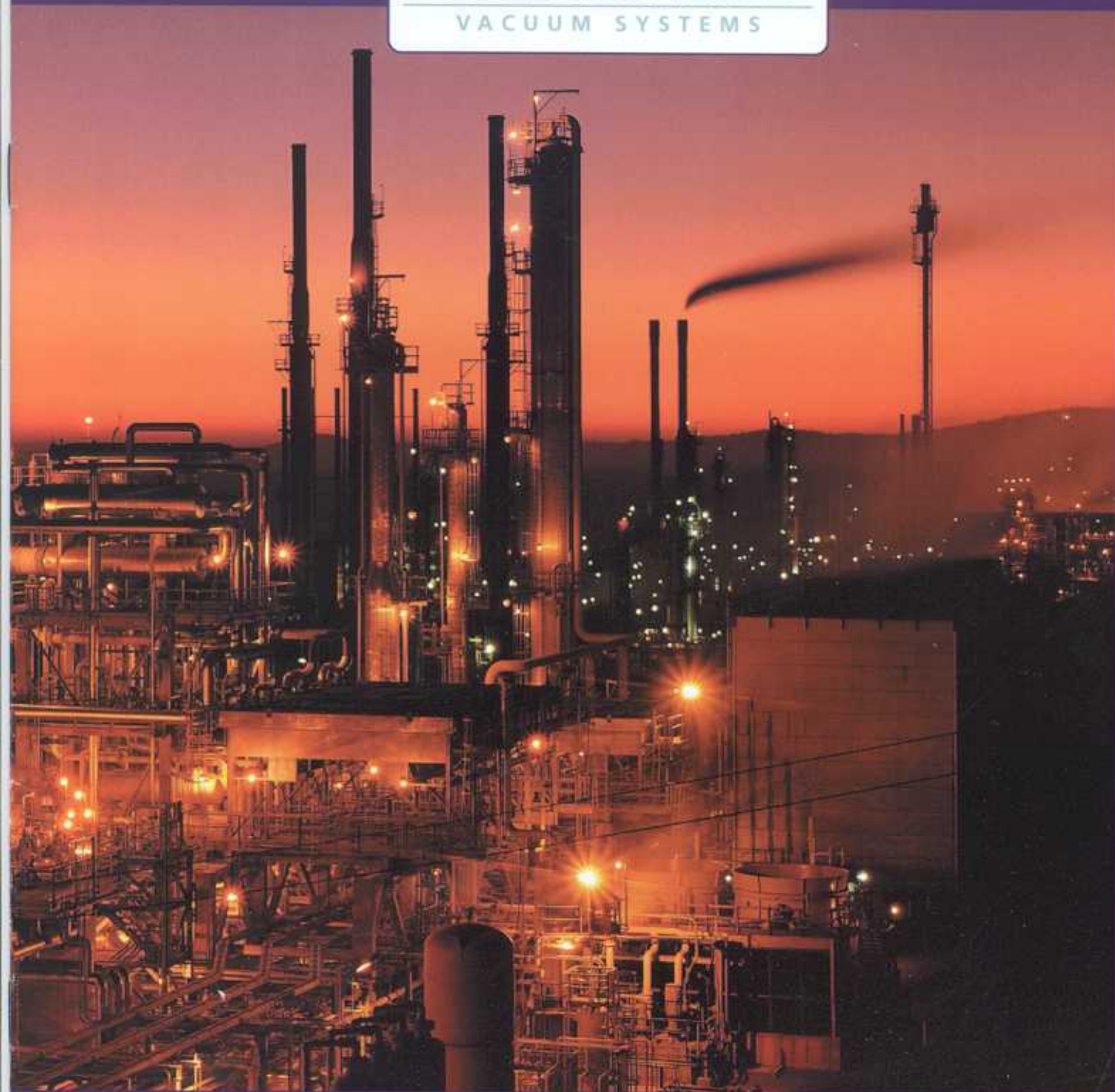
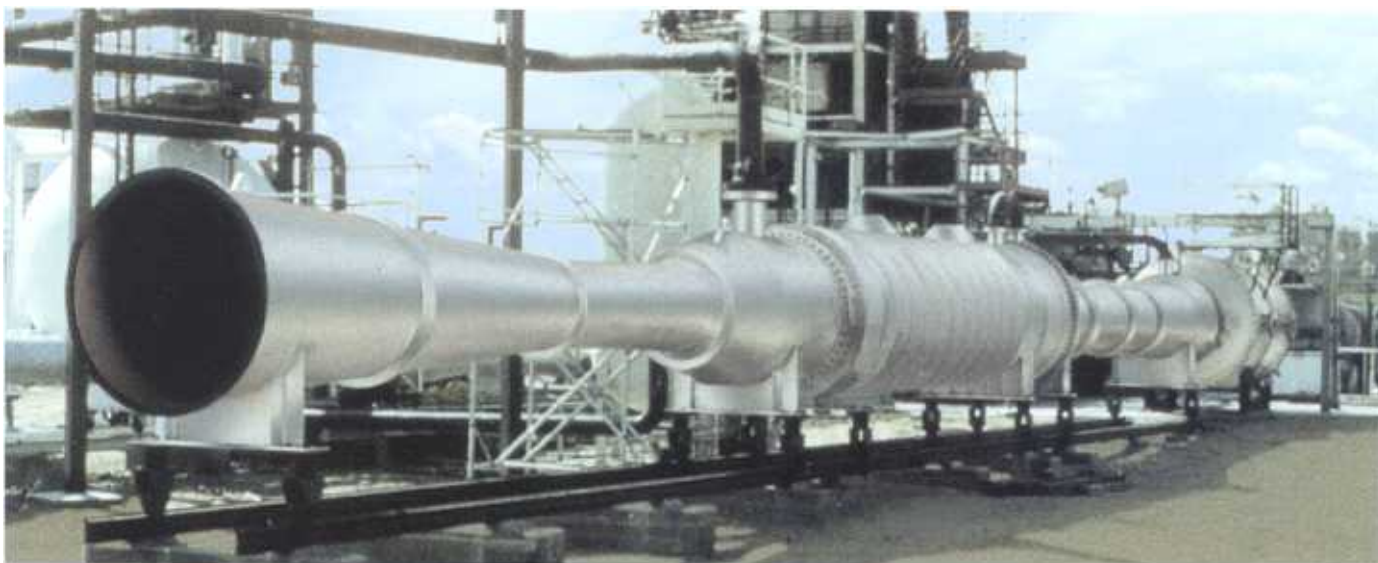


**CROLL-REYNOLDS**  
VACUUM SYSTEMS



***Precision Engineering for the Process Industries***

## THE LEADER IN VACUUM SYSTEMS TECHNOLOGY



Croll-Reynolds is the leading source for innovative, high-performance vacuum systems for all segments of the Process Industries. State-of-the-art design, production and test facilities create an environment for the manufacture of consistently superior systems and components.

Applications include crystallization, deaeration, drying and cooling of liquids and solids, high vacuum distillation, metallurgy, vegetable oil refining, and the processing of essential oils, food products, flavorings, fertilizers, and a broad range of chemical products.

### A Century of Innovation

Croll-Reynolds' reputation for the highest quality is an outgrowth of its years of service to the Process Industries. Since 1917 when it became the preeminent supplier of custom-designed vacuum systems in the world, Croll-Reynolds has engaged in an intensive program of research and development. Croll-Reynolds' design engineers and support professionals have achieved an unparalleled depth of experience and continue to set benchmarks for the industry.



### Serving all segments of the Process Industries

		CHEMICAL	PETROCHEMICAL	PHARMACEUTICAL	FOOD	PAPER	AEROSPACE
<b>Ejectors</b>	Single-nozzle and multiple-nozzle designs for operation with steam, liquid, gas or vapor motives.	•	•	•	•	•	•
<b>Rotajectors®</b>	Combined Ejectors/Condenser/Liquid Ring Pumps for generating high vacuum with low pressure steam.	•	•	•	•	•	
<b>Chill-Vactors®</b>	High efficiency, high volume vacuum flash cooling systems for quick chilling of liquids and bulk materials without the need for compressors or refrigerants.	•	•	•	•	•	
<b>Thermo-compressors</b>	Single-nozzle, multiple-nozzle and spindle-operated Ejectors used to recompress, and reclaim spent steam, and process fluids.	•	•	•	•	•	
<b>Core-Chillers®</b>	High efficiency vacuum cooling systems for the food industry.				•		
<b>Wet Scrubbers</b>	Jet Venturi / Packed Towers / High Energy	•	•	•	•	•	•



## EJECTORS

### Steam Jet Ejector Operation

Steam jet ejectors offer a reliable and economical means for producing vacuum. The primary advantages of the steam jet ejector are its low initial cost, lack of moving parts, and simplicity of operation.

The conventional steam jet ejector has four basic parts; the steam chest, the nozzle(s), the mixing chamber and the diffuser. The adjacent diagram illustrates basic ejector operation: a high pressure motivating fluid enters at 1 and expands through the converging-diverging nozzle to 2; suction fluid enters at 3 and mixes with the motivating fluid in the mixing chamber 4; both are then recompressed through the diffuser to 5.

Croll-Reynolds' exclusive ejector design, represents nearly a century of innovation.

### Ejector Construction

The simplicity of the Croll-Reynolds Ejector design permits fabrication from any workable or weldable material such as: cast iron, carbon steel, stainless steel, Monel, Teflon, Hastelloy, Ni-Resist, Hareg, graphite-lined and rubber-lined carbon steel, titanium and fiberglass reinforced plastic (FRP).

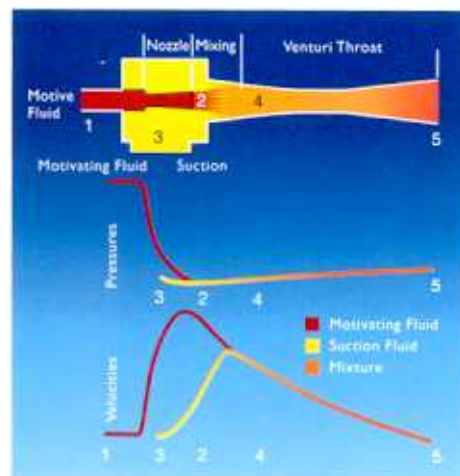
### Multiple-Stage Ejectors

Single-stage Ejectors are used to create vacuum ranging from atmosphere to 3" Hg absolute. Higher vacuum, ranging from 3" Hg absolute to 3 microns Hg absolute, may be achieved by multiple staging. Multiple-staged systems often include surface or direct contact type condensers. Intercondensers reduce motive steam requirements and, under certain conditions, permit recovery of product condensate.

Croll-Reynolds' multiple-staged systems are custom-engineered for optimum performance and minimum utility consumption. They are designed to handle a variety of process gases including air, water, HCl, butane, SO<sub>2</sub>, ethylene glycol, and many other organic and inorganic vapors. Where conditions warrant, corrosion-resistant materials of construction are utilized.

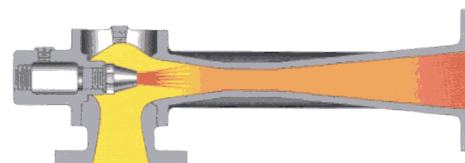
While most Ejectors are steam motivated, other fluids can be used. For example, to maintain the purity of a product, a process compatible fluid can serve as the motive fluid.

Croll-Reynolds supplies complete packaged, turnkey systems which include Ejectors, Condensers, Interconnecting Piping, Instrumentation, and Electronic Controls.



#### BASIC EJECTOR OPERATION

A high pressure motivating fluid enters at 1 and expands through the converging-diverging nozzle to 2; the suction fluid enters at 3 and mixes with the motivating fluid in the mixing chamber 4; both are then recompressed through the diffuser to 5.



#### SINGLE-NOZZLE EJECTOR

Single-Nozzle Ejectors are used for either critical or non-critical flow, but usually for only one set of design conditions.



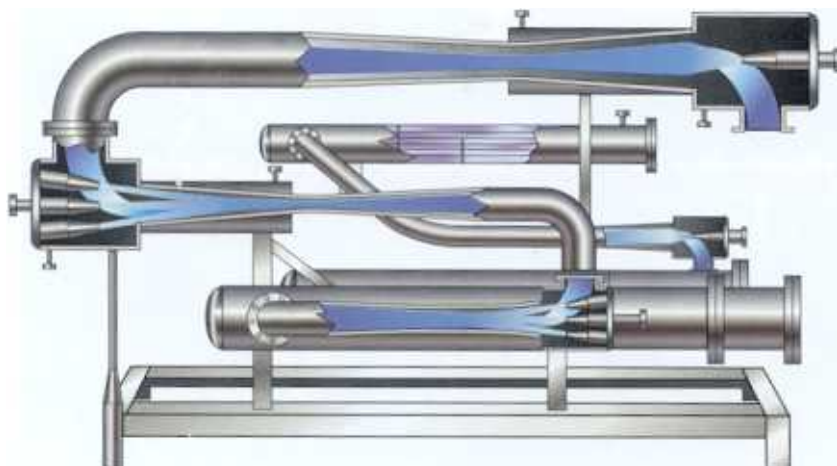
#### MULTIPLE NOZZLE EJECTOR

Croll-Reynolds Multiple-Nozzle Ejectors are unique in both design and performance. In most cases, they offer steam savings of 10% to 20% when compared with single-nozzle units designed for the same conditions.



#### SPINDLE-OPERATED EJECTOR

Spindle-Operated Ejectors are indicated wherever suction or discharge pressures vary. During operation, a pneumatically-driven tapered spindle moves in and out of the nozzle orifice to control motive fluid flow.



#### FIVE STAGE SYSTEM

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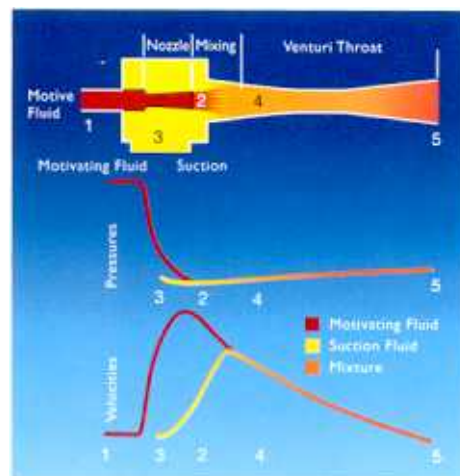
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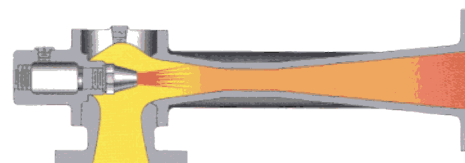
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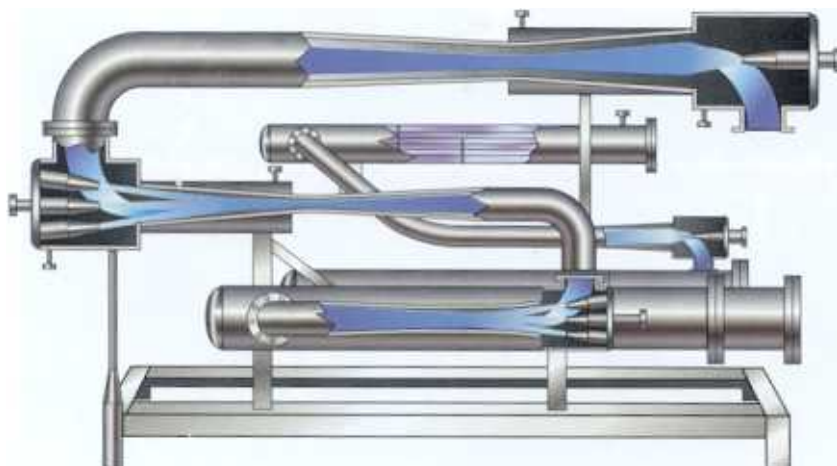
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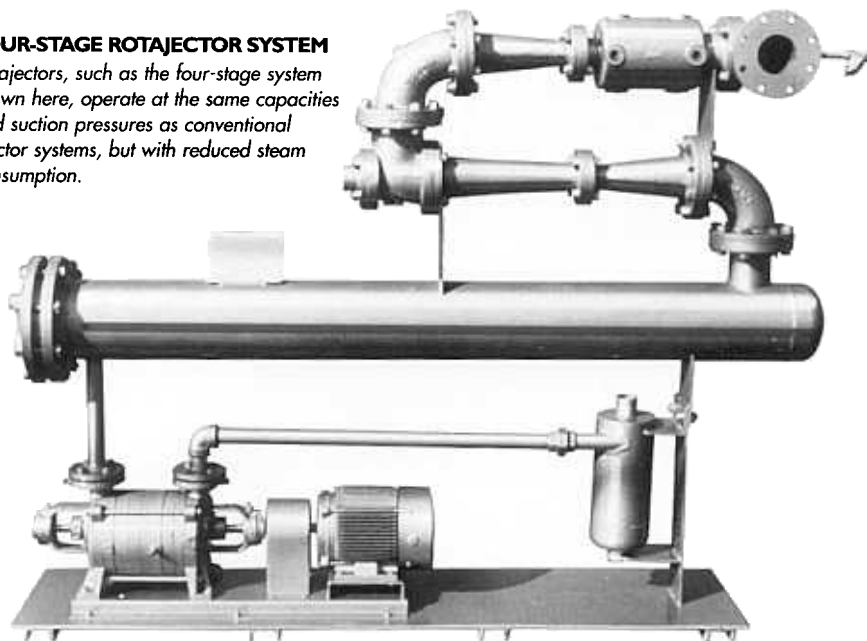
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## ROTAJECTOR®

### FOUR-STAGE ROTAJECTOR SYSTEM

*Rotajectors, such as the four-stage system shown here, operate at the same capacities and suction pressures as conventional ejector systems, but with reduced steam consumption.*



- Reliable high vacuum system
- Designed for use with low pressure steam
- Reduced steam consumption
- Designed for low elevation installation
- Low purchase and operation costs
- Custom-designed for each application

Rising energy costs have created an increased demand for process vacuum systems which operate at the lowest possible cost. To answer this need, Croll-Reynolds pioneered the research and development of the Rotajector, a combined Ejector/Condenser/Liquid Ring Pump high vacuum system.

### Operation

In a typical rotajector, such as the four-stage configuration shown above, process gases or vapors are drawn into the suction port of the first stage Ejector and compressed by subsequent stages. The condenser cools the gases and condenses the vapors, thus reducing the load to the liquid ring vacuum pump, which serves as the final compression stage. The pump also handles condensate, eliminating the need for a condensate removal pump.

### Configurations

Croll-Reynolds Rotajector systems are manufactured in up to six-stage configurations and in a wide range of capacities. Design and configuration flexibility makes the Rotajector a highly versatile vacuum system, readily adapted to a variety of process applications.

### Chemical Industry

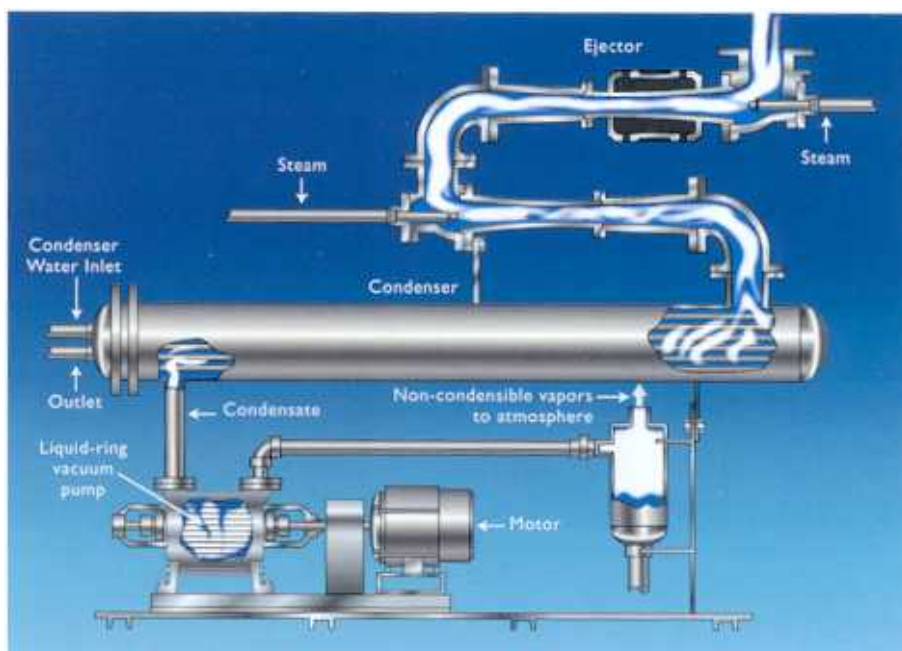
High efficiency Rotajector systems, designed for operation with low pressure steam, are used for process applications including distillation, evacuation, drying, crystallization, evaporation and cooling.

### Pharmaceutical Industry

Vacuum drying at a relatively low temperature is critical in many pharmaceutical applications where heat-sensitive compounds could be destroyed by alternative drying methods.

### Food Industry

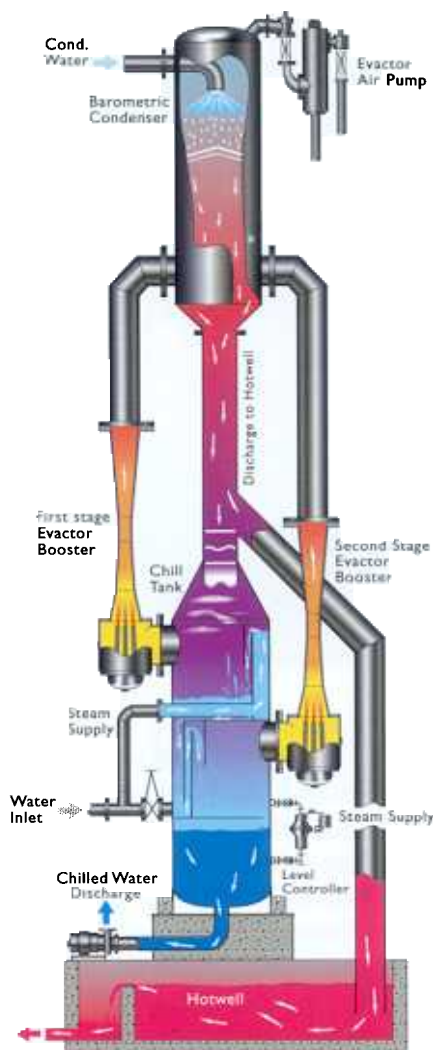
The high vacuum created by a Rotajector results in flash evaporative cooling of food products – thus preserving flavor, color and freshness without the need for preservatives or flavor enhancing additives. For chilling just-cooked foods, Rotajectors offer the advantage of using the same low pressure steam source that is used for cooking.



*In this low-maintenance system, the only moving part is the impeller of the liquid-ring vacuum pump. And, no special vacuum oils, lubricants or special cooling systems are needed.*



## CHILL-VECTOR®



A series of Ejectors reduce pressure in the chill tank resulting in the flash evaporation of the incoming water. The latent heat of vaporization required in this phase change is supplied by liquid resulting in a lower liquid temperature. Each stage of the system achieves successively lower liquid temperatures.

- Highly reliable chilling systems
- Deaerate liquids as they are chilled
- Custom-designed
- Eliminate hazardous and corrosive refrigerants
- Designed for outdoor installation
- Require no operating supervision
- Virtually maintenance free

Chill-Vectors are used where large flow rates of cool water are continuously required, such as in the paper and pharmaceutical industries.

The Croll-Reynolds Chill-Vector is a highly reliable vacuum flash cooling system with applications in water chilling, food processing and a variety of industrial uses. Chill-Vectors installed as long as forty years ago are still in operation.

Automatic controllers can be added to enhance Chill-Vector efficiency by reducing energy used during off-peak demand periods. For example, a ratio controller will provide up to 40% in steam savings by throttling motive steam pressure when condensing water temperature is below design specifications.

### Paper Industry

Chill-Vectors are used for chilling and deaerating water to absorb the chlorine dioxide used in paper bleaching operations. Due to the greater solubility of chlorine dioxide in cold deaerated water, the bleaching agent is more efficiently absorbed.

### Pharmaceutical Industry

Chill-Vectors produce the high volume of chilled water required to manufacture organic acids, vitamins, antibiotics and synthetic medicines.

### Food Industry

Croll-Reynolds vacuum cooling systems are manufactured for applications which require batch or continuous cooling. They are widely used for chilling foods such as: leafy vegetables – lettuce, cabbage – cut, diced or mashed potatoes, sauces, small fruits, mushrooms, grains, meat, fowl parts, fish and shrimp.

### Other Applications

Additional Chill-Vector applications include the cooling of sod, tobacco, sand, gravel and other granular materials.

### CASE STUDY

#### *Chill-Vector Provides Reliable, Around the-Clock Service for Paper Mill.*

A paper mill needed to double its chilled water production to support an expanded chlorine dioxide plant. A constant source of chilled, deaerated water was imperative for chlorine dioxide absorption. Mechanical refrigeration was considered, but the Croll-Reynolds Chill-Vector proved to be superior.

The new unit had to cool 600 gpm of water from 85°F to 45°F, or the equivalent of 1000 tons of refrigerant. The unit was to work with another, smaller Chill-Vector installed 10 years earlier that was still providing trouble-free operation. The new "maintenance-friendly" unit is equipped with remote-operating controls, and the closed-loop system uses steam efficiently for lower utility costs. The Chill-Vector easily meets all of the mill's chilled water requirements.



## THERMOCOMPRESSORS

- Reclaim waste steam
- Reduce steam/water consumption
- Custom-designed
- Single-nozzle, multiple-nozzle and spindle-operated configurations

In theory, a Thermocompressor and an Ejector are identical. The difference lies only in the application. Ejectors are used to produce a vacuum. A Thermocompressor is used to entrain and compress a low pressure fluid to an intermediate reusable pressure/temperature. The resultant recompressed fluid can then be used for another process and its heat value, which might otherwise have been wasted, reclaimed.

Croll-Reynolds Thermocompressors are available in single-nozzle, multiple-nozzle and spindle-operated configurations. They are used throughout the Process Industries.



*In the Petrochemical and Chemical Process Industries, Croll-Reynolds' Thermocompressors recycle waste steam and reduce energy consumption by 30% or more.*

### Thermocompressor Operation

During operation, the mixture of motive steam and entrained fluid is recompressed through the diffuser, which converts velocity energy to pressure energy. The recompressed vapor can be reclaimed for return to the process.

### Paper Industry

Thermocompressors compensate for changes in the temperature and discharge pressures of steam dryers while reclaiming waste steam.

### Pharmaceutical Industry

Heat-sensitive chemicals are usually vacuum dried at relatively low temperatures. Thermocompressors operate efficiently at these temperatures and therefore provide an excellent means for reclaiming waste steam.

### Food Industry

Tomato paste and other food concentrates, as well as dairy products, are produced in evaporators and dryers. Thermocompressors recover the vapors removed from food products during the concentration process.

### Chemical Processing and Petrochemical Industries

Dryers, stills, strippers and deodorizers usually discharge water vapor at relatively low pressures. Thermocompressors reclaim this vapor



*This triple-effect, falling-film, dairy products evaporator produces as much as 150,000 gallons of condensed milk per hour. A thermocompressor between the first and second effects reduces steam consumption. As a result, the evaporator uses less water and requires less heat transfer area.*



*Multiple-nozzle assembly viewed through the suction connection.*



## AIR POLLUTION CONTROL: MEETING THE CHALLENGE



*The California site of the TRW Strategic Defense Initiative (SDI) laser project is one of the world's largest vacuum and air pollution control installations. Ejectors manufactured by Croll-Reynolds simulate the atmosphere of space for the testing of a hydrogen/fluorine laser. Gases produced during laser generation are removed by a Croll-Reynolds custom-designed Packed Tower Scrubber.*

For over 40 years Croll-Reynolds has provided solutions to those faced with the challenge of efficient resource utilization and the responsibility for meeting stringent emission standards. Current and proposed regulations call for swift compliance, while the recovery and reuse of valuable process vapor has become standard operating procedure throughout the world.

Regardless of the air pollutant or industrial source, Croll-Reynolds has the engineering know-how and application experience to design and manufacture a system to meet the most demanding performance requirements.

### System Design

Croll-Reynolds offers a full range of air pollution control technologies. Our engineers are prepared to analyze your requirements and engineer a solution for virtually any application. From a single-stage, stand alone unit to an automated, multi-stage system complete with state-of-the-art instrumentation and programmable logic controllers, Croll-Reynolds' team of chemical, mechanical and electrical engineers will work together to meet your performance needs.

We specialize in the design of High Energy Venturi Scrubbers, Jet Venturi Scrubbers and Packed Towers. Croll-Reynolds' strength lies in its ability to integrate these products into a solution tailored to meet the most exacting requirements.

### Solving Problems Others Won't Touch

Years of research and innovative engineering experience have earned Croll-Reynolds a reputation for resolving the most difficult challenges. We have handled a wide variety of toxic, hazardous, common, and uncommon gases, including:  
HCl, HF, HBr, H<sub>2</sub>S, SO<sub>2</sub>, NH<sub>3</sub>, Cl<sub>2</sub>,  
Alcohols, Silicon Dioxide, Silicon,  
Tetrachloride, Fine Oil Mist, Boron,  
Trifluoride, Organic Anhydrides, Sulfuric  
Acid Mist, Lime Dust, Phosgene,  
Ethylene Oxide, Propylene, Oxide,  
VOC's... to name a few!

### Specialized Applications

#### EtO/PO Scrubbers

Ethylene Oxide gas (EtO) is used to reduce or render inactive microbial populations in sterilization processes. Propylene Oxide (PO) and Ethylene Oxide are also utilized as precursors in the production of a number of critical chemicals.

Croll-Reynolds' proprietary EtO/PO scrubbing systems utilize absorption and hydrolysis of these oxides to glycols to effectively treat EtO and PO contaminated gases. Efficiencies greater than 99.99% can be guaranteed. Fully automated systems are available.

#### NOx Scrubbers

Conventional scrubbers are limited to low NOx removal efficiencies due to the nature of the aqueous absorption chemistry involved. Croll-Reynolds' patented "Surface Active" media effectively overcomes those limitations – without the need for exotic or expensive chemicals or a costly and complex operational scheme.

This technology is particularly well suited for applications where the infamous "orange" plume is produced by high levels of NO<sub>2</sub>.



## WET SCRUBBERS



The Croll-Reynolds Jet-Venturi Fume Scrubber is one of the most economical answers to the growing problem of air pollution. It is an efficient means for minimizing smoke and undesirable odors, cleaning and purifying air and other gases as well as reclaiming valuable product which may be exhausting to atmosphere. It can also be used as a concentrator by having the motivating fluid adsorb the fume for recirculation until a desired concentration is reached. And the Fume Scrubber can do all this with a minimum of maintenance since there are no moving parts and because it operates at low velocities.



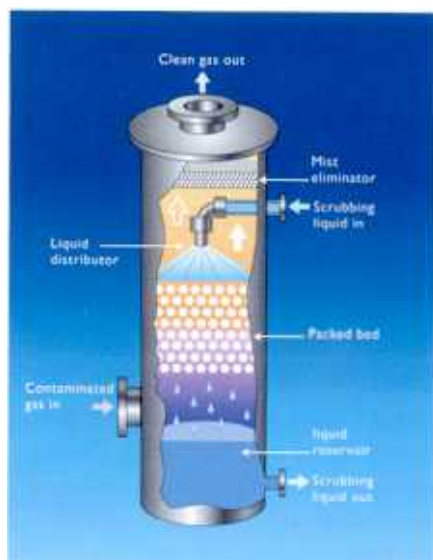
### JET VENTURI SCRUBBER

*Motivating fluid exits the nozzle in a hollow cone spray pattern, creating a draft. Contact between the scrubbing liquid and the gas results in high gas mass transfer and/or particulate capture. This mixture discharges into a Croll-Reynolds designed separator.*

### Jet Venturi Scrubber

The Jet Venturi Scrubber utilizes a liquid motivated ejector design to entrain contaminated gases, generally without the need for a blower. The relatively high liquid-to-gas ratio, liquid atomization, and open internal design provide effective scrubbing of heavily contaminated gases with minimal maintenance and virtually unlimited turndown capabilities.

Its ability to handle wide ranging conditions makes the Jet Venturi one of the most flexible designs available. It is often used as a first stage in a multi-stage air pollution control system.



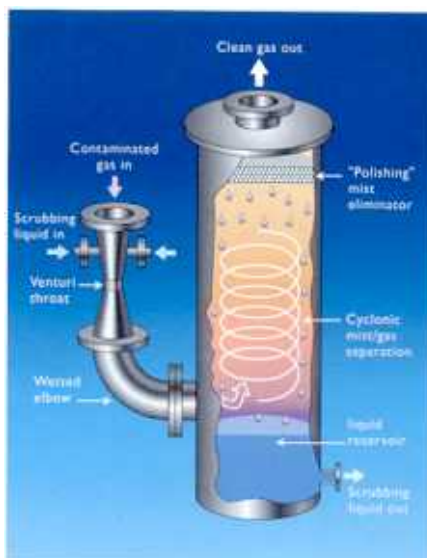
#### **PACKED TOWER SCRUBBER**

*Utilizing the most modern packing designs to provide contact between gas and liquid streams, the Packed Tower Scrubber achieves the extremely low toxic gas discharge limits required to meet emission standards.*

#### **Packed Tower Scrubber**

The Croll-Reynolds Packed Tower Scrubber utilizes a vertical counter-current design for highly efficient absorption of a variety of toxic gases. In addition to its extensive use in air pollution control, the Packed Tower can serve as a gas/liquid contactor in a number of process applications. Efficiencies of 99.99% and greater are not unusual for many scrubbing applications.

During operation, gas flows upward through a packed bed while scrubbing liquid flows down (by gravity) over the packing material. The counter-flow design principle offers optimal mass transfer. Croll-Reynolds supplies cross flow and co-current flow Packed Tower designs as well.



#### **HIGH ENERGY VENTURI SCRUBBER**

*Energy from a high-velocity, dust laden gas stream is used to atomize a liquid stream. Cyclonic gas flow in the separator drives the dust laden liquid to the outside wall. The liquid is collected and returned to the sump.*

#### **High Energy Venturi Scrubber**

The High Energy Venturi Scrubber is ideally suited to the capture of small particles less than 3 microns in size. It is effective as well in the submicron range and requires little or no maintenance.

For applications where variations in gas flow require throat gas velocity compensation to maintain specified scrubbing efficiencies, Croll-Reynolds offers automatic and manually variable throat designs. The automatic throat is used where flow conditions vary widely and frequent adjustments are required. When occasional variations occur, a manually-controlled throat is available.

#### **CASE STUDY**

##### *Systems Work Together for HCl Removal and Recovery*

A specialty chemical manufacturer was looking for a way to remove HCl from its off-gas before it was discharged to the atmosphere.

Croll-Reynolds designed and manufactured a system which uses two Jet Venturi Fume Scrubbers in series, followed by two Packed Towers in series. Intimate mixing of the gas stream and scrubbing liquid allows the Jet Venturi Scrubbers to remove 98% of the HCl and the Packed Towers to remove the remainder. The Jet Venturi Scrubbers collect 98% of the HCl while creating a marketable aqueous HCl solution. The Packed Towers recirculate the diluted NaOH solution, and "polish" the gas stream to meet low HCl discharge limits.

The units have proved to be virtually maintenance free, with final emissions concentrations of approximately 2 PPM. Liquid waste production is minimal and the recovery of marketable HCl has offset the cost of the system.





## **ENGINEERING: QUALITY, PERFORMANCE AND RESPONSIVENESS TO OUR CUSTOMERS' NEEDS**



### **Innovative Engineering**

Croll-Reynolds' commitment to its customers begins with a thorough evaluation of such factors as applications feasibility, operational efficiency, performance requirements and cost effectiveness. The success of any installation is virtually assured before it goes on-line.

Sophisticated Computer Aided Design and Finite Element Analysis programs permit Croll-Reynolds engineers to share information throughout the design process. Careful attention to detail during all phases of design and test results in products that consistently exceed customer expectations.

### **Life-Cycle Product Support**

Croll-Reynolds stands behind every installation from design through operation. As part of its commitment to customer support, life-cycle records are maintained on every vacuum system. Records include: system and component specifications, detailed lists of parts and construction materials, and performance data.

Whenever upgrade components or replacement parts are required, they are supplied to the specifications of the original equipment – with the added benefits of enhancements in technology, design, materials and production techniques.

### **Operational and Application Support**

Croll-Reynolds engineers are always available to assist with application and technical matters as well as with system operation. Croll-Reynolds field representatives are trained in the technical and operational aspects of our products.

### **Quality Manufacturing/Quality Control**

Manufacturing and test facilities in the United States, as well as in the Far East, include a wide range of state-of-the-art automated machine tools. Shop and supervisory personnel, many with more than 35 years of experience at Croll-Reynolds, take pride in a total team effort. Every project is monitored by quality control professionals.

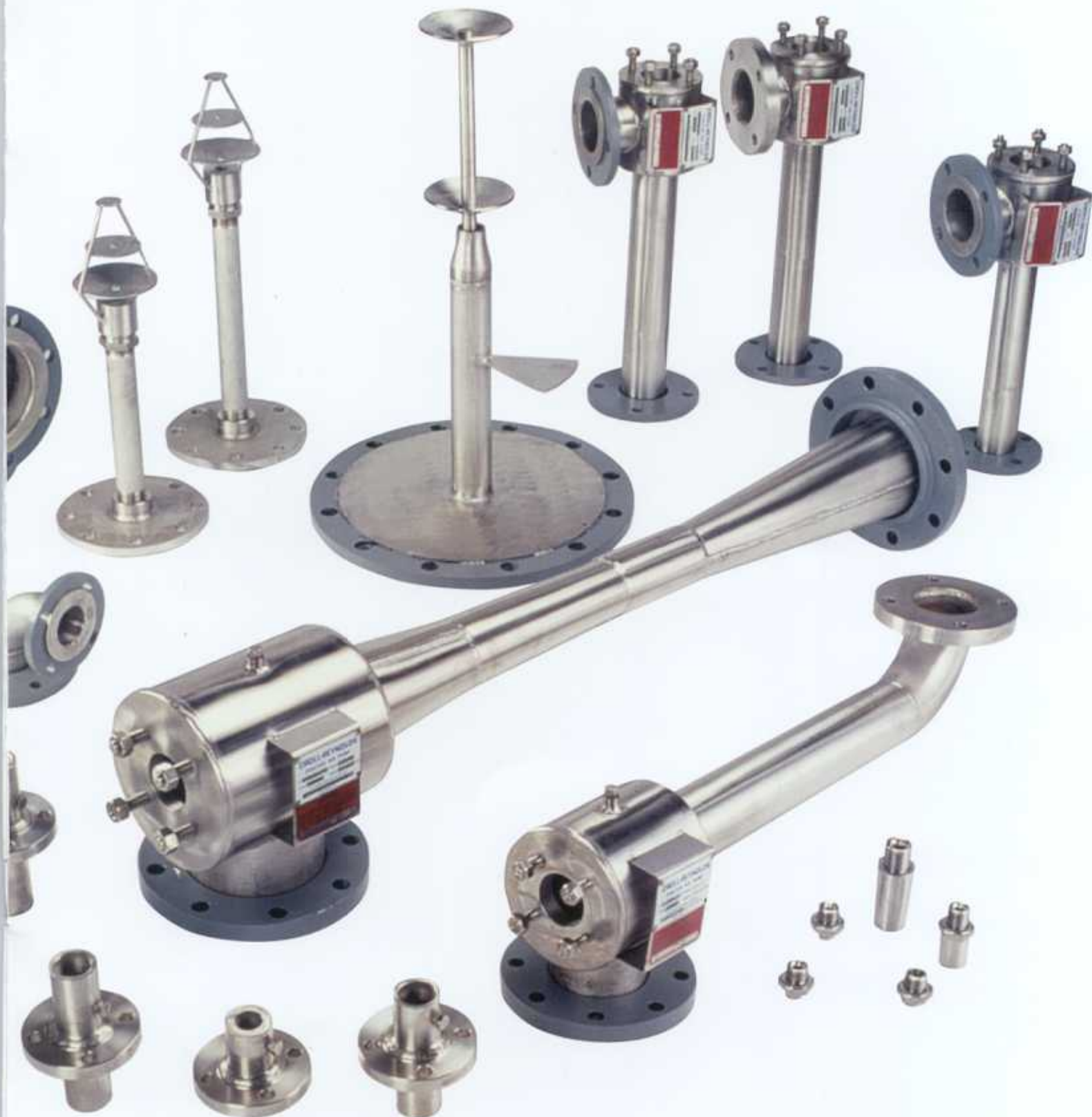
All equipment is designed and manufactured to meet or exceed industry standards and all applicable codes (HEI, TEMA, RTP-I, ASME).

### **Croll-Reynolds Research and Test Centers**

Croll-Reynolds Research and Test Centers provide a real-world environment for the pilot development of custom systems and new product concepts.

Multiple steam generation facilities offer the flexibility and capacity required to test systems and components prior to shipment.





For further information, visit [www.croll.com](http://www.croll.com)





## PROVIDING WORLDWIDE SOLUTIONS

With Manufacturing, Research and Test facilities in the Far East as well as in the United States, and a worldwide network of representatives, Croll-Reynolds has emerged as a leading supplier of high-performance Process Vacuum equipment to the world.

From the Pharmaceutical Plants of New Jersey to the Edible Oil Refineries of Brazil; from the Industrialized Plains of India to the Palm Plantations of Malaysia; Croll-Reynolds is the resource for innovative engineering and unparalleled expertise.

In the 1950s, Croll-Reynolds began manufacturing air pollution control systems based on liquid motivated ejector technology. The synergy between our Process Vacuum and Air Pollution Control technology continues to offer a powerful design and engineering advantage.

Call us for the office location of the factory-trained process vacuum or air pollution control specialist nearest you.

## CROLL-REYNOLDS

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