



Thermo Scientific Twin-Screw Extruders

A Better Mix of Science and Technology

**TWIN-SCREW EXTRUSION
MIXING. COMPOUNDING.
PROCESSING.**



What is Twin-Screw Extrusion?

Twin-screw extruders are well-established in the industry for mixing, compounding and processing of viscous materials. They are used in a great variety of polymer, pharmaceutical and food applications. The flexibility of twin-screw extrusion equipment allows designing these machines specifically to the desired task.

Twin-screw extruders can have a conical or parallel design. The two screws can be counter-rotating or co-rotating, intermeshing or non-intermeshing. Also, the configurations of the screws themselves can be varied using different conveying and mixing elements. Counter-rotating twin-screw extruders are used mainly for processing PVC products, such as pipe, profile, sheet, pellets and film. The co-rotating units are used for compounding materials where thorough mixing is important. Co-rotating twin-screw extruders usually have modular configurations, which makes the equipment quite flexible for adapting to changing applications and material properties.

Advanced application sectors are:

- Polymer compounding
- Masterbatch production
- Nanomaterials research
- Industrial hybrid polymer optimization
- Continuous granulation and hot-melt extrusion (HME) for pharmaceuticals
- Processing high performance and engineering polymers
- Extruding and mixing ceramic compounds
- Extrusion and sample measurement with advanced analytical methods, such as NIR and rheology
- Processing of hazardous ingredients under controlled environments



Advantages of Thermo Scientific Twin-Screw Extruders

- Reduce waste by using smaller quantities of material during compounding
- Decrease costs with quicker cleaning times
- Save time with quick, simple changes of trial materials
- Improve data acquisition with ancillary devices
- Optimize process simulation with independent screw configuration to suit your application
- Customized machine configurations to meet unique application demands
- Global sales and support

Ask us about financing and rental options.

Unleash the Full Power of Extrusion Science

We produce a wide range of versatile twin-screw extruders with customizable options to fit the demanding and changing environments of research, development, production and quality control for pharmaceutical, industrial and polymer companies.

You can also find our twin-screw extruders as an integral part of scientific research in a large number of universities all over the world. With adaptability in mind, we created our parallel, co-rotating twin-screw extruders with unsurpassed flexibility and modularity. You can modify the extruder to meet your needs now and in the future.

We also designed our extruders for easy accessibility. A horizontally split, hinged barrel lets you take a closer look at the material during the extrusion procedure. To optimize the process or change the application, you can quickly convert the screw and barrels – reducing both time and expense. In fact, this is five times faster than most other solutions in the market.

TWIN-SCREW EXTRUSION IN-DEPTH EXPERTISE

"We are scientists and engineers – with 50 years of experience in producing solutions."



Scientific Is Part of Our Name for Good Reason

Whether your company is involved in pharmaceuticals, polymers or industrial material sciences, it's vital your equipment manufacturer has the in-depth scientific expertise in your specific industry.

In the field of material sciences, accuracy and consistency are of the highest priority.

You may be dealing with government regulations that demand equipment meet specific calibration requirements.

As well as accuracy and repeatability, you may want equipment that can:

- Feed and process challenging materials
- Work with very small sample sizes
- Safely contain hazardous materials
- Provide industry specific options and data acquisition

Wherever you are in the product cycle – research, development, production, quality control – it's key that a vendor understands the specific requirements of these areas and creates equipment that meets the demands unique to each.

But your needs don't end with the arrival of equipment at your facilities. You want access to support, skills and turnkey solutions to the problems you may encounter in a processing environment.

We are also scientists and engineers and have 50 years of experience in producing solutions as well as creating scientific instruments and equipment.

As scientific knowledge and technology progresses, your needs change as well. This is where Thermo Scientific products excel – matching scientific evolution with equipment and solutions that answer new challenges.



Our advanced Thermo Scientific portfolio features:

- Equipment with ultimate configurability
- Customized solutions to meet your unique requirements
- In-depth experience with containment solutions
- Integration of analytical tools, such as NIR
- Strong global sales and service network
- Option for bundled solutions with external upstream and downstream partners

Place your process
in a containment
solution



Accurate and
continuous sheet
and ribbon haul-off
system



The suite features the:

- HAAKE MiniCTW
- Pharma *mini* HME
- HAAKE MiniLab II



Micro-Compounding

Our suite of micro-twin-screw conical compounders is well-suited for research and development in the polymer, pharmaceutical, bioscience, and nanotechnology sectors.

All models use as little as five grams or seven milliliters of material for compounding. This is especially beneficial if you compound expensive or small-scale materials. By using the optional force feeder, you can continuously extrude very small material volumes.

The instruments are based on proven, conical twin-screw technology with co- and counter-rotating screws, and work as standalone units with data export. Residence time is well defined due to the channel and bypass valve.

You can couple the micro-compounder with our mini-injection moulder, Thermo Scientific HAAKE MiniJet, as an extended workflow solution. Easily produce various test specimens from the compounded material in the HAAKE MiniJet, for further testing on our Thermo Scientific HAAKE MARS or HAAKE RheoStress 6000 rheometers.



The Thermo Scientific HAAKE MiniCTW is excellent for the precisely controlled extrusion and compounding of a wide range of materials. By running the instrument in circulation mode, you have full control of the dwell time of the extrusion process. At the end of the test, you can open the bypass valve and extrude the sample as a strand. Effectively monitor the process by measuring the torque of the drive motor.

The Thermo Scientific Pharma *mini* HME micro-compounder combines the proven experience of the HAAKE MiniLab II and the special requirements of the pharmaceutical industry. With a completely modular and removable barrel and crevice-free design, this machine provides enhanced features for specialty pharmaceutical environments. It's ideal for feasibility testing of solubility challenged formulations.

The Thermo Scientific HAAKE MiniLab II micro-compounder combines compounding and relative viscosity tests for small volume samples. The pneumatic force feeder guarantees easy sample loading. An integrated bypass valve lets you recirculate the sample in a slit capillary backflow channel or extrude it for further tests. With its hinged barrel and fast cooling capacity, the HAAKE MiniLab allows you to freeze the compound for further examination. Use this HAAKE MiniLab as a stand-alone unit or as a fully computer-controlled system.

HAAKE MiniCTW

- Ideal for industrial research and development
- Removable top barrel for quick, easy cleaning

Pharma *mini* HME

- GMP design for pharmaceutical sector
- Excellent for testing solubility challenged formulations

HAAKE MiniLab II

- Perfect for expensive or small sample compounding (5 g)
- Integrated viscosity measurement capabilities

Laboratory Scale

Thermo Scientific laboratory-scale equipment enables you to simulate production – offering the insights needed to optimize the process.

Our twin-screw laboratory extruders have a proven record in continuous compounding with feeding of different additives (solid, liquid or gas) along the extruder barrel. The combination of a twin-screw extruder unit with additional sensors offers the ability to measure material properties of the melt during processing. Our twin-screw extruders can be quickly and easily configured for a wide variety of applications and conditions.



Experiments or test runs in early phases of the new product lifecycle provide data on:

- Viscosity and flow behavior of the compound
- Extrudability and scale-up data
- Predictions for the injection molding process
- Morphology of polymer and nanocomposites
- Recycling properties and reusability of the polymer
- Influence of screw geometry on processes
- Decomposition of biopolymers and active pharmaceutical ingredients
- Direct scale for lowest risk technology transfer

The Thermo Scientific EuroLab 16 XL bench top twin-screw extruder is used for research, development, quality control, and small-scale production. Prepare small or different samples in a short time with a minimum of product waste.

From sample batches of 50 grams up to outputs of 10 kg/h, the bench mounted 16 mm EuroLab XL twin-screw extruder is the heart of a complete compounding and sample preparation system. The segmented screw configuration with modular and extendable barrel design delivers flexibility for the full range of polymer processes. A horizontally split barrel of 25:1 L/D can be changed to 40:1 with a bolt on, plug and play extension. Once attached, the extension is automatically recognized by the EuroLab 16 XL and the heating controls appear on the touch screen. The segmented top barrel half is constructed in modules and is easy to reconfigure and clean. Barrel segments are available for feeding solids and liquids or for venting. Secondary feeders and vacuum pumps can form part of the system.

A rugged, color touch-screen interface incorporates real-time trending as standard. An option is available to log data on a remote computer for analysis and archiving. Also offered is a PLC control with real-time trending display and recipe storage to preset extruder parameters for repeatable process conditions. The advanced heater algorithm delivers precise temperature control. A low maintenance, brushless 2.5 kW motor drives the screws at 1000 rpm.



EuroLab 16 XL

- Versatile extruder: R&D, quality control, & small-scale production
- Extendable barrel delivers flexibility for full range of polymer processes

TWIN-SCREW EXTRUSION

LABORATORY SCALE

The parallel small-scale-compounder Thermo Scientific HAAKE Rheomex PTW 16 OS with its unique design is the perfect instrument for running lab-scaled compounding and blending tests. With its 16 mm screw diameter, only very small sample volumes are needed to enable research and development teams to run tests in the early stages of formulation developments. The horizontally split barrel, with top half fitting upward, allows easy inspection of the melting and mixing behavior. For an optimization of this behavior, the screws can be configured individually.



HAAKE Rheomex PTW 16 OS

- Small sample size - excellent for early stage formulation development
- Design allows easy inspection of melting and mixing behavior

The Thermo Scientific HAAKE Rheomex PTW 24 OS with its 24 mm screw diameter is specifically designed for laboratory applications with higher throughput. The barrel layout and screw geometries are taken directly from the production process. The individually configurable barrel and screws enable users to adapt to changing requirements in compound development and processing optimization.



HAAKE Rheomex PTW 24 OS

- Great choice for continuous compounding applications
- Easy to configure barrels/screws for changing requirements

The Thermo Scientific HAAKE Rheomex CTW 100 OS is a counter-rotating, conical twin-screw extruder. It enables high shear compounding in a lab environment. The different screw geometries allow a wide range of tasks in laboratories and pilot plants. The counter-rotating design supplies a positive material displacement from the hopper to the die, delivering high levels of pressure and shear, and enables very well-defined dwell times.

This extruder supports applications such as extrusion of PVC compounds, processing of thermal critical compounds, wood fiber compounding, and blending of polymers with different viscosity.



HAAKE Rheomex CTW 100 OS

- Excellent for processing thermal critical compounds
- Conical design – recognizes short dwell times; avoids dead volumes



Pilot Processing and Production

When you use only modest quantities of expensive or difficult to handle polymers or even pharma compositions, smaller equipment like a pilot system is an excellent choice.

Thermo Scientific twin-screw compounders offer flexible compounding configurations for small batches in lab production, pilot-scale production or low-volume manufacturing. The co-rotating twin-screw compounders feature segmented screws, modular barrel construction with ports for split, feeding, and liquid injection and venting that can be utilized according to requirements. The full-length opening barrel allows easy access to the screws for easy cleaning and changing of screws.

These compounders feature:

- Segmented screws and barrels
- Split barrel design with liners
- Short cleaning time and fast product change
- Minimum product waste
- Small foot print

With sample outputs up to 50 kg/h, the Thermo Scientific TSE 24 MC floor-mounted twin-screw extruder is suited for test sample and small-scale manufacturing. It's flexible, easy to operate, and simple to clean. The hinged horizontally split barrel with a processing length, up to 40:1 L/D, is ideal for quick access to the screws, and permits rapid configuration changes. The barrel is constructed in segmented modules that can be configured to suit a variety of polymer processes.

Replaceable barrel liners can be made from special steel for particular applications. Barrel segments are available for venting or feeding solids and liquids. Secondary feeders and vacuum pumps can also be incorporated into the system. The PLC controller automatically recognizes the feeders and ancillary devices. The large, color touch-screen interface incorporates on-screen, real-time trend display. An ancillary device can download data to a remote computer for archiving and analysis. The controls include recipe storage to preset extruder temperature profiles for repeatable process conditions. Each barrel section has independent temperature control with PID logic for precise processing conditions. To assist with scale up, the touch screen displays heating/cooling balance for each zone. A low maintenance, brush-less 5.5 kW motor drives the screws at 500 rpm. If higher output is needed, an 11 kW drive doubles the screw speed to 1000 rpm.



TSE 24 MC

- Segmented module barrel for wide variety of polymer processes
- PLC control with integrated feeders and ancillaries

The Pharma HME twin-screw extruder with co-rotating screws (available as a 16 and 24 mm version) provides easy track recording and handling. The Thermo Scientific Pharma HME includes PLC control with data logging and recipe storage to ensure reliable and repeatable results. A clamshell barrel, with simple-to-remove liners, allows easy cleaning of contact parts (remote from the process area) without the need to completely disconnect the barrel. The stainless steel compounders are built to GMP standards with a focus on a clean, streamlined design. For pharmaceutical hot-melt extrusion, the Pharma HME lines can be used for product and process development through to production, delivering the product in pellet or flake form.



Pharma 24 HME

- Precise replication with PLC control with data logging and recipe storage
- Stainless steel compounders built to GMP standards
- Also available as 16 mm version for lab scale

Like the Pharma HME, the Pharma TSG co-rotating twin-screw granulator (available as a 16 and 24 mm version) includes PLC control with data logging and recipe storage. With removable liners, the clamshell barrel permits easy and thorough cleaning of contact parts.

For continuous pharmaceutical granulation, the Thermo Scientific Pharma TSG offers a more reliable product than a batch process. Multiple samples can be produced from small amounts of API, with minimal scale-up problems.



Pharma 24 TSG

- Perfect for process development through to production
- Proven solutions for continuous granulation
- Also available as 16 mm version for lab scale

Ancillary Options. Global Service. Complete Training. The Keys for Connecting Science to Success

We produce a diverse range of ancillary instruments and offer extensive training and worldwide service to support our twin-screw extruders and enhance your workflow process.

Feeders

Developing new materials comes with many challenges; feeding various and challenging ingredients is one of our key strengths. With years of experience, we have overcome processing challenges, such as feeding of low bulk density materials, to provide customers with unique feeding solutions. Manual or integrated solutions are available to provide flexibility in automation and consistency or control of critical feed rates.

Containment

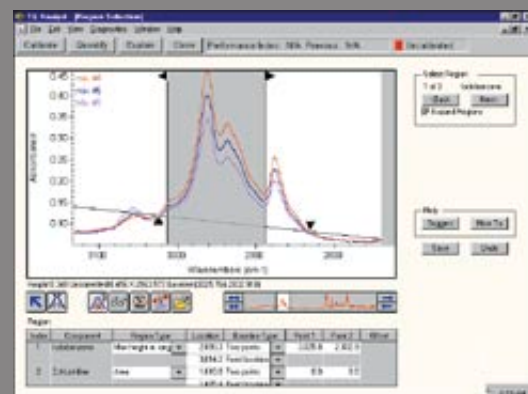
Handling materials within the extrusion process that are hazardous to humans and/or the environment require a containment solution you can always rely on. Understanding your specific process requirements,

we can deliver customized isolator solutions that match the highest standards of safety regulations. We help protect your equipment operator with failsafe components, contamination-free filter exchange, and constantly pressurized interlocked transfer systems for getting products in and out of the isolator. By designing the isolator for your specific process requirements, we produce seamless integration with the extrusion equipment.

You're guaranteed maximum productivity because the entire machine is easy to clean and operate. Containment solutions are also available to protect moisture and oxygen sensitive materials prior to extrusion.

Online Analytics

We research and develop new techniques and tools that assist customers in data acquisition and materials analysis. For example, our near infrared spectroscopy (NIR) equipment can be incorporated into the extrusion process. The continuous analysis of the product provides you with vital information on what's happening to materials during the extrusion process. We also have NIR analyzers designed specifically for hazardous environments.

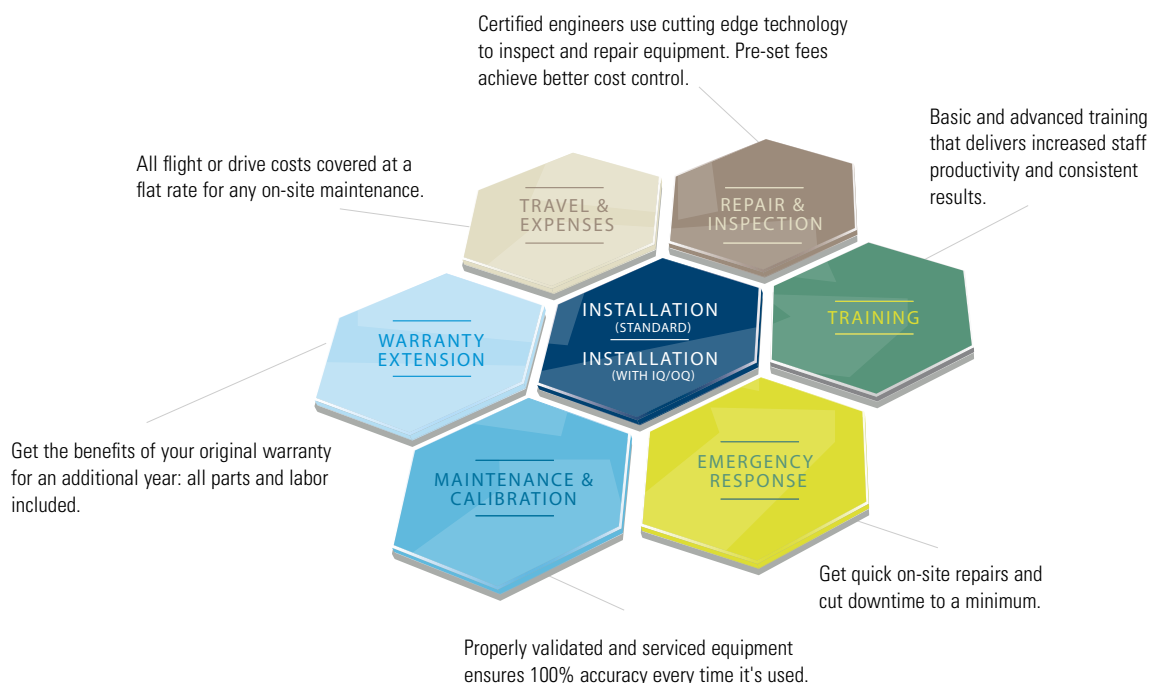


The Service Module Solution

We offer a wide array of professional services to a variety of industries to help customers improve their productivity and decrease costs. Individual solutions to support our customers and maintain their instruments are a standard service. Warranty enhancements and additional service packages can be conveniently bundled to allow accurate planning and budgeting for maintenance and service support. All services are performed by our skilled, certified engineers.

Select only the service modules you want. Add modules at the time of equipment purchase, during warranty, or after. Combine modules. Or create a customized service plan that matches your unique requirements. We can offer comprehensive consultation to help choose the right options.

And if you require services not described here, please call us. We'll develop customized solutions for you. Visit www.thermoscientific.com/mc for more detailed information. And then phone our sales representative to arrange for your free service assessment.



Post-Extrusion

The post-extrusion units enable a defined downstream transport of the extruded material and preparation for additional analytical testing. The design characteristics of dies and Postex units differ only slightly from their production scale counterparts. This guarantees that all tests are performed under conditions similar to those in the preformed production environment.

The Postex family for polymers consists of

- Blown film take-off
- Sheet, tape and ribbon take-off
- Wire coating take-off
- Water bath and pelletizer
- Face-cut pelletizer
- Conveyor belt

The Postex family for pharma applications consists of

- Conveyor belt
- Pelletizer/face-cut pelletizer
- Chill rolls

TWIN-SCREW EXTRUSION
OPTIONS. SERVICE. TRAINING.

Application Solutions

Application Laboratories

Our laboratories are in constant demand for testing customer samples and developing and optimizing cutting-edge applications. Our fully equipped laboratories reflect our applications expertise and commitment to innovation.

Services to Meet Your Unique Requirements

From the development of a polymer in the laboratory to the pilot plant where small batches of test material can be compounded, to quality control in production, to processing small quantities of special polymers or composites, Thermo Scientific solutions help our customers to be more successful in their markets.

Designing Solutions, Not Just Equipment

Wherever you are in the research, development or production process, the Thermo Scientific brand provides a host of products and services that offer complete turnkey solutions for your requirements. See the contact information on the back cover for your closest branch.

Designing Solutions, Not Just Equipment

No matter whether you need us to help with:

- Extrusion and Compounding
- Physical properties testing
- Analytical analyses
- Sample preparation

You can rely on us.



Application Report 15-06
HAAKE MiniLab - Compounder and Reactor

Application Report 15-05
Residence time measurements in Bench top twin-screw extruders

Application Report 15-04
Correlation between Mixer Tests and the Extrusion Behaviour of PVC Dry Blends

Application Report 15-03
Nanocomposites - Examples on Compounding Blends in Twin screw extruders

REQUEST, NOW!
INFO.MC.DE@THERMOFISHER.COM

Application Reports

We have specifications sheets and technical papers for a number of our twin-screw extruders and applications, including:

- ✓ PP014-e HAAKE Rheomex PTW 24 MC – twin-screw extruder module for HAAKE PolyLab OS
- ✓ LR38-e Production of a blend of two different concentrations by a parallel double screw extruder and a further processing through a melt pump and following measurement of the rheological characteristics in slot and rod capillary dies
- ✓ LR43-e HAAKE MiniLab _Compounder and Reactor
- ✓ LR 52 Degradation tests – A new test procedure to examine polymers and antioxidants with the HAAKE MiniLab
- ✓ LR 53 Pharma *mini* HME – a small scale compounder for pharmaceutical research
- ✓ LR 56 Ceramics – Compounding of feed stock with HAAKE Rheomex PTW 16 XL and sample production with HAAKE MiniJet
- ✓ LR55-e Residence time measurements in bench top twin-screw extruders
- ✓ LR60-e Correlation between mixer tests and the extrusion behaviour of PVC dry blends
- ✓ LR62-e Nanocomposites – Examples on compounding of nanoclay blends in twin-screw extruders
- ✓ Looking for something else? Contact us!

Looking for professional training options?

We provide comprehensive training programs at our education centers located in Karlsruhe (Germany), Breda (The Netherlands), Paris (France), Mumbai (India), Shanghai (China), Somerset/NJ and Sugar Land/TX (USA).

Renowned external experts share their profound knowledge of particular topics in our expert seminars on polymers or pharmaceutical applications.

Head of research and development and those involved in the development, processing, characterization and testing of polymers will learn more about combined lab-scale measuring methods (polymer workflow solutions).

Attendees who work in the research and development, processing or quality control department in the pharmaceutical, dentistry, cosmetics and biotechnology industries will understand how to improve bioavailability and patient compliance or learn more about twin-screw granulation for controlled continuous processing.

Twin-Screw Extruders For Your Individual Needs

Micro-Compounding Only 5 g of material needed!	Ø	Length L/D	di/Da	Typical output (kg/h)	Temperature °C
HAAKE MiniCTW	Conical			0.01 to 0.2	300
Pharma <i>mini</i> HME	Conical			0.01 to 0.1	280
HAAKE MiniLab	Conical			0.01 to 0.2	350 (420)
Laboratory Scale					
EuroLab XL	16 mm	25 (40)	1.73	0.2 to 10	400 (450)
HAAKE Rheomex PTW 16 OS	16 mm	25 (40)	1.73	0.2 to 10	400 (450)
HAAKE Rheomex PTW 24 OS	24 mm	25 (40)	1.77	0.5 to 50	400 (450)
HAAKE Rheomex CTW 100 OS	Conical			0.2 to 5	450
Pilot Processing and Production					
TSE 24 MC	24 mm	28 (40)	1.77	0.2 to 50	400 (450)
Pharma 16 HME	16 mm	40	1.73	0.2 to 5	300
Pharma 24 HME	24 mm	40	1.77	0.5 to 20	300
Pharma 16 TSG	16 mm	40	1.73	0.2 to 20	100
Pharma 24 TSG	24 mm	40	1.77	0.5 to 50	100

* = Common set point
 ** = Driven by HAAKE RheoDrive base unit
 *** = Depending on length

() = Optional
 ○ = no
 ● = yes

Thermo Scientific Twin-Screw Extruders

Continuous compounding with twin-screw extruders

Thermo Scientific twin-screw laboratory extruders have a proven record in continuous compounding with feed-dosing of different additives (liquid or solid) along the extruder barrel. The combination of a twin-screw extruder unit with additional sensors offers the ability to measure material properties of the melt during processing. The following properties and data can be derived from an experiment or test run in the early part of the lifecycle of a new product:

- Viscosity and flow behavior of the compound
- Extrudability and scale-up data
- Predictions for the injection molding process
- Morphology of polymer and nano-composites
- Recycling properties and re-usability of the polymer
- Influence of screw geometry on processability
- Compounding of biopolymers

Design (co-, counter rotating)	Max. screw speed (rpm)	Temperature Zones ***	Operating Concept	Drive Power kW	Segmented screw
Conical co- & counter rotating	360	2*	PC	0.4	○
Conical co- & counter rotating	360	2*	TS (Touch Screen)	0.4	○
Conical co- & counter rotating	360	2*	PC / TS	0.4	○
Parallel co-rotating	500 (1000)	7 (10)	TS	1.25 (2.5)	●
Parallel co-rotating	1100	7 (10)	PC	7 (16)**	●
Parallel co-rotating	1100 (560)	7 (10)	PC	16 (7)**	●
Conical counter rotating	250	3	PC	7 (16)**	○
Parallel co-rotating	500 (1000)	7 (10)	TS	5.5 (11)	●
Parallel co-rotating	1000	8	TS	2.5	●
Parallel co-rotating	1000	8	TS	11	●
Parallel co-rotating	1000	7	TS	2.5	●
Parallel co-rotating	1000	7	TS	11	●



About Thermo Fisher Scientific

Thermo Fisher Scientific Inc. (NYSE: TMO) is the world leader in serving science. Our mission is to enable our customers to make the world healthier, cleaner and safer. With revenues of more than \$10 billion, we have approximately 35,000 employees and serve customers within pharmaceutical and biotech companies, hospitals and clinical diagnostic labs, universities, research institutions and government agencies, as well as in environmental and process control industries. We create value for our key stakeholders through two premier brands, Thermo Scientific and Fisher Scientific, which offer a unique combination of continuous technology development and the most convenient purchasing options. Our products and services help accelerate the pace of scientific discovery, and solve analytical challenges ranging from complex research to routine testing to field applications. Visit www.thermofisher.com.

Thermo Fisher Scientific, one of the pioneers in rheology, successfully supports a wide range of industries with its comprehensive Thermo Scientific material characterization solutions. Material characterization solutions analyze and measure viscosity, elasticity, processability and temperature-related mechanical changes of plastics, food, cosmetics, pharmaceuticals and coatings, chemical or petrochemical products, plus a wide variety of liquids or solids. For more information, please visit www.thermoscientific.com/mc.

© 2010 Thermo Fisher Scientific Inc. • 623-3086 • All Rights Reserved. This document is for informational purposes only and is subject to change without notice. Specifications, terms and pricing are subject to change. Not all products are available in all countries. Please consult your local sales representative for details. Copyright for the environment and people images (except the person next to glovebox on page 5, pages 9, 16, 19) are owned by a third party and licensed for limited use only to Thermo Fisher Scientific by Getty Images, Shutterstock and iStockphoto. The product and remaining people images are owned by Thermo Fisher Scientific.

Process Instruments

Benelux

Tel. +31 (0) 76 579 55 55
info.mc.nl@thermofisher.com

China

Tel. +86 (21) 68 65 45 88
info.mc.china@thermofisher.com

France

Tel. +33 (0) 1 60 92 48 00
info.mc.fr@thermofisher.com

India

Tel. +91 (20) 6626 7000
info.mc.in@thermofisher.com

Japan

Tel. +81 (45) 453-9167
info.mc.jp@thermofisher.com

United Kingdom

Tel. +44 (0) 1606 548 100
info.mc.uk@thermofisher.com

USA

Tel. 603 436 9444
info.mc.us@thermofisher.com

International/Germany

Dieselstr. 4
76227 Karlsruhe
Tel. +49 (0) 721 4 09 44 44
info.mc.de@thermofisher.com
www.thermoscientific.com/mc

Thermo
SCIENTIFIC