



Pure Water. Clean Air.
Better World.

Superior Sugar Refining with ISEP[®] Technology



BULK RAW SUGAR

AFFINATION

MELT

CLARIFICATION

FILTRATION

Decolorization of Raw Sugar

Sugar cane is the primary feedstock for the world's sugar supply, but sugar cane must be harvested, milled and refined to produce sugar. Refining is a multi-step process and decolorization is one of the important unit operations in the production of liquid and crystalline sugar. Sugar colorants can come from natural components in the cane plant or be developed during processing. Typically, colorants are non-polar, anionic in nature and span a wide range of molecular weights. Some examples of sugar colorants include polyphenols, melanoidins and products from hexose degradation. With increasing consumer and market demands for higher quality sugar, refineries must adopt cost-effective means to remove color bodies from cane sugar.

Decolorization of raw sugar for the production of high-grade sugar products is typically performed with the assistance of a range of media such as bone char, activated carbon and ion exchange resins. There are a number of factors that influence a refinery's decision to adopt a certain technology or combination of technologies, and, in many cases, ion exchange resins offer the lowest capital and operating costs for both large and small applications.

Calgon Carbon Corporation (CCC) is a world leader in offering ion exchange technology for sugar decolorization and deashing. CCC has supplied commercial plants for these processes using IonSEPARATOR (ISEP®) technology for over 20 years. Our continuous ISEP® technology is reliable, versatile and cost-effective, compared to alternative technologies and fixed bed systems.

Benefits of Using ISEP® Continuous Ion Exchange Resin Technology for Decolorization

Improvements in the efficiency of macroporous strong base anion (SBA) resins, along with lower capital and operating costs, have increased the acceptance of ion exchange technology for secondary decolorization in many refineries. A single SBA resin, or a combination of acrylic and/or styrenic resins, provides broad and effective color removal, and Calgon Carbon's continuous ISEP® system is the most flexible and efficient option for applying these resin technologies for decolorization.

Calgon Carbon's ISEP® system easily lends itself to a variety of resin combinations, process configurations, construction materials and layout choices. The ISEP® system has proven to use up to 50% less water than competitive fixed bed systems, while at the same time using up to 50% less resin. In addition, chemicals consumed and waste volumes generated during the resin bed regeneration are dramatically reduced due to the counter-current, multi-pass nature of the continuous system.

DECOLORIZATION AND DEASHING

EVAPORATION

CRYSTALLIZATION

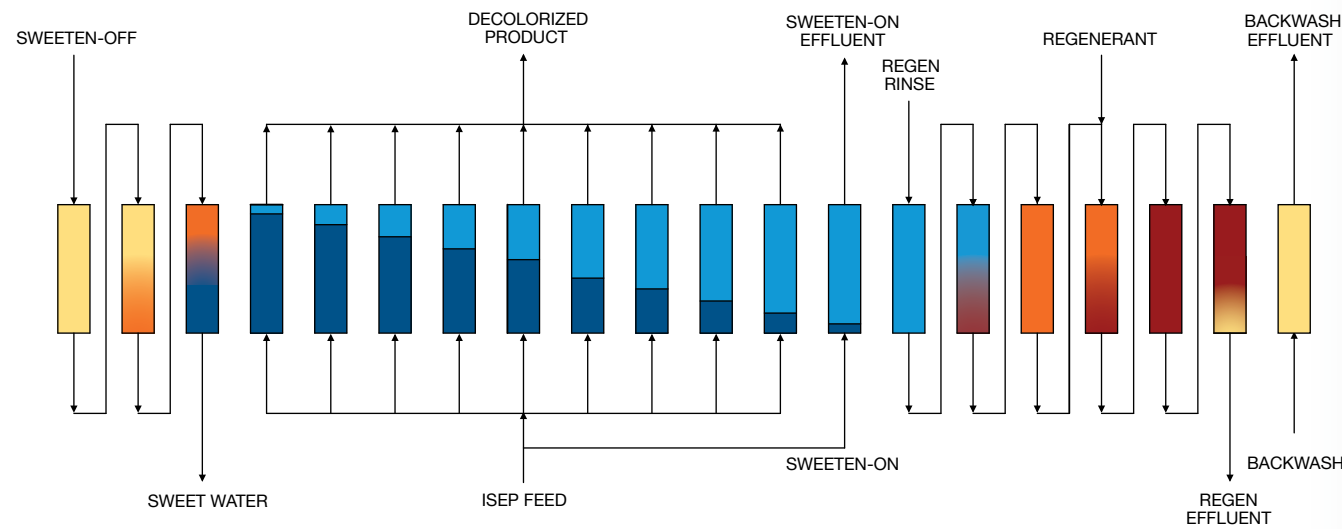
SEPARATION



Calgon Carbon has installed more than 650 continuous ISEP® installations in more than 40 applications since 1990.



Typical Decolorization ISEP® Process Flow Diagram



Ion Exchange Decolorization with Brine Recovery

There are many advantages to selecting an ion exchange system over other technologies for cane sugar decolorization. However, one of the few challenges related to an ion exchange system is the waste from the resin regeneration process. When an ion exchange resin is exhausted with colorants, the resin must be regenerated for re-use. Regeneration is accomplished by passing a caustic brine solution through the resin, resulting in a concentrated brine effluent. Historically, the brine effluent would be disposed of as waste and a new brine solution would be prepared for each regeneration cycle. However, new technology has made it economically feasible to recycle the brine effluent.

Calgon Carbon's continuous ISEP® technology produces significantly less waste brine effluent than fixed bed systems. While the ISEP® process will still generate some waste brine effluent, refineries can reduce salt usage and waste volume by up to 90% by utilizing the appropriate brine recovery system.

Nanofiltration systems are being used commercially to recycle the brine effluent produced during the regeneration process. The utilization of nanofiltration is proven to reduce both salt and water consumption. Studies have shown that the use of a brine recovery system reduces the operational costs of an ion exchange decolorization system by over 50% and makes the process more environmentally friendly. By combining the use of continuous ion exchange with nanofiltration membranes for brine recovery, cane sugar refineries can significantly reduce the already favorable operational costs of continuous ion exchange.

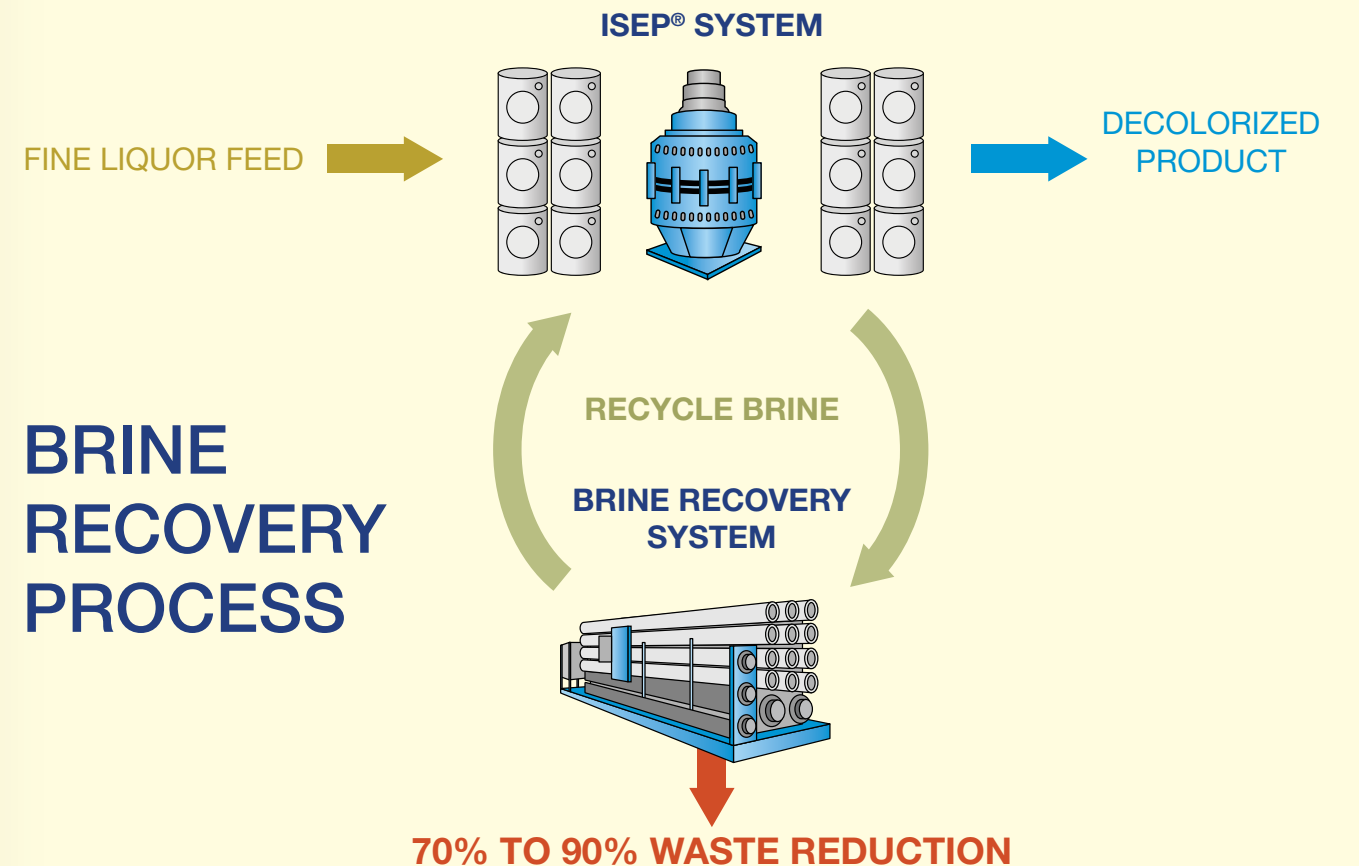
The core of every ISEP® system is a rotary distributor that continuously directs the feed, wash, regeneration and rinse streams through the media cells. This configuration ensures that all media is in active duty and the process is advanced through each operation one step at a time, with a step time proportional to the color removal load required.

Syrup Deashing Options in an ISEP®

A recent focus of the sugar industry has been low invert liquid sugar, and the ISEP® system is ideal for this application. An ISEP® deashing system offers the process advantage necessary to prevent invert formation and additional color degradation often generated in traditional fixed bed technologies, while also eliminating the potential need for a mixed bed ion exchange resin system with its complicated and difficult regeneration process. ISEP® systems have been used for decades in syrup deashing services from corn to beet to cane operations. The ISEP® rotary distributor technology has stood the test of time and has proven to improve efficiencies and reduce cost. The flexibility of an ISEP® system allows for optimization for both high and low ash and color loads by simply adjusting the valve rotation speed.

ISEP® Continuous Ion Exchange Advantages

- Improved efficiency
 - Counter current contact
 - Counter flow regeneration
 - High ionic/color loading
- Reduced media inventory
 - No dormant media
- Reduced operating costs
 - Less media
 - Less water
 - Fewer chemicals
 - Less waste
- Steady-state operation
 - Consistent product and effluent quality
 - Concentrated products and effluents
- Reduced manpower — typically less than one operator per shift
- Reduced space requirements
- Chemical regeneration — a major cost reduction compared to thermal regeneration



Operational Cost Comparison for Two Typical Decolorization Systems

Basis: 800 TPD Raw Sugar Plant with 600–800 ICUMSA Feed Color and Brine Recovery

	Back-End Refinery		Stand-Alone Refinery	
	Refined Sugar Using Fixed Bed IX Technology	Refined Sugar Using Calgon Carbon's ISEP® Technology	Refined Sugar Using Fixed Bed IX Technology	Refined Sugar Using Calgon Carbon's ISEP® Technology
Average Operating Time Per Year	210 days	210 days	365 days	365 days
Life of Resin Used in the Process	4 years	4 years	2.3 years	2.3 years
Resin Required	55 cubic meters	18 cubic meters	55 cubic meters	18 cubic meters
Amortized Costs of Resins/Media	\$80,000 USD	\$26,000 USD	\$139,000 USD	\$46,000 USD
Cost of Sweetwater Evaporation, Rinse Water, Waste Water	\$171,000 USD	\$66,000 USD	\$297,000 USD	\$116,000 USD
Cost of Other Acids/Chemicals	\$106,000 USD	\$54,000 USD	\$185,000 USD	\$94,000 USD
Other Operational Costs	\$67,000 USD	\$50,000 USD	\$116,000 USD	\$87,000 USD
Total Costs	\$424,000 USD	\$196,000 USD	\$737,000 USD	\$343,000 USD
Annual Sugar Production	168,000 MT	168,000 MT	292,000 MT	292,000 MT
PER METRIC TON COST	\$2.52	\$1.17	\$2.52	\$1.17

54% Lower Operating Cost Using an ISEP®

Ion Exchange in Combination with Activated Carbon

Many sugar refineries are using a combination of ion exchange resins and granular activated carbon to meet their treatment objectives and overall product quality. In these applications, the granular activated carbon will perform the primary (gross) decolorization of the feed, and the feed will then be polished using an ion exchange resin. In addition to improving product quality, this combination results in longer service cycles for the activated carbon and ion exchange resin.

Activated carbon removes color by physically adsorbing color molecules as a result of intermolecular attractions or forces inherent to the carbon surface. The surface forces create a stronger attraction between the carbon surface and the color molecule than between the color molecules and the sugar liquor. Activated carbon is not specific for any type of color, but performs good overall gross color removal. Further, the massive effective surface area of activated carbon allows for a large quantity of color to be removed without exhausting the adsorbent.

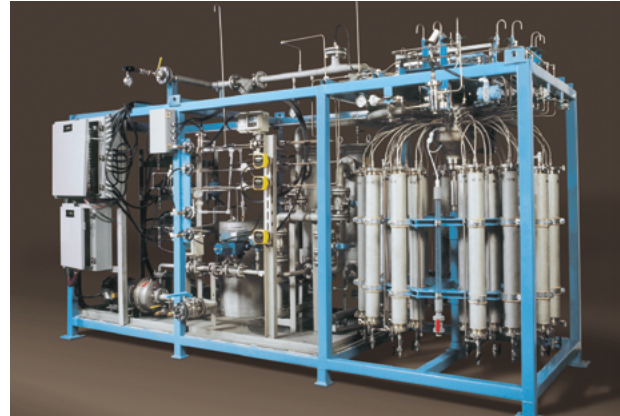
As a global leader in activated carbon and ion exchange systems, Calgon Carbon is uniquely positioned to provide the best solution for achieving the treatment objectives of sugar refineries.

Calgon Carbon is the preferred solutions provider for state-of-the-art continuous ion exchange systems.

Calgon Carbon's Rotary Valve Distributor Technology

At the heart of every ISEP® system is a single, multi-port, rotating distributor valve that directs all incoming and outgoing streams with the most flexibility and efficiency of any system available. The advanced valve technology indexes at a specific rate using a minimum of moving parts, thereby increasing reliability and system up-time. The multi-port distributor is configurable for any number of processes from ion exchange, chromatography, adsorption to even media cycle testing. In essence, the rotary valve technology is an elegant continuous media contactor. The flexibility goes even further because the valves can be configured for either moving bed (ISEP® technology) or simulated moving bed technology (ISEP®-IOVSB technology).

In the traditional ISEP® technology, the cells are mounted on a turntable powered by the valve or by a separate dedicated drive, while, in the ISEP®-IOVSB technology, the cells are mounted directly on the floor and the rotation is simulated.



The extreme flexibility afforded by the rotary valve allows for use of any design of cell from a higher aspect ratio to a lower aspect ratio cell for shallow bed technology. The use of shallow beds with good distribution further results in maximum media utilization and reduced pressure. In every ISEP® system, the media is constantly in use, with none of the media in an idle state, and this high resin utilization results in a much lower media inventory than compared to conventional ion exchange systems. Counter-current and counter-flow regeneration and rinse steps, along with low media volume, combine to reduce the amount of chemicals and effluent required to regenerate and clean the media.

The choice of ISEP® rotary valve configuration for a particular application is determined by:

- Process design
- Flow rate
- Spacial considerations
- Overall benefit to customer
- Economics

Calgon Carbon's Advanced Rotary Valve Distributor ISEP®-IOVSB



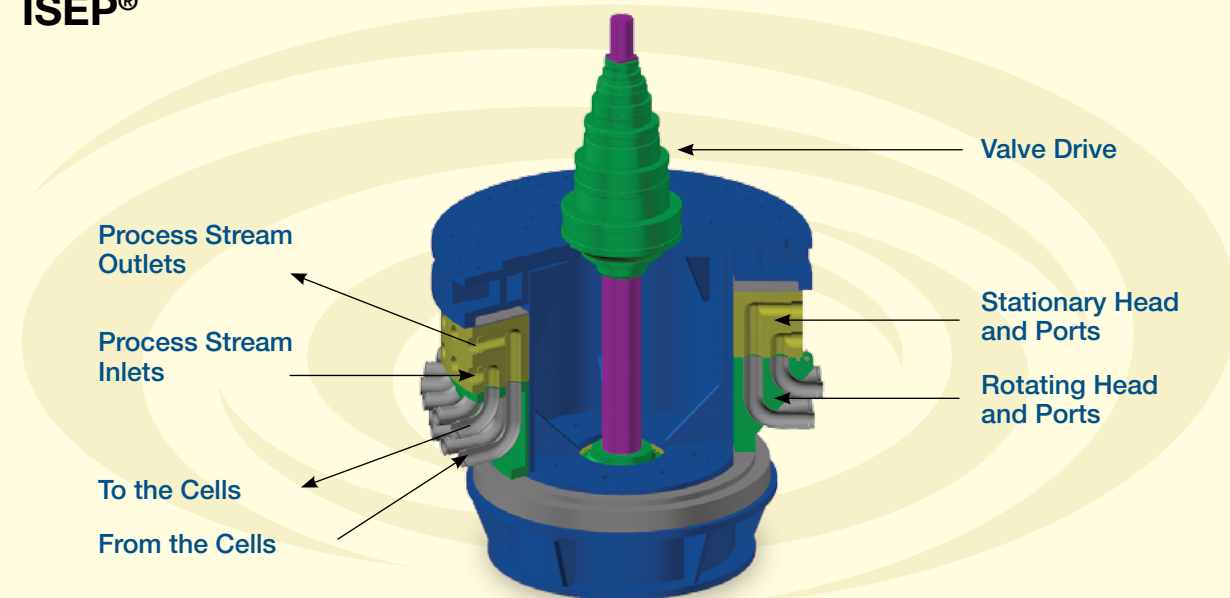
By maintaining flow symmetry throughout the ISEP®-IOVSB valve design, all process connections sequentially index through the stationary cells with no loss of flexibility. All potential process configurations such as up-flow, down-flow, series or parallel flow are determined by exterior piping to the valve and not the valve proper. This allows one valve design to be used for any number of applications and installations with minimal spare parts. The ISEP®-IOVSB is also extremely beneficial in applications with variable conditions resulting in flow configuration changes, a feature not available in competing rotary valves of limited flexibility. Valve symmetry also results in reduction of liquid sealing surfaces. The ISEP®-IOVSB valve has only two simple planar surfaces compared to complicated competing rotary valves of annular faces with multiple O-ring seals.

The ISEP®-IOVSB configuration of the rotary distributor is the latest offering by CCC, and precludes the need for a turntable while still maintaining the advantages of Calgon Carbon's ISEP® continuous ion exchange technology. When developing a new rotary valve, it was essential that Calgon Carbon maintain the design parameters that have made the ISEP® such a success over the last 25 years. This objective meant preserving the symmetry, simplicity and flexibility inherent in the ISEP® system while offering a rotary valve that allowed for stationary beds. In addition to the stationary bed component of the design, the IOVSB valve also allows many variations in layout that can better fit within the refineries' space constraints. Along with improved layout, the IOVSB version can improve access and reduce overall installation cost and maintenance.

All the parameters of Calgon Carbon's ISEP® valve were maintained in the ISEP®-IOVSB rotary valve:

- Truly continuous process flow
- More flexible equipment layout
- Use of traditional stationary columns
- Reduced maintenance
- Reduction in spare parts inventory

ISEP®



ISEP®-IOVSB



About Calgon Carbon

Calgon Carbon Corporation is an industry leader through unmatched innovations in the purification, separation, and concentration of liquids and gases. Throughout our history, Calgon Carbon has been a pioneer in creating new products, systems and services from the infancy stages to global commercialization. As the industry forerunner in activated carbon, ultraviolet light disinfection/oxidation and ion exchange technology, Calgon Carbon provides cutting-edge purification solutions in more than 700 distinct market applications, from purifying sweeteners and pharmaceuticals, air and water, to separating gases and removing mercury emissions from coal-fired power plants.



Each year, hundreds of municipalities, government agencies, and food, biotech, chemical and pharmaceutical manufacturers turn to Calgon Carbon to solve their purification challenges. Technical experts are available to help choose the most cost-effective methods to apply its technologies in air, water, process purification, food and beverage production, site remediation and marine water treatment. Its goal is to help customers reduce the time and expense associated with maintaining purification systems. Protecting the environment is a vital responsibility. The quality of our lives depends on the purity of the air we breathe, the water we drink, and the food we eat. Calgon Carbon is dedicated to providing solutions to address environmental needs.

Pure Water. Clean Air. Better World.

Calgon Carbon's Processing Solutions

Calgon Carbon offers superior processing options using not only regenerable and non-regenerable ion exchange and adsorbent resins, but also silica gels, activated carbon and molecular sieves based on the unique application. Since 1990, manufacturers and industries have discovered the exceptional value of Calgon Carbon's continuous ISEP® equipment technology for separating, purifying and synthesizing materials. With more than 450 installations in more than 40 applications, ISEP® continues to prove that it is capable of solving complex problems economically.





*Pure Water. Clean Air.
Better World.*

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