ENGINEERING
TOMORROW

Danfoss

Danfoss | Sugar applications

On top of **sugar production** with the **widest Free Flow plate portfolio** in the world

We offer you a complete heat exchanger portfolio to support your production

FULL
range of plate gaps available to suit your needed configuration

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SONDEX®

Complete heat exchanger portfolio for sugar production

The sugar industry subsumes the production, processing, and marketing of sugars. At the heart of any sugar production is always a crop rich in sucrose.

Extracting sugar from the crop is a complex and fascinating process that leads to the finished products that most of us are probably familiar with, like refined sugar, molasses, or even ethanol / alcohol.

In some sugar refineries, you will even find integrated power plants that produce electricity and heat by utilizing the residual plant material.

Globally, most sugar is extracted from sugarcane (~80 %, mostly in the tropics) and sugar beets (~20%, mostly in temperate climate like in the U.S. or Europe).

Sugar beet and sugarcane processing have similar stages of obtaining sugar, with some differences (detailed in the diagrams on the following pages).

Danfoss offers a wide range of SONDEX® heat exchangers for the entire sugar refinery application, such as:

Free Flow plate heat exchangers, designed specifically for operation with media containing fibers and high-viscosity media.

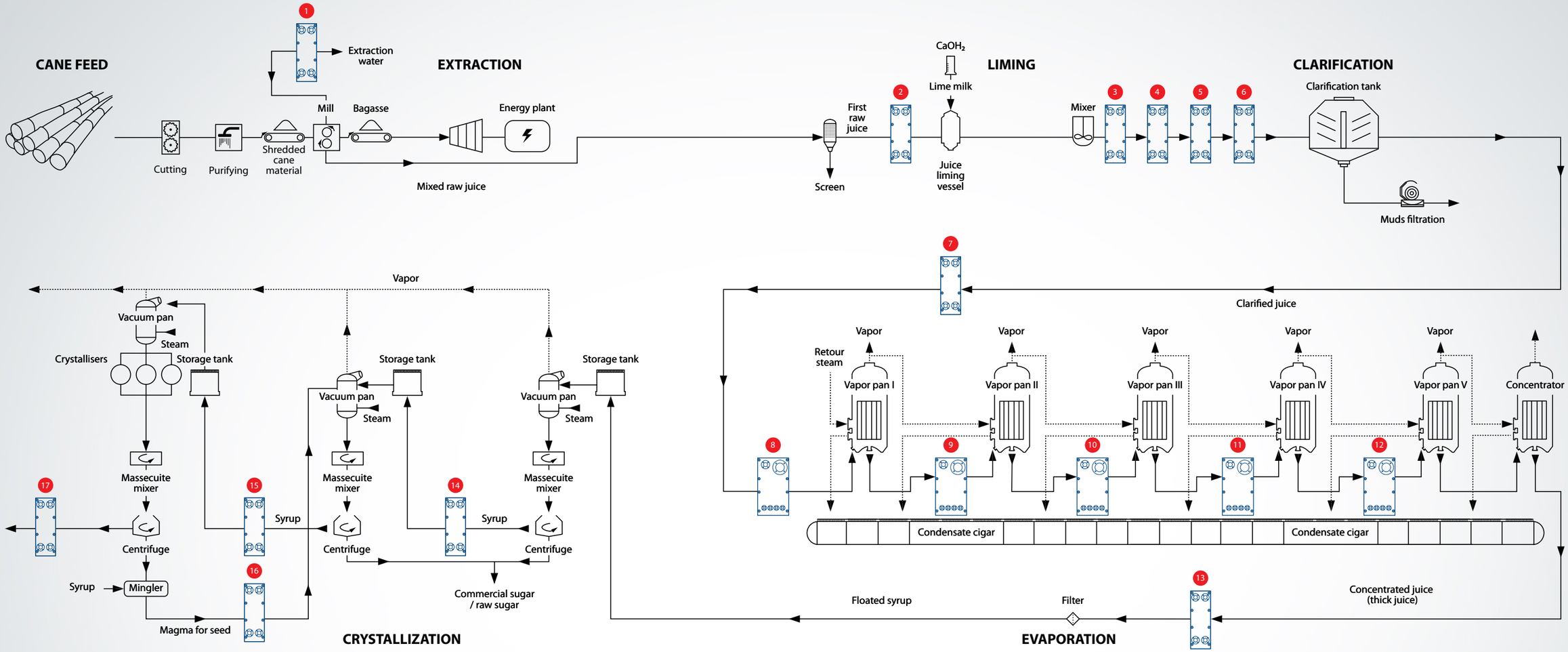
Standard gasketed plate heat exchangers, used in many sub-processes.

Special **plate evaporators**, specifically targeting multi-effect concentration duties.

Special **plate condensers** for distillation of e.g. alcohol and ethanol.

Spiral heat exchangers, used as economizers and for cooling molasses and vinasses.

Sugarcane processing



The cane is delivered to the mill, where it is cut, cleaned (purified), and transferred to the mill. Here, the cane is cut into pieces with revolving knives, shredders, or crushers (for breaking down the organic material) and then ground (or milled) in a series of roller mills (consisting of 3-6 rollers each), being transported from one mill to the next.

1 | Extraction water heater (standard)
The extraction water is heated up in the heat exchanger (1) and fed to the mill in order to enhance the extraction of the juice from the crushed cane.

The crushed cane, or residual fibre, exiting the mill, is called "Bagasse". It serves as a fuel for running the micro power plant that is typically part of the installation site.

2 | Raw juice heater (Free Flow)
The mixed raw juice coming out of the mills is filtered to remove large particles and then clarified and heated up in the heat exchanger (2).

One of the most widely used methods to clarify raw sugarcane juice is carbonatation, which generally employs treatment with lime and controlled addition of carbon dioxide (CO_2).

Prior to liming, the mixed raw juice is preheated to a temperature of 50-85°C in the heat exchanger (2) for optimal clarification.

The milk of lime, calcium hydroxide or $Ca(OH)_2$, is added to the juice to neutralize the organic acids and raise the pH. CO_2 gas is then introduced into the limed juice to remove alkalinity.

3, 4, 5, 6 | Group of limed juice heaters (Free Flow)
Next, the temperature of the carbonatated juice is raised to the boiling point to remove excess carbonic acid, and the juice enters a gravitational settling tank, a clarifier, where heavy precipitate forms and is separated from the juice. The clarified juice (so-called thin juice) is processed in the evaporators without additional treatment.

7 | Clarified juice heater (standard)
The clarified juice reaches the first evaporator step, which has steam (of 100-110°C at saturation pressure) on the hot side.

8, 9, 10, 11, 12 | Group of plate evaporators (special evaporator plates)
On the product side, the evaporation begins inside the special evaporation units (semi-welded), due to lower pressure on the evaporator side (phase change occurs).

The low pressure is created in the separation vessel (Vapor pan) partly due to re-condensation and due to the condensate ejector pump.

In the next phase, the cane juice steam is taken from the first separation tank (Vapor pan I), and used as the hot side input on the next evaporator (9) – typically a total of 4 or 5 evaporator steps are the most economical from a Total Cost of Ownership perspective.

During this process of repeated evaporation at lower and lower pressure / temperature, the sugar content gradually increases in the remaining condensate, until approximately 70 Brix is reached.

13 | Concentrated juice heater (Free Flow)
In the crystallization process, the sugar rich fluid goes to the final evaporation in a vacuum pan, and seed crystals are added.

Seed crystals (basically a "handful of sugar") act as a catalyst for crystal formation, and all the sugar in the fluid now changes state from being a soluble part of the fluid, into a separate crystal.

The resulting material, which contains liquid (syrup) and crystals (sugar) is called cooked mass. The crystallization work is performed by using the three cooking system or batches in order to obtain better sucrose recovery.

Now the mother liquid (Massequite) is ready to be sent to the centrifuge. Here, the fluid is separated into two components: fluid molasses and raw unrefined sugar (a wet and sticky granulate matter).

The raw sugar is then led to a rotary drier that dries the sugar, after which the raw sugar is now ready for the final steps (typically bleaching, grinding, and sifting to create fine white sugar).

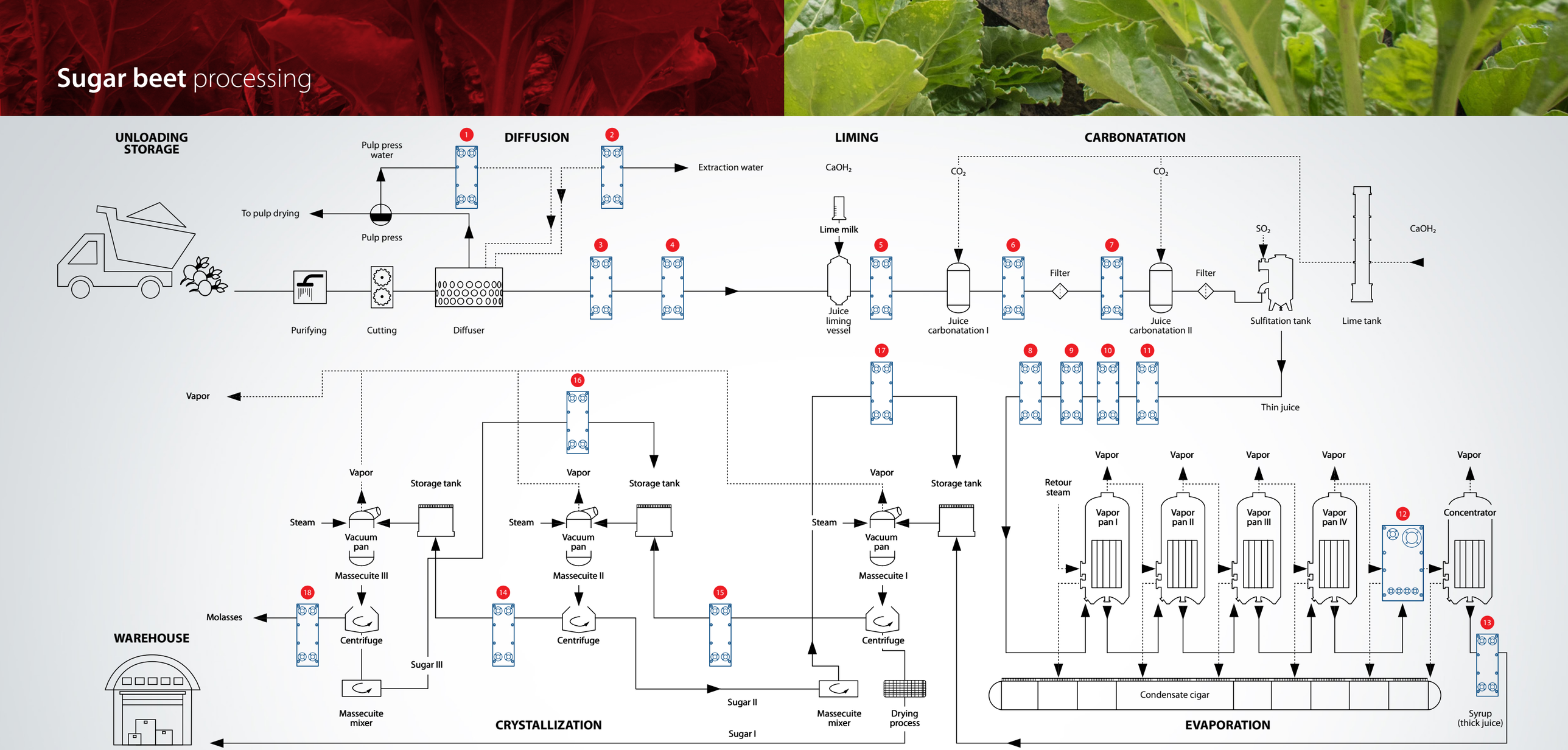
14, 15 | Syrup heater (Free Flow)

16 | Magma for seed heater (Free Flow)

17 | Molasses cooler (Free Flow)

The setup of the crystallization stage may vary in different regions and sugar refineries.

Sugar beet processing



Nowadays, a diffusion method is usually applied for obtaining beet juice. The first step in the diffusion process is to cut the beet roots into thin strips called cossettes. The cossettes then undergo countercurrent processing with hot water at temperatures of 72-75°C in a special machine referred to as a diffuser.

1 | Pulp press water heater (Free Flow)
Cossettes without sugar content (pulp) leave the diffuser to be pressed, and then the pressed pulp is dried or sold raw.

Pulp-press water is subject to heat treatment in the heat exchanger (1), purified from suspended impurities and returned to the diffuser. Caught wet pulp is also returned to the diffuser.

2 | Extraction water heater (standard)
In the diffuser, the sugar content is extracted from the counter flow of cossettes and hot water, which has been preheated in the heat exchanger (2).

The diffused juice is separated from the wet pulp in a pulp catcher and sent for the lime and carbon-dioxide purification.

3, 4 | Diffusion juice heater (Free Flow)
The diffusion juice is preheated in the heat exchangers (3 and 4) and is then filtered and purified by CaOH and CO_2, which is obtained at the plant during the calcination of limestone (this stage is called liming).

5 | Limed juice heater (Free Flow)
The heat exchanger preheats the limed juice before it is treated with carbonation gas CO_2 (Juice carbonatation I). In this process the lime is converted into calcium carbonate ($CaCO_3$), on the surface of which non-sugars are adsorbed.

6 | Juice heater after carbonatation I (Free Flow)
The juice is heated before filtration, where the precipitate of $CaCO_3$ and non-sugars are separated from the juice.

7 | Juice heater before carbonatation II (Free Flow)
The juice is heated to 92-95°C in the heat exchanger (7) and before its second carbonatation (Juice carbonatation II). After the separation of the saturation precipitate via filtration, the juice is sulfated, filtered, and fed to the evaporation station.

8, 9, 10, 11 | Group of juice heaters before evaporation (standard)
The purified juice (so-called "thin juice") with 11-16 Brix is sulfated by sulfur dioxide (SO_2) and preheated in the group of juice heaters by steam and then concentrated to 60-65 Brix at the evaporation station.

12 | Optional plant capacity booster (Plate evaporator)

13 | Syrup heater (Free Flow)
The syrup (thick juice) is preheated in the heat exchanger (13) and mixed with melt syrup of sugar II and III, sulfated, filtered, and passed along to the crystallization process.

14, 15 | Liquor heater (Free Flow)
To obtain pure granulated sugar, the syrup is boiled in a special pan under vacuum to the oversaturation state.

Powdered sugar is then added to start the crystal formation to get a mixture of crystals and syrup, the so-called massecuite (Massecuite I).

The massecuite is spun in centrifuges to separate the sugar from the first mother liquor. The sugar is then washed in centrifuges with hot water, producing a second mother liquor.

The sugar is dried. The first and second mother liquors (with sugar content) are boiled (Massecuite II) and is preheated in the heat exchangers (14 and 15). The massequite is centrifuged, and the sugar is washed with hot water.

16, 17 | Melt syrup heater (Free Flow)
Sugar III (low-grade sugar) contains more impurities than sugar II (middling sugar), so it is preheated in the heat exchanger (16). It is then mixed with the diluted first mother liquor of Massecuite I, a so-called affined solution, after which it is centrifuged.

During stirring, part of the non-sugar passes from the film on the crystals to the affined solution, resulting in cleaner sugar.

The mixture of low-grade sugar and the diluted first mother liquor of Massecuite I, the so-called affined massecuite, is centrifuged with Massecuite II.

The middling sugar and low-grade sugar are dissolved in purified juice to 65-68 Brix (this solution is called melt syrup) and this juice is mixed with the syrup from the evaporation station before sulfitation.

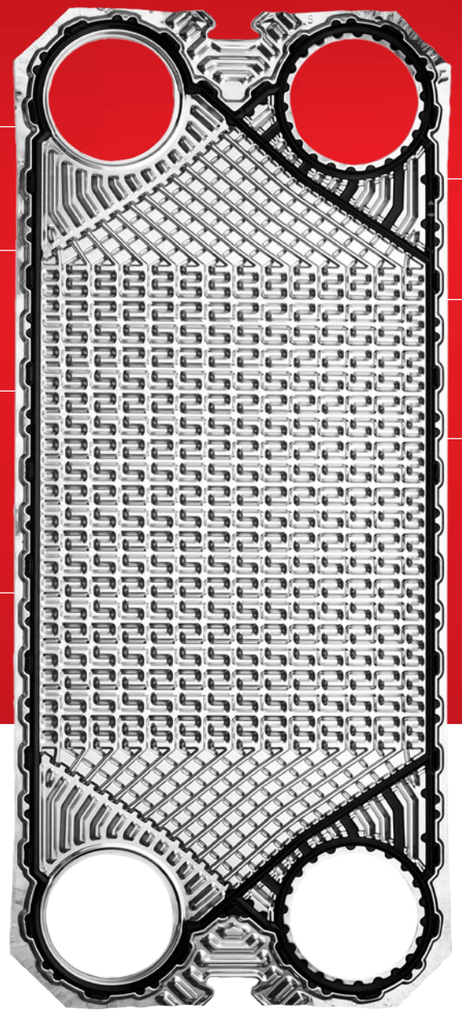
18 | Molasses cooler/heater (Free Flow)
Depending on the technological setup of the plant, the molasses is cooled down or heated up in the heat exchanger (18) and sent to other factories for further processing.

DN25 - DN400
porthole connections

1 m - 3.4 m
plate heights

Up to 2700 m³/hour
flow rates

Designed to handle media with fibers and particles, high-viscosity media, and fouling media



Very stable plate pack even with only line contact

5 mm - 12 mm
plate gap

Asymmetric
patterns available

Free Flow plates

Comprehensive process insight brings about the crowning achievement within treatment of hard-to-handle media.

The spacious SONDEX® Free Flow pattern is designed to treat media that is unsuitable for regular heat exchangers due to high viscosity, fiber and particle contents, or considerable risk of fouling.

The deep and wide channels provide ample room for difficult media to flow effortlessly, ensuring gentle treatment of the output product, leading to sustainable quality improvements.

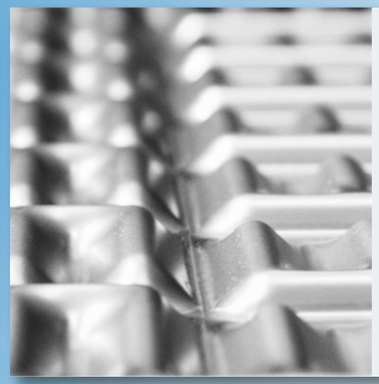
Free Flow plate benefits
Since there is only line contact, even long and sticky particles will not get stuck and clog the heat exchanger.

The Free Flow plates are also well-suited for media that have a tendency to cause fouling, and are designed with the fouling factor in mind.

The plate channels allow for an efficient flow and heat transfer, and have strong anti-fouling properties.

This enables a sugar producer, for example, to operate at full capacity throughout an entire campaign without losing valuable production time and product output.

Free Flow plate highlights

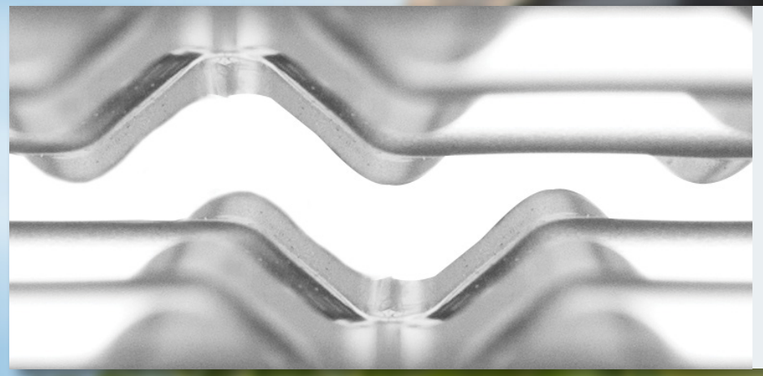


Spacious channels
The SONDEX® Free Flow pattern ensures an unimpeded flow due to the deep channels.

With only line-contact, the media has ample room to flow inside the plate channels, benefiting greatly from the increased level of turbulence, compared to tubular heat exchangers.

Contact-free inlets
The design of the SONDEX® Free Flow inlets maintains the sturdy and robust construction of the traditional plate design, while having no contact points at all.

This greatly minimizes the risk of clogging the inlets and subsequently decommissioning the heat exchanger for service and maintenance.



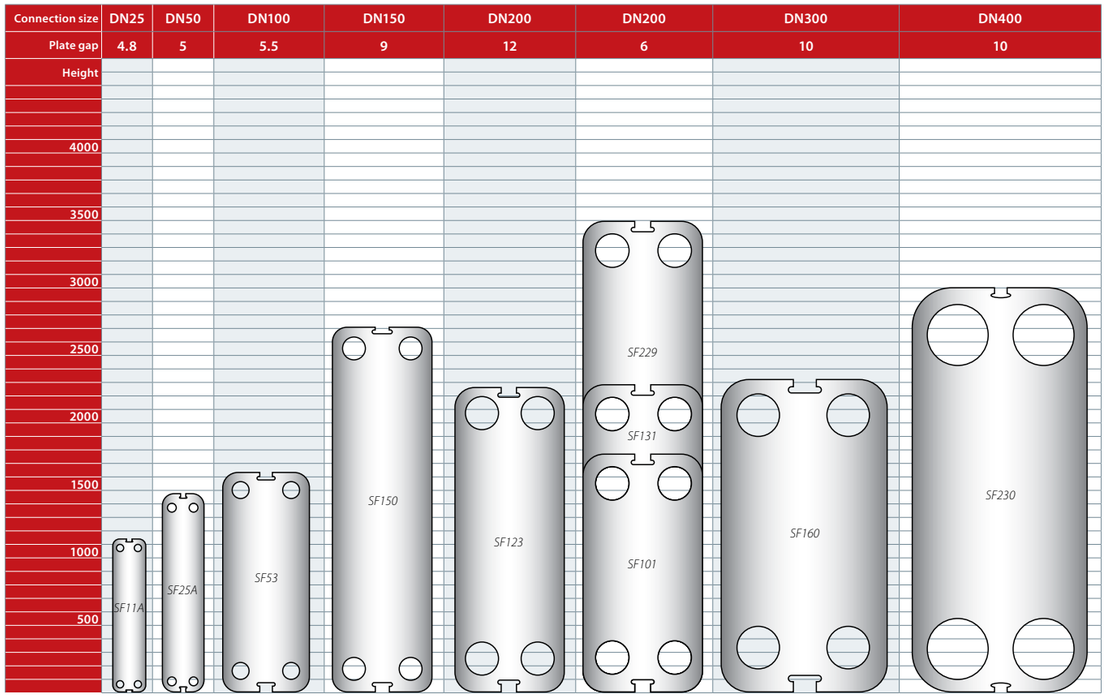
Large plate gap
The large plate gap is designed to handle media that would otherwise cause fouling and clog regular heat exchangers.

Our process and application knowledge enables us to design Free Flow plate heat exchangers that perform optimally, regardless of the media's viscosity, fouling tendency, and particle contents.

Line-contact
The Free Flow plates feature only line-contact between each plate. The design forms straight-line contact that maintains the sturdiness of conventional plate design, but allows for an unimpeded flow.

The pinnacle of design for hard-to-handle media, our Free Flow pattern ensures longer intervals between cleaning and service, maximizing the uptime of your installation.

SONDEX® Free Flow heat exchanger plate portfolio



Measurements in mm

Rev.11.10.2019

With our extensive Free Flow plate portfolio, we can provide you with an optimal solution for your business and applications.

Design pressure:
PN 10, PN 16

Min. working temperature:
-20°C (depending on gasket material selected)

Max. working temperature:
180°C (depending on gasket material selected)

Frame (head and follower) materials:
Mild steel, painted in RAL 5010.
Other colors are available upon request

Plate materials:
AISI 304, AISI 316, titanium.
Other materials are available upon request

Gasket materials:
NBR, EPDM and Viton.
Other materials are available upon request

Construction standard:
PED 2014/68/EU (EN13445),
ASME sec VIII, Div. 1 (In select countries)

Compliant to:
FDA, 3A

Performance certificates:
AHRI (LLHE)

Plate gap configurations:
Symmetric, asymmetric

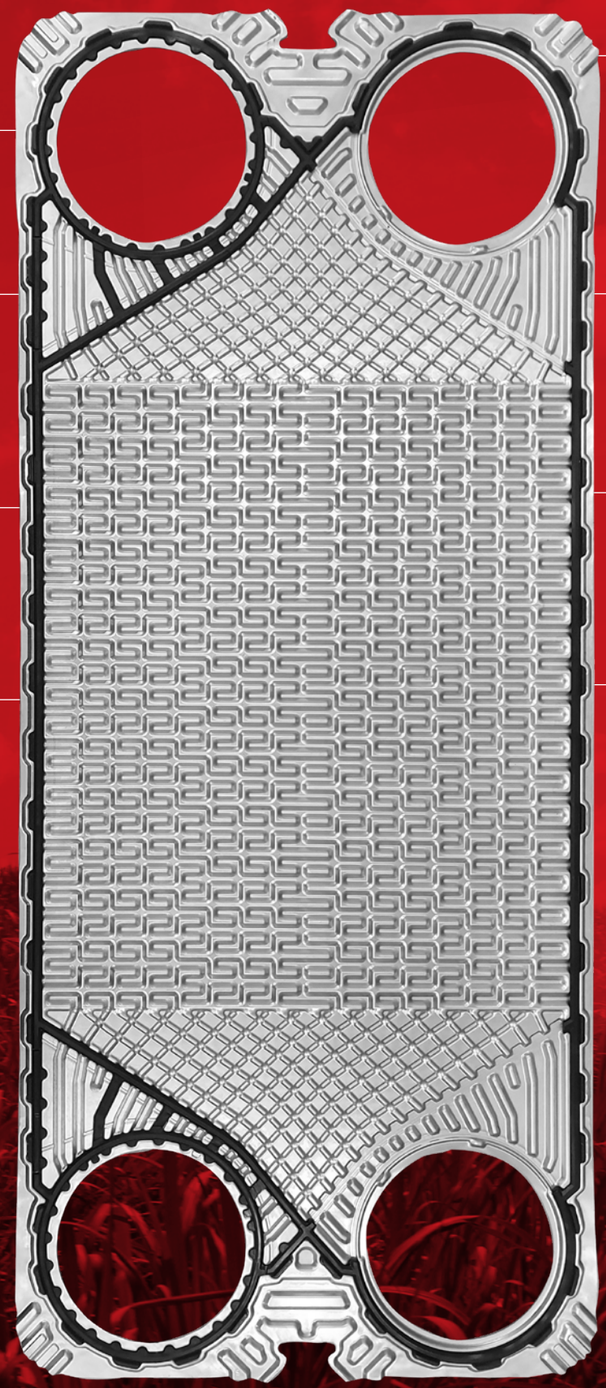
Introducing the **largest** Free Flow plate on the market, SF230

DN400 porthole connections

2840 mm plate height

Heat transfer area up to 750 m² in a single unit

Flow rates up to 2700 m³/hour



Reinforced corner supports for increased plate pach stability

Improved reinforcements for increased plate strength

10 mm plate gap

1235 mm plate width

SONDEX® provides the complete **heat exchanger** product range for **sugar/ethanol** applications

Plate evaporators

- Multi-effect concentration duties
- Clean liquids
- Specialized plates for optimal evaporation conditions and maximum product output

Standard heat exchangers

- Various sub-processes
- Clean liquids
- High thermal efficiency

Spiral heat exchangers

- Molasses and vinasses cooling
- Media containing fibers and particles, and high-viscosity media
- Excellent heat recovery

Plate condensers

- Distillation of e.g. ethanol
- Clean liquids
- Specialized condensation plates for optimal treatment of media

Evaporators

Our SONDEX® evaporators are designed to handle advanced evaporation duties. Using semi-welded plate cassettes, the media are guaranteed to never mix. The plate cassettes are designed to ensure the optimal level of turbulence on both sides while providing an even distribution of the media for superior performance and product quality.

Features and benefits

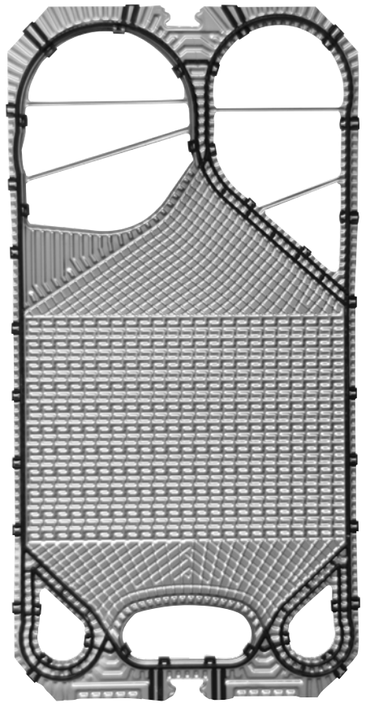
- Special plate design featuring an extra-large inlet connection for steam. Steam consumption can be reduced when operating with multi-stage evaporators, as the product vapor will serve as the heating media.

- Flexible design that makes it easy to increase capacity by adding additional cassettes or decrease it to save energy. Low residence time leads to perfect evaporation conditions and superior product quality.

- High performance, even with low temperature differences between the media, which is especially great for mechanical vapor recompression (MVR) and thermal vapor recompression (TVR).

Common applications

- Food production, for example juice and alcohol processing.
- Sugar production, for example concentration of sugar content in sugarcane juice.
- Biogas production.
- Pulp and paper industry.
- Chemical industry.



Spiral heat exchangers

Our SONDEX® spiral heat exchangers are the definitive solution for applications that require treatment of challenging fluids, such as sludges, slurries, waste water, liquids that cause fouling or contain fibers and solids, and liquids with high viscosity.

Features and benefits

- The design allows for a countercurrent flow that makes it possible to achieve very close temperature approaches.

- Single-channel design that generates high shear rates which contribute to a self-cleaning effect, preventing clogging of the unit. Spiral heat exchangers are the perfect solution for high-viscosity media.

- The channel size is selected to fit the flow and qualities of the media. The many variations in diameters and widths of the spiral coil allow for many different combinations, which mean that we can create the optimal solution for every duty.

- Designed to handle a very aggressive temperature program and with a wide range of materials and plate thicknesses available, we customize each spiral heat exchanger to match the requirements of your application.

- Limited need for maintenance and cleaning ensures extended operational uptime. If particularly difficult media makes it necessary to clean, the hinged covers provide easy access to the entire heat transfer surface.

- Our spiral heat exchangers have minimal space requirements. Despite being small, the long, curved flow paths allow for very high heat transfer coefficients up to twice as high as their shell and tube counterparts.

Common applications

- Food/beverage industry
- Biogas industry
- Wastewater industry
- Pulp and paper industry
- Heavy industry
- Petrochemical industry
- Chemical industry

Standard plate heat exchangers

Our SONDEX® standard plate heat exchangers are the ideal choice for a wide range of applications across numerous market segments. We have one of the largest plate portfolio in the world, and we configure each heat exchanger to meet your requirements. Innovative technologies and smart design make our traditional plate heat exchangers a stellar investment.

Features and benefits

- Experience the benefit of a heat transfer solution that perfectly matches your requirements and lowers your energy consumption.

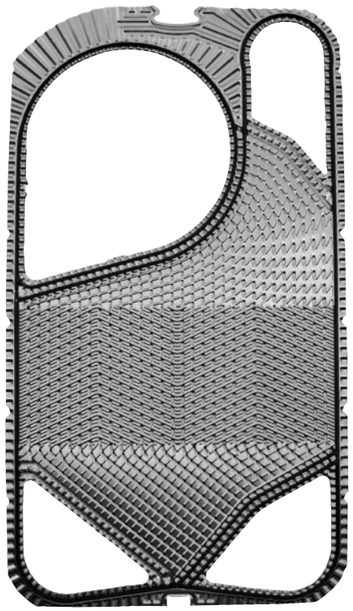
- High performance and a low pressure drop eliminate unnecessary burdens on your system and optimize overall system performance.

- The design results in a compact solution with a small footprint, simple installation, and easy access for maintenance.

Common applications

- Marine applications, such as central and lubrication oil cooling.
- District cooling solutions using seawater and groundwater as a cooling source.
- District heating solutions using, for example, solar and geothermal energy as heating source.
- Food and dairy applications, including pasteurization, heat recovery, and duties that require gentle treatment.
- Chemical applications, for example waste heat recovery from condenser water.

Condensers



Our SONDEX® condensers are the perfect choice for special applications that regular plate heat exchangers cannot handle. Designed to accommodate high-volume vapor flows, this product features a large inlet for the vapor stream. This, combined with a short residence time creates the optimal condensation conditions – even for low-pressure vapor duties.

Features and benefits

- Designed specifically for demanding condensation duties that benefit from a special asymmetric plate design that is unavailable for regular heat exchangers.

- Experience the high thermal efficiency of our SONDEX® heat exchangers and enjoy peace of mind with an ideal turbulent flow that reduces the risk of fouling.

- Special Multi-gap plate design that can lower the energy consumption considerably for condensation duties that differ in flow volume.

Common applications

- Vapor condensation of fruit juice, for example, and pasteurization and cooling of soft drinks.
- Vacuum condensation duties, for example in sugar refineries.
- Biogas production.
- Pulp and paper industry.
- Chemical and petrochemical industries.

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Welcome to our world of heat exchangers

We have one of the most extensive heat exchanger (HEX) product portfolios on the market and we offer optimized heat transfer solutions for a wide range of applications and industries.

Want to know more?
Visit heatexchangers.danfoss.com to learn more about our heat exchanger solutions.

Gasketed HEX

Standard plate HEX
Semi-welded plate HEX
Free Flow plate HEX
Sanitary plate HEX
Evaporators
Condensers

Welded HEX

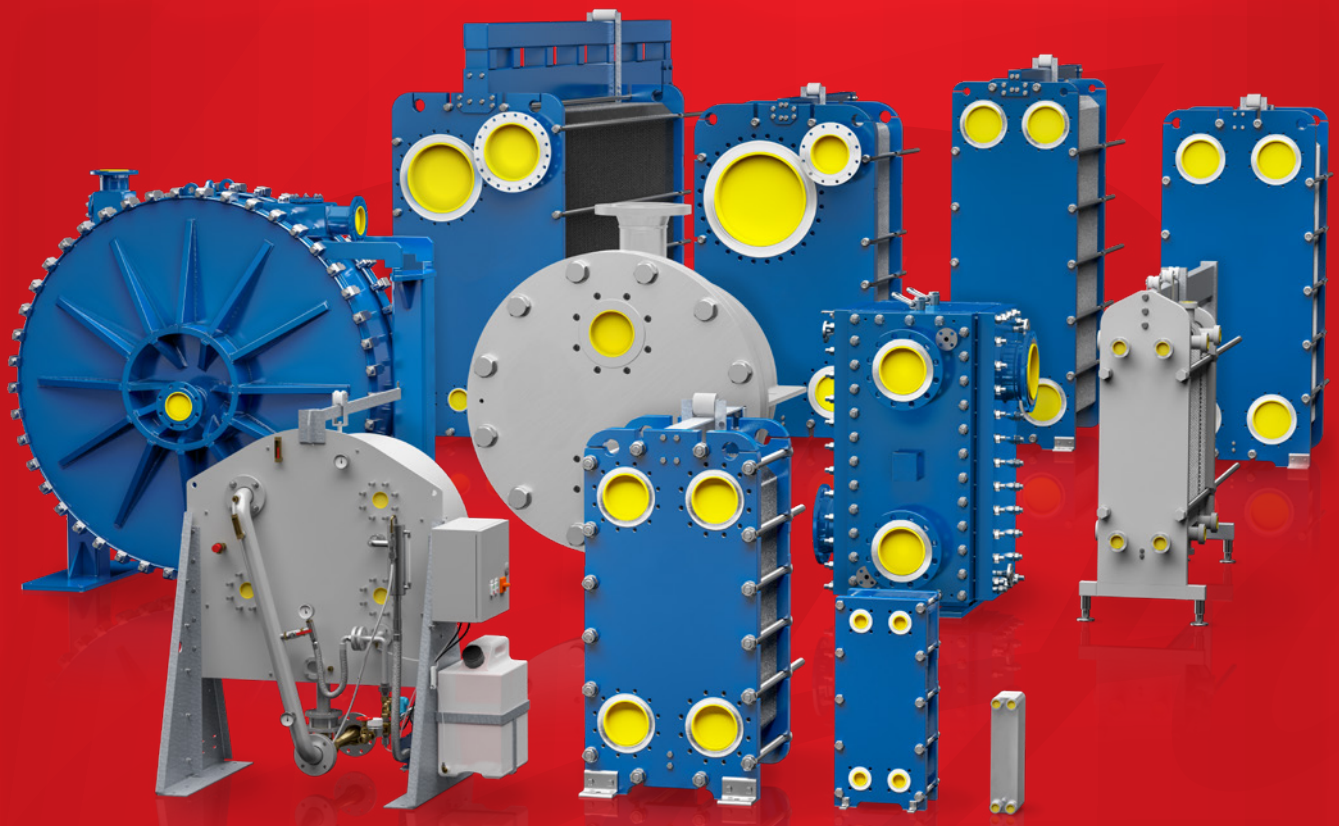
Fully welded plate HEX
Plate and shell HEX
SondBlock HEX
Spiral HEX

Brazed HEX

Fishbone brazed HEX
Micro Plate™ brazed HEX

Fresh Water Distillers

Single-stage FWD
Multi-stage FWD



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