Process Engineering
Series
No. 64001 e

Evaporators

Thin-Film Evaporators

QVF GROUP

Schott Process Engineering Series

Publications which present novelties and details of thermal process engineering solutions proven in practise, appear at varying intervals in this series.

The Process Systems Product Group of Schott Glaswerke at Mainz plans and constructs equipment and plant for the entire field of thermal process engineering. With this experience gained over many years, Schott has a comprehensive know-how available in the sector of processing highly aggressive and highly pure media.

The PROCESS ENGINEERING SERIES endeavours to convey this knowledge to the user. The solutions shown are fully developed and standardised types of equipment or interesting new processes and the appropriate equipment for them.

Corrosion-resistant plant, apparatus and piping with DURAN for the chemical and pharmaceutical industries.

High operational reliability and lowest maintenance costs are the outstanding features of Schott plant.

Our flexible modular system with standardized DURAN® components of borosilicate glass allows individual solutions of problems in the construction of corrosion-resistant equipment, even at temperatures up to 200 °C.

In combination with other corrosion-resistant materials such as, for example, PTFE, titanium, tantalum, enamelled steel, graphite, etc., economical and reliable installations can be constructed.

The corrosion-resistant modular system with the safe flange.

All parts of Schott plant and piping construction are fully corrosion-resistant and exchangeable. The reliable coupling flange system ensures additional safety and maintenance-free operation. Every installation can be rapidly modified and dismantled if required. All the components can be re-used without any problems.

The range comprises:
- ☐ Piping systems from DN 15 to DN 300
- ☐ Centrifugal pumps and metering pumps
- ☐ Heat exchangers of up to 50 m^2
- ☐ Vessel and column construction up to DN 1000

The Schott process engineering know-how

means more than construction appropriate to the material. The existing engineering resources are also available for the design and planning of complete plant for distillation, rectification, absorption, adsorption, extraction, reaction and crystallization.

Schott offers comprehensive engineering for individual solutions

In the field of the construction of corrosion-resistant chemical plant, Schott have themselves developed a number of processes; these include, in particular, units in the environmental field:
- ☐ Waste gas purification
- ☐ Solvent recovery
- ☐ Biological purification of industrial effluent containing high levels of organic pollution
- ☐ Purification and concentration of waste acids (nitric acid, hydrochloric acid, sulphuric acid).

In addition to the provision of equipment, the scope of planning also covers instrumentation and control, energy installations and the building.

Test your process without any risk

In the pilot plant in Mainz, Schott has facilities for economical testing of both individual process steps and different processes. Thus, for example, a three-stage sulphuric acid purification and concentration plant is available, so that your full-scale plant can be designed exactly, in view of the large number of possible impurities.

Thin-Film Evaporators DSV 80, 150, 300

General

Schott plans and supplies evaporator systems of borosilicate glass ranging from laboratory apparatus up to complete production plants.

For the demanding area of the treatment of temperature-sensitive products, Schott offers not only the tried-and-tested falling film evaporators with free-flowing liquid film, but also thin-film evaporators with DURAN.

Temperature-sensitive products can suffer considerable losses in quality in thermal treatment, the extent of which depends essentially on the processing time and the temperature level.

Therefore, two main requirements are demanded of systems for the gentle evaporation of temperature-sensitive substances, requirements which the thin-film evaporators from Schott meet very well:

1. Lowest possible operating temperatures,
2. Shortest possible residence times.

In addition, the thin-film evaporator from Schott is distinguished by narrow residence time ranges, low hold-up, its suitability for highly viscous media and its universal chemical resistance.

A fully developed modular system for all glass components permits flexible design and rapid assembly of apparatuses and plants. On the basis of this system, we have developed a standard range for our thin-film evaporators, which on the one hand specifies essential components but on the other hand allows for the special needs and wishes of our customers.

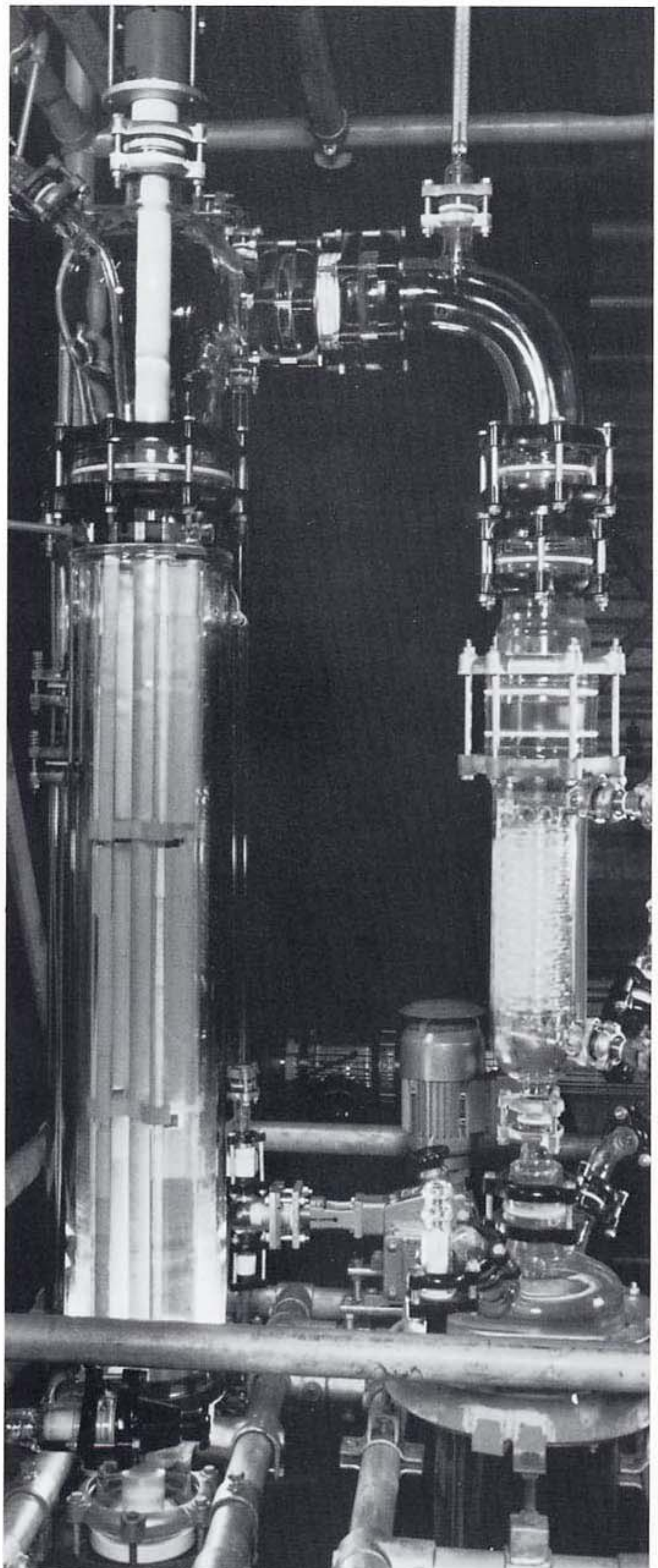


Fig. 1:
Thin-film evaporator DN 150 in pilot-plant operation.

The Process

The thin-fim evaporator is charged with a product from a receiving vessel or some other stage of a process. A liquid predistributor ensures that the product wets the entire circumference of the evaporator when it enters the evaporating zone, before it is taken up by a rotating wiper system. In this way a well mixed, uniform liquid film is obtained on the heating surface.

The thickness of the film is dependent on the quantity of product charged and its viscosity as well as on the speed of the wiper system and is about 0.1 to 0.5 mm. These small film thickness result in minimum hold-up and consequently short residence times.

Only very small temperature and concentration gradients develop in the well mixed and turbulent film. Due to the rotation of the wiper system and the resulting constant circulation of the film, the heat exchange from the heating medium to the product is improved and at the same time the product on the inside of the heating jacket is prevented from overheating.

Along with the advantages already mentioned, the mechanical circulation of the product film has the effect that the evaporator wall is kept largely free of encrusted deposits.

The vapour rises – in counterflow to the liquid flowing down in the film – is condensed and flows via a product cooler into a receiver. The concentrate leaves the thin-film evaporator via the bottom drain and is likewise cooled in a product cooler before it reaches the bottom product receiver.

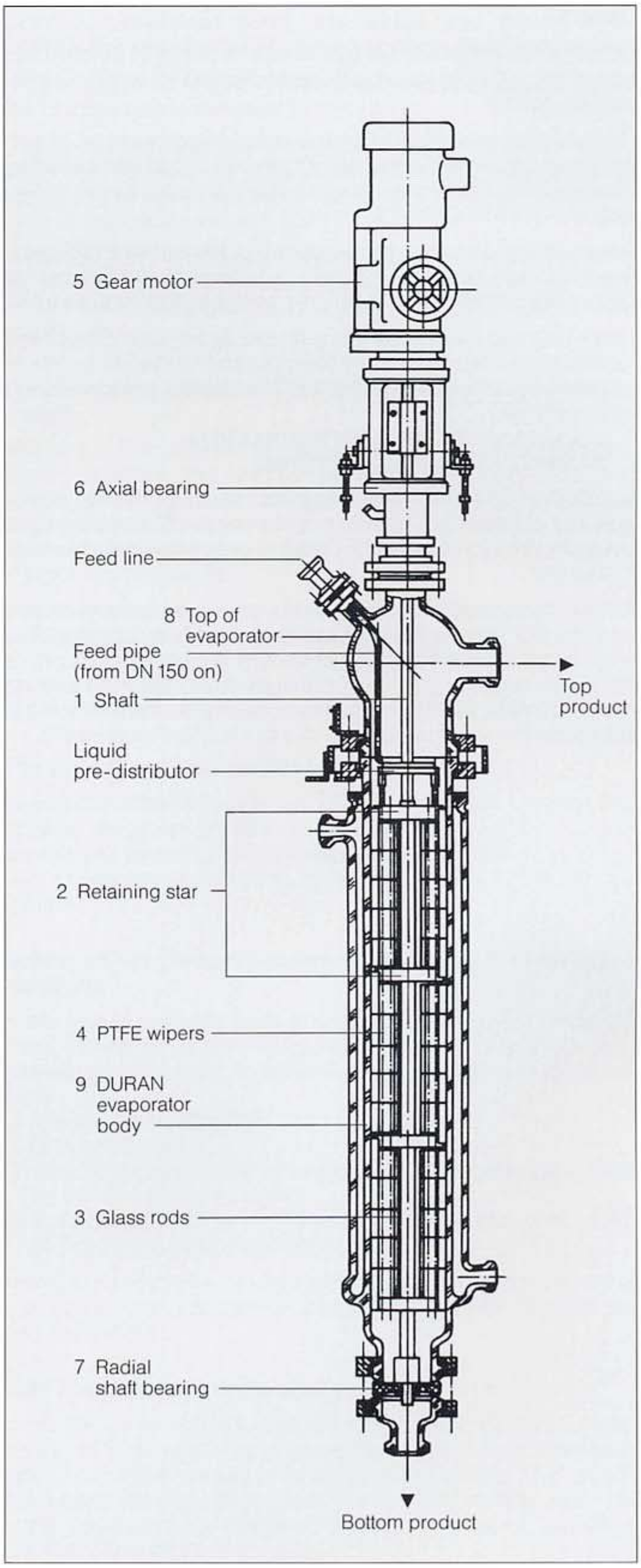


Fig. 2:
Sectional representation of the DURAN thin-film evaporator DN 150.

Construction

The key component of a thin-film evaporator is its rotating, fully corrosion-resistant wiper system. On a shaft (1) mounted in a double bearing there are at equal intervals retaining stars (2), which hold two to six continuous glass rods (3). The glass rods serve as moveable retainers for the PTFE wipers (4).

Depending on the nominal width, the two to six rows of wipers provide a high wiping frequency, and, therefore, a optimum renewal speed of the boundary layer, which are prerequisites for good mixing of the liquid film and high evaporation rates.

If the wiper system is set in rotation by the geared motor (5) arranged above it, the moveably mounted wipers (4) are applied to a greater or lesser extent, depending on the speed and the viscosity of the product, to the inside of the heating surface and thus determine the thickness of the product film.

On the standard models, the shaft (1) is passed through an axial bearing (6) with a single-acting mechanical seal at the top of the evaporator and through a radial bearing (7) underneath the wiper zone. For special applications, the radial bearing may be omitted.

The top (8) of the evaporator has two branches for connection of the feed line and of the top-product line. Depending on the size of the thin-film evaporator, it is of a cylindrical or sperical design.

The evaporator body is designed as a jacketed pipe (9) and generally consists of borosilicate glass. When designed in this way, it can be used for heating with saturated steam up to 110 °C or thermal oils up to 200 °C. For operating pressures of up to 6 bar gauge pressure in the heating jacket, evaporator bodies of enamelled steel are available.

The wiper system of the Schott thin-film evaporators is driven as standard with motors rated at between 0.37 and 1.1 kW; the speeds are infinitely variable.

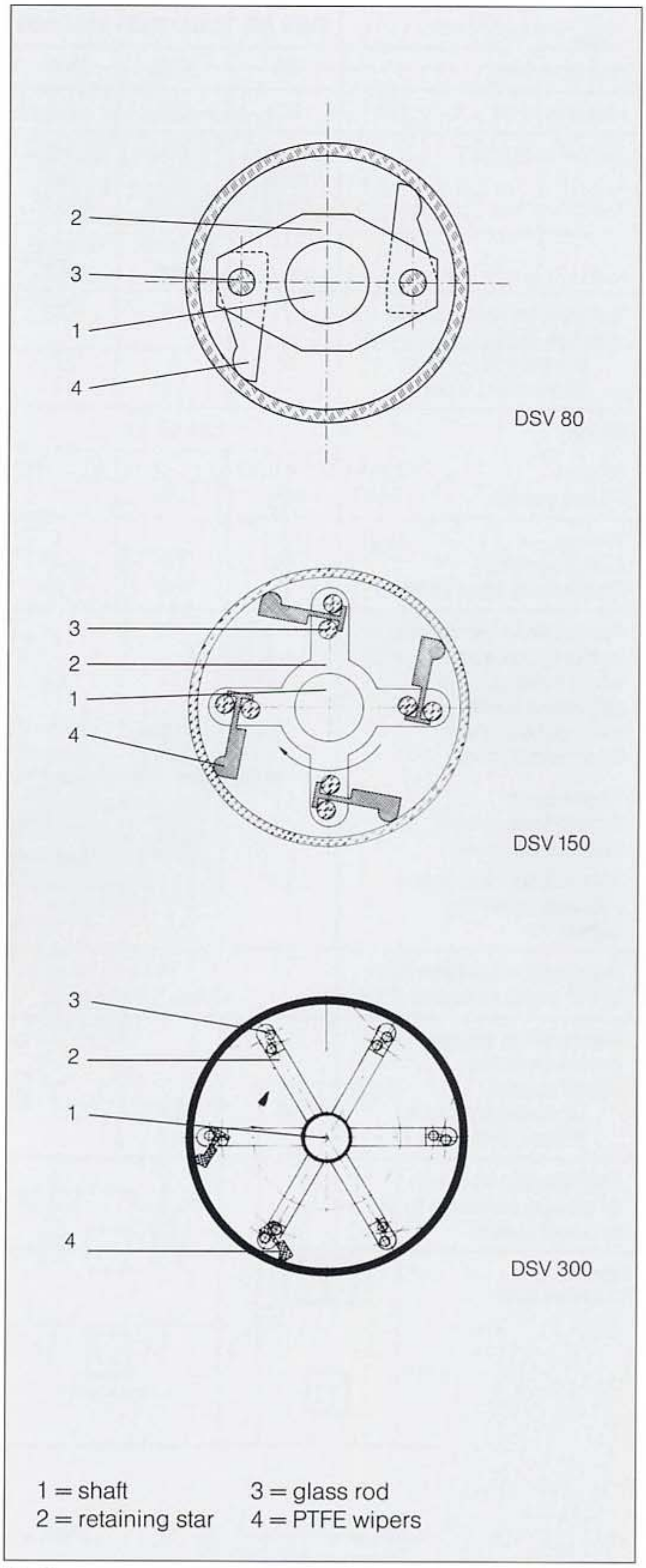


Fig. 3:
Arrangement of the wipers and the glass rods on the retaining star.

Technical Data

Thin-film evaporator	DSV 80	DSV 150	DSV 300
Nominal width	80	150	300
Heating area (m²)	0.2	0.5	1.0
Jacket material	Borosilicate glass	Borosilicate glass	Borosilicate glass
		Enamel. steel	Enamel. steel
Volume, product space (l)	7	23	122
Volume, jacket space (l)			
Borosilicate glass	2	5	22
Enamelled steel	–	19	47
Drive	EEx ell T4		
Speed (rpm)	71 – 430	71 – 215	42 – 150
Rated output (kW)	0.37	0.55	1.1
Weight (kg)			
Glass version	39	79	170
Enamelled steel version	–	157	415
Permissible temperature in the jacket space (°C) when heated with saturated steam:			
Borosilicate glass	110		
Enamelled steel	160		
Thermal oil*:			
Borosilicate glass	200		
Enamelled steel	200		
**Do not use thermal oils with synthetic additives!*			
Permissible temperature in the product space (°C)	max. 150		
Permissible gauge pressure in the jacket space (bar)			
Borosilicate glass	0.5		
Enamelled steel	6.0		
Permissible vacuum or gauge pressure in the product space (bar)	–1 / 0.5		

Table 1:
Technical data

Efficiency Data

The following diagram illustrates the evaporating efficiency as a function of the heat transfer coefficient of Schott thin-film evaporators. Regions 1 – 4 indicate the efficiencies for the product groups water, aqueous solutions, organic products and solvents. They are based on measurements taken at the Schott pilot plant in Mainz. For each region the principle applies that the higher the purity of the substance to be evaporated, the greater the evaporator efficiency per m² of heating area and accordingly the greater the heat transfer coefficient.

Example: Toluene is to be evaporated at a rate of 20 kg/h. The diagram indicates that the specific evaporating efficiency lies at about 70 kg/m² · h, corresponding to a heat transfer coefficient of about 130 W/m² · K. If in the case under consideration the evaporator is operated with an average temperature difference of 70 K, this gives a required heat exchange area of 0.22 m². The left-hand table reveals that the evaporator DSV 80 has an area of 0.2 m². This is large enough for the given task if the heating temperature is increased to bring the average temperature difference to 80 K. If this is not possible, the evaporator DSV150 must be chosen, to be able under the given conditions to evaporate toluene at about 45 kg/h.

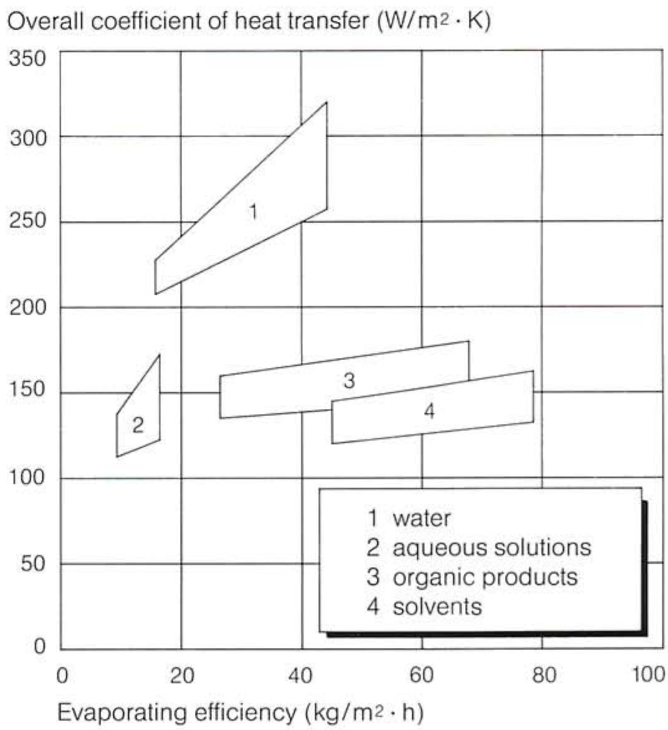


Figure 4:
The evaporating efficiency of Schott thin-film evaporators, depending on the overall coefficient of heat transfer.

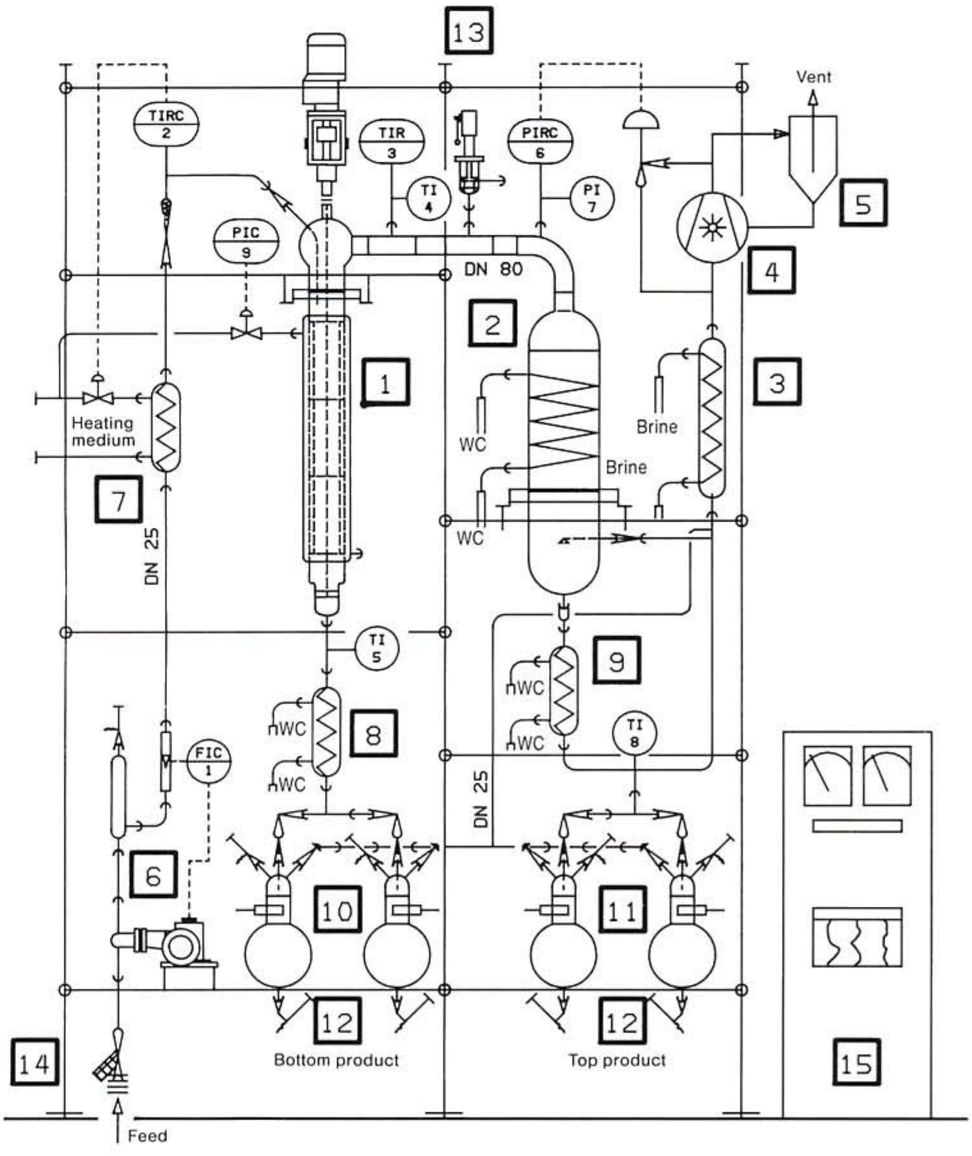
Complete Thin-Film Evaporator Systems from Schott

Apart from the actual thin-film evaporator, a complete, ready-to-use system includes a number of other components, such as for example, pumps, receivers and heat exchangers. Due to the selected use of measuring and control equipment, these systems can be extensively automated.

Schott plans and supplies complete systems with all the necessary components and required measuring and control equipment. The thin-film evaporator systems are installed on site in a sturdy tubular frame.

Thin-film evaporator	DSV 80	DSV 150	DSV 300
Feed receiver	50 l	100 l	200 l
Bottom product receiver	2 x 10 l	2 x 20 l	2 x 50 l
Top product receiver	2 x 10 l	2 x 20 l	2 x 50 l
Condenser (Cooling area)	1.0 m^2	1.5 m^2	2.5 m^2
Preheater (Heating area)	0.3 m^2	0.3 m^2	0.3 m^2
Product cooler (Cooling area)	0.3 m^2	0.3 m^2	0.3 m^2

Table 2:
Examples of receivers and heat exchangers in thin-film evaporator systems.



- 1 Thin-film evaporator with drive
- 2 Condenser (WAT)
- 3 After-cooler (NAK)
- 4 Vacuum pump (Liquid seal pump)
- 5 Liquid separator
- 6 Pulsation-damped feed pump (DOPU)
- 7 Preheater (PRO)
- 8 Bottom product cooler (PRO)
- 9 Top product cooler (PRO)
- 10 Receiver for the bottom product
- 11 Receiver for the top product
- 12 Draining of the receivers
- 13 Safety valve
- 14 Frame
- 15 Measuring and control equipment

Figure 5:
Example of a complete thin-film evaporator system.

Safety

Process engineering plants of glass have been tried and tested in many years of use in tough operating conditions.

Consequently, the material borosilicate glass, as specified in DIN ISO 3585, has been adopted in technical and statutory codes of practice which have been created for the implementation of safety at work.

Schott thin-film evaporators conform to all safety regulations which apply to the construction, operation and testing of thin-film evaporators, as well as to the generally recognised rules of the art (DIN-ISO standards, VDI specifications, VDE regulations, AD information sheets etc.)

Furthermore, additional measures to guard against external damage and for the safety of operating personnel, such as glass-fibre polyester resin reinforcement or Levasint® coating of the glass and the fitting of protective walls of plastic to the frame, may be provided.

Schott has a wide range of safety equipment and will make specific proposals on request.

Preliminary tests at the Schott pilot plant

Along with other installations from the area of thermal process engineering, the Schott pilot plant in Mainz has a thin-film evaporator at its disposal. Practical trials can be carried out here on behalf of a customer to examine whether a specific product is suitable for treatment in a thin-film evaporator and what results can be achieved thereby.

Planing and Design of Thin-Film Evaporators

To plan and design thin-film evaporators, we require the information itemised on the "thin-film evaporators questionnaire". If the questionnaire has already been detached, please ask for a new copy from Schott in Mainz. We will send you one immediately.

All of the information given in this publication is subject to technically related change.

Questionnaire
Thin-Film Evaporator DSV

To plan and design thin-film evaporators we require the following informations:

Company	Department/Building
Person in charge	Telephone
Street	Telex
Post Code / Town	Telefax

Description of problem / sketch

Components:
A:
B:
C:

Product data		Feed	Distillate	Concentrate
Throughput (m^3/h)				
Concentration of the dissolved components (% by weight)	A			
	B			
	C			
Inlet temperature (°C)				

Operational data

Pressure in the evaporating space (mbar):
Permissible product temperature (°C):
What is the valuable product: ☐ Concentrate ☐ Distillate

Operating materials

Heating media:	Pressure (bar)	Temperature (°C)
Cooling media:	Pressure (bar)	Temperature (°C)
Electrical connections:	Voltage (V)	Frequency (Hz)
Instrument air:	Pressure (bar)	

Material data
Reference pressure (mbar):
Reference temperature (°C):

		Components A	B	C	Feed	Distillate	Concentrate
Enthalpy of vaporization	(kJ/kg)						
Boiling temperature	(°C)						
Melting temperature	(°C)						
Decomposition temp.	(°C)						
Specific heat capacity	(kJ/kg K)						
Thermal conductivity	(kJ/m h K)						
Viscosity	(mPas)						
Density	(kg/m^3)						

Is the product

O tacky
O abrasive
O hygroscopic

O charged with suspended matter
O caustic
O toxic

O readily combustible
upper explosion limit:
lower explosion limit:

Oxidises on exposure to air? O Yes O No

Tests at the Schott pilot plant

What experience has there been of evaporation of the product?

Should tests be carried out at the Schott pilot plant?
O Yes O No

Details on the installation site

Further details

How is the product processed today?

Which improvement shall be reached?

Please send the filled-up questionnaire to your national Schott sales organization or to:

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