Options for High Pressure Capillary Rheometers
Introduction

The Göttfert High Pressure Capillary Rheometers are already equipped with large basic functions. Our extensive option program provides a more detailed characterisation of the test materials as well as supplementing accessories to the completion of the basic equipment. The options are also valid for the previous test device generations like Rheograph 2003/6000, Rheo-Tester 2000.

Optional Variants

<table>
<thead>
<tr>
<th>Test chamber type</th>
<th>RG25</th>
<th>RG75</th>
<th>RG120</th>
<th>SK</th>
<th>TC</th>
<th>PVT</th>
<th>SW</th>
<th>CP</th>
<th>NP</th>
<th>TC</th>
<th>CS</th>
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1) SK = Shark Skin
2) TC = Thermal conductivity measurement
3) PVT = Pressure volume temperature
4) SW = Die swell measurement
5) CP = Counter pressure chamber
6) NP = Nitrogen purge unit
7) TC = Thermocouple
8) CS = Cleaning set
Components and Order Information

Detection of Flow Instabilities (Shark Skin)

Flow-instabilities such as shark skin have long been observed, but difficult to measure. Common pressure or force transducers (typical 10 Hz max.) cannot pick up the slight pressure spikes caused by the instability. In cooperation with Professor M. Wilhelm (Institute of Applied Chemistry and Polymer Chemistry in Karlsruhe, Germany), a revolutionary sensory device was developed. Using a slit die and high frequency sensors with up to 20 kHz sampling rate, the smallest pressure peaks can be measured and analyzed. Results are evaluated in our special software and used to optimize extrusion, film and coating processes.

Details and closer information you will find in the separate product description "Detection of Flow Instabilities (Shark Skin)".

Thermal Conductivity

- Measurement of heat conductivity Temperature range up to 450°C, pressure up to 1000 bar
- Developed according to ASTM D5930
- Test probe with integrated heater element and temperature sensor
- No mechanical changeover required
- Process simulation and optimization of injection molding cycle times

Details and closer information you will find in the separate product description "Thermal Conductivity".

PVT (Pressure – Volume – Temperature)

- Measurement according to ISO 17744
- Determination of characteristics
- Pressure, Volume and Temperature
- Measurements isobar and isotherm
- Presentation of a PVT diagram
- Variable test sample volume Easy handling with quick die locking system
- Optimizing of the flow and shrinkage properties during production process

The PVT behavior of a plastic material describes the specific volume as a function of temperature and pressure. Within the test method the volume of a same is measured under given temperature and pressure condition.
There are two measurement procedures:

- at a constant temperature (isothermal measurement)
- at a constant pressure (isobaric measurement)

The barrel-piston system of a high pressure capillary rheometer can be used to determine a PVT diagram in a technological relevant area. These tests can be run in isothermal and isobar mode and newly standardized in ISO17443. Comparison measurements in a Round-Robin-Test showed that is procedure is useful for amorphous and crystalline polymers.

To perform the test in a capillary rheometer the barrel is closed at the lower end. A defined weight of material is given inside the barrel. The pressure is measured by pressure transducer in the molten or by a piston force transducer in the solid state. Changing the volume of a sample by driving the piston of the capillary rheometer and temperature PVT diagrams from 0-2500 bar and 20-400°C can be generated. The measurement can be performed with all thermoplastic and rubber materials and also liquids.

Figure 1 shows a view cut of a capillary rheometer barrel with tempering jacket necessary for isobar measurement.

For isothermal measurement also a standard barrel can be used. Isothermal measurement is a standard measurement to generate data for shrinkage and process modeling in extrusion, gear pumps, shrinkage of materials and also injection moulding. Figure 2 shows an example of isothermal measurement of a crystalline polymer. The data can be approximated with model equations, for example Tait model, and stored in databases. These data are absolute necessary for modeling injection moulding process.
To achieve a better description of the real injection moulding process the isobaric measurement is established. During the test the material is cooled down under constant pressure and this measurement describes better material behavior under high cooling rates of the injection moulding process, which mostly is done under constant pressure after the initial injection phase. The isobar pVT measurement is essential for exact mould design from simulation data.

Depending on the system the options **Force Measurement** and **Test Piston with Teflon Ring** or **Test Piston with HP sealing** are required.

At the multi-barrel system only one test barrel can be used for the PVT measurement.

Included accessories:
- 1 Capillary locking device
- 1 Support for capillary locking device
- 1 Arresting clip for piston reception
- 1 Round hole capillary 25/2 (only for PVT test)

Göttfert offers PVT measurements according DIN 17744 isotherm in a temperature range* up to 450°C and isobar up to 400°C. This upper limit provides now the possibility to measure and evaluate also the most technical plastics and especially fluor polymers.

For isobaric PVT measurements a test chamber with tempering jacket is required. The use of an external thermostat is recommended to guarantee constant cooling rates (see description "High power thermostat, order number 4.52.966").

* For selection of the optimal sealing the temperature range must be defined exactly.

**Rheograph 25, 75, 120:**

**PVT for Test Chamber Design 1**
Order number .................................................................5.29.321

**PVT for Test Chamber Design 2**
Order number .................................................................5.29.372
PVT for Test Chamber Design 3
Order number ..............................................................................................................................................5.30.161

PVT-Software for RHEOGRAPH 25 / 75 / 120 (essential option)
Order number ..............................................................................................................................................5.29.321

Rheograph 6000:

PVT for test barrel Ø 12 mm (3 barrel system)
Order number ..............................................................................................................................................5.13.685

PVT for test barrel Ø 12 mm / 20 mm (1 barrel system)
Order number ..............................................................................................................................................5.13.686

Rheo-Tester 2000:

PVT for test barrel Ø 12 mm (1 barrel system)
Order number ..............................................................................................................................................5.19.050

PVT for test barrel Ø 12 mm (2 barrel system)
Order number ..............................................................................................................................................5.19.070

Capillary quick-lock-system

For 1-barrel-system
Required to close and release the capillary for PVT- and Thermal Conductivity measurements (essential option at PVT- and Thermal Conductivity measurement).
Order number ..............................................................................................................................................5.29.621

For 2 and 3-barrel-system
Required to close and release the capillary for PVT- and Thermal Conductivity measurements (essential option at PVT- and Thermal Conductivity measurement).
Order number ..............................................................................................................................................5.29.623

Die Swell Measurement

- Dynamic and static measurement
- Analysis of swell profile (Basell Method)
- Height adjustable mount
- Standard resolution with 7 µm (micrometer) or with the high resolution system 0.1 µm
- Melt cutting system
Rheograph 25, 75, 120:

Die Swell Tester, standard resolution

to determine the static and dynamic die swell by measuring the diameter of the extruded strand about 20 mm below the capillary end, installed below the test chamber.
Consisting of:
- Laser measuring head: Laser diode class 2 (670nm), Resolution 0,44 µm
  Operating range 28 mm, measuring range 0,15 up to 28 mm, repeatability ± 3 µm
- Swiveling arm with adjustable height for reception of laser measuring head and melt cutting unit. Adjustment range: approx. 80 mm.
Power supply and data acquisition by means of the instrument.

1 and 2 barrel system:
Order number ..............................................................................................................................................5.29.607

3 barrel system:
Order number ..............................................................................................................................................5.29.608

Die Swell Tester, high resolution

to determine the static and dynamic die swell by measuring the diameter of the extruded strand directly below the capillary end, installed below the test chamber.
Consisting of:
- Laser measuring head: laser unit class 2 (630-680nm, power < 1 mW), Resolution 0,1 µm
  Operating range 32 mm, measuring range 0,2 up to 32 mm, repeatability ± 0,2 µm
- Swiveling arm with adjustable height for reception of laser measuring head and melt cutting unit, Adjustment range: approx. 80 mm.
Power supply and data acquisition by means of the instrument.
Order number ..............................................................................................................................................5.29.375

Rheograph 6000:

Die swell tester, high resolution

Directly below the test chamber.
Consisting of:
- Laser measuring head: laser unit class 2 (630-680nm, power < 1 mW), Resolution 0,1 µm
  Operating range 32 mm, measuring range 0,2 up to 32 mm, repeatability ± 0,2 µm
- Electronic
- Swiveling arm with adjustable height for reception of laser measuring head and melt cutting unit, Adjustment range: approx. 80 mm.
Power supply and data acquisition by means of the instrument.
The electronics of die swell tester is integrated in the machine.
Order number ..............................................................................................................................................5.13.690

Rheo-Tester 2000:

Die swell tester, high resolution

Directly below the test chamber.
Consisting of:
- Laser measuring head: laser unit class 2 (630-680nm, power < 1 mW, Resolution 0,1 µm
  Operating range 32 mm, measuring range 0,2 up to 32 mm, repeatability ± 0,2 µm
- Electronic
- Swiveling arm with adjustable height for reception of laser measuring head and melt cutting unit, with manual release. Adjustment range: approx. 80 mm.

Power supply and data acquisition are located in a separate table housing.

**1 barrel system:**
Order number ..............................................................................................................................................5.19.015

Die swell tester, low resolution
Directly below the test chamber.
To determine the static and dynamic die swell by measuring the diameter of the extruded strand.
Consisting of:
- Laser measuring head: Laser diode class 1 (780nm), Resolution 7 µm
  - Operating range 28 mm, measuring range 0.15 up to 28 mm, repeatability ± 14 µm
- Swiveling arm with adjustable height for reception of laser measuring head and melt cutting unit. Adjustment range: approx. 80 mm.

Power supply and data acquisition by means of the instrument.

**1 barrel system:**
Order number ..............................................................................................................................................5.19.245

**Melt Cutting Unit**

The pneumatic driven melt cutting unit is used for cutting off the out-flowing melt strand. The melt cutting unit is an additional option to the die swell tester, which helps to achieve a better reproducibility of the test data. The construction of the melt cutting unit is based on two counter-running knifes which work like scissors.

**Rheograph 25, 75, 120:**

**Melt Cutting Unit with Pneumatic Drive**

**high resolution** (5.29.375), the release of the cutting off procedure takes place software controlled.
Order number ..............................................................................................................................................5.29.377

**Melt Cutting Unit with Pneumatic Drive**

**low resolution** (5.29.376), the release of the cutting off procedure takes place software controlled.

**1 barrel system:**
Order number ..............................................................................................................................................5.29.378

**2 barrel system:**
Order number ..............................................................................................................................................5.29.540

**3 barrel system:**
Order number ..............................................................................................................................................5.29.541

**Rheograph 6000:**

**Melt Cutting Unit with Pneumatic Drive**

the release of the cutting off procedure takes place manual.
Order number ..............................................................................................................................................5.13.691
Rheo-Tester 2000:

Melt Cutting Unit with Pneumatic Drive  
**high resolution** (5.19.015), the release of the cutting off procedure takes place manual.
Order number ..............................................................................................................................................5.19.024

Melt Cutting Unit with Pneumatic Drive  
**low resolution** (5.19.245), the release of the cutting off procedure takes place manual.
Order number ..............................................................................................................................................5.19.190

Counter Pressure Chamber to measure pressure dependant viscosity

Process conditions in production of plastics and rubber (such as injection molding, extrusion with long deformation paths, pump flow, etc) often occur under high pressures. Here, viscosity often shows its pressure dependency. The new Counter Pressure Chamber can be adjusted to simulate different pressure drops, thereby measuring the viscosity close to process conditions.

- Measurement of pressure coefficient
- Measurement of wall slip’s critical shear rate
- Max. Pressure (Pm) 120 MPa

Details and closer information you will find in the separate product description "Counter Pressure Chamber to measure pressure dependant viscosity".

Nitrogen Purge Unit

To attach to the feeding bore of the test chamber. Consisting of a capillary ring with connection part for the nitrogen gas. The testing material has to be conditioned and fed by the customer.

Rheograph 25, 75, 120:

1 barrel system  
for Rheograph 25,75 und 120
Order number ..............................................................................................................................................5.29.379

2 barrel system  
for Rheograph 25,75 und 120
Order number ..............................................................................................................................................5.29.380

3 barrel system  
for Rheograph 75 und 120
Order number ..............................................................................................................................................5.29.406

Rheograph 6000:

1 barrel system  
for Rheograph 6000
Order number ..............................................................................................................................................5.13.698

3 barrel system  
for Rheograph 6000
Order number ..............................................................................................................................................5.13.699
Rheo-Tester 2000:

1 barrel system
for Rheo-Tester 2000
Order number .............................................................................................................................................. 5.19.140

2 barrel system
for Rheo-Tester 2000
Order number .............................................................................................................................................. 5.19.023

Slit Capillary

To use a slit capillary following options are required:
Slit capillary – basic part; slit capillary – slit height 0,5 and/or 1 and/or 2 mm as well as a heater element. 
Please note that in principle the slit capillary is not suitable for all materials. Furthermore, the accessible shear rate range of the slit capillary is limited compared to the accessible shear rate range of the round hole capillaries.

Slit Capillary
Only for Test Chamber Design (1 - Barrel)
The slit capillary can be equipped with 3 pressure transducers and 2 thermocouples (Fe-Co) for test temperature measurement. With the slit capillary the pressure difference is determined with the following equation:

\[ \Delta P = Pent - Pexi \]

Pbef : Test pressure before the capillary
Pent : Test pressure in the inlet of capillary
Pmid : Test pressure in the middle of capillary
Pexi : Test pressure in the outlet of capillary

By means of pressure transducer Pmid (option) it is possible to say whether the viscosity of the material is dependent on pressure or not. The viscosity is pressure dependent, if the pressure decrease of the capillary is non-linear. Furthermore, when using Pmid the elastic pressure loss at the inlet \( \Delta Pe \) can be more accurately calculated.

The real shear stress is calculated with the pressure difference \( \Delta P \) under consideration of the gap width and the distance of the pressure transducer.
The direct acquisition of the real wall shear stress with the slit capillaries saves a lot of time compared to several tests with round hole capillaries and following Bagley correction.

Dimensions of slit capillary:
Slit width: 10 mm; Slit height: 0,5 mm, 1 mm or 2 mm; Slit length: 100 mm; Inlet length: 30 mm; Outlet length: 20 mm
Distance of pressure transducer: Pent - Pexi: 50 mm
Pent - Pmid: 25 mm
Pmid - Pexi: 25 mm

Thread: \( \frac{3}{4}^\text{“} \)–20 UNF (or M18x1.5)

Rheograph 25, 75, 120:

Slit capillary
Basic part
Order number .............................................................................................................................................. 5.29.381

Slit capillary
Capillary part with 0,5 mm slit height.
Order number .............................................................................................................................................. 5.29.382
Slit capillary
Capillary part with 1,0 mm slit height.
Order number ................................................................. 5.29.383

Slit capillary
Capillary part with 2,0 mm slit height
Order number ................................................................. 5.29.384

Heater element up to operation temperature 400 °C
With reflector jacket for slit capillary.
Order number ................................................................. 5.29.385

Heater element up to operation temperature 500 °C
With Reflector jacket for slit capillary.
Order number ................................................................. 5.29.386

Thermocouple for Slit Capillary
Thermocouple with holder and socket suitable for slit die for measuring the melt temperature.
Length: 87 mm, diameter: 1 mm, type: iron-constantan
Order number ................................................................. 5.13.650

Rheograph 6000:
For the use of a slit capillary at the Rheograph 6000 a measurement ring incl. test barrel, as well as the slit capillary (base) and a capillary block is necessary.

Measurement Ring incl. Test barrel
For incorporation in the test chamber to measure test pressure and test temperature in front of the slit capillary. The measurement ring has a bore hole to receive a thermocouple, iron-constantan, and also a bore hole to receive a pressure transducer.
With the additional pressure transducer Pbef (option) in the measurement ring the elastic pressure loss at the inlet $\Delta$Pe can be determined directly.

Measurement ring incl. Test barrel (1 barrel) with 12 mm diameter
Order number ................................................................. 5.13.715

Measurement ring incl. Test barrel (1 barrel) with 20 mm diameter
Order number ................................................................. 5.13.716

Slit capillary
Basic part
Order number ................................................................. 5.13.711

Slit capillary
Capillary part with 0,5 mm slit height.
Order number ................................................................. 5.13.712

Slit capillary
Capillary part with 1 mm slit height.
Order number ................................................................. 5.13.713

Slit capillary
Capillary part with 2 mm slit height
Order number ................................................................. 5.13.714
Heater Element up to operating temperature 400 °C
With reflector jacket for the slit capillary and the measurement ring.
Order number ..............................................................................................................................................5.13.717

Heater Element up to operating temperature 500 °C
With reflector jacket for the slit capillary and the measurement ring.
Order number ..............................................................................................................................................5.13.718

Thermocouple for Slit Capillary
Thermocouple incl. holding adapter kit suitable for the measurement ring and slit capillary to measure the melt temperature.
Length: 75 mm Diameter: 1 mm Type: iron-constantan
Order number ..............................................................................................................................................5.13.650

Thermocouple
Rheograph 25, 75, 120:
By means of following thermocouples it is possible to measure the melt temperatures in the round hole capillaries. Each thermocouple needs an input of a thermo-voltage-module. A double thermo-voltage-module is already supplied together with the basic instrument.
Thermocouple with holder and screwing, suitable for round hole capillaries to measure the melt temperature.
Length: 87 mm, diameter: 1 mm, type: iron-constantan

Thermocouple for Test Chamber Design 1
Order number ..............................................................................................................................................5.29.559

Thermocouple for Test Chamber Design 2 and 3
Order number ..............................................................................................................................................5.13.679

Thermo-voltage-module
For signal amplification of 2 thermocouples. This thermo voltage module is used for a third thermocouple.
Order number ..............................................................................................................................................5.29.537

High power thermostat (temperature controller)
For external tempering of the test chamber with a cooling medium (bath fluid) in the range of 20 up to 380 °C. The thermostat can be used for constant cooling rates for isobaric PVT measurements according to ISO17744 as well as for faster lowering the test chamber temperature when performing viscosity or isothermal PVT measurements (also ISO17744).
The set temperature is being transmitted via the software of the test device or directly onto the control unit display of the thermostat. The controlling of the temperature is completely managed by the thermostat, the measuring of the test chamber temperature is detected by a thermocouple (optional).
To control the temperature of the high power thermostat a fresh water supply with a pressure of 0.5...6 bar is needed on installation site as well as a waste water connection. Alternatively an external circulation cooling unit can be used instead (order number 5.98.129).
The delivery consists 5 liters of cooling medium (bath fluid) as well as 2 insulated metal tubes with connecting unit M16x1 to fix directly with the test device. Power supply 230V/50Hz, power consumption 3,2 kW, heating power 3,0 kW, pump capacity 22l/min, weight approx. 17 kg.
Order number ..............................................................................................................................................4.52.966
Circulation cooling unit
to control the temperature of the high power thermostat, order number 4.52.966. With adjustable bypass valve to limit the pressure, cooling rate at 20°C 2.2 kW, discharge volume max 40 L/min, size (WxDxH) 450 x 550 x 790 mm, power supply 230V/50Hz
Order number ..............................................................................................................................................5.98.129

Gas-Aspiration

Aspiration ring with tube connection, top position
for external aspiration of gases, smokes, … in the top test chamber area, connection diameter 70 mm.
Order number ..............................................................................................................................................5.29.128

Aspiration ring with tube connection, bottom position
for external aspiration of gases, smokes, … in the bottom test chamber area, connection diameter 70 mm. The aspiration ring can be moved backwards for cleaning or installation works.
Order number ..............................................................................................................................................5.29.119

Aspiration and filter unit
for aspiration of gases, smokes and humid and sticky dusts in the top and bottom test chamber area. Effective air volume stream 30…480 m³/h, multi step filter system (incl. activated carbone filter), max distance to aspiration point about 12 m, aspiration ports: 2x NW50, 1x NW80, 1x NW125, completely with filter elements as well as tube connectors (5.29.128 und 5.29.119), power supply cable and 4 wheels for movable use, electronic control, weight about 90 kg, size HxWxD 1010x350x655 mm, power supply 230V/50Hz.
Order number ..............................................................................................................................................5.29.120

Cleaning Devices

With the following mentioned cleaning devices the cleaning of the test barrel can be simplified and done in a more effective way:

Pneumatic Cleaning Device
Together with the cleaning set the cleaning of test barrel can be done much quicker and easier with the pneumatic cleaning device:
The device requires an air supply of 4 - 6 bar. The compressed-air supply has to be oiled and free of water. We recommend the maintenance unit (5.03.343).
Supplied accessories: 1 Quick closure coupling for connection of air hose NW 9
1 Extension hose
Order number ..............................................................................................................................................5.11.082
Maintenance unit (for pneumatic cleaning device)
Maintenance unit 2-fold, comprising of 2 m compressed air hose with 1/4" thread connection, filter controller with pressure range from 0.5 -12 bar and filter 40µm with half-automated condensate removal, oiler with 90 cm³ volume capacity and a 2-fold coupling socket size 7.2 for connection of 2 pneumatic cleaning devices, throughput: max. 1660 l/min, inlet pressure: 0,8-14 bar, temperature range: -10 to +60°C, medium: oily and oil less compressed air, oil dosing: 1 to 2 drops /min at 1000 l/min
Order number ..............................................................................................................................................5.03.343

Battery Operated Cleaning Device
Together with the cleaning set the cleaning of test barrel can be done much quicker and easier with the battery operated cleaning device:
Technical data:
9,6V nominal voltage
0-800 min⁻¹ idle rotation speed
335mm whole length
Right / left run
Overload protection
Weight 1,3 kg
Supplied accessories:
1 battery charger 230 V
2 additional batteries 9,6V; 1300 mAh
1 coupling 5.11.155
Order number ..............................................................................................................................................5.11.160

Cleaning set
Consisting of steel brush and cleaning piston for the cleaning of test barrel with respectively one hinge part for the pneumatic cleaning device and the battery cleaning device.
Order number ..............................................................................................................................................5.11.161

Cleaning set for 9.55 mm Test barrel
Order number ..............................................................................................................................................5.11.135

Cleaning set for 12 mm Test barrel
Order number ..............................................................................................................................................5.11.136

Cleaning set for 15 mm Test barrel
Order number ..............................................................................................................................................5.11.137

Cleaning set for 20 mm Test barrel (not usable for Rheo-Tester 2000)
Order number ..............................................................................................................................................5.11.144

Cleaning set for 25 mm Test barrel (for 25, 75, 120)
Order number ..............................................................................................................................................5.11.161

Cleaning set for 30 mm Test barrel (for 25, 75, 120)
Order number ..............................................................................................................................................5.11.159

PC, Printer and Accessory
For visualization and for the operation of Goettfert testing devices personal computers (PC’s), with the Microsoft Windows® operating system, are used.
Details and closer information you will find in the separate product description "Visualizaiton-PC".
Table

**Machine table (Rheograph 25)**

For reception of the Rheograph 25.
The Rheograph is screwed tight with the machine table.
The table is made of anodized aluminium beams
Width: 920 mm, Depth: 700 mm, Height: 620 mm

Order number ..............................................................................................................................................5.29.087

**Machine table (Rheograph 75)**

For reception of the Rheograph 75 (photo see machine table Rheograph 25).
The Rheograph is screwed tight with the machine table.
The table is made of anodized aluminium beams
Width: 1020 mm, Depth: 700 mm, Height: 620 mm
Order number ..............................................................................................................................................5.29.294

**Drawer for machine table**

Robust drawer made of powder coated steel plate (RAL 7042) with 3 drawers 50 mm, 100 mm and 150 mm height. The drawer is screwed to the right of the machine table. The drawers are equipped with maintenance-free ball bead pullouts (85% pullout depth) and have a bearing capacity of up to 50 kg. They are laid with sliding protective mats and are variable in space allocation inside. Marking inserts in the handle strip enable an individual marking of the single drawers. The drawer can be closed through the central locking.

Order number ..............................................................................................................................................5.29.295

**Machine table (Rheo-Tester 2000)**

For reception of the Rheo-Tester.
Width: 1100 mm, Depth: 800 mm, Height: 580 mm
Order number ..............................................................................................................................................5.13.300
**PC Table** (without PC and monitor)
For reception of the Personal Computer (PC) and printer.  
With 6-fold multiple socket for 230 V supply voltage.  
Width: 920 mm, Depth: 700 mm, Height: 650 mm

Order number ..............................................................................................................................................5.29.086

**Sliding table for RHEOTENS** (Rheograph 25)
For reception of the RHEOTENS equipment.  
RHEOTENS see separate product description.

Order number ..............................................................................................................................................5.29.325

**Sliding table for RHEOTENS** (Rheograph 75, 120)
For reception of the RHEOTENS equipment (photo see Sliding table Rheograph 25).  
RHEOTENS see separate product description.

Order number ..............................................................................................................................................5.29.332

**Note**
Subject to change due to technical developments

**Contact**

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