

# AUTOCLAVES AND VULCANIZERS WITH QUICK CLOSURE

 **ZVU** Engineering a.s., Member of ZVU Group

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# 1 INTRODUCTION

The autoclaves with quick closure are used for many years namely in wood heat treatment processes, composite production, glass laminating and rubber vulcanizing, where timely controlled uniform heating of the heat treated charges is to be performed in relatively limited space.

ZVU Engineering belongs among the most important suppliers of the autoclaves with quick closure. ZVU Engineering, as member of ZVU Group, has delivered, installed and commissioned 59 autoclaves, out of them 20 autoclaves since 1990.

Major part of rubber vulcanizing shops in Czech and Slovak Republic utilizes the autoclaves with quick closure of ZVU Engineering design.

Based on our practical experiences with design, manufacturing and operation of current autoclaves with quick closure ZVU Engineering has developed and commissioned highly reliable and safe equipment that is able to fulfill all demanding requirements of the end-users.

The automatically operated quick closure is the feature of ZVU Engineering's autoclaves ensuring safety operation during process phase, as well as quick and safety access during the completion of process phase.

The universal design of the autoclave enables, subject to request of the end-user, to apply various types of the charge heating and cooling, or pressurizing of the working space.



*Fig. 1 Vulcanizer – general view*

## 2 TECHNICAL DESIGN

### 2.1 Concept

The autoclaves with quick closure of ZVU Engineering design are featured by their compact arrangement that rationally joins functionality and manipulation of the autoclave with its functional design.



*Fig. 2 Vulcanizer general view Semperflex Optimit Odry*

The autoclave is horizontal or vertical cylindrical pressure vessel furnished with the quick closure on its one or both ends.

The autoclaves are standardly furnished with:

- hydraulically operated hinged bridge for drive-in of the charge car in case of the autoclave horizontal design,
- hydraulically operated quick closure of the autoclave working space,
- hydraulic unit for controlling of the autoclave quick closure,
- electric or steam heating,
- automatic control unit controlled by the unique software developed for this purpose,
- safety interlocking equipment and with the equipment for monitoring of its operation.

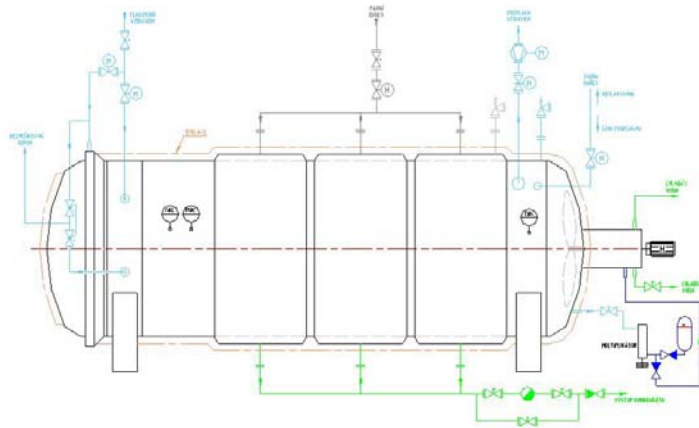


Fig. 3 Autoclave with indirect steam heating

The autoclaves can be, subject to the client's request, provided with the charging/pulling-off equipment, external steam generator, pressure air or nitrogen source, external spray water cooling unit.

Subject to the type, the autoclaves with quick closure can be furnished with electric heating of the internal space and with the fan for inner air circulation.

Subject to their handling size, the autoclaves can be supplied in the completely assembled skid mounted execution or in the completed parts ready for on-site assembly.

## 2.2 Dimension and Operation Parameters

The technical parameters are subject to the requirements of the end-user and technological process.

Even though the autoclaves parameters are not basically limited, there are still practical limits that exceeding is not economically advantageous.

Based on the evaluation of the parameters convenience and statistic ZVU Engineering applies its standard dimension series.

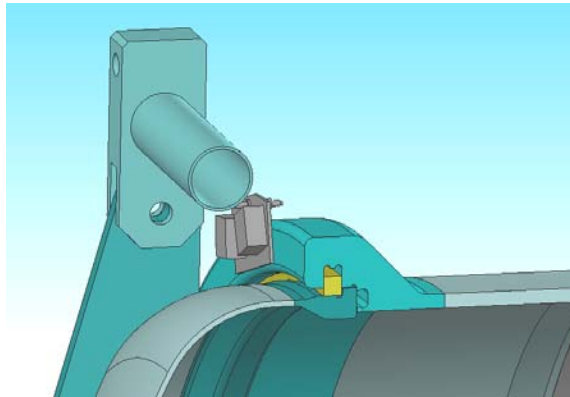
Nominal Diameter (mm)	Nominal Length max. (mm)	Nominal Pressure max. (MPa)	Nominal Temperature max. (°C)
850	10 000	1,1	200
1 600			
2 000			
2 500			
2 800	15 000		
4 500	20 000		

In case of the reasonable requirement of the end-user and subject to modified delivery terms, the different dimensions and parameters can be agreed.

## 2.3 Quick Closure

The three-part heavy duty quick closure of ZVU Engineering design, operated by the hydraulic power unit, forms the entire part of the autoclave.

The only two-axis movement of the cover, without necessity of its complicated rotation, is advantage of this design concept. Such design concept of the quick closure markedly increases the life time of the sealing element, which is only affected by the operation parameters of the technological process.



*Fig. 4 Autoclave quick closure detail*

The quick closure is furnished with safety lock that prevents autoclave from accidental opening, unless inner space is completely depressurized.

The quick closure is operated by the hydraulic power cylinders. The hydraulic pump, which output is derived from the time function and from the hydraulic cylinders size, supplies hydraulic liquid from the receiver.



*Fig. 5 Vulcanizer quick closure detail*

## 2.4 Accessories

The charge is charged into the autoclave by the charging car that is suitably adopted according type of the charge.

The charging car is usually moving on the rails placed inside the autoclave and in front of it.

The movement of the charging car into and from the autoclave is performed by the drive unit placed outside the autoclave. The chain drive unit is standardly used.



Fig. 6 Charging car

## 2.5 Autoclave Pressurizing

The technological process in the autoclave is usually performed under raised pressure. The operation pressure standardly varies between range of 3 to 10 bar (g).

However, any requirements for the raised pressure evidently result in the increased investment and operation costs and such requirements always should be economically considered.

The operation pressure can be attained by several ways depending on the technological conditions and lay-out possibilities of the end-user.

<i>Type of heating</i>	<i>Pressurizing medium</i>
Autoclave with direct steam heating	Pressurizing is performed by direct steam used also for heating. The pressure is set by required process temperature.
Autoclave with indirect heating	Pressurizing is performed by air, gaseous nitrogen or their mixture. The pressure is set by process requirements.
Autoclave with electric heating	Pressurizing is performed by air, gaseous nitrogen or their mixture. The pressure is set by process requirements.

The pressurizing rate depends, first of all, on economic capacities of the pressurizing medium sources. 1 bar/min is standard pressurizing rate.

The continuous or step pressure value change is controlled with accuracy of 5 % measurement range. Subject to the end-user requirement the more accurate system can be installed.

Subject to the end-user requirement, ZVU Engineering completes the autoclave with quick closure by the external steam, air or nitrogen source.

## 2.6 Charge Heating

The heating of the autoclave internal space and charge depends, first of all, on the technological requirements of the charge processing and on the economical parameters of the heat sources.

The autoclave is standardly furnished with one of the following three heating modes:

- The charge direct heating – first of all used for rubber vulcanizing and sterilization. Steam is directly fed into the autoclave and it is used like heating medium as well as like pressurizing medium.
- The charge indirect steam heating – used for the cases, when steam cannot be used for direct charge heating due to the technological reasons. The steam is fed into the autoclave jacket and indirectly provides heating of the autoclave internal space. By other way, the charge steam heating is performed by the autoclave internal heating coils. In such case, the pressurizing of the autoclave space is performed by air or gaseous nitrogen or their mixture.
- The electrical heating – the most common mode of the charge heating in the workshops, where electricity is available in economic favorable price. In such case, pressurizing of the autoclave space is performed by air, or gaseous nitrogen or their mixture.

The thermal source capacity depends on the end-user requirements on the heating period and on the charge volume. When selecting the charge heating period, the economical factors of the technological process time period should be considered at the rate of the financial costs of the thermal source.

5 °C/min is standard temperature progress.

## 2.7 Autoclave Cooling

Cooling of the autoclave internal space and charge, first of all, depends on the technological requirements of the processed charge and on the economical evaluation of the cooling medium.

Cooling is performed from the operation temperature to the temperature that enables safety opening of the autoclave. Standardly the temperature 50°C is selected.

Subject to the end-user's requirement, the autoclave is standardly equipped with one of the following two modes of cooling:

- The indirect cooling – the cooling medium, standardly cooling water, is fed into the autoclave shell jacket. The course of cooling depends on the achieved heat transfer. The standard temperature decrease is 3°C/min.
- The direct cooling - the cooling medium, standardly cooling water, is sprayed by means of the jet nozzles into the internal space of the autoclave and directly cools



the hot charge. The more intensive heat transfer and due to it required shorter cooling period is a feature of this mode. The standard temperature decrease is 5°C/min.

The warm return water is collected at the autoclave outlet and discharged for the external cooling.

Subject to the end-user requirement, ZVU Engineering completes the autoclave with quick closure by the external water cooling unit.

## 2.8 Inner Circulation

The technological process of the charge processing requires a uniform distribution of the inner temperature in the autoclave.

For most of the technological processes utilizing the autoclaves with quick closure, the uniform temperature distribution in the range of  $\pm 2^\circ\text{C}$  is mostly suitable.

The uniform temperature distribution inside the autoclave is provided by:

- uniform and control inlet of the direct steam into the autoclave space, or
- in case of the indirect heating, forced air circulation inside the autoclave.

Standardly, the air circulation is forced by the inner installed fan with the diffuser and with the guide internals.

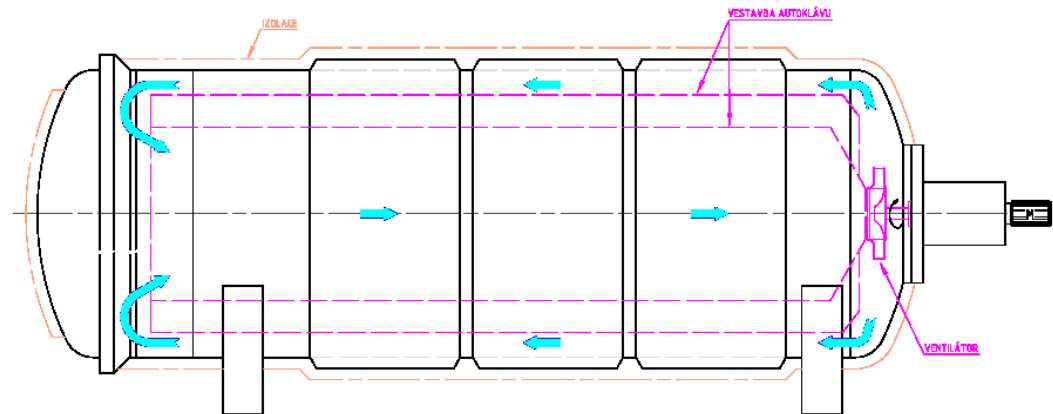


Fig. 7 Fundamental circulation schema

ZVU Engineering gives high consideration to the inner circulation and has performed several model measurements aiming to optimization of the circulation. The effective circulation not only maintains uniform distribution of the temperature, but also markedly increases transfer of the externally supplied heat into the internal space of the autoclave.

For most technological processes the circulation number 70 is applicable.

For each autoclave ZVU Engineering verifies, in cooperation with the end-user, process convenience of the standard circulation number and, subject to the requirement, to change the circulation number by alternation of the fan characteristic.

## 2.9 Temperature Measurement

The temperature measurement is performed by the remote thermometer placed in the thermometer well that measures the temperature inside the autoclave. The measured temperature is transferred into the control unit that automatically controls process.

The smaller autoclaves are standardly equipped with one thermometer of the range  $250 \pm 0,5^{\circ}\text{C}$ , the larger autoclaves shall be equipped at least with two thermometers at both autoclave ends.

Subject to the end-user request, the autoclaves can be equipped with other thermometers.

## 2.10 Ventilation

Under reasonable cases the autoclave can be pressurized by nitrogen. In such case the internal space of the autoclave has to be properly flushed by fresh air prior opening of the closure and entering into the autoclave.

The autoclaves of the larger volume, or the autoclaves pressurized by nitrogen or its mixture are standardly equipped with the automatic monitoring and alarming system of the safety oxygen content.

## 2.11 Control Software

The autoclave is controlled by the logical easy-operated control system.



*Fig. 8 Control panel view, Autopal Nový Jičín*

The control system operates on the base of monitoring of the decisive process parameters (temperature, pressure), monitoring of the position of each moving elements and monitoring of the position of each quick closure control elements.

The control system provides, by its program, the technological and safety functions, controlling of the sequences of single formulas of the autoclave charge processing, evaluation of the end switches failure stages, controlling of the valves and mechanisms displacement period between end positions etc. The failure stage or equipment malfunction are acoustically alarmed and displayed on the control panel monitor. In case of the serious failure the control program performs actions leading to removal or rectification of the unsafe stage.

The control system is equipped with the interlocking systems that safely prevent from performing of any safe-unsuitable operations or actions.

The operation of the autoclave with quick closure of ZVU Engineering design is controlled by the graphic touch screen.

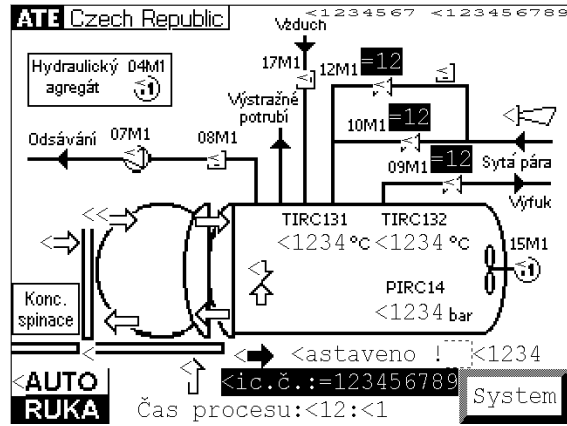


Fig. 9 Control touch screen

The control system is equipped with two emergency stop buttons. Anytime after pressing any of the buttons, the autoclave with quick closure is automatically put in safety stage.

### 3 APPLIED STANDARDS

The autoclaves with quick closure are designed, manufactured and operated in compliance with the European Union standards, to ensure maximum safety of the end-user.

Design and manufacturing of the autoclaves with quick closure is performed and controlled in compliance with CSN standards (respecting requirements of the European Parliament and Council Directive No. 97/23/ES – PED), EN standards, or, subject to the agreement with end-user, in compliance with other international standards like ASME, GOST etc.

The electrical equipment is designed, supplied and installed in compliance with the valid electrical CSN standards specification of that depends on the classification of the autoclave and its elements with respect to the categories requirements on safety elements of the control system. The standards (CSN) EN 292.1 and (CSN) EN 292.2 are to be maintained. The category 2 of the standard (CSN) EN 954-1 is valid for the autoclave. The electrical and control system complies with requirements of this classification.

# 4 MANUFACTURING, INSTALLATION AND OPERATION

## 4.1 Production

The production of all parts of the autoclave with quick closure is performed under close supervision of ZVU Engineering quality inspectors.

The quality inspection of the produced elements is performed continuously according to the verified and agreed quality plan.

At the final stage of manufacturing the pressure and function test are performed at the presence of the end-user representative.



*Fig. 10 Autoclave manufacturing*

## 4.2 Installation

Subject to their handling size, the completely assembled skid mounted autoclaves or the handling parts ready for on-site assembly are supplied.

The entire part of the technical documentation there are relevant manuals for installation, testing and commissioning.

In spite of the above manuals, logically structured, it is recommended to have supervision of ZVU Engineering technician during installation, testing and commissioning.

Subject to the end-user request, ZVU Engineering provides and performs complete installation of the autoclave on the turn key basis.



*Fig. 11 Autoclave installation, Gumotex Břeclav*

### 4.3 Operation

Prior to the autoclave commissioning, function of all control elements, namely with respect to their operation safety, is to be verified. The instructions for functional tests are entire part of the autoclave technical documentation, nevertheless the presence of our technician is recommended namely with respect to the provided function guarantees.

Simultaneously with the autoclave commissioning the technicians of ZVU Engineering instruct the operators of the end-user.

The autoclave operation is predominantly controlled by automat control system, whereas the instructions for operation and maintenance, submitted together with delivery of the autoclave, have to be maintained.



*Fig. 12 Opening of quick closure*

# 5 SERVICE, MODERNIZATION

## 5.1 Post-guarantee Service

The autoclave is designed and manufactured with respect to the maximum service life of any parts. Nevertheless, the equipment is relatively sophisticated and demanding and proper attention has to be given to its maintenance.

To ensure long-time safety operation, it is recommended to perform periodic inspections and any part showing even slightest damage should be immediately replaced.

Subject to the agreement with the end-user, ZVU Engineering performs periodic inspections and recommends replacement of the damaged parts, as well as other improvements.

## 5.2 Modernization

Notwithstanding that the autoclaves are designed with their service life for more than 15 years, the technical and innovation modifications progress more rapidly.

ZVU Engineering, based on its development, periodically makes innovations of the design and concept of the autoclave with quick closure so that its construction and design shall comply with the modern technical trends.

ZVU Engineering recommends the end-users to maintain their permanent contact with ZVU Engineering so that they are permanently kept informed about all improvements and innovation of the autoclave design and function.

ZVU Engineering performs inspections of the autoclaves with quick closure, proposes eventual repairs, modifications and modernizations and subject to the end-user request performs and implements such repairs, modifications and modernizations.