NEW GENERATION

# Production System MoSES

## Modular Supercritical Extraction System


$CO_2$

- modular design
- fully automated system
- high-quality manufacture
- certified and tested in accordance with EU standards

MoSES **1.25.1**
MoSES **1.25.2**
MoSES **1.25.3**

CERTIFIED IQNet MANAGEMENT SYSTEM

SIQ ISO 9001 Q-326 ISO 14001 E-390

TÜV SÜD

# Supercritical Extraction

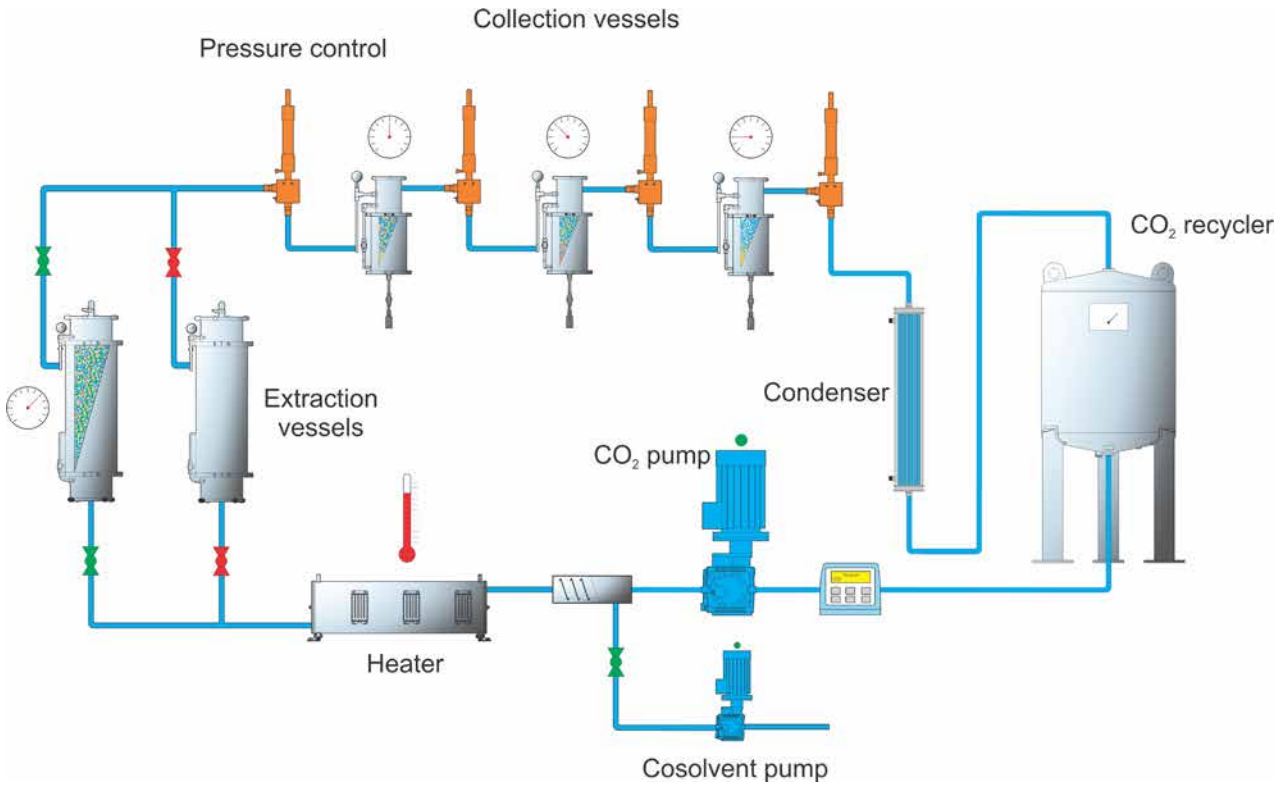
Extractions are important processes for the production of natural and synthetic bioactive components used in medicine, pharmacology, various process industries, and everyday life.

**Supercritical extraction (SCE)** is considered one of the most efficient extraction methods currently available. However, the highly sophisticated technical equipment is normally limited to specialized laboratories or industries.

Škrlj MoSES Extractors are designed to function as bulk-scale, high-pressure extraction systems that can be used to obtain a variety of substances from a broad range of matrices.

The systems provide high extraction efficiency and the possibility of a selective fractionation of different extracts in a single run. Completely integrated, the extraction systems ensure consistent final product quality from run to run.

Schematic diagram of the MoSES 1.25.2 extraction system




Due to the ability to carry out the process at increased pressures, extractions can run up to four times faster compared to other traditional systems. The system operates at decreased temperatures, which means the extracts are cleaner and have a higher purity due to lower decarboxylation.

The MoSES systems extract chemical compounds using supercritical $CO_2$ instead of organic solvents or hydrocarbons.

The supercritical fluid state occurs when a fluid's temperature and pressure are above their critical points (Tc and Pc). Supercritical fluids are substances with both gas-like and liquid-like properties: their surface tension and viscosity tend to be low, but they still have a high solvating power.

By regulating the temperature and pressure, it is possible to control the polarity and solvating power of a supercritical fluid and, consequently, target and selectively extract the required components. With a controlled pressure release, the supercritical fluid passes into the gas phase and evaporates. In such a way, it is possible to produce highly concentrated and solvent-free extracts.

Due to its low toxicity, low denaturation rate, and low environmental impact, $CO_2$ is the most used supercritical fluid.

The main drawback of $CO_2$ is its nonpolarity, because in order to extract more polar components, like polyphenolics or simple carbohydrate complexes, it is usually necessary to add polar co-solvents.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The MoSES 1.25 Series extractors are modular systems designed to perform supercritical extractions using supercritical $CO_2$ with the possibility of adding polar solvents, soluble in $CO_2$ up to 30 wt. %.

In this way, the extraction portfolio encompasses semipolymeric components such as phytosterols, carotenoids, tocopherols, tocotrienols, and more polar components such as condensed terpenoids, polyphenols and their complexes like polyketides, glycosides, azo compounds, etc.

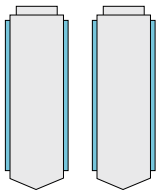
By manipulating the pressure and temperature, the $CO_2$ can selectively extract the compounds of interest from different materials. The sample is placed in an extraction vessel and pressurized with $CO_2$, which is sometimes combined with a small percentage of co-solvent (depending on the application), in order to extract the components of interest. These dissolved components are then transferred from the extraction vessel to a series of collection vessels.

## MoSES 1.25.x Line

MoSES 1.25.x systems feature 25-liter extraction vessels which can hold up to 25 kg of material each.

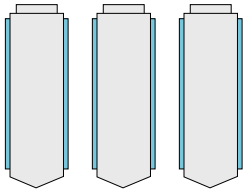
**MoSES 1.25.1**

1 x 25 L extraction vessel



**MoSES 1.25.2**

2 x 25 L extraction vessel



**MoSES 1.25.3**

3 x 25 L extraction vessel


*MoSES 1.25.2 with 2 extraction vessels*


*Separator / Collection vessels*


The automatic back pressure regulator (ABPR), located between the extraction vessel and the cyclone separators (collection vessels), enables a controlled pressurization of the compounds of interest with $CO_2$.

After exiting the ABPR, the system pressure is reduced, causing the $CO_2$ to lose its solvating power. When the manual back pressure regulators (MBPRs) are properly set, the extracted material precipitates out of the solution and into the collection vessels.

The cyclones are arranged in consecutive order to enable a series of steps with decreasing pressures to isolate the collected compounds. This enables extract fractionation, resulting in purer, cleaner fractions that require less post-processing purification.

The trapped and condensed $CO_2$, still in the gas state, is finally transferred to a recycling system and can be simply and cost-efficiently reused.



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## Modular design

The modular design enables upgrades, which increase system capacities, and component additions, which further extend system flexibility without replacing the basic system framework.

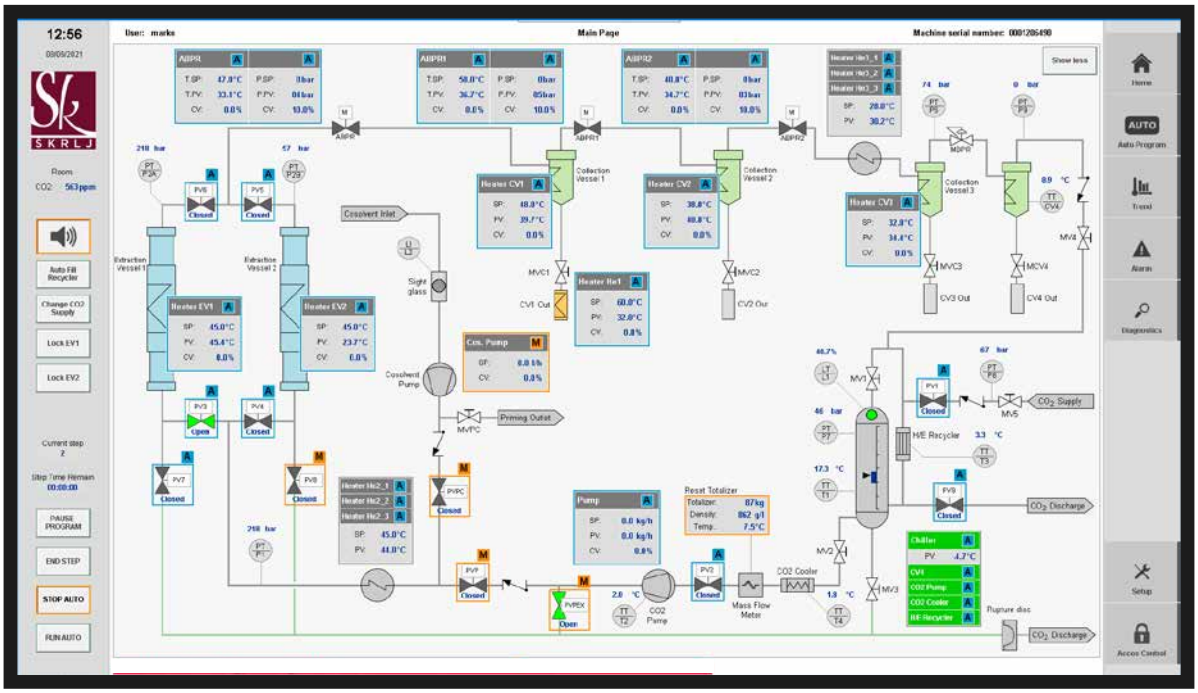
The MoSES extractor is equipped with an optional co-solvent addition accessory that enables a user-friendly self-cleaning feature. This feature improves system flexibility and efficiency and can be very useful when the process requires frequent changes of the extraction matrices or if the components which are going to be extracted are not readily soluble and have a high viscosity.

## Automated system

The optional automation with a unique user-friendly communication system intuitively leads the operator through the extraction process and system control.

All methods, commands, and parameter adjustments are presented graphically on the touch screen and can be executed in on-fly mode.

As an option, the system can be completely PC-controlled. Preinstalled and integrated methods enable immediate and efficient extraction even when the conditions and the extraction matrix are changed frequently.





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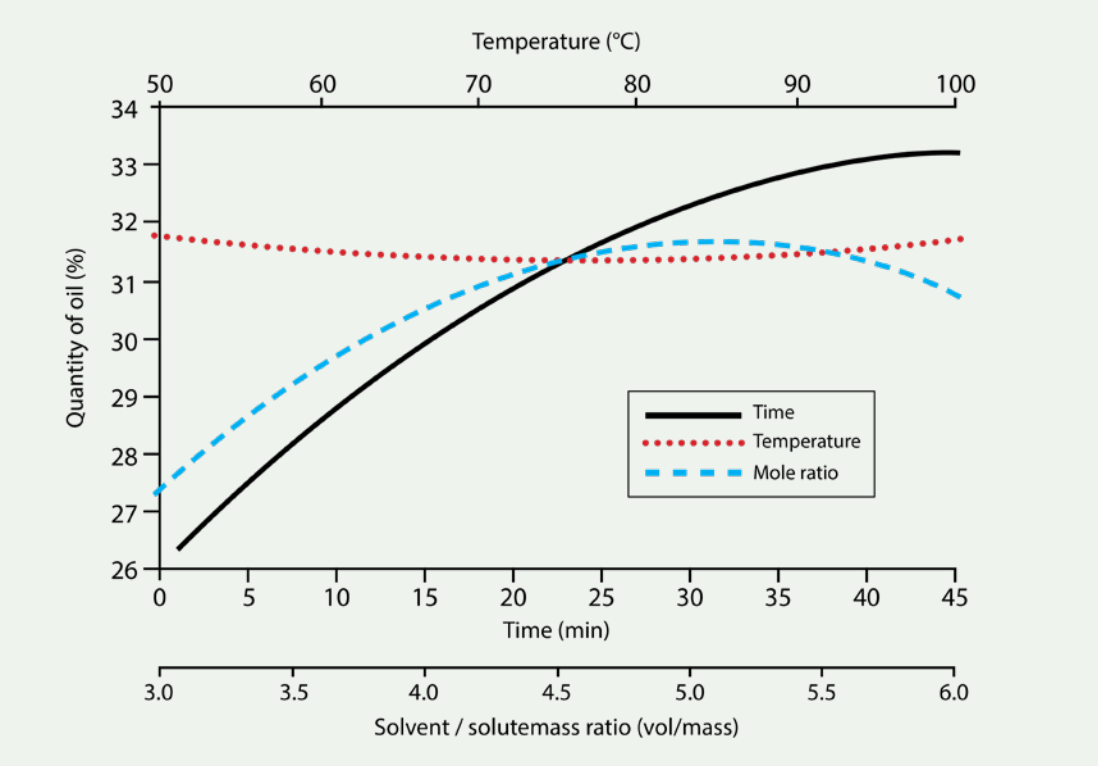
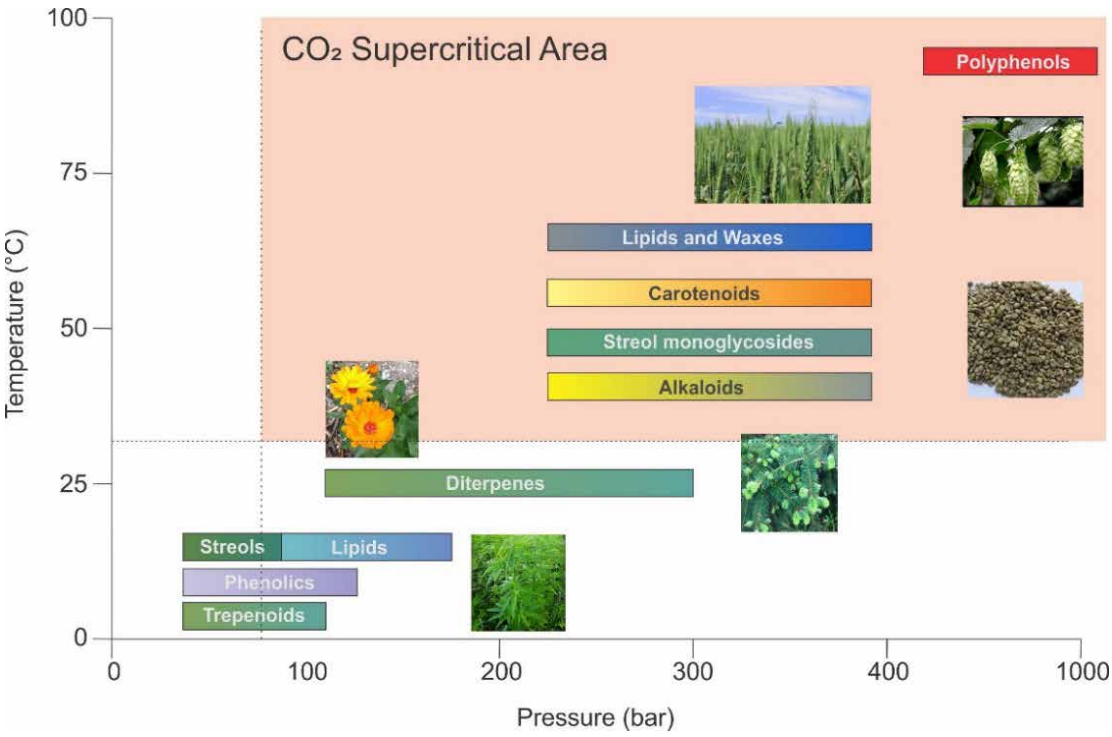
The integrated logic system is designed to allow unique automatic adjustments of the solid to solute "S/S" ratio parameter, with the aim of simple scalability of the extraction process from laboratory to industrial-scale within a single method.




*Graphical presentation of Solvent/solute mass ratio*

The recommended $CO_2$ tunable parameters and polarity for selectivity are presented in the image bellow:




*Basic SCE parameters for particular extractions*
*(source: Warren B Potts; Let's Get CRITICAL, Supercritical Fluid Extraction (SFE)*

The basic system enables extraction under pressures up to 325 bar and at temperatures up to 85 °C, at a functional $CO_2$ flow rate up to 200 kg/h.

The predetermined S/S factor automatically counterbalances the parameters (like flow rate and time) based on the quantity of the extraction matrix present. Customized parameter adjustment ensures the final degree of extraction yield, improved scalability, and repeatability of the extractions.

SCE is a very selective and efficient extraction method for non-polar compounds. A suitable adjustment of the pressure and temperature values enables a precise extraction of the compounds of interest from the matrix.

However, the extractability of the compounds depends on the nature of the extractable. For example, if the temperature rises, the vapor pressure and diffusivity of the compounds will increase as well; consequently, the solubility of the extractable will increase. But at the same time, the pressure will act in the opposite direction.

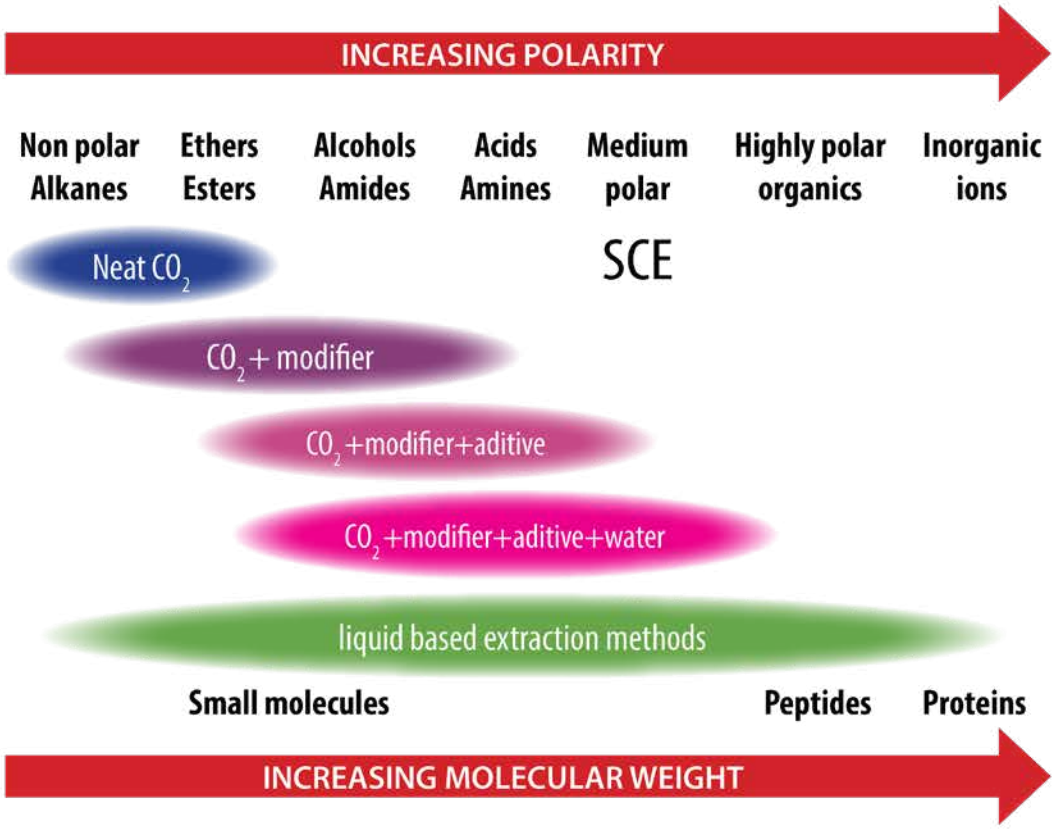
Because of this behavior, it is necessary to fine tune the system to achieve efficient extraction. The introduction of a miscible polar co-solvent into the $CO_2$ stream substantially improves the efficiency of this process, as it lowers the temperature and pressure needed for an efficient extraction of more polar components.

The introduction of a co-solvent into the processing stream serves as an efficient cleaning method in deep-cleaning processes between different extraction runs, which prolongs the period of time between regular services.

The system is optimized for the extraction of bioactive components from natural matrices. However, it can also serve as a reactor for the preparation of advanced materials, for orthopedic implant cleaning, or to run catalytic reactions.

The system has been widely tested for the extraction of different materials, as listed below:

- Resin from hemp, spruce tips, rosemary, sage;
- Extracts (essential oils, active ingredients) from herbs, such as immortelle, chamomile, marigold, peppermint, linden, stinging nettle, buckwheat leaves and blossoms;
- Extracts from fruits, such as juniper, coffee beans, hop, elderberry, raspberry;
- Oils from grape seeds, wheat germ, millet bran, buckwheat;
- Defatted grape seeds, grape skins;
- Isolation of bioactive components from sweet wormwood.




*Basic SCE parameters for particular extractions with the addition of co-solvents*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# Summary

The MoSES supercritical $CO_2$ extraction line enables fast, selective, and run-to-run repeatable extractions using supercritical fluids alone or in combination with co-solvents.

**Advantages**

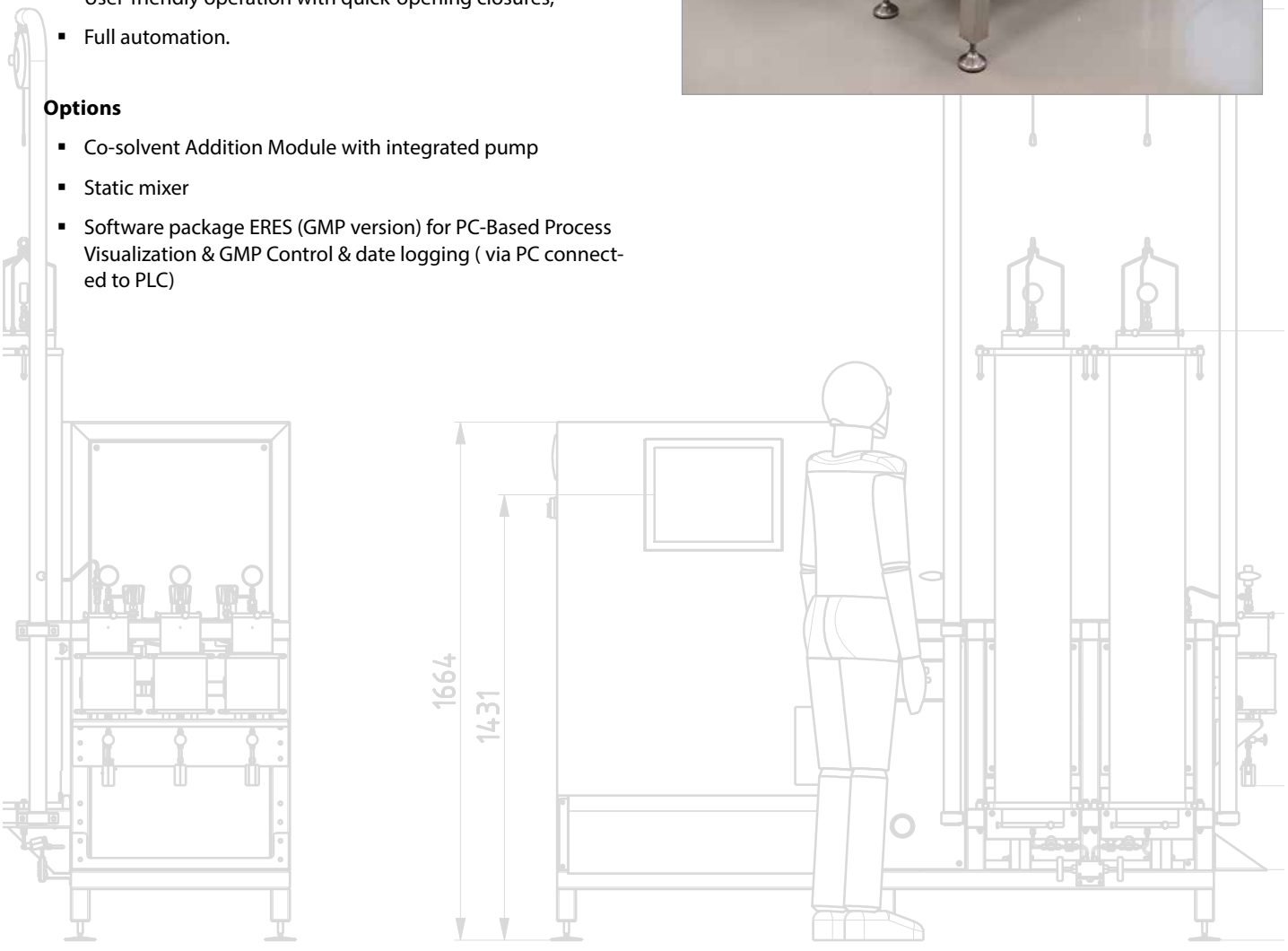
- Low-temperature extraction processes protect the basic properties of natural extracts;
- Inertness is ensured due to the use of inert and non-toxic supercritical fluids that leave no residues in the extracts;
- The flexibility of the process parameters (pressure and temperature) allows the user to change the solvating power of the solvent;
- The SCE method ensures high selectivity.

**Main features**

- Closed $CO_2$ loop, minimal solvent loss;
- Recirculation of supercritical solvent without contamination;
- Multivessel system for higher throughput;
- High efficiency of each separation step;
- Fourth collection vessel with cooling system to prevent overflowing;
- User-friendly operation with quick-opening closures;
- Full automation.

**Options**

- Co-solvent Addition Module with integrated pump
- Static mixer
- Software package ERES (GMP version) for PC-Based Process Visualization & GMP Control & date logging ( via PC connected to PLC)





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# MoSES Extraction System components

The system consists of a $CO_2$ pump, a Coriolis mass flow meter, one (1), two (2), or three (3) extraction vessels, an automatic back pressure regulator, two heat exchangers, and four (4) fraction collection vessels.

Options include a co-solvent pump and static mixer.

**CO2 pump**

Durable and robust diaphragm pump, ideal for high pressure, supercritical fluids, and pulseless flow applications.

**Co-solvent pump (optional)**

Conveys co-solvent to the primary solvent stream ($CO_2$). The amount of co-solvent depends on the desired concentration (wt %) of the solution ($CO_2$ + co-solvent). Adding a co-solvent like food grade ethanol enables the extraction of polar compounds.

**Cooling heat exchanger**

Cools and liquefies the $CO_2$ before it enters the pump for maximum efficiency.

**Flow meter**

Located on the $CO_2$ pump inlet; it measures liquefied $CO_2$ mass output from the flow meter.

**Heat exchanger**

Located upstream from the vessel to ensure that the fluid is heated prior to vessel entry.


**Extraction vessels**

Vessels with a pivoting option for efficient loading and unloading. Caps with spring-loaded seals enhance safety and enable efficient loading and unloading of large vessels. The MoSES system can be equipped with up to three extraction vessels.

**Automatic BPR**

Motor-driven and temperature-controlled to compensate for cooling during depressurization. A built-in pressure sensor provides closed-loop feedback for control and pressure alarm monitoring.

**Separator / Collection vessels with manual BPR**

The mixed fluid is introduced into the high-pressure collection vessels, efficiently separated, and collected at the bottom of the vessels. The system is equipped with four collection vessels with varying pressures, which enables efficient collection of different extracts.

**Recycler**

Reclaims the vented $CO_2$ from the extraction process. This system consists of a storage vessel with a level sensor for $CO_2$ storage, a level sensor module for level display, a condensing heat exchanger, a condensing cooling bath, and valves. The system also features a pressure relief valve that can be vented to relieve pressure in case of over-pressurization or overfilling.



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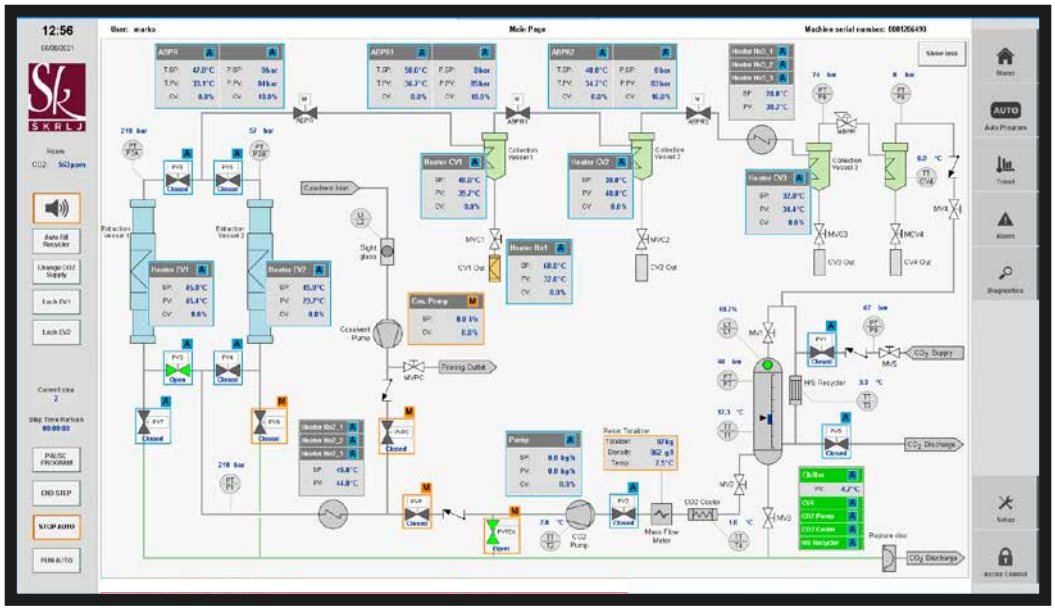
**PLC Control System B&R (ABB Group), with 21.5" touch screen monitor 16:9**

TFT, Resolution 1920 x 1080 pixels, IP65 protection, Ethernet port, Intel Celeron processor. The integrated PLC provides automated and reproducible operation, where the process parameters (temperature, pressure, flow, extraction time, S/S ratio) are set and stored as a method (recipe). The software is fully intuitive and enables "manual" and "automatic" mode.

**Software GMP version (optional)**

With multilevel electronic signatures (entered, checked, approved) and recipe preview, data export options and printout possibilities. The system access is fully password-protected and includes a data logger for process traceability, with the ability to export tables for process auditing. The collected data can be analyzed to remove gaps during subsequent extractions.




## General technical specifications of the MoSES Extraction System:

| Nominal capacity | | |
|---|---|---|
| | MoSES 1.25.1 | 1 x 25 L |
| | MoSES 1.25.2 | 2 x 25 L |
| | MoSES 1.25.3 | 3 x 25 L |
| $CO_2$ flow rate | | up to 200 kg/h |
| Extraction pressure range (PS) | | 325 bar |
| Extraction temperature range (TS) | | 10 … 85 °C |
| Construction material - internal (process side) | | 1.4418 (QT900) |
| Construction material - external (outside process) | | 1.4301 (AISI 304) |
| System weight (approx.) | | 3100 kg |

| Utility requirements | |
|---|---|
| Installed Power | 86.7 kW (3F 230/400 V 50 Hz) |
| Electricity usage (estimation only) | 12 kW (may vary according to working conditions) |
| Drain tube | 1/2" |
| Air (dry & clean) | quick connection, 6-8 bar |
| $CO_2$ | food grade quality, bottles for taking out Liquid $CO_2$ (with Dip Tube), connection socket for the pipe 1/4" |

| Extraction vessel | |
|---|---|
| Internal volume | 25 L |
| Quantity | 1, 2 or 3 |
| Operating pressure | 325 bar |
| Material | stainless steel 1.4418 (QT900) |
| Sealing | spring seal |
| Heating | electrically heated |

| Separator / Collection vessel | |
|---|---|
| Internal volume | 5 L |
| Operating pressure (separators 1, 2, 3) | up to 325 bar (separator 1)<br>up to 200 bar (separator 2)<br>up to 100 bar (separator 3) |
| Operating pressure (separator 4) | up to 60 bar |
| Cooling | +5 / +30 °C |
| Material | stainless steel 1.4418 (QT900) |
| Sealing | spring seal |
| Heating | electrically heated |

| $CO_2$ recycling system | |
|---|---|
| Internal net capacity | 50 L |
| Quantity | 1 |
| Operating pressure | 86 bar |
| Material | stainless steel 1.4404 (AISI 316L) |
| Sealing | spring seal |
| Cooling | with chilled water |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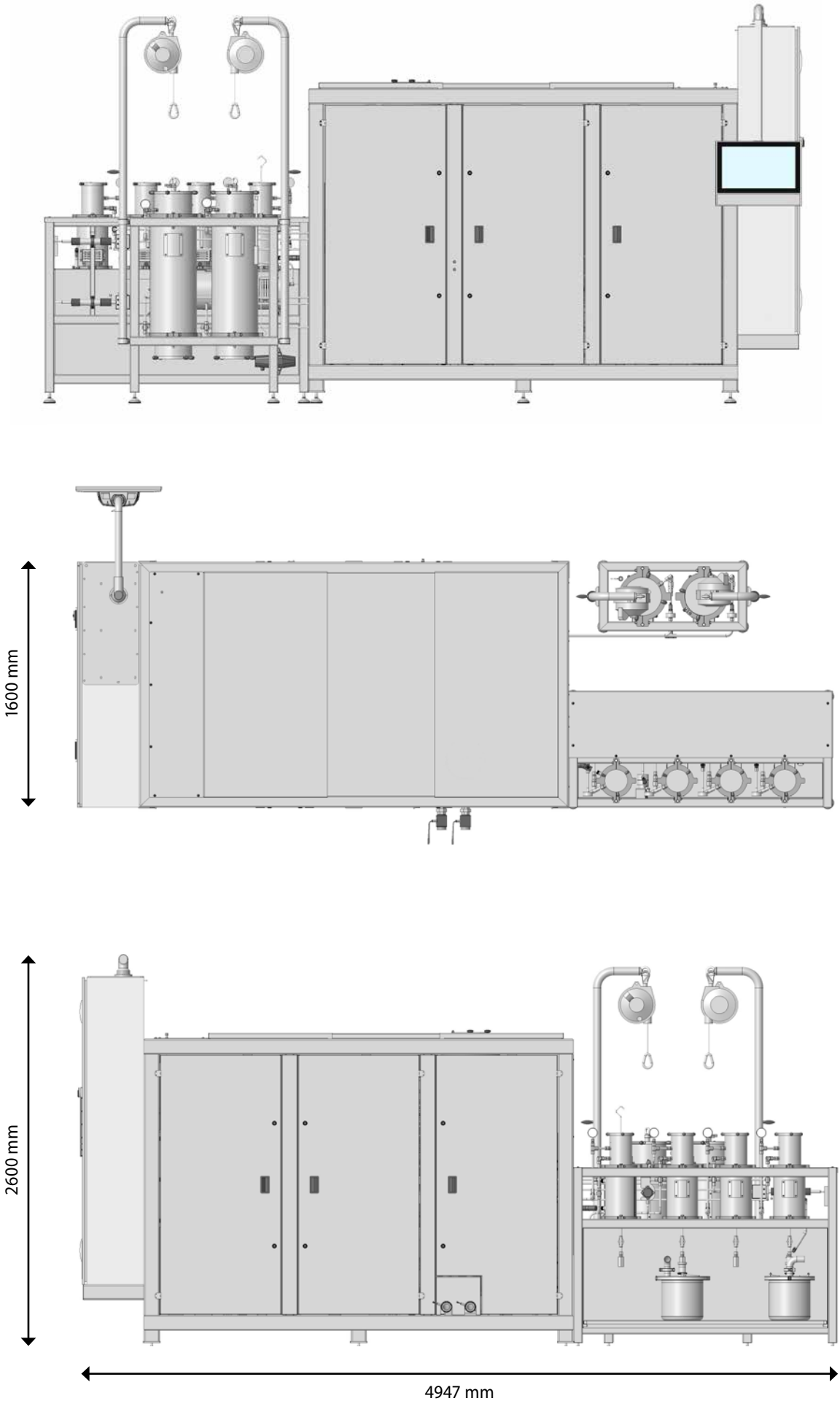
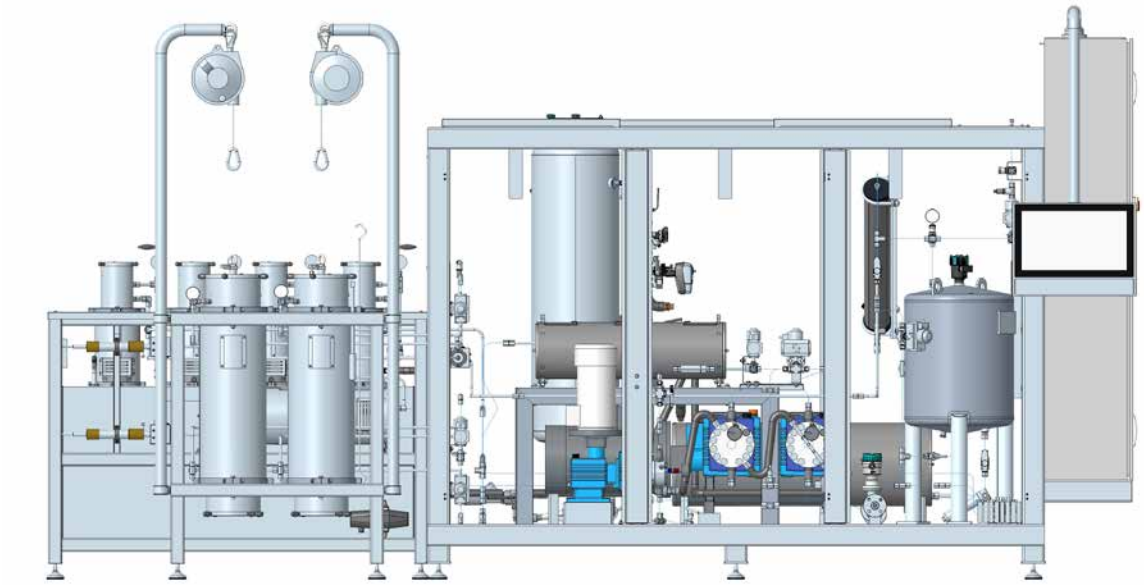
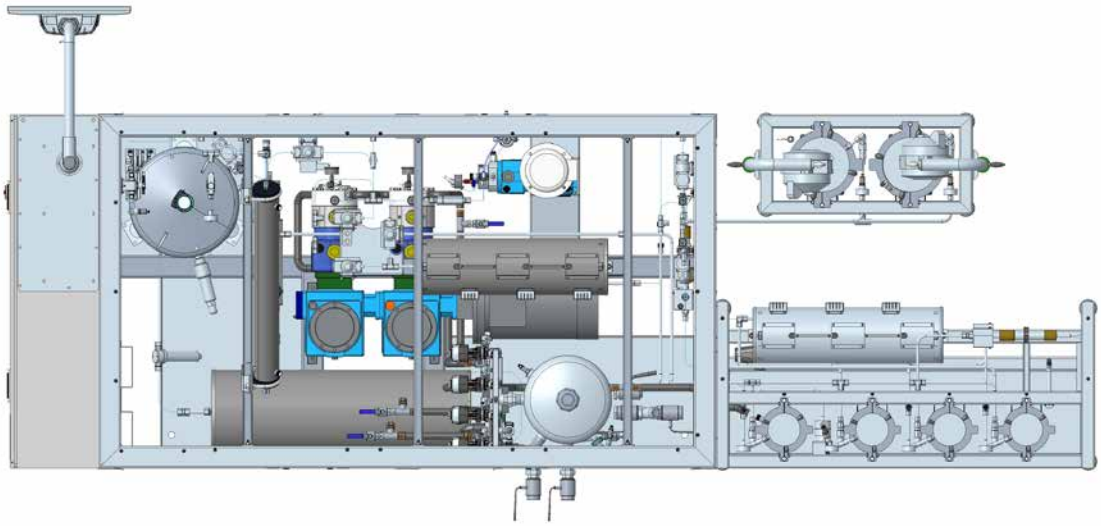
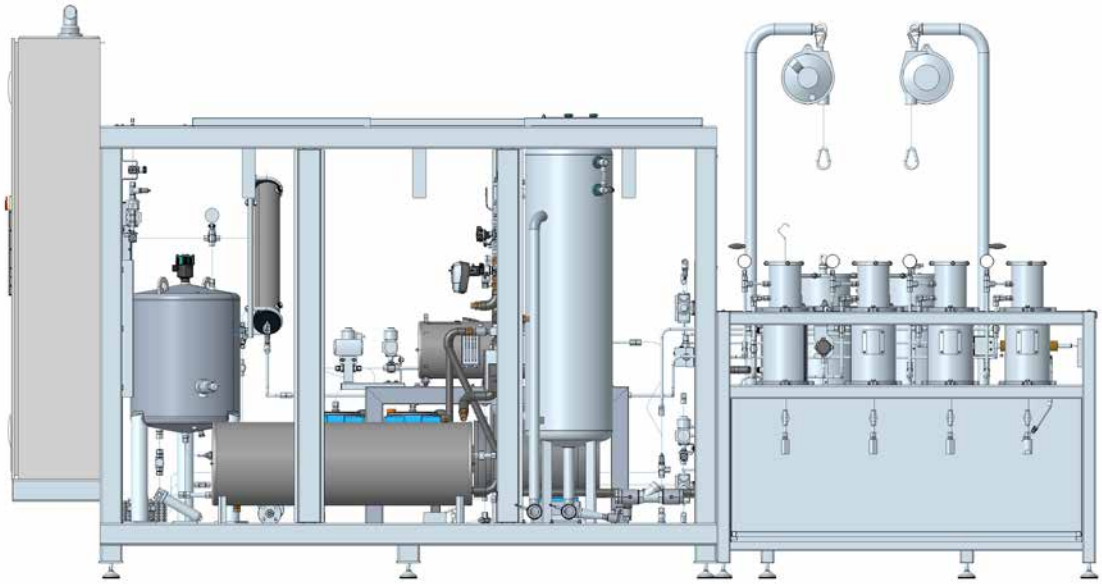
DIMENSIONS:









# Škrlj d.o.o.

Škrlj d.o.o. is a well-established European company that specializes in manufacturing stainless steel equipment for the winemaking, beer brewing, pharmaceutical, and food processing industry.

The company has more than 50 years of experience in the process industries and operates in accordance with international standards and practices ISO 9001, ISO 14001, IQNet, ASME, PED 2014/68/EU, GMP.

High-quality products, adaptability, and innovation - this is what convinced the customers.

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Škrlj d.o.o. is currently working on the development of state-of-the-art extraction systems for the production of bioactive components from plants and other tissues.

We are developing

- highly flexible sub- and supercritical extraction systems (MoSES),
- cryo-alcoholic extraction systems (MoAES), and
- hydrocarbon extraction systems (MoHES)

to expand our range of extraction systems, applicable in the modern process industries.

We take pride in our personal approach to customer service and are always ready to help find the optimal solutions for our customers.

For more information, please visit www.sk-skrlj.com.

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