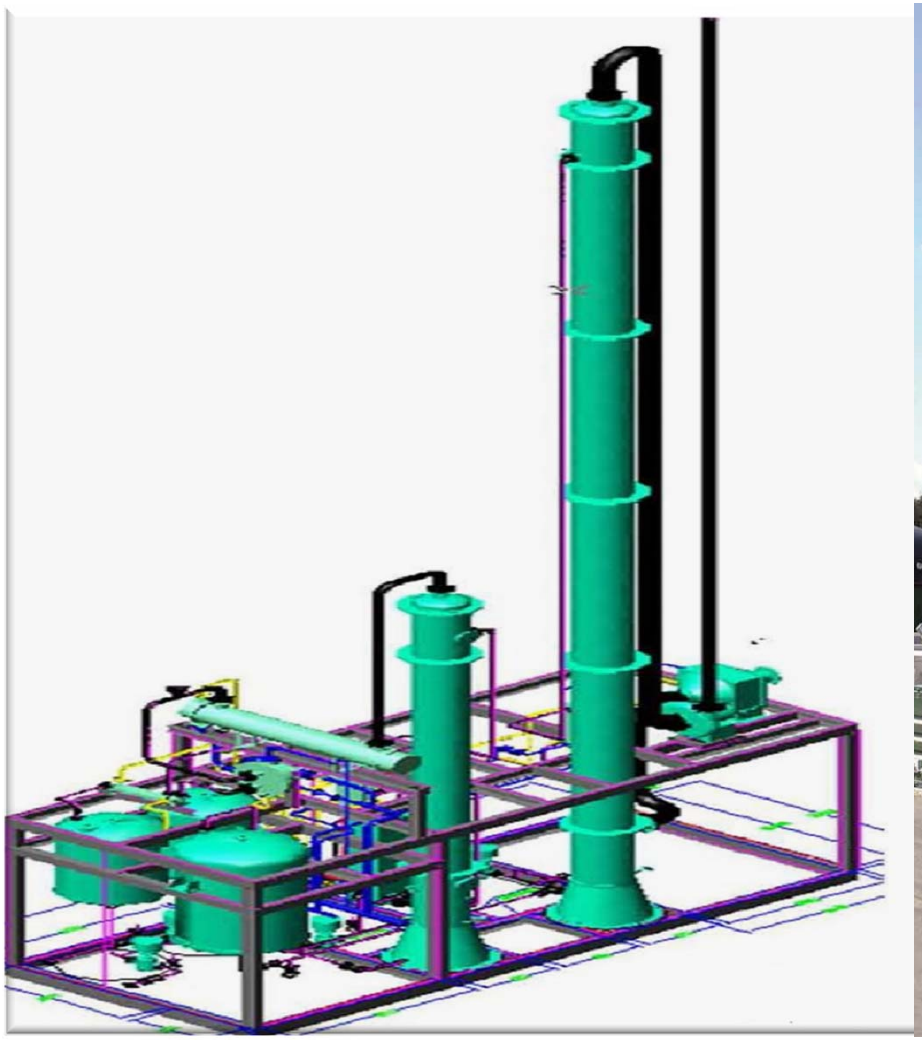

# Alternative Scrubbing Fluids

VERANTIS
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| Specifications | Performance | Applications |
|---|---|---|
| Gas flow rates from 100 $Nm^3/h$ to 200,000 $Nm^3/h$ | Removal of VOCs like vapors from alcohols, esters, ketones, aldehydes and chlorinated hydrocarbons | COD reduction in effluent treatment (anerobic digestion) |
| Inlet Gas containing VOC | | API and Formulations |
| Proprietary Scrubbing Solution has low vapor pressure as these contain special stabilizers against oxidation | | Synthetic Organic Chemicals |
| Physical Absorption at $20^0$ C or lower | | Solvents |
| Desorption takes place by stripping with steam, air under vacuum conditions at lower temperatures | | Cleaning used ethylene for re-use in Polyolefins Plant |
| | | |
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# Alternative Scrubbing Fluids

VERANTIS
Environmental Solutions Group

| Specifications | Performance | Applications |
|---|---|---|
| Gas flow rates from 100 $Nm^3/h$ to 200,000 $Nm^3/h$ | Removal of CO2 / $H_2S$ from Biogas | Removal of $H_2S$ from Syngas |
| Inlet Gas containing $CO_2$, $H_2S$ , COS, $NH_3$, R-SH | >99.99% removal of $H_2S$ from inlet gas | Biogas Upgrade |
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# Alternative Scrubbing Fluids

VERANTIS
Environmental Solutions Group

| Specifications | Performance | Applications |
|---|---|---|
| Gas flow rates from 100 $Nm^3/h$ to 200,000 $Nm^3/h$ | Removal of $SO_2$ from Flue Gas | Desulfurization of Flue Gas |
| Flue gas containing 0.5% $SO_2$ | Meets stringent environmental norms | Production of Sulfuric acid / Liquid $SO_2$ |
| $SO_2$ scrubbed with proprietary absorption liquid. | Waste $SO_2$ is concentrated to 500kg/h rich $SO_2$ that can be used for sulfuric acid production | Gypsum – free FGD |
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# Aerosol Removal

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# Aerosol Collectors

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**HEAF® (High Efficiency Air Filtration System):**

- The HEAF® system is designed to deliver high collection efficiency for aerosol emissions utilizing about 50% of the energy required for the equivalent performance in a high energy scrubbing system such as a venturi or ejector.

- HEAF® systems utilize a fibrous filter media operated at relatively high face velocities to deliver high removal efficiency for solid and liquid aerosol emissions.

- The CHEAF® system is similar in design the to HEAF but also utilizes a suitable solvent to solubilize collected aerosol particulate after collection on the filter media.

# HEAF® Product Features

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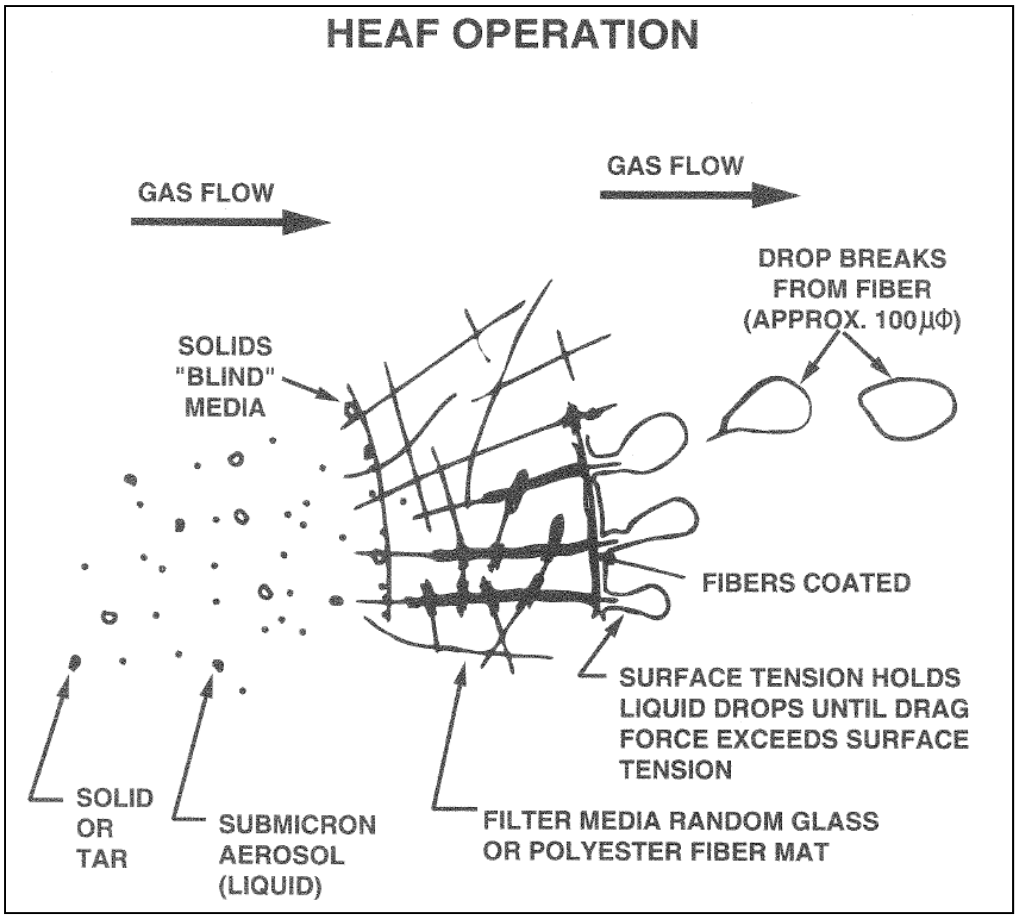
| Specifications | Performance | Applications |
|---|---|---|
| Gas Flow Rates: 100 to 70,000 ACFM | Removal of particulate matter less than 1.5 microns which exists as either solid or liquid. | • Coffee and Coca Bean Roasters<br>• Curing Ovens<br>• Asphalt Roofing Production<br>Carbon Electrode Production<br>• Commercial Printing<br>• Fiberglass Insulation Production<br>• Flakeboard /Pressboard Production<br>• Food Processing<br>• Foundries<br>• Heat Treating and Annealing<br>• Meat Curing<br>• Metal Forging<br>• Plastic Resin Manufacturing<br>• Rubber Mold Press<br>• Scrap Metal Processing<br>• Soap/Detergent Manufacturing<br>• Tank Vents<br>• Tire Manufacturing<br>• Wire and Tube Manufacturing |
| Pressure Drop: 28” W.C. | Reductions in aerosol emissions | |
| Inlet Temperatures Range: 100 to 120°F range, (Cooling chamber may be required) | Removal efficiency greater than 99% | |
| HEAF Housing: Mild Steel | | |
| Filter Media: Fiberglass or Polyester Mat | | |
| Fan: Heavy Duty Pressure Fan, Arrangement 4 or Arrangement 8 | | |
| Mist-Eliminator: 304 S.S Mesh Pad with a Mild Steel Housing | | |
| Automated indexing of filter media (or easy manual change for mini-HEAF) | | |
| Instrumentation: DP Transmitters | | |

# HEAF Operating Principle




- Gas is drawn thru the filter media at a face velocity of 1,300 to 1800 ft./min
- Filter media is about 1/8” thick
- Particulates matter impacts on the fiber and then it is separated from the gas streams
- Low viscosity liquids collected from the gas stream migrate through the filter media as larger liquid droplets
- These droplets pass through an exhaust fan, and then impacted on a mesh type mist separator .

# **IWS®** Ionizing Wet Scrubber Overview

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# IWS® Ionizing Wet Scrubber

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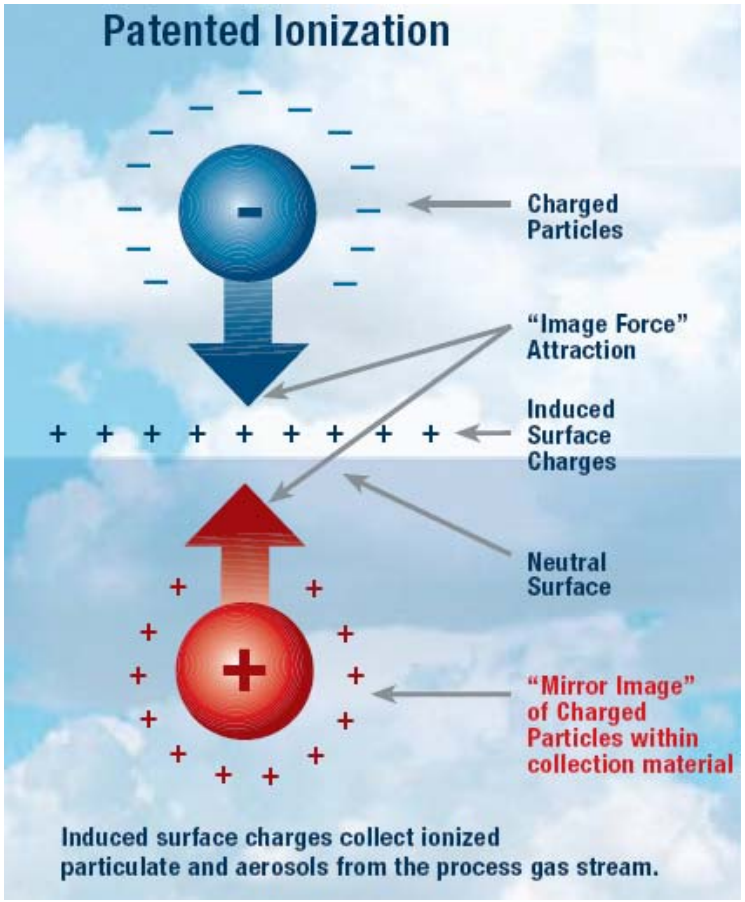
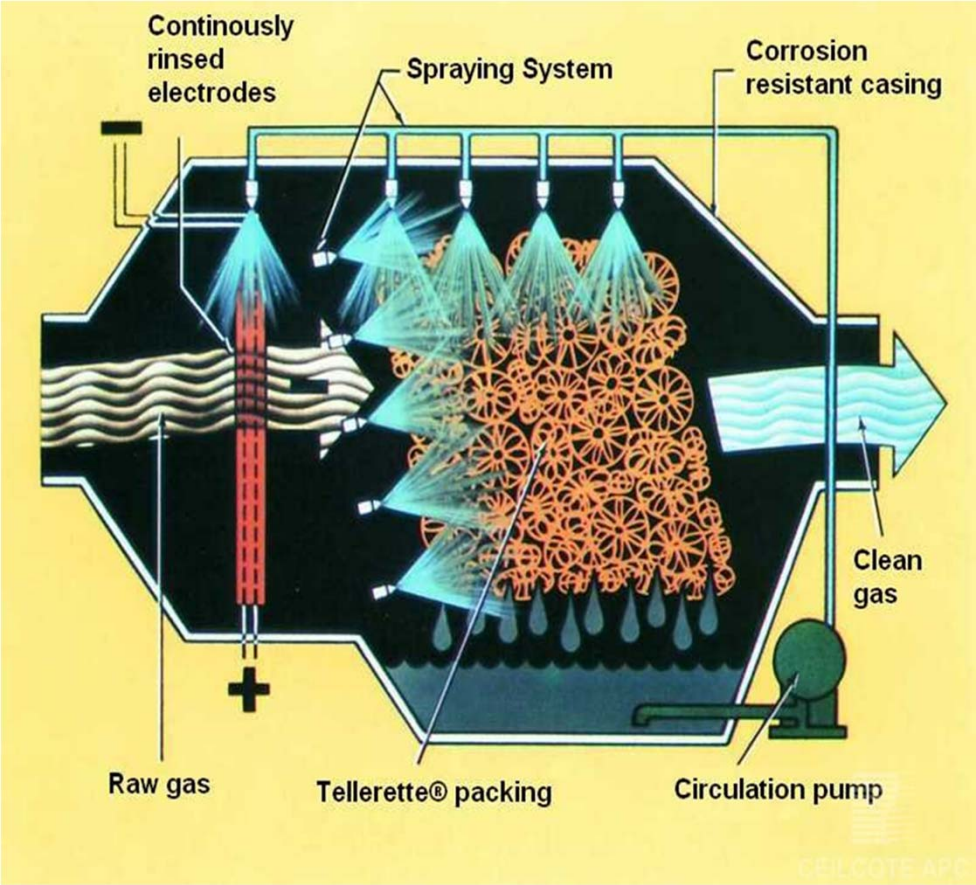



- Ionizing scrubbing technology was developed by Verantis in the 1970's through a joint design venture with General Electric Corp
- The original U.S. patent for this technology was awarded to Verantis in 1972 based on the principle of "Image-Force Attraction"
- There are more than 200 Verantis ionizing wet scrubbers operating worldwide, processing over 3,000,000 CFM of process exhaust gases

# Principles Of Operation




- Fine particles and/or droplets are charged in a high-intensity electrostatic field.
- Charged particles through a wetted packed bed (Tellerette) section.
- Particles are collected on the packing surface and wash away by the recirculation liquid.
- Gases are scrubbed simultaneously in the packed section.
- Additional cleaning is provided by an automated flush based on timer control.

# Product Features

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| Specifications | Performance | Applications |
|---|---|---|
| Gas Flow Rates: 3000 – 30,000 ACFM per module. Modules can be arranged in parallel for higher capacity designs. | Can achieve 0% opacity (clear stack) with tested performance to loadings less than 1 $mg/m^{3.}$ | • Chemical Waste Incineration<br>• Fiber Optics Manufacturing<br>• Precious Metals Processing<br>• LCD Production<br>• Specialty Glass Production<br>• Fiberglass Curing Ovens<br>• Plywood and OSB Dryers<br>• Add-on to existing APC systems to meet new PM2.5 regulations |
| Pressure Drop: 1” - 1.5” W.C. per stage | Removal efficiency improves with turndown. | |
| IWS Housing MOC - FRP or steel<br>Ionizer Plates MOC - C-276, SS2205, 316SS, and other alloys. | Collects all types of submicron particulate: SiO2, heavy metals, salts, acid mists, and aerosols. | |
| Modular construction for ease of installation. | Acts as a fractional collector and can be staged to achieve extremely low outlet loadings. | |
| Fully-Automated HV controls and flushing cycle. | Expandable – additional stages can be added as needed for future process or regulatory changes. | |
| Recognized as an EPA-MACT technology for combustion of hazardous waste. | | |

# **Verantis** Thermal Treatment

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# Thermal Processing

Verantis now has the capability to provide a broad range of thermal processing systems including:

- Thermal Oxidizers for liquid and fume waste streams
- Rotary Kiln Incinerators for hazardous, solid, liquid and sludge waste

Worldwide capabilities for engineering, fabrication, construction and commissioning of incineration plants is also a major advantage over other suppliers

# Rotary Kiln Systems

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- Broad range of capacities up to 5 MT/hr.
- Cocurrent design
- Multiple feed systems
- Fully integrated material storage and delivery systems
  - Tank Farms
  - Sludge storage
  - Solids handling/mixing/shredding
- Wet and dry ash removal options

# Rotary Kiln Systems

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# Rotary Kiln Systems

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# Rotary Kiln Systems

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# Liquid Fume Systems

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- Provide the highest flexibility for processing a wide variety of fume and liquid waste streams
- Can easily achieve VOC destruction efficiencies in excess of 99.99% at temperatures as low as 790° C
- Horizontal or vertical down fired systems
- Can be equipped with waste heat boiler equipment to provide for increased efficiency

# Fume Incinerator

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# **Verantis** FRP Fans – General Information & Overview

# Verantis Centrifugal Fan

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- Our centrifugal fans provide optimum performance with minimal interruption.

- Housings are manufactured from premium grade, fire-retardant resins that provide excellent corrosion resistance in most chemical environments.

- Clockwise or counterclockwise rotation in all 8 standard discharge positions is available.

- The fans are available in sizes from 4" to 73" in diameter with capacities from 500 cfm to 150,000 cfm at static pressures to over 30".

# Verantis Centrifugal Fan

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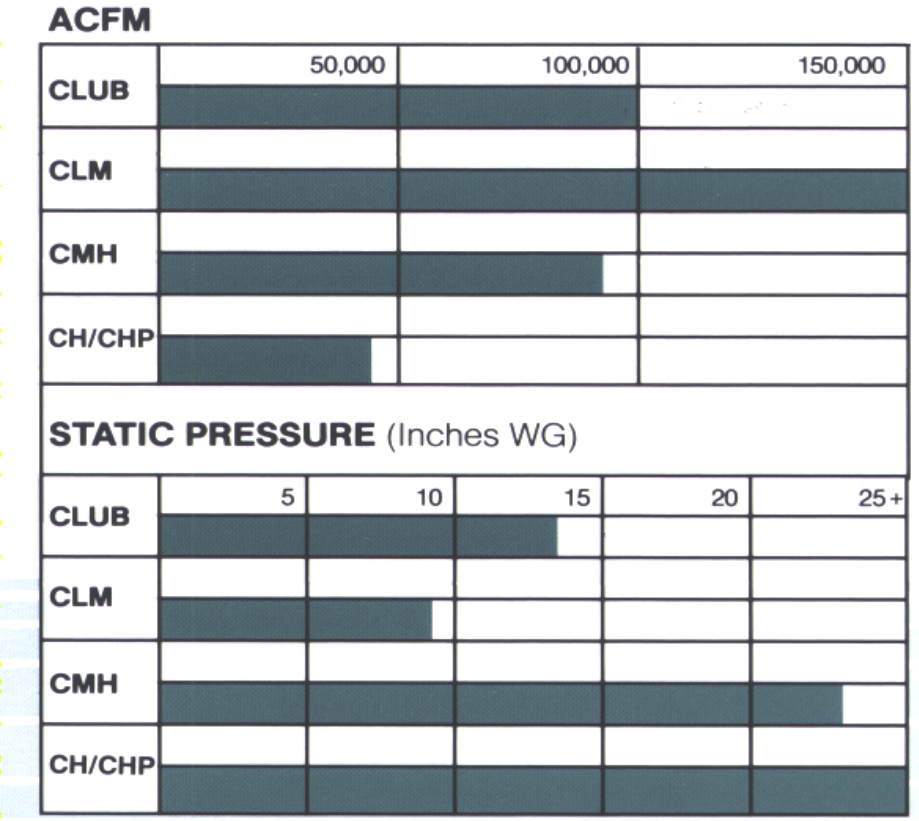
Typical Ranges for CFM and SP of Verantis Centrifugal Fans




The CLUB fan is suitable for approximately 80% of all fan applications

# Fan Selection Graph

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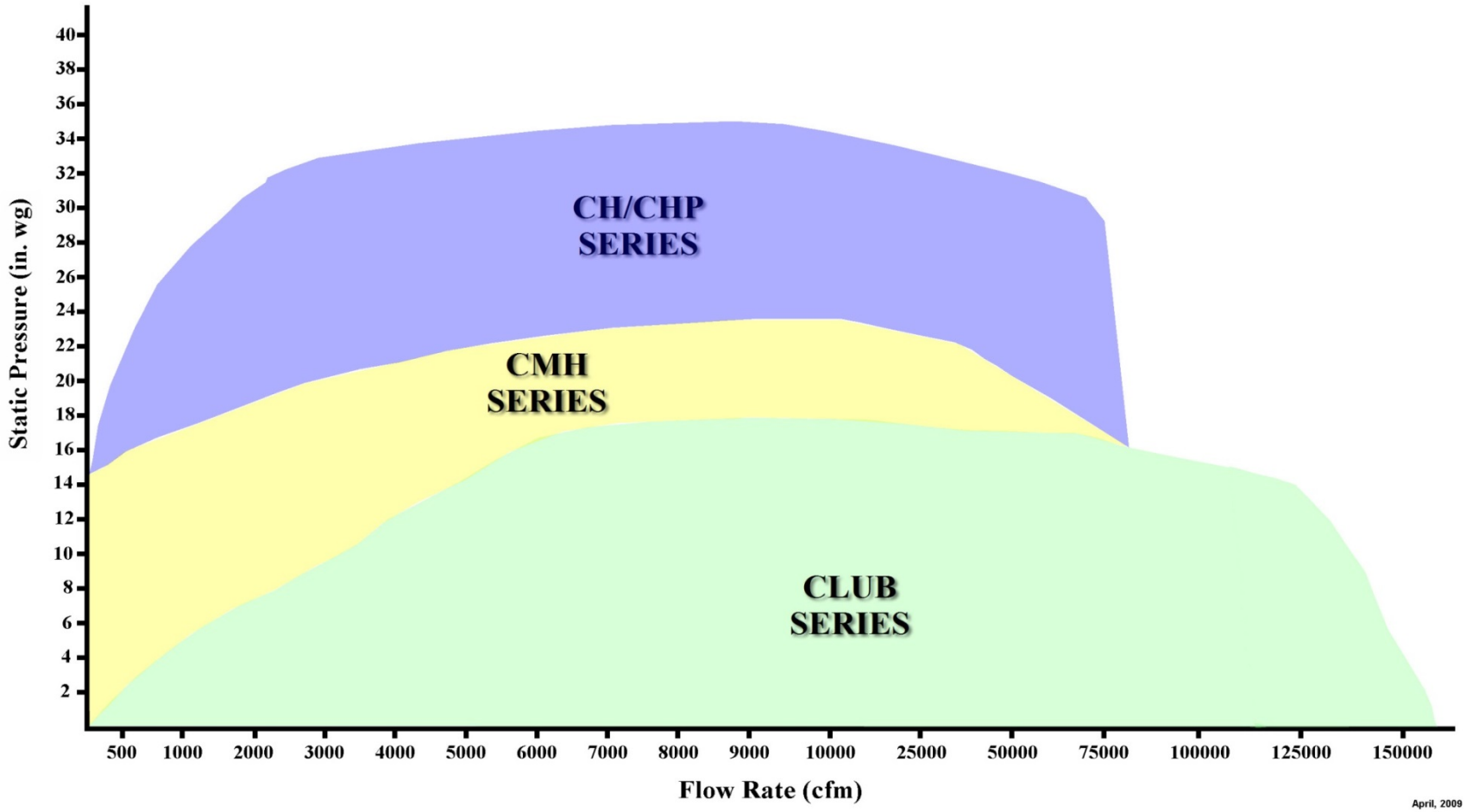

# High Quality Construction

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# Inline Axial & Roof Ventilator Fans

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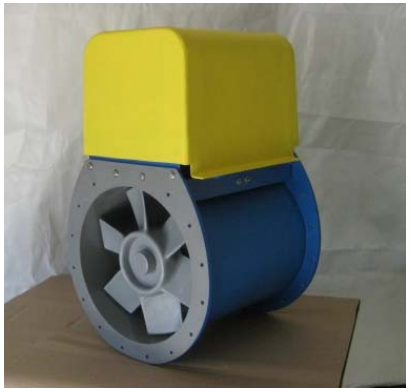
- Inline Axial Fans (FL Series) and Roof Ventilator Fans (FLR Series)
- Available up to 125,000 CFM and 3 inches of SP



# Inline Centrifugal Fans

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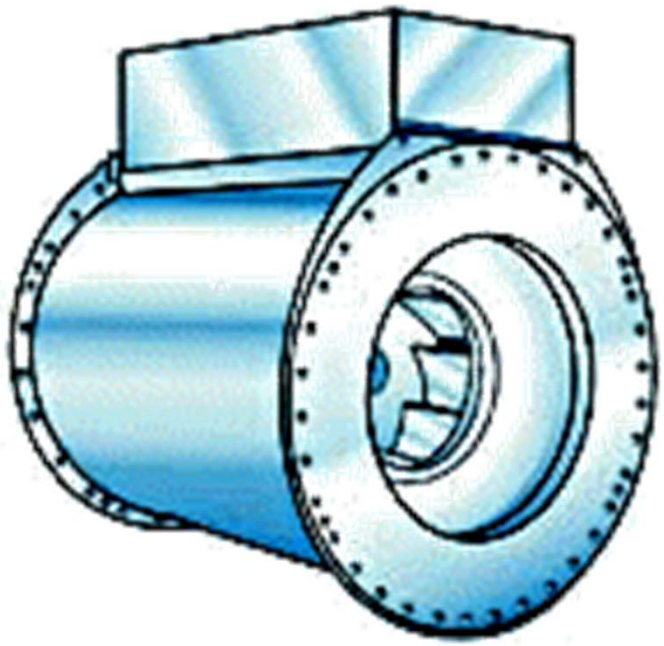
- Inline Centrifugal fans (FLC Series)up to 75,000 CFM and 9 inches of SP



# The Verantis Advantage

- Verantis meets or exceeds the industry standard for balancing tolerance
  - Maximum of $0.078^{in}/_{sec}$ velocity
  - This allows for longevity
- Verantis fans have interior C-Veil as STANDARD, for added corrosion resistance
  - This is a glass fiber tissue bonded into a sheet by a polymer resin. The fibers are produced from C glass, a chemically resistant glass which is highly resistant to attack by both acid and alkaline environments.
- Verantis provides as standard, a totally encapsulated hub, to eliminate any contact between metal components and the corrosive gas stream

# The Verantis Advantage

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- Verantis belt & shaft guards and canopies are made of FRP for long life
- Verantis fans are 100% hand built, making them customizable in virtually any way
- Verantis offers the largest FRP fans in the industry - up to 73” diameter impellers
- Verantis tests and balances each impeller TWICE, both statically and dynamically
- All Verantis fans are factory tested before shipping, in accordance with AMCA Standards
- Verantis Design Standards are extremely high - Meeting ASTM C-582 & ASTM D-4167 (PS15-69)

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# **Tower** Internals and Systems Aftermarket

# How do Tellerettes work?

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- Liquid is collected by inertial impaction.
- Droplets form at countless interstitial holdup points.
- As each droplet falls, it strikes the next packing element and bursts, exposing fresh surfaces to gas.
- This agglomeration/dispersal cycle repeats continuously with no additional energy requirements.
- Contaminants are absorbed with unique efficiency.

# Tellerette® Tower Packing

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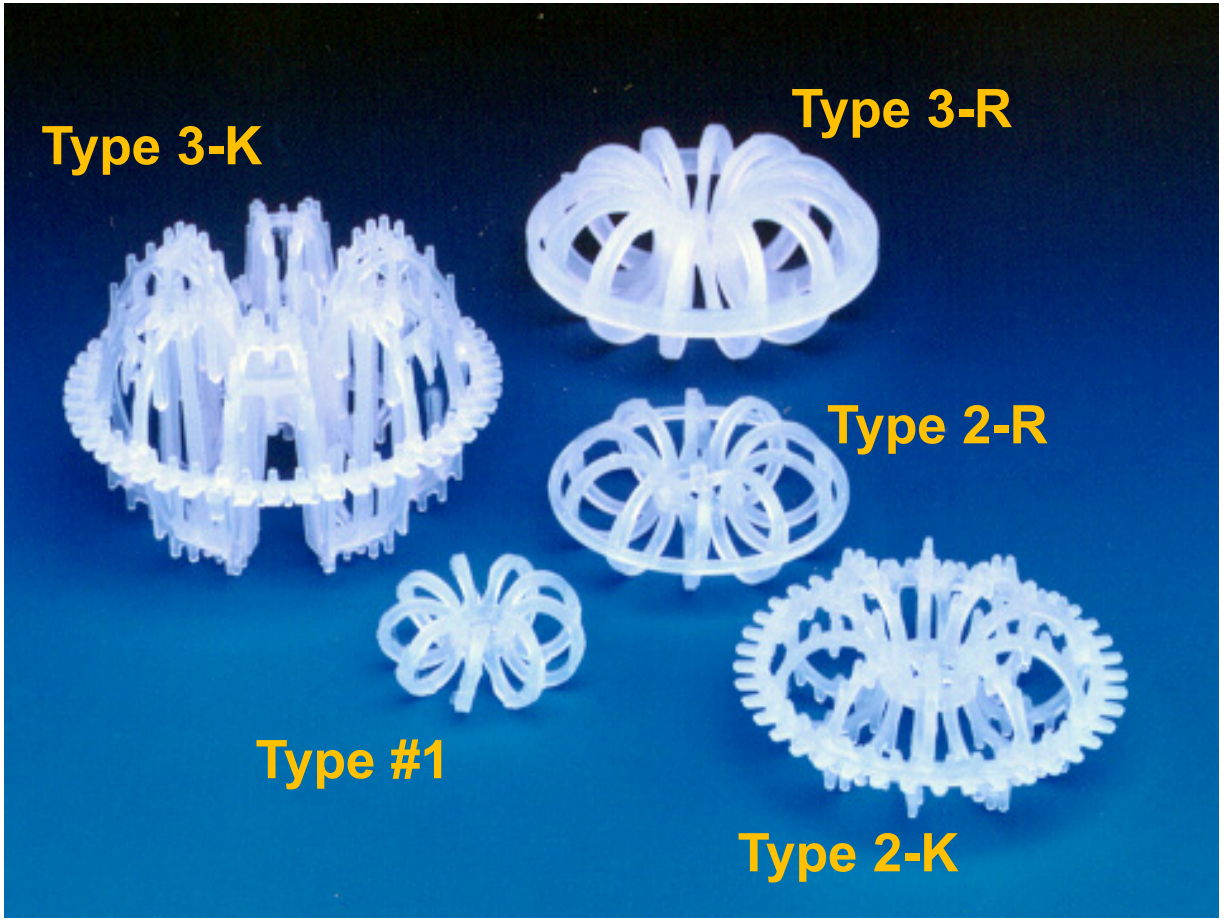

# The Tellerette® Advantage

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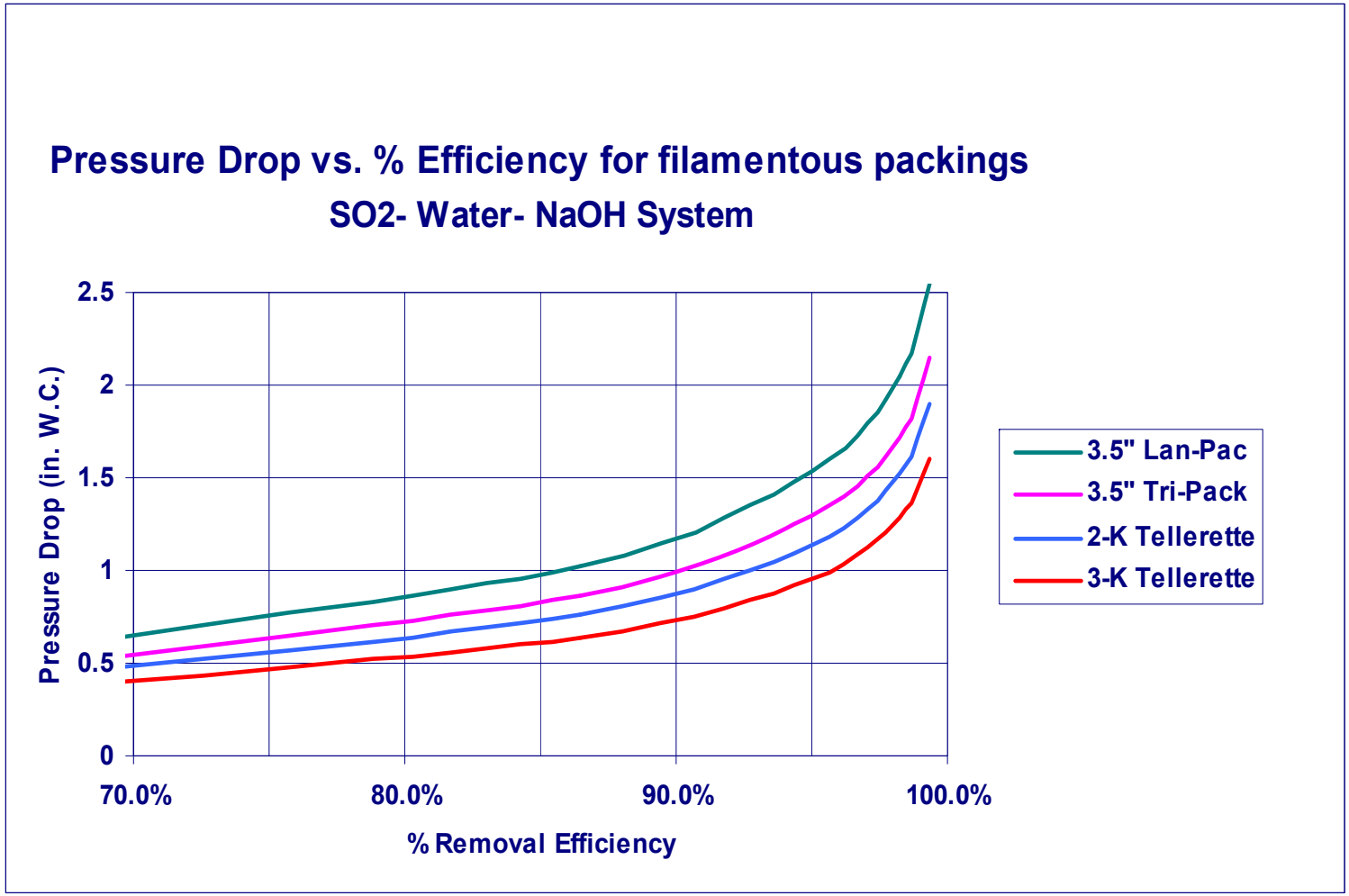

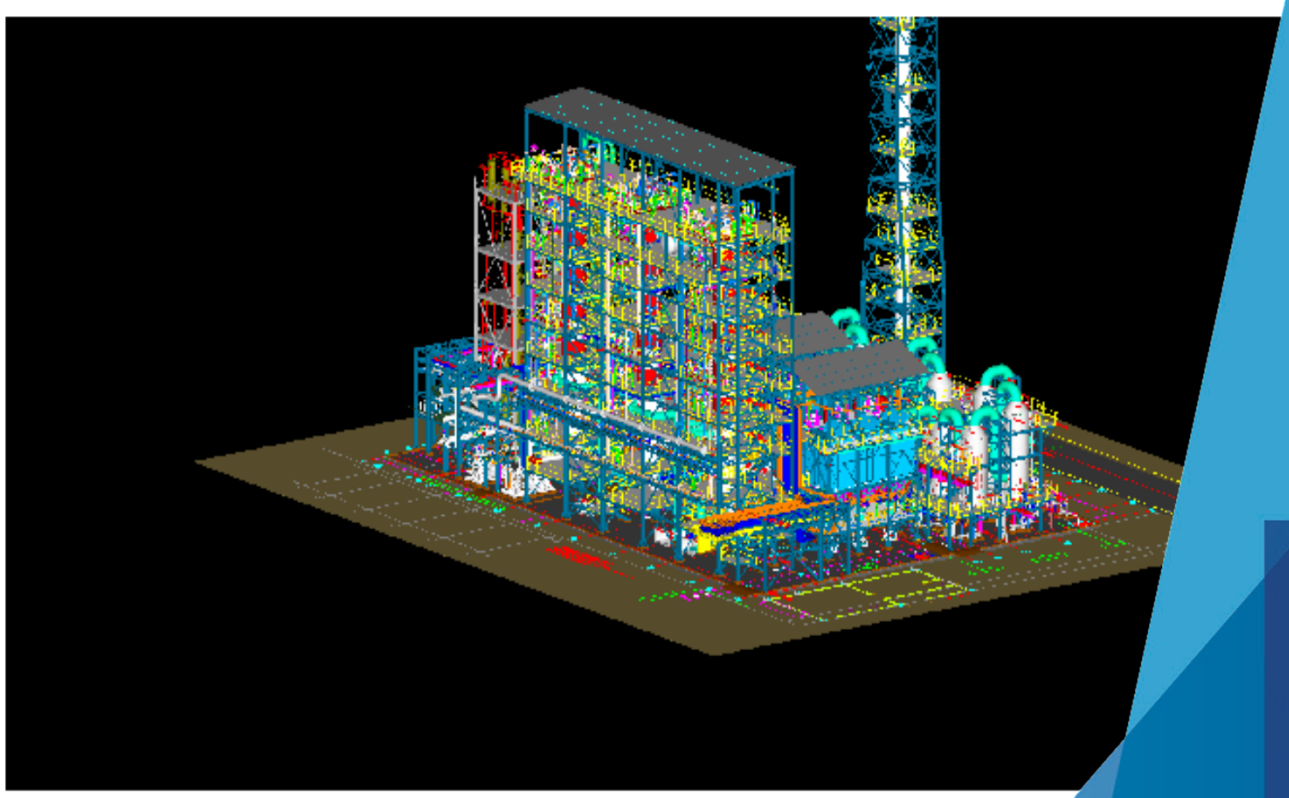

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# Engineering and Process Optimization

# Engineering Services

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- Verantis provides a wide range of engineering services
  - Existing process evaluation and modeling
  - Processing capacity enhancement
  - Improved efficiencies – Regulatory compliance requirements
  - Permitting assistance – EIA and environmental permitting
  - Front end engineering design (FEED) studies

# Customized Equipment Enhancements

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- In addition to engineering and equipment optimization assistance Verantis can also provide:
  - Fabrication and installation of custom retrofit equipment for thermal treatment and air pollution control systems
  - Control upgrades and instrumentation services
  - Combustion system optimization
  - Continuous emissions monitoring and data acquisition equipment packages
  - On-site service and maintenance packages

# Combustion Systems

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# Materials Handling-Liquids

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# Materials Handling- Sludges

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# Materials Handling- Sludges

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# Materials Handling- Sludges

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# Materials Handling- Sludges

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# Materials Handling- Solids

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# Ash Removal

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# Waste Characterization and Blending Analysis

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# Engineering Services

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- Engineering Disciplines
  - Process – proprietary material balance/process modeling program
  - Structural
  - 3D modeling
  - Piping/pipe stress
  - Environmental


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