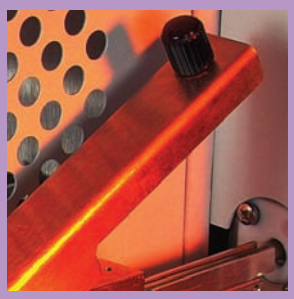
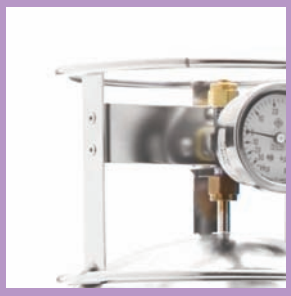
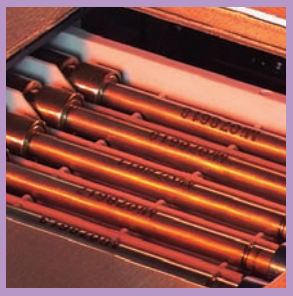
# Thermal Desorption Accessories & Consumables



2013/2014

MARKES international

# World-leading products for thermal desorption

# Contents

## Ordering information

Ordering from Markes couldn't be simpler, either by phone, fax, email or online. Payment is accepted by credit card (Mastercard or Visa) on account. If you need help with your order, simply contact one of our highly experienced chemists or customer service agents at either of Markes' main sales locations:

- Markes International Ltd
  Gwaun Elai Medi Science Campus
  Llantrisant
  RCT
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  United Kingdom

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www.markes.com/Global-Distributors.aspx

## Introduction to Markes International

Formed in 1997, Markes International Ltd is the world's foremost supplier of thermal desorption (TD) equipment, accessories and consumables for monitoring trace toxic and odorous chemicals in air, gas and materials. Serving a wide range of markets from environmental, health & safety to materials testing, and from food/flavour/fragrance to defence/forensic, Markes' global customer base includes major industry, government agencies, academia and the service laboratory sector.

Markes is globally recognised for its innovation, high-quality products, technical expertise and customer service within the field of analytical thermal desorption.

To complement its leading-range of instruments, Markes also has an unrivalled range of TD accessories and consumables. Many of these are also compatible with thermal desorption systems from other manufacturers.

## Quality-assured accessories and consumables from the TD experts

When it comes to accessories and consumables for thermal desorption, we offer our customers nothing but the best:

- Application expertise that is second-to-none
- Fast delivery and excellent customer service
- Innovative technologies and product enhancements
- World-leading, patented technologies for thermal desorption
- Stringent quality control of our manufacturing procedures
- ISO 9001 accreditation
- Worldwide distributor and user base
- Online shop for simple and rapid ordering
- Custom service – if you want something special, we can do it

**And most importantly... a 100% quality guarantee.**
If you're not satisfied with the products we supply, we will provide replacements or give you your money back, whichever you prefer.

# Sorbent tubes

Markes International is the world's leading supplier of TD systems and associated sampling equipment. In this section, we have used our expertise to select the best sorbent tubes for a wide range of air and vapour monitoring applications.

Backed up by fast and friendly service, Markes' tubes provide optimum sampling and analytical performance. Our range includes everything from cost-effective packages of industry-standard tubes to the last word in sorbent tube innovation.



## Markes' sorbent tubes – The best in the business

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## Markes' sorbent tubes – Quality assured

As well as the inherent advantages of buying your thermal desorption accessories from the TD experts at Markes, we offer an outstanding service for sorbent tubes.

Order your sorbent tubes from us and benefit from:

- ✓ The world's widest range of sorbent tubes and related accessories
- ✓ Our capping and conditioning service, for tubes that are ready to use on delivery
- ✓ Stringent quality control of every tube
- ✓ Markes' ISO 9001-accredited manufacturing procedures
- ✓ All tubes etched with a unique serial number for easy identification, and barcoded for rapid automation
- ✓ Flexible options for tube banding, etching and labelling
- ✓ Great value for money
- ✓ Online shop for simple, secure and rapid ordering
- ✓ Custom service – if you want something special, we can do it.



***Outstanding service from an outstanding company – Buy your sorbent tubes from the TD experts at Markes***

## Sorbent tube options

Markes supplies an unrivalled choice of tubes. If you would like advice about which sorbents or sampling options to choose, please contact our specialists at consumables@markes.com, or consult Application Note TDTS 5p 92.

Our tubes are packed to a tolerance of ±2.5% or better, and each one is flow-checked prior to shipment. For quality assurance, every pack of tubes comes with a signed-and-dated quality report.

### Stainless steel tubes

Stainless steel tubes are suitable for the majority of VOC air monitoring applications across a wide range of compound types and atmospheric concentrations. They can be used for both pumped and diffusive (passive) sampling. For pumped sampling applications, use of more than one sorbent bed can greatly extend the analyte range.

### Inert-coated stainless steel tubes

Inert-coated stainless steel tubes have an extremely thin inert layer bonded to the metal surfaces of the tube and the front sorbent-retaining gauze. This makes these tubes suitable for sampling thermally labile and reactive compounds. As the tube dimensions are not affected by this coating, they also remain compatible with diffusive sampling.

### Glass tubes

Markes' glass tubes are also widely used for sampling reactive species, and have a sorbent-retaining restriction 15 mm from one end for optimum performance both during air sampling and thermal desorption analysis. Specially treated glass tubes are also available for compatibility with amines.

Glass tubes are also popular for direct desorption of materialsp 62, as they allow easy assessment of the state of the sample after desorption. In this case, we recommend the use of tubes with a restriction 30 mm from the end, because this helps ensure the sample material is positioned correctly within the tube.

### DAAMS tubes

Depot Area Air Monitoring Systems (DAAMS) tubes can be constructed from either glass, stainless steel or inert-coated stainless steel. We supply both regular and high-flow DAAMS tubes with 6 mm ends[1], but are also happy to discuss your specific DAAMS tube requirements.

***If you've got any questions or need any advice, please contact us (consumables@markes.com)***


***Specialist DAAMS tubes – also available barcoded***

1. Standard DAAMS tubes: 4½″ (115 mm) long × 6 mm o.d.
   High-flow DAAMS tubes: 4½″ (115 mm) long × 10 mm o.d. with 6 mm o.d. ends (available in glass only).

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## SafeLok™ technology for sorbent tubes

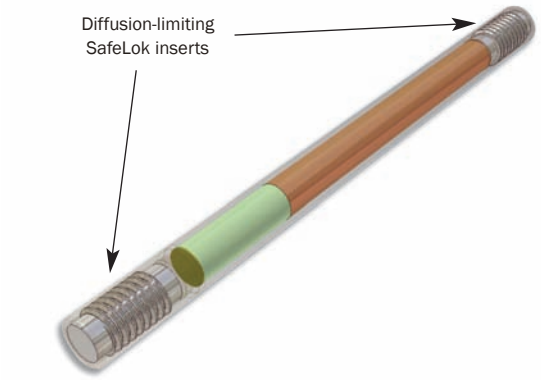
Markes' patented diffusion-locking technology provides unrivalled protection for trace and toxic samples.

SafeLok tubes incorporate a diffusion-locking insert at each end, preventing ingress or loss of volatiles when trace-level samples are being uncapped and recapped in the laboratory. This allows the integrity of clean and sampled tubes to be maintained throughout storage, transport and analysis.

By eliminating diffusive ingress, SafeLok tubes allow pumped sampling over extended periods at low flow rates (1–2 mL/min). The SafeLok inserts also make it safe to handle tubes that have been used to collect very toxic compounds.

SafeLok tubes are available in stainless steel or inert-coated stainless steel, and contain the same mass and bed length of sorbent as standard tubes. They are fully compliant with key international methods for pumped sampling, *i.e.* published data on retention and safe sampling volume data (see Application Note TDTS 20 for further detailsp92).

SafeLok tubes are compatible with all Markes' TD instrumentation and most standard tube fittings and accessories, including Markes' low-flow sampling pumpp32, storage capsp20, DiffLok capsp21, TubeTAGp7, the TC-20 conditioning unitp50, and the MTS-32 sequential samplerp33.




***Schematic of SafeLok tube packed with two sorbents***

***SafeLok and standard tubes***

## *SafeLok tubes – Guaranteeing sample integrity*

## TubeTAG™ – The ultimate in sorbent tube informatics

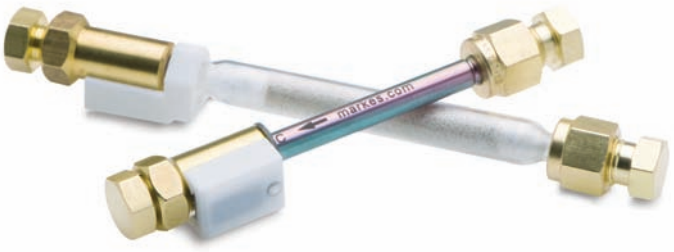
Markes' patented TubeTAG system is the world's first electronic tagging and labelling system for thermal desorption tubes. TubeTAG allows tube- and sample-specific information to be electronically associated with a particular tube for the duration of a monitoring project, or for the whole life of the tube.

TubeTAG provides a cost-effective and sophisticated solution for recording tube history and for fail-safe tracking of tubes in transit during field monitoring projects. Radio-frequency identification (RFID) technology allows information such as sample collection details to be associated with each tag. Information can be written to the tags in the field, and all stored information downloaded once back in the laboratory.

Markes' thermal desorption autosamplers include TubeTAG read/write capability as standard, but tags can alternatively be removed for compatibility with other systems (see the TAGLok tool on page 19).

Note that pre-tagged tubes require either TAG*SCRIBE* (see page 19) or a TAG-ready Markes TD autosampler to allow full functionality.

For further information about TubeTAG, please contact one of our specialists (enquiries@markes.com), or visit our website to download the brochure.





***Track the history of every tube for optimum quality assurance***

## Tube labelling – Standard features

Tube labelling is provided as standard on Markes tubes[1], and complements our innovative TubeTAG technologyp 19. Tube labelling helps you keep track of samples and tube stock, and is a major step forward in routine quality control for TD laboratories.

Labels are laser-etched onto metal tubes, and applied with kiln-fired ceramic decal on glass tubes (black on a white background), ensuring that they are both clear and permanent. Our standard tube labels comprise the following three components:

### Serial number

Every sorbent tube has a unique serial number on the side to allow rapid, visual identification every time.

The serial number is presented in a large clear font on both metal and glass tubes, and is visible even when the tube is capped and sealed.

### Barcoding

The unique tube serial number also appears on the side of each tube in barcode form. This reduces errors when recording and tracking tubes, and eliminates time-consuming manual data entry. It is especially useful for large-scale monitoring studies and for laboratories with significant tube stock.

Markes' barcodes use Code 128 symbology, which, with its higher information density and check-sum feature, is fast becoming the international standard. For rapid and reliable barcode-scanning, we especially recommend one of the high-performance barcode readers shown on the next page.

Markes also offers a barcoding service for existing metal tubes. Please contact enquiries@markes.com for more details.

### Sampling arrow

The side of every sorbent tube has an arrow indicating the direction of the air/gas sampling flow. This minimises risk of errors during field monitoring.


*Markes' tube labelling – Tube tracking made simple*

1. Excluding glass DAAMS tubes and glass tubes with a restriction at 30 mm.

## Tube labelling – Further options

In addition to the standard tube labelling features described on the previous page, Markes offers you the ability to tailor labels on metal tubes to your own requirements[1]. These options include alphanumeric labelling and tube banding – just let us know what you'd like.

### Alphanumeric etching (*metal tubes only*)

Alphanumeric etching allows you to specify up to 10 characters (A–Z, 0–9) to be laser-etched on the side of metal tubes. Popular examples of etching include specification of:

- The maximum safe temperature for the sorbents (*e.g.* TMax 320C)
- The tube type (*e.g.* Tnx/C5TD)
- Details of the company or department (*e.g.* Jones Chem).

Just include clear details of your special etching requirements with your order, or contact one of our technical specialists to discuss the best option for you.


### Banding (*metal tubes only*)

Banding is perfect for rapid visual identification of sorbent tubes – for example, a particular sorbent combination or tubes associated with a specific project or application.

Metal tubes can be permanently marked with up to five black bands. Specify your tube banding requirements on your order, or contact a Markes specialist to discuss your requirements in more detail.


## Barcode readers for sorbent tubes

We supply a range of barcode readers for accurate and reliable reading of barcodes on Markes' metal and glass sorbent tubes.

We offer corded USB-powered barcode readers for at-screen use, as well as cordless models (with a docking station) for remote operation. Advanced barcode readers have a screen for automatic display of scanned information, and an integral memory to hold information about the tubes scanned prior to download onto a PC.

Contact us for more information about the range of barcode readers we offer, and to identify the best one for your application.

***Examples of barcode readers available from Markes***

1. Please note that tubes with alphanumeric etching and banding are made to order, and are not available as stock items.

## Our most popular sorbent tubes

***All these tubes are industry-standard size (3½″ × ¼″), and are supplied in packs of 10***


### Empty tubes

| Description (all in packs of 10) | Tube code |
|---|---|
| Stainless steel | C0-AXXX-0000 |
| Inert-coated stainless steel | C0-CXXX-0000 |
| Glass, with restriction at 15 mm | C0-BXXX-0000 |
| Glass, with restriction at 30 mm | C0-NXXX-0000 |
| Glass, unrestricted | C0-FXXX-0000 |

### Stainless steel tubes

| Description (all in packs of 10) | Tube code | |
|---|---|---|
| | Unconditioned, without caps | Conditioned and capped |
| Packed with Tenax TA | C1-AXXX-5003 | C1-AAXX-5003 |
| Packed with Tenax TA/Carbograph 1TD | C2-AXXX-5032 | C2-AAXX-5032 |
| Packed with Carbograph 2TD/Carbograph 1TD | C2-AXXX-5126 | C2-AAXX-5126 |
| Packed with Carbograph 1TD/Carboxen 1003 (air toxics) | C2-AXXX-5270 | C2-AAXX-5270 |
| Packed with Tenax TA/Carbograph 1TD/Carboxen 1003 (universal) | C3-AXXX-5266 | C3-AAXX-5266 |

### Inert-coated stainless steel tubes

| Description (all in packs of 10) | Tube code | |
|---|---|---|
| | Unconditioned, without caps | Conditioned and capped |
| Packed with Tenax TA | C1-CXXX-5003 | C1-CAXX-5003 |
| Packed with Tenax TA/SulfiCarb | C2-CXXX-5314 | C2-CAXX-5314 |

### Glass tubes, with restriction at 15 mm

| Description (all in packs of 10) | Tube code | |
|---|---|---|
| | Unconditioned, without caps | Conditioned and capped |
| Packed with Tenax TA | C1-BXXX-5039 | C1-BAXX-5039 |
| Packed with Carbograph 1TD/Carboxen 1003 (air toxics) | C2-BXXX-5259 | C2-BAXX-5259 |

### Stainless steel tubes, fitted with SafeLok

| Description (all in packs of 10) | Tube code | |
|---|---|---|
| | Unconditioned, without caps | Conditioned and capped |
| Packed with Tenax TA | C1-DXXX-5003 | C1-DAXX-5003 |
| Packed with Tenax TA/Carbograph 1TD/Carboxen 1003 (universal) | C3-DXXX-5266 | C3-DAXX-5266 |

***If you can't see what you're looking for here, have a look at the tube configurator on page 14, or contact us (enquiries@markes.com)***

*N.B.* The tubes on this page use the following mesh sizes: Carbograph 1TD (40/60), Carbograph 2TD (40/60), Carboxen 1003 (60/80), SulfiCarb (40/70), Tenax TA (35/60).

## Your quick guide to sorbent selection

| Sorbent | Compound range | Temperature limits | Main features/comments |
|---|---|---|---|
| Carbograph 2TD<br>Carbopack C<br>Carbotrap C | n-$C_8$ to n-$C_{20}$ | • Up to 360°C for analysis<br>• 380°C for conditioning | • Hydrophobic<br>• Some activity<br>• Low background<br>• Individual artefacts <0.1 ng |
| Tenax TA | n-$C_{6/7}$ to ~n-$C_{30}$ | • 280–320°C for analysis<br>• 330°C for conditioning | • Inert and hydrophobic<br>• Individual artefacts in the order of 1–2 ng<br>• Very efficient release of high-boilers |
| Carbograph 1TD<br>Carbopack B<br>Carbotrap | n-$C_6$ to n-$C_{12/14}$ | • Up to 360°C for analysis<br>• 380°C for conditioning | • Some activity (*e.g.* with monoterpenes)<br>• Hydrophobic<br>• Low background<br>• Individual artefacts <0.1 ng |
| Carbograph 5TD<br>Carbopack X | Buta-1,3-diene to n-$C_7$ | • Up to 360°C for analysis<br>• 380°C for conditioning | • Some activity<br>• Hydrophobic<br>• Extensive conditioning may be required to remove high-boiling contamination<br>• Low background<br>• Individual artefacts <0.1 ng |
| Chromosorb 106 | n-$C_5$ to n-$C_{10}$ | • Up to 200°C for analysis<br>• 220°C for conditioning | • Hydrophobic<br>• Inert<br>• Extensive conditioning may be required to remove high-boiling contamination<br>• High background<br>• Individual artefacts >10 ng |
| SulfiCarb | $C_3$ to n-$C_6$ | • Up to 360°C for analysis<br>• Bring temperature up to 380°C slowly during conditioning | • Replaces UniCarb – see page 28 for more details<br>• Moderate water retention<br>• Inert<br>• Pumped sampling: use weaker carbon sorbent in front to prevent irreversible contamination with high-boilers<br>• Individual artefacts <1 ng |
| Carboxen 1003 | $C_3$ to n-$C_6$ | • Up to 360°C for analysis<br>• Bring temperature up to 380°C slowly during conditioning | • Moderate water retention<br>• Pumped sampling: use weaker carbon sorbent in front to prevent irreversible contamination with high-boilers<br>• Individual artefacts <1 ng |
| Carbosieve SIII | $C_2$ to n-$C_5$ | • Up to 360°C for analysis<br>• Bring temperature up to 380°C slowly during conditioning | • Significant water retention<br>• Pumped sampling: use weaker carbon sorbent in front to prevent irreversible contamination with high boilers<br>• Individual artefacts <1 ng |

***Should you have any questions about sorbents, please contact our experts at enquiries@markes.com***

# Application-specific sorbent tubes

We've drawn on our analytical experience to suggest the optimum sorbent tubes for seven key applications.

All the tubes listed on these pages come in packs of 10, and are supplied conditioned and capped. Contact us if you'd like to check whether they'll be suitable for your application, or if you'd be interested in a modified tube type.

## Soil gas/vapour intrusion

Soil gas tubes are ideal for identifying underground contamination sources and for assessing the potential risk to human health from vapour intrusion into nearby buildings. They are compatible with everything from light hydrocarbons to middle-distillate fuels.

| | |
|---|---|
| **Tube type** | Stainless steel |
| **Sorbent(s)** | Quartz wool/Tenax TA/Carbograph 5TD |
| **Tube code** | C3-AAXX-5304 |
| **Target analytes** | n-$C_4$ to n-$C_{30/32}$ |

## Air toxics

'Air toxics' range in volatility from propylene to hexachlorobuta-1,3-diene, and include polar as well as apolar organic compounds. The tubes specified below easily cover this range of analytes, and when used with Markes' TD system are perfect for complying with USA EPA Method TO-17.

| | |
|---|---|
| **Tube type** | Glass |
| **Sorbent(s)** | Carbograph 1TD/Carboxen 1003 (air toxics) |
| **Tube code** | C2-BAXX-5259 |
| **Target analytes** | $C_{2/3}$ to n-$C_{14}$ |


## Tubes for monitoring unknown atmospheres

This optimised combination of three sorbents allows near-universal screening of (S)VOCs in uncharacterised indoor and outdoor environments, while the use of SafeLok technology makes these tubes very resistant to analyte losses and contamination.

| | |
|---|---|
| **Tube type** | Stainless steel with SafeLok insert |
| **Sorbent(s)** | Tenax TA/Carbograph 1TD/ Carboxen 1003 |
| **Tube code** | C3-DAXX-5266 |
| **Target analytes** | $C_{2/3}$ to n-$C_{30/32}$ |

## Odorous emissions

Sulfur compounds such as thiols have unpleasant odours even at trace concentrations, and are also thermally labile. They are indicative of meat decomposition, and are present in emissions from landfill sites, sewage farms and some industrial processes. Reliable detection of these challenging analytes requires both an inert-coated tube and a carefully optimised sorbent combination.

| | |
|---|---|
| **Tube type** | Inert-coated stainless steel |
| **Sorbent(s)** | Tenax TA/SulfiCarb |
| **Tube code** | C2-CAXX-5314 |
| **Target analytes** | Thiols (mercaptans) |

## Material emissions testing and indoor air

The material emissions tube detailed below extends the range of compounds that can be sampled and analysed quantitatively, and is particularly suitable for use with Markes' Micro-Chamber/Thermal Extractor[p52]. It complies with recommendations in the latest edition of ISO 16000-6 (Annex D) for monitoring VVOCs, VOCs and SVOCs in material emissions and in indoor air.

| | |
|---|---|
| **Tube type** | Stainless steel |
| **Sorbent(s)** | Quartz wool/Tenax TA/Carbograph 5TD |
| **Tube code** | C3-AAXX-5304 |
| **Target analytes** | n-$C_4$ to n-$C_{30/32}$ |

## CWA monitoring

Tenax TA is the most widely used sorbent for monitoring chemical warfare agents (CWAs).

| | |
|---|---|
| **Tube type** | Glass DAAMS |
| **Sorbent(s)** | Tenax TA |
| **Tube code** | C1-LXXX-7001 |
| **Target analytes** | Most of the 'G' agents (GB, GD, GF, GA and homologues such as ethylsarin and crotylsarin), mustard gas (HD), VX and Russian VX, amongst others |

HayeSep D is also used to monitor the derivitised G analogue of VX (obtained by passing VX over a pad impregnated with AgF).

| | |
|---|---|
| **Tube type** | Glass DAAMS |
| **Sorbent(s)** | HayeSep D |
| **Tube code** | C1-LXXX-7003 |
| **Target analytes** | G analogue of VX |

## Direct desorption of materials

The glass tubes recommended below guarantee correct positioning of material samples within the tube, and allow easy inspection of the state of the sample before and after analysis.

| | |
|---|---|
| **Tube type** | Glass, with restriction at 30 mm |
| **Sorbent(s)** | — |
| **Tube code** | C0-NXXX-0000 |
| **Target analytes** | — |

***Glass tube with restriction at 30 mm – Ideal for direct desorption***

## *Tried-and-tested monitoring solutions for challenging applications*

# 14

## Markes' tube configurator

Whatever combination of tube type and sorbent(s) you need, this tube configurator and associated code tables on page 15 will help you construct the correct part number.

Alternatively, let our thermal desorption specialists help you configure a bespoke sorbent tube for your application – see page 15.

Part numbers should be constructed using the following format, using the letters/numbers defined below:

**C N-$X_1$ $X_2$ $X_3$ $X_4$-####**

| Step | Code | Description |
|---|---|---|
| Prefix letter | C | |
| Number of sorbent beds (N) | 0 | Empty tube |
| | 1 | 1 sorbent bed |
| | 2 | 2 sorbent beds |
| | 3 | 3 sorbent beds |
| Tube type ($X_1$) | A | Stainless steel tube, 3½″ × ¼″ |
| | B | Glass tube, 3½″ × ¼″, restriction at 15 mm |
| | C | Inert-coated stainless steel tube, 3½″ × ¼″ |
| | D | Stainless steel SafeLok tube, 3½″ × ¼″ |
| | E | Inert-coated stainless steel SafeLok tube, 3½″ × ¼″ |
| | F | Glass tube, 3½″ × ¼″, unrestricted |
| | G | Repacked tube |
| | H | Unpacked/repacked tube |
| | L | Glass DAAMS tube, 4½″ × 6 mm |
| | M | Glass DAAMS tube, 4½″ × 10 mm with 6 mm ends (high-flow) |
| | N | Glass tube, 3½″ × ¼″, restriction at 30 mm |
| | P | Glass tube, 3½″ × 6 mm, unrestricted |
| | Q | Glass tube, 3½″ × 6 mm, restriction at 15 mm |
| | R | Inert-coated glass tube, 3½″ × ¼″, restriction at 15 mm (for amine analysis) |
| Tube conditioning ($X_2$) | A | ¼″ tubes, conditioned and capped with brass storage caps |
| | B | 6 mm tubes, conditioned and capped with brass storage caps |
| | C | TubeTAG-fitted ¼″ metal tubes, conditioned and capped with brass storage caps |
| | D | TubeTAG-fitted ¼″ glass tubes, conditioned and capped with brass storage caps |
| | E | TubeTAG-fitted 6 mm glass tubes, conditioned and capped with brass storage caps |
| | F | Tubes conditioned only (customer to supply caps) |
| | X | Tubes not conditioned or capped |
| TubeTAG ($X_3$) | A | TubeTAG attached to stainless steel tubes (¼″) |
| | B | TubeTAG attached to glass tubes (both ¼″ and 6 mm) |
| | X | No TubeTAG required |
| Tube labelling options ($X_4$) | A | Etching or banding (*metal tubes only*) – please contact us to discuss options |
| | X | No etching, banding, or colour labelling required |
| **Four-digit sorbent code** | #### | See page 15 for popular sorbent codes. For empty tubes use 0000 |

### Hints and tips:

- Ensure you match the o.d. of your tubes (¼″ or 6 mm) to the correct storage caps.
- If using the TubeTAG option, check that you've chosen the right storage caps for your tubes (stainless steel or glass).

## Four-digit codes for popular sorbent combinations

To help you construct part numbers for industry-standard 3½″ × ¼″ sorbent tubes using the tube configurator, we've listed some popular sorbent combinations in the following tables.

### Single-bed sorbent tubes

| Sorbent | Metal tubes Code | Glass tubes Code |
|---|---|---|
| Tenax TA | 5003 | 5039 |
| Tenax GR | 5005 | 5041 |
| Carbograph 1TD | 5009 | 5045 |
| Chromosorb 106 | 5004 | 5040 |
| HayeSep D | 5153 | 5170 |
| Carbograph 5TD | 5015 | 5051 |
| SulfiCarb | 5312 | 5313 |
| Carboxen 1003 | 5277 | 5258 |

### Two-bed sorbent tubes

| Sorbents[1] | Metal tubes Code | Glass tubes Code |
|---|---|---|
| Quartz wool/Carbograph 2TD | 5141 | 5134 |
| Quartz wool/Tenax TA | 5138 | 5189 |
| Quartz wool/HayeSep D | 5146 | 5196 |
| Carbograph 2TD/Carbograph 1TD | 5126 | 5197 |
| Tenax TA/Carbograph 1TD **(Hydrophobic)** | 5032 | 5068 |
| Tenax TA/Carbograph 5TD | 5149 | 5201 |
| Tenax TA/SulfiCarb **(Landfill gas/odorous emissions)** | 5314 | 5315 |
| Carbograph 1TD/Carbograph 5TD | 5180 | 5203 |
| Carbograph 1TD/Carboxen 1003 **(Air toxics)** | 5270 | 5259 |

### Three-bed sorbent tubes

| Sorbents[1] | Metal tubes Code | Glass tubes Code |
|---|---|---|
| Quartz wool/Carbograph 2TD/Carbograph 1TD | 5164 | 5212 |
| Carbograph 2TD/Carbograph 1TD/Carbosieve SIII | 5163 | 5216 |
| Carbopack C/Carbopack B/Carbosieve SIII **(TO-17, type 3)** | 5035 | 5071 |
| Tenax TA/Carbograph 1TD/Carbograph 5TD | 5154 | 5217 |
| Tenax TA/Carbograph 1TD/Carboxen 1003 **(Universal)** | 5266 | 5267 |
| Carbograph 1TD/Carbograph 5TD/Carboxen 1003 | 5273 | 5274 |
| Quartz wool/Tenax TA/Carbograph 5TD **(Material emissions and soil gas)** | 5304 | 5310 |

1. Tubes containing two or three sorbents are packed by mass to give approximately equal bed lengths for each sorbent; quartz wool is packed to ~1 cm bed length.

## Bespoke solutions for sorbent tubes

Should you not see what you're looking for on the preceding pages, then you may be interested in our custom service.

Over the years, we've developed custom solutions for numerous TD users – from special-dimension DAAMS tubes to customer-specified banding.

Each custom solution is treated as a stand-alone project on our system, meaning that one of our specialists will be dedicated to working with you.

Simply contact us if you're interested in:

- labelling or barcoding of existing tubes
- custom labelling of glass tubes
- non-standard tube dimensions
- alternative sorbent mesh sizes, bed lengths, or packing mixes
- our tube unpacking and repacking service
- our conditioning service for existing tubes
- any other query you may have.

***Contact consumables@markes.com with details of your request***

*N.B.* The tubes on this page use the following sorbent mesh sizes: Carbograph 1TD (40/60), Carbograph 2TD (40/60), Carbograph 5TD (40/60), Carbopack B (60/80), Carbopack C (60/80), Carbosieve SIII (60/80), Carboxen 1003 (40/60), Chromosorb 106 (60/80), HayeSep D (60/80), SulfiCarb (40/70), Tenax TA (35/60), Tenax GR (35/60).

# Tube accessories

Markes offers a range of tube accessories to support every TD application. From tools to assist with routine tube maintenance and storage, to labour-saving tube inserts for direct desorption, Markes' tube accessories are designed to make your life easier.



## Practical tools for enhanced tube sampling

## Gauzes, springs and clips

### Sorbent-retaining gauzes for metal tubes

Markes' sorbent-retaining gauzes are manufactured to precise tolerances to ensure that they correctly fit the front groove of metal (stainless steel or inert-coated) tubes. The placement of the front gauze is critical for diffusive sampling, as it defines the diffusion gap on which uptake rate data is based (for more information, see Application Note TDTS 8p92). All Markes' 3½″ metal tubes are supplied with this front gauze correctly and firmly fitted. Gauzes can also be used to separate sorbent beds in metal multi-sorbent tubes. For inert-coated tubes, gauzes in contact with the sample stream are also inert-coated.

### Gauze-retaining springs

Gauze-retaining springs are used in metal tubes to ensure the rear sorbent-retaining gauze remains positioned correctly on top of the sorbent bed. Springs can be inserted and removed from the tubes using Markes' labour-saving TubeMate tool.

### Torsion springs for glass tubes

Torsion springs are used in glass tubes to ensure that the rear plug of quartz wool remains positioned correctly on top of the sorbent bed. They may also be used during direct desorption of materials to secure the sample in place centrally in the heated zone of the tube.

### Penclips

Penclips attach to the groove on 3½″ metal tubes, so that they can be easily fastened to a lapel or pocket for personal monitoring.


| Description | Part number |
|---|---|
| Sorbent-retaining gauze, pk 20 | C-GZ020 |
| Sorbent-retaining gauze, pk 200 | C-GZ200 |
| Sorbent-retaining gauze, pk 2000 | C-GZ2000 |
| Sorbent-retaining gauze, inert, pk 10 | C-GZI10 |
| Sorbent-retaining gauze, inert, pk 100 | C-GZI100 |
| Gauze-retaining spring, pk 10 | C-SP010 |
| Gauze-retaining spring, pk 100 | C-SP100 |
| Spring, torsion, for 4 mm i.d. glass tubes, pk 10 | C-GTSP10 |
| Penclip, pk 10 | C-CL010 |
| Penclip, pk 100 | C-CL100 |

## Tools

### CapLok™ tool

Long-term storage capsp20 must be correctly tightened in order to ensure a leak-tight seal. Caps are recommended to be tightened 'finger-tight plus quarter turn'. Although this is possible with conventional spanners/wrenches, using two spanners can be awkward, and can lead to incorrect positioning of caps and other errors. For example, over-tightening of the caps may cause distortion of the PTFE ferrules and a leak in the seal. In extreme cases it is even possible to break the ends of glass tubes or deform the ends of steel tubes.

Markes' CapLok tool overcomes all these issues. It was designed by scientists at INERIS (l'Institut National de l'Environnement Industriel et des Risques, France) specifically to simplify tube capping/uncapping procedures and minimise the risk of errors. The CapLok tool is manufactured exclusively by Markes International[1].

### TubeMate™ tool

TubeMate is used to insert (and remove) gauze-retaining springs in metal tubes. Once the spring is partially inserted into the end of the tube, TubeMate grips the spring and enables it to be twisted into place with very little effort. Reversing this process aids the removal of the springs when unpacking old tubes. The other end of the TubeMate tool can also be used to position the rear sorbent-retaining gauze on the sorbent surface[2].

| Description | Part number |
|---|---|
| CapLok tool | C-CPLOK |
| CapLok tool, pk 10 | C-10LOK |
| TubeMate tool | C-TBMTE |

***CapLok and TubeMate tools, gauzes, gauze-retaining springs and penclips***

1. For tubes fitted with TubeTAGp7, a TAGLok toolp19 should be used. TAGLok fits both standard caps and tag-ready caps.
2. TubeMate is not recommended for accurate positioning of the primary sorbent-retaining gauze at the sampling end of the tube.

## TubeTAG accessories

Markes' patented TubeTAG system is the world's only electronic tagging and labelling system for glass and steel thermal desorption tubes. TubeTAG allows tube- and sample-specific information to be electronically associated with a particular tube for the duration of a monitoring project, or for the whole life of the tube. It is the ultimate quality-assurance system for sorbent tubes.

Accessories for TubeTAG are described below.

### Packs of tags for fitting to sorbent tubes

As well as sorbent tubes pre-fitted with tags, Markes offers loose tags for attaching to existing sorbent tubes – different versions are available for stainless steel and glass tubes.

Note that tagged tubes require special long-term storage caps, which are described on page 20.

#### TAG*SCRIBE* ™

Information is entered onto the tags either *via* a Markes' TAG-ready TD autosampler or a stand-alone PC-controlled TAG*SCRIBE*. TAG*SCRIBE* device can be used prior to tube despatch, to enter sample information in the field, and to retrieve information from the tags after monitoring.

### Pumped sampling adaptor for tagged tubes

Pumped sampling adaptors ease the connection of tagged tubes to personal monitoring pumps.

***TubeTAG – The ultimate quality-assurance system for TD tubes***

### TubeTAG starter kit

A **TubeTAG starter kit** for stainless steel tubes is available in a convenient carry-case. The kit contains:

| | |
|---|---|
| TAG*SCRIBE* read/write device for all TubeTAGs | C-SCRIBE |
| TubeTAG for stainless steel tubes, pk 10 | C-TAG10 |
| TubeTAG fixing/removal tool for ¼" stainless steel tubes | C-TAGTL |
| Cap, brass, ¼" & PTFE ferrule (one standard, one tag-ready), pk 10 pairs, for ¼" metal tubes | C-TCFP10 |
| TAGLok tool for tightening/removing standard and TAG-ready ¼" storage caps | C-TAGLOK |


***TubeTAG kit***

**For further information about TubeTAG, please contact one of our specialists (enquiries@markes.com), or visit our website to download the brochure.**

| Description | Part number |
|---|---|
| TubeTAG for stainless steel tubes, pk 10 | C-TAG10 |
| TubeTAG for stainless steel tubes, pk 100 | C-TAG100 |
| TubeTAG for glass tubes, pk 10 | C-TAGG10 |
| TubeTAG for glass tubes, pk 100 | C-TAGG100 |
| TAG*SCRIBE* read/write device for all TubeTAGs | C-SCRIBE |
| TubeTAG fixing/removal tool for stainless steel tubes | C-TAGTL |
| TubeTAG fixing/removal tool for glass tubes | C-TAGKY |
| TAGLok tool for tightening/removing standard and TAG-ready ¼" storage caps | C-TAGLOK |
| Pumped sampling adaptor, ¼" tubes, pk 10 | C-TPA10 |
| Pumped sampling adaptor, ¼" tubes, pk 100 | C-TPA100 |
| Pumped sampling adaptor, 6 mm tubes, pk 10 | C-TPAX10 |
| Pumped sampling adaptor, 6 mm tubes, pk 100 | C-TPAX100 |
| TubeTAG starter kit (for stainless steel tubes) | C-TAGKT |

## Long-term storage caps

For long-term storage (or transport) of conditioned or sampled tubes, two-piece metal storage caps fitted with one-piece PTFE ferrules (¼" or 6 mm i.d.) must be used. They are available in brass and lightweight aluminium. These caps are recommended by international standard methods such as US EPA Method TO-17, ASTM D6196 and EN ISO 16017, and have been validated for storage of sampled/blank tubes for up to 27 months[1]. The caps meet a stringent cleanliness specification and tight manufacturing tolerances.

For tubes fitted with TubeTAGp 7, an extended 'tag-ready' long-term storage cap must be used on the tagged end of the tube.

*Note that use of Markes' CapLokp 18 or TAGLokp 19 tools extend the life of combined PTFE ferrules, but that ferrules should nevertheless be replaced after approximately 20 operations.*

Standard ¼" brass and aluminium long-term storage caps for industry-standard tubes (stainless steel or glass)[2]

| Description | Part number |
|---|---|
| Cap, storage, brass, ¼" & PTFE ferrule, pk 10 | C-CF010 |
| Cap, storage, brass, ¼" & PTFE ferrule, pk 20 | C-CF020 |
| Cap, storage, brass, ¼" & PTFE ferrule, pk 100 | C-CF100 |
| Cap, storage, brass, ¼" & PTFE ferrule, pk 200 | C-CF200 |
| Cap, storage, aluminium, ¼" & PTFE ferrule, pk 20 | C-CFA20 |
| Cap, storage, aluminium, ¼" & PTFE ferrule, pk 200 | C-CFA200 |
| Ferrule, ¼", combined PTFE, pk 20 | C-FP020 |
| Ferrule, ¼", combined PTFE, pk 200 | C-FP200 |

6 mm brass long-term storage caps for 6 mm stainless steel tubes or glass tubes with 6 mm o.d. ends[2]

| Description | Part number |
|---|---|
| Cap, storage, brass, 6 mm & PTFE ferrule, pk 10 | C-CF010-XZ |
| Cap, storage, brass, 6 mm & PTFE ferrule, pk 20 | C-CF020-XZ |
| Cap, storage, brass, 6 mm & PTFE ferrule, pk 100 | C-CF100-XZ |
| Cap, storage, brass, 6 mm & PTFE ferrule, pk 200 | C-CF200-XZ |
| Ferrule, 6 mm, combined PTFE, pk 20 | C-FP020-XZ |
| Ferrule, 6 mm, combined PTFE, pk 200 | C-FP200-XZ |

1 F. Lindquist and H. Bakkeren, Stability of chlorinated hydrocarbons on Tenax, CEC commissioned report from TNO, No. R90/268, 1990.
2. These items are also suitable for the untagged end of ¼" or 6 mm stainless steel or glass tubes as appropriate.

Tag-ready ¼" brass long-term storage caps for industry-standard stainless steel tubes

| Description | Part number |
|---|---|
| Cap, brass, ¼" & PTFE ferrule, tag-ready, pk 10, for ¼" metal tubes | C-TCF10 |
| Cap, brass, ¼" & PTFE ferrule, tag-ready, pk 100, for ¼" metal tubes | C-TCF100 |

Tag-ready ¼" or 6 mm brass long-term storage caps for glass tubes

| Description | Part number |
|---|---|
| Cap, brass, ¼" & blind PTFE ferrule, tag-ready, pk 10, for ¼" glass tubes | C-T4GCF10 |
| Cap, brass, ¼" & blind PTFE ferrule, tag-ready, pk 100, for ¼" glass tubes | C-T4GCF100 |
| Cap, brass, 6 mm & blind PTFE ferrule, tag-ready, pk 10, for 6 mm glass tubes | C-T6GCF10 |
| Cap, brass, 6 mm & blind PTFE ferrule, tag-ready, pk 100, for 6 mm glass tubes | C-T6GCF100 |

Pairs of long-term storage caps for ¼" tagged tubes

| Description | Part number |
|---|---|
| Cap, brass, ¼" & PTFE ferrule (one standard, one tag-ready), pk 10 pairs, for ¼" metal tubes | C-TCFP10 |
| Cap, brass, ¼" & PTFE ferrule (one standard, one tag-ready), pk 100 pairs, for ¼" metal tubes | C-TCFP100 |

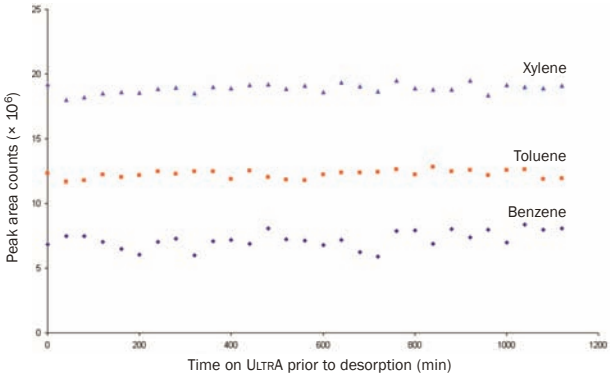

***CapLok tool, capped tube, and ¼" brass long-term storage caps***

## *Storage caps – For method-compliant tube storage*

## DiffLok™ caps

Tubes on all Markes' TD autosamplers (TD-100 and UltraA) are sealed with unique DiffLok caps, which simply push onto both ends of every tube. DiffLok caps use Markes' patented[1] diffusion-limiting technology (also found in SafeLok tubes[p6]), to preserve sample integrity by preventing both analyte loss and artefact ingress. They ensure that even volatile analytes are successfully retained, guaranteeing reproducible results for standards at the beginning and end of a 100-tube sequence.

DiffLok caps remain on the tubes throughout an analytical sequence. This preserves sample and tube integrity before and after desorption, but at the same time also simplifies the automatic TD process, thus optimising uptime and productivity. DiffLok caps have been field-proven to seal sampled and blank tubes much more effectively than alternative PTFE push-on caps incorporating PTFE-coated O-rings[2].




***No analyte loss from Tenax tubes capped with DiffLok caps and analysed on Markes' UltraA autosampler over a 24-hour period***

DiffLok caps are available for ¼″ and 6 mm o.d. tubes, and in stainless steel or inert-coated stainless steel. Inert-coated caps are only ever required for the sampling/desorption end of the tube when analysing reactive compounds. Replacement O-rings are also available for routine maintenance of the caps.

For DiffLok caps and O-rings compatible with 8 mm diameter DAAMS tubes, contact Markes (consumables@markes.com).

| Description | Part number |
|---|---|
| Cap, DiffLok, stainless steel, ¼″, pk 10 | C-DL010 |
| Cap, DiffLok, stainless steel, ¼″, pk 100 | C-DL100 |
| Cap, DiffLok, inert, ¼″, pk 10 | C-DLS10 |
| Cap, DiffLok, inert, ¼″, pk 100 | C-DL1S0 |
| Cap, DiffLok (one stainless steel, one inert), ¼″, pk 10 pairs | C-DLP10 |
| Cap, DiffLok (one stainless steel, one inert), ¼″, pk 100 pairs | C-DL1P0 |
| O-Ring, low-emission, pk 10 (replacements for ¼″ DiffLok caps) | U-COV10 |
| O-Ring, low-emission, pk 100 (replacements for ¼″ DiffLok caps) | U-COV100 |
| Cap, DiffLok, stainless steel, 6 mm, pk 10 | C-DL010-XZ |
| Cap, DiffLok, stainless steel, 6 mm, pk 100 | C-DL100-XZ |
| Cap, DiffLok, inert, 6 mm, pk 10 | C-DLS10-XZ |
| Cap, DiffLok, inert, 6 mm, pk 100 | C-DL1S0-XZ |
| Cap, DiffLok (one stainless steel, one inert), 6 mm, pk 10 pairs | C-DLP10-XZ |
| Cap, DiffLok (one stainless steel, one inert), 6 mm, pk 100 pairs | C-DL1P0-XZ |
| O-Ring, low-emission, pk 10 (replacements for 6 mm DiffLok caps) | U-COV45 |
| O-Ring, low-emission, pk 100 (replacements for 6 mm DiffLok caps) | U-COV450 |

***DiffLok caps maintain sample integrity throughout the analytical sequence***

1. UK Patent No. GB 2337513; US Patent No. US 6,564,656 B1.
2. Push-on PTFE caps have been shown to allow significant analyte loss – see: P.P. Ballesta, Losses from ATD-400, *The Diffusive Monitor*, 1997, issue 9.

## Short-term storage caps

Aluminium push-on caps with O-ring seals are convenient for short-term storage of cleaned or sampled ¼″ tubes, for example, when they are being analysed almost immediately after sampling. Note that push-on caps should not be used for long-term storage or transport of tubes.

| Description | Part number |
|---|---|
| Cap, push-on, aluminium, ¼″, pk 20 | C-AC020 |
| Cap, push-on, aluminium, ¼″, pk 200 | C-AC200 |

## Tube connection unions

Multi-bed sorbent tubes are commonly used for sampling atmospheres containing VOCs over a wide volatility range. However, single-bed sorbent tubes connected in series are a useful alternative, for example when monitoring breakthrough from the front (primary) tube.

Standard ¼″ o.d. tubes can be connected in series using ¼″–¼″ stainless steel unions fitted with the same one-piece PTFE ferrules used in ¼″ storage caps. After sampling, the tubes are disconnected, capped and stored individually prior to analysis. Linking sorbent tubes in series allows the use of sorbent combinations that cannot be packed into a single tube (*e.g.* Chromosorb and SulfiCarb). It also completely eliminates the risk of higher-boiling analytes migrating to the stronger sorbents during sample storage.

| Description | Part number |
|---|---|
| Unions, ¼″–¼″, stainless steel & ¼″ PTFE ferrules, pk 10 | C-UNS10 |
| Unions, ¼″–¼″, stainless steel & ¼″ PTFE ferrules, pk 100 | C-UNS100 |

## Sorbent tube shipment boxes

Markes provides two types of lightweight and robust storage boxes for convenient shipment of sorbent tubes:

- Standard ribbed cardboard box for a pack of 10 pre-packed (uncapped and unconditioned) industry-standard tubes
- Large ribbed cardboard box for a pack of 5 pre-conditioned, capped and/or tagged industry-standard tubes.

Storage boxes for DAAMS tubes are also available – please contact Markes for details (consumables@markes.com).

***Large ribbed storage box***

| Description | Part number |
|---|---|
| Box, 10-slot, unconditioned tubes, pk 10 | C-10BX10 |
| Box, 10-slot, unconditioned tubes, pk 100 | C-10BX100 |
| Box, 5-slot, conditioned/tagged tubes, pk 10 | C-5BX10 |
| Box, 5-slot, conditioned/tagged tubes, pk 100 | C-5BX100 |

# Sorbents

To complement our extensive range of pre-packed tubes, Markes offers a wide range of bulk sorbents for customers who wish to pack their own tubes, or who have other sorbent requirements.

Careful selection of sorbent type and mesh size is critical for the successful outcome of any thermal desorption application. Contact our team of specialists for expert help and advice, with fast and friendly service.



## Sorbents from Markes – Opening up a range of tube packing options

## Porous polymers

Most porous polymer sorbents are inert, making them suitable for the analysis of labile and reactive compounds such as thiols and CS gas. In addition, their broadly hydrophobic nature allows them to be used for sampling in humid conditions.

However, some porous polymer sorbents (Chromosorb, PoraPak and HayeSep) can exhibit high artefact levels[1], and may display significant batch-to-batch variation.

***For a quick guide to sorbent selection for different TD applications, see our Quick Reference Guide on page 11***

**Notes**

- Where several mesh sizes are available, recommended mesh sizes are marked by a '*'. Note that fine mesh sizes can lead to high tube impedance/back-pressure.
- Attention must be paid to the temperature limitations of sorbents, particularly when packing multi-bed sorbent tubes.

### Tenax® TA (35/60*, 60/80)
### Tenax® GR (35/60*, 60/80)

Tenax TA is arguably the world's favourite TD sorbent, offering quantitative trapping and efficient release for VOCs and SVOCs ranging in volatility from n-hexane to n-$C_{26}$ and above. It is the most thermally stable of the porous polymers, but still benefits from being used at the lowest practical temperature for the application, to minimise artefacts and extend tube life.

Tenax GR contains 23% graphitised carbon as an integral part of the material (the graphitised carbon is co-precipitated with the Tenax polymer). For some compounds, Tenax GR offers slightly higher breakthrough volumes than Tenax TA, and its use is widely reported in the scientific literature.

For both Tenax TA and Tenax GR, the 35/60 mesh size is strongly recommended for optimum performance in sorbent tubes.

| | |
|---|---|
| **Sorbent strength** | Weak |
| **Specific surface area** | ~35 $m^2/g$ |
| **Approx. analyte volatility range** | n-$C_7$ to n-$C_{30}$<br>b.p. 100 °C to 450 °C |
| **Example analytes** | Aromatics (except benzene);<br>apolar compounds b.p. >100 °C;<br>polar compounds b.p. >150 °C;<br>semi-volatile compounds, including many CW agents |
| **Recommended conditioning temp.** | Up to 330 °C |
| **Recommended desorption temp.** | Up to 320 °C |

### Hints and tips for Tenax

- Hydrophobic – great for humid atmospheres
- Low inherent artefacts (<1 ng) – good for trace-level monitoring
- Inert – suitable for labile components
- Do not exceed sorbent maximum temperature – sorbent will break down and may contaminate system flow path
- Repack sorbent tubes after 100 thermal cycles
- Allows efficient desorption, giving quantitiative recovery of high-boiling compounds and sharp GC peaks.

| Description | Part number |
|---|---|
| Sorbent, Tenax TA (35/60), 10 g | C-TNXTA |
| Sorbent, Tenax TA (60/80), 10 g | C-TNXTA60 |
| Sorbent, Tenax GR (35/60), 10 g | C-TNXGR |
| Sorbent, Tenax GR (60/80), 10 g | C-TNXGR60 |

1. M. Henderson, The effect of storage on blank levels of benzene and total hydrocarbons on Chromosorb 106 tubes, *The Diffusive Monitor*, 2000, issue 11.

## PoraPak™ Q (50/80)
## PoraPak™ N (50/80)

There are several PoraPak porous polymers available that vary both in strength (specific surface area) and polarity. The two most commonly used in thermal desorption applications are PoraPak Q and PoraPak N.

PoraPak Q is the weaker of these two sorbents – it is only slightly polar, and is a general-purpose PoraPak sorbent. PoraPak N is the most polar (and least thermally stable) PoraPak sorbent, and is typically used for monitoring volatile nitriles.

| | |
|---|---|
| **Sorbent strength** | Medium |
| **Specific surface area** | ~500 $m^2/g$ (Q)<br>~300 $m^2/g$ (N) |
| **Approx. analyte volatility range** | b.p. 50 °C to 200 °C |
| **Example analytes** | Oxygenated compounds (Q)<br>Volatile nitriles (N) |
| **Recommended conditioning temp.** | Up to 220 °C (Q)<br>Up to 170 °C (N) |
| **Recommended desorption temp.** | Up to 190 °C (Q)<br>Up to 165 °C (N) |

### Hints and tips for PoraPak

- PoraPak Q is hydrophobic, but PoraPak N is less so. Care is therefore required when using PoraPak N in humid environments.
- High artefacts (~10–50 ng/component) limits the use of these sorbents for trace-level monitoring, *e.g.* ambient atmospheres.
- Keep the desorption temperature to a minimum to reduce artefact levels
- Conditioned PoraPak may self-generate aromatic hydrocarbons over time. It is recommended that tubes packed with this sorbent are used as soon as possible after conditioning
- Inert – suitable for labile components
- Repack sorbent tubes after 50 thermal cycles
- Not generally suitable for:
  - Multi-bed sorbent tubes
  - Cold traps (special applications only)
  - Long-term (>8 h) diffusive sampling.

| Description | Part number |
|---|---|
| Sorbent, PoraPak N (50/80), 20 g | C-2PPKN |
| Sorbent, PoraPak Q (50/80), 20 g | C-2PPKQ |

**Other PoraPak sorbents (P, T, S, R, *etc.*) are available from consumables@markes.com on request.**

## Chromosorb® 102 (60/80)
## Chromosorb® 106 (60/80)

There are several Chromosorb Century series porous polymers varying in strength and polarity. The two most commonly used in thermal desorption applications are Chromosorb 102 and Chromosorb 106.

Chromosorb 102 is the weaker of these two medium-strength sorbents and is slightly polar. Chromosorb 106 is the strongest of the Chromosorb series and is completely non-polar. It is widely used in occupational hygiene TD applications.

| | |
|---|---|
| **Sorbent strength** | Medium |
| **Specific surface area** | ~350 $m^2/g$ (Chromosorb 102)<br>~750 $m^2/g$ (Chromosorb 106) |
| **Approx. analyte volatility range** | b.p. 50 °C to 200 °C |
| **Example analytes** | Chromosorb 102 is commonly used for monitoring volatile halogenated hydrocarbons in workplace air; Chromosorb 106 is used for benzene, volatile hydrocarbons and oxygenates |
| **Recommended conditioning temp.** | Up to 220 °C |
| **Recommended desorption temp.** | Up to 200 °C (see Hints and tips) |

### Hints and tips for Chromosorb

- Hydrophobic
- High artefacts (~10–50 ng/component) limits the use of these sorbents for trace-level monitoring, *e.g.* ambient atmospheres
- Keep the desorption temperature to a minimum to reduce artefact levels
- Conditioned Chromosorb may self-generate aromatic hydrocarbons over time. It is recommended that tubes packed with this sorbent are used as soon as possible after conditioning
- Inert – suitable for labile components
- Repack sorbent tubes after 100 thermal cycles or less
- Not generally suitable for:
  - Multi-bed sorbent tubes
  - Cold traps (special applications only)
  - Long-term (>8 h) diffusive sampling.

| Description | Part number |
|---|---|
| Sorbent, Chromosorb 102 (60/80), 20 g | C-2C102 |
| Sorbent, Chromosorb 106 (60/80), 20 g | C-2C106 |

**Other Chromosorb sorbents (101, 103, 105, 107, 108) are available from consumables@markes.com on request.**

## HayeSep® D (60/80)

HayeSep polymers were developed to exhibit less bleed and shrinkage than Chromosorb and PoraPak sorbents. HayeSep D is the strongest sorbent in this series. However, its use tends to be restricted to very specialised applications, *e.g.* monitoring volatile chemical warfare agents.

| | |
|---|---|
| **Sorbent strength** | Medium |
| **Specific surface area** | ~800 $m^2/g$ |
| **Approx. analyte volatility range** | n-$C_5$ to n-$C_{12}$<br>b.p. 50 °C to 200 °C |
| **Example analytes** | Specifically used for GB/GE derivatives of VX (chemical warfare agents) |
| **Recommended conditioning temp.** | Up to 280 °C |
| **Recommended desorption temp.** | Up to 260 °C (see Hints and tips) |

## Hints and tips for HayeSep D

- Hydrophobic
- High artefacts (~10–50 ng/component) limits the use of this sorbent for trace-level monitoring, *e.g.* ambient atmospheres
- Keep the desorption temperature to a minimum to reduce artefact levels
- Inert – suitable for labile components
- Repack sorbent tubes after 50 thermal cycles or more frequently if used near the maximum temperature limit
- Not generally suitable for:
  - Multi-bed sorbent tubes
  - Cold traps (special applications only).

| Description | Part number |
|---|---|
| Sorbent, HayeSep D (60/80), 20 g | C-2HSPD |

**Other HayeSep sorbents are available are available from consumables@markes.com on request.**

## Graphitised carbon blacks

These are non-specific carbon sorbents, widely used for trace-level applications due to their minimal artefact levels. They vary from very weak to medium/strong, and are used for a wide range of VOCs and SVOCs. They are fairly hydrophobic and therefore suitable for sampling under humid conditions. They can, however, contain trace levels of metals, which means they are not always 100% inert. This makes them less suitable for some labile or highly reactive species, *e.g.* thiols and monoterpenes.

Note that these sorbents are prone to formation of fines, and that over-compression during tube packing can lead to high back-pressure. Remember all Markes' sorbent tubes are flow-checked before shipment to ensure reliable sampling and performance.

Although generally considered to be non-porous, the strongest graphitised carbon sorbents (*e.g.* Carbograph 5TD) do exhibit microporosity, which improves the ability of these sorbents to trap ultra-volatile compounds. These sorbents therefore provide a 'bridge' between the graphitised carbon blacks and the stronger carbonised molecular sievesp 28.

All the graphitised carbon blacks have certain general characteristics, as indicated below.

| | |
|---|---|
| **Recommended conditioning temp.** | Up to 380 °C |
| **Recommended desorption temp.** | Up to 360 °C |

### Hints and tips for graphitised carbon blacks

- Hydrophobic – unaffected by high humidity
- Minimal (<0.1 ng) artefacts – good for monitoring at all concentration levels
- Friable and compressible – CARE: Compressing these sorbents can lead to high back-pressures and blocked tubes
- 40/60 mesh is recommended for ideal flow characteristics in sorbent tubes and cold traps
- Repack tubes after 200 thermal cycles.

### Carbograph™ 2TD (20/40, 40/60*, 60/80)

| | |
|---|---|
| **Sorbent strength** | Very weak |
| **Specific surface area** | ~10 $m^2/g$ |
| **Approx. analyte volatility range** | n-$C_8$ to n-$C_{20}$ |
| **Example analytes** | Alkylbenzenes, hydrocarbons to n-$C_{20}$, semi-volatiles |

### Hints and tips for Carbograph 2TD

- Not as efficient as Tenax at releasing high-boiling compounds.

### Carbograph™ 1TD (20/40, 40/60*, 60/80)

| | |
|---|---|
| **Sorbent strength** | Weak/medium |
| **Specific surface area** | ~100 $m^2/g$ |
| **Approx. analyte volatility range** | n-$C_{5/6}$ to n-$C_{14}$ |
| **Example analytes** | Ketones, alcohols, aldehydes; apolar components; perfluorocarbon tracer gases; benzene, toluene, xylene (1–4-week diffusive exposure in ambient air) |

### Hints and tips for Carbograph 1TD

- Widely used 'general-purpose' sorbent. Often used in two- or three-bed sorbent tubes.

### Carbograph™ 4TD (20/40)

| | |
|---|---|
| **Sorbent strength** | Medium |
| **Specific surface area** | ~130 $m^2/g$ |
| **Approx. analyte volatility range** | n-$C_{4/5}$ to n-$C_{12}$ |
| **Example analytes** | Light hydrocarbons |

### Carbograph™ 5TD (20/40, 40/60*)

| | |
|---|---|
| **Sorbent strength** | Medium/strong |
| **Specific surface area** | ~100 $m^2/g$ |
| **Approx. analyte volatility range** | n-$C_{3/4}$ to n-$C_{6/7}$<br>b.p. 50 °C to 150 °C |
| **Example analytes** | Light hydrocarbons; buta-1,3-diene (1-week diffusive exposure) |

| Description | Part number |
|---|---|
| Sorbent, Carbograph 2TD (20/40), 10 g | C-CG220 |
| Sorbent, Carbograph 2TD (40/60), 10 g | C-CG240 |
| Sorbent, Carbograph 2TD (60/80), 10 g | C-CG260 |
| Sorbent, Carbograph 1TD (20/40), 10 g | C-CG120 |
| Sorbent, Carbograph 1TD (40/60), 10 g | C-CG140 |
| Sorbent, Carbograph 1TD (60/80), 10 g | C-CG160 |
| Sorbent, Carbograph 4TD (20/40), 10 g | C-CG420 |
| Sorbent, Carbograph 5TD (20/40), 10 g | C-CG520 |
| Sorbent, Carbograph 5TD (40/60), 10 g | C-CG540 |

**Other graphitised carbon blacks are available from consumables@markes.com on request.**

## Carbonised molecular sieves

Carbonised molecular sieves are the strongest sorbents and are used to trap the most volatile compounds. Because they function according to adsorption and molecular sieve principles, their specific surface area is not a key indicator of their strength. The size and shape of both the analyte molecule and the particle pores also determine the analytes that each sorbent is most suited to.

All carbonised molecular sieves have certain basic characteristics, and these are indicated below.

| | |
|---|---|
| **Recommended conditioning temp.** | Up to 380 °C<br>*N.B.* The temperature should be increased gradually from 100 °C, especially during initial conditioning, to remove oxygen and avoid rapid expansion of volatiles which can crack the sieves |
| **Recommended desorption temp.** | Up to 360 °C |

### Hints and tips for carbonised molecular sieves

- These sorbents are not very hydrophobic and may therefore require dry-purging prior to desorption to remove excess water (see page 50)
- Assume safe sampling volumes are reduced by a factor of 10 when sampling in air at >80% relative humidity
- Due to their strength, carbonised molecular sieves are easily contaminated by higher-boiling compounds, and should be protected by a front bed of weaker sorbent, except when used for diffusive sampling (see page 35)
- Minimal (<0.1 ng) artefacts allow monitoring at trace levels
- Inert – suitable for labile compounds
- Repack tubes after 200 thermal cycles
- For optimum performance, increase the temperature gradually during conditioning (see table).

### Carboxen™ 569 (20/45)

| | |
|---|---|
| **Sorbent strength** | Strong |
| **Specific surface area** | ~485 $m^2/g$; also functions on molecular sieve principles |
| **Approx. analyte volatility range** | n-$C_3$ to n-$C_8$<br>b.p. –30 °C to 150 °C |
| **Example analytes** | Volatile hydrocarbons |

### Hints and tips for Carboxen 569

- More hydrophobic than most carbonised molecular sieves.

### SulfiCarb™ (40/70) (replaces UniCarb™)

| | |
|---|---|
| **Sorbent strength** | Very strong |
| **Specific surface area** | ~1200 $m^2/g$; also functions on molecular sieve principles |
| **Approx. analyte volatility range** | n-$C_3$ to n-$C_8$<br>b.p. –30 °C to 150 °C |
| **Example analytes** | Very volatile compounds, *e.g.* vinyl chloride monomer, $CS_2$, methanol, ethanol, acetone *etc.* Used for very volatile but sterically large molecules, *e.g.* $SF_6$ |

### Hints and tips for SulfiCarb

- UniCarb is no longer available. However, we are able to supply a similarly inert sorbent, SulfiCarb, which has the same physical properties and very similar performance for reactive sulfur species and light VOCs.

### Carbosieve™ SIII (60/80)

| | |
|---|---|
| **Sorbent strength** | Very strong |
| **Specific surface area** | ~800 $m^2/g$, but primarily functions on molecular sieve principles |
| **Approx. analyte volatility range** | Ethane to n-$C_5$ (also ethylene from small volumes)<br>b.p. –60 °C to 80 °C |
| **Example analytes** | Ultra-volatile hydrocarbons |

### Hints and tips for Carbosieve SIII

- Significantly water-retentive – avoid using in humid conditions if at all possible, and dry-purge extensively.

### Carboxen™ 1003 (40/60)

| | |
|---|---|
| **Sorbent strength** | Very strong for small molecules |
| **Specific surface area** | 1000 $m^2/g$; also functions on molecular sieve principles |
| **Approx. analyte volatility range** | Ethane to n-$C_{5/6}$ |
| **Example analytes** | Ultra-light compounds |

### Hints and tips for Carboxen 1003

- Carboxen 1003 offers the best performance of all the carbon molecular sieves (*e.g.* Carbosieve SIII, Carboxen 1000), from the perspective of retention of ultra-light compounds whilst allowing breakthrough of water. Markes recommends using Carboxen 1003 for many air monitoring methods that may previously have specified Carboxen 1000 or Carbosieve SIII.

## Carboxen™ 1000 (60/80)

| | |
|---|---|
| **Sorbent strength** | Very strong for small molecules |
| **Specific surface area** | >1200 $m^2/g$; also functions on molecular sieve principles |
| **Approx. analyte volatility range** | Permanent gases and light hydrocarbons<br>b.p. –60 °C to 80 °C |
| **Example analytes** | Ultra-volatile hydrocarbons |

### Hints and tips for Carboxen 1000

- Retains some water – avoid using in humid conditions if possible, and dry-purge extensively.

| Description | Part number |
|---|---|
| Sorbent, Carboxen 569 (60/80), 10 g | C-C569 |
| Sorbent, SulfiCarb (40/70), 10 g | C-SLCRB |
| Sorbent, Carbosieve SIII (60/80), 10 g | C-CSIII |
| Sorbent, Carboxen 1003 (40/60), 10 g | C-C1000 |
| Sorbent, Carboxen 1000 (60/80), 10 g | C-C1003 |

**Other carbonised molecular sieves are available from consumables@markes.com on request.**

***Graphitised carbon black and porous polymer sorbents available from Markes International***

***Get the best out of your sorbents and sorbent tubes with expert advice from Markes (see also Application Note TDTS 27p92)***

## Zeolite molecular sieves

These are very selective hydrophilic sorbents that work on molecular sieve principles. They are used for specific TD applications, *e.g.* monitoring nitrous oxide (MS 5 Å).

### Molecular sieve 5 Å

| | |
|---|---|
| **Sorbent strength** | Very strong |
| **Pore size** | 5 Å |
| **Typical application** | Nitrous oxide monitoring in occupational hygiene applications |
| **Recommended conditioning temp.** | 300 °C to 350 °C<br>*N.B.* Increase gradually from 100 °C during initial conditioning, to remove oxygen and avoid rapid expansion of volatiles which can crack the sieve |
| **Recommended desorption temp.** | 165 °C (for $N_2O$ applications) |

### Hints and tips for molecular sieve 5 Å

- High (~10 ng) artefacts
- Significantly hydrophilic – do not use in humid conditions
- Repack tubes after 200 thermal cycles
- Molecular sieve tubes used for $N_2O$ monitoring are desorbed in the sampling direction to allow selective release of $N_2O$.

### Molecular sieve 13X

| | |
|---|---|
| **Sorbent strength** | Very strong |
| **Pore size** | 9 Å |
| **Typical application** | Buta-1,3-diene monitoring in occupational hygiene applications |
| **Recommended conditioning temp.** | 300 °C to 350 °C<br>*N.B.* Increase gradually from 100 °C during initial conditioning, to remove oxygen and avoid rapid expansion of volatiles which can crack the sieve |
| **Recommended desorption temp.** | 265 °C (for buta-1,3-diene applications) |

### Hints and tips for molecular sieve 13X

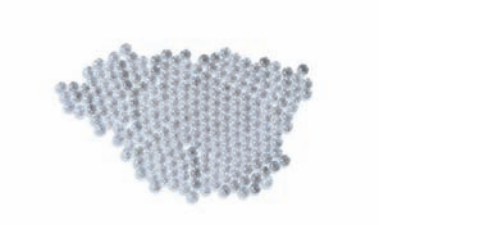
- High (~10 ng) artefacts
- Significantly hydrophilic – do not use in humid conditions
- Repack tubes after 200 thermal cycles
- Note that some of the latest standard methods recommend Carbograph 5TD as a more robust alternative sorbent for buta-1,3-diene.

| Description | Part number |
|---|---|
| Sorbent, molecular sieve 5Å, 20 g | C-MSV5A |
| Sorbent, molecular sieve 13X, 20 g | C-MS13X |

## Other non-carbon sorbents

### Quartz beads

Quartz beads are completely inert and are used primarily in TD instrument cold traps[p77] when monitoring high-boiling, chemically active compounds such as chemical warfare agents. Quartz beads can be used in sorbent tubes in place of quartz wool (see below), if required.



### Quartz wool

Quartz wool is often used in sorbent tubes as the first 'sorbent' in a multi-bed sorbent tube when the range of compounds of interest includes very high-boiling and/or reactive compounds, such as PAHs, phthalates and explosives. It is important that the fibres are the correct diameter – coarse-grade quartz wool has a high proportion of broken fibres, which can reduce its inertness and introduce particles into the TD flowpath. If total inertness is required, *e.g.* when analysing extremely labile compounds, then silanised glass wool is recommended.

### Silanised glass wool

Silanised glass wool is used in sorbent tubes and focusing traps when analysing extremely labile compounds. However, it has a maximum recommended operating temperature of 250 °C. Above 275 °C, residual silanising reagent can break down, coating the TD flowpath with active degradation products and compromising system performance, especially with regard to recovery of high-boilers.

### Unsilanised glass wool

Unsilanised glass wool can be used in sorbent tubes where inertness is not an issue. Tubes packed with unsilanised glass wool must be rigorously conditioned.

| Description | Part number |
|---|---|
| Quartz beads, 1.5 mm, pk 100 | C-QTZBD |
| Quartz wool, 10 g | C-QUTZW |
| Glass wool, silanised, 10 g | C-SILGW |
| Glass wool, unsilanised, 10 g | C-UNSGW |

## Activated charcoal

Activated charcoal is prone to causing poor analyte recovery and sample degradation during thermal desorption. It is **only recommended for use in split-flow filter tubes**, and should not be used in TD sampling tubes.

| Description | Part number |
|---|---|
| Sorbent, activated charcoal, 5 g | C-CHARC |

***If you can't see the sorbent you need, contact us and we'll find it for you, or recommend a good alternative***

# Pumped sampling

While no single sampling method suits all air monitoring applications, pumped (active) sampling onto sorbent tubes perhaps provides the most versatile option for simultaneous monitoring of multiple target compounds and/or monitoring unknown atmospheres.

Markes' sorbent tubes are ideal for pumped monitoring. They can be packed with up to three discrete sorbent beds, and are compatible with all but the most volatile species (*e.g.* acetylene and ultra-volatile freons).



## Pumped-tube sampling – The most versatile air monitoring option

## Pumped sampling

Pumped sampling onto sorbent tubes is one of the most versatile TD sampling methodologies. Precise volumes from 20 mL to several hundred litres may be drawn through the tubes, ensuring compatibility with a huge concentration range (sub-ppt to high ppm).

A pump is connected to the rear (non-sampling) end of the sorbent tube so that air is drawn onto the front (sampling/grooved) end. Pumped sampling is typically performed at flow rates of around 20–100 mL/min. However, higher flow rates (up to 500 mL/min) may be used for short sampling periods (~15 minutes), as long as the safe sampling volumes of the components of interest are not exceeded. Safe sampling volumes for a wide range of analytes are given in key standard methods (*e.g.* EN ISO 16017 Part 1) and other documents (see Application Note TDTS 20p 92).

Many personal air sampling pumps are available on the market, but not all are optimised for sampling onto thermal desorption tubes. Lower-cost 'constant-pressure' pumps may struggle to deal with the relatively high back-pressure/impedance of some two- or three-bed TD tubes, whereas Markes' **ACTI-VOC** delivers a constant flow rate irrespective of normal tube impedance.

Other accurate low-volume sampling options include Markes' **Easy-VOC grab-sampler**p 33.


***ACTI-VOC low-flow pump***

## ACTI-VOC™ low-flow pump

Markes' ACTI-VOC low-flow pump is tailor-made for TD tubes. The pump is constant-flow, meaning that once it has been calibrated (either using the calibrator below, or the flowmeter on page 82) it will maintain this flow to within ±5%, even when using TD tubes of significantly different impedance. The pump operates between 1 and 350 mL/min (or between 20 and 200 mL/min in constant flow mode), and is powerful enough to achieve these flow rates even when there is significant back-pressure (up to 25″ of water or 0.9 psi), making it suitable for use with high-impedance sorbents and SafeLok tubesp 6.

ACTI-VOC is robust, and ideal for personal monitoring applications. It includes a belt clip for ease of use, but is also compact and lightweight enough to fit into a shirt or jacket pocket. It is simple to operate, with a clock that displays the elapsed sampling time. ACTI-VOC has intrinsic safety certification, and the NiMH battery allows fast charges and consistent performance for at least 8 hours.

The **ACTI-VOC kit** includes:

- Tubing and adaptors providing push-fit connections to TD tubes, guaranteeing constant-flow operation
- CapLok tool to simplify tube capping
- Tool for flow adjustment
- Mains charger
- Adaptor for bag sampling
- Convenient carry-case.

A pack of five ACTI-VOC kits is also available.

**If you need advice about sampling with flows above 350 mL/min, please contact Markes (enquiries@markes.com).**

### Primary-standard low-flow calibrator

All sample pumps require calibration before and after sampling to guarantee measurement accuracy. The low-flow calibrator measures flows between 1 and 250 mL/min, is certified for accuracy (±1% of reading), and is traceable to NIST.

The system comprises an electronic base coupled with a wet bubble cell, which produces perfect bubble films at the touch of a button. Flow rates are measured by an infrared sensor, and are shown on the LCD display. The calibrator can run either from an internal battery or direct from an AC power source, and is available in 120 V and 230 V models.

| Description | Part number |
|---|---|
| ACTI-VOC low-flow pump kit | C-LFP-01 |
| ACTI-VOC Low-flow pump kit, pack of 5 | C-LFP-05 |
| Primary standard low-flow calibrator, 120 V model | C-LFPCAL-120 |
| Primary standard low-flow calibrator, 230 V model | C-LFPCAL-230 |

## Easy-VOC™ grab-sampler

Easy-VOC allows the rapid 'grab-sampling' of up to 1000 mL air/gas samples directly onto sorbent tubes, without the need for calibrated pumps or complicated mass flow control equipment.

Typical 50–200 mL Easy-VOC sampling volumes are ideal for monitoring workplace and industrial atmospheres, and are also suitable for many urban and indoor air monitoring applications (depending on the sensitivity of your TD–GC(MS) system).

Easy-VOC allows multiple accurate aliquots of 50–100 mL air or gas to be steadily introduced to standard or SafeLok tubes over a period of several seconds. The small air/gas volumes sampled by Easy-VOC reduce the risk of analyte breakthrough, allowing quantitative retention of more volatile compounds. Accurate sampling of smaller air/gas volumes also minimises water management issues.

The **Easy-VOC starter kit** contains:

| | |
|---|---|
| Easy-VOC pump (plus CapLok tool and carry-case) | C-EZVOCPO |
| Stainless steel, SafeLok sorbent tubes, packed with Tenax TA/Carbograph 1TD/Carboxen 1003, conditioned and capped, pk 10<br>*For pumped sampling of VOCs from $C_{3/4}$ to $C_{30}$* | C3-DAXX-5266 |

The versatile three-bed sorbent tubes supplied in each Easy-VOC starter kit harness Markes' patented SafeLokp6 technology. This helps preserve the integrity of clean and sampled tubes without compromising method compliance.

The Easy-VOC is also available in a cost-effective **Easy-VOC accessory pack**. This contains the pump itself, three spare rubber inlets, two spare gaskets, and lubricant.

| Description | Part number |
|---|---|
| Easy-VOC pump (plus CapLok tool and carry-case) | C-EZVOCPO |
| Easy-VOC starter kit | C-EZVOCKT |
| Easy-VOC accessory pack | C-EZVOCAK |


***Easy-VOC – Simple, fast and accurate air sampling***

## MTS-32™ multiple tube sampler

The MTS-32 is a compact, portable sampler, designed for unattended sequential sampling of air onto sorbent tubes. Ambient air is pulled sequentially through a series of up to 32 (3½") sorbent tubes by a low-flow sampling pumpp32. Each tube is sampled at the same flow rate regardless of any impedance variation, so that the same volume of air is collected in each case.

During automated sampling, it is essential that unused tubes are effectively sealed, to prevent sample losses from the tubes and ingress of contaminants by diffusion. The MTS-32 achieves this by harnessing diffusion-locking technology in the form of SafeLok tubesp6 and/or DiffLok capsp21.

***MTS-32 multiple tube sampler***

The MTS-32 allows users to select sampling times. It is housed in a showerproof case constructed of low-outgassing materials, and can be powered by mains electricity or a battery. An integral fan continually refreshes the air inside the case, ensuring that the air sampled accurately reflects the immediate environment. Custom interfaces can be designed for specific applications (contact enquiries@markes.com).

| Description | Part number |
|---|---|
| MTS-32 multiple tube sampler<br>*Also requires constant-flow pump (e.g. low-flow sampling pumpp32), 12 V battery and charger, or mains power supply* | MTS-32 |
| Power supply accessory for MTS-32 | MTS-5011 |
| 12 V Battery assembly for MTS-32 | MTS-5009 |
| Mains charger for 12 V battery of MTS-32 | MTS-5010 |
| Cable assembly for connecting MTS-32 to external 12 V battery<br>*Required if 12 V battery is not supplied by Markes* | MTS-5013 |

# Diffusive (passive) sampling

Diffusive (passive) sampling using sorbent tubes provides a convenient and quantitative method for a range of air monitoring applications:

- Personal exposure assessment in the workplace
- Time-weighted-average monitoring of ambient outdoor or indoor air over extended periods (*e.g.* 2 weeks)
- Sub-slab soil gas and vapour-intrusion studies
- Monitoring fugitive and area emissions from industrial sites, *e.g.* at the factory fenceline.

Markes' TD tubes (stainless steel and inert-coated stainless steel) are specifically designed for method-compliant diffusive sampling as well as pumped monitoring. They are also supported by Markes' expertise in sorbents and TD–GC(MS) analysis.



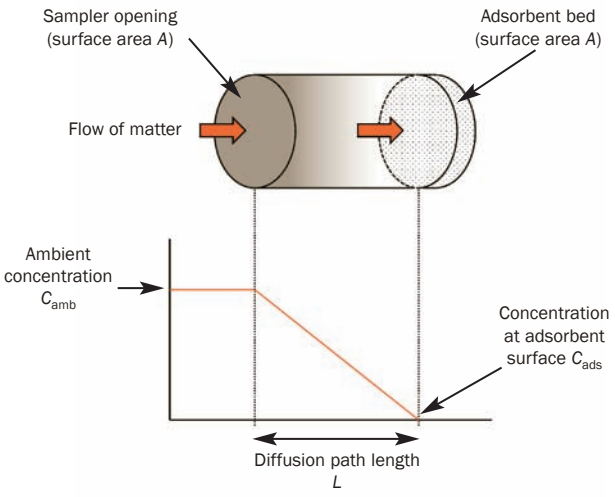
## Diffusive sampling – low-cost and quantitative

# 36

## Diffusive (passive) sampling

Quantitative diffusive (passive) sampling onto sorbent tubes combined with TD–GC analysis first came to the fore for workplace air monitoring in the early 1980s[1,2] as a means of overcoming the limitations of using traditional charcoal/solvent extraction methods – namely poor sensitivity, variable recovery and solvent toxicity.

Markes' diffusive passive samplers are based on standard 3.5″ (89 mm) × 6.4 mm o.d. stainless steel tubes with a precise air (diffusion) gap (5 mm i.d. × 15 mm long) at the sampling end as required by standard methods. One side of the diffusion gap is defined by the sampling surface of the sorbent in the tube and the other by the gauze in the diffusion cap. VOCs move across this air gap, driven by the concentration gradient, and the mass of each analyte retained is proportional to its time-weighted average concentration in the air throughout the exposure period.




***Axial diffusive sampling***

With no need for a pump or other bulky apparatus, passive samplers are extremely unobtrusive, convenient and low-cost. This makes them ideal for personal exposure studies and large-scale air monitoring campaigns (pollution mapping).

***Deploying diffusive samplers for fenceline monitoring.***

*Picture courtesy of BP Chemicals, Hull, UK*

Diffusive sampling rates are relatively slow – the equivalent of pumped sampling rates from 0.5–1.0 mL/min – but this means they can be used in almost any environment (high or low air flow rates). They are ideal for both short-term personal exposure monitoring (0.5–12 hours) in the workplace and extended (1–4-week) monitoring of ambient, indoor or industrial air.

Compatible compounds range from the very volatile (*e.g.* nitrous oxide, buta-1,3-diene) to the semi-volatile (*e.g.* naphthalene), and from non-polar (*e.g.* n-nonane) to polar (*e.g.* ethanol). The precise sampling rate (uptake rate) for each compound must be determined according to specific protocols[3]. However, 30 years of widespread use has resulted in a database of over 100 published uptake rates, which are available in various reference standards (*e.g.* EN ISO 16017 part 2) and other documents (see Application Note TDTS 1[p92]). Diffusive/passive tubes have minimum detection limits of about 10 ppb for short-term (8 hour) exposure and ~0.1 ppb for long-term (2–4 week) sampling.

1. R.H. Brown, J. Charlton and K.J. Saunders, The development of an improved diffusive sampler, *American Industrial Hygiene Association Journal*, 1981, 42: 865–869.
2. E. Woolfenden, Sorbent-based sampling methods for volatile and semi-volatile organic compounds in air: Part 1: Sorbent-based air monitoring options, *Journal of Chromatography A*, 2010, 1217: 2674–2684.
3. EN 838 Workplace atmospheres – Diffusive samplers for the determination of gases and vapours – Requirements and test methods.

**Relevant standard methods include:**

- **EN ISO 16017:** Air quality – Sampling and analysis of volatile organic compounds in ambient air, indoor air and workplace air by sorbent tube/thermal desorption/capillary gas chromatography. Part 2: Diffusive sampling
- **ASTM D6196:** Standard practice for selection of sorbents, sampling and thermal desorption analysis procedures for volatile organic compounds in air
- **EN 14662:** Ambient air quality – Standard method for the measurement of benzene concentrations. Part 4: Diffusive sampling followed by thermal desorption and gas chromatography
- **US EPA Draft Method 325:** Volatile organic chemicals in air – Monitoring fugitive industrial emissions and area sources using passive samplers and TD-GC/(MS) analysis. Part A: Deployment and Part B: Analysis
- **UK HSE: MDHS 80:** Volatile organic compounds in air. Laboratory method using diffusive solid sorbent tubes, thermal desorption and gas chromatography (August 1995).

***Diffusive (passive) sampling – The ideal low-cost and unobtrusive sampling option for personal exposure assessment***

## Diffusion sampling technology from Markes

Markes is at the forefront of diffusive (passive) sampling using sorbent tubes, and was the first to pioneer inert-coated stainless steel tube options for passive sampling of reactive compounds. Tubes fitted with Markes' TubeTAG[p 7] are also fully compatible with diffusive sampling. Exposure start and end times can be recorded electronically using TubeTAG.

Markes' diffusion caps are usually made of clean, anodised aluminium. However, we can also supply stainless steel versions for use in more corrosive atmospheres if required. For traceability purposes, diffusion caps can also be supplied etched with a unique serial number.

The diffusion cap replaces the storage cap at the sampling (grooved) end of the TD sample tube for the duration of the exposure/monitoring period. The storage cap at the other end of the tube is left in place.


***Stainless steel sorbent tube with diffusion caps***

| Description | Part number |
|---|---|
| Caps, diffusion, axial, aluminium, pk 10 | C-DF010 |
| Caps, diffusion, axial, aluminium, pk 100 | C-DF100 |
| Caps, diffusion, axial, aluminium, etched with serial number, pk 10 | C-DF010E |
| Caps, diffusion, axial, aluminium, etched with serial number, pk 100 | C-DF100E |
| Caps, diffusion, axial, stainless steel, pk 20 | C-DFS20 |

**For information on Markes' Diffusive monitoring starter kit, please see page 65.**

# Canister sampling

Canisters are useful for sampling very volatile, non-polar compounds such as $C_2$ hydrocarbons and the most volatile freons, which can be difficult to retain on sorbent tubes at ambient temperature. Canisters and sorbent tubes are thus complementary, allowing analysts equipped with both to address a larger range of applications than either method on its own. For discussion of the relative merits of canisters and sorbent tubes, see Markes' Application Note TDTS 79[p92].

Markes manufactures the best available technology for automated canister analysis. The CIA *Advantage* system operates cryogen-free, offers up to 27 channels, and is fully compliant with US EPA Method TO-14/TO-15. See page 73 of this catalogue or the CIA *Advantage* brochure for more details.

To complement the CIA *Advantage*, we also provide a wide range of canisters and canister sampling accessories.



## Canisters for air monitoring – Simple sampling for very volatile organics in air

## Canisters

To complement the versatility of Markes' CIA *Advantage* system for automated canister analysis, Markes offers three types of canisters:

- **TO-Can® air monitoring canisters** are optimised for US EPA Methods TO-14/TO-15 and ASTM D5466. The canisters are electropolished and contain high-quality metal-to-metal seals and a stainless steel diaphragm valve.
- **SilcoCan® air monitoring canisters** with Siltek®-treated valves offer unsurpassed inertness, even for brominated or sulfur-containing species.

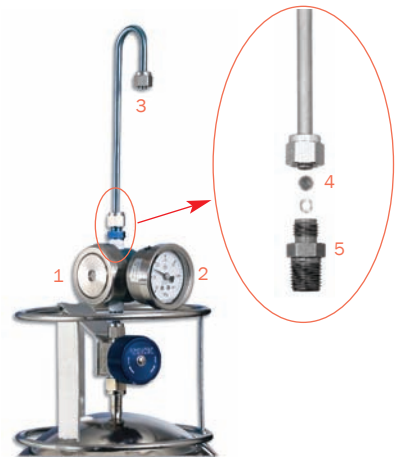
  Both the above are available in 1 L and 6 L sizes and are pre-fitted with a ¼″ three-port valve and a vacuum pressure gauge (reading from –30 inHg to 60 psi).
- **Miniature air sampling canisters** are also available, either electropolished or Siltek-treated, and fitted with a Quick-Connect stem fitting.

All canisters are shipped clean and pressurised with contaminant-free nitrogen.

***Everything you need for canister air sampling and analysis***

## Canister air sampling

Evacuated canisters are predominantly used for grab-sampling but can also be applied for extended monitoring periods. For time-weighted-average (TWA) air sampling using canisters, we recommend the use of an air sampling kit. This incorporates all the necessary hardware, and is easy to assemble for field use. The air sampling kits supplied by Markes enable 1 hour of sampling into a 1 L canister, or 8 hours of sampling into a 6 L canister.




***TWA canister air sampling kit***

1. Flow controller: maintains constant mass flow as the pressure within the canister changes from –30 inHg to 7 inHg (we recommend sampling is stopped before 7 inHg). Siltek options available.
2. Stainless steel vacuum gauge: monitors canister vacuum change during sampling.
3. ¼″ sample inlet: Siltek option available.
4. Replaceable 2 µm frit, filter, washer: prevents particles from blocking the critical orifice. Siltek option available.
5. Critical orifice: selected according to canister volume and sampling time required. Interchangeable with other sizes. Siltek option available.

| Description | Part number |
|---|---|
| TO-Can with gauge and ¼″ valve, 1 L | C-TOCAN1 |
| TO-Can with gauge and ¼″ valve, 6 L | C-TOCAN6 |
| SilcoCan with gauge and Siltek ¼″ valve, 1 L | C-SLCAN1 |
| SilcoCan with gauge and Siltek ¼″ valve, 6 L | C-SLCAN6 |
| TWA air sampling kit, stainless steel<br>*Gives 1 h sampling from a 1 L canister or 8 h sampling from a 6 L canister* | C-ASK1168SS |
| TWA air sampling kit, Siltek-treated<br>*Gives 1 h sampling from a 1 L canister or 8 h sampling from a 6 L canister* | C-ASK1168SL |
| Miniature air sampling canister (400 mL), electropolished with Quick-Connect stem fitting | C-MNCANSS |
| Miniature air sampling canister (400 mL), Siltek-treated with Quick-Connect stem fitting | C-MNCANSL |
| TWA air sampling kit, electropolished, 0.5–2 mL/min (for miniature canisters only) | C-ASKMNSS |
| TWA air sampling kit, Siltek-treated, 0.5–2 mL/min (for miniature canisters only) | C-ASKMNSL |
| Replacement 2 µm frit filter for critical orifice (includes washers), stainless steel, pk 3 | C-ASK2USS |
| Replacement 2 µm frit filter for critical orifice (includes washers), Siltek-treated, pk 3 | C-ASK2UST |

## Canister racks

Markes' canister racks are available as accessories for supporting canisters attached to CIA *Advantage* systems. Each canister rack holds up to 15 canisters (14 samples and one internal standard). The bench-mounted model (Bench Rack) holds canisters up to 1 L, and the floor-mounted model (Maxi Rack) holds canisters up to 6 L.

***Markes' Bench Rack and Maxi Rack***

| Description | Part number |
|---|---|
| Bench Rack (400 mL to 1 L canisters) | U-RACK01 |
| Maxi Rack (1 L to 6 L canisters) | U-RACK02 |

## Standard dilution into canisters

Markes' diluter makes possible the accurate dilution of a standard gas, allowing the creation of multiple calibration levels from a single original standard, with the option of humidification.

| Description | Part number |
|---|---|
| Diluter | U-DILUT |
| Humidification option for diluter or CIA *Advantage* | U-HUMID |

## Canister cleaning

Cleaning canisters is a critical part of any canister-based air monitoring methodology. The TO-14/TO-15-compliant TO-Clean canister cleaning system available from Markes can be adapted to clean canisters of different sizes – from twelve 6 L canisters to 48 miniature canisters – and at temperatures up to 110°C.

***TO-Clean canister cleaning system***

The system is fully automated, allowing the user to start a cleaning cycle and walk away. Using the touch-screen controller, up to ten custom cleaning methods can be defined and loaded as needed. The system also comes with an automated leak-check method, ensuring consistently high performance.

### Hints and tips

- Note that, unlike canisters, sorbent tubes are automatically cleaned by the TD analytical process. However, for automatic conditioning of freshly packed tubes, or tubes that have been unused for an extended time, we recommend the TC-20 multi-tube conditioner and dry-purge unit – please see page 50 for details.

| Description | Part number |
|---|---|
| TO-Clean canister cleaning system with isothermal oven (120 V a.c.) | U-TOCLN120 |
| TO-Clean canister cleaning system with isothermal oven (220–240 V a.c.) | U-TOCLN220 |
| Miniature canister brackets for TO-Clean, pk 12 | C-TOCLNMN |
| 1 L brackets for TO-Clean, pk 12 | C-TOCLN1L |
| 3 L brackets for TO-Clean, pk 12 | C-TOCLN3L |

# Calibration and standards

Calibration is one of the most important considerations for any quantitative analysis, and Markes provides a wide range of standards and accessories to make TD calibration as easy as possible for busy labs. We supply everything from stand-alone tube loading rigs and internal standard addition accessories to audit and check-standards pre-loaded onto sorbent tubes.

Markes' Application Notes TDTS 7 and TDTS 75[p92] present detailed technical advice on preparing sorbent tube standards and calibrating your thermal desorption system. Markes' team of TD specialists is also always on hand to help you succeed.



## Standards and accessories for reliable and quantitative thermal desorption

## Calibration Solution Loading Rig (CSLR™)

Key TD standard methods (*e.g.* ISO 16017 and US EPA Method TO-17) recommend that liquid- and gas-phase standards are loaded onto the sampling end of clean sorbent tubes in a stream of carrier gas using unheated apparatus.

***Calibration Solution Loading Rig***

Markes' Calibration Solution Loading Rig (CSLR) has been specifically designed for loading sorbent tubes with gas- or liquid-phase standards. It has a flow-path constructed of stainless steel and consists of an unheated injector port with a controlled carrier gas supply. The sampling end of a packed sorbent tube is connected to the CSLR by a ¼″ brass nut and PTFE ferrule.

The carrier gas flow is adjusted using a needle valve, and is normally set between 50 and 100 mL/min, according to standard methods. This sweeps the injection port and carries the standard into the sorbent tube. The calibration standard (gas or liquid phase) is introduced through the injector septum using an appropriate precision syringe. The compounds of interest are swept onto the sampling end of the attached tube in the stream of carrier gas, and reach the sorbent bed in the vapour phase.

Advice on routine calibration of TD methods is given in Markes' Application Notes TDTS 7 and TDTS 75[p92].

### Hints and tips

- Wherever possible, to simplify the analytical procedure, a sufficient volume of carrier gas is allowed to pass through the sorbent bed to remove the bulk of solvent (for liquid standards), while quantitatively retaining compounds of interest.

| Description | Part number |
|---|---|
| Calibration Solution Loading Rig | C-CSLR |
| Septum, 9.5 mm (for CSLR), pk 10 | C-SPTA |

## Liquid-phase external calibration

It is not always possible or convenient to introduce liquid standards in a stream of carrier gas as described above. In these cases, liquid standards can be injected directly onto the back of specially packed sorbent tubes (glass is recommended) containing a 1 cm bed of Tenax TA held in place by a 1 cm bed of quartz wool. See Application Note TDTS 7[p92] for more details.

***Syringe (top) and liquid-phase calibration tube containing a 1 cm bed of Tenax TA (bottom)***

| Description | Part number |
|---|---|
| Tube, glass, Tenax TA, 1 cm calibration, pk 10 | C1-BXXX-5072 |
| Tube, glass, Tenax TA, 1 cm calibration, conditioned and capped, pk 10 | C1-BAXX-5072 |

## Check-standards

Check-standards contain a range of routine and challenging analytes, and are useful when setting up instrumentation or troubleshooting. Markes supplies two types of check-standard, both prepared on conditioned Tenax TA sorbent tubes.

**Instrumentation check-standards** contain benzene, toluene, *o*-xylene, isobornyl methacrylate (IBMA) and dioctyl phthalate at a nominal concentration of 90 ng/µL for each component. A single check-standard is supplied with all Markes' systems. Replacement check-standards are available in packs of 10.

**Material emissions check-standards** enhance validation and quality control for service and manufacturing labs using TD–GC(MS) to test chemical emissions from products and materials. The Tenax TA sorbent tubes are pre-loaded in the gas phase with a range of polar and non-polar VOCs ranging in volatility from $C_6$ (n-hexane) to $C_{16}$ (n-hexadecane), at a nominal loading of 100 ± 10 ng per compound. The standard complies with the ISO 17025 method for loading tubes (also in accordance with ISO 9001).

The material emissions check-standard contains:

n-Hexane
4-Methylpentan-2-one
Toluene
n-Butyl acetate
Cyclohexanone
Phenol
1,2,3-Trimethylbenzene
4-Phenylcyclohexene
n-Hexadecane

*Note that all these compounds are included in the 'Indoor air and material emissions' proficiency testing scheme described below.*

| Description | Part number |
|---|---|
| Check-standard (BTX, isobutyl methacrylate (IBMA) and dioctyl phthalate), 90 ng/µL (nominal), Tenax TA, pk 10 | C-CHK10 |
| Check-standard (material emissions), 100 ng per tube (nominal), Tenax TA, pk 10 | C-CHK10-ME |

## Do you participate in a Proficiency Testing scheme for TD?

As part of our service to customers, Markes likes to make thermal desorption users aware of complementary third-party services that could be of interest and benefit. Proficiency testing (PT) schemes are a case in point.

PT schemes for thermal desorption work by providing participating laboratories with spiked tubes for analysis. The tubes are analysed by these laboratories, preferably as part of their routine operation, and the results reported to the scheme organisers. The laboratories involved are then provided with a report showing how closely their results agree with the accepted values.

Regular participation in a proficiency-testing scheme:

- Provides a laboratory with an important independent insight into their performance
- Benchmarks laboratory performance against other scheme participants
- Allows laboratories to demonstrate commitment to measurement quality to regulatory agencies, accreditation bodies and laboratory customers.

## The Workplace Analysis Scheme for Proficiency

One of the most popular PT schemes for thermal desorption is the **Workplace Analysis Scheme for Proficiency** (WASP). This tests the performance of laboratories measuring exposure to hazardous chemical substances in the ambient, indoor and workplace air environments using TD methods. The scheme was established in 1988, and currently has more than 200 laboratory participants worldwide. The WASP scheme is operated by the UK Health & Safety Laboratory, which oversees management, registration and membership, together with preparation and distribution of the spiked tubes, processing the participant data and providing reports.

WASP can offer the following useful PT analyte/sample combinations:

**Ambient air**

| | | | |
|---|---|---|---|
| Testing environment: ISO 16017-1 & 2 and US EPA TO-17 | Analytes: BTEX | Loading: 15–300 ng | † |

**Indoor air and material emissions**

| | | |
|---|---|---|
| Testing environment: ISO 16000-6 | Analytes: A range of 13 indoor-relevant (S)VOCs | Loading: 50–300 ng |

**Workplace air**

| | | | |
|---|---|---|---|
| Testing environment: ISO 16017-1 & 2 | Analytes: BTEX | Loading: 0.5–200 µg | † |
| Testing environment: ISO 16000-3 | Analyte: Formaldehyde | Loading: 3–60 µg | ‡ |

† Analytes provided together on a TD sorbent tube packed with Tenax TA. Test samples dynamically loaded from a standard atmosphere based upon procedures set out in ISO 6145-4.

‡ Glass fibre filter spiked with DNPH derivative. Note this requires HPLC, and is not compatible with TD–GC(MS) methods.

**If you are interested in WASP, please contact the UK Health & Safety Laboratory on +44 (0)1298 218553 or proficiency.testing@hsl.gov.uk**

## Certified reference standard (CRS) tubes

All analytical methodology is subject to performance criteria and quality assurance tests. Reference standards should be used at regular intervals for analytical quality assurance and to confirm routine calibration procedures.

CRS tubes offered by Markes International are prepared by an expert national standards laboratory following approved methodology (ISO 6145 parts 4 or 8, accredited to ISO 17025). They are certified traceable to primary standards. CRS tubes are prepared by introducing known concentrations of compounds into individually labelled sorbent tubes. Analyte masses are accurate to ±3% at levels above 100 ng, and at ±5% for masses from 10–100 ng.

Typically, CRS tubes are loaded with a small number of analytes that are representative of the method being undertaken. They provide a convenient tool for in-house quality assurance of the complete TD–GC(MS) analytical process and associated calibration protocols. Routine use of CRS tubes complies with guidance given in international standard methods and provides continual assurance of system and procedure reliability, thus contributing to staff confidence. In these respects, in-house use of CRS tubes complements participation in external proficiency testing schemes such as WASPp 45.

All CRS tubes are supplied in packs of 10 standards with an additional shipping blank. Standards are wrapped in aluminium foil and sealed into air-tight boxes prior to shipment. A chromatogram of the shipping blank is supplied, together with a certificate of standard traceability. BTX and TO-17 standards are supplied with an example chromatogram and full user instructions.

### BTX standards

BTX CRS tubes loaded with benzene, toluene and *o*-xylene are available either at 100 ng per component (suitable for the majority of environmental applications) or at 1 µg per component (suitable for many industrial air and material emissions applications). These standards are prepared using conditioned Tenax TA tubes and have a certified shelf-life of 6–12 months.

### TO-17 standard

A TO-17 CRS is available loaded with nine components of varying volatilities and polarities that are typical of the compounds found during air toxics monitoring. (*N.B.* This standard is prepared to order and typically has a longer lead time than the BTX standards.)

The compounds included[1] are benzene, toluene, *o*-xylene, 1,2,4-trimethylbenzene, dichloromethane, 1,1,1-trichloroethane, methyl *tert*-butyl ether, methyl ethyl ketone and ethyl acetate. The required concentration of the standard can be specified. These standards are prepared on conditioned Tenax TA tubes and have a certified shelf-life of 6 months.

### Custom standards

If you require a special combination of components pre-loaded onto conditioned sorbent tubes, Markes also offers a custom CRS tube service. Up to eight components can be specified, with the sorbent typically being Tenax TA (although others are available). However, data must be available to demonstrate the stability of the compound/sorbent combination requested. If you require custom-specified CRS tubes, please discuss your requirements with a Markes specialist prior to ordering (enquiries@markes.com).

| Description | Part number |
|---|---|
| CRS (BTX), 100 ng, pk 10 | C-BTX100-10 |
| CRS (BTX), 1 µg, pk 10 | C-BTX1UG-10 |
| CRS (TO-17), specify concentration, pk 10 | C-TO17XX-10 |
| CRS (custom), pk 10 | C-CUST-10 |
| CRS (custom), pk 20 | C-CUST-20 |
| CRS (custom), pk 40 | C-CUST-40 |

***TD quality assurance from Markes – Your peace of mind***

1. Prior to March 2008, TO-17 CRS standards included butan-1-ol. New data shows that this component is not stable over the shelf-life of the CRS, and therefore it is no longer included in the standard.

## Internal standards

Many TD air monitoring methods (tube- or canister-based) benefit from the addition of a gas-phase internal standard (IS). Markes provides the option of IS addition capability on all automated TD configurations, whether tube- or canister-based – see the relevant sections on ULTRA autosamplersp 71, TD-100 systemsp 70 and CIA *Advantage* systemsp 73 for more details.

### Hints and tips

- Selection of the optimum IS gas depends on the application. Typical internal standard compounds include deuterated hydrocarbons (*e.g.* toluene-$d_8$) and halogenated compounds (such as bromofluorobenzene).
- The internal standard gas should be supplied in a pressurised cylinder fitted with a high-purity regulator capable of supplying standard to the TD system at pressures up to 50 psig.
- The concentration of internal standard required depends on the expected concentration of the analytes. As a general rule-of-thumb:
  - If the expected mass of analyte on the tube is about a nanogram, then a 1 ppmv internal standard is suggested
  - If the expected mass of analyte on the tube is about a picogram, then a 1 ppbv internal standard is suggested.

Markes offers[1] a 1 ppm IS gas containing four halogenated/deuterated compounds (in bulk nitrogen), suitable for use with US EPA Methods TO-14/TO-15/TO-17 and other TD–GC/MS applications:

| | |
|---|---|
| **Compounds (in $N_2$)** | Bromochloromethane<br>1-Bromo-4-fluorobenzene<br>Chlorobenzene-$d_5$<br>1,4-Difluorobenzene |
| **Cylinder[2]** | Aluminium construction (8.3 cm × 29.5 cm)<br>PI-marked for compliance with EU regulations and US DOT specifications 3AL2216<br>2.2 lb/1 kg |
| **Pressure/regulation** | 110 L of gas at 1800 psig<br>CGA-180 outlet fitting |

| Description | Part number |
|---|---|
| Standard, gas cylinder, TO-14A IS/tuning mix, 1 ppm | C-GS14A-1PPM |
| Regulator, high-purity VOC, 0–100 psi outlet | C-GSREG-100 |
| Tubing, stainless steel, ⅛", to connect IS to ISDP | SERZ-0022 |

## Gas standards for external calibration of environmental methods

Markes also offers a selection of gas standards[1] suitable for a variety of canister-based air monitoring methods. All cylinders are of aluminium construction (8.3 cm × 29.5 cm)[2] and PI-marked for compliance with EU transport regulations and US DOT specification 3AL2216.

### Sulfur component mix – 1 ppm

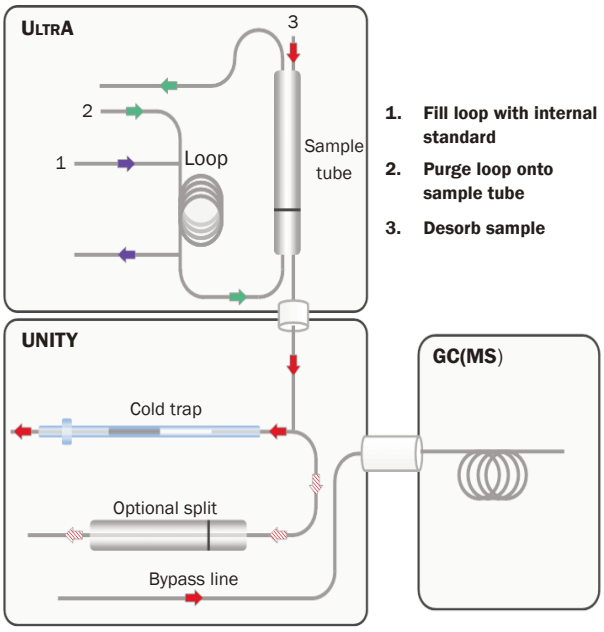
Supplied in nitrogen at 1800 psig, this standard has a 6-month stability and an accuracy of ±10%. 1 mL of this standard contains approximately 2 ng of the following components:

Carbonyl sulfide
Dimethyl sulfide
Ethane thiol
Hydrogen sulfide
Methane thiol

### Volatiles (Japan) component mix – 1 ppm

Supplied in nitrogen at 1800 psig, this mixture of volatile organics contains some compounds that are traditionally difficult to prepare as calibration standards. 1 mL of this standard contains approximately 2–7 ng of the following components:

Acrylonitrile
Benzene
Buta-1,3-diene
Chloroform
1,2-Dichloroethane
Dichloromethane
Tetrachloroethene
Trichloroethene
Vinyl chloride




***Schematic of internal standard/dry-purge (ISDP) accessory for ULTRA***

1. These items may be unavailable in some territories – please contact Markes International for further information.
2. Pressurised cylinders of gas standards are subject to 'hazardous materials' shipping supplements by most freight carriers.

## TO-15 'Air toxics'/TO-17 65-component mix – 1 ppm

Supplied in nitrogen at 1800 psig. Injecting 1 mL of this mix onto a sorbent tube or cold trap introduces 2–4 ng of each component.

Acetone
Acrolein
Benzene
Benzyl chloride*
Bromodichloromethane
Bromoform
Bromomethane
Buta-1,3-diene
Butan-2-one (methyl ethyl ketone)
Carbon disulfide*
Carbon tetrachloride
Chlorobenzene
Chloroethane
Chloroform
Chloromethane
Cyclohexane
Dibromochloromethane
1,2-Dibromoethane
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Dichlorodifluoromethane (Freon® 12)
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethene
*cis*-1,2-Dichloroethene
*trans*-1,2-Dichloroethene
Dichloromethane
1,2-Dichloropropane
*cis*-1,3-Dichloropropene
*trans*-1,3-Dichloropropene
1,2-Dichlorotetrafluoroethane (Freon® 114)
1,4-Dioxane
Ethanol*
Ethyl acetate
Ethylbenzene
4-Ethyltoluene
Heptane
Hexachlorobuta-1,3-diene
Hexane
Hexan-2-one (methyl butyl ketone)
Methyl methacrylate
4-Methylpentan-2-one (methyl isobutyl ketone)
Methyl *tert*-butyl ether
Naphthalene
Propan-2-ol
Propene
Styrene
1,1,2,2-Tetrachloroethane
Tetrachloroethene
Tetrahydrofuran
Toluene
1,2,4-Trichlorobenzene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethene
Trichlorofluoromethane (Freon® 11)
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon® 113)
1,2,4-Trimethylbenzene
1,3,5-Trimethylbenzene
Vinyl acetate
Vinyl chloride
*m*-Xylene
*o*-Xylene
*p*-Xylene

* Note that the stability of these compounds cannot be guaranteed.

## Ozone precursor/PAMS 57-component mix – EPA concentrations 20–60 ppbC[1]

Supplied in nitrogen at 1800 psig. Injecting 1 mL of this mix onto a TD cold trap introduces approximately 0.1 ng of each component (in the list below, individual concentrations in ppbC[1] are given in parentheses).

Acetylene (40)
Benzene (30)
n-Butane (40)
But-1-ene (30)
*cis*-But-2-ene (35)
*trans*-But-2-ene (25)
Cyclohexane (40)
Cyclopentane (20)
n-Decane (30)
*m*-Diethylbenzene (40)
*p*-Diethylbenzene (25)
2,2-Dimethylbutane (40)
2,3-Dimethylbutane (50)
2,3-Dimethylpentane (50)
2,4-Dimethylpentane (40)
n-Dodecane (40)
Ethane (25)
Ethylbenzene (25)
Ethene (20)
*m*-Ethyltoluene (25)
*o*-Ethyltoluene (30)
*p*-Ethyltoluene (40)
n-Heptane (25)
n-Hexane (30)
Hex-1-ene (60)
Isobutane (25)
Isopentane (40)
Isoprene (40)
Isopropylbenzene (40)
Methylcyclohexane (30)
Methylcyclopentane (25)
2-Methylheptane (25)
3-Methylheptane (25)
2-Methylhexane (25)
3-Methylhexane (25)
2-Methylpentane (20)
3-Methylpentane (40)
n-Nonane (25)
n-Octane (30)
n-Pentane (25)
Pent-1-ene (25)
*cis*-Pent-2-ene (35)
*trans*-Pent-2-ene (25)
Propane (40)
n-Propylbenzene (30)
Propene (25)
Styrene (40)
Toluene (40)
1,2,3-Trimethylbenzene (25)
1,2,4-Trimethylbenzene (40)
1,3,5-Trimethylbenzene (25)
2,2,4-Trimethylpentane (30)
2,3,4-Trimethylpentane (25)
n-Undecane (30)
*o*-Xylene (25)
*m*/*p*-Xylene (combined) (40)

### Hints and tips

- This standard contains some very volatile analytes and is not suitable for loading onto standard sorbent tubes at ambient temperature.

| Description | Part number |
|---|---|
| Standard, gas cylinder, sulfur mix, 1 ppm | C-GSSUL-1PPM |
| Standard, gas cylinder, volatiles (Japan mix), 1 ppm | C-GSVOL-1PPM |
| Standard, gas cylinder, TO-15, 65-component mix, 1 ppm | C-GS15-1PPM |
| Standard, gas cylinder, $O_3$/PAMS, 57-component mix, EPA concentration, 20–60 ppb | C-GSPAMS-EPA |
| Regulator, high-purity VOC, 0–100 psi outlet | C-GSREG-100 |

1. ppbC = parts per billion expressed as carbon.

# Sampling accessories

Markes provides the widest available range of specialist accessories for thermal desorption. Together, these innovative sampling tools offer compatibility with gas-, liquid- and solid-phase samples, and enhance a broad range of applications.



## An extensive range of sampling accessories for every TD application

## TC-20™ multi-tube conditioner and dry-purge unit

The TC-20 is used to clean or dry-purge up to 20 industry-standard sorbent tubes simultaneously. All it needs is power and a clean, high-purity gas supply (typically nitrogen).


***TC-20 multi-tube conditioner and dry-purge unit***

A uniform flow of gas is passed through each attached tube, at a rate that is independent of tube impedance. The temperature and time required are selected using the controls on the front of the instrument, and the flow rate is set by adjusting the pressure of gas supplied (displayed on the gauge).

### Hints and tips

- We recommend the use of a secondary gas regulation system (*e.g.* the single regulator pneumatics accessory, U-GAS03[p 82]) and gas purifiers[p 83] on the carrier gas input line.
- For automated canister cleaning, we recommend the TO-CLEAN system – please see page 41 for details.

### Sorbent tube conditioning

Sorbent tubes require stringent conditioning whenever they are:

- freshly packed with sorbent
- stored without being properly capped
- heavily contaminated during a sampling procedure
- required for trace-level monitoring.

Typically, tubes should be conditioned for 10–15 minutes, or at least as long as their standard desorption time. Where possible, temperatures and gas flow rates for conditioning should be higher than those used in the analytical method. Freshly packed tubes should be conditioned for much longer, typically 2–6 hours.

Many commercial thermal desorbers, such as (ULTRA–)UNITY and TD-100, offer a dedicated tube conditioning mode. Whilst this is a useful feature, it can take up valuable analytical instrument capacity.

The TC-20 tube conditioning system saves time and money by cleaning up to 20 industry-standard sorbent tubes simultaneously. It also eliminates any risk of contamination of the analytical system and allows expensive helium carrier gas to be replaced with lower-cost, high-purity nitrogen if required.

### Hints and tips

- Note that electronic TubeTAGs[p 7] must be removed using the appropriate fixing/removal tool, before tubes can be inserted into the TC-20.
- After conditioning/dry-purging, tags can be reattached to the associated tubes, and the number of thermal cycles increased, if applicable.
- For more information on tube conditioning, please refer to Application Note TDTS 5[p 92].

***Get your tubes ultra-clean quickly and easily with the TC-20***

## TC-20 as a dry-purge unit

Although modern carbonised molecular sieves[p 28] are much less water-retentive than older molecular sieves or charcoal, some water will still be retained when sampling in humid atmospheres. The TC-20 can also be used to selectively remove this excess water from a batch of sampled sorbent tubes, thus eliminating its adverse effects on GC/MS analysis.

Water is eliminated by 'dry-purging' the tubes with a known volume of pure dry gas in the sampling direction before desorption. This is achieved by inserting the tubes into the TC-20 manifold block, with the sampling end first. Clean, dry nitrogen gas is then passed through the tubes in the sampling direction. Dry-purging is usually carried out at ambient temperature.

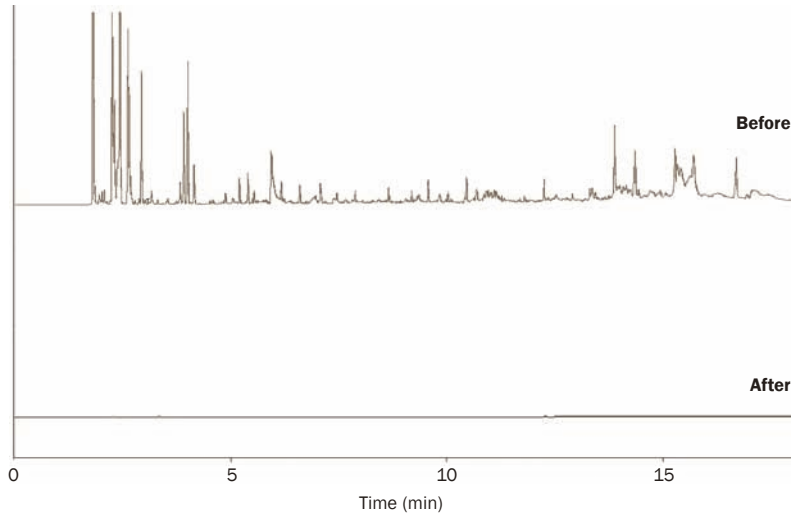
### Hints and tips

- Care must be taken when dry-purging to ensure that safe sampling volumes are not exceeded for the most volatile target analytes, *i.e.* that volatile target analytes are not swept to vent along with the excess water.
- For further guidance on VOC retention and safe sampling volumes, please see Application Note TDTS 20[p 92].
- Dry-purging is also available as an optional part of the tube desorption process on some configurations of Markes' TD autosamplers (*e.g.* Advanced models of TD-100, UltrA 50:50, and any Markes tube autosampler configured with ISDP)[pp 70,71].

## Gas purifiers

We recommend the use of gas purifiers to remove hydrocarbons, oxygen and water on carrier gas lines supplying all our analytical equipment and specialised sampling accessories. Full information on the range of available purifiers is available on page 83.

| Description | Part number |
|---|---|
| TC-20 multi-tube conditioner and dry-purge unit (115 V) | R-TC20-1 |
| TC-20 multi-tube conditioner and dry-purge unit (230 V) | R-TC20-2 |
| Filter for TC-20, carbon, 120 mm × 120 mm, pk 4 (replacement filters for cooling fan at rear of TC-20) | R-FLTR4 |




***Tenax tube before and after conditioning for 2 hours at 320 °C using the TC-20, showing its effectiveness for tube conditioning***

## Micro-Chamber/Thermal Extractor™ (µ-CTE™)

Markes' Micro-Chamber/Thermal Extractor (µ-CTE) units provide the perfect solution for monitoring vapour profiles and emissions from a wide variety of complex materials. Each micro-chamber has a capacity of 44 or 114 mL, and can operate anywhere from ambient temperature to 250°C, giving real application versatility.

Clean, dry gas (air, nitrogen or helium) is purged through each micro-chamber at a flow rate between 10 and 500 mL/min. Compounds released from the test specimen are swept through the exhaust and collected onto sample tubes (sorbent tubes for (S)VOC analysis, DNPH cartridges for formaldehyde analysis). A constant flow is maintained through each chamber (independent of sorbent tube impedance), without need for pumps or electronic mass flow control equipment. The Micro-Chamber/Thermal Extractor is compatible with 6 mm and 6.4 mm (¼") o.d. sorbent tubes. Adaptors are also available to connect DNPH cartridges with 4 mm Luer lock ends. Material emissions screening data from the Micro-Chamber/Thermal Extractor has been shown to correlate with reference methods[1].

The Micro-Chamber/Thermal Extractor is available in two versions:

**Six-chamber Micro-Chamber/Thermal Extractor (max. 120°C)**
Comprises six inert-coated micro-chambers, each with a volume of 44 $cm^3$ (45 mm i.d. × 28 mm deep), allowing surface or bulk emissions to be tested from up to six samples simultaneously. Samples can be heated from ambient temperature to 120°C.

**Four-chamber Micro-Chamber/Thermal Extractor (max. 250°C)**
Comprises four inert-coated micro-chambers, each with a volume of 114 $cm^3$ (64 mm i.d. × 36 mm deep), allowing surface or bulk emissions to be tested from up to four samples simultaneously. Samples can be heated from ambient temperature to 250°C.

Both the six- and four-chamber models can be supplied with toggle valves, enabling the gas flow in unused chambers to be turned off, and therefore reducing operating costs.

### A world of applications

Markes' Micro-Chamber/Thermal Extractor is a highly versatile and convenient sample preparaion tool for a wide range of TD–GC(MS) applications. Key examples include:

- **Material emissions screening**: Surface-only or bulk emissions testing can both be accommodated. Compatible materials include construction and decorative products, car trim components, furniture, furnishings, toys, electronics and general consumer goods
- **Aroma and fragrance profiling**: The Micro-Chamber/Thermal Extractor is ideal for everything from cheese and potato chips to soap powder and shampoo
- **Accelerated food shelf-life studies**: Product odours can be monitored as they change over time
- **Off-gassing of semi-volatiles**: High-boiling 'fogging' compounds from polymeric products can be evaluated according to ISO 16000-25.

### Hints and tips

- The Micro-Chamber/Thermal Extractor is compatible with a variety of sample types including polymers, textiles, paints/resins, foodstuffs, wood-based products, plasterboard, insulation materials and adhesives. Samples can be weighed directly into an empty chamber, placed in a custom-made 'sample boat' within the chamber, or raised up to enable surface-only emissions.
- We recommend the use of a secondary gas regulation system (*e.g.* the single regulator pneumatics accessory, U-GAS03p 82) and gas purifiersp 83 on the gas input line.

1. T. Schripp, B. Nachtwey, J. Toelke, T. Salthammer, E. Uhde, M. Wensing and M. Bahadir, A microscale device for measuring emissions from materials for indoor use, *Analytical and Bioanalytical Chemistry*, 2007, 387: 1907–1919.

## Starter kits for the Micro-Chamber/Thermal Extractor

The starter kit for the 6-chamber Micro-Chamber/Thermal Extractor (max. 120 °C) (part number M-STUKTI) contains:

| | |
|---|---|
| Sample pans, inert-coated, pk 6 | M-MCHSI |
| Detachable sample lids, inert-coated, pk 6 | M-MCTOPI |
| Tube interface caps, pk 6 | M-TICAP |
| M4 flanged nuts for removable lids, pk 6 | SERZ-NM4FLGSS |
| Nut driver tool (for releasing lids) | SERZ-0669 |
| Adjustable sprung spacers, pk 6 | M-SPGSC-120 |
| Aluminium collar spacers (15 mm), pk 6 | M-SPC15-120 |
| Aluminium collar spacers (5 mm), pk 6 | M-SPC05-120 |
| Aluminium spacer discs (1.5 mm), pk 24 | M-DSK15-120 |
| Routine maintenance kit (selection of O-rings) | RMK-0006 |
| Inert-coated stainless steel tubes, packed with Tenax TA, conditioned and capped, 2 × pk 10 | **2 ×** C1-CAXX-5003 |
| CapLok tool | C-CPLOK |

The starter kit for the 4-chamber Micro-Chamber/Thermal Extractor (max. 250 °C) (part number M-STUKT250I) contains:

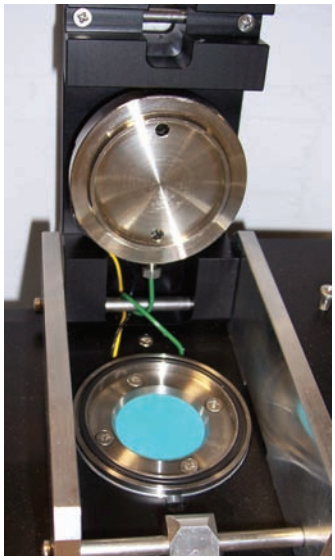
| | |
|---|---|
| Sample pans, inert-coated, pk 4 | M-MCHSS250I |
| Detachable sample lids, inert-coated, pk 4 | M-MCTOP250I |
| Tube interface caps, pk 6 | M-TICAP |
| M3 hexagonal ball driver (spanner) | SERZ-0861 |
| Adjustable sprung spacer assemblies, pk 4 | M-SPGSC-250 |
| Aluminium collar spacers (15 mm), 2 × pk 4 | **2 ×** M-SPC15-250 |
| Aluminium collar spacers (5 mm), 3 × pk 4 | **3 ×** M-SPC05-250 |
| Aluminium spacer disks (1.5 mm), pk 24 | M-DSK15-250 |
| Liquid sample inserts, pk 4 | M-TSTIN |
| Routine maintenance kit (selection of O-rings) | RMK-0006HT |
| Inert-coated stainless steel tubes, packed with Tenax TA, conditioned and capped, pk 10 | C1-CAXX-5003 |
| CapLok tool | C-CPLOK |

## Accessory for permeation testing

Barrier materials are often used in protective clothing and product packaging to mitigate potentially harmful product emissions. Typical examples include:

- Vehicle seat coverings – to prevent VOCs from polyurethane foam contaminating car cabin air
- Food packaging film – to prevent oxygen or VOCs tainting foodstuffs
- Protective gloves, masks, *etc.* – to protect against harmful chemicals, *e.g.* chemical warfare agents
- Membranes used in vehicle fuel systems to prevent the loss of fuel vapour.

Permeation testing of such materials is required by a number of standard methods[1–5]. However, traditional methods for permeation testing require complex, expensive apparatus and can only accommodate one test material at a time. Markes' permeation accessory for the Micro-Chamber/Thermal Extractor enables permeation testing to be carried out on four or six samples simultaneously.



***Permeation accessory in situ in a Markes Micro-Chamber/Thermal Extractor***

## *Micro-Chamber/Thermal Extractor – Rapid screening of product emissions and odour profiles*

1. ISO 15105-1 and -2; ASTM F1307-02: Plastic films, sheeting, laminates *etc.*
2. EN 374-3; ASTM F739: Gloves.
3. ISO 13994: Penetration test.
4. ASTM F739-99a: Resistance of protective clothing materials – continuous contact.
5. ASTM F1407-99a: Resistance of chemical protective clothing – liquid permeation.

To test the permeability of a material, a sample is stretched across the permeation accessory and secured in place as shown. A small droplet of test compound is then injected into a well at the bottom of the accessory. The complete assembly is then placed inside one of the micro-chambers, and clean air is passed over the surface of the stretched material. Permeation is then readily assessed by monitoring the air exiting each micro-chamber, using sorbent tubes and TD–GC/MS analysis in the normal way.

***Latex sample secured in the permeation accessory***

## Accessories for surface emissions testing

Markes provides a range of sample supports that allow surface-only emissions to be studied using the Micro-Chamber/Thermal Extractor. Variable-depth spacers raise samples up, so that when the micro-chamber lid is closed the ring protruding from the lid precisely and reproducibly defines the area of material that will be sampled. This eliminates edge effects and allows area-specific emission rates to be quantitatively determined.

***Adjustable sprung spacers for correctly positioning rigid planar materials within the Micro-Chamber/Thermal Extractor***

## Accessories for formaldehyde sampling

Markes provides O-rings and spacers that allow the Micro-Chamber/Thermal Extractor to be used for testing formaldehyde emissions. These fittings reduce the size of the connector on the micro-chamber, allowing it to accommodate the 4 mm Luer fitting of the standard DNPH cartridge sampler.

## Other accessories for the Micro-Chamber/Thermal Extractor

### PTFE discs

A pack of 1 mm thick PTFE discs is available for use with sticky or resinous samples such as adhesives and pastes. Applying such samples to the PTFE disc ensures that the chambers are kept clean during sampling. The discs can usually be re-used depending on the nature of the samples.

### Inserts for liquid standards

PTFE inserts with centrally-positioned wells are available for use with small-volume (<1 mL) liquid samples and standards[1].

### Routine maintenance kits

Maintenance kits are also available for the Micro-Chamber/Thermal Extractor. These contain a useful selection of O-rings and an O-ring insertion tool, and are recommended for routine operation.

***Innovative sampling accessories from Markes extend the TD application range***

1. Care should be taken when using liquids with the Micro-Chamber/Thermal Extractor. For further information please contact Markes Technical Support team (enquiries@markes.com).

## Part numbers for the 6-chamber Micro-Chamber/Thermal Extractor (max. 120°C)

| Description | Part number |
|---|---|
| Micro-Chamber/Thermal Extractor, 6-chamber, inert | M-CTE120I |
| Micro-Chamber/Thermal Extractor, 6-chamber, inert, with 6 toggle valves | M-CTE120TI |
| Starter kit for Micro-Chamber/Thermal Extractor, inert | M-STUKTI |
| Sample pan, stainless steel, pk 6 | M-MCHSS |
| Removable lids, stainless steel, pk 6 | M-MCTOP |
| Sample pan, inert, pk 6 | M-MCHSI |
| Removable lids, inert, pk 6 | M-MCTOPI |

### Accessories for permeation testing

| Description | Part number |
|---|---|
| Permeation accessory, stainless steel, pk 1 | M-PRMIN1 |
| Permeation accessory, stainless steel, pk 6 | M-PRMIN |
| Permeation accessory, inert, pk 1 | M-PRMINSS1-120 |
| Permeation accessory, inert, pk 6 | M-PRMINSS-120 |
| O-Ring, 30 mm o.d., permeation accessory seal, pk 6 | M-PRO30-120 |
| Septa, ¼", for permeation accessory injection port, pk 6 | M-PRSPT-120 |

### Accessories for surface emissions testing

| Description | Part number |
|---|---|
| Collar spacer, Al, 15 mm, pk 6 | M-SPC15-120 |
| Collar spacer, Al, 5 mm, pk 6 | M-SPC05-120 |
| Spacer disc, Al, 1.5 mm, pk 24 | M-DSK15-120 |
| Adjustable sprung spacer, pk 6 | M-SPGSC-120 |

### Accessories for formaldehyde sampling[1]

| Description | Part number |
|---|---|
| O-Ring, size 007, and spacer to connect 4 mm Luer cartridge, pk 6 (for DNPH cartridges) | M-TCN04 |

### Other accessories

| Description | Part number |
|---|---|
| Sample disc, 1.0 mm thickness, PTFE, pk 6 | M-DSKPF |
| Routine maintenance kit for Micro-Chamber/Thermal Extractor | RMK-0006 |
| Pneumatics accessory (single regulator)[2] | U-GAS03 |
| O-Ring, size 010, to connect ¼" o.d. tubes, pk 6 (for standard tubes) | M-TCN64 |
| O-Ring, 5.92 mm i.d., to connect 6 mm o.d. tubes, pk 6 | M-TCN06 |
| O-Ring, size 006, for gas line connection to removable lid, pk 6 | M-MC006 |
| Tube interface cap for removable lid, pk 6 | M-TICAP |
| O-Ring, micro-chamber pan seal, pk 6 | M-MCHOR |

## Part numbers for the 4-chamber Micro-Chamber/Thermal Extractor (max. 250°C)

| Description | Part number |
|---|---|
| Micro-Chamber/Thermal Extractor, 4-chamber, inert | M-CTE250I |
| Micro-Chamber/Thermal Extractor, 4-chamber, inert, with 4 toggle valves | M-CTE250TI |
| Starter kit for Micro-Chamber/Thermal Extractor, inert | M-STUKT250I |
| Sample pan, stainless steel, pk 4 | M-MCHSS250 |
| Removable lids, stainless steel, pk 4 | M-MCTOP250 |
| Sample pan, inert, pk 4 | M-MCHSS250I |
| Removable lids, inert, pk 4 | M-MCTOP250I |

### Accessories for permeation testing

| Description | Part number |
|---|---|
| Permeation accessory, stainless steel, pk 1 | M-PRMIN1-250 |
| Permeation accessory, stainless steel, pk 4 | M-PRMIN-250 |
| Permeation accessory, inert, pk 1 | M-PRMINSS1-250 |
| Permeation accessory, inert, pk 4 | M-PRMINSS-250 |
| O-Ring, 30 mm o.d., permeation accessory seal, pk 4 | M-PRO30-250 |
| Septa, ¼", for permeation accessory injection port, pk 6 | M-PRSPT-250 |

### Accessories for surface emissions testing

| Description | Part number |
|---|---|
| Collar spacer, Al, 15 mm, pk 4 | M-SPC15-250 |
| Collar spacer, Al, 5 mm, pk 4 | M-SPC05-250 |
| Spacer disc, Al, 1.5 mm, pk 24 | M-DSK15-250 |
| Adjustable sprung spacer, pk 4 | M-SPGSC-250 |

### Accessories for formaldehyde sampling[1]

| Description | Part number |
|---|---|
| O-Ring, size 007, and spacer, to connect 4 mm Luer cartridge, pk 6 (for DNPH cartridges) | M-TCN04 |

### Other accessories

| Description | Part number |
|---|---|
| Sample disc, 1.0 mm thickness, PTFE, pk 6 | M-DSKPF |
| Inserts for liquid standard introduction, PTFE, pk 6 | M-TSTIN |
| Routine maintenance kit for Micro-Chamber/Thermal Extractor | RMK-0006HT |
| Pneumatics accessory (single regulator)[2] | U-GAS03 |
| O-Ring, size 010, to connect ¼" o.d. tubes, pk 6 (for standard tubes) | M-TCN64 |
| O-Ring, 5.92 mm i.d., to connect 6 mm o.d. tubes, pk 6 | M-TCN06 |
| O-Ring, size 006, for gas line connection to removable lid, pk 6 | M-MC006 |
| Tube interface cap for removable lid, pk 6 | M-TICAP |
| O-Ring, micro-chamber pan seal, standard (for applications <200°C), pk 4 | M-MCHOR250 |
| O-Ring, micro-chamber pan seal, ultra-high purity standard (for applications >200°C), pk 4 | M-MCHOR250HT |

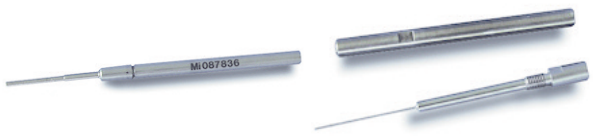
1. DNPH cartridges are not included.
2. It is recommended that a pneumatics accessory (U-GAS03p 82) is used with every Micro-Chamber/Thermal Extractor.

## Thermal analysis/evolved gas collection

Thermal desorption can also be used to investigate the nature of gases evolved during thermogravimetric analysis (TGA) and microthermal analysis. Gases evolved from these thermal analysis processes are pumped onto specially designed MacroTubes™ (TGA analysis) or MicroTubes™ (microthermal analysis). Both tube types are packed with sorbents and analysed by Markes' thermal desorption systems.

Evolved gas analysis is used for a range of applications including:

- Studies of degradation mechanisms for stabilisers, flame retardants, smoke suppressants, *etc.*
- Polymer characterisation
- Toxicity studies
- Catalyst investigations
- Studies of solid- or gas-phase reactions.



***MacroTubes and MicroTubes for evolved gas analysis***

| Description | Part number |
|---|---|
| MacroTubes, general screening (n-$C_5$ to n-$C_{30}$), conditioned and capped, pk 5 | E-MATBG5 |
| MacroTubes, high volatility (n-$C_3$ to n-$C_{10}$), conditioned and capped, pk 5 | E-MATBV5 |
| Macro connector | E-MACNT |
| Macro connector carrier | E-MACAR |
| MicroTubes, general screening (n-$C_5$ to n-$C_{30}$), condition before use, pk 5 | E-MITBE5 |
| MicroTubes, general screening (n-$C_5$ to n-$C_{30}$), condition before use, pk 50 | E-MITBE50 |
| MicroTube carrier | E-MICAR |
| MicroTube carriers, pk 10 | E-MICAR10 |
| O-Ring, chemically inert, spare for MicroTube carrier | E-MICOR |

## SPE-tD™ sorptive extraction cartridges

Markes' SPE-tD cartridges offer a simple, convenient method for sampling less volatile impurities in aqueous samples – applications that would otherwise require manually intensive extraction or distillation techniques before GC/MS analysis. Applications include:

- Off-odours/taints in drinking water
- Volatiles and semi-volatiles in processed fruit juices
- Profiling of hydrosols (the aqueous fraction from steam distillation of natural oils).

***SPE-tD cartridge alongside a glass tube***

SPE-tD cartridges comprise a hollow tube, coated inside and out with poly(dimethylsiloxane) (PDMS) for optimum sampling capacity. The cartridge is placed into a sample and agitated, causing volatile and semi-volatile organics in the sample to partition between the aqueous matrix and the PDMS until equilibrium is reached. The cartridge is then removed, rinsed, and placed into an empty TD tube prior to analysis by direct TD–GC/MS. This allows semi-quantitative analysis of less volatile organics, and direct comparison of organic chemical concentrations in two similar samples.

An **SPE-tD starter kit** is also available, containing:

| | |
|---|---|
| SPE-tD cartridges (30 mm length), pk 5 | C-SPTD5 |
| Glass tubes, empty, restriction at 15 mm, pk 10 | C0-BXXX-0000 |
| Springs, torsion, for 4 mm i.d. glass tubes, pk 10 | C-GTSP10 |
| Quartz wool (10 g) | C-QUTZW |
| Cold trap, Tenax TA, UNITY 2/TD-100 | U-T9TNX-2S |
| Cap, storage, brass, ¼" & PTFE ferrule, pk 20 | C-CF020 |

| Description | Part number |
|---|---|
| SPE-tD cartridge (30 mm), pk 1 | C-SPTD1 |
| SPE-tD cartridge (30 mm), pk 5 | C-SPTD5 |
| SPE-tD cartridge (30 mm), pk 10 | C-SPTD10 |
| SPE-tD cartridge (6 mm), pk 1 | C-SPTD1-6MM |
| SPE-tD cartridge (6 mm), pk 5 | C-SPTD5-6MM |
| SPE-tD cartridge (6 mm), pk 10 | C-SPTD10-6MM |
| Starter kit for SPE-tD | C-KITSP-2S |

***SPE-tD and HS–TD – Extending the power of thermal desorption to the aqueous phase***

## Headspace–Thermal Desorption (HS–TD)

Markes' HS–TD systems bring together two powerful GC introduction techniques: headspace (HS) and thermal desorption (TD). By combining an HS system with TD, users are offered optimum sensitivity for trace VOCs in solid, liquid and vapour-phase samples, all on one versatile analytical platform.

These HS–TD systems are based on Markes' world-leading UNITY 2 or UltrA–UNITY 2 thermal desorbers, and are designed to integrate with a range of equilibrium HS systems to suit all applications and budgets.

The following equilibrium HS units can be integrated with (UltrA–)UNITY 2 using the appropriate connection kit:

- Markes' HS5-TD: an entry-level system for up to five vials
- G1888: an automated HS system for 70 vials (Agilent Technologies)
- G1290: an automated HS system (HP7694) for 44 vials (Agilent Technologies)
- HS40 and HS40XL: automated HS systems for 40 vials (Perkin Elmer)[1].

In addition to these systems, the manual Universal Direct Inlet Accessory (U-INLET) for UNITY allows HS vapours from a wide range of sample containers to be focused directly on the UNITY cold trap.

### Hints and tips

- These connection kits do not hinder standard tube desorption, and can be readily exchanged with the link to an UltrA 2 autosampler for automated tube analysis.

An **HS5-TD starter kit** is also available, containing:

| | |
|---|---|
| Crimp-top vials, pk 500 | **0.5 ×** U-HSV00 |
| Crimp tops, pk 500 | **0.5 ×** U-HSVC0 |
| Crimper tool | U-HSVCR |

### Mode of operation

In HS–TD, pressurised headspace vapours are transferred from the sample vial into the electrically cooled cold trap of the UNITY 2 thermal desorber by a 'pulsed direct sampling' process. This process can be repeated many times before the trap is finally desorbed and GC analysis starts.

### The key advantages of HS–TD

- Typically 10–100 times more sensitive then static equilibrium headspace techniques, and without the foaming or aerosol issues that sometimes accompany purge-and-trap methods
- Increased recovery of higher-boiling analytes relative to conventional static headspace
- Automatic purging of the focusing trap with dry carrier gas prior to desorption selectively eliminates unwanted interferents such as water and ethanol, simplifying the chromatographic analysis of complex vapour profiles.


***Markes' HS5-TD system with UNITY thermal desorber***

### HS5-TD™

The HS5-TD accessory for UNITY 2 is an entry-level, manually operated HS-trap system designed for up to five standard headspace vials. Vials are accommodated in a common heated zone, and are manually selected for analysis. An inert needle is inserted into the HS vial before sample pressurisation and extraction by the UNITY 2. In addition to HS-trap functionality, a UNITY 2 with HS5-TD is also fully compatible with standard TD operation with sorbent tubes.

**For more information on Markes' HS5-TD accessory, please contact one of our specialists (enquiries@markes.com), or visit our website to download the brochure.**

1. Not compatible with the Perkin Elmer TurboMatrix HS40 system.

## Universal Direct Inlet Accessory (U-INLET™)

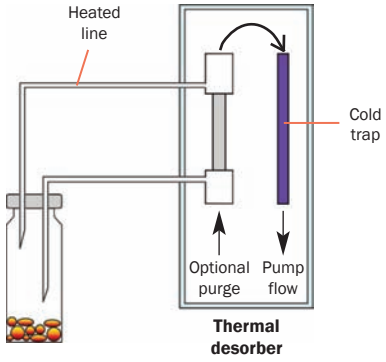
The Universal Direct Inlet Accessory can be added to any manual UNITY TD platform (series 1 or 2). It provides a simple and convenient mechanism for direct introduction of headspace vapours from a wide range of bulk sample containers.

U-INLET comprises a purge line (which can be used to direct carrier gas into the sample vessel) and a heated inert sampling line through which headspace vapours are pumped or purged straight into the UNITY cold trap. Compatible sample vessels include smaller, sealed containers (*e.g.* headspace vials or reaction vessels), and open or compressible containers such as bell jars or gas sampling bags.

If sampling is to be performed from a non-pressurised system, *i.e.* ambient air or a gas sampling bag, then a pump is required to draw sample through the system (*e.g.* the U-ASPM1 or U-ASPM2).

The accessory may also be used to sample vapours from the same vessel semi-continuously in a user-defined sequence. This is either done to increase the volume of vapour sampled, thus enhancing sensitivity, or to monitor vapour composition changes over time.

The U-INLET can operate in two sampling modes: **dynamic direct** and **pulsed direct**. Sampling times/sequences for both are controlled directly from the UNITY software.




***Schematic of Universal Direct Inlet Accessory (U-INLET)***

Dynamic direct sampling

In dynamic mode, U-INLET delivers a continuous flow of carrier gas that sweeps through the sample vessel, purging the headspace vapours into the UNITY cold trap for a defined time. This method is compatible with sampling from:

- a sealed reaction vessel (with/without an external gas supply)
- a pressurised container, *e.g.* a canister
- a non-pressurised system, *e.g.* ambient air or a sampling bag.

Pulsed direct sampling

This is the same approach used in the HS-trap systems described on page 57.

## Applications for HS–TD

Typical HS–TD applications include:

- **Environmental monitoring and health & safety**
  - VOCs in drinking water, groundwater, soils and waste
  - Detection of trace odorants in drinking water.
- **Food, flavour and fragrance**
  - Profiling of consumer products
  - Off-odour and taint in foods and beverages
  - Residual solvents in packaging and investigation of odour complaints
  - Biological emissions (*e.g.* kinetic studies, fragrance profiling and species identification)
  - Tobacco profiling and smoking research.
- **Volatiles in materials**
  - Residual monomer in polymer
  - Product and materials emissions screening
  - Forensic applications (ink characterisation, fire debris, explosive residues, proscribed drugs, *etc.*)
  - Organics in water-based paints
  - Residual solvents in powdered pharmaceuticals, ointments and creams.

See our Applications Guides[p 91] and Application Notes TDTS 78, 88, 91 and 96[p 92] for examples of the use of HS–TD.

| Description | Part number |
|---|---|
| HS5-TD headspace system | U-HS5TD |
| HS–TD connection kit, UNITY(e) to G1290 | U-HSTD-G1290 |
| HS–TD connection kit, UNITY(e) to G1888 | U-HSTD-G1888 |
| HS–TD connection kit, UNITY(e) to HS40 | U-HSTD-HS40 |
| Starter kit for HS5-TD | U-HSKIT |
| Vials, crimp-top, 20 mL, clear, pk 1000 | U-HSV00 |
| Crimps, 20 mm aluminium cap, silicone/PTFE liner, pk 1000 | U-HSVC0 |
| Crimper, 20 mm crimp-top vials | U-HSVCR |
| Decapper, 20 mm crimp-top vials | U-HSVDC |
| Routine maintenance kit for HS5-TD | RMK-0008 |
| Replacement needle assembly for HS5-TD | U-HSNAS |
| Universal Direct Inlet Accessory (U-INLET) | U-INLET |
| Pump (115 V) | U-ASPM1 |
| Pump (230 V) | U-ASPM2 |

***20 mL crimp-top vials***

## Bio-VOC™ breath sampler

Based on pioneering work carried out at the UK Health & Safety Laboratory[1], Markes' Bio-VOC breath sampler is a simple-to-use device designed for non-invasive biological exposure monitoring of volatile organic compounds (VOCs). Elevated levels of one or more VOCs within the body may indicate:

- Environmental or occupational exposure (*i.e.* absorption of chemicals from the environment or workplace through the skin, or by ingestion or inhalation)
- A clinical condition (there is evidence that VOC patterns in exhaled breath can be characteristic of certain diseases, and this is an area of continued research).

Conventional workplace biological monitoring methods measure target compounds or their metabolites directly in blood or urine. However, these methods are invasive and may require medically trained staff. This has made it expensive and difficult to undertake large-scale surveys of biological exposure in the past, either in the workplace or of the general public. As a result, occupational and environmental scientists have had to rely on standard tests of chemical concentrations in the atmosphere, and ignore (or estimate) potential exposure *via* skin absorption and ingestion.

The sampler harnesses the close relationship between chemical concentrations in the blood and the air deep down in the lungs – known as end-tidal (or alveolar) air. There is a rapid, almost instantaneous, partitioning of VOCs between the blood and alveolar air. Measurement of the VOCs in end-tidal air is therefore an ideal non-invasive method of monitoring the blood concentration and body burden of VOCs.

***Taking a breath sample using the Bio-VOC***

Constructed of safe, non-emitting plastic, the Bio-VOC can be operated with minimal training and without medically qualified staff in attendance. Each Bio-VOC is supplied with a disposable cardboard mouthpiece. Additional packs of mouthpieces are available to order.

An adult, exhaling deeply, typically breathes out over 4 L of air, of which just the last 127 mL is retained by the Bio-VOC. The sampler therefore collects a representative sample of end-tidal air, without contamination or dilution with breath from the bronchial tubes or mouth.


***Bio-VOC parts***

Once the breath has been collected, a screw-in plunger is used to steadily discharge the sample into a sorbent tube (or a direct read-out instrument). After collection onto a sorbent tube, the sample is sealed[p 20], ensuring the breath sample is stable for transportation and analysis – another distinct advantage over blood and urine samples. The Bio-VOC sampler may be used repeatedly by the same individual during the course of a day (typically using a new mouthpiece each time), and is then discarded or cleaned before re-use.

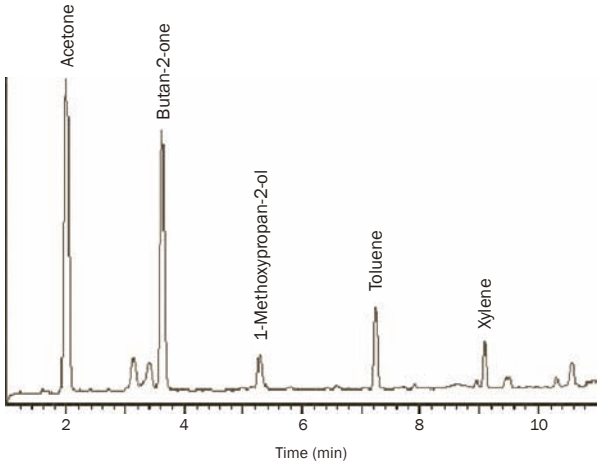
***Bio-VOC breath sampling – A simple non-invasive approach to biological monitoring and disease diagnosis***

1. H.K. Wilson, Breath analysis. Physiological basis and sampling techniques, *Scandinavian Journal of Work, Environment & Health*, 1986, 12: 174–192.

## Industrial applications of breath sampling

Biological monitoring, *i.e.* measuring the actual body burden of VOCs, is a way of assessing total exposure by all routes (dermal, inhalation, ingestion), and is the ultimate exposure test for workers in high-risk industries such as paint, petrochemicals and dry-cleaning.

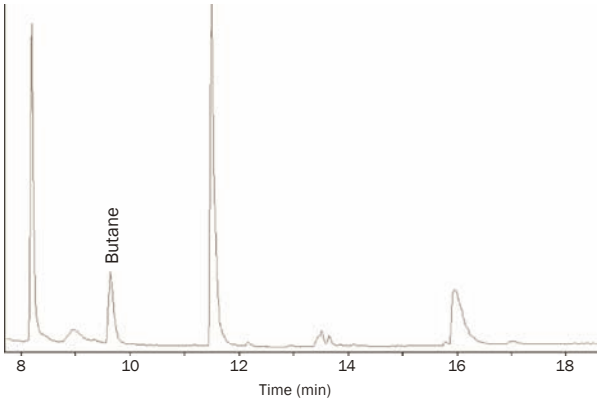
Such monitoring can also provide vital information on the potentially harmful build-up of chemicals in the body, particularly in fatty tissues, after prolonged low-level (chronic) exposure, *e.g.* to halogenated solvents. In addition, breath monitoring provides a valuable check on the efficacy of respiratory protective apparatus and protective clothing at work. It can also be used to assess risk, by taking samples before and after the operation of a particular task and recording changes in the VOC profile of the breath. Guidance notes are available[1] that provide information on interpreting solvent exposure with respect to occupational limits.




***Skin-absorbed solvents in the breath of workers in a shoe factory collected using the Bio-VOC***

## Clinical applications of breath sampling

The Bio-VOC sampler is also used for research into the clinical diagnostic potential of breath. Clinicians have long used the fruity smell of acetone on the breath as an early indication of diabetes and the pungent smell of ammonia as a sign of possible kidney failure. It is now widely hypothesised that the presence of specific chemicals or specific combinations of chemicals in the breath may provide a reliable diagnosis of certain otherwise difficult-to-diagnose and disabling diseases – among them psychiatric conditions, various cancers and metabolic failure in premature infants. Laboratory and clinical research in this area has previously been hampered by the lack of a simple and reliable method of sampling the alveolar portion of breath from patients and control groups. However, several research groups worldwide are now using the Bio-VOC to pursue this exciting field of study.




***Bio-VOC breath sample from a patient. Trace levels of VOCs, e.g. butane, are used to assist in clinical diagnoses***

*Chromatogram reproduced by kind permission of Psychiatric Diagnostics Ltd, Inverness, Scotland*

| Description | Part number |
|---|---|
| Bio-VOC breath sampler, pk 1 | C-BIO01 |
| Bio-VOC breath sampler, pk 10 | C-BIO10 |
| Bio-VOC breath sampler, pk 50 | C-BIO50 |
| Bio-VOC breath sampler, pk 100 | C-BIO100 |
| Disposable cardboard mouthpieces, pk 100 | C-B100M |

1. Breath sampler guidance notes – Information on interpreting solvent exposure, UK Health & Safety Laboratory (available from Markes International).

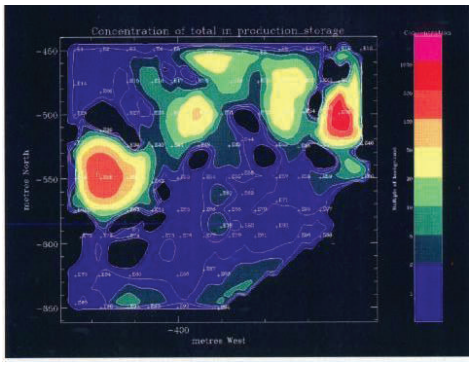
## VOC-Mole™ soil probe

Underground fuel or chemical leaks can present a grave environmental risk and slow down the remediation of brownfield sites. Markes' VOC-Mole provides a simple method of screening for volatile organic compounds in contaminated land. It facilitates effective surveys of commercial, waste and brownfield sites, pinpointing underground leaks or surface spills and cost-effectively tracking pollution flow.

***VOC-Mole soil probe and additional cap assembly with sample tube***

Soil probes allow cost-effective *in situ* screening of large areas of land, including active production sites. They can also be placed along the length of fuel pipelines to provide early warning of a leak. Diffusive tubes inside the soil probes can monitor the soil gases for ~24 hours. Pumped tubes can also be used.

VOC-Moles are typically arranged in a grid pattern over the site of interest, allowing organic pollutants to migrate into the hollow probe and collect (either diffusively or by active sampling) onto sorbent tubes inside. Automated TD–GC/MS analysis allows rapid identification of the nature, source and spread of ground contamination, and gives a good indication of soil gas/vapour levels.




***VOC-Mole soil probes arranged in a grid pattern around an industrial site allow low-cost mapping of contaminated ground***

Constructed of stainless steel, the VOC-Mole can be left *in situ* for long periods of time, with vapour samples collected onto sorbent tubes at whatever frequency is demanded by the application.

The VOC-Mole is available in three probe lengths and there is also a modified version for use in marshy ground. The unique aluminium sampling cap (a Markes copyrighted design) makes the probe suitable for both diffusive and pumped sampling. The cap contains O-ring seals to prevent the ingress of water, wildlife and general soil debris. Tube and sampling cap assemblies can be prepared in the laboratory and sealed ready for transportation to the field (where the probes may already be *in situ*).

A variety of different sampling regimes can be undertaken, for example:

- Standard diffusive monitoring over a long time period (*i.e.* 24 hours)
- Pumped monitoring, with the sample tube placed within or outside the probe
- Pumped sampling using two tubes in series, to monitor potential breakthrough of highly volatile components
- Using hand-held PID or FID detectors to screen organic vapour levels inside the VOC-Mole.

| Description | Part number |
|---|---|
| VOC-Mole assembly, 29.5 cm long, pk 1 | P-0001 |
| VOC-Mole assembly, 29.5 cm long, pk 10 | P-00010 |
| VOC-Mole assembly, 44.5 cm long, pk 10 | P-00020 |
| VOC-Mole assembly, 89.5 cm long, pk 10 | P-00030 |
| VOC-Mole assembly, 89.5 cm long, modified for use in marshy ground, pk 10 | P-00040 |
| VOC-Mole cap assembly, pk 1 | P-CP001 |
| VOC-Mole cap assembly, pk 10 | P-CP010 |
| Brass impact former for driving soil probes into the ground | P-FORMR |
| O-Rings, for VOC-Mole cap assembly, 23 mm × 3 mm i.d., pk 20 | P-CP020 |
| Unions, for VOC-Mole cap assembly, pk 10 | P-CPU10 |
| Blanking plugs, for VOC-Mole cap assembly, pk 10 | P-CPP10 |
| Dowty seals, for VOC-Mole cap assembly, pk 20 | P-CPS20 |
| Ferrules, PTFE, for VOC-Mole cap assembly, pk 10 | P-CPF10 |

***Soil gas and underground leaks – VOC-Mole takes air monitoring underground***

## Direct desorption

Thermal desorption isn't just for sorbent tubes and vapour samples. It can also be used for the direct desorption (extraction) of VOCs from a wide range of sample matrices, *e.g.* powdered solids, sugar/salt solutions, suspensions, resins, creams, fibres and films (see Application Note TDTS 9p 92). Applications include:

- Residual volatiles in ointments, packaging films, pharmaceuticals/drug powders and polymer beads
- VOC emissions from consumer goods (*e.g.* paints, car trim components, moulded PVC and adhesives)
- Characteristic vapour profiles from foodstuffs and fragrant products (*e.g.* soap powder and shampoo).

Direct desorption provides information on the (S)VOC content of materials that is complementary to that obtained by conventional emissions testing. It facilitates selective concentration of the compounds of interest, while water or other solvents are purged to vent, and features in several standard methods[1,2].

To carry out direct desorption using TD tubes, a known amount of sample is weighed into an empty tube or tube liner and desorbed (normally at low temperatures). In this case, sample cleanup, analyte extraction and sample injection are all combined into one simple, automated operation. The method can be tailored to meet specific analytical requirements, *e.g.* to obtain a representative vapour profile, or to achieve complete quantitative extraction of one or more specific target volatiles.

### Hints and tips

- Some samples (materials/products) are homogeneous and suitable for direct thermal desorption/extraction in empty TD tubes (see below). Other materials require larger samples to be representative. In these cases, the Micro-Chamber/Thermal Extractorp 52 or HS–TDp 57 are often used.
- Glass tubes are ideal for direct desorption. Their transparency makes method development easier, as the physical state of the sample can be easily seen after each desorption.
- Empty, unrestricted glass tubes can be used if the product is retained between two plugs of quartz wool, held in place with a small torsion springp 18. Alternatively, glass tubes can be used that have a restriction at 30 mm (this ensures the sample is positioned correctly with respect to the thermal desorption oven). A quartz wool plug and a torsion spring are positioned behind the sample to retain it in the tube.

If direct desorption in an empty tube could cause irreversible contamination of that tube, its best to place the sample in a disposable tube liner. Markes' direct desorption liners are made from PTFE and designed for use with stainless steel tubes. They protect the tube walls and simplify sample weighing. Two types of liners are available:

- **Snug-fit liners**, which should be used for most powdered/granular samples
- **Loose-fit liners**, suitable for semi-solid samples, which need to be smeared around the inside of the liner.


***PTFE liners for direct sampling shown alongside an empty tube***

### Hints and tips

- In all cases, it is critical that the sample does not plug the liner and that carrier gas can continue to flow through unimpeded.
- Loose-fit liners may also be inserted into tubes packed with a small bed (~1 cm) of sorbent, preventing high-boiling debris from the sample matrix migrating into the flow path.

### Direct desorption starter kit

This kit contains:

| | |
|---|---|
| Glass tubes, empty, restriction at 30 mm, pk 10 | C0-NXXX-0000 |
| Stainless steel tubes, empty, pk 10 | C0-AXXX-0000 |
| Cold trap, material emissions, UNITY 2/TD-100 *Compatible with the simultaneous analysis of analytes from n-$C_4$ to n-$C_{32}$* | U-T12ME-2S |
| PTFE liners, snug-fit, pk 10 | C-PI010 |
| PTFE liners, loose-fit, pk 10 | C-PL010 |
| Quartz wool, 10 g | C-QUTZW |
| Sorbent, Tenax TA (35/60), 10 g | C-TNXTA |
| Springs, torsion, for 4 mm i.d. glass tubes, pk 10 | C-GTSP10 |

| Description | Part number |
|---|---|
| Tube, empty, glass, restriction at 30 mm, pk 10 | C0-NXXX-0000 |
| Tube, empty, glass, restriction at 15 mm, pk 10 | C0-BXXX-0000 |
| Tube, empty, glass, unrestricted, pk 10 | C0-FXXX-0000 |
| Tube, empty, stainless steel, pk 10 | C0-AXXX-0000 |
| Tube, empty, inert, pk 10 | C0-CXXX-0000 |
| Liner, PTFE, snug-fit, pk 10 | C-PI010 |
| Liner, PTFE, snug-fit, pk 100 | C-PI100 |
| Liner, PTFE, loose-fit, pk 10 | C-PL010 |
| Liner, PTFE, loose-fit, pk 100 | C-PL100 |
| Direct desorption starter kit | C-KITDD-2S |

1. VDA 278 – Determination of organic emissions from non-metallic trim components used to manufacture the interior of motor vehicles by TD.
2. US EPA Method 311 – Hazardous air pollutants in paints and coatings.

# Starter kits

Markes provides a range of general-purpose and application-specific kits to get you started in thermal desorption. These kits contain all the consumables you need to set up your Markes TD system for application in question.

Details of additional kits, specific to individual instruments or accessories, can be found on the relevant pages within other sections, as follows:

- Page 19 for the TubeTAG starter kit
- Page 33 for the Easy-VOC starter kit
- Page 53 for the Micro-Chamber/Thermal Extractor starter kits
- Page 56 for the SPE-tD starter kit.

Should you have any questions about which accessories or consumables are best suited to your application, please don't hesitate to contact us (enquiries@markes.com).



## Kits to get you up and running quickly

## General TD starter kits

Two general-purpose TD starter kits (with standard 3½″ tubes) are available for the UNITY 2 and TD-100.

The **Basic TD starter kit** contains:

| | |
|---|---|
| Stainless steel sorbent tubes, packed with Tenax TA/Carbograph 1TD, conditioned and capped, pk 10<br>*Suitable for pumped sampling of VOCs from n-$C_{5/6}$ to n-$C_{30/32}$* | C2-AAXX-5032 |
| CapLok tool for tightening and undoing ¼″ brass storage caps | C-CPLOK |
| Cold trap, general-purpose carbon, UNITY 2/TD-100, n-$C_{4/5}$ to n-$C_{30/32}$ | U-T11GPC-2S |
| Quick-seal column connector, pk 10 | C-QSC10 |

The **Advanced TD starter kit** contains:

| | |
|---|---|
| Stainless steel sorbent tubes, packed with Tenax TA/Carbograph 1TD/Carboxen 1003, conditioned and capped, pk 10<br>*Suitable for pumped sampling of VOCs from $C_{2/3}$ to n-$C_{30/32}$* | C3-AAXX-5266 |
| Stainless steel sorbent tubes, packed with Tenax TA/Carbograph 1TD, conditioned and capped, pk 10<br>*Suitable for pumped sampling of VOCs from n-$C_{5/6}$ to n-$C_{30/32}$* | C2-AAXX-5032 |
| Stainless steel sorbent tubes, packed with Tenax TA, conditioned and capped, pk 10<br>*Suitable for pumped or diffusive sampling of VOCs from n-$C_{6/7}$ to n-$C_{30/32}$* | C1-AAXX-5003 |
| Diffusion caps, pk 10 | C-DF010 |
| Empty stainless steel tubes, pk 10 | C0-AXXX-0000 |
| Quartz wool, 10 g | C-QUTZW |
| Spring, gauze-retaining, pk 10 | C-SP010 |
| Penclip, pk 10 | C-CL010 |
| Ferrule, ¼″ PTFE, pk 20 | C-FP020 |
| PTFE liners, loose fit, pk 10 | C-PL010 |
| Cold trap, TO-15/TO-17 air toxics, UNITY 2/TD-100<br>*Compatible with the simultaneous analysis of analytes from $C_{2/3}$ to n-$C_{30/32}$* | U-T15ATA-2S |
| Easy-VOC pump, including CapLok tool and carry-case | C-EZVOCPO |
| Check-standard (BTX, isobornyl methacrylate (IBMA) and dioctyl phthalate), 90 ng/µL (nominal), Tenax TA, pk 10 | C-CHK10 |

*N.B.* Markes' Comprehensive TD starter kit (C-KIT02-2S) is still available for those people who wish to re-order.

| Description | Part number |
|---|---|
| Basic TD starter kit | C-KIT012-2S |
| Advanced TD starter kit | C-KIT03-2S |

## Chemical warfare agent starter kit

Markes' TD technology provides the ultimate pre-concentration and high-sensitivity analytical solution for detecting airborne chemical warfare agents (CWAs). Military and civilian security agencies and government scientists from across the world are using Markes' TD systems for monitoring:

- CWA stockpile sites
- Personal exposure of military personnel
- Performance of protective equipment
- Agent destruction facilities
- Key civilian locations (counter-terrorism).

The **CWA starter kit** is compatible with standard UNITY 2 or TD-100 systems and is intended specifically for analysts in the field of military and homeland defence. It contains:

| | |
|---|---|
| Inert-coated stainless steel 3½″ × ¼″ o.d. sorbent tubes, packed with quartz wool/Tenax TA, conditioned and capped, pk 10<br>*Suitable for sampling of G-type nerve agents, mustard gas (HD) and VX* | C2-CAXX-5138 |
| Inert-coated stainless steel 3½″ × ¼″ o.d. sorbent tubes, packed with HayeSep D/Tenax TA, conditioned and capped, pk 10<br>*Suitable for sampling of G-type nerve agents, mustard gas (HD), VX and the G-analogue of VX* | C2-CAXX-5250 |
| Cold trap, chemical warfare agents, UNITY 2/TD-100<br>*Compatible with the simultaneous analysis of all the above-mentioned analytes* | U-T10CW-2S |

Note that equivalent 4½″ long DAAMS tubes are also available for Ultra-X and UNITY-X TD configurations – contact a Markes specialist (enquiries@markes.com) for more details.

For examples of Markes' technology being used in real-world situations across the field of CWAs and forensics, please refer to our Application Notes[p 92] and the publication *Thermal Desorption: A Practical Applications Guide. Volume III. Defence and Forensic*[p 91].

| Description | Part number |
|---|---|
| CWA starter kit | C-KITCW-2S |

## Environmental monitoring starter kits

TD is now recognised as the technique of choice for environmental air monitoring and occupational health & safety. A number of standard methods are relevant to this area, including tube-based methods (ISO 16017, ASTM D6196, ISO 16000-6, EN 14662 parts 1 and 4, and US EPA Method TO-17), plus US EPA Method TO-15 and ASTM D5466 for canister-based sampling.

Complementing our leading range of analytical equipment for environmental and workplace air monitoring, we now also offer a number of environmental starter kits for those new to the field. Four kits are available[1]:

The **Basic environmental starter kit** is suitable for pumped tube sampling. It contains:

| | |
|---|---|
| Stainless steel tubes, packed with Tenax TA/Carbograph 5TD, conditioned and capped, pk 10<br>*Suitable for pumped sampling of VOCs from n-$C_4$ to n-$C_{30/32}$* | C2-AAXX-5149 |
| Cold trap, TO-15/TO-17 air toxics, UNITY 2/TD-100<br>*Compatible with the simultaneous analysis of analytes from $C_{2/3}$ to n-$C_{30/32}$* | U-T15ATA-2S |
| Easy-VOC pump, including CapLok tool and carry-case | C-EZVOCPO |

The **Diffusive monitoring starter kit** is perfect for TD users new to diffusive (passive) air sampling. It contains:

| | |
|---|---|
| Stainless steel tubes, packed with Tenax TA, conditioned and capped, pk 10<br>*Please see Application Notes TDTS 1 and TDTS 20p92 for analyte ranges* | C1-AAXX-5003 |
| Stainless steel tubes, packed with Carbograph 1TD, conditioned and capped, pk 10<br>*Please see Application Notes TDTS 1 and TDTS 20p92 for analyte ranges* | C1-AAXX-5009 |
| Diffusion caps, aluminium, 2 × pk 10 | **2 ×** C-DF010 |
| CapLok tool for tightening and undoing ¼" brass storage caps | C-CPLOK |
| Penclips, 2 × pk 10 | **2 ×** C-CL010 |
| Cold trap, TO-15/TO-17 air toxics, UNITY 2/TD-100<br>*Compatible with the simultaneous analysis of analytes from $C_{2/3}$ to n-$C_{30/32}$* | U-T15ATA-2S |
| Certified reference standard (BTX), 100 ng, pk 10 (includes certificate, chromatogram and shipping blank) | C-BTX100-10 |

## *Application-specific starter kits from the TD experts at Markes*

The **TO-15 starter kit** is ideal for analysts setting up canister-based sampling compliant with US EPA Method TO-15 (see Application Note TDTS 81p92). Note that although canisters are compatible with ultra-volatiles such as the lightest freons and $C_2$ hydrocarbons, they are inherently limited to analytes more volatile than n-$C_{9-12}$. The kit contains:

| | |
|---|---|
| Cold trap, TO-15/TO-17 air toxics, UNITY 2/TD-100<br>*Compatible with the simultaneous analysis of analytes from $C_{2/3}$ to n-$C_{30/32}$* | U-T15ATA-2S |
| **5 ×** TO-Can, 1 L, with gauge and ¼" valve | **5 ×** C-TOCAN1 |
| **2 ×** Canister air sampling kit, stainless steel | **2 ×** C-ASK1168SS |
| Frit, stainless steel, for critical orifice, pk 3 | C-ASK2USS |

The **TO-17 starter kit** is designed for those wishing to monitor air toxics using pumped tubes in compliance with US EPA Method TO-17 – see Application Note TDTS 86p92. The kit contains:

| | |
|---|---|
| Glass tubes, packed with Carbograph 1TD/Carboxen 1003, conditioned and capped, pk 10<br>*Suitable for pumped sampling of VOCs from $C_{2/3}$ to n-$C_{14}$* | C2-BAXX-5259 |
| Stainless steel tubes, packed with Tenax TA/Carbograph 1TD/Carboxen 1003, conditioned and capped, pk 10<br>*Suitable for pumped sampling of VOCs from $C_{2/3}$ to n-$C_{30/32}$* | C3-AAXX-5266 |
| CapLok tool for tightening and undoing ¼" brass storage caps | C-CPLOK |
| Cold trap, TO-15/TO-17 air toxics, UNITY 2/TD-100<br>*Compatible with the simultaneous analysis of analytes from $C_{2/3}$ to n-$C_{30/32}$* | U-T15ATA-2S |
| Certified reference standard, 9-component TO-17 mix, 100 ng, pk 10 (plus certificate, chromatogram and shipping blank) | C-TO17XX-10 |

Note that pumps such as Easy-VOCp33 or a Low-flow sampling pumpp32 are not included, and should be obtained separately.

Within the field of environmental monitoring, TD is also used for monitoring gas and vapour intrusion in soil, fugitive/stack emissions, and for testing odorants, volatiles and semi-volatiles in water (HS–TDp57 and SPE-tDp56). For further details on these and other applications related to environmental monitoring, please refer to our Application Notesp92 and the publication *Thermal Desorption: A Practical Applications Guide. Volume I. Environmental Monitoring & Exposure to Chemicals at Work*p91.

| Description | Part number |
|---|---|
| Basic environmental starter kit | C-KITEV01-2S |
| Diffusive monitoring starter kit | C-KITEV02-2S |
| TO-15 starter kit | C-KITEV03-2S |
| TO-17 starter kit | C-KITEV04-2S |

1. Note that all the tubes included in environmental monitoring starter kits are 3½" long × ¼" o.d., in compliance with standard methods.

## Material emissions starter kits

Increasing awareness of harmful VOCs emitted from furnishings, construction materials and consumer goods is driving new legislation requiring the measurement and reporting of VOC emissions from everyday products. This in turn is increasing pressure on manufacturers to control the levels of (S)VOCs released by their products.

The chemicals of interest cover a wide volatility range and many compound types. Standard reference or screening methods specify some form of chamber, cell or micro-chamber sampling followed by TD–GC(MS) analysis (IS 16000-6, ASTM D6196, *etc.*)

Markes offers three kits for material emissions testing and chemical content analyses[1]:

The **Basic material emissions starter kit** is ideal for those carrying out routine in-house tests of product emissions in compliance with ISO 16000, ISO 12219 or equivalent ASTM standards. It contains:

| | |
|---|---|
| Inert-coated stainless steel sorbent tubes, packed with Tenax TA, conditioned and capped, pk 10<br>*Suitable for sampling VOCs from n-$C_{6/7}$ to n-$C_{30/32}$* | C1-CAXX-5003 |
| Stainless steel sorbent tubes, packed with quartz wool/Tenax TA/Carbograph 5TD, conditioned and capped, pk 10<br>*Suitable for sampling VOCs from n-$C_4$ to n-$C_{32}$* | C3-AAXX-5304 |
| CapLok tool for tightening and undoing ¼″ brass storage caps | C-CPLOK |
| Cold trap, material emissions<br>*Compatible with the simultaneous analysis of analytes from n-$C_4$ to n-$C_{32}$* | U-T12ME-2S |
| Quick-seal column connector, pk 10 | C-QSC10 |

The **Comprehensive material emissions starter kit** provides a wider range of parts ideal for high-throughput service or manufacturing laboratories carrying out product emissions testing using standard reference or screening methods. It contains:

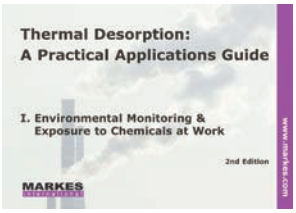
| | |
|---|---|
| Inert-coated stainless steel sorbent tubes, packed with Tenax TA, conditioned and capped, 2 × pk 10<br>*Suitable for sampling VOCs from n-$C_{6/7}$ to n-$C_{30/32}$* | **2 ×**<br>C1-CAXX-5003 |
| Stainless steel sorbent tubes, packed with quartz wool/Tenax TA/Carbograph 5TD, conditioned and capped, 2 × pk 10<br>*Suitable for sampling VOCs from n-$C_4$ to n-$C_{32}$* | **2 ×**<br>C3-AAXX-5304 |
| Glass sorbent tube with restriction at 30 mm, empty, for direct desorption, pk 10 | C0-NXXX-0000 |
| CapLok tool for tightening and undoing ¼″ brass storage caps | C-CPLOK |
| Spring, gauze-retaining, pk 10 | C-GTSP10 |
| Quartz wool, 10 g | C-QUTZW |
| Ferrule, PTFE, one-piece, pk 20 | C-FP020 |
| Check-standard (material emissions), 100 ng, Tenax TA, pk 10 | C-CHK10-ME |
| Cold trap, material emissions<br>*Compatible with the simultaneous analysis of analytes from from n-$C_4$ to n-$C_{32}$* | U-T12ME-2S |
| Quick-seal column connector, pk 10 | C-QSC10 |

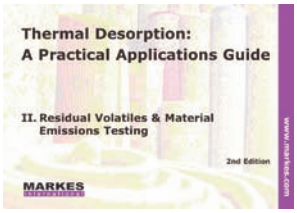
The **Direct desorption starter kit** contains a range of consumables for measuring chemical content or emissions from small samples of materials using direct desorption in glass tubes according to VDA 278 or equivalent methods. It contains:

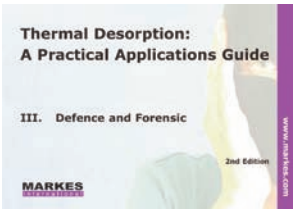
| | |
|---|---|
| Glass tubes, empty, restriction at 30 mm, pk 10 | C0-NXXX-0000 |
| Stainless steel tubes, empty, pk 10 | C0-AXXX-0000 |
| Cold trap, material emissions, UNITY 2/TD-100<br>*Compatible with the simultaneous analysis of analytes from n-$C_4$ to n-$C_{32}$* | U-T12ME-2S |
| PTFE liners, snug-fit, pk 10 | C-PI010 |
| PTFE liners, loose-fit, pk 10 | C-PL010 |
| Quartz wool, 10 g | C-QUTZW |
| Sorbent, Tenax TA (35/60), 10 g | C-TNXTA |
| Springs, torsion, for 4 mm i.d. glass tubes, pk 10 | C-GTSP10 |

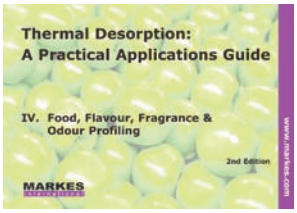
The need to measure chemicals released from products and materials has an impact on a large number of trades and manufacturing sectors – everything from paints to carpet and from toys to car trim components. For a summary of relevant applications please refer to our Application Notesp92 and the publication *Thermal Desorption: A Practical Applications Guide. Volume II. Residual Volatiles & Material Emissions Testing*p91.

| Description | Part number |
|---|---|
| Basic material emissions starter kit | C-KITME01-2S |
| Comprehensive material emissions starter kit | C-KITME02-2S |
| Direct desorption starter kit | C-KITDD-2S |




***Thermal desorption applications guides – See page 91 for more details***

1. Note that all the tubes included in material emissions starter kits are 3½″ long × ¼″ o.d., in compliance with standard methods.

# Instrument spares

Since 1997, Markes has pioneered and commercialised enhancements to analytical TD instrumentation and associated sampling apparatus. In this section we briefly describe our instruments and detail the associated spares and accessories that will ensure ongoing high performance.

For more information about Markes' range of TD instruments, please request a brochure or talk to one of our specialists.



## Spares and accessories for the world's leading TD systems

# UNITY™ 2


## General information

UNITY 2, Markes' second-generation TD platform, incorporates every system innovation of the last 15 years and the field-proven reliability inherent to all Markes' instrumentation. The main features of UNITY 2 are:

- **Compatibility** with electronically-tagged[p 7] or untagged tubes, (versions available for 3½″ or 4½″ tubes with ¼″ or 6 mm o.d.)
- Provides a **single platform for all TD applications** – *i.e.* labile species, semi-volatiles (up to n-$C_{40}$) and ultra-volatiles (including acetylene and freons) – both at trace levels (ppt) and high concentrations (ppm/%)
- **Repeat analysis** using SecureTD-Q™ overcomes the one-shot limitation of conventional TD systems
- **Cryogen-free operation** – electrically-cooled sorbent trapping to –30 °C prevents down-time and reduces running costs
- **Full compliance** with key international standard methods[1]:
  - No-flow ambient-temperature leak testing
  - Pre-purging of air to vent
  - Inert flow path
  - Cryogen-free cold trap.

### Electronic control of split and desorb flows

UNITY 2 instruments can be configured with one or two electronic mass flow controllers (MFCs), which provide versatile electronic control of both split and desorption flows. The MFC modules also facilitate flow-rate recall during an automated sequence with multiple TD methods.

### TubeTAG read/write technology

See page 7 for details of how Markes' TubeTAG technology can help you track your sorbent tubes.

### Automation accessories

Markes provides a comprehensive range of automation upgrades for UNITY 2. Options include:

- The ULTRA autosampler for 100 (3½″ or 4½″) tubes[p 71]
- 3-Channel Air Server accessory (3½″ or 4½″ tubes)[p 72]
- 8-Channel Air Server accessory (3½″ or 4½″ tubes)[p 72]
- The CIA *Advantage* for automated canister analysis[p 73]
- The HS5-TD for headspace analysis[p 57].

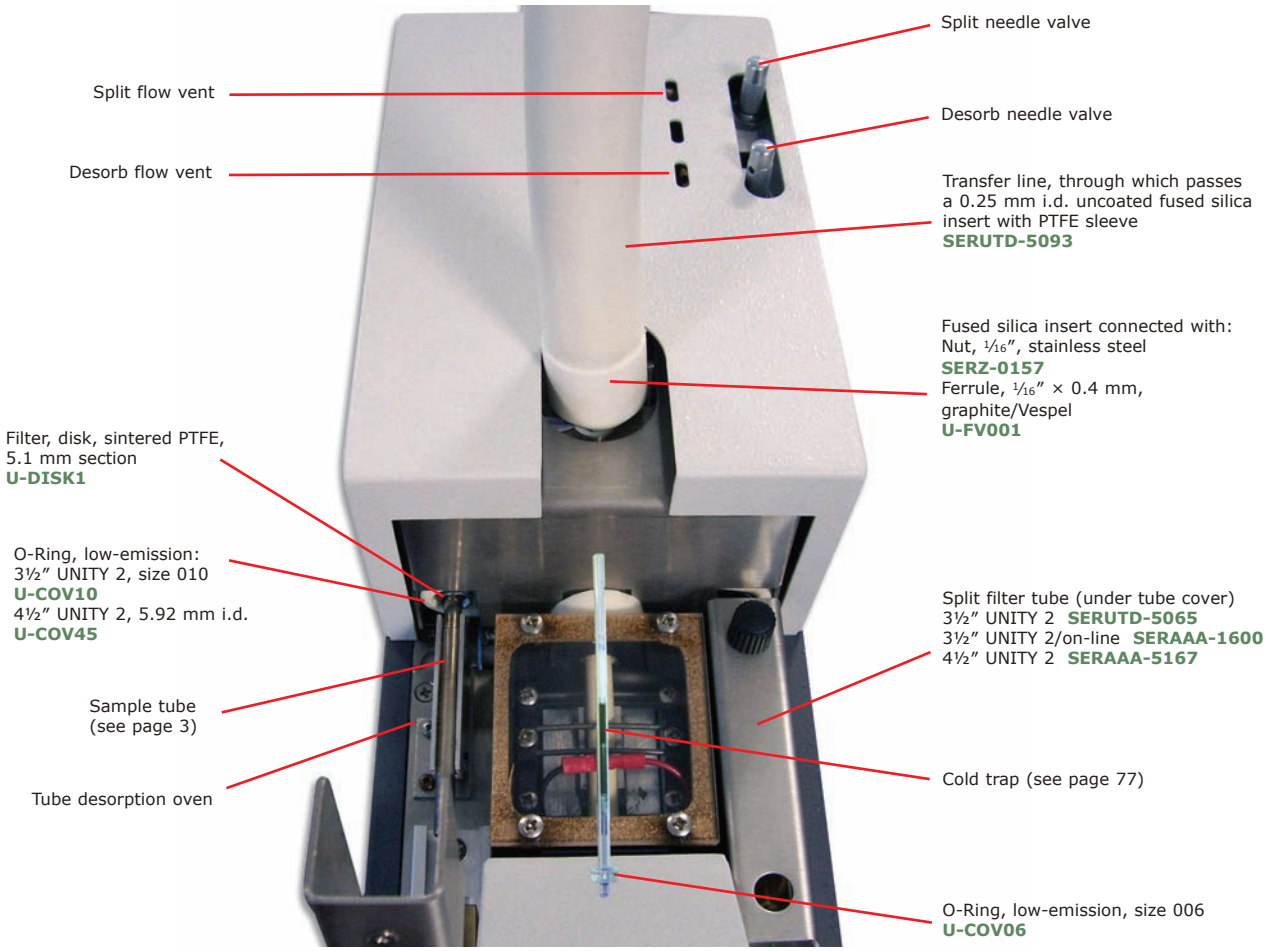
Further information on all accessories for UNITY 2 is available on our website and in the relevant brochures. Please email us (enquiries@markes.com) for more information, or contact your local distributor.

## Spares and consumables

### General (see diagram on next page)

| Description | Part number |
|---|---|
| O-Ring, low-emission, size 006, pk 10 | U-COV06 |
| O-Ring, low-emission, size 010, pk 10 | U-COV10 |
| O-Ring, low-emission, size 010, pk 100 | U-COV100 |
| O-Ring, low-emission, 5.92 mm i.d., pk 10 | U-COV45 |
| Split filter tube, stainless steel, 3½″, packed with charcoal | SERUTD-5065 |
| Split filter tube, glass, 3½″, packed with charcoal *(used for on-line systems)* | SERAAA-1600 |
| Split filter tube, glass, 4½″, packed with charcoal | SERAAA-5167 |
| Fused silica transfer line insert (0.25 mm i.d.) and PTFE sleeve | SERUTD-5093 |
| Ferrule, 1/16″ × 0.4 mm graphite/Vespel®, pk 10 *(connects fused silica transfer line)* | U-FV001 |
| Ferrule, 1/16″ × 1/16″ graphite/Vespel, pk 10 *(PEEK connections/bypass line/bulkhead union)* | U-FV002 |
| Ferrule, 1/8″ × 1/16″ graphite/Vespel, pk 10 *(PEEK connections/gas supply connections)* | U-FV003 |
| Filter, disk, sintered PTFE, 5.1 mm section, pk 10 | U-DISK1 |
| Quick-fit capillary connectors, pk 10 *(connects fused silica to column)* | C-QSC10 |
| Nut, 1/16″, for unions, stainless steel *(to connect fused silica insert)* | SERZ-0157 |

1. Examples include EN ISO 16017, ISO 16000-6, ASTM D6196-03, US EPA Method TO-17, and NIOSH 2549.




## Tools and installation connections

| Description | Part number |
|---|---|
| O-Ring insertion tool | SERZ-0285 |
| O-Ring extraction tool | SERZ-0351 |
| O-Ring service kit, 3½" tubes only *(includes U-COV10, U-DISK1, SERZ-0285, SERZ-0351)* | U-ORKIT |
| Tube extractor tool | SERUTD-5062 |
| Trap alignment tool | SERUTD-5064 |
| Standard tool kit | SERUTD-5063 |
| UNITY-to-GC transfer line clamp *(for use as spacer inside GC oven)* | SERUTD-1125 |
| Washer, ¼" × 1" *(for use with SERUTD-1125)* | SERZ-0371 |
| Washer, ¼" × 1½" *(for use with SERUTD-1125)* | SERZ-0372 |
| Nut, ¼"-20 UNC, stainless steel, for end of transfer line | SERZ-NU14SS |
| Quick-fit capillary connectors, pk 10 | C-QSC10 |

## Cables[1]

| Description | Part number |
|---|---|
| Cable assembly, lead, null modem *(PC to TD communications cable)* | SERZ-0189 |
| Cable assembly, UNITY 2 to GC, standard | SERUTE-5141 |
| Cable assembly, UNITY 2 to GC, Agilent | SERUTE-5142 |
| Cable assembly, UNITY 2 to GC, Thermo | SERUTE-5143 |
| Cable assembly, UNITY 2 to GC, Varian/Bruker | SERUTE-5144 |

## Miscellaneous spares and accessories

| Description | Part number |
|---|---|
| UNITY 2 software CD *(includes automation)* | U-SW001-2S |
| Markes' technical manual for series 2 TD systems on CD | U-TECHCD |
| UNITY to UNITYe conversion kit *(converts UNITY 2 from manual to electronic carrier control)* | SERUTE-5103 |
| UNITY 2 tube oven conversion kit, 3½" to 4½" *(user-installable)* | U-35TO45KT |
| UNITY 2 tube oven conversion kit, 4½" to 3½" *(user-installable)* | U-45TO35KT |
| Mass flow controller (MFC), digital, 2–500 mL/min | U-DMFC-2S |
| Universal Direct Inlet Accessoryp 58, 3½" | U-INLET |
| Universal Direct Inlet Accessoryp 58, 4½" | U-INLET-XZ |

1. UNITY 1 cables are also compatible with UNITY 2.

# TD-100™


## General information

The TD-100 is a highly versatile and robust TD instrument, dedicated to automated tube desorption. With capacity for 100 industry-standard 3½″ tubes, the TD-100 integrates all the main features and functionality of the series 2 UltrA–UNITY system into a single unit.

The **TD-100 Standard system** features manual re-collection of samples and in-built TubeTAG read/write functionality. The following upgrade options are available for this system:

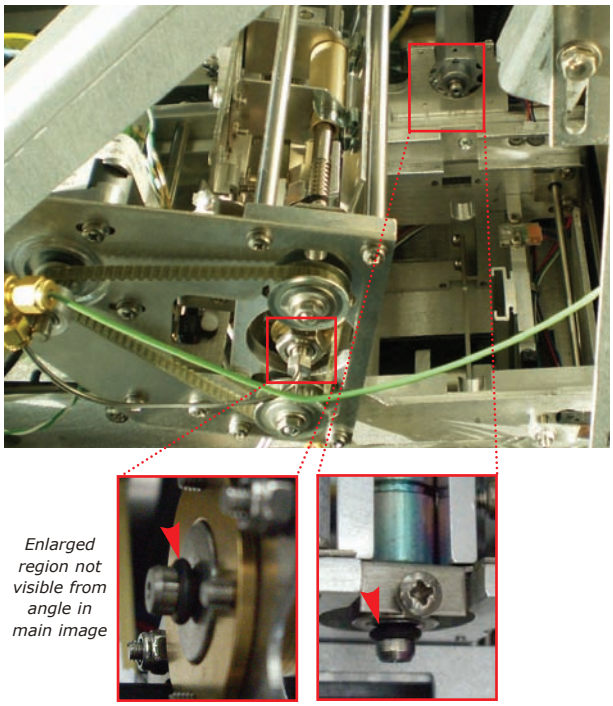
- Electronic mass flow control (MFC) of split and desorption flows
- Automated sample re-collection for repeat analysis (also includes dry-purge functionality)
- Internal standard/dry-purge (ISDP) functionality.

In addition to TubeTAG, the **TD-100 Advanced system** offers automated sample re-collection (including dry-purge functionality) and dual-electronic MFC as standard. It can also be upgraded to incorporate ISDP functionality if required.

**Please note:** TD-100 sytems are not compatible with Air Server, CIA 8, CIA *Advantage* or HS–TD units.

Further information on all accessories for the TD-100 is available on our website and in the relevant brochures. Please email us (enquiries@markes.com) for more information, or contact your local distributor.

## Spares and consumables



*Enlarged region not visible from angle in main image*

O-Ring, low-emission, size 007 **U-COV07**

### Cables

| Description | Part number |
|---|---|
| Cable assembly, lead, null modem *(PC to TD communications cable; two per instrument)* | SERZ-0189 |
| Cable assembly, UNITY 2 to GC, standard | SERUTE-5141 |
| Cable assembly, UNITY 2 to GC, Agilent | SERUTE-5142 |
| Cable assembly, UNITY 2 to GC, Thermo | SERUTE-5143 |
| Cable assembly, UNITY 2 to GC, Varian/Bruker | SERUTE-5144 |

### Miscellaneous

| Description | Part number |
|---|---|
| O-Ring, low-emission, size 006, pk 10 | U-COV06 |
| O-Ring, low-emission, size 007, pk 10 | U-COV07 |
| O-Ring, low-emission, size 010, pk 10 | U-COV10 |
| O-Ring, low-emission, size 010, pk 100 | U-COV100 |
| Ferrule, 1/16″ × 0.4 mm graphite/Vespel, pk 10 *(connects fused silica transfer line)* | U-FV001 |
| Ferrule, 1/16″ × 1/16″ graphite/Vespel, pk 10 *(PEEK connections/bypass line/bulkhead union)* | U-FV002 |
| Ferrule, 1/8″ × 1/16″ graphite/Vespel, pk 10 *(PEEK connections/gas supply connections)* | U-FV003 |
| UltrA/TD-100 O-ring insertion tool | SERMTD-1382 |
| Fused silica transfer line insert (0.25 mm i.d.) and PTFE sleeve | SERUTD-5093 |
| Split filter tube, stainless steel, 3½″, packed with charcoal | SERUTD-5065 |
| Filter, disk, sintered PTFE, 5.1 mm section, pk 10 | U-DISK1 |
| Tray assemblies for autosampler, 3½″, including 20 tray labels, pk 10 | U-TRAY |
| Labels, autosampler tray, 3½″, strip of 10, blue | SERMTD-1213BU |
| Quick-fit capillary connectors, pk 10 *(connects fused silica to column)* | C-QSC10 |

# UltrA™ 2

## General information

The UltrA 2 is a multi-functional TD autosampler that adds to any UNITY, featuring:

- Capacity for up to 100 tubes. Versions are available for 3½" tubes (standard model) and 4½" tubes (UltrA-X model)
- TubeTAG[p 7] compatibility
- Stringent sample sealing before and after desorption with patented DiffLok[p 21] caps
- Full compliance with key international standard methods.

UltrA 2 autosamplers can be factory-configured with either or both of the following options:

- **50:50 option** – Allows automatic re-collection of trap desorption (outlet) split flow. This means that the outlet split flow from up to 50 samples can be re-collected on to 50 fresh sorbent tubes. It can also be used to dry-purge tubes prior to desorption/analysis and, if necessary, can incorporate either one or two mass flow controllers (MFCs)
- **Internal standard/dry-purge (ISDP) option** – Allows an aliquot of gaseous internal standard to be added to the sampling end of each tube before desorption to aid analytical quality assurance. Can also be used to dry-purge tubes prior to desorption/analysis. See page 47 for a schematic.

Further information on all accessories for the UltrA 2 is available on our website and in the relevant brochures. Please email us (enquiries@markes.com) for more information, or contact your local distributor.

## Spares and consumables

| Description | Part number |
|---|---|
| Cap, DiffLok, stainless steel, ¼", pk 10 | C-DL010 |
| Cap, DiffLok, stainless steel, ¼", pk 100 | C-DL100 |
| Cap, DiffLok, inert, ¼", pk 10 | C-DLS10 |
| Cap, DiffLok, inert, ¼", pk 100 | C-DL1S0 |
| Cap, DiffLok, one stainless steel, one inert-coated, ¼", pk 10 pairs | C-DLP10 |
| Cap, DiffLok, one stainless steel, one inert-coated, ¼", pk 100 pairs | C-DL1P0 |
| Cap, DiffLok, stainless steel, 6 mm, pk 10 | C-DL010-XZ |
| Cap, DiffLok, stainless steel, 6 mm, pk 100 | C-DL100-XZ |
| Cap, DiffLok, inert, 6 mm, pk 10 | C-DLS10-XZ |
| Cap, DiffLok, inert, 6 mm, pk 100 | C-DL1S0-XZ |
| Cap, DiffLok, one stainless steel, one inert-coated, 6 mm, pk 10 pairs | C-DLP10-XZ |
| Cap, DiffLok, one stainless steel, one inert-coated, 6 mm, pk 100 pairs | C-DL1P0-XZ |
| O-Ring, low-emission, size 010, pk 10 *(for ¼" DiffLok caps)* | U-COV10 |
| O-Ring, low-emission, size 010, pk 100 *(for ¼" DiffLok caps)* | U-COV100 |
| O-Ring, low-emission, 5.92 mm i.d., pk 10 *(for 6 mm DiffLok caps)* | U-COV45 |
| O-Ring, low-emission, size 007, pk 10 *(UltrA tube receiver)* | U-COV07 |
| Tray assemblies for autosampler, 3½", including 20 tray labels, pk 10 | U-TRAY |
| Labels, autosampler tray, 3½", strip of 10, blue | SERMTD-1213BU |
| Tray assemblies for UltrA, 4½", including 20 tray labels, pk 10 | U-TRAY-XZ |
| Labels, UltrA tray, 4½", strip of 10, blue | SERMTD-1394BU |
| UltrA/TD-100 U-COV07 O-ring insertion tool | SERMTD-1382 |
| AutoSecureTD™ interface kit, 3½" *(to add a second UltrA 2 to UNITY 2)* | U-USKIT-2S |
| AutoSecureTD interface kit, 4½" *(to add a second UltrA 2 to UNITY 2)* | U-USKIT-XZ |
| AutoSecureTD interface kit, 3½" *(to add a second UltrA 2 to UNITY 1)* | U-USKIT |
| TubeTAG read/write option for UltrA 2 | U-TAGRW-2S |
| Connection kit, to connect series 2 Air Server 3/8 and UltrA 2 to the same UNITY 2, 3½" | U-UASK2-2S |
| Connection kit, to connect series 2 Air Server 3/8 and UltrA 2 to the same UNITY 2, 4½" | U-UASK2-XZ |

O-Ring, low-emission, size 007 **U-COV07**

***Tray assemblies for autosampler***

# Air Server™ and Canister Interface Accessory (CIA) systems

## General information

Markes' cryogen-free TD systems for on-line air monitoring and canister analysis include 3- or 8-channel Air Servers and Canister Interface Accessories (CIA). These add to any UNITY 2 (or ULTRA–UNITY 2) system to deliver a controlled flow of air or gas directly into the electrically-cooled cold trap of the desorber.

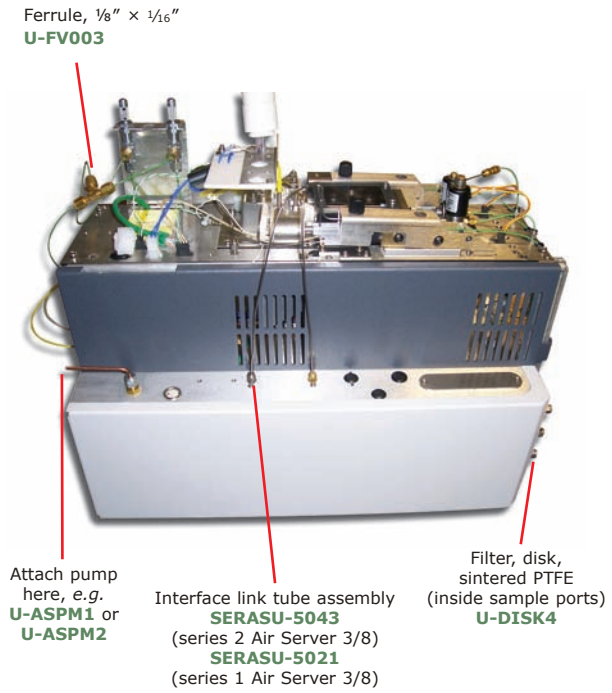
With 3- and 8-channel systems available, Air Server systems are ideal for automated round-the-clock unattended monitoring of ambient-temperature on-line air/gas streams. They are also compatible with canister and bag samples.

The CIA 8 and its successor the CIA *Advantage* (see next page), are designed for automated analysis of air/gas samples from canisters or bags. They offer multiple channels, heated lines and internal standard addition.

Further information is available on our website and in the relevant brochures. Please email us (enquiries@markes.com) for more information, or contact your local distributor.


***CIA 8***

## Spares and consumables




***UNITY 2 thermal desorber with 3-channel Air Server***

| Description | Part number |
|---|---|
| Ferrule, ⅛" × 1/16", graphite/Vespel, pk 10 *(PEEK to ⅛" brass unions)* | U-FV003 |
| Tubing, PEEK, 1/16" o.d. × 0.03" bore, 1 m | SERZ-0108 |
| Split filter tube, glass, 3½", packed with charcoal | SERAAA-1600 |
| Tubing, PTFE, ⅛", 1 m | SERZ-0062 |
| Interface link tube assembly *(series 1 Air Server 3/8)* | SERASU-5021 |
| Interface link tube assembly *(series 2 Air Server 3/8)* | SERASU-5043 |
| Sample transfer line *(ASIS 8™ and CIA 8 only)* | SERASU-5041 |
| Pump, 115 V, for unpressurised samples | U-ASPM1 |
| Pump, 230 V, for unpressurised samples | U-ASPM2 |
| Ferrule, ⅛" × ⅛", Vespel *(used on UNITY copper vents)* | U-FV004 |
| Filter, disk, sintered PTFE, 3.2 mm section, pk 10 | U-DISK4 |
| Dryer kit for series 2 Air Server and CIA systems | U-ASDRY |
| Dryer kit for series 1 Air Server 3/8 | U-ASDRY-1S |
| Connection kit, to connect series 1 Air Server 3/8 (or CIA 8) and ULTRA (50:50) to the same UNITY 1 | U-UASK2 |
| Connection kit, to connect series 2 Air Server 3/8 and ULTRA 2 to the same UNITY 2, 3½" | U-UASK2-2S |
| Connection kit, to connect series 2 Air Server 3/8 and ULTRA 2 to the same UNITY 2, 4½" | U-UASK2-XZ |

# CIA *Advantage*™

## General information

The CIA *Advantage* is an advanced system for automated analysis of VOCs in canister air. The main features are:

- Cryogen-free operation, leading to substantial cost savings
- Heated internal lines (up to 200 °C) and uniquely efficient purging combine to eliminate carryover and increase sample throughput
- Compatibility with high- and low-concentration samples in the same sequence
- Compatibility with both canisters and sorbent tubes, allowing a wider range of applications to be accommodated.

Two models are available:

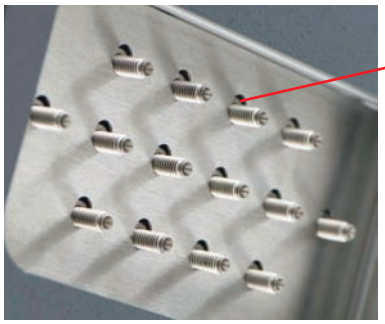
- The **CIA *Advantage*-T**™ incorporates mass flow control technology and provides a dedicated system for analysis of trace-level components. Up to four canisters are accommodated on the standard T model, and the minimum sample volume is 10 mL
- The **CIA *Advantage*-HL**™ is a versatile system for analysis of both high- and low-concentration samples and for screening unknowns. It incorporates gas-loop sampling in addition to mass flow control. Up to fourteen canisters are accommodated on the standard HL model, and the minimum sample volume is 0.5 mL.

Accessories available for the CIA *Advantage* include:

- The **CIA Satellite**™ module increases the capacity of both CIA *Advantage* models by 13 channels
- Markes' **diluter**p 41 offers accurate dilution of a standard gas, allowing the creation of multiple calibration levels from a single original standard
- Markes' **canister racks**p 41 hold up to 15 canisters (14 samples and one internal standard)
- The addition of Markes' **UltrA autosampler**p 71 to CIA *Advantage* systems allows up to 100 sorbent tubes to be processed automatically.

Further information on all accessories for the CIA *Advantage* is available on our website and in the relevant brochures. Please email us (enquiries@markes.com) for more information, or contact your local distributor.

## Spares and consumables




| Description | Part number |
|---|---|
| Dryer kit for CIA *Advantage* systems | U-ASDRY |
| Humidifier, for humidification of purge gas | U-HUMID |
| Heated sample lines (14 lines, each 1.8 m length) | U-HTLNKT |
| Filter, disk, sintered PTFE, 3.2 mm section, pk 10 | U-DISK4 |
| Pump, 115 V, for unpressurised samples | U-ASPM1 |
| Pump, 230 V, for unpressurised samples | U-ASPM2 |
| Split filter tube, glass, 3½", packed with charcoal | SERAAA-1600 |
| Sample loop, 0.1 mL | SERZ-0993 |
| Sample loop, 0.5 mL | SERZ-0994 |
| Sample loop, 1 mL | SERZ-0516 |
| Sample loop, 2 mL | SERZ-0995 |

# UNITY™ 1


## General information

In February 2008, UNITY 1 was replaced by UNITY 2. However, key accessories and consumables are still available from Markes International to enhance your existing UNITY 1 installation.

For further information on all accessories for UNITY 1, please email us (enquiries@markes.com), or contact your local distributor.

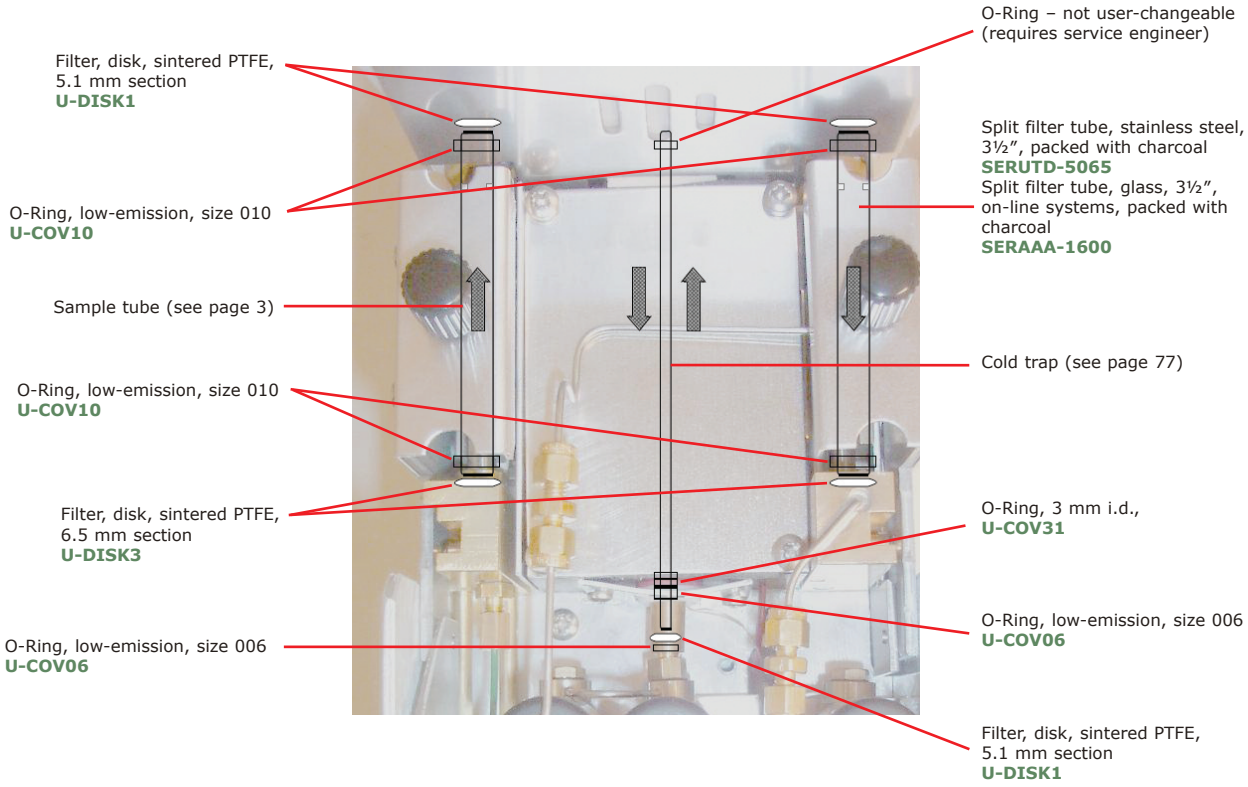
## Spares and consumables

General (see diagram on next page)

| Description | Part number |
|---|---|
| O-Ring, low-emission, size 006, pk 10 | U-COV06 |
| O-Ring, low-emission, size 010, pk 10 | U-COV10 |
| O-Ring, low-emission, size 010, pk 100 | U-COV100 |
| O-Ring, 3 mm i.d., pk 10 | U-COV31 |
| Fused silica transfer line insert (0.25 mm i.d.) and PTFE sleeve | SERUTD-5093 |
| Split filter tube, stainless steel, 3½", packed with charcoal | SERUTD-5065 |
| Split filter tube, glass, 3½", packed with charcoal *(used for on-line systems)* | SERAAA-1600 |
| Fuse, 5 mm × 20 mm, 6.3 A, antisurge | SERZ-FS6A3 |
| Ferrule, 1/16" × 0.4 mm graphite/Vespel, pk 10 *(connects fused silica transfer line)* | U-FV001 |
| Ferrule, 1/16" × 1/16" graphite/Vespel, pk 10 *(PEEK connections/bypass line)* | U-FV002 |
| Ferrule, 1/8" × 1/16" graphite/Vespel, pk 10 *(PEEK connections/bulkhead unions)* | U-FV003 |
| Filter, disk, sintered PTFE, 5.1 mm section, pk 10 | U-DISK1 |
| Filter, disk, sintered PTFE, 6.5 mm section, pk 10 | U-DISK3 |
| Quick-fit capillary connectors, pk 10 *(connects fused silica to column)* | C-QSC10 |

Tools and installation connections

| Description | Part number |
|---|---|
| O-Ring insertion tool | SERZ-0285 |
| O-Ring extraction tool | SERZ-0351 |
| O-Ring service kit, 3½" tubes only *(includes U-COV10, U-DISK1, SERZ-0285, SERZ-0351)* | U-ORKIT |
| Tube extractor tool | SERUTD-5062 |
| Trap alignment tool | SERUTD-5064 |
| Standard tool kit | SERUTD-5063 |
| UNITY-to-GC transfer line clamp *(for use as spacer inside GC oven)* | SERUTD-1125 |
| Washer, ¼" × 1", for use with SERUTD-1125 | SERZ-0371 |
| Washer, ¼" × 1½", for use with SERUTD-1125 | SERZ-0372 |
| Nut, ¼"-20 UNC, stainless steel, for end of transfer line *(for UNITY 1 from U-10284)* | SERZ-NU14SS |
| Nut, M6, stainless steel, for end of transfer line *(for UNITY 1 prior to U-10284)* | SERZ-NM6FSS |




## Cables

| Description | Part number |
|---|---|
| Cable assembly, lead, null modem *(PC to TD communications cable)* | SERZ-0189 |
| Cable assembly, PCB GC interface and cable, standard | SERUTD-5095 |
| Cable assembly, PCB GC interface and cable, Agilent | SERUTD-5098 |
| Cable assembly, PCB GC interface and cable, Thermo | SERUTD-5108 |
| Cable assembly, PCB GC interface and cable, Varian/Bruker | SERUTD-5116 |

## Miscellaneous spares and accessories

| Description | Part number |
|---|---|
| UNITY to UNITYe conversion kit *(converts UNITY 1 from manual to electronic carrier control)* | SERUTD-5103 |
| Universal Direct Inlet Accessoryp58, 3½" | U-INLET |

# TT24-7™


## General information

Markes' TT24-7 is a robust, transportable, near-real-time TD system incorporating two electrically-cooled large-capacity traps that are sampled sequentially at high flow rates (up to 500 mL/min). This allows efficient pre-concentration of trace-level agents with 100% sampling efficiency (*i.e.* no dead time), and fast (typically 5–15 min) cycle times. The TT24-7 connects to any make of GC/MS and is used, for example, to continuously monitor the atmosphere at a number of key civilian locations and military installations worldwide.

Three TT24-7 systems are available from Markes:

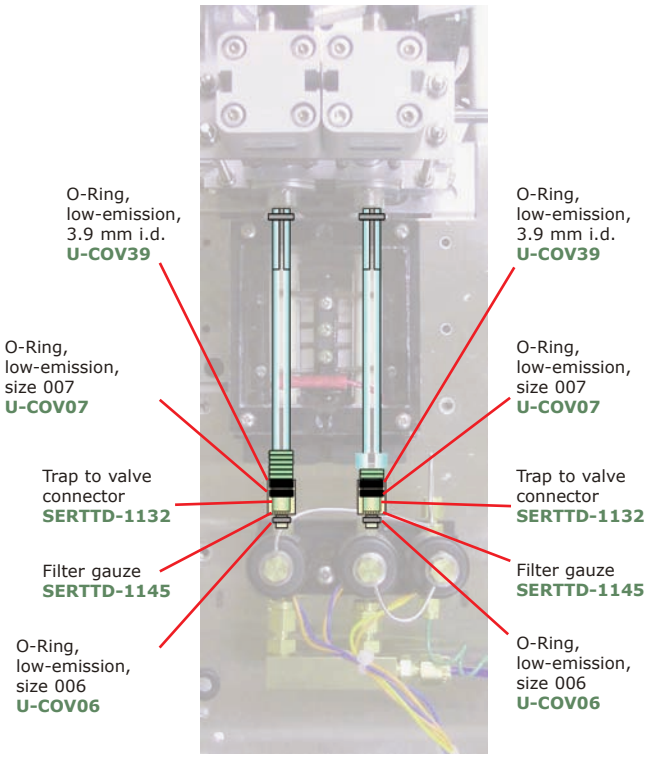
- **TT24-7e1** – standard system
- **TT24-7e2** – standard system plus tube desorption, pre-purge to vent facility and leak test
- **TT24-7e3** – standard system plus tube desorption, pre-purge to vent facility, leak test and split option.

The following accessories are available for any of the TT24-7 configurations:

- **Power recycle box** – Enables remote power cycling of the instrument, ideal for systems operating in remote locations. In the event of a power failure, a TT24-7 connected to a power recycling box can be re-started *via* a remote desktop connection, avoiding the requirement to visit the site to re-start the system
- **Heated sample lines** – For transport of sample from the monitoring location to the TT24-7. The sample inlet transfer line is constructed of inert materials and can be heated to 200°C. Sample inlet transfer lines of various lengths and internal diameters are available. Please contact Markes to discuss your requirements.

Further information on all accessories for the TT24-7 is available on our website. Please email us (enquiries@markes.com) for more information, or contact your local distributor.

## Spares and consumables




| Description | Part number |
|---|---|
| O-Ring, low-emission, size 006, pk 10 | U-COV06 |
| O-Ring, low-emission, size 007, pk 10 | U-COV07 |
| O-Ring, low-emission, size 010, pk 10 *(e2/e3 systems)* | U-COV10 |
| O-Ring, low-emission, 3.9 mm i.d., pk 10 | U-COV39 |
| Filter, disk, sintered PTFE, 5.1 mm section, pk 10 | U-DISK1 |
| Filter, disk, sintered PTFE, 6.5 mm section, pk 10 | U-DISK3 |
| Gauze filter, flexible link | SERTTD-1145 |
| Gauze filter, ¼", inert, sample inlet, TT24-7 | SERTTD-1150 |
| Fused silica transfer line insert (0.25 mm i.d.) and PTFE sleeve | SERUTD-5093 |
| Split filter tube, stainless steel, 3½", packed with charcoal *(e3 systems)* | SERUTD-5065 |
| Ferrule, 1/16" × 0.4 mm graphite/Vespel, pk 10 *(connects fused silica transfer line)* | U-FV001 |
| Recycle power box for TT24-7 *(assists remote operation)* | U-RCYBX |
| Trap-to-valve connector | SERTTD-1132 |

## Cold traps (focusing traps)

The following cold traps are recommended for UNITY and TD-100 instruments. Note that UNITY 2 and TD-100 cold traps are not compatible with UNITY 1 and *vice versa* – be sure to order the trap which is compatible with your thermal desorber.

| Description | Part number | |
|---|---|---|
| | UNITY 1 | UNITY 2 & TD-100 |
| Cold trap, high-boilers, n-$C_6$ to n-$C_{40}$ | U-T1HBL | U-T1HBL-2S |
| Cold trap, general-purpose hydrophobic, n-$C_{4/5}$ to n-$C_{30/32}$ | U-T2GPH | U-T2GPH-2S |
| Cold trap, sulfur/labile | U-T6SUL | U-T6SUL-2S |
| Cold trap, empty | U-T7EMP | U-T7EMP-2S |
| Cold trap, custom-packed | U-T8CUS | U-T8CUS-2S |
| Cold trap, chemical warfare agents | U-T10CW | U-T10CW-2S |
| Cold trap, general-purpose carbon, n-$C_{4/5}$ to n-$C_{30/32}$ | U-T11GPC | U-T11GPC-2S |
| Cold trap, material emissions, n-$C_4$ to n-$C_{32}$ | U-T12ME | U-T12ME-2S |
| Cold trap, TO-15/TO-17 air toxics, $C_{2/3}$ to n-$C_{30/32}$ | U-T15ATA | U-T15ATA-2S |
| Cold trap, greenhouse gases, $C_2$ to n-$C_{14}$ | U-T16GHG | U-T16GHG-2S |
| Cold trap, ozone precursors | U-T17O3P | U-T17O3P-2S |

The following cold traps are recommended for the TT24-7 (*N.B.* two are required for each system):

| Description | Part number |
|---|---|
| Cold trap, TT24-7, for CWAs *(in particular VX)* | T-1VX |
| Cold trap, TT24-7, for CWAs *(in particular HD)* | T-2HD |
| Cold trap, TT24-7, for CWAs *(in particular the GB/GE analog of VX)* | T-3GBGE |
| Cold trap, TT24-7, empty for packing | T-6EMP |
| Cold trap, TT24-7, custom-packed | T-7CUS |
| Cold trap extraction tool for TT24-7 | SERTTD-5032 |

Please note: Packs of 10 cold traps can be ordered by adding '10' to the end of the main section of the part number, *e.g.* U-T15ATA**10**, U-T15ATA**10**-2S.

***Empty (top) and packed (bottom) cold traps for UNITY 2/TD-100***

The entire range of previously listed traps is still available from Markes International. Email us (consumables@markes.com) for further details.

***Markes' cold traps heat at rates up to 100 °C per second for optimum desorption efficiency***

# Instrument starter kits

## UNITY 2

The **Basic TD starter kit**, for 3½″ (standard) tubes, contains:

| | |
|---|---|
| Stainless steel sorbent tubes, packed with Tenax TA/Carbograph 1TD, conditioned and capped, pk 10<br>*Suitable for pumped sampling of VOCs from n-$C_{5/6}$ to n-$C_{30/32}$* | C2-AAXX-5032 |
| CapLok tool for tightening and undoing ¼″ brass storage caps | C-CPLOK |
| Cold trap, general-purpose carbon, UNITY 2/TD-100, n-$C_{4/5}$ to n-$C_{30/32}$ | U-T11GPC-2S |
| Quick-seal column connector, pk 10 | C-QSC10 |

The **Advanced TD starter kit**, for 3½″ (standard) tubes, contains:

| | |
|---|---|
| Stainless steel sorbent tubes, packed with Tenax TA/Carbograph 1TD/Carboxen 1003, conditioned and capped, pk 10<br>*Suitable for pumped sampling of VOCs from $C_{2/3}$ to n-$C_{30/32}$* | C3-AAXX-5266 |
| Stainless steel sorbent tubes, packed with Tenax TA/Carbograph 1TD, conditioned and capped, pk 10<br>*Suitable for pumped sampling of VOCs from n-$C_{5/6}$ to n-$C_{30/32}$* | C2-AAXX-5032 |
| Stainless steel sorbent tubes, packed with Tenax TA, conditioned and capped, pk 10<br>*Suitable for pumped or diffusive sampling of VOCs from n-$C_{6/7}$ to n-$C_{30/32}$* | C1-AAXX-5003 |
| Diffusion caps, pk 10 | C-DF010 |
| Empty stainless steel tubes, pk 10 | C0-AXXX-0000 |
| Quartz wool, 10 g | C-QUTZW |
| Spring, gauze-retaining, pk 10 | C-SP010 |
| Penclip, pk 10 | C-CL010 |
| Ferrule, ¼″ PTFE, pk 20 | C-FP020 |
| PTFE liners, loose fit, pk 10 | C-PL010 |
| Cold trap, TO-15/TO-17 air toxics, UNITY 2/TD-100<br>*Compatible with the simultaneous analysis of analytes from $C_{2/3}$ to n-$C_{30/32}$* | U-T15ATA-2S |
| Easy-VOC pump, including CapLok tool and carry-case | C-EZVOCPO |
| Check-standard (BTX, isobornyl methacrylate (IBMA) and dioctyl phthalate), 90 ng/µL (nominal), Tenax TA, pk 10 | C-CHK10 |

*N.B.* Markes' Comprehensive TD starter kit (C-KIT02-2S) is still available for those people who wish to re-order.

## UltrA 2 and TD-100

The **Automated TD starter kit** for the UltrA 2 autosampler and TD-100, compatible with 3½″ (standard) tubes, contains:

| | |
|---|---|
| Cap, DiffLok, stainless steel, ¼″, pk 160<br>*(sufficient for 80 tubes, for routine analysis[1])* | C-DL160 |
| O-Rings, size 007, pk 10 *(for UltrA tube receiver)* | U-COV07 |
| O-Rings, size 010, pk 10 *(for tube interface seal)* | U-COV10 |

## UltrA-X™

The **Automated TD starter kit** for the UltrA-X (the model of the UltrA 2 autosampler compatible with 4½″ tubes with 6 mm o.d. ends) contains:

| | |
|---|---|
| Cap, DiffLok, pk 80 pairs (80 stainless steel, 80 inert-coated)<br>*(sufficient for 80 tubes, for routine analysis)* | C-DLP80-XZ |
| O-Rings, size 007, pk 10 *(for UltrA tube receiver)* | U-COV07 |
| O-Rings, 5.92 mm i.d., pk 10<br>*(for tube interface seal)* | U-COV45 |

For kits specific to accessories or applications, please see:

- Page 19 for the TubeTAG starter kit
- Page 33 for the Easy-VOC starter kit
- Page 53 for the Micro-Chamber/Thermal Extractor starter kits
- Page 56 for the SPE-tD starter kit
- Page 62 for the direct desorption starter kit
- Pages 64–66 for application-specific starter kits.

| Description | Part number |
|---|---|
| Basic TD starter kit | C-KIT012-2S |
| Advanced TD starter kit | C-KIT03-2S |
| Automated TD starter kit, for 3½″ tubes | U-ULKIT |
| Automated TD starter kit, for 4½″ tubes | U-ULKIT-XZ |

1. Note that if thermally labile or reactive species are to be analysed, the use of inert-coated DiffLok caps[p 21] at the sampling end is highly recommended.

## Routine maintenance kits

Routine maintenance kits are available for UNITY 1 and 2, TD-100, TT24-7, Air Servers and CIA systems. Kits contain sufficient consumable items (O-rings, PTFE filters, *etc.*) for approximately 12 months' use. Where indicated, the relevant cold trap is included (specify trap typep 77 with order).

### Suggested maintenance schedule

Suggested maintenance frequencies are given below. However, in some cases (depending on the application), items may need replacing more frequently.

UNITY 1 and 2

| | |
|---|---|
| Condition/change charcoal filter (split tube) | 3 months[1] |
| Replace/repack cold trap | 12 months[1] |
| Replace fused silica transfer line | 12 months |
| Change sample tube O-rings/filters | 12 months, or if damaged/leaking |
| Cold trap seals | 12 months, or if damaged/leaking |

TD-100

| | |
|---|---|
| Condition/change charcoal filter (split tube) | 3 months[1] |
| Replace/repack cold trap | 12 months[1] |
| Replace fused silica transfer line | 12 months |
| Change sample tube O-rings/filters | 12 months, or if damaged/leaking |
| Cold trap seals | 12 months, or if damaged/leaking |
| Replace O-rings in DiffLok caps | If damaged/leaking |
| Change nozzle seals | If damaged/leaking |

ULTRA

| | |
|---|---|
| Replace O-rings in DiffLok caps | If damaged/leaking |
| Change nozzle seals | If damaged/leaking |

Air Server 3/8, CIA 8 and CIA *Advantage*

| | |
|---|---|
| Replace filter disks | 12 months |

### Hints and tips

- As well as routine maintenance procedures carried out by the user, it is strongly recommended that a routine maintenance service is carried out on your TD system, by a trained service engineer, at least once a year.

| Description | Part number |
|---|---|
| Routine maintenance kit, UNITY 1, specify cold trap | RMK-0001 |
| Routine maintenance kit, UNITY 1, without cold trap | RMK-0004 |
| Routine maintenance kit (ECC), UNITY 1, contains U-T11GPC cold trap | RMK-012 |
| Routine maintenance kit, UNITY 2, 3½", specify cold trap | RMK-0001-2S |
| Routine maintenance kit, UNITY 2, 3½", without cold trap | RMK-0004-2S |
| Routine maintenance kit (ECC), UNITY 2, 3½", with U-T11GPC-2S cold trap | RMK-012-2S |
| Routine maintenance kit, UNITY 2, 4½", specify cold trap | RMK-0001-XZ |
| Routine maintenance kit, UNITY 2, 4½", without cold trap | RMK-0004-XZ |
| Routine maintenance kit, TD-100, specify cold trap | RMK-0009 |
| Routine maintenance kit, TD-100, without cold trap | RMK-0010 |
| Routine maintenance kit for TT24-7, specify cold traps (two supplied) | RMK-0005 |
| Routine maintenance kit, 3½", Air Servers and CIA systems | RMK-0003-2S |

***Markes' TD service support specialists – There to support you and to back up our global network of service providers***

1. Note that these parts may require changing more frequently in automated systems.

# Laboratory accessories

Markes offers a range of laboratory accessories and tools to assist with successful thermal desorption (TD)–GC/MS analyses.



## A comprehensive range of accessories for your TD–GC(MS) laboratory

## Pneumatic control accessories

### Dual regulator pneumatics accessory


TD equipment typically requires a supply of high-purity carrier gas (usually helium) and a supply of dry gas (either air or nitrogen). The dual regulator pneumatics accessory controls both these gas supplies immediately upstream of the TD system. It consists of a high-quality stainless steel regulator (0–60 psig) for control of the carrier gas, and a standard regulator (0–100 psig) for control of the dry gas. Both lines also have on/off toggle valves.

Markes strongly recommends that all thermal desorbers (UNITY, TD-100 and TT24-7) are configured with a dual regulator pneumatics accessory.

### Single regulator pneumatics accessory

The single regulator pneumatics accessory consists of a high-quality (stainless steel) regulator (0–60 psig) and an on/off toggle valve.

It is recommended for use in the following configurations:

- Controlling purge gas supply on UltrA and TD-100 autosamplers with internal standard functionality
- Regulating the pressure of internal standard (IS) gas if no other appropriate regulation is supplied
- Controlling the supply gas to the Micro-Chamber/Thermal Extractorp52 or TC-20p50.

| Description | Part number |
|---|---|
| Dual regulator pneumatics accessory *(for dry gas and carrier gas regulation)* | U-GAS01 |
| Single regulator pneumatics accessory *(for carrier gas regulation)* | U-GAS03 |

## Helium leak detector

Accurate, sensitive and rapid detection of carrier gas leaks is essential for TD–GC(MS) troubleshooting. Traditional 'wet' methods of leak detection using soap solution should be avoided, as this can lead to contamination of the gas lines and TD flow path. Markes offers a portable, highly sensitive leak detector, designed to detect helium leaks in TD–GC systems. It works on thermal conductivity principles, with gas leaks being indicated by an LED display. The detector uses rechargeable batteries and is supplied with a mains-powered battery charger.

| Description | Part number |
|---|---|
| Helium leak detector including 230 V charger | C-HEL23 |
| Helium leak detector including 115 V charger | C-HEL11 |

## Flowmeter

Markes offers a solid-state digital flowmeter for measuring TD gas flows (split flow, desorb flow, *etc.*). The flowmeter allows measurement of eight gases: air, argon, argon–5% methane, carbon dioxide, helium, hydrogen, nitrogen and oxygen, in the range 0.1–500 mL/min. Resolution is 0.1 mL/min and accuracy is typically better than ±2.5%. Calibration is traceable to the UK National Physical Laboratory (NPL) standards, and an annual recalibration service (for helium, air and nitrogen) is offered on a return-to-factory basis.

| Description | Part number |
|---|---|
| Digital flowmeter | C-FLMTR |
| Recalibration service for digital flowmeter (return to Markes) | C-FLCAL |

## Gas purifiers

Markes strongly recommends the use of carrier gas purifiers upstream of the analytical system to remove hydrocarbons, oxygen and water. General-purpose purifiers are available for standard TD–GC(MS) operation as well as high-capacity purifiers for specialised applications.

### Hydrocarbon trap

The hydrocarbon trap is suitable for the removal of $C_{3+}$ hydrocarbons in helium, hydrogen, nitrogen, argon–methane and air. Refill kits are also available. The trap has a maximum flow capacity of 2 L/min and the stated life is 16 cylinders[1].

### Water vapour trap

Molecular sieve 5 Å efficiently removes water from helium, hydrogen, nitrogen, air, *etc.* A refill kit is available. The trap has a maximum flow capacity of 2 L/min and the stated life is 68 cylinders[1].

### Oxygen/water trap

This trap reduces $O_2$ levels to less than 2 ppb[2]. It can extract contaminating oxygen at 10 ppm from at least three 8.5 $m^3$ cylinders, and the maximum flow capacity is 250 mL/min.

### Helium purifier

Removes $O_2$, $H_2O$, hydrocarbons, $CO_2$ and CO from helium, giving an output gas which is 99.99999% pure. The maximum flow capacity is 8 L/min, and the stated life is 13 standard cylinders[2] of 99.999% helium.

### High-capacity gas purifier

This specialised gas purifier removes both $O_2$ and $H_2O$ from any common carrier gas (except hydrogen) by a catalytic reaction. It can purify up to 60 tanks of heavily contaminated gas containing 100 ppm $O_2$ and/or $H_2O$ at flow rates of up to 1.1 L/min. A pressure gauge should be fitted at the outlet to monitor the pressure drop across the purifier – when the drop exceeds 10 psi the purifier tube should be replaced. Replacement purifier tubes are available.

| Description | Part number |
|---|---|
| Gas purifier, hydrocarbon trap, 120 cc, ⅛″ fittings | C-HCTRP |
| Gas purifier, hydrocarbon trap, refill material | C-RFHCT |
| Gas purifier, water vapour trap, 200 cc, ⅛″ fittings | C-MSTRP |
| Gas purifier, water vapour trap, refill material | C-RFMST |
| Gas purifier, oxygen/water trap, 120 cc, ⅛″ fittings | C-O2TRP |
| Gas purifier, helium purifier, ⅛″ fittings | C-HEPUR |
| Gas purifier, high-capacity, 230 V, ⅛″ fittings | C-HCP23 |
| Gas purifier, high-capacity, 110 V, ⅛″ fittings | C-HCP11 |
| Gas purifier, high-capacity, replacement purifier tube, ⅛″ fittings | C-HCPTB |
| Gas purifier, high-capacity, replacement element, 230 V | C-HCE23 |
| Gas purifier, high-capacity, replacement element, 110 V | C-HCE11 |
| Gas purifier, high-capacity, outlet pressure gauge | C-HCPPG |

## Syringes

Markes offers a selection of precision syringes, for both liquid and gas injections.

1 µL liquid syringe

A 1 µL plunger-in-needle syringe fitted with a repeating adaptor provides ±2% accuracy and reproducibility for injection volumes down to 0.1 µL.

5 µL liquid syringe

A 5 µL plunger-in-barrel syringe provides ±1% accuracy and reproducibility for injection volumes between 1 and 5 µL.

50 mL and 100 mL gas syringes

50 mL and 100 mL removeable Luer lock gas-tight syringes provide ±1% accuracy and reproducibility for injection volumes down to 10 mL. Maximum gas temperature is 120°C.

| Description | Part number |
|---|---|
| Syringe, 1 µL, plunger-in-needle with repeating adaptor, 50 mm needle length, 0.63 mm needle o.d. | C-SYL00-1UL |
| Syringe, 1 µL, replacement needle and plunger repair kit | C-SYLRP-1UL |
| Syringe, 5 µL, plunger-in-barrel fixed needle, 50 mm needle length, 0.47 mm needle o.d. | C-SYL00-5UL |
| Syringe, 50 mL, gas-tight, removeable Luer lock | C-SYG00-50ML |
| Syringe, 50 mL, gas-tight, replacement plunger | C-SYGPL-50ML |
| Syringe, 50 mL, gas-tight, replacement Luer lock needles, 50 mm needle length, 0.63 mm needle o.d., pk 5 | C-SYGND-50ML |
| Syringe, 100 mL, gas-tight, removeable Luer lock | C-SYG00-100ML |
| Syringe, 100 mL, gas-tight, replacement plunger | C-SYGPL-100ML |
| Syringe, 50 mL, gas-tight, replacement Luer lock needles, 50 mm needle length, 0.63 mm needle o.d., pk 5 | C-SYGND-100ML |

1. Based on standard 218 $ft^3$ cylinder containing 50 ppm contaminants.
2. When the level in the incoming gas does not exceed 10 ppm.

# Miscellaneous supplies

## Capillary column cutting tool

Used to cut the ends of fused silica tubing (*e.g.* transfer line insert or capillary columns) to ensure burr-free square ends, and reliable capillary–capillary connections.

## Fused silica capillary column connectors

### Quick-seal column connector

Quick-fit capillary column connectors are supplied with every Markes TD system. They are used to connect the fused silica transfer line insert to the GC capillary column inside the GC oven, and are suitable for most routine applications. The connectors are single-use, and a new one must be used must be discarded each time the connection is remade.


***Quick-seal column connectors***

### SilTite™ mini-unions

For TD–GC systems incorporating an MS detector, a mini-union is recommended for capillary–capillary connections. SilTite mini-unions use nuts and ferrules to make the connection, and can therefore be reused (with new ferrules when applicable).

***SilTite mini-union – The optimum capillary–capillary connector for high-performance TD–GC(MS) systems***

## Copper tubing and unions

Gases supplied to TD–GC(MS) systems (*i.e.* carrier gas and dry gas) should be supplied in solvent-washed refrigeration-grade ⅛″ copper tubing. This tubing should never be brazed, and should only be connected using GC-compatible Swage-type unions.

| Description | Part number |
|---|---|
| Fused silica column-cutting tool | C-FSCCT |
| Quick-seal column connector, pk 10 | C-QSC10 |
| SilTite mini-union, connects 0.25 mm fused silica transfer line to capillary column (up to 0.25 mm i.d.) | C-MU000 |
| Ferrules, SilTite mini-union, 0.1–0.25 mm i.d. (columns up to 0.25 mm i.d.), pk 10 | C-MUF25 |
| Ferrules, SilTite mini-union, 0.32 mm i.d. (0.32 mm i.d. columns), pk 10 | C-MUF32 |
| Copper tubing, 3 m | C-CUTUB-3M |
| Union, brass, ⅛″, T-shaped | SERZ-0104 |
| Union, brass, ⅛″–⅛″ | SERZ-0026 |

# GC/MS software

ClearView and TargetView are innovative software packages providing powerful post-run processing of GC/MS data in an easy-to-learn software environment.

ClearView provides dynamic baseline compensation (DBC) for GC/MS chromatograms (TICs). This suppresses baseline anomalies such as column bleed and air/water background by minimising ions that are not related to chromatographic peaks, thus dramatically improving signal-to-noise ratios and spectral purity.

TargetView software builds on ClearView and provides sophisticated GC/MS data-mining for the identification of trace compounds in complex TIC profiles. Processing includes spectral deconvolution and principal components analysis, allowing reliable identification of co-eluting compounds. A simple report then allows the analyst to see exactly which target and non-target compounds are present.

Both packages can process data in a matter of seconds, and are compatible with GC/MS data files from major vendors.



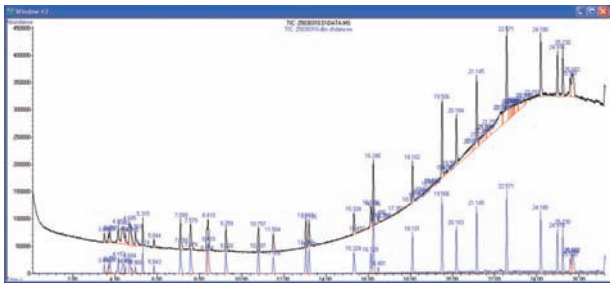
## Simplifying the analysis of complex mixtures

## ClearView™

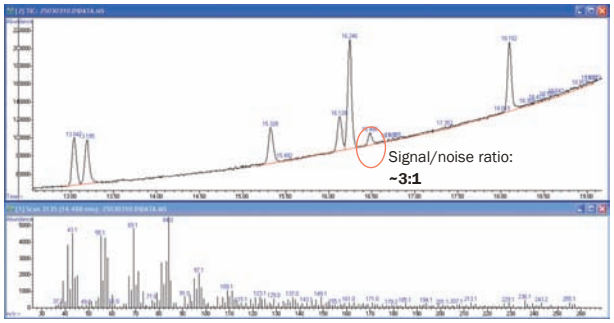
ClearView uses sophisticated dynamic background compensation (DBC) algorithms to distinguish between chromatographic peaks and baseline anomalies, such as GC column bleed, humps of unresolved sample matrix, extended solvent tails and air ingress. By removing such interferences, ClearView:

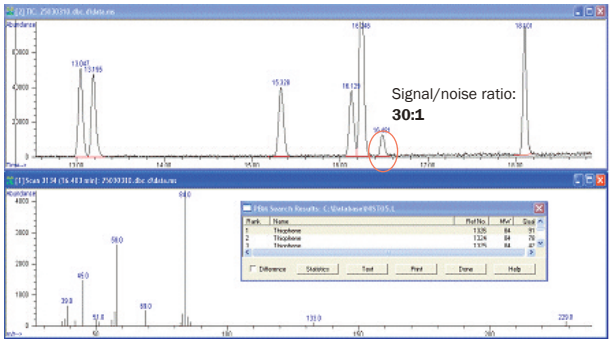
- reduces noise and increases sensitivity in full-scan mode
- improves the accuracy of peak integration
- aids compound identification
- improves laboratory productivity, by reducing the need for manual re-integration of complex chromatograms.

The software is fast and intuitive, and files can be processed individually or as a batch for optimum efficiency. Processing generates a separate file, with the original GC/MS file remaining intact for comparison or future reference.



***TD-GC/MS analysis of a landfill-gas standard with high column bleed. The top chromatogram is the original TIC data, and the bottom chromatogram shows the same data following ClearView reprocessing***




***Benefit of ClearView reprocessing for a landfill-gas standard. Top: Analysis of the TIC data does not correctly identify the trace component circled. Bottom: ClearView reprocessing enables automatic identification of the circled component as thiophene***

## Compatible GC/MS file formats

The following GC/MS file types are accommodated by ClearView:

- Agilent (*.d) format for processing directly in ChemStation®
- Thermo (*.raw) format for processing in Xcalibur®
- ANDI/netCDF (*.cdf) format, for compatibility with other vendors (*e.g.* Perkin Elmer, Shimadzu)
- ALMSCO (*.lsc) format for BenchTOF-dx.

## Free 30-day ClearView trial

A free 30-day trial copy of ClearView is available directly from Markes International. Contact clearview@markes.com to request your copy, or download directly from www.markes.com/software.

## Buying and operating ClearView

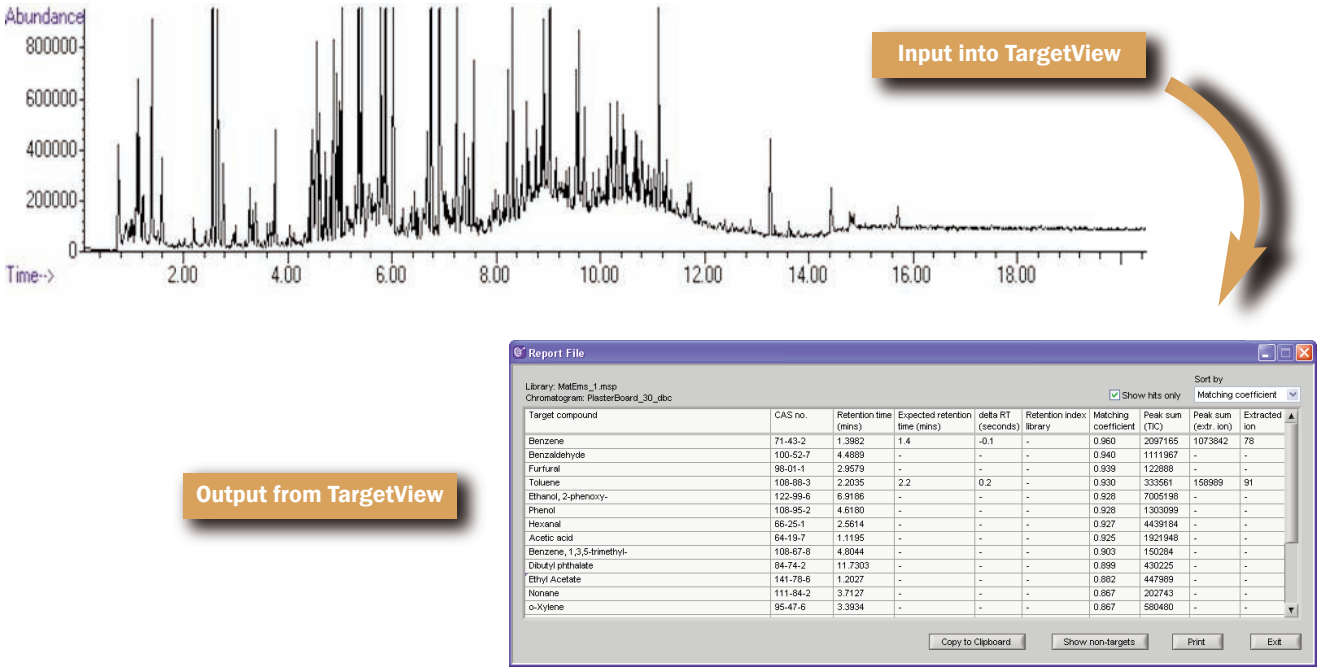
A single-user copy of ClearView can be delivered on CD or downloaded from the Markes website *via* the online shop.

ClearView will only operate on the PC used for initial software installation. (Contact Markes to renew your ClearView licence if the installation PC is replaced within 12 months.)

Please contact Markes directly if you require any other combination of licences (clearview@markes.com).

| Description | Part number |
|---|---|
| ClearView GC/MS software (single user licence) | C-CVIEW1 |
| ClearView GC/MS software (12-month licence) | C-CVIEWYR |

## TargetView™




***TargetView data-mines a complex total ion chromatogram and automatically generates a report of target hits together with associated peak abundances***

TargetView incorporates a similar dynamic background compensation (DBC) algorithm to that used by ClearView, and takes the analysis further, providing a complete identification solution for post-run GC/MS data processing. Powerful deconvolution algorithms separate co-eluting compounds, while advanced chemometrics provide confident matching against target libraries.

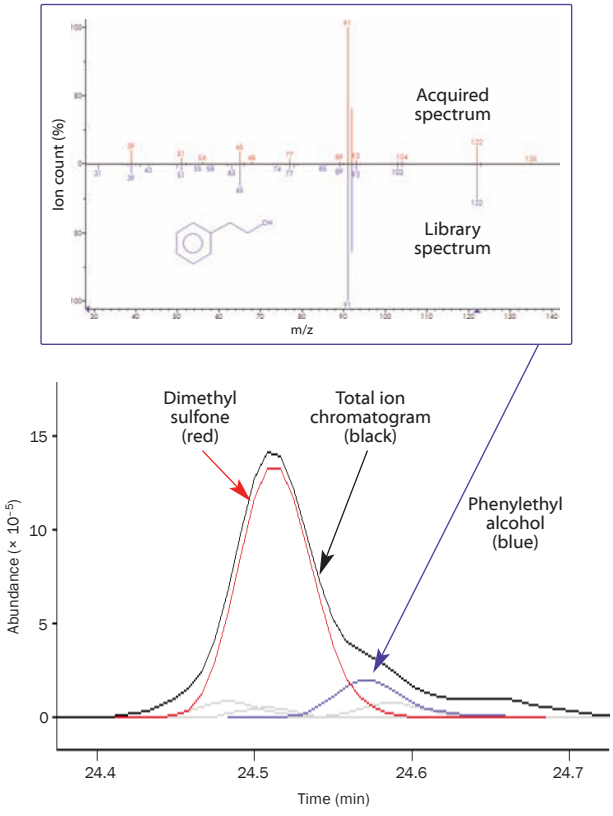
TargetView is simple to use, and ideal for those who analyse trace compounds in challenging mixtures. The rapid and effective processing offered by TargetView improves efficiency and saves valuable time.

### Elimination of background interferences

As in ClearView, the DBC algorithm selectively eliminates ions due to chromatographic background noise, such as column bleed. This minimises interference, making it much easier to analyse compounds of interest.

### Separation of co-eluting components

With background interferences removed, TargetView then deconvolves all individual components (targets and unknowns), providing accurate peak areas and clean mass spectra even when there are co-eluting components present. This is especially useful in complex chromatograms where complete peak separation is not always possible.




***TargetView's deconvolution algorithms enable high-quality mass spectra to be obtained from overlapping peaks, simplifying compound identification***

## Library searching for targets and 'unknowns'

TargetView applies advanced chemometric algorithms to match each deconvolved mass spectrum against a library. Individual compounds are indicated on the total ion chromatogram (TIC) by a red bar overlay (see image below). A simple, customisable report is then generated, which provides the full details (retention time, match coefficient, abundance, *etc.*) of all target compounds. Residual non-target compounds can also be automatically cross-searched against external databases, *e.g.* NIST.

## Easy library creation

Creation of TargetView libraries is simple, whether from in-house datasets or using spectra imported from databases such as those provided by NIST and Wiley.

## One-click report generation

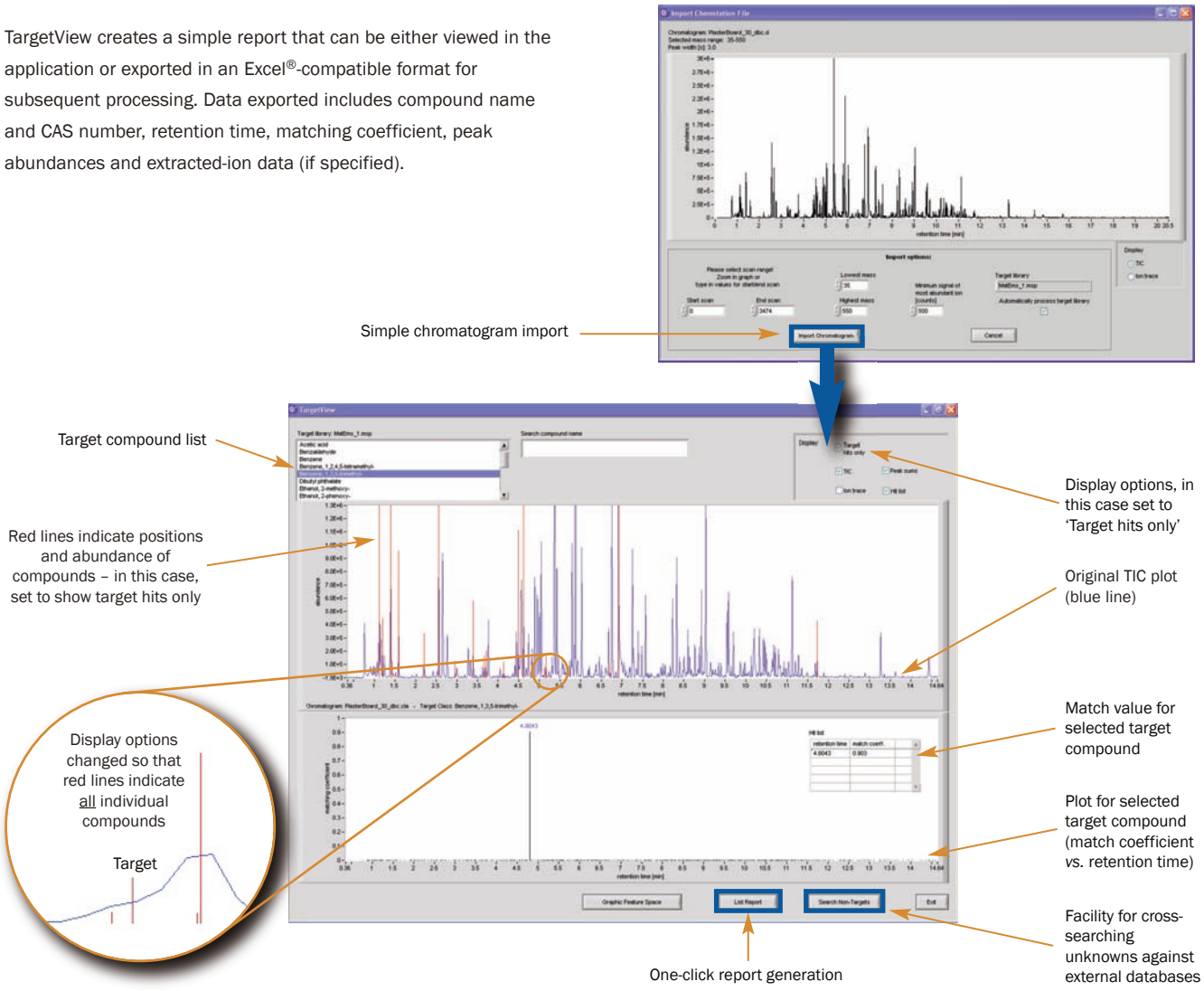
TargetView creates a simple report that can be either viewed in the application or exported in an Excel®-compatible format for subsequent processing. Data exported includes compound name and CAS number, retention time, matching coefficient, peak abundances and extracted-ion data (if specified).

## Quantitation

The removal of background interferences and deconvolution processes carried out by TargetView means that peak areas of chromatographic peaks are uncompromised by background ions and co-eluting components. Exported data can therefore be confidently used to quantitate compounds of interest.

## Batch processing

Files can be processed individually or in batch mode, with the original files always being retained for future reference, providing an audit trail for contract laboratories.




***The simple user interface of TargetView. Top: imported GC/MS chromatogram. Bottom: Results generated in TargetView, with retention time and abundance of target compounds indicated by vertical red lines. Inset: Plot showing target compound identified amongst co-eluting components, with the display options changed so that all individual compounds are marked with red lines***

## File preview

Double-clicking a class file in the main project window opens up an instant preview of the file content.

## Compatible GC/MS file formats

The following GC/MS file types are accommodated by TargetView:

- Agilent (*.d) format for processing directly in ChemStation®
- ANDI/netCDF (*.cdf) format, for compatibility with other vendors (e.g. Perkin Elmer, Shimadzu)
- ALMSCO (*.lsc) format for BenchTOF-dx.

## Free 60-day TargetView trial

A free 60-day trial copy of TargetView is available directly from Markes International. Contact targetview@markes.com to request your copy, or download directly from www.markes.com/software.

| Description | Part number |
|---|---|
| TargetView GC/MS software (single-user 12-month licence) | MS-TVYR |
| TargetView GC/MS software (single-user full licence) | MS-TV01 |

## Buying and operating TargetView

A single-user copy of TargetView can be delivered on CD or downloaded from the Markes website *via* the online shop.

TargetView will only operate on the PC used for initial software installation. (Contact Markes to renew your TargetView licence if the installation PC is replaced within 12 months.) Please contact Markes directly if you require any other combination of licences (targetview@markes.com).

**Please see the TargetView brochure and Markes' website for additional information.**


***Simple, reliable, automatic – Speed up your TD–GC/MS data analysis with TargetView***

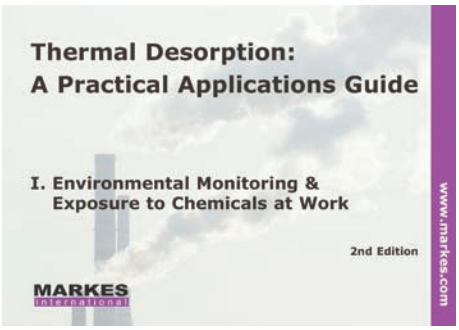
## Applications Guides

Four comprehensive and clearly illustrated TD Applications Guides are available **FREE** from Markes. Each one contains 20–50 pages of representative applications across the following areas:

### I. Environmental Monitoring & Exposure to Chemicals at Work

Covering:

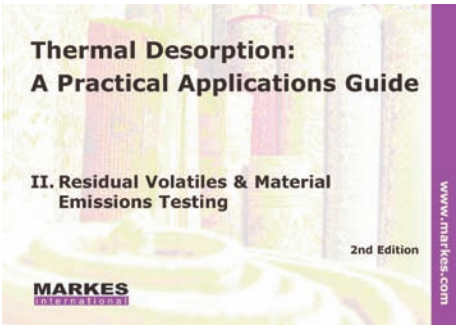
- *Industrial emissions* – stack tests, fenceline monitoring, soil gas and vapour intrusion.
- *Detection of VOCs in air* – whether urban or rural, workplace or residental.
- *Assessment of personal exposure* – by diffusive (passive) monitoring or breath testing.




### II. Residual Volatiles & Material Emissions Testing

Covering:

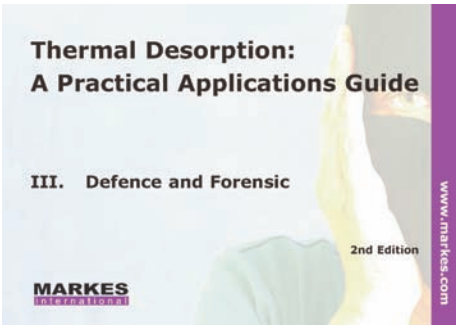
- *VOC emissions* – from vehicle trim, paint, adhesives, flooring tiles, carpet, plasterboard, wood, children's toys, computer components, ointments and textiles.
- *VOC content* – of raw materials and products.
- *Residual compounds* – monomers in polymers, additives/solvents in food packaging, solvents in drugs and pharmaceutical powders.




### III. Defence and Forensic

Covering:

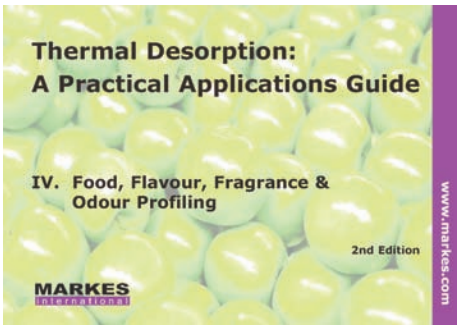
- *Detection of chemical warfare agents* – continuous near-real-time monitoring of military/civilian facilities, studies of permeation through protective material.
- *Forensic analysis* – drugs of abuse, arson residues, explosive vapours, shotgun propellant, inks, paper and paint.




### IV. Food, Flavour, Fragrance & Odour Profiling

Covering:

- *VOC characterisation of foods and beverages* – cheese, meat, dried foodstuffs, fruit juices, wine, whisky, beer and milk.
- *Detection of off-odours or contaminants* – off-odour/taint analysis in wine and water, residual volatiles from packaging, halitosis in breath
- *Fragrance/odour profiling* – toiletries, essential oils, tobacco, incense, mosquito coils, fabrics.




**Please email us (enquiries@markes.com) to request your free copy**

For more detailed information on individual applications, our Application Notes may also be of interest – see the next page.

## Application Notes

Providing a wealth of in-depth information, our Application Notes deal with a variety of aspects of thermal desorption, including technical guidance and know-how as well as experimental conditions for a wide range of applications. Our most popular Application Notes are given below – visit our website to view the full list or to download PDF files.

**General**

TDTS 4 Publications and presentations citing Markes' products
TDTS 12 Analytical thermal desorption: History, technical aspects and application range
TDTS 14 Monitoring labile, high-boiling organic vapours such as those found in cleanroom air in semiconductor plants
TDTS 27 A review of sorbent-based sampling methods for monitoring VOCs and SVOCs in air
TDTS 32 Analysis of sulfur compounds using on-line and off-line TD–GC(MS)
TDTS 35 Thermal desorption of dioctyl phthalate and other plasticisers
TDTS 53 Quantitative recovery and method validation of high-boiling SVOCs using TD–GC/MS
TDTS 64 Simultaneous TD–GC(MS) analysis of VOCs and SVOCs
TDTS 79 Air monitoring – The respective advantages and applications of canisters and tubes

**Technical support**

TDTS 1 Uptake rates for tube-type axial diffusive samplers
TDTS 5 Advice on sorbent selection, tube conditioning, tube storage and air sampling
TDTS 7 Calibration: Preparing and introducing thermal desorption standards using sorbent tubes
TDTS 8 Principles of diffusive monitoring
TDTS 9 Monitoring materials and processes for VOCs at high and trace levels
TDTS 19 Minimising artefacts – Considerations for storage and transport of sorbent tubes
TDTS 20 Confirming sorbent tube retention volumes and checking for analyte breakthrough
TDTS 21 Developing and optimising TD methods
TDTS 22 Selection of gas flows and split ratios during thermal desorption
TDTS 26 Minimising analytical interference from water during the analysis of sorbent tubes
TDTS 75 Tube impedance and other factors that may cause discrimination during the calibration of TD methods

**Application area – Environmental monitoring**

TDTS 16 Round-the-clock, on-line and cryogen-free monitoring of hydrocarbons from acetylene to trimethylbenzene in ambient air
TDTS 29 VOC air monitoring technology and its application to contaminated land
TDTS 47 The analysis of landfill gas compounds using TD–GC/MS, GC/MS and a retention-time-locked database
TDTS 49 Fenceline and ambient monitoring of benzene and other hydrocarbons using diffusive sampling and TD analysis
TDTS 77 Using TD for industrial (stack) emission testing
TDTS 80 Evaluation of a 'soil gas' sorbent tube for improving the measurement of volatile and semi-volatile fuel vapours in contaminated land
TDTS 81 Analysis of canister air samples using cryogen-free TD in compliance with US EPA Method TO-15
TDTS 86 US EPA Method TO-17 for monitoring 'air toxics' in ambient air using sorbent tubes and automated cryogen-free TD
TDTS 87 A cryogen-free method for monitoring trace greenhouse gases in air
TDTS 97 Analysis of polycyclic aromatic hydrocarbons from vehicle exhaust using TD–GC/MS
TDTS 99 Using the CIA *Advantage* for automated cryogen-free analysis of canister air and gas

**Application area – Residual volatiles and material emissions**

TDTS 33 Analysis of the interior atmosphere of a passenger car by TD–GC/MS
TDTS 40 Direct desorption of VOCs and SVOCs from leather furnishings
TDTS 56 Identifying and quantifying VOC emissions from materials by TD–GC/MS
TDTS 59 Direct desorption of car trim materials for VOC and SVOC analysis, in accordance with Method VDA 278
TDTS 62 Material emissions testing in the semiconductor and electronics industries
TDTS 67 Using the Micro-Chamber/Thermal Extractor for rapid screening of chemicals released from products and materials
TDTS 89 Thermal desorption technology for testing chemical emissions from construction products and consumer goods
TDTS 91 Using headspace–thermal desorption to enhance the measurement of residual solvents in drugs

**Application area – Defence and forensic**

TDTS 44 The analysis of free-VX from sorbent tubes at low and sub-nanogram levels
TDTS 58 The application of thermal desorption to forensic investigations
TDTS 63 Using the TT24-7 for continuous monitoring of trace-level toxic chemicals in air

**Application area – Food, flavour, fragrance and odour profiling**

TDTS 52 The use of TD–GC(MS) in flavour/fragrance profiling
TDTS 78 Detecting low ppt levels of odorants in drinking water using headspace–thermal desorption
TDTS 84 Using TD to enhance aroma profiling by GC/MS
TDTS 88 Enhancing olfactory profiling of fruit juices and wine using complementary TD techniques
TDTS 94 Using TD to automate 'High/Low' analysis of a complex beer sample
TDTS 95 Food decomposition analysis using the Micro-Chamber/Thermal Extractor and TD–GC/MS
TDTS 96 A comparison of the VOC content of Indian and UK tobacco by headspace–thermal desorption
TDTS 98 Analysis of a betel-nut foodstuff by direct TD
TDTS 101 Rapid aroma profiling of cheese using a Micro-Chamber/Thermal Extractor with TD–GC/MS analysis

# Index

Where a component with a main entry is also mentioned elsewhere, the main entry is underlined.

## List of part numbers

Where a component appears as part of a kit, a letter 'K' appears after the page number.

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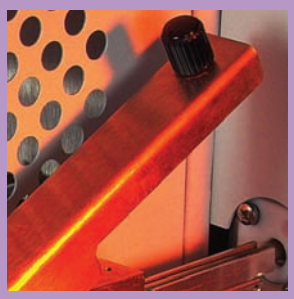

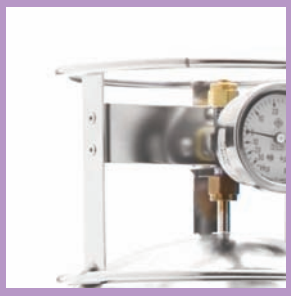

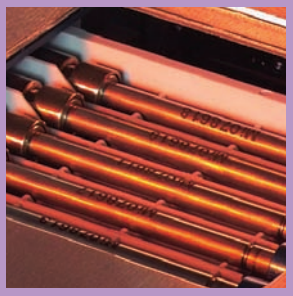


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