



ultraWAVE 3 INFOPACK



Thank you for your interest in Milestone's ultraWAVE 3 Single Reaction Chamber Technology. This Infopack will help you learn how the game-changing ultraWAVE 3 can enhance your lab's metals prep needs.

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MILESTONE
H E L P I N G
C H E M I S T S



TAKING PRODUCTIVITY
AND PERFORMANCE
TO NEW HEIGHTS



ultraWAVE 3

Single Reaction Chamber
Microwave Digestion System



HIGHEST
PRODUCTIVITY



UNMATCHED
PERFORMANCE



UNCOMPROMISED
SAFETY



UNPARALLELED
USABILITY



LOW COST
OF OWNERSHIP

WE FOCUS ON ADDRESSING YOUR CHALLENGES

Customer Centric Innovation

The many benefits of microwave closed-vessel technology have led to its broad adoption in sample preparation for elemental analysis over the past three decades. At the same time, modern laboratories have been facing more types of samples and more stringent detection limit and accuracy requirements, while also being expected to provide shorter turnaround times and higher productivity - all at a lower cost. Since the late 1990's, Milestone has been a leader in microwave closed-vessel technology innovation and the creation of a new path for addressing the evolving needs of laboratories. Starting with ultraCLAVE and then with ultraWAVE, Milestone has invented and refined Single Reaction Chamber (SRC) technology to better meet the challenges of the modern laboratory. This technology has been successfully implemented by thousands of laboratories across several industries. Today, ultraWAVE 3 represents another significant step forward for SRC technology, embracing our 20+ years of expertise.



*ultraCLAVE
(5th generation)*



*ultraWAVE
(1st and 2nd generation)*



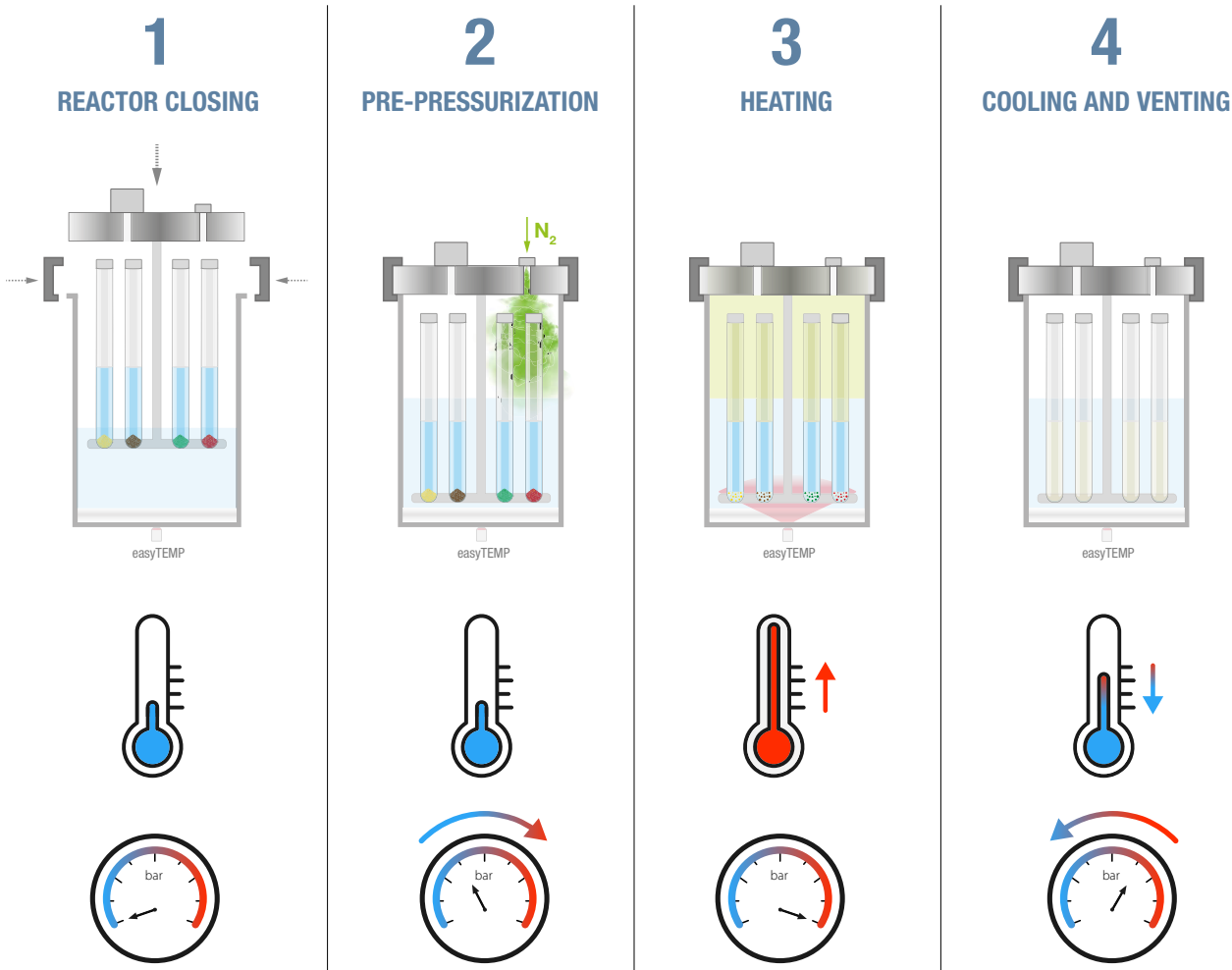
| THE GAME CHANGER IN MICROWAVE DIGESTION

Explore ultraWAVE 3: the latest generation of SRC technology that further elevates the value of this technology for elemental analysis in terms of performance, time, workflow, and cost of ownership.

THE MOST ADVANCED TECHNOLOGY EVEN BETTER

SINGLE REACTION CHAMBER TECHNOLOGY

At the heart of ultraWAVE 3 is the Single Reaction Chamber (SRC), a stainless-steel reactor with a high-purity PTFE-TFM liner and cover, which serves as both microwave cavity and digestion vessel. Samples and reagents are placed in vials and racks, lowered into the PTFE-TFM liner containing a water-based solution, and then the reactor is closed (1). The water-based load homogenizes the temperature regardless of the sample and acid mixtures in the vials. After the chamber is closed it is pre-pressurised with inert gas to prevent boiling of the reagents, loss of elements, and sample cross-contamination (2). Microwave heating starts and the digestion cycle is continuously controlled in all vials using an advanced contactless temperature sensor (3). An integrated water-cooling circuit maintains the stainless steel chamber at a reduced temperature. At the end of the heating cycle, it promotes rapid cooling of the digestion vials, which is followed by automatic venting of the chamber (4). The reactor is then opened and the digested sample solutions are ready for dilution and analysis.



ultraWAVE 3 FEATURES

Updated construction that includes several technology advances further enhances the well-proven benefits of the SRC technology. The new features of ultraWAVE 3 merge with those already intrinsic in the technology, so

that labs will experience higher performance, greater productivity, and more streamlined workflow, providing them with improved competitiveness and a lower cost of ownership.

RUGGED CONSTRUCTION

Designed with all wetted components made of PTFE-TFM, fully compatible with any acid mixture and ensuring minimal maintenance to lower the cost of ownership.

HIGH-PRESSURE LINES

Made of acid-resistant stainless steel, the two pressure lines, one for inlet and one for outlet, ensure high safety and lower blanks.

RACKS

Available with racks of 7, 20, 27 and 40 vials to provide even higher throughput than previous generations.

TEMPERATURE CONTROL (easyTEMP)

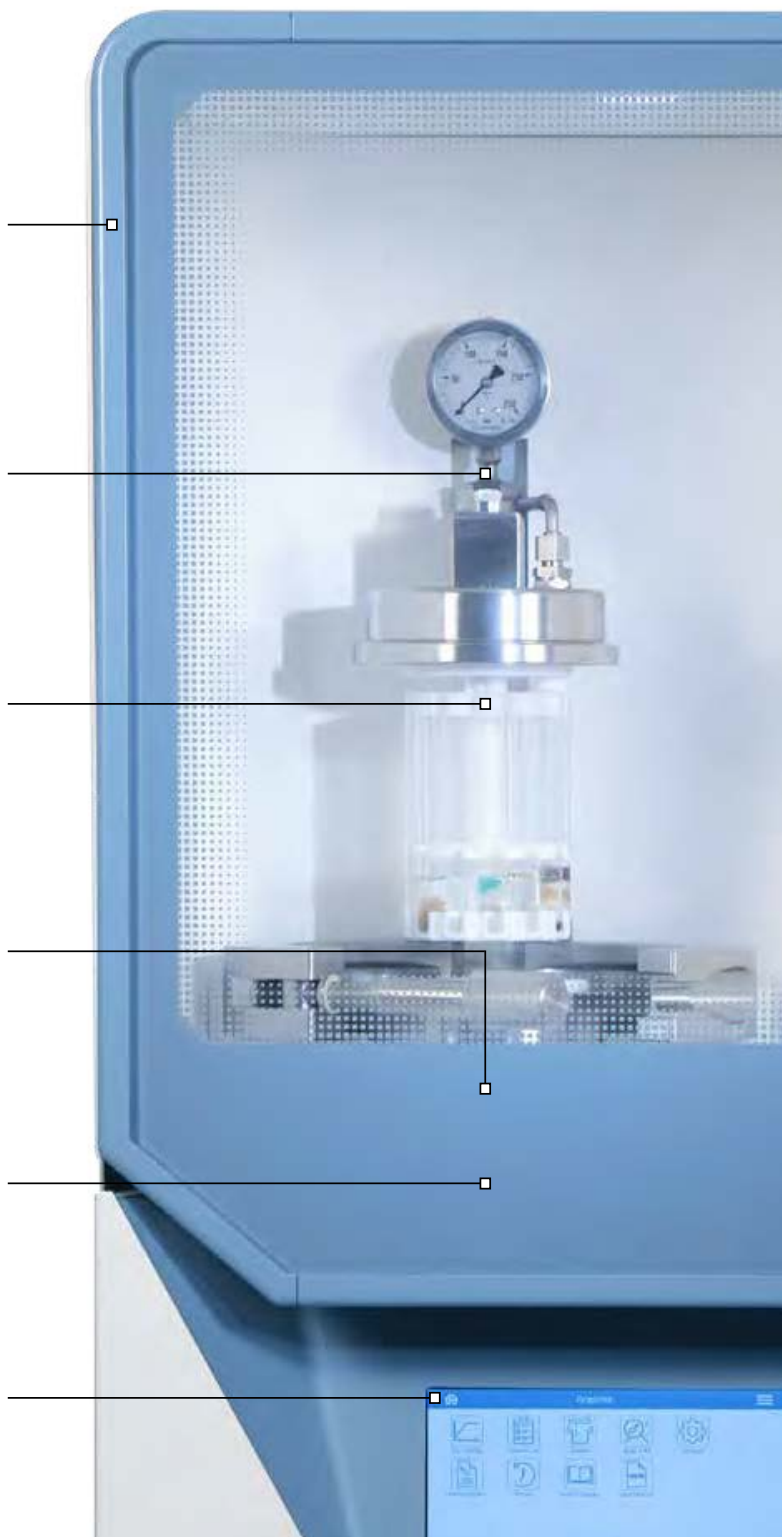
True contactless temperature sensor to directly control the digestion of the samples from the inside out, without reading delays.

ADVANCED HEATING TECHNOLOGY

The noiseless water-cooled magnetron ensures higher heating efficiency along with superior working conditions.

USER INTERFACE

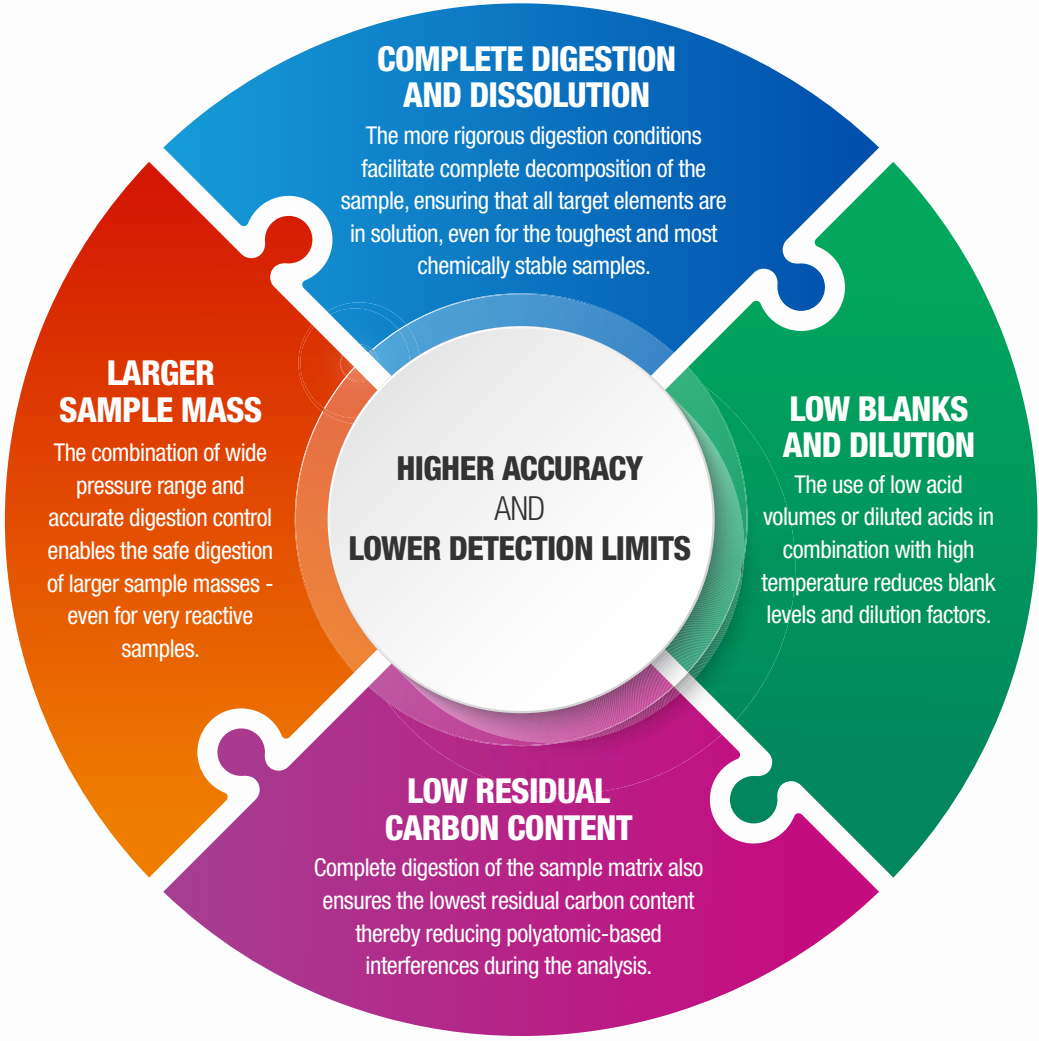
Equipped with the most up-to-date features to bring all digestion information within easy reach of the operator.



THE POWER OF SRC TECHNOLOGY WITH UNCOMPROMISED SAFETY

UNMATCHABLE SRC CAPABILITIES

Today, the trend in several industries is toward lower detection limits and greater accuracy due to new regulations and evolving production and QC needs. The quality of sample preparation plays a central role in enabling modern analytical instruments to meet these more stringent requirements. Thanks to its superior digestion capabilities that result from its higher temperature and pressure capabilities, ultraWAVE's unique SRC technology provides greater digestion efficiency, making it an ideal solution to address these challenges.



I DIGESTION ALWAYS UNDER CONTROL

Temperature plays a critical role in the digestion process. ultraWAVE is equipped with the advanced easyTEMP contactless temperature sensor and feedback mechanism to control the digestion process, ensure high safety, and optimize ease of use. The built-in easyTEMP sensor continuously communicates with the

system to adjust the microwave energy and follow the pre-set method. Even in the case of an exothermic reaction, easyTEMP quickly reduces the power emission to control and limit the reaction, ensuring a safe process and superior digestion quality.



I UNCOMPROMISED SAFETY

Microwave closed-vessel digestion operates at elevated temperature and pressure with concentrated acids; therefore safe operation of the system is of critical importance. ultraWAVE 3 has been designed and tested to the highest safety standards. The stainless steel reaction chamber as well as all high-pressure lines are designed for and tested at pressures far above their regulatory limits. Several components, key for safe operation, are made of a special stainless steel that is highly resistant to corrosion. The built-in exhaust prevents operator exposure to acid fumes, which are diverted into the lab extraction system during the chamber venting and opening processes. Several position and reaction sensors ensure proper closure of the system and full control of the digestion process.

ACCELERATING ELEMENTAL ANALYSIS WORKFLOW

ELIMINATE SAMPLE PREP BOTTLENECKS

ultraWAVE 3 is designed to simplify and expedite lab workflow in elemental analysis. Its use improves productivity without increasing operator time. Several aspects of the system, such as reduced handling and cleaning and the ability to process any samples simultaneously, streamline the daily routine of the lab, reducing turnaround time and increasing lab efficiency.

SIMPLIFIED HANDLING

The vials and racks of ultraWAVE 3 are specifically designed to reduce assembly and disassembly time. The operator has only to place loose-fitting caps on the vials and the rack is ready for the digestion process. This approach eliminates the operator time required for closing and opening of the vessels, typically involved with the rotor-based systems.

The wide selection of racks and vials enables to match the detection limit, productivity, and application requirements of modern laboratories. Racks are available with different capacities to fit any sample type and mass. Vials are available in high-purity PTFE-TFM, high-purity quartz, and common laboratory glass (disposable) to address the detection limit and application needs of every lab.

# of position	Volume (mL)	Vials material
7	40	PTFE-TFM, Quartz, Disposable glass
20	15	
27	8	
40	4.5	Glass



AVOID VESSEL CLEANING

Rotor-based systems require digestion vessels with a complex construction to contain the elevated pressure within each vessel. Conversely, the SRC approach ensures equal pressures between the inside and outside of the vials, so vials can withstand elevated pressures using a much simpler construction. Thanks to this unique capability, the SRC technology even enables the use of inexpensive disposable glass tubes. This approach is commonly implemented for more routine applications and allows complete elimination of the tedious vessel cleaning step and concern for potential memory effects.



RUN ANY SAMPLES SIMULTANEOUSLY

Traditional microwave digestion systems work with similar samples and the same acid mixture in a given run to ensure homogenous digestion. SRC technology overcomes this limitation and ensures the same digestion conditions regardless of the sample and the reagents used. This is made possible by the combination of the SRC technology, the use of a water-base load, and accurate temperature control. With ultraWAVE 3, laboratories don't need to batch similar samples, but instead, all types of samples can be processed simultaneously, while ensuring complete digestion, avoiding sample re-processing, and making the workflow more efficient.



REDUCED OPERATOR TIME

Laboratories are more often than not seeking ways to make sample preparation less labor-intensive. ultraWAVE 3 is a major advancement in this direction and reduces hands-on labor time up to 50%. Several steps are done automatically by the system, such as the closing and venting of the chamber and automatic sealing of the vials, which reduces the operator time, raises the productivity and the safety of operation.

THE IDEAL MATE FOR YOUR DAILY WORK

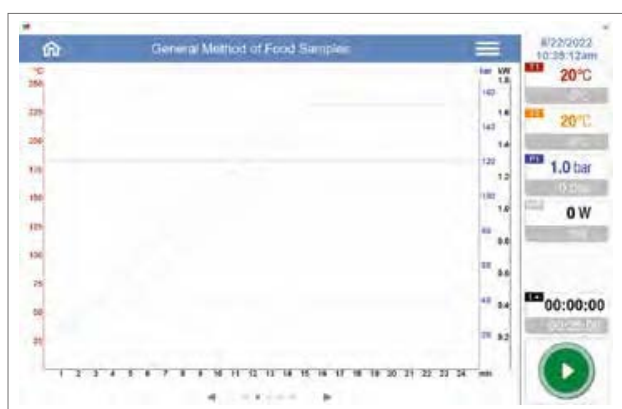
UNPARALLELED USABILITY

The ultraWAVE 3 user interface provides the operator with all the information they need at their fingertips. The large integrated touchpad with the all-new easyCONTROL 3 software facilitates a streamlined workflow for routine operations and offers an extensive library of user-support resources. The Home page give quick access to all functions and information, such as the recent methods listed in the bottom line or the chamber parameters shown in the right sidebar. The easyCONTROL software integrates the world's first on-line platform for additional digestion resources, the Milestone Connect, which includes tutorial videos, tips and techniques, an application library, and lists of accessories and spare parts. Moreover, Milestone Connect allows remote control of the system from other devices to see the progress of the digestion process or to view other information displayed on the touchpad.



ONE METHOD FITS ALL

The ultraWAVE 3 user interface supports fast and easy operation. For a routine digestion, beginning the process only requires few seconds: open the method and press “start”. Single Reaction Chamber technology enables the use of a single method for the majority of sample types encountered in a typical lab. All the digestion parameters are automatically controlled by the system through a PID algorithm and are reported in the graph page as well as listed on the side bar present in all display pages.



The system incorporates a comprehensive list of methods, including official and standard methods, that guides the operator in the optimization of parameters based on specific matrices, so that the time for any method development and refinement that is called for can be minimized. Customized methods can then be easily created and stored on the system. At the end of the process the run can be saved on the terminal or on the lab server. The software complies with FDA regulation 21 CFR part 11 requirements to match several regulator bodies requirements. Moreover, a comprehensive Milestone Validation Package, which incorporates several protocols, is available to fulfill the GMP requirements and ensure the highest quality standards.



REDUCED MAINTENANCE COSTS FOR GREATER RETURN ON INVESTMENT

LOW COST OF OWNERSHIP

The evaluation of a new investment often includes the costs involved with maintenance as well as operation. ultraWAVE’s Single Reaction Chamber technology introduces a completely new approach to sample preparation that impacts both of these cost areas. The consumables costs have been significantly reduced, moving from complex and expensive digestion vessels to simple and less expensive vials or even disposable glass tubes. Moreover, ultraWAVE 3 leverages Milestone’s 20+ years of experience with SRC technology to further reduce the maintenance costs of the system. The new system construction ensures limited costs that together with a usage-based preventive maintenance program minimize lab costs. When combined with an increase in productivity and the lower operator time required, your ROI has never been higher.



MILESTONE HELPING CHEMISTS

Established in 1988, Milestone is headquartered in Italy with its R&D and manufacturing centre in Germany and Switzerland and offices in the United States, China, Japan and Korea. We

operate worldwide through a network of over 100 exclusive distributors, all providing our customers with premium application and service support. Milestone's mission is to help chemists by offering them the most advanced instrumentation for sample preparation and direct mercury analysis in the world. Our industry-leading technology, in combination with fast, responsive service and applications support, allows Milestone to support our goal of giving you the highest return on investment possible.

ADDITIONAL MILESTONE SOLUTIONS FOR ELEMENTAL ANALYSIS



ETHOS UP

High Performance
Microwave Digestion
System



duoPUR/subCLEAN

Acid Purification
System



traceCLEAN

Acid Steam
Cleaning System



DMA-80 *evo*

Direct Mercury Analyzer

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| How ultraWAVE 3 works



Learn about how the ultraWAVE 3 with Single Reaction Chamber (SRC) technology provides significantly greater digestion capabilities for even the most difficult sample types over traditional digestion systems. High-performance stainless steel construction allows for higher pressures and temperatures, while disposable vessels eliminate the need to assemble, disassemble or clean between processing. Just as important, dissimilar samples can be processed simultaneously, saving time and money.

→ **see how ultraWAVE 3 works**

ultraWAVE 3 VIDEO



The ultraWAVE 3, at its third generation, encompasses Milestones 20 years of experience on Single Reaction Chamber (SRC) technology. This latest model incorporates several features to enhance the lab workflow and productivity without compromising the quality of the digestion process and the following analysis. The ultraWAVE 3 boosts to the next level: Productivity, Performance, Safety and Usability whilst reducing the cost of ownership.

→ [see the ultraWAVE 3 Video](#)

ultraWAVE 3 RACK GUIDE



The ultraWAVE 3 rack guide describes the capabilities of the 7, 20, 27 and 40 positions racks, available with PTFE, quartz and or disposable glass vials to match the specific needs of any laboratory. Choosing the optimal vial material depends on factors such as sample type, sample amount to be digested, acid mixture, elements of interest and desired limit of quantification. The table below provides guidelines on choosing the vial size and material which will be best suited for your application.



VIALS MATERIAL	MATERIAL PROPERTIES AND FEATURES	BENEFITS
High purity PTFE	High purity material No inherent material contaminants Suitable for applications requiring HF	Optimal for trace element determination Suitable for any acid mixture Great for digestion of geological material and inorganic samples Low blanks
High purity Quartz	Easy to clean No inherent material contaminants (except for silicon) Low porosity	Great for trace metals analysis in food, pharmaceuticals and other organic samples Low memory effect High durability and long lifetime
Disposable Glass	Disposable Suitable for the analysis of all elements. Inherent material contaminants may include: B, Na, Mg, Al, K, Ca, which could prevent low detection capability	Inexpensive Great for routine analysis Suitable for the large majority of heavy metals No cleaning step Higher throughput

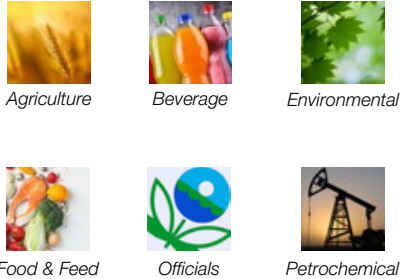
HIGH PURITY PTFE AND QUARTZ VIALS

TYPICAL APPLICATIONS



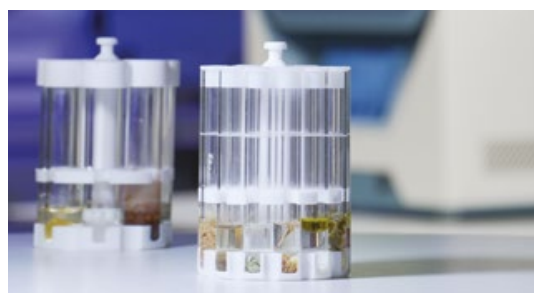
DISPOSABLE GLASS VIALS


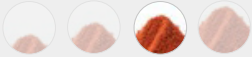










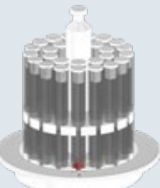
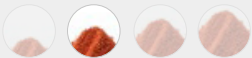



TYPICAL APPLICATIONS




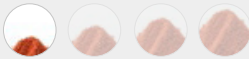




WE FOCUS ON ADDRESSING YOUR CHALLENGES

Choosing the number of positions is influenced by the type of sample, sample amount and productivity required. The ultraWAVE 3 racks provide unparalleled flexibility, as they easily accommodate both large sample masses and high productivity. The below table shows all the available racks, providing guidelines on the typical applications and solutions they provide.



RACKS	TYPICAL WORKING CONDITIONS & SAMPLES	TYPICAL APPLICATIONS	BENEFITS
<p>20 POSITIONS</p>  <p>Glass PTFE/TFM Quartz</p>	<p>Suggested volume: 5 ml Sample amount: up to 1 g</p>  <p>Large organic sample amount</p> <p>Medium to Highly reactive sample</p>	 Food & Feed  Environmental  Inorganics  Pharmaceutical  Petrochemical	<ul style="list-style-type: none"> – High productivity – Ease of use – Mixed samples – Lower consumables cost – Lower labor cost
<p>7 POSITIONS</p>  <p>Glass PTFE/TFM Quartz</p>	<p>Suggested volume: 10 ml Sample amount: up to 3 g</p>  <p>Extra-large organic sample amount</p> <p>Highly reactive sample</p>	 Metals  Reasearch  Food & Feed	<ul style="list-style-type: none"> – Achieve instrument DL for trace elements detection – Representative sample amount – Sample homogeneity – Long runs at high temperature – Lower running cost (consumables)
<p>27 POSITIONS</p>  <p>Glass PTFE/TFM Quartz</p>	<p>Suggested volume: 3 ml Sample amount: up to 0.3 g</p>  <p>Medium sample amount</p> <p>Low reactive sample</p>	 Biological  Reasearch  Food & Feed	<ul style="list-style-type: none"> – Ultratrace metals analysis – Low acid volume – Ease of use – Lower consumables cost – Lower labor cost



RACKS	TYPICAL WORKING CONDITIONS & SAMPLES	TYPICAL APPLICATIONS	BENEFITS
<p>40 POSITIONS</p>  <p>Glass</p>	<p>Suggested volume: 2 ml Sample amount: up to 0.1 g</p>  <p>Small sample amount</p>  <p>Low reactive sample</p>	 Biological  Reasearch  Food & Feed	<ul style="list-style-type: none"> – Ultratrace metals analysis – Low acid volume – Ease of use

ABOUT THE ultraWAVE 3

The new Milestone ultraWAVE 3 is the latest generation of SRC technology that further elevates the value of this technology for elemental analysis in terms of performance, time, workflow, and cost of ownership.

It's unique high-performance stainless steel construction allows for higher pressures and temperatures, while disposable vessels eliminate the need to assemble, disassemble or clean between processing. Just as important, dissimilar samples can be processed simultaneously, saving time and money.

The vials and racks of ultraWAVE 3 are specifically designed to reduce assembly and disassembly time. The operator has only to place loose-fitting caps on the vials and the rack is ready for the digestion process. This approach eliminates the operator time required for closing and opening of the vessels, typically involved with the rotor-based systems.



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Tech Report

TECHNOLOGY REPORT

SRC DIGESTION | ULTRAWAVE 3



MILESTONE

HELPING
CHEMISTS



**BREAKTHROUGH
SRC DIGESTION
FOR ELEMENTAL ANALYSIS**

Advances in State-of-the-Art SCR Digestion Technology and Their Impacts on Analytical Laboratories

INTRODUCTION

Since the late 1990's, Milestone has been a leader in microwave closed-vessel technology innovation and the creation of a new path for addressing the evolving needs of laboratories. Starting with the ultraCLAVE and then with the ultraWAVE, Milestone has invented and refined Single Reaction Chamber (SRC) technology to better meet the challenges of the modern laboratory. Following the adoption by some of the most discriminating users in the world, SRC technology has been successfully implemented by thousands of laboratories across several industries.

The technology behind Single Reaction Chamber (SRC) microwave digestion systems has been described previously¹ and

its advantages have been well-established². Recognized attributes of Milestone's state-of-the-art digestion systems based on SRC technology include:

- Highest productivity
- Unmatched performance
- Uncompromised safety
- Unparalleled usability
- Low costs of ownership

Even so, modern laboratories have been facing the challenges of more types of samples to analyze and more stringent detection limit and accuracy requirements, while also being expected to provide shorter turnaround times and higher productivity - all at a lower cost.

Tech Report



To help address these needs of the user community, Milestone’s scientists and engineers leveraged their several decades of expertise in microwave digestion to examine every aspect of their current generation SRC products and technology – from hardware to software, from user experience to laboratory economics, and of course, safety – to identify opportunities to advance the state-of-the-art even further.

The result of this endeavor is ultraWAVE 3, the next generation in state-of-the-art SRC-based microwave sample digestion.

This Technology Report describes the design and construction advances implemented in ultraWAVE 3, along with the practical impacts these advances have on the productivity, performance, safety, user experience, and costs of operation and ownership of the system in analytical laboratories.

REACTION CHAMBER ADVANCES

As the name may suggest, at the heart of SRC technology is the reaction chamber in which the microwave-heated sample digestions take place. In ultraWAVE 3, the reaction chamber was redesigned not for one specific purpose, but rather to accommodate several other design advances that are described below.

NEW RACKS

1. GREATER CAPACITY

The first advancement in the ultraWAVE 3 sample digestion racks is that they have

greater capacities with respect to the number of vials than their same-volume counterparts from the previous generation product. To accommodate this, the reaction chamber dimensions and volume have been optimized to increase the number of vials (see Figure 1) and still meet the same rigorous safety certification standards, without compromising the digestion performance of the system in any way.

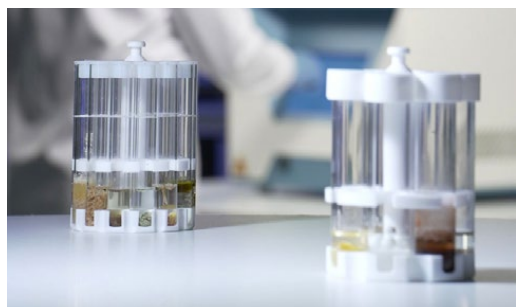


Figure 1: new racks

The table below compares the number of positions available in the old and new racks.

ultraWAVE (1 st and 2 nd generation)	ultraWAVE 3 # of positions	Vials material
5	7	PTFE-TFM Quartz Disposable glass
15	20	
22	27	
26	40	Disposable glass

Table 1: number of positions available in old and new racks

Increasing the number of samples that can be digested in a run significantly increases the productivity of the digestion system in

Tech Report

TECHNOLOGY REPORT SRC DIGESTION | ULTRAWAVE 3



terms of samples digested per hour/day/week/year. And for many laboratories, where sample preparation may be a bottleneck in the elemental analysis workflow, this may impact the overall productivity and profitability of the lab.

For certain applications where a sample may be divided into multiple vials to maximize the total mass for that sample digested in a single run³, the increased total mass capacity can have an even greater impact on meeting challenging detection limit and accuracy objectives.

2. NEW RACK DESIGN

A second advancement in the ultraWAVE 3 sample racks is its new 2-piece design that adds a flow-through pathway near the base (see Figure 2).

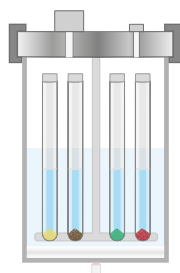


Figure 2: new 2-piece design feature

This new 2-piece design features higher mechanical and thermal stability, offering longer rack lifetimes compared to previous generations as well as the ability to operate at higher temperatures for a longer period. The flow-through path enables faster temperature equilibration between the reaction mixtures in

the vials and the base load in the chamber. This leads to more rapid and even heating of the samples and the ability of the system to respond more quickly to exothermic reactions that may occur.

3. NEW VIAL CAPS

The next advancement in ultraWAVE 3 sample racks is the inclusion of new loose-fitting vial caps in combination with a smaller gap between the tops of the caps and reaction chamber cover. The new caps are designed with a larger pressure exchange area to provide faster pressure equilibration between the inside of a vial and the reaction chamber environment.

In cases where there is a rapid increase in pressure inside a vial due to a fast, exothermic reaction, it is possible that the cap could “pop off” inside previous-generation reaction chambers, potentially leading to sample loss and possible cross-contamination. In ultraWAVE 3, if a strong exothermal reaction occurs, the new cap lifts slightly and the increased area of the hole allows for a faster release of excess pressure inside a vial. At the same time, the closer proximity of the cap to the previous-generation reaction chambers cover keeps the cap on the vial during the pressure equilibration.

4. SIMPLIFIED RACK HANDLING

In ultraWAVE 3, the reaction chamber cover has been redesigned to accommodate easier and error-free plug-in of the rack into the cover. In addition, a new rack base has been developed that has the effect of slightly elevating two of the digestion vials to make it easier to begin removing the vials from the rack (see Figure 3).

Tech Report



Figure 3: simplified rack handling

These improvements in rack handling improve the user experience by addressing some minor, yet real, inconveniences. Beyond that, as potential mishandling of a rack or vials containing concentrated acid could constitute a safety hazard, simplifying their handling should improve the overall safety of a laboratory.

NEW TEMPERATURE CONTROL

ultraWAVE 3 incorporates the easyTEMP temperature control popularized in Milestone’s ETHOS UP rotor-based digestion system. The contactless easyTEMP temperature sensor, which replaces the baseload-immersed thermocouple-based sensor from previous-generation systems, works by measuring the IR light from the inside of the reaction chamber (see Figure 4).

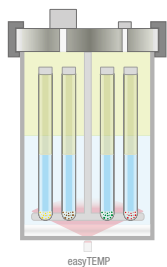


Figure 4: contactless easyTEMP sensor

Because the easyTEMP sensor surveys a larger, “bulk” area of the reaction chamber, compared to the single measurement point of a thermocouple, it can sense temperature changes and accordingly adjust the microwave power more quickly.

The bulk chamber temperature survey and faster response allow ultraWAVE 3 to better control exothermic reactions, leading to even greater safety and more complete digestions. In addition, replacing the thermocouple with the contactless easyTEMP sensor also provides the following benefits:

- Easier rack plug-in (see also Simplified rack handling above).
- Compatibility with HF without the need of a protective material.
- Lower maintenance costs due to the longer lifetime of the easyTEMP sensor.
- Zero risk of contamination, leading to lower blanks and detection limits.

QUARTZ REACTION CHAMBER BOTTOM

Available as an option for earlier systems, a quartz-construction reaction chamber bottom piece is standard on ultraWAVE 3.

The quartz construction accommodates the use of the easyTEMP temperature control and its benefits as described above. As already proven in previous ultraWAVE systems, the quartz bottom is also less affected by contamination, providing a longer lifetime and reducing the maintenance costs for the system.

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EASIER CHAMBER LINER REMOVAL

Removing the reaction chamber liner for ultraWAVE 3 has been simplified by the addition of a gas-pressured lift assist that raises the lip of the liner to facilitate an easier grip by the operator and subsequent removal of the liner.

While it is a helpful improvement to this specific operational step, this new feature is also an example of the attention given to even the smallest details toward the goal of continually improving the user experience with the system.

STIRRING CAPABILITY

An optional magnetic stirring capability is now available for ultraWAVE 3. This option can be used for stirring both the base load and individual vials using magnetic stir bars.

For certain limited applications, e.g., complete digestion of polymer samples containing silicon, which requires the use of HF and PTFE vials, the sample may float on top of the digestion mixture and stick to the vial wall. This can create a hot spot on the vial, which affects both digestion performance and the lifetime of the vial. Stirring will prevent the sample from sticking to the vial wall, avoiding these problems.

NEW HIGH-PRESSURE LINES

The high-pressure lines used in transporting gases into and out of the reaction chamber are key components of any SRC technology. The design and construction of these lines have several important impacts, including:

- Capability to work at trace levels for elemental analysis
- Labour time required for cleaning
- Parts lifetime and total cost of ownership
- Lab safety

The high-pressure lines for ultraWAVE 3 have been redesigned with all these aspects in mind. The following sections describe the specific advances and their respective impacts.

1. CHEMICALLY RESISTANT MATERIAL

The ultraWAVE 3 high-pressure lines are constructed from chemically resistant Hastelloy steel (see Figure 5).



Figure 5: chemical resistant high-pressure lines

Use of Hastelloy for these parts eliminates the corrosion that can occur when vapors or solutions of concentrated acids come in contact with them. The potential for such corrosion when non-chemically resistant metallic parts are used leads to a need for daily cleaning and periodic replacement of the parts that are affected. In addition, if these maintenance procedures are not followed correctly, it can lead to contamination of the samples being processed, and in cases of

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extreme corrosion, it can constitute a safety hazard in the lab.

2. SEPARATE INLET AND OUTLET LINES

Some SRC designs use the same high-pressure line for both the inlet and outlet functions of the reaction chamber. ultraWAVE 3 has separate inlet and outlet lines to and from the chamber.

Having separate lines allows them to be optimized for their respective purposes, those being introducing pre-pressurization gas for the inlet, and reaction chamber pressure release and flushing for the outlet (see Figure 6).



Figure 6: separate inlet and outlet lines

For example, having a dedicated outlet line provides for more efficient and effective flushing of the reaction chamber at the conclusion of a digestion. If the pressure release and flushing are performed using a line shared for the inlet function, there is a much greater opportunity for contamination when the pre-pressurization gas is introduced through the inlet line for the next batch of samples. Therefore, having separate inlet and outlet lines leads to lower blanks and

detection limits.

In addition, the automatic flushing of the outlet line reduces the risk from having acid condensate sitting in the line for hours, or even days, which could potentially corrode the line and necessitate its early replacement.

3. OPTIMIZED GAS INLET DESIGN

The ultraWAVE 3 gas inlet line is positioned so that the nitrogen gas used for pre-pressurization is introduced into the chamber near the reactor wall (see Figure 7).

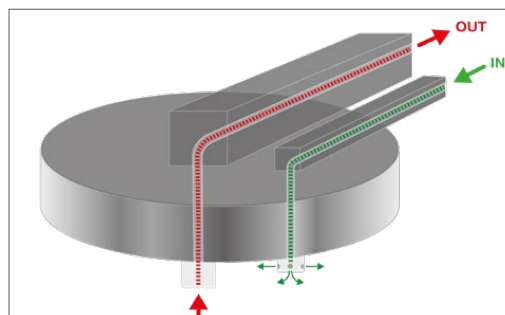


Figure 7: gas inlet design

Directing the gas toward the chamber wall, as opposed to toward the sample vials, keeps the vials from being perturbed by the gas flow. This reduces the opportunity for contamination within the chamber, leading to superior blanks, low-level accuracy, and detection limits.

3. RUGGEDIZED CONSTRUCTION

The ultraWAVE 3 high-pressure lines are not only more chemically resistant, the fixed-in-place all-steel design, which replaces the externally exposed flexible tubing from the prior design, make the lines much less susceptible to physical damage from

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inadvertent rough handling in the working area around the reactor.

AUTOMATED PRESSURE HANDLING

ultraWAVE 3 automates the previously manual processes of loading the nitrogen gas before a digestion to pre-pressurize the chamber and then flushing the system with clean gas at the conclusion of a digestion to remove acid vapors and condensates. This is accomplished using computer-controlled valves that have been added to the system pneumatics.

Automating these processes has multiple benefits: 1) reduces operator labor time, 2) improves ease of use, 3) eliminates both analytical and safety risks associated with operator negligence, and 4) provides longer component lifetimes.

SYSTEM CONSTRUCTION AND CONTROL ADVANCES

EXPANDED LIQUID COOLING

ultraWAVE 3 is the first piece of microwave laboratory equipment that is fully liquid-cooled. In this more efficient approach to thermal management, the chiller that is used to cool the reaction chamber is also used to cool the microwave magnetrons, eliminating the need for noisy and less efficient cooling fans.

The most immediately obvious benefit to the operator of liquid cooling is that eliminating the magnetron cooling fans allows ultraWAVE 3 to operate silently. As noise pollution is

becoming an increasing issue in today's working environments, a quiet system is a welcome relief and much more pleasurable to have in the lab.

Furthermore, when magnetrons get hot, they tend to emit less microwave energy (i.e., power). Providing better cooling efficiency to the magnetrons allows ultraWAVE 3 to deliver higher and more consistent microwave power to the reaction chamber, which is helpful for challenging digestions involving high temperatures and larger sample masses, as well as for performing back-to-back digestions for all-day operation. Operating at lower temperatures due to the more effective cooling also reduces the stress on the magnetrons and their related components, which can help increase the reliability and lifetimes of the magnetrons and other electronics.

For laboratories that experience wide fluctuations in temperature, cooling the magnetrons with ambient air can also make them less stable with respect to their power output. Replacing cooling fans with more consistent water cooling helps to ensure stable power delivery to the reaction chamber, leading to more reliable and reproducible digestion conditions and performance. Water cooling additionally eliminates the corrosion risks to the internal electronic components that would be present if the system is installed in a corrosive or dirty environment, also leading to lower maintenance costs over the lifetime of the system.

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SYSTEM STATUS INDICATOR

The color-coded system status indicator for ultraWAVE 3 has transitioned from use of a backlit Milestone logo on previous systems, to a light that fills the entire reactor working compartment of the system and can be easily seen from across the laboratory (see Figure 8).



Figure 8: color-code system status indicator

In busy laboratories where instrument operators are often responsible for multiple tasks, having a simple, “at-a-glance” knowledge of the status of an operation can make the operators more efficient in the use of their time.

NEW CONTROL TERMINAL

User control of ultraWAVE 3 has gone from the use of a separate tethered terminal to an integrated industrial tablet (see Figure 9). This new controller features a 10.1-inch (diagonal) capacitive-type touch screen, multiple USB ports, LAN connectivity, and optional Bluetooth™ and Wi-Fi connections. The availability of multiple connectivity options provides the flexibility for using ultraWAVE 3 in a variety of settings with

respect to laboratory networks and preferred communication modes, simplifying the installation of the system and reducing the need for the customized IT work required for less flexible systems.

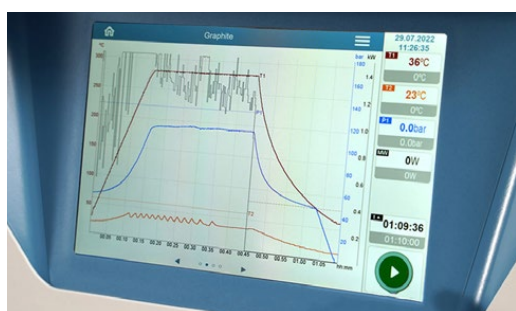


Figure 9: new integrated control terminal

EASYCONTROL 3.0

ultraWAVE 3 is operated using Milestone’s new easyCONTROL 3.0 software. This software incorporates several features that advance the state-of-the-art in usability for which ultraWAVE is already known. Features include a new customizable, icon-driven home screen and shortcut menu to help streamline system operation, an always-

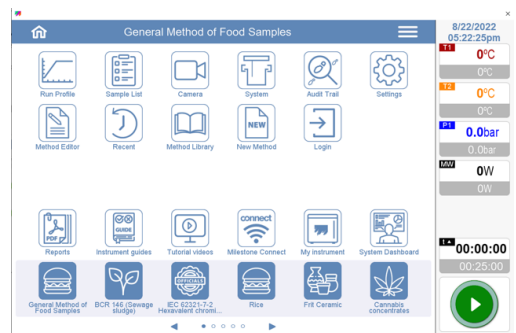


Figure 10: Home page with sidebar

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present sample and system status sidebar to provide the user rapid feedback regarding a digestion program in progress (see Figure 10-11), and a system dashboard to provide information on the total number of samples processed and the system condition.

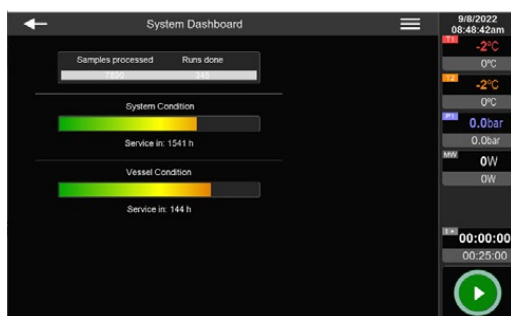


Figure 11: Dashboard

The exclusive-to-users Milestone Connect service is now integrated into easyCONTROL 3.0 (see Figure 12), in addition to being available through a separate device. This service provides always up-to-date on-line user-support aids such as tutorial videos, an applications library, technical documents, spare parts lists, and numerous tips and techniques to optimize use of the digestion system.

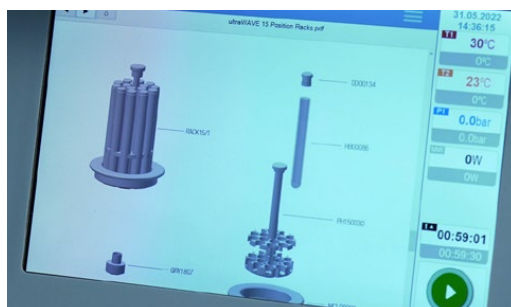


Figure 12: Milestone Connect for online user support

Other advanced features of easyCONTROL 3.0 include a remote-control function that allows the user to view and even control certain operations of the system while it is in use. This feature can also be used to perform service diagnostics on the system from a remote location, potentially avoiding unnecessary and costly in-person service calls. The software also includes a full Search function and the option of a modern “dark mode” screen configuration that has become popular (again) due to its greater usability in certain environments.

It is universally accepted that the quality of a user interface has direct correlations to the usability of a product as well as the overall user experience. Built on over two decades of experience in delivering task-oriented, easy-to-use software, easyCONTROL 3.0 incorporates the kind of advances that take users, and thus the ultraWAVE system, to new levels of efficiency and user satisfaction, the impacts of which include less operator time, reduced training burden, and improved performance because of fewer errors. The IT-friendly communications options also help decrease the total cost of ownership.

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SUMMARY

The development of a truly impactful next-generation SRC-based microwave digestion system required the examination of every aspect of the hardware, software, user experience, and economics of the existing system. ultraWAVE 3 is the culmination of a multitude of both major and minor changes that impact each of these aspects in meaningful ways that are summarized below:

Higher Productivity – number of samples that can be digested in a day/week/month/year.

- Increased rack capacities by up to 40%
- Automatic pressurization and flushing of chamber and lines
- Maximized heating source efficiency

Higher Performance – improved detection limits, accuracy, and reproducibility.

- Higher total sample mass per run
- Improved reaction chamber base load homogeneity
- Higher sustained digestion temperatures
- Potential contamination sources eliminated
- Contactless, more accurate digestion temperature control
- Optional stirring capability

Greater Safety – reduced risk of hazardous conditions.

- Superior digestion temperature control
- More rugged high-pressure lines
- Automatic pressurization and flushing of chamber and lines
- Easier handling of acid-containing components
- Optional stirring capability

Greater Usability – more efficient system operation.

- Better grip on vials and chamber liner
- Easier rack mounting
- Automatic pressurization and flushing of chamber and lines
- More intuitive software
- Larger display
- Integrated tutorial-based training
- Flexible connectivity

Lower Total Cost of Ownership – reduced costs of operation and maintenance.

- Rugged, more thermal-resistant racks
- Quartz reaction chamber bottom
- Longer-life temperature sensor
- Chemical-resistant high-pressure lines
- Longer-life magnetrons
- Longer-life high-voltage components
- Scalable Preventive Maintenance plans

Superior Working Conditions – a pleasure to have in the lab.

- Lower operator time required
- Simplified manual operations
- No cooling fan noise
- Attractive design



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