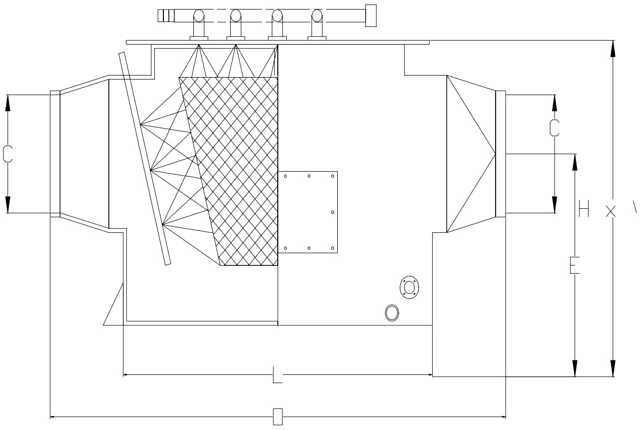
EUROX

CROSS-FLOW SCRUBBERS

Eurox Cross-Flow (HT) Scrubbers offer combined flexibility for efficient removal of gas , liquid and solid contaminants from exhaust air streams. Contaminated air moves horizontally through a packed bed and is irrigated by the scrubbing liquid which flows vertically down through the Q-PAC packing. The cross-flow scrubber design is characterized by low liquid irrigation rates, high volume airflow and low pressure drop. Eurox factory assembles Cross-flow scrubbers are available in 2,000 to 100,000 CFM capacities.



Model No.	Capacity ACFM T=70°F	Liquid Rate GPM	Minimum Overall Length O	Overall Width W	Overall Height H	Base to Centerline Inlet E	Duct Diameter C
HT-20	2,000	24-32	12'-0"	1'-0"	8'-0"	4'-6"	12"
HT-40	4,000	48-64	11'-8"	2'-0"	8'-0"	4'-6"	16"
HT-50	5,000	48-64	12'-10"	2'-0"	9'-0"	5'-0"	20"
HT-75	7,500	96-128	10'-8"	4'-0"	7'-6"	4'-3"	22""
HT-100	10,000	96-128	12'-6"	4'-0"	9'-0"	5'-0"	24"
HT-125	12,500	96-128	13'-11"	4'-0"	10'-6"	4'-3"	28"
HT-150	15,000	144-192	12'-0"	6'-0"	9'-0"	5'-0"	30"
HT-175	17,500	144-192	12'-6"	6'-0"	10'-0"	5'-6"	36"
HT-200	20,000	144-192	14'-0"	6'-0"	11'-3"	6'-0"	36"
HT-250	25,000	192-256	13'-6"	8'-0"	10'-6"	5'-9"	42"
HT-300	30,000	192-256	14'-6"	8'-0"	12'-0"	6'-6"	42"
HT-350	35,000	240-320	15'-0"	10'-0"	11'-6"	6'-3"	48"
HT-400	40,000	240-320	15'-6"	10'-0"	12'-9"	6'-10.5"	48"
HT-450	45,000	288-384	16'-6"	12'-0"	12'-0"	6'-6"	54"
HT-500	50,000	288-384	17'-0"	12'-0"	13'-0"	7'-0"	54"
HT-600	60,000	384-512	20'-0"	16'-0"	12'-0"	6'-6"	60"
HT-800	80,000	480-640	23'-6"	20'-0"	12'-9"	6'-10.5"	72"
HT-1000	100,000	624-832	28-6"'	26'-0"	12'-6"	6'-8"	84"

APPLICTIONS

The Eurox Cross-flow scrubber is the most versatile of all the wet packed scrubber types. The unit's capabilities include the removal of the following either individually or in various combinations:

1. Soluble gases
2. Liquid particulates
3. Solid particulates(up to 1.0grains/cu.ft.)
4. Odor removal

Eurox HT units have also been used successfully throughout industry as cooling towers and humidifiers. Industries presently using cross-flow scrubbers include: metalworking, chemical processing, metals finishing, pulp and paper, fertilizer, rendering and aluminum reduction.

Eurox scrubbers are designed to satisfy the specific requirements of each installation. HT units are effective in removing particles down to 3 microns by inertial impaction . With nucleation, these units will remove sub-micron particles.

Mass Transfer Principle(Gas Absorption)

Removal of gaseous pollutants by Eurox Cross-Flow Scrubbers is based on principles of mass transfer. This principle is defined as the transfer of gaseous molecules from the air stream into 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 and the horizontal depth of the packed bed in relationship to its height and width. Depending on the depth of the bed, the liquid flow rate and composition of the scrubbing liquid , efficiencies up to 99.99% can be obtained in the removal of gaseous contaminants .

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 because it's flow geometry permits the use of two or more packed beds, thus allowing different scrubbing liquids to be used without mixing.

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.

The followings equation is used to determine the number of transfer units (NOG) required to give a specified scrubbing efficiency.

NOG=In Y1/Y2

NOG=number of mass transfer units required to give a specific scrubbing efficiency

Y1 =concentration of incoming polluted gas
Y2 =desired pollution concentration of the effluent gas

Based on the preceding equation, the transfer units required for various scrubbing efficiencies are as follows:

NOG	%Scrubbing Efficiency
0.5	39.0
1	63.0
2	86.5
3	95.0
4	98.2
5	99.3
6	99.75

With the above formula, NOG is controlled by the inlet and outlet concentrations of only the polluting gas, assuming that the polluting gas dissolved in the scrubbing liquid exerts no vapor pressure to retard further absorption. More complex calculations are required when the scrubbing liquid exerts vapor pressure from absorbed gases.

After determining NOG, the following equation is used to calculate the required packing depth for a specific scrubbing application:

Z=(NOG)(HOG)
Where
Z =packing depth
NOG=number of transfer units
HOG =height of transfer unit

The height of a transfer unit(HOG) is determined experimentally and depends on the following factors:

1. Type of scrubber packing
2. Concentration and solubility of the polluting gas
3. Gas and liquid flow rates
4. Type of scrubbing liquid
5. Liquid and air stream temperatures

Scrubber packing manufacturers have run tests on their packings to determine the HOG values for various scrubbing system such as NH_3-air –water, Cl_2-air –NaOH, and HCl-air-water. HOG values are stated in feet(or inches)of packing for the system at various gas and liquid flow rates and temperatures. For example, packing in a 1% NH_3-air-water system has an HOG of 0.8ft., Based on a gas rate(G) of 500lbs./hr.ft^2 and a liquid rate (L) of 1000lb./hr.ft^2. at 70°F. In the same system, the HOG is reduced to 0.5ft. when the liquid rate is increased to 4000lb./hr.ft^2.

The following typical scrubbing problem illustrates the above equations and principles:

Problem

Determine the packing depth required to remove 95% of the ammonia from an air stream.

Specifications

1. The ammonia concentration of the inlet gas(Y1) is 100 ppm by volume,
2. The gas rate(G)is 500lb./hr.ft^2
3. The liquid rate(L) is 1000lb./hr.ft^2.
4. For this system and the hydrodynamic conditions of this problem the HOG for packing is 0.8ft.

Y1=100ppm
Y2=100ppm(100%-95%)=5ppm
NOG=In Y1/Y2=In 100/5=3.0
Z=(NOG)(HOG)=3(0.8)=2.4ft.

In actual practice, a packing depth(Z) of slightly more than 2.4feet would be used. This would compensate for variances between theoretical design calculations and performance under actual operating conditions.

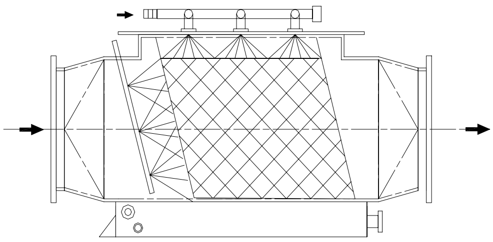
The above fundamentals of cross-flow scrubber design have been shown in elementary form. For a more detailed discussion of mass transfer principles applied to scrubber design, consult references such as Absorption and Extraction by Sherwood and Pigford, or Section 18 on Liquid-Gas Systems in Perry's Chemical Engineer's Handbook, 4th Edition.

Solids Handing Capabilities

Cross –flow scrubbers are capable of handling and removing solid particulates, This has been proven many applications, including the phosphate fertilizer industry, where cross-flow scrubbers are in operation.

In this industry , the cross-flow scrubbers are handling inlet concentrations of total solids in the range of 15mg.to 25mg. Per SCF. Much higher loadings are actually found in the duct system ahead of inexpensive pre-treatment equipment where the loadings are reduced to the levels indicated. These loadings are which would cause rapid plugging or fouling of a counter-current packed scrubber.

To obtain satisfactory operation reliability when entrained solids are to be removed, blinding of the front packing support plate and the first few inches of packing must be prevented . This is done by the use of front washing sprays and high liquid irrigation rates in those zones most subject o plugging. The front spray operates at a rate of 0.5 to 2.0 gpm per square foot. Washing the front packing support Plate. The top spray rates are increased substantially in the area immediately behind the front packing support plate.



In most applications removing solids, the greatest weight of particulates are removed in the first 12 inches of packing depth. This is shown by examining the following table showing the approximate percentage of particles removed by particle size down to 5 microns, based on a particle specific gravity of 2.0 and 4.0.

	Packing Depth Air Velocity	12 inches 8Ft/Sec
Particle Size	Collection Efficiency by Particle Count Sp.gr=2.0	Collectoin Efficiency by Particle Count Sp.gr=4.0
10	99.5	99.9
9	99.3	99.9
8	98.7	99.8
7	94.7	99.7
6	87.0	99.5
5	57.0	99.5

Assuming normal particle distribution, the quantity of particles removed on a weight basis in the first 12 inches of packing is often in the order of 97% to 99% since weight is a function of the cube of the particle diameter. Because most of the solids are deposited in this zone, high liquid rates in the range of 4gpm/ft^2 to 20 gpm/ft.^{2} are used to give high washing rates for removal of solids.

The cross-flow scrubber is a excellent selection for those applications where solid particulates are present in combination with soluble gases and /or liquid particulates. Provided all of the above factors are taken into consideration, the cross-flow scrubber offers high operational reliability at low pressure drop and low operating cost.

Q-PAC Packing

Surface Appeal
Specify Q-PAC(Plastic) for your scrubber and discover why it is the most advanced engineering surface ever manufactured. You can increase capacity, reduce pressure drop, maximize efficiency and make your installation less expensive to build , operate and maintain.

Deceptively Simple
Q-PAC is the culmination of an exhaustive, two-year design initiative by some of the industry's most gifted engineers. Using sophisticated 3-D modeling software and real-world trials, Q-PAC was tested and refined, re-tested and re-refined, again and again, until it outperformed any product on the market.

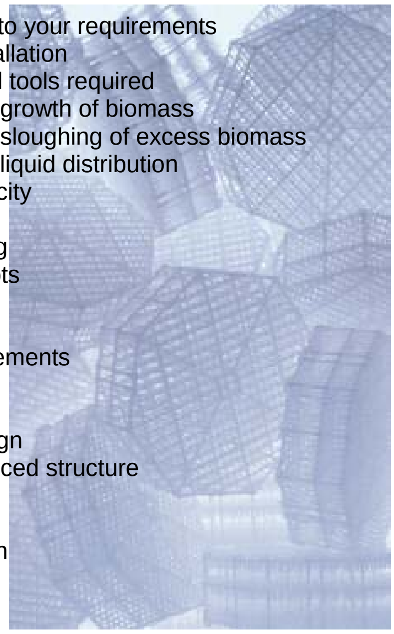
Q-PAC Delivers on Performance
Imagine a packing boasting a pressure drop that is five times lower than the competition while maintaining efficiency that is as good or better . Imagine a packing that can reduce the cost by reducing tower and pump sizes by 30 percent . Imagine a packing so effective it can double the capacity of an existing column.

Flexibility
Q-PAC comes in a variety of plastics and two configurations to accommodate towers as small as two feet in diameter or as large your specification demands.

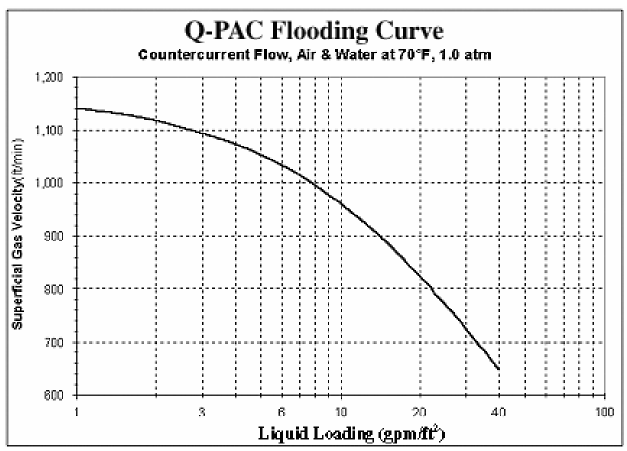
Tested and proven

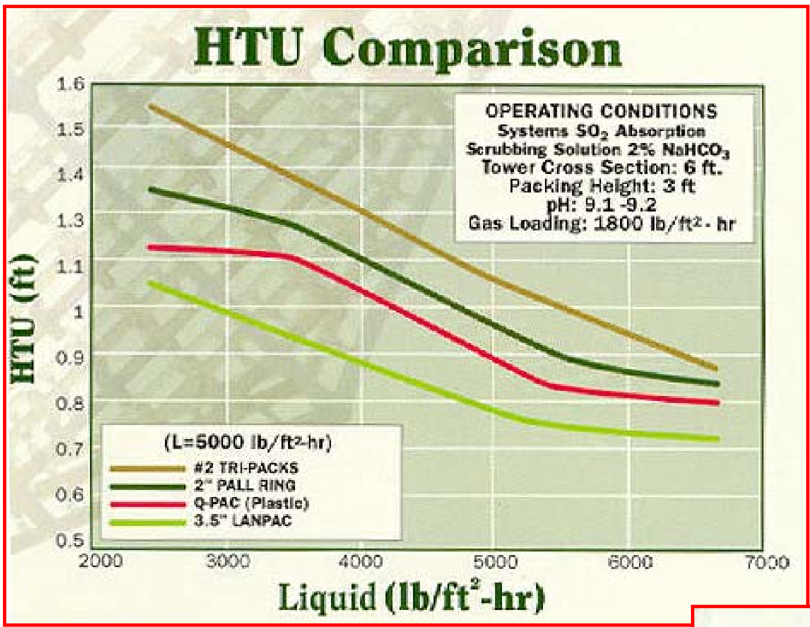
It took years of experience and a team of dedicated, talented and highly skilled chemicals engineers to develop Q-PAC, the most significant contribution to biological filtration in decades. So good a media in fact, it is being used in the largest most modern industrial trickling filters in the world.

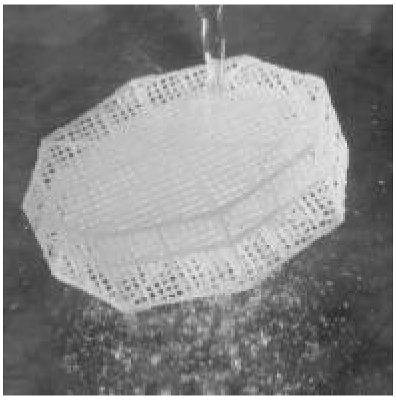
Benefits:

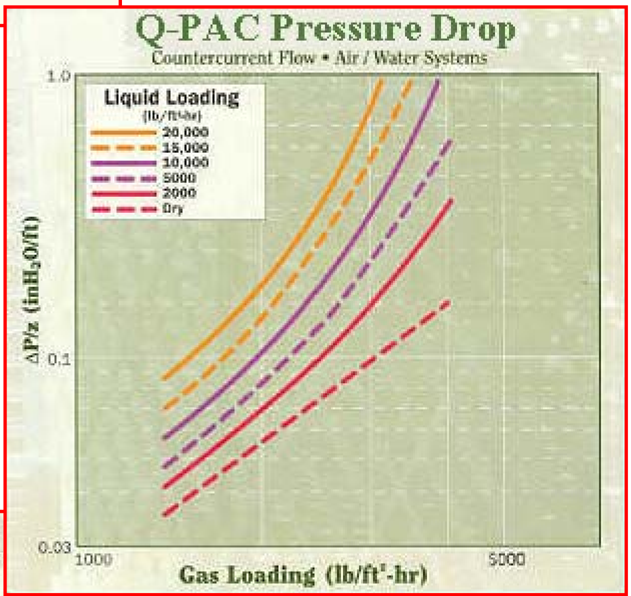


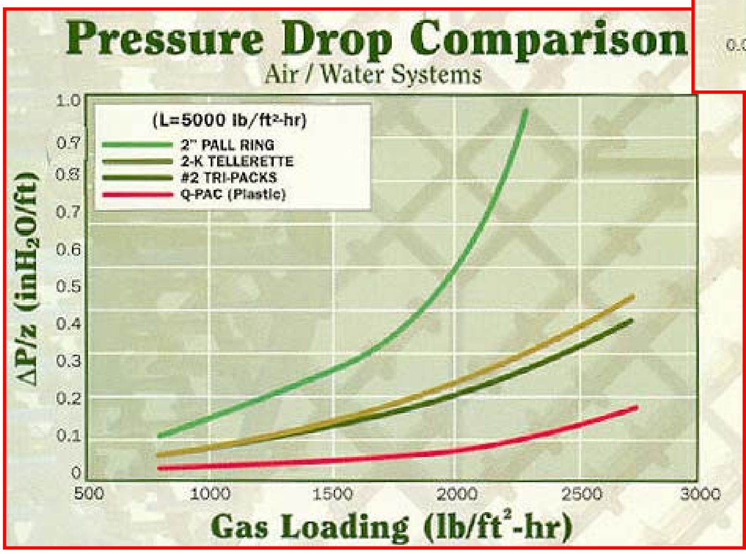
- Low cost
- Can be customized to your requirements
- Easy and quick installation
- No cutting or special tools required
- Continuous uniform growth of biomass
- Continuous uniform sloughing of excess biomass
- Continuous uniform liquid distribution
- High hydraulic capacity
- High durability
- Resistant to clogging
- Eliminates dead spots
- Features:
- High surface area
- Ultra fine surface elements
- No narrow crevices
- High void fraction
- Simple uniform design
- Triangular rib reinforced structure
- Randomly packed
- Light weight
- Customizable design











Q-PAC Physical Characteristics

Nominal Size(in)	7	4.5
Void Fraction(%)	97.5	97.5
Weight(lbs/ft^3)		
Polypropylene	1.6	1.6
PVDF	3.0	3.0
Geometric Surface Area(ft^2/ft^3)	30	30
Number of Pieces(/ft^3)	5	20
Packing Factor (1/ft)	4	4
Number of Dripping pts.(#/ft^3)	11,000	11,000

SCRUBBING LIQUID

Liquid flow rates for each Eurox scrubber are based on specific operating conditions. The scrubbing liquid is usually recirculated, thus reducing both fresh makeup liquid consumption and the overflow effluent from the scrubber. A small amount of fresh makeup liquid is usually fed continuously to the scrubber. This fresh liquid keeps the absorbed gaseous pollutant concentration in the recycled liquid at a sufficiently low level to maintain efficient absorption. Fresh makeup liquid is also required to balance evaporation losses. Fresh makeup liquid can be either fresh water, relatively clean process water, or chemically treated water. Water treated with chemicals with chemicals such as treated water. Water treated with chemicals such as caustic soda, lime 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.

The cross-flow design permits the use of variable liquid rates across the packed bed. As shown earlier, 98% to 99% by weight of the solids collected will usually be removed in the first 12 inches of packing. Thus a high liquid rate of 8000-20,000lb/hr.ft^2. (16gpm/ft.^{2} to 40 gpm/ft.^{2}) is used to irrigate and wash this section of the packing.

Below is shown the difference in operation between a cross-flow design and a counter-current design and how the variable liquid rate possible with the cross-flow design and required for solids removal, still results in a lower pressure drop.

	Cross-flow	Counter-current
Gas rate lb./hr.ft.^{2}	1800	1800
Depth of packing inches	36	36
Liquid rate(lb./hr.ft.^{2})	pressure drop(in. w.c.)	
1st 6 inches	12,000/0.45	3000/0.25
2nd 6 inches	4000/0.23	3000/0.25
3rd 6 inches	2000/0.19	3000/0.25
Balance 18 inches	1500/0.44	3000/0.75
Total pressure drop across 36 inches Packing (in.w.c.)	1.31	1.50

ENTRAINMENT SEPARATION

HT packed scrubbers normally contain a liquid entrainment separator following the irrigated section of packing . This entrainment section may be either an integral part of a single packed bed or set apart as a separate section within the common shell.When entrainment removal is to be accomplished as part of the single bed, a section of packing is left unirrigated. Single bed entrainment removal

Is left unirrigated. Single bed entrainment removal is restricted to applications where gas velocities are below 500 feet per minute. Above this level, liquid may migrate through the entrainment separator and be re-entrained in the exhaust air stream.

The Q-PAC packed entrainment separator will give 99+% collection efficiency of the entrained liquid particles. Other entrainment separators may also be used depending on the specific application.

The amount of entrainment is based on the droplet size emitted from the liquid distribution spray nozzles. Eurox's liquid distribution system gives liquid droplets of 50 to 1500 microns in diameter. Test results show that a 6 inch deep Q-PAC entrainment separator will remove virtually all liquid particles over 10 microns from HT scrubbers operation within their rated capacity range.

PACKING SUPPORT PLATE

The packing support plate used in Eurox Cross-flow packed scrubbers is a special Eurox proprietary design made from injection molded polypropylene.

Packing support plate design is critical, since the support plates must have a large open area to permit maximum gas or liquid flow, but have small enough openings to retain the packing.

The plugging potential of a cross-flow packed scrubber is a direct function of the net cross-sectional open area at the front packing support plate. The larger net cross-sectional open area achieved in Eurox scrubbers greatly reduces the plugging potential.

The net open cross-sectional area of the packing support plate is calculated by the following formula:

AN=ApApsp

Where
AN=Net open area(%)

Ap=Open area of the packing(%)

Apsp=Open area of the pacing support plate(%)

Eurox's proprietary design packing support plate has an 83% open area and Q-PAC have a 97% open area. Thus, the net cross-sectional open area of the packing support plate is 80%. Extended surface packing on a perforated-type of only about 50%. Therefore, using the Eurox support plate and Q-PAC, with their larger open area, reduces the pressure drop across a Eurox scrubber to between 33% and 50% less than other designs achieving the same collection efficiency.

An added advantage of the Eurox support plate is that all surfaces are hydrophobic, which helps pre vent solids accumulation. In addition, the horizontal members of the packing support plate are kept to a minimum depth.

Most of the strength is achieved by deep section vertical members which are washed readily by the front washing sprays.

DESIGN CONSIDERATIONS

Shell

Regardless of the packing type or depth selected, a scrubber can only provide maximum performance if the shell is properly designed. The shell design for Eurox HT Scrubbers includes the following factors:

A. The wall thickness of both the sides and bottom must be adequate to take stress caused by the static pressure developed by the fan.

B. The top is adequately designed to support on man.

C. Maximum corrosion resistance for both the interior and exterior surfaces is provided to assure long service life and low maintenance costs.

D. Access manholes, nozzles, and internal supports attached to the shell are designed to withstand all expected stresses , and to assure the same corrosion resistance as the shell

Often, the shell is designed with additional space for future increase in packing depth .This minimizes the initial investment, while permitting an increase in scrubber efficiency at the lowest possible cost if future air pollution control regulations require greater scrubbing efficiency.

Construction Materials

The shells and structural components of Eurox Cross-Flow scrubbers are usually fabricated from fiber-glass reinforced plastic(FRP).FRP is available in a number of different chemically resistant formulas, and can handle most air pollution control environments. All FRP fabrications meet the Product Standard for Custom Contact-Molded Reinforced Polyester Chemical Resistant Process Equipment as established by the National Bureau of Standards.

Sump

Eurox HT Scrubbers usually contain an integral sump. This reduces the floor area required for the scrubber, as well as the scrubber's initial cost. The sump will normally provide a two or three minute supply of recirculating liquid. This assures good mixing and keeps the solution constantly agitated to hold insoluble in suspension. he suspended insoluble can then
be carried out through the overflow piping. Use of the lower scrubber shell as an integral sump gives a completely unitized, corrosion-resistant scrubber at minimum cost.

In specific applications where an integral sump is not feasible, a separate recirculation sump is specifically designed for the application.

The liquid distribution system for Eurox HT scrubbers is designed to make maximum use of the scrubbing liquid, is achieve optimum scrubbing efficiency.

To realize the best possible scrubbing liquid distribution, spray header assemblies with low pressure, large orifice, non-plugging spray nozzles are used for most applications. Most plastic packings, Most plastic packings , require uniform initial liquid distribution to achieve the expected scrubbing efficiency. Therefore, liquid distribution by weirs is usually not recommended. The droplets formed by the liquid distributor spray nozzles also add absorption capacity. All header piping and spray nozzles can be easily inspected, and removed for maintenance or cleaning if necessary.

Component Parts

The design and integration of various component parts within or on the scrubber shell affect the cost of installation, operation, and maintenance for the scrubber. Component parts in a horizontal packed scrubber include access doors, piping connections, drains, overflow nozzles, lifting lugs, hod-down lugs, and internal structural supports.

While some component parts are optional accessory equipment, the engineering of each component part must be carefully evaluated for its effect on scrubber location, installation, operation, and maintenance.

Access doors are positioned and sized to allow inspection or possible removal of the packing, plus inspection and cleaning of the liquid distribution system. Access to the sump and entrainment separator sections are also provided when necessary.

Piping connections for the liquid distribution system are sized to handle the maximum recommended flow with minimum head loss. The pump connection is sized and positioned to minimize head loss and maximize recirculation efficiency. The makeup nozzle is large enough to handle the recommended makeup rate, and to quickly fill the system when necessary.

The integral sump drain in a Eurox scrubber will completely empty the sump if prolonged shutdown is required. The overflow nozzle is sized to remove the maximum full scrubbing liquid input flow rate from the sump by gravity flow.

All internal structural supports are completely corrosion-resistant, and strong enough to support the scrubber at maximum operating weight. In addition, they are located to minimize turbulence, pressure drop, and channeling.

Other components, such as lifting lugs and hold down lugs, are optional. Their construction and location depend on the physical requirements of the specific system.

Recirculation Piping

Recirculaion piping for Eurox Scrubbers is custom designed to suit each application. Piping is provided in PVC, polypropylene, Swancor FRP, or other corrosion-resistant material to fit the specific corrosive service. When beneficial for the specific application, the recirculation piping system includes line strainers. throttling valves, shutoff valves, and pressure gauges.

INSTALLATION

Eurox's FRP Scrubbers, containing Q-PAC packing, are much lighter than lined-steel scrubbers or those containing metal or ceramic packing. Eurox scrubber mezzanine without added structural support. The scrubber, fan , and recirculation pump can also be mounted as a single unit, thus simplifying job sit installation.

Fans for the scrubbing system can be locate either before or after the scrubber, as determined by the specific application. The fan can be integrally mounted on the scrubber, separately mounted near the scrubber, or separately mounted some distance from the scrubber. Space limitation are a major factor in determining fan location.

Specially designed scrubbers are available for unusual locations that will not accept standard scrubbers.

UNIT RESPONSIBILITY

Eurox has qualified field installation crews available, and can therefore offer unit responsibility for a complete air pollution control system, including design, fabrication, installation, and final testing.

RESERCH AND DEVELOPMENT

Eurox employs a large, full time technical staff assigned to a continuous program of air pollution control research and development. Their efforts have improved scrubbing systems as well as provided new and better methods of air pollution control.

Basic design and performance data is obtained from pilot plant scrubbers using the same operation principles as the full-scale equipment designed and manufactured by Eurox. Portable pilot scrubbers (See Eurox bulletin) are available to verify the performance of proposed full-scale equipment. Portable pilot equipment is also used to obtain design data for unusual air pollution control problems.

FIELD TESTING

An important criteria for scrubber selection is the vendor's capability to field test the system after installation and startup.

Eurox's research and development staff is fully equipped to provide this performance verification. If the installation does require this testing. Eurox can submit a quotation for this work. Frequently the nee for such testing is known prior to placement of a purchase order for the equipment. In this case , the cost of such testing is stated as being included in the original bid.

Whenever Eurox is committed to field test, a detailed report of scrubber performance under operating conditions is submitted for the customer's records.

Field surveys of plant air pollution conditions can also be made before a scrubber is purchased or designed, thus assuring an adequate scrubbing system. Pre-purchase surveys are made on a contract basis, and costs may be prorated against purchased equipment.