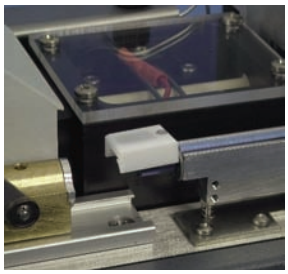
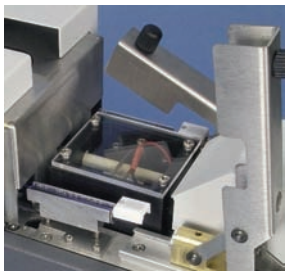




Series 2
UNITY
Thermal desorber

A universal TD platform for tagged and untagged tubes

MARKES international

Series 2
UNITY

Thermal desorption–GC(–MS)

Thermal desorption (TD) is a highly versatile, sensitive and labour-saving sample preparation technique for the measurement of volatile and semi-volatile organic compounds (VOCs and SVOCs) in air and materials. It provides the ultimate sample introduction technology for GC and GC–MS, combining selective concentration enhancement with direct extraction into the carrier gas and efficient transfer/injection, all in one fully automated and labour-saving package.

TD is applicable to GC-compatible organics ranging in volatility from acetylene and freons to high-boilers such as n-C_{40}, phthalate plasticisers and benzo[a]pyrene. It also offers quantitative concentration for some inorganic gases, including nitrous oxide, SF_6, CS_2 and H_2S. Key applications include:

- Environmental and workplace air monitoring
- Civil defence and forensic analysis
- Materials and material emissions testing
- Food, flavour and fragrance profiling.

Many material samples, such as polymers, paints, drugs, foods and textiles, can be directly thermally desorbed. Weighed samples placed in a thermal desorption tube are heated in a stream of carrier gas, allowing volatiles to be extracted into the gas flow, refocused and injected into the GC(–MS) analyser as a discrete, concentrated band of vapour.

Alternatively, vapours in gas or air can be concentrated on- or off-line onto sorbent traps/tubes before TD–GC–MS analysis. Several hundred litres of air or gas can be sampled and the vapours transferred/injected into the analyser in as little as 200 µL of carrier gas. Concentration factors as high as 10^6 can be obtained.

Thermal desorption is now recognised as the technique of choice for air monitoring (workplace and environmental), and is the subject of many international standard methods. Key examples include: EN ISO 16017, ISO 16000-6, EN 14662 (parts 1 & 4), prEN13649, ASTM D6196, US EPA TO-15 (canisters) & TO-17 (tubes), NIOSH 2549, UK Environment Agency guidance on landfill gas (LFGH 04) and US EPA guidance for on-line ozone precursor monitoring. Markes TD systems offer full compliance with all of these standards.

Thermal desorption offers significant advantages compared to solvent extraction. Key benefits include: typically 1000-fold enhancement in sensitivity; greatly enhanced recovery (>95% *vs.* 30–80% with solvent extraction); re-usable sample tubes; no need for toxic solvent; reduced analytical interference.

UNITY 2 Main Features

- Compatible with 3½″ (standard) or 4½″ (DAAMS*) length tubes, electronically-tagged or untagged. UNITY 2 allows an individual **TubeTAG™** to remain with a specific sample tube throughout its life, recording tube history and facilitating sample tracking between field and lab.
- Provides a **single platform for all TD applications** – labile species, semi-volatiles (up to n-C_{40}), ultra-volatiles (including acetylene and freons), trace levels (ppt) and high concentrations (ppm/%).
- Repeat analysis *via* SecureTD-Q™: **Overcomes the one-shot limitation** of conventional TD systems.
- **Cryogen-free operation**: Electrically-cooled sorbent trapping to –30°C eliminates ice plug formation and reduces running costs.
- **Fully method-compliant** including stringent leak testing without heat or gas flow applied.
- **Fully upgradeable** to multi-tube, multi-canister and/or on-line automation. Can also be coupled with headspace for even greater sample flexibility.
- **Time-saving** overlap mode allows desorption of a subsequent sample to begin while GC analysis of a previous sample continues.
- Plug-and-play TD: UNITY 2 adds to any commercial GC(–MS) and is **designed for easy maintenance**.

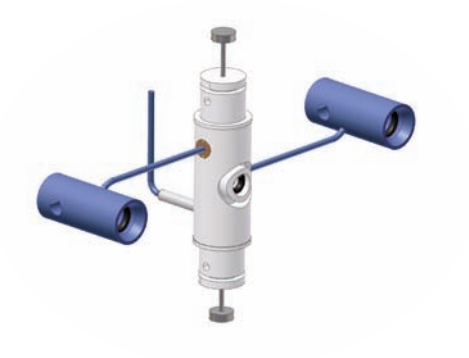
* DAAMS: Depot Area Air Monitoring Systems as used in some chemical agent destruction facilities.

Markes International: TD innovators

For over a decade, Markes International has pioneered and commercialised enhancements to analytical TD instrumentation and associated sampling apparatus. The following technical advances have all been introduced by Markes since 1997 and now set the standard for TD instrumentation:

- SecureTD-Q (quantitative re-collection of split flow for repeat analysis), which overcomes the historical one-shot limitation of TD methods and simplifies method/data validation[1].
- Electronic tube tagging (TubeTAG): RFID tube tags available for industry-standard sorbent tubes and 4½″ (DAAMS) tubes[2].
- Diffusion-locking[3] (DiffLok™) for enhanced sample integrity and robust (mechanically simple) automation.
- Patented inert valving[4] for compatibility with every TD application on a single analytical platform; ultra-volatiles, semi-volatiles (up to n-C_{40}) plus reactive species (mercaptans, CS gas, *etc.)* all on one TD system.
- Automated internal standard introduction onto blank as well as sampled tubes.
- Electrically-cooled sorbent trapping with uniquely fast trap heating rates for splitless capillary GC operation and optimum sensitivity, without risk of ice formation.
- Off-line conditioning for multiple tubes without the need to blank-off unused tube connections.
- On-line desorbers with twin, electrically cooled, reciprocally operated focusing traps for truly continuous air monitoring (TT24-7™).
- Specialist sorbent tubes: Certified reference standards, SafeLok™ tubes[3], Silcosteel® tubes.
- A range of innovative sampling tools, for measuring volatile and semi-volatile organics in challenging matrices, including: liquids; solids; emulsions; breath; *in situ* soil; polymers; natural materials; construction products[5].

1. Patent No. GB 2395785 (Automated re-collection using a single TD autosampler); US 7,373,847 B2. 2. Patent No. US 6,446,515 B2. 3. Patent No. GB 2337513; US 6,564656 B1.
4. Patent No. GB 2336649. 5. UK patent application reference 0501928.6 (μ-CTE).



Introducing the Series 2 UNITY

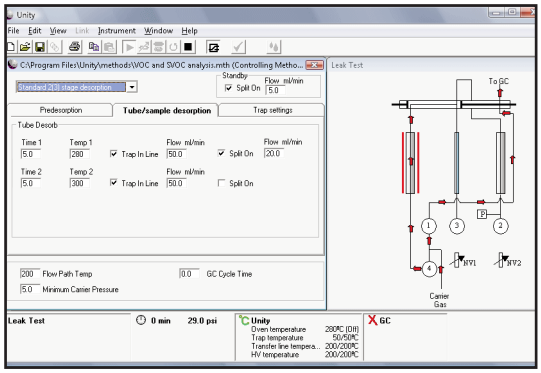
UNITY 2, Markes' next-generation thermal desorption platform, harnesses these technical advances. It incorporates every feature required for TD method compliance, every system innovation of the last ten years and the field-demonstrated reliability characteristic of all Markes instrumentation. It provides the platform for a state-of-the-art yet robust range of thermal desorbers with systems available at prices to suit every budget.

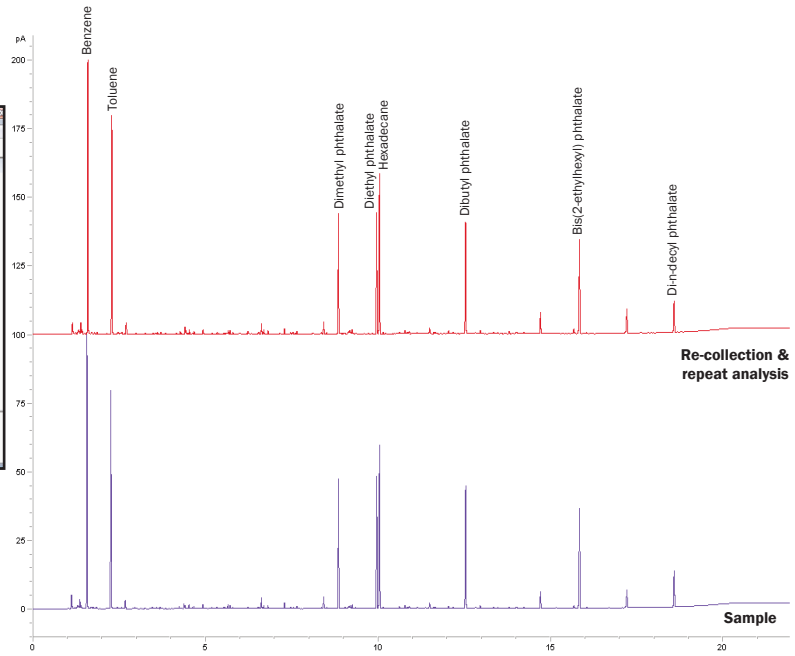
Building on the field-proven strengths of UNITY 1, UNITY 2 combines tube desorption with cryogen-free analyte re-focusing and efficient back-flush desorption of the focusing trap. Trap desorption injects analytes (split or splitless) into the GC capillary column in a narrow, focused band of vapour and triggers the GC(–MS) run.

The patented, inert heated valve integrated into UNITY 2 facilitates the ambient-temperature, zero-flow leak-testing specified by standard methods, and allows simultaneous analysis of volatile and semi-volatile compounds. The short, narrow-bore sample flow path is uniformly heated and optimises analyte recovery.

SecureTD-Q (re-collection of tube and/or trap desorption split flow) offers quantitative repeat analysis and is available as standard on every UNITY 2. SecureTD-Q overcomes the one-shot limitation of older thermal desorbers.

UNITY 2 provides a method-compliant TD platform that is ideally suited to meet the ever-more stringent demands of laboratory accreditation, data/method validation and good laboratory practice. It is operated using intuitive software loaded onto the same PC as that providing GC(–MS) control/data handling.





Simultaneous analysis of VOCs and SVOCs, with SecureTD-Q repeat analysis validating recovery across the range

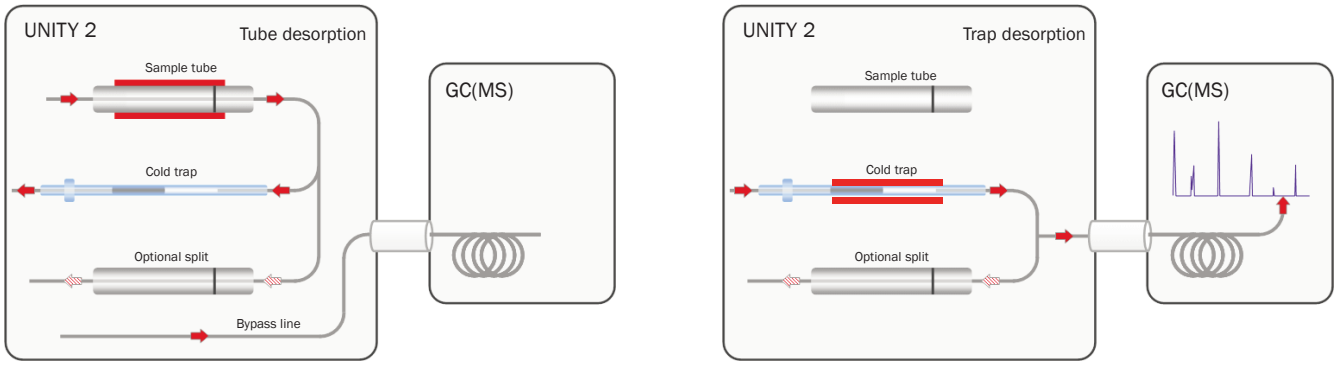
One TD platform...

Universal TD platform for all applications

UNITY 1 is renowned for its application flexibility and versatility. UNITY 2 takes this to the next level. With extended electrical cooling of the entire 60 mm sorbent bed, the UNITY 2 focusing trap offers quantitative, cryogen-free retention of ultra-volatiles such as freons and acetylene from larger volumes of air/gas. Markes offers a range of off-the-shelf, pre-packed UNITY 2 traps, each containing up to four sorbents. Some of these are almost universally applicable, others are optimised for the retention of ultra-volatiles/volatiles (*e.g.* C_2 hydrocarbons/freons to n-C_{12}) and others offer quantitative retention of target analytes with selective purging of water or solvents prior to analysis.

Tube desorption and conditioning is now possible at temperatures above 400 °C and optional extended-range mass flow controllers (MFCs) offer control of split flows from 2–500 mL/min for maximum application versatility. Critical sections of the internal flow path have also been optimised, both for enhanced recovery of higher-boiling 'sticky' compounds and quantitative analysis of reactive components. Example analytes include 5/6-ring PAHs, phthalates, PCBs, hydrocarbons to n-C_{40}, mercaptans, explosives and chemical warfare agents.

The patented heated valve built into UNITY 2 is specifically designed for analytical TD. It can be operated at the low temperatures that are required for enhanced recovery of labile components and also allows quantitative recovery of high-boilers such as n-C_{40}.



Schematics depicting the flow path of gas during tube desorption (left) and focusing trap desorption (right)

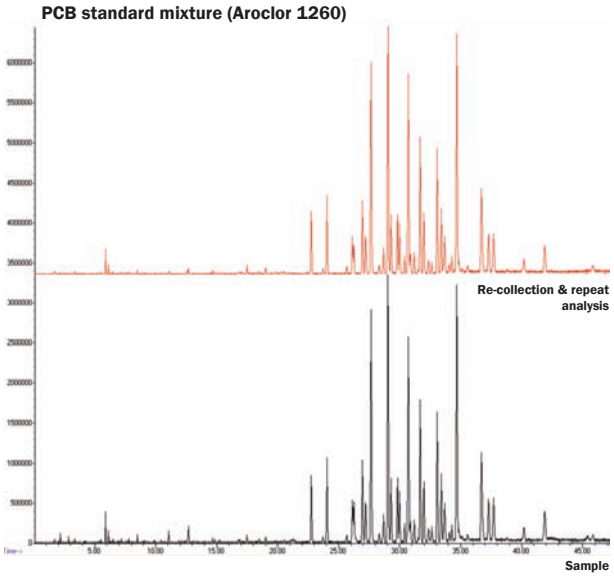
...every application

Easy-change focusing trap with collar

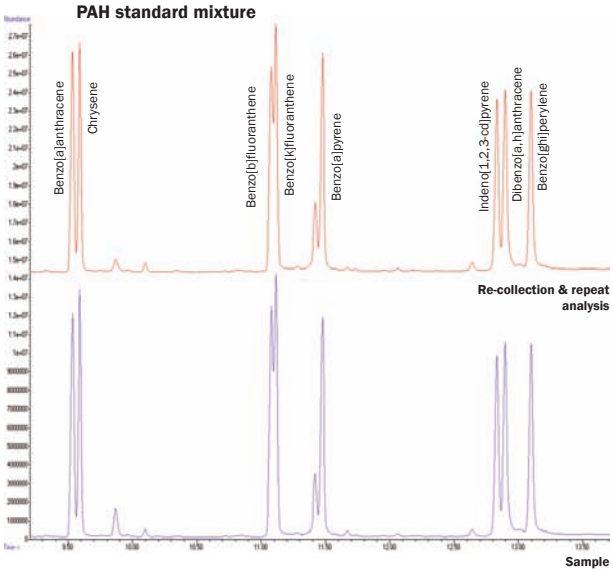
60 mm sorbent trap length, –30 °C cooling, uniquely fast trap heating and patented TD valving combine to ensure UNITY 2 offers optimum performance for the widest possible TD application range

Quantitative recovery of high-boilers (*e.g.* PCBs, phthalates and PAHs)

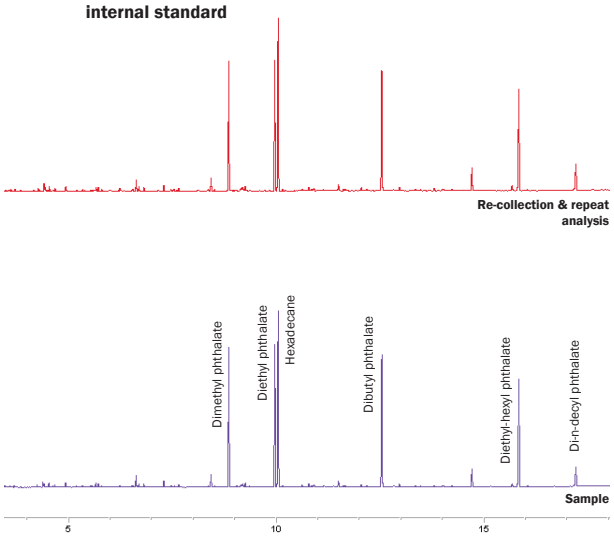
PCB standard mixture (Aroclor 1260)



PAH standard mixture

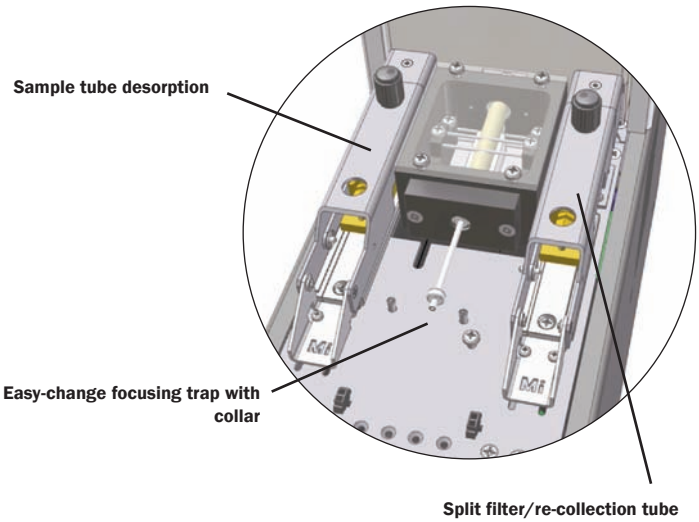


Phthalate standard mixture with internal standard

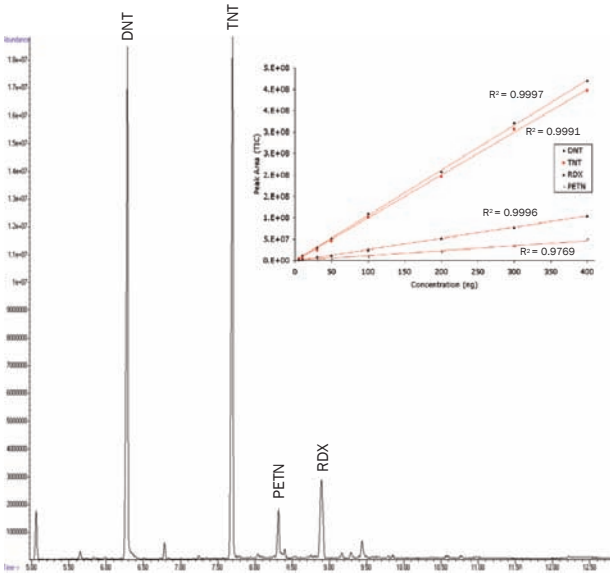


The Markes advantage: Your TD resource

Markes International is the world's leading manufacturer and supplier of thermal desorption (TD) equipment for monitoring trace toxic and odorous chemicals in air, water and materials. Serving fast-growing markets from environmental health & safety to materials testing, and from food, flavour and fragrance to defence and forensic, Markes has been serving its global customer base, which includes major industry, government agencies, academia and the service laboratory sector, since its formation in 1997.



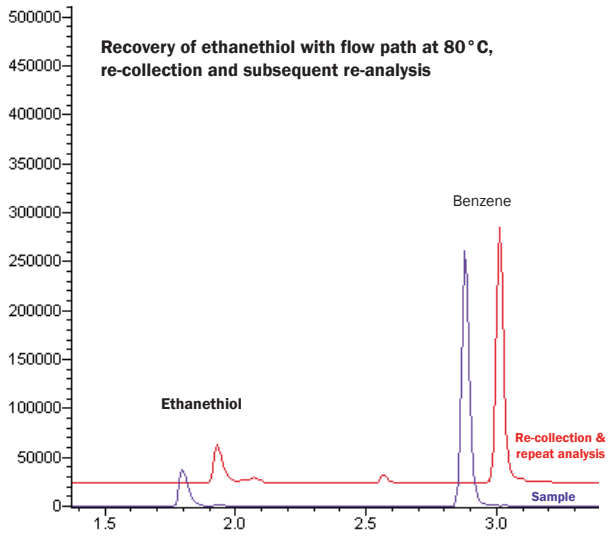
Compatible with labile analytes (*e.g.* explosives & mercaptans)



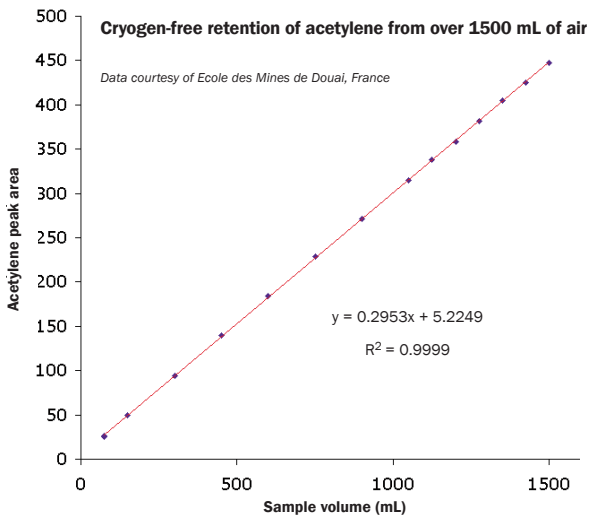
Quantitative analysis of four explosives at low-ng levels

Enhanced user accessibility

Simplifying routine maintenance operations has been a key focus during UNITY 2 development. Changing the focusing trap, for example, is a simple, user-enabled process. No tightening or loosening of fittings is required and a new easy-grip collar at the non-sampling end of each trap makes it very easy to withdraw and replace. Other relevant features include simple user access to split filters and transfer line connections. Sealing O-rings have also been selected both for long life (typically at least 12 months) and negligible artefact formation.



Cryogen-free retention of ultra-volatile analytes from large volumes of air/gas

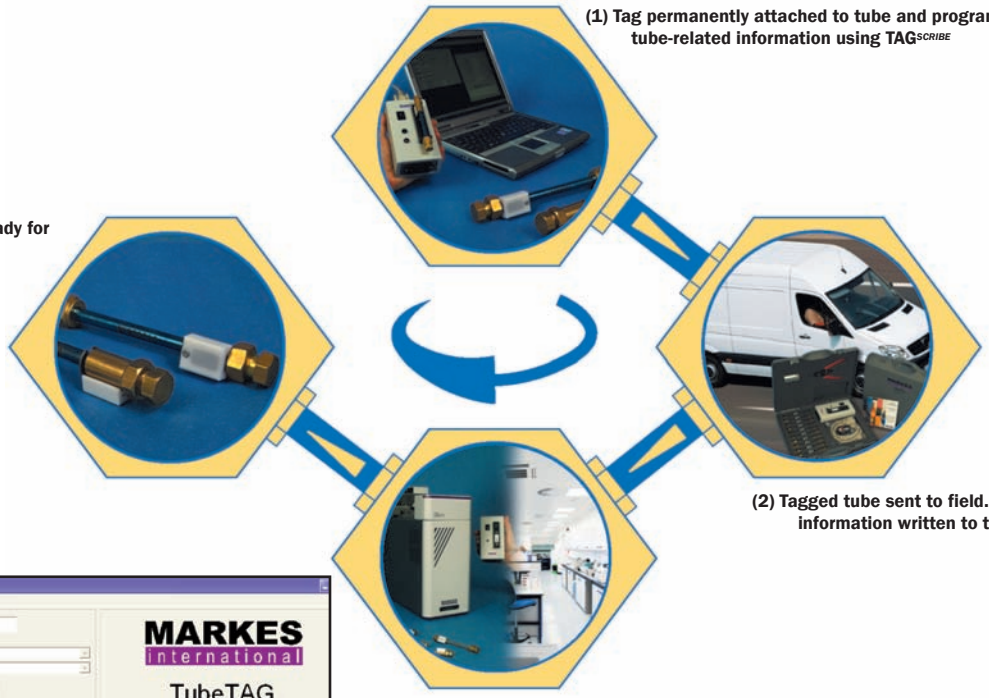


Sample tracking with TubeTAG

Error-free tube and sample tracking

Electronic tube tagging and tracking allows individual TD sample tubes to be tracked from laboratory to field and within a laboratory. RFID tags can be programmed with tube- and sample-specific data such as tube ID, type and date of packing, number of thermal cycles, sampling times/flows and customer reference number. (More information is given in the TubeTAG brochure.)

TubeTAG is being heralded as a future standard requirement for large-scale environmental monitoring projects, industrial hygiene applications, civil defence, *etc.* and is particularly important whenever monitoring data is being linked to human health/comfort or public safety. UNITY 2 can be used to analyse tagged tubes (tags do not have to be removed), thus simplifying the process of tracking tube history and performance. With TubeTAG compatibility as standard, UNITY 2 ensures a future-proof analytical platform.

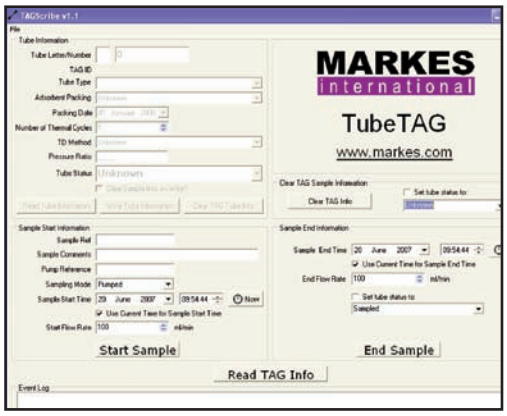


(1) Tag permanently attached to tube and programmed with tube-related information using TAG*SCRIBE*

(2) Tagged tube sent to field. Sample start & end information written to tag using TAG*SCRIBE*

(3) Tagged tube returned to lab, and data retrieved using TAG*SCRIBE*. Tagged tube desorbed using UNITY 2

(4) Tagged tube ready for re-use



UNITY 2 configured for both tube and canister/on-line automation

Multiple tube sizes providing enhanced versatility

UNITY 2 is available in standard (3½″ long × ¼″ o.d.) or DAAMS tube (4½″ long × 6 mm o.d.) configurations for both tagged and untagged tubes. Users can reconfigure UNITY 2 for 3½″ or 4½″ tubes by interchanging the desorption oven whenever required.

Unattended operation for extended periods

Featuring cryogen-free operation and lower consumption of supply gases than other brands of TD, UNITY 2 offers long-term unattended operation. It needs only ~100 mL/min dry gas flow, much less than other electrically-cooled TD systems. 100 mL/min equates to over 8 weeks' continuous operation on a standard cylinder, making it ideal for continuous field monitoring and operation in mobile laboratories.

Fully upgradeable: Tubes, canisters & on-line gas streams

UNITY 2 is compatible with any transportable or bench-top GC(–MS) and offers state-of-the-art two-stage TD performance for individual sorbent tubes in a small, affordable package. To complement UNITY 2, Markes International offers a wide range of configurable system upgrades that allow your analytical capacity to expand as demand for TD increases.

UNITY 2 upgrade options include:

- The Universal Direct Heated Inlet for interfacing **headspace vapours from custom sample vessels** directly to the UNITY 2 focusing trap.
- **On-line/canister sequencing.** Including 3- or 8-channel options for on-line monitoring and up to 27-channel canister automation. These combined systems offer full compliance with key methods such as continuous monitoring of trace-level ozone precursors (C_2–C_{10} hydrocarbons) and US EPA Method TO-14/15 'Air Toxics', respectively.
- **Series 2 ULTRA 100-tube automation.** Now available for standard 3½″ tubes or for 4½″ DAAMS tubes. The ULTRA is available with built-in options for everything from internal standard addition to automated sample re-collection.
- **Headspace:** The cost-effective HS5-TD™ module adds to UNITY 2 to provide sensitive HS-TD analysis for volatiles in liquids or solids. The HS5-TD accommodates up to five samples in standard 20 mL headspace vials and offers 10–100-fold improvement in detection limits relative to conventional static headspace methods. UNITY 2 can also be interfaced to several leading brands of headspace autosampler for high-capacity headspace–TD operation.

Maximum flexibility

High-throughput laboratories may prefer to invest in TD-100™, Markes' dedicated system for automated tube desorption, but for future-proof upgradeability, UNITY 2 offers maximum flexibility, *e.g.* canisters, real-time monitoring and multi-tube automation.

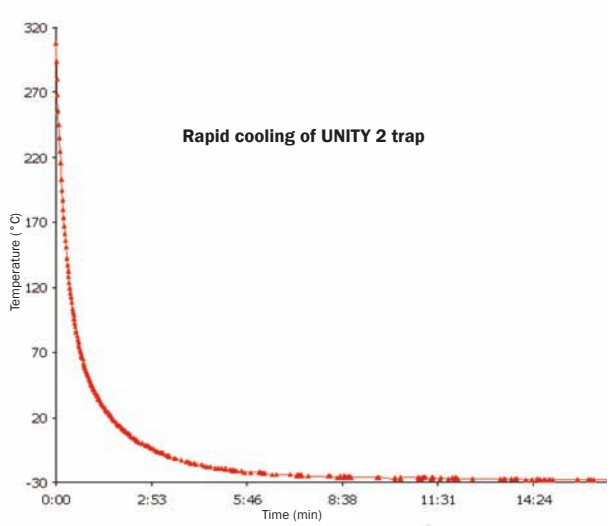
Please see relevant brochures for further information on all of these upgrade options.

Fully upgradeable... fully flexible

Productivity & flexibility

Optimised productivity

UNITY 2 trap cooling times have been optimised to reduce cycle times and increase throughput. This feature, coupled with overlap mode (whereby a subsequent sample tube is desorbed while GC analysis of the previous sample is ongoing), makes UNITY 2 highly time-efficient.



Enhanced electronic control of gas flows

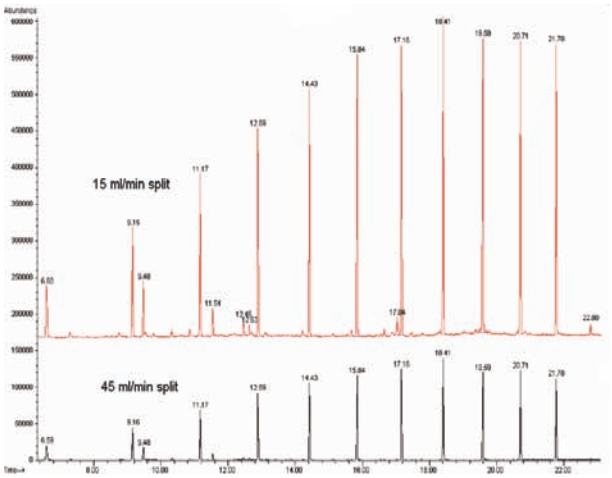
Electronic carrier gas control (ECC)

UNITY 2 offers compatibility with the back-pressure-regulated **electronic carrier gas control (ECC)** of leading brands of GC. ECC provides precise control of carrier gas flow/pressure through the entire TD–GC(–MS) system as an integral part of the GC(–MS) programme. This stabilises retention times, independent of TD analytical conditions (split flows, sorbents, desorption temperatures, *etc.*), ultimately aiding analyte identification. ECC also allows accurate monitoring and closed-loop control of the column head pressure, whatever the stage of thermal desorption operation and whatever the required flow.

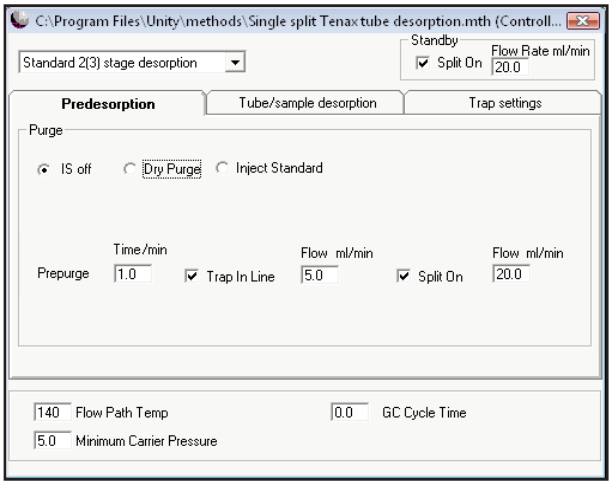
Multiple splitting options

Building on the compatibility of UNITY 1 with analyte levels from sub-ppt to percent, every UNITY 2 offers unsurpassed split versatility. Users can select from splitless operation, single-split (split open during either tube or trap desorption) or double-split (split open during both tube and trap desorption).

Every UNITY 2 features **SecureTD-Q** quantitative re-collection of all split flow, for repeat analysis and method/data validation.



ECC stabilises retention times for GC(–MS)



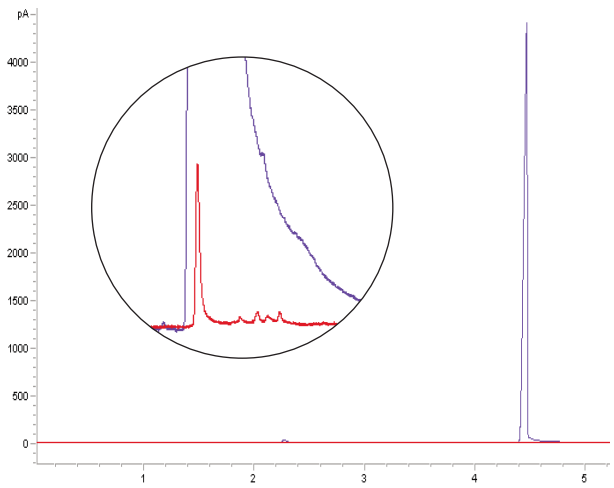
Accurate automatic control over split and desorb flows with MFC options

Automatic control over split flows

Standard UNITY 2 systems feature the full range of split options (splitless, single-split and double-split), but with manually controlled flow rates. Electronic control of split and desorb flows is offered by one or two optional **mass flow controllers (MFCs) integrated into UNITY 2.** These provide precise electronic control of both split and desorption flows from 2–500 mL/min, which enables exceptional split ratio flexibility (zero to 125,000 : 1). The UNITY 2 MFC modules also facilitate flow rate recall during an automated sequence with multiple TD methods.

Negligible carryover

With significantly less than 0.1% carryover, UNITY 2 facilitates automated multi-method analysis when coupled with the ULTRA 2 autosampler. High-level samples, such as stack gases or residual solvents, can be included in the same automated sequence as sub-ppb environmental air monitoring samples if required.



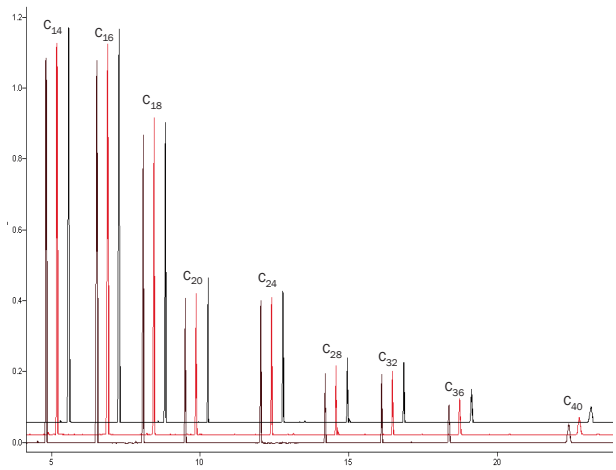
Negligible carryover (0.03%) following analysis of 1.3 mg toluene

Building on the strengths of UNITY 1

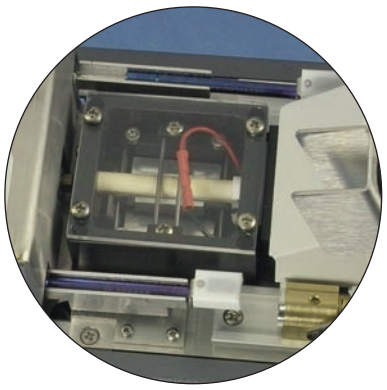
In addition to the enhancements described above, UNITY 2 has drawn key strengths from its eminent predecessor. Key features pioneered on UNITY 1 and now available on UNITY 2 include:

SecureTD-Q

- **Repeat analysis:** SecureTD-Q (*i.e.* quantitative re-collection of any or all split flow during both tube and trap desorption) was pioneered by Markes in 1998. Each sample is re-collected on a conditioned tube (tagged or untagged) and may be used for **repeat analysis, method/data validation or archiving of critical samples.** SecureTD-Q is available as standard on every UNITY 2 and **overcomes the one-shot limitation** of traditional TD systems and methods. No other single-tube desorber offers quantitative recovery of all split flow for repeat analysis.



99% recovery of C_{40} validated using SecureTD-Q

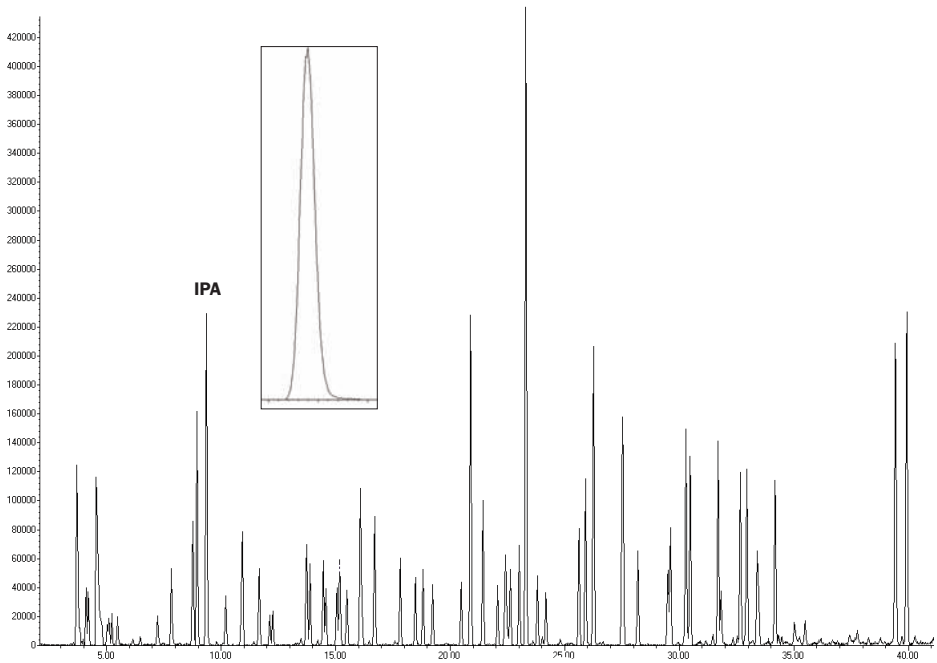


Peerless analytical performance

- UNITY 2 provides a universal TD platform for very volatile, high-boiling and reactive compounds at high and low concentrations.
- Unsurpassed trap heating rates (100 °C/s) and unique trap heater design offer optimum desorption efficiency even under low flow (<2 mL/min) splitless conditions. This ensures **best possible detection limits for trace-level compounds.**
- Pre-purge of air to vent and flexible water management options prevent risk of sorbent/analyte oxidation and **minimise analytical interference.**

Ease of use

- **Cryogen-free operation** for minimal running costs, optimum up-time and no risk of ice blocking the flow path during desorption of humid samples.
- **Small footprint.** At only 16 cm (6″) wide, UNITY 2 occupies minimal bench space.
- **Intuitive user interface.** Every TD method parameter is displayed on one easy-to-understand screen, minimising the operator learning curve.



Sample equivalent to 1 L of a 1 ppb air toxics standard analysed splitless using ATA tubes and a DB-624 column. The inset shows good peak shape for isopropyl alcohol (IPA)

Repeat analysis as standard

Method compliance and system validation

- **Full compliance with key international standard methods** such as EN ISO 16017, ISO 16000-6, ASTM D6196, US EPA Method TO-17, NIOSH 2549 and others.
- Stringent no-flow, ambient-temperature **leak test to ensure data integrity.** Failed tubes are preserved intact for operator intervention. Fully interlinked ready/start signals ensure that trap desorption only occurs when the rest of the analytical system is ready for analysis.
- **Validation of desorption efficiency/analyte recovery** is simplified using SecureTD-Q (see above). Use of repeat analysis for TD method/data validation is described in standard TD methods such as ASTM D6196.
- Continuous monitoring of carrier gas pressure downstream of the sorbent tube and focusing trap. This pressure reading may be logged for every sample and for all stages of TD operation, **allowing tubes with anomalously high back-pressures to be identified.** Moreover, if a tube is completely blocked, this is detected by the UNITY 2 leak test and logged as a sample failure. In the case of tagged tubes, back-pressure can be recorded on the tag and stored as part of tube history if required. *It should also be noted that all Markes sorbent tubes are impedance-tested prior to shipment.*

Productivity and versatility

- UNITY 2 can be **upgraded** to automatic tube desorption and/or automated canister/on-line analysis and/or headspace–trap.
- **Time-saving overlap mode:** When one sample is being analysed by GC(–MS) another can be leak-tested and desorbed.
- **System versatility:** UNITY 2 is compatible with any commercial GC(–MS) and a wide range of alternative vapour analysers such as process MS and sensor arrays. The selective concentration offered by UNITY 2 allows target analytes to be quantitatively retained while unwanted interferents (water, solvents, *etc.*) are purged to vent.
- **Application versatility:** With a 'universal' heated valve, backflush trap desorption, flexible upgrade path and widest available split ratio range (125,000 : 1), UNITY 2 offers compatibility with every TD application on a single analytical platform:
  - VOCs, SVOCs and reactive compounds.
  - Passive or pumped tubes, on-line, canisters and direct desorption.
  - Part-per-trillion to percent-level concentrations.

Future-proof your laboratory with UNITY 2.

Example international standard methods for thermal desorption
US EPA Method TO-17: Pumped monitoring of ambient air
EN ISO 16017: Pumped or diffusive sampling of ambient, indoor and workplace air, plus material emissions
ASTM D6196: Pumped or diffusive sampling of ambient, indoor and workplace air plus material emissions
ISO 16000-6: TD–GC–MS or FID analysis of material + emissions collected using emission test cells or chambers
EN 14662: Benzene in ambient air
TS 13649: Solvents in stack emissions
Various occupational-hygiene-related national standards, including **NIOSH 2549 (US)** and **MDHS 72/80 (UK)**

Automated TD requirements for compliance with standard methods
No-flow, ambient-temperature **leak test**
Internal Standard/Dry-Purge (ISDP) addition in sampling direction
Pre-purge of air to vent to prevent interference
Inert flow path for compatibility with reactive compounds like mercaptans
Cryogen-free focusing trap desorbed rapidly in backflush mode for simultaneous compatibility with very volatile and semi-volatile analytes
Tubes sealed throughout autosampler operation
Quantitative repeat analysis for method and data validation (ASTM D6196)

Markes International...

Markes International: Everything for thermal desorption

UNITY 2 is complemented by Markes' comprehensive portfolio of thermal desorption instrumentation and associated sampling equipment. Many of the innovative and labour-saving accessories available are unique to Markes, including specialist low-flow sample tubes, multi-sample test equipment for material emissions screening, calibration accessories, breath samplers, soil probes, *etc.* Full details are given in Markes' Thermal Desorption Accessories & Consumables catalogue.

Wide range of empty and prepacked TD sample tubes

TubeTAG RFID tag system for sorbent tube informatics

VOC-Mole soil probes for *in situ* monitoring of contaminated land

TC-20 multi-tube conditioning/dry-purge unit for up to 20 tubes

Calibration accessory for TD tubes

Canisters and related accessories

Bio-VOC sampler for collecting alveolar breath samples and transferring them to sorbent tubes

Micro-Chamber/Thermal Extractor for measuring emissions from materials and consumer products

MTS-32 for sequential pumped sampling onto multiple tubes

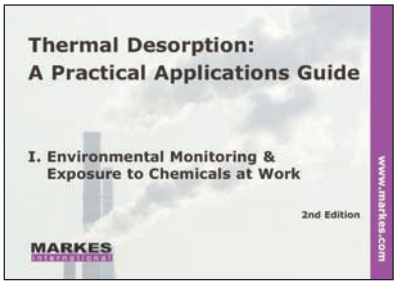
Markes' expertise and TD application guides

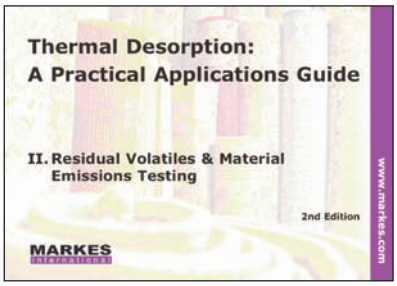
Recognised around the world for the reliability and unique versatility of its range of thermal desorption instrumentation, plus the quality of its technical and application support, Markes International has a strong team of applications/technical specialists to assist users. Fax- or email-compatible TD consultancy forms are available in many languages and can be provided by your local Markes distributor. Your local distributor will be pleased to forward completed consultancy forms to us. Alternatively, completed forms can be sent directly to Markes. In either case you will receive a detailed response within 1–2 working days of receipt.

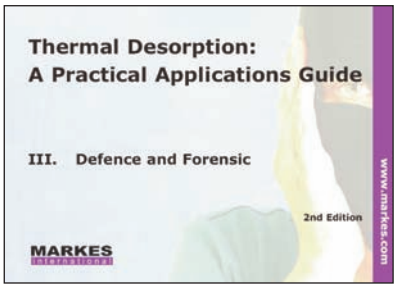
Markes has also published a series of TD application guides covering the following fields:

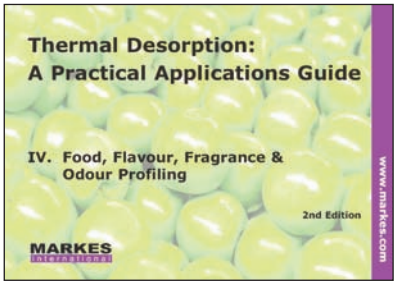
- Environmental and workplace air monitoring
- Materials quality control and materials emissions testing
- Defence and forensic applications
- Food, flavour, fragrance profiling

Each guide features example TD applications with key analytical conditions. They are available free-of-charge from your local Markes distributor.









Trademarks

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