

EXPLORATION & PRODUCTION OIL AND GAS





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Technical competence, flexibility and commitment to the consumer are the main features that lead to Clark Solutions development.

From design concept to post sale operation, in each step of the process we work under strict quality standards, always aiming to surpass our client's expectations. In an optimized structure, Clark Solutions allows total flexibility when serving the client and agility to adapt quickly to the market demands. Efforts to solve client's problems are limitless. We are committed to find a satisfactory solution to our partner's needs.

Knowledge and expertise acquired during more than 25 years and wide experience puts Clark Solutions in a privileged position in thermal and mechanical separation, mass transfer and pollution control areas.

There are thousands of projects and equipment which are developed and assembled in Brazil and abroad, following technical specifications that ensure reliability and quality to our products. The factories in Embu das Artes/SP and Santiago/Chile, builds our range of products with our own know-how and technology, developed in Brazil and approved all around the world.



Photo: Embu das Artes Industrial Plant - SP - Brazil



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MIST ELIMINATORS

Mist eliminators are equipment designed to retain the liquid entrained by the gas, which are in small particles.

Its geometry favors the agglomeration of small droplets by inertial impact, that is, when the gas flow

MaxiMesh®

MaxiMesh® is a knitted mesh-pad type mist eliminator. Its knitting pattern and crimping are developed for maximum efficiency in liquid collection keeping volumetric capacity.

Depending on the process, MaxiMesh® may be made of

is subjected to a change of direction, the liquid and gas phases are separated by density difference, and the liquid phase agglomerates creating a drainable liquid film.

different mesh styles, low corrosion materials and can be co-knitted with special fibers, ensuring greater efficiency and durability.

- 5 µm and smaller particle collection;
- Higher design velocities



Agglomerator MaxiMesh®

The MaxiMesh®, in loads that exceed its capacity (flow per area) limit, has the property of acting as an agglomerating mesh. Particles impact and coalesce with very high efficiency in the mesh-pad, but are re-entrained downstream due to high flow velocity. During the re-entrainment process, however, the droplets are substantially larger than the ones that previously reached the mesh.

Thus, the agglomerating mesh increases the volume of the droplets and consequently eases the removal by other equipment.

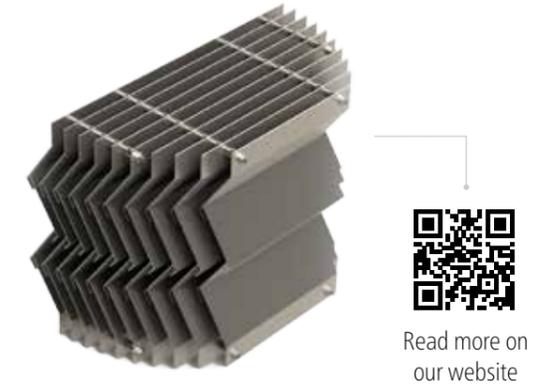


MaxiChevron®

MaxiChevron® Mist Eliminators are a set of parallel blades with a zig-zag profile, tailored for vertical or horizontal flow. Its number of flow changes, angles, spacings and draining channels are specially designed to achieve the best efficiency and plug resistance in each process.

They are typically designed to:

- 10 µm and smaller particle collection;
- Limited flow area



HeliFlow®



The principle of operation of these cyclones is to force the gas to change direction in a centrifugal movement and directing the solid and liquid particles to the collection region. These particles are removed by a draining system positioned downstream the spin element, and the collected product is drained to the bottom of the vessel through drainage tubes positioned in the cyclones boxes.

- 10 µm and smaller particle collection;
- Very limited flow area, maximum design velocity

CS Systems

CS Systems consist on the combinations of two or more equipments in order to associate the particularities of each mist eliminator, using one's efficiency and other's capacity or fouling resistance due to the presence of solids.

Applications that require increased capacity and high turndown rely on CS Systems to ensure high efficiency under severe conditions or with fluctuations in the inlet.



TOWER PACKINGS

Packings are structures that favor the mass transfer between the liquid and gaseous phases by providing contact area between the phases and the liquid residence time.

Their models can range from random or structured packings, plastic or metallic and must be chosen based on the properties of the process, required efficiency, maximum pressure drop and presence of fouling components.

Plastic

The MaxiRing and 3-Pack™ random packings are the Clark Solutions models to serve the plastic packings market.

MaxiRing™ is the conventional solution, equivalent to Pall Ring widely known in the market. Still is widely used in all types of towers nowadays. It has been tested by many researchers over the years and is known to be appropriate and perform well in almost any tower packing process.

3-Pack™ is a 3rd generation random packing, with a spheroid geometry, especially designed to maximize the specific interfacial area in absorption and desorption towers and columns gases. Its unique shape offers an excellent surface area and constant renewal of the liquid stream, maximizing the global mass transfer coefficient, raising this coefficient from 20 to 30% when

compared to 1st and 2nd plastic rings (Raschig Rings and Pall Rings).

Besides these, other unusual models like Raschig Rings or B-Ring®, which can be used in specific applications, are also offered by the Clark Solutions. Consult our team for more information and a directed study.



Read more on our website

Metal

CMTP™



Read more on our website

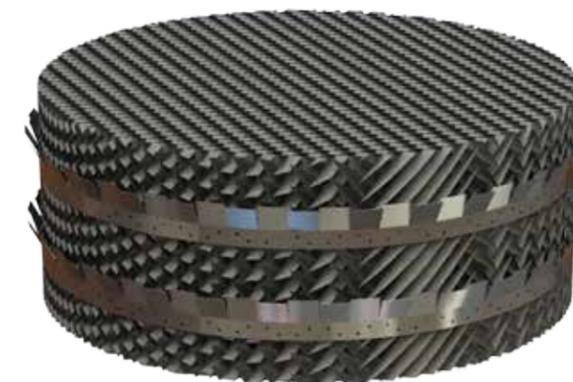
CMTP™ - is specially designed to have maximum surface area per bed volume to minimize the pressure drop. Made in any stainless steel or exotic alloy, it is suitable for all kinds of applications.

Combining the advantages of the saddle shape with characteristics that give high performance to the packing type, the CMTP™ was used with excellence in numerous cases of distillation and absorption.

Structured Packing

MaxiPac®

MaxiPac® is the high performance Clark Solutions line for packed towers. The arrangement in corrugated sheets and perforated surfaces maximize the mass transfer efficiency and the system capacity, in addition to a substantial pressure drop reduce.



Read more on our website

Structured packings are applied in processes that require:

- Higher gas/liquid flow;
- Higher final product purity;
- Reduced reflux ratio;
- High gas and liquid flow;
- Lower pressure drop;
- Increase of tower limit capacity.

Comparison between tower packings

High Performance Metallic Random Packing Data				
Equipment	Type	Void Fraction (%)	Surface Area (m ² /m ³)	Packing Factor
CMTP™ 25 - 1"	Random	96,2%	207	135
CMTP™ 25 - 1½"	Random	97,1%	151	79
CMTP™ 25 - 2"	Random	97,7%	98	59
MaxiPac® 125	Structured	98,7%	125	-
MaxiPac® 250	Structured	98,1%	250	-
MaxiPac® 350	Structured	97,4%	350	-

High Performance Plastic Random Packing Data				
Equipment	Type	Void Fraction (%)	Surface Area (m ² /m ³)	Packing Factor
3-Pack™ - 1½"	Random	92%	230	82
3-Pack™ - 2"	Random	93%	157	52
3-Pack™ - 3½"	Random	95%	125	39

DISTRIBUTORS

Gas or liquid distributors are essential for the correct operation of the process, which is for uniform flow through the equipment, guaranteeing its maximum efficiency.

The wrong choice of distributor may occur on preferred paths for gas/liquid flow, increase of the formation of

mists and foam, and causes of shearing on particles, turning them into smaller droplets which are much harder to be removed by the system.

Therefore, the distributor is critical to an efficient phase separation and mass transfer.

Gas distributors

Ciclone CS Foambreaker™

The CS Foambreaker™ inlet device consists in a set of cyclones with a specially designed internal geometry to separate and break the foam, pre-separating the phases and calming the flow at the inlet, avoiding agitation inside the vessels.

The internal geometry consists on a set of angled

blades in the annular region, favoring the phase separation and foam breaking on high rotation speeds, followed by abrupt expansion, forcing all the gas to flow through the top and other phases (aqueous, oil, light or heavy solids) to the bottom of the cyclone.



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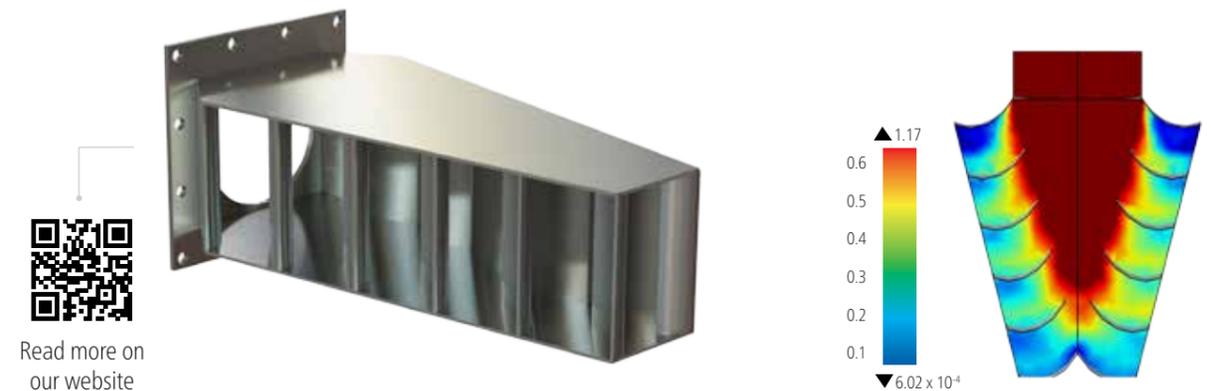
EvenFlow™

The Evenflow™ distributor is a high load inlet device that avoids agitation and inefficiency within the process vessels, and eliminates channeled flow inside the vessel. After CFD analysis, it was observed that deflector baffles favor preferred paths and cause shear of the liquid droplets in smaller particles, which are dragged more easily to the top of the vessel and are more difficult to be removed.

The Evenflow™ blades are angled, spaced and

sized so that the flow inside the vessel is more homogeneous and that the change of direction is not abrupt.

The Evenflow™ outlet area is calculated to guarantee a low momentum and to avoid particles shearing, mixing and preferred paths inside the vessel.



Read more on our website

Liquid Distributors

MaxiFlow™

MaxiFlow™ distributors are designed to each specific application, maximizing the number of irrigation points and always considering:

- Maximum allowable pressured drop;
- Mist generation;
- Packing model;
- Ease of installation;
- Operation turndown.

MaxiFlow™ can have several configurations, from through and downcommers, tubular arrangements, sprays, as well as special modifications for each layout internal tower.



Read more on our website

SUPPORT

Weldless support

Weldless support devices are designed to position the new internals only with mechanical assembly. Can be projected in any vessel and in pieces to pass through the manhole.

Weldless support benefits

- Reduced shutdown time;
- No need for welding in the field, therefore without isolation of the area;
- No need to re-certify the vessel for safety requirements;
- Minimized internals installation time;
- All parts tailor-made for the application and for the specific vessel;
- Designable to any vessel
- Allows internals future changes

To assemble the weldless support system, Clark Solutions has a team of supervisors with a great deal of experience in platform installations, with numerous assembled systems in Petrobras.



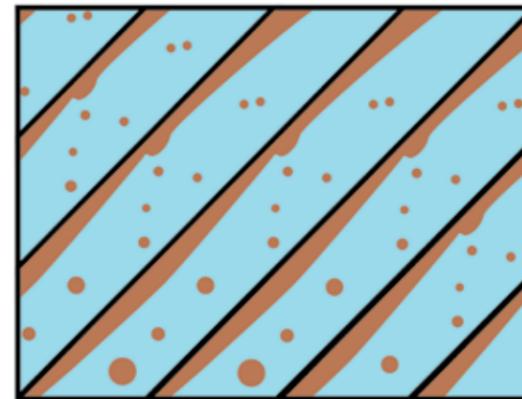
COALESCER

Plate-Pack® Coalescer

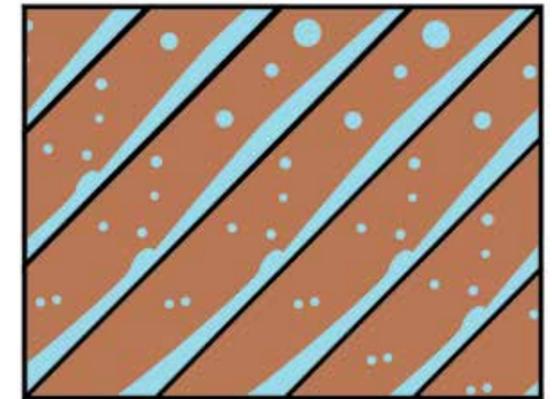
Plate-Pack® coalescers consist of plates arranged evenly to increase liquid-liquid separation efficiency. The goal is to reduce the residence time required for the phase separation, as it favors agglomeration of small particles between the plates. After agglomeration, the particles are larger and arrive more quickly at the interface, where droplets are effectively separated from the continuous phase. Other effect that favors separation is the stabilization of the flow, which will suffer less impact with oscillations of the inlet load.



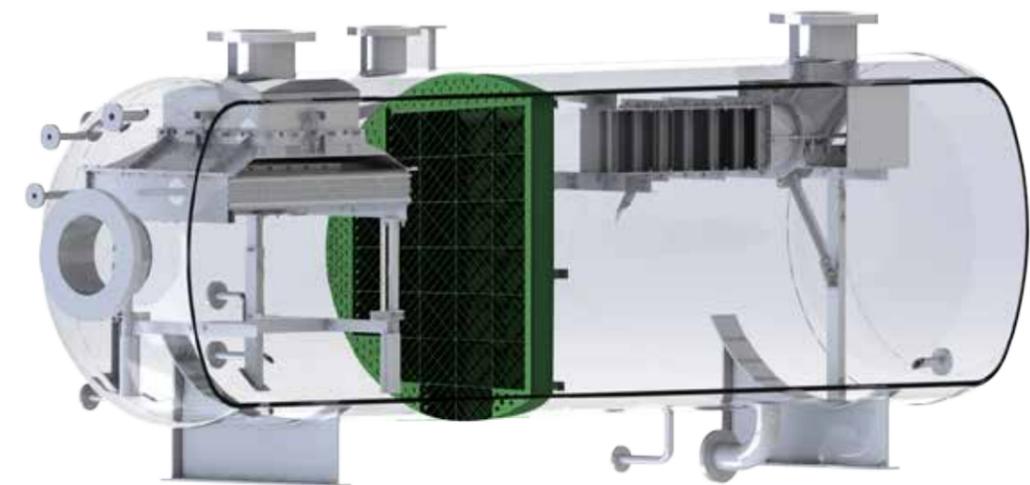
Read more on our website



Oil dispersed in water, coalescing and draining to the top of the system



Water dispersed in oil, coalescing and draining to the bottom of the system



SAFETY GAS AND COMPRESSION SUCTION SCRUBBERS

Generally, these vessels are designed with deflection baffles at the entrance and a vane-type mist eliminator before outlet. This system operates well under a load limit, but after a time, the load in these vessels tends to be much higher, and large liquid volumes are detected in the turbomachinery. Furthermore, the

inlet deflection baffle causes serious problems with high loads, since it causes shearing on particles that collide on its surface, and direct gas to the bottom of the vessel, which will pass through the liquid. Both effects increase the mist load dragged to the top of the vessel.

Conventional system



Vane-type mist eliminator

Conventionally used mist eliminators of angled blades in this position of the vessel. At high mass flow and pressurized conditions, however, these elements have low efficiencies. Thus, a great amount of the entrained volume is not collected in this mist eliminator.

Deflection baffle

With high loads in the inlet nozzles, this solution is commonly taken as suitable for this type of system. However, this configuration generates problems such as:

- Direction of the flow to the bottom of the vessel, where there is liquid level and consequent agitation and dragged liquid in the gas flow.
- Shearing of droplets by collision effect with the surface of the deflector, making it even harder to separate the entrained mist.
- Channeled gas flow inside the vessel, generating velocity profiles and causing inefficiency in the designed system.

High capacity solution



HeliFlow®

The gas stream, after passing through the CS Evenflow™ and agglomerating mesh MaxiMesh® 421, is routed to a set of HeliFlow® axial flow cyclones. The set consists of a deck where the cyclones, accommodated in boxes, contains each an internal spin element.

MaxiMesh®

The MaxiMesh® Agglomerator is a mesh designed to favor the coalescence of droplets, changing the distribution of droplet size, reducing the concentration of fine mists. The liquid re-entrained downstream of the mesh, due to the nature of the droplets formation, has much larger droplets than before, being much more easily removed by the HeliFlow®s, next stage of mist separation.

CS EvenFlow™

The CS Evenflow™ inlet device promotes proper distribution of gas and liquid, avoiding preferential paths along the vessel, pre-separating droplets and reducing the liquid load in the mist eliminator

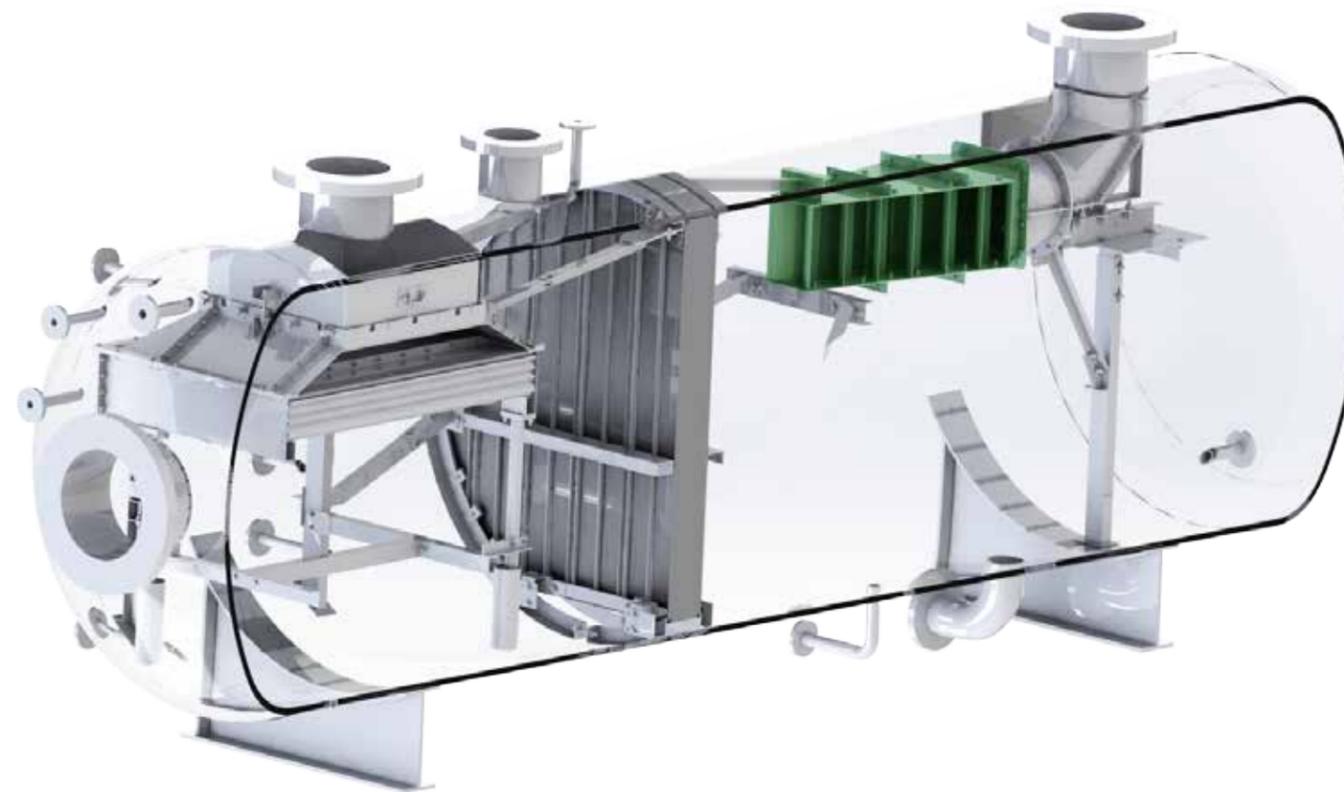
PRIMARY SEPARATION

- Evenflow inlet device or FoamBreaker™
- MaxiChevron® Mist Eliminator and MaxiChevron® Double-Pocket
- Plate-Pack® Coalescers

The flow from the well to the platform has various components - oil, water, gas and solids. All these phases must be separated and the primary separation occurs in stages at high and low pressure. These vessels are used for separation of three fluid phases: gaseous, aqueous and oily.

For these systems, Clark Solutions offers the following individual equipment and combinations:

- Evenflow™ input device or CS FoamBreaker™ cyclones;



Coalescers

PlatePack®

Even under severe conditions, the use of parallel plates for phase separation guarantees less dispersed phase concentration in the oil and water streams.

Benefits

- Design prioritizing plug resistance and cleaning ease;
- High efficiency for dispersed oil in water and dispersed water in oil;
- Very low pressure drop
- Design spacing from 10 to 50 mm
- Can be designed for installation without the use of welding;

Inlet device

With large gas, water and oil flow, the separation in these vessels is strongly impacted by the agitation and mixing effect inside the vessel. High velocity in the inlet generates turbulence and substantially reduces separation efficiency, increasing the amount of water at the oil outlet, loss of oil at the water outlet and entrained liquid into the gas outlet.

The input devices are for pre-separating and reducing the velocity of the load at the vessel inlet, increasing the overall efficiency of the system. The Evenflow distributes the load evenly over a larger area than the inlet, reducing shearing and mixing.

In extreme conditions of inlet velocities, the CS FoamBreaker™ cyclone system removes foaming in the separator and pre separates the phases with high efficiency. The pressure reduction ensures the efficiency of the system even with flow rate much greater than the designed – up to 400% increasing on design capacity.

Mist eliminators

MaxiChevron®

Due to the high turn-down of the process and intense fouling conditions, the use of the blade type mist eliminator MaxiChevron® is adequate because it has

both efficiency on a wide turndown range and plug resistance, keeping gas outlet with the least liquid load with great reliability

Benefits of CS System on Primary Separation:

- Allows greater process turn-down;
- Good efficiency for droplet removal in gas flow;
- Provides process safety because it prevents foam at the gas outlet even at severe conditions;
- Increase in revamp capacity;
- System designed for high plug resistance;

SWEETENING AND DEHYDRATION

After the steps of compression and mechanical separation of entrained and condensed oil, the gas must be treated for removing acid components and moisture, especially in order to avoid corrosion on the lines downstream of gas production. The first step is to force contact with amine in order to remove acidic components, such as CO₂ and mainly H₂S of the natural gas stream.

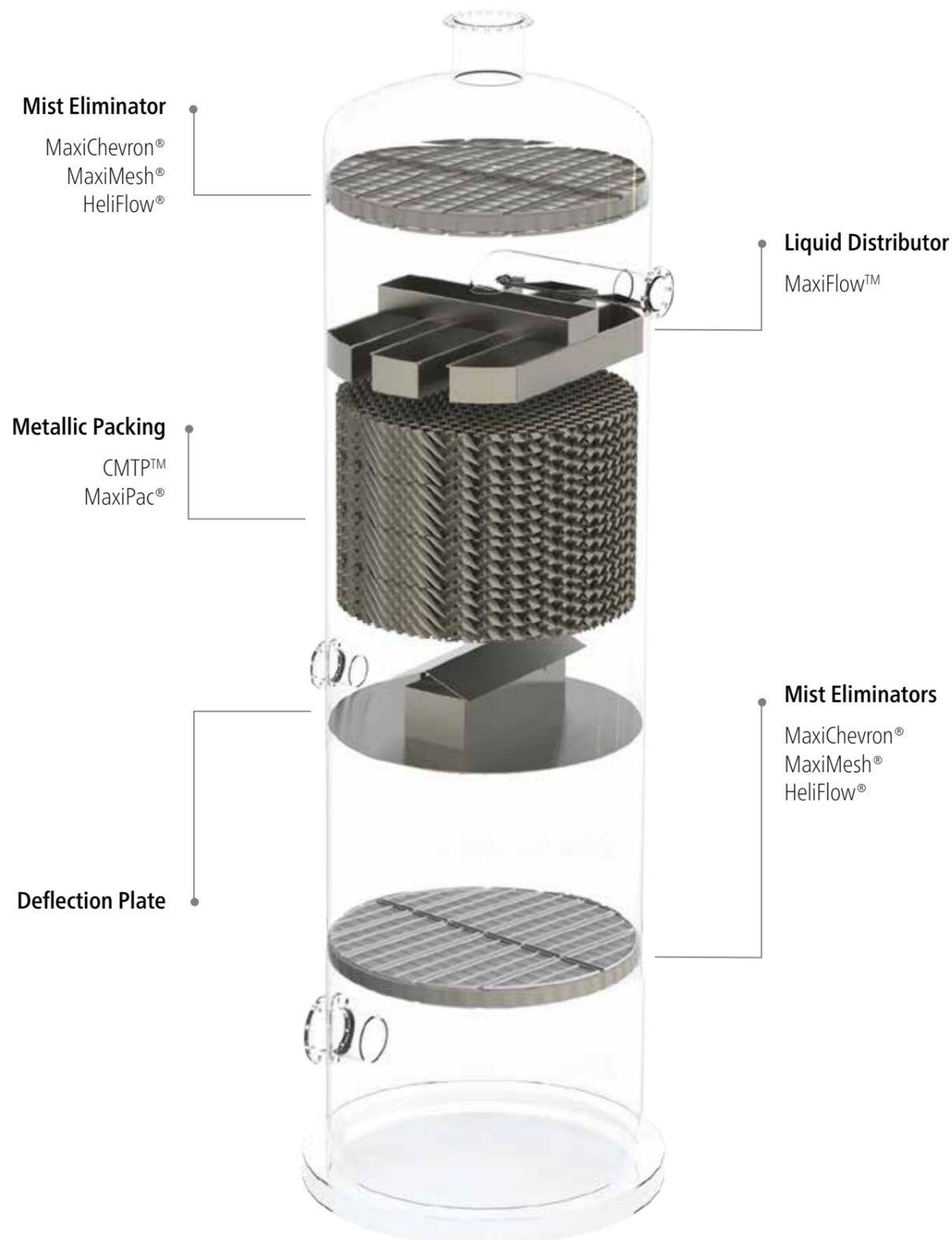
This is done in the amine tower, where the liquid stream absorbs the acidic components and flows to a regeneration system. In this stage of intense contact, water is also transferred to the gas phase, so the gas flows saturated in moisture. Therefore, the next step consists on the dehydration of this stream, which is made in the TEG contactor tower.

After this step, the natural gas flows dry and acid free to land.

Amine tower

The process of removing acid gases or sweetening gas is made in the amine treatment unit. The tower contains internals that favor the mass transfer between the gas and the aqueous amine solution, which may be made on trays or, more commonly, packed beds. To ensure an adequate contact, a liquid distributor is required for the packed bed. It is also required that the gas is well distributed, and if needed a gas distributor at the entrance should be applied.

The amine solution is first heated by the poor amine that arrives at the tower and then in a reboiler. When free of acid gases, the natural gas stream pass through the mist eliminator to avoid entrainment and loss of inlet amine - and may be vented or sent to a sulfur recovery system. The recovered amine is redirected to



the tower, closing the cycle.

The flue gas from the top of the column is purified from acid gases, then proceeding to the contacting unit of TEG since it is now humid.

TEG Contactor Tower

The gas, free of acidic components, must have its moisture removed to prevent corrosion and formation of hydrates along ducts. For this to happen it is necessary to force the contact between the gas and ethylene glycol in a packed bed.

The great advantage of using packed beds is that because of their high efficiency, we can use smaller towers to make the same separation, which results in lower cost and lower total system weight, critical for platforms.

In order to avoid loss of TEG, it is necessary to use mist eliminators in two tower positions: downstream and upstream to dehydration. Before contact with the TEG, it is necessary to remove any liquid droplets because the gas may be entraining aqueous amine solution or even oil droplets, both contaminants for the TEG. After dehydration, the process of contact inherently forms liquid entrainment on gas phase, and the separation of this mist guarantees considerably lower losses of inlet TEG.

Clark designs and supplies process towers since 1991, including in its internal supplies of high performance specifications for the process and warranty of performance. Whether in revamped condition or new design, we provide the most suitable set to the client's process, considering efficiency, capacity and turndown.



Liquid Distributors

Distributors are an important element in the functioning of these systems. An adequate distribution ensures maximum utilization of the area of stuffed bed exchange.

Small distributor inefficiencies, as few distribution points, improper sizing or minor deviations in the installation cause non-homogeneous distribution in the tower and insufficient mass exchange, in addition to located increase of gas velocity, generating higher drag loads.

Clark Solutions scales, tests, and projects liquid distributors since 1991, and has these installed in several process towers, guaranteeing the reliability of these equipment for long years operation.



Packings

The choice of an appropriate packing to the process leads to advantages such as:

Benefits

- High efficiency
- Low head loss
- High operating turndown
- Increasing tower limit capacity
- Reduced liquid content for the mist or downstream of the process
- Reduced downtime for maintenance and with respect to trays

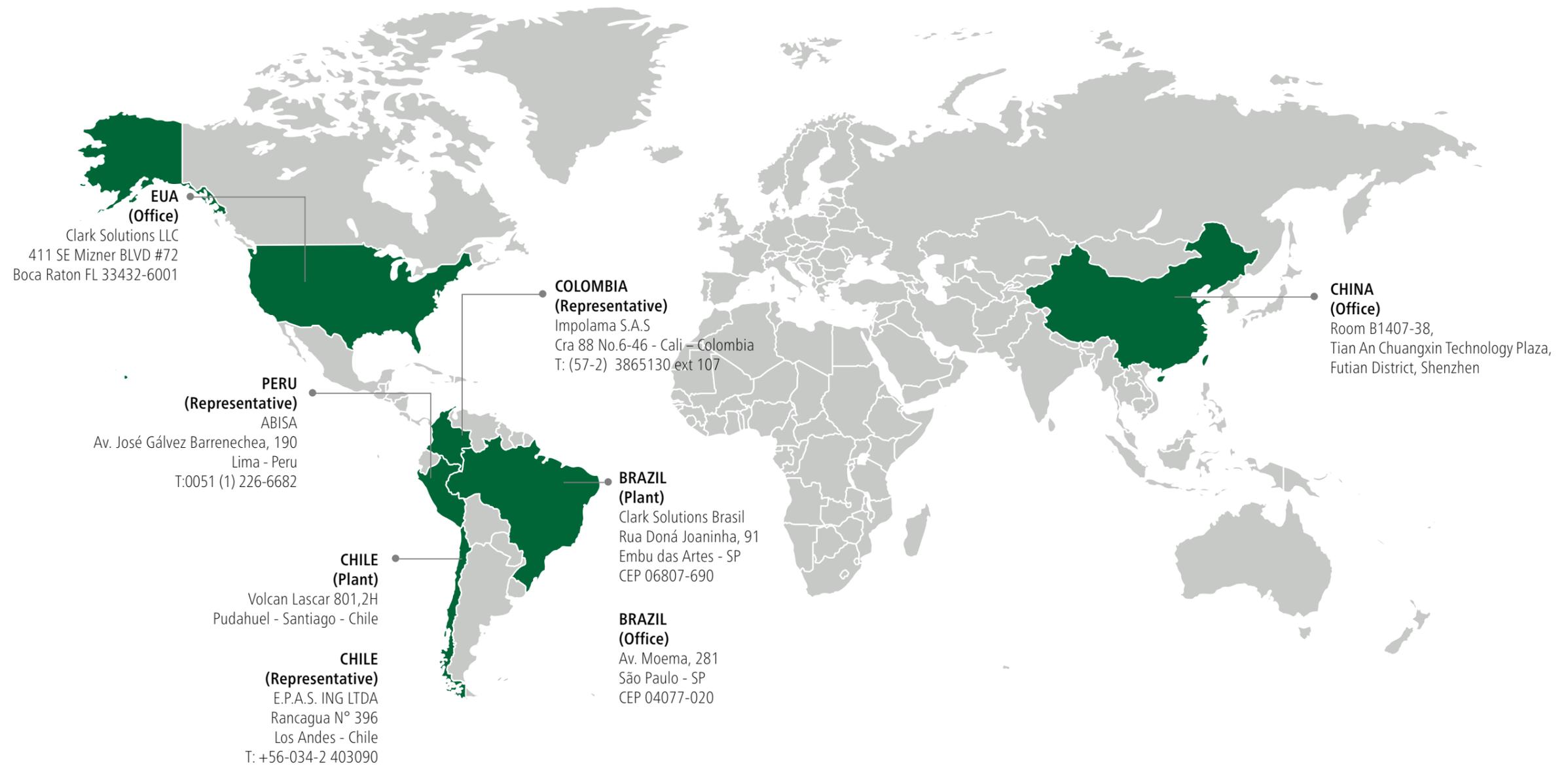
Mist Eliminators

The separation of entrained droplets is of high importance of input lower to the process due to the significant reduction caused by mass drag and contamination. After a process of contact, the gas always entraps liquid droplets. If this is not solved, in addition to losing this liquid with time, which requires make-up, these drops carried by gases will come into contact with a liquid stream, making it difficult to recover and resulting in losses.

Mist eliminator models can be chosen by prioritizing efficiency and capacity, to collect dragger particles even with high gas velocities in the towers. Projects including mist eliminators are able to provide up to 300% greater capacity for compared to conventional projects.



OUR FACILITIES



MaxiMesh®, MaxiChevron®, HeliFlow®, CMTPTM, 3-PackTM, β-Ring®, MaxiRingTM, MaxiPac®, PlatePack®, EvenFlowTM, FoamBreakerTM, MaxiFlowTM are registered trademark of Clark Solutions, or in process.

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Brazil Office

Av. Moema, 281 - Planalto Paulista
São Paulo / SP 04077-020

Embu Plant

91 Dn. Joaquina - Moinho Velho
Embu das Artes / SP 06807-690

Chile Office

Volcan Lascar 801,2H
Pudahuel - Santiago - Chile

USA Office

411 SE Mizner BLVD #72
Boca Raton FL 33432-6001

China Office

Tian An Chuangxin Technology Plaza
Futian District, Shenzhen

Website: www.clarksolutions.com.br

Email: contato@clarksolutions.com.br

Telephone: 55 11 3472-3333



Thermal and Mechanical Separation Solutions

