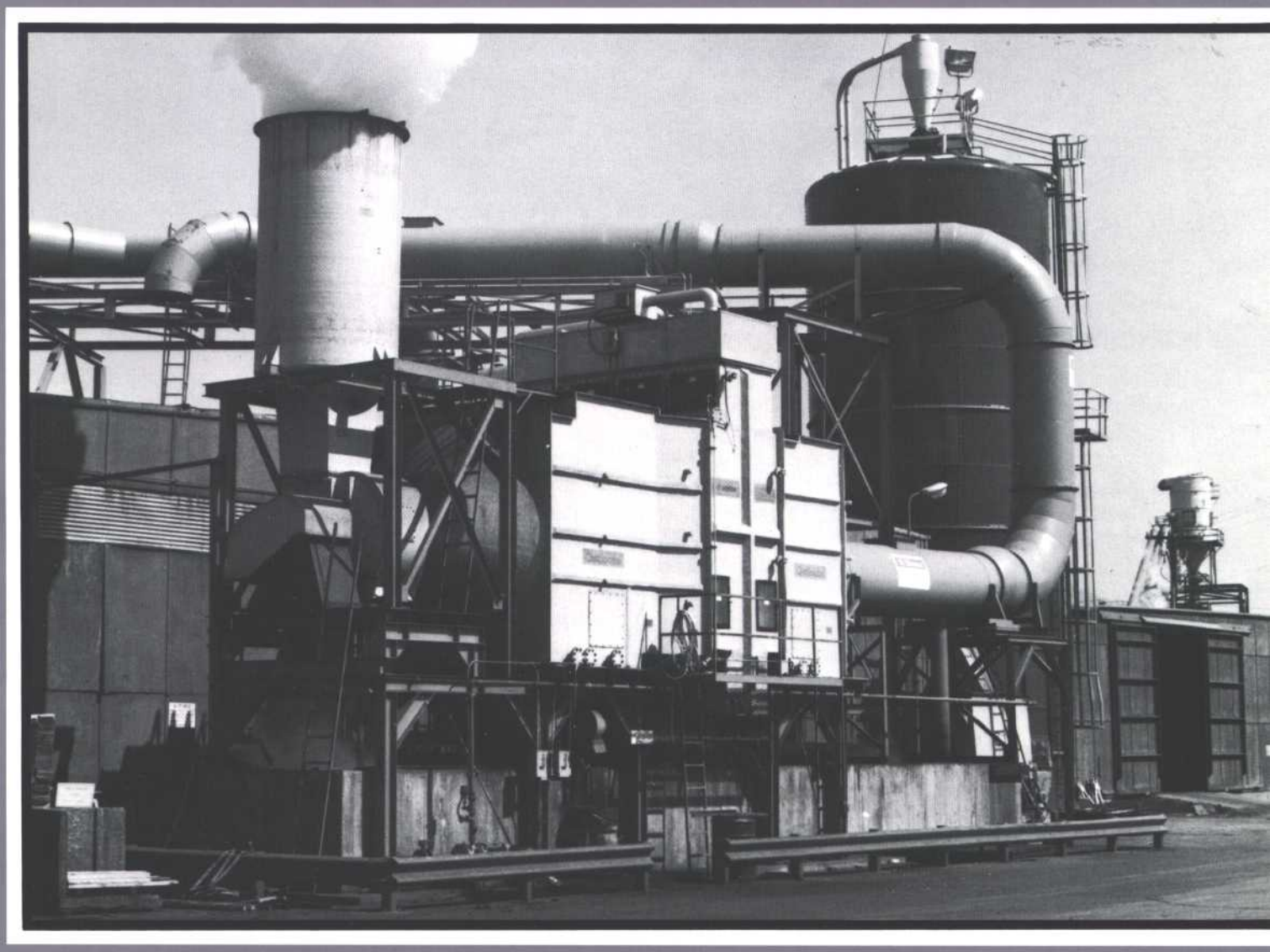
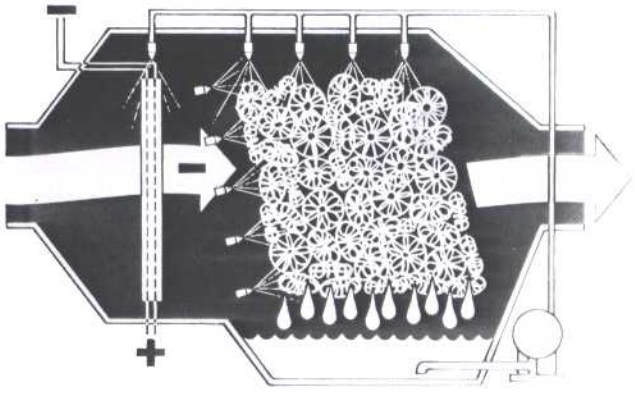
VERANTIS
Environmental Solutions Group



IWS™ System

Ionizing Wet Scrubber

BULLETIN 12-19



PRINCIPLES OF OPERATION

The Ceilcote Ionizing Wet Scrubber* (IWS)™ system is a proven means for the removal of pollutants from industrial process gas streams. The IWS combines the established principles of electrostatic particle charging, image force attraction, inertial impaction, and gas absorption to collect submicron solid particles, liquid particles and noxious and malodorous gases simultaneously. The IWS system requires little energy and its collection efficiency is high for both submicron and micron size particles.

The Ionizing Wet Scrubber utilizes high voltage ionization to electrostatically charge particulate in the gas stream before the particles enter a Tellerette® packed scrubber section where they are removed by attraction of the charged particles to neutral surfaces. Larger particles of seven to eight microns and larger are collected through inertial impaction. As small particles flow through the scrubber, they pass close to the surfaces of Tellerettes and scrubbing liquid droplets. The electrostatic charge on the particles cause them to be attracted to these neutral surfaces by image force attraction. All particles are eventually washed out of the scrubber with the exit liquor. Noxious and malodorous gases are absorbed and reacted in the same scrubbing liquor.

*Patent Nos. 3,874,858 and 3,958,958
® Registered trademark of The Ceilcote Co.

OPERATING ADVANTAGES

Particle Collection—The IWS system utilizes neutral plates and Tellerette packing as its collection surface to achieve particulate removal. Scrubbing liquid droplets also act as collection surfaces. Particles of any size or composition are collected by the IWS. Fine particles (0.05 to 2 microns) are collected with high efficiency as well as coarse particles (2 microns and larger), regardless of their composition (organic or inorganic with either high or low resistivity). Particle collection efficiency over long term service remains consistently high.

Gas Absorption—The IWS system simultaneously absorbs gases. Noxious gases are removed through physical absorption and/or absorption that is accompanied by chemical reaction.

Low Energy Consumption—Pressure drop through a single stage IWS is only ½ in. to 1½ in. water column. Energy for particle charging is low–approximately 0.2 to 0.4 KVA per 1000 CFM.

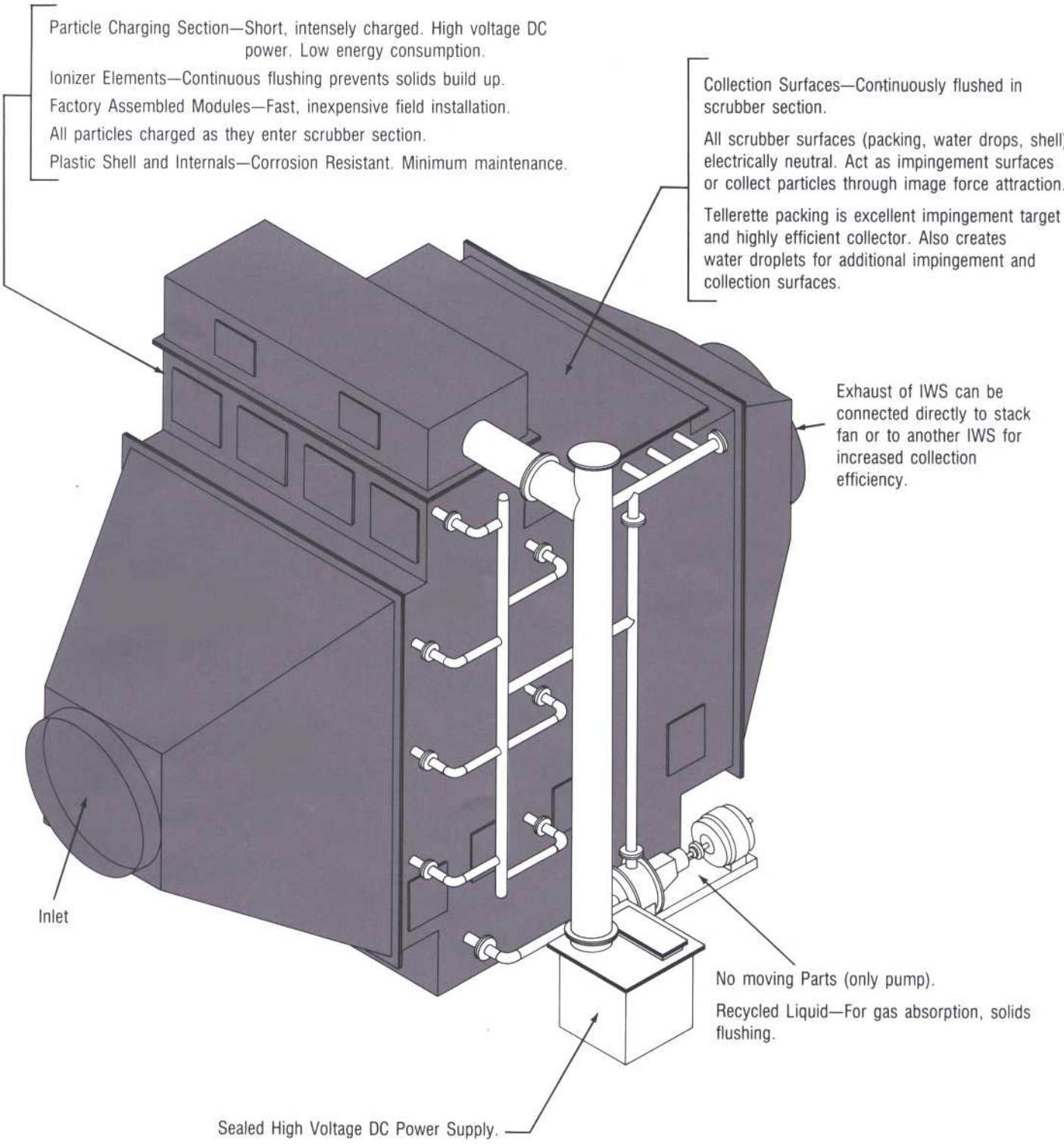
Corrosion Resistance—The shell and most internal parts of the IWS are commonly fabricated of Duracor® (fiberglass reinforced plastic) and thermoplastic materials. This predominance of plastic construction assures corrosion-free operation in the presence of acid gases such as HCl, HF, Cl_2, NH_3, SO_2 and SO_3. For noncorrosive application, metallic construction is also available.

Fractional Collector—The IWS system acts as a fractional collector. The percent of particulate removed varies little with load and particle size distribution over a wide range. As particulate load increases, the percent removed remains nearly constant. The collection efficiency for fine particles is nearly as great as for coarse particles.

Turn Down—Collection efficiency improves with turn down from 100% to 0% load.

Size Range—Factory assembled modules, available in standard capacities from 900 to 54,000 ACFM, can also be grouped together to handle virtually any gas volume.

SUBMICRON PARTICULATE AND NOXIOUS GASES REMOVED SIMULTANEOUSLY



Verantis Corporation successor in interest to Air Cure Dynamics, Inc. - DBA Ceilcote Air Pollution Control

IWS SYSTEM COMPONENTS

Ionizer (Charging) Section

Particles are first electrostatically charged within an ionizer section that utilizes a high voltage, D.C. power source. Discharge electrodes have negative polarity and wetted "mini-plates" serve as grounded electrodes.

High Voltage Transformer/Rectifier

High voltage D.C. power for the ionizing section is provided by a high voltage transformer/rectifier. This is a sealed, water-tight, oil-filled unit. Rectification is accomplished by silicon diodes which are suitably protected against transient voltages for efficient and long-term, trouble-free service.

Control Cabinet

All control and remaining power functions for the IWS are combined in a single, standard, factory pre-wired control cabinet which can be located at any convenient location, either adjacent to or remotely located from the IWS. Field hook-up is simple. The control cabinet is connected to the high voltage transformer/rectifier by five leads attached to cabinet terminals. Maximum voltage on the interconnecting wiring is 480 volts.

Voltage control for high voltage is achieved by thyristor control through phase-angle variation. An ultra-fast response, solid state, plug-in type standard control module automatically controls high voltage levels and spark rate for optimum performance. A manual control is also provided for backup and for trouble shooting.

Operation is simple and straightforward. All functions are automatic. Necessary meters and indicator lights are provided to monitor the operation. Protective interlocks and circuits safeguard the equipment against overloads or malfunctions.

Flushing

The grounded electrode plate surfaces of the IWS are continuously flushed by a flow of water or other suitable liquid. This assures that optimum electrical performance is maintained at all times by washing away any resistive solids or residues that could collect on the "mini plates" and cause reduced performance.

A second flushing system is also provided which periodically deluge flushes all internal areas of the ionizer section.

The deluge flushing is completely automatic and is set to provide a flushing cycle every four hours or as experience dictates. Water for the periodic deluge flush is recycled liquid from the scrubber recycle system.

Charged Particle Scrubber

The IWS incorporates a crossflow scrubber section following the ionization section. The scrubber section employs Tellerette packing to absorb gases and collect both liquid and solid particles from the gas stream.

The contaminated gas stream moves horizontally through a Tellerette packing bed that is irrigated by scrubbing liquid flowing vertically down through the packing. The inherent advantages of the crossflow design result in high operating reliability, high air flow rate, low pressure drop and low operating cost.

Sump

The IWS contains an integral sump to recirculate the scrubbing liquid directly after it passes through the packed-bed section. Use of an integral sump reduces cost and minimizes floor space requirements.

Recycle Pump and Piping

Pump(s) and complete recirculation piping for the IWS is normally provided for continuous wetting of the ionizer plates, deluge flushing of the ionizer section and continuous irrigation of the crossflow scrubber.

Alternate design approaches can be adapted for use in the IWS liquid distribution system. The method employed is contingent upon the customer's requirements and job site restrictions.

Construction and Corrosion Resistance

The IWS shell and most internal parts are normally fabricated of Duracor® fiberglass reinforced plastic (FRP) and other polymeric materials. The preponderance of plastic as a material of construction assures corrosion-free operation in the presence of gases such as HCl, HF, NH_3, SO_2 and SO_3. Additionally, structural support requirements are minimized by the units' light-weight.

Extensive use of proven, long service life plastics throughout the IWS is possible because of its unique design, construction and operating principles. The only metal required is for the electrical components employed within the ionizing section. These metallic components are fabricated of alloy materials chosen for each application to provide maximum corrosion resistance in the service environment.

The IWS can also be constructed of metallic components where corrosive conditions are not a problem and the use of FRP materials are not economical or practical in a specific application.

IWS OPERATING CHARACTERISTICS

Particle Collection

Results from pilot tests and more than 500 actual full size operating systems verify that particles of virtually any size and composition are collected by the IWS™. Submicron solid/liquid particles as minute as 0.05 microns, coarse particles having organic or inorganic structures and conductive or highly resistive particles are all collected at high efficiency.

Image Force Attraction

The predominant influence acting within the IWS to collect submicron size particulate is the mechanism of impingement of electrons on particulate "Image Force Attraction".

Image force attraction occurs whenever an electrostatically charged particle comes within the boundary layer (usually within one millimeter) of a neutral surface. As the charged particle comes close to the neutral surface, an electrostatic charge of opposite polarity is induced at the neutral surface. The force of attraction is similar to that which would exist between a charged particle and an imaginary particle of equal but opposite polarity located at an equal distance behind the surface. It is as though the charged particle was seeing its "mirror image".

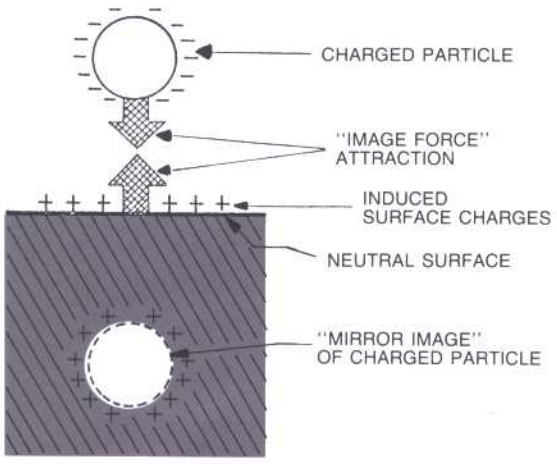
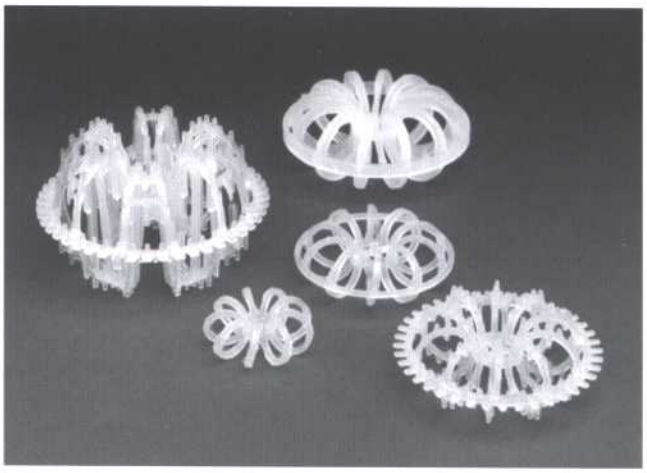


Image Force Attraction

Inertial Impaction

Particles of seven to eight microns in size (7-8 μ) and larger are collected by inertial impaction. Particles impinge on a Tellerette packing surface, are captured, and flushed away. Tellerette packing is used exclusively in the IWS.

The unique geometrical design configuration of the Tellerette makes it an excellent impingement target. Highly efficient collection is due to the large number of small target areas. Greater particulate collection efficiency, higher gas absorption efficiency and greater flow capacities are all characteristic of Tellerette packing, as opposed to extended surface packings.



Scrubbing and Gas Absorption (Mass Transfer)

Removal of gaseous contaminants in the scrubber is achieved by the principles of mass transfer whereby gaseous molecules from the air stream are transferred to the scrubbing liquid. Transfer is achieved by a combination of diffusion, physical absorption and/or chemical reaction.

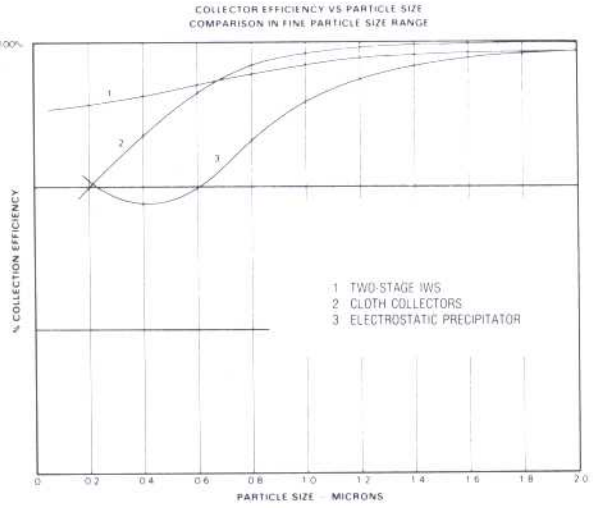
Gaseous collection efficiency is directly dependent upon the irrigation rate, the horizontal depth of packing and the gas velocity through the scrubber. Depending on the depth of the Tellerette packed bed, the liquid flow rate, and composition of the scrubbing liquid, efficiencies up to 99.9% gas absorption can be obtained.

In an application where two or more gaseous contaminants are to be removed, it is often desirable to scrub with chemically different liquids. This can readily be achieved with the cross-flow scrubber geometry which easily accommodates two or more separate scrubbing beds.

The use of two or more packed beds is usually associated with applications requiring odor abatement, multiple gas/solids removal, solids/odor removal and other complex scrubbing problems.

Collection Efficiency

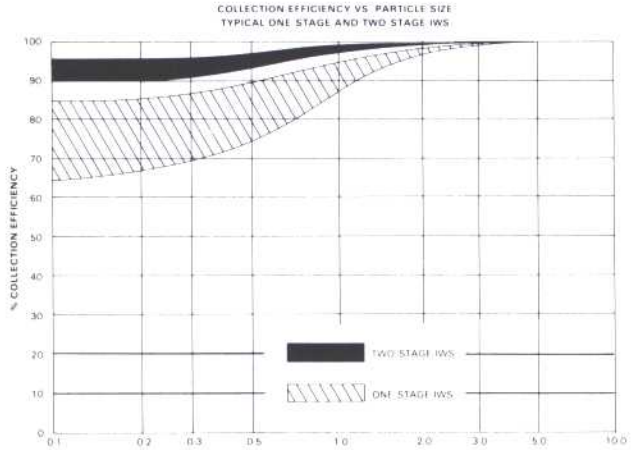
IWS collection efficiency in the fine particle range decreases only slightly as the particles become smaller. In conventional electrostatic precipitators, collection efficiency drops in the submicron area, especially in the 0.2 to 0.6 micron range. For cloth collectors, collection efficiency decreases sharply when particles are 0.5 microns and smaller. A comparison of the collection efficiency characteristics versus particle size of these devices are depicted below.



Staging For Higher Efficiency

The IWS is a fractional collector. A single-stage IWS unit will remove a nearly constant percentage of incoming particles regardless of particle size distribution. Where a higher collection efficiency is required than is possible with a single-stage IWS, a second IWS stage can be used. The percent collection efficiency of the second-stage IWS will be approximately the same as the first-stage IWS despite the reduction in loading to it.

Shown below are typical collection efficiency curves for single and two-stage systems. Consider the application where a single-stage unit will remove 83% of the entering particulate. By adding a second-stage and obtaining a similar collection efficiency of 83%, an overall efficiency of 97% is achieved. Because of the fractional collector characteristics of the IWS, the performance of an existing unit can be upgraded with a second stage to meet more stringent code requirements.



Liquid Irrigation

The IWS is designed to maximize efficient use of the scrubbing liquid. To achieve optimum scrubbing liquid distribution, the scrubber contains spray header assemblies with low pressure, large orifice nozzles. Droplets formed by the spray nozzles enhance the absorption capacity of the scrubber.

Scrubbing Liquid

Liquid flow rates are based on specific operating conditions. The scrubbing liquid is usually recirculated, thus reducing both consumption of fresh liquid and overflow or blowdown from the scrubber. A small amount of fresh makeup liquid is usually fed continuously to the scrubber system. The fresh liquid keeps the absorbed gaseous pollutant concentration in the recycled liquid at a sufficiently low level to maintain efficient gas absorption. Fresh makeup liquid is also required to balance evaporation losses. Liquid can be fresh water, clean process water, or chemically treated liquids. Water treated with chemicals such as caustic soda, or soda ash is used only when fresh water or process water will not achieve the desired collection efficiency, or when treated water suits the waste treatment criteria of the specific plant.

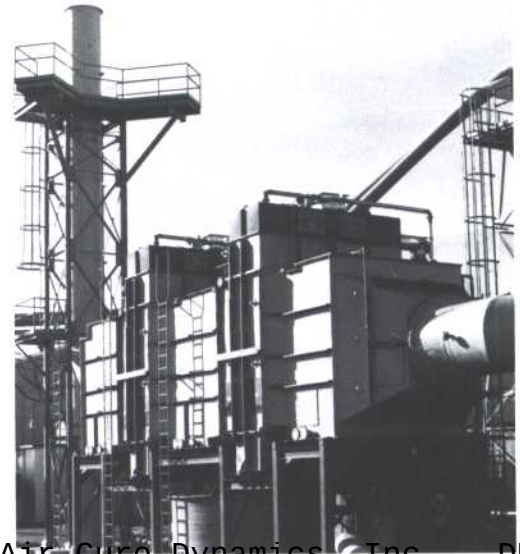
Opacity Reduction

The IWS can remove the light loadings of submicron particulate that cause a "blue haze" emission. Generally, an emission having an opacity of 20% (Ringemann 1) or less is acceptable. The IWS can be designed to obtain opacities of 5% or less to give clear or nearly clear stack discharges.

Energy

Pressure drop through a single-stage IWS is only ½ to 1.5 inches water column and is controlled primarily by the pressure drop through the wet scrubber section. Additional small amounts of energy are required for high-voltage charging and for the recycle pump.

Total system energy usage is approximately 2.0-2.5 BHP/1000 ACFM for a single-stage IWS and 4.0-5.0 BHP/1000 ACFM for a two-stage IWS installation.



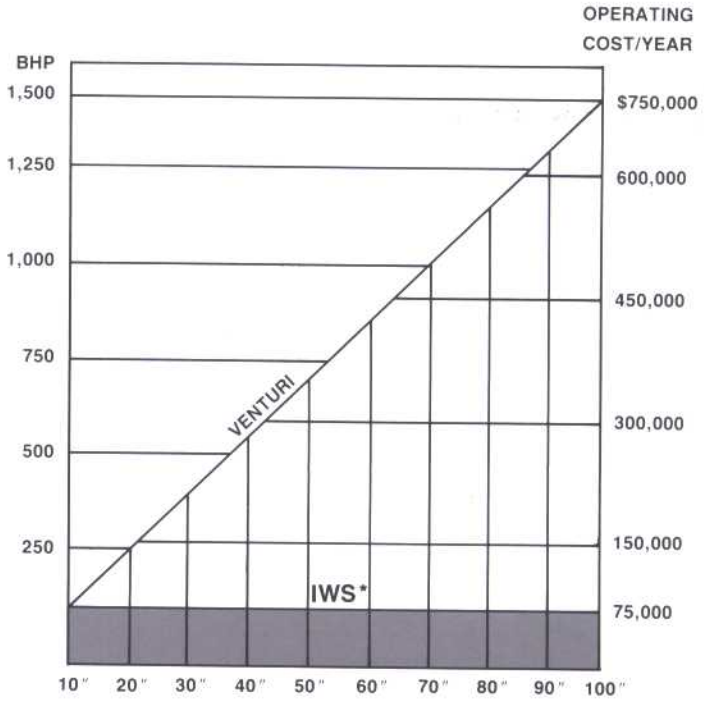
IWS COMPARISONS

Other types of air pollution control equipment i.e. venturi scrubbers, electrostatic precipitators, and baghouses generally require metal hardware/components. Therefore, use of this equipment in corrosive environments is severely limited. Additionally, sophisticated design configurations makes this equipment extremely costly and/or difficult to operate and maintain. These problems do not exist with the IWS because of the simplified design, minimum use of metallic hardware, low pressure drop and low operating/maintenance costs.

Venturi Scrubbers which are specifically designed for fine particulate removal in corrosive environments can be constructed of corrosion resistant materials. However, these require high-speed, high-energy fans constructed of exotic alloys which makes the venturi expensive to fabricate, difficult to maintain and costly to operate. Also, venturi scrubbers frequently require expensive reduced voltage starting equipment, costly electrical substation installation and elaborate controls to handle fluctuating loads.

Operating energy costs of the IWS are only a fraction of that of a venturi. The accompanying graph provides a comparison, and is based on the following parameters and use of a two-stage system:

Capacity	50,000 CFM @ (Standard Conditions)
Pump	Includes 15 BHP for both systems
Duty	24 hrs. x 365 days = 8760 hrs.
Energy Costs	6¢/KWH assumed 1 BHP/yr. @ 6¢/KWH = $490/yr.
Fan Efficiency	60%
Motor Efficiency	80%



REQUIRED Δ P FOR VENTURI — INCHES WATER COLUMN

NOTE: TWO STAGE UNIT* (FOR SINGLE-STAGE UNIT OPERATION COST IS ½ OF THAT SHOWN)

Conventional Electrostatic Precipitators (ESP) require large metallic collection surfaces and contain a multitude of internal hardware components which are exposed to the gas stream. If ESP's are used in corrosive environments, non-corrosion resistant metallic surfaces must be covered with corrosion resistant materials or expensive, corrosion-resistant alloys must be used.

Baghouses are susceptible to corrosive operating environments particularly when water vapor content is high and condensation can occur; where the particulate to be collected is sticky, gummy, and cannot be removed by normal bag shaking or pulsing; or where the service conditions seriously degrade the bag fabric.

PILOT TESTING EQUIPMENT AND FACILITIES

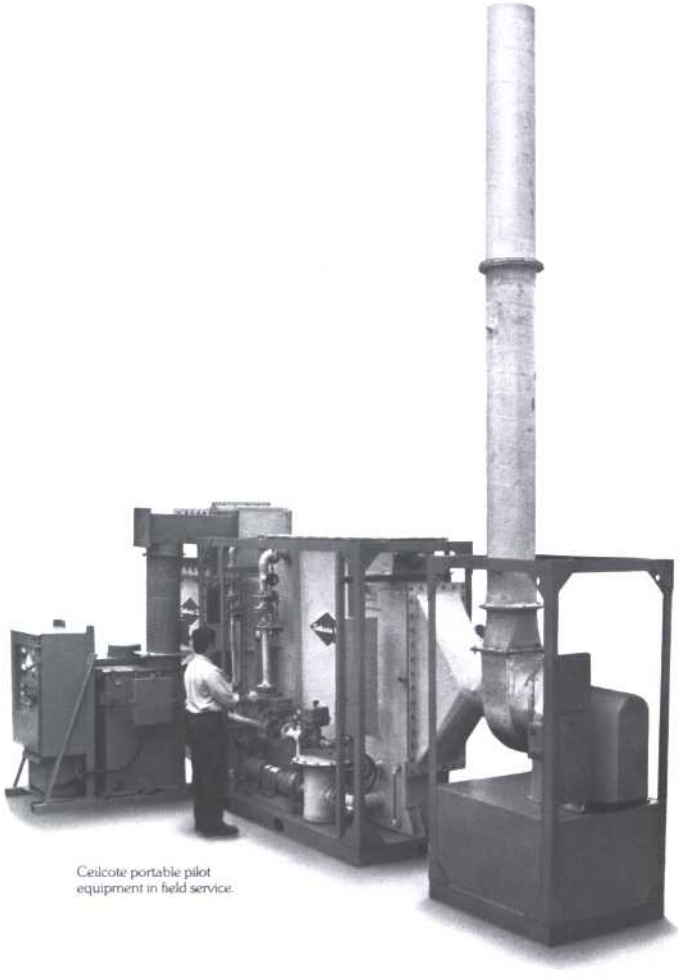
Portable pilot test units having 1000 to 2000 CFM capacity are available for test purposes. These units permit tests to be conducted in the field using actual process slip streams or under laboratory conditions at Ceilcote Air Pollution Control.

Pilot tests can be conducted to confirm performance and effectiveness of the IWS for the application, and to provide engineering data for designing full size equipment.

The test equipment is complete so that the potential user has only to duct a slip stream to the unit and supply the necessary utility services; i.e., electrical supply, fresh water make-up, and drain lines.

Field Performance Testing Services

Field performance testing to verify the performance and efficiency of the IWS can be conducted by a contracted testing server. The test method and equipment employed for evaluation and/or performance verification testing depends on the nature of the contaminants, applicable codes, and as mutually agreed upon by all parties.

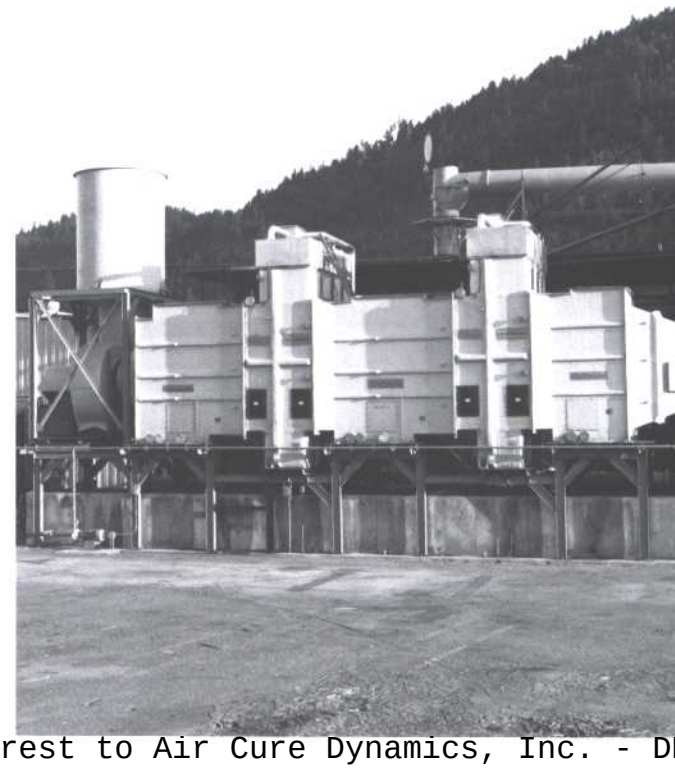


Ceilcote portable pilot equipment in field service.

Ceilcote Air Pollution Control Capabilities

Ceilcote Air Pollution Control has the design expertise, engineering knowhow and field installation experience to undertake contracts ranging from consulting engineering only to complete turnkey jobs. The matrix below shows the six basic types of contracts and related services which are offered to solve a broad range of customers' needs.

	Consulting Engineer	Engineer/Plans/Specs	Engineer/Warranty	Engineer/Supply	Engineer/Supply/Install	Turnkey
• Turnkey job						●
• Field install major equipment items					●	●
• Supply major equipment items				●	●	●
• Project management			●	●	●	●
• Performance warranty on emission control requirements		●	●	●	●	●
• Detailed plans and specifications which client can use for purchasing and installing a complete system		●	●	●	●	●
• Startup and debugging	●	●	●	●	●	●
• Quality assurance	●	●	●	●	●	●
• Process duty for major equipment	●	●	●	●	●	●
• Piping and instrumentation diagram	●	●	●	●	●	●
• Heat and material balances	●	●	●	●	●	●
• Final process flow diagram	●	●	●	●	●	●
• Pilot test (if required)	●	●	●	●	●	●
• Develop design conditions	●	●	●	●	●	●



IWS EQUIPMENT SPECIFICATIONS

IWS equipment is available in standard factory assembled modules having 900 to 54,000 ACFM capacities. The IWS modules can be arranged in parallel to handle an infinite variety of gas stream flow rates having capacities much greater than the maximum module available.

For example, five IWS Model 700's can be placed in parallel to handle a 208,000 ACFM gas stream.

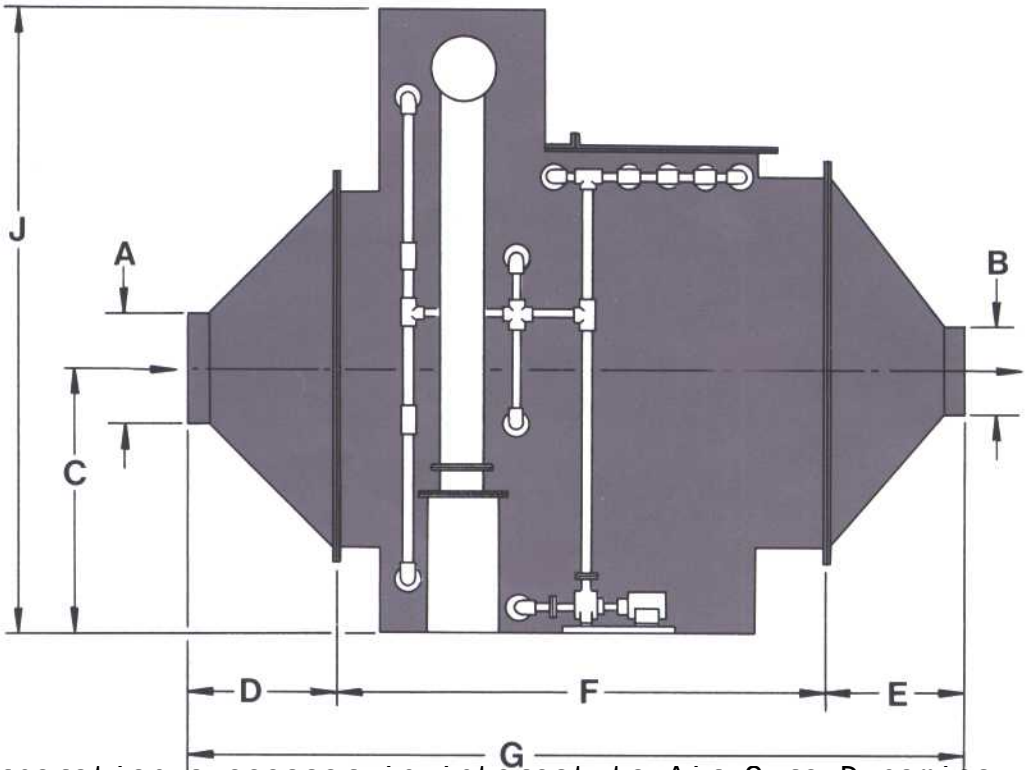
In addition to standard IWS modules Ceilcote Air Pollution Control can provide custom designed IWS equipment to suit the application whether it is a retrofit or new installation. Individual units for applications having requirements greater than 54,000 ACFM capacity can be field erected.

Standard factory assembled IWS module specifications are given below:

Model No.		50	100	200	300	400	500	600	700	800	900
Capacity Range ACFM(1)		900	1800	3600	5400	7200	9000	10,800	12,600	14,400	16,200
		3000	6000	12000	18000	24000	30000	36000	42000	48000	54000
Inlet Dia.	A	18"	24"	36"	42"	48"	54"	60"	66"	72"	72"
Outlet Dia.	B	12	14	20	24	30	30	36	36	42	42
Centerline Height	C	6'5"	6'5"	7'5"	7'5"	8'5"	8'5"	8'5"	8'5"	8'9"	8'9"
Inlet Transition	D	48"	48"	60"	60"	60"	60"	72"	72"	72"	84"
Outlet Transition	E	24	24	30	36	42	42	42	48	48	48
Body Length	F	12'	12'	12'	12'	12'	12'	12'	12'	12'	12'
Overall Length	G	18'	18'	19'6"	20'	20'6"	20'6"	21'6"	22'	22'	23'
Width	H	2'	3'4"	4'6"	6'	7'	8'	10'	11'4"	12'	13'6"
Height	J	15'	15'	17'	17'	19'	19'	19'	19'	20'	20'
Water Make-Up (GPM) (2)		3	5	10	15	19	24	29	34	38	43
Recirculation Rate (GPM)		90	140	220	300	330	430	520	600	650	740
P - Inch W.C. (3)		1½"	1½"	1½"	1½"	1½"	1½"	1½"	1½"	1½"	1½"
BHP - Fan (3)		2	4	9	13	16	24	26	32	34	40
BHP - Pump		3	5	7	8	9	11	13	14	15	17
BHP - H. Voltage (Equiv.)		4	5	7	9	12	13	13	14	15	16
BHP - Total		9	14	23	30	37	48	52	60	64	73
Operating Weight		6,700	9,700	12,000	14,700	17,000	19,000	22,200	24,700	26,500	29,000
Dry Weight		4,500	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000

(1) Capacity varies with application & efficiency requirements.
(2) Make-up depends on process conditions.
(3) Assumes no external requirements.

NOTE: All Dimensions Approximate. P varies from ½" to 1½" depending on air velocity. For multi-stage applications, multiply dimension F by number of stages. Dimension J add approximately 3' for concrete pad.



Products and Services of Ceilcote Air Pollution Control

Strong product / system support is an integral part of Ceilcote Air Pollution Control's resource capabilities. We are broadly experienced in the design, engineering and installation of a wide range of air pollution control equipment and systems. We will undertake contracts ranging from consulting engineering to complete green field turnkey jobs.

Ceilcote Air Pollution Control has a network of qualified representatives in the U.S. and Canada ready to serve you. Answers to your air pollution control needs are only a phone call away.

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