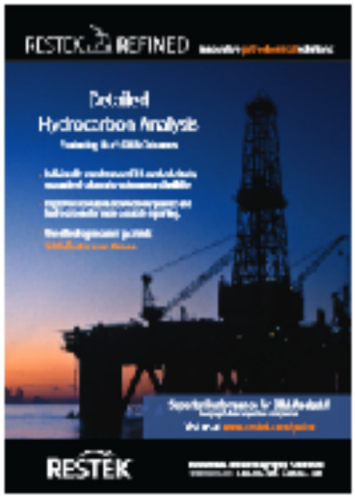
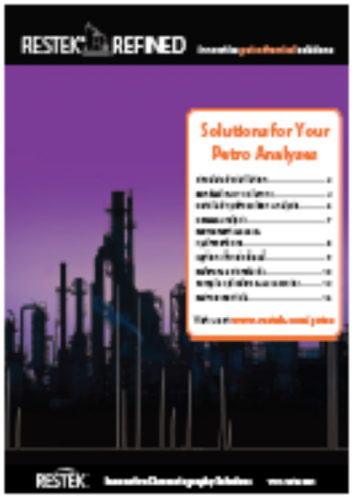
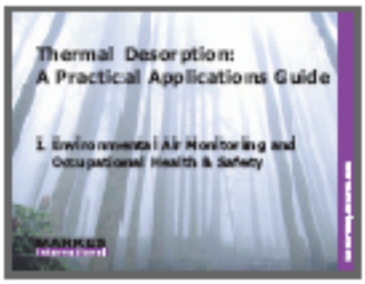




RESTEK Technical Guides /Applications 2/2

Restek Tech Notes VOL 1 (478p)



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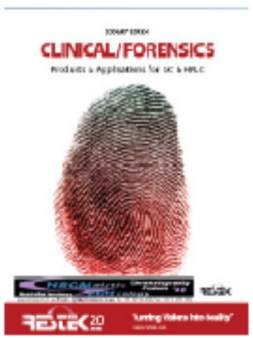

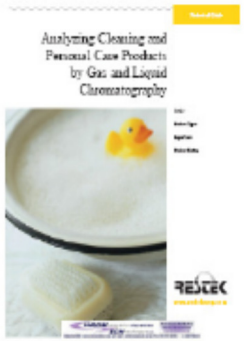

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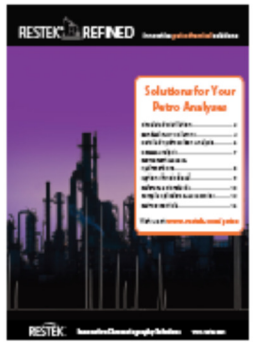

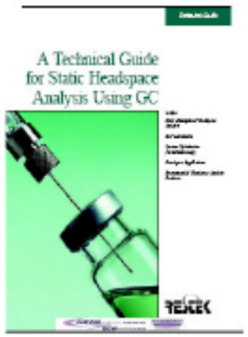

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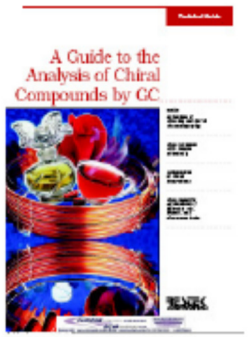

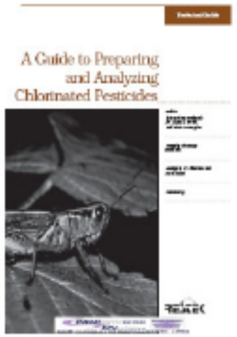

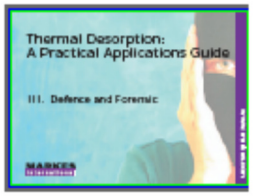

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Clinical, Forensic & Toxicology

Raptor Biphenyl LC Columns Brochure

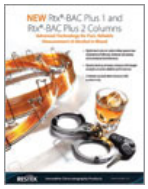
Raptor™ LC columns combine the speed of superficially porous particles (i.e., SPP or "core-shell") with the resolution of highly selective USLC® technology. Featuring Restek's most popular LC stationary phase, the rugged Raptor™ Biphenyl is extremely useful for fast separations in bioanalytical testing applications like drug and metabolite analyses, especially those that require a mass spectrometer (MS). (PDF - 5050kB)

Dissecting Raptor™ LC Columns: A closer look at a new species

When we engineered our superficially porous particle (SPP or "core-shell") Raptor™ LC columns, we developed the bonding chemistries that are best suited to both the SPP construction and our highly selective USLC® phases. But we didn't stop here. Take a closer look at a new species as we dissect the upgraded hardware and new, proprietary packing techniques behind Raptor™ LC columns and Raptor™ EXP® guard columns. (PDF - 571kB)

Fast, Robust LC-MS/MS Method for Quantification of Multiple Therapeutic Drug Classes Using an Ultra Biphenyl Column

Therapeutic drug monitoring requires streamlined, cost-effective testing procedures. This article details a fast, robust LC-MS/MS method for the quantification of 29 therapeutic drugs and metabolites in urine from several classes including opiates, benzodiazepines, tricyclic antidepressants, and anticonvulsants. Good linearity, accuracy, and precision results were obtained for most analytes in a fast, 5.5-minute analysis.



New Rtx®-BAC Plus 1 and Rtx®-BAC Plus 2 Columns: Advanced Technology for Fast, Reliable Measurement of Alcohol in Blood

New Rtx®-BAC Plus columns outperform other blood alcohol column pairs and ensure baseline separation of all critical compounds. These columns provide definitive data in a fast, 2-minute analysis, so you can be certain of your results and maximize sample throughput. (PDF - 940kB)

Fast, Definitive Data for Blood Alcohol Testing

New Rtx®-BAC Plus 1 and Rtx®-BAC Plus 2 columns provide definitive results quickly, so you can maximize sample throughput. These columns baseline separate all critical blood alcohol compounds, including ethanol, methanol, acetone, tert-butanol, acetaldehyde, isopropanol, and n-propanol, in less than 2 minutes. (PDF - 522kB)

USLC® Columns Put the Right Tools in Your LC Method Development Toolbox

Column selectivity has the most significant influence on chromatographic peak separation, or resolution, so choosing the right column can greatly speed up HPLC and UHPLC method development. In this article, we discuss column choice and identify a set of just 4 stationary phases—Restek's USLC® column set—that encompasses the widest range of reversed phase selectivity available today.

Restek Ultra Biphenyl Columns: Next Generation Phenyl Columns are the Best Choice for Pain Panel Analyses

The aromatic retention of Ultra Biphenyl columns for pharmaceutical and drug-like compounds makes them ideal for pain panel analyses, such as the AB SCIEX Cliquid® pain method, as well as clinical methods for NSAIDs, THC and metabolites, synthetic cannabinoids, steroids, hormones, and sulfonamides in milk. (PDF - 566kB)

4.5 Minute Analysis of Benzodiazepines in Urine and Whole Blood Using LC/MS/MS and an Ultra Biphenyl Column

Sample throughput for benzodiazepines in urine and whole blood can be increased by adopting this dilute-and-shoot LC/MS/MS method which uses an Ultra Biphenyl HPLC column. Partial validation data are presented in this application note.

LC/MS/MS Analysis of Metabolites of Synthetic Cannabinoids JWH-018 and JWH-073 in Urine

This application note details a fast extraction and analysis method for a wide range of metabolites of synthetic cannabinoids JWH-018 and JWH-073 in urine. Quantitative results are reported for carboxylated and mono-hydroxylated metabolites, including positional isomers.

Biphenyl: Leading Resolution in LC for Clinical and Forensic Applications

Versatile Biphenyl columns provide excellent retention of both polar and nonpolar compounds, resulting in improved resolution of benzodiazepines, cannabinoids, and other key target compounds for clinical or forensic applications. (PDF - 633kB)

Rxi®-5Sil MS: Assured Performance for Forensic Applications

Rxi®-5Sil MS columns produce excellent results for a number of forensic applications. The versatile selectivity separates a wide variety of compounds, which lets you keep analyzing samples instead of changing columns between methods. (PDF - 625kB)

Fast Screening of Recalled Tylenol® for Tribromoanisole and Related Adulterants Using QuEChERS and GC-TOFMS

Screening methods for consumer product adulteration cases, such as the recent Tylenol recall, can benefit from fast QuEChERS-based sample preparation and sensitive, full mass-range GC/TOF-MS.

Sensitive GC/MS Analysis for Drugs of Abuse

An Rxi®-5ms column will resolve acidic/neutral or free basic drugs under one set of conditions. There is no interference from column bleed — not even at 330°C. This is one of the first published applications for our new family of Rxi® columns.

Reduce Downtime and Cost of Materials with Rugged Rxi®-5Sil MS GC Columns

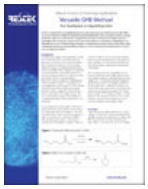
New Rxi®-5Sil MS columns produce consistent results for amphetamine—even after 400 injections of derivatizing reagent—resulting in less time and money spent on column maintenance and replacement.

5 Minute Analysis of Vitamin D in Serum by LC/MS/MS

Conventional techniques for vitamin D analysis often lack adequate sensitivity, specificity, and speed. This LC/MS/MS assay results in highly symmetric peaks that elute in just 5 minutes.

Fast Screening and Confirmation of Gamma-Hydroxybutyrate (GHB) in Urine

The headspace (HS) analysis of gamma-hydroxybutyrate (GHB) described here reduces contamination and eliminates time-consuming derivatization. Confirmation testing using an Rtx®-5MS column, provides definitive results in less than 7 minutes.



Versatile GHB Method For Headspace or Liquid Injection

The headspace (HS) analysis of gamma-hydroxybutyrate (GHB) described here reduces contamination and eliminates time-consuming derivatization. Confirmation testing using an Rtx®-5MS column, provides definitive results in less than 7 minutes. (PDF - 210kB)

Reliably Confirm Cannabinoids by GC-MS

Screening for evidence of marijuana use is typically done using an immunoassay method to detect derivatives in urine, but confirmation of positive results requires GC-MS. Here we describe a GC-MS method, using an Rxi®-5ms column, that resolves all major cannabinoid metabolites to baseline and exhibits very low bleed, even at 300 °C. We also prolonged column life by baking at 340 °C to remove derivatization by-products.

Rapid Analysis of Steroid Hormones by GC/MS

GC/MS analysis of urinary steroid hormones is a demanding application, and the Rxi®-1ms column meets the requirements for low bleed and inertness better than any column we have tested. We analyzed a variety of derivatized steroid sex hormones in less than 25 minutes, with excellent resolution and symmetric peaks. At 300°C or above, bleed from the Rxi®-1ms column was negligible.

GC Inlet Liner Deactivations for Basic Drug Analysis

Basic drugs can interact with active sites on the surface of the inlet liner, reducing responses. The combination of a base-deactivated liner and a base-deactivated Rtx®-5Amine column ensures the greatest responses in analyses for these compounds.

Thermal Desorption: A Practical Applications Guide: III. Defence and Forensic

Thermal desorption is used extensively for forensic science. This 16-page publication from Markes International Ltd. presents several key applications including drugs, arson accelerants, trace explosives, shotgun propellant, and inks. (PDF - 665kB)

Environmental

Helium, Hydrogen, or Nitrogen—The Choice is Yours: Unique Rtx®-CLPesticides Column Set Provides Optimal Results for Organochlorine Pesticides GC-Micro-ECD Analysis Using Any Carrier Gas

Using an Rtx®-CLPesticides column set is the best strategy for labs considering alternate carrier gases as a way to reduce helium consumption. These columns have a unique selectivity and produce faster results than competitor columns when using either helium or hydrogen. In addition, only Rtx®-CLPesticides columns can be used with nitrogen, which give labs the freedom to choose the carrier gas option that is best for them.

A Guide to the Analysis of Halogenated Environmental Pollutants Using Electron Capture Detection

Analyses of halogenated pollutants can be difficult because samples often are contaminated with nontarget compounds and methods can require rigorous quality control. This technical guide covers sample extraction, cleanup, and GC-ECD analysis. Includes chromatographic analysis of chlorinated pesticides, PCBs, chlorinated herbicides, haloacetic acids and more on a single column set. Request free printed copies today. (PDF - 3612kB)

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Half the Column, Same Chromatogram: Maintain Resolution of BDE 49 and BDE 71 With Proper Method Translation After Trimming an Rtx®-1614 Column for Maintenance

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Ship Our Rugged Air Canisters at No Extra Cost

Air sampling canisters from Restek are durable, easy to use, and highly inert. They weigh just grams more than canisters from other vendors and cost the same to ship. Check out this weight and cost comparison to see for yourself! (PDF - 1795kB)

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Ensure cleaner sample extracts and obtain high recoveries of target pesticides by adding a Resprep® CarboPrep® SPE cleanup step when preparing samples for chlorinated pesticides analysis. (PDF - 1683kB)

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Comprehensive two-dimensional gas chromatography time-of-flight mass spectrometry (GCxGC-TOFMS) was used to analyze petroleum biomarkers creating unique fingerprints of crude oil samples and tarballs collected after the Deepwater Horizon oil spill.

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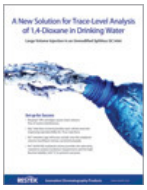
New Rxi®-PAH GC Column; Resolve Important Isobaric Polycyclic Aromatic Hydrocarbons for Food Safety and Environmental Methods

Separate isobaric polycyclic aromatic hydrocarbons, including priority EFSA PAH4 compounds benz[a]anthracene, chrysene, benzo[b]fluoranthene, and benzo[a]pyrene, easily and accurately on an Rxi®-PAH column. Whether you need more resolution or faster analysis, these new GC columns offer the selectivity and efficiency you need for food safety and environmental PAH analysis. (PDF - 826kB)



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Increase Productivity for Dioxin and Furan Analysis with Rtx®-Dioxin2 GC Columns

Rtx®-Dioxin2 columns have higher temperature stability (340 °C) than other confirmation columns and also provide isomer specificity for both 2,3,7,8-TCDD and 2,3,7,8-TCDF in a single column. These attributes allowed the Maxxam Analytics HR-MS group to make productivity improvements that resulted their being honored with a Kaizen award. (PDF - 691kB)

Rxi®-624Sil MS Columns—Exceptionally Inert, Low Bleed Columns for Volatiles Analysis

Analyze volatile compounds and polar analytes with greater confidence using Rxi®-624Sil MS columns. Optimized selectivity, higher inertness, and lower bleed result in reliable separations and accurate, trace-level determinations. Includes environmental and pharmaceutical applications. (PDF - 3111kB)

Restek Airmail, 2012 vol. 1

This 4-page newsletter includes an analysis of Massachusetts DEP air-phase petroleum hydrocarbons, as well as an update on the U.S. EPA Photochemical Assessment Monitoring Stations (PAMS) program. Also features Tedlar® bags and air canisters. (PDF - 774kB)

Large Volume Splitless Injection Using an Unmodified Split/Splitless Inlet and GC-TOFMS for Pesticides and Brominated Flame Retardants

Concurrent solvent recondensation large volume splitless injection (CSR-LVSI) GC/MS is used here for analyzing pesticides and brominated flame retardants in drinking water based on EPA Method 527. CSR-LVSI allows a time-consuming sample extract concentration step to be eliminated, but can also be used with extract concentration for lower detection limits.

Rxi® GC Columns: 3-IN-1 TECHNOLOGY

Rxi® GC columns deliver more accurate, reliable trace-level results than any other fused silica column on the market. Take variation out of the equation and lower detection limits with highly inert, low bleed Rxi® gas chromatography columns. (PDF - 1929kB)

Avoid Resampling Soil Vapors: Confirm Tracer Gas in the Field Using a Leak Detector

Confirming sample port integrity with a leak detector is a simple, cost-effective alternative to lab analysis of tracer gas in vapor intrusion VOC samples. Prevent resampling of soil vapors by confirming sample port integrity in the field prior to sampling.

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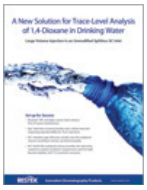

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Rtx®-Dioxin2 columns have higher temperature stability (340 °C) than other confirmation columns and also provide isomer specificity for both 2,3,7,8-TCDD and 2,3,7,8-TCDF in a single column. These attributes allowed the Maxxam Analytics HR-MS group to make productivity improvements that resulted their being honored with a Kaizen award. (PDF - 691kB)

Rxi®-624Sil MS Columns—Exceptionally Inert, Low Bleed Columns for Volatiles Analysis

Analyze volatile compounds and polar analytes with greater confidence using Rxi®-624Sil MS columns. Optimized selectivity, higher inertness, and lower bleed result in reliable separations and accurate, trace-level determinations. Includes environmental and pharmaceutical applications. (PDF - 3111kB)

Restek Airmail, 2012 vol. 1

This 4-page newsletter includes an analysis of Massachusetts DEP air-phase petroleum hydrocarbons, as well as an update on the U.S. EPA Photochemical Assessment Monitoring Stations (PAMS) program. Also features Tedlar® bags and air canisters. (PDF - 774kB)

Large Volume Splitless Injection Using an Unmodified Split/Splitless Inlet and GC-TOFMS for Pesticides and Brominated Flame Retardants

Concurrent solvent recondensation large volume splitless injection (CSR-LVSI) GC/MS is used here for analyzing pesticides and brominated flame retardants in drinking water based on EPA Method 527. CSR-LVSI allows a time-consuming sample extract concentration step to be eliminated, but can also be used with extract concentration for lower detection limits.

Rxi® GC Columns: 3-IN-1 TECHNOLOGY

Rxi® GC columns deliver more accurate, reliable trace-level results than any other fused silica column on the market. Take variation out of the equation and lower detection limits with highly inert, low bleed Rxi® gas chromatography columns. (PDF - 1929kB)

Avoid Resampling Soil Vapors: Confirm Tracer Gas in the Field Using a Leak Detector

Confirming sample port integrity with a leak detector is a simple, cost-effective alternative to lab analysis of tracer gas in vapor intrusion VOC samples. Prevent resampling of soil vapors by confirming sample port integrity in the field prior to sampling.

Environmental

Seven EPA Methods on One Column Pair using a µ-ECD

Get improved resolution, faster analyses, and less downtime by using Rtx®-CLPesticides and Rtx®-CLPesticides2 columns for multiple GC/ECD methods. Instead of changing columns between methods, you can save time by analyzing chlorinated pesticides, PCBs, herbicides, and other halogenated compounds on a single column set. Rtx®-CLPesticides and Rtx®-CLPesticides2 columns have a unique selectivity and outperform other column sets offered specifically for multiple GC/ECD methods.

Guide to Whole Air Canister Sampling

Ambient air sampling involves collecting a representative sample of ambient air for analysis. There are two general approaches: 1) "whole air" sampling with canisters or Tedlar® bags and 2) "in-field concentration" sampling using sorbent tubes or cold traps. In this guide, we focus on collecting whole air samples in canisters, a flexible technique with many applications. (PDF - 1408kB)

Optimized Volatiles Analysis Ensures Fast VOC Separations

Analytical conditions for GC analysis of volatile organic compounds have been optimized to ensure good resolution of critical pairs, while maximizing sample throughput. Rxi®-624Sil MS columns are shown to outperform other 624s.

Gas Sampling Bags: Cost-Effective Alternatives for Air Monitoring

Gas sampling bags can be a cost-effective alternative to canisters and thermal desorption tubes for many air monitoring applications, including VOCs and permanent gases. This 4-page flyer provides general guidelines, product specifications, and recommended applications. (PDF - 953kB)

New Wool Ensures More Accurate Semivolatiles Analyses

New Semivolatiles Wool, pre-packed in Restek liners, is designed specifically for semivolatiles analysis and result in more accurate results at lower levels, compared to similar products.

Analyze Haloacetic Acids in Under 13 Minutes with Rtx®-CLPesticides Columns

Sample throughput for haloacetic acids in drinking water can be increased significantly using Rtx®-CLPesticides/Rtx®-CLPesticides2 columns. Target HAAs were fully resolved in under 13 minutes.

3-Fold Faster Polybrominated Diphenyl Ether (PBDE) Short Column Method

Sample throughput for PBDE analysis can be significantly increased using a 15m Rtx®-1614 column. Excellent responses and peak shapes are obtained for all congeners, including BDE-209, in just 20 minutes.

Reliably Detect Pesticides Down to 10pg with Sensitive SIM GC/MS Multiresidue Method

As labs operate in an extremely competitive market, the demand for more sensitive multiresidue pesticide methods is increasing. Here we demonstrate linearity down to 10pg on-column for a wide range of pesticides differing in volatility, compound class, and degree of activity. The inertness of the Rxi®-5Sil MS column ensures linear performance and more accurate low level quantification for multiresidue pesticide methods.

PTV On-Column Liner Gives You Two Inlets in One

Programmable temperature vaporization inlets are versatile, yet normally do not accommodate on-column injection. Now, using a PTV On-Column liner, the capabilities of PTV can be expanded to include true on-column injections.

Characterizing All 136 Tetra- to Octachlorinated Dioxins and Furans

The Rtx®-Dioxin2 column has a unique selectivity for dioxins and furans, including specificity for 2,3,7,8-TCDD and 2,3,7,8-TCDF. Here we characterize all 136 tetra- through octachlorine dioxins and furans and define all possible coelutions. While commonly used cyanopropyl columns are limited by a low maximum operating temperature of 240°C, the Rtx®-Dioxin2 column is stable up to 340°C, extending column lifetime and improving the analyses of dioxins and furans.

Restek develops reference standards for underground storage tank testing. This flyer includes UST fuel composite standards, single source fuel standards, fuel surrogate & internal standards, & standards blended for specific state methods. (PDF - 438kB)

Increase Polycyclic Aromatic Hydrocarbon Sample Throughput

Here we analyze polycyclic (polynuclear) aromatic hydrocarbons (PAHs) from the US EPA, European Union (EU), and Portugal lists by UHPLC and HPLC. Procedures shown use two optimized stationary phases (Pinnacle® DB PAH and Pinnacle® II PAH) and provide 3.5 to 6 minute analyses, allowing labs to achieve significantly faster sample throughput.

One Stop Shop for EPA Method 535

An optimized EPA Method 535 procedure offers superior sensitivity for the ethanesulfonic acid (ESA) and oxanilic acid (OA) degradates of chloroacetanilide herbicides alachlor, acetochlor, and metolachlor. Alachlor ESA and acetochlor ESA isomers are reliably resolved, and the procedure is simplified with a full line of Method 535 products, including reference standards, solid phase extraction cartridges, and HPLC columns.

Thermal Desorption: A Practical Applications Guide: I. Environmental Air Monitoring and Occupational Health & Safety

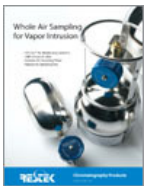
Thermal desorption is now recognized as the technique of choice for environmental air monitoring and occupational health and safety. This 28-page publication from Markes International Ltd. presents several real world thermal desorption applications. (PDF - 1137kB)

Enhancing Air Monitoring Methods with Thermal Desorption

The use of carbon disulfide (CS_2) extraction as an air monitoring method for vapor-phase organic compounds (VOCs) is fundamentally limited with respect to detection limits. Thermal desorption (TD) is a complementary gas extraction technique whereby sorbent tubes are heated in a flow of carrier gas. Trapped vapors desorb from the sample tubes into the gas stream and are transferred into the GC/MS analyzer. Here, we summarize the key advantages of thermal desorption versus solvent extraction.

13 Minute Chlorophenoxyacid Herbicides Analysis

The Rtx®-CLPesticides and Rtx®-CLPesticides2 column pair is an excellent choice for chlorophenoxyacid herbicide analysis. Now, with an optimized film thickness for the 0.32mm ID version, this difficult analysis can be made in less than 13 minutes on both the primary and confirmation columns. Near baseline resolution is achieved for all analytes except for bentazon/picloram on the Rtx®-CLPesticides column; however, this pair is fully resolved on the Rtx®-CLPesticides2.



Whole Air Sampling for Vapor Intrusion

This 2-page note describes the features and benefits of our popular TO-Can® air monitoring canisters (SUMMA® can equivalents), our new canister air sampling timer, and our convenient, reliable passive air sampling kits. (PDF - 206kB)

A Guide to Preparing and Analyzing Chlorinated Pesticides

Analyses of chlorinated pesticides can be difficult because samples often are contaminated with non-target compounds (e.g., lipids), and the method can require rigorous quality control. Our 24-page guide covers sample extraction methodology, sample cleanup, and chromatography. A chromatographic analysis of widely used chlorinated herbicides also is illustrated. One of our most popular technical guides. (PDF - 4062kB)

Accurately Quantify PAHs Down to 5pg On-Column

Semivolatiles methods, such as EPA Method 8270, place stringent demands on gas chromatography (GC) columns. Here we demonstrate the performance of Rxi®-5Sil MS columns for semivolatiles analysis in terms of bleed, efficiency, and activity. Excellent sensitivity and resolution are seen, even for difficult PAHs such as benzo(b)fluoranthene & benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene and dibenzo(a,h)anthracene. Both basic and acidic compounds show good response even at low levels.

Complete Resolution of 13 DNPH Carbonyls as Derivatives

The new Allure® AK HPLC column was developed specifically for the analysis of aldehydes and ketones, including the 13 carbonyl compounds specified in the California Air Resources Board (CARB) Method 1004. The data shown in this article demonstrate excellent resolution, even of buteraldehyde and methyl ethyl ketone (MEK), in less than 12 minutes using a 200mm Allure® AK HPLC column.

Resolving the Benzo(j)fluoranthene Challenge

Polynuclear aromatic hydrocarbons are a significant, and wide-spread, source of pollution. The US EPA mandates testing of the 16 PAHs they designate as most hazardous; the target list in other countries is expanding and includes new compounds that are difficult to separate. Here we demonstrate the ability of the Rxi®-17 column to effectively resolve dibenzo pyrene isomers, as well as to separate benzo(j)fluoranthene from benzo(b)fluoranthene and benzo(k)fluoranthene.

Faster Organochlorine Pesticide Sample Throughput

Increasing sample throughput is an effective way to reduce operating costs for environmental labs. Here we introduce new film thicknesses for the Rtx®-CLPesticide and Rtx®-CLPesticide2 GC columns,

Method 8081 organochlorine pesticides are resolved in <9 min. We also show complete separation of these compounds in <5 min. using these columns and a Gerstel MACH column heating system.

Choosing a Liner for Semivolatiles Analyses

Liner choice is a critical decision in semivolatiles analysis. Liners containing wool packing are recommended to minimize molecular weight discrimination. Attributes of different types of liners, including the Drilled Uniliner , are discussed.

Resolving Benzo(j)fluoranthene from Other PAHs

Nineteen polycyclic aromatic hydrocarbons (PAHs), including benzo(b) and benzo(j)fluoranthene, were fully resolved using a Pinnacle II PAH column. Greater sensitivity was achieved by coupling UV and fluorescence detection. This HPLC method offers improved resolution compared to standard GC techniques.

Foods, Flavors & Fragrances

Prepare Olive Oil Samples for Pesticide Residue Analysis in Half the Time With a Fraction of the Solvent Using dSPE

Simplify and speed up sample preparation with Resprep® dSPE tubes! Here we show the extraction and clean-up of pesticide residues from olive oil samples—twice as fast as GPC, with only a fraction of the solvent required for conventional SPE.

Accurately Determine Mineral Oil Hydrocarbons in Food and Packaging

Accurate testing for mineral oil hydrocarbons (MOHs) in food and packaging is imperative to the safety of our food supply. Turn to Restek for the certified reference materials (CRMs), HPLC columns, GC guard columns, and GC analytical columns you need for world-class analysis of mineral oil saturated hydrocarbons (MOSH) and mineral oil aromatic hydrocarbons (MOAH) via online LC/GC coupling. (PDF - 1193kB)

HPLC Analysis of Glucosinolates in Vegetable Extracts without Ion Pairing Using an Ultra Aqueous C18 Column

Convenient, reproducible analyses for hydrophilic molecules with widely varying polarity Glucosinolates with hydrophilic functional groups are very difficult to retain by conventional reversed phase HPLC, and when the functional groups in a sample are diverse, polarity can differ widely, complicating the problem. Until now, reversed phase HPLC with an ion pairing reagent has been the inconvenient, but necessary, approach to these analyses. This 2-page note describes a column and conditions for analyses of glucosinolates, without ion pairing. (PDF - 435kB)

Evaluation of Dispersive and Cartridge Solid Phase Extraction (SPE) Cleanups for Multiresidue Pesticides in QuEChERS Extracts of Finished Tobacco Using GCxGC-TOFMS

We compared the efficacy of dSPE and cSPE cleanup methods for multiresidue pesticide analysis of QuEChERS extracts of finished tobacco products using GCxGC-TOFMS. Cleanup with dSPE tubes containing 7.5 mg of GCB and 25 mg of PSA produced better results than other methods, with average recoveries of 92% and 91% for 500 ppb and 50 ppb fortifications respectively.

Mitigating Matrix Effects: Examination of Dilution, QuEChERS, and Calibration Strategies for LC-MS/MS Analysis of Pesticide Residues in Diverse Food Types

LC-MS/MS is popular for monitoring pesticide residues in food due to its selectivity and sensitivity; however, matrix effects can cause poor data quality and difficult quantification. We evaluated the relative effectiveness of sample dilution, QuEChERS cleanup, solvent-based calibration, and matrix-matched calibration strategies to mitigate matrix effects in celery, kale, avocado, lime, and brown rice flour.

Accurately Detect and Quantify 204 Pesticides of Global Concern by LC-MS/MS With Our New Certified Reference Materials Kit

Stop spending your time and money developing LC-MS/MS multi-residue pesticide methods and mixing reference standards when you could be running samples! Restek's trusted food safety experts have already done the work for you—with guaranteed accuracy and at a lower cost. (PDF - 2034kB)

New Rxi®-PAH GC Column; Resolve Important Isobaric Polycyclic Aromatic Hydrocarbons for Food Safety and Environmental Methods

Separate isobaric polycyclic aromatic hydrocarbons, including priority EFSA PAH4 compounds benz[a]anthracene, chrysene, benzo[b]fluoranthene, and benzo[a]pyrene, easily and accurately on an Rxi®-PAH column. Whether you need more resolution or faster analysis, these new GC columns offer the selectivity and efficiency you need for food safety and environmental PAH analysis. (PDF - 826kB)

QuEChERS Products: Fast, Simple Sample Prep for Multiresidue Pesticide Analysis

Learn how to use the QuEChERS approach to perform faster, easier sample preparation and cleanup for multiresidue pesticide analysis. Q-sep™ QuEChERS products save time, money, and materials compared to modified Luke methods. (PDF - 2874kB)

A Comprehensive Approach to Pesticide Residue Testing, Including

Food commodities that varied in water, fat, and pigment content were fortified with pesticides and processed using a QuEChERS sample preparation technique. Samples were analyzed by both GCxGC-TOFMS and LC-MS/MS, and good recoveries were obtained for most pesticides in most commodities.

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The unique selectivity and high retention of Biphenyl columns produce complete separation of sulfonamide residues and benefit both UV and MS detection. In addition, Biphenyl columns in a UHPLC format allow faster sample throughput when testing for these antibiotics.

USLC® Columns Put the Right Tools in Your LC Method Development Toolbox

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The novel approach used here combines QuEChERS extraction, cartridge SPE cleanup, and GCxGC-TOFMS analysis, resulting in good recoveries for a wide range of pesticides in dietary supplements. Matrices include dandelion root, sage, and a multi-herb finished product.

Q-sep™ New Product Supplement

QuEChERS solid phase extraction cartridges. SPE tubes, columns, and reference standards for fast, simple extraction, cleanup, and analysis of pesticide residue samples. Designed for AOAC and European methods. (PDF - 123kB)

Meet New Requirements for Melamine Analysis at 1µg/g in Infant Formula

The recent establishment of a 1µg/g safety threshold for melamine in infant foods has led to an immediate need for more sensitive methods. Here we established GC/MS conditions for highly reproducible analyses and evaluated the effectiveness of both solvent-based and matrix-matched standards. Using this method, melamine and cyanuric acid were reliably detected at and below 1µg/g in infant formula.

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Analysis of pesticide residues in foods is complicated by the large number of target compounds. LC-MS/MS analysis using an Aqueous C18 column provides more comprehensive results than GC alone.

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QuEChERS dSPE methods simplify extract cleanup, reduce material costs, and improve sample throughput. Here we demonstrate the effectiveness of QuEChERS sample cleanup using a multiresidue analysis of pesticides on strawberries. (PDF - 158kB)

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Rapid Screening Method for Carbamates in Orange Oil

matrices, which often contain interferences and require time-consuming sample preparation. We developed an easy, accurate screening method for carbamates in a complex matrix using an Ultra Carbamate HPLC column in conjunction with the Leco Unique TOF- MS. This method requires no sample preparation and provides fast analysis times, significantly increasing sample throughput.

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Nitrofurans are a class of veterinary antibiotics used to increase growth rate and prevent or treat disease in animals. Determining levels of nitrofurans in animal tissue, or even products such as honey, is important in studying drug resistance and allergies in humans. The Ultra C18 HPLC column is an excellent choice for LC/MS/MS analysis of nitrofurans at low levels in complex matrices such as honey. Here we show excellent sensitivity, resolution, and peak shape at trace levels.

Simple, Reliable HPLC Analyses of Organic Acids

Commonly used organic acid methods (e.g. AOAC method 986.13) depend on reversed phase HPLC and C18 columns, however these columns are vulnerable to phase collapse when used with the aqueous mobile phases necessary for optimal organic acid analysis. Restek's Ultra Aqueous C18, Allure® Aqueous C18, and Allure® Organic Acids columns all withstand phase collapse and resolve organic acids in a 100% aqueous mobile phase, compared to a conventional C18 column which shows a complete loss of retention.

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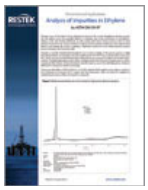
Petroleum & Petrochemical

Eliminate Column Breakage in High Temperature Biodiesel Analysis

Using metal columns to analyze glycerides in biodiesel offer significant performance advantages compared to fused silica columns, as shown in this evaluation.

Stable Sulfur & Mercury Sampling in Refineries

Refinery and natural gas samples often contain trace amounts of sulfur- and mercury-containing compounds, which can interfere with reactions, poison catalysts in petrochemical processes, and damage equipment. Because these compounds quickly react with stainless steel surfaces, accurate determination of these compounds is impossible when samples are collected and stored in untreated sample cylinders. Restek's Siltek® and Sulfinert® passivation techniques bond an inert layer into the surface of stainless steel, preventing active compounds from reacting with or adsorbing to the steel.



Analysis of Impurities in Ethylene by ASTM D6159-97

When testing for impurities in ethylene using ASTM D6159-97, the combination of an Rt®-Alumina BOND column coupled to an Rtx®-1 column provides the best resolution of the most common hydrocarbon contaminants. (PDF - 175kB)

High Temp. Stability Problem Solved with New Metal Columns

The high temperatures required for biodiesel analysis by gas chromatography present a considerable challenge to analytical columns. Fused silica columns, even those rated for high-temperature tolerance, breakdown relatively quickly. Restek's new MXT®-Biodiesel columns are more stable up to 430°C and offer excellent chromatography for glycerides. These columns are available in two configurations: factory-coupled to a 0.53mm retention gap, or with a built-in, leak-proof Integra-Gap™ retention gap.

Fast, Accurate FAMEs Analyses of Biodiesel Fuel

As biodiesel fuel continues to stimulate interest worldwide as an energy source, several gas chromatographic methods have been developed to determine the quality of B100 fuel. Here we show excellent peak symmetry, resolution, and reproducibility for determining the fatty acid methyl ester (FAME) and linolenic acid methyl ester content in B100 biodiesel fuel, using European standard method EN 14103 on a Stabilwax® fused silica GC column.

Biodiesel Analysis by European Methodology

Glycerin is a notoriously difficult challenge in GC, particularly at the levels involved in biodiesel oil analysis, but an Rtx®-Biodiesel column provides a symmetric peak that makes quantification easier and more reliable. The column performs well at elevated temperatures: peaks for glycerin and glycerides exhibit minimal tailing, and bleed is low at 370°C, as specified in European method DIN EN14105.

Separate Argon from Oxygen Above Ambient Temperatures

A Restek PLOT column can be your best solution for difficult separations of gaseous analytes. Rt-Msieve™ 5A PLOT columns offer fast, efficient separation of argon/oxygen, hydrogen/helium, and other permanent gases, including permanent gases in refinery or natural gas. You can make difficult separations without subambient temperatures, e.g.: separate oxygen from argon to baseline in approximately 4 minutes.

Analyze Biodiesel Oil for Glycerin

We challenged our Rtx®-Biodiesel column with analysis for glycerin in biodiesel according to method ASTM D-6584-00. Excellent linearity was established for glycerin, triolein, monolein, and diolein, with r^2 values exceeding the method criteria for all compounds. Mono-, di-, and triglycerides resolved well from other compounds in B100 biodiesel oil. Column performance was strong at high temperatures, with low bleed even at 380°C. An Alumaseal™ connector and guard column were used to extend column life.

How Good is Your PONA Column?

We evaluated our 100 meter x 0.25mm ID x 0.5df PONA column and equivalent columns from four other vendors, following ASTM D-6730 methodology (hydrogen carrier gas). Data and chromatograms presented here show that only the Restek PONA column performed to method specifications admirably. Column efficiency exceeded specification.

Sulfinert®-Treated Sample Cylinders

Recovery of a 17ppbv test standard of hydrogen sulfide exceeded 85% after 54 hours in a Sulfinert®-treated cylinder; recoveries of methyl mercaptan, ethyl mercaptan, carbonyl sulfide, and dimethyl disulfide exceeded 90%. A Sulfinert®-treated sampling/transfer system can assure accurate sulfur content data for natural gas, beverage-grade carbon dioxide, or other samples.

GC Analysis of Total Reduced Sulfurs at ppbv Levels

sulfide, carbonyl sulfide, dimethyl sulfide, mercaptans) on our new column, with excellent peak shapes and reliable quantification at ppbv levels. A Sulfinert® treated sampling/transfer system assures no adsorption losses of these very reactive compounds.

Parker PEM Hydrogen Generators

Relative to helium as the GC carrier gas, hydrogen from a gas generator reduces gas costs, cuts analysis time by 50%, and reduces temperatures needed for eluting analytes — which increases column lifetime. Parker ChromGas® hydrogen generators are safe, convenient, reliable, and easy to use.

Analyze Hydrocarbons on OPN/Res-Sil™ C Bonded GC Packing

In process GC analyses, this material offers unique selectivity for the difficult-to-separate saturated and unsaturated C4 hydrocarbons, eluting *cis*-2-butene before 1,3-butadiene. Innovative bonding chemistry assures batch-to-batch reproducibility, excellent thermal stability, and long column life.

MXT®-1HT Sim Dist

ASTM Method D-6352, a simulated distillation of petroleum distillates, requires a capillary column compatible with oven temperatures to 430°C. At temperatures above 380°C, polyimide-coated fused silica becomes brittle, and column lives are very short. MXT®-1 HT Sim Dist columns combine the inertness of fused silica and durability of stainless steel, to meet all criteria in the method. Data for a series of 400 injections at 430°C affirm the low-bleed, long-lifetime characteristics of this column. (PDF - 97kB)

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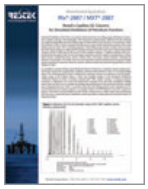
Res-Sil™ C Bonded GC Packings for Analyses of Light Hydrocarbons

n-Octane on Res-Sil™ C packing provides excellent, reproducible separations of volatile hydrocarbons in petroleum products, including the difficult-to-separate saturated and unsaturated C4 compounds. An OPN on Res-Sil™ C column separates C1-C5 hydrocarbons in half the time required by alternative columns.

GC Analysis of Petroleum Products

MXT®-1 Sim Dist and MXT®-500 Sim Dist columns combine the inertness of fused silica with the durability of stainless steel, meeting all ASTM Method D6352 (petroleum simulated distillation) criteria. MXT®-500 Sim Dist columns have lower bleed and longer lifetimes, but calculated boiling points for aromatics are higher (closer to true values); MXT®-1 Sim Dist columns offer polarity that matches published data. Includes chromatograms. (PDF - 111kB)



Rtx®-2887 / MXT®-2887: Restek's Capillary GC Columns for Simulated Distillation of Petroleum Fractions

ASTM D2887-01a is used to monitor petroleum products, excluding gasoline, with final boiling points of less than 538°C. Metal MXT®-2887 columns and fused silica Rtx®-2887 columns offer lower bleed, faster analysis times, and longer column lifetimes. (PDF - 76kB)

Rtx®-1 SimDist 2887: A Bonded Packed Column for Simulated Distillation

The stationary phase in Rtx®-1 Sim Dist columns is bonded to a highly deactivated silica support, ensuring inertness, stability, and column lifetime characteristics superior to conventional packed columns for Sim Dist analysis (ASTM Methods D2887, D3710). (PDF - 136kB)

Analyzing Oxygenates in Gasoline Using TCEP and Rtx®-1/MXT®-1 Columns

Two methods are used to quantify individual alcohols and ethers in gasoline: a single column OFID method (e.g., ASTM Method D5599-94) and dual-column ASTM Method D4815-93. Restek offers columns, calibration mixtures, and inert capillary tubing for both approaches. 4-page note. (PDF - 76kB)

New D3606 Column Set Outperforms TCEP Columns for Benzene Analysis

Restek's new D3606 column set outperforms TCEP columns for gasoline testing. The D3606 set has higher thermal stability and reliably resolves benzene from ethanol, resulting in more accurate quantitation.

OPN and n-Octane on Res-Sil® C Packing for the Separation of Hydrocarbons

Res-Sil® support is an excellent replacement for discontinued Poracil® C. Stringent testing of the bonded packing ensures reproducible separations and retention times for C1-C5 hydrocarbons, including difficult-to-separate saturated and unsaturated C4 compounds. (PDF - 99kB)

Petroleum & Petrochemical

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NEW! Rt®-Silica BOND Columns

Rt®-Silica BOND PLOT columns from Restek are ideal for light hydrocarbon, permanent gas, and CFC analyses. We individually QC test every column with sensitive C4 probes to ensure consistent column-to-column selectivity. Our proprietary manufacturing process practically eliminates particle release, resulting in highly stable retention times. (PDF - 601kB)

Benefits and Considerations of Converting to Hydrogen Carrier Gas

The current helium shortage has severely impacted gas chromatographers who are finding that helium has become significantly more expensive and is not always available when needed. This article explores the benefits and considerations of replacing helium with hydrogen carrier gas.

MXT®-1HT SimDist Columns (5 m x 0.53 mm x 0.10 µm) are Individually Application Tested up to 430 °C for Guaranteed Method Performance!

Only MXT®-1HT SimDist columns (5 m x 0.53 mm x 0.10 µm, cat.# 70112) are individually tested against ASTM Method 6352 specifications, guaranteeing they will meet performance requirements! (PDF - 949kB)

Fingerprinting Crude Oils and Tarballs using Biomarkers and Comprehensive Two-Dimensional Gas Chromatography

Comprehensive two-dimensional gas chromatography time-of-flight mass spectrometry (GCxGC-TOFMS) was used to analyze petroleum biomarkers creating unique fingerprints of crude oil samples and tarballs collected after the Deepwater Horizon oil spill.

Using Micropacked GC Columns for Analyzing Volatiles in Light Hydrocarbon Streams

Most analysts still use traditional packed columns for light hydrocarbon analysis, but many adsorbents are also available in micropacked column formats. Micropacked columns are a good alternative when both efficiency and sample loadability are desired.

Advanced Capillary Column Technology Improves Analysis of Volatile Amines

Volatile amines, such as monomethylamine, diethylamine, and triethylamine, are widely used in the petrochemical industry, but are prone to poor peak shape and difficult to analyze. Low levels of volatile amines can now be accurately reported using new Rtx®-Volatile Amine columns due high column inertness.

Analyze ppb Level Sulfur Compounds Using an Rt®-XLSulfur Micropacked GC Column or an Rtx®-1 Thick Film Capillary GC Column

Trace levels of sulfur compounds are separated and quantified by using an Rtx®-1 capillary column or an Rt®-XLSulfur micropacked column. The latter column is a specially deactivated porous polymer in Sulfinert®-passivated stainless steel tubing.

Rt®-XLSulfur Packed GC Column for Analysis of Low-Level Sulfur Compounds in C1-C6 Hydrocarbon Streams

Rt®-XLSulfur columns resolve hydrocarbons from sulfur compounds in hydrocarbon process streams, and exhibit excellent inertness with low ppbv levels of sulfurs.

Restek's PLOT Column Family — The Benchmark For Performance!

Restek's PLOT column family is the benchmark for performance! Our innovative bonding process minimizes particle release, reducing column blockage and protecting instrument parts. More consistent flow means stable retention times in Deans and related flow switching techniques.And outstanding peak symmetry improves impurity analysis for gases, solvents, and hydrocarbons. (PDF - 2296kB)

Rt®-XLSulfur Packed Column: Specialized packed and micropacked columns for eXtra-Low Sulfur analysis

Rt®-XLSulfur packed and micropacked columns combine a unique, efficient porous polymer packing material and true inertness toward active analytes, to ensure excellent and reliable results in trace-level analyses of hydrogen sulfide, sulfur dioxide, and other lightweight sulfur compounds. (PDF - 433kB)

Detailed Hydrocarbon Analysis Featuring Rtx®-DHA Columns

Superior performance for DHA analysis! Rtx®-DHA columns offer 50% faster run times when used with hydrogen, improved resolution between oxygenates and hydrocarbons, and guaranteed column-to-column reproducibility. These columns also meet or exceed all ASTM and CAN/CGSB method guidelines. (PDF - 3922kB)

Improve Trace Analysis of Acetylene, Propadiene, and Methyl Acetylene Impurities With Higher Sample Capacity Alumina MAPD Columns

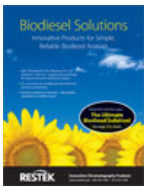
Rt®-Alumina BOND/MAPD columns offer higher capacity than other MAPD columns and are ideal for analyzing acetylene, propadiene, and methyl acetylene in petroleum gases. Greater capacity improves data accuracy due to better peak symmetry and a wide linear range.

Resolve Benzene and Toluene in Spark Ignition Fuels Containing Ethanol

This 2-column set for modified ASTM Method D3606-10 completely resolves benzene from ethanol in reformulated fuels containing ethanol. The aromatic compounds also are fully separated and can easily be quantified using sec-butanol as an internal standard. (PDF - 1852kB)

Analysis of Trace Hydrocarbon Impurities in 1,3-Butadiene Using Optimized Rt®-Alumina BOND/MAPD PLOT Columns

Impurity analysis of 1,3-butadiene on an Rt®-Alumina BOND/MAPD column results in good separation of both light polar impurities (methyl acetylene, propadiene) and 4-vinylcyclohexene, a heavier contaminant that often requires testing on a second column.



Biodiesel Solutions: Innovative Products for Simple, Reliable Biodiesel Analysis

This flyer includes data demonstrating the performance of recommended GC columns for the analysis of total glycerin, fatty acid methyl esters (FAMEs), and residual methanol in biodiesel. Features a comparison of metal and fused silica columns. (PDF - 1652kB)

Analyze Trace Polar Hydrocarbons More Accurately and Reliably With New Alumina BOND/MAPD PLOT Columns!

Rt®- and MXT®-Alumina BOND/MAPD PLOT columns outperform other MAPD columns for trace analysis of methyl acetylene, acetylene, propadiene, and other polar hydrocarbons. The new deactivation results in more predictable responses, increased capacity, and higher temperature stability. (PDF - 827kB)

GCxGC Analysis of Complex Petroleum Hydrocarbons: Sulfur Speciation in Diesel

Comprehensive 2D GC, also known as GCxGC, is a powerful technique with a great deal of potential for improving separations of complex petroleum and petrochemical samples that contain hundreds—or even thousands—of components. While GCxGC is still considered emerging technology and is used primarily in research and development labs, it has undergone significant growth in the past few years.

New Alumina Column Shows Promise for Analyzing Chlorofluorocarbons

Rt®-Alumina BOND/CFC columns provide high retention and high selectivity for volatile halogenated hydrocarbons, without the activity that is usually observed with alumina adsorbents. Chlorofluorocarbon analysis, in particular, can benefit from this new technology.

Extending the Power of Stabilized PLOT Column Technology to Process GC Analyzers

New metal MXT® PLOT columns offer greater stability than conventional PLOT columns, making them a better choice for process GC analyzer applications. New bonding techniques result in highly reproducible flow characteristics, improved layer stability, and excellent separation efficiencies.

Solutions for Your Petro Analyses

Chromatograms, technical tips, and products developed specifically for petrochemical testing. Details recommendations for simulated distillation, PLOT column applications, DHA, D3606, biodiesel, permanent gases and hydrocarbons. (PDF - 2160kB)

Solutions for Gas Sampling

Ensure sample integrity with robust, reliable gas sampling products from Restek. This 4-page note details the benefits Sulfinert® passivation treatment and provides product information for sample cylinders, high pressure sample cylinders, valves, and more. (PDF - 1898kB)

Protect Natural Gas Sample Integrity and Prevent Sulfur Loss with Sulfinert® Sample Cylinders

Sulfur compounds in fuel streams can damage equipment and reduce BTU values. Sulfinert® sample cylinders are significantly more inert than stainless steel cylinders and assure sample integrity during collection, transportation, and storage.

Faster DHA Analyses Using Helium or Hydrogen

Rtx®-DHA columns are highly stable and can be run with helium or hydrogen under accelerated conditions. Restek has developed a new DHA method using Rtx®-DHA columns with hydrogen that can double refinery sample throughput.

Tighten Control of Distillation Processes with the New MXT®-1HT Sim Dist Column

New MXT®-1HT SimDist GC columns outperform competitors, allowing more productive D6352 analyses. Here we demonstrate lower bleed levels and higher efficiency, improving resolution and assuring more samples can be run within method specifications.

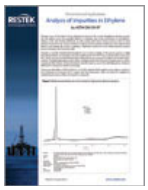
17 Minute D2712 Analysis of Impurities in Propylene Using PLOT Columns

When analyzing hydrocarbon impurities in propylene by ASTM D2712, using an Rt®-Alumina BOND Na2SO4 PLOT column instead of a packed column setup provides the greatest degree of resolution in the least amount of time. (PDF - 121kB)

Petroleum & Petrochemical

Eliminate Column Breakage in High Temperature Biodiesel Analysis
Using metal columns to analyze glycerides in biodiesel offer significant performance advantages compared to fused silica columns, as shown in this evaluation.

Stable Sulfur & Mercury Sampling in Refineries
Refinery and natural gas samples often contain trace amounts of sulfur- and mercury-containing compounds, which can interfere with reactions, poison catalysts in petrochemical processes, and damage equipment. Because these compounds quickly react with stainless steel surfaces, accurate determination of these compounds is impossible when samples are collected and stored in untreated sample cylinders. Restek's Siltek® and Sulfinert® passivation techniques bond an inert layer into the surface of stainless steel, preventing active compounds from reacting with or adsorbing to the steel.



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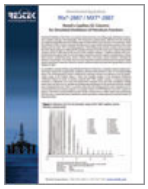

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ASTM D2887-01a is used to monitor petroleum products, excluding gasoline, with final boiling points of less than 538°C. Metal MXT®-2887 columns and fused silica Rtx®-2887 columns offer lower bleed, faster analysis times, and longer column lifetimes. (PDF - 76kB)

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The stationary phase in Rtx®-1 Sim Dist columns is bonded to a highly deactivated silica support, ensuring inertness, stability, and column lifetime characteristics superior to conventional packed columns for Sim Dist analysis (ASTM Methods D2887, D3710). (PDF - 136kB)

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Two methods are used to quantify individual alcohols and ethers in gasoline: a single column OFID method (e.g., ASTM Method D5599-94) and dual-column ASTM Method D4815-93. Restek offers columns, calibration mixtures, and inert capillary tubing for both approaches. 4-page note. (PDF - 76kB)

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Pharmaceutical

High-Quality Analysis of Pesticides in Cannabis Using QuEChERS, Cartridge SPE Cleanup, and GCxGC-TOFMS

As medical marijuana is more frequently prescribed, patient safety must be ensured. Pesticide residue testing is an important part of assuring safe product is dispensed, but analysis can be extremely challenging due to matrix complexity. The use of QuEChERS, cartridge SPE cleanup, and GCxGC-TOFMS as presented here produces high-quality quantitative data for this difficult analysis.

Don't Overestimate Cannabidiol During Medical Cannabis Potency Testing by Gas Chromatography

Proper GC column choice is essential for accurate and robust medical cannabis potency testing. Using an Rxi®-35Sil MS column under the instrument conditions shown here allows fast, accurate reporting of cannabichromene and cannabidiol in medical marijuana samples.

Raptor Biphenyl LC Columns Brochure

Raptor™ LC columns combine the speed of superficially porous particles (i.e., SPP or "core-shell") with the resolution of highly selective USLC® technology. Featuring Restek's most popular LC stationary phase, the rugged Raptor™ Biphenyl is extremely useful for fast separations in bioanalytical testing applications like drug and metabolite analyses, especially those that require a mass spectrometer (MS). (PDF - 5050kB)

Dissecting Raptor™ LC Columns: A closer look at a new species

When we engineered our superficially porous particle (SPP or "core-shell") Raptor™ LC columns, we developed the bonding chemistries that are best suited to both the SPP construction and our highly selective USLC® phases. But we didn't stop here. Take a closer look at a new species as we dissect the upgraded hardware and new, proprietary packing techniques behind Raptor™ LC columns and Raptor™ EXP® guard columns. (PDF - 571kB)

Characterizing Cellular Fatty Acid Methyl Ester (FAME) Profiles to Identify Bacteria Using Gas Chromatography

Dr. Radomír Čabala, Head of the Toxicology Department at the General University Hospital in Prague, presents work on the potential utility of GC-TOFMS analysis of cellular fatty acid methyl esters (FAMEs) in identifying clinically relevant bacteria.

Excellent LC-MS Separation of Penicillins and Cephalosporins Using Ultra IBD Columns

Unlike C18 columns, Ultra IBD (intrinsically base deactivated) columns can interact in normal phase mode with analytes that possess charged functional groups, providing greater versatility for LC-MS analyses. Excellent peak shape in either normal phase mode or reversed phase mode increases sensitivity and improves quantification. The 4-page note shows example analyses of penicillins and cephalosporins. (PDF - 987kB)

Rxi®-624Sil MS Columns—Exceptionally Inert, Low Bleed Columns for Volatiles Analysis

Analyze volatile compounds and polar analytes with greater confidence using Rxi®-624Sil MS columns. Optimized selectivity, higher inertness, and lower bleed result in reliable separations and accurate, trace-level determinations. Includes environmental and pharmaceutical applications. (PDF - 3111kB)

USLC™ Column Selection & Mobile Phase Adjustment Guide

USLC™ columns and this guide will help you easily choose the right stationary phase to target nearly any analyte in reversed phase or HILIC method development. It will also help you adjust your mobile phase to further improve results without guesswork or wasted time. (PDF - 1682kB)

USLC® Columns Put the Right Tools in Your LC Method Development Toolbox

Column selectivity has the most significant influence on chromatographic peak separation, or resolution, so choosing the right column can greatly speed up HPLC and UHPLC method development. In this article, we discuss column choice and identify a set of just 4 stationary phases—Restek's USLC® column set—that encompasses the widest range of reversed phase selectivity available today.

Not all column deactivations are appropriate for analyzing basic compounds. Here we demonstrate the effect of column inertness on peak shape, and discuss its role in improving method accuracy, sensitivity, and development time. (PDF - 227kB)

Fast Screening of Recalled Tylenol® for Tribromoanisole and Related Adulterants Using QuEChERS and GC-TOFMS

Screening methods for consumer product adulteration cases, such as the recent Tylenol recall, can benefit from fast QuEChERS-based sample preparation and sensitive, full mass-range GC/TOF-MS.

Determining Pesticides in Dietary Supplements with QuEChERS Extraction, Cartridge SPE, and GCxGC-TOFMS

The novel approach used here combines QuEChERS extraction, cartridge SPE cleanup, and GCxGC-TOFMS analysis, resulting in good recoveries for a wide range of pesticides in dietary supplements. Matrices include dandelion root, sage, and a multi-herb finished product.

USLC™ Columns: Choose Columns Fast. Develop Methods Faster.

Restek USLC™ columns offer the widest range of selectivity available and are an integral part of successful method development. Ideal for column switching systems, these columns provide orthogonal separations to create optimal resolution and robust methods—all in a 4-column set. (PDF - 1813kB)

Column Choice: A Critical Factor for Successful UHPLC Integration

Column choice is a critical factor in successfully transferring methods between UHPLC and HPLC. Here, we discuss the column qualities that contribute to the successful integration of UHPLC technology.

Novel Column Chemistry—High Impact, Low Cost Technology

Novel column chemistries are a simple change in an already budgeted consumable that can lead to optimized and more reliable methods—giving a fast return on a minimal investment.

Beyond C18—Increase Retention of Hydrophilic Compounds Using Biphenyl Columns

The Pinnacle® DB Biphenyl column offers enhanced retention and alternate selectivity for aromatic, unsaturated, and sulfur-containing hydrophilic compounds. Here we demonstrate significantly greater retention of sulfone- and sulfoxide-containing drug probes, compared to phenyl, phenyl hexyl, and alkyl (C18) columns. Only the Biphenyl column, using pi-pi interactions, separated both test probes to k' > 2, the level needed to ensure separation from unretained matrix contaminants.

Two Options for Analyzing Potential Genotoxic Impurities in Active Pharmaceutical Ingredients

Two options for the analysis of PGIs in API have been developed by Merck and Restek to meet different laboratory needs. The first option is a fast method for the analysis of sulfonate esters on the Rxi®-5Sil MS column. The second option is a comprehensive method for the analysis of both sulfonate esters and alkyl halides on the Rtx®-200 column. Both methods require very little sample preparation, which helps increase laboratory productivity.

How do intrinsically base-deactivated phases work?

Analyzing basic compounds can be somewhat troublesome on traditional alkyl stationary phases, namely conventional C18 columns. This is largely due to the interaction of analyte molecules with silanol groups present on the silica surface. To better understand the workings of silanol interactions, it is important to consider the composition of the support material. Silica is the most commonly used support in the production of HPLC columns, mainly because it is well-suited to high-pressure chromatographic separations, giving high efficiencies and good reproducibility. Silica offers bed and pressure stability and is highly porous, which ultimately gives rise to its large surface area, increased bonding capacity and high peak efficiencies. Silica also possesses widely-studied and effective bonding chemistries, making possible diverse analyte selectivities through a wide variety of bonded stationary phases.

Easy Transfer of HPLC Methods to UHPLC

Ultra High Pressure Liquid Chromatography (UHPLC) is a rapidly growing technique that can provide faster analysis times. Scaling conventional HPLC methods down to UHPLC can be an effective way to take advantage of shorter run times and increase sample throughput. Here we review the factors that must be considered when scaling down an existing method. A sulfonamides method transfer is used as an example; chromatograms and formulas for all required calculations are included.

Optimize Selectivity & Efficiency in UHPLC Separations

Ultra-high pressure liquid chromatography (UHPLC) can significantly increase efficiency and produce faster separations. The small particle sizes used in UHPLC improve efficiency; however selectivity is still the most important factor affecting compound resolution. Here we demonstrate the importance of stationary phase choice in UHPLC separations. By optimizing selectivity for your analytes of interest, faster separations can be achieved without compromising resolution.

Revised USP 467 Residual Solvent Method

The United States Pharmacopeia recently revised the general chapter on residual solvent analysis, USP <467>, to mirror the International Conference on Harmonization (ICH) guidelines for the identification, control and quantification of residual solvents. This revision, effective July 1, 2007, replaces previous

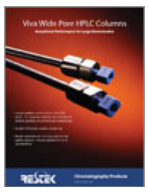
methods that were not consistent with the ICH guidelines. Here we provide an overview, chromatograms, and technical tips for successfully running the new procedure.

Developing New Methods for Pesticides in Dietary Supplements

QuEChERS is a simple, effective approach to sample prep that can be applied to the analysis of pesticides in dietary supplements. Here we demonstrate a QuEChERS, cSPE, GC-TOFMS procedure that results in good recoveries for a wide range of pesticides in dandelion root. (PDF - 5523kB)

Residual Solvent Analysis: Implementing USP <467>

This 12-page reference includes a review of headspace fundamentals, the revised USP <467> method (July, 2008), chromatography for Procedures A, B, and C, and technical tips for optimization. Guidance on fast, effect method development is given. (PDF - 471kB)



Viva Wide Pore HPLC Columns

How do small particle size columns increase sample throughput?

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Why do smaller particle size columns improve resolution?

Explaining the Small Particle Advantage

Small particle HPLC columns can offer faster analysis times but only if the particle size distribution is tightly controlled. Restek's 1.9µm Pinnacle™ DB columns have tight, symmetric particle size distributions and contain no particles less than 1µm. Here we demonstrate how our stringent quality requirements translate into faster, more reproducible results compared to competitor columns. Greater column efficiency and reproducibility mean faster throughput and more consistent results.

Organic Volatile Impurities: Retention Time Index

To make column selection for residual solvents easy, Restek has benchmarked the ICH Class 1, 2 and 3 residual solvents on our most popular OVI columns.

Separating NSAIDs through Aromatic Selectivity

Non-steroidal anti-inflammatory drugs (NSAIDs) are typically separated on C18 phases. Separations on our Allure® Biphenyl HPLC column are based on pi-pi interactions, resulting in optimized retention and selectivity. Increased retention requires higher organic content in the mobile phase, increasing desolvation efficiency in LC/MS. Simple mobile phase changes enhance selectivity, making this column a great alternative to conventional phenyl phase columns, especially in method development.

Optimized RP-HPLC Method for Hydroxybenzoic Acids

Among hydroxybenzoic acids, hydroxyl groups on the benzene ring vary by position and number, creating differences in overall polarity and solubility. The unique bonding chemistry of the Ultra Aqueous C18 phase assures high resolving power, the best separations across a broad range of analyte polarity, and compatibility with 100% aqueous mobile phases.

Assaying Local Anesthetics by GC/FID

An Rxi®-5ms column and a wool-packed inlet liner provide the stability and inertness needed for these basic, active analytes. Chromatography from a six-replicate system suitability analysis was well within normal acceptance criteria. USP tailing factors were approximately 1.00 for all analytes; retention times and area responses were very stable.

8-Minute GC Analysis of Residual Solvents

Single-injection, dual-column detection/confirmation assay is feasible for regulated solvents in pharmaceutical products, but no temperature program provides sufficient resolution on both columns. Using a Restek G43/G16 column pair and independent temperature programs in a Gerstel MACH column heating system, we analyzed and confirmed 23 Class 2 solvents in 8 minutes.

RP-HPLC Analysis of Selective Serotonin Reuptake Inhibitors

Two Restek columns provide good retention, selectivity, and peak shape for SSRIs, without ion-pairing chromatography. Choose an Allure™ Basix column and neutral pH conditions, or an Ultra PFP column and acidic conditions — either will improve performance for these basic compounds, relative to alkyl phases.

Using π-π Interactions to Enhance Selectivity for Unsaturated Compounds

Relative to phases that separate via hydrophobic or polar interactions, the Allure™ Biphenyl stationary phase offers better retention, selectivity, and efficiency, when analyzing compounds with differences in the numbers and locations of unsaturated bonds in the hydrocarbon ring structure.

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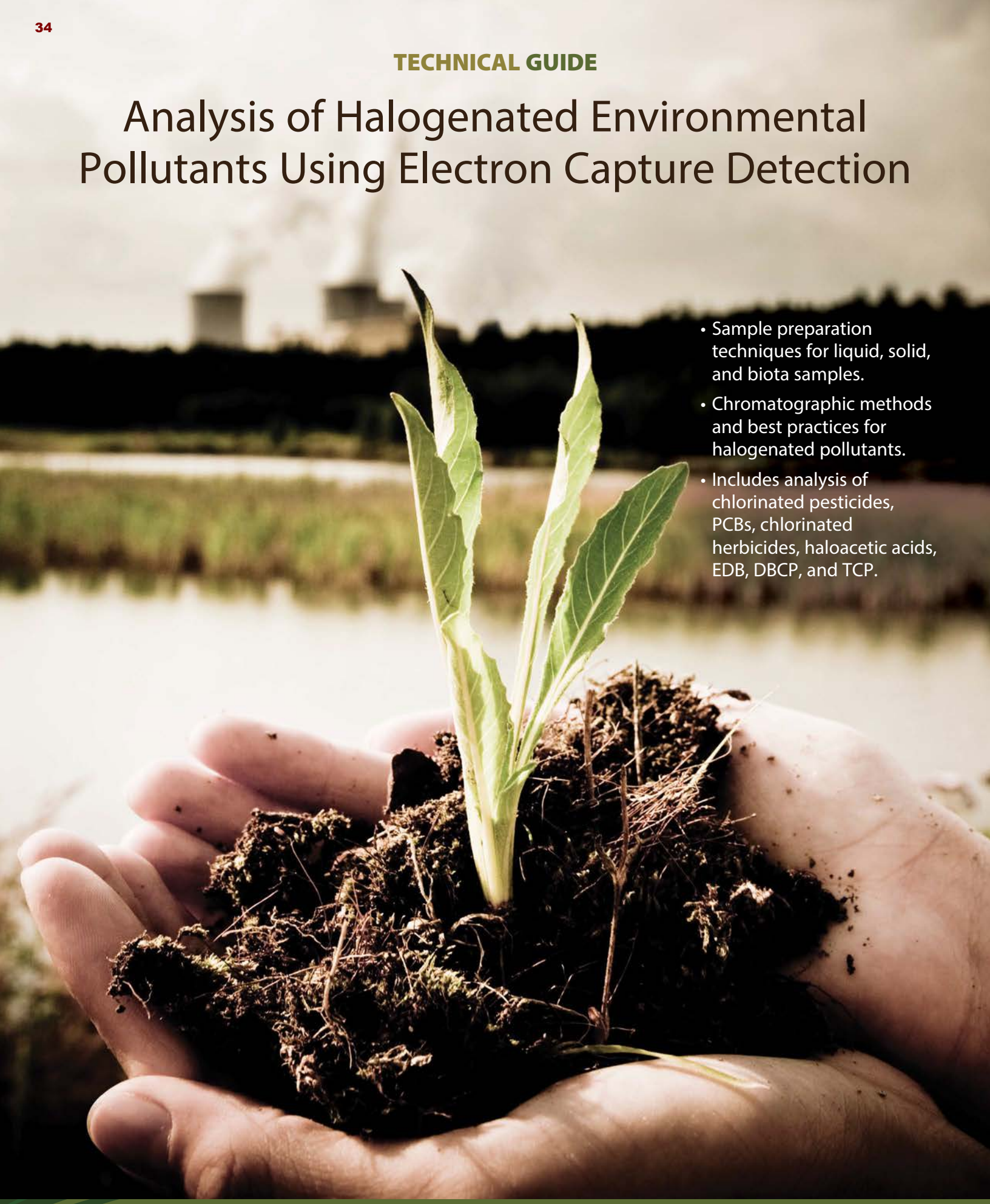
TECHNICAL GUIDE

Analysis of Halogenated Environmental Pollutants Using Electron Capture Detection



- Sample preparation techniques for liquid, solid, and biota samples.
- Chromatographic methods and best practices for halogenated pollutants.
- Includes analysis of chlorinated pesticides, PCBs, chlorinated herbicides, haloacetic acids, EDB, DBCP, and TCP.

Overview

This guide discusses analytical methods for monitoring halogenated pollutants in a wide variety of matrices including water, solids (soils and plant materials), and biota (fish and animal tissue). Classes of compounds such as chlorinated pesticides, polychlorinated biphenyls (PCBs), chlorinated herbicides, disinfection byproducts, and fumigants are among the pollutants addressed here. Gas chromatography (GC) combined with electron capture detection (ECD) is a common technique used for analyzing these compounds. ECD provides high sensitivity to these electronegative compounds, which results in extremely low detection limits. To ensure accurate identification, each sample can be analyzed simultaneously using a dual ECD instrument and two columns of differing selectivity for confirmational analysis.

Extremely low detection limits, combined with interferences from sample matrices, present an analytical challenge for laboratories involved in chlorinated pesticide and herbicide analyses. Samples are often highly contaminated with non-target compounds such as lipids and hydrocarbons, and the methods require rigorous quality control protocols. In addition, some of these compounds can break down or be adsorbed during the analytical procedure leading to inaccurate results.

Using Restek's Rtx®-CLPesticides column set, coupled with the methods and recommendations presented in this guide, will make your analyses easier and allow you to perform other environmental testing, such as PCB analysis, using the same columns and GC setup.

This guide offers information on the extraction, cleanup, and GC analysis of chlorinated pesticides, PCBs, herbicides, disinfection byproducts, and fumigants from a wide range of sample matrices. Also included are listings of products to simplify the analysis of these compounds.

Sample Preparation Methods for Liquid, Solid, and Biota Samples

Proper extraction procedures must be followed in order to ensure reproducible quantitative transfer of target analytes from the sample matrix. However, the wide variety of sample matrices combined with the extremely low levels of compounds typically found in environmental samples presents a challenge when extracting samples. Basic instructions for the most common techniques for liquid, solid, and biota samples are presented here. In some cases, the pH of the sample may need to be adjusted to ensure that the compounds of interest are extracted from the sample matrix. Specific methods, such as the U.S. Environmental Protection Agency (EPA) methods referred to in this guide, can be consulted for details on solvent type and pH adjustments.

Liquid Samples

Separatory funnel extraction (EPA Method 3510) or automated liquid-liquid extraction (EPA Method 3520) are common extraction techniques for liquid samples. Extractions using separatory funnels are less time consuming and less expensive to set up, but have issues with samples that tend to form emulsions with the extraction solvent. Automated liquid-liquid extractors are less labor intensive and present fewer issues with emulsion-forming samples, but are more expensive to set up and can be more difficult to clean. Solid phase extraction (EPA Method 3535) can be used to extract pesticide compounds from aqueous samples that have low particulate levels and minimal matrix interferences, such as drinking water samples.

Separatory Funnel Extraction

The typical aqueous sample volume is 1-liter and a 2-liter separatory funnel is used for extraction (Figure 1). The sample pH is measured and adjusted to conform to the method requirements. A specified volume of method-recommended solvent is added to the sample and shaken for two minutes. The separatory funnel should be vented periodically during shaking to prevent pressure build-up. It is critical to shake all samples in the same manner to minimize variations in extraction efficiency. The best way to ensure consistency is to use a mechanical separatory funnel shaker. The extraction step is repeated two more times with fresh aliquots of solvent to achieve quantitative recovery of all analytes. Extracts from all three separations are combined into the same collection vessel.

Continuous Liquid-Liquid Extraction

Continuous liquid-liquid extraction systems offer the convenience of unattended extraction, as well as significant advantages for samples that form emulsions. However, proper glassware washing procedures are critical because, due to the extended contact time of the organic compounds with the glass surfaces, reactive compounds can break down if these surfaces become contaminated. Liquid-liquid extractors are available in two versions: conventional and accelerated. The accelerated type uses a hydrophobic membrane to separate the aqueous and organic phases, and the extraction time can be reduced by ⅓ to ¼ of the conventional extractor time. Note that the volume of solvent is based on the design of the extractor.

Solid Phase Extraction (SPE)

Solid phase extraction (SPE) can also be used for the extraction of chlorinated pesticides and PCBs from aqueous samples (EPA Methods 3535 and 508.1). SPE allows faster extraction times and a significant reduction in solvent use. The aqueous sample is passed through a cartridge or disk that contains a C18 packing material. The pesticides and PCBs are adsorbed by the C18 packing. The analytes are then eluted from the cartridge or disk using a small volume of ethyl acetate and methylene chloride. When using SPE, it is extremely important to follow the method recommendations. There are several manufacturers of C18 cartridges and disks (Figure 2), which are the typical media used for these compounds, and the extraction steps will vary somewhat depending

Figure 1: Separatory funnel.

Figure 2: SPE cartridges and disks commonly used for extracting chlorinated pesticides and PCBs from aqueous samples.

Figure 3: Soxhlet extractor.

on the manufacturer and the format of the extraction media. Disks are more commonly used for the extraction of larger volumes of aqueous samples because they allow more rapid flow compared to tubes, which reduces extraction time. The two biggest issues with SPE are the clogging of the disk or tube with suspended solids and the breakthrough of targeted compounds. The use of pre-filters may reduce clogging of the extraction media. Breakthrough can occur if the sample contains a high level of organic material that will overload the capacity of the adsorbent. Samples with high concentrations of suspended solids and/or high organic content should not be extracted by SPE techniques.

Solid and Biota Samples

For solids and biota samples, Soxhlet or sonication extraction methods have historically been the most commonly used approach. In recent years, new extraction technologies, such as pressurized fluid and microwave extraction, have become more prevalent because they reduce solvent usage and are less labor intensive.

Soxhlet and Sonication Extraction

Soxhlet and sonication extraction work well for extracting halogenated pollutants from solid matrices and biological materials (Figure 3). Soxhlet extraction is time consuming and requires a large volume of solvent for extraction. Sonication (i.e., ultrasonic extraction) is a faster technique, but requires constant operator attention. In both techniques, problems such as contamination are attributed to either contaminated reagents, especially sodium sulfate, or poor laboratory practices being used when transferring sample extracts. Samples are commonly mixed with sodium sulfate to achieve a sandy consistency prior to solvent addition. Using granular sodium sulfate is recommended because some pesticides can adsorb to the powdered material.

Figure 4: Dionex ASE® system.

Pressurized Fluid/Microwave/Supercritical Fluid Extraction

Several automated extraction methods have been developed for solid and biological samples. Pressurized fluid extraction (EPA Method 3545) runs unattended and utilizes much smaller solvent volumes than Soxhlet or sonication procedures. Two commercially available pressurized fluid extraction systems are the Dionex ASE® system (Figure 4) and the Applied Separations PSE system. Both systems are capable of extracting multiple samples unattended. Microwave extraction (EPA Method 3546) can be useful for automated extraction as well. Microwave extraction extracts multiple samples simultaneously. Commercially available microwave extraction systems are offered by Milestone Scientific and CEM Corporation. Supercritical fluid extraction (EPA Method 3560) has been promoted for a number of years as a "solventless" extraction technique for environmental samples. Its application is limited due to severe matrix-related variation, resulting in the need to modify the SFE conditions depending on soil type, water content, sample size, and the type of analytes. This ultimately requires additional sample preparation prior to the actual extraction. These requirements have limited the use of SFE as an extraction technique for many environmental applications.

Extraction Solvent Selection

For all sample extractions, use pesticide residue grade solvents and verify their purity prior to use by analyzing solvent blanks. This ensures that interferences are not caused by impurities in the solvent. To perform a solvent assay, reduce 300 to 400 mL of solvent to a final volume of 1 mL, and exchange to hexane for analysis by GC-ECD.

Since soil and biota samples are essentially wet particles, acetone and dichloromethane usually are used in a 1:1 combination as the extraction solvent. The acetone is needed to adequately penetrate into the soil particle so that compounds contained in the particle can be extracted. Several other solvent systems can be used for unique extractions, but generally this combination works for most applications.

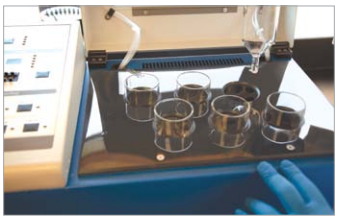
When using dichloromethane as an extraction solvent it is important to note that it can form hydrochloric acid spontaneously without a stabilizer present. There are two classes of stabilizers: stabilizers that keep hydrochloric acid from forming, and stabilizers that eliminate hydrochloric acid upon formation. Methanol is used to stop hydrochloric acid from forming. It is not recommended to extract aqueous samples, or solid samples that contain water, using methanol-stabilized dichloromethane. The methanol will partition into the water, leaving an unstable extract. Hydrochloric acid forms quickly in unstabilized dichloromethane, and injection of an acidic solvent will result in reactive liners and columns. The second type of stabilizer, amylene (1-pentene), is commonly used to reduce hydrochloric acid formation. It is recommended to use dichloromethane stabilized with amylene since it has a low boiling point and will not interfere with early eluting target compounds.

Extract Drying

After the extraction has been completed, the extract is dried by passing it through anhydrous sodium sulfate. Removing water from the dichloromethane with sodium sulfate is critical before the extract is concentrated to final volume. Dichloromethane can hold approximately 1 mL of water per 100 mL of solvent. If water remains in the extract, it will partition out of the extract when the volume is reduced. If this occurs, either the dichloromethane will evaporate first, leaving only water in the collection vessel, or a two-layer extract will form. In either event, the recoveries of the target compounds will be lower than desired, and the presence of water will interfere with gas chromatographic analysis. The best way to remove the water is to filter the dichloromethane extract through granular sodium sulfate held in a funnel with a high-quality grade (Whatman® 541) filter paper or glass wool (Figure 5). Approximately 30 g of sodium sulfate is sufficient for most samples. *This step must not be skipped!* After drying the sample, thoroughly rinse the sodium sulfate to ensure that the entire sample is transferred to the collection vessel. Avoid using powdered sodium sulfate since some compounds can be adsorbed onto the smaller particles. Use only a 10-60 mesh granular sodium sulfate for best results. It also is important that this material be free from organic contaminants. Use pesticide residue grade sodium sulfate and store it in glass containers. If purchased in bulk packages where exposure to plastic is an issue, bake the material in a muffle furnace. To bake the sodium sulfate, spread it no more than 1 inch thick in a Pyrex®-type glass container, place into a muffle furnace, and bake at 400 °C for a minimum of two hours. After this time, place hot sodium sulfate into a glass container and securely cap the container to prevent re-adsorption of moisture from the atmosphere.

Figure 5: Drying the sample extract with sodium sulfate.

Figure 6: Extract concentrators.



TurboVap®

Reacti-Vap on Reacti-Therm

Kuderna-Danish (KD)

Glassware

See **page 25** or visit

www.restek.com/**glassware**

Extract Concentration

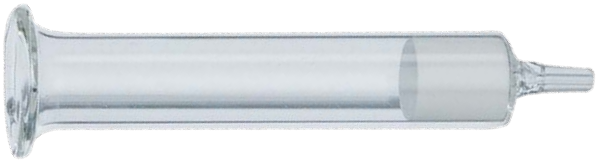
After drying the sample extract, the extraction solvent must be reduced in volume to concentrate the analytes prior to analysis. Kuderna-Danish (KD) type concentrators are most commonly used for this purpose. Alternatively, automated concentrators such as TurboVap® or RapidVap® concentrators can be used to reduce the solvent volume (Figure 6). If dichloromethane was the only solvent used as the extraction solvent, it is important to exchange it with hexane or isooctane during the concentration process. Even a small amount of dichloromethane will overwhelm an electron capture detector (ECD). Add 1 to 2 mL of hexane or isooctane to the sample extract prior to the evaporation process. Since dichloromethane is more volatile than hexane or isooctane it will evaporate first leaving the concentrated sample in a methylene chloride-free solution. The extract should never be allowed to dry completely during the concentration step. This could lead to loss of the more volatile components.

Extract Cleanup for Chlorinated Pesticides and PCBs

Sample extract cleanup is probably the most important step in maintaining long-term instrument and column performance. Generally, when instrument and column problems arise, they are caused by exposure of the injection port and the column to nonvolatile compounds from the sample matrix. Environmental samples often contain high molecular weight hydrocarbons, sulfur compounds, and phthalate esters. Plant and biota samples will contain pigments and lipids. While this nonvolatile material cannot be completely eliminated, some interferences can be reduced to levels where they become much less of a problem for the inlet and analytical column. Solid phase extraction (SPE) is the most common technique for removing these interfering compounds from the sample extracts. The choice of cleanup will depend on the type and concentration of the interfering compounds and the analytes being monitored. While cleanup procedures may add some additional processing time and cost, the resulting increase in instrumental stability, decrease in instrument and column maintenance, and potential improvements in detection limits can reduce the overall time and cost of analysis.

The two most common SPE cleanup materials used for chlorinated pesticide analysis are Florisil® and carbon adsorbents. These materials are available in pre-packed cartridges or in bulk for laboratories wishing to pack their own cartridges. Florisil® adsorbent is a magnesium silicate which is useful in removing polar contaminants from sample extracts. It is also useful for retaining co-extractants, such as phenols, that may interfere with GC analysis of pesticides. Florisil® material must be properly cleaned and activated prior to use. Activation requires heating to 130 °C for 16 hours in an oven. It is very important to check each lot of Florisil® adsorbent to ensure minimal background and to verify that the packing is at maximum activity level in order to maintain the expected retention capacity. Resprep® pre-packed Florisil® SPE cartridges are method-tested and suitable for most applications. For ultra-trace work, glass SPE cartridges with PTFE frits may be required to eliminate any trace interferences that might leach from the cartridge (Figure 7).

Figure 7: Glass SPE cartridge for extract cleanup.



Chromatographic-grade graphitized carbon is a versatile, nonporous adsorbent, which has been successfully used to remove high molecular weight nonpolar interferences from pesticide extracts. It is available in commercially prepacked SPE cartridges. In general, carbon elutes polar compounds first, then nonpolar compounds. For this reason, carbon makes a very good adsorbent to remove nonpolar matrix interferences from sample extracts. Since graphitized carbon retains or extracts a variety of compounds, the extraction system can be adjusted to retain and elute aliphatic, aromatic, polar, and nonpolar analytes. For optimal recoveries, compounds of interest should be applied in weak solvents or solutions with low solubility for the analytes, and eluted with strong solvents. Mixed solvent systems that include dichloromethane often are the most effective for elution. For ECD analysis it is critical to exchange the eluted sample into a non-halogenated solvent prior to analysis. Note that, due to the variability and high capacity of graphitized carbon, all fractionation and elution volumes should be verified for each lot of material. In addition, caution should be taken when using graphitized carbon to clean extracts for PCB congener analysis because the coplanar PCB congeners BZ#77, 81, 126, and 169 are very strongly retained and do not elute using the above solvent. These congeners can be eluted using a 1:1 mixture of ethyl acetate and toluene. Other cleanup techniques, such as sulfur removal using activated copper and gel permeation chromatography (GPC) may be used when necessary.

Analyzing Halogenated Pollutants

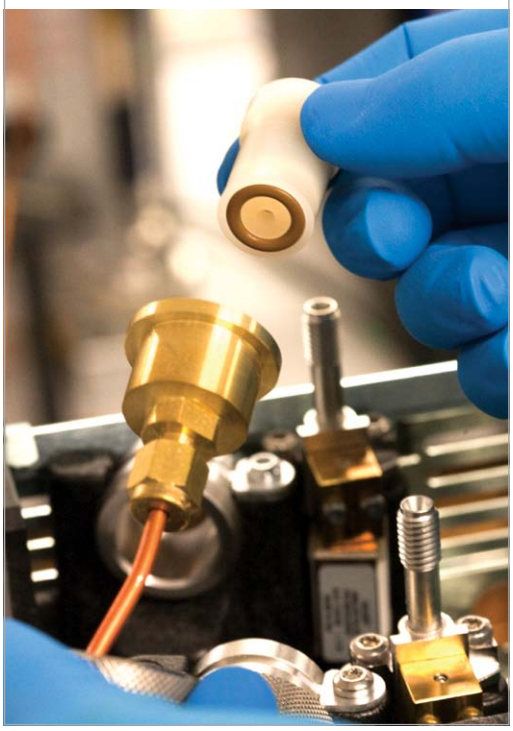
Choosing the most appropriate analytical column and injection technique are critical for achieving optimal results when testing for halogenated pollutants in environmental samples. A wide range of capillary columns have been recommended for the separation of different halogenated pollutants, which can result in frequent column changes and recalibration of the GC system. Using an Rtx®-CLPesticides column set for multiple methods is a much better approach, as these columns have been developed to separate a wide range of halogenated pollutants. Use of this column pair can result in shorter analysis time, improved separation, and increased sample throughput in the laboratory. Due to its high sensitivity for halogenated compounds, electron capture detection (ECD) is commonly used for halogenated pollutants. GC-MS is also used for analyzing halogenated pollutants, particularly now that newer, more sensitive instruments are available. Proper instrument setup and optimization are critical for accurate and consistent analyses. Many of these important considerations will be addressed here.

Column Selection

A wide variety of columns have been used for analyzing chlorinated pesticides and herbicides. The ideal column for this analysis would completely separate the compounds of interest, demonstrate excellent inertness to minimize breakdown and adsorption, and also exhibit low bleed at the high temperatures required to elute the target compounds and high molecular weight matrix interferences. Since confirmation is often required, dual column systems using two columns of different selectivity are usually used. It is critical that the primary and secondary (confirmational) columns be significantly different in selectivity in order to obtain the elution order and retention time changes that are needed to verify analytical results. In addition, both columns must be of the same length and internal diameter to ensure the same amount of sample is delivered to each column.

The Rtx®-CLPesticides and the Rtx®-CLPesticides2 columns were developed for the analysis of a wide range of halogenated pollutants. These two columns have significantly different selectivities and can be used for accurate reporting of many halogenated pollutants, which eliminates the need to change columns when analyzing samples for different methods. Both columns feature excellent inertness, low bleed, and high thermal stability. The high inertness of the Rtx®-CLPesticides column set ensures minimal breakdown and adsorption of active compounds such as endrin, DDT, and methoxychlor. The maximum temperature limit of the Rtx®-CLPesticides column and the Rtx®-CLPesticides2 column is up to 340 °C (depending on configuration), which allows analysts to use high temperature treatment in order to remove high boiling point contaminants. In addition, these columns can be operated under identical temperature programmed conditions for simultaneous confirmational analysis, while still providing different elution patterns. Each column is available in 0.18 mm, 0.25 mm, 0.32 mm, and 0.53 mm inner diameters (ID) and the phase ratio of each dimension has been optimized for maximum resolution and reduced analysis time.

Figure 8: Carbon trap installed on GC split vent.



Although Rtx®-CLPesticides columns are available in all common ID dimensions, the 0.32 mm ID size is typically recommended. This size provides the best combination of sample loading capacity and analysis time. If your sample extracts are particularly contaminated, you may find that the 0.53 mm ID columns allow for longer lasting calibration because of their larger capacity. Columns of 0.18 mm and 0.25 mm ID provide better resolution, but do not have sufficient sample loading capacity for contaminated or high concentration samples. In most cases, the 0.32 mm ID is the size of choice for pesticide and herbicide analyses. Example chromatograms are shown in the method section of this guide beginning on page 14.

Injection Techniques

Several injection techniques can be used for analyzing halogenated pollutants: splitless, direct, and on-column injections. Splitless injection requires careful optimization for consistent and accurate results. Direct injection is a variation of splitless injection that offers some advantages when analyzing compounds that can react with active sites in the injection system. Cool on-column injection has also been used for analyzing these compounds. Each of these techniques, as well as their advantages and disadvantages, are discussed below.

Splitless Injection

Splitless injection is a heated vaporization technique that requires a split/splitless injection system. Using a syringe, the sample is introduced into a glass liner inside the heated inlet. This causes the sample to vaporize; however, the injection port must be hot enough to completely vaporize the solvent and the analytes. During the splitless injection mode, the split valve (purge valve) is closed, allowing all of the carrier gas flow and injected sample to be directed into the column. The split valve remains closed for a short time (30 sec to 2 min) after the injection in an attempt to transfer as much of the vaporized sample as possible from the injection port onto the column. After this splitless hold, the purge vent is opened, and the remaining solvent and non-transferred sample are vented out of the injection port. Since an ECD is a non-destructive detector, the purge vent should have a carbon trap (Figure 8) attached to prevent any organic compounds from being vented into the laboratory. The purge time must be optimized to ensure that the maximum amount of analyte is transferred to the column, while minimizing the amount of solvent. Generally, the purge time is determined by maximizing the area count of the last eluting analyte. This technique allows for the maximum amount of sample to be delivered to the column while excess solvent and contaminants are purged from the system, which can lead to attaining lower detection limits.

Because ECDs are very sensitive detectors, you may need to condition your column overnight. Before doing so, check thoroughly for leaks and use high-quality oxygen-removal traps to purify your carrier gas. Visit **www.restek.com/gc-condition** for column conditioning instructions.

Splitless injection is prone to inertness problems because of the long residence time in the inlet and exposure of the analytes, such as endrin and 4,4'-DDT, to reactive surfaces in the injection system. The liner must be properly deactivated to prevent adsorption or breakdown and should be cleaned or replaced frequently to maintain proper inertness. Nonvolatile and very high boiling compounds from the sample matrix that are not vaporized can be left behind in the injection system. These materials will eventually contaminate the injection port liner and the injection system itself, leading to adsorption and lower response of active compounds. Another inertness problem is caused when the vaporized sample expands outside the liner, exposing reactive analytes to the metal surfaces inside the injector. The most common active area in the injection port is at the bottom. The vaporized sample cloud can expand past the column and come in contact with the metal disk (inlet seal) below the liner when using an Agilent® injection port. Installing gold-plated inlet seals will provide greater inertness. These inlet seals should be replaced along with the liner during routine maintenance because they will also become contaminated from nonvolatile sample residue.

Direct Injection

Direct injection is also a heated vaporization technique. The major difference between splitless and direct injection is how the column connects to the injection system. In conventional splitless injection, the liner is open at the bottom to allow the sample and solvent to vent out of the injector when the split valve is opened. With direct injection, the analytical column seals into a specially designed Uniliner® inlet liner using a tapered press-fit connection at the bottom of the liner. This allows the entire sample to enter the column and the GC system and eliminates analyte contact with the active metal surfaces below the bottom of the liner (Figure 9). An added benefit of using this type of injection is the reduction in injection port discrimination, which results in improved response for higher boiling compounds. When using a Uniliner® inlet liner, the split valve (purge valve) should be set in the off mode and a "higher than normal" flow rate should be used to contain the sample vapor cloud in the liner.

Cool On-Column Injection

In cool on-column injections, the needle is inserted directly into the column and the sample extract is deposited. On-column injections typically provide the narrowest peak width and the best reproducibility compared to other injection techniques. While on-column injection works extremely well for relatively clean samples, it is not a recommended technique for samples that contain nonvolatile residue. On-column injections are best suited for the analysis of drinking water sample extracts, where analyte concentration levels are usually low and the amount of nonvolatile material is relatively small. Conventional on-column injections are typically less than 1 µL and require the use of a 0.53 mm ID analytical column or a 0.53 mm ID guard column installed in the inlet and connected to a smaller diameter analytical column.

Dual Column Analysis

For confirmation purposes, two columns of differing selectivity are used when analyzing halogenated pollutants. This requires a GC system with dual electron capture detectors. The two most common techniques for installing two columns into the same injection system are a "Y" connector or a two-hole ferrule (Figure 10). There are several advantages of using a "Y" connector and guard column, which is why this configuration is recommended. First, this setup allows the user to perform splitless, direct, or on-column injections. Second, guard columns are commonly used to protect the analytical column from nonvolatile sample contaminants and increase column lifetime. Guard columns are deactivated, but uncoated, lengths of fused silica tubing that are connected to the front of the analytical column in order to protect it. Typically, a 5 m section of guard column is connected to the single leg side of

Figure 9: Direct injection using a Uniliner® inlet liner.

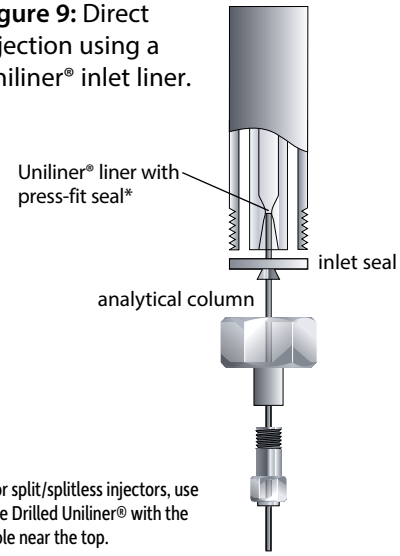
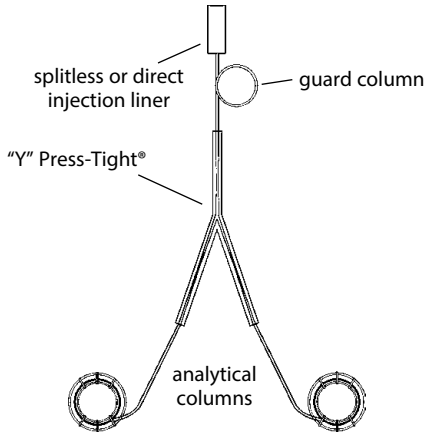
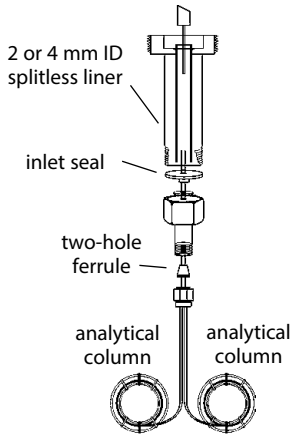


Figure 10: Dual column setups for different injection techniques.

A. Using a "Y" Press-Tight® connector for splitless or direct injection is recommended.



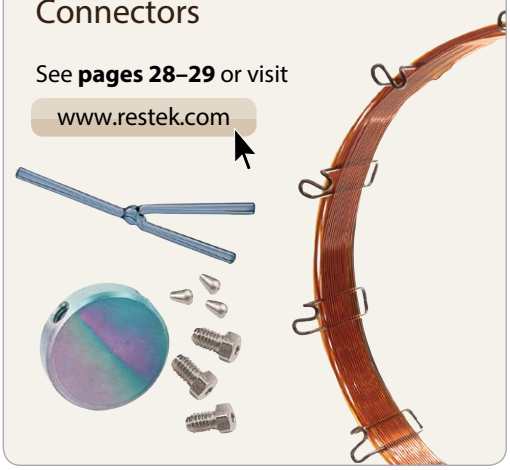
B. Alternatively, two-hole ferrules can be used for splitless injection.



How to Obtain a Leak-Tight Seal Using a Press-Tight® Connector

Press-Tight® connectors are easy to use, but leaks will occur if they are not properly sealed. The keys to successful sealing are:

1. Using a SeCure® "Y" connector kit.
2. Making a clean, square cut on the column.
3. Moistening the end of the column with methanol before seating it into the connector.
4. Using a Restek® electronic leak detector (cat.# 22655) to verify a leak-free connection at high inlet pressure (30–50 psi) following an oven cycle.



the "Y" and the injector. The two analytical columns are then installed into the other two legs of the "Y" and into separate detectors. There are three styles of "Y" connectors. The more common Press-Tight® "Y" connector uses concentric compressive forces to form a leak-tight seal under normal operating pressures. This is also available in a SeCure® "Y" configuration for added stability. The MXT® "Y" connector is a metal connector that uses polyimide ferrules (see photos below). A less common approach is using a two-hole ferrule for installing two columns into one injector, but this requires two separate guard columns and separate connections between the guard columns and each of the analytical columns. The sample split between the two analytical columns will be dictated by their lengths and IDs. If the columns are the same length and ID, the split between the two columns will be approximately even. This setup cannot be used for on-column injection because the syringe needle can only enter one column. It also cannot be used for direct injections since only one column can be installed in the liner.

Electron Capture Detector Systems

One benefit of the ECD is its sensitivity to halogenated compounds, which allows extremely low detection limits for many of these compounds. Another benefit of using an ECD is its selectivity for electronegative compounds, which can eliminate some of the interferences in the sample matrix. To function properly, an ECD requires either nitrogen or 5% methane in argon (P5) as a make-up gas. The linearity of ECDs for a 16- to 100-fold concentration range is sufficient to pass most method calibration requirements. Linearity for ECDs is strongly affected by the flow rate of the make-up gas. To achieve linear response for chlorinated pesticides on an ECD, start by setting the flow rate of the make-up gas according to the manufacturer's recommendation and run a calibration curve including α-BHC and methoxychlor. Using these response factors, calculate the relative standard deviation (RSD) of each compound. Adjust the make-up gas flow rate so the percent RSD of these two compounds is approximately the same. Increasing the make-up gas flow will improve the linearity of α-BHC but make linearity worse for methoxychlor. The remaining pesticides will exhibit linear curves once the make-up gas has been set to give good linearity for α-BHC and methoxychlor. For more information on operating and maintaining your ECD, please consult your manufacturer's manual.

Analytical Methods

Chlorinated Pesticides and PCBs

Several methods have been developed for the analysis of chlorinated pesticides and PCBs (Table I). The Rtx®-CLPesticides and the Rtx®-CLPesticides2 column combination results in the separation of the majority of chlorinated pesticides and is suitable for PCB analysis as well. PCBs are most frequently analyzed as multi-component technical mixtures called Aroclors. Aroclor mixtures are differentiated by a numbering system that indicates the chlorination level of the mixture (e.g., Aroclor 1242 is 42% chlorine by weight). The increasing level of chlorination generates mixtures with components that have increasing numbers of chlorine atoms. This results in unique peak patterns for each of the Aroclor mixtures. The critical aspect of Aroclor analysis is pattern recognition, which is used to identify the specific Aroclor present in the sample. This can be difficult due to weathering or biodegradation of the sample. Also, some samples may contain more than one Aroclor which can greatly confuse pattern recognition.

Table I: Target analyte lists for chlorinated pesticides and PCBs in EPA methods.

Compound	CAS Registry Number	Method 508.1	Method 608	Method 8081B	Method 8081B Add'l Compounds	Method 8082A
Alachlor	15972-60-8	√			√	
Aldrin	309-00-2	√	√	√		
Aroclor 1016*	12674-11-2	√	√			√
Aroclor 1221*	11104-28-2	√	√			√
Aroclor 1232*	11141-16-5	√	√			√
Aroclor 1242*	53469-21-9	√	√			√
Aroclor 1248*	12672-29-6	√	√			√
Aroclor 1254*	11097-69-1	√	√			√
Aroclor 1260*	11096-82-5	√	√			√
Atarazine	1912-24-9	√				
Butachlor	23184-66-9	√				
α-BHC (α-HCH)	319-84-6	√	√	√		
β-BHC (β-HCH)	319-85-7	√	√	√		
δ-BHC (δ-HCH)	319-86-8	√	√	√		
γ-BHC (γ-HCH, Lindane)	58-89-9	√	√	√		
Captafol	2425-06-1				√	
Carbophenothion	786-19-6				√	
cis-Chlordane	5103-71-9	√		√		
trans-Chlordane	5103-74-2	√		√		
Chlorneb	2675-77-6	√			√	
Chlorobenzilate	510-15-6	√		√		
Chloropropylate	5836-10-2				√	
Chlorothalonil	1897-45-6	√			√	
Cyanazine	21725-46-2	√				
DBCP	96-12-8			√		
DCPA (Dacthal)	1861-32-1	√			√	
4,4'-DDD	72-54-8	√	√	√		
4,4'-DDE	72-55-9	√	√	√		
4,4'-DDT	50-29-3	√	√	√		
Diallate	2303-16-4			√		
Dichlone	117-80-6				√	
Dichloran	99-30-9				√	
Dicofol	115-32-2				√	
Dieldrin	60-57-1	√	√	√		
Endosulfan I	959-98-8	√	√	√		
Endosulfan II	33213-65-9	√	√	√		
Endosulfan sulfate	1031-07-8	√	√	√		
Endrin	72-20-8	√	√	√		
Endrin aldehyde	7421-93-4	√	√	√		
Endrin ketone	53494-70-5		√	√		
Etridiazole	2593-15-9	√			√	
Halowax-1000	58718-66-4				√	
Halowax-1001	58718-67-5				√	
Halowax-1013	12616-35-2				√	
Halowax-1014	12616-36-3				√	
Halowax-1051	2234-13-1				√	
Halowax-1099	39450-05-0				√	
Heptachlor	76-44-8	√	√	√		
Heptachlor epoxide	1024-57-3	√	√	√		
Hexachlorobenzene	118-74-1	√		√		
Hexachlorocyclopentadiene	77-47-4	√		√		
Isodrin	465-73-6			√		
Methoxychlor	72-43-5	√		√		
Metoachlor	51218-45-2	√				
Metribuzin	21087-64-9	√				
Mirex	2385-85-5				√	
Nitrofen	1836-75-5				√	
trans-Nonachlor	39765-80-5				√	
PCNB	82-68-8				√	
Permethrin (*cis* & *trans*)	52645-53-1				√	
cis-Permethrin	61949-76-6	√				
trans-Permethrin	61949-77-7	√				
Perthane	72-56-0				√	
Propachlor	1918-16-7	√			√	
Simazine	122-34-9	√				
Strobane	8001-50-1				√	
Technical chlordane*	57-74-9		√	√		
Toxaphene*	8001-35-2	√	√	√		
Trifluralin	1582-09-8	√			√	

*Multi-component standards.

Establishing and Maintaining Method Performance

The instrument used for the analysis of chlorinated pesticides and PCBs must be calibrated prior to performing quantitative analysis. The calibration should be linear over a 16- to 100-fold concentration range. The calibration of three to five points includes analyzing a low standard to meet the required reporting limit, as well as a high standard to minimize the need for dilutions. The linearity check should contain all the pesticides being reported. When using phenyl phase or cyanopropyl phase columns, not all analytes are resolved; therefore, two separate mixtures of pesticides must be used in order to ensure accurate calibration. This doubles the amount of time needed to calibrate for all the chlorinated pesticides. Because no coelution problems occur with the Rtx®-CLPesticides and Rtx®-CLPesticides2 columns, the calibrations can be completed with a single mixture, which reduces the overall time required to complete the calibration. Verifying linearity for all target compounds is important because different classes of pesticides (e.g., α-BHC vs. methoxychlor) will differ in injection port discrimination, chromatographic peak shape, and detector linearity. There are some chlorinated pesticides, such as technical chlordane and toxaphene, that are multi-component mixtures; due to their complexity, accurate calibrations are difficult to achieve. Typically, a few of the dominant peaks in each of the multi-component analytes are used to establish response factors. PCB calibration is handled the same way as the multi-component pesticides. Preferably, five peaks are chosen for the identification of each Aroclor. Initially, a five-point calibration of Aroclor 1016 and Aroclor 1260 is used. Single points at the midrange are then analyzed for the remaining Aroclor compounds.

Tips for Ensuring Optimum System Performance

Start With an Inert Injection Port

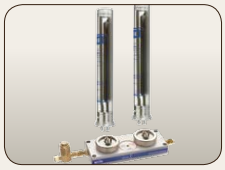
Active sites in the injection port can cause analyte breakdown and reduce recoveries. We recommend using deactivated Sky® inlet liners and gold-plated dual Vespel® ring inlet seals to maximize inertness and prevent the loss of active compounds, such as endrin, DDT and 2,4-dinitrophenol.

Use Deactivated Guard Columns and Connectors

Guard columns protect your analytical column from nonvolatile residue and are also used for analyte focusing. Choose a deactivated guard column and attach it with a Press-Tight® connector to create an inert sample path and prevent the loss of target compounds.

Make Clean, Square Cuts for Leak-Free Connections

Restek® scoring wafers make cutting columns properly a quick and easy task. Just draw the smooth edge of the wafer perpendicularly across the fused silica surface, tap the column tubing, and then check your cut for jagged edges. Square cuts ensure a leak-free seal with the connector.



Prevent Contaminants From Entering the System

Oxygen, water, and hydrocarbon contaminants in carrier gas and detector gas lines will damage GC columns and cause noisy baselines. Use Super Clean® gas filters from Restek to purify incoming gases and protect your GC system.

Check for Leaks at all Connections

Catch a leak before it becomes a costly problem! Leaks allow oxygen and moisture to enter your system, which can cause permanent damage to GC columns and also to some detectors, including ECDs. Checking for leaks with an electronic leak detector allows you to identify and fix leaks before they cause problems.

The injection port is where many of the analytical problems occur in the analysis of chlorinated pesticides. Breakdown of endrin and 4,4'-DDT is not uncommon and usually is indicative of a chemical reaction taking place in the injection port. This breakdown could be caused by active glass wool, a contaminated or non-deactivated liner, an active metal surface in the injection system, septa particles, or impurities in the carrier gas. The breakdown of 4,4'-DDT is generally indicative of a dirty injection port caused by the analysis of oily or "dirty" sample extracts. GPC or carbon column cleanup can be useful in removing some of the matrix interferences that cause 4,4'-DDT breakdown (see Extract Cleanup for Chlorinated Pesticides and PCBs section). Frequent replacement of the inlet liner and inlet seal may be necessary to maintain low breakdown levels of endrin and 4,4'-DDT. It may also be necessary to cut 6 to 12 inches off the front of the analytical column or guard column to reduce the breakdown of endrin and 4,4'-DDT. Trimming the analytical or guard column removes any nonvolatile residue buildup in the column. Using a guard column will extend the lifetime of the analytical column and minimize the loss of separation that will result from trimming the analytical column.

Best practices and EPA methodology dictate that the inertness of the chromatographic system be confirmed on a regular basis. This is accomplished by analyzing a system evaluation mix that contains endrin and 4,4'-DDT. Endrin decomposes to endrin aldehyde and endrin ketone. 4,4'-DDT decomposes to 4,4'-DDD and 4,4'-DDE. The percentage of decomposition can be measured and must be below 15% for both compounds. If the breakdown is above 15%, instrument maintenance must be performed. Restek provides a complete range of system evaluation test mixes, surrogate standards, and calibration standards for chlorinated pesticides and PCBs. Visit **www.restek.com** for a complete product listing.

If replacing the inlet liner and trimming the front of the analytical column do not reduce breakdown, it may be necessary to perform additional inlet maintenance. When samples are injected into the hot injection port, the vaporized extract can backflash and escape from the top and bottom of the liner, causing analytes to come into contact with metal surfaces. This will leave nonvolatile residue on the metal surfaces of the injection port and create active sites. Keeping the injection port body clean requires frequent cleaning or replacement of the inlet seal. Periodic swabbing of the inside of the injection port with solvent may also be necessary if other maintenance does not reduce endrin and 4,4'-DDT breakdown. It may even be necessary to rinse the carrier gas lines coming into the injector to remove contamination that has backflashed into these lines. Do not flush solvent through any actuator valves or rubber parts and be certain the injection port is at room temperature prior to rinsing.

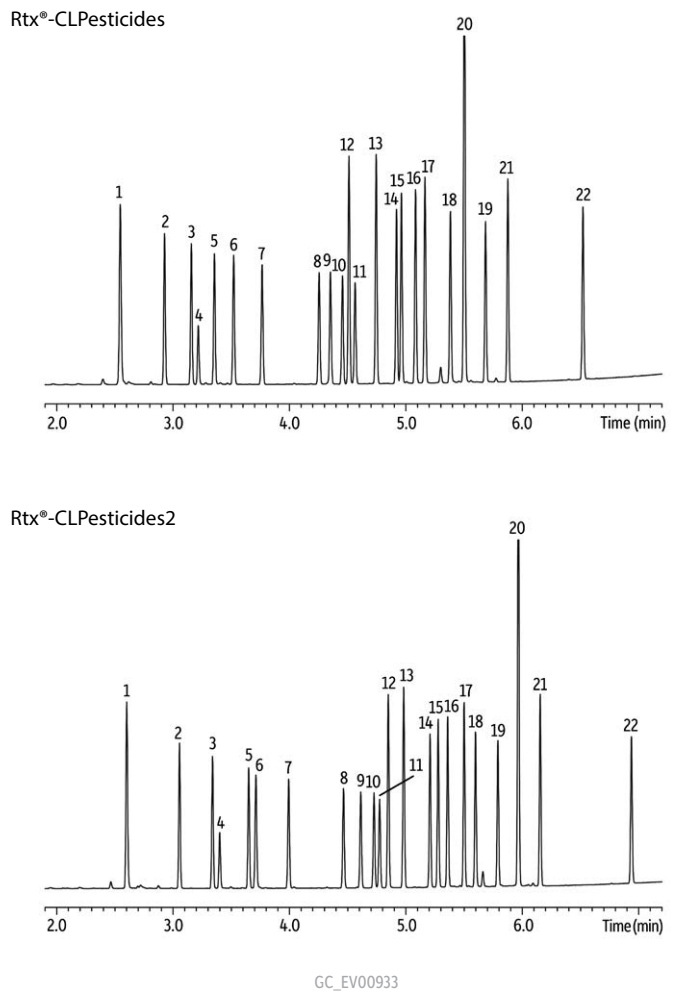
Some labs choose to clean and reuse inlet liners. When this is done, it is critical to use proper deactivation procedures to minimize endrin breakdown. There are two approaches to liner deactivation: perform the operation in-house or send liners out to be deactivated. Sending injection port liners to a company like Restek for cleaning and deactivating is inexpensive and allows analysts to spend their time more productively. There is a standard procedure for deactivating liners that includes a process of cleaning the liners and deactivating them. Contact Restek's Technical Service group at support@restek.com; 1-800-356-1688, ext. 4; or 1-814-353-1300, ext. 4 for more information.

Septa particles are another major cause of endrin breakdown. Over time, the septum will core and septum particles will sit on top of a glass wool plug or at the bottom of the liner. Changing septa frequently and using high-quality septa can reduce coring and particle generation. Ensuring that the syringe needle is free of burrs will also help reduce this problem. Alternatively, Merlin Microseal septa can eliminate particles from collecting in the liner. Information on Merlin Microseal septa is available at www.restek.com

Carrier gas contamination is another potential cause of endrin breakdown. Endrin can react with contaminants that are carried into the injection port by the carrier gas. Using in-line gas purifiers for the carrier gas will help remove contaminants so they are not introduced into the analytical system.

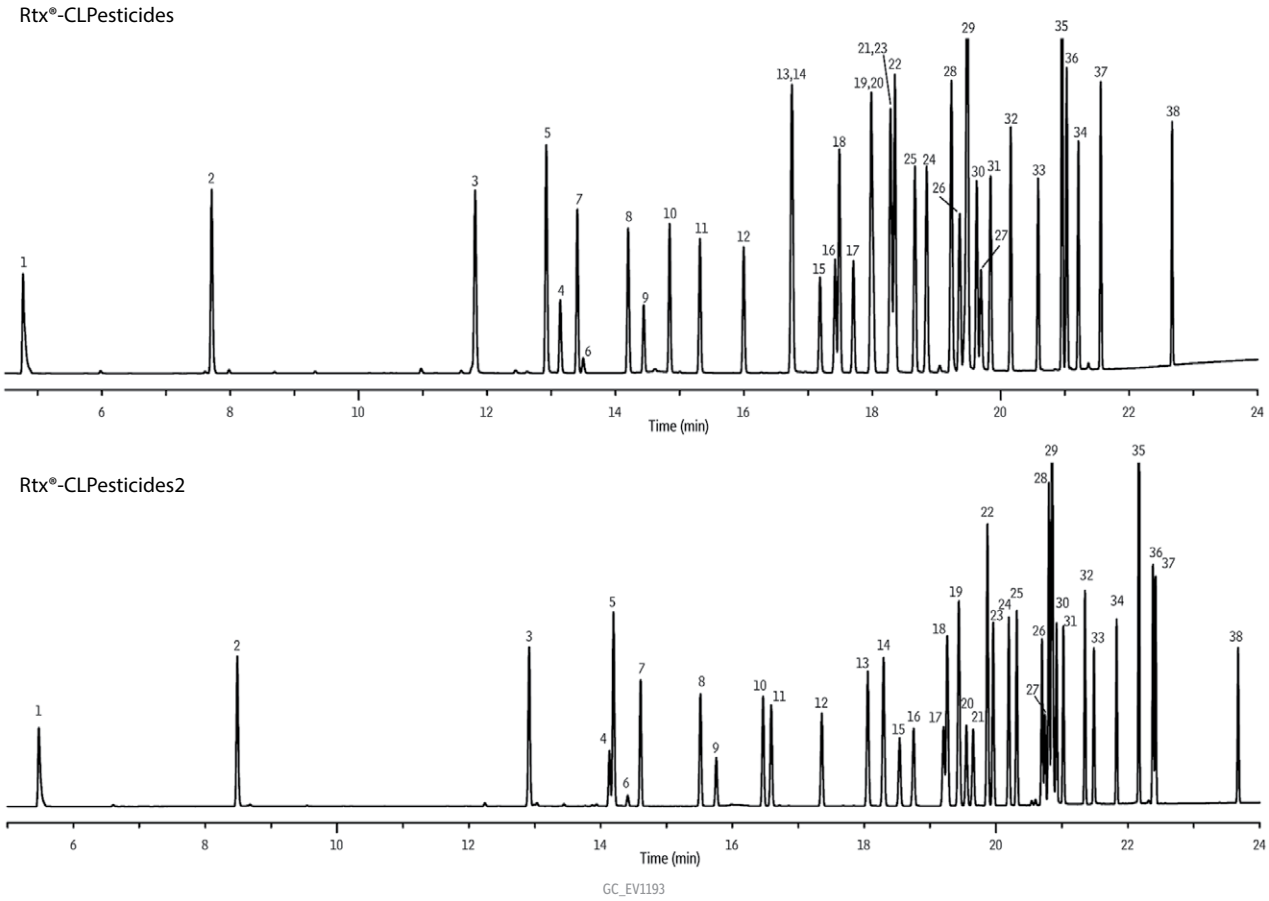
Figures 11 through 16 show example chromatograms of chlorinated pesticides and PCBs on the Rtx®-CLPesticides column set using optimized analysis conditions.

Figure 11: For commonly analyzed chlorinated pesticides, 0.32 mm ID columns provide the best balance of capacity and resolution.



Columns	Rtx®-CLPesticides 30 m, 0.32 mm ID, 0.32 µm (cat.# t) and Rtx®-CLPesticides2 30 m, 0.32 mm ID, 0.25 µm (cat.# 11324) using Rxi® guard column 5 m, 0.32 mm ID (cat.# 10039) with deactivated universal "Y" Press-Tight® connector (cat.# 20405-261)
Sample	Organochlorine pesticide mix AB #2 (cat.# 32292) Pesticide surrogate mix, EPA 8080, 8081 (cat.# 32000)
Injection	
Inj. Vol.:	1 µL splitless (hold 0.3 min)
Liner:	Splitless taper (4 mm) (cat.# 20799)
Inj. Temp.:	250 °C
Oven	
Oven Temp:	120 °C to 200 °C at 45 °C/min to 230 °C at 15 °C/min to 330 °C at 30 °C/min (hold 2 min)
Carrier Gas	He
Detector	µ-ECD @ 330 °C
Notes	Instrument was operated in constant flow mode. Linear velocity: 60 cm/sec @ 120 °C. This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

Figure 12: Analysis of an extended list of organochlorine pesticides (EPA Method 8081B) on the Rtx®-CLPesticides and Rtx®-CLPesticides2 columns.



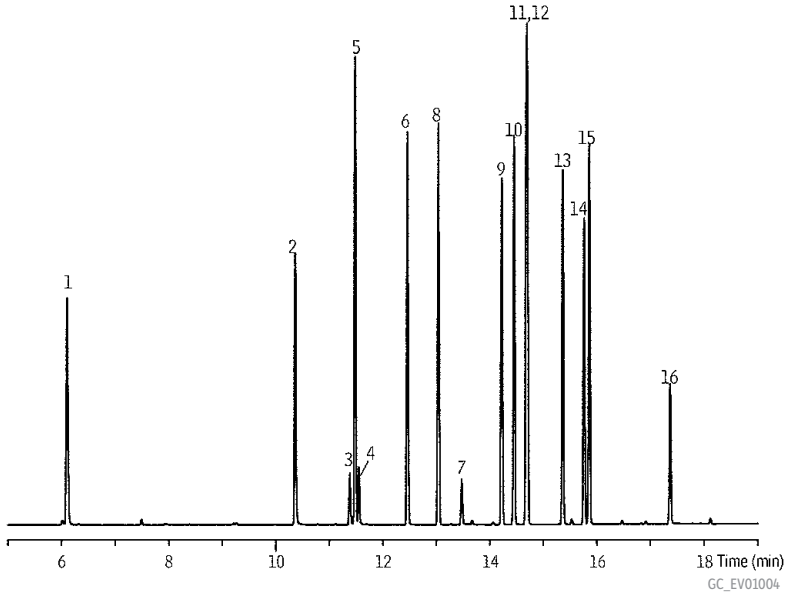
Columns	Rtx®-CLPesticides2 30 m, 0.32 mm ID, 0.25 µm (cat.# 11324) and Rtx®-CLPesticides 30 m, 0.32 mm ID, 0.32 µm (cat.# 11141) using Rxi® guard column 5 m, 0.32 mm ID (cat.# 10039) with deactivated universal "Y" Press-Tight® connector (cat.# 20405-261)
Sample	Organochlorine pesticide mix AB #2 (cat.# 32292) Organochlorine pesticide mix C #1 (cat.# 32296) 2,4,5,6-Tetrachloro-*m*-xylene (cat.# 32027) Decachlorobiphenyl (BZ #209) (cat.# 32029) Chlorpyrifos (cat.# 32212) 2,4'-DDE (cat.# 32099) 2,4'-DDD (cat.# 32098) Chlorobenzilate (cat.# 32211) Captan (cat.# custom) *cis*-Nonachlor (cat.# custom) Mirex (cat.# custom) Oxychlordone (cat.# custom) Diallate (cat.# custom)
Diluent:	Hexane
Injection	
Inj. Vol.:	1 µL splitless (hold 0.3 min)
Liner:	Cyclo double taper (4 mm) (cat.# 20896)
Inj. Temp.:	250 °C
Oven	
Oven Temp:	80 °C to 175 °C at 8 °C/min to 195 °C at 11 °C/min to 235 °C at 7 °C/min to 320 °C at 25 °C/min (hold 3 min)
Carrier Gas	He, constant flow
Linear Velocity:	28 cm/sec
Detector	µ-ECD @ 330 °C
Make-up Gas Flow Rate:	60 mL/min
Make-up Gas Type:	N_2
Instrument	Agilent/HP6890 GC
Notes	This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

	Peaks	Conc. (ng/mL)		Peaks	Conc. (ng/mL)
1.	1,2-Dibromo-3-chloropropane	100	20.	*cis*-Chlordane*	40
2.	Hexachlorocyclopentadiene	100	21.	Endosulfan I	40
3.	Tetrachloro-*m*-xylene (SS)	100	22.	Captan	100
4.	*cis*-Diallate	500	23.	4,4'-DDE	100
5.	Hexachlorobenzene	100	24.	Dieldrin	80
6.	*trans*-Diallate	500	25.	2,4'-DDD	100
7.	α-BHC	40	26.	Endrin	80
8.	γ-BHC	40	27.	Chlorobenzilate	500
9.	β-BHC	40	28.	2,4'-DDT	100
10.	δ-BHC	40	29.	*cis*-Nonachlor	100
11.	Heptachlor	40	30.	4,4'-DDD	80
12.	Aldrin	40	31.	Endosulfan II	80
13.	Chlorpyrifos	100	32.	4,4'-DDT	80
14.	Isodrin	100	33.	Endrin aldehyde	80
15.	Oxychlordane	50	34.	Endosulfan sulfate	80
16.	Heptachlor epoxide	40	35.	Methoxychlor	400
17.	*trans*-Chlordane*	40	36.	Mirex	100
18.	2,4'-DDE	100	37.	Endrin ketone	80
19.	*trans*-Nonachlor	100	38.	Decachlorobiphenyl	100

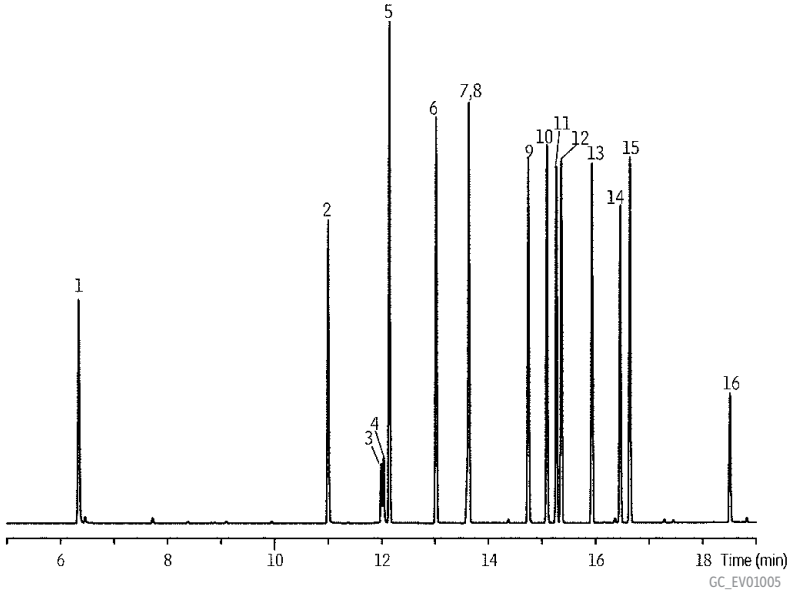
* For information regarding the nomenclature used for *cis*-chlordane and *trans*-chlordane, visit **www.restek.com/chlordane-notice**

Figure 13: Common pesticides monitored for in drinking water and groundwater.

Rtx®-CLPesticides



Rtx®-CLPesticides2



Peaks

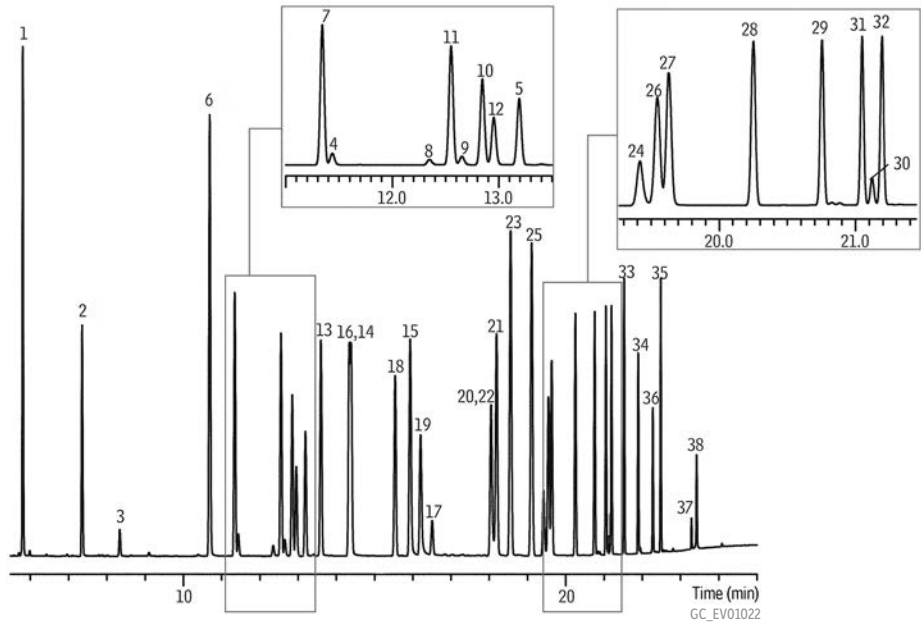
1. Hexachlorocyclopentadiene
2. Hexachlorobenzene
3. Simazine
4. Atrazine
5. γ-BHC
6. Heptachlor
7. Alachlor
8. Aldrin
9. Heptachlor epoxide
10. *trans*-Chlordane*
11. *trans*-Nonachlor
12. *cis*-Chlordane*
13. Dieldrin
14. Endrin
15. *cis*-Nonachlor
16. Methoxychlor

* For information regarding the nomenclature used for *cis*-chlordane and *trans*-chlordane, visit **www.restek.com/chlordane-notice**

Columns	Rtx®-CLPesticides 30 m, 0.32 mm ID, 0.32 µm (cat.# 11141) and Rtx®-CLPesticides2 30 m, 0.32 mm ID, 0.25 µm (cat.# 11324) using Rxi® guard column 5 m, 0.32 mm ID (cat.# 10039) with deactivated universal "Y" Press-Tight® connector (cat.# 20405-261)
Sample	200 ng/mL 505 organohalide pesticide mix (cat.# 32024) 4.2 µg/mL simazine (cat.# 32236) 4.2 µg/mL atrazine (cat.# 32208)
Diluent:	Methanol
Injection	
Inj. Vol.:	2 µL splitless (hold 0.75 min)
Liner:	Cyclo double taper (4 mm) (cat.# 20896)
Inj. Temp.:	250 °C
Oven	
Oven Temp:	90 °C (hold 1 min) to 310 °C at 10 °C/min (hold 5 min)
Carrier Gas	He, constant flow
Linear Velocity:	40 cm/sec
Detector	µ-ECD @ 325 °C
Instrument	Agilent/HP6890 GC
Notes	This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

Figure 14: Pesticides and herbicides monitored for in drinking water and groundwater on the Rtx®-CLPesticides and Rtx®-CLPesticides2 columns.

Rtx®-CLPesticides

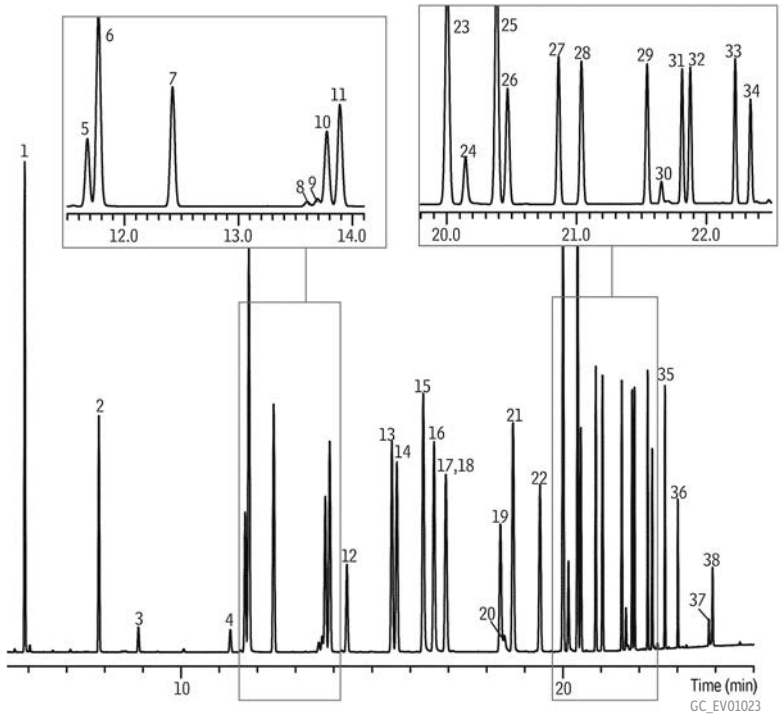


Peaks

1. Hexachlorocyclopentadiene
2. Etridiazole
3. Chlorneb
4. Propachlor
5. Trifluralin
6. Hexachlorobenzene
7. α-BHC
8. Simazine
9. Atrazine
10. Pentachloronitrobenzene (IS)
11. γ-BHC
12. β-BHC
13. δ-BHC
14. Heptachlor
15. Chlorothalonil
16. Metribuzin
17. Alachlor
18. Aldrin
19. 4,4'-Dibromobiphenyl (SS)
20. Metachlor
21. DCPA
22. Heptachlor epoxide
23. *trans*-Chlordane*
24. Cyanazine
25. *cis*-Chlordane*
26. Endosulfan I
27. 4,4'-DDE
28. Dieldrin
29. Endrin
30. Chlorobenzilate
31. 4,4'-DDD
32. Endosulfan II
33. 4,4'-DDT
34. Endrin aldehyde
35. Endosulfan sulfate
36. Methoxychlor
37. *cis*-Permethrin
38. *trans*-Permethrin

* For information regarding the nomenclature used for *cis*-chlordane and *trans*-chlordane, visit **www.restek.com/chlordane-notice**

Rtx®-CLPesticides2

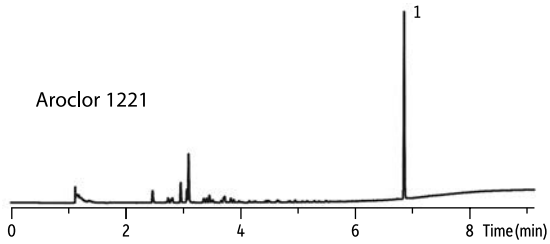


Columns	Rtx®-CLPesticides2 30 m, 0.32 mm ID, 0.25 µm (cat.# 11324) and Rtx®-CLPesticides 30 m, 0.32 mm ID, 0.32 µm (cat.# 11141) using Rxi® guard column 5 m, 0.32 mm ID (cat.# 10039) with deactivated universal "Y" Press-Tight® connector (cat.# 20405-261)
Sample	50 ng/mL 508.1 calibration mix #1 (cat.# 32094) 100 ng/mL 508.1 calibration mix #2 (cat.# 32095) 100 ng/mL 508.1 calibration mix #3 (cat.# 32096) 50 ng/mL pentachloronitrobenzene (cat.# 32091) 250 ng/mL 4,4'-dibromobiphenyl (cat.# 32092) 500 ng/mL atrazine (cat.# 32208) 500 ng/mL simazine (cat.# 32236)
Diluent:	Ethyl acetate
Injection	
Inj. Vol.:	2 µL splitless (hold 0.75 min)
Liner:	Cyclo double taper (4 mm) (cat.# 20896)
Inj. Temp.:	250 °C
Oven	
Oven Temp:	80 °C (hold 0.5 min) to 155 °C at 19 °C/min (hold 1 min) to 210 °C at 4 °C/min to 310 °C at 25 °C/min (hold 0.5 min)
Carrier Gas	He, constant flow
Linear Velocity:	26 cm/sec
Detector	µ-ECD @ 325 °C
Notes	This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

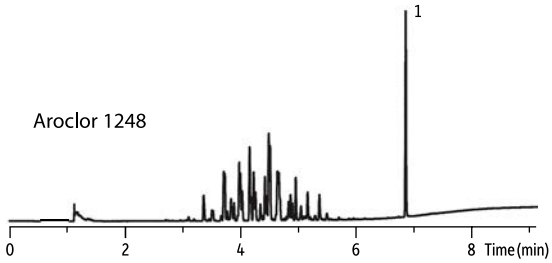
Figure 15: Aroclor compounds on Rtx®-CLPesticides columns.

Rtx®-CLPesticides
30 m, 0.32 mm ID, 0.32 µm (cat.# 11141)

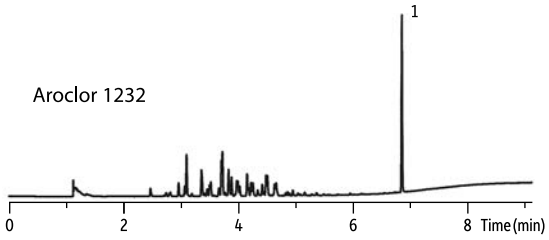
Peaks
1. Decachlorobiphenyl (DCB)



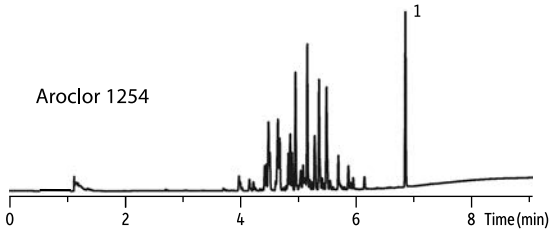
GC_EV00993



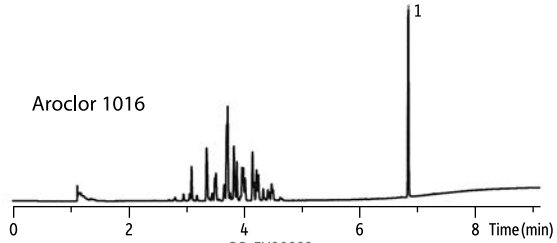
GC_EV00996



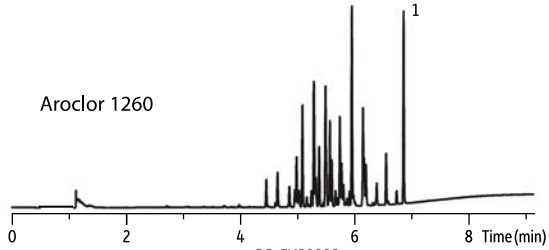
GC_EV00994



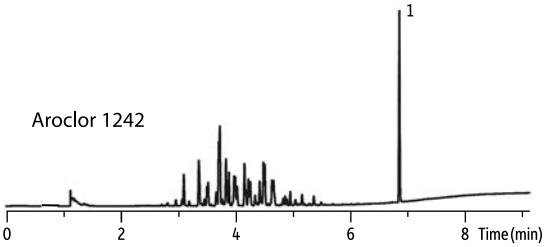
GC_EV00997



GC_EV00992



GC_EV00998



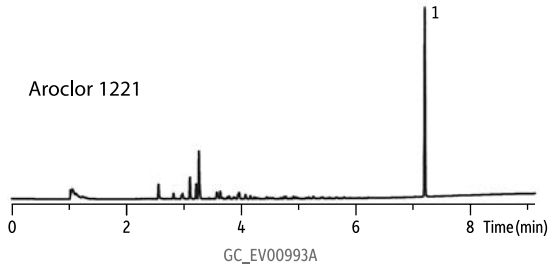
GC_EV00995

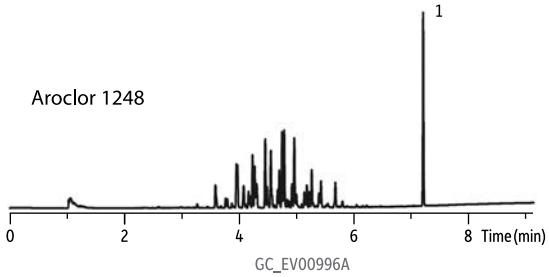
Column	Rtx®-CLPesticides, 30 m, 0.32 mm ID, 0.32 µm (cat.# 11141)
Sample	PCB kit #1 diluted to 1,000 ppb in hexane (cat.# 32089) Decachlorobiphenyl (BZ #209) diluted to 100 ppb in acetone (cat.# 32029)
Injection	
Inj. Vol.:	1.0 µL pulsed splitless (hold 0.3 min)
Liner:	Cyclo double taper (4 mm) (cat.# 20895)
Inj. Temp.:	250 °C
Pulse Pressure:	30 psi (206.8 kPa)
Oven	
Oven Temp:	120 °C to 200 °C at 45 °C/min to 230 °C at 15 °C/min to 330 °C at 30 °C/min (hold 2 min)
Carrier Gas	He, constant flow
Linear Velocity:	60 cm/sec
Detector	µ-ECD @ 330 °C
Notes	This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

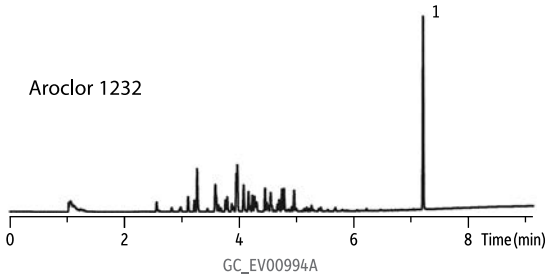
Figure 16: Aroclor compounds on Rtx®-CLPesticides2 columns.

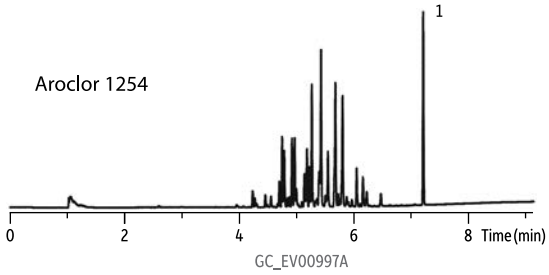
Rtx®-CLPesticides2
30 m, 0.32 mm ID, 0.25 µm (cat.# 11324)

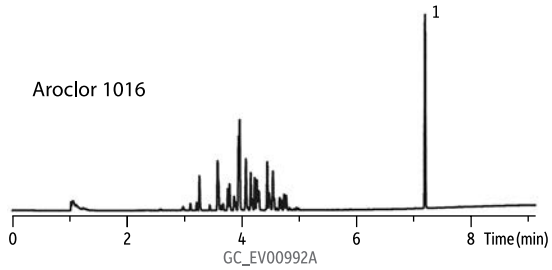
Peaks
1. Decachlorobiphenyl (DCB)

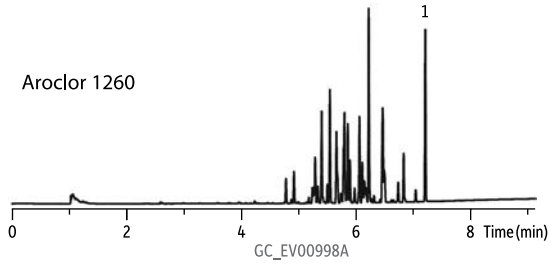


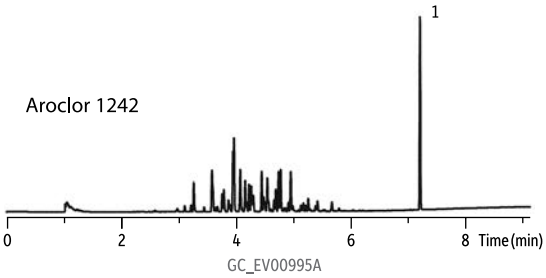












Column	Rtx®-CLPesticides2, 30 m, 0.32 mm ID, 0.25 µm (cat.# 11324)
Sample	PCB kit #1 diluted to 1,000 ppb in hexane (cat.# 32089) Decachlorobiphenyl (BZ #209) diluted to 100 ppb in acetone (cat.# 32029)
Injection	
Inj. Vol.:	1.0 µL pulsed splitless (hold 0.3 min)
Liner:	Cyclo double taper (4 mm) (cat.# 20895)
Inj. Temp.:	250 °C
Pulse Pressure:	30 psi (206.8 kPa)
Oven	
Oven Temp:	120 °C to 200 °C at 45 °C/min to 230 °C at 15 °C/min to 330 °C at 30 °C/min (hold 2 min)
Carrier Gas	He, constant flow
Linear Velocity:	60 cm/sec
Detector	µ-ECD @ 330 °C
Notes	This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

Chlorinated Herbicides

Several methods have been developed for the analysis of chlorinated herbicides, including the methods listed in Table II. Since these compounds are used in different forms (free acids, salts, and esters) the methods require a hydrolysis step to convert all compounds to the free acid form. However, the free acid form is not amenable to gas chromatography and must be derivatized to the methyl ester form before GC analysis. This esterification is accomplished using diazomethane. *Diazomethane is a highly toxic, reactive, and potentially explosive material that should only be handled by analysts experienced with this process.* Pentafluorobenzyl bromide has also been used for the derivatization of chlorinated acid herbicides, but interferences from phenols and chlorinated phenols can be problematic for this derivatization reagent. Since hydrolyzed acids can readily react with basic surfaces, it is critical to acid rinse all glassware used for sample extraction and transfer. It is also recommended to acid rinse the sodium sulfate used for extract drying.

Table II: Target analyte lists for chlorinated herbicides by EPA method.

Compound	CAS #	Method 515.1	Method 615	Method 8151
Acifluorfen	50594-66-6	√		
Bentazon	25057-89-0	√		
Chloramben	133-90-4	√		
2,4-D	94-75-7	√	√	√
Dalapon	75-99-0	√	√	√
2,4-DB	94-82-6	√	√	√
DCPA acid metabolites	-	√		
Dicamba	1918-00-9	√	√	√
3,5-Dichlorobenzoic acid	51-36-5	√		
Dichlorprop	120-36-5	√	√	√
Dinoseb	88-85-7	√	√	√
5-Hydroxydicamba	7600-50-2	√		
MCPA	94-74-6		√	√
MCPP	7085-19-0		√	√
4-Nitrophenol	100-02-7	√		√
Pentachlorophenol (PCP)	87-86-5	√		√
Picloram	1918-02-1	√		
2,4,5-T	93-76-5	√	√	√
2,4,5-TP	93-72-1	√	√	√

Once esterified, the chlorinated herbicides can be analyzed by GC and Rtx®-CLPesticides and Rtx®-CLPesticides2 columns can be used to separate these derivatized compounds. Both internal and surrogate standards are specified for these methods to ensure accurate quantitative results. Restek provides a complete range of internal and surrogate standards, as well as calibration standards, for chlorinated herbicides as both free acids and methyl esters. Figure 17 shows example chromatograms of chlorinated herbicides on the Rtx®-CLPesticides column set using optimized analysis conditions.

Table III: Target analyte lists for haloacetic acids (EPA Method 552.2).

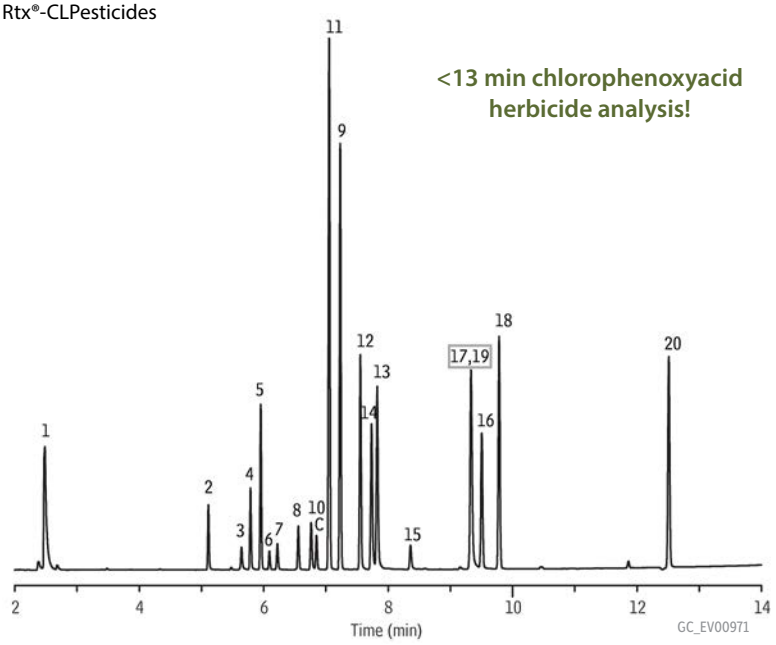
Compound	CAS #
Bromochloroacetic acid (BCAA)	5589-96-8
Bromodichloroacetic acid (BDCAA)	7113-314-7
Chlorodibromoacetic acid (CDBAA)	5278-95-5
Dalapon	75-99-0
Dibromoacetic acid (DBAA)	631-64-1
Dichloroacetic acid (DCAA)	79-43-6
Monobromoacetic acid (MBAA)	79-08-3
Monochloroacetic acid (MCAA)	79-11-8
Tribromoacetic acid (TBAA)	75-96-7
Trichloroacetic acid (TCAA)	76-03-9

Haloacetic Acids

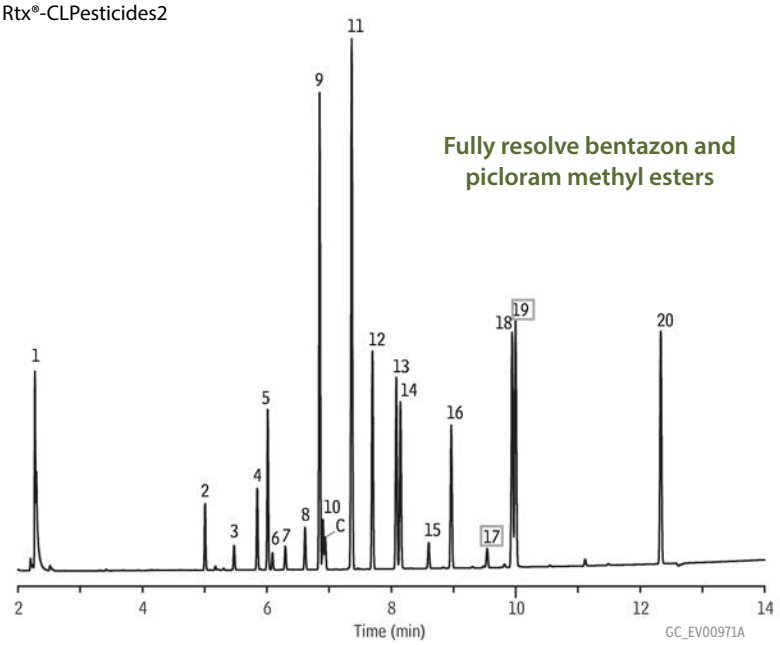
Haloacetic acids are byproducts created when drinking water is chlorinated. Analytical methods (such as EPA 552.2) were developed for the analysis of haloacetic acids in drinking water. Table III shows the target list of compounds included in this method. A 100 mL sample of water is adjusted to a pH of 11.5 and extracted with methyl *tert*-butyl ether (MTBE) to remove basic and neutral compounds from the sample. The sample is then acidified to pH 0.5 and the haloacetic acids are extracted into MTBE. The acids are then converted to methyl esters using diazomethane and analyzed by capillary GC using an ECD detector. *Diazomethane is a highly toxic, reactive, and potentially explosive material that should only be handled by analysts experienced with this process.* Note that derivatization can also be accomplished using acidic methanol and heat.

Figure 17: Analysis of chlorinated herbicides on the Rtx®-CLPesticides column set.

Rtx®-CLPesticides



Rtx®-CLPesticides2



Peaks

1. Dalapon methyl ester
2. 3,5-Dichlorobenzoic acid methyl ester (SS)
3. 4-Nitroanisole
4. DCAA methyl ester (SS)
5. Dicamba methyl ester
6. MCPP methyl ester
7. MCPA Methyl ester
8. Dichlorprop, methyl ester
9. 4,4'-DBOB (IS)
10. 2,4-D methyl ester
11. Pentachloroanisole
12. 2,4,5-TP, methyl ester
13. 2,4,5-T methyl ester
14. Chloramben, methyl ester
15. 2,4-DB methyl ester
16. Dinoseb methyl ester
17. Bentazon methyl ester
18. DCPA
19. Pichloram methyl ester
20. Acifluorfen methyl ester

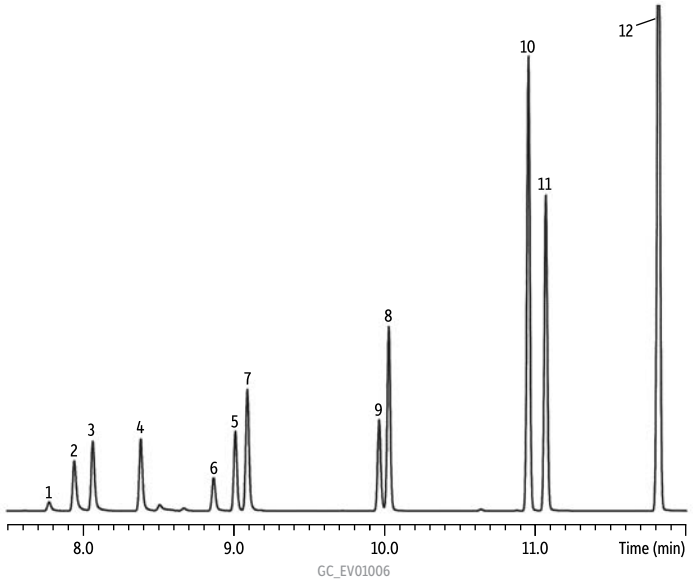
C. contaminant

Columns	Rtx®-CLPesticides2 30 m, 0.32 mm ID, 0.25 µm (cat.# 11324) and Rtx®-CLPesticides 30 m, 0.32 mm ID, 0.32 µm (cat.# 11141) using Rxi® deactivated guard column 5 m, 0.32 mm ID (cat.# 10039) with universal "Y" Press-Tight® connector (cat.# 20405-261)
Sample	200 ng/mL herbicide mix #1 (cat.# 32055) 1,000 ng/mL dalapon methyl ester (cat.# 32057) 20,000 ng/mL herbicide mix #3 (cat.# 32059) 200 ng/mL herbicide mix #4 (cat.# 32062) 250 ng/mL 4,4'-dibromooctafluorobiphenyl (cat.# 32053) 400 ng/mL 2,4-dichlorophenyl acetic acid methyl ester (cat.# 32050)
Diluent:	Hexane
Injection	
Inj. Vol.:	1.0 µL splitless (hold 0.75 min)
Liner:	Cyclo double taper (4 mm) (cat.# 20895)
Inj. Temp.:	250 °C
Oven	
Oven Temp:	70 °C (hold 0.5 min) to 190 °C at 25 °C/min (hold 1 min) to 300 °C at 11 °C/min (hold 5 min)
Carrier Gas	He, constant pressure
Linear Velocity:	36 cm/sec @ 70 °C
Detector	µ-ECD @ 325 °C
Instrument	Agilent/HP6890 GC
Notes	This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

Figure 18 shows example chromatograms of derivatized haloacetic acids on the Rtx®-CLPesticides column set using optimized analysis conditions. Both internal and surrogate standards are specified for this method to ensure accurate quantitative results. Restek provides a complete range of internal and surrogate standards, as well as calibration standards, for haloacetic acids as both free acids and methyl esters.

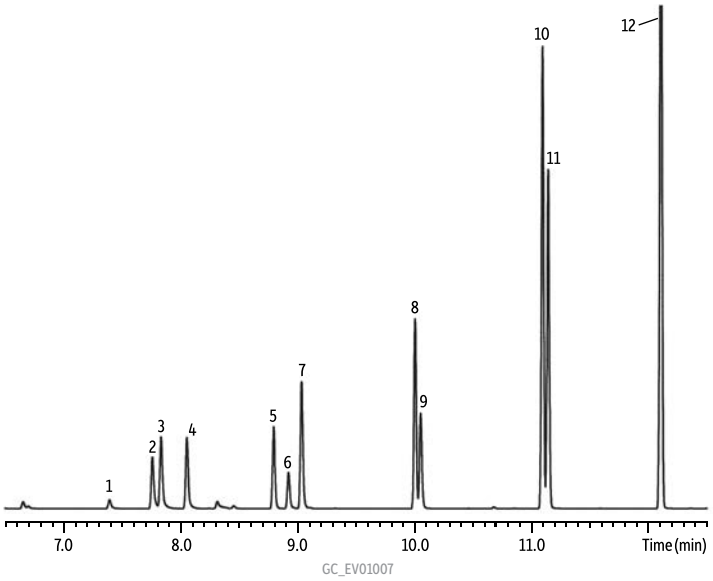
Figure 18: Analysis of derivatized haloacetic acids on Rtx®-CLPesticides and Rtx®-CLPesticides2 columns.

Rtx®-CLPesticides



	Peaks	Conc. (µg/mL)
1.	Methyl monochloroacetate	1.2
2.	Methyl monobromoacetate	0.8
3.	Methyl dichloroacetate	1.2
4.	Dalapon methyl ester	2
5.	Methyl trichloroacetate	0.4
6.	1,2,3-Trichloropropane (IS)	4
7.	Methyl bromo(chloro)acetate	0.8
8.	Methyl bromodichloroacetate	0.8
9.	Methyl dibromoacetate	0.4
10.	Methyl chlorodibromoacetate	2
11.	Methyl 2,3-dibromopropionate (SS)	2
12.	Methyl tribromoacetate	4

Rtx®-CLPesticides2



Columns	Rtx®-CLPesticides2 30 m, 0.32 mm ID, 0.25 µm (cat.# 11324) and Rtx®-CLPesticides 30 m, 0.32 mm ID, 0.32 µm (cat.# 11141) using Rxi® guard column 5 m, 0.32 mm ID (cat.# 10039) with deactivated universal "Y" Press-Tight® connector (cat.# 20405-261)
Sample	Haloacetic acid methyl ester mix #2 (cat.# 31647) Dalapon methyl ester (cat.# 32057) Methyl-2,3-dibromopropionate (cat.# 31656) 1,2,3-Trichloropropane (cat.# 31648)
Diluent:	Methyl *tert*-butyl ether (MTBE)
Injection	
Inj. Vol.:	1.0 µL splitless (hold 0.75 min)
Liner:	Cyclo double taper (4 mm) (cat.# 20896)
Inj. Temp.:	250 °C
Oven	
Oven Temp:	35 °C (hold 4 min) to 250 °C at 15 °C/min (hold 5 min)
Carrier Gas	He, constant flow
Linear Velocity:	25 cm/sec
Detector	µ-ECD @ 300 °C
Notes	This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

EDB, DBCP, and TCP

1,2-Dibromoethane (EBD), 1,2-dibromo-3-chloropropane (DBCP), and 1,2,3-trichloropropane (TCP) are common byproducts created when drinking water is chlorinated. EPA Methods 504.1 and 8011 were developed for the analysis of EBD, DBCP, and TCP in drinking water. A 35 mL sample of drinking water is extracted with 2 mL of hexane and analyzed by capillary gas chromatography using ECD detection. Figure 19 shows example chromatograms of these compounds on the Rtx®-CLPesticides columns using optimized analysis conditions. Restek provides a complete range of calibration standards for these compounds.

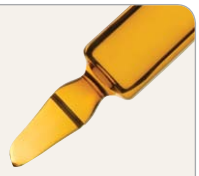
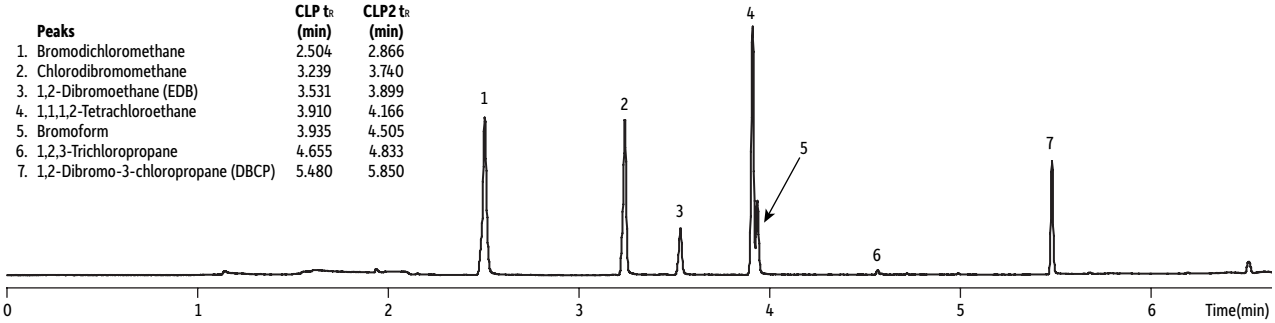


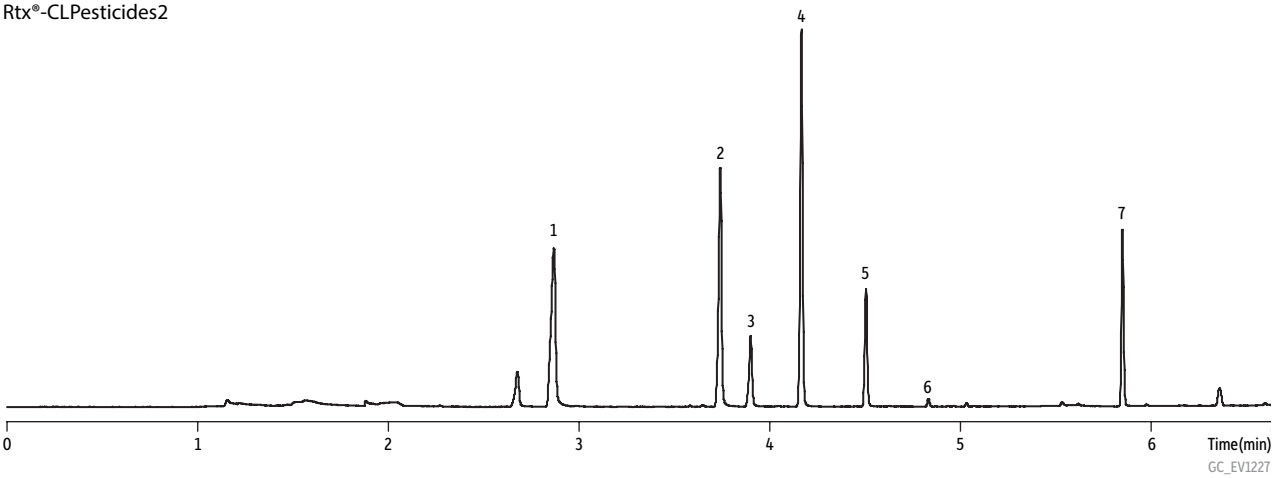
Figure 19: Analysis of EDB, DBCP, and TCP on the Rtx®-CLPesticides column set.

Rtx®-CLPesticides

Peaks	CLP t_R (min)	CLP2 t_R (min)
1. Bromodichloromethane	2.504	2.866
2. Chlorodibromomethane	3.239	3.740
3. 1,2-Dibromoethane (EDB)	3.531	3.899
4. 1,1,1,2-Tetrachloroethane	3.910	4.166
5. Bromoform	3.935	4.505
6. 1,2,3-Trichloropropane	4.655	4.833
7. 1,2-Dibromo-3-chloropropane (DBCP)	5.480	5.850



Rtx®-CLPesticides2



Columns	Rtx®-CLPesticides2 30 m, 0.32 mm ID, 0.25 µm (cat.# 11324) and Rtx®-CLPesticides 30 m, 0.32 mm ID, 0.32 µm (cat.# 11141) using Rxi® guard column 5 m, 0.32 mm ID (cat.# 10039) with Universal "Y" Press-Tight® connector (cat.# 20405)
Sample	Dibromochloromethane (chlorodibromochloromethane) (cat.# 30271) Bromodichloromethane (cat.# 30251) 504.1 calibration mix (cat.# 30239) 1,1,1,2-tetrachloroethane (cat.# 30411) Bromoform (cat.# 30252)
Diluent:	*n*-Hexane
Conc.:	10 ng/mL
Injection	
Inj. Vol.:	2 µL splitless (hold 0.50 min)
Liner:	Sky® 4 mm single taper inlet liner w/wool (cat.# 23303.1)
Inj. Temp.:	200 °C
Purge Flow:	50 mL/min
Oven	
Oven Temp:	30 °C (hold 2.0 min) to 220 °C at 30 °C/min
Carrier Gas	He, constant flow
Linear Velocity:	60 cm/sec
Detector	µ-ECD @ 220 °C
Make-up Gas Flow Rate:	50 mL/min
Make-up Gas Type:	He
Data Rate:	50 Hz
Instrument	Agilent/HP6890 GC
Notes	This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual-columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

Using Restek's Rtx®-CLPesticides column set, coupled with the methods and recommendations presented in this guide, will make your analyses easier and allow you to perform other environmental testing, such as PCB analysis, using the same columns and GC setup.

Summary

Although the analysis of chlorinated pesticides and herbicides historically has been one of the more difficult tests performed by environmental testing laboratories, using Restek's Rtx®-CLPesticides column set, coupled with the methods and recommendations presented in this guide, will make your analyses easier and allow you to perform other environmental testing, such as PCB analysis, using the same columns and GC setup. Careful sample preparation and extract cleanup, proper injection technique, and suitable analytical columns and standards will improve your results and increase your lab's throughput.

When problems occur, using proper troubleshooting and maintenance techniques can quickly re-establish system integrity. When faced with difficulties in your pesticide or herbicide analysis, remember that the majority of problems occur during the sample preparation and cleanup steps, or at the injection port of the GC. If you are still having difficulties with your analysis after following the steps in this guide, please contact Restek's technical service at support@restek.com; 1-800-356-1688, ext. 4; or 1-814-353-1300, ext. 4 and we will be happy to help you.

Sample Preparation

Glassware

Soxhlet Extraction Apparatus

Soxhlet extraction is used for the continuous solvent extraction of organic analytes from a solid matrix. All parts are connected with ST joints to reduce any risk of contamination. All flask joints are ST 24/40 joints.

Description	ID	Volume	Taper Size	qty.	cat.#
Extraction Apparatus	30 mm	125 mL	34/45	kit	23342
Extraction Apparatus	40 mm	250 mL	45/50	kit	23343
Extraction Apparatus	50 mm	300 mL	55/50	kit	23344

Separatory Funnels, Squibb Type with PTFE Stopcock

With solid ST stopper.

Description	Volume	Stopcock	qty.	cat.#
Separatory Funnel, Squibb Type	30 mL	2 PTFE	kit	23381
Separatory Funnel, Squibb Type	60 mL	2 PTFE	kit	23382
Separatory Funnel, Squibb Type	125 mL	2 PTFE	kit	23383
Separatory Funnel, Squibb Type	250 mL	4 PTFE	kit	23384
Separatory Funnel, Squibb Type	500 mL	4 PTFE	kit	23385
Separatory Funnel, Squibb Type	1 L	4 PTFE	kit	23386
Separatory Funnel, Squibb Type	2 L	6 PTFE	kit	23387

Kuderna-Danish Evaporator Concentrator

This apparatus is used to concentrate analytes from volatile solvents. Apparatus consist of a 3-ball Snyder distilling column, flask and concentrator tube. The flask and receivers are held together by ST joints and the included poly joint clamp. Concentrator tube is graduated.

Description	Volume	Receiver Capacity	qty.	cat.#
Kuderna-Danish Evaporator	250 mL	10 mL	kit	23339
Kuderna-Danish Evaporator	500 mL	15 mL	kit	23340

Concentrator Tube

Description	Volume	Taper Size	qty.	cat.#
Graduated Concentrator Tube	10 mL	19/22	ea.	23341

Solid Phase Extraction

Resprep® SPE Cartridges (Normal Phase)

Hydrophilic (polar) adsorbents used to extract hydrophilic analytes from nonpolar matrices, such as organic solvents (e.g., polar contaminants from sample extracts).

	3 mL/500 mg (50-pk.)	6 mL/500 mg (30-pk.)	6 mL/1,000 mg (30-pk.)	15 mL/2 g (15-pk.)
Florisil (EPA SW 846 methods and CLP protocols)	24031 24032*	26086**	24034 26085**	26228

*PTFE frits **Glass tubes with PTFE frits

All cartridges are manufactured using high density polypropylene and have polyethylene frits unless otherwise noted.

Cartridges may be processed by any one or all of these techniques: positive pressure, sidearm flask, centrifuge, or vacuum manifold.

▶ Visit **www.restek.com** for additional products and services

Solid Phase Extraction, cont.

Excellent for Pesticide Residue Cleanup!

Resprep® CarboPrep® SPE Cartridges

- Improved recovery of sulfonylurea herbicides, phenols, carbamates, and triazine herbicides, compared to C18 and C8 cartridges.
- Wide range of selectivity for both analytes and their metabolites or degradation products.
- Rapid sampling flow rates; uncompromised recoveries.
- Maximum capacity for contaminant cleanup.
- Controlled manufacturing improves cleanliness, ensures reproducible performance.

SPE Cartridge	Tube Volume, Bed Weight	qty.	cat.#
CarboPrep 90	3 mL, 250 mg	50-pk.	26091
CarboPrep 90	6 mL, 500 mg	30-pk.	26092

Resprep® disks & flow filters extract analytes of interest at high flow rates and significantly reduce clogging.

Resprep®-C18 SPE Disks

- Glass fiber disks embedded with C18 bonded silica.
- Extract semivolatile organic compounds.
- Deep-pore design reduces clogging and allows faster flow rates.
- Meet requirements for EPA Methods 525.1, 506, 550.1, and 549.1.
- Lower cost than PTFE disks.

Description	Diameter	qty.	cat.#
Resprep-C18	47 mm	20-pk.	24004
Resprep-C18	90 mm	12-pk.	25988

Resprep® SPE Flow Filters

- Designed specifically to improve flow when filtering oil and grease samples.
- Use with Resprep® Diskcover-47 reservoir, or any 47 mm glass sample reservoir.

Description	qty.	cat.#
Resprep SPE Flow Filters	20-pk.	26024

Sodium Sulfate (Bulk Adsorbent)

- Ideal for removing water from sample extracts.
- Activate by heating to 400 °C for four hours before use.
- Packaged in recloseable 5 kg buckets.

Anhydrous sodium sulfate is the most common drying agent used to remove moisture from sample extracts. We package our 60 mesh material in recloseable buckets.

Description	qty.	cat.#
Sodium Sulfate	5 kg	26204

Florisil® PR (Bulk Adsorbent)

- Pesticide residue grade.
- Packaged in glass containers.

Florisil® PR is commonly used to remove polar interferences from pesticide residues. This bulk material is ideal for labs packing their own extraction cartridges for pesticide residue extractions.

Description	qty.	cat.#
Florisil PR, 60/100 mesh	500 g	26135

Granulated Activated Copper (Bulk Adsorbent)

- Convenient form for removing sulfur from environmental extracts.
- Acidified and activated—ready for use.

Activated copper effectively removes elemental sulfur from environmental extracts. Our acid-washed and activated material can be used right out of the package. The 30 mesh granular material eliminates the potential for fine copper particles in filtered extracts.

Description	qty.	cat.#
Granulated Activated Copper, 30 mesh	1 kg	26136

Accelerated Solvent Extraction

Extraction Cell Bodies for ASE® 200 Systems

- Cell bodies are serialized for easy sample identification.
- Inner surfaces polished for easier cleaning.

Extraction Cell Body	Similar to Dionex part #	Stainless Steel qty.	cat.#
1 mL for ASE 200	054973	ea.	26110
5 mL for ASE 200	054974	ea.	26112
11 mL for ASE 200	048820	ea.	26114
22 mL for ASE 200	048821	ea.	26098
33 mL for ASE 200	048822	ea.	26116

Cell bodies are serialized for easy sample identification.

Extraction Cell Caps & Replacement Parts for ASE® 200 Systems

- Inner surfaces polished for easier cleaning.
- Caps include frit, washer, PTFE O-ring, and threaded insert.

Description	Similar to Dionex part #	Stainless Steel qty.	cat.#
Replacement Extraction Cell End Caps for ASE 200	049450	2-pk.	26096
Cap Inserts for ASE 200		2-pk.	26166
Replacement Frits for ASE 200	049453	10-pk.	26100
Replacement Frits for ASE 200	049453	100-pk.	25959
Description	**Similar to Dionex part #**	**qty.**	**cat.#**
Snap Rings for Caps for ASE 200	049456	10-pk.	26184
Funnel for ASE 200	056958	ea.	26180
PTFE O-Rings for ASE 200 & ASE 300 Caps	049457	100-pk.	26187
Viton O-Rings for ASE 200 & ASE 300 Caps	056325	50-pk.	26188

▶ Other ASE® 200 and ASE® 300 replacement parts are available at **www.restek.com/ase**

Reference Standards

▶ Additional reference standards for chlorinated pesticides, PCBs, and chlorinated herbicides are available at **www.restek.com**

Organochlorine Pesticide Mix AB #1 (20 components)

aldrin	*cis*-chlordane	dieldrin	endrin aldehyde
α-BHC	*trans*-chlordane	endosulfan I	endrin ketone
β-BHC	4,4'-DDD	endosulfan II	heptachlor
δ-BHC	4,4'-DDE	endosulfan sulfate	heptachlor epoxide (isomer B)
γ-BHC (lindane)	4,4'-DDT	endrin	methoxychlor

200 µg/mL each in hexane:toluene (1:1), 1 mL/ampul — cat.# 32291

Organochlorine Pesticide Mix AB #2 (20 components)

aldrin	8 µg/mL	*cis*-chlordane	8	dieldrin	16	endrin aldehyde	16
α-BHC	8	*trans*-chlordane	8	endosulfan I	8	endrin ketone	16
β-BHC	8	4,4'-DDD	16	endosulfan II	16	heptachlor	8
δ-BHC	8	4,4'-DDE	16	endosulfan sulfate	16	heptachlor epoxide (isomer B)	8
γ-BHC (lindane)	8	4,4'-DDT	16	endrin	16	methoxychlor	80

In hexane:toluene (1:1), 1 mL/ampul — cat.# 32292

Pesticide Surrogate Mix (2 components)

decachlorobiphenyl — 2,4,5,6-tetrachloro-*m*-xylene

200 µg/mL each in acetone, 1 mL/ampul	cat.# 32000
200 µg/mL each in acetone, 5 mL/ampul	cat.# 32457

Organochlorine Pesticide System Evaluation Mix (2 components)

- Designed for daily assessment of system performance.
- Reveals active sites in the injection port and/or GC column.
- Prepared in MTBE—low expansion volume helps minimize backflash.

4,4'-DDT 200 µg/mL — endrin 100 µg/mL

In methyl *tert*-butyl ether, 1 mL/ampul — cat.# 32417

Instrument Supplies

Guard Columns and Connectors

Deactivated guard columns minimize breakdown and improve recovery of analytes!

Rxi® Guard/Retention Gap Columns (fused silica)

- Extend column lifetime.
- Excellent inertness—obtain lower detection limits for active compounds.
- Sharper chromatographic peaks by utilizing retention gap technology.
- Maximum temperature: 360 °C.

Nominal ID	Nominal OD	5-Meter cat.#	5-Meter/6-pk. cat.#	10-Meter cat.#	10-Meter/6-pk. cat.#
0.25 mm	0.37 ± 0.04 mm	10029	10029-600	10059	10059-600
0.32 mm	0.45 ± 0.04 mm	10039	10039-600	10064	10064-600
0.53 mm	0.69 ± 0.05 mm	10054	10054-600	10073	10073-600

Intermediate-Polarity Deactivated Guard/Retention Gap Columns/ Transfer Lines (fused silica)

- Tested with a comprehensive test mix to ensure high inertness.
- Useful for a wide range of applications.
- Use with most common solvents.
- Maximum temperature: 325 °C

Nominal ID	Nominal OD	5-Meter	5-Meter/6-pk.
0.53 mm	0.69 ± 0.05 mm	10045	10045-600

Guard Columns and Connectors, cont.

Press-Tight® Connectors

- Deactivated Press-Tight® connectors maintain complete inertness along the GC flow path.
- Fit 0.33–0.74 mm OD columns (Restek 0.1–0.53 mm ID).

Universal Angled "Y" Press-Tight® Connectors

- Perform confirmation analysis with a single injection.
- Inlet and outlet ends conform to the column curvature—alleviates column-end connection strain.

Description	ea.	3-pk.
Universal Angled "Y" Press-Tight Connector	20403	20404
Universal Angled "Y" Press-Tight Connector, Deactivated	20403-261	20404-261

Columns and Kits

Rtx®-CLPesticides/Rtx®-CLPesticides2

- Application-specific columns for organochlorine pesticides and herbicides.
- Low bleed—ideal for GC-ECD or GC-MS analyses.
- Baseline separations in less than 10 minutes.
- Stable to 340 °C.
- Analyze EPA Method 8081B, 8082A, 8151A, 504.1, 515, 508.1, and 552.2 compounds without time-consuming column change.

Rtx®-CLPesticides Columns (fused silica)
(proprietary Crossbond® phases)

ID	df	temp. limits	15-Meter	20-Meter	30-Meter	60-Meter
0.18 mm	0.18 µm	-60 to 320/340 °C		42102		
0.25 mm	0.25 µm	-60 to 320/340 °C	11120		11123	11126
0.32 mm	0.32 µm	-60 to 320/340 °C			11141	
	0.50 µm	-60 to 320/340 °C	11136		11139	
0.53 mm	0.50 µm	-60 to 300/320 °C	11137		11140	

Rtx®-CLPesticides2 Columns (fused silica)
(proprietary Crossbond® phases)

ID	df	temp. limits	10-Meter	15-Meter	20-Meter	30-Meter	60-Meter
0.18 mm	0.14 µm	-60 to 320/330 °C	42301		42302		
0.25 mm	0.20 µm	-60 to 320/340 °C				11323	11326
0.32 mm	0.25 µm	-60 to 320/340 °C		11321		11324	
	0.50 µm	-60 to 320/340 °C				11325	
0.53 mm	0.42 µm	-60 to 300/320 °C		11337		11340	

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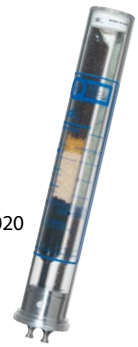


22020

base plate

Inlet Supplies and Accessories

Restek Super Clean® Gas Filter Kits and Replacements

- High-purity output ensures 99.9999% pure gas (at max. flow of 2 L/min).
- "Quick connect" fittings for easy, leak-tight cartridge changes.
- Glass inside to prevent diffusion; polycarbonate housing outside for safety.
- All traps measure 10 5/8" x 1 3/4" (27 x 4.4 cm).
- Each base plate unit measures 4" x 4" x 1 7/8" (10.2 x 10.2 x 4.8 cm).

Description	qty.	cat.#
Carrier Gas Cleaning Kit Includes: mounting base plate, 1/8" inlet/outlet fittings, and oxygen/moisture/hydrocarbon triple gas filter	kit	22019
Replacement Triple Gas Filter (removes oxygen, moisture, and hydrocarbons)	ea.	22020
Helium-Specific Carrier Gas Cleaning Kit Includes: mounting base plate, 1/8" inlet/outlet fittings, and oxygen/moisture/hydrocarbon helium-specific filter	kit	21983
Replacement Helium-Specific Gas Filter (removes oxygen, moisture, and hydrocarbons)	ea.	21982

Extend column lifetime!

Dual Vespel® Ring Inlet Seals Washerless, leak-tight seals for Agilent® GCs

- Does not require a separate washer.
- Requires less torque to seal.
- Does not require retightening of reducing nut after several oven cycles.
- Extends column lifetime by preventing oxygen from reaching the column.
- Same price as the regular inlet seals with washers.

0.8 mm ID Dual Vespel Ring Inlet Seal	2-pk.	10-pk.	50-pk.
Gold-Plated	21240	21241	23418

Sky® Inlet Liners for Agilent GCs

Splitless Liners for Agilent GCs	ID OD x Length	Similar to Agilent part #	ea.	cat.# 5-pk.	25-pk.
 4 mm Single Taper	4.0 mm 6.5 mm x 78.5 mm	5181-3316 (ea.) 5183-4695 (5-pk.) 5183-4696 (25-pk.)	23302.1	23302.5	23302.25
 4 mm Single Taper w/Wool	4.0 mm 6.5 mm x 78.5 mm	5062-3587 (ea.) 5183-4693 (5-pk.) 5183-4694 (25-pk.)	23303.1	23303.5	23303.25
 4 mm Double Taper	4.0 mm 6.5 mm x 78.5 mm	5181-3315 (ea.) 5183-4705 (5-pk.) 5183-4706 (25-pk.)	23308.1	23308.5	23308.25
 4 mm Cyclo Double Taper	4.0 mm 6.5 mm x 78.5 mm		23310.1	23310.5	23310.25
Direct Injection Liners for Agilent GCs (for 0.25/0.32/0.53mm ID Columns)	**ID OD x Length**	**Similar to Agilent part #**	**ea.**	**cat.# 5-pk.**	**25-pk.**
 Drilled Uniliner (hole near top)	4.0 mm 6.3 mm x 78.5 mm		23311.1	23311.5	23311.25

Patent pending

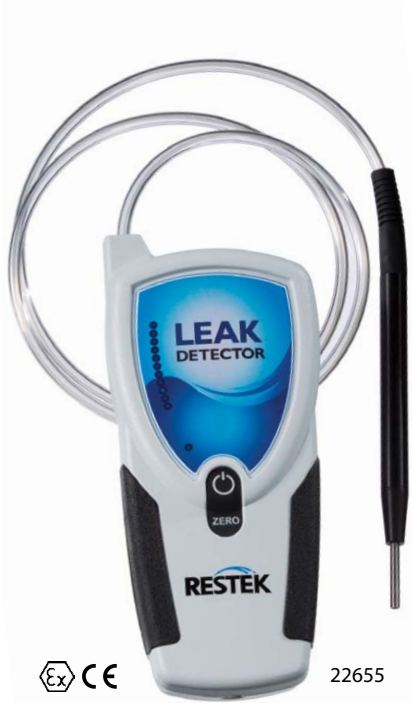
Restek Electronic Leak Detector

Don't let a small leak turn into a costly repair—protect your analytical column by using a Restek leak detector.

Features & benefits include:

- Audible tone indicates the severity of a leak.
- Redesigned circuitry offers 12 hours of operation between charges.
- Detects a broad range of gases; EX rated for use with hydrogen and other explosive gases.*
- Ergonomic, handheld design.
- Rugged side grips for added durability.
- Handy probe storage for cleanliness and convenience.
- Long-lasting battery; up to 12 hours of continuous use.
- Automatic shutoff.
- A convenient hard-sided carrying and storage case.
- Easy-to-clean probe assembly.
- A universal charger set (U.S., European, UK, and Australian plugs included).

Backed by a one-year warranty, the Restek leak detector is the industry standard for performance and affordability in handheld leak detectors.



22655

Leak Detector Specifications

Detectable Gases:	Helium, nitrogen, argon, carbon dioxide, hydrogen
Battery:	Rechargeable lithium ion internal battery pack (12 hours normal operation)
Operating Temperature Range:	32–120 °F (0–48 °C)
Humidity Range:	0–97%
Warranty:	One year
Certifications:	CE, Ex, Japan
Compliance:	WEEE, RoHS

Limits of Detection

These gases can be detected with the Restek electronic leak detector at the following leak rates:

Minimum Detectable Gas Limits and Indicating LED Color:
Helium, 1.0 x 10^{-5}, red LED
Hydrogen*, 1.0 x 10^{-5}, red LED
Nitrogen, 1.4 x 10^{-3}, yellow LED
Argon, 1.0 x 10^{-4}, yellow LED
Carbon dioxide, 1.0 x 10^{-4}, yellow LED

Gas detection limits measured in atm cc/sec.

22657

Optional soft-side storage case is ideal for storing your leak detector or flowmeter in smaller spaces, such as your toolbox.

Description	qty.	cat.#
Leak Detector With Hard-Sided Carrying Case and Universal Charger Set (U.S., UK, European, Australian)	ea.	22655
Small Probe Adaptor for Leak Detector	ea.	22658
Dynamic Duo Combo Pack (Restek Leak Detector and ProFLOW 6000 Flowmeter)	kit	22654
Soft-Sided Storage Case for Leak Detector or ProFLOW 6000 Flowmeter	ea.	22657

Avoid using liquid leak detectors on a GC! Liquids can be drawn into the system and/or into the leak detector.

*Caution: The Restek electronic leak detector is designed to detect trace amounts of hydrogen in a noncombustible environment. It is NOT designed for determining leaks in a combustible environment. A combustible gas detector should be used for determining combustible gas leaks under any condition. When using it to detect hydrogen, the Restek electronic leak detector may only be used for determining trace amounts in a GC environment.

22658

Verify hard-to-reach leaks using the small probe adaptor (sold separately).

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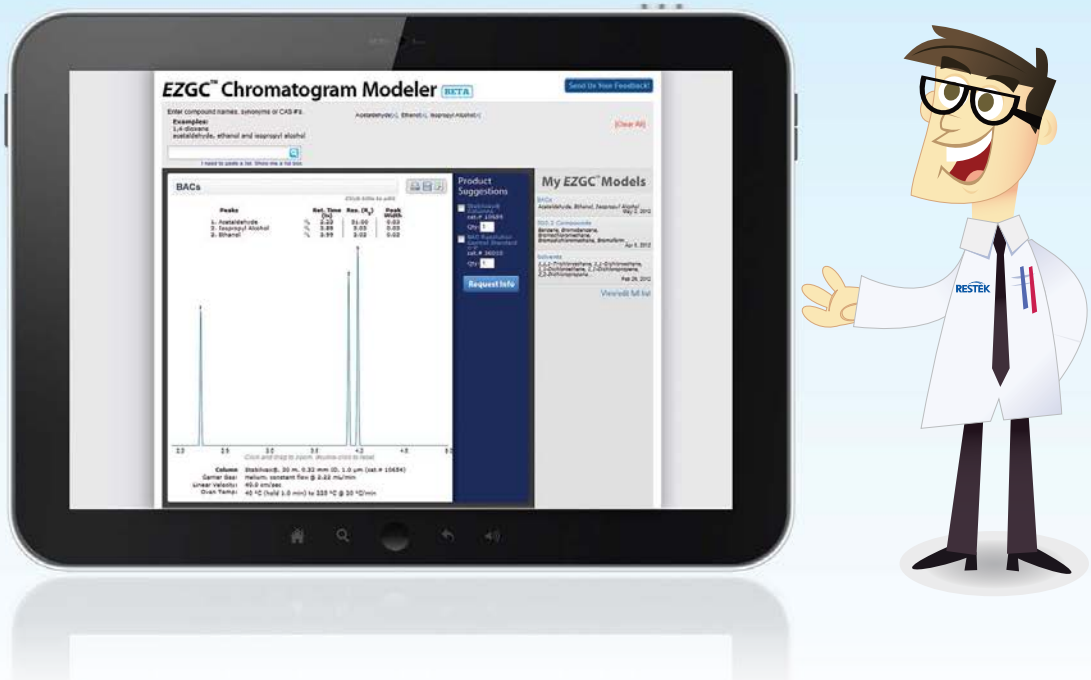
NOW ONLINE!

Our *EZ*GC® Web App Will Kick-Start Your GC Method Development



It Doesn't Get Much Easier Than the *EZ*GC® Chromatogram Modeler

A revolutionary new version of our popular *EZ*GC® application is now live—it's easier to use and ***it's absolutely free.*** Just enter your compounds, and our cutting-edge system will recommend not only a GC column, but also the conditions to reliably separate your target analytes. It will even show you a modeled chromatogram! On a PC or Mac, desktop or tablet, the *EZ*GC® web app can go anywhere and will quickly become your go-to resource for creating optimized, custom methods.

- ***EZ* to Use** – Just enter your target compounds, and in seconds, the *EZ*GC® system gives you a customized method, including column, conditions, and model chromatogram.
- ***EZ* to Analyze** – Model chromatograms are fully interactive. Zoom in, view chemical structures, and even overlay mass spectra.
- ***EZ* to Save** – Print your chromatogram and custom settings, or save them for future reference.

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China • phone: +86-10-5629-6620 • fax: +86-10-5814-3980 • cn.restek.com
France • phone: +33 (0)1 60 78 32 10 • fax: +33 (0)1 60 78 70 90 • www.restek.fr
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Italy • phone: +39-02-7610037 • fax: +39-02-70100100 • www.superchrom.it
Japan • phone: +81 (3)6459 0025 • fax: +81 (3)6459 0025 • e-mail: restekjapan@restek.com
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Save Time and Money with QuEChERS

- Ready-to-use extraction and dSPE tubes, no glassware required.
- Preweighed adsorbents for dSPE cleanup.
- Convenient, method-specific internal and QC standards.

Quick, Easy, Cheap, Effective, Rugged, and Safe, the QuEChERS ("catchers") method is a fast, simple, and effective alternative to conventional sample prep for multiresidue pesticide analysis. QuEChERS is based on work done by the U.S. Department of Agriculture Eastern Regional Research Center in Wyndmoor, PA.[1] Researchers there were looking for a simple, effective, and inexpensive way to extract and clean pesticide residues from the many varied sample matrices that they worked with routinely. They had been using the modified Luke extraction method, which is highly effective and rugged, but is solvent, labor, and glassware intensive, leading to a relatively high cost per sample. In contrast, QuEChERS employs a very short shake-extraction step, making it faster and less labor intensive. Solid phase extraction cleanup of extracts from other methods also had been effective, but the complex matrices the investigators were dealing with required multiple individual cartridges to remove the many classes of interferences, which added significant cost and complexity to the process. To reduce costs and speed up sample preparation, they developed a novel dispersive solid phase extraction (dSPE) technique, which effectively removes sugars, lipids, organic acids, sterols, proteins, pigments and excess water, but is far simpler and less expensive than conventional methods (Table I).

Using QuEChERS, samples are prepared in three simple steps. As shown on the following page, samples are first homogenized, then extracted and partitioned with an organic solvent and salt solution, with the extracts finally cleaned using the dSPE technique. Using the dSPE approach, the quantity and type of sorbents can easily be optimized for different matrix interferences and difficult analytes. Results from this approach have been verified and modified at several USDA and Food and Drug Administration labs, and the method now is widely accepted for many types of pesticide residue samples. Validation and proficiency data for the QuEChERS method are available for a wide variety of pesticides in several common food matrices at **www.quechers.com**

Restek Q-sep™ products make QuEChERS even simpler. All extraction salts, adsorbents, and sample tubes are included—no specialized equipment or glassware is required. The dSPE centrifuge tube format, available in 2 mL and 15 mL sizes, contains magnesium sulfate (to partition water from organic solvent) and PSA adsorbent (to remove sugars and fatty acids), with or without graphitized carbon (to remove pigments and sterols) or C18 (to remove nonpolar interferences). Custom products are available by request. If you are frustrated with the time and expense of your current pesticide sample cleanup procedure, we suggest you try this simple, economical new method.

Table I: Prepare samples more quickly, easily, and cost-effectively with QuEChERS.

	Mini-Luke or Modified Luke Method	QuEChERS	Savings with QuEChERS
Estimated time to process 6 samples (min)	120	30	4x faster
Solvent used (mL)	60-90	10	6-9x less solvent
Chlorinated waste (mL)	20-30	0	Safer, cheaper, greener
Glassware/specialized equipment	capacity for 200 mL, quartz wool, funnel, water bath, or evaporator	none	Ready-to-use

Try QuEChERS risk-free today!

Call 1-814-353-1300 or 1-800-356-1688 to request a free sample pack of Q-sep™ QuEChERS tubes.

Quick and Easy...

Prepare Samples for LC or GC Analysis in 3 Simple Steps

1. Blend

Homogenize the sample.

See QuEChERS in Action!

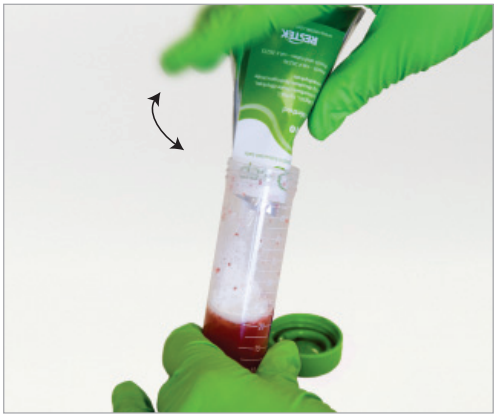
Restek Learning Network

visit **www.restek.com/webinars**

2. Extract and Dry

Add acetonitrile and internal standard, then shake vigorously for 1 minute.

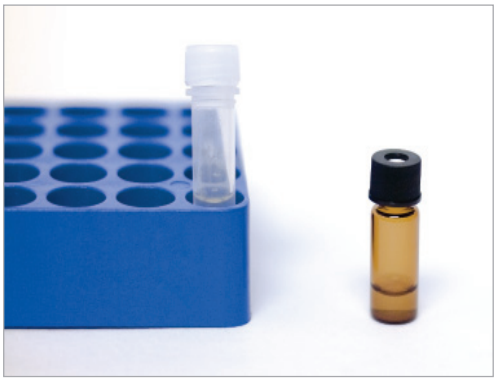
Add buffering salts and shake, then centrifuge for 5 minutes to separate the phases.



3. Clean Up

Transfer supernatant to dSPE tube.

Shake, centrifuge, and transfer to an autosampler vial for analysis by GC or LC.

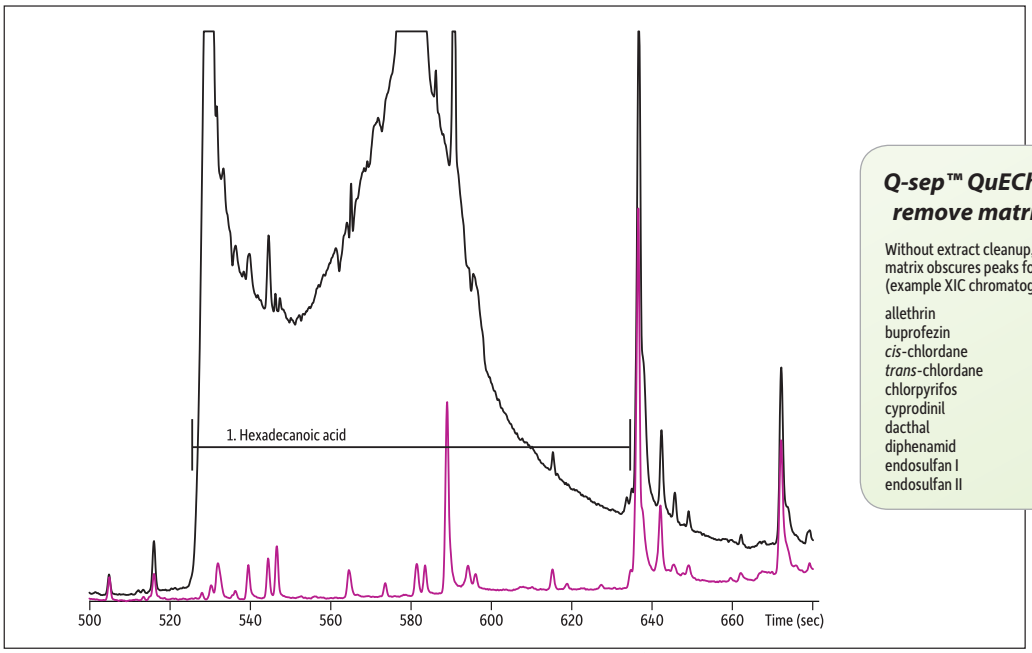


Effective...

QuEChERS dSPE Cleanup Assures Optimal Results for Pesticide Analysis

- Improves integration and mass spectral matches.
- Removes matrix interferences that obscure target analytes or cause ion suppression.
- Protects GC inlet, and LC and GC columns from contamination.

Figure 1: QuEChERS dSPE cleanup removes interferences that obscure target pesticides.

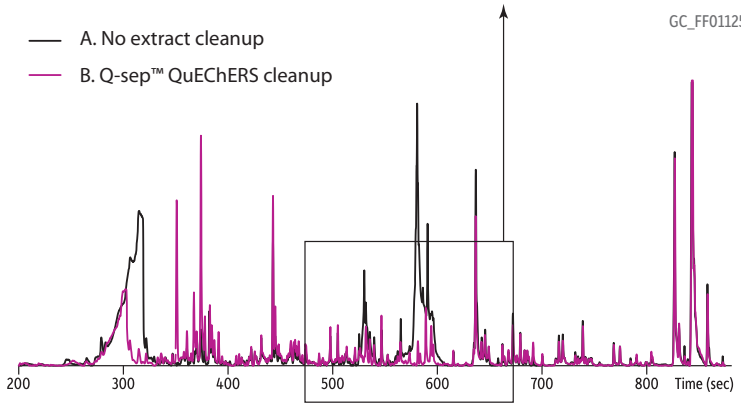


Q-sep™ QuEChERS tubes easily remove matrix interferences.

Without extract cleanup, hexadecanoic acid from the matrix obscures peaks for all the following pesticides. (example XIC chromatogram = endosulfan I)

allethrin
buprofezin
cis-chlordane
trans-chlordane
chlorpyrifos
cyprodinil
dacthal
diphenamid
endosulfan I
endosulfan II
fenthion
metolachlor
myclobutanil
oxyfluorfen
pendimethalin
pentachlorothioanisole
pirimiphos methyl
triadimefon
triadimenol

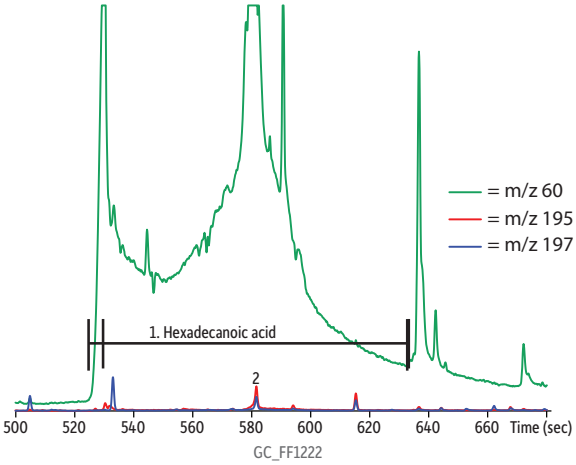
GC_FF01125-27



Column	Rxi®-5Sil MS, 20 m, 0.18 mm ID, 0.18 µm (cat.# 43602)
Sample	Sweet potato spiked with pesticide mix and extracted with acetonitrile and Q-sep™ QuEChERS EN Method 15662 extraction salts
Injection	
Inj. Vol.:	1.0 µL splitless (hold 1 min)
Liner:	Gooseneck splitless (4 mm) w/deact. wool (cat.# 22405)
Inj. Temp.:	250 °C
Oven	
Oven Temp:	72.5 °C (hold 1 min) to 350 °C at 20 °C/min
Carrier Gas	He, constant flow
Flow Rate:	1.2 mL/min
Detector	MS
Mode:	
Transfer Line Temp.:	300 °C
Analyzer Type:	TOF
Ionization Mode:	EI
Acquisition Range:	45-550 amu
Instrument	Agilent/HP6890 GC
Notes	A. Extract (without cleanup step) acidified with formic acid to pH 5 B. Extract with cleanup using Q-sep™ QuEChERS dSPE cleanup tube (cat.# 26124) acidified with formic acid to pH 5. Scan range: m/z 60, 73, 87, 129, 256 plotted

Figure 2: QuEChERS dSPE cleanup significantly improves quantification and identification.

Without cleanup, matrix masks Endosulfan I.

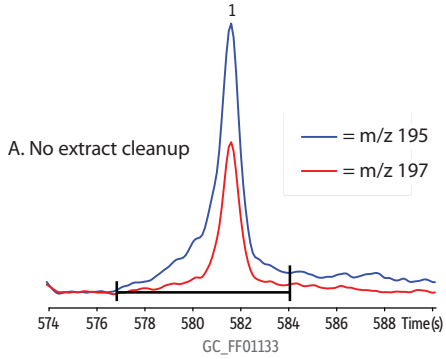


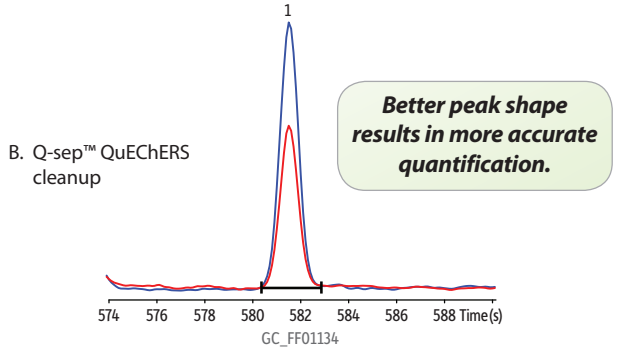
Peak List
1. Hexadecanoic acid
2. Endosulfan I

Column:	Rxi®-5Sil MS, 20 m, 0.18 mm ID, 0.18 µm (cat.# 43602)
Sample:	sweet potato spiked with pesticide mix, extracted with acetonitrile and Q-sep™ QuEChERS EN Method 15662 extraction salts, then acidified with formic acid to pH 5
Inj.:	1.0 µL splitless (hold 1 min.), 4 mm single gooseneck liner with w/wool (cat.# 22405)
Inj. temp.:	250°C
Carrier gas:	helium, constant flow
Flow rate:	1.2 mL/min.
Oven temp.:	72.5°C (hold 1 min.) to 350°C @ 20°C/min.
Det:	TOFMS
Transfer line temp.:	225°C
Scan range:	45-550 amu, m/z 60, 195, 197 plotted
Ionization:	EI
Instrument:	Agilent 6890, LECO Pegasus III

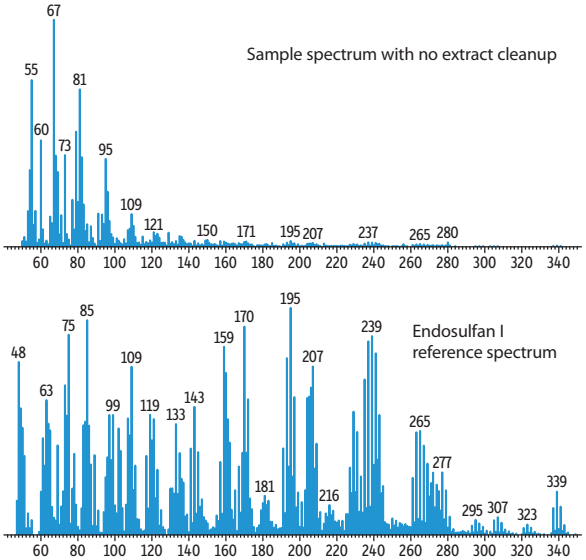
QuEChERS dSPE cleanup improves quantification and identification.

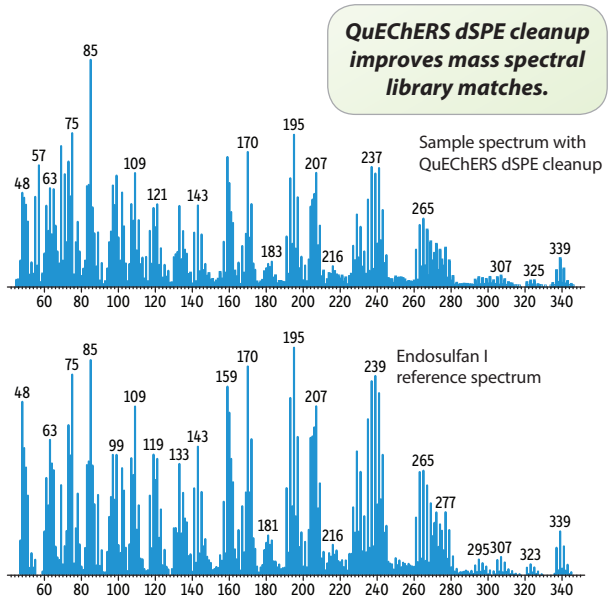
Peak Integration (extracted ion chromatograms)





Spectral Identification





Optimize Analysis with Sorbent Choice

Choosing a QuEChERS dSPE Sorbent

Primary and secondary amine exchange material (PSA) is the base sorbent used for QuEChERS dSPE cleanup of fruit and vegetable extracts because it removes many organic acids and sugars that might act as instrumental interferences. In addition, C18 or graphitized carbon black (GCB) may be used to remove lipids or pigments, respectively. Choice of sorbent should be based on matrix composition and target analyte chemistry. Most methods make specific recommendations for acidic, basic, and planar pesticides, which may require additional considerations.

As seen in Table II, GCB can have a negative effect on the recoveries of certain pesticides that can assume planar shapes (e.g. chlorothalonil and thiabendazole). The work shown here was done with 50 mg GCB per mL extract, which emphasizes this effect. The EN 15662 QuEChERS method recommends less GCB, which improves recoveries of planar pesticides, but still assures the removal of pigments that can degrade GC-MS performance. To simplify and speed up sample prep, Restek QuEChERS tubes are available in the sorbent combinations and amounts specified by EN 15662 and AOAC methods.

Table II: Select sorbents based on matrix and target analyte chemistry. (Percent recovery using C18 or GCB, relative to PSA alone).

Rt (min)	pesticide	CAS Number	action/use	classification	C18*	GCB**
9.50	dichlorvos	62-73-7	insecticide	organophosphorus	111	116
9.67	methamidophos	10265-92-6	insecticide	organophosphorus	105	107
11.75	mevinphos	7786-34-7	insecticide	organophosphorus	112	130
12.02	*o*-phenylphenol	90-43-7	fungicide	unclassified	106	97
12.14	acephate	30560-19-1	insecticide	organophosphorus	128	147
13.89	omethoate	1113-02-6	insecticide	organophosphorus	120	119
14.74	diazinon	333-41-5	insecticide	organophosphorus	108	127
14.98	dimethoate	60-51-5	insecticide	organophosphorus	124	151
15.69	chlorothalonil	1897-45-6	fungicide	organochlorine	125	13
15.86	vinclozolin	50471-44-8	fungicide	organochlorine	102	98
16.21	metalaxyl	57837-19-1	fungicide	organonitrogen	105	117
16.28	carbaryl	63-25-2	insecticide	carbamate	114	111
16.60	malathion	121-75-5	insecticide	organophosphorus	124	160
16.67	dichlofluanid	1085-98-9	fungicide	organohalogen	122	103
17.51	thiabendazole	148-79-8	fungicide	organonitrogen	88	14
17.70	captan	133-06-2	fungicide	organochlorine	88	91
17.76	folpet	133-07-3	fungicide	organochlorine	108	63
18.23	imazalil	35554-44-0	fungicide	organonitrogen	115	95
18.39	endrin	72-20-8	insecticide	organochlorine	104	101
18.62	myclobutanil	88671-89-0	fungicide	organonitrogen	119	114
19.07	4,4-DDT	50-29-3	insecticide	organochlorine	102	95
19.22	fenhexamid	126833-17-8	fungicide	organochlorine	118	77
19.40	propargite 1	2312-35-8	acaricide	organosulfur	110	95
19.43	propargite 2	2312-35-8	acaricide	organosulfur	121	114
19.75	bifenthrin	82657-04-3	insecticide	pyrethroid	106	81
20.04	dicofol	115-32-2	acaricide	organochlorine	98	54
20.05	iprodione	36734-19-7	fungicide	organonitrogen	118	90
20.21	fenpropathrin	39515-41-8	insecticide	pyrethroid	113	96
21.32	*cis*-permethrin	52645-53-1	insecticide	pyrethroid	106	65
21.47	*trans*-permethrin	51877-74-8	insecticide	pyrethroid	109	71
23.74	deltamethrin	52918-63-5	insecticide	pyrethroid	97	52

*50 mg PSA, 50 mg C18, **50 mg PSA, 50 mg GCB

$$\% \text{ recovery} = \frac{\text{RRF C18 or GCB}}{\text{RRF PSA}} \times 100$$

Strawberry extracts were spiked at 200 ng/mL with pesticides and subjected to dSPE with PSA only. Results were used to generate single point calibration curves. Spiked extracts were then subjected to additional dSPE sorbents (either C18 or GCB). Results are shown as percent recoveries relative to PSA alone.

Sorbent Guide

Sorbent	Removes
PSA*	sugars, fatty acids, organic acids, anthocyanine pigments
C18	lipids, nonpolar interferences
GCB**	pigments, sterols, nonpolar interferences

*PSA—primary and secondary amine exchange material
**GCB—graphitized carbon black

Try QuEChERS risk-free today!

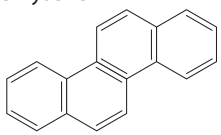
Call 1-814-353-1300 or 1-800-356-1688 to request a free sample pack of Q-sep™ QuEChERS tubes.

Example dSPE Cleanup: PAHs in Infant Formula

Analyzing polycyclic aromatic hydrocarbons (PAHs) in infant formula can be difficult as both the target analytes and certain matrix elements are lipophilic in nature and difficult to separate. Proper sorbent choice is critical to removing matrix interferences, while assuring good PAH recoveries. When choosing a sorbent, target analyte and matrix component chemistry must be considered. PAHs are relatively nonpolar, planar compounds with no pH-dependent functional groups. Infant formula typically contains significant amount of sugars and can be fortified with fatty acids.

Here, PSA was chosen for dSPE cleanup since both sugars and fatty acids can be removed through hydrogen bonding. Using PSA to remove these matrix compounds is optimal, because it will not bind to the relatively nonpolar PAHs, thus ensuring they remain available for analysis. GCB is not recommended here because it also can bind planar PAHs. (Note: GCB is not needed since infant formula does not contain pigments.) Based on the chemical structure of the analytes of interest, as well as the most dominant matrix compounds, PSA is the best choice when analyzing PAHs in infant formula.

Chrysene



Phenanthrene

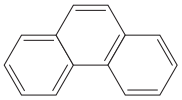
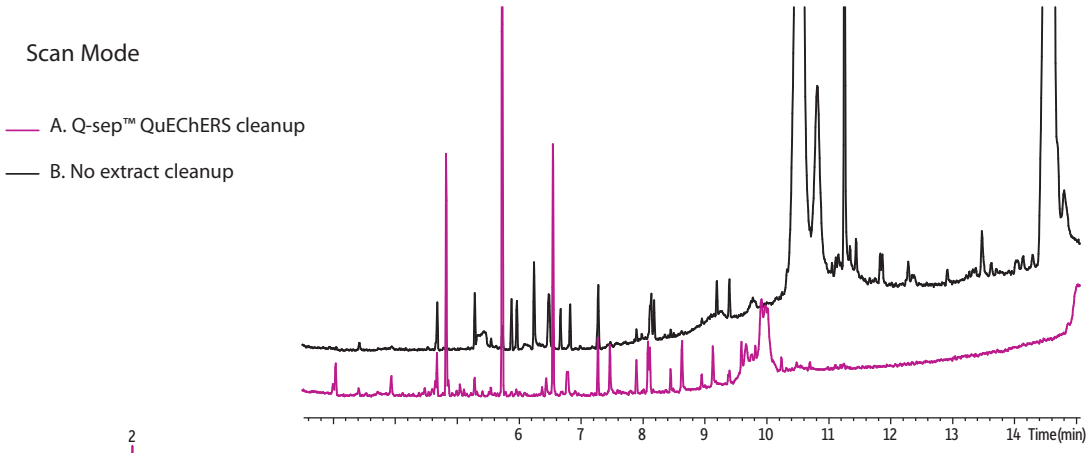


Figure 3: PSA is ideal for removing matrix sugars and fatty acids, while leaving PAHs behind for analysis.



Compound list and ions monitored (SIM mode)

Compound	m/z
1. decafluorobiphenyl (SS)	265
2. Naphthalene	128
3. 2-Methylnaphthalene	142
4. 1-Methylnaphthalene	142
5. Acenaphthylene	152
6. Acenaphthene	152
7. Fluorene	166
8. Phenanthrene-d10 (IS)	188
9. Phenanthrene	178
10. Anthracene	178
11. Fluoranthene	202
12. Pyrene	202
13. Benzo[a]anthracene	228
14. Chrysene	228
15. Benzo[b]fluoranthene	252
16. Benzo[k]fluoranthene	252
17. Benzo[a]pyrene	252
18. Indeno[1,2,3-cd]pyrene	276
19. Dibenz[a,h]anthracene	278
20. Benzo[ghi]perylene	276

Column Rxi®-5Sil MS, 30 m, 0.25 mm ID, 0.25 µm (cat.# 13623)
Sample See notes
Injection
Inj. Vol.: 1 µL splitless (hold 0.15 min)
Liner: 3.5 mm Gooseneck Splitless w/Wool (cat.# 22286-200.1)
Inj. Temp.: 300 °C
Oven
Oven Temp: 50 °C (hold 0.5 min) to 290 °C at 25 °C/min to 320 °C at 5 °C/min (hold 5 min)
Carrier Gas He, constant flow
Flow Rate: 1.4 mL/min

Detector MS
Mode: Scan
Transfer Line Temp.: 290 °C
Analyzer Type: Quadrupole
Ionization Mode: EI
Scan Range: 100-350 amu
Instrument Shimadzu 2010 GC & QP2010+ MS
Notes Sample Details:
Liquid infant formula spiked at 1 µg/mL with decafluorobiphenyl (cat.# 31842) and EPA Method 8310 PAH mixture (cat.# 31841) and at 0.5 µg/mL with internal standard phenanthrene-d10 (cat.# 31045), then extracted with acetonitrile and Q-sep™ QuEChERS extraction salts.
A. Extract with cleanup using Q-sep™ QuEChERS dSPE cleanup tube (cat.# 26215)
B. Extract without dSPE cleanup

Rugged Technique...

QuEChERS Methods for Complex and Varied Matrices

QuEChERS has been successfully applied to many different types of matrices. When developing procedures for your lab, start with these selected references—or visit **www.restek.com/quechers** for an expanded version that includes hyperlinks. (Note: references not available from Restek.)

General/Original

1. Fast and Easy Multiresidue Method Employing Acetonitrile Extraction/Partitioning and "Dispersive Solid-Phase Extraction" for the Determination of Pesticide Residues in Produce. (M. Anastassiades, S.J. Lehotay, D. Stajnbaher, F.J. Schenck, J. AOAC International 86 (2003) 412.)
2. QuEChERS—A Mini-Multiresidue Method for the Analysis of Pesticide Residues in Low-Fat Products. (http://www.quechers.com (accessed July 15, 2008).)
3. Pesticide Residues in Foods by Acetonitrile Extraction and Partitioning with Magnesium Sulfate. (AOAC Official Method 2007.01.)
4. Foods of Plant Origin—Determination of Pesticide Residues Using GC-MS and/or LC-MS/MS Following Acetonitrile Extraction/Partitioning and Cleanup by Dispersive SPE (QuEChERS-method). (EN 15662 Version 2008.)

General Fruits and Vegetables

5. Validation of a Fast and Easy Method for the Determination of Residues from 229 Pesticides in Fruits and Vegetables Using Gas and Liquid Chromatography and Mass Spectrometric Detection. (S.J. Lehotay, A. de Kok, M. Hiemstra, P. Van Bodegraven, J. AOAC Int. 88 (2005) 595.)
6. Multiresidue Analysis of 102 Organophosphorus Pesticides in Produce at Parts-Per-Billion Levels Using a Modified QuEChERS Method and Gas Chromatography with Pulsed Flame Photometric Detection. (F. Schenck, J. Wong, C. Lu, J. Li, J.R. Holcomb, L.M. Mitchell, J. AOAC Int. 92 (2009) 561.)

Dairy and Fatty Matrices

7. Evaluation of the QuEChERS Sample Preparation Approach for the Analysis of Pesticide Residues in Olives. (S.C. Cunha, S.J. Lehotay, K. Mastovska, J.O. Fernandes, M. Beatriz, P.P. Oliveira, J. Sep. Sci. 30 (2007) 620.)
8. Dispersive Solid-Phase Extraction Followed by Liquid Chromatography-Tandem Mass Spectrometry for the Multi-Residue Analysis of Pesticides in Raw Bovine Milk. (T. Dagnac, M. Garcia-Chao, P. Pulleiro, C. Garcia-Jares, M. Llompart, J. Chromatogr. A 1216 (2009) 3702.)

Grains, Nuts, and Seeds

9. A Multi-Residue Method for the Determination of 203 Pesticides in Rice Paddies Using Gas Chromatography/Mass Spectrometry. (T.D. Nguyen, E.M. Han, M.S. Seo, S.R. Kim, M.Y. Yun, D.M. Lee, G.H Lee, Anal. Chim. Acta 619 (2008) 67.)
10. Development of a Multi-Residue Method for the Determination of Pesticides in Cereals and Dry Animal Feed Using Gas Chromatography-Tandem Quadrupole Mass Spectrometry II. Improvement and Extension to New Analytes. (S. Walorczyk, J. Chromatogr. A 1208 (2008) 202.)

Oils

11. Simplified Pesticide Multiresidue Analysis of Soybean Oil by Low-Temperature Cleanup and Dispersive Solid-Phase Extraction Coupled with Gas Chromatography/Mass Spectrometry. (L. Li, Y. Xu, C. Pan, Z. Zhou, S. Jianc, F. Liu, J. AOAC Int. 90 (2007) 1387.)

Baby Food

12. Determination of 142 Pesticides in Fruit- and Vegetable-Based Infant Foods by Liquid Chromatography/Electrospray Ionization-Tandem Mass Spectrometry and Estimation of Measurement Uncertainty. (J. Wang, D. Leung, J. AOAC Int. 92 (2009) 279.)
13. Method for Routine Screening of Pesticides and Metabolites in Meat Based Baby-Food Using Extraction and Gas Chromatography-Mass Spectrometry. (C. Przybylski, C. Segard, J. Sep. Sci. 32 (2009) 1858.)

Non-Food Matrices

14. Multiresidue Analytical Method Using Dispersive Solid-Phase Extraction and Gas Chromatography/Ion Trap Mass Spectrometry to Determine Pharmaceuticals in Whole Blood. (F. Plössl, M. Giera, F. Bracher, J. Chromatogr. A 1135 (2006) 19.)
15. Comparison of Four Extraction Methods for the Analysis of 24 Pesticides in Soil Samples with Gas Chromatography-Mass Spectrometry and Liquid Chromatography-Ion Trap-Mass Spectrometry. (C. Lesueur, M. Gartner, A. Mentler, M. Fuerhacker, Talanta 75 (2008) 284.)

Muscle and Tissues

16. The Development and Validation of a Multiclass Liquid Chromatography Tandem Mass Spectrometry (LC-MS/MS) Procedure for the Determination of Veterinary Drug Residues in Animal Tissue Using a QuEChERS (QUick, Easy, CHeap, Effective, Rugged and Safe) Approach. (G. Stubbings, T. Bigwood, Anal. Chim. Acta 637 (2009) 68.)

Q-sep™ QuEChERS Products

Fast, Simple Sample Prep for Multiresidue Pesticide Analysis

- Ready-to-use tubes, no glassware required.
- Preweighed, ultra-pure sorbents.
- Support original unbuffered, AOAC (2007.01) and European (EN 15662) QuEChERS methods.

QuEChERS methods are fast, easy, and cost-effective, and Restek Q-sep™ products make QuEChERS procedures even simpler. All extraction salts, sorbents and sample tubes are included—no specialized equipment or glassware is required. Prepare samples more efficiently with a complete line of QuEChERS supplies from Restek.

MORE!

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Q-sep™ QuEChERS Sample Prep Packets & Tubes

Q-sep™ QuEChERS Extraction Salts

- Salt packets eliminate the need for a second empty tube to transfer salts.
- Go green by using packets with reusable tubes.
- Convenient and easy to use.

26235

Description	Material	Methods	qty.	cat#
Q-sep Kit	4 g $MgSO_4$, 1 g NaCl with 50 mL Centrifuge Tube	Original Unbuffered	50 packets & 50 tubes	23991
Q-sep Packets	4 g $MgSO_4$, 1 g NaCl	Original Unbuffered	50 packets	23992
Q-sep Kit	4 g $MgSO_4$, 1 g NaCl, 1 g TSCD, 0.5 g DHS with 50 mL Centrifuge Tube	European EN 15662	50 packets & 50 tubes	26235
Q-sep Packets	4 g $MgSO_4$, 1 g NaCl, 1 g TSCD, 0.5 g DHS	European EN 15662	50 packets	26236
Q-sep Kit	6 g $MgSO_4$, 1.5 g NaOAc with 50 mL Centrifuge Tube	AOAC 2007.01	50 packets & 50 tubes	26237
Q-sep Packets	6 g $MgSO_4$, 1.5 g NaOAc	AOAC 2007.01	50 packets	26238
Empty 50 mL Centrifuge Tube, Polypropylene			50-pk.	26239
Empty 50 mL Centrifuge Tube, FEP			2-pk.	23997

TSCD—trisodium citrate dihydrate; DHS—disodium hydrogen citrate sesquihydrate; NaOAc—sodium acetate

Q-sep™ QuEChERS dSPE Tubes for Extract Cleanup

- Packaged in mylar subpacks for enhanced protection and storage stability.
- Individually labeled tubes for easy sorbent identification.

26126

26123

Description	Methods	qty.	cat#
2 mL Micro-Centrifuge Tubes for dSPE (cleanup of 1 mL extract)			
150 mg $MgSO_4$, 25 mg PSA	Original Unbuffered, Mini-Multiresidue, European EN 15662	100-pk.	26215
150 mg $MgSO_4$, 25 mg PSA, 25 mg C18	Mini-Multiresidue	100-pk.	26216
150 mg $MgSO_4$, 25 mg PSA, 2.5 mg GCB	Mini-Multiresidue, European EN 15662	100-pk.	26217
150 mg $MgSO_4$, 25 mg PSA, 7.5 mg GCB	Mini-Multiresidue, European EN 15662	100-pk.	26218
150 mg $MgSO_4$, 50 mg PSA	AOAC 2007.01	100-pk.	26124
150 mg $MgSO_4$, 50 mg PSA, 50 mg C18	AOAC 2007.01	100-pk.	26125
150 mg $MgSO_4$, 50 mg PSA, 50 mg GCB	AOAC 2007.01	100-pk.	26123
150 mg $MgSO_4$, 50 mg PSA, 50 mg C18, 50 mg GCB	AOAC 2007.01	100-pk.	26219
150 mg $MgSO_4$, 50 mg C18	NA	100-pk.	26242
150 mg $MgSO_4$, 50 mg PSA, 50 mg C18, 7.5 mg GCB	Universal	100-pk.	26243
15 mL Centrifuge Tubes for dSPE (cleanup of 6 mL and 8 mL extract)			
1200 mg $MgSO_4$, 400 mg PSA	AOAC 2007.01	50-pk.	26220
1200 mg $MgSO_4$, 400 mg PSA, 400 mg C18	AOAC 2007.01	50-pk.	26221
1200 mg $MgSO_4$, 400 mg PSA, 400 mg C18, 400 mg GCB	AOAC 2007.01	50-pk.	26222
1200 mg $MgSO_4$, 400 mg C18	similar to AOAC 2007.01	50-pk.	26244
900 mg $MgSO_4$, 150 mg PSA	Original Unbuffered, European EN 15662	50-pk.	26223
900 mg $MgSO_4$, 150 mg PSA, 15 mg GCB	European EN 15662	50-pk.	26224
900 mg $MgSO_4$, 150 mg PSA, 45 mg GCB	European EN 15662	50-pk.	26225
900 mg $MgSO_4$, 150 mg PSA, 150 mg C18	similar to European EN 15662	50-pk.	26226
900 mg $MgSO_4$, 300 mg PSA, 300 mg C18, 45 mg GCB	similar to European EN 15662	50-pk.	26245
900 mg $MgSO_4$, 300 mg PSA, 150 mg GCB	NA	50-pk.	26126

PSA—primary and secondary amine exchange material; GCB—graphitized carbon black

Sorbent Guide

Sorbent	Removes
PSA	sugars, fatty acids, organic acids, anthocyanine pigments
C18	lipids, nonpolar interferences
GCB	pigments, sterols, nonpolar interferences

Q-sep™ Accessories

Q-sep™ Bottle Top Solvent Dispenser

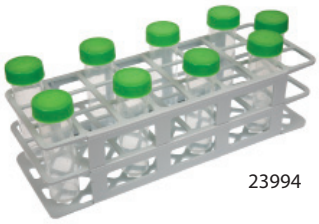
- Adjustment knob offers 56 output volume settings from 2.5 mL to 30 mL per stroke (0.5 mL increments)—ideal for QuEChERS methods!
- Base features 30 mm threads and includes four adaptors (25 mm, 28 mm, 38 mm, and 45 mm).
- Individually calibrated in accordance with ISO 8655 standards (certificate included) and can also be recalibrated by the user.
- PTFE, glass, and polypropylene construction for excellent chemical compatibility and 100% autoclavability.
- Integral safety discharge reduces risk of accidental dispensing and nozzle cap prevents dripping.
- Easy to disassemble for cleaning and servicing.

Accurately and precisely dispense liquids for QuEChERS extractions with this versatile pump. A quick, simple adjustment lets you set the output volume anywhere from 2.5 mL to 30 mL per stroke, and the included adaptors will accommodate most reagent bottles.

Description	qty.	cat.#
Q-sep Bottle Top Solvent Dispenser, 2.5 mL - 30 mL	ea.	23990

Q-sep™ Tube Racks

- Available for 2 mL, 15 mL, and 50 mL tubes.
- Alphanumerical grid reference on top tier for easy identification of samples.
- Easy to assemble, simply fold and snap together securely.


23994


23995

Description	Size	Material	qty.	cat.#
Q-sep Tube Rack for 2 mL Centrifuge Tube	Holds 100	Polypropylene, White	ea.	23995
Q-sep Tube Rack for 15 mL Centrifuge Tube	Holds 60	Polypropylene, White	ea.	23993
Q-sep Tube Rack for 50 mL Centrifuge Tube	Holds 24	Polypropylene, White	ea.	23994

Q-sep™ 3000 Centrifuge

- Meets or exceeds requirements of original unbuffered, AOAC, and European QuEChERS methodology.
- Supports 50 mL, 15 mL, and 2 mL centrifuge tubes.
- Small footprint requires less bench space.
- Safe and reliable—UL, CSA, and CE approved, 1-year warranty.

Centrifuge includes 50 mL tube carriers (6), 50 mL conical tube inserts (6), 4-place 15 mL tube carriers (6), and 2 mL tube adaptors (24).

Dimensions:
9"h x 14.5"w x 17"d
(22.9 cm x 36.8 cm
x 43.2 cm)

Description	qty.	cat.#
Q-sep 3000 Centrifuge, 110V	ea.	26230
Q-sep 3000 Centrifuge, 220V	ea.	26231
Replacement Accessories		
50 mL Tube Carrier for Q-sep 3000 Centrifuge	2-pk.	26232
50 mL Conical Tube Insert for Q-sep 3000 Centrifuge	6-pk.	26249
4-Place Tube Carrier for Q-sep 3000 Centrifuge	2-pk.	26233
2 mL Tube Adaptors for Q-sep 3000 Centrifuge	4-pk.	26234

GC and HPLC Columns

Rxi®-5Sil MS Columns (fused silica)

(low polarity Crossbond® silarylene phase; similar to 5% phenyl/95% dimethyl polysiloxane)

- Engineered to be a low bleed GC-MS column.
- Excellent inertness for active compounds.
- Temperature range: -60 °C to 350 °C.

Description	temp. limits	cat.#
20 m, 0.18 mm ID, 0.18 µm	-60 to 330/350 °C	43602
20 m, 0.18 mm ID, 0.36 µm	-60 to 330/350 °C	43604
30 m, 0.25 mm ID, 0.25 µm	-60 to 330/350 °C	13623
30 m, 0.25 mm ID, 0.50 µm	-60 to 330/350 °C	13638

Ultra Aqueous C18 Columns (USP L1)

particle size: 3µm or 5µm, spherical
pore size: 100Å
carbon load: 15%
endcap: no
pH range: 2.5 to 8
temperature limit: 80 °C

Highly retentive and selective for reversed phase separations of polar analytes. Highly base-deactivated. Compatible with highly aqueous (up to 100%) mobile phases.

Length		1.0 mm ID cat.#	2.1 mm ID cat.#	3.2 mm ID cat.#	4.6 mm ID cat.#
3µm Columns	30 mm	9178331	9178332	9178333	9178335
	50 mm	9178351	9178352	9178353	9178355
	100 mm	9178311	9178312	9178313	9178315
	150 mm	9178361	9178362	9178363	9178365
5µm Columns	30 mm	9178531	9178532	9178533	9178535
	50 mm	9178551	9178552	9178553	9178555
	100 mm	9178511	9178512	9178513	9178515
	150 mm	9178561	9178562	9178563	9178565
	200 mm	9178521	9178522	9178523	9178525
	250 mm	9178571	9178572	9178573	9178575

Inlet Liners

23303.1

For Agilent GCs equipped with split/splitless inlets

Sky™ 2.0 mm ID Inlet Liners for Agilent MMI

2.0 mm ID x 6.4 mm x 78.5 mm Length	ea.	5-pk.
Single Taper w/Dimple, Sky Technology, Borosilicate Glass	23334.1	23334.5

Sky™ 4.0 mm ID Single Taper Inlet Liner w/ Wool

4.0 mm ID x 6.5 mm OD x 78.5 mm Length	ea.	5-pk.	25-pk.
Single Taper, Sky Technology, Wool	23303.1	23303.5	23303.25

Sky™ 4.0 mm ID Single Taper Inlet Liner

4.0 mm ID x 6.5 mm OD x 78.5 mm Length	ea.	5-pk.	25-pk.
Single Taper, Sky Technology	23302.1	23302.5	23302.25

Sky™ 4.0 mm ID Cyclo Double Taper Inlet Liner

4.0 mm ID x 6.5 mm OD x 78.5 mm Length	ea.	5-pk.	25-pk.
Cyclo Double Taper, Sky Technology	23310.1	23310.5	23310.25

Sky™ 4.0 mm ID Double Taper Inlet Liner

4.0 mm ID x 6.5 mm OD x 78.5 mm Length	ea.	5-pk.	25-pk.
Double Taper, Sky Technology	23308.1	23308.5	23308.25

5.0 mm ID Single Taper Inlet Liner

5.0 mm ID x 6.5 mm OD x 78.5 mm Length	ea.	5-pk.
Single Taper, Intermediate Polarity (IP), Borosilicate Glass	22973	22974

5.0 mm ID Single Taper Inlet Liner w/ Wool

5.0 mm ID x 6.5 mm OD x 78.5 mm Length	ea.	5-pk.
Single Taper, Intermediate Polarity (IP), Deact. Wool, Borosilicate Glass	22973-200.1	22974-200.5

QuEChERS Standards

- Ready to use for QuEChERS extractions—no dilutions necessary.
- Support for GC and HPLC with MS, MS/MS, and selective detectors.

QuEChERS Internal Standard Mix for GC-ECD Analysis (4 components)

PCB 18 PCB 52
PCB 28 tris-(1,3-dichloroisopropyl)phosphate

50 µg/mL each in acetonitrile, 5 mL/ampul cat.# 33265 (ea.)

QuEChERS Internal Standard Mix for GC-MS

PCB 18	50 µg/mL	triphenyl phosphate	20
PCB 28	50	tris-(1,3-dichloroisopropyl)phosphate	50
PCB 52	50	triphenylmethane	10

In acetonitrile, 5 mL/ampul cat.# 33267 (ea.)

QuEChERS Internal Standard Mix for GC-NPD and LC-MS/MS Analysis

triphenyl phosphate 20µg/mL
tris-(1,3-dichloroisopropyl)phosphate 50µg/mL

In acetonitrile, 5 mL/ampul cat.# 33266 (ea.)

QuEChERS Single-Component Reference Standards

Concentration is µg/mL.

Compound	CAS #	Solvent	Conc.	cat.#
PCB 18 (5 mL)	37680-65-2	ACN	50	33255
PCB 28 (5 mL)	7012-37-5	ACN	50	33256
PCB 52 (5 mL)	35693-99-3	ACN	50	33257
PCB 138 (5 mL)	35065-28-2	ACN	50	33262
PCB 153 (5 mL)	35065-27-1	ACN	50	33263
triphenylmethane (5 mL)	519-73-3	ACN	10	33260
triphenylphosphate (5 mL)	115-86-6	ACN	20	33258
tris(1,3-dichloroisopropyl) phosphate (5 mL)	13674-87-8	ACN	50	33259

ACN = acetonitrile

QuEChERS Internal Standard Mix for LC-MS/MS Analysis

nicarbazin

10 µg/mL in acetonitrile, 5 mL/ampul cat.# 33261 (ea.)

QuEChERS Quality Control Standards for GC-MS Analysis

PCB 138 PCB 153
50 µg/mL each in acetonitrile, 5 mL/ampul cat.# 33268 (ea.)

anthracene
100 µg/mL in acetonitrile, 5 mL/ampul cat.# 33264 (ea.)

AOAC QuEChERS QC Spike Mix (27 components)

40 µg/mL each in acetonitrile:acetic acid (99.9:0.1), 5 mL/ampul
cat.# 31999 (ea.)

AOAC QuEChERS Triphenylphosphate Solution

triphenylphosphate

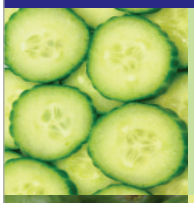
2 µg/mL in acetonitrile:acetic acid (99:1), 5 mL/ampul cat.# 31964 (ea.)

AOAC QuEChERS IS Solution

α-BHC-d6 (α-HCH-d6) parathion-d10

40 µg/mL each in acetonitrile, 5 mL/ampul cat.# 31963 (ea.)

Selection Guide for Q-sep™ dSPE Tubes

Commodity types and examples	AOAC 2007.01	EN 15662	Mini-multiresidue	Additional products
 **Low fat & low pigment fruits & vegetables** • Celery • Cucumber • Head lettuce • Melon	**2 mL, 100-pk.** (cat.# 26124) **15 mL, 50-pk.** (cat.# 26220)	**2 mL, 100-pk.** (cat.# 26215) **15 mL, 50-pk.** (cat.# 26223)	**2 mL, 100-pk.** (cat.# 26215)	
 **Fatty or waxy fruits & vegetables** • Cereals • Avocado • Nuts & seeds • Dairy	**2 mL, 100-pk.** (cat.# 26125) **15 mL, 50-pk.** (cat.# 26221)		**2 mL, 100-pk.** (cat.# 26216)	**15 mL, 50-pk.** (cat.# 26226) **2 mL, 100-pk.** (cat.# 26242) **15 mL, 50-pk.** (cat.# 26244)
 **Pigmented fruits & vegetables** • Strawberries • Sweet potatoes • Tomatoes	**15 mL, 50-pk.** (cat.# 26222)	**2 mL, 100-pk.** (cat.# 26217) **15 mL, 50-pk.** (cat.# 26224)	**2 mL, 100-pk.** (cat.# 26217)	**2 mL, 100-pk.** (cat.# 26123)
 **Highly pigmented fruits & vegetables** • Red peppers • Spinach • Blueberries	**2 mL, 100-pk.** (cat.# 26219)	**2 mL, 100-pk.** (cat.# 26218) **15 mL, 50-pk.** (cat.# 26225)	**2 mL, 100-pk.** (cat.# 26218)	**15 mL, 50-pk.** (cat.# 26126)
 **Universal use** Wide range of commodities, including fatty & pigmented fruits & vegetables.				**2 mL, 100-pk.** (cat.# 26243) **15 mL, 50-pk.** (cat.# 26245)
Download free instructions at **www.restek.com/quechers**	Instruction sheet# 805-01-002	Instruction sheet# 805-01-001	Instruction sheet# 805-01-001	Generic dSPE 805-01-003

RESTEK

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Restek France • phone: +33 (0)1 60 78 32 10 • fax: +33 (0)1 60 78 70 90 • e-mail: restek@restekfrance.fr
Restek GmbH • phone: +49 (0)6172 2797 0 • fax: +49 (0)6172 2797 77 • e-mail: info@restekgmbh.de
Restek Ireland • phone: +44 (0)2890 814576 • fax: +44 (0)2890 814576 • e-mail: restekireland@aol.com
Restek Japan • phone: +81 (3)6459 0025 • fax: +81 (3)6459 0025 • e-mail: restekjapan@restek.com
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Solutions for Your Petro Analyses

Visit us at **www.restek.com/petro**

Get More Runs from Your SimDist Setup Using Stabilized MXT®-1HT Columns

- Stable up to 450 °C—lowest bleed column, for longer lifetime.
- Meets all ASTM D6352 and D7500 specifications.
- 100% dimethyl polysiloxane phase allows easy comparisons to historical data.
- Unbreakable columns offer security when using hydrogen.

Accurate determination of the boiling range distribution of medium and heavy fractions using GC simulated distillation requires columns and phase polymers that are robust enough to withstand the high method temperatures without significant degradation. Metal columns are a much better alternative than fused silica, and the MXT®-1HT SimDist columns, with stabilized dimethyl polysiloxane polymer, outperform other metal columns for critical method parameters, including bleed and C50/C52 resolution (Figures 1 and 2). Field testing of the MXT®-1HT SimDist column shows excellent performance, even under faster analytical conditions than those in the published method (Figure 3). Note that in both cases bleed is minimal, even at 430 °C, which is essential for precise time-slices and accurate final boiling point determination. MXT®-1HT SimDist columns are the lowest bleed column on the market, which translates directly into more analyses per calibration and longer column lifetimes.

Figure 1: Low-bleed, high-efficiency MXT®-1HT SimDist columns outperform competitors (ASTM D6352 conditions).

Lower bleed means:

- Longer column lifetime.
- More stable calibrations.
- Accurate boiling point determinations.

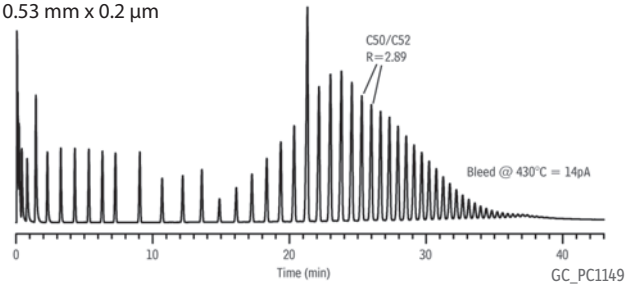
RESTEK® ADVANTAGE:
Longer column lifetime and more accurate data!

Higher efficiency means:

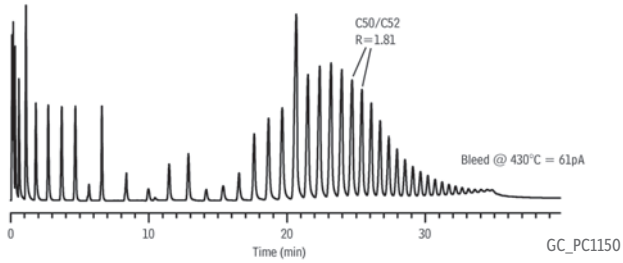
- Greater resolution; analyze more samples before method criteria are reached.
- Assured method performance.

RESTEK® ADVANTAGE:
Run more samples within method specifications!

Restek, 5 m x 0.53 mm x 0.2 µm



Agilent/J&W, 5 m x 0.53 mm x 0.15 µm



Varian, 5 m x 0.53 mm x 0.17 µm

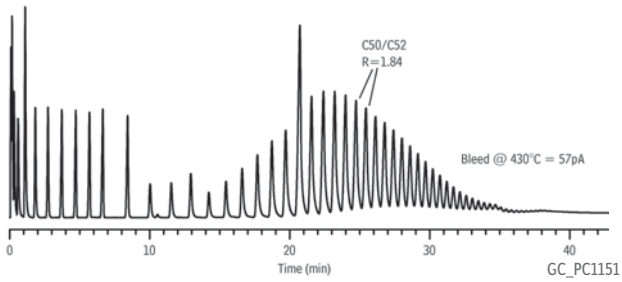
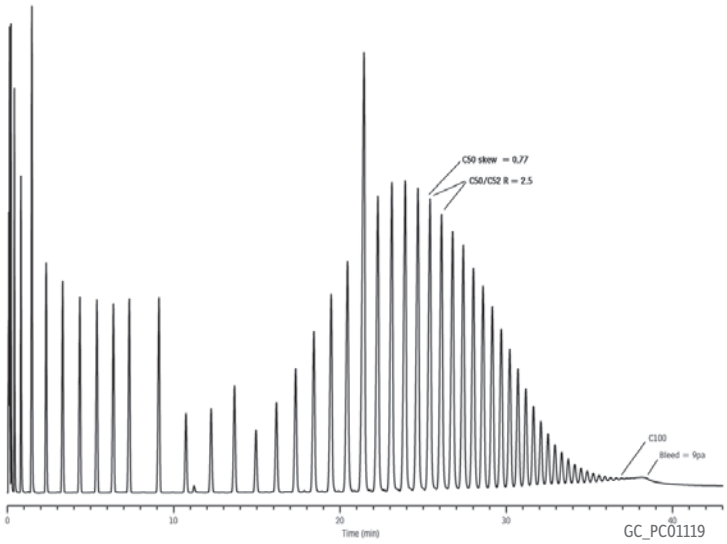


Figure 2: Superior resolution and peak shape on MXT®-1HT SimDist columns result in more accurate final boiling point determinations.



Column	MXT®-1HT SimDist, 5 m, 0.53 mm ID, 0.20 µm (cat.# 70115)	**Oven**	
Sample	C5-C100	Oven Temp.:	50 °C to 430 °C at 10 °C/min (hold 5 min)
Diluent:	carbon disulfide	**Carrier Gas**	He, constant flow
Conc.:	1 % each	Flow Rate:	18 mL/min
Injection		**Detector**	FID @ 430 °C
Inj. Vol.:	1 µL ptv splitless	**Instrument**	Shimadzu 2010 GC
Liner:	on column		
Inlet Temp. Program:	53 °C to 430 °C at 10 °C/min (hold 5 min)		

SimDist Products

Method Recommended Columns

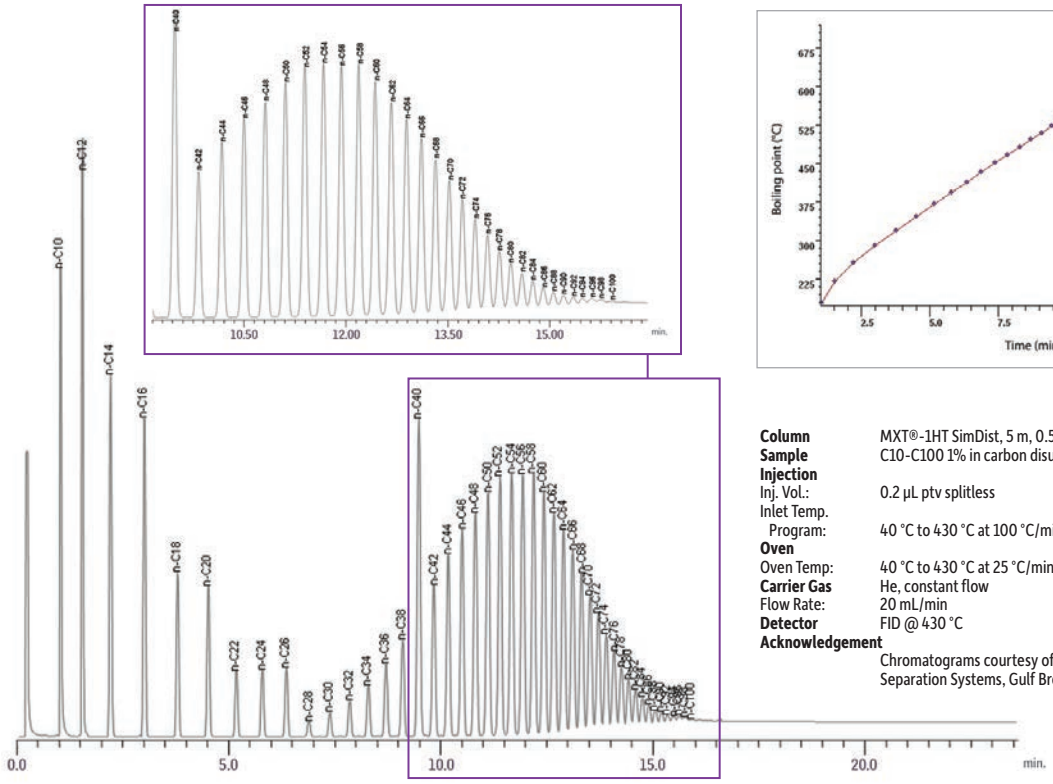
ASTM Method	Hydrocarbon Range	Dimensions	cat.#
D2887	C5–C44	5 m x 0.53 mm, 0.88 µm	70131
		10 m x 0.53 mm, 2.65 µm	70132
D7213 (D2887-ext)	C5–C60	5m x 0.53 mm, 0.88 µm	70131
		5 m x 0.53 mm, 0.20 µm	70115
		5 m x 0.53 mm, 0.10 µm	70112
D3710	gasoline up to C14	10 m x 0.53 mm, 2.65 µm	70132
D7096	gasoline up to C16	10 m x 0.53 mm, 2.65 µm	70132
D5307	crude up to C42	5 m x 0.53 mm, 0.20 µm	70115
D6352	C10–C90	5 m x 0.53 mm, 0.10 µm	70112
		5 m x 0.53 mm, 0.20 µm	70115
D7500	C7–C110	5 m x 0.53 mm, 0.10 µm	70112
		5 m x 0.53 mm, 0.20 µm	70115
D7169	C5–C100	5 m x 0.53 mm, 0.10 µm	70112
		5 m x 0.53 mm, 0.20 µm	70115

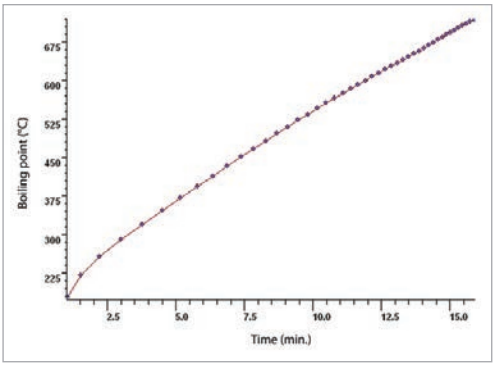
MXT®-1HT SimDist Column

(Siltek®-treated stainless steel) (nonpolar phases)

Description	temp. limits	qty.	cat.#
5 m, 0.53 mm ID, 0.10 µm	-60 to 400/450 °C	ea.	70112
5 m, 0.53 mm ID, 0.20 µm	-60 to 400/430 °C	ea.	70115
10 m, 0.53 mm ID, 0.21 µm	-60 to 400/430 °C	ea.	70118
5 m, 0.53 mm ID, 0.88 µm	-60 to 380/430 °C	ea.	70131
10 m, 0.53 mm ID, 0.88 µm	-60 to 400/430 °C	ea.	70134
10 m, 0.53 mm ID, 1.00 µm	-60 to 380/400 °C	ea.	70130
10 m, 0.53 mm ID, 1.20 µm	-60 to 380/380 °C	ea.	70119
10 m, 0.53 mm ID, 2.65 µm	-60 to 360/400 °C	ea.	70132
10 m, 0.53 mm ID, 5.00 µm	-60 to 360/400 °C	ea.	70133

Figure 3: Robust MXT®-1HT SimDist columns meet all ASTM D6352 requirements, even under accelerated conditions.





Column	MXT®-1HT SimDist, 5 m, 0.53 mm ID, 0.20 µm (cat.# 70103)
Sample	C10-C100 1% in carbon disulfide
Injection	
Inj. Vol.:	0.2 µL ptv splitless
Inlet Temp. Program:	40 °C to 430 °C at 100 °C/min
Oven	
Oven Temp:	40 °C to 430 °C at 25 °C/min
Carrier Gas	He, constant flow
Flow Rate:	20 mL/min
Detector	FID @ 430 °C
Acknowledgement	Chromatograms courtesy of Joaquin Lubkowitz, Separation Systems, Gulf Breeze, FL.

Chromatograms courtesy of Joaquin Lubkowitz, Separation Systems, Gulf Breeze, FL.

GC_PC01120

Protect Equipment and Assure Predictable Retention Times Using Bonded PLOT Column Technology

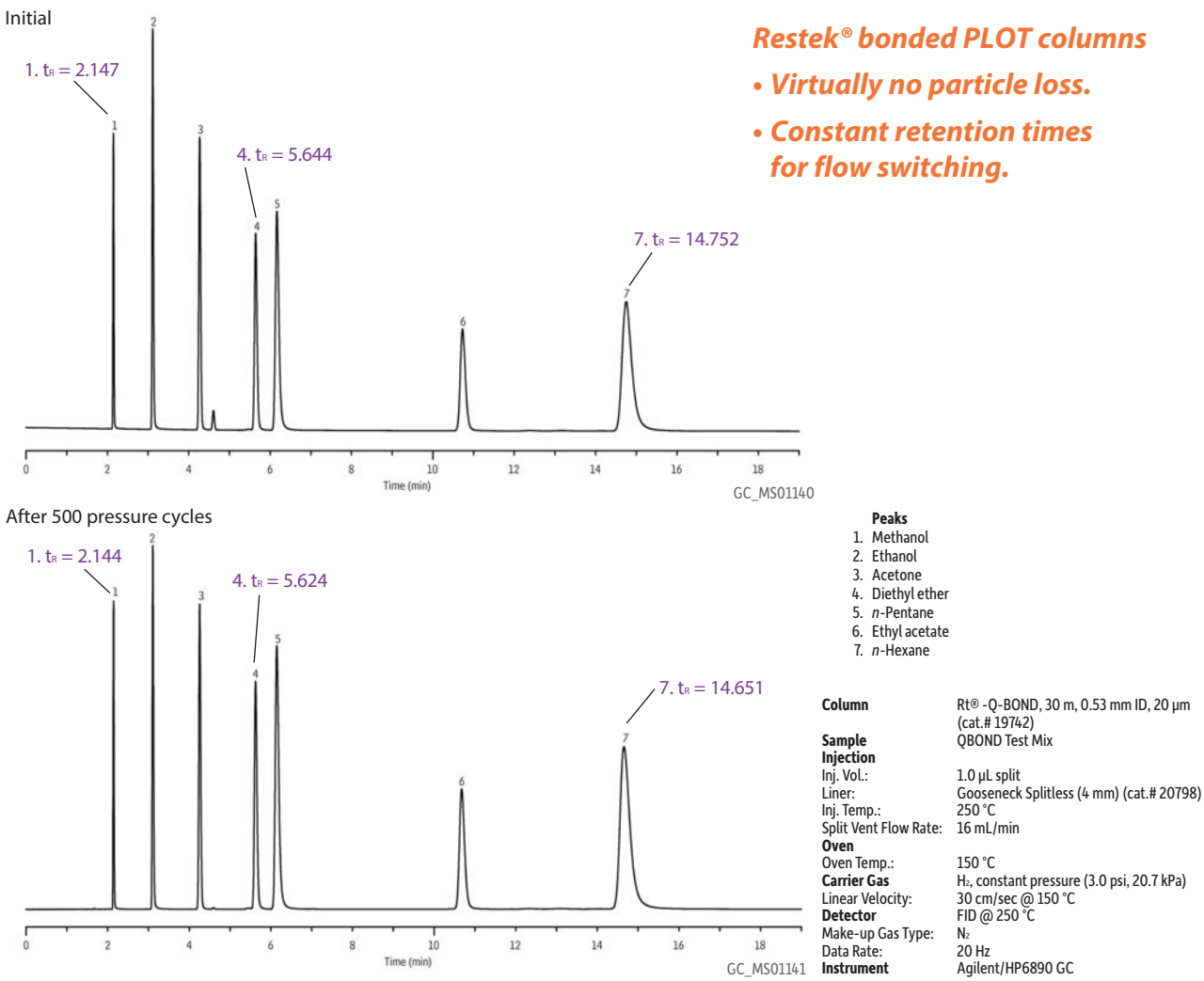
- Bonding process minimizes particle release, reducing column blockage and protecting instrument parts.
- More consistent flow means stable retention times; ideal for Deans and related flow switching techniques.
- Outstanding peak symmetry improves accuracy of impurity analysis for gases, solvents, and hydrocarbons.

PLOT columns are widely used in the petroleum industry because their retention and selectivity characteristics allow gases and volatiles to be separated with high resolution at above ambient temperatures. However, the utility of PLOT columns is significantly limited by the mechanical instability of the particle layers. Routine vibrations or changes in gas pressure can cause a release of particles that clog the column, resulting in highly variable flow behaviors over time and between columns.

Restek has developed a bonding process that established a new benchmark for PLOT column stabilization. This innovative process significantly reduces particle release and column blockage, resulting in highly stable flows and retention times, both run-to-run and column-to-column (Figure 4). By replacing conventional PLOT columns with bonded PLOT columns manufactured using this Restek® technology, labs can increase the accuracy of impurities analysis and make better process decisions.

This stabilization technology is especially beneficial to flow switching applications and is available for porous polymer (4 selectivities), alumina (MAPD, CFC, KCl, and Na_2SO_4 deactivations), and molecular sieve PLOT columns.

Figure 4: Restek® PLOT column technology assures stable retention times, even after 500 pressure cycles.



Fused Silica PLOT Columns

Rt®-Q-BOND Columns (fused silica PLOT)

100% divinylbenzene

- Nonpolar PLOT column incorporating 100% divinylbenzene.
- Excellent for analysis of C1 to C3 isomers and alkanes up to C12.
- High retention for CO_2 simplifies gas analysis; CO_2 and methane separated from $O_2/N_2/CO$ (Note: $O_2/N_2/CO$ not separated at room temperature).
- Use for analysis of oxygenated compounds and solvents.
- Maximum temperature of 300 °C.

ID	df	temp. limits	15-Meter cat.#	30-Meter cat.#
0.25 mm	8 µm	to 280/300 °C	19764	19765
0.32 mm	10 µm	to 280/300 °C	19743	19744
0.53 mm	20 µm	to 280/300 °C	19741	19742

Rt®-QS-BOND Columns (fused silica PLOT)

porous divinylbenzene homopolymer

- Intermediate polarity PLOT column incorporating low 4-vinylpyridine.
- Separates ethane, ethylene, and acetylene to baseline.

ID	df	temp. limits	15-Meter cat.#	30-Meter cat.#
0.25 mm	8 µm	to 250 °C	19767	19768
0.32 mm	10 µm	to 250 °C	19739	19740
0.53 mm	20 µm	to 250 °C	19737	19738

Rt®-S-BOND Columns (fused silica PLOT)

porous divinylbenzene homopolymer

- Midpolarity PLOT column, incorporating high 4-vinylpyridine.
- Use for the analysis of nonpolar and polar compounds.

ID	df	temp. limits	15-Meter cat.#	30-Meter cat.#
0.25 mm	8 µm	to 250 °C	19769	19770
0.32 mm	10 µm	to 250 °C	19747	19748
0.53 mm	20 µm	to 250 °C	19745	19746

Rt®-U-BOND Columns (fused silica PLOT)

divinylbenzene ethylene glycol/dimethylacrylate

- Polar PLOT column, incorporating divinylbenzene ethylene glycol/dimethylacrylate.
- Use for the analysis of polar and nonpolar compounds.

ID	df	temp. limits	15-Meter cat.#	30-Meter cat.#
0.25 mm	8 µm	to 190 °C	19771	19772
0.25 mm	12 µm	to 190 °C	19782	—
0.32 mm	10 µm	to 190 °C	19751	19752
0.53 mm	20 µm	to 190 °C	19749	19750

did you know?

Restek® chemists developed a new process for manufacturing PLOT columns. This process bonds the particles to the walls of the tubing, so there is virtually no particle generation. Reduced particle generation assures reproducible selectivity and flow on every run and every column.

Rt®-Alumina BOND/KCl Columns (fused silica PLOT)

(KCl deactivation)

ID	df	temp. limits	30-Meter cat.#	50-Meter cat.#
0.25 mm	4 µm	to 200 °C	19776	—
0.32 mm	5 µm	to 200 °C	19761	19762
0.53 mm	10 µm	to 200 °C	19759	19760

Rt®-Alumina BOND/Na_2SO_4 Columns (fused silica PLOT)

(Na_2SO_4 deactivation)

ID	ID	temp. limits	30-Meter cat.#	50-Meter cat.#
0.25 mm	4 µm	to 200 °C	19775	—
0.32 mm	5 µm	to 200 °C	19757	19758
0.53 mm	10 µm	to 200 °C	19755	19756

Rt®-Alumina BOND/CFC Columns (fused silica PLOT)

ID	df	temp. limits	30-Meter cat.#
0.53 mm	10 µm	to 200 °C	19763

Rt®-Alumina BOND/MAPD Columns (fused silica PLOT)

ID	df	temp. limits	30-Meter cat.#	50-Meter cat.#
0.25 mm	4 µm	to 250 °C	19781	—
0.32 mm	5 µm	to 250 °C	19779	19780
0.53 mm	10 µm	to 250 °C	19777	19778

Rt®-Msieve 5A Columns (fused silica PLOT)

ID	df	temp. limits	15-Meter cat.#	30-Meter cat.#
0.25 mm	20 µm	to 300 °C	19773	—
0.32 mm	30 µm	to 300 °C	19720	19722
0.53 mm	50 µm	to 300 °C	19721	19723

Metal MXT® PLOT Columns

Advantages of metal MXT® PLOT columns include:

- Can be made in small coil diameters—perfect for tight spaces.
- Rugged material withstands rough handling and shock.
- Designed for robust performance in process GCs and field instruments.
- Available in 3.5"-coil diameter or 7"-diameter, 11-pin cage.

ID	df	temp. limits	3.5" coil 15-Meter cat.#	7" diameter 11-pin cage 15-Meter cat.#	3.5" coil 30-Meter cat.#	7" diameter 11-pin cage 30-Meter cat.#
MXT-Msieve 5A						
0.25 mm	20 µm	to 300 °C	79717-273	79717	—	—
0.53 mm	50 µm	to 300 °C	—	—	79723-273	79723
MXT-Alumina BOND/Na_2SO_4						
0.53 mm	10 µm	to 200 °C	—	—	79714-273	79714
MXT-Alumina BOND/MAPD						
0.53 mm	10 µm	to 250 °C	—	—	79728-273	79728
MXT-Q-BOND						
0.25 mm	8 µm	to 300 °C	79718-273	79718	—	—
0.53 mm	20 µm	to 280/300 °C	—	—	79716-273	79716
MXT-S-BOND						
0.53 mm	20 µm	to 250 °C	—	—	79712-273	79712

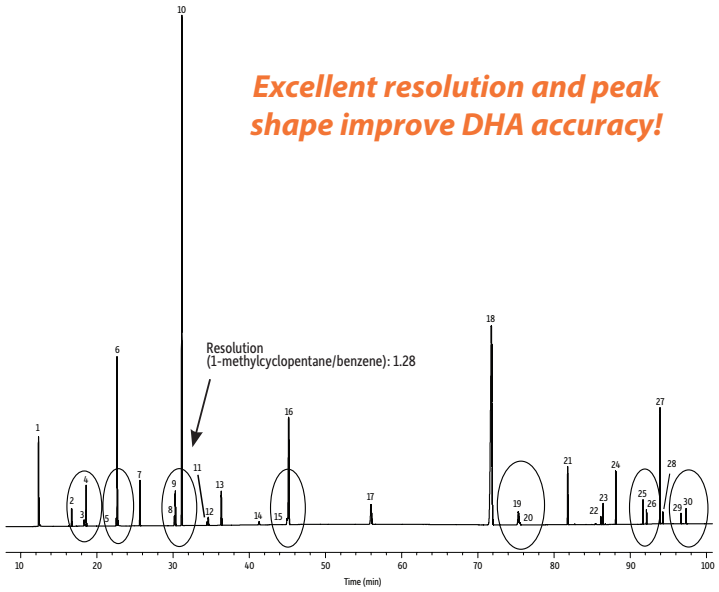
Visit **www.restek.com/petro** for more PLOT column applications.

Accurate DHA Analysis Including Alcohols Using Rtx®-DHA Columns

- Columns designed for ASTM Methods D6729, D6730, D6733, D5134, and D5501.
- Columns individually QC tested to meet or exceed all ASTM and CAN/CGSB method guidelines.
- Excellent responses and peak symmetry for polar oxygenates.
- Guaranteed column-to-column reproducibility for efficiency, peak skewness, and low bleed.

Gasolines are complex mixtures of hundreds of compounds. Information about concentrations of the individual components is important for evaluating raw materials and for controlling refinery processes. ASTM D6730-01 outlines a high-resolution GC method for detailed hydrocarbon analysis (DHA) of gasolines. Rtx®-DHA columns are ideal for DHA methods and easily meet or exceed both ASTM D6730-01 and Canadian General Standards Board CAN/CGSB 3.0 No. 14.3-99 requirements (Figure 5). Every Rtx®-DHA column is tested for efficiency, peak skewness, and bleed—guaranteeing reproducible column-to-column performance.

Figure 5: Critical pairs of gasoline components resolved per ASTM specifications on an Rtx®-DHA column.



Peaks

1. Ethanol
2. C5
3. *tert*-Butanol
4. 2-Methylbutene-2
5. 2,3-Dimethylbutane
6. Methyl *tert*-butyl ether (MTBE)
7. C6
8. 1-Methylcyclopentene
9. Benzene
10. Cyclohexane
11. 3-Ethylpentane
12. 1- *tert*-2-Dimethylcyclopentane
13. C7
14. 2,2,3-Trimethylpentane
15. 2,3,3-Trimethylpentane
16. Toluene
17. C8
18. Ethylbenzene
19. *p*-Xylene
20. 2,3-Dimethylheptane
21. C9
22. 5-Methylnonane
23. 1,2-Methylethylbenzene
24. C10
25. C11 (undecane)
26. 1,2,3,5-Tetramethylbenzene
27. Naphthalene
28. C12 (dodecane)
29. 1-Methylnaphthalene
30. C13 (tridecane)

Column	Rtx®-DHA-100, 100 m, 0.25 mm ID, 0.50 µm (cat.# 10148) using Rtx®-5 DHA tuning column, 2.62 m, 0.25 mm ID, 1.0 µm (cat.# 10165)
Sample	Custom detailed hydrocarbons analysis (DHA) mix
Conc.:	Neat
Injection	
Inj. Vol.:	0.01 µL split (split ratio 150:1)
Liner:	Cup splitter with Siltek® deactivation (cat.# 20709-214.1)
Inj. Temp.:	200 °C
Oven	
Oven Temp.:	5 °C (hold 15 min) to 50 °C at 5 °C/min (hold 50 min) to 200 °C at 8 °C/min (hold 10 min)
Carrier Gas	He, constant flow
Flow Rate:	2.3 mL/min
Linear Velocity:	28 cm/sec
Detector	FID @ 250 °C

Circles indicate critical pairs that must be resolved.

DHA Products

did you know?

Using hydrogen instead of helium can cut analysis time in half! Visit **www.restek.com/petro** for complete analytical details.

similar phases

Petrocol DH, DB-Petro, HP-PONA

Rtx®-DHA Columns (fused silica)

(Crossbond® 100% dimethyl polysiloxane—optimized for hydrocarbon analysis)

Description	temp. limits	qty.	cat.#
50 m, 0.20 mm ID, 0.50 µm	-60 to 300/340 °C	ea.	10147
100 m, 0.25 mm ID, 0.50 µm	-60 to 300/340 °C	ea.	10148
150 m, 0.25 mm ID, 1.00 µm	-60 to 280/340 °C	ea.	10149

Rtx®-5 DHA Tuning Column (fused silica)

(Crossbond® 5% diphenyl/95% dimethyl polysiloxane—optimized for hydrocarbon analysis)

Description	temp. limits	qty.	cat.#
5 m, 0.25 mm ID, 1.00 µm	-60 to 325/350 °C	ea.	10165

Method Recommended Columns

ASTM Method	Column	Dimensions	cat. #
D6729	Rtx-DHA-100	100 m x 0.25 mm, 0.50 µm	10148
D6730	Rtx-DHA-100 & Rtx-5 DHA Tuning Column	100 m x 0.25 mm, 0.50 µm w/ precolumn	10148 & 10165
D6733	Rtx-DHA-50	50 m x 0.20 mm, 0.50 µm	10147
D5501	Rtx-DHA-150	150 m x 0.25 mm, 1.0 µm	10149

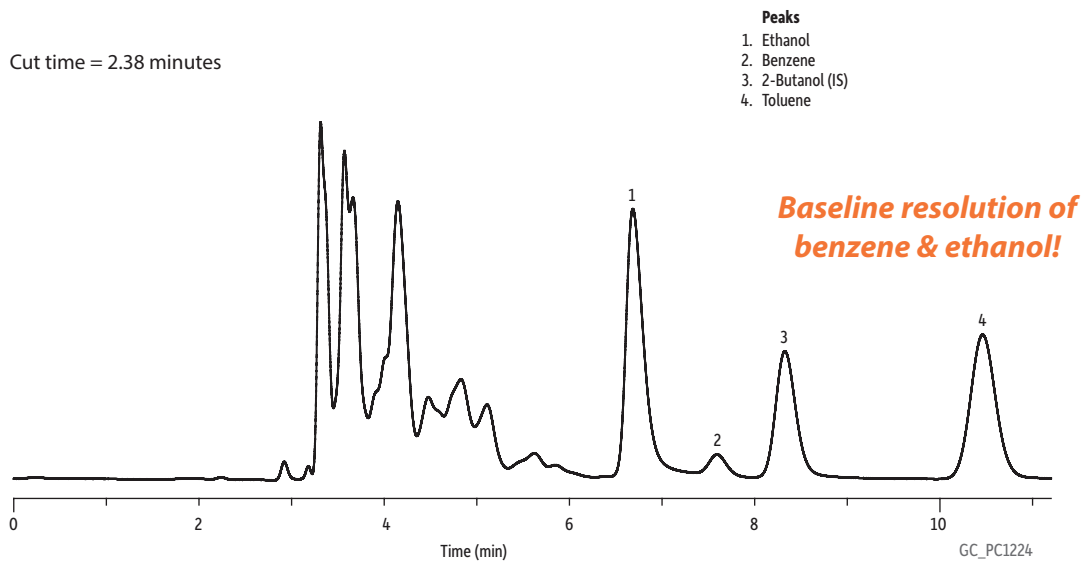
Note: Rtx®-1 PONA columns have been renamed as Rtx®-DHA columns. There are no changes in manufacturing process or column performance.

Complete Resolution of Benzene From Ethanol in Spark Ignition Fuels Using the D3606 Column Set

- Easy, accurate quantification of benzene and toluene.
- Fully conditioned, ready-to-use column set.
- Guaranteed performance: every set is tested for method application and includes chromatogram.

Laboratories analyzing reformulated spark ignition fuels that contain ethanol for the determination of benzene and toluene must use a modified ASTM D3606-10 method to prevent the coelution of ethanol and benzene. The primary challenge in this analysis is twofold: the tailing of the ethanol peak into benzene and the retention time shift of the aromatics, particularly benzene, toward the ethanol peak. Restek solved these issues by developing the D3606 column set, specifically for the modified ASTM D3606-10 application. Using this column set, the aromatic compounds are fully resolved and can easily be quantified using the internal standard 2-butanol (Figure 6). This column set is fully conditioned and ready to use out of the box with only a 10-minute carrier gas purge at ambient temperature, followed by a 30-minute hold at 165 °C.

Figure 6: Complete resolution of benzene from ethanol using a D3606 column set for modified ASTM D3606-10.



Column	D3606 application column (2 column set). Column 1: 6' (1.8 m), 1/8" OD, 2.0 mm ID, nonpolar Rtx®-1; Column 2: 16' (4.9 m), 1/8" OD, 2.0 mm ID, proprietary packing material (cat.# 83606-800)
Sample	Ethanol-containing gasoline with internal standard (IS)
Diluent:	
Injection	Sample valve
Sample Loop Vol.:	1.5 µL
Valve Temp.:	150 °C
Oven	
Oven Temp:	135 °C (hold 12 min)
Carrier Gas	He, constant flow
Flow Rate:	20.0 mL/min
Detector	TCD @ 200 °C
Notes	2.38 minute backflush (must be determined for each GC system).

D3606 Products

D3606 Application Column (2 column set)

Description	cat.#*
D3606 Application Column (2 column set)**	
Column 1: 6' (1.8 m), 1/8" OD, 2.0 mm ID, nonpolar Rtx-1	83606-
Column 2: 16' (4.9 m), 1/8" OD, 2.0 mm ID, proprietary packing material	

*Please add column instrument configuration suffix number to cat.# when ordering. See chart on page 8.

**The column set is designed to accommodate both valve injection and/or syringe injection. Column 1 is configured with a 2" inlet void to facilitate on-column injection. The inlet is identified on both column 1 and column 2. Note: The inlet of column 2 is identified for proper orientation for connection to the valve.

ordering note

www.restek.com/petro for a complete list of D3606 standards.

Single Column Separation of CO and CO_2 in Presence of O_2/N_2 Using a ShinCarbon ST Packed/Micropacked Column

- Separate permanent gases, as well as CO/CO_2, without cryogenic cooling.
- Excellent compatibility with most GC detectors—low bleed and minimal baseline rise.
- Preconditioned; takes less than 30 minutes to stabilize.

Analyze oxygen, nitrogen, methane, carbon monoxide, and carbon dioxide with one column and at room temperature. Restek's ShinCarbon ST material is a high surface area carbon molecular sieve (~1,500 m^2/g) that is ideal for separating gases and highly volatile compounds by GSC. ShinCarbon ST is an exceptionally stable material with good loadability. Its 330 °C upper temperature limit minimizes bleed and baseline rise during temperature programming, making it compatible with most detection systems, including TCD or HID (Figure 7). All ShinCarbon ST columns are fully conditioned in an oxygen/moisture-free environment to prevent contamination. This minimizes stabilization time (less than 30 minutes) when installing a new column, which, in turn, minimizes downtime. Custom-made ShinCarbon ST columns are available on request.

restek® innovation!

ShinCarbon ST is an ideal packing material for permanent gases, low molecular weight hydrocarbons, sulfur dioxide, and Freon® gases.

a plus 1 story

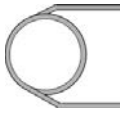
"Being one of the first labs to utilize the ShinCarbon column in a real working environment, I was pleased to find that I was able to do all my permanent gas analysis on one column instead of the customary two. The peaks were sharper than I had experienced in the past and run time was significantly reduced. We are extremely pleased with the performance of the ShinCarbon column and will continue to find even more applications for it."
Bruce Nasser, Quality Control Chemist, Oxygen Service Spec Lab

ordering note

Installation kits available at **www.restek.com**

Packed Column Instrument Configurations


General Configuration
Suffix -800


Agilent 5880, 5890, 5987, 6890, 7890:
Suffix -810*


Varian 3700, Vista Series, FID:
Suffix -820

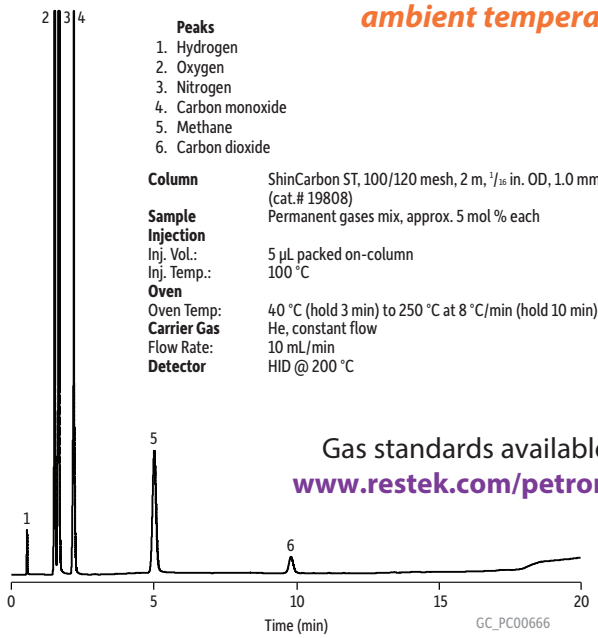
PE 900-3920, Sigma 1,2,3:
Suffix -830

PE Auto System 8300, 8400, 8700:
Suffix -840

Visit www.restek.com for additional configurations.

Note: Initial 2" of column will be empty to accommodate a needle. For a completely filled column (not on-column) add suffix -901.
*-810 suffix also includes 1 1/2" void on detector side.

Figure 7: Separate permanent gases in 10 minutes, without cryogenics.



ShinCarbon Products

ShinCarbon ST Columns (packed) (SilcoSmooth® Stainless Steel)*

OD	ID	Mesh	2-Meter cat.#*
1/8" Silcosmooth	2.0 mm	80/100	80486-

ShinCarbon ST Columns (micropacked) (SilcoSmooth® Stainless Steel)**

OD	ID	Mesh	1-Meter cat.#	2-Meter cat.#
1/16"	1.0 mm	100/120	19809	19808
0.95 mm	0.75 mm	100/120	19810	—
0.74 mm	0.53 mm	80/100	19045	19043

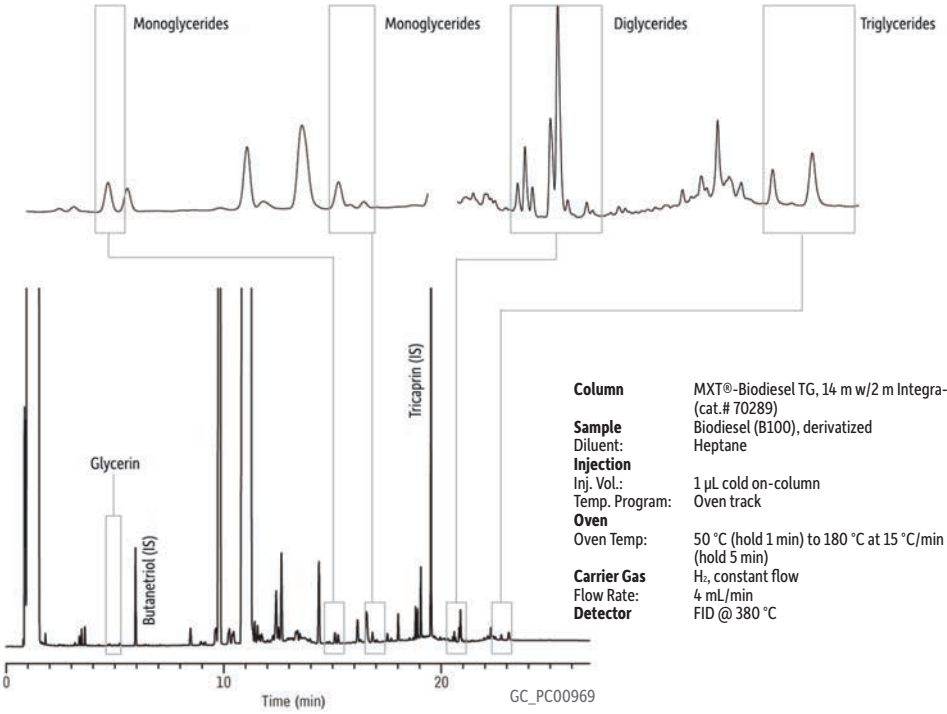
*Please add column instrument configuration suffix number to cat.# when ordering.
**Does not include column nuts and ferrules. Optional installation kits can be ordered separately.

Accurate, Reliable Analysis of Glycerides in Biodiesel
Choose Metal or High Temperature Fused Silica Column Solutions

- Complete resolution of all compounds from interference peaks.
- Columns available in metal and fused silica.
  - Use Rtx®-Biodiesel TG fused silica columns up to 380 °C—low bleed for accurate, reliable results.
  - Use MXT®-Biodiesel TG metal columns up to 430 °C—same performance as fused silica with longer column lifetimes.

One of the biggest challenges in biodiesel analysis is the accurate determination of residual glyceride content. The high temperatures required to elute triglycerides cause most fused silica columns to deteriorate rapidly. Restek offers high-temperature fused silica columns that are stable up to 380 °C, and the metal MXT®-Biodiesel TG column line is an even better solution. MXT®-Biodiesel TG columns offer the same chromatographic performance as fused silica columns, but are designed for maximum heat tolerance, even up to 430 °C. These columns provide good resolution and peak shape for all glycerides, as well as highly reproducible retention times (Figure 8). Additionally, metal MXT® columns are available with Integra-Gap® technology, a built-in retention gap that eliminates connector-related leaks, reducing tailing and minimizing downtime for maintenance.

Figure 8: Robust metal MXT®-Biodiesel TG columns meet resolution criteria and show excellent response for determining glycerides in biodiesel.



The best solution for analyzing total glycerides in biodiesel!

Column	MXT®-Biodiesel TG, 14 m w/2 m Integra-Gap® (16 m total length), 0.53 mm ID, 0.16 µm (cat.# 70289)
Sample	Biodiesel (B100), derivatized
Diluent:	Heptane
Injection	
Inj. Vol.:	1 µL cold on-column
Temp. Program:	Oven track
Oven	
Oven Temp:	50 °C (hold 1 min) to 180 °C at 15 °C/min to 230 °C at 7 °C/min to 380 °C at 30 °C/min (hold 5 min)
Carrier Gas	H_2, constant flow
Flow Rate:	4 mL/min
Detector	FID @ 380 °C

Biodiesel Products

MXT®-Biodiesel TG Columns (Siltek®-treated stainless steel)

Description	temp. limits	3.5" Coil cat.#	7" diameter 11-pin cage cat.#
14 m, 0.53 mm ID, 0.16 µm with 2 m Integra-Gap*	-60 to 380/430 °C	70289-273	70289
10 m, 0.32 mm ID, 0.10 µm	-60 to 380/430 °C	—	70292
10 m, 0.32 mm ID, 0.10 µm with 2 m x 0.53 mm Retention Gap**	-60 to 380/430 °C	70290-273	70290
15 m, 0.32 mm ID, 0.10 µm	-60 to 380/430 °C	—	70293
15 m, 0.32 mm ID, 0.10 µm with 2 m x 0.53 mm Retention Gap**	-60 to 380/430 °C	70291-273	70291
2 m x 0.53 mm MXT Biodiesel TG Retention Gap		—	70294

*Total column length = 16 meters.
**Connected with low dead volume MXT connector.

Rtx®-Biodiesel TG Columns (fused silica)

Description	temp. limits	cat.#
10 m, 0.32 mm ID, 0.10 µm	to 330/380 °C	10292
10 m, 0.32 mm ID, 0.10 µm with 2 m x 0.53 mm ID Retention Gap**	to 330/380 °C	10291
15 m, 0.32 mm ID, 0.10 µm	to 330/380 °C	10294
15 m, 0.32 mm ID, 0.10 µm with 2 m x 0.53 mm ID Retention Gap**	to 330/380 °C	10293

**Connected with Alumaseal® connector.

Visit **www.restek.com/biodiesel** for a complete list of biodiesel standards, products, and applications.

Reference Standards

Petroleum

Gravimetrically prepared, NIST-traceable by weight, and verified by one or more analytical methods.

Sulfur Simulated Distillation Standard (SSDS)

30 ppm total sulfur by weight from ethanethiol
60 ppm total sulfur by weight from 1-propanethiol
30 ppm total sulfur by weight from 1-butanethiol
60 ppm total sulfur by weight from 1-pentanethiol
30 ppm total sulfur by weight from 1-hexanethiol
60 ppm total sulfur by weight from 1-heptanethiol
30 ppm total sulfur by weight from 3,5-dimethlybenzenethiol
60 ppm total sulfur by weight from 1-octanethiol
30 ppm total sulfur by weight from 1-nonanethiol
60 ppm total sulfur by weight from 1-decanethiol
30 ppm total sulfur by weight from 1-pentadecanethiolol
60 ppm total sulfur by weight from 1-hexadecanethiol
30 ppm total sulfur by weight from 1-octadecanethiol
Balance: toluene:isooctane (1:15)

1 mL pre-scored amber ampul.
cat.# 33049 (ea.)

SimDist

D2887 Calibration Mix (17 components)

Compound	Conc. (% w/w)	Compound	Conc. (% w/w)
n-Hexane (C6) (110-54-3)	6	*n*-Eicosane (C20) (112-95-8)	2
n-Heptane (C7) (142-82-5)	6	*n*-Tetracosane (C24) (646-31-1)	2
n-Octane (C8) (111-65-9)	8	*n*-Octacosane (C28) (630-02-4)	1
n-Nonane (C9) (111-84-2)	8	*n*-Dotriacontane (C32) (544-85-4)	1
n-Decane (C10) (124-18-5)	12	*n*-Hexatriacontane (C36) (630-06-8)	1
n-Undecane (C11) (1120-21-4)	12	*n*-Tetracontane (C40) (4181-95-7)	1
n-Dodecane (C12) (112-40-3)	12	*n*-Tetratetracontane (C44) (7098-22-8)	1
n-Tetradecane (C14) (629-59-4)	12		
n-Hexadecane (C16) (544-76-3)	10		
n-Octadecane (C18) (593-45-3)	5		

Packaged 1 mL/ampul
cat.# 31222 (ea.)

No data pack available.

ASTM D2887-12 Calibration Standard

(20 components)

n-Pentane (C5) (109-66-0)
n-Hexane (C6) (110-54-3)
n-Heptane (C7) (142-82-5)
n-Octane (C8) (111-65-9)
n-Nonane (C9) (111-84-2)
n-Decane (C10) (124-18-5)
n-Undecane (C11) (1120-21-4)
n-Dodecane (C12) (112-40-3)
n-Tetradecane (C14) (629-59-4)
n-Pentadecane (C15) (629-62-9)
n-Hexadecane (C16) (544-76-3)
n-Heptadecane (C17) (629-78-7)
n-Octadecane (C18) (593-45-3)
n-Eicosane (C20) (112-95-8)
n-Tetracosane (C24) (646-31-1)
n-Octacosane (C28) (630-02-4)
n-Dotriacontane (C32) (544-85-4)
n-Hexatriacontane (C36) (630-06-8)
n-Tetracontane (C40) (4181-95-7)
n-Tetratetracontane (C44) (7098-22-8)

1% w/w in carbon disulfide, 1 g solution/ampul
cat.# 31674 (ea.)

5% w/w, Neat, 1 g /ampul
cat.# 31675 (ea.)

No data pack available.

Polywax Standards

These high molecular weight hydrocarbon waxes are useful for simulated distillation and other high-temperature GC work.

Compound	CAS #	Solvent	Conc.	cat.#
Polywax 500	9002-88-4	Neat	1 g	36224
Polywax 655	9002-88-4	Neat	1 g	36225
Polywax 850	9002-88-4	Neat	1 g	36226
Polywax 1,000	9002-88-4	Neat	1 g	36227

No data pack available.

Reference Standards

DHA

DHA PONA VI Mix (426 components)
PONA-VI (PONA 6) is a qualitative mixture of various gasoline and refinery materials prepared to provide nearly every component that may be encountered in feedstock and finished gasolines. Some oxygenates have been added to allow this blend to be used for DHA method setup.
Visit **www.restek.com/petromixes** for a component list.
Neat, 0.1 mL in Autosampler Vial
cat.# 30723 (ea.)

No data pack available.

Oxy Set-Up Blend (30 components)
Gravimetrically prepared and NIST-traceable.
Visit **www.restek.com/petromixes** for a component list.
2 mL prescored ampul
cat.# 33034 (ea.)

PIANO Blends

The PIANO blends are standards used for calibrating complex hydrocarbon analyses and provide the greatest number of gravimetrically determined values for quantitative calibration.

DHA PIONA Blend (136 components)
Neat, 0.1 mL in Autosampler Vial
cat.# 30712 (ea.)

No data pack available.

DHA Paraffins Mix (11 components)
Neat, 0.1 mL in Autosampler Vial
cat.# 30713 (ea.)

No data pack available.

DHA Isoparaffins Mix (34 components)
Neat, 0.1 mL in Autosampler Vial
cat.# 30715 (ea.)

No data pack available.

DHA Aromatics Mix (38 components)
Neat, 0.1 mL in Autosampler Vial
cat.# 30717 (ea.)

No data pack available.

DHA Naphthenes Mix (27 components)
Neat, 0.1 mL in Autosampler Vial
cat.# 30719 (ea.)

No data pack available.

DHA Olefins Mix (26 components)
Neat, 0.1 mL in Autosampler Vial
cat.# 30721 (ea.)

No data pack available.

D3606

ASTM D3606 Calibration Kit Without Internal Standard
Contains 25 mL each of these mixtures.
30647: ASTM D3606 Calibration Standard #1 Without Internal Standard
30648: ASTM D3606 Calibration Standard #2 Without Internal Standard
30649: ASTM D3606 Calibration Standard #3 Without Internal Standard
30650: ASTM D3606 Calibration Standard #4 Without Internal Standard
30651: ASTM D3606 Calibration Standard #5 Without Internal Standard
30652: ASTM D3606 Calibration Standard #6 Without Internal Standard
30653: ASTM D3606 Calibration Standard #7 Without Internal Standard
Contains 25 mL each of these mixtures.
kit
cat.# 30672 (kit)

ASTM D3606 Calibration Kit With MEK Internal Standard
Contains 1 mL each of these mixtures.
30654: ASTM D3606 Calibration Standard #1 With MEK Internal Standard
30655: ASTM D3606 Calibration Standard #2 With MEK Internal Standard
30656: ASTM D3606 Calibration Standard #3 With MEK Internal Standard
30657: ASTM D3606 Calibration Standard #4 With MEK Internal Standard
30658: ASTM D3606 Calibration Standard #5 With MEK Internal Standard
30659: ASTM D3606 Calibration Standard #6 With MEK Internal Standard
30660: ASTM D3606 Calibration Standard #7 With MEK Internal Standard
Contains 1 mL each of these mixtures.
kit
cat.# 30673 (kit)

ASTM D3606 Calibration Kit With *sec*-Butanol Internal Standard
Contains 1 mL each of these mixtures.
30661: ASTM D3606 Calibration Standard #1 With *sec*-Butanol Internal Standard
30662: ASTM D3606 Calibration Standard #2 With *sec*-Butanol Internal Standard
30663: ASTM D3606 Calibration Standard #3 With *sec*-Butanol Internal Standard
30664: ASTM D3606 Calibration Standard #4 With *sec*-Butanol Internal Standard
30665: ASTM D3606 Calibration Standard #5 With *sec*-Butanol Internal Standard
30666: ASTM D3606 Calibration Standard #6 With *sec*-Butanol Internal Standard
30667: ASTM D3606 Calibration Standard #7 With *sec*-Butanol Internal Standard
Contains 1 mL each of these mixtures.
kit
cat.# 30674 (kit)

ASTM D3606 Quality Control Standard With MEK Internal Standard (3 components)

Benzene (71-43-2)	0.6432% vol/vol
2-Butanone (MEK) (78-93-3)	4
Toluene (108-88-3)	4.8

In isooctane, 25 mL/ampul
cat.# 30669 (ea.)

ASTM D3606 Quality Control Standard With *sec*-Butanol Internal Standard (3 components)

Benzene (71-43-2)	0.6432% vol/vol
2-Butanol (*sec*-butyl alcohol) (78-92-2)	4
Toluene (108-88-3)	4.8

In isooctane, 25 mL/ampul
cat.# 30670 (ea.)

Visit **www.restek.com/petromixes** for our complete line of petrochemical reference standards.

Reference Standards

cylinder design

CG Partnership Cylinders:

Size: 7.6 x 24 cm
CGA-170/110 connection
U.S. DOT Specs:
DOT-4B-240ET

Please note: This cylinder is not approved for use in Canada.

Please note: Gas standards on this page are not available in Pi-marked (TPED-rated) cylinders required for EU countries.

More gas standards available at **www.restek.com/petromixes**

Natural Gas and Refinery Gas Standards

- Each available in three varying concentrations.
- Mini-regulator designed specifically for these standards.

Natural Gas Standards

Available in three mixes, from lean to rich. Each has an extended list of C6+ components.

	Natural Gas Standard #1 cat.# 34438, ea. **% each compound***	**Natural Gas Standard #2** cat.# 34439, ea. **% each compound***	**Natural Gas Standard #3** cat.# 34440, ea. **% each compound***
nitrogen	1.000	2.500	5.000
carbon dioxide	0.500	1.000	1.500
methane UHP	94.750	85.250	70.000
ethane UHP	2.000	5.000	9.000
propane	0.750	3.000	6.000
isobutane	0.300	1.000	3.000
n-butane	0.300	1.000	3.000
isopentane	0.150	0.500	1.000
n-pentane	0.150	0.500	1.000
hexanes plus	0.100	0.250	0.500
Concentration	mole	mole	mole
Volume	13.16 L @ 200 psig (1,379 kPa)	13.16 L @ 200 psig (1,379 kPa)	5.5 L @ 75 psig (517 kPa)
Ideal Heating Value (Dry BTU/SCF)	1,048 gross	1,142 gross	1,317 gross

Refinery Gas Standards

Available in three mixes with varying C5 unsaturates or extended C6+ components.

	Refinery Gas Standard #1 cat.# 34441, ea. **% each compound***	**Refinery Gas Standard #2** cat.# 34442, ea. **% each compound***	**Refinery Gas Standard #5** cat.# 34443, ea. **% each compound***
hydrogen	40.750	12.500	12.500
argon	0.500	1.000	1.000
nitrogen	4.000	37.200	37.200
carbon monoxide	1.000	1.000	1.000
carbon dioxide	3.000	3.000	3.000
methane	8.500	5.000	5.000
ethane	6.000	4.000	4.000
ethylene	2.000	2.000	2.000
acetylene	—	1.000	1.000
propane	7.000	6.000	6.000
propylene	3.000	3.000	3.000
propadiene	0.850	1.000	1.000
cyclopropane	—	0.040	—
isobutane	6.000	5.000	5.000
n-butane	4.000	4.000	4.000
isobutylene	2.000	1.000	1.000
1,3 butadiene	3.000	3.000	3.000
cis-2-butene	2.000	2.000	2.000
trans-2-butene	2.000	3.000	3.000
1-butene	2.000	2.000	2.000
2-methyl-2-butene	—	0.200	0.200
isopentane	1.000	1.000	1.000
n-pentane	1.000	1.000	1.000
cis-2-pentene	—	0.400	0.400
trans-2-pentene	—	0.160	0.200
pentene-1	—	0.400	0.400
n-hexane	0.500	0.100	—
hexanes plus	—	—	0.100
Concentration	mole	mole	mole
Volume	5.2 L @ 70 psig (483 kPa)	4.9 L @ 60 psig (414 kPa)	4.6 L @ 60 psig (414 kPa)

*Precise concentrations are provided on the data sheet included with each cylinder and may vary slightly from those listed here.

Visit **www.restek.com/petromixes** for our complete line of petrochemical reference standards.

Sample Cylinders, Valves & Accessories

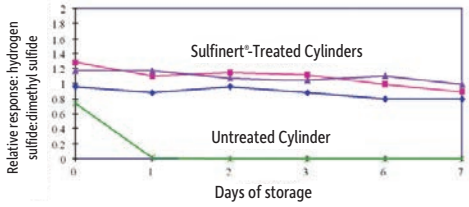
Sulfinert®-Treated High-Pressure Sample Cylinders

- Sulfinert® coating provides stable storage of sulfur and mercury at ppb levels in petroleum samples.
- Inert coating doesn't flake; more durable than PTFE.
- TPED compliant cylinders now available for shipping into EU countries.
- All cylinders have ¼" female NPT threads on both ends.

Refinery and natural gas samples often contain trace amounts of sulfur-containing compounds, which can interfere with reactions or poison catalysts in petrochemical processes. Because sulfur compounds react quickly with stainless steel surfaces, accurate determination of these compounds is impossible when samples are collected and stored in untreated sample cylinders. Restek's Sulfinert® passivation technique bonds an inert silica layer into the surface of stainless steel, preventing active compounds from reacting with or adsorbing to the steel. These Swagelok® high-pressure sample cylinders are Sulfinert®-treated for greater stability of sulfur compounds and mercury. DOT rating to 1,800 psig (12,411 kPa) and 5,000 psig (34,474 kPa) allows sampling at gas wellheads as well as in the refinery. Use of high-pressure sample cylinders is cited in ASTM D1265, Standard Practice for Sampling Liquefied Petroleum (LP) Gases, Manual Method.

Sulfur compounds are stable in Sulfinert®-treated stainless steel systems.

17 ppbv hydrogen sulfide in 500 mL cylinders



also available

Certificates are available upon request.

Sample Cylinders, High Pressure

(Stainless Steel & Sulfinert® Treated)

	1,800 psig (12,411 kPa), 304L SS		TPED, 1,450 psig (9,997 kPa), 304L SS	
	Stainless Steel	Sulfinert Treated	Stainless Steel	Sulfinert Treated
Size	cat.#	cat.#	cat.#	cat.#
75 cc	22921	24130	22921-PI	24130-PI
150 cc	22922	24131	22922-PI	24131-PI
300 cc	22923	24132	22923-PI	24132-PI
500 cc	22924	24133	22924-PI	24133-PI
1,000 cc	22925	24134	22925-PI	24134-PI
2,250 cc	22926	21394	22926-PI	21394-PI

Sample Cylinders, Ultra-High Pressure

(Stainless Steel & Sulfinert® Treated)

	5,000 psig (34,474 kPa), 316L SS		TPED, 4,350 psig (29,992 kPa), 316L SS	
	Stainless Steel	Sulfinert Treated	Stainless Steel	Sulfinert Treated
Size	cat.#	cat.#	cat.#	cat.#
150 cc	22927	22111	22927-PI	22111-PI
300 cc	22928	22112	22928-PI	22112-PI
500 cc	22929	22113	22929-PI	22113-PI

Sample Cylinder Valves (Stainless Steel & Sulfinert® Treated)

- Multiple valve configurations, including dip tube and rupture disks.
- Large, durable, Kel-F® seat ensures leak-free operation.
- Temperature range: -40 °C to 120 °C

Description	Stainless Steel cat.#	Sulfinert Treated cat.#
3,500 psig (24,132 kPa) DOT Pressure Rating		
¼" Male NPT x ¼" Male NPT	26297	21400
¼" Male NPT x ¼" Female NPT	26298	26299
¼" Male NPT x ¼" Male Compression	26300	21401
¼" Male NPT x ¼" Male NPT w/5.25" Dip Tube*	26301	21402*
¼" Male NPT x ¼" Male NPT w/1,800 psi (12,411 kPa) Rupture Disc	26302	26303
¼" Male NPT x ¼" Female NPT w/1,800 psi (12,411 kPa) Rupture Disc	26304	26305
Replacement Rupture Disc, 1,800 psig (12,411 kPa)	26320	—
5,000 psig (34,474 kPa) DOT Pressure Rating		
¼" Male NPT x ¼" Male NPT	26306	26307
¼" Male NPT x ¼" Female NPT	26308	26309
¼" Male NPT x ¼" Male Compression	26310	26311
¼" Male NPT x ¼" Male NPT w/5.25" Dip Tube*	26312	26313
¼" Male NPT x ¼" Male NPT w/2,850 psi (19,650 kPa) Rupture Disc	26314	26315
¼" Male NPT x ¼" Female NPT w/2,850 psi (19,650 kPa) Rupture Disc	26316	26317
Replacement Rupture Disc, 2,850 psig (19,650 kPa)	26324	—

*To order a sample cylinder valve with dip tube, please contact your Restek® representative. Specify dip tube length or % outage when ordering (maximum length = 5.25"/ 13.3 cm). Note: End of part will not be treated after cutting tube to length.


21400


21401


21402


26298


26300


26314

Sample Cylinders, Valves & Accessories

Sample Cylinder Accessories

Description	Fittings	qty.	cat.#
Sample Cylinder Carrying Handle, 304 SST for 1.9" & 2" OD Cylinders (Includes handle and two attachment rings)		ea.	26373
Sample Cylinder Carrying Handle, 304 SST for 3.5" & 4" OD Cylinders (Includes handle and two attachment rings)		ea.	26374
Sample Cylinder 316 SST End Pipe Plug, Stainless Steel	1/4" MPT	ea.	26375
Sample Cylinder 316 SST End Pipe Plug, Sulfinert Treated	1/4" MPT	ea.	26376
Sample Cylinder 316 SST Hollow Hex Plug	1/4" MPT	ea.	26377
Sample Cylinder SST Pipe Cap w/Lanyard	1/4" Female NPT & 20" Lanyard	ea.	26378
Sample Cylinder SST Pipe Cap, Stainless Steel	1/4" Female NPT	ea.	22969
Sample Cylinder SST Pipe Cap, Sulfinert Treated	1/4" Female NPT	ea.	22970

Metering Control Valves (Stainless Steel & Sulfinert® Treated)

- Reduces pressure between sample cylinder and GC injector.
- Maintains fine metering control.
- Contains Kel-F® seat.

Description	Stainless Steel cat.#	Sulfinert Treated cat.#
3,500 psig (24,132 kPa) DOT Pressure Rating		
Metering Control Valve, 1/4" Male NPT x 1/4" Male NPT	26326	26327

Sample Cylinders, Valves & Accessories

Gas Sampling Valves and Sample Loops (Sulfinert® Treated)

- Ideal for samples containing low concentrations of sulfur or other active compounds.
- Sample loop sizes from 5 µL to 5 mL.

Sulfinert® treatment eliminates active sites in the valve or loop for better recovery of active compounds.

20585

Gas Sampling Valves & Replacement Rotors (Sulfinert® Treated)

(1/16" Fittings, 0.40 mm Port Diameter; "W Type" Valve)

Description	qty.	cat.#
Sulfinert Gas Sampling Valve; 4-Port	ea.	20584
Sulfinert Gas Sampling Valve; 6-Port	ea.	20585
Sulfinert Gas Sampling Valve; 10-Port	ea.	20586

Replacement Rotors (Not Coated)

Description	qty.	cat.#
Replacement Rotor (not coated) for 4-Port Sulfinert Gas Sampling Valve	ea.	20587
Replacement Rotor (not coated) for 6-Port Sulfinert Gas Sampling Valve	ea.	20588
Replacement Rotor (not coated) for 10-Port Sulfinert Gas Sampling Valve	ea.	20589

Gas Sample Loops (Sulfinert® Treated) (1/16" fittings, for "W Type" valves)

Description	Size	qty.	cat.#
Sample Loops, Sulfinert Treated	5 µL	ea.	22840
Sample Loops, Sulfinert Treated	10 µL	ea.	22841
Sample Loops, Sulfinert Treated	20 µL	ea.	22842
Sample Loops, Sulfinert Treated	25 µL	ea.	22843
Sample Loops, Sulfinert Treated	50 µL	ea.	22844
Sample Loops, Sulfinert Treated	100 µL	ea.	22845
Sample Loops, Sulfinert Treated	250 µL	ea.	22846
Sample Loops, Sulfinert Treated	500 µL	ea.	22847
Sample Loops, Sulfinert Treated	1 mL	ea.	22848
Sample Loops, Sulfinert Treated	2 mL	ea.	22849
Sample Loops, Sulfinert Treated	5 mL	ea.	22850

Jumbo Syringe

Clear acrylic syringes, ideal for holding and dispensing large volumes of gas. An adjustable plunger on the O-ring ensures that the syringe is gas-tight over a long period of time. The central port is supplied with a luer lock fitting; the secondary port is supplied with a septum nut. This enables access to the gas sample for adding standards or removing a subsample. The plunger stem is detachable, making sample storage easy.

21276

	SGE		Restek	
Volume	Model	cat.#	qty.	cat.#
500 mL	500MAR-LL-GT	009910	ea.	21275
1,000 mL	1000MAR-LL-GT	009920	ea.	21276
2,000 mL	2000MAR-LL-GT	009930	ea.	21277

Syringe O-Rings

Syringe Volume	SGE cat.#	Restek qty.	Restek cat.#
500 mL	032527	ea.	21278
1,000 mL	032532	ea.	21279

21279

21278

Petro Essentials

Restek® Filter Base Plates

- End fittings available in brass or stainless steel.
- Base plates fit all stand alone Super-Clean gas filters offered.

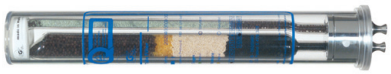

22025

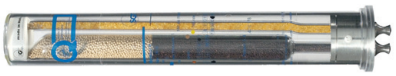

22026


22027

	Brass		Stainless Steel	
Description	**qty.**	**cat.#**	**qty.**	**cat.#**
Filter Base Plate, Single-Position	ea.	22025	ea.	22344
Filter Base Plate, 2-Position	ea.	22026	ea.	22345
Filter Base Plate, 3-Position	ea.	22027	ea.	22346

Each single-position base plate unit measures: 4" x 4" x 1 $^{7}/_{8}$" (10.2 x 10.2 x 4.8 cm)
Each 2-position base plate unit measures: 8" x 4" x 1 $^{7}/_{8}$" (10.2 x 10.2 x 4.8 cm)
Each 3-position base plate unit measures: 12" x 4" x 1 $^{7}/_{8}$" (10.2 x 10.2 x 4.8 cm)
Standard base plate inlet/outlet fittings accept $^{1}/_{8}$" tubing. To adapt to $^{1}/_{4}$" tubing, order $^{1}/_{8}$" to $^{1}/_{4}$" tube end reducers.


22020


22022


base plate

Restek® Super-Clean Gas Filter Kits and Replacements

- High-purity output ensures 99.9999% pure gas (at max. flow of 2 L/min).
- "Quick connect" fittings for easy, leak-tight filter cartridge changes.
- Glass inside to prevent diffusion; polycarbonate housing outside for safety.
- All traps measure 10 $^{5}/_{8}$" x 1 $^{3}/_{4}$" (27 x 4.4 cm).
- Each base plate unit measures 4" x 4" x 1 $^{7}/_{8}$" (10.2 x 10.2 x 4.8 cm).

Description	qty.	cat.#
Carrier Gas Cleaning Kit Includes: mounting base plate, $^{1}/_{8}$" inlet/outlet fittings, and oxygen/moisture/hydrocarbon triple gas filter	kit	22019
Fuel Gas Purification Kit Includes: mounting base plate, $^{1}/_{8}$" inlet/outlet fittings, and hydrocarbon/moisture fuel gas filter	kit	22021
Ultra-High Capacity Hydrocarbon Filter	ea.	22030
Ultra-High Capacity Moisture Filter	ea.	22028
Ultra-High Capacity Oxygen Filter	ea.	22029
Replacement Triple Gas Filter (removes oxygen, moisture, and hydrocarbons)	ea.	22020
Replacement Fuel Gas Filter (removes moisture and hydrocarbons)	ea.	22022
Helium-Specific Carrier Gas Cleaning Kit Includes: mounting base plate, $^{1}/_{8}$" inlet/outlet fittings, and oxygen/moisture/hydrocarbon helium-specific filter	kit	21983
Replacement Helium-Specific Gas Filter (removes oxygen, moisture, and hydrocarbons)	ea.	21982
Gas Filter Bundle Kit Includes: one triple gas filter (cat.# 22020) and two fuel gas filters (cat.# 22022)	kit	22031

Dynamic Duo (Restek Leak Detector and ProFLOW 6000 Flowmeter)

Protect your instrument and improve data quality with this powerful pair from Restek. Checking for leaks and verifying flows before you start helps you avoid costly problems later.

Description	qty.	cat.#
Dynamic Duo Combo Pack (Restek Leak Detector and ProFLOW 6000 Flowmeter)	kit	22654
Related Products and Accessories		
Leak Detector With Hard-Sided Carrying Case and Universal Charger Set (U.S., UK, European, Australian)	ea.	22655
Small Probe Adaptor for Leak Detector	ea.	22658
Restek ProFLOW 6000 Electronic Flowmeter With Hard-Sided Carrying Case	ea.	22656
Soft-Sided Storage Case for Leak Detector or ProFLOW 6000 Flowmeter	ea.	22657

Restek's New Leak Detector

Redesigned and better than ever, our new leak detector is an essential tool for troubleshooting and routine maintenance of your gas chromatograph. Don't risk damaging your system or losing sensitivity; check for leaks often and protect your GC column and instrument with a Restek leak detector!

Leak Detector Specifications

Detectable Gases:	Helium, nitrogen, argon, carbon dioxide, hydrogen
Battery:	Rechargeable lithium ion internal battery pack (12 hours normal operation)
Operating Temperature Range:	32–120 °F (0–48 °C)
Humidity Range:	0–97%
Warranty:	One year
Certifications:	CE, Ex, Japan
Compliance:	WEEE, RoHS

Limits of Detection

These gases can be detected with the Restek electronic leak detector at the following leak rates:

Minimum Detectable Gas Limits and Indicating LED Color:

- Helium, 1.0 x 10^{-5}, red LED
- Hydrogen*, 1.0 x 10^{-5}, red LED
- Nitrogen, 1.4 x 10^{-3}, yellow LED
- Argon, 1.0 x 10^{-4}, yellow LED
- Carbon dioxide, 1.0 x 10^{-4}, yellow LED

Gas detection limits measured in atm cc/sec.

*Caution: The Restek electronic leak detector is designed to detect trace amounts of hydrogen in a noncombustible environment. It is NOT designed for determining leaks in a combustible environment. A combustible gas detector should be used for determining combustible gas leaks under any condition. When using it to detect hydrogen, the Restek electronic leak detector may only be used for determining trace amounts in a GC environment.

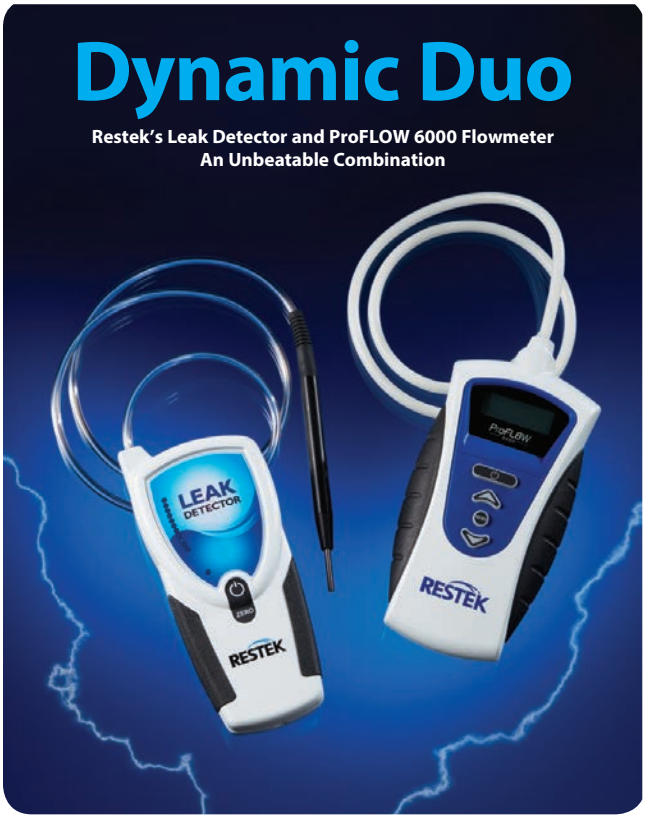
ProFLOW 6000 Flowmeter

With its wide range of capabilities, the ProFLOW 6000 flowmeter simplifies gas flow measurement in the lab. Real-time measurements can be made for various types of flow paths, including continually changing gas types.

Flowmeter Specifications:

Type of Flowmeter:	Volumetric
Battery:	2-AA
Operating Temperature Range:	32–120 °F (0–48 °C)
Warranty:	One year
Certifications:	CE, Ex
Compliance:	WEEE, RoHS

Patented.



Petro Essentials

Sulfinert® and Silcosteel®-CR Treated Tubing and Fittings

Restek sets the standard in tubing for analytical and process applications. Complete your system with precleaned or treated tubing and treated fittings and valves for an inert, corrosion-resistant pathway. Restek offers the following coatings:

Silcosteel®-CR

A corrosion-resistant layer that increases the lifetime of system components in acidic environments containing hydrochloric acid, nitric acid, or seawater.

Sulfinert®

The ultimate passivation of treated surfaces; ideal for automotive exhaust testing, stack gas sampling, or analyzing for parts-per-billion levels of organosulfur compounds.

Minimum Bend Radius for Coated Tubing

OD	Min. Bend Radius
1/16"	1" (2.5 cm)
1/8"	2" (5.1 cm)
1/4"	4" (10.2 cm)
3/8"	6" (15.2 cm)

did you know?

Other lengths and diameters of treated tubing are available on a custom basis.

Call for availability of lengths greater than 1,000 ft

ordering note

Required length in meters x 3.2808 = length in feet.

Treated Welded/Drawn 304 Grade Stainless Steel Tubing

Our most popular grade of tubing. Recommended for:

- Chromatography applications.
- Gas delivery systems.
- Lower pressures.
- Inert applications.

Maximum temperature of 450 °C in an inert atmosphere.

Siltek®/Sulfinert® Treated (Coiled)

OD	ID	Wall Thickness	cat.#
0.022" (0.56 mm)	0.011" (0.28 mm)		22500
0.029" (0.74 mm)	0.021" (0.53 mm)		22501
1/16" (1.59 mm)	0.010" (0.25 mm)		22502
1/16" (1.59 mm)	0.020" (0.51 mm)		22503
1/16" (1.59 mm)	0.030" (0.76 mm)		22504
1/16" (1.59 mm)	0.040" (1.02 mm)		22505
1/8" (3.18 mm)	0.085" (2.16 mm)	0.020"	22506
1/4" (6.35 mm)	0.210" (5.33 mm)	0.020"	22507

Treated Seamless 316L Grade Stainless Steel Tubing

High durability tubing. Recommended for:

- Inert applications.
- High temperatures.
- High pressures.
- Corrosive environments.
- Zero bleed.

Siltek®/Sulfinert® Treated (Coiled)

OD	ID	Wall Thickness	cat.#
1/8" (3.18 mm)	0.055" (1.40 mm)	0.035"	22508
1/4" (6.35 mm)	0.180" (4.57 mm)	0.035"	22509
3/8" (9.52 mm)	0.277" (7.04 mm)	0.049"	22914

Silcosteel®-CR Treated (Coiled)

OD	ID	Wall Thickness	cat.#
1/8" (3.18 mm)	0.055" (1.40 mm)	0.035"	22896
1/4" (6.35 mm)	0.180" (4.57 mm)	0.035"	22897
3/8" (9.52 mm)	0.277" (7.04 mm)	0.049"	22915

1/4" OD: 5 ft. to 500 ft. in one continuous coil; 3/8" OD: 5 ft. to 250 ft. in one continuous coil. Longer lengths will be more than one coil.

Treated Seamless Electropolished 316L Grade Stainless Steel Tubing

Our highest performing tubing. Recommended for:

- Demanding/corrosive environments.
- High temperatures.
- Ultimate inertness.

Siltek®/Sulfinert Treated (Coiled)

OD	ID	Wall Thickness	cat.#
1/8" (3.18 mm)	0.085" (2.16 mm)	0.020"	22538
1/4" (6.35 mm)	0.180" (4.57 mm)	0.035"	22539

Silcosteel®-CR Treated (Coiled)

OD	ID	Wall Thickness	cat.#
1/8" (3.18 mm)	0.085" (2.16 mm)	0.020"	22536
1/4" (6.35 mm)	0.180" (4.57 mm)	0.035"	22537

1/8" OD: 5 ft to 95 ft in one continuous coil; 1/4" OD: 5 ft to 300 ft in one continuous coil. Longer lengths will be more than one coil.
Note: required length in meters x 3.2808 = length in feet.

Swagelok® Fittings (Siltek®/Sulfinert® & Silcosteel®-CR Treated)

- Full line of treated 1/16", 1/8", and 1/4" fittings.
- Silcosteel®-CR treatment enhances corrosion resistance by 10x or more.
- For custom treatment on any Swagelok® fitting or other system parts not listed here, call us or contact your Restek representative.

			Siltek/Sulfinert Treated		Silcosteel-CR Treated	
Fitting Type	**Size**	**Swagelok #**	**qty.**	**cat.#**	**qty.**	**cat.#**
Union	1/16"	SS-100-6	ea.	22540	ea.	22575
	1/8"	SS-200-6	ea.	22541	ea.	22576
	1/4"	SS-400-6	ea.	22542	ea.	22577
	3/8"	SS-600-6	ea.	22909	ea.	22904
Tee	1/16"	SS-100-3	ea.	22543	ea.	22578
	1/8"	SS-200-3	ea.	22544	ea.	22579
	1/4"	SS-400-3	ea.	22545	ea.	22580
	3/8"	SS-600-3	ea.	22910	ea.	22905
Reducing Union	1/8" to 1/16"	SS-200-6-1	ea.	22546	ea.	22581
	1/4" to 1/16"	SS-400-6-1	ea.	22547	ea.	22582
	1/4" to 1/8"	SS-400-6-2	ea.	22548	ea.	22583
	3/8" to 1/4"	SS-600-6-4	ea.	22911	ea.	22906
Elbow	1/8"	SS-200-9	ea.	22549	ea.	22584
	1/4"	SS-400-9	ea.	22550	ea.	22585
Plug	1/8"	SS-200-P	ea.	22573	ea.	22620
	1/4"	SS-400-P	ea.	22574	ea.	22597
Cross	1/8"	SS-200-4	ea.	22551	ea.	22586
	1/4"	SS-400-4	ea.	22552	ea.	22587
Tube End Reducer	1/8" to 1/16"	SS-100-R-2	ea.	22553	ea.	22588
	1/4" to 1/16"	SS-100-R-4	ea.	22554	ea.	22589
	1/8" to 1/4"	SS-400-R-2	ea.	22555	ea.	22590
	1/4" to 1/8"	SS-200-R-4	ea.	22556	ea.	22591
Port Connector	1/8"	SS-201-PC	ea.	22557	ea.	22592
	1/4"	SS-401-PC	ea.	22558	ea.	22593
	1/8" to 1/4"	SS-401-PC-2	ea.	22559	ea.	22594
Male Connector	1/8" to 1/8" NPT	SS-200-1-2	ea.	22561	ea.	22595
	1/4" to 1/4" NPT	SS-400-1-4	ea.	22562	ea.	22596
	1/16" to 1/8" NPT	SS-100-1-2	ea.	22563	ea.	22610
	1/8" to 1/4" NPT	SS-200-1-4	ea.	22564	ea.	22611
	1/4" to 1/8" NPT	SS-400-1-2	ea.	22565	ea.	22612
	3/8" to 3/8" NPT	SS-600-1-6	ea.	22912	ea.	22907
Female Connector	1/8" to 1/8" NPT	SS-200-7-2	ea.	22566	ea.	22613
	1/4" to 1/4" NPT	SS-400-7-4	ea.	22567	ea.	22614
	1/4" to 1/8" NPT	SS-400-7-2	ea.	22568	ea.	22615
	1/8" to 1/4" NPT	SS-200-7-4	ea.	22569	ea.	22616
Bulkhead Union	1/8"	SS-200-61	ea.	22570	ea.	22617
	1/4"	SS-400-61	ea.	22571	ea.	22618


union


tee


reducing union


elbow


plug


cross


tube end reducer


port connector


male connector


female connector


bulkhead union

Industry Experts at Your Service

At Restek, we have invested in highly focused product development and a world-class team of industry professionals. We are dedicated to bringing you the innovative chromatography solutions you need to make better process-control decisions.

Jan Pijpelink

Petrochemical Market Development Manager

Jan is a 30-plus-year veteran of the petrochemical industry with extensive international experience in petro laboratories and with process applications throughout North America, Europe, and Asia. Jan leads our scientific collaborations and key industry partnerships in the petro market.

E-mail: jan.pijpelink@restek.com

Jaap de Zeeuw

International GC Specialist

Jaap is a renowned chromatographer with over 30 years of petrochemical experience, including 28 years with Varian/Chrompack where he focused primarily on industrial analysis issues. Jaap is widely published and travels extensively for seminars and international workshops.

E-mail: jaap.dezeeuw@restek.com

Barry Burger

Sr. Petrochemical Innovations Chemist

Barry has more than 30 years of chromatography experience and has been a voting member of the ASTM D2 committee for 12 years. He specializes in petrochemical applications and the development of capillary, packed, and micropacked GC columns.

E-mail: barry.burger@restek.com

Katarina Oden

Petrochemical Innovations Chemist

Katarina came to Restek with a B.S. in Chemistry from the University of Ljubljana, Slovenia, and research experience in both commercial and university labs. After three years as a QA Analyst, she joined Innovations, where she supports the petroleum and chemical markets.

E-mail: katarina.oden@restek.com

Kristi Sellers

Product Marketing Manager for GC Columns

With over 25 years of experience in chromatography, Kristi has worked for Restek as a Clinical/Forensic Innovations Chemist, GC Column QA Chemist, and GC Process Chemist. She has also managed GC column manufacturing, QA, the applied science group, and R&D.

E-mail: kristi.sellers@restek.com

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U.S. • 110 Benner Circle • Bellefonte, PA 16823 • 1-814-353-1300 • 1-800-356-1688 • fax: 1-814-353-1309 • **www.restek.com**
China • phone: +86-10-5629-6620 • fax: +86-10-5814-3980 • cn.restek.com
France • phone: +33 (0)1 60 78 32 10 • fax: +33 (0)1 60 78 70 90 • www.restek.fr
Germany • phone: +49 (0)6172 2797 0 • fax: +49 (0)6172 2797 77 • www.restekgmbh.de
Italy • phone: +39-02-7610037 • fax: +39-02-70100100 • www.superchrom.it
Japan • phone: +81 (3)6459 0025 • fax: +81 (3)6459 0025 • e-mail: restekjapan@restek.com
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RESTEK REFINED innovative petrochemical solutions

Detailed Hydrocarbon Analysis

Featuring Rtx®-DHA Columns

- Individually tested to meet DHA method criteria; guaranteed column-to-column reproducibility.
- Improved resolution between oxygenates and hydrocarbons for more accurate reporting.
- Use of hydrogen carrier gas yields **50% faster run times.**

Superior Performance for DHA Analysis!

See page 5 for competitor comparison.

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Accurate DHA Analysis, Including Alcohols, Using Rtx®-DHA Columns

- Columns designed for ASTM Methods D6729, D6730, D6733, D5134, and D5501.
- Columns meet or exceed all ASTM and CAN/CGSB method guidelines.
- Excellent responses and peak symmetry for polar oxygenates.
- Guaranteed column-to-column reproducibility for efficiency, peak skewness, and low bleed.

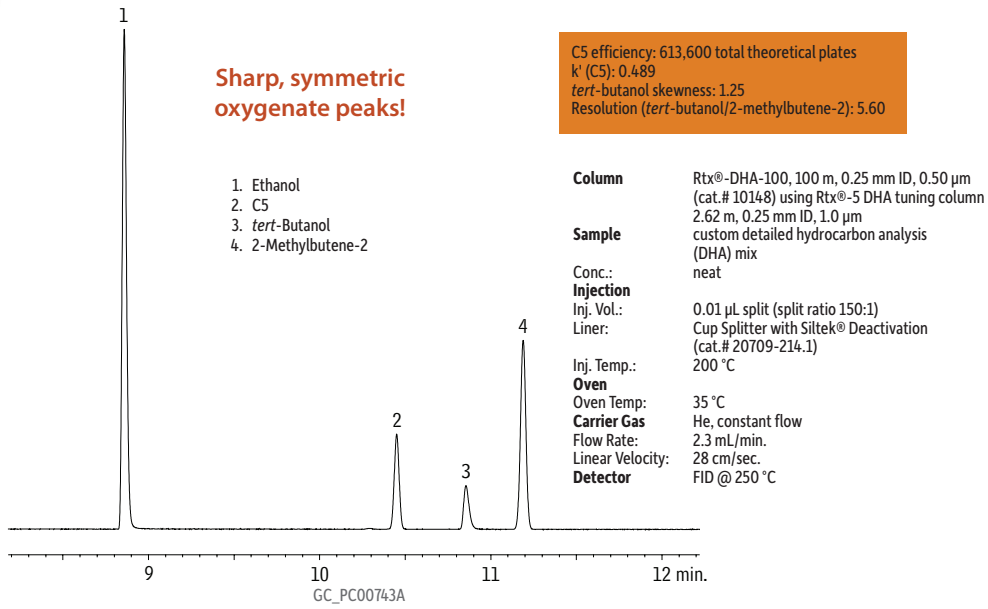
Gasolines are complex mixtures of hundreds of compounds. Information about concentrations of the individual components is important for evaluating raw materials and for controlling refinery processes. A high-resolution GC method for detailed hydrocarbon analysis (DHA) of gasolines is outlined in American Society of Testing and Materials (ASTM) Method D6730-01. ASTM D6730-01 is specific for the analysis of hydrocarbon components, plus oxygenated additives such as methanol, ethanol, *tert*-butanol, methyl *tert*-butyl ether (MTBE), and *tert*-amyl methyl ether (TAME) in spark-ignition engine fuels.

To maximize resolution of these complex mixtures, the ASTM method recommends a 100 m x 0.25 mm ID capillary column coated with 0.5 µm of 100% dimethyl polysiloxane stationary phase and sets minimum resolution criteria for several critical pairs of closely eluting compounds. To retain the aromatics, and accomplish the separations, a short tuning column, approximately 2-3 m long, coated with 5% diphenyl/95% dimethyl polysiloxane polymer, is connected to the inlet of the 100 m analytical column. Through a series of trial analyses, the length of the tuning column is adjusted to ensure the critical resolutions are achieved. Rtx®-DHA-100 columns are ideal for DHA methods and easily meet or exceed performance requirements.

Quality & Consistency

Analytical columns used for DHA applications must exhibit high efficiency and exceptional inertness, especially for polar oxygenates in gasoline. Figure 1 illustrates a column efficiency of 613,600 total theoretical plates, measured on C5, and shows excellent peak symmetry for the oxygenated additives, including ethanol and *tert*-butanol (*tert*-butanol skewness = 1.25). We test every Rtx®-DHA-100 column for retention (k'), efficiency (n), stationary phase selectivity (α), and bleed, according to ASTM D6730. Data are shown on each test report, assuring that your Rtx®-DHA column will meet method specifications.

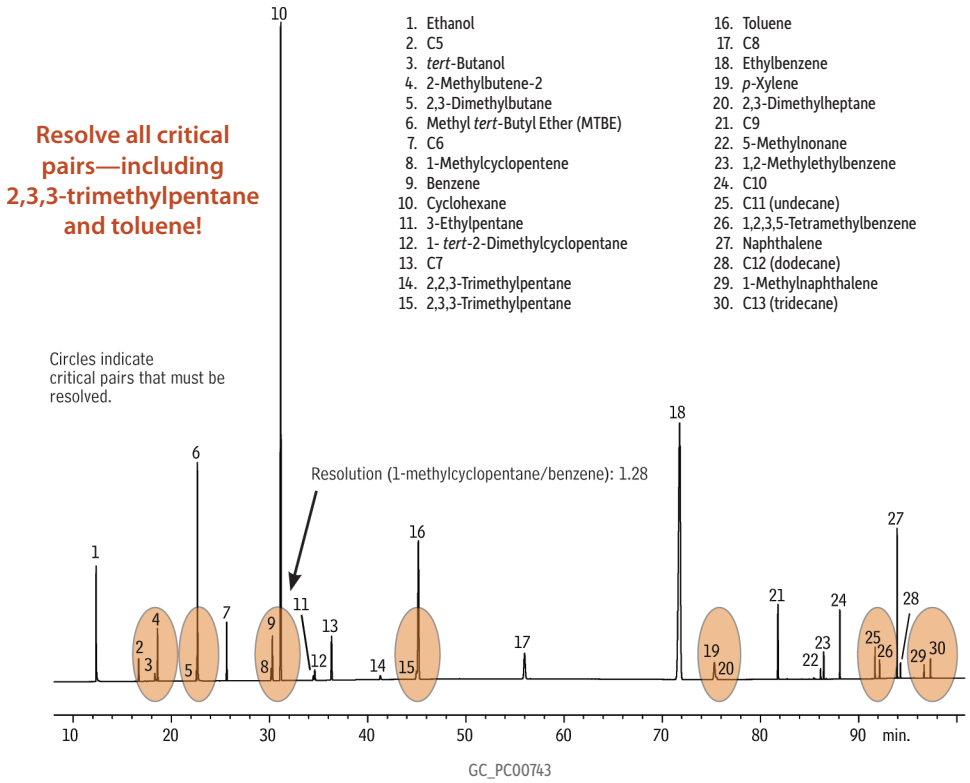
Figure 1 Rtx®-DHA-100 columns meet or exceed ASTM D6730 specifications.



Resolution of Critical Pairs

There are a number of critical compound pairs that must be resolved as measured by an oxy set-up blend mix. An Rtx®-DHA-100 column meets all ASTM D6730-01 requirements for critical pair resolution, as demonstrated in Figure 2. A 2.6 m tuning column was used to achieve the highlighted resolutions based on retention of the aromatics (e.g., resolution for 1-methylcyclopentene/benzene = 1.28). In addition to qualifying for the ASTM D6730-01 analysis, Rtx®-DHA-100 columns meet the similarly stringent Canadian General Standards Board CAN/CGSB 3.0 No. 14.3-99 requirements.

Figure 2 Critical pairs of gasoline components resolved per ASTM specifications, using an Rtx®-DHA-100 column.



Column	Rtx®-DHA-100, 100 m, 0.25 mm ID, 0.50 µm (cat.# 10148) using Rtx®-5 DHA Tuning Column, 2.62m, 0.25mm ID, 1.0µm (cat.# 10165)
Sample	custom detailed hydrocarbons analysis (DHA) mix
Conc.:	neat
Injection	
Inj. Vol.:	0.01 µL split (split ratio 150:1)
Liner:	Cup Splitter with Siltek® Deactivation (cat.# 20709-214.1)
Inj. Temp.:	200 °C
Oven	
Oven Temp:	5 °C (hold 15 min.) to 50 °C at 5 °C/min. (hold 50 min.) to 200 °C at 8 °C/min. (hold 10 min.)
Carrier Gas	He, constant flow
Flow Rate:	2.3 mL/min.
Linear Velocity:	28 cm/sec.
Detector	FID @ 250 °C

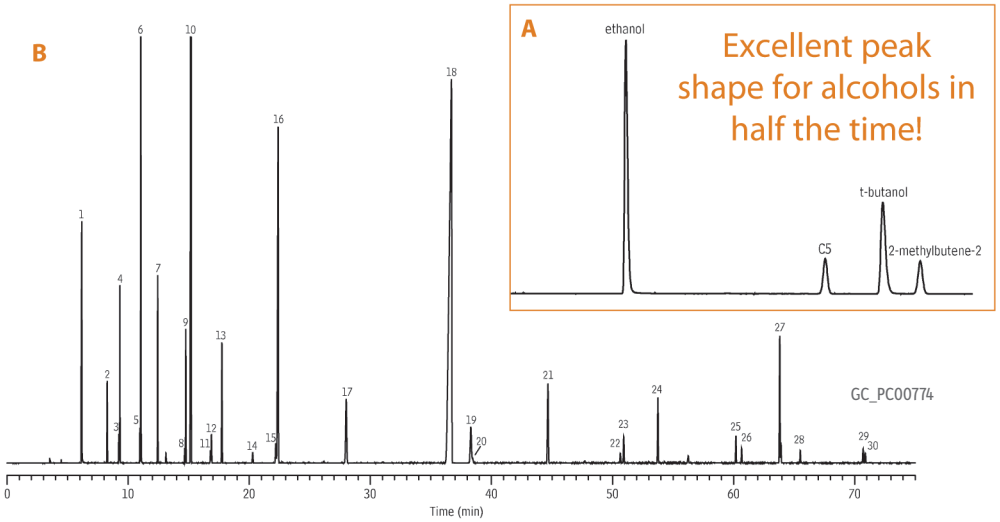
Speed Up Analysis Time Using Hydrogen

Rtx®-DHA-100 columns easily meet all ASTM and CGSB method requirements when using helium as the carrier gas. However analysis times can be improved significantly—with no loss in chromatographic performance—by switching to hydrogen as the carrier gas. Rtx®-DHA-100 columns meet or exceed all criteria in these standardized methods in up to 50% less time when using hydrogen (Figure 3).

Figure 3 Achieve up to 50% faster analysis times using hydrogen instead of helium.

	Optimized D6730 with hydrogen*	Optimized D6730 with helium*	Standard D6730 conditions
Approximate analysis time	72 min.	98 min.	146 min.
% Time savings (relative to standard method conditions)	51% faster	33% faster	—

* Optimized conditions and chromatographic results for hydrogen shown below; for helium, see Figure 2.



Column Rtx®-DHA-100, 100 m, 0.25 mm ID, 0.50 µm (cat.# 10148) plus Rtx®-5 DHA tuning column 5 m, 0.25 mm ID
Sample DHA/oxygenates setup blend (see notes)
Injection
Inj. Vol.: 0.01 µL split (split ratio 150:1)
Liner: Cup Splitter with Siltek® Deactivation (cat.# 20709-214.1)
Inj. Temp.: 250 °C
Oven
Carrier Gas H_2, constant flow
Flow Rate: 3.62 mL/min.
Linear Velocity: 55 cm/sec.
Detector FID @ 300 °C
Oven Temp A: 35 °C;
B: 5 °C (hold 8.32 min.) (elute C5) to 48 °C at 22°C/min. (hold 26.32 min.) (elute ethylbenzene) to 141 °C at 3.20 °C/min. (elute C12) to 300 °C at 1 °C/min.

Acknowledgement Chromatogram courtesy of Neil Johansen, Inc., Aztec, New Mexico, in association with Envantage Analytical Software, Inc., Cleveland, Ohio.

A: Front end of DHA/oxygenates set-up blend
C5 Efficiency: 586,825 plates
C5 k': 0.476
tert-Butanol skew: 2.10
Resolution: (*tert*-butanol/2-methylbutene-2: 5.39

B: DHA/oxygenates setup blend
1. Ethanol
2. C5
3. *tert*-Butanol
4. 2-Methylbutene-2
5. 2,3-Dimethylbutane
6. Methyl *tert*-Butyl Ether (MTBE)
7. C6
8. 1-Methylcyclopentene
9. Benzene
10. Cyclohexane
11. 3-Ethylpentane
12. 1,2-Dimethylcyclopentane
13. C7
14. 2,2,3-Trimethylpentane
15. 2,3,3-Trimethylpentane
16. Toluene
17. C8
18. Ethylbenzene
19. *p*-Xylene
20. 2,3-Dimethylheptane
21. C9
22. 5-Methylnonane
23. 1,2-Methylethylbenzene
24. C10
25. C11
26. 1,2,3,5-Tetramethylbenzene
27. Naphthalene
28. C12
29. 1-Methylnaphthalene
30. C13

Superior Performance for DHA Analysis

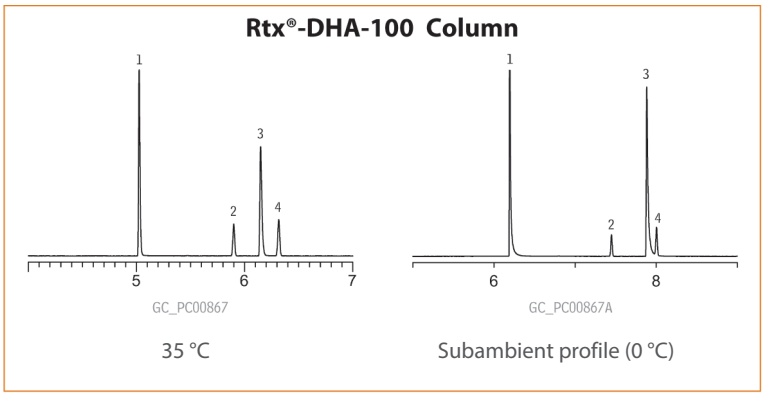
A comparison of DHA columns (also referred to as PIANO, PIONA, or PONA columns by other manufacturers) shows that the Rtx®-DHA-100 column is the best overall DHA column for peak shape, theoretical plates, and required resolution. Figure 4 shows that, at 35 °C, as specified in the ASTM methods, the Vendor A and Vendor B PONA columns did not meet ASTM D6730 method specifications. The Vendor C and Vendor D PONA columns performed within specifications, but column efficiency was less than ideal. In contrast, the performance of the Rtx®-DHA-100 column at 35 °C was well within ASTM D6730 method specifications, and column efficiency exceeded the specification. The column also performed well at subambient temperature. [Additional evidence of Rtx®-DHA-100 column performance is available at www.restek.com/DHAreport, which shows processed data from Neil Johansen identifying more than 400 individual components in finished gasoline.]

Figure 4 Rtx®-DHA-100 columns outperform competitor columns for detailed hydrocarbon analysis.

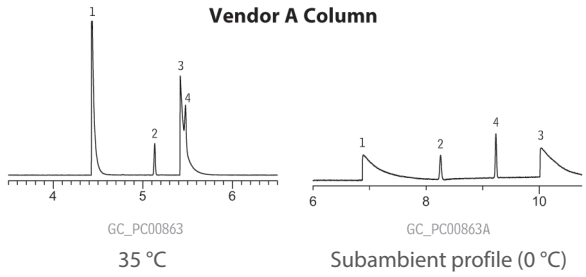
PONA Test Mix

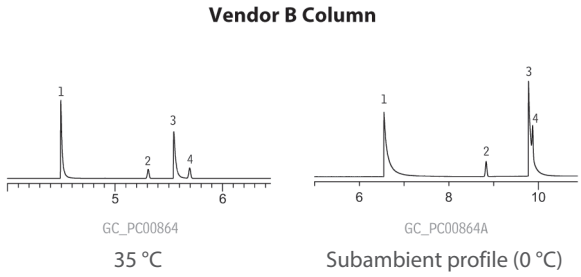
	ASTM D6730 guidelines	**Rtx-DHA-100**	Vendor A	Vendor B	Vendor C	Vendor D
Minimum C5 Efficiency*	400,000-550,000 plates	**613,600**	523,000	466,100	490,000	483,400
k' (C5)	0.45-0.50	**0.49**	0.46	0.51**	0.47	0.46
tert-Butanol Skewness	>1.00-<5.00	**1.25**	>5.00**	3.60	1.71	1.59
Minimum Resolution (*tert*-butanol/2-methylbutene-2)*	3.25-5.25	**5.60**	1.00**	4.32	5.01	5.07

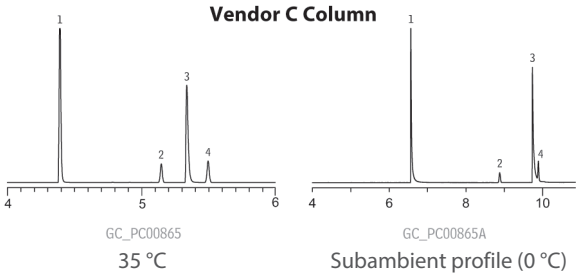
* Minimum values; criteria may be exceeded for these parameters.
** Fails method criteria (results based on analyses at 35 °C).

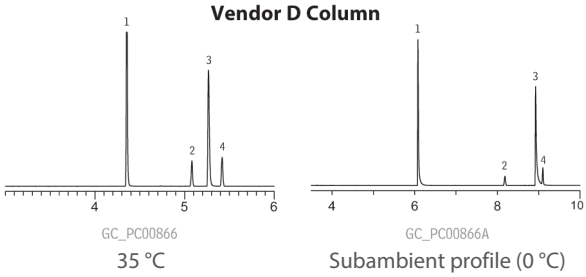


Superior performance for ASTM D6730 method specifications!









Column:	100 m, 0.25 mm ID, 0.50 µm
Sample:	DHA Oxy-Setup mix (Transition Labs #94100)
Inj.:	0.01 µL split (split ratio 150:1)
Inj. temp.:	275 °C
Carrier gas:	hydrogen
Linear velocity:	48 cm/sec.
Det.:	FID
Det. temp.:	300 °C

Oven temp.:	35 °C and Method D 6730 temperature profile
Temperature Profile	
Column A:	5 °C > 8.23 min. > 22 °C/min. > 48 min.
Column B:	5 °C > 8.84 min. > 22 °C/min. > 48 min.
Column C:	5 °C > 8.87 min. > 22 °C/min. > 48 min.
Column D:	5 °C > 8.19 min. > 22 °C/min. > 48 min.
Rtx®-DHA-100:	5 °C > 8.20 min. > 22 °C/min. > 48 min.

1. ethanol
2. pentane (C5)
3. *t*-butanol
4. 2-methylbutene-2

Columns Tested:
J&W: HP-DHA1
SGE: BPI-PONA
Supelco: Petrocol DH
Varian: CP Sil PONA CB

Conclusion

Rtx®-DHA-100 columns offer the best overall value and performance for detailed hydrocarbon analysis. These columns meet or exceed all ASTM D6730-01 and Canadian General Standards Board method requirements and outperform other commercially available columns. Make your next DHA column an Rtx®-DHA-100 column—individually tested to meet DHA method criteria, assuring outstanding performance and column-to-column reproducibility.

Product Listing

Columns

Rtx®-DHA Columns (fused silica)

(Crossbond® 100% dimethyl polysiloxane—optimized for hydrocarbon analysis)

similar phases

Petrocol DH, DB-Petro, HP-PONA, CP-Sil PONA C8

Description	temp. limits	cat.#
Rtx-DHA-50		
50m, 0.20mm ID, 0.50µm	-60 to 300/340°C	10147
Rtx-DHA-100		
100m, 0.25mm ID, 0.50µm	-60 to 300/340°C	10148
Rtx-DHA-150		
150m, 0.25mm ID, 1.00µm	-60 to 300/340°C	10149

Method Recommended Columns

ASTM Method	Column	Dimensions	cat.#
D6729	Rtx-DHA-100	100m x 0.25mm, 0.50µm	10148
D6730	Rtx-DHA-100 & Rtx-5 DHA Tuning Column	100m x 0.25mm, 0.50µm w/ precolumn	10148 & 10165
D6733	Rtx-DHA-50	50m x 0.20mm, 0.50µm	10147
D5134	Rtx-DHA-50	50m x 0.20mm, 0.50µm	10147
D5501	Rtx-DHA-150	150m x 0.25mm, 1.0µm	10149

Rtx®-5 DHA Tuning Column (fused silica)

(Crossbond® 5% diphenyl/95% dimethyl polysiloxane—optimized for hydrocarbon analysis)

Description	temp. limits	cat.#
5m, 0.25mm ID, 1.00µm	-60 to 340°C	10165

Note: Rtx®-1PONA columns have been renamed as Rtx®-DHA columns. There are no changes in column manufacturing or performance.

Press-Tight® Connectors

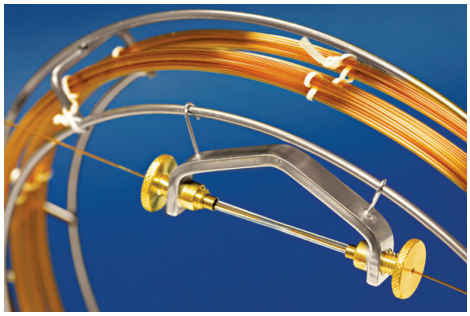
- Deactivated Press-Tight® connectors maintain complete intertness for the GC flow path.
- Fit column ODs from 0.33–0.74 mm (Restek 0.1 mm–0.53 mm ID).

Universal Press-Tight® Connectors

- Connect a guard or tuning column to an analytical column.
- Repair a broken column.
- Connect a column outlet to a transfer line.

Description	5-pk.	25-pk.	100-pk.
Universal Press-Tight Connectors	20400	20401	20402
Universal Press-Tight Connectors, Deactivated	20429	20430	
Universal Press-Tight Connectors, Siltek Deactivated	20480	20449	

Vu2 Union® Connectors



- Can be used anywhere a Universal Press-Tight® connector can.
- Fit both Restek cage designs.

Kits include:

Vu2 Union® body, 2 knurled nuts, 2 Press-Tight® unions, and 4 ferrules

Description	Ferrules Fit Column ID	qty.	cat.#
Vu2 Union Connector Kit	0.18–0.28mm	kit	21105
Knurled nut		2-pk.	21108

NOTE: This product is not recommended for GC column-to-MS connections. Visit www.restek.com for more information.

Inlet Liners

4.0mm ID Cup Inlet Liner

For Agilent GCs equipped with split/splitless inlets

ID x OD x Length	qty.	cat.#
Cup, Intermediate Polarity (IP), Borosilicate Glass		
4.0mm x 6.3mm x 78.5mm	ea.	20709
4.0mm x 6.3mm x 78.5mm	5-pk.	20710
Cup, Siltek, Borosilicate Glass		
4.0mm x 6.3mm x 78.5mm	ea.	20709-214.1
4.0mm x 6.3mm x 78.5mm	5-pk.	20710-214.5

For a wide selection of Restek inlet liners
www.restek.com/liners

Sky™ Inlet Liners

Exceptionally inert, Sky™ inlet liners with a new state-of-the-art deactivation improve trace-level analysis.

- Increase accuracy and precision by preventing loss of sensitive analytes—even when using wool.
- Achieve lower detection limits for a wide range of active compounds.
- Ensure liner-to-liner reproducibility through consistent manufacturing and extensive testing.

Sky™ 4.0mm ID Cyclo Inlet Liner

For Agilent GCs equipped with split/splitless inlets

ID x OD x Length	qty.	cat.#
Cyclo, Sky Technology, 4.0mm x 6.3mm x 78.5mm	ea.	23312.1
	5-pk.	23312.5
	25-pk.	23312.25

Learn more and view the full Sky™ product listing at
www.restek.com/sky

restek **exclusive**!

Restek Thermolite® Septa

- Usable to 340 °C inlet temperature.
- Precision molding assures consistent, accurate fit.
- Excellent puncturability.
- Preconditioned and ready to use.
- Do not adhere to hot metal surfaces.
- Packaged in precleaned glass jars.

Septum Diameter	25-pk.	50-pk.	100-pk.
5mm (3/16")	27120	27121	27122
6mm (1/4")	27123	27124	27125
7mm	27126	27127	27128
8mm	27129	27130	27131
9mm	27132	27133	27134
9.5mm (3/8")	27135	27136	27137
10mm	27138	27139	27140
11mm (7/16")	27141	27142	27143
11.5mm	27144	27145	27146
12.7mm (1/2")	27147	27148	27149
17mm	27150	27151	27152
Shimadzu Plug	27153	27154	27155

Restek Electronic Leak Detector

- Optimized sample flow path.
- Ergonomic, hand-held design.
- Handy probe storage for cleanliness and convenience.
- Longer lasting battery, up to 6 hours of continuous use.
- Automatic shut-off.
- Easy to clean probe assembly.
- A universal charger set (US, European, UK, and Australian plugs included).

Learn more at
www.restek.com/leakdetector

Description	qty.	cat.#
Leak Detector with Hard-Sided Carrying Case and Universal Charger Set (US, UK, European, Australian)	ea.	22839
Leak Detector Routine Maintenance Review	ea.	22839-R
Small Probe Adaptor	ea.	22658

Product Listing

Reference Standards

Widest variety of standards available!

Visit **www.restek.com/petro** for our most current list.

Oxy Set-Up Blend (30 components)

ASTM method D6730-01 is specifically designed for the determination of the individual hydrocarbons present in spark ignition fuels, as well as fuel blends containing oxygenates such as methyl *tert*-butyl ether, ethyl *tert*-butyl ether, *tert*-butanol, ethanol, etc.

Gravimetrically prepared and NIST-traceable.

benzene	1.00%
tert-butanol	0.50%
cyclohexane	28.9%
n-decane	1.00%
2,3-dimethylbutane	0.50%
trans-1,2-dimethylcyclopentane	0.50%
2,3-dimethylheptane	0.20%
dodecane	0.25%
ethanol	8.00%
ethylbenzene	25.0%
3-ethylpentane	0.20%
n-heptane	2.00%
n-hexane	2.00%
2-methylbutene-2	2.50%
methyl *tert*-butyl ether	10.0%
1-methylcyclopentene	0.50%
1-methyl-2-ethylbenzene	0.50%
1-methylnaphthalene	0.25%
5-methylnonane	0.20%
naphthalene	0.50%
n-nonane	2.00%
n-octane	2.00%
n-pentane	2.00%
1,2,3,5-tetramethylbenzene	0.25%
toluene	7.00%
tridecane	0.25%
2,2,3-trimethylpentane	0.52%
2,3,3-trimethylpentane	0.50%
undecane	0.50%
p-xylene	1.00%
2 mL prescored ampul	cat.# 33034 (ea.)

DHA Standards

These blends are standards used for calibrating complex hydrocarbon analyses and provide the greatest number of gravimetrically determined values for quantitative calibration.

DHA PIANO Blend (136 components)

Neat, 0.1 mL in Autosampler Vial	cat.# 30712 (ea.)
Neat, 0.1 mL in Vial with Mininert Valve	cat.# 30709 (ea.)

DHA Paraffins Mix (11 components)

Neat, 0.1 mL in Autosampler Vial	cat.# 30713 (ea.)
Neat, 0.1 mL in Vial with Mininert Valve	cat.# 30714 (ea.)

DHA Isoparaffins Mix (34 components)

Neat, 0.1 mL in Autosampler Vial	cat.# 30715 (ea.)
Neat, 0.1 mL in Vial with Mininert Valve	cat.# 30716 (ea.)

DHA Aromatics Mix (38 components)

Neat, 0.1 mL in Autosampler Vial	cat.# 30717 (ea.)
Neat, 0.1 mL in Vial with Mininert Valve	cat.# 30718 (ea.)

DHA Naphthenes Mix (27 components)

Neat, 0.1 mL in Autosampler Vial	cat.# 30719 (ea.)
Neat, 0.1 mL in Vial with Mininert Valve	cat.# 30720 (ea.)

DHA Olefins Mix (26 components)

Neat, 0.1 mL in Autosampler Vial	cat.# 30721 (ea.)
Neat, 0.1 mL in Vial with Mininert Valve	cat.# 30722 (ea.)

DHA PONA VI Mix

PONA-VI (PONA 6) is a qualitative mixture of various gasoline and refinery materials prepared to provide nearly every component that may be encountered in feedstock and finished gasolines. Some oxygenates have been added to allow this blend to be used for DHA method setup.

Contact us for component listing.

Neat, 0.1 mL in Autosampler Vial	cat.# 30723 (ea.)
Neat, 0.1 mL in Vial with Mininert Valve	cat.# 30724 (ea.)

No data pack available.

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Thermal Desorption: A Practical Applications Guide

I. Environmental Air Monitoring and Occupational Health & Safety

MARKES international

www.markes.com

Introduction to Markes International Ltd.

Formed in 1997, Markes International Ltd. is one of the world's leading suppliers of thermal desorption (TD) equipment for monitoring trace toxic and odorous chemicals in air, gas and materials. Serving fast growing markets from environmental health and 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 has introduced several highly successful brands of TD instruments to the market including: **UNITY™** – a universal TD platform for single tubes, the 100-tube **ULTRA**™ TD autosampler, the **Air Server™** interface for canisters and on-line sampling, the **µ-CTE™** Micro-Chamber / Thermal Extractor for materials testing, the **TT24-7™** for continuous on-line monitoring and the **TC-20™** multi-tube conditioner.

Markes also supplies a wide range of sampling accessories and consumables for all TD application areas.

What is TD?

Since the early 1980s, thermal desorption has provided the ultimate versatile sample introduction technology for GC / GC-MS. It combines selective concentration enhancement with direct extraction into the carrier gas and efficient transfer / injection all in one fully automated and labour-saving package.

Markes International Ltd. UK headquarters

Applications

Thermal desorption is now recognised as the technique of choice for environmental air monitoring and occupational health & safety. Relevant standard methods include: ISO/EN 16017, EN 14662 (parts 1 & 4), ASTM D6196, US EPA TO-17 and NIOSH 2549. Related applications include monitoring chemical warfare agents (CWA) in demilitarisation / destruction facilities & civilian locations (counter-terrorism).

TD is also routinely used for monitoring volatile and semi-volatile organic compounds (S)VOCs in products and materials. Examples include residual solvents in packaging & pharmaceuticals, materials emissions testing and food / flavour / fragrance profiling.

This publication presents several real world applications in environmental air monitoring and occupational health & safety. Accompanying publications cover the application areas of:

- Food, flavour, fragrance & odour profiling
- Defence & forensic
- Emissions from products and materials

Environmental air monitoring

- Atmospheric research
- Ambient / urban air monitoring
- Industrial (stack) emissions
- Odour components
- Indoor air quality

Occupational health & safety

- Personal exposure monitoring (inhalation)
- Biological exposure assessment (breath testing)

Markes International Ltd.
T: +44 (0)1443 230935 **F:** +44 (0)1443 231531
E: enquiries@markes.com **W:** www.markes.com

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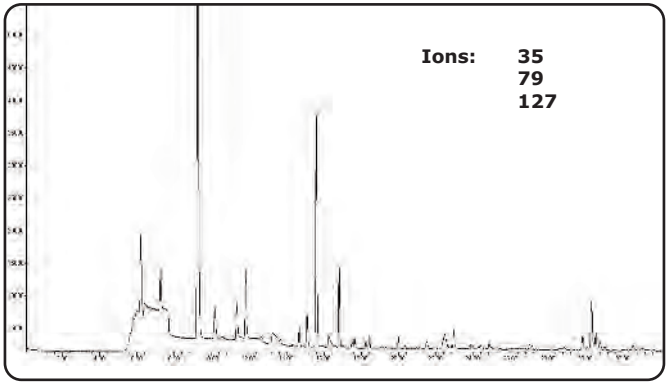
Atmospheric research



30 ml of air from bubbles in the ice core collected in canisters. Analysis by TD-GC-MS in NCI mode. Unit ppt detection limits

Typical analytes of interest:

- Freons
- Volatile aromatics such as benzene
- C_2 - C_{10} hydrocarbons
- Nitrates

Concentrations: ppt levels

Background:

Thermal desorption is used extensively in atmospheric research for monitoring trace organic vapours. For example:

- Global migration of pollution
- Research into stratospheric chemistry
- Marine research – studying the oceans as a potential 'sink' or reservoir for air pollutants
- Historical pollution data – *e.g.* levels of freons in air bubbles trapped in polar ice

Std. methods: EN ISO 16017-1, ASTM D 6196, US EPA TO-17, (tubes) or US EPA TO-15 (canisters)

Typical TD-GC conditions:

Sampling: Pumped multi-sorbent tube or canister

TD: ULTRA-UNITY or UNITY-Air Server (+dryer)

Dry purge if no dryer used during sampling

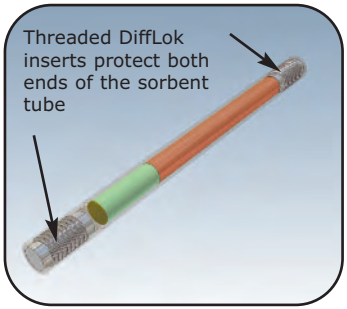
Splitless desorption

Trap: Air Toxics / water m'gement: -15 to 320°C

Analysis by GC-MS using SIM or NCI

Reference: TDTS17 UNITY detection limits, TDTS31 UNITY system performance

SafeLok™ – Specialist sample tubes for trace detection



SafeLok samplers incorporate Markes' patented* DiffLok technology to prevent artifact ingress. This aids trace level monitoring

Typical analytes:

- Freons & other halogenated hydrocarbons
- Volatile aromatics
- Oxygenates

Concentrations: ppt levels

Background:

SafeLok samplers have the same capacity as standard tubes but incorporate Markes' patented* diffusion-locking (DiffLok™) technology at both ends of the tube to prevent artifact ingress.

With the same external dimensions as standard TD tubes, SafeLok tubes are ideal for monitoring ultra-low concentration environments – for example at the North Pole or in mid-Pacific. Samples are protected from contamination during storage / transport and during subsequent TD-GC-MS analysis in a conventional laboratory.

Std methods: EN ISO 16017-1, US EPA TO-17, ASTM D 6196

Typical TD-GC conditions:

Sampling: Pumped multi-sorbent SafeLok tube

TD: ULTRA-UNITY

Dry purge

Splitless desorption

Trap: Air Toxics / water m'gment: -15 to 320°C

Analysis by GC-MS using SIM or NCI

Reference: TDTS61 on diffusion locking technology, Markes SafeLok tubes leaflet

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US 6,564,656 B1

Markes International Ltd.
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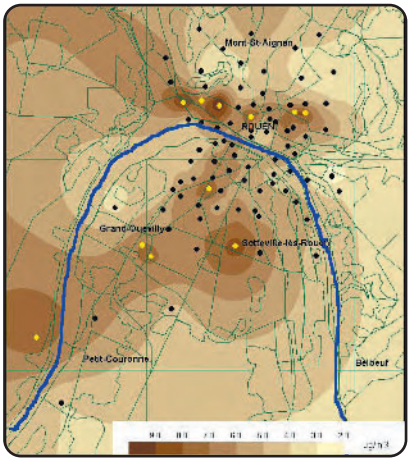
MARKES international

Criteria pollutants in ambient air by diffusive sampling



Rouen (Northern France)
Interpolated benzene isoconcentration plot
Measurements performed from 19-23/01/98

Typical analytes:

- Volatile aromatics
- 1,3-butadiene

Concentrations: Sub to low ppb levels

Background:

Accurate mapping of pollution levels across a major urban centre requires hundreds of sampling points. Diffusive samplers, combined with automated TD-GC(-MS) analysis, provide an affordable and easily deployed monitoring option.

Std. methods: EN 14662-4, EN ISO 16017-2, ASTM D 6196

Typical TD-GC analytical conditions:

Sampling: Diffusive (passive)

Sorbent: Carbograph 1TD™ (benzene),

Sorbent: Carbopack X™ (1,3-butadiene)

Monitoring time: 7-14 days (axial), 4-6 hours (radial)

Desorption: 5-10 minutes at 320ºC

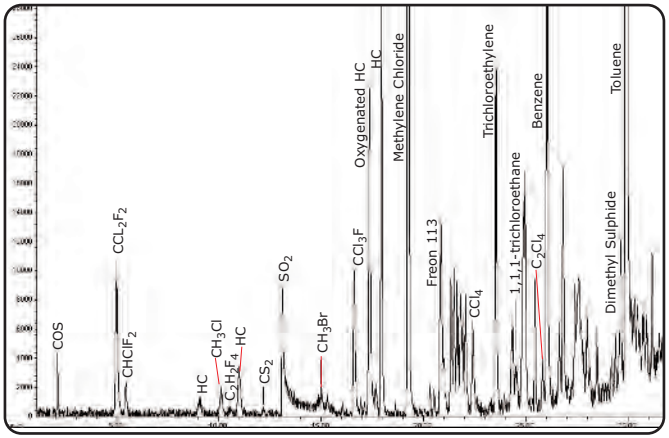
Trap: C'graph 1TD / Carb X from +30 to 320°C

Split: ~20:1 during trap desorption only

Analysis by GC-FID or GC-MS

Reference: TDTS10 on diffusive monitoring of ambient air, TDTS01 on uptake rates, TDTS42 on radial diffusion for TD

TO-17 'Air Toxics' in urban air using pumped sorbent tubes



Active sampling of volatiles in ambient air using sorbent tubes / traps

Typical analytes:

Hydrocarbons, halogenated hydrocarbons, CS_2, volatile aromatics, ketones, esters & other odorous / toxic VOCs ranging in volatility from freons to hexachlorobutadiene

Concentrations: Sub to low ppb levels

Background:

US Clean Air Act regulations have identified specific 'Hazardous Air Pollutants' (HAPs) also known as 'Air Toxics'. These analytes cover a wide range of polarities & volatilities and are most effectively monitored using pumped sampling onto multi-sorbent tubes / traps with automated TD-GC-MS(SCAN) analysis.

Std. method: US EPA Method TO-17

Typical TD-GC analytical conditions:

Sampling: Pumped sorbent tube

Sorbent: Dual-sorbent – *e.g.* 'Air Toxics' tube

TD system: ULTRA-UNITY

On- or off-line dry purge before desorption

Desorption: 10 mins at 320ºC

Trap: Air Toxics trap: +30 to 330°C

Split: Low split during trap desorption only

Analysis: GC-MS(SCAN)

Reference: Markes Technical Support Document for TO-17, TDTS27 on sampling methods for VOCs in air

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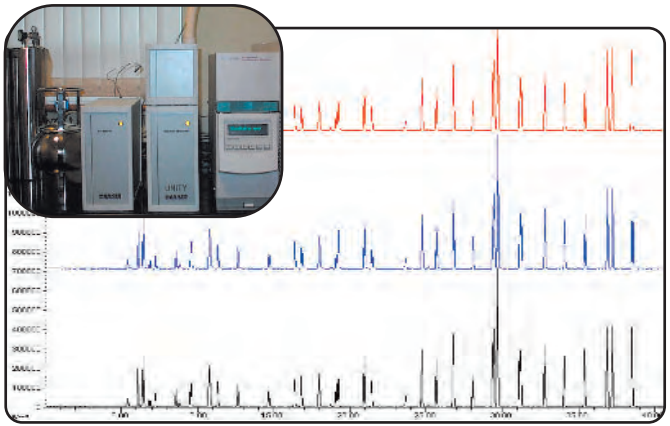
TO-15 'Air Toxics' in urban air using canisters



Repeat analysis of TO-14 / 15 canister standard using UNITY-Air Server (up to 8 channels)

Typical analytes:

Hydrocarbons, halogenated hydrocarbons, CS_2, volatile aromatics, esters & other odorous / toxic VOCs ranging in volatility from freons to hexachlorobutadiene

Concentrations: Sub to low ppb levels

Background:

While sorbent tubes provide the most cost-effective and versatile sampling solution for VOC Air Toxics, passivated and evacuated canisters can also be used for 'grab' sampling ambient air. Subsequent analysis is by TD-GC-MS(SCAN). Very volatile apolar VOCs are quantitatively recovered from the canisters, however, polar and less volatile compounds may be lost due to condensation on inner surfaces.

Std. method: US EPA Method TO-15 (formerly TO-14)

Typical TD-GC analytical conditions:

Sampling: Evacuated canister

TD system: UNITY-Air Server (no dryer)

Trap: Air Toxics trap: +30 to 330°C

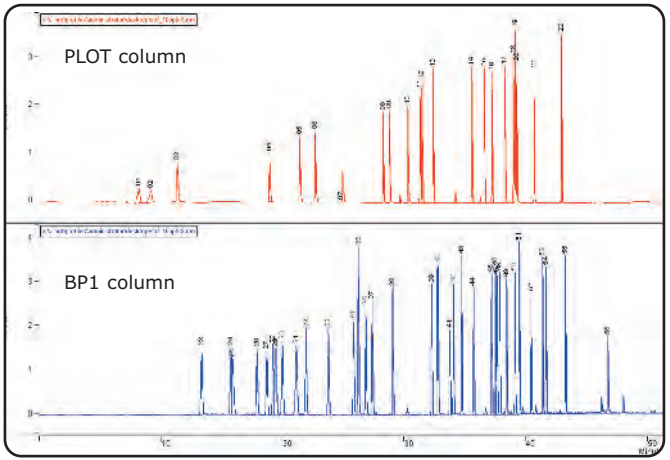
Dry purge of cold trap before desorption

Split: Low split during trap desorption only

Analysis: GC-MS(SCAN)

Reference: TDTS27 on sampling methods for VOCs in air

'Ozone precursors' (C_2 to C_{10} hydrocarbons) in ambient air



Splitless desorption of 56-compound US EPA mix of ozone precursors using UNITY-Air Server with dual column / dual FID GC with Deans switch

Typical analytes:

Hydrocarbons ranging in volatility from ethane, ethene and ethyne (acetylene) to trimethyl benzene

Concentrations: Sub to low ppb levels

Background:

C_2 to C_{10} hydrocarbons, primarily from car exhausts, have been identified as precursors to the formation of street level ozone and urban smog. US, European and other regulators require round-the-clock monitoring of these compounds in major urban centres during the summer months. UNITY-Air Server allows continuous, unattended and cryogen-free monitoring at low to sub ppb levels. Chromatographic data, from multiple stations, are accessed via telemetry and processed / validated at remote network control centres.

Official guidance: US EPA Tech. Assist. Document for sampling and analysis of ozone precursors

Typical TD-GC analytical conditions:

Sampling: On-line from manifold at 10-15 ml/min

Sampling volume: ~400 ml

TD system: UNITY-Air Server (with dryer)

Trap: Ozone Precusor trap: -15 to 320°C

Splitless desorption

Analysis: GC, dual column, dual FID & Deans switch

Reference: TDTS16 On-line monitoring of ozone precursors in ambient air

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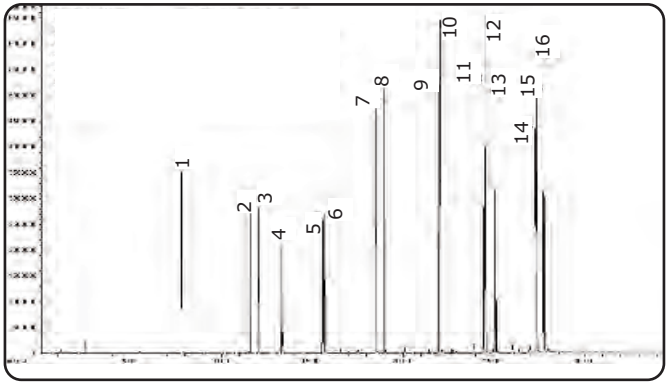
Vapour-phase PAH by TD



Semi-volatile PAHs are quantitatively recovered using a Markes UltrA-UNITY TD system

Analytes shown:

1: naphthalene
2: acenaphthylene
3: acenaphthene
4: fluorene
5: phenanthrene
6: anthracene
7: fluoranthene
8: pyrene
9: benz(a)anthracene
10: chrysene
11: benzo(b)fluoranthene
12: benzo(k)fluoranthene
13: benzo(a)pyrene
14: dibenz(a,h)anthracene
15: benzo(g,h,i)perylene
16: indeno(1,2,3-cd)pyrene

Background:

Polyaromatic hydrocarbons (PAH) are toxic semi-volatile organic compounds present in ambient air in both particulate and vapour form. Fast (~500 ml/min) pumped sampling of the vapour fraction onto tubes packed with a combination of quartz wool and carbon sorbents followed by TD-GC-MS analysis allows measurement of PAH at low ppt levels.

Typical TD-GC analytical conditions:

Sampling: Pumped sorbent tube

Sorbent: Quartz wool with 1 or 2 carbon blacks

Sample volume: ~100 L at 500 ml/min

TD system: UltrA-UNITY

Desorption: 15 mins at 350°C

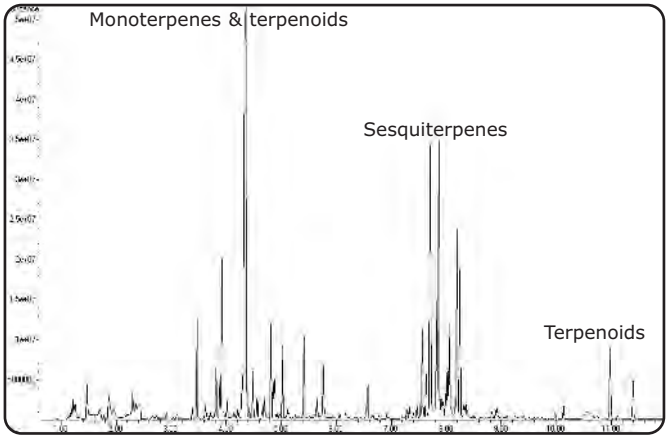
Trap: High boilers trap: -10 to 350°C

Split: Typically 30:3 during trap desorption only

Analysis: GC-MS(SIM)

Reference: M. Caputi, 'Monitoring of VOCs and PAHs in the atmosphere', PhD thesis 2004, TDTS53 on quantitative recovery of semi-volatiles with Markes (UltrA-)UNITY TD systems

Biogenic emissions - VOCs from moulds, plants, *etc.*



Terpenes from leaf litter

Typical analytes:

Isoprene, monoterpenes (α-pinene, limonene, *etc.*), sulphur compounds, ketones

Concentrations: 0.1 to 100 ppb

Background:

Plants, moulds, animals and other life forms emit VOCs and contribute to the 'cocktail' of organic vapours in ambient air. Monoterpenes, for example, are emitted by pine trees on sunny days, possibly as a defence against potential photochemical damage. These reactive hydrocarbons are monitored using pumped sampling onto inert, Tenax tubes followed by TD-GC-MS analysis. Mould emissions of methyl benzoate are monitored in indoor air using a similar method.

Std. methods: EN ISO 16017-1, ASTM D 6196

Typical TD-GC analytical conditions:

Sampling: Pumped sorbent tube

Sorbent: Tenax TA™ in stainless / Silcosteel™ tube

TD system: ULTRA-UNITY

Desorption: 5 mins at 220°C

Trap: Tenax trap: -10 to 250°C

Split: Low split during trap desorption only

Analysis: GC-MS(SCAN)

Reference: J. Kristensson *et al.*, 'Sampling & analysis of atmospheric monoterpenes', Dept of Meteology, Stockholm University, 1991

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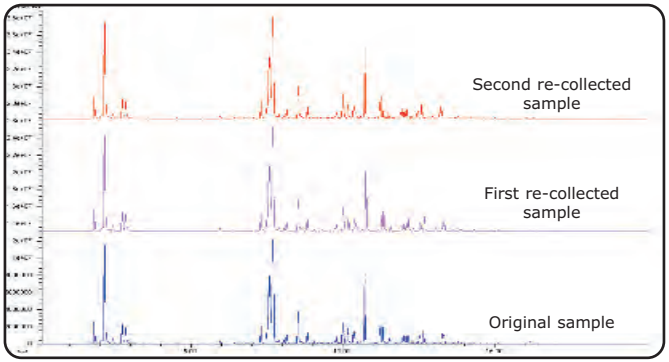
Industrial (stack) emissions - solvents



Quantitative stack analysis confirmed by SecureTD-Q

Analyte	Mass in µg for 3 repeats		
MEK	580	583	580
Benzene	0.14	0.18	0.18
Toluene	94	91	93
Ethyl benzene	30	30	29
PGMEA	43	43	43
Xylene	274	275	271
DMS	28	28	28
Trimethylbenzene	43	44	42

Background:

Stack gases are aggressive matrices requiring a sampling train to remove particles, acids etc. The resultant air is either pulled through a TD tube using a gas syringe (grab sampling) or pumped onto a tube at low flow rates (time weighted average). Analysis by TD-GC(-MS) using a high (double) split ratio, allows fast, solvent-free quantification of high VOC concentrations. Mi SecureTD-Q (re-collection for repeat analysis) validates quantitative data.

Official guidance: UK Env Agency docs M2, S4.01, S4.02

Typical TD-GC analytical conditions:

Sample volume: 100-1500 ml

Sampling: Pull through tube (gas syringe / low flow pump)

Sorbent: Tenax / carbon or carbon / carbon

TD system: ULTRA-UNITY

Desorption: 5 mins at 330°C or 280°C (if Tenax)

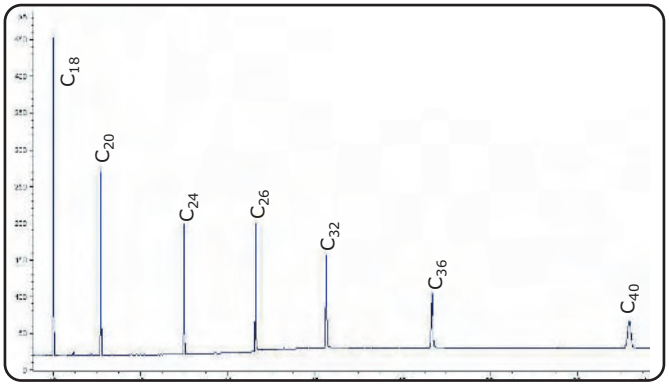
Trap: Tenax / carbon or 2 carbons 30 to 300°C

Split: 3,000:1 double split with SecureTD-Q

Analysis: GC-MS(SCAN) or GC-FID

Reference: TDTS77 on stack emissions monitoring

Vapour-phase semi-volatiles by Thermal Desorption



Complete recovery of n-C_{40} through Markes UNITY TD

Typical analytes:

- Polychlorinated biphenyls (PCBs)
- Polyaromatic hydrocarbons (PAHs)
- Plasticisers such as phthalates
- Hydrocarbons from diesel emissions

Background:

Thermal desorption is usually associated with analysis of volatile organic chemicals. However, the short, inert, heated flow path of Markes TD systems also ensures quantitative recovery of semi-volatiles up to n-C_{40}.

Typical TD-GC analytical conditions:

Sampling: Pumped sorbent tube

Sorbent: Quartz wool with 1 or 2 carbon blacks

Sample volume: ~100 L at 500 ml/min

TD system: UltrA-UNITY

Desorption: 15 mins at 350ºC

Trap: High boilers trap: -10 to 350°C

Split: Typically 50:2.5 during trap desorption only

Analysis: GC-MS(SCAN)

Reference: TDTS53 on quantitative recovery of semi-volatiles with Markes (UltrA-)UNITY TD systems

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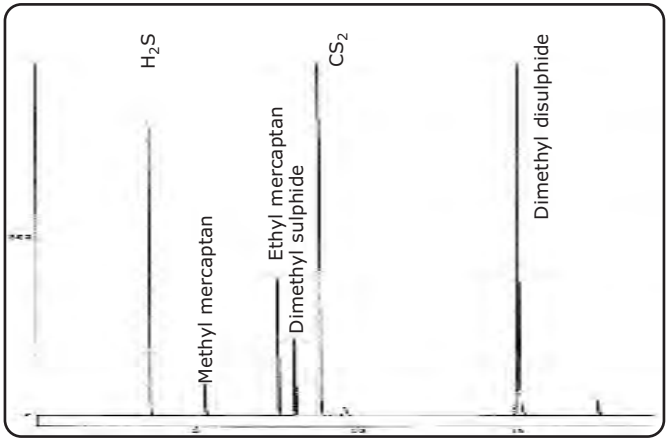
Odorous industrial emissions



Reduced sulphur compounds *via* UNITY-Air Server

Typical analytes:

- CS_2
- H_2S (NB: requires special focusing trap)
- Mercaptans (thiols)
- Sulphides

Concentrations: Sub to low ppb

Background:

Highly odorous sulphur compounds in industrial or landfill emissions must be controlled to sub or low-ppb levels. These very volatile and highly reactive compounds are usually sampled on-line or in canisters / bags and analysed using TD-GC-FPD.

Std. method: Korean Government Guidance Method - Standard Method for Off-Odour Analysis (2005)

Typical TD-GC analytical conditions:

Sample volume: 100-500 ml

TD system: UNITY-Air Server (+ dryer)

TD flowpath: 80ºC

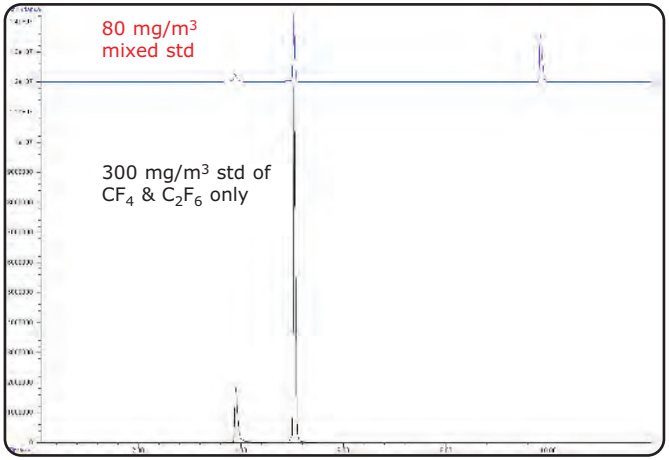
Trap: Sulphur trap or H_2S trap -15 to 250°C

Split: 5:1

Analysis: GC-FPD

Reference: TDTS32 on analysis of sulphur compounds

Stack emissions of freons



30 ml volumes of freon standard showing quantitative trapping of CF_4 without liquid cryogen

Typical analytes:

Freons such as CF_4, C_2F_6 and C_3F_8

Concentrations: Low mg/m^3

Background:

Highly volatile freons are emitted by aluminium smelting and industrial halogenation processes. Freons are known to damage the protective ozone layer in the higher atmosphere and their emissions are rigorously controlled. With a bpt. of -169°C, CF_4 is extremely difficult to trap, but sampling into bags / cans combined with TD-GC-MS or ECD analysis of small volumes of the gas allows cryogen free monitoring at low levels.

Typical TD-GC analytical conditions:

Sampling: On-line or whole air / gas containers

TD system: UNITY-Air Server

Trap: Carbon molecular sieve -15 to 320°C

Low split during both tube and trap desorption

Analysis: GC-MS or GC-ECD

Note that TD-GC-MS (SCAN) was used in the example shown

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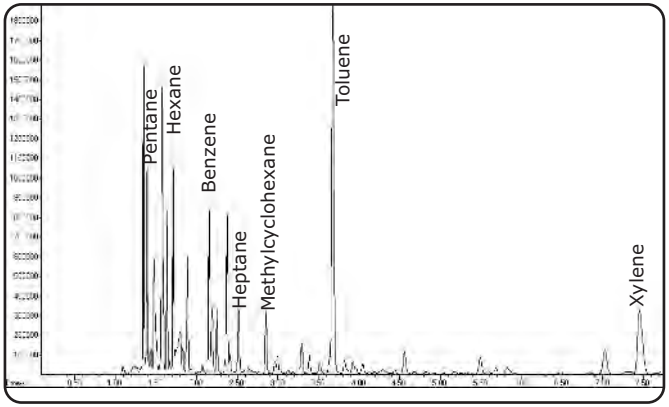
Industrial fence-line monitoring



2-week diffusive sampling around a refinery perimeter. VOCs detected include benzene, toluene & xylene

Typical analytes:

- Benzene
- 1,3-butadiene
- Mixed solvents and hydrocarbons

Concentrations: ppb to ppm

Background:

Is your industry a good neighbour? Unobtrusive diffusive (passive) samplers may be placed around a factory fence-line for extended time periods – *e.g.* 3 to 14 days. When combined with subsequent automated TD-GC(-MS) analysis, this provides a low cost and reliable method for monitoring perimeter concentrations at ppb-ppm levels.

Std. methods: EN 14662-4, EN ISO 16017-2, ASTM D 6196

Typical TD-GC analytical conditions:

Sampling: Diffusive (passive) tubes

Sorbent: Carbograph 1TD, Carbopack X or other

TD system: ULTRA-UNITY

Desorption: 5 mins at 320ºC

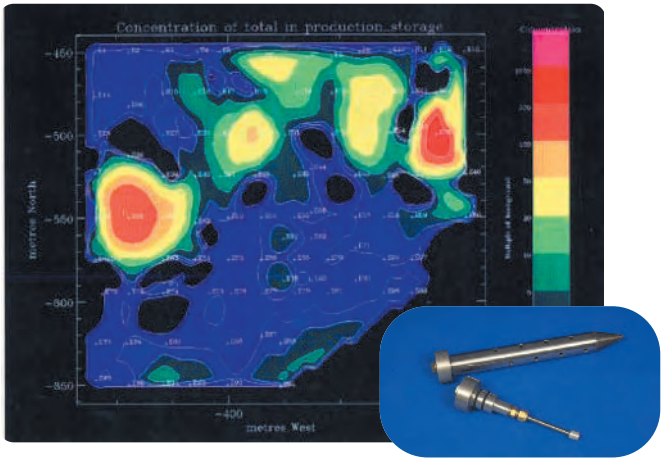
Trap: Dual carbon black -10 to 320°C

Split: Low split during trap desorption only

Analysis: GC-MS(SCAN) or GC-FID

Reference: TDTS49 on fence-line monitoring

In-situ monitoring of underground fuel leaks



VOC-Mole™ Soil Probes arranged in a grid pattern around an industrial site allow low-cost mapping of contaminated ground

Typical analytes:

- Hydrocarbons from fossil fuels
- Halogenated solvents

Concentrations: 1 to 100 ppm

Background:

Underground fuel or chemical leaks present a grave environmental risk. Soil probes containing standard diffusive tube samplers 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 monitor the soil gases for ~24 hours. Automated TD-GC analysis allows rapid identification of the nature, source and spread of ground contamination.

Typical TD-GC analytical conditions:

Sampling: Diffusive tubes inside soil probes

Sorbent: Tenax TA

TD system: ULTRA-UNITY

Desorption: 5 mins at 280ºC

Trap: Tenax TA or dual bed -10 to 300°C

Split: Double split

Analysis: GC-MS(SCAN) or GC-FID

Reference: TDTS29 on monitoring soil pollution using soil probes

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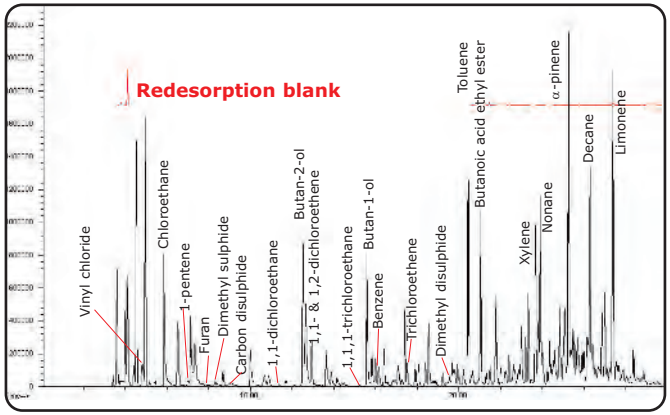
Odours and toxics in landfill gas



100 ml landfill gas with trace target analytes and many major components identified

Target compounds include:

Chloroethane, VCM, benzene, 2-butoxy ethanol, 1,1-dichloroethane, trichloroethene, tetrachloromethane, 1,1-dichloroethene, 1,2-dichloroethene, CS_2, methanethiol, butyric acid, ethyl butyrate, 1-propanethiol, dimethyl disulphide, ethanethiol, 1-pentene, 1-butanethiol, dimethyl sulphide, 1,3-butadiene, furan

Concentrations: 10 to 100 ppb

Background:

New EU regulations require monitoring of trace toxic and odorous compounds in landfill gas. 100-200 ml samples are drawn through a special sorbent tube using a gas syringe. Subsequent gentle desorption on an inert ULTRA-UNITY TD set at low (<100°C) flow path temperatures allows measurement of trace target analytes including thiols.

Official guidance: UK Env. Agency publication 'Monitoring trace components in landfill gas.'

Typical TD-GC analytical conditions:

Sample volume: 100-500 ml

Silcosteel tube with Tenax TA / UniCarb™

TD system: ULTRA-UNITY

TD flowpath: 120ºC

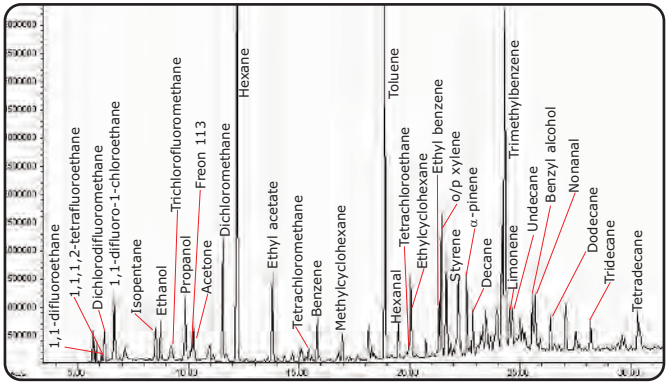
Trap: Sulphur trap -15 to 220°C (40°/min)

Split: From 10:1 to 50:1

Analysis: GC-MS(SCAN)

Reference: TDTS47 and TDTS74 on analysis of landfill gas

Profiling indoor air quality



Clean indoor air pumped onto multi-sorbent tube and analysed by TD-GC-MS

Typical analytes:

Almost any VOC or (S)VOC

Concentrations: Sub to low ppb levels

[Note that in this example detection limits are in the order of 10-50 ppt.]

Background:

TD is used extensively for monitoring indoor air quality and for related applications such as evaluating emissions from building materials. In this example, pumped tube samplers were used with subsequent TD-GC-MS analysis for profiling of ppt-ppb level VOCs.

Std. methods: US EPA Method TO-17, EN ISO 16017-1, ASTM D 6196

Typical TD-GC analytical conditions:

Sampling: Pumped sampling: 2-20 L

Sorbent: Typically multi-sorbent

TD system: ULTRA-UNITY

Desorption: 5 mins at 280ºC (depends on sorbent)

Trap: Tenax TA or dual bed -10 to 300°C

Split: During trap desorption only ~15:1

Analysis: GC-MS(SCAN)

Reference: TDTS28 on monitoring indoor air

Thermal Desorption: A Practical Applications Guide. II. Residual Volatiles & Materials Emissions Testing

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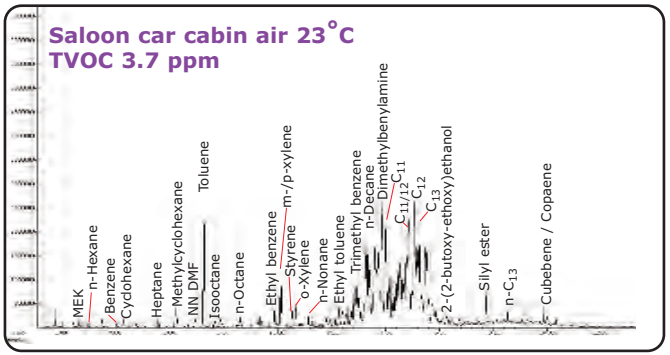
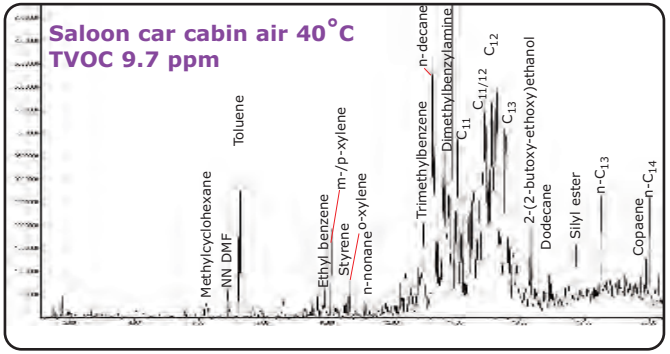
Monitoring car cabin air





Air from the cabin of a small saloon car showing a complex range of VOCs and high total-VOC levels

Background:

Car cabins are small confined spaces. Vapour-phase (S)VOC levels can build up – especially in parked cars on a hot day. Car manufacturers and their suppliers are currently focused on improving the quality of cabin air and reducing emissions from vehicle trim components. This will reduce the exposure of drivers and passengers. Pumped sampling onto sorbent tubes with TD-GC-MS analysis is the method of choice for profiling car cabin air.

Std. methods: EN ISO 16017-1, ISO 16000-6, ASTM D6196

TD-GC analytical conditions:

Sampling: Pumped sampling of 2 L volume

Sorbent: Tenax TA or multi-sorbent

TD system: ULTRA-UNITY

Desorption: 6 mins at 280°C

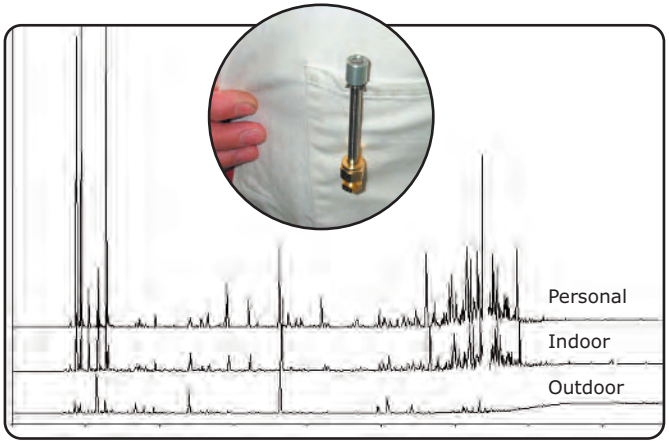
Trap: Tenax or dual bed -10 to 300°C

Split: 75:1

Analysis: GC-MS(SCAN)

Reference: TDTS33 on profiling car cabin air

Personal exposure indoors



Poor indoor air quality and high personal exposure in this home were linked to a diesel car parked in a garage under the living space

Typical analytes:

- Benzene
- 1,3-butadiene
- General VOCs

Concentrations: Sub to low ppb

Background:

TD is used for several applications relating to 'Sick Building Syndrome'. Here, diffusive tube samplers were used with subsequent TD-GC-MS analysis for indoor & outdoor air sampling & simultaneous personal monitoring. Diffusive (passive) samplers are unobtrusive, low cost (no pumps) & simple to deploy facilitating personal exposure assessment & large scale studies of indoor air quality & human exposure.

Std. methods: EN 14662-4, EN ISO 16017-2, ASTM D6196

Typical TD-GC analytical conditions:

Sampling: Diffusive sampling

Sorbent: Carbograph 1TD, Carbopack X or Tenax depending on target analyte range

TD system: ULTRA-UNITY

Desorption: 5 mins at 320°C

Trap: Dual carbon -10 to 320°C

Split: ~10:1 during trap desorb only

Analysis: GC-MS(SCAN)

Reference: TDTS10 on diffusive sampling in indoor air, TDTS01 on uptake rates, TDTS54 on personal exposure to 1,3-butadiene.

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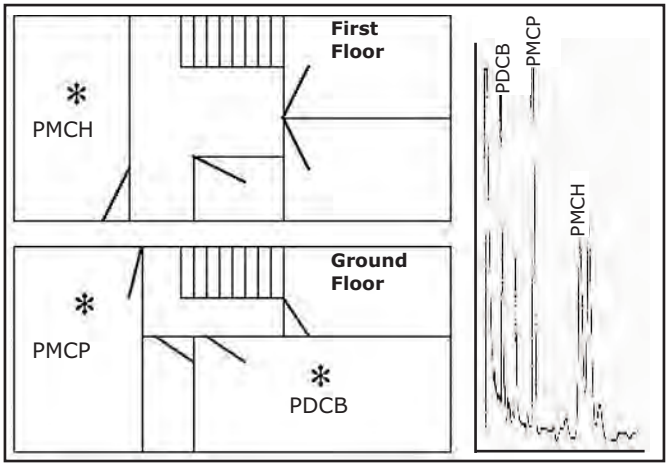
Building ventilation tests with tracer gases



Typical tracer gases:

- PDCB – perfluorodimethylcyclobutane
- PMCP – perfluoromethylcyclopentane
- PMCH – perfluoromethylcyclohexane

Concentrations: ppt to low ppb

Background:

To test building ventilation, sources of individual perfluorocarbon tracer gases are placed in different rooms. They are sampled, diffusively or with pumps, onto sorbent tubes. Use of diffusion reduces monitoring costs. After sample collection tubes are analysed *via* TD-GC-MS/ECD. The rise and subsequent decay in tracer gas concentrations allows the building ventilation (rate of air exchange) to be monitored.

Typical TD-GC analytical conditions:

Sampling: Diffusive or pumped

Sorbent: Carbograph 1TD (40-60 mesh)

TD system: ULTRA-UNITY

Desorption: 5 mins at 320°C

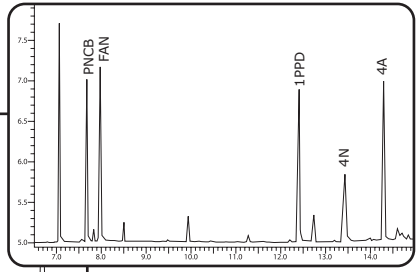
Trap: Carbograph 1TD -10 to 300°C

Split: ~10:1

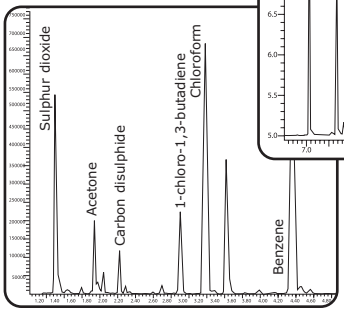
Analysis: GC-MS or ECD

Reference: H. Bloemen *et al.*, 'Ventilation rate and exchange of air in dwellings', RIVM, Netherlands, 1992

Occupational hygiene - monitoring inhalation exposure



Reactive amines in workplace air



Personal exposure to solvents at work

Typical analytes:

- Solvents
- Hydrocarbons and haloforms
- Ketones, esters, glycol ethers
- Amines and nitriles

Concentrations: ppb to low ppm

Background:

Health and safety at work legislation requires personal exposure assessment of workers potentially exposed to toxic chemicals. Pumped or diffusive sampling onto sorbent tubes followed by TD-GC(-MS) analysis provides a solvent-free, safe analytical option with ~1000 x more sensitivity than conventional charcoal tube / CS_2 extraction methods. TD tubes are also reusable indefinitely.

Std. methods: UK MDHS series, EN ISO 16017, ASTM D 6196, NIOSH 2549

Typical TD-GC analytical conditions:

Sampling: Diffusive or pumped

Typical sorbent: Tenax or Chromosorb™ 106

TD system: ULTRA-UNITY

Desorption: 5 mins at 300°C or 200°C (for C106)

Trap: Tenax or Tenax/Carb 1TD from -10 to 300°C

Split: 50:1 to 500:1

Analysis: GC-MS(SCAN) or ECD

Reference: TDTS37 on industrial air monitoring, TDTS38 on occupational exposure limit levels, TDTS50 on workplace monitoring

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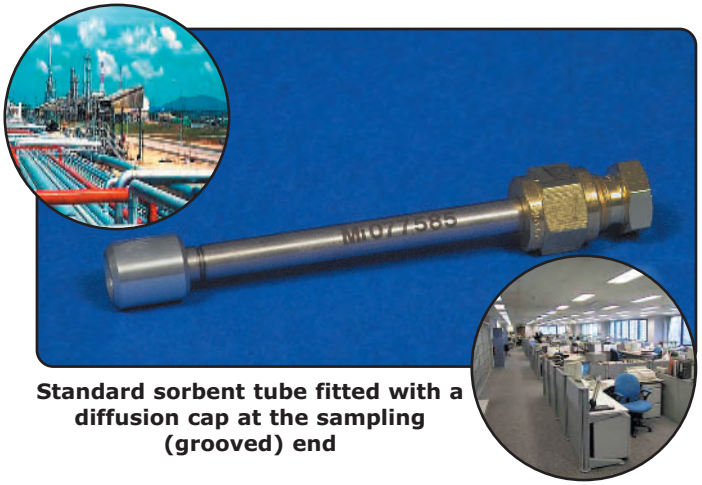
Diffusive (passive) sampling in the workplace



Standard sorbent tube fitted with a diffusion cap at the sampling (grooved) end

Typical analytes:

- Solvents
- Hydrocarbons and haloforms
- Ketones, esters, glycol ethers
- Amines and nitriles

Concentrations: ppb to low ppm

Background:

Unobtrusive, low-cost diffusive samplers facilitate personal exposure monitoring because they can be worn close to the breathing zone without impacting worker behaviour. Analysis by thermal desorption means tubes are re-usable indefinitely. The enhanced sensitivity of TD, relative to solvent extraction, also allows compliance with new lower threshold limit values.

Std. methods: UK MDHS series, EN ISO 16017, ASTM D 6196, NIOSH 2549

Typical TD-GC analytical conditions:

Sorbent: Tenax, carbon or porous polymer

TD system: ULTRA-UNITY

Desorption: 5-10 mins. Temp depends on sorbent

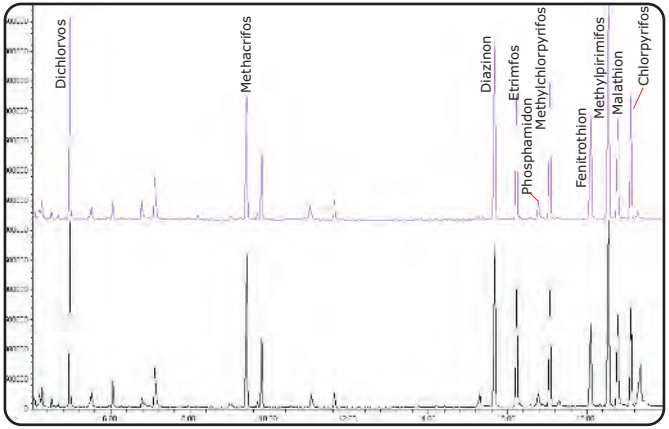
Trap: Dual sorbent -10 to 300°C

Split: Between 50:1 and 500:1

Analysis: GC(-MS)

Reference: TDTS01 on uptake rates, TDTS08 on principles of diffusive sampling, TDTS38 on limit levels, TDTS50 on workplace monitoring

Monitoring inhalation exposure to pesticides



Primary and repeat analysis of pesticides for personal exposure monitoring

Analytes:

Dichlorvos	Diazinon
Chlorpyrifos	Methacrifos
Etrimfos	Phosfamidon
Chlorpyrifos-methyl	Pyrimifos-methyl
Fenitrothion	Malathion

Concentrations: ppb

Background:

Agricultural workers involved in pesticide application must be monitored to ensure that their exposure to these highly toxic chemicals does not exceed safe levels. Pumped monitoring using inert (glass or Silcosteel) tubes together with TD-GC-MS analysis provides a reliable and highly sensitive monitoring method.

Std. methods: UK MDHS series, EN ISO 16017-1, ASTM D 6196, NIOSH 2549

Typical TD-GC analytical conditions:

Sampling: Pumped

Sorbent: Tenax in glass or Silcosteel tubes

TD system: ULTRA-UNITY

Desorption: 10 mins at 280°C

Trap: Tenax -10 to 300ºC

Split: ~10:1 during trap desorption only

Analysis: GC-MS

Reference: TDTS39 on using TD with SecureTD-Q to monitor vapour phase pesticides

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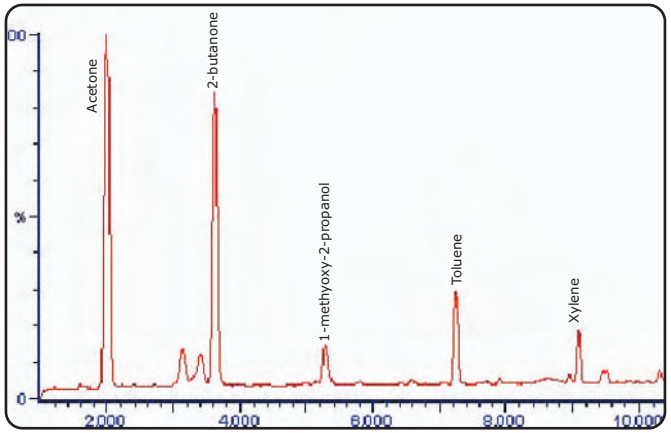
Biological monitoring via alveolar breath



Skin-absorbed solvents in the breath of shoe workers collected using the Bio-VOC™

Typical analytes include:

- Halogenated solvents
- Styrene
- Ketones
- Aromatics

Background:

Biological exposure monitoring allows assessment of the whole body burden of chemicals via all routes of exposure – skin absorption, ingestion and inhalation. Alveolar breath sampling using the disposable Bio-VOC allows large-scale, non-invasive biological monitoring of workers using PPE or handling skin-absorbed chemicals. After breath collection, the sample is discharged into a Tenax tube and analysed by TD-GC-MS.

Official guidance: Suite of breath sampling guidance notes available from UK HSL.

Typical TD-GC analytical conditions:

Sorbent: Tenax TA (35-60 mesh)

TD system: ULTRA-UNITY

Desorption: 5 mins at 250°C

Trap: Tenax TA -10 to 280°C

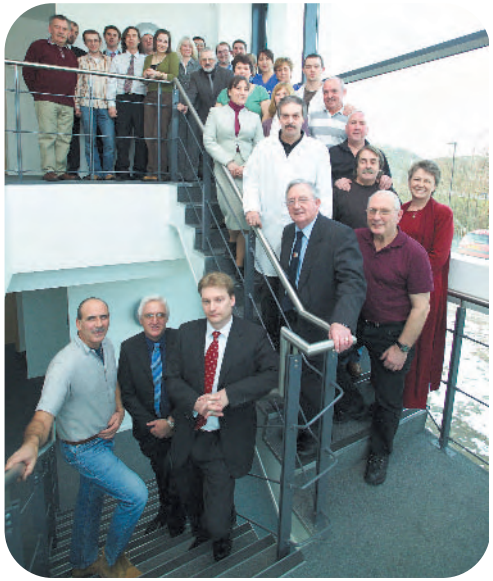
Split: ~10:1

Analysis: GC-MS(SCAN)

Reference: TDTS13 Evaluation of the Bio-VOC, TDTS48 Overview of breath sampling

The Markes International advantage

- Markes leads the market in TD
- Unparalleled reputation for product quality and reliability
- Excellence in technical and applications support
- For further information on Markes comprehensive range of instruments, sampling accessories and consumables please use one of the contact numbers / email address below or browse the web site



The Markes International team

Markes International Ltd.
T: +44 (0)1443 230935 **F:** +44 (0)1443 231531
E: enquiries@markes.com **W:** www.markes.com

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Thermal Desorption: A Practical Applications Guide

III. Defence and Forensic

Introduction to Markes International Ltd.

Formed in 1997, Markes International Ltd. is one of the world's leading suppliers of thermal desorption (TD) equipment for monitoring trace toxic and odorous chemicals in air, gas and materials. Serving fast growing markets from environmental health and 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 has introduced several highly successful brands of TD instruments to the market including: UNITY™ – a universal TD platform for single tubes, the 100-tube ULTRA™ TD autosampler, the Air Server™ interface for canisters and on-line sampling, the **µ**-CTE™ Micro-Chamber / Thermal Extractor for materials testing, the TT24-7™ for continuous on-line monitoring and the TC-20™ multi-tube conditioner.

Markes also supplies a wide range of sampling accessories and consumables for all TD application areas.

What is TD?

Since the early 1980s, thermal desorption has provided the ultimate versatile sample introduction technology for GC / GC-MS. It combines selective concentration enhancement with direct extraction into the carrier gas and efficient transfer / injection all in one fully automated and labour-saving package.

Markes International Ltd. UK headquarters

Overview

Thermal desorption is now recognised as the technique of choice for environmental air monitoring and occupational health & safety. Relevant standard methods include: ISO/EN 16017, EN 14662 (parts 1 & 4), ASTM D6196, US EPA TO-17 and NIOSH 2549. Related applications include monitoring chemical warfare agents (CWA) in demilitarisation / destruction facilities & civilian locations (counter-terrorism).

TD is also routinely used for monitoring volatile and semi-volatile organic compounds (S)VOCs in products and materials. Examples include residual solvents in packaging & pharmaceuticals, materials emissions testing and food / flavour / fragrance profiling.

This publication presents several real world applications for thermal desorption in forensic science and monitoring chemical warfare agents (CWA). Accompanying publications cover the application areas of:

- Food, flavour, fragrance & odour profiling
- Emissions from materials
- Environmental monitoring and occupational health & safety

Forensic Applications for TD

Thermal desorption is extensively used for forensic science. Key applications include:

- Detection of drugs of abuse
- Arson residue analysis for accelerants
- Forensic analysis of drugs
- Detection of trace explosive vapours
- Shotgun propellant
- Forensic analysis of inks

Chemical Warfare Agents (CWA)

Markes thermal desorption technology provides the ultimate pre-concentration and analytical solution for CWA applications. Military & civilian security agencies and government scientists from across the world are working with Markes TD systems for monitoring:

- CW stockpile sites
- Personal exposure of military personnel
- Agent destruction facilities
- Key civilian locations (counter-terrorism)

Relevant TD options from Markes International include both automated processing of off-line sorbent tube samples (ULTRA-UNITY) and continuous near-real time (NRT) detection (TT24-7). Systems can be installed at-line in destruction facilities, in off-line laboratories or in mobile labs for deployment to incident sites. Both on- and off-line TD systems offer rugged operation, quantitative recovery, optimum resolution / speciation (to minimise false positives) and lowest possible detection limits (ng/m^3 and below).

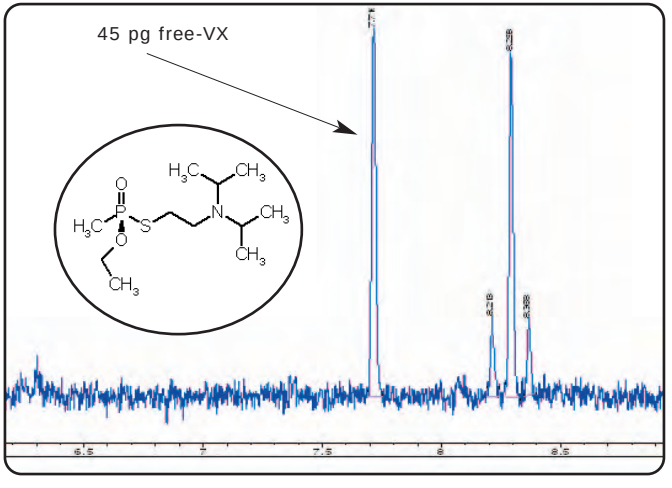
TT24-7

The transportable, near-real time TT24-7 TD system enables continuous on-line and at-line sampling and pre-concentration of airborne chemical agents. The enriched vapour sample is subsequently analysed by GC-(MS) or direct MS technology.

Continuous monitoring is essential to protect security agency personnel and the general public from potential exposure to highly toxic chemical agents.

The TT24-7 incorporates two, electrically-cooled (Peltier) large-capacity traps which are sampled sequentially at high flow rates (~ 500 ml/min), allowing efficient pre-concentration of trace-level agent in the shortest possible time (*i.e.* providing near real-time analysis).

Chemical warfare agents: Free-VX



Analysis of 45 pg of free-VX using sorbent tube sampling and off-line TD-GC analysis

Concentration: Sub-ppt vapour concentrations and pg levels on tube

Background:

The nerve agent VX and the Russian equivalent (RVX) (ethyl S-2-diisopropyl aminoethylmethyl phosphonothioate) are some of the most toxic CW compounds in existence today. The analysis of free (*i.e.* underivitised) VX/RVX at sub ppt levels is very challenging because of the low volatility, "stickiness" and high reactivity of these compounds. VX and RVX are typically monitored using off-line sorbent tubes sampling large (>500 L) air volumes with subsequent analysis by thermal desorption GC/FPD or GC/MS. However, the TD system used must be highly inert and uniformly heated. Markes ULTRA-UNITY is ideal for the analysis of underivitised VX/RVX at trace levels.

Typical TD-GC conditions:

Sampling: Silcosteel™ CW tubes

TD system: ULTRA-UNITY

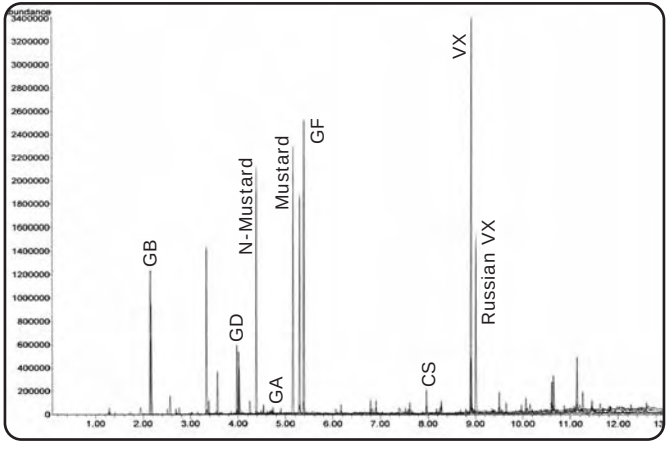
Primary desorption: 8 mins at 300°C

Trap: Chemical weapons trap

Split: Splitless Analysis: GC-FPD

Reference: TDTS44 The analysis of free-VX from sorbent tubes at low and sub-nanogram levels

Chemical warfare agents: DAAMS tubes



Analysis of mixed CW standard (5 ng level) by UNITY TD with GC-MS

Typical analytes:

GB, GD, GA, GF, CS, VX, RVX, mustard, N-mustard

Concentration: ppt to ppb levels (sub/low ng levels on tube)

Background:

The ability to screen for multiple CW agents, using a single TD-GC-MS method is extremely useful having applications in both the military and civil defense arenas. Where mixed CW material is stockpiled and/or destroyed there is a need to monitor the operational environment both as a check on the occupational health of plant operatives and for confirmatory analysis (DAAMS - Depot Air Analysis Monitoring Systems) of on-line systems. Similarly, for civil defence, monitoring the location of any known or suspected chemical incident is essential to identify the specific agent released, so that correct remedial and decontamination procedures can be actioned.

Typical TD-GC conditions:

Sampling: Silcosteel CW tubes - manual pumps or automated sequential tube sampling (MTS-32™ - picture inset)

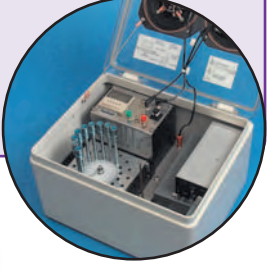
TD system: ULTRA-UNITY

Primary desorption: 8 mins at 300°C

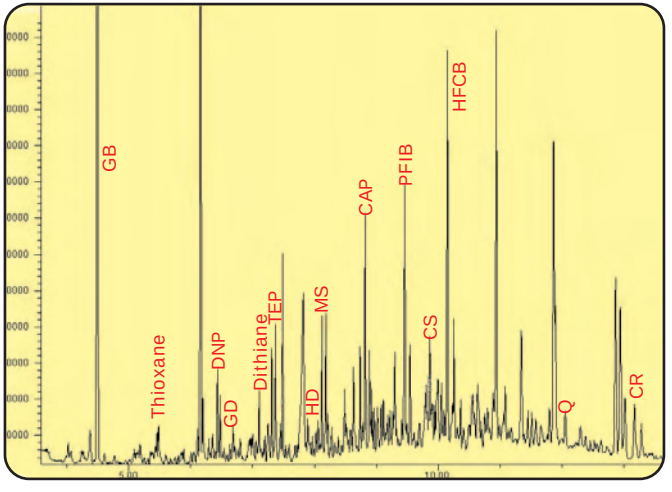
Trap: Chemical weapons trap

Split: 15 ml/min (secondary desorption)

Analysis: GC-MS (SCAN)



Chemical warfare agents: Trace target analytes in a complex background



CW test mix diluted to 2.5 ppm with diesel fuel and analysed with spectral deconvolution software

Background:

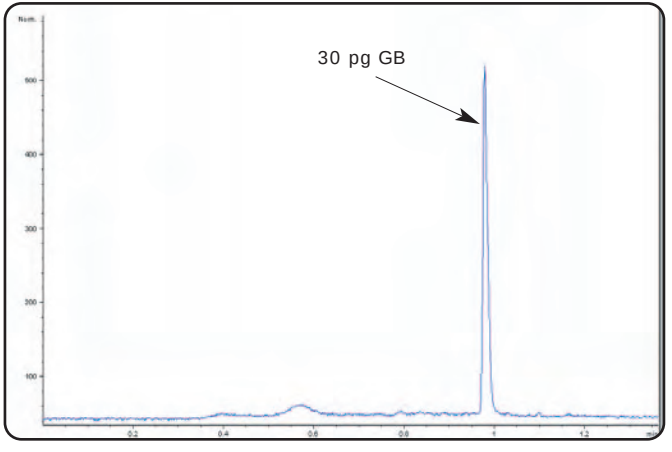
Analysing complex real air samples for the presence of trace CWA material can be very demanding as the background levels of other organic vapours (hydrocarbons, solvents, *etc.*) can be high relative to that of the target compunds. The risk is that this can cause high incidences of "false-positive" results which is problematical and potentially dangerous; for example, if it triggers large scale evacuations of public buildings. MS detection reduces this risk as it provides 3D data, including spectral information, for each compound.

In a recent development, retention time and spectral data can be further processed by a mathematical procedure (deconvolution) using software such as AMDIS which is provided by NIST in the USA. This identifies individual components in co-eluting / overlapping peaks and provides much greater confidence in the correct identification of trace target compounds thus eliminating false positives.

Typical TD-GC conditions:

As the previous page

Chemical warfare agents: NRT monitoring



Monitoring CW Agents using the TT24-7 NRT System with GC-FPD – An illustration with GB

Background:

Near Real Time (NRT) monitoring of extremely toxic compounds such as the G type nerve agents, requires continuous sampling with no time 'blind' spots and rapid on-line analysis. At trace levels, TT24-7 focusing traps desorb super-efficiently producing sharp peaks (opposite) for optimum sensitivity.

The NRT mode of operation is an absolute requirement for CW monitoring at military-stockpile sites or demilitarisation / destruction facilities and can also be used for continuous monitoring of civilian locations in case of terrorist attack.

Typical TD-GC conditions:

Sampling: Continuous monitoring

Sampling time / flow: 10 mins at 600 ml/min

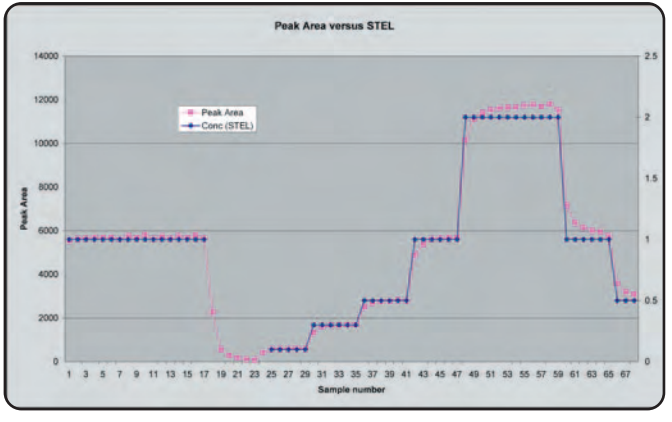
TD system: TT24-7

Traps: Chemical weapons traps

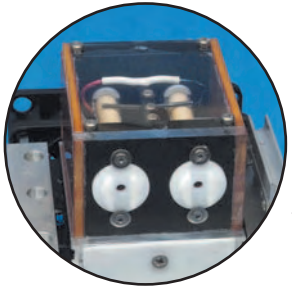
Analysis: GC-FPD

Reference: TDTS63 Using the TT24-7 with twin electrically-cooled focusing traps for continous monitoring of trace level toxic chemicals (*e.g.* CW agents) in air

TT24-7 performance



TT24-7 data tracks atmospheric concentration exactly - Nominal set point (blue), actual measured (pink)



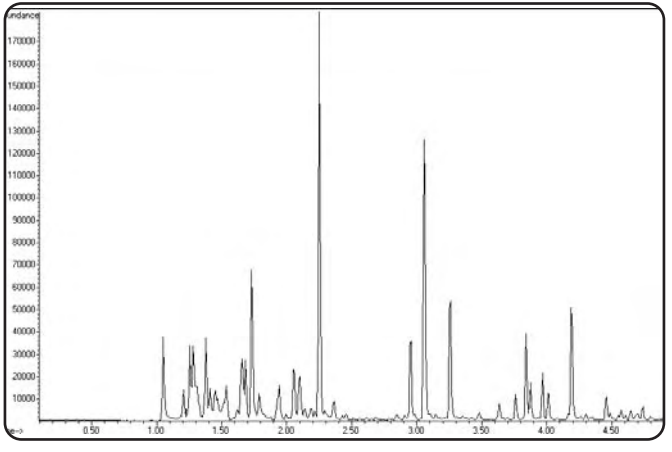
TT24-7 dual trap

Background:

NRT monitoring of chemical warfare agents and other toxic chemicals offers early alert and compound identification in the event of a chemical incident. Organisations, such as the Centre for Disease Control (CDC) in the USA, have defined parameters for 'NRT' monitoring including completion of the entire sampling and analytical process within 15 mins plus continuous sampling of air with no 'blind' spots. This requires dual reciprocating sampling traps such that sampling can continue on one channel, while the other is desorbed and analysed. Air is drawn into the system using either positive sample pressure or by vacuum pump at electronic mass flow controlled rates of ~500 ml/min for up to 10 mins. Sampling of each channel is followed by rapid desorption and fast GC, MS or GCMS analysis (*i.e.* < 5 minutes). The TT24-7 TD tracks actual atmospheric concentrations closely with negligible time lag (see opposite).

Reference: TDTS63 Using the TT24-7 with twin electrically-cooled focusing traps for continous monitoring of trace level toxic chemicals (*e.g.* CW agents) in air

Arson residue analysis: Gasoline vapours



Sample of headspace from cloth soaked in petrol.

Typical analytes:
Hydrocarbons

Concentration: ppb to % levels

Background:

In suspected arson cases, it is often necessary to identify the fuel accelerant that was used to start the fire. A representative sample of debris is typically collected from the scene using a nylon bag, and then returned to the laboratory. The bag and contents are first heated (gently) to help release fuel vapours into the headspace of the bag. A small hole is then made in the bag allowing a measured volume of headspace to be withdrawn using a gas syringe and transferred into a thermal desorption tube for pre-concentration. The tube is then analysed by TD-GC-(MS) allowing the VOC profile of the fire debris headspace to be analysed for fuels / accelerants.

Typical TD-GC conditions:

Sampling: ~100 ml of headspace transferred to Tenax tube.

TD system: ULTRA-UNITY

Primary desorption: 5 mins at 280°C

Trap: General purpose hydrophobic

Split: 30 ml/min

Analysis: GC-MS

Reference: TDTS58 The application of TD-GC(-MS) as a tool in forensic investigations

Explosive vapours

Detection of explosives at low ng levels illustrates the inertness of the UNITY flow-path

Typical analytes:

DNT, TNT, RDX

Concentration: Typically ppt to ppb levels of vapours in air

Background:

Both military and civilian security agencies need to monitor for explosives. Thermal desorption is used for monitoring trace explosive vapours in air at crime scenes, from possible arms storage locations and from vehicles suspected of being used to transport bombs or other weapons.

The high boiling point and reactive nature of explosives necessitates the use of inert sample tubes and sorbent materials.

Typical TD-GC conditions:

Sampling: Silcosteel tubes packed with quartz wool and Tenax TA™

TD system: ULTRA-UNITY

Primary desorption: 3 mins at 180°C followed by 2 mins at 210°C

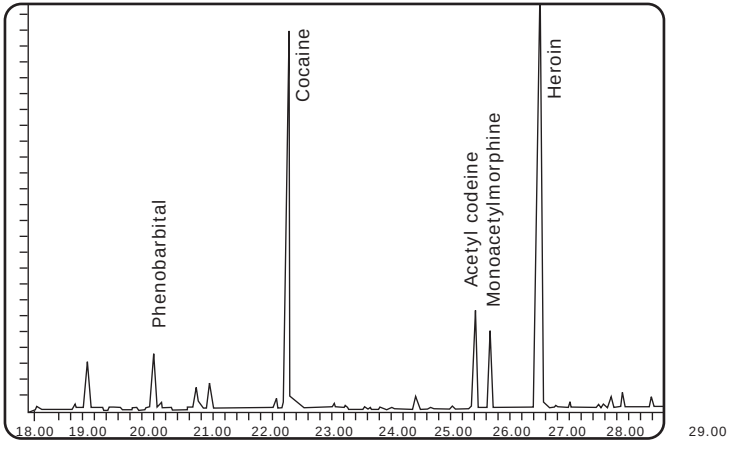
Trap: CW trap

Split: 18 ml/min

Analysis: GC-MS

Reference: TDTS58 The application of TD-GC(-MS) as a tool in forensic investigations

Direct desorption for detecting drugs of abuse in house dust



Direct desorption of house dust, indicating presence of drugs of abuse such as heroin & cocaine

Typical analytes:

- Phenobarbital
- Cocaine
- Acetyl codeine
- Monoacetylmorphine
- Heroin

Concentration: ppb to %

Background:

Many real-world samples can be tested for proscribed drugs using direct thermal desorption / extraction with GC-MS. In this example, gentle direct desorption was used to detect drugs of abuse in house dust collected from a UK crime scene. High levels of heroin and cocaine plus traces of other drugs were identified. Direct TD eliminates sample preparation so reducing the risk of contamination. This technique is suitable for detection and identification rather than absolute quantification of the drugs. Direct desorption of a pure drug sample would also facilitate detailed analysis of impurities allowing the source of the drug to be traced.

Typical TD-GC conditions:

Sampling: Small amount of dust placed inside glass tube, secured between 2 plugs of quartz wool

Primary desorption: 10 mins at 150°C

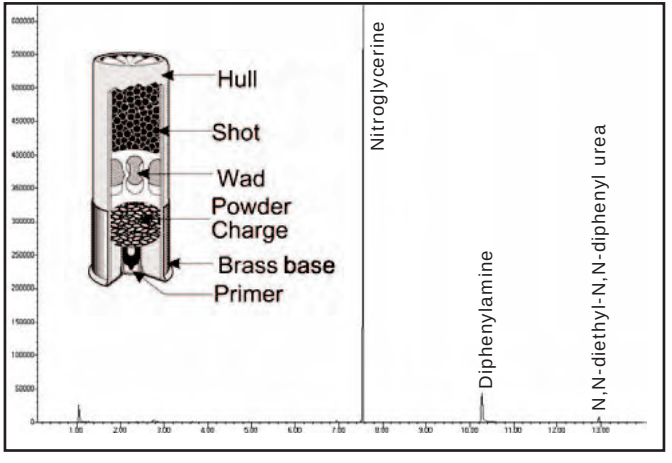
Trap: High boilers trap

Split: 10 ml/min

Analysis: GC-MS

Reference: TDTS58 The application of TD-GC(-MS) as a tool in forensic investigations

Shotgun propellant



Direct desorption of fine particles of firearm propellant

Analytes:

N,N-diethyl-N,N-diphenyl urea, diphenylamine, nitroglycerine

Concentration: ppm to % in particles

Background:

The composition of small particles suspected to be firearm propellant can be analysed by gentle, direct desorption inside a Silcosteel TD tube. Volatile / semi-volatile components of interest are released into the carrier gas stream during the desorption process while solid residues remain behind in the sample tube. This allows clean analysis of the propellant, without matrix interference, thus optimising detection limits.

Typical TD-GC conditions:

Sampling: Small pellet of shotgun propellant placed inside an empty thermal desorption tube

Primary desorption: Direct desorption at 60°C

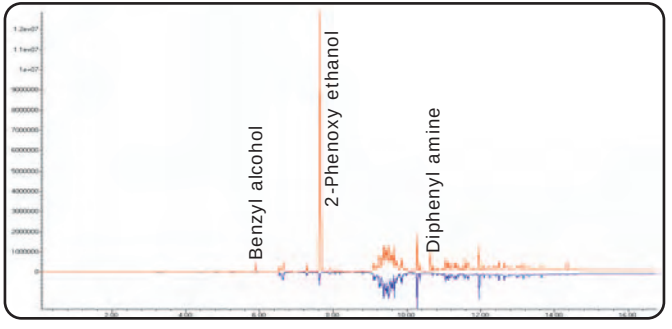
Trap: CW trap

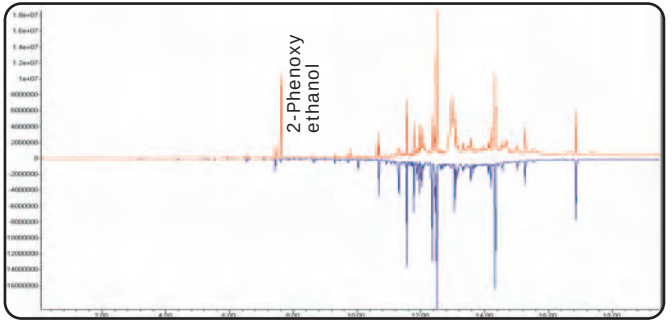
Split: 20 ml/min

Analysis: GC-MS

Reference: TDTS58 The application of TD-GC-(MS) as a tool in forensic investigations

Forensic analysis of ballpoint pen ink





Black ink: fresh (top) and aged (bottom). The blue chromatograms are from blank paper

Analytes:
2-Phenoxy ethanol, benzyl alcohol, diphenylamine

Background:

In general, inks are composed of dyes in solvents and other materials that impart selected characteristics. Ink analysis is usually limited to comparisons of the organic dye components. However, this does not allow inks with similar formulations to be distinguished nor does it allow forensic scientists to tell how long ink has been on a particular document.

Direct desorption of paper samples, with and without writing, can be used to generate a comprehensive profile / “fingerprint” of the ink comprising both solvents and dye components. This facilitates detailed forensic analysis of the ink used - age, source, matches with other documents, *etc.*

Typical TD-GC conditions:

Sampling: Direct desorption

TD System: UNITY

Primary desorption: 15 mins at 100°C

Trap: General purpose - graphitised carbon

Split: 20 ml/min

Analysis: GC-MS

The Markes International advantage

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- Unparalleled reputation for product quality and reliability
- Excellence in technical and applications support
- For further information on Markes comprehensive range of instruments, sampling accessories and consumables please use one of the contact numbers / email address below or browse the web site

The Markes International team

Residual Solvent Analysis

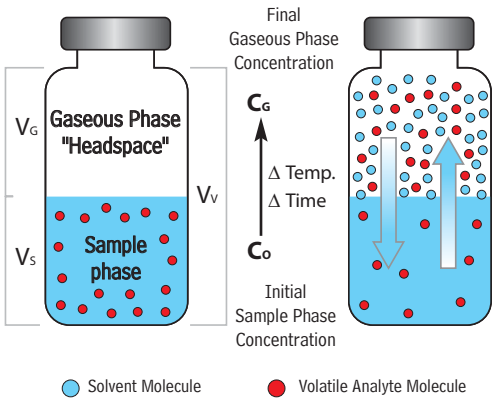
Complete Solutions for Residual Solvent Testing

- How to successfully implement the USP <467> revision.
- Improve system suitability pass rates with an optimized system.
- Save column evaluation time and expense using a retention time index.

The Chemistry of Static Headspace Gas Chromatography

Improve Method Performance with Fundamentals

Figure 1 Volatile components partition into gaseous phase until equilibrium is reached.



Once the sample phase is introduced into the vial and the vial is sealed, volatile components diffuse into the gas phase until the headspace has reached a state of equilibrium as depicted by the arrows. The sample is then taken from the headspace.

Figure 2 Fundamental headspace relationship.

$$A \alpha C_G = \frac{C_O}{K + \beta}$$

Phase Ratio $\beta = V_G / V_S$ — Volume dependent

Partition Coefficient $K = C_S / C_G$ — Concentration dependent

$$K \alpha \frac{1}{P_i^0 \cdot \gamma_i}$$

Vapor Pressure (P_i^0) Affected by Temperature

Activity Coefficient (γ_i) Affected by salting-out, Affected by foreign solvent, Affected by derivitization

Where:
A = area
V_G = volume of gas phase
V_S = volume of sample phase
V_V = total vial volume
C_O = initial analyte concentration in sample
C_G = analyte concentration in gas phase
C_S = analyte concentration in sample phase
P_i^0 = analyte vapor pressure
γ_i = activity coefficient

Organic volatile impurities (OVIs), commonly referred to as residual solvents, are trace level chemical residues in drug substances and drug products that are byproducts of manufacturing or that form during packaging and storage. Drug manufacturers must ensure that these residues are removed, or are present only in limited concentrations. The International Conference on Harmonization (ICH) Q3C guideline lists the acceptable amounts of solvent residues that can be present. Methodology, both independently developed and compendial, should strive to coincide with this guideline. In this guide, we will take a comprehensive look at residual solvent analysis, in both theory and practice, and illustrate options for the practicing chromatographer.

The analysis of residual solvents is commonly performed using static headspace gas chromatography (HS/GC). The basic premise behind headspace analysis begins with the addition of an exact, known volume or weight of sample into a closed, sealed vial. This creates two distinct phases in the vial—a sample phase and a gaseous phase, or "headspace". Volatile components inside the sample phase, whether a solid or solution, can be extracted, or partitioned, from the sample phase into the headspace. An aliquot of the headspace can then be taken and delivered into a GC system for separation and detection. If we look at the anatomy of a headspace vial (Figure 1), we can begin to see the relationship of the vial components and how we can control these parameters to create analytical methods.

Residual solvent analysis by static HS/GC can be enhanced by careful consideration of two basic concepts—partition coefficient (K) and phase ratio (β). Partition coefficients and phase ratios work together to determine the final concentration of volatile compounds in the headspace of sample vials. Volatile components partition from the sample phase and equilibrate in the vial headspace. Striving for the lowest values for both K and β when preparing samples will result in higher concentrations of volatile analytes in the gas phase and, therefore, better sensitivity (Figure 2).

Controlling the Partition Coefficient

The partition coefficient (K) is defined as the equilibrium distribution of an analyte between the sample and gas phases. Compounds that have low K values will tend to partition more readily into the gas phase, and have relatively high responses and low limits of detection. K can be further described as a relationship between analyte vapor pressure (p_i^0) and activity coefficient (γ_i). In practice, K can be lowered by increasing the temperature at which the vial is equilibrated (vapor pressure) or by changing the composition of the sample matrix (activity coefficient) by adding an inorganic salt or a solvent of lesser solubility, often referred to as a foreign solvent. High salt concentrations and foreign solvents decrease analyte solubility in the sample phase (decrease activity) and promote transfer into the headspace, thus resulting in lower K values. The magnitude of this effect on K is not the same for all analytes. Compounds with inherent low K values in the matrix will experience little change in partition coefficient in response to the addition of a salt and temperature, while volatile compounds in a matrix of similar polarity will show the largest responses.

Adjusting the Phase Ratio

The phase ratio (β) is defined as the volume of the headspace over the volume of the sample in the vial. Lower values for β (i.e., larger sample sizes) will yield higher responses for compounds with inherently low K values. However, decreasing β will not always yield the increase in response needed to improve sensitivity. When β is decreased by increasing sample size, compounds with high K values will partition less into the headspace compared to compounds with low K values and yield correspondingly smaller changes in sensitivity.

Achieving USP<467> Compliance

Your Guide to Successfully Implementing the Revised Method

The USP general chapter <467> Residual Solvents is a widely used compendial method for identifying and quantifying residual solvents when no information is available on what solvents are likely to be present. In an attempt to harmonize with the ICH guidelines, the USP has proposed a more comprehensive method in the current USP 30/NF 25. This revision significantly increases the number of residual solvents to be routinely tested and includes three distinct procedures.[1]

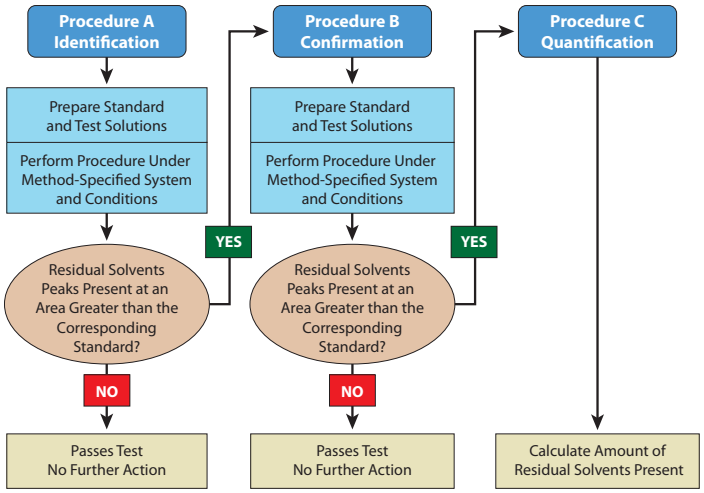
Initially set to become effective July 1, 2007, the implementation of the current version of USP <467> has been delayed until July 1, 2008. Until that time, the Other Analytical Procedures section of the previous version will be retained. However, in preparation for the implementation of the revised method, this application will comply with the procedure and criteria set forth in the USP30/NF25, second supplement (effective December 1, 2007) and the interim revision announcement.

Overview of Method

The revised USP <467> method consists of a static headspace extraction coupled with a gas chromatographic separation and flame ionization detection. In this guide we demonstrate the USP <467> application using two different types of headspace autosamplers. Procedure A was performed using a pressured loop autosampler and transfer line. Procedure B was performed using a heated syringe injection. Either system can be used to meet method requirements.

USP <467> is divided into two separate sections based upon sample solubility: water-soluble and water-insoluble articles. The methodology for both types of articles is similar, but the diluent used in both standard and sample preparations differs based upon the solubility of the test article. The test method consists of three procedures (A, B, and C), that are designed to identify, confirm, and then quantify residual solvents in drug substances and products (Figure 3).

Figure 3 Analytical flow chart for residual solvent testing under the revised USP <467> method.



[1] This number of analytes to be tested represents the sum of Class 1 and 2 residual solvents that can be effectively assayed using HS/GC. The actual number of analytes may be more if xylenes, ethyl benzene and *cis/trans* 1,2 dichloroethylene are differentiated, or if circumstances require the quantification of specific Class 3 residual solvents.

tech tip

Compatibility concerns?
Refer to the Septum Selection Guide at **www.restek.com/septaguide**

free literature

Download your free copy of our Technical Guide for Static Headspace Analysis from **www.restek.com/ovi**

lit. cat.# 59895A

Achieving USP<467> Compliance *(continued from page 3)*

Residual Solvents - Class 1

benzene	10mg/mL	1,1-dichloroethene	40
carbon tetrachloride	20	1,1,1-trichloroethane	50
1,2-dichloroethane	25		

In dimethyl sulfoxide, 1mL/ampul

cat. # 36279 (ea.)

Quantity discounts not available.

Residual Solvents Class 2 - Mix A (15 components)

acetonitrile	2.05mg/mL	methylcyclohexane	5.90
chlorobenzene	1.80	methylene chloride	3.00
cyclohexane	19.40	tetrahydrofuran	3.45
cis-1,2-dichloroethene	4.70	toluene	4.45
trans-1,2-dichloroethene	4.70	*m*-xylene	6.51
1,4-dioxane	1.90	*o*-xylene	0.98
ethylbenzene	1.84	*p*-xylene	1.52
methanol	15.00		

In dimethyl sulfoxide, 1mL/ampul

cat. # 36271 (ea.)

Residual Solvents Class 2 - Mix B (8 components)

chloroform	60µg/mL	nitromethane	50
1,2-dimethoxyethane	100	pyridine	200
n-hexane (C6)	290	tetralin	100
2-hexanone	50	trichloroethene	80

In dimethyl sulfoxide, 1mL/ampul

cat. # 36280 (ea.)

Quantity discounts not available.

Residual Solvents Class 2 - Mix C (8 components)

2-ethoxyethanol	800µg/mL	2-methoxyethanol (methyl Cellosolve®)	250
ethylene glycol	3,100	N-methylpyrrolidone	2,650
formamide	1,100	sulfolane	800
N,N-dimethylacetamide	5,450		
N,N-dimethylformamide	4,400		

In dimethyl sulfoxide, 1mL/ampul

cat. # 36273 (ea.)

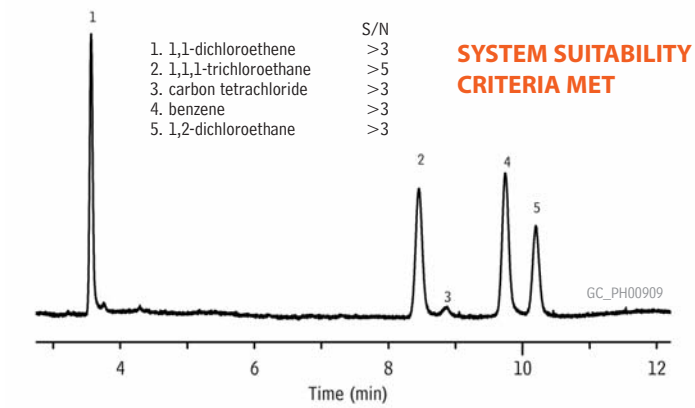
Analytical Reference Materials

The ICH guideline classifies residual solvents by class according to toxicity. Class 1 compounds are carcinogenic and pose a risk to both the consumer and the environment. The use of these solvents must be avoided or tightly controlled. Class 2 compounds are nongenotoxic animal carcinogens and their concentration should be limited. Both Class 1 and 2 compounds require chromatographic determination and are separated into 3 test mixes: Class 1 Mixture, Class 2 Mixture A, and Class 2 Mixture B. Class 3 compounds have low toxic potential. Concentration levels of up to 0.5% are acceptable and, therefore, they can be assayed by nonspecific techniques, such as weight loss on drying. Class 2 Mixture C is not used in the second supplement of USP 30/NF 25, but contains solvents that are not readily detectable by headspace analysis. These solvents should be assayed by other appropriately validated procedures.

Procedure A - Identification

Procedure A is the first step in the identification process and is performed on a G43 column to determine if any residual solvents are present in the sample at detectable levels. First, Class 1 standard and system suitability solutions and Class 2 Mix A standard solutions are assayed under the method-specified operating conditions to establish system suitability. All peaks in the Class 1 system suitability solution must have a signal-to-noise ratio not less than 3, the Class 1 standard solution must have a 1,1,1-trichloroethane response greater than 5, and the resolution of acetonitrile and dichloromethane must be not less than 1 in the Class 2 Mixture A solution. When system suitability has been achieved, the test solutions are assayed along with the Class 1 and Class 2 Mixtures A and B standard solutions. If a peak is determined in the sample that matches a retention time and has a greater response than that of a corresponding reference material, then Procedure B is performed for verification of the analyte. In the second supplement of USP 30/NF 25, an exemption is made for 1,1,1-trichloroethane, where a response greater than 150 times the peak response denotes an amount above the percent daily exposure limit. Figures 4 through 6 illustrate the analysis of Class 1, Class 2 Mixture A, and Class 2 Mixture B residual solvent mixes by Procedure A. The resolution between acetonitrile and dichloromethane was easily achieved using an Rtx®-1301 column.

Figure 4 USP residual solvent Class 1 standard solution on an Rtx®-1301 column (G43).

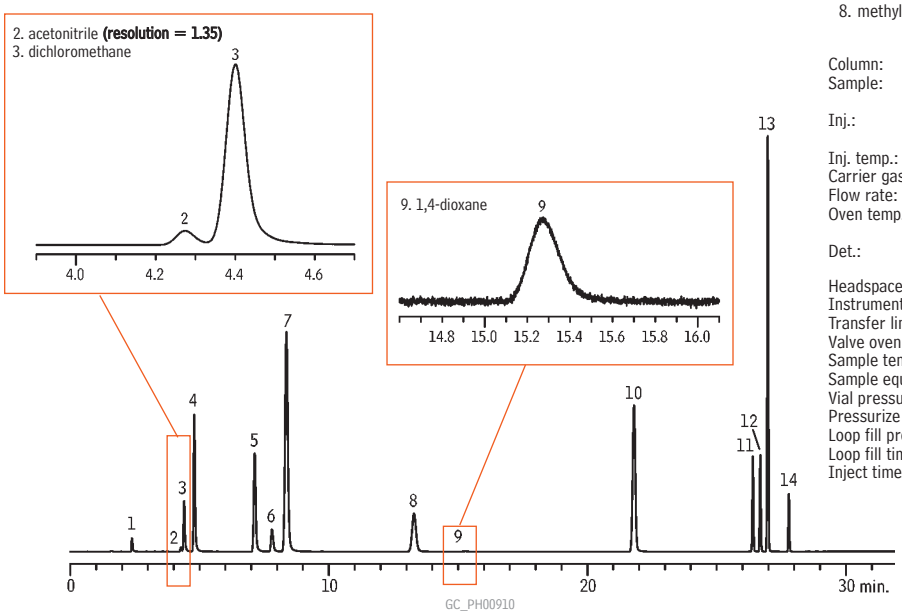


Column:	Rtx®-1301, 30m, 0.32mm ID, 1.8µm (cat.# 16092)	Headspace Conditions	
Sample:	USP <467> Class 1 standard solution (cat.# 36279) in 20mL headspace vial	Instrument:	Tekmar HT3
Inj.:	headspace injection (split ratio 1:5), 1mm split liner, Siltek® deactivated (cat.# 20972-214.1)	Transfer line temp.:	105°C
Inj. temp.:	140°C	Valve oven temp.:	105°C
Carrier gas:	helium, constant flow	Sample temp.:	80°C
Flow rate:	2.16mL/min., 35.3cm/sec.	Sample equil. time:	45 min.
Oven temp.:	40°C for 20 min. to 240°C @ 10°C/min. (hold for 20 min.)	Vial pressure:	10psi
Det.:	FID @ 240°C	Pressurize time:	0.5 min.
		Loop fill pressure:	5psi
		Loop fill time:	2.00 min.
		Inject time:	1.00 min.

Figure 5 USP residual solvent Class 2 Mixture A standard solution on an Rtx®-1301 column (G43).

SYSTEM SUITABILITY CRITERIA MET

1. methanol
2. acetonitrile (resolution=1.35)
3. dichloromethane
4. *trans*-1,2-dichloroethene
5. *cis*-1,2-dichloroethene
6. tetrahydrofuran
7. cyclohexane
8. methylcyclohexane
9. 1,4-dioxane
10. toluene
11. chlorobenzene
12. ethyl benzene
13. *m*-xylene/*p*-xylene
14. *o*-xylene



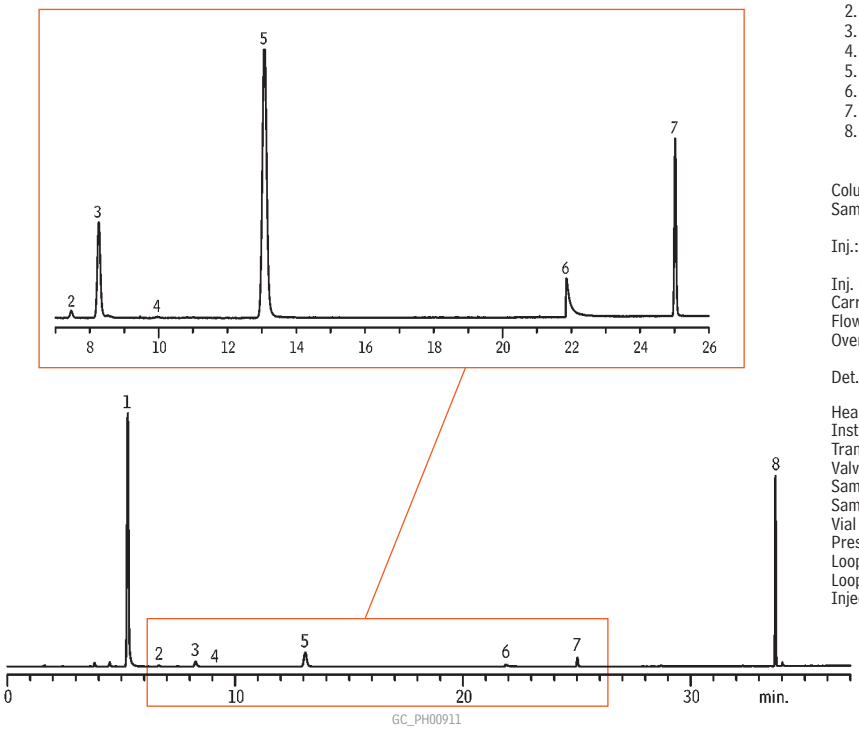
Column:	Rtx®-1301, 30m, 0.32mm ID, 1.8µm (cat.# 16092)
Sample:	USP <467> Class 2 Mixture B standard solution (cat.# 36280) in 20mL headspace vial
Inj.:	headspace injection (split ratio 1:5), 1mm split liner Siltek® deactivated (cat.# 20972-214.1)
Inj. temp.:	140°C
Carrier gas:	helium, constant flow
Flow rate:	2.16mL/min., 35.3cm/sec.
Oven temp.:	40°C for 20 min. to 240°C @ 10°C/min. (hold for 20 min.)
Det.:	FID @ 240°C

Headspace Conditions

Instrument:	Tekmar HT3
Transfer line temp.:	105°C
Valve oven temp.:	105°C
Sample temp.:	80°C
Sample equil. time:	45 min.
Vial pressure:	10psi
Pressurize time:	0.5 min.
Loop fill pressure:	5psi
Loop fill time:	2.00 min.
Inject time:	1.00 min.

Figure 6 USP residual solvent Class 2 Mixture B standard solution on an Rtx®-1301 column (G43).

1. hexane
2. nitromethane
3. chloroform
4. 1,2-dimethoxyethane
5. trichloroethylene
6. pyridine
7. 2-hexanone
8. tetralin



Column:	Rtx®-1301, 30m, 0.32mm ID, 1.8µm (cat.# 16092)
Sample:	USP <467> Class 2 Mixture B standard solution (cat.# 36280) in 20mL headspace vial
Inj.:	headspace injection (split ratio 1:5), 1mm split liner Siltek® deactivated (cat.# 20972-214.1)
Inj. temp.:	140°C
Carrier gas:	helium, constant flow
Flow rate:	2.16mL/min., 35.3cm/sec.
Oven temp.:	40°C for 20 min. to 240°C @ 10°C/min. (hold for 20 min.)
Det.:	FID @ 240°C

Headspace Conditions

Instrument:	Tekmar HT3
Transfer line temp.:	105°C
Valve oven temp.:	105°C
Sample temp.:	80°C
Sample equil. time:	45 min.
Vial pressure:	10psi
Pressurize time:	0.5 min.
Loop fill pressure:	5psi
Loop fill time:	2.00 min.
Inject time:	1.00 min.

Achieving USP<467> Compliance *(continued from page 5)*

Capillary Column—Procedure A

Rtx®-1301 (G43) Columns (fused silica)
(Crossbond® 6% cyanopropylphenyl/94% dimethyl polysiloxane)

ID	df (µm)	temp. limits	length	cat. #
0.32mm	1.80	-20 to 240°C	30-Meter	16092
0.53mm	3.00	-20 to 240°C	30-Meter	16085

Capillary Column—Procedure B

0.32mm	0.25	40 to 250°C	30-Meter	10624
0.53mm	0.25	40 to 250°C	30-Meter	10625

Procedure B - Confirmation

Once a residual solvent is identified and found to be above the percent daily exposure limit, Procedure B is performed to confirm analyte identity. A G16 capillary column is used here as a confirmation column, because it yields an alternate selectivity compared to a G43 column. The same standard and system suitability preparations are used in Procedures A and B. The system suitability requirements differ here in that the Class 1 standard solution must have a benzene response greater than 5 and the resolution of acetonitrile and *cis*-dichloroethene must not be less than 1 in the Class 2 Mixture A solution, a change from the original version. If the analyte identified in Procedure A again matches the retention time and exceeds the peak response of the reference materials (with the same exception to 1,1,1-trichloroethane), the analyst must quantify the analyte using Procedure C. Figures 7 through 9 illustrate the analysis of Class 1, Class 2 Mixture A, and Class 2 Mixture B residual solvent mixes on a Stabilwax® column. Again, the system suitability requirements were easily met.

Procedure C – Quantification

Once a residual solvent has been identified and verified, Procedure C is used to quantify the analyte by analyzing the sample against compound-specific reference materials. Individual standards are prepared by diluting the analyte in solution to a concentration of 1/20 of the concentration limit given under concentration limit Table 1 or 2 of the method. Following the procedure and instrument conditions in either Procedure A or B (whichever provides the most definitive results), a quantifiable result is produced. For water-insoluble articles, the same procedure is followed, except dimethylformamide or dimethylsulfoxide is used as the diluent.

Figure 7 USP residual solvent Class 1 standard solution on a Stabilwax® column (G16).

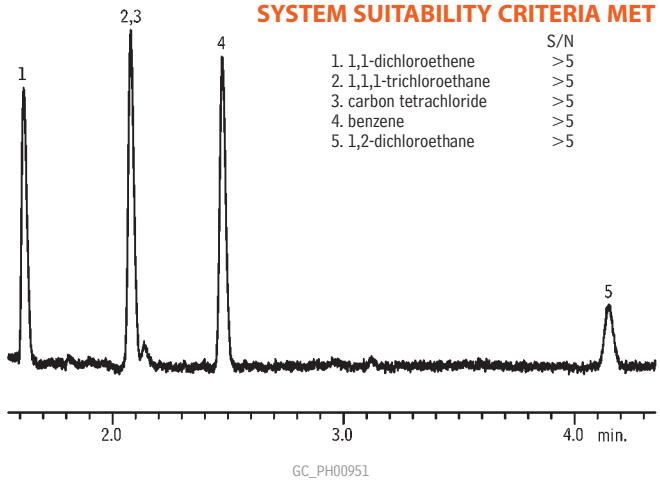


Figure 8 USP residual solvent Class 2 Mixture A standard solution on a Stabilwax® column (G16).

SYSTEM SUITABILITY CRITERIA MET—
RESOLUTION BETWEEN PEAKS 7 & 8 > 1.0

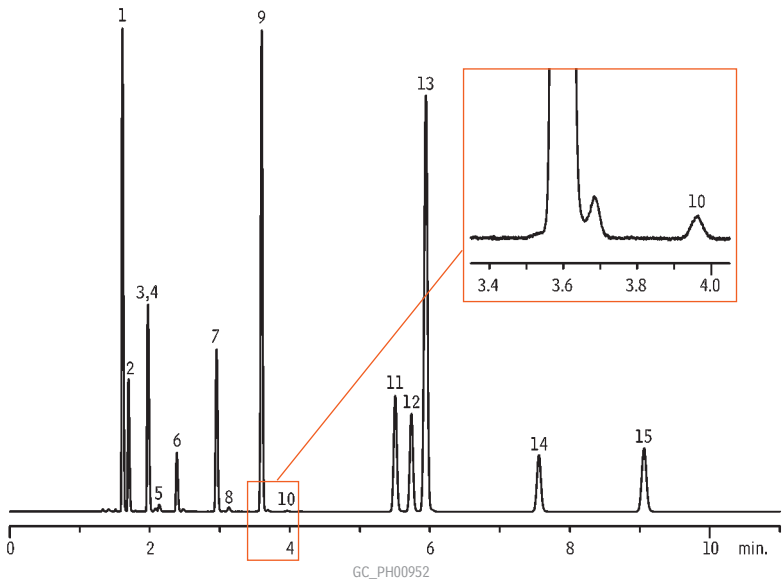
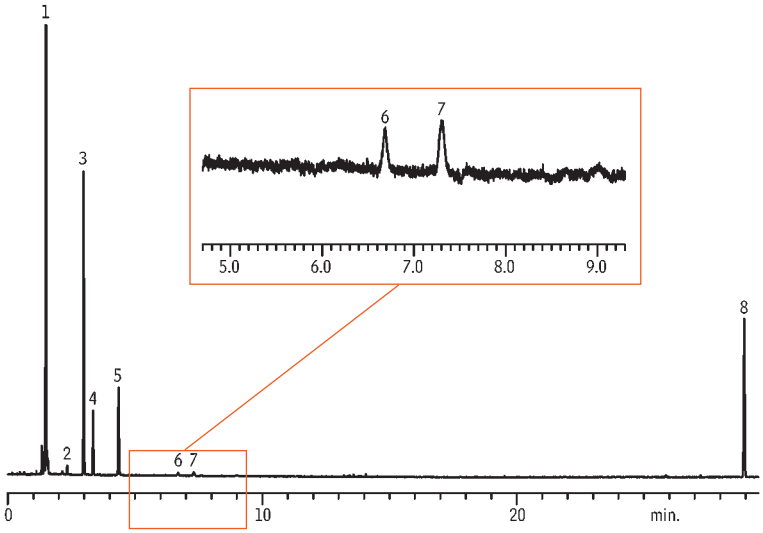


Figure 9 USP residual solvent Class 2 Mixture B standard solution on a Stabilwax® column (G16).



1. hexane
2. 1,2-dimethoxyethane
3. trichloroethylene
4. chloroform
5. 2-hexanone
6. nitromethane
7. pyridine
8. tetralin

Column:	Stabilwax®, 30m, 0.32mm ID, 0.25µm (cat.# 10624)
Sample:	USP Stock Standard Residual Solvents Class 2 Mix B (cat.# 36272) in 20mL headspace vial (cat.# 24685), water diluent
Inj.:	headspace injection (split ratio 1:5), 2mm splitless liner IP deactivated (cat.# 20712)
Inj. temp.:	140°C
Carrier gas:	helium, constant flow
Flow rate:	2.15mL/min., 35.2cm/sec.
Oven temp.:	50°C for 20 min. to 165°C @ 6°C/min. (hold for 20 min.)
Det.:	FID @ 250°C

Headspace Conditions

Instrument:	Overbrook Scientific HT200H
Syringe temp.:	100°C
Sample temp.:	80°C
Sample equil. time.:	45 min.
Injection vol.:	1.0mL
Injection speed:	setting 8
Injection dwell:	5 sec.

Optimize Your Testing Procedure

Tools, Tips, & Techniques for Improving Method Performance

Use Smaller Bore Liners for Better Efficiency

1mm Split Liners for Agilent GCs

ID* x OD & Length	qty.	cat.#
1mm Split**		
1.0mm x 6.3mm x 78.5mm	ea.	20972
1.0mm x 6.3mm x 78.5mm	5-pk.	20973

2mm Splitless Liners for Agilent GCs

ID* x OD & Length	qty.	cat.#
2mm Splitless		
2.0mm x 6.5mm x 78.5mm	ea.	20712
2.0mm x 6.5mm x 78.5mm	5-pk.	20713
2.0mm x 6.5mm x 78.5mm	25-pk.	20714

Split Liners for Varian 1075/1077 GCs

ID* x OD & Length	qty.	cat.#
1mm Split		
1.0mm x 6.3mm x 72mm	ea.	20970
1.0mm x 6.3mm x 72mm	5-pk.	20971

Split Liners for Shimadzu GCs

ID* x OD & Length	qty.	cat.#
1mm Split		
1.0mm x 5.0mm x 95mm	ea.	20976
1.0mm x 5.0mm x 95mm	5-pk.	20977
1.0mm x 5.0mm x 95mm	25-pk.	20978

SPME Liners for Shimadzu 17A, 2010, and 2014 GCs

ID* x OD & Length	qty.	cat.#
SPME Liner		
.75mm x 5.0mm x 95mm	ea.	22278
.75mm x 5.0mm x 95mm	5-pk.	22279

Zero Dilution Liners for PerkinElmer Auto SYS™ and Clarus GCs

ID* x OD & Length	qty.	cat.#
Zero Dilution Inner Liner		
1.0mm x 2.0mm x 73mm	ea.	22990
1.0mm x 2.0mm x 73mm	5-pk.	22991

Zero Dilution Outer Liner		
2.5mm x 6.2mm x 90mm	ea.	22992
2.5mm x 6.2mm x 90mm	5-pk.	22993

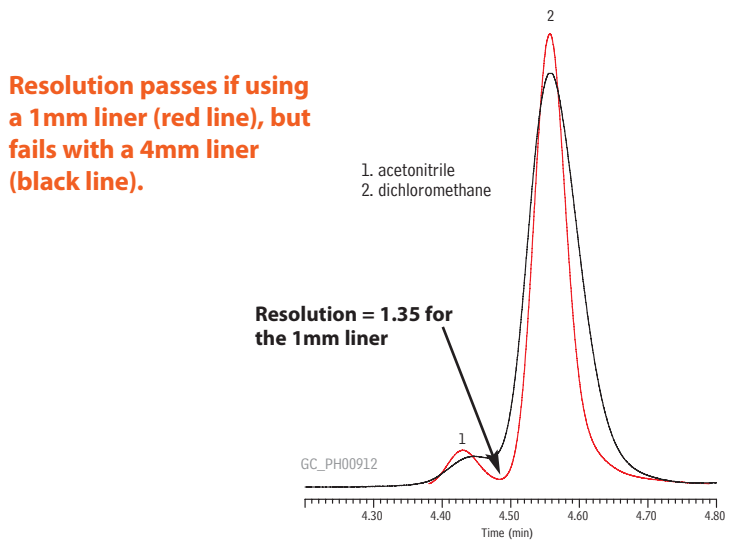
*Nominal ID at syringe needle expulsion point.
**Use this liner for increased sensitivity.

Implementing the revised method for USP<467> can be difficult if the instrument is not optimized correctly. Key issues to address when setting up headspace GC systems include minimizing system dead volume, maintaining inert sample flow paths, and achieving efficient sample transfer. While the second supplement contains a change that allows for modifications to the split ratio, column and liner choices are critical to analytical success.

Use Smaller Bore Liners for Better Resolution

The function of an injection port in headspace analysis is very different than in direct liquid injection. In direct injection, the sample is vaporized in the injection port and larger volume liners (e.g., 4mm) are typically used since the liner must be able to accommodate the solvent expansion volume. In contrast, in headspace analysis, the sample is vaporized inside the headspace vial and the resulting gas sample is simply transferred into the injection port via a transfer line or syringe injection. Since solvent vaporization does not occur in the liner, a large volume liner is not needed and, in fact, the use of one can cause deleterious effects such as band broadening and decreased peak efficiency. For headspace applications, a smaller bore liner, preferably 1mm, is recommended. The smaller liner volume reduces band broadening by increasing linear velocity in the liner allowing faster sample transfer and improving resolution (Figure 10).

Figure 10 Improve system suitability pass rates using smaller bore liners.



Speed Up Method Development Using a Retention Time Index

ICH guideline Q3C states that residual solvents need only be tested when production or purification processes are known to result in the presence of such solvents. Therefore, in many cases exhaustive testing is not needed and individual validated methods for smaller, specific analyte lists are an option. To simplify column selection and reduce method development time, Restek has created a retention time index for ICH Class 1, 2, and 3 residual solvents on various phases (Table I). To use this index, simply locate the analytes of interest on the list and determine which phase gives the optimal amount of resolution—or difference in retention time—between your target compounds. A critical coelution is indicated by a failure to achieve a retention time difference of greater than 1.5 minutes.

Table I Reduce method development time—use a retention time index for column selection.

Retention time data collected using the following conditions:
G16 Stabilwax®: 30m, 0.25mm ID, 0.5µm df, Phase ratio: 125, Oven program: 40ºC, hold 1 min., to 190ºC @ 4ºC/min., hold 15 min., Carrier flow: 1.2mL/min., Dead time: 1.38 min. @ 45ºC
G16 Rtx®-WAX: 30m, 0.25mm ID, 0.5µm df, Phase ratio: 125, Oven program: 40ºC, hold 1 min., to 190ºC @ 4ºC/min., hold 15 min., Carrier flow: 1.2mL/min., Dead time: 1.40 min. @ 45ºC
G43 Rtx®-1301: 30m, 0.25mm ID, 1.0µm df, Phase ratio: 63, Oven program: 40ºC, hold 1 min., to 190ºC @ 4ºC/min., hold 15 min., Carrier flow: 1.2mL/min., Dead time: 1.40 min. @ 45ºC
G27 Rxi®-5ms: 30m, 0.25mm ID, 1.0µm df, Phase ratio: 63, Oven program: 40ºC, hold 1 min., to 190ºC @ 4ºC/min., hold 15 min., Carrier flow: 1.1mL/min., Dead time: 1.49 min. @ 45ºC
G1 Rtx®-1: 60m, 0.53mm ID, 3.00µm df, Phase ratio: 43, Oven program: 30ºC, hold 4 min., to 220ºC @ 4ºC/min., Carrier flow: 6.3mL/min., Dead time: 2.54 min. @ 35ºC
Rtx®-200: 60m, 0.53mm ID, 3.00µm df, Phase ratio: 43, Oven program: 30ºC, hold 4 min., to 220ºC @ 4ºC/min., Carrier flow: 7.8mL/min., Dead time: 2.22 min. @ 35ºC

Carrier gas: helium **Compound**	**ICH Class**	**G16 Stabilwax® Retention Time**	**G16 Rtx®-WAX Retention Time**	**G43 Rtx®-1301 Retention Time**	**G27 Rxi®-5ms Retention Time**	**G1 Rtx®-1 Retention Time**	**NA Rtx®-200 Retention Time**
1,1,1-trichloroethane	1	3.96	3.49	5.43	5.40	10.82	8.35
1,1,2-trichloroethene	2	15.72	14.28	10.99	9.77	16.75	14.94
1,1-dichloroethene	1	2.23	2.04	2.79	4.41	5.73	4.16
1,2-dichloroethane	1	8.80	7.68	6.15	5.46	10.38	9.74
cis-1,2-dichloroethene	2	6.50	5.65	4.79	2.88	8.71	7.11
trans-1,2-dichloroethene	2	3.63	3.20	3.55	3.54	7.17	5.16
1,2-dimethoxyethane	2	4.80	4.18	6.03	5.54	10.98	10.63
1,4-dioxane	2	8.55	7.49	7.86	7.26	13.54	14.34
1-butanol	3	11.13	10.08	7.18	5.76	11.49	10.13
1-pentanol	3	14.95	13.75	11.19	9.44	16.99	14.95
1-propanol	3	7.69	6.80	4.20	3.37	6.81	6.13
2-butanol	3	7.25	6.44	5.08	4.16	8.51	7.69
2-ethoxyethanol	2	13.99	12.70	8.69	7.36	13.91	13.99
2-methoxyethanol	2	12.42	11.11	6.02	5.14	9.83	10.74
2-methyl-1-propanol	3	9.32	8.40	6.00	4.79	*	*
2-propanol	3	4.81	4.25	3.00	2.55	4.91	4.69
3-methyl-1-butanol	3	13.42	12.25	9.86	8.26	15.28	13.55
acetic acid	3	22.47	20.34	6.52	4.61	8.84	8.96
acetone	3	3.02	2.64	2.89	2.50	4.64	7.68
acetonitrile	2	6.91	5.83	3.28	2.47	4.32	8.89
anisole	3	18.65	17.09	17.12	16.28	25.00	22.84
benzene	1	5.23	4.54	5.98	3.83	11.63	9.17
butyl acetate	3	8.86	7.88	12.12	11.38	19.43	19.63
carbon tetrachloride	1	3.96	3.49	5.61	5.90	11.89	7.42
chlorobenzene	2	13.91	12.54	13.55	13.14	21.56	18.48
chloroform	2	7.31	6.41	5.23	4.64	9.18	6.66
cumene	3	12.36	11.17	16.66	16.69	25.88	20.90
cyclohexane	2	2.16	2.01	5.37	5.89	*	*
dichloromethane	2	5.01	4.33	3.31	3.06	5.87	4.88
dimethylsulfoxide	3	26.47	24.43	16.62	13.01	18.81	30.95
ethanol	3	4.98	4.37	2.52	2.19	4.03	3.80
ethyl acetate	3	4.08	3.56	4.87	4.44	9.04	10.35
ethyl benzene	2	10.72	9.58	13.86	13.81	22.54	18.18
ethyl ether	3	1.72	1.63	2.58	2.67	5.34	3.87
ethyl formate	3	3.16	2.78	3.00	2.78	5.46	6.48
ethylene glycol	2	28.06	26.23	10.77	6.63	12.59	13.86
formamide	2	32.99	30.93	11.85	7.30	12.72	19.93
formic acid	3	24.64	22.09	5.19	2.60	5.59	5.06
heptane	3	1.98	1.86	6.34	6.98	14.18	7.84
hexane	2	1.65	1.58	3.77	4.11	9.06	4.86
isobutyl acetate	3	6.99	6.18	10.39	9.69	17.35	18.02
isopropyl acetate	3	4.26	3.74	6.19	5.71	11.47	12.38
methanol	2	4.23	3.64	1.96	1.80	3.14	2.93
methyl acetate	3	3.19	2.80	3.17	2.93	5.80	7.10
methylbutyl ketone	2	9.10	8.05	11.81	10.50	17.94	20.81
methylcyclohexane	2	2.50	2.30	7.31	7.95	15.49	9.21
methylethyl ketone	3	4.33	3.76	4.90	4.09	7.99	11.55
methylisobutyl ketone	3	6.84	5.97	9.64	8.49	15.35	18.41
m-xylene	2	11.21	10.04	15.46	14.17	23.01	18.78
N,N-dimethylacetamide	2	20.75	19.01	12.95	13.96	21.42	30.00
N,N-dimethylformamide	2	18.04	16.26	13.09	10.23	16.52	26.19
nitromethane	2	11.82	10.31	4.84	3.53	6.30	12.01
N-methylpyrrolidone	2	29.84	27.86	25.09	21.85	29.99	38.08
o-xylene	2	12.79	11.51	15.46	15.26	24.23	20.33
pentane	3	1.49	1.45	2.39	2.62	5.36	3.29
propyl acetate	3	5.98	5.29	8.03	7.44	*	*
p-xylene	2	10.98	9.82	14.29	15.27	22.99	18.69
pyridine	2	12.64	11.24	9.60	8.57	15.40	16.45
sulfolane	2	47.62	43.31	34.02	28.90	36.76	48.67
tert-butylmethyl ether	3	1.94	1.82	3.50	3.59	7.52	5.73
tetrahydrofuran	3	3.63	3.19	5.12	4.90	9.81	9.48
tetralin	2	25.12	23.48	27.49	27.44	37.27	31.72
toluene	2	7.86	6.91	9.80	9.66	17.36	14.00
1,1-diethoxypropane	—	5.42	4.84	11.39	11.38	19.82	15.08
2,2-dimethoxypropane	—	3.11	2.79	5.48	5.55	11.37	8.67
2-chloropropane	—	1.96	1.82	2.67	2.66	5.20	4.61
2-methylpentane	—	1.58	1.52	3.22	3.56	7.72	4.32
acetaldehyde	—	2.05	1.85	1.86	1.84	3.14	3.90
chloroethane	—	1.83	1.71	2.14	2.10	3.97	3.55
chloromethane	—	1.63	1.55	1.70	1.70	3.01	2.73
ethylene oxide	—	2.05	1.86	1.89	2.02	3.59	3.92
formaldehyde	—	2.25	1.57	1.68	1.58	2.66	2.59
isoamyl acetate	—	10.51	9.43	14.84	14.18	22.80	22.62
isooctane	—	1.85	1.75	5.84	6.59	13.66	8.07
isopropyl ether	—	1.86	1.76	4.03	4.23	9.03	5.83
methyl cyclopentane	—	1.91	1.79	4.50	4.93	10.41	5.81
methyl isopropyl ketone	—	4.93	4.29	6.58	5.69	11.04	14.47
methylal	—	2.26	2.06	2.84	2.82	5.65	5.09
trichloroethene	—	6.50	5.70	7.07	7.05	13.58	9.75
water	—	8.24	7.18	1.74	1.68	2.75	2.57

* Not determined

Restek Offers An Extensive Selection of Capillary Columns

For Successful Method Development & Validation

Rtx®-624 Columns (fused silica)

G43

(Crossbond® 6% cyanopropylphenyl/94% dimethyl polysiloxane)

ID	df (µm)	temp. limits	30-Meter	60-Meter
0.25mm	1.40	-20 to 240°C	10968	10969
0.32mm	1.80	-20 to 240°C	10970	10972
0.53mm	3.00	-20 to 240°C	10971	10973
ID	**df (µm)**	**temp. limits**	**20-Meter**	**40-Meter**
0.18mm	1.00	-20 to 240°C	40924	40925

Rtx®-1301 Columns (fused silica)

G43

(Crossbond® 6% cyanopropylphenyl/94% dimethyl polysiloxane)

ID	df (µm)	temp. limits*	30-Meter	60-Meter
0.25mm	0.50	-20 to 270°C	16038	16041
	1.00	-20 to 260°C	16053	16056
	1.40	-20 to 240°C		16016
0.32mm	0.50	-20 to 270°C	16039	16042
	1.00	-20 to 260°C	16054	16057
	1.50	-20 to 250°C	16069	16072
	1.80	-20 to 240°C	16092	16093
0.53mm	0.50	-20 to 270°C	16040	16043
	1.00	-20 to 260°C	16055	16058
	1.50	-20 to 250°C	16070	16073
	3.00	-20 to 240°C	16085	16088

Stabilwax® Columns (fused silica)

G16

(Crossbond® Carbowax® polyethylene glycol)

ID	df (µm)	temp. limits	30-Meter	60-Meter
0.25mm	0.25	40 to 250°C	10623	10626
	0.50	40 to 250°C	10638	10641
0.32mm	0.25	40 to 250°C	10624	10627
	0.50	40 to 250°C	10639	10642
	1.00	40 to 240/250°C	10654	10657
0.53mm	1.00	40 to 240/250°C	10655	10658
	1.50	40 to 230/240°C	10669	10672
	2.00	40 to 220/230°C	10670	

Rxi®-5ms Columns (fused silica)

G27

(Crossbond® 5% diphenyl/95% dimethyl polysiloxane)

ID	df (µm)	temp. limits	30-Meter	60-Meter
0.25mm	0.50	-60 to 330/350°C	13438	13441
	1.00	-60 to 330/350°C	13453	13456
0.32mm	0.50	-60 to 330/350°C	13439	13442
	1.00	-60 to 330/350°C	13454	13457
0.53mm	1.00	-60 to 330/350°C	13455	
	1.50	-60 to 330/350°C	13470	
ID	**df (µm)**	**temp. limits**	**20-Meter**	
0.18mm	0.18	-60 to 330/350°C	13402	
	0.30	-60 to 330/350°C	13409	
	0.36	-60 to 330/350°C	13411	

Rtx®-1 Columns (fused silica)

G1

(Crossbond® 100% dimethyl polysiloxane)

ID	df (µm)	temp. limits	30-Meter	60-Meter
0.25mm	0.50	-60 to 330/350°C	10138	10141
	1.00	-60 to 320/340°C	10153	10156
0.32mm	1.00	-60 to 320/340°C	10154	10157
	1.50	-60 to 310/330°C	10169	10172
	3.00	-60 to 280/300°C	10184	10187
	4.00	-60 to 280/300°C	10198	
	5.00	-60 to 260/280°C	10178	10180
0.53mm	1.50	-60 to 310/330°C	10170	10173
	3.00	-60 to 270/290°C	10185	10188
	5.00	-60 to 270/290°C	10179	10183
	7.00	-60 to 240/260°C	10192	10193
ID	**df (µm)**	**temp. limits**	**20-Meter**	**40-Meter**
0.18mm	0.20	-60 to 330/350°C	40102	40103
	0.40	-60 to 320/340°C	40111	40112

Rtx®-200 Columns (fused silica)

(Crossbond® trifluoropropylmethyl polysiloxane)

ID	df (µm)	temp. limits*	30-Meter	60-Meter
0.25mm	0.50	-20 to 310/330°C	15038	15041
	1.00	-20 to 290/310°C	15053	15056
0.32mm	1.00	-20 to 290/310°C	15054	15057
	1.50	-20 to 280/300°C	15069	15072
0.53mm	1.00	-20 to 290/310°C	15055	15058
	1.50	-20 to 280/300°C	15070	15073
	3.00	-20 to 260/280°C	15085	15088
ID	**df (µm)**	**temp. limits**	**20-Meter**	**40-Meter**
0.18mm	0.20	-20 to 310/330°C	45002	45003
	0.40	-20 to 310/330°C	45011	45012

*Maximum temperatures listed are for 15- and 30-meter lengths. Longer lengths may have a slightly reduced maximum temperature.

free literature

Genuine Restek Replacement Parts

Use our handy new Genuine Restek Replacement Parts (GRRP) mini-catalogs to help you select the supplies and replacement parts you need for your specific GC. We now have customized GRRP mini-catalogs for each major instrument manufacturer to simplify your product search. Download these and other pieces from our website at **www.restek.com/grrp.**

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For Agilent 5890 GCs
(lit. cat.# 580216)

For PerkinElmer GCs
(lit. cat.# 580038)

For Shimadzu GCs
(lit. cat.# 580037)

For Thermo Scientific GCs
(lit. cat.# 580039)

For Varian GCs
(lit. cat.# 59224A)

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If you do not see the column dimension you need, call our customer service team, and we will make the column for you.

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0.8mm ID Dual Vespel Ring Inlet Seal	2-pk./price	10-pk./price
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Siltek Treated	21242	21243
Stainless Steel	21238	21239
1.2mm ID Dual Vespel Ring Inlet Seal	**2-pk./price**	**10-pk./price**
Gold-Plated	21246	21247
Siltek Treated	21248	21249
Stainless Steel	21244	21245

Dual Vespel® Ring Cross-Disk Inlet Seals for Agilent GCs

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- Washerless, leak-tight seals.

0.8mm ID Dual Vespel Ring Cross-Disk Inlet Seal	2-pk./price	10-pk./price
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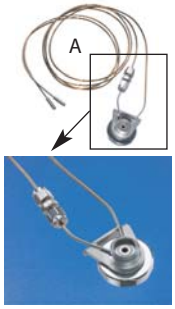
Siltek Treated	22085	22086
Stainless Steel	22087	22088

Injection Port Weldments for Agilent GCs

Easily attach your autosampler with pre-installed low dead volume fittings.

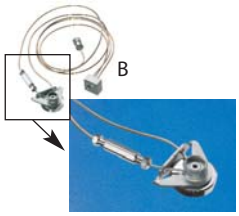


For Agilent GCs with Tekmar Transfer Lines

Description	qty.	cat.#
A) Weldment for Agilent 6890 GCs	ea.	22664
Weldment for Agilent 6890 GCs with optional canister filter	ea.	22668
Weldment for Agilent 5890 GCs	ea.	22666

For Agilent GCs with OI Purge and Trap Systems

Description	qty.	cat.#
B) Weldment for Agilent 6890 GCs	ea.	22665
Weldment for Agilent 6890 GCs with optional canister filter	ea.	22669
Weldment for Agilent 5890 GCs	ea.	22667



FID Replacement Jets

Standard Version

- Engineered with a fluted tip to guide the capillary column into the jet.
- Threads specially coated for easy installation and removal.
- Special processing ensures the highest degree of cleanliness.

High-Performance Version

- Similar to the standard version, but Siltek® treated.
- Extremely inert, for use with active compounds.

Capillary Adaptable FID Replacement Jet for Agilent 5890/6890/6850 GCs

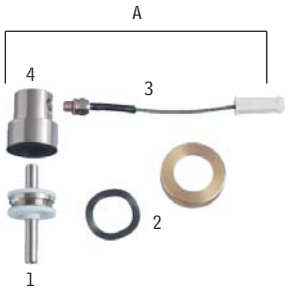
0.011-Inch ID Tip	Similar to Agilent part #	qty.	cat.#	qty.	cat.#
Standard, 0.011-Inch ID Tip	19244-80560	ea.	20670	3-pk.	20671
High-Performance Siltek Treated, 0.011-Inch ID Tip	19244-80560	ea.	20672	3-pk.	20673

Capillary Dedicated FID Replacement Jet for Agilent 6890/6850/7890 GCs

0.011-Inch ID Tip	Similar to Agilent part #	qty.	cat.#	qty.	cat.#
Standard, 0.011-Inch ID Tip	G1531-80560	ea.	21621	3-pk.	21682
High-Performance Siltek Treated, 0.011-Inch ID Tip	G1531-80560	ea.	21620	3-pk.	21683

did you know?

Restek carries a full line of FID replacement jets. Visit **www.restek.com** for a complete selection.



Direct Replacement FID Collector Assembly Kit for Agilent 6890/6850/7890 GCs

- Constructed of high-quality stainless steel.
- Meets or exceeds manufacturer's performance.

Description	Similar to Agilent part #	qty.	cat.#
A) FID Collector Assembly Kit (includes insulator)	G1531-60690	kit	21699
FID Collector Assembly Kit w/Siltek Ignitor Castle	—	kit	21132

Replacement FID Parts for Agilent 6890/6850/7890 GCs

- Meets or exceeds manufacturer's performance.

Description	Similar to Agilent part #	qty.	cat.#
1) FID Collector (includes insulators)	G1531-20690 G1531-20700	ea.	21139
2) FID Collector Nut and Washer	19231-20940 5181-3311	set	21136
3) FID Ignitor*	19231-60680	ea.	21001
4) FID Ignitor Castle	19231-20910	ea.	21137
Siltek FID Ignitor Castle	—	ea.	21135

*Also fits OI Analytical 4410 detector (similar to OI part # 191833).

The New Restek Electronic Leak Detector!

We are pleased to introduce the new, enhanced Restek Electronic Leak Detector. With our new unit you'll receive the great performance that you've come to trust from our current Leak Detector; but with new features designed with the end-user in mind, including:

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- Handy probe storage for cleanliness.
- Longer battery lifetime.
- Automatic shut-off capabilities.
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- A universal power adapter set (US, European, UK and Australian plugs included).

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Description	qty	cat.#
Leak Detector with Universal Adapter Set	ea	22839

tech tip

Avoid using liquid leak detectors on a capillary system! Liquids can be drawn into the system.

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Volatiles

Volatile organic compounds (VOCs) are usually analyzed using a purge and trap system connected to a GC. The column used must have a selective stationary phase to resolve the volatile pollutants, have a sufficient film thickness to retain and resolve the low boiling volatile compounds (i.e., dichlorodifluoromethane), and must be thermally stable to elute the high boiling volatiles compounds (i.e., hexachlorobutadiene & naphthalene).

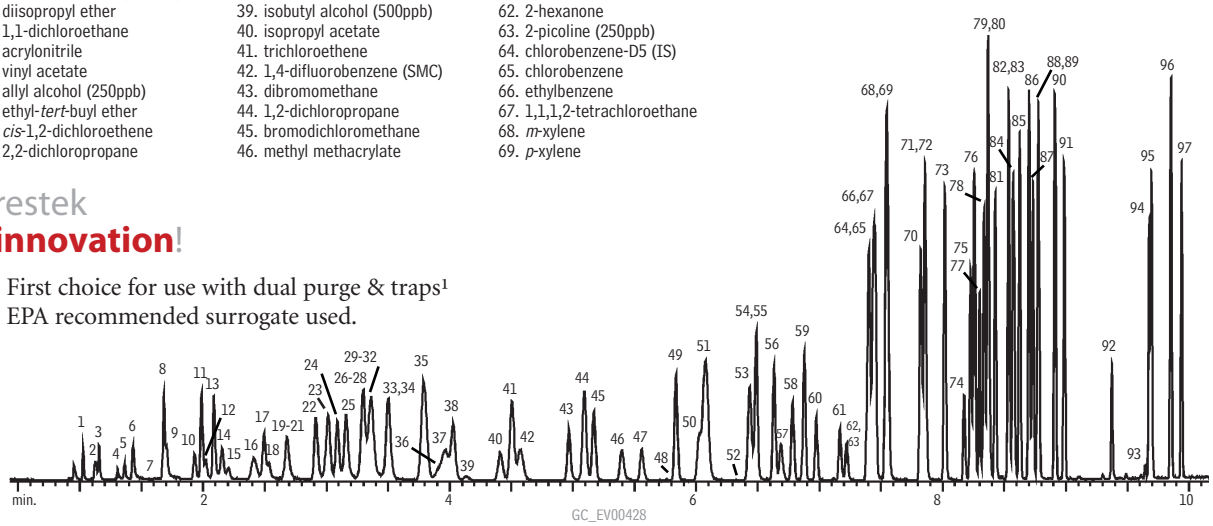
The first fused silica columns used for analyzing volatiles were based on diphenyl/dimethyl polysiloxane stationary phases. However, resolution of gases has always been problematic with these phases. Restek designed the Rtx®-VMS column specifically to optimize separation of volatiles in the most commonly used EPA volatiles methods. A faster oven ramp rate is possible because these compounds elute farther apart on the Rtx®-VMS phase, eliminating partial coelutions that interfere with quantification. Using the EPA suggested surrogates (i.e., chlorobenzene-d5) analysis time can be less than 10 minutes with a narrow bore column, allowing you to connect two purge and trap units to one GC/MS instrument – significantly increasing sample throughput.

Figure 1 Excellent resolution of bromomethane and chloroethane, as well as challenging isomer pairs like 2-/4-chlorotoluene on the Rtx®-VMS column.

1. dichlorodifluoromethane
2. chloromethane
3. vinyl chloride
4. bromomethane
5. chloroethane
6. trichlorofluoromethane
7. ethanol (2500ppb)
8. 1,1-dichloroethene
9. carbon disulfide (40ppb)
10. allyl chloride
11. methylene chloride
12. acetone
13. *trans*-1,2-dichloroethene
14. methyl *tert*-butyl ether
15. *tert*-butyl alcohol (100ppb)
16. diisopropyl ether
17. 1,1-dichloroethane
18. acrylonitrile
19. vinyl acetate
20. allyl alcohol (250ppb)
21. ethyl-*tert*-buyl ether
22. *cis*-1,2-dichloroethene
23. 2,2-dichloropropane
24. bromochloromethane
25. chloroform
26. ethyl acetate
27. carbon tetrachloride
28. methyl acrylate
29. propargyl alcohol (500ppb)
30. dibromofluoromethane (SMC)
31. tetrahydrofuran
32. 1,1,1-trichloroethane
33. 2-butanone
34. 1,1-dichloropropene
35. benzene
36. pentafluorobenzene (IS)
37. *tert*-amyl-methyl ether
38. 1,2-dichloroethane
39. isobutyl alcohol (500ppb)
40. isopropyl acetate
41. trichloroethene
42. 1,4-difluorobenzene (SMC)
43. dibromomethane
44. 1,2-dichloropropane
45. bromodichloromethane
46. methyl methacrylate
47. *n*-propyl acetate
48. 2-chloroethanol (2500ppb)
49. *cis*-1,3-dichloropropene
50. toluene-d8 (SMC)
51. toluene
52. pyridine (250ppb)
53. tetrachloroethene
54. 4-methyl-2-pentanone
55. *trans*-1,3-dichloropropene
56. 1,1,2-trichloroethane
57. ethyl methacrylate
58. dibromochloromethane
59. 1,3-dichloropropane
60. 1,2-dibromoethane
61. *n*-butyl acetate
62. 2-hexanone
63. 2-picoline (250ppb)
64. chlorobenzene-D5 (IS)
65. chlorobenzene
66. ethylbenzene
67. 1,1,1,2-tetrachloroethane
68. *m*-xylene
69. *p*-xylene
70. *o*-xylene
71. stryrene
72. bromoform
73. isopropylbenzene
74. 4-bromo-1-fluorobenzene (SMC)
75. bromobenzene
76. *n*-propylbenzene
77. 1,1,2,2-tetrachloroethane
78. 2-chlorotoluene
79. 1,3,5-trimethylbenzene
80. 1,2,3-trichloropropane
81. 4-chlorotoluene
82. *tert*-butylbenzene
83. pentachloroethane
84. 1,2,4-trimethylbenzene
85. *sec*-butylbenzene
86. *p*-isopropyltoluene
87. 1,3-dichlorobenzene
88. 1,4-dichlorobenzene-d4 (IS)
89. 1,4-dichlorobenzene
90. *n*-butylbenzene
91. 1,2-dichlorobenzene
92. 1,2-dibromo-3-chloropropane
93. nitrobenzene (250ppb)
94. hexachlorobutadiene
95. 1,2,4-trichlorobenzene
96. naphthalene
97. 1,2,3-trichlorobenzene

restek
innovation!

- First choice for use with dual purge & traps[1]
- EPA recommended surrogate used.



Column:	Rtx®-VMS 20m, 0.18 mm ID, 1.00µm (cat.# 49914)	Interface:	0.53mm ID Silcosteel® tubing transfer line
Conc.:	10ppb in 5mL of RO water unless otherwise noted; ketones at 2.5X		1:40 split at injection port. 1mm ID liner.
Concentrator:	Tekmar LSC-3100 Purge and Trap	Oven temp.:	50°C (hold 4 min.) to 100°C @ 18°C/min. (hold 0 min.) to 230°C @ 40°C/min. (hold 3 min.)
Trap:	Vocarb 3000 (type K)	Carrier gas:	helium @ ~1.0mL/min. constant flow
Purge:	11 min. @ 40mL/min. (ambient temperature)		Adjust dichlorodifluoromethane to a retention time of 1.03 min. @ 50°C.
Dry purge:	1 min. @ 40mL/min.		
Desorb preheat:	245°C	Detector:	Agilent 5973 MSD
Desorb:	250°C for 2 min., flow 40mL/min.	Scan range:	35-300amu
Bake:	260°C for 8 min.		

[1]A.L. Hilling and G. Smith, Environmental Testing & Analysis, 10(3), 15-19, 2001.

Recommended Column

Rtx®-VMS Columns (fused silica)
(proprietary Crossbond® phase)

ID	df (µm)	temp. limits	length	cat. #
0.18mm	1.00	-40 to 240/260°C	20-Meter	49914

Analytical Reference Materials

8260A Internal Standard Mix
chlorobenzene-d5 fluorobenzene
1,4-dichlorobenzene-d4
2,500µg/mL each in P&T methanol, 1mL/ampul
cat. # 30241 (ea.)

8260 Internal Standard Mix
chlorobenzene-d5 1,4-difluorobenzene
1,4-dichlorobenzene-d4 pentafluorobenzene
2,500µg/mL each in P&T methanol, 1mL/ampul
cat. # 30074 (ea.)

8260A Surrogate Mix
4-bromofluorobenzene 1,2-dichloroethane-d4
dibromofluoromethane toluene-d8
2,500µg/mL each in P&T methanol, 1mL/ampul
cat. # 30240 (ea.)

8260 Surrogate Mix
4-bromofluorobenzene toluene-d8
dibromofluoromethane
2,500µg/mL each in P&T methanol, 1mL/ampul
cat. # 30073 (ea.)

8260B MegaMix® Calibration Mix (76 components)
Please visit us online for compound list
2,000µg/mL each in P&T methanol, 1mL/ampul
cat. # 30633 (ea.)

8260B MegaMix® Calibration Mix Kit
30633: 8260B MegaMix®
30265: 2-chlorethyl vinyl ether
Contains 1mL each of these mixtures.
cat. # 30475 (kit)

502.2 Calibration Mix #1 (gases)
bromomethane dichlorodifluoromethane (CFC-12)
chloroethane trichlorofluoromethane (CFC-11)
chloromethane vinyl chloride
200µg/mL each in P&T methanol, 1mL/ampul
cat. # 30439 (ea.)
2,000µg/mL each in P&T methanol, 1mL/ampul
cat. # 30042 (ea.)

VOA Calibration Mix #1 (ketones)
acetone 2-hexanone
2-butanone 4-methyl-2-pentanone
5,000µg/mL each in P&T methanol:water (90:10), 1mL/ampul
cat. # 30006 (ea.)

California Oxygenates Mix
diisopropyl ether 2,000µg/mL *tert*-butyl alcohol 10,000
ethyl-*tert*-butyl ether 2,000 methyl *tert*-butyl ether 2,000
tert-amyl methyl ether 2,000
In P&T methanol, 1mL/ampul
cat. # 30465 (ea.)

Reduce Dead Volume, Contamination, & Cold Spots

The injection port can be a source for dead volume, which is especially critical when dealing with a sample in the gas phase. The severity of the problem is a combination of the inside diameter of the injection port liner and the total desorb flow through the port. To reduce dead volume in the injection port, use a 1mm ID inert split liner. Always be sure to use insulation where the transfer line attaches to the inlet line since this is a cold spot that will condense high molecular weight analytes.

Transfer lines often are the first place contamination occurs. When the response factor for bromoform fails the method criteria, changing the transfer line is the first step to getting the system working again. Replace your transfer line with our Siltek® deactivated tubing, for optimum performance.

1mm Split Inlet Liner for Agilent GCs

ID*/OD & Length (mm)	cat.# ea.	cat.# 5-pk.
1.0 ID 6.3 OD x78.5	20972	20973

*Nominal ID at syringe needle expulsion point.
Also available with Siltek® deactivation, upon request.

Siltek®/Sulfinert® Treated Coiled 304 Grade Stainless Steel Tubing

Our most popular grade of tubing.
- chromatography applications.
- gas delivery systems.
- lower pressures.
- inert applications.

ID	OD	cat.#	5-24 ft.	25-199 ft.	200-399 ft.	>400 ft.
0.040" (1.02mm)	1/16" (1.59mm)	22505				

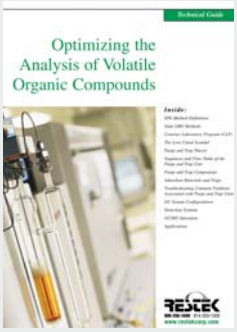
*0.020" wall thickness

An extra charge is applied for cutting Siltek®/Sulfinert®, Silcosteel®, or Silcosteel®-CR tubing, calculated from the total number of pieces produced for each line item.

free literature

Optimizing the Analysis of Volatile Organic Compounds
lit. cat.# 59887A

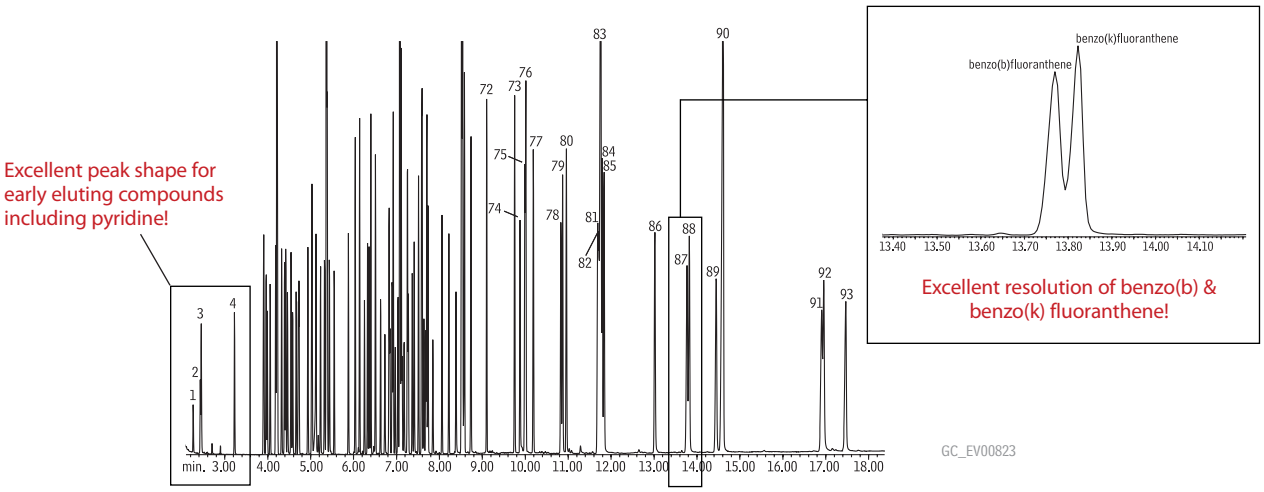
Contact your Restek representative, to request your free copy!



Semivolatiles

Semivolatile analysis is a challenging area covering a wide range of compound classes – neutral, acidic, and basic compounds, including anilines, phenols, PAHs, and more – that differ in both volatility and reactivity. While the chromatography is complicated by a broad list of target analytes, many problems can be avoided by proper attention to the inlet system and an informed column choice.

Figure 1 Separate greater than 90 semivolatile compounds in less than 18 minutes, using an Rxi™-5ms column.



For complete identifications, please visit www.restek.com/rxi

Column:	Rxi™-5ms, 30m, 0.25mm ID, 0.25µm (cat.# 13423)
Sample:	US EPA Method 8270D mix: 8270 MegaMix™ (cat.# 31850), Benzoic Acid Standard (cat.# 31879), Benzidine Standard (cat.# 31852), Acid Surrogate Mix (cat.# 31025), B/N Surrogate Standard Mix (cat.# 31887), 1,4-Dioxane (cat.# 31853)
Inj.:	1.0µL, 10ppm each analyte (10ng on column), splitless (hold 0.1 min.) 4mm Drilled Uniliner® inlet liner (hole at bottom) (cat.# 20756)
Instrument:	Agilent 6890
Inj. temp.:	250°C
Carrier gas:	helium, constant flow
Flow rate:	1.2mL/min.
Oven temp.:	50°C (hold 0.5 min.) to 265°C @ 25°C/min., to 330°C @ 6°C/min. (hold 2 min.)
Det.:	Agilent 5973 GC/MS
Transfer line temp.:	280°C
Scan range:	35-550 amu
Solvent delay:	2 min.
Tune:	DFTPP
Ionization:	EI

1. 1,4-dioxane
2. N-nitrosodimethylamine •
3. pyridine •
4. 2-fluorophenol
5. phenol-d6
6. phenol •
7. aniline •
8. bis(2-chloroethyl) ether •
9. 2-chlorophenol •
10. 1,3-dichlorobenzene •
11. 1,4-dichlorobenzene-d4
12. 1,4-dichlorobenzene •
13. benzyl alcohol •
14. 1,2-dichlorobenzene •
15. 2-methylphenol •
16. bis(2-chloroisopropyl) ether •
17a. 4-methylphenol •
17b. 3-methylphenol •
18. N-nitroso-di-*n*-propylamine •
19. hexachloroethane •
20. nitrobenzene-d5
21. nitrobenzene •
22. isophorone •
23. 2-nitrophenol •
24. 2,4-dimethylphenol •
25. benzoic acid
26. bis(2-chloroethoxy)methane •
27. 2,4-dichlorophenol •
28. 1,2,4-trichlorobenzene •
29. naphthalene-d8
30. naphthalene •
31. 4-chloroaniline •
32. hexachlorobutadiene •
33. 4-chloro-3-methylphenol •
34. 2-methylnaphthalene •
35. 1-methylnaphthalene •
36. hexachlorocyclopentadiene •
37. 2,4,6-trichlorophenol •
38. 2,4,5-trichlorophenol •
39. 2-fluorobiphenyl
40. 2-chloronaphthalene •
41. 2-nitroaniline •
42. 1,4-dinitrobenzene •
43. dimethyl phthalate •
44. 1,3-dinitrobenzene •
45. 2,6-dinitrotoluene •
46. acenaphthylene •
47. 1,2-dinitrobenzene •
48. 3-nitroaniline •
49. acenaphthene-d10
50. acenaphthene •
51. 2,4-dinitrophenol •
52. 4-nitrophenol •
53. dibenzofuran •
54. 2,4-dinitrotoluene •
55. 2,3,4,6-tetrachlorophenol •
56. 2,3,5,6-tetrachlorophenol •
57. diethyl phthalate •
58. 4-chlorophenyl phenyl ether •
59. fluorene •
60. 4-nitroanaline •
61. 4,6-dinitro-2-methylphenol •
62. N-nitrosodiphenylamine (as diphenylamine) •
63. 1,2-diphenylhydrazine (as azobenzene) •
64. 2,4,6-tribromophenol
65. 4-bromophenyl phenyl ether •
66. hexachlorobenzene •
67. pentachlorophenol •
68. phenanthrene-d10
69. phenanthrene •
70. anthracene •
71. carbazole •
72. di-*n*-butyl phthalate •
73. fluoranthene •
74. benzidine
75. pyrene-d10
76. pyrene •
77. *p*-terphenyl-d14
78. 3,3'-dimethylbenzidine
79. butyl benzyl phthalate •
80. bis(2-ethylhexyl) adipate •
81. 3,3'-dichlorobenzidine
82. benzo(a)anthracene •
83. chrysene-d12
84. chrysene •
85. bis(2-ethylhexyl) phthalate •
86. di-*n*-octyl phthalate •
87. benzo(b)fluoranthene •
88. benzo(k)fluoranthene •
89. benzo(a)pyrene •
90. perylene-d12 •
91. indeno(1,2,3-cd)pyrene •
92. dibenzo(a,h)anthracene •
93. benzo(ghi)perylene •

• 8270 MegaMix® components

Recommended Columns

Rxi™-5ms Columns (fused silica)

(Crossbond® 5% diphenyl / 95% dimethyl polysiloxane)

ID	df (µm)	temp. limits	length	cat. #
0.18mm	0.18	-60 to 330/350°C	20-Meter	13402
0.18mm	0.30	-60 to 330/350°C	20-Meter	13409
0.25mm	0.25	-60 to 330/350°C	30-Meter	13423
0.25mm	0.40	-60 to 330/350°C	30-Meter	13481

Rtx®-5Sil MS Columns (fused silica)

(Crossbond®, selectivity similar to 5% diphenyl/95% dimethyl polysiloxane)

ID	df (µm)	temp. limits	length	cat. #
0.18mm	0.18	-60 to 330/350°C	20-Meter	42702
0.18mm	0.36	-60 to 330/350°C	20-Meter	42704
0.25mm	0.25	-60 to 330/350°C	30-Meter	12723
0.25mm	0.50	-60 to 330/350°C	30-Meter	12738

Analytical Reference Materials

SV Internal Standard Mix

acenaphthene-d10 naphthalene-d8
chrysene-d12 perylene-d12
1,4-dichlorobenzene-d4 phenanthrene-d10

2,000µg/mL each in methylene chloride, 1mL/ampul
cat. # 31206 (ea.)

4,000µg/mL each in methylene chloride, 1mL/ampul
cat. # 31006 (ea.)

B/N Surrogate Mix (4/89 SOW)

2-fluorobiphenyl *p*-terphenyl-d14
nitrobenzene-d5

1,000µg/mL each in methylene chloride, 1mL/ampul
cat. # 31024 (ea.)

5,000µg/mL each in methylene chloride, 1mL/ampul
cat. # 31062 (ea.)

5,000µg/mL each in methylene chloride, 5mL/ampul
cat. # 31086 (ea.)

5,000µg/mL each in methylene chloride, 10mL/ampul
cat. # 33028 (ea.)

Acid Surrogate Mix (4/89 SOW)

2-fluorophenol 2,4,6-tribromophenol
phenol-d6

2,000µg/mL each in methanol, 1mL/ampul
cat. # 31025 (ea.)

10,000µg/mL each in methanol, 1mL/ampul
cat. # 31063 (ea.)

10,000µg/mL each in methanol, 5mL/ampul
cat. # 31087 (ea.)

10,000µg/mL each in methylene chloride, 10mL/ampul
cat. # 33029 (ea.)

GC/MS Tuning Mixture

benzidine DFTPP
4,4'-DDT pentachlorophenol

1,000µg/mL each in methylene chloride, 1mL/ampul
cat. # 31615 (ea.)

605 Benzidines Calibration Mix

benzidine 3,3'-dichlorobenzidine

2,000µg/mL each in methanol, 1mL/ampul
cat. # 31030 (ea.)

2,000µg/mL each in methylene chloride, 1mL/ampul
cat. # 31834 (ea.)

8270 Matrix Spike Mix (76 components)

200µg/mL each in methanol:methylene chloride (80:20), 5mL/ampul
cat. # 31687 (ea.)

8270 MegaMix® (76 components)

1,000µg/mL each in methylene chloride, 1mL/ampul, •
cat. # 31850 (ea.)

• Refer to figure for compound list

Inert Sample Path Increases Accuracy

Injection port liners are designed in many configurations, four of which are commonly used for semivolatiles analysis: the single gooseneck, double gooseneck, cyclo double gooseneck, and the Drilled Uniliner®. While all four liner types are used for 8270 analysis, we recommend the Drilled Uniliner® when using constant flow, and the cyclo double gooseneck with pressure pulse conditions.

Liners shown are for Agilent instruments; liners for other instrument brands also are available. For a complete list of liners and seals refer to our catalog or website.

Gooseneck Splitless (4mm)

4.0 ID 6.5 OD x 78.5 20799 5 pk.

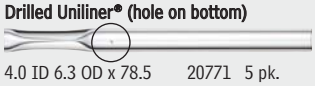
Cyclo Double Gooseneck (4mm)

4.0 ID 6.5 OD x 78.5 20896 5 pk.

Double Gooseneck Splitless (4mm)

4.0 ID 6.5 OD x 78.5 20785 5 pk.

Drilled Uniliner® (hole on bottom)



4.0 ID 6.3 OD x 78.5 20771 5 pk.

The Drilled Uniliner® is the most inert liner because the metal injection port outside the glass liner does not contact the sample path – the sample is virtually "funneled" into the column. Also, when using the Drilled Uniliner® inlet seals do not need to be replaced – a savings in maintenance cost and time. The cyclo double gooseneck liner is recommended with pressure pulse conditions. Its corkscrew type sample path enhances sample vaporization and helps prevent sample contact with metal surfaces below the liner. When using a gooseneck type liner, however, routinely replacing the inlet seal below the liner is critical. Gold plated and Siltek® treated liners and seals both ensure an inert sample path, however, Siltek® treated surfaces are more resistant to abrasion during cleaning.

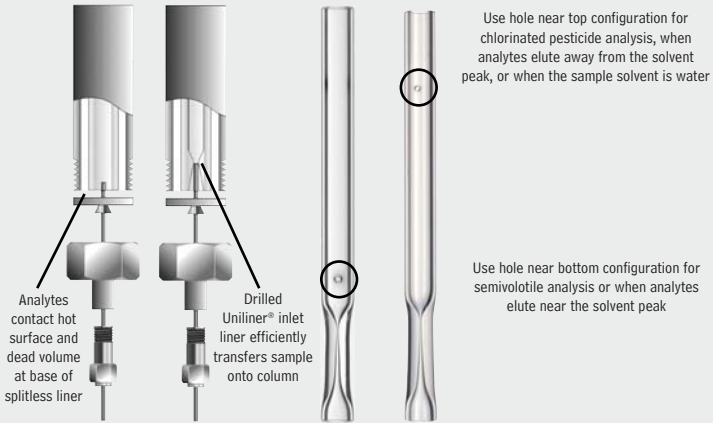
0.8mm ID Dual Vespel® Ring Inlet Seal

Siltek® Treated	21242	2-pk.
Stainless Steel	21238	2-pk.
Gold Plated	21240	2-pk.

restek **innovation**!

The Drilled Uniliner®

The Drilled Uniliner® provides the most inert sample pathway of all inlet liners for splitless injection techniques. This liner connects directly to the column, eliminating contact between the active compounds and active metal surfaces in the injector, and ensuring an inert sample pathway for analyte transfer from the injection port to the column.



Organochlorine Pesticides and PCB

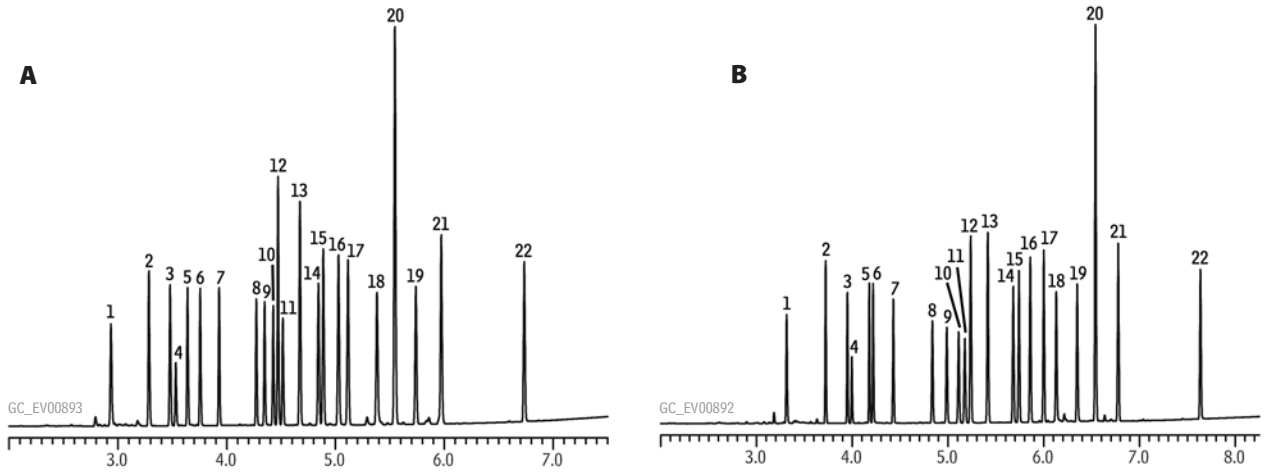
In organochlorine pesticide analysis, careful consideration of the instrument set-up and column choice can greatly improve sample throughput – reducing costs and saving time. The most critical aspects of the inlet system are inertness and efficiency of target analyte transfer to the analytical column. For pesticide and PCB analysis we recommend the Drilled Uniliner® for its unsurpassed inertness (see page 5).

In the analysis shown, 20m x 0.18mm ID Rtx®-CLPesticides and Rtx®-CLPesticides2 primary and confirmation columns were used. We connected a 5m x 0.53mm guard column to the dual analytical columns, using a SeCure™ "Y" connector kit. These columns have been specifically designed to resolve the chlorinated pesticides when used in parallel under the same temperature program and inlet backpressure. As shown in Figure 1, all the organochlorine pesticide compounds are baseline resolved in less than 8 minutes.

Figure 1 Organochlorine pesticides on Rtx®-CLPesticides and Rtx®-CLPesticides2 columns.

5%Column:	**A:** Rtx®-CLPesticides, 20m, 0.18mm ID, 0.18µm (cat.# 42102) and **B:** Rtx®-CLPesticides2, 20m, 0.18mm ID,0.14µm (cat.# 42302) with 5m x 0.53mm ID intermediate-polarity deactivated guard tubing (cat.# 10045), connected using SeCure™ "Y" Connector Kit (cat.# 20276) with Universal "Y" Press-Tight® Connector
Sample:	Organochlorine Pesticide Mix AB #2 (cat.# 32292), 8-80µg/mL each component in hexane/toluene, Pesticide Surrogate Mix (cat.# 32000), 200µg/mL each component in acetone
Inj.:	0.5µL splitless (hold 0.75 min.), 2mm single gooseneck inlet liner (cat.# 20796)
Inj. temp.:	250°C
Carrier gas:	helium, constant flow
Linear velocity:	20cm/sec. @ 140°C
Oven temp.:	140°C (hold 1 min.) to 250°C @ 35°C/min. (hold 1 min.) to 330°C @ 35°C/min. (hold 3 min.)
Det.:	ECD @ 350°C

1. 2,4,5,6-tetrachloro-m-xylene (surr.)
2. α-BHC
3. γ-BHC
4. β-BHC
5. δ-BHC
6. heptachlor
7. aldrin
8. heptachlor epoxide
9. γ-chlordane
10. α-chlordane
11. endosulfan I
12. 4,4' DDE
13. dieldrin
14. endrin
15. 4,4' DDD
16. endosulfan II
17. 4,4' DDT
18. endrin aldehyde
19. endosulfan sulfate
20. methoxychlor
21. endrin ketone
22. decachlorobiphenyl (surr.)



Recommended Columns

Rtx®-CLPesticides Columns (fused silica)

ID	df (µm)	temp. limits	length	cat. #
0.18mm	0.18	-60 to 310/330°C	20-Meter	42102
0.25mm	0.25	-60 to 320/340°C	30-Meter	11123
0.32mm	0.50	-60 to 320/340°C	30-Meter	11139
0.53mm	0.50	-60 to 300/320°C	30-Meter	11140

Rtx®-CLPesticides2 Columns (fused silica)

ID	df (µm)	temp. limits	length	cat. #
0.18mm	0.14	-60 to 310/330°C	20-Meter	42302
0.25mm	0.20	-60 to 320/340°C	30-Meter	11323
0.32mm	0.50	-60 to 320/340°C	30-Meter	11325
0.53mm	0.42	-60 to 300/320°C	30-Meter	11340

Organochlorine Pesticide Mix AB #1

(20 components)

aldrin	dieldrin
α-BHC	endosulfan I
β-BHC	endosulfan II
δ-BHC	endosulfan sulfate
γ-BHC (lindane)	endrin
α-chlordane	endrin aldehyde
γ-chlordane	endrin ketone
4,4'-DDD	heptachlor
4,4'-DDE	heptachlor epoxide (B)
4,4'-DDT	methoxychlor

200μg/mL each in hexane:toluene (1:1), 1mL/ampul
cat. # 32291 (ea.)

Organochlorine Pesticide Mix AB # 3

(20 components)
same listing as Organochlorine Pesticide Mix AB #1, shown above.

2,000μg/mL each in hexane:toluene (1:1), 1mL/ampul
cat. # 32415 (ea.)

Pesticide Surrogate Mix

decachlorobiphenyl 2,4,5,6-tetrachloro-*m*-xylene
200μg/mL each in acetone, 1mL/ampul
cat. # 32000 (ea.)

Pesticide Surrogate Mix

decachlorobiphenyl 200μg/mL
2,4,5,6-tetrachloro-*m*-xylene 100
In P&T methanol, 1mL/ampul
cat. # 32453 (ea.)

Organochlorine Pesticide System Evaluation Mix

4,4'-DDT 200μg/mL endrin 100μg/mL
In MTBE, 1mL/ampul
cat. # 32417 (ea.)

508.1 GC Degradation Check Mix

4,4'-DDT endrin
100μg/mL each in ethyl acetate, 1mL/ampul
cat. # 32093 (ea.)

Technical Chlordane, Toxaphene Solutions

Compound	cat.# (ea.)
1,000μg/mL in hexane, 1mL/ampul	
chlordane (technical)	32021
toxaphene	32005
2,000μg/mL in methanol, 1mL/ampul	
chlordane (technical)	32016
toxaphene	32015
5,000μg/mL in isooctane, 1mL/ampul	
chlordane (technical)	32072
toxaphene	32071

also **available**

Aroclor® Solutions!
Visit our website, see our newest catalog, or call your Restek representative for details.

Increase Sample Throughput Using Dual Analytical Columns and a "Y" Connector Union

Most laboratories need to confirm the compound identification obtained on one column with a second column of different selectivity. This is best achieved by making a single injection onto a guard column which is connected to two analytical columns, using a "Y" splitter. This allows data to be collected from both columns simultaneously, allowing samples to be processed without waiting for the confirmation result.

Rtx®-CLPesticides Column Kits

0.25mm ID Rtx®-CLPesticides Kit cat.# 11199 (kit),

Includes:	cat.#
30m, 0.25mm ID, 0.25μm Rtx®-CLPesticides Column	11123
30m, 0.25mm ID, 0.20μm Rtx®-CLPesticides2 Column	11323
Universal Angled "Y" Press-Tight® Connector	20403
5m, 0.25mm ID Siltek® Guard Column	10026

0.32mm ID Rtx®-CLPesticides Kit cat.# 11198 (kit),

Includes:	cat.#
30m, 0.32mm ID, 0.50μm Rtx®-CLPesticides Column	11139
30m, 0.32mm ID, 0.25μm Rtx®-CLPesticides2 Column	11324
Universal Angled "Y" Press-Tight® Connector	20403
5m, 0.32mm ID Siltek® Guard Column	10027

0.53mm ID Rtx®-CLPesticides Kit cat.# 11197 (kit),

Includes:	cat.#
30m, 0.53mm ID, 0.50μm Rtx®-CLPesticides Column	11140
30m, 0.53mm ID, 0.42μm Rtx®-CLPesticides2 Column	11340
Universal Angled "Y" Press-Tight® Connector	20403
5m, 0.53mm ID IP Deactivated Guard Column	10045

"Y" connectors

"Y" connectors are available in both metal and glass. Glass connectors offer the best chromatography, but are prone to leaks. To eliminate leaks we developed the SeCure™ "Y" connector, which takes advantage of our Press-Tight® connector and adds mechanical strength to hold the columns in place. A second connector, the MXT™ "Y"-Union, is available for fused silica columns.

SeCure™ "Y" - The most secure connector available!

Kits include: SeCure™ "Y" connector body, 3 knurled nuts, "Y" Universal Press-Tight® union, 3 ferrules.

Ferrules Fit Column ID	qty.	cat.#
0.25/0.28mm	kit	20276
0.32mm	kit	20277
0.45/0.53mm	kit	20278

MXT™ "Y"-Union Connector Kits for Fused Silica Columns

Each kit contains the MXT™ union, three 1/32-inch nuts and three one-piece fused silica adaptors.

Description	qty.	cat.#
For 0.25mm ID Fused Silica Columns	kit	21389
For 0.32mm ID Fused Silica Columns	kit	21388
For 0.53mm ID Fused Silica Columns	kit	21387

Volatile Organic Compounds in Air

One of the most widely used VOC methods for ambient air monitoring specifies sample collection with a specially prepared stainless steel canister, followed by GC/MS analysis. Restek can support all facets of your air monitoring program – from state-of-the-art sampling equipment to high quality analytical reference standards.

An inert canister surface is critical to obtaining accurate sample results. Restek offers a complete line of TO-Cans™ (Summa® canisters) which are electropolished and extensively cleaned prior to shipping to ensure a high-quality passivated surface for improved analyte stability. No weld marks on the spheres further reduce the occurrence of active sites. For reactive compounds, such as sulfur-containing components, a SilcoCan™ is your best canister choice. SilcoCan™ canisters are deactivated with Siltek® surface treatment resulting in exceptional inertness and maximum sample stability, even for low level sulfur compounds.

Optional gauge

- Quickly confirm vacuum or pressure inside canister.
- Monitor pressure changes.
- Fully protected by canister frame.
- Can be heated to 90°C during cleaning.

Siltek® tee

High-quality vacuum gauge

Enhanced valve and canister bracket
Canister holder and valve bracket protect canister, tube stub, and valve.

2-3 Port high quality valve
Metal-to-metal seal, 2/3 turn with stainless steel diaphragm.

We consider your TO-Cans™ and SilcoCans™ to be an investment and offer check-ups and reconditioning when needed.

Serial-controlled label
For quick, sure identification.

TO-Can™ Air Monitoring Canisters

Optimized for US EPA Methods TO-14 and TO-15, and ASTM D5466

Description	qty.	cat.#
6L Volume*		
TO-Can™ Canister, 1/4" Valve	ea.	24174
TO-Can™ Canister with Gauge, 1/4" Valve	ea.	24178
TO-Can™ Canister with No Valve	ea.	22096

SilcoCan™ Air Monitoring Canisters

Ideal for low-level reactive sulfur (1-20ppb), TO-14, or TO-15 compounds

Description	qty.	cat.#
6L Volume*		
SilcoCan™ Canister, 1/4" Valve	ea.	24182
SilcoCan™ Canister, Siltek® Treated 1/4" Valve	ea.	24182-650
SilcoCan™ Canister with Gauge, 1/4" Valve	ea.	24142
SilcoCan™ Canister with Gauge, Siltek® Treated 1/4" Valve	ea.	24142-650
SilcoCan™ Canister with No Valve	ea.	22092
Replacement 1/4" Valves for Air Monitoring Canisters		
1/4" Replacement Valve (2-port)	ea.	24145
1/4" Siltek® Replacement Valve (2-port)	ea.	24144
1/4" Replacement Valve (3-port)	ea.	24147
1/4" Siltek® Replacement Valve (3-port)	ea.	24146

Restek canisters are originally equipped with high-quality Parker Hannifin diaphragm valves. Each valve is helium leak-tested to 4 x 10^{-9}cc/sec. The all-stainless steel construction eliminates contamination and withstands temperatures from -100°C to 250°C. Compression outlet fitting, indicator plate to display open or closed position, 1/4" inlet and outlet.

All configurations also available in 1L, 3L, and 15L volumes.

Recommended Columns

Rxi™-1ms Columns (fused silica)

(Crossbond® 100% dimethyl polysiloxane)

ID	df (µm)	temp. limits	length	cat. #
0.32mm	1.00	-60 to 330/350°C	60-Meter	13357

Analytical Reference Materials

TO-15 62 Component Mix (62 components)

Cylinder Construction: aluminum
Cylinder Size: 8 x 24 cm.
Volume/Pressure: 104 liters of gas @ 1800psig
Cylinder Fitting: CGA-180 outlet
Weight: 1.5 lbs./0.7 kg

acetone
benzene
benzyl chloride*
bromodichloromethane
bromoform
bromomethane
1,3-butadiene
2-butanone (MEK)
carbon disulfide*
carbon tetrachloride
chlorobenzene
chloroethane
chloroform
chloromethane
cyclohexane
dibromochloromethane
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
1,1-dichloroethane
1,2-dichloroethane
1,1-dichloroethene
cis-1,2-dichloroethene
trans-1,2-dichloroethene
1,2-dichloropropane
cis-1,3-dichloropropene
trans-1,3-dichloropropene
1,4-dioxane
ethanol*
ethyl acetate
ethyl benzene
ethylene dibromide (1,2-dibromoethane)
4-ethyltoluene
trichlorofluoromethane (Freon® 11)
dichlorodifluoromethane (Freon® 12)
1,1,2-trichloro-1,2,2-trifluoroethane (Freon® 113)
1,2-dichlorotetrafluoroethane (Freon® 114)
heptane
hexachloro-1,3-butadiene
hexane
2-hexanone (MBK)
4-methyl-2-pentanone (MIBK)
methylene chloride
methyl *tert*-butyl ether (MTBE)
2-propanol
propylene
styrene
1,1,2,2-tetrachloroethane
tetrachloroethene
tetrahydrofuran
toluene
1,2,4-trichlorobenzene
1,1,1-trichloroethane
1,1,2-trichloroethane
trichloroethene
1,2,4-trimethylbenzene
1,3,5-trimethylbenzene
vinyl acetate
vinyl chloride
m-xylene
o-xylene
p-xylene

In nitrogen, 104 liters @ 1800psig

1ppm	cat. # 34436 (ea.)
100ppb	cat. # 34437 (ea.)

*Stability of this compound cannot be guaranteed.

TO-14A Internal Standard/Tuning Mix

Cylinder Construction: aluminum
Cylinder Size: 8 x 24 cm.
Volume/Pressure: 104 liters of gas @ 1800psig
Cylinder Fitting: CGA-180 outlet
Weight: 1.5 lbs./0.7 kg

bromochloromethane
1-bromo-4-fluorobenzene (4-bromofluorobenzene)
chlorobenzene-d5
1,4-difluorobenzene

In nitrogen, 104 liters @ 1800psig

1ppm	cat. # 34408 (ea.)
100ppb	cat. # 34425 (ea.)

Simplify Sampling, Increase Accuracy & Efficiency

Air Canister Heating Jacket

Our heating jackets can help you prepare your canisters for sampling faster and more efficiently. The jacket's novel design ensures complete cleaning by heating the canister and valve together and prevents condensation, ensuring more accurate results. Two temperature settings, 75ºC and 150ºC. Fits all canisters up to 6L in size.

Description	qty.	cat.#
Air Canister Heating Jacket	ea.	24123

*Not CE certified.

The ultimate in controlled heating, for reliably cleaning your air canisters!

Passive Air Sampling Kits

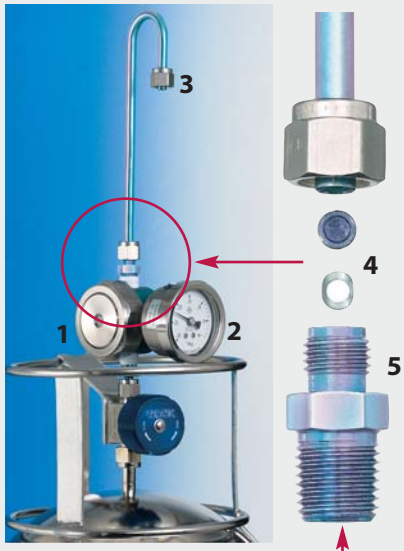
Our passive sampling kits include all hardware required for field sampling (except the canister) and assemble easily. Our kit was designed to reduce the number of potential leak sites and is available in seven flow ranges, and in stainless steel or with Siltek® surface treatment. Individual parts are also available.

1. Veriflo™ SC423XL flow controller
This flow controller is the heart of the sampling train. It is a high-quality device designed to maintain a constant mass flow as the pressure changes from 30" Hg to 5" Hg (we recommend you stop sampling at or before 5" Hg of vacuum). All wetted parts of the flow controller can be Siltek® treated.

2. Stainless steel vacuum gauge
Fitted to the flow controller, the gauge monitors canister vacuum change during sampling.

3. ¼-inch Siltek® sample inlet
The 0.3m x ¼-inch tubing includes a stainless steel nut on the inlet end, to prevent water droplets from accumulating at the edge of the tubing, where they could be pulled into the sampling train.

4. 2-micron frit filter and washer
Located prior to the critical orifice to prevent airborne particles from clogging the critical orifice. Replaceable. Available in stainless steel, or Siltek® treated for optimum inertness.



All fitting connections are ¼" tube, except where noted.

¼" NPT

See our catalog for other canister volumes and sampling times.

5. Interchangeable critical orifice
An interchangeable ruby critical orifice allows you to control the flow with very high precision. To select the correct critical orifice for your sample, see table below. Available in stainless steel, or Siltek® treated for optimum inertness.

Sampling Time 6 Liter	Flow (sccm)	Orifice size	Siltek® Treated Sampling Kits*	Stainless Steel Sampling Kits*
125 hour	0.5–2	0.0008"	24217	24216
24 hour	2–4	0.0012"	24160	24165
12 hour	4–8	0.0016"	24161	24166
8 hour	8–20	0.0020"	24162	24167
3 hour	20–40	0.0030"	24163	24168
1.5 hour	40–80	0.0060"	24164	24169
0.5 hour	80–350	0.0090"	22101	22100

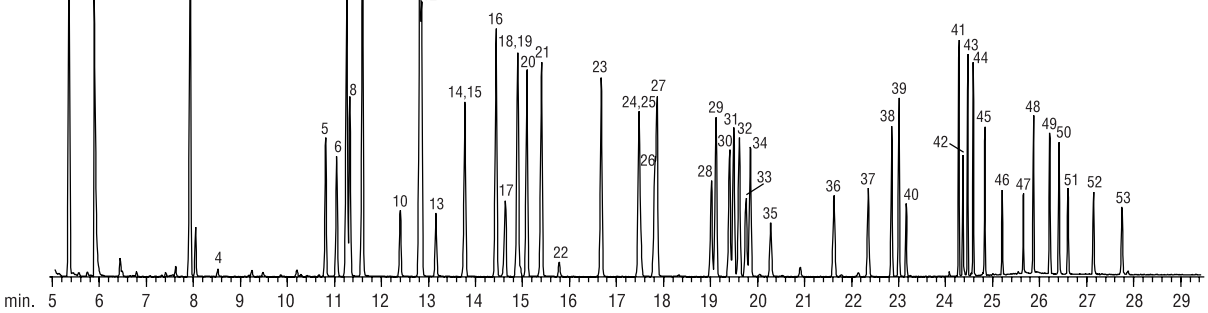
*Air sampling canisters sold separately. Available in 400cc, 1L, 3L, 6L, and 15L volumes.

Organophosphorus Pesticides

Organophosphorus pesticides (OPPs) are commonly used as insecticides, fungicides, and herbicides. Due to their widespread use however, they have become an environmental concern. We reccommend the Rtx®-OPPesticides2 column for separating organophosphorus pesticides (OPP). Separation is improved, and analysis time is significantly reduced, compared to other columns. The extended upper temperature limit of this phase (330°C) allows analysts to bake out high molecular weight contamination typically associated with pesticide samples. The low bleed column is a perfect match for sensitive detection systems.

Figure 1 Organophosphorus pesticides on an Rtx®-OPPesticides2 column.

1. dichlorvos
2. hexamethylphosphoramide
3. mevinphos
4. trichlorfon
5. TEPP
6. demeton-O
7. thionazin
8. tributyl phosphate (IS)
9. ethoprop
10. naled
11. sulfotepp
12. phorate
13. dicrotophos
14. demeton-S
15. monocrotophos
16. terbufos
17. dimethoate
18. dioxathion
19. fonophos
20. diazinon
21. disulfoton
22. phosphamidon isomer
23. dichlorofenthion
24. chlorpyrifos methyl
25. phosphamidon
26. parathion-methyl
27. ronnel
28. fenitrothion
29. aspon
30. malathion
31. chlorpyrifos
32. trichloronate
33. parathion-ethyl
34. fenthion
35. merphos
36. chlorfenvinphos
37. crotoxyphos
38. stirofos
39. tokuthion
40. merphos oxone (breakdown product)
41. ethion
42. fensulfothion
43 bolstar
44. carbophenothion
45. famphur
46. triphenyl phosphate (SS)
47. EPN
48. phosmet
49. leptophos
50. tri-*o*-cresyl phosphate
51. azinphos-methyl
52. azinphos-ethyl
53. coumaphos



GC_EV00602

Column:	Rtx®-OPPesticides2, 30m, 0.25mm ID, 0.25µm (cat.# 11243)	Inj. temp.:	250°C
Sample:	US EPA Method 8141A Custom Standard Mix 1µL 100ppm (100ng on column) Triphenylphosphate Standard (cat.# 32281) Tributylphosphate Standard (cat.# 32280) 8140/8141 OP Pesticides Calibration Mix A (cat.# 32277) 8141 OP Pesticides Calibration Mix B (cat.# 32278) *Custom Mixes: Call Restek for Information*	Carrier gas:	helium, constant flow
		Flow rate:	1.0mL/min.
		Oven temp.:	80°C (hold 0.5 min.) to 140°C @ 20°C/min. to 210°C @ 4°C/min. (hold 1 min.) to 280°C @ 30°C (hold 5 min.)
		Det:	MS
Inj.:	1.0µL splitless (hold 0.4 min.), 4mm double gooseneck inlet liner (cat.# 20785)	Transfer line temp.:	280°C
		Scan range:	35-400amu
		Ionization:	EI

Recommended Columns

Rtx®-OPPesticides2 Columns (fused silica)

ID	df (µm)	temp. limits	length	cat. #
0.18mm	0.20	-20 to 310/330°C	20-Meter	11244
0.25mm	0.25	-20 to 310/330°C	30-Meter	11243
0.32mm	0.32	-20 to 310/330°C	30-Meter	11241
0.53mm	0.50	-20 to 310/330°C	30-Meter	11242

Sample Preparation

CarboPrep™ Cartridges

SPE Cartridge	Tube Volume, Bed Weight	qty.	cat#
CarboPrep™ 90	3mL, 250mg	50-pk.	26091
CarboPrep™ 90	6mL, 500mg	30-pk.	26092

Excellent for Pesticide Residue Cleanup!

Carbamates by HPLC

Carbamates are widely used insecticides that pose a health risk as endocrine disruptors. Our Ultra Carbamate column, in a 50mm length, separates common carbamates in less than 10 minutes (Figure 1), significantly less than the time required by traditional C18 columns. In addition to the best column choice for the analysis, we offer reference mixes for Method 531 carbamates, a performance check mix, and the specified internal standard, 4-bromo-3,5-dimethylphenyl-N-methylcarbamate (BDMC).

Figure 1 Carbamate pesticides on an Ultra Carbamate column.

Peak List:
1. aldicarb sulfone
2. aldicarb sulfoxide
3. oxamyl
4. methomyl
5. 3-hydroxycarbofuran
6. aldicarb
7. propoxur
8. carbofuran
9. carbaryl
10. methiocarb
11. 4-bromo-3,5-dimethylcarbamate

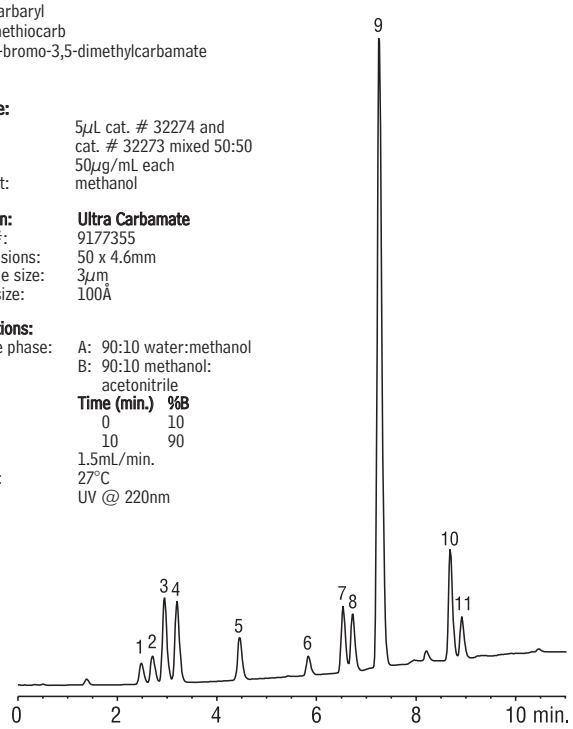
Sample:
Inj.: 5µL cat. # 32274 and cat. # 32273 mixed 50:50
Conc.: 50µg/mL each
Solvent: methanol

Column: Ultra Carbamate
Cat. #: 9177355
Dimensions: 50 x 4.6mm
Particle size: 3µm
Pore size: 100Å

Conditions:
Mobile phase: A: 90:10 water:methanol
B: 90:10 methanol: acetonitrile

Time (min.)	%B
0	10
10	90

Flow: 1.5mL/min.
Temp.: 27°C
Det.: UV @ 220nm



LC_0225

free literature

Simple, Sensitive HPLC/UV Analysis for Paraquat and Diquat

These highly charged quaternary amines are poorly retained on alkyl stationary phases. Using only acetonitrile, water, and a solvation-blocking reagent, our separation system alters the interactions among analyte, mobile phase, and stationary phase, and promotes solubility of the analytes in the stationary phase. In our system, the detection limit is 6ppb for either herbicide, and the analysis is completed in less than 10 minutes. An optimized solid phase extraction cartridge concentrates the herbicides for the analysis.

Lit. cat. # 580006

Recommended Columns

Ultra Carbamate Columns

Physical Characteristics:

particle size: 3µm or 5µm, spherical
pore size: 100Å
pH range: 2.5 to 7.5
temperature limit: 80°C

3µm Column	cat. #
50mm (2.1mm ID)	9177352
50mm (4.6mm ID)	9177355
5µm Column	**cat. #**
250mm (4.6mm ID)	9177575

*For post-column derivatization / fluorescence detection applications for a 4.6mm ID column the total system dead volume, including the post-column reactor, must be less than 650µL. For standard post-column reactor systems, we recommend a 250 x 4.6mm, 5µm column. Call Restek technical service for more information.

ordering note
For guard cartridges for these columns, visit our website at www.restek.com.

Analytical Reference Materials

531.1 Carbamate Pesticide Calibration Mixture

(10 components)

aldicarb
aldicarb sulfone
aldicarb sulfoxide
carbaryl (Sevin®)
carbofuran
3-hydroxycarbofuran
methiocarb
methomyl
oxamyl
propoxur (Baygon®)

100µg/mL each in methanol, 1mL/ampul
cat. # 32273 (ea.)

531.2 Carbamate Pesticide Calibration Mixture

(11 components)

aldicarb
aldicarb sulfone
aldicarb sulfoxide
carbaryl (Sevin®)
carbofuran
3-hydroxycarbofuran
methiocarb
methomyl
1-naphthol
oxamyl
propoxur (Baygon®)

100µg/mL in acetonitrile, 1mL/ampul
cat. # 32435 (ea.)

Internal Standard

4-bromo-3,5-dimethylphenyl-N-methylcarbamate (BDMC)
100µg/mL in methanol, 1mL/ampul
cat. # 32274 (ea.)

531.1 Performance Check Mix

aldicarb sulfoxide	100µg/mL	3-hydroxycarbofuran	2
BDMC	10	methiocarb	20

In methanol, 1mL/ampul
cat. # 32275 (ea.)

Polyaromatic Hydrocarbons (PAHs) by HPLC

Most HPLC PAH methods recommend using a C18 column with fluorescence and/or UV/VIS detection. Our Pinnacle™ II PAH columns have a highly reproducible modified alkyl phase on Restek manufactured silica, specifically developed for this application. Figure 1 shows the analysis of 16 target PAHs in less than 18 minutes, and Figure 2 shows a separation of 20 target PAHs and related compounds, in less than 6 minutes, using a 5cm column.

Figure 1 Baseline separation of 16 PAHs in less than 18 minutes on a Pinnacle™ II PAH column.

Sample:
Inj.: 5µL
Solvent: 1:9 methylene chloride:acetonitrile

Column: Pinnacle™ II PAH (Cat. # 9219563)
150mm x 3.2mm ID

Conditions:
Mobile phase: A: water, B: acetonitrile

Time (min.)	%B
0	40
7	60
11	100
17.9	100
18	40

Flow: 1.2 mL/min.
Temp.: ambient
Det.: UV @ 254nm

Peak List:	Conc. (µg/mL)
1. naphthalene	100
2. acenaphthylene	100
3. acenaphthene	100
4. fluorene	100
5. phenanthrene	50
6. anthracene	100
7. fluoranthene	50
8. pyrene	50
9. benzo(a)anthracene	50
10. chrysene	50
11. benzo(b)fluoranthene	50
12. benzo(k)fluoranthene	50
13. benzo(a)pyrene	50
14. dibenzo(a,h)anthracene	50
15. benzo(ghi)perylene	50
16. indeno(1,2,3-cd)pyrene	50

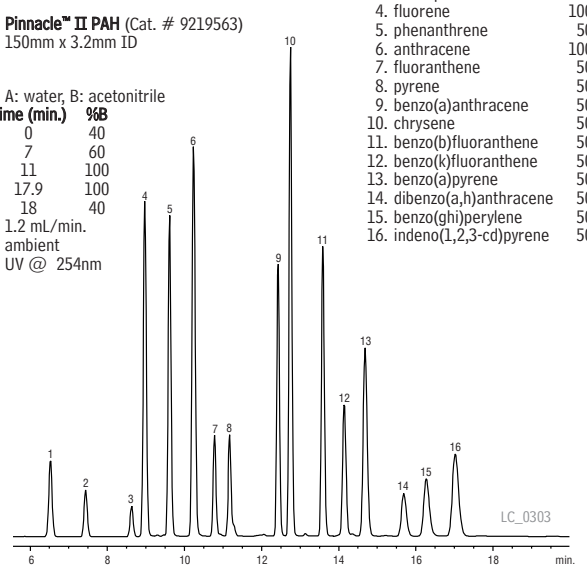


Figure 2 Fast, efficient separation of 20 target PAHs and related compounds using a 5cm Pinnacle™ II PAH column.

Sample:
Inj.: 5µL
Conc.: 5-10ppm each
Sample diluent: methylene chloride:acetonitrile (1:9 v/v)

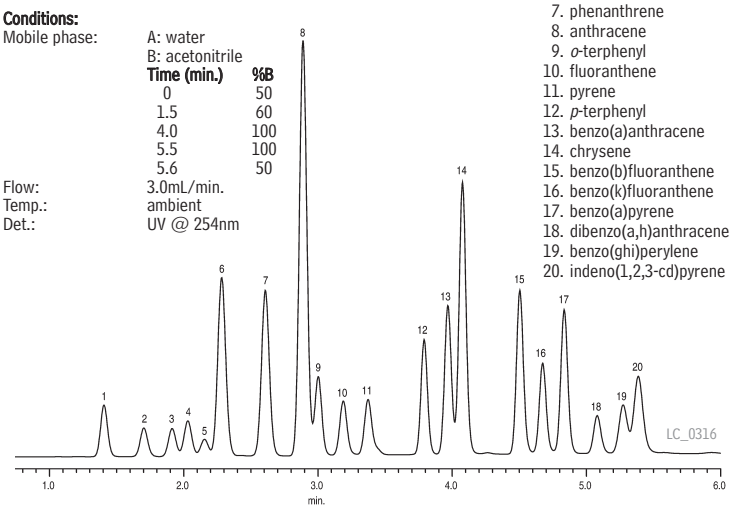
Column: Pinnacle™ II PAH (Cat. # 9219555)
50mm x 4.6mm ID

Conditions:
Mobile phase: A: water
B: acetonitrile

Time (min.)	%B
0	50
1.5	60
4.0	100
5.5	100
5.6	50

Flow: 3.0mL/min.
Temp.: ambient
Det.: UV @ 254nm

Peak List:
1. naphthalene
2. acenaphthylene
3. 1-methylnaphthalene
4. 2-methylnaphthalene
5. acenaphthene
6. fluorene
7. phenanthrene
8. anthracene
9. *o*-terphenyl
10. fluoranthene
11. pyrene
12. *p*-terphenyl
13. benzo(a)anthracene
14. chrysene
15. benzo(b)fluoranthene
16. benzo(k)fluoranthene
17. benzo(a)pyrene
18. dibenzo(a,h)anthracene
19. benzo(ghi)perylene
20. indeno(1,2,3-cd)pyrene



Recommended Columns

Pinnacle™ II PAH Columns

Physical Characteristics:

particle size: 5µm, spherical
pore size: 110Å
endcap: fully endcapped
pH range: 2.5 to 10
temperature limit: 80°C

5µm Column	cat. #
50 x 2.1mm	9219552
50 x 3.2mm	9219553
150 x 3.2mm	9219563
50 x 4.6mm	9219555
150 x 4.6mm	9219565
10 x 2.1mm	921950212
10 x 4.0mm	921950210
20 x 2.1mm	921950222
20 x 4.0mm	921950220

ordering note
For guard cartridges for these columns, visit our website at **www.restek.com**.

Analytical Reference Materials

EPA Method 8310 PAH Mixture (18 components)

acenaphthene
acenaphthylene
anthracene
benzo(a)anthracene
benzo(a)pyrene
benzo(b)fluoranthene
benzo(ghi)perylene
benzo(k)fluoranthene
chrysene
dibenzo(a,h)anthracene
fluoranthene
fluorene
indeno(1,2,3-cd)pyrene
1-methylnaphthalene
2-methylnaphthalene
naphthalene
phenanthrene
pyrene

500µg/mL each in acetonitrile, 1mL/ampul
cat. # 31841 (ea.)

EPA Method 8310 Quality Control Check

(18 components)

acenaphthene	100µg/mL	dibenzo(a,h)anthracene	10
acenaphthylene	100	fluoranthene	10
anthracene	100	fluorene	100
benzo(a)anthracene	10	indeno(1,2,3-cd)pyrene	10
benzo(a)pyrene	10	1-methylnaphthalene	100
benzo(b)fluoranthene	10	2-methylnaphthalene	100
benzo(ghi)perylene	10	naphthalene	100
benzo(k)fluoranthene	5	phenanthrene	100
chrysene	10	pyrene	10

In acetonitrile, 1mL/ampul
cat. # 31843 (ea.)

EPA Method 8310 Surrogate Standard

decafluorobiphenyl
1,000µg/mL in acetonitrile, 1mL/ampul
cat. # 31842 (ea.)

free literature

Environmental Flyer
HPLC analyses described in this 8-page publication include carbamates, carbonyls, explosives, paraquat/diquat, phenoxyacid herbicides, and polyaromatic hydrocarbons.

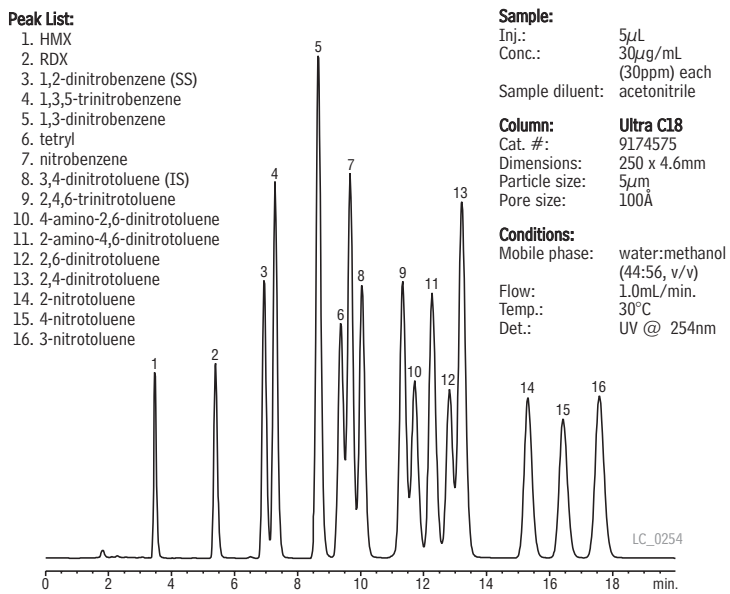
Lit. cat. # 59741A

Explosives by HPLC

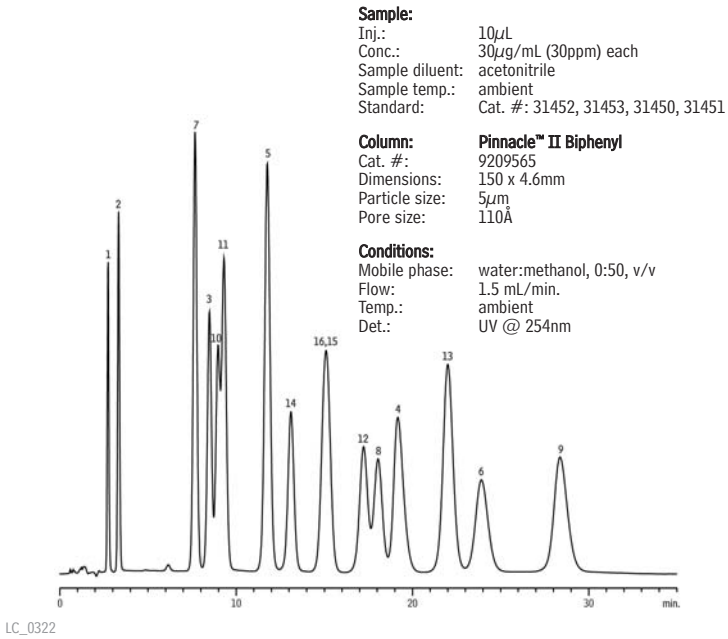
Common methods for quantifying explosives call for reversed phase HPLC with UV detection, using a primary column and a confirmation column. While cyano phases typically have been used for the confirmation column, resolution of the target explosive compounds is poor. The Pinnacle™ II Biphenyl column provides excellent resolution of Method 8330 explosives, as shown in Figure 1, and selectivity is markedly different from C18 phases, making the Pinnacle™ II Biphenyl column an ideal confirmation column. If a cyano phase must be used for confirmation, we recommend a Pinnacle™ II Cyano column.

Figure 1 An outstanding column pair for explosives analysis.

For superior performance, use an Ultra C18 primary column...



...coupled with a Pinnacle II™ Biphenyl column.



Recommended Columns

Ultra C18 Columns (USP L1)

Physical Characteristics:

particle size: 3µm or 5µm, spherical
pore size: 100Å
carbon load: 20%
endcap: fully endcapped
pH range: 2.5 to 7.5
temperature limit: 80°C

5µm Column, 4.6mm	cat. #
150mm	9174565
250mm	9174575

Pinnacle™ II Biphenyl Columns (USP L11)

Physical Characteristics:

particle size: 5µm, spherical
pore size: 110Å
endcap: yes
pH range: 2.5 to 7.5
temperature limit: 80°C

5µm Column, 4.6mm	cat. #
150mm	9209565
250mm	9209575

ordering note
For guard cartridges for these columns, visit our website at **www.restek.com**.

Analytical Reference Materials

Nitroaromatics and Nitramine Explosives by HPLC (14 components)

1,3-dinitrobenzene
2-amino-4,6-dinitrotoluene
4-amino-2,6-dinitrotoluene
2,4-dinitrotoluene
2,6-dinitrotoluene
HMX
nitrobenzene
2-nitrotoluene
3-nitrotoluene
4-nitrotoluene
RDX
tetryl
1,3,5-trinitrobenzene
2,4,6-trinitrotoluene

1,000µg/mL each in acetonitrile, 1mL/ampul
cat. # 33905 (ea.)

8095 Internal Standard

3,4-dinitrotoluene
1,000µg/mL in methanol, 1mL/ampul
cat. # 31452 (ea.)

8330 Surrogate

1,2-dinitrobenzene
1,000µg/mL in methanol, 1mL/ampul
cat. # 31453 (ea.)

free literature

HPLC Analysis of Trace-Level Explosives Using Pinnacle II™ C18 and Cyano Columns
Pinnacle II™ C18 reversed phase columns and Pinnacle II™ Cyano normal phase columns are effective primary and confirmation columns for analyzing explosives according to US EPA Method 8330A. Analytical conditions and example chromatograms are presented in this 2-page note. Per recommendation in the method, the same mobile phase is used for the primary and confirmation analysis.

Lit. cat. # 59361

Environmental Essentials

Direct Injection Liners - What's a drilled uniliner? See page 5.

COLUMN INSTALLS THIS END

Description	ID*/OD & Length (mm)	cat.# ea.	cat.# 5-pk.
DI Liners for Agilent 5890 & 6890 GCs (For 0.25/0.32/0.53mm ID Columns)			
Drilled Uniliner® ▲	4.0 ID 6.3 OD x 78.5	21054	21055
Siltek® Drilled Uniliner® ▲	4.0 ID 6.3 OD x 78.5	21054-214.1	21055-214.5
Drilled Uniliner® ▼	4.0 ID 6.3 OD x 78.5	20756	20771
Double Gooseneck Drilled Uniliner® ▲	4.0 ID 6.3 OD x 78.5	20508	20509
Double Gooseneck Drilled Uniliner® ▼	4.0 ID 6.3 OD x 78.5	20954	20989
Siltek® 1mm Drilled Uniliner® ▲	1.0 ID 6.3 OD x 78.5	21390-214.1	21391-214.5
DI Liners for Varian 1177 GCs (For 0.25/0.32/0.53mm ID Columns)			
Drilled Uniliner® ▲	4.0 ID 6.3 OD x 78.5	21470	21471
Drilled Uniliner® ▼	4.0 ID 6.3 OD x 78.5	21468	21469
DI Liners for Shimadzu 17A, 2010, and 2014 GCs (For 0.32/0.53mm ID Columns)			
Open-top Drilled Uniliner® ▲	3.5 ID 5.0 OD x 95	21285	21286
Open-top Drilled Uniliner® ▼	3.5 ID 5.0 OD x 95	21287	21288
Gooseneck Drilled Uniliner® ▲	3.5 ID 5.0 OD x 95	21289	21290
Gooseneck Drilled Uniliner® ▼	3.5 ID 5.0 OD x 95	21291	21292
DI Liners for PerkinElmer GCs (For 0.32/0.53mm ID Columns)			
Auto SYS™ Drilled Uniliner® ▲	4.0 ID 6.2 OD x 92.1	20819	20822
Auto SYS™ Drilled Uniliner® ▼	4.0 ID 6.2 OD x 92.1	21293	21294
Auto SYS™ Gooseneck Drilled Uniliner® ▲	4.0 ID 6.2 OD x 92.1	21295	21296
Auto SYS™ Gooseneck Drilled Uniliner® ▼	4.0 ID 6.2 OD x 92.1	21297	21298
Direct Injection Liners for Thermo Electron TRACE™ & Focus SSL (0.32 & 0.53mm ID columns)			
Drilled Uniliner® ▲	5.0 ID 8.0 OD x 105	22411	22412
Drilled Uniliner® ▼	5.0 ID 8.0 OD x 105	22413	22414

*Nominal ID at syringe needle expulsion point. ▲ Hole on top. ▼ Hole on bottom.

O-Rings

	Max. temp.	qty.	cat.#
A) Viton® O-Rings for Agilent GCs			
	250°C	25-pk.	20377
B) Graphite O-rings for Agilent & Varian split liners (6.35mm ID)			
	450°C	10-pk.	20296
B) Graphite O-rings for Agilent & Varian splitless liners (6.5mm ID)			
	450°C	10-pk.	20298
C) 5mm Graphite Liner Seals for Varian 1078/1079 GCs			
	450°C	10-pk.	22683
D) Viton® O-Rings for Shimadzu 17A, 2010, and 2014 GCs			
	250°C	10-pk.	21477
E) Graphite O-Rings for Shimadzu 17A, 2010, & 2014 Split Liners			
	450°C	5-pk.	20243
E) Graphite O-Rings for Shimadzu 17A, 2010, & 2014 Splitless Liners			
	450°C	5-pk.	20244
F) Silicone O-Rings for PerkinElmer Auto SYS™ GCs			
	250°C	10-pk.	20262
G) Viton® O-Rings for PerkinElmer PSS			
	250°C	10-pk.	20366
H) Inlet Liner Seals for TRACE™ PTV			
	450°C	2-pk.	21392
I) Graphite Sealing Ring for TRACE™ and Focus SSL Instruments			
	450°C	ea.	21898
I) Graphite Sealing Rings for TRACE™ and Focus SSL Instruments			
	450°C	2-pk.	21899

Restek Septa

- Precision molding assures consistent, accurate fit.
- Ready to use.
- Do not adhere to hot metal surfaces.
- Packaged in non-contaminating glass jars.

Septum Diameter	25-pk.	50-pk.	100-pk.
Thermolite® Septa			
5mm (3/16")	27120	27121	27122
6mm (1/4")	27123	27124	27125
7mm	27126	27127	27128
8mm	27129	27130	27131
9mm	27132	27133	27134
9.5mm (3/8")	27135	27136	27137
10mm	27138	27139	27140
11mm (7/16")	27141	27142	27143
11.5mm	27144	27145	27146
12.5mm (1/2")	27147	27148	27149
17mm	27150	27151	27152
Shimadzu Plug	27153	27154	27155
IceBlue™ Septa			
9mm		27156	27157
9.5mm (3/8")		27158	27159
10mm		27160	27161
11mm (7/16")		27162	27163
11.5mm		27164	27165
12.5mm (1/2")		27166	27167
17mm		27168	27169
Shimadzu Plug		27170	27171
BTO® Septa			
5mm CenterGuide™		27100	27101
6mm (1/4")		27102	27103
9mm CenterGuide™		27104	27105
9.5mm (3/8")		27106	27107
10mm		27108	27109
11mm (7/16") CenterGuide™		27110	27111
11.5mm CenterGuide™		27112	27113
12.5mm (1/2") CenterGuide™		27114	27115
17mm CenterGuide™		27116	27117
Shimadzu Plug		27118	27119

Thermolite® Septa
- Usable to 340°C inlet temperature.
- Excellent puncturability.

IceBlue™ Septa
- Usable to 250°C inlet temperature.
- General-purpose septa.
- Excellent puncturability.
- Ideal for SPME.

BTO® Septa
- CenterGuide™ design—requires less force for initial penetration.
- Usable to 400°C inlet temperature.
- Each batch GC-FID tested.
- Bleed and temperature optimized; ideal for demanding GC and GC/MS applications.

Dual Vespel® Ring Inlet Seals - Eliminates the need for a washer!

0.8mm ID Dual Vespel® Ring Inlet Seal	2-pk.	10-pk.
Siltek® Treated	21242	21243
Gold-Plated	21240	21241
Stainless Steel	21238	21239
1.2mm ID Dual Vespel® Ring Inlet Seal	**2-pk.**	**10-pk.**
Siltek® Treated	21248	21249
Gold-Plated	21246	21247
Stainless Steel	21244	21245

Replacement Inlet Seals with Washers

Single-Column Installation, 0.8mm Opening*		0.25/0.32mm ID Dual-Column Installation, 1.2mm Opening		0.53mm ID Dual-Column Installation (1/16-inch opening)	
2-pk.	10-pk.	2-pk.	10-pk.	2-pk.	10-pk.
Stainless Steel Inlet Seal					
21315	21316	20390	20391	20392	20393
Gold-Plated Inlet Seal					
21317	21318	21305	21306	—	—
Siltek® Treated Inlet Seal					
21319	21320	21307	21308	—	—

*0.8mm ID stainless steel inlet seal is similar to Agilent part #18740-20880, 0.8mm ID gold-plated inlet seal is similar to Agilent part #18740-20885.

HANDY septum size chart

Instrument	Septum Diameter (mm)
Agilent (HP)	
5880A, 5890, 6890, 6850, PTV	11
5700, 5880	9.5/10
On-Column Injection	5
Thermo Electron	
TRACE™ GC	17
GCQ w/TRACE™, PTV	17
8000 series	17
Finnigan (TMQ)	
GC 9001	9.5
GCQ	9.5
QCQ™	9.5
TRACE™ 2000	9.5
Gow-Mac	
6890 series	11
All other models	9.5
PerkinElmer	
Sigma series	11
900,990	11
8000 series	11
Auto SYS™	11
Auto SYS™ XL	11
Pye/Unicam	
All models	7
Shimadzu	
All models	Plug
SRI	
All models	Plug
Tracor	
540	11.5
550,560	9.5
220,222	12.5
Varian	
Injector type:	
Packed column	9.5/10
Split/splitless	
1078/1079	10/11
1177	9
1075/1077	11

septum handling tips

- Handle septa carefully, to prevent contamination.
- Minimize bleed—use preconditioned, low-bleed septa.
- Follow septum and instrument manufacturers' recommendations.

Restek Trademarks:
CarboPrep, Crossbond, IceBlue, MegaMix, MXT, Pinnacle, Press-Tight, Rtx, Rxi, SeCure, SilcoCan, Silcosteel, Siltek, Sulfinert, Thermolite, TO-Can, Uniliner.

Other Trademarks:
BTO (Chromatography Research Supplies, Inc.), Freon, Vespel, Viton (E.I. du Pont de Nemours & Co., Inc.), QCQ (Finnigan Corp.), SUMMA (Moletrics), Auto SYS (Perkin-Elmer), Baygon (S.C. Johnson & Son, Inc.), TRACE (Thermo Scientific), Sevin (Union Carbide Corp.), Veriflo (Veriflo Corp.)

Lit. Cat.# 580127

Biodiesel Solutions

Innovative Products for Simple, Reliable Biodiesel Analysis

- MXT®, Rtx®, and Stabilwax® biodiesel columns—engineered specifically for high performance biodiesel analysis.
- GC accessories to simplify your lab work and increase productivity.
- Analytical reference materials—high quality standards for reliable results.

Integrated retention gaps—

The Ultimate Biodiesel Solution!

See page 5 for details

Introduction to Biodiesel

Today, as oil prices climb and pollution levels soar, there is significant worldwide interest in alternative fuels. Biodiesel is one of the most popular alternative fuels available today. It may be used in engines, either pure or blended with diesel fuel, to reduce exhaust pollutants. It can be produced easily from sunflowers, soy, rapeseed, tallow, lard, yellow grease, and other sources. Chemically, it is the product obtained when a vegetable oil or animal fat is reacted with an alcohol in the presence of a catalyst, such as sodium or potassium hydroxide, to produce fatty acid methyl esters.

Methods used to test the quality of biodiesel fuels can be categorized into three types based on the target compounds: ASTM D6584 and EN 14105 test for total glycerin, EN 14103 tests for fatty acid methyl esters (FAMEs), and EN 14110 tests for residual methanol. These methods may be performed using either fused silica or metal columns, but the column chosen must have extremely high temperature tolerance. Restek offers both fused silica and metal columns designed specifically for high temperature biodiesel analysis. These columns, the Rtx®-Biodiesel TG, MXT®-Biodiesel TG, Stabilwax®, and Rtx-1® column lines, offer outstanding performance for biodiesel testing.

Rtx®-Biodiesel TG Columns (fused silica)

Rtx®-Biodiesel TG Columns:

- Low column bleed at high temperatures.
- Alumaseal™ connector provides leak-free connection, retention gap extends column life.
- Complete resolution for all compounds from interference peaks.

Description	temp. limits	cat.#
10m, 0.32mm ID, 0.10	to 330/380°C	10292
10m, 0.32mm ID, 0.10 w/2m x 0.53mm retention gap**	to 330/380°C	10291
15m, 0.32mm ID, 0.10	to 330/380°C	10294
15m, 0.32mm ID, 0.10 w/2m x 0.53mm retention gap**	to 330/380°C	10293

**Connected with low-dead-volume Alumaseal™ connector.

Biodiesel Calibration Standards

Concentration is µg/mL in pyridine. Volume is 1mL/ampul unless otherwise noted.

Compound	Solvent	cat.#
(s)-(-)-1,2,4-butanetriol	1,000	33024
(s)-(-)-1,2,4-butanetriol (5mL)	1,000	33032
diolein(1,3-di[*cis*-octadecenoyl] glycerol)	5,000	33022
glycerin	500	33020
monolein (1-mono[*cis*-9-octadecenoyl]-rac-glycerol)	5,000	33021
monopalmitin	5,000	33026
tricaprin (1,2,3-tricaprinoyl glycerol)	8,000	33025
tricaprin (1,2,3-tricaprinoylglycerol) (5mL)	8,000	33033
triolein (1,2,3-Tri[*cis*-octadecenoyl] glycerol)	5,000	33023

Silylation Derivatization Reagents

Compound	CAS#	cat.#
MSTFA (N-methyl-N-trimethylsilytrifluoroacetamide)		
10-pk. (10x1g)	24589-78-4	35600
25g Flex Tube	24589-78-4	35601

Analyzing Total Glycerin in Biodiesel

Rtx®-Biodiesel TG Fused Silica Columns

Glycerin in biodiesel falls out of solution, causing gumming in fuel systems and malfunctioning of engine parts, which eventually leads to inferior engine performance. Total glycerin presents itself in two forms: free glycerin and bound glycerin in the form of glycerides. Derivatization is required for analysis, and both ASTM D6584 and EN 14105 use N-methyl-N-trimethylsilytrifluoroacetamide derivatization reagent.

A 10m x 0.32mm ID Rtx®-Biodiesel TG column with a 2m x 0.53mm ID retention gap is ideal for glycerin analysis. The retention gap is factory coupled using Restek's unique Alumaseal™ connector (Figure 1). This innovative connector is leak-tight and low dead volume, making it advantageous for high temperature work. The data in Figure 2 show the elution of glycerin, monoglycerides, diglycerides, and triglycerides in B100 biodiesel following ASTM Method D6584, utilizing cool on-column injection. The Rtx®-Biodiesel TG column provides good resolution and signal-to-noise ratios for mono-, di-, and triglycerides.

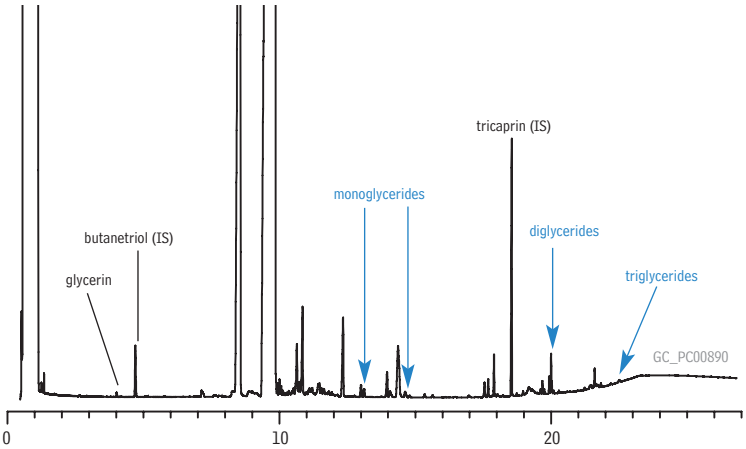
Figure 1: The Alumaseal™ connector

The Alumaseal™ connector is the best column connector for coupling fused silica and metal columns, even columns of different internal diameters. Made of aluminum, it is designed for high temperature performance. These connectors have been factory-coupled and tested using temperature programmed mass spectrometry and have shown no signs of leaks, even at 430°C.

The Alumaseal™ connector offers:

- A leak-tight connection.
- Low dead volume.
- Low thermal mass.
- High inertness.

Figure 2 The Rtx®-Biodiesel TG column meets resolution criteria and shows excellent response for determining glycerin in biodiesel.



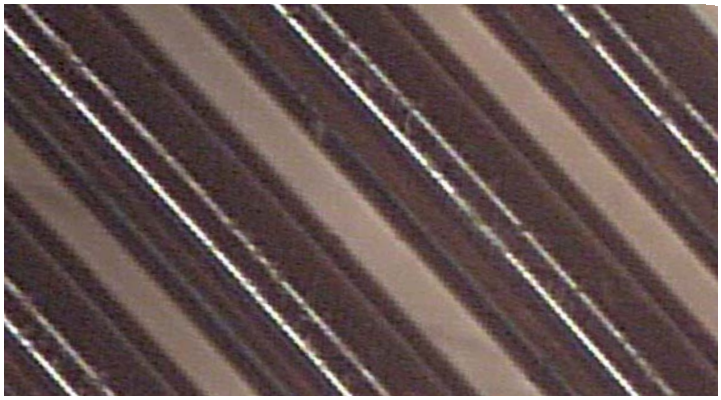
Column:	Rtx®-Biodiesel TG, 10m, 0.32mm ID, 0.10µm connected to 2m x 0.53mm Hydroguard™ tubing using Alumaseal™ connector (cat.# 10291)
Sample:	biodiesel (B100) plus monoolein, diolein, triolein, glycerin, butanetriol, tricaprin
Inj.:	1µL, cool on-column
Inj. temp.:	oven track
Carrier gas:	hydrogen, constant flow
Flow rate:	4mL/min.
Oven temp.:	50°C (hold 1 min.) to 180°C @ 15°C/min. (hold 7 min.) to 230°C @ 30°C/min. to 380°C @ 30°C/min. (hold 5 min.)
Det.:	FID
Det. temp.:	380°C

Comparing Fused Silica to Metal

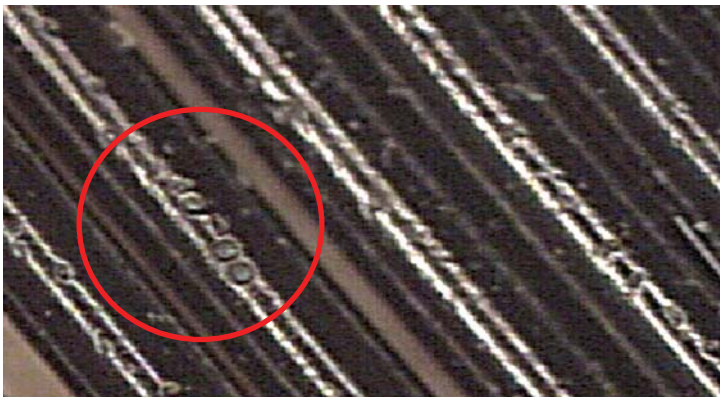
High temperature applications shorten the lifetime of fused silica columns due to deterioration of the polyimide resin used to make the columns. When fused silica columns are exposed to oven temperatures over 400°C the polyimide coating becomes brittle and the deactivation of the column is compromised. Figure 3 shows the effect of cycling a commercially available fused silica column to 430°C for 5 minutes 100 times. Although the column was labeled as stable up to 430°C, the polyimide coating shows damage. The inertness of the column also deteriorates as shown by the loss of peak symmetry for the internal standard butanetriol over multiple injections (Figure 4).

Metal MXT®-Biodiesel TG columns are a better alternative to fused silica columns. As shown in Figure 4, they clearly outperform high temperature fused silica columns under the cycling conditions required for biodiesel analysis. Metal MXT®-Biodiesel TG columns offer greater stability and longer column lifetimes compared to fused silica columns.

Figure 3 Fused silica columns, labeled as stable up to 430°C, show significant pitting and breakdown.



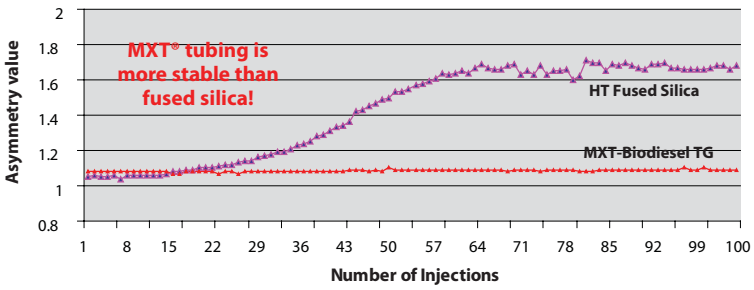
Before



After

100 temperature cycles to 430°C totaling 500 minutes at maximum temperature.

Figure 4 Stable peak shape for internal standard butanetriol on MXT®-Biodiesel TG columns gives more accurate quantification.



Metal Column Solutions: Two Options for Increased Stability and Performance

- 0.32mm MXT®-Biodiesel TG column with a 0.53mm retention gap, factory coupled with an Alumaseal™ connector
- 0.53mm MXT®-Biodiesel TG column with a built-in 0.53mm Integra-Gap™ integrated retention gap

The primary advantage of using metal MXT® columns is that they are more stable at high temperatures than fused silica columns. This means they will exhibit lower bleed, improving analytical performance, and have longer lifetimes, making them a cost-effective option. They also can be brought to high temperatures (430°C) allowing nonvolatile material to be baked off of the column, removing carryover contamination and improving cycle times.

Metal MXT®-Biodiesel TG columns are offered in the same column dimensions as their fused silica counterparts. Two different column configurations are available for cool on-column injection: 1) a 10m (or 15m) x 0.32mm ID MXT®-Biodiesel TG column factory coupled to a 2m x 0.53mm retention gap using an Alumaseal™ connector, and 2) a 14m x 0.53mm ID MXT ®-Biodiesel TG column with a built-in 2m x 0.53mm ID Integra-Gap™ integrated retention gap.

Target analytes resolve well and the solvent and triglyceride peaks show excellent symmetry on both columns (Figures 5 and 6), but the 0.53mm MXT ®-Biodiesel TG column with the Integra-Gap™ integrated retention gap eliminates the need for a connector, making connector-related leaks a thing of the past. Peak shape for butanetriol is very good, demonstrating inertness, and the resolution and response for the mono-, di- and triglycerides is excellent. The leak-proof 0.53mm MXT®-Biodiesel TG column with the Integra-Gap™ integrated retention gap is the ultimate biodiesel solution (Figure 7).

Figure 5 Derivatized B100 samples resolve well on the 15m x 0.32mm MXT®-Biodiesel TG column, which is factory coupled to a 0.53mm retention gap using an Alumaseal™ connector.

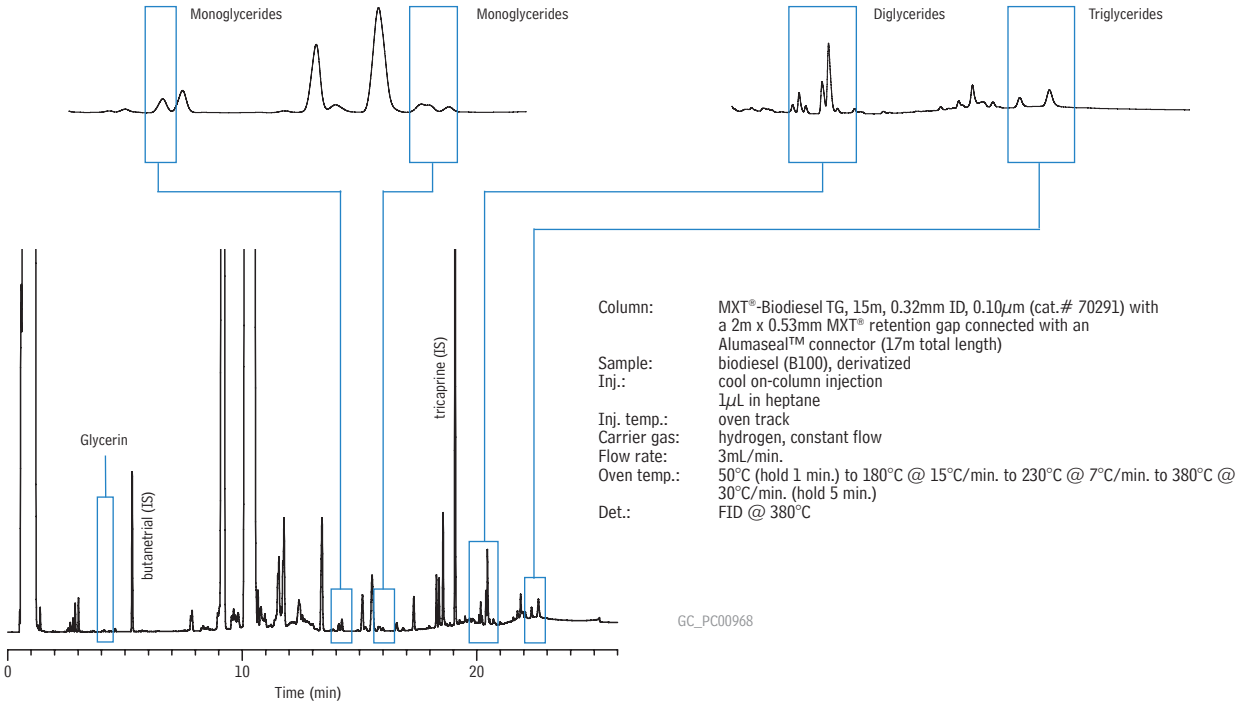
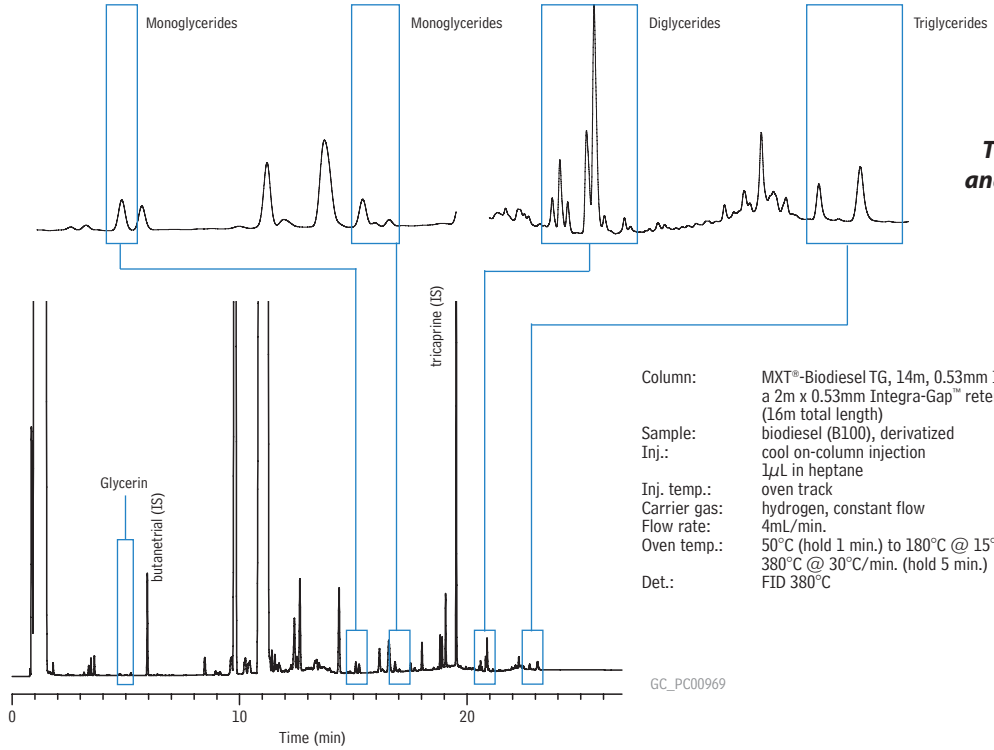


Figure 6 Excellent chromatographic quality and resolution on the 0.53mm MXT®-Biodiesel TG column, with the Integra-Gap™ integrated retention gap.

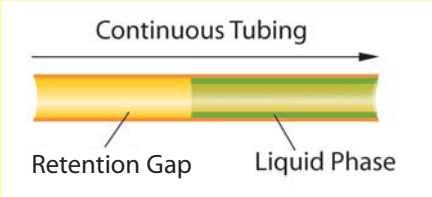


The best solution for analyzing total glycerin in biodiesel!

Column:	MXT®-Biodiesel TG, 14m, 0.53mm ID, 0.16µm (cat.# 70289) with a 2m x 0.53mm Integra-Gap™ retention gap (16m total length)
Sample:	biodiesel (B100), derivatized
Inj.:	cool on-column injection 1µL in heptane
Inj. temp.:	oven track
Carrier gas:	hydrogen, constant flow
Flow rate:	4mL/min.
Oven temp.:	50°C (hold 1 min.) to 180°C @ 15°C/min. to 230°C @ 7°C/min. to 380°C @ 30°C/min. (hold 5 min.)
Det.:	FID 380°C

Figure 7 The Ultimate Biodiesel Solution: MXT®-Biodiesel TG column with Integra-Gap™ integrated retention gap.

The 0.53mm MXT®-Biodiesel TG columns are an innovative alternative to using a 0.32mm column coupled to a 0.53mm retention gap. Restek applied the Integra-Gap™ integrated retention gap technology to the 0.53mm MXT®-Biodiesel TG columns, eliminating the column coupling. These 100% leak-proof columns feature a built-in retention gap, reducing the risk of peak broadening and tailing, and guaranteeing the user many analyses without downtime.



MXT®-Biodiesel TG Columns

- Fast analysis times and sharp glyceride peaks.
- Stable at 430°C for reliable, consistent performance.
- Integra-Gap™ built-in retention gap eliminates manual connection.

MXT®-Biodiesel TG Columns (Siltek® treated stainless steel)

Description	temp. limits	cat.#
14m, 0.53mm ID, 0.16 w/2m Integra-Gap™	-60 to 380/430°C	70289
10m, 0.32mm ID, 0.10	-60 to 380/430°C	70292
10m, 0.32mm ID, 0.10 w/2m x 0.53mm retention gap**	-60 to 380/430°C	70290
15m, 0.32mm ID, 0.10	-60 to 380/430°C	70293
15m, 0.32mm ID, 0.10 w/2m x 0.53mm retention gap**	-60 to 380/430°C	70291

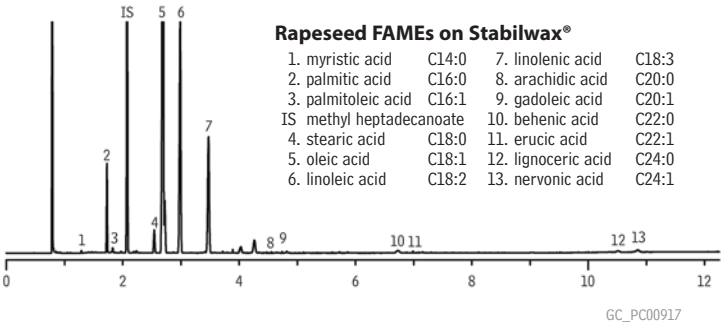
*Total column length=16 meters.
**Connected with low-dead-volume Alumaseal™ connector.

Analyzing FAMES in Biodiesel

FAMEs are the desired end product of biodiesel production and they are analyzed to determine the percent of usable fuel in the final product. A Stabilwax® fused silica GC column affords excellent peak symmetry, resolution, and reproducibility for determining the FAMEs and linolenic acid methyl ester content in B100 biodiesel fuel, following European standard method EN 14103.

As shown in Figure 8, C14:0-C24:1 FAMEs and linolenic acid methyl ester can be determined in less than 11 minutes using a 30m x 0.32mm ID x 0.25µm Stabilwax® column. Particularly notable are the stability of the baseline, excellent peak symmetry, and baseline resolution of all compounds of interest. The Stabilwax® column shows excellent peak shape for all FAMEs, even at low concentrations, which is critical for accurate quantification (Table 1).

Figure 8 Stable baselines, excellent peak symmetry, and rapid, baseline resolution of all compounds characterize FAMEs analyses on a Stabilwax® column.



Rapeseed FAMEs on Stabilwax®

1.	myristic acid	C14:0	7.	linolenic acid	C18:3
2.	palmitic acid	C16:0	8.	arachidic acid	C20:0
3.	palmitoleic acid	C16:1	9.	gadoleic acid	C20:1
IS	methyl heptadecanoate		10.	behenic acid	C22:0
4.	stearic acid	C18:0	11.	erucic acid	C22:1
5.	oleic acid	C18:1	12.	lignoceric acid	C24:0
6.	linoleic acid	C18:2	13.	nervonic acid	C24:1

Column:	Stabilwax®, 30m, 0.32mm ID, 0.25µm (cat.# 10624)
Sample:	rapeseed source of biodiesel (B100), prepared according to European Method EN 14103
Inj.:	1.0µL split (split ratio 100:1), Cyclosplitter® inlet liner (cat.# 20706)
Inj. temp.:	250°C
Carrier gas:	hydrogen, constant flow, 3mL/min.
Linear velocity:	60cm/sec.
Oven temp.:	210°C (hold 5 min.) to 230°C @ 20°C/min. (hold 5 min.)
Det.:	FID
Det. temp.:	250°C

Table I Sources of FAMEs in B100 biodiesel fuel (% m/m).

		Soy	Tallow	Rapeseed	Yellow Grease
Myristic acid	C14:0	0.21	1.7	0.11	0.68
Palmitic acid	C16:0	11.24	25.5	4.1	16.35
Palmitoleic acid	C16:1	0.2	3.27	0.27	1.23
Stearic acid	C18:0	4.04	14.41	1.8	9.32
Oleic acid	C18:1	21.93	40.34	58.57	47.8
Linoleic acid	C18:2	53.84	12.02	22.2	20.01
Linolenic acid	C18:3	7.29	0.99	13.26	2.93
Arachidic acid	C20:0	0.36	0.4	0.79	0.46
Gadoleic acid	C20:1	0.26	1.03	1.79	0.39
Behenic acid	C22:0	0.45		0.57	0.44
Erucic acid	C22:1			0.13	0.23
Lignoceric acid	C24:0	0.16	0.34	0.3	0.24
Nervonic acid	C24:1		0.17	0.54	

Stabilwax® Column (fused silica)

(Crossbond® Carbowax® polyethylene glycol)

ID	df (µm)	temp. limits	length	cat. #
0.32mm	0.25	40 to 250°C	30-Meter	10624

Analyzing Methanol in Biodiesel

Methanol is commonly used to produce biodiesel by derivatizing the fatty acids to methyl esters. The amount of residual methanol must be determined because engine performance can be negatively affected if the methanol concentration in the final product is too high. Methanol in biodiesel is quantified using a headspace method (e.g. EN 14110). We recommend an Rtx®-1 column (30m, 0.32mm ID, 3µm) for this analysis. The selectivity of the Rtx®-1 column is ideal for resolving methanol from interfering peaks in biodiesel fuels.

Conclusion

Whether testing for glycerin, FAMEs, or methanol, Restek can supply the high quality chromatography products required for biodiesel testing. We offer an array of metal and fused silica GC columns designed for high performance biodiesel analysis, including our innovative MXT®-Biodiesel TG column with an Integra-Gap™ integrated retention gap (Table II). Our columns, accessories, and analytical reference materials are designed to improve analytical quality, simplify lab work, and increase productivity. Rely on Restek for innovative solutions to your biodiesel testing needs.

Rtx®-1 Columns (fused silica)

(Crossbond® 100% dimethyl polysiloxane)

ID	df (µm)	temp. limits	length	cat. #
0.32mm	3.00	-60 to 280/300°C	30-Meter	10184

Table II GC Column Selection Guide for Biodiesel Fuel Methods.

Fused Silica GC Columns	Description	Injection Type	ASTM D6584 Free and Total Glycerin	EN 4103 Ester and Linoleic acid methyl esters	EN 14105 Free and total glycerine and mono, di, and triglycerides	EN 14110 Methanol
Rtx-Biodiesel TG (max temp. 380°C)	15m, 0.32mm ID, 0.1µm w/ 2m x 0.53mm ID retention gap	cool on-column	10293	—	10293	—
Rtx-Biodiesel TG (max temp. 380°C)	15m, 0.32mm ID, 0.1µm	PTV**	10294	—	10294	—
Rtx-Biodiesel TG (max temp. 380°C)	10m, 0.32mm ID, 0.1µm w/ 2m x 0.53mm ID retention gap	cool on-column	10291	—	10291	—
Rtx-Biodiesel TG (max temp. 380°C)	10m, 0.32mm ID, 0.1µm	PTV**	10292	—	10292	—
Stabilwax	30m, 0.32mm ID, 0.25µm	split/splitless	—	10624	—	—
Rtx-1	30m, 0.32mm ID, 3.0µm	headspace	—	—	—	10184
Metal (MXT) GC Columns						
*MXT-Biodiesel TG (max temp. 430°C)	14m, 0.53mm ID, 0.16µm w/ 2m Integra Gap	cool on-column	70289	—	70289	—
MXT-Biodiesel TG (max temp. 430°C)	15m, 0.32mm ID, 0.1µm w/ 2m x 0.53mm ID retention gap	cool on-column	70291	—	70291	—
MXT-Biodiesel TG (max temp. 430°C)	15m, 0.32mm ID, 0.1µm	PTV**	70293	—	70293	—
MXT-Biodiesel TG (max temp. 430°C)	10m, 0.32mm ID, 0.1µm w/ 2m x 0.53mm ID retention gap	cool on-column	70290	—	70290	—
MXT-Biodiesel TG (max temp. 430°C)	10m, 0.32mm ID, 0.1µm	PTV**	70292	—	70292	—

*Recommended for total glycerin analysis.

**PTV=programmed temperature vaporizer.

GC Accessories

Thermolite® Septa

- Usable to 340°C inlet temperature.
- Preconditioned and precision molded.
- Do not adhere to hot metal surfaces.
- Packaged in precleaned glass jars.

Septum Diameter	25-pk.	50-pk.	100-pk.
9mm	27132	27133	27134
9.5mm (3/8")	27135	27136	27137
10mm	27138	27139	27140
11mm (7/16")	27141	27142	27143
11.5mm	27144	27145	27146
12.5mm (1/2")	27147	27148	27149
17mm	27150	27151	27152
Shimadzu Plug	27153	27154	27155

Parker Balston® Hydrogen Generators

- Proton Exchange Membrane (PEM) cell eliminates the need for liquid electrolytes.
- Reliably generate 99.9995% pure hydrogen, for better chromatography.
- Cost-effective, convenient, and safe alternative to high pressure cylinders.

Specifications

Purity:	99.9995% pure hydrogen	Physical Dimensions:	17.12"h x 13.46"w x 17.95"d (43.48 x 34.19 x 45.6cm)
Delivery Pressure:	10-100psig ± 1psig (69-689kPa ± 7kPa)	Shipping Weight:	40 lbs. (18kg) dry
Outlet Port:	1/8" compression		
Electrical Requirements:	100-230VAC/50-60Hz		

- Dimensions: 17.12"h x 13.46" x 17.95"
- 40 lb. dry weight

Description	Capacity	qty.	cat.#
H2PEM-100	100cc/min.	ea.	23065
H2PEM-165	165cc/min.	ea.	23066
H2PEM-260	260cc/min.	ea.	23067
H2PEM-510	510cc/min.	ea.	23068

Small, compact unit—easy to hold and operate.

Restek Electronic Leak Detector

- Reliable thermal conductivity leak detector.
- Responds to leaks in less than 2 seconds.
- Audible alarm plus LED readout.
- Auto zeros with the touch of a button.
- Built-in rechargeable 7.2-volt battery.

Leak Detector Facts

Detectable gases:	helium, nitrogen, argon, carbon dioxide
Battery:	Rechargeable Ni-MH, 7.2 volt
Operating Temperature Range:	32°-120°F (0°-48°C)
Humidity Range:	0-97%
CE Approved:	Yes

Description	qty.	cat.#
Leak Detector with 110Volt Battery Charger	ea.	22451
Leak Detector with 220Volt European Battery Charger	ea.	22451-EUR
Leak Detector with 220Volt UK Battery Charger	ea.	22451-UK

Caution: The Restek Electronic Leak Detector is NOT designed for determining leaks of combustible gases. A combustible gas detector should be used for determining combustible gas leaks under any condition. The Restek Electronic Leak Detector may be used for determining trace amounts of hydrogen in a GC environment only.

Also available in money-saving 50-packs!

Capillary Ferrules—For 1/16-Inch Compression-Type Fittings

Graphite Ferrules

- Preconditioned to eliminate out-gassing.
- High-purity, high-density graphite.
- Stable to 450°C.

Vespel®/Graphite Ferrules

- 60%/40% Vespel®/graphite blend, offering the best combination of sealing and workability.
- Stable to 400°C.

Ferrule ID	Fits Column ID	qty.	Graphite	Vespel®/Graphite
0.5mm	0.32mm	10-pk.	20201	20212
0.8mm	0.45/0.53mm	10-pk.	20202	20213

tech tip

Which FID Jet Should I Use?
There are two FID jet configurations for Agilent GCs. The longer "adaptable" jet fits both 5890 and 6890 GCs, and can be used with capillary or packed columns. The shorter "dedicated" jet is for the FID in the 6890 GC that is designed only for use with capillary columns.

Replacement Jets

- Available untreated or Siltek® treated, for maximum inertness.

Capillary Adaptable FID Replacement Jet for Agilent 5890/6890/6850 GCs

0.011-Inch ID Tip	Similar to Agilent part #	qty.	cat.#	qty.	cat.#
Standard	19244-80560	ea.	20670	3-pk.	20671
High-Performance Siltek® Treated	19244-80560	ea.	20672	3-pk.	20673

Capillary Dedicated FID Replacement Jet for Agilent 6890/6850 GCs

0.011-Inch ID	Similar to Agilent part #	qty.	cat.#	qty.	cat.#
Standard	G1531-80560	ea.	21621	3-pk.	21682
High-Performance Siltek® Treated	G1531-80560	ea.	21620	3-pk.	21683

FID Jet Removal Tool for Agilent 5890/6890/6850 FIDs

- Securely grips jet in socket for easy removal or installation.
- Unique, ergonomic handle—easy to hold.

Description	qty.	cat.#
FID Jet Removal Tool for Agilent 5890/6890/6850 FIDs	ea.	22328

Residual Solvent Analysis

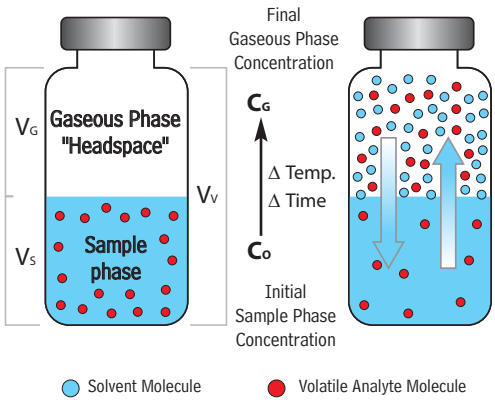
Complete Solutions for Residual Solvent Testing

- How to successfully implement the USP <467> revision.
- Improve system suitability pass rates with an optimized system.
- Save column evaluation time and expense using a retention time index.

The Chemistry of Static Headspace Gas Chromatography

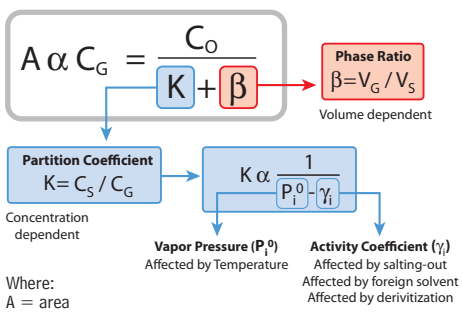
Improve Method Performance with Fundamentals

Figure 1 Volatile components partition into gaseous phase until equilibrium is reached.



Once the sample phase is introduced into the vial and the vial is sealed, volatile components diffuse into the gas phase until the headspace has reached a state of equilibrium as depicted by the arrows. The sample is then taken from the headspace.

Figure 2 Fundamental headspace relationship.



Where:
A = area
V_G = volume of gas phase
V_S = volume of sample phase
V_V = total vial volume
C_O = initial analyte concentration in sample
C_G = analyte concentration in gas phase
C_S = analyte concentration in sample phase
P_i^0 = analyte vapor pressure
γ_i = activity coefficient

Organic volatile impurities (OVIs), commonly referred to as residual solvents, are trace level chemical residues in drug substances and drug products that are byproducts of manufacturing or that form during packaging and storage. Drug manufacturers must ensure that these residues are removed, or are present only in limited concentrations. The International Conference on Harmonization (ICH) Q3C guideline lists the acceptable amounts of solvent residues that can be present. Methodology, both independently developed and compendial, should strive to coincide with this guideline. In this guide, we will take a comprehensive look at residual solvent analysis, in both theory and practice, and illustrate options for the practicing chromatographer.

The analysis of residual solvents is commonly performed using static headspace gas chromatography (HS/GC). The basic premise behind headspace analysis begins with the addition of an exact, known volume or weight of sample into a closed, sealed vial. This creates two distinct phases in the vial—a sample phase and a gaseous phase, or "headspace". Volatile components inside the sample phase, whether a solid or solution, can be extracted, or partitioned, from the sample phase into the headspace. An aliquot of the headspace can then be taken and delivered into a GC system for separation and detection. If we look at the anatomy of a headspace vial (Figure 1), we can begin to see the relationship of the vial components and how we can control these parameters to create analytical methods.

Residual solvent analysis by static HS/GC can be enhanced by careful consideration of two basic concepts—partition coefficient (K) and phase ratio (β). Partition coefficients and phase ratios work together to determine the final concentration of volatile compounds in the headspace of sample vials. Volatile components partition from the sample phase and equilibrate in the vial headspace. Striving for the lowest values for both K and β when preparing samples will result in higher concentrations of volatile analytes in the gas phase and, therefore, better sensitivity (Figure 2).

Controlling the Partition Coefficient

The partition coefficient (K) is defined as the equilibrium distribution of an analyte between the sample and gas phases. Compounds that have low K values will tend to partition more readily into the gas phase, and have relatively high responses and low limits of detection. K can be further described as a relationship between analyte vapor pressure (p_i^0) and activity coefficient (γ_i). In practice, K can be lowered by increasing the temperature at which the vial is equilibrated (vapor pressure) or by changing the composition of the sample matrix (activity coefficient) by adding an inorganic salt or a solvent of lesser solubility, often referred to as a foreign solvent. High salt concentrations and foreign solvents decrease analyte solubility in the sample phase (decrease activity) and promote transfer into the headspace, thus resulting in lower K values. The magnitude of this effect on K is not the same for all analytes. Compounds with inherent low K values in the matrix will experience little change in partition coefficient in response to the addition of a salt and temperature, while volatile compounds in a matrix of similar polarity will show the largest responses.

Adjusting the Phase Ratio

The phase ratio (β) is defined as the volume of the headspace over the volume of the sample in the vial. Lower values for β (i.e., larger sample sizes) will yield higher responses for compounds with inherently low K values. However, decreasing β will not always yield the increase in response needed to improve sensitivity. When β is decreased by increasing sample size, compounds with high K values will partition less into the headspace compared to compounds with low K values and yield correspondingly smaller changes in sensitivity.

Achieving USP<467> Compliance

Your Guide to Successfully Implementing the Revised Method

The USP general chapter <467> Residual Solvents is a widely used compendial method for identifying and quantifying residual solvents when no information is available on what solvents are likely to be present. In an attempt to harmonize with the ICH guidelines, the USP has proposed a more comprehensive method in the current USP 30/NF 25. This revision significantly increases the number of residual solvents to be routinely tested and includes three distinct procedures.[1]

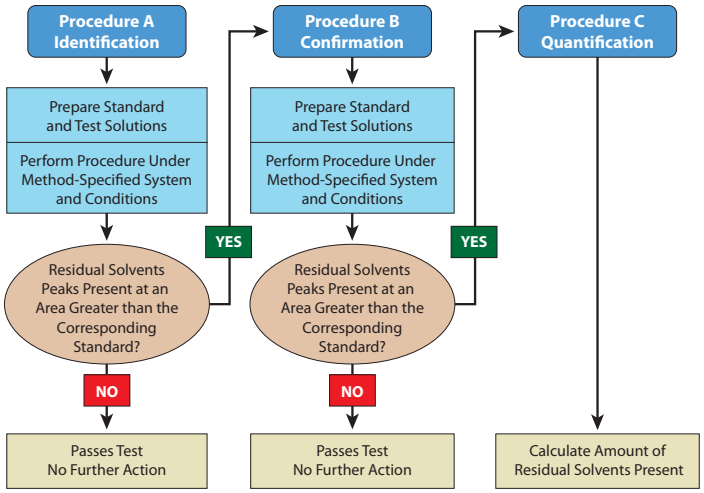
Initially set to become effective July 1, 2007, the implementation of the current version of USP <467> has been delayed until July 1, 2008. Until that time, the Other Analytical Procedures section of the previous version will be retained. However, in preparation for the implementation of the revised method, this application will comply with the procedure and criteria set forth in the USP30/NF25, second supplement (effective December 1, 2007) and the interim revision announcement.

Overview of Method

The revised USP <467> method consists of a static headspace extraction coupled with a gas chromatographic separation and flame ionization detection. In this guide we demonstrate the USP <467> application using two different types of headspace autosamplers. Procedure A was performed using a pressured loop autosampler and transfer line. Procedure B was performed using a heated syringe injection. Either system can be used to meet method requirements.

USP <467> is divided into two separate sections based upon sample solubility: water-soluble and water-insoluble articles. The methodology for both types of articles is similar, but the diluent used in both standard and sample preparations differs based upon the solubility of the test article. The test method consists of three procedures (A, B, and C), that are designed to identify, confirm, and then quantify residual solvents in drug substances and products (Figure 3).

Figure 3 Analytical flow chart for residual solvent testing under the revised USP <467> method.



[1] This number of analytes to be tested represents the sum of Class 1 and 2 residual solvents that can be effectively assayed using HS/GC. The actual number of analytes may be more if xylenes, ethyl benzene and *cis/trans* 1,2 dichloroethylene are differentiated, or if circumstances require the quantification of specific Class 3 residual solvents.

tech tip

Compatibility concerns?
Refer to the Septum Selection Guide at **www.restek.com/septaguide**

free literature

Download your free copy of our Technical Guide for Static Headspace Analysis from **www.restek.com/ovi**

lit. cat.# 59895A

Achieving USP<467> Compliance *(continued from page 3)*

Residual Solvents - Class 1

benzene	10mg/mL	1,1-dichloroethene	40
carbon tetrachloride	20	1,1,1-trichloroethane	50
1,2-dichloroethane	25		

In dimethyl sulfoxide, 1mL/ampul

cat. # 36279 (ea.)

Quantity discounts not available.

Residual Solvents Class 2 - Mix A (15 components)

acetonitrile	2.05mg/mL	methylcyclohexane	5.90
chlorobenzene	1.80	methylene chloride	3.00
cyclohexane	19.40	tetrahydrofuran	3.45
cis-1,2-dichloroethene	4.70	toluene	4.45
trans-1,2-dichloroethene	4.70	*m*-xylene	6.51
1,4-dioxane	1.90	*o*-xylene	0.98
ethylbenzene	1.84	*p*-xylene	1.52
methanol	15.00		

In dimethyl sulfoxide, 1mL/ampul

cat. # 36271 (ea.)

Residual Solvents Class 2 - Mix B (8 components)

chloroform	60µg/mL	nitromethane	50
1,2-dimethoxyethane	100	pyridine	200
n-hexane (C6)	290	tetralin	100
2-hexanone	50	trichloroethene	80

In dimethyl sulfoxide, 1mL/ampul

cat. # 36280 (ea.)

Quantity discounts not available.

Residual Solvents Class 2 - Mix C (8 components)

2-ethoxyethanol	800µg/mL	2-methoxyethanol (methyl Cellosolve®)	250
ethylene glycol	3,100	N-methylpyrrolidone	2,650
formamide	1,100	sulfolane	800
N,N-dimethylacetamide	5,450		
N,N-dimethylformamide	4,400		

In dimethyl sulfoxide, 1mL/ampul

cat. # 36273 (ea.)

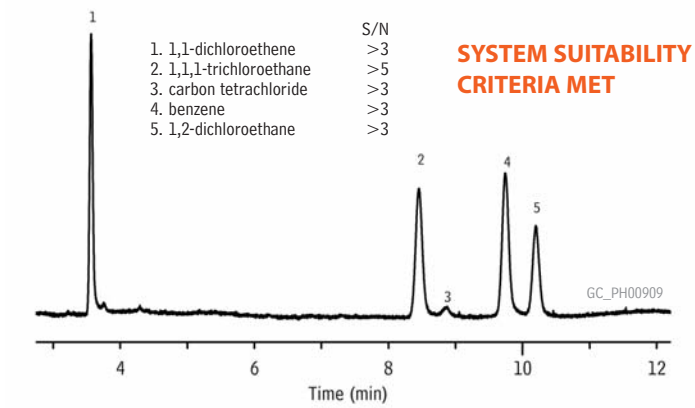
Analytical Reference Materials

The ICH guideline classifies residual solvents by class according to toxicity. Class 1 compounds are carcinogenic and pose a risk to both the consumer and the environment. The use of these solvents must be avoided or tightly controlled. Class 2 compounds are nongenotoxic animal carcinogens and their concentration should be limited. Both Class 1 and 2 compounds require chromatographic determination and are separated into 3 test mixes: Class 1 Mixture, Class 2 Mixture A, and Class 2 Mixture B. Class 3 compounds have low toxic potential. Concentration levels of up to 0.5% are acceptable and, therefore, they can be assayed by nonspecific techniques, such as weight loss on drying. Class 2 Mixture C is not used in the second supplement of USP 30/NF 25, but contains solvents that are not readily detectable by headspace analysis. These solvents should be assayed by other appropriately validated procedures.

Procedure A - Identification

Procedure A is the first step in the identification process and is performed on a G43 column to determine if any residual solvents are present in the sample at detectable levels. First, Class 1 standard and system suitability solutions and Class 2 Mix A standard solutions are assayed under the method-specified operating conditions to establish system suitability. All peaks in the Class 1 system suitability solution must have a signal-to-noise ratio not less than 3, the Class 1 standard solution must have a 1,1,1-trichloroethane response greater than 5, and the resolution of acetonitrile and dichloromethane must be not less than 1 in the Class 2 Mixture A solution. When system suitability has been achieved, the test solutions are assayed along with the Class 1 and Class 2 Mixtures A and B standard solutions. If a peak is determined in the sample that matches a retention time and has a greater response than that of a corresponding reference material, then Procedure B is performed for verification of the analyte. In the second supplement of USP 30/NF 25, an exemption is made for 1,1,1-trichloroethane, where a response greater than 150 times the peak response denotes an amount above the percent daily exposure limit. Figures 4 through 6 illustrate the analysis of Class 1, Class 2 Mixture A, and Class 2 Mixture B residual solvent mixes by Procedure A. The resolution between acetonitrile and dichloromethane was easily achieved using an Rtx®-1301 column.

Figure 4 USP residual solvent Class 1 standard solution on an Rtx®-1301 column (G43).

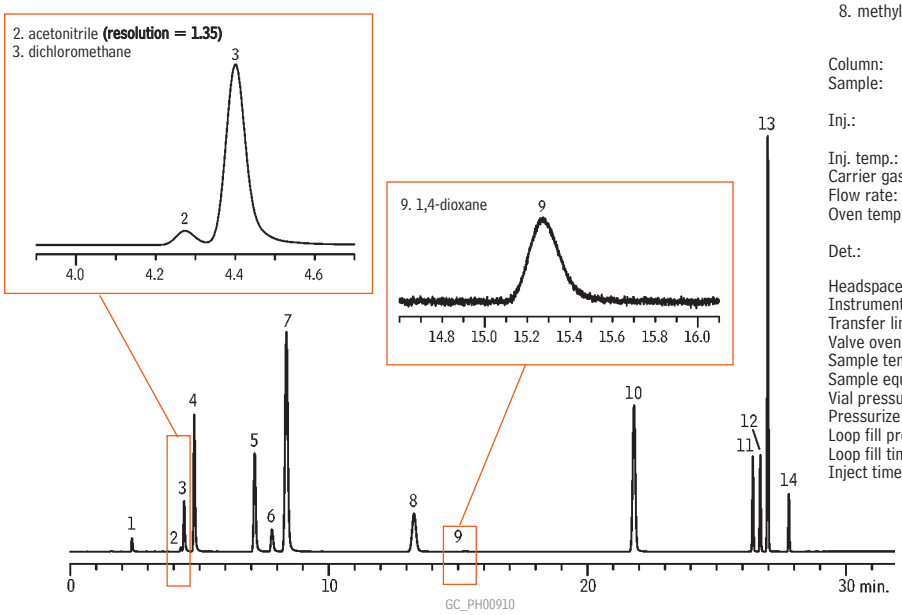


Column:	Rtx®-1301, 30m, 0.32mm ID, 1.8µm (cat.# 16092)	Headspace Conditions	
Sample:	USP <467> Class 1 standard solution (cat.# 36279) in 20mL headspace vial	Instrument:	Tekmar HT3
Inj.:	headspace injection (split ratio 1:5), 1mm split liner, Siltek® deactivated (cat.# 20972-214.1)	Transfer line temp.:	105°C
Inj. temp.:	140°C	Valve oven temp.:	105°C
Carrier gas:	helium, constant flow	Sample temp.:	80°C
Flow rate:	2.16mL/min., 35.3cm/sec.	Sample equil. time:	45 min.
Oven temp.:	40°C for 20 min. to 240°C @ 10°C/min. (hold for 20 min.)	Vial pressure:	10psi
Det.:	FID @ 240°C	Pressurize time:	0.5 min.
		Loop fill pressure:	5psi
		Loop fill time:	2.00 min.
		Inject time:	1.00 min.

Figure 5 USP residual solvent Class 2 Mixture A standard solution on an Rtx®-1301 column (G43).

SYSTEM SUITABILITY CRITERIA MET

1. methanol
2. acetonitrile (resolution=1.35)
3. dichloromethane
4. *trans*-1,2-dichloroethene
5. *cis*-1,2-dichloroethene
6. tetrahydrofuran
7. cyclohexane
8. methylcyclohexane
9. 1,4-dioxane
10. toluene
11. chlorobenzene
12. ethyl benzene
13. *m*-xylene/*p*-xylene
14. *o*-xylene

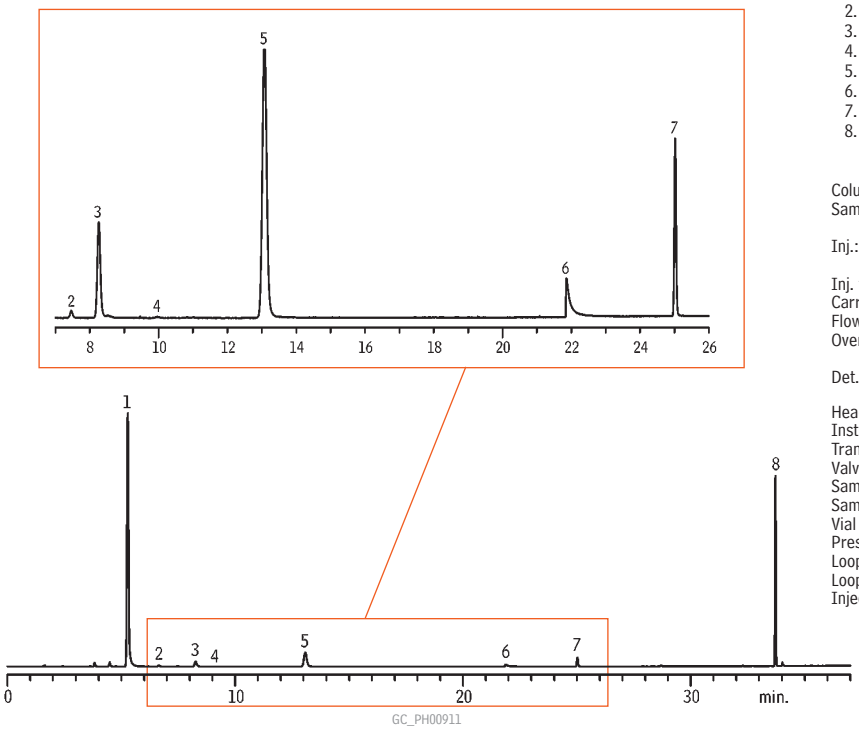


Column: Rtx®-1301, 30m, 0.32mm ID, 1.8µm (cat.# 16092)
Sample: USP <467> Class 2 Mixture B standard solution (cat.# 36280) in 20mL headspace vial
Inj.: headspace injection (split ratio 1:5), 1mm split liner Siltek® deactivated (cat.# 20972-214.1)
Inj. temp.: 140°C
Carrier gas: helium, constant flow
Flow rate: 2.16mL/min., 35.3cm/sec.
Oven temp.: 40°C for 20 min. to 240°C @ 10°C/min. (hold for 20 min.)
Det.: FID @ 240°C

Headspace Conditions
Instrument: Tekmar HT3
Transfer line temp.: 105°C
Valve oven temp.: 105°C
Sample temp.: 80°C
Sample equil. time: 45 min.
Vial pressure: 10psi
Pressurize time: 0.5 min.
Loop fill pressure: 5psi
Loop fill time: 2.00 min.
Inject time: 1.00 min.

Figure 6 USP residual solvent Class 2 Mixture B standard solution on an Rtx®-1301 column (G43).

1. hexane
2. nitromethane
3. chloroform
4. 1,2-dimethoxyethane
5. trichloroethylene
6. pyridine
7. 2-hexanone
8. tetralin



Column: Rtx®-1301, 30m, 0.32mm ID, 1.8µm (cat.# 16092)
Sample: USP <467> Class 2 Mixture B standard solution (cat.# 36280) in 20mL headspace vial
Inj.: headspace injection (split ratio 1:5), 1mm split liner Siltek® deactivated (cat.# 20972-214.1)
Inj. temp.: 140°C
Carrier gas: helium, constant flow
Flow rate: 2.16mL/min., 35.3cm/sec.
Oven temp.: 40°C for 20 min. to 240°C @ 10°C/min. (hold for 20 min.)
Det.: FID @ 240°C

Headspace Conditions
Instrument: Tekmar HT3
Transfer line temp.: 105°C
Valve oven temp.: 105°C
Sample temp.: 80°C
Sample equil. time: 45 min.
Vial pressure: 10psi
Pressurize time: 0.5 min.
Loop fill pressure: 5psi
Loop fill time: 2.00 min.
Inject time: 1.00 min.

Figure 8 USP residual solvent Class 2 Mixture A standard solution on a Stabilwax® column (G16).

SYSTEM SUITABILITY CRITERIA MET—
RESOLUTION BETWEEN PEAKS 7 & 8 > 1.0

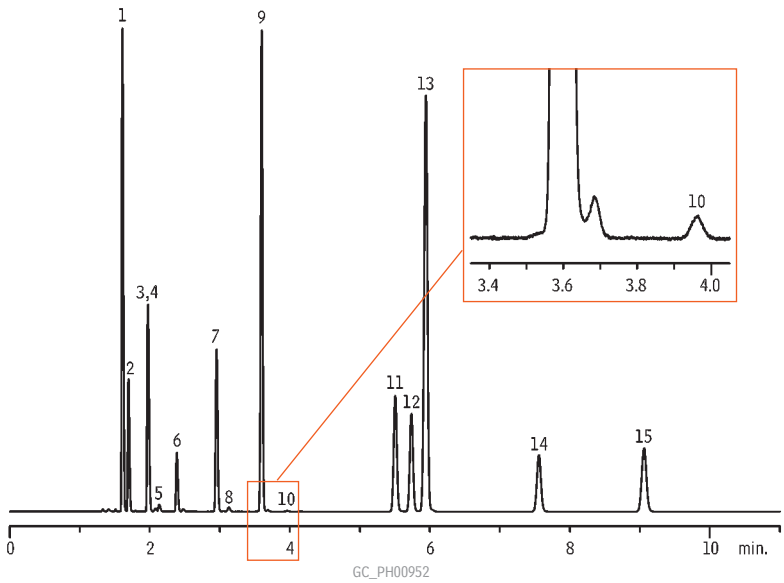
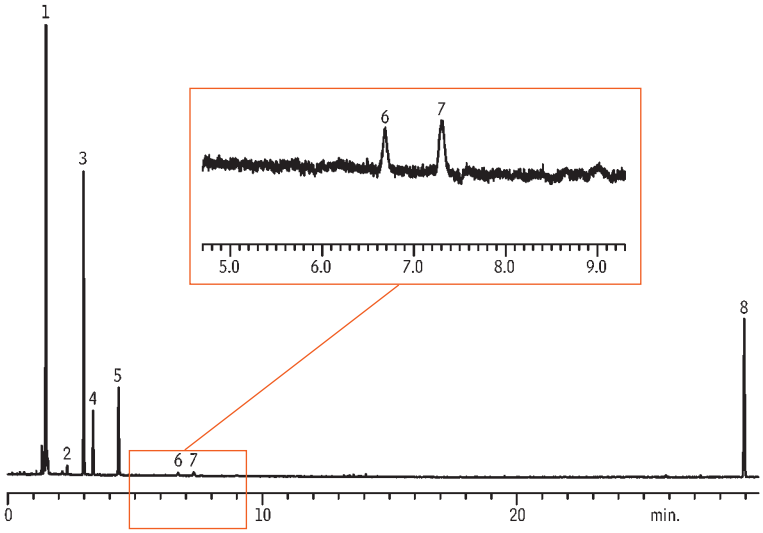


Figure 9 USP residual solvent Class 2 Mixture B standard solution on a Stabilwax® column (G16).



1. hexane
2. 1,2-dimethoxyethane
3. trichloroethylene
4. chloroform
5. 2-hexanone
6. nitromethane
7. pyridine
8. tetralin

Column:	Stabilwax®, 30m, 0.32mm ID, 0.25µm (cat.# 10624)
Sample:	USP Stock Standard Residual Solvents Class 2 Mix B (cat.# 36272) in 20mL headspace vial (cat.# 24685), water diluent
Inj.:	headspace injection (split ratio 1:5), 2mm splitless liner IP deactivated (cat.# 20712)
Inj. temp.:	140°C
Carrier gas:	helium, constant flow
Flow rate:	2.15mL/min., 35.2cm/sec.
Oven temp.:	50°C for 20 min. to 165°C @ 6°C/min. (hold for 20 min.)
Det.:	FID @ 250°C

Headspace Conditions

Instrument:	Overbrook Scientific HT200H
Syringe temp.:	100°C
Sample temp.:	80°C
Sample equil. time.:	45 min.
Injection vol.:	1.0mL
Injection speed:	setting 8
Injection dwell:	5 sec.

Optimize Your Testing Procedure

Tools, Tips, & Techniques for Improving Method Performance

Use Smaller Bore Liners for Better Efficiency

1mm Split Liners for Agilent GCs

ID* x OD & Length	qty.	cat.#
1mm Split**		
1.0mm x 6.3mm x 78.5mm	ea.	20972
1.0mm x 6.3mm x 78.5mm	5-pk.	20973

2mm Splitless Liners for Agilent GCs

ID* x OD & Length	qty.	cat.#
2mm Splitless		
2.0mm x 6.5mm x 78.5mm	ea.	20712
2.0mm x 6.5mm x 78.5mm	5-pk.	20713
2.0mm x 6.5mm x 78.5mm	25-pk.	20714

Split Liners for Varian 1075/1077 GCs

ID* x OD & Length	qty.	cat.#
1mm Split		
1.0mm x 6.3mm x 72mm	ea.	20970
1.0mm x 6.3mm x 72mm	5-pk.	20971

Split Liners for Shimadzu GCs

ID* x OD & Length	qty.	cat.#
1mm Split		
1.0mm x 5.0mm x 95mm	ea.	20976
1.0mm x 5.0mm x 95mm	5-pk.	20977
1.0mm x 5.0mm x 95mm	25-pk.	20978

SPME Liners for Shimadzu 17A, 2010, and 2014 GCs

ID* x OD & Length	qty.	cat.#
SPME Liner		
.75mm x 5.0mm x 95mm	ea.	22278
.75mm x 5.0mm x 95mm	5-pk.	22279

Zero Dilution Liners for PerkinElmer Auto SYS™ and Clarus GCs

ID* x OD & Length	qty.	cat.#
Zero Dilution Inner Liner		
1.0mm x 2.0mm x 73mm	ea.	22990
1.0mm x 2.0mm x 73mm	5-pk.	22991

Zero Dilution Outer Liner		
2.5mm x 6.2mm x 90mm	ea.	22992
2.5mm x 6.2mm x 90mm	5-pk.	22993

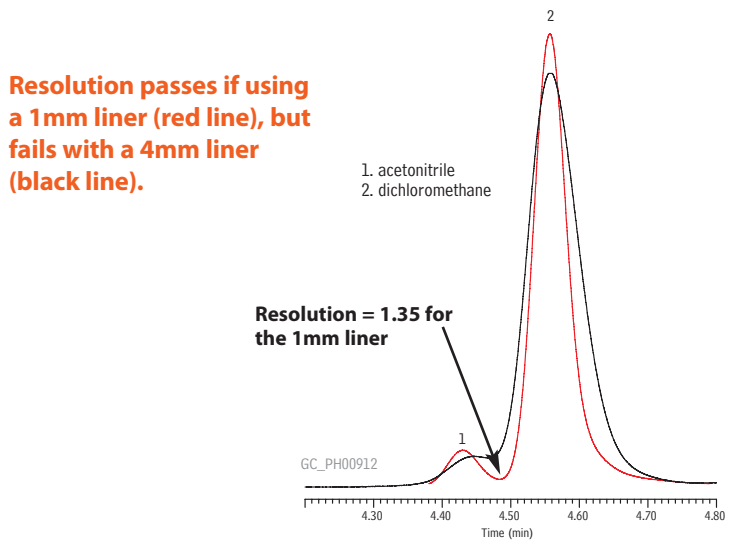
*Nominal ID at syringe needle expulsion point.
**Use this liner for increased sensitivity.

Implementing the revised method for USP<467> can be difficult if the instrument is not optimized correctly. Key issues to address when setting up headspace GC systems include minimizing system dead volume, maintaining inert sample flow paths, and achieving efficient sample transfer. While the second supplement contains a change that allows for modifications to the split ratio, column and liner choices are critical to analytical success.

Use Smaller Bore Liners for Better Resolution

The function of an injection port in headspace analysis is very different than in direct liquid injection. In direct injection, the sample is vaporized in the injection port and larger volume liners (e.g., 4mm) are typically used since the liner must be able to accommodate the solvent expansion volume. In contrast, in headspace analysis, the sample is vaporized inside the headspace vial and the resulting gas sample is simply transferred into the injection port via a transfer line or syringe injection. Since solvent vaporization does not occur in the liner, a large volume liner is not needed and, in fact, the use of one can cause deleterious effects such as band broadening and decreased peak efficiency. For headspace applications, a smaller bore liner, preferably 1mm, is recommended. The smaller liner volume reduces band broadening by increasing linear velocity in the liner allowing faster sample transfer and improving resolution (Figure 10).

Figure 10 Improve system suitability pass rates using smaller bore liners.



Speed Up Method Development Using a Retention Time Index

ICH guideline Q3C states that residual solvents need only be tested when production or purification processes are known to result in the presence of such solvents. Therefore, in many cases exhaustive testing is not needed and individual validated methods for smaller, specific analyte lists are an option. To simplify column selection and reduce method development time, Restek has created a retention time index for ICH Class 1, 2, and 3 residual solvents on various phases (Table I). To use this index, simply locate the analytes of interest on the list and determine which phase gives the optimal amount of resolution—or difference in retention time—between your target compounds. A critical coelution is indicated by a failure to achieve a retention time difference of greater than 1.5 minutes.

Optimize Your Testing Procedure

Tools, Tips, & Techniques for Improving Method Performance

Use Smaller Bore Liners for Better Efficiency

1mm Split Liners for Agilent GCs

ID* x OD & Length	qty.	cat.#
1mm Split**		
1.0mm x 6.3mm x 78.5mm	ea.	20972
1.0mm x 6.3mm x 78.5mm	5-pk.	20973

2mm Splitless Liners for Agilent GCs

ID* x OD & Length	qty.	cat.#
2mm Splitless		
2.0mm x 6.5mm x 78.5mm	ea.	20712
2.0mm x 6.5mm x 78.5mm	5-pk.	20713
2.0mm x 6.5mm x 78.5mm	25-pk.	20714

Split Liners for Varian 1075/1077 GCs

ID* x OD & Length	qty.	cat.#
1mm Split		
1.0mm x 6.3mm x 72mm	ea.	20970
1.0mm x 6.3mm x 72mm	5-pk.	20971

Split Liners for Shimadzu GCs

ID* x OD & Length	qty.	cat.#
1mm Split		
1.0mm x 5.0mm x 95mm	ea.	20976
1.0mm x 5.0mm x 95mm	5-pk.	20977
1.0mm x 5.0mm x 95mm	25-pk.	20978

SPME Liners for Shimadzu 17A, 2010, and 2014 GCs

ID* x OD & Length	qty.	cat.#
SPME Liner		
.75mm x 5.0mm x 95mm	ea.	22278
.75mm x 5.0mm x 95mm	5-pk.	22279

Zero Dilution Liners for PerkinElmer Auto SYS™ and Clarus GCs

ID* x OD & Length	qty.	cat.#
Zero Dilution Inner Liner		
1.0mm x 2.0mm x 73mm	ea.	22990
1.0mm x 2.0mm x 73mm	5-pk.	22991

Zero Dilution Outer Liner		
2.5mm x 6.2mm x 90mm	ea.	22992
2.5mm x 6.2mm x 90mm	5-pk.	22993

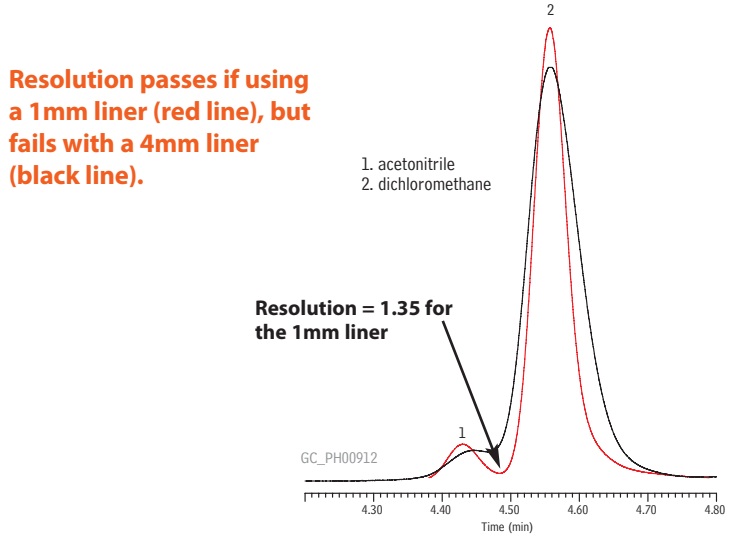
*Nominal ID at syringe needle expulsion point.
**Use this liner for increased sensitivity.

Implementing the revised method for USP<467> can be difficult if the instrument is not optimized correctly. Key issues to address when setting up headspace GC systems include minimizing system dead volume, maintaining inert sample flow paths, and achieving efficient sample transfer. While the second supplement contains a change that allows for modifications to the split ratio, column and liner choices are critical to analytical success.

Use Smaller Bore Liners for Better Resolution

The function of an injection port in headspace analysis is very different than in direct liquid injection. In direct injection, the sample is vaporized in the injection port and larger volume liners (e.g., 4mm) are typically used since the liner must be able to accommodate the solvent expansion volume. In contrast, in headspace analysis, the sample is vaporized inside the headspace vial and the resulting gas sample is simply transferred into the injection port via a transfer line or syringe injection. Since solvent vaporization does not occur in the liner, a large volume liner is not needed and, in fact, the use of one can cause deleterious effects such as band broadening and decreased peak efficiency. For headspace applications, a smaller bore liner, preferably 1mm, is recommended. The smaller liner volume reduces band broadening by increasing linear velocity in the liner allowing faster sample transfer and improving resolution (Figure 10).

Figure 10 Improve system suitability pass rates using smaller bore liners.



Speed Up Method Development Using a Retention Time Index

ICH guideline Q3C states that residual solvents need only be tested when production or purification processes are known to result in the presence of such solvents. Therefore, in many cases exhaustive testing is not needed and individual validated methods for smaller, specific analyte lists are an option. To simplify column selection and reduce method development time, Restek has created a retention time index for ICH Class 1, 2, and 3 residual solvents on various phases (Table I). To use this index, simply locate the analytes of interest on the list and determine which phase gives the optimal amount of resolution—or difference in retention time—between your target compounds. A critical coelution is indicated by a failure to achieve a retention time difference of greater than 1.5 minutes.

Table I Reduce method development time—use a retention time index for column selection.

Retention time data collected using the following conditions:
G16 Stabilwax®: 30m, 0.25mm ID, 0.5µm df, Phase ratio: 125, Oven program: 40ºC, hold 1 min., to 190ºC @ 4ºC/min., hold 15 min., Carrier flow: 1.2mL/min., Dead time: 1.38 min. @ 45ºC
G16 Rtx®-WAX: 30m, 0.25mm ID, 0.5µm df, Phase ratio: 125, Oven program: 40ºC, hold 1 min., to 190ºC @ 4ºC/min., hold 15 min., Carrier flow: 1.2mL/min., Dead time: 1.40 min. @ 45ºC
G43 Rtx®-1301: 30m, 0.25mm ID, 1.0µm df, Phase ratio: 63, Oven program: 40ºC, hold 1 min., to 190ºC @ 4ºC/min., hold 15 min., Carrier flow: 1.2mL/min., Dead time: 1.40 min. @ 45ºC
G27 Rxi®-5ms: 30m, 0.25mm ID, 1.0µm df, Phase ratio: 63, Oven program: 40ºC, hold 1 min., to 190ºC @ 4ºC/min., hold 15 min., Carrier flow: 1.1mL/min., Dead time: 1.49 min. @ 45ºC
G1 Rtx®-1: 60m, 0.53mm ID, 3.00µm df, Phase ratio: 43, Oven program: 30ºC, hold 4 min., to 220ºC @ 4ºC/min., Carrier flow: 6.3mL/min., Dead time: 2.54 min. @ 35ºC
Rtx®-200: 60m, 0.53mm ID, 3.00µm df, Phase ratio: 43, Oven program: 30ºC, hold 4 min., to 220ºC @ 4ºC/min., Carrier flow: 7.8mL/min., Dead time: 2.22 min. @ 35ºC

Carrier gas: helium **Compound**	**ICH Class**	**G16 Stabilwax® Retention Time**	**G16 Rtx®-WAX Retention Time**	**G43 Rtx®-1301 Retention Time**	**G27 Rxi®-5ms Retention Time**	**G1 Rtx®-1 Retention Time**	**NA Rtx®-200 Retention Time**
1,1,1-trichloroethane	1	3.96	3.49	5.43	5.40	10.82	8.35
1,1,2-trichloroethene	2	15.72	14.28	10.99	9.77	16.75	14.94
1,1-dichloroethene	1	2.23	2.04	2.79	4.41	5.73	4.16
1,2-dichloroethane	1	8.80	7.68	6.15	5.46	10.38	9.74
cis-1,2-dichloroethene	2	6.50	5.65	4.79	2.88	8.71	7.11
trans-1,2-dichloroethene	2	3.63	3.20	3.55	3.54	7.17	5.16
1,2-dimethoxyethane	2	4.80	4.18	6.03	5.54	10.98	10.63
1,4-dioxane	2	8.55	7.49	7.86	7.26	13.54	14.34
1-butanol	3	11.13	10.08	7.18	5.76	11.49	10.13
1-pentanol	3	14.95	13.75	11.19	9.44	16.99	14.95
1-propanol	3	7.69	6.80	4.20	3.37	6.81	6.13
2-butanol	3	7.25	6.44	5.08	4.16	8.51	7.69
2-ethoxyethanol	2	13.99	12.70	8.69	7.36	13.91	13.99
2-methoxyethanol	2	12.42	11.11	6.02	5.14	9.83	10.74
2-methyl-1-propanol	3	9.32	8.40	6.00	4.79	*	*
2-propanol	3	4.81	4.25	3.00	2.55	4.91	4.69
3-methyl-1-butanol	3	13.42	12.25	9.86	8.26	15.28	13.55
acetic acid	3	22.47	20.34	6.52	4.61	8.84	8.96
acetone	3	3.02	2.64	2.89	2.50	4.64	7.68
acetonitrile	2	6.91	5.83	3.28	2.47	4.32	8.89
anisole	3	18.65	17.09	17.12	16.28	25.00	22.84
benzene	1	5.23	4.54	5.98	3.83	11.63	9.17
butyl acetate	3	8.86	7.88	12.12	11.38	19.43	19.63
carbon tetrachloride	1	3.96	3.49	5.61	5.90	11.89	7.42
chlorobenzene	2	13.91	12.54	13.55	13.14	21.56	18.48
chloroform	2	7.31	6.41	5.23	4.64	9.18	6.66
cumene	3	12.36	11.17	16.66	16.69	25.88	20.90
cyclohexane	2	2.16	2.01	5.37	5.89	*	*
dichloromethane	2	5.01	4.33	3.31	3.06	5.87	4.88
dimethylsulfoxide	3	26.47	24.43	16.62	13.01	18.81	30.95
ethanol	3	4.98	4.37	2.52	2.19	4.03	3.80
ethyl acetate	3	4.08	3.56	4.87	4.44	9.04	10.35
ethyl benzene	2	10.72	9.58	13.86	13.81	22.54	18.18
ethyl ether	3	1.72	1.63	2.58	2.67	5.34	3.87
ethyl formate	3	3.16	2.78	3.00	2.78	5.46	6.48
ethylene glycol	2	28.06	26.23	10.77	6.63	12.59	13.86
formamide	2	32.99	30.93	11.85	7.30	12.72	19.93
formic acid	3	24.64	22.09	5.19	2.60	5.59	5.06
heptane	3	1.98	1.86	6.34	6.98	14.18	7.84
hexane	2	1.65	1.58	3.77	4.11	9.06	4.86
isobutyl acetate	3	6.99	6.18	10.39	9.69	17.35	18.02
isopropyl acetate	3	4.26	3.74	6.19	5.71	11.47	12.38
methanol	2	4.23	3.64	1.96	1.80	3.14	2.93
methyl acetate	3	3.19	2.80	3.17	2.93	5.80	7.10
methylbutyl ketone	2	9.10	8.05	11.81	10.50	17.94	20.81
methylcyclohexane	2	2.50	2.30	7.31	7.95	15.49	9.21
methylethyl ketone	3	4.33	3.76	4.90	4.09	7.99	11.55
methylisobutyl ketone	3	6.84	5.97	9.64	8.49	15.35	18.41
m-xylene	2	11.21	10.04	15.46	14.17	23.01	18.78
N,N-dimethylacetamide	2	20.75	19.01	12.95	13.96	21.42	30.00
N,N-dimethylformamide	2	18.04	16.26	13.09	10.23	16.52	26.19
nitromethane	2	11.82	10.31	4.84	3.53	6.30	12.01
N-methylpyrrolidone	2	29.84	27.86	25.09	21.85	29.99	38.08
o-xylene	2	12.79	11.51	15.46	15.26	24.23	20.33
pentane	3	1.49	1.45	2.39	2.62	5.36	3.29
propyl acetate	3	5.98	5.29	8.03	7.44	*	*
p-xylene	2	10.98	9.82	14.29	15.27	22.99	18.69
pyridine	2	12.64	11.24	9.60	8.57	15.40	16.45
sulfolane	2	47.62	43.31	34.02	28.90	36.76	48.67
tert-butylmethyl ether	3	1.94	1.82	3.50	3.59	7.52	5.73
tetrahydrofuran	3	3.63	3.19	5.12	4.90	9.81	9.48
tetralin	2	25.12	23.48	27.49	27.44	37.27	31.72
toluene	2	7.86	6.91	9.80	9.66	17.36	14.00
1,1-diethoxypropane	—	5.42	4.84	11.39	11.38	19.82	15.08
2,2-dimethoxypropane	—	3.11	2.79	5.48	5.55	11.37	8.67
2-chloropropane	—	1.96	1.82	2.67	2.66	5.20	4.61
2-methylpentane	—	1.58	1.52	3.22	3.56	7.72	4.32
acetaldehyde	—	2.05	1.85	1.86	1.84	3.14	3.90
chloroethane	—	1.83	1.71	2.14	2.10	3.97	3.55
chloromethane	—	1.63	1.55	1.70	1.70	3.01	2.73
ethylene oxide	—	2.05	1.86	1.89	2.02	3.59	3.92
formaldehyde	—	2.25	1.57	1.68	1.58	2.66	2.59
isoamyl acetate	—	10.51	9.43	14.84	14.18	22.80	22.62
isooctane	—	1.85	1.75	5.84	6.59	13.66	8.07
isopropyl ether	—	1.86	1.76	4.03	4.23	9.03	5.83
methyl cyclopentane	—	1.91	1.79	4.50	4.93	10.41	5.81
methyl isopropyl ketone	—	4.93	4.29	6.58	5.69	11.04	14.47
methylal	—	2.26	2.06	2.84	2.82	5.65	5.09
trichloroethene	—	6.50	5.70	7.07	7.05	13.58	9.75
water	—	8.24	7.18	1.74	1.68	2.75	2.57

* Not determined

Table I Reduce method development time—use a retention time index for column selection.

Retention time data collected using the following conditions:
G16 Stabilwax®: 30m, 0.25mm ID, 0.5µm df, Phase ratio: 125, Oven program: 40ºC, hold 1 min., to 190ºC @ 4ºC/min., hold 15 min., Carrier flow: 1.2mL/min., Dead time: 1.38 min. @ 45ºC
G16 Rtx®-WAX: 30m, 0.25mm ID, 0.5µm df, Phase ratio: 125, Oven program: 40ºC, hold 1 min., to 190ºC @ 4ºC/min., hold 15 min., Carrier flow: 1.2mL/min., Dead time: 1.40 min. @ 45ºC
G43 Rtx®-1301: 30m, 0.25mm ID, 1.0µm df, Phase ratio: 63, Oven program: 40ºC, hold 1 min., to 190ºC @ 4ºC/min., hold 15 min., Carrier flow: 1.2mL/min., Dead time: 1.40 min. @ 45ºC
G27 Rxi®-5ms: 30m, 0.25mm ID, 1.0µm df, Phase ratio: 63, Oven program: 40ºC, hold 1 min., to 190ºC @ 4ºC/min., hold 15 min., Carrier flow: 1.1mL/min., Dead time: 1.49 min. @ 45ºC
G1 Rtx®-1: 60m, 0.53mm ID, 3.00µm df, Phase ratio: 43, Oven program: 30ºC, hold 4 min., to 220ºC @ 4ºC/min., Carrier flow: 6.3mL/min., Dead time: 2.54 min. @ 35ºC
Rtx®-200: 60m, 0.53mm ID, 3.00µm df, Phase ratio: 43, Oven program: 30ºC, hold 4 min., to 220ºC @ 4ºC/min., Carrier flow: 7.8mL/min., Dead time: 2.22 min. @ 35ºC

Carrier gas: helium **Compound**	**ICH Class**	**G16 Stabilwax® Retention Time**	**G16 Rtx®-WAX Retention Time**	**G43 Rtx®-1301 Retention Time**	**G27 Rxi®-5ms Retention Time**	**G1 Rtx®-1 Retention Time**	**NA Rtx®-200 Retention Time**
1,1,1-trichloroethane	1	3.96	3.49	5.43	5.40	10.82	8.35
1,1,2-trichloroethene	2	15.72	14.28	10.99	9.77	16.75	14.94
1,1-dichloroethene	1	2.23	2.04	2.79	4.41	5.73	4.16
1,2-dichloroethane	1	8.80	7.68	6.15	5.46	10.38	9.74
cis-1,2-dichloroethene	2	6.50	5.65	4.79	2.88	8.71	7.11
trans-1,2-dichloroethene	2	3.63	3.20	3.55	3.54	7.17	5.16
1,2-dimethoxyethane	2	4.80	4.18	6.03	5.54	10.98	10.63
1,4-dioxane	2	8.55	7.49	7.86	7.26	13.54	14.34
1-butanol	3	11.13	10.08	7.18	5.76	11.49	10.13
1-pentanol	3	14.95	13.75	11.19	9.44	16.99	14.95
1-propanol	3	7.69	6.80	4.20	3.37	6.81	6.13
2-butanol	3	7.25	6.44	5.08	4.16	8.51	7.69
2-ethoxyethanol	2	13.99	12.70	8.69	7.36	13.91	13.99
2-methoxyethanol	2	12.42	11.11	6.02	5.14	9.83	10.74
2-methyl-1-propanol	3	9.32	8.40	6.00	4.79	*	*
2-propanol	3	4.81	4.25	3.00	2.55	4.91	4.69
3-methyl-1-butanol	3	13.42	12.25	9.86	8.26	15.28	13.55
acetic acid	3	22.47	20.34	6.52	4.61	8.84	8.96
acetone	3	3.02	2.64	2.89	2.50	4.64	7.68
acetonitrile	2	6.91	5.83	3.28	2.47	4.32	8.89
anisole	3	18.65	17.09	17.12	16.28	25.00	22.84
benzene	1	5.23	4.54	5.98	3.83	11.63	9.17
butyl acetate	3	8.86	7.88	12.12	11.38	19.43	19.63
carbon tetrachloride	1	3.96	3.49	5.61	5.90	11.89	7.42
chlorobenzene	2	13.91	12.54	13.55	13.14	21.56	18.48
chloroform	2	7.31	6.41	5.23	4.64	9.18	6.66
cumene	3	12.36	11.17	16.66	16.69	25.88	20.90
cyclohexane	2	2.16	2.01	5.37	5.89	*	*
dichloromethane	2	5.01	4.33	3.31	3.06	5.87	4.88
dimethylsulfoxide	3	26.47	24.43	16.62	13.01	18.81	30.95
ethanol	3	4.98	4.37	2.52	2.19	4.03	3.80
ethyl acetate	3	4.08	3.56	4.87	4.44	9.04	10.35
ethyl benzene	2	10.72	9.58	13.86	13.81	22.54	18.18
ethyl ether	3	1.72	1.63	2.58	2.67	5.34	3.87
ethyl formate	3	3.16	2.78	3.00	2.78	5.46	6.48
ethylene glycol	2	28.06	26.23	10.77	6.63	12.59	13.86
formamide	2	32.99	30.93	11.85	7.30	12.72	19.93
formic acid	3	24.64	22.09	5.19	2.60	5.59	5.06
heptane	3	1.98	1.86	6.34	6.98	14.18	7.84
hexane	2	1.65	1.58	3.77	4.11	9.06	4.86
isobutyl acetate	3	6.99	6.18	10.39	9.69	17.35	18.02
isopropyl acetate	3	4.26	3.74	6.19	5.71	11.47	12.38
methanol	2	4.23	3.64	1.96	1.80	3.14	2.93
methyl acetate	3	3.19	2.80	3.17	2.93	5.80	7.10
methylbutyl ketone	2	9.10	8.05	11.81	10.50	17.94	20.81
methylcyclohexane	2	2.50	2.30	7.31	7.95	15.49	9.21
methylethyl ketone	3	4.33	3.76	4.90	4.09	7.99	11.55
methylisobutyl ketone	3	6.84	5.97	9.64	8.49	15.35	18.41
m-xylene	2	11.21	10.04	15.46	14.17	23.01	18.78
N,N-dimethylacetamide	2	20.75	19.01	12.95	13.96	21.42	30.00
N,N-dimethylformamide	2	18.04	16.26	13.09	10.23	16.52	26.19
nitromethane	2	11.82	10.31	4.84	3.53	6.30	12.01
N-methylpyrrolidone	2	29.84	27.86	25.09	21.85	29.99	38.08
o-xylene	2	12.79	11.51	15.46	15.26	24.23	20.33
pentane	3	1.49	1.45	2.39	2.62	5.36	3.29
propyl acetate	3	5.98	5.29	8.03	7.44	*	*
p-xylene	2	10.98	9.82	14.29	15.27	22.99	18.69
pyridine	2	12.64	11.24	9.60	8.57	15.40	16.45
sulfolane	2	47.62	43.31	34.02	28.90	36.76	48.67
tert-butylmethyl ether	3	1.94	1.82	3.50	3.59	7.52	5.73
tetrahydrofuran	3	3.63	3.19	5.12	4.90	9.81	9.48
tetralin	2	25.12	23.48	27.49	27.44	37.27	31.72
toluene	2	7.86	6.91	9.80	9.66	17.36	14.00
1,1-diethoxypropane	—	5.42	4.84	11.39	11.38	19.82	15.08
2,2-dimethoxypropane	—	3.11	2.79	5.48	5.55	11.37	8.67
2-chloropropane	—	1.96	1.82	2.67	2.66	5.20	4.61
2-methylpentane	—	1.58	1.52	3.22	3.56	7.72	4.32
acetaldehyde	—	2.05	1.85	1.86	1.84	3.14	3.90
chloroethane	—	1.83	1.71	2.14	2.10	3.97	3.55
chloromethane	—	1.63	1.55	1.70	1.70	3.01	2.73
ethylene oxide	—	2.05	1.86	1.89	2.02	3.59	3.92
formaldehyde	—	2.25	1.57	1.68	1.58	2.66	2.59
isoamyl acetate	—	10.51	9.43	14.84	14.18	22.80	22.62
isooctane	—	1.85	1.75	5.84	6.59	13.66	8.07
isopropyl ether	—	1.86	1.76	4.03	4.23	9.03	5.83
methyl cyclopentane	—	1.91	1.79	4.50	4.93	10.41	5.81
methyl isopropyl ketone	—	4.93	4.29	6.58	5.69	11.04	14.47
methylal	—	2.26	2.06	2.84	2.82	5.65	5.09
trichloroethene	—	6.50	5.70	7.07	7.05	13.58	9.75
water	—	8.24	7.18	1.74	1.68	2.75	2.57

* Not determined

Restek Offers An Extensive Selection of Capillary Columns

For Successful Method Development & Validation

Rtx®-624 Columns (fused silica)

G43

(Crossbond® 6% cyanopropylphenyl/94% dimethyl polysiloxane)

ID	df (µm)	temp. limits	30-Meter	60-Meter
0.25mm	1.40	-20 to 240°C	10968	10969
0.32mm	1.80	-20 to 240°C	10970	10972
0.53mm	3.00	-20 to 240°C	10971	10973
ID	**df (µm)**	**temp. limits**	**20-Meter**	**40-Meter**
0.18mm	1.00	-20 to 240°C	40924	40925

Rtx®-1301 Columns (fused silica)

G43

(Crossbond® 6% cyanopropylphenyl/94% dimethyl polysiloxane)

ID	df (µm)	temp. limits*	30-Meter	60-Meter
0.25mm	0.50	-20 to 270°C	16038	16041
	1.00	-20 to 260°C	16053	16056
	1.40	-20 to 240°C		16016
0.32mm	0.50	-20 to 270°C	16039	16042
	1.00	-20 to 260°C	16054	16057
	1.50	-20 to 250°C	16069	16072
	1.80	-20 to 240°C	16092	16093
0.53mm	0.50	-20 to 270°C	16040	16043
	1.00	-20 to 260°C	16055	16058
	1.50	-20 to 250°C	16070	16073
	3.00	-20 to 240°C	16085	16088

Stabilwax® Columns (fused silica)

G16

(Crossbond® Carbowax® polyethylene glycol)

ID	df (µm)	temp. limits	30-Meter	60-Meter
0.25mm	0.25	40 to 250°C	10623	10626
	0.50	40 to 250°C	10638	10641
0.32mm	0.25	40 to 250°C	10624	10627
	0.50	40 to 250°C	10639	10642
	1.00	40 to 240/250°C	10654	10657
0.53mm	1.00	40 to 240/250°C	10655	10658
	1.50	40 to 230/240°C	10669	10672
	2.00	40 to 220/230°C	10670	

Rxi®-5ms Columns (fused silica)

G27

(Crossbond® 5% diphenyl/95% dimethyl polysiloxane)

ID	df (µm)	temp. limits	30-Meter	60-Meter
0.25mm	0.50	-60 to 330/350°C	13438	13441
	1.00	-60 to 330/350°C	13453	13456
0.32mm	0.50	-60 to 330/350°C	13439	13442
	1.00	-60 to 330/350°C	13454	13457
0.53mm	1.00	-60 to 330/350°C	13455	
	1.50	-60 to 330/350°C	13470	
ID	**df (µm)**	**temp. limits**	**20-Meter**	
0.18mm	0.18	-60 to 330/350°C	13402	
	0.30	-60 to 330/350°C	13409	
	0.36	-60 to 330/350°C	13411	

Rtx®-1 Columns (fused silica)

G1

(Crossbond® 100% dimethyl polysiloxane)

ID	df (µm)	temp. limits	30-Meter	60-Meter
0.25mm	0.50	-60 to 330/350°C	10138	10141
	1.00	-60 to 320/340°C	10153	10156
0.32mm	1.00	-60 to 320/340°C	10154	10157
	1.50	-60 to 310/330°C	10169	10172
	3.00	-60 to 280/300°C	10184	10187
	4.00	-60 to 280/300°C	10198	
	5.00	-60 to 260/280°C	10178	10180
0.53mm	1.50	-60 to 310/330°C	10170	10173
	3.00	-60 to 270/290°C	10185	10188
	5.00	-60 to 270/290°C	10179	10183
	7.00	-60 to 240/260°C	10192	10193
ID	**df (µm)**	**temp. limits**	**20-Meter**	**40-Meter**
0.18mm	0.20	-60 to 330/350°C	40102	40103
	0.40	-60 to 320/340°C	40111	40112

Rtx®-200 Columns (fused silica)

(Crossbond® trifluoropropylmethyl polysiloxane)

ID	df (µm)	temp. limits*	30-Meter	60-Meter
0.25mm	0.50	-20 to 310/330°C	15038	15041
	1.00	-20 to 290/310°C	15053	15056
0.32mm	1.00	-20 to 290/310°C	15054	15057
	1.50	-20 to 280/300°C	15069	15072
0.53mm	1.00	-20 to 290/310°C	15055	15058
	1.50	-20 to 280/300°C	15070	15073
	3.00	-20 to 260/280°C	15085	15088
ID	**df (µm)**	**temp. limits**	**20-Meter**	**40-Meter**
0.18mm	0.20	-20 to 310/330°C	45002	45003
	0.40	-20 to 310/330°C	45011	45012

*Maximum temperatures listed are for 15- and 30-meter lengths. Longer lengths may have a slightly reduced maximum temperature.

free literature

Genuine Restek Replacement Parts

Use our handy new Genuine Restek Replacement Parts (GRRP) mini-catalogs to help you select the supplies and replacement parts you need for your specific GC. We now have customized GRRP mini-catalogs for each major instrument manufacturer to simplify your product search. Download these and other pieces from our website at **www.restek.com/grrp.**

For Agilent GCs
(lit. cat.# 59627F)

For Agilent 5890 GCs
(lit. cat.# 580216)

For PerkinElmer GCs
(lit. cat.# 580038)

For Shimadzu GCs
(lit. cat.# 580037)

For Thermo Scientific GCs
(lit. cat.# 580039)

For Varian GCs
(lit. cat.# 59224A)

also available

Custom Column Lengths:
If you do not see the column dimension you need, call our customer service team, and we will make the column for you.

Simplify Lab Work with Innovative Accessories

Dual Vespel® Ring Inlet Seals for Agilent GCs

- Vespel® ring embedded in bottom surface eliminates need for washer.
- Vespel® ring embedded in top surface reduces operator variability by requiring minimal torque to seal.
- Prevents oxygen from permeating into the carrier gas, increasing column lifetime.


Patented.

Washerless, leak-tight seals for Agilent GCs

0.8mm ID Dual Vespel Ring Inlet Seal	2-pk./price	10-pk./price
Gold-Plated	21240	21241
Siltek Treated	21242	21243
Stainless Steel	21238	21239
1.2mm ID Dual Vespel Ring Inlet Seal	**2-pk./price**	**10-pk./price**
Gold-Plated	21246	21247
Siltek Treated	21248	21249
Stainless Steel	21244	21245

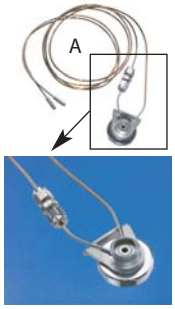
Dual Vespel® Ring Cross-Disk Inlet Seals for Agilent GCs

- Ideal for high-flow split applications.
- Washerless, leak-tight seals.

0.8mm ID Dual Vespel Ring Cross-Disk Inlet Seal	2-pk./price	10-pk./price
Gold-Plated	22083	22084
Siltek Treated	22085	22086
Stainless Steel	22087	22088

Injection Port Weldments for Agilent GCs

Easily attach your autosampler with pre-installed low dead volume fittings.

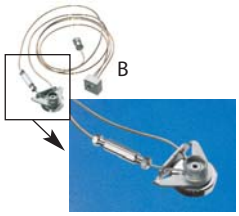


For Agilent GCs with Tekmar Transfer Lines

Description	qty.	cat.#
A) Weldment for Agilent 6890 GCs	ea.	22664
Weldment for Agilent 6890 GCs with optional canister filter	ea.	22668
Weldment for Agilent 5890 GCs	ea.	22666

For Agilent GCs with OI Purge and Trap Systems

Description	qty.	cat.#
B) Weldment for Agilent 6890 GCs	ea.	22665
Weldment for Agilent 6890 GCs with optional canister filter	ea.	22669
Weldment for Agilent 5890 GCs	ea.	22667



FID Replacement Jets

Standard Version

- Engineered with a fluted tip to guide the capillary column into the jet.
- Threads specially coated for easy installation and removal.
- Special processing ensures the highest degree of cleanliness.

High-Performance Version

- Similar to the standard version, but Siltek® treated.
- Extremely inert, for use with active compounds.

Capillary Adaptable FID Replacement Jet for Agilent 5890/6890/6850 GCs

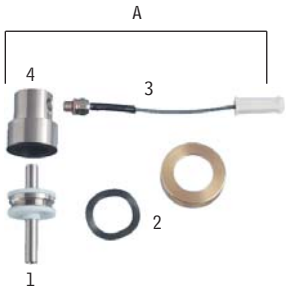
0.011-Inch ID Tip	Similar to Agilent part #	qty.	cat.#	qty.	cat.#
Standard, 0.011-Inch ID Tip	19244-80560	ea.	20670	3-pk.	20671
High-Performance Siltek Treated, 0.011-Inch ID Tip	19244-80560	ea.	20672	3-pk.	20673

Capillary Dedicated FID Replacement Jet for Agilent 6890/6850/7890 GCs

0.011-Inch ID Tip	Similar to Agilent part #	qty.	cat.#	qty.	cat.#
Standard, 0.011-Inch ID Tip	G1531-80560	ea.	21621	3-pk.	21682
High-Performance Siltek Treated, 0.011-Inch ID Tip	G1531-80560	ea.	21620	3-pk.	21683

did you know?

Restek carries a full line of FID replacement jets. Visit **www.restek.com** for a complete selection.



Direct Replacement FID Collector Assembly Kit for Agilent 6890/6850/7890 GCs

- Constructed of high-quality stainless steel.
- Meets or exceeds manufacturer's performance.

Description	Similar to Agilent part #	qty.	cat.#
A) FID Collector Assembly Kit (includes insulator)	G1531-60690	kit	21699
FID Collector Assembly Kit w/Siltek Ignitor Castle	—	kit	21132

Replacement FID Parts for Agilent 6890/6850/7890 GCs

- Meets or exceeds manufacturer's performance.

Description	Similar to Agilent part #	qty.	cat.#
1) FID Collector (includes insulators)	G1531-20690 G1531-20700	ea.	21139
2) FID Collector Nut and Washer	19231-20940 5181-3311	set	21136
3) FID Ignitor*	19231-60680	ea.	21001
4) FID Ignitor Castle	19231-20910	ea.	21137
Siltek FID Ignitor Castle	—	ea.	21135

*Also fits OI Analytical 4410 detector (similar to OI part # 191833).

The New Restek Electronic Leak Detector!

We are pleased to introduce the new, enhanced Restek Electronic Leak Detector. With our new unit you'll receive the great performance that you've come to trust from our current Leak Detector; but with new features designed with the end-user in mind, including:

- A sleek, new ergonomic, hand-held design.
- Rugged side grips for added durability.
- Handy probe storage for cleanliness.
- Longer battery lifetime.
- Automatic shut-off capabilities.
- A convenient carrying and storage case.
- A universal power adapter set (US, European, UK and Australian plugs included).

Available July 2008

Backed by a 1 year warranty, the new Restek Leak Detector will again set an industry standard for performance and affordability in a hand-held Leak Detector.

We will have units available for delivery in July 2008. Don't miss this opportunity to reserve your new Leak Detector. Call Restek customer service to reserve yours today! To find out more, visit **www.restek.com/leakdetector.**

Description	qty	cat.#
Leak Detector with Universal Adapter Set	ea	22839

tech tip

Avoid using liquid leak detectors on a capillary system! Liquids can be drawn into the system.

Order your unit today! 1-800-356-1688, ext. 3

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Volatiles

Volatile organic compounds (VOCs) are usually analyzed using a purge and trap system connected to a GC. The column used must have a selective stationary phase to resolve the volatile pollutants, have a sufficient film thickness to retain and resolve the low boiling volatile compounds (i.e., dichlorodifluoromethane), and must be thermally stable to elute the high boiling volatiles compounds (i.e., hexachlorobutadiene & naphthalene).

The first fused silica columns used for analyzing volatiles were based on diphenyl/dimethyl polysiloxane stationary phases. However, resolution of gases has always been problematic with these phases. Restek designed the Rtx®-VMS column specifically to optimize separation of volatiles in the most commonly used EPA volatiles methods. A faster oven ramp rate is possible because these compounds elute farther apart on the Rtx®-VMS phase, eliminating partial coelutions that interfere with quantification. Using the EPA suggested surrogates (i.e., chlorobenzene-d5) analysis time can be less than 10 minutes with a narrow bore column, allowing you to connect two purge and trap units to one GC/MS instrument – significantly increasing sample throughput.

Figure 1 Excellent resolution of bromomethane and chloroethane, as well as challenging isomer pairs like 2-/4-chlorotoluene on the Rtx®-VMS column.

1. dichlorodifluoromethane
2. chloromethane
3. vinyl chloride
4. bromomethane
5. chloroethane
6. trichlorofluoromethane
7. ethanol (2500ppb)
8. 1,1-dichloroethene
9. carbon disulfide (40ppb)
10. allyl chloride
11. methylene chloride
12. acetone
13. *trans*-1,2-dichloroethene
14. methyl *tert*-butyl ether
15. *tert*-butyl alcohol (100ppb)
16. diisopropyl ether
17. 1,1-dichloroethane
18. acrylonitrile
19. vinyl acetate
20. allyl alcohol (250ppb)
21. ethyl-*tert*-buyl ether
22. *cis*-1,2-dichloroethene
23. 2,2-dichloropropane
24. bromochloromethane
25. chloroform
26. ethyl acetate
27. carbon tetrachloride
28. methyl acrylate
29. propargyl alcohol (500ppb)
30. dibromofluoromethane (SMC)
31. tetrahydrofuran
32. 1,1,1-trichloroethane
33. 2-butanone
34. 1,1-dichloropropene
35. benzene
36. pentafluorobenzene (IS)
37. *tert*-amyl-methyl ether
38. 1,2-dichloroethane
39. isobutyl alcohol (500ppb)
40. isopropyl acetate
41. trichloroethene
42. 1,4-difluorobenzene (SMC)
43. dibromomethane
44. 1,2-dichloropropane
45. bromodichloromethane
46. methyl methacrylate
47. *n*-propyl acetate
48. 2-chloroethanol (2500ppb)
49. *cis*-1,3-dichloropropene
50. toluene-d8 (SMC)
51. toluene
52. pyridine (250ppb)
53. tetrachloroethene
54. 4-methyl-2-pentanone
55. *trans*-1,3-dichloropropene
56. 1,1,2-trichloroethane
57. ethyl methacrylate
58. dibromochloromethane
59. 1,3-dichloropropane
60. 1,2-dibromoethane
61. *n*-butyl acetate
62. 2-hexanone
63. 2-picoline (250ppb)
64. chlorobenzene-D5 (IS)
65. chlorobenzene
66. ethylbenzene
67. 1,1,1,2-tetrachloroethane
68. *m*-xylene
69. *p*-xylene
70. *o*-xylene
71. stryrene
72. bromoform
73. isopropylbenzene
74. 4-bromo-1-fluorobenzene (SMC)
75. bromobenzene
76. *n*-propylbenzene
77. 1,1,2,2-tetrachloroethane
78. 2-chlorotoluene
79. 1,3,5-trimethylbenzene
80. 1,2,3-trichloropropane
81. 4-chlorotoluene
82. *tert*-butylbenzene
83. pentachloroethane
84. 1,2,4-trimethylbenzene
85. *sec*-butylbenzene
86. *p*-isopropyltoluene
87. 1,3-dichlorobenzene
88. 1,4-dichlorobenzene-d4 (IS)
89. 1,4-dichlorobenzene
90. *n*-butylbenzene
91. 1,2-dichlorobenzene
92. 1,2-dibromo-3-chloropropane
93. nitrobenzene (250ppb)
94. hexachlorobutadiene
95. 1,2,4-trichlorobenzene
96. naphthalene
97. 1,2,3-trichlorobenzene

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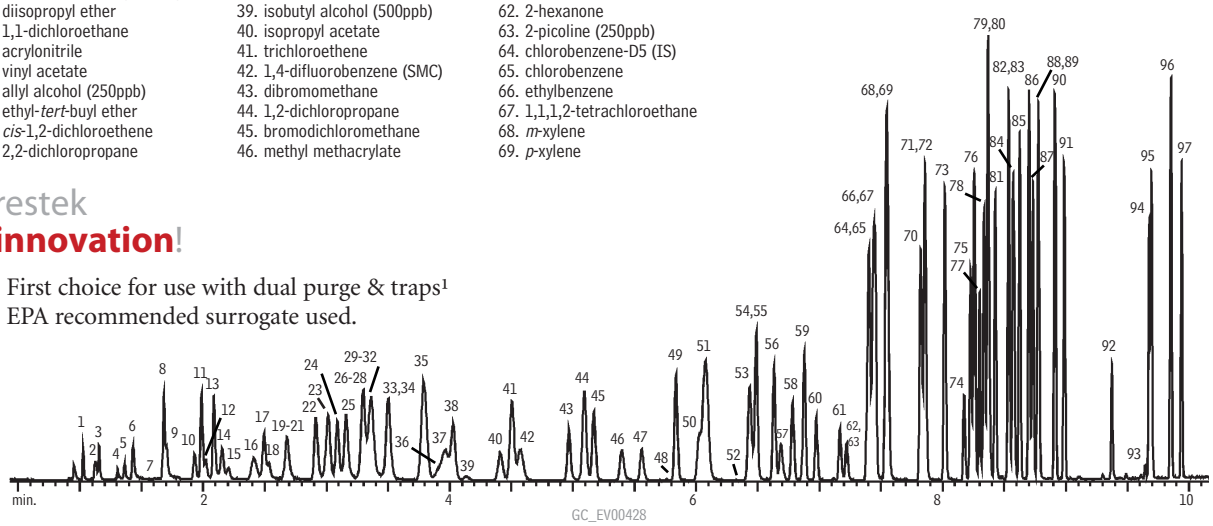
innovation!

- First choice for use with dual purge & traps[1]
- EPA recommended surrogate used.



Column:	Rtx®-VMS 20m, 0.18 mm ID, 1.00µm (cat.# 49914)	Interface:	0.53mm ID Silcosteel® tubing transfer line
Conc.:	10ppb in 5mL of RO water unless otherwise noted; ketones at 2.5X		1:40 split at injection port. 1mm ID liner.
Concentrator:	Tekmar LSC-3100 Purge and Trap	Oven temp.:	50°C (hold 4 min.) to 100°C @ 18°C/min. (hold 0 min.) to 230°C @ 40°C/min. (hold 3 min.)
Trap:	Vocarb 3000 (type K)	Carrier gas:	helium @ ~1.0mL/min. constant flow
Purge:	11 min. @ 40mL/min. (ambient temperature)		Adjust dichlorodifluoromethane to a retention time of 1.03 min. @ 50°C.
Dry purge:	1 min. @ 40mL/min.		
Desorb preheat:	245°C	Detector:	Agilent 5973 MSD
Desorb:	250°C for 2 min., flow 40mL/min.	Scan range:	35-300amu
Bake:	260°C for 8 min.		

[1]A.L. Hilling and G. Smith, Environmental Testing & Analysis, 10(3), 15-19, 2001.

Recommended Column

Rtx®-VMS Columns (fused silica)
(proprietary Crossbond® phase)

ID	df (µm)	temp. limits	length	cat. #
0.18mm	1.00	-40 to 240/260°C	20-Meter	49914

Analytical Reference Materials

8260A Internal Standard Mix
chlorobenzene-d5 fluorobenzene
1,4-dichlorobenzene-d4
2,500µg/mL each in P&T methanol, 1mL/ampul
cat. # 30241 (ea.)

8260 Internal Standard Mix
chlorobenzene-d5 1,4-difluorobenzene
1,4-dichlorobenzene-d4 pentafluorobenzene
2,500µg/mL each in P&T methanol, 1mL/ampul
cat. # 30074 (ea.)

8260A Surrogate Mix
4-bromofluorobenzene 1,2-dichloroethane-d4
dibromofluoromethane toluene-d8
2,500µg/mL each in P&T methanol, 1mL/ampul
cat. # 30240 (ea.)

8260 Surrogate Mix
4-bromofluorobenzene toluene-d8
dibromofluoromethane
2,500µg/mL each in P&T methanol, 1mL/ampul
cat. # 30073 (ea.)

8260B MegaMix® Calibration Mix (76 components)
Please visit us online for compound list
2,000µg/mL each in P&T methanol, 1mL/ampul
cat. # 30633 (ea.)

8260B MegaMix® Calibration Mix Kit
30633: 8260B MegaMix®
30265: 2-chlorethyl vinyl ether
Contains 1mL each of these mixtures.
cat. # 30475 (kit)

502.2 Calibration Mix #1 (gases)
bromomethane dichlorodifluoromethane (CFC-12)
chloroethane trichlorofluoromethane (CFC-11)
chloromethane vinyl chloride
200µg/mL each in P&T methanol, 1mL/ampul
cat. # 30439 (ea.)
2,000µg/mL each in P&T methanol, 1mL/ampul
cat. # 30042 (ea.)

VOA Calibration Mix #1 (ketones)
acetone 2-hexanone
2-butanone 4-methyl-2-pentanone
5,000µg/mL each in P&T methanol:water (90:10), 1mL/ampul
cat. # 30006 (ea.)

California Oxygenates Mix
diisopropyl ether 2,000µg/mL *tert*-butyl alcohol 10,000
ethyl-*tert*-butyl ether 2,000 methyl *tert*-butyl ether 2,000
tert-amyl methyl ether 2,000
In P&T methanol, 1mL/ampul
cat. # 30465 (ea.)

Analytical Reference Materials

Reduce Dead Volume, Contamination, & Cold Spots

The injection port can be a source for dead volume, which is especially critical when dealing with a sample in the gas phase. The severity of the problem is a combination of the inside diameter of the injection port liner and the total desorb flow through the port. To reduce dead volume in the injection port, use a 1mm ID inert split liner. Always be sure to use insulation where the transfer line attaches to the inlet line since this is a cold spot that will condense high molecular weight analytes.

Transfer lines often are the first place contamination occurs. When the response factor for bromoform fails the method criteria, changing the transfer line is the first step to getting the system working again. Replace your transfer line with our Siltek® deactivated tubing, for optimum performance.

1mm Split Inlet Liner for Agilent GCs

ID*/OD & Length (mm)	cat.#	ea.	cat.#	5-pk.
1.0 ID 6.3 OD x78.5	20972		20973	

*Nominal ID at syringe needle expulsion point.
Also available with Siltek® deactivation, upon request.

Siltek®/Sulfinert® Treated Coiled 304 Grade Stainless Steel Tubing

Our most popular grade of tubing.
- chromatography applications.
- stems.
- s.
- ons.

OD	cat.#	5-24 ft.	25-199 ft.	200-399 ft.	>400 ft.
(1.59mm)	22505				

An extra charge is applied for cutting Siltek®/Sulfinert®, Silcosteel®, or Silcosteel®-CR tubing, calculated from the total number of pieces produced for each line item.

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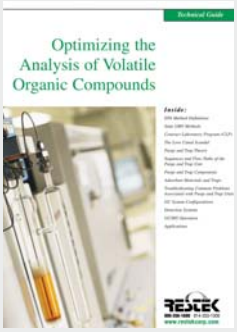
Optimizing the Analysis of Volatile Organic Compounds
lit. cat.# 59887A

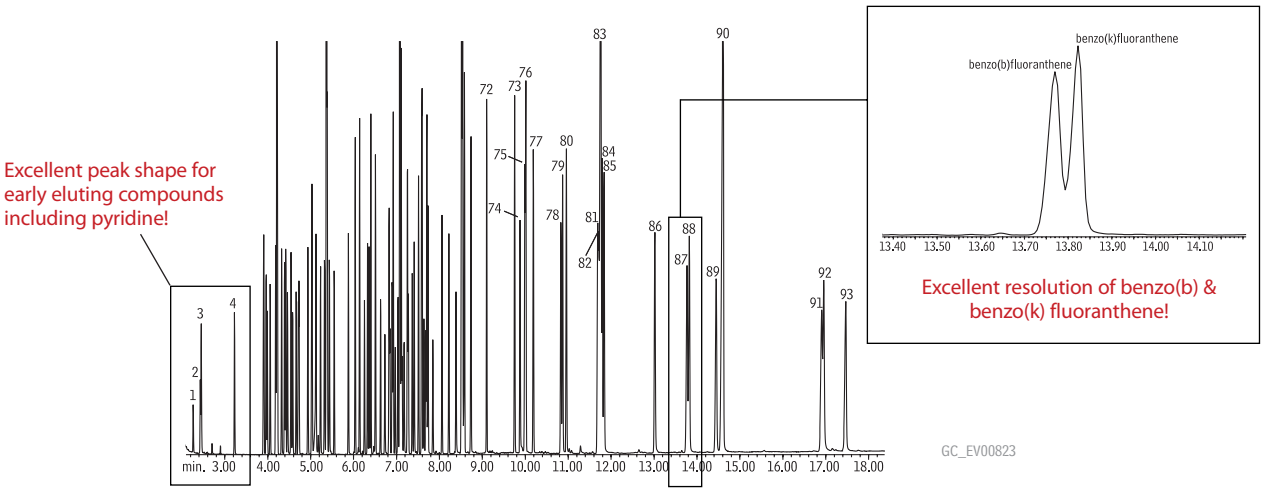
Contact your Restek representative, to request your free copy!



Semivolatiles

Semivolatile analysis is a challenging area covering a wide range of compound classes – neutral, acidic, and basic compounds, including anilines, phenols, PAHs, and more – that differ in both volatility and reactivity. While the chromatography is complicated by a broad list of target analytes, many problems can be avoided by proper attention to the inlet system and an informed column choice.

Figure 1 Separate greater than 90 semivolatile compounds in less than 18 minutes, using an Rxi™-5ms column.



For complete identifications, please visit www.restek.com/rxi

Column:	Rxi™-5ms, 30m, 0.25mm ID, 0.25µm (cat.# 13423)
Sample:	US EPA Method 8270D mix: 8270 MegaMix™ (cat.# 31850), Benzoic Acid Standard (cat.# 31879), Benzidine Standard (cat.# 31852), Acid Surrogate Mix (cat.# 31025), B/N Surrogate Standard Mix (cat.# 31887), 1,4-Dioxane (cat.# 31853)
Inj.:	1.0µL, 10ppm each analyte (10ng on column), splitless (hold 0.1 min.) 4mm Drilled Uniliner® inlet liner (hole at bottom) (cat.# 20756)
Instrument:	Agilent 6890
Inj. temp.:	250°C
Carrier gas:	helium, constant flow
Flow rate:	1.2mL/min.
Oven temp.:	50°C (hold 0.5 min.) to 265°C @ 25°C/min., to 330°C @ 6°C/min. (hold 2 min.)
Det.:	Agilent 5973 GC/MS
Transfer line temp.:	280°C
Scan range:	35-550 amu
Solvent delay:	2 min.
Tune:	DFTPP
Ionization:	EI

1. 1,4-dioxane
2. N-nitrosodimethylamine •
3. pyridine •
4. 2-fluorophenol
5. phenol-d6
6. phenol •
7. aniline •
8. bis(2-chloroethyl) ether •
9. 2-chlorophenol •
10. 1,3-dichlorobenzene •
11. 1,4-dichlorobenzene-d4
12. 1,4-dichlorobenzene •
13. benzyl alcohol •
14. 1,2-dichlorobenzene •
15. 2-methylphenol •
16. bis(2-chloroisopropyl) ether •
17a. 4-methylphenol •
17b. 3-methylphenol •
18. N-nitroso-di-*n*-propylamine •
19. hexachloroethane •
20. nitrobenzene-d5
21. nitrobenzene •
22. isophorone •
23. 2-nitrophenol •
24. 2,4-dimethylphenol •
25. benzoic acid
26. bis(2-chloroethoxy)methane •
27. 2,4-dichlorophenol •
28. 1,2,4-trichlorobenzene •
29. naphthalene-d8
30. naphthalene •
31. 4-chloroaniline •
32. hexachlorobutadiene •
33. 4-chloro-3-methylphenol •
34. 2-methylnaphthalene •
35. 1-methylnaphthalene •
36. hexachlorocyclopentadiene •
37. 2,4,6-trichlorophenol •
38. 2,4,5-trichlorophenol •
39. 2-fluorobiphenyl
40. 2-chloronaphthalene •
41. 2-nitroaniline •
42. 1,4-dinitrobenzene •
43. dimethyl phthalate •
44. 1,3-dinitrobenzene •
45. 2,6-dinitrotoluene •
46. acenaphthylene •
47. 1,2-dinitrobenzene •
48. 3-nitroaniline •
49. acenaphthene-d10
50. acenaphthene •
51. 2,4-dinitrophenol •
52. 4-nitrophenol •
53. dibenzofuran •
54. 2,4-dinitrotoluene •
55. 2,3,4,6-tetrachlorophenol •
56. 2,3,5,6-tetrachlorophenol •
57. diethyl phthalate •
58. 4-chlorophenyl phenyl ether •
59. fluorene •
60. 4-nitroanaline •
61. 4,6-dinitro-2-methylphenol •
62. N-nitrosodiphenylamine (as diphenylamine) •
63. 1,2-diphenylhydrazine (as azobenzene) •
64. 2,4,6-tribromophenol
65. 4-bromophenyl phenyl ether •
66. hexachlorobenzene •
67. pentachlorophenol •
68. phenanthrene-d10
69. phenanthrene •
70. anthracene •
71. carbazole •
72. di-*n*-butyl phthalate •
73. fluoranthene •
74. benzidine
75. pyrene-d10
76. pyrene •
77. *p*-terphenyl-d14
78. 3,3'-dimethylbenzidine
79. butyl benzyl phthalate •
80. bis(2-ethylhexyl) adipate •
81. 3,3'-dichlorobenzidine
82. benzo(a)anthracene •
83. chrysene-d12
84. chrysene •
85. bis(2-ethylhexyl) phthalate •
86. di-*n*-octyl phthalate •
87. benzo(b)fluoranthene •
88. benzo(k)fluoranthene •
89. benzo(a)pyrene •
90. perylene-d12 •
91. indeno(1,2,3-cd)pyrene •
92. dibenzo(a,h)anthracene •
93. benzo(ghi)perylene •

• 8270 MegaMix® components

Recommended Columns

Rxi™-5ms Columns (fused silica)

(Crossbond® 5% diphenyl / 95% dimethyl polysiloxane)

ID	df (µm)	temp. limits	length	cat. #
0.18mm	0.18	-60 to 330/350°C	20-Meter	13402
0.18mm	0.30	-60 to 330/350°C	20-Meter	13409
0.25mm	0.25	-60 to 330/350°C	30-Meter	13423
0.25mm	0.40	-60 to 330/350°C	30-Meter	13481

Rtx®-5Sil MS Columns (fused silica)

(Crossbond®, selectivity similar to 5% diphenyl/95% dimethyl polysiloxane)

ID	df (µm)	temp. limits	length	cat. #
0.18mm	0.18	-60 to 330/350°C	20-Meter	42702
0.18mm	0.36	-60 to 330/350°C	20-Meter	42704
0.25mm	0.25	-60 to 330/350°C	30-Meter	12723
0.25mm	0.50	-60 to 330/350°C	30-Meter	12738

Analytical Reference Materials

SV Internal Standard Mix

acenaphthene-d10 | naphthalene-d8
chrysene-d12 | perylene-d12
1,4-dichlorobenzene-d4 | phenanthrene-d10

2,000µg/mL each in methylene chloride, 1mL/ampul
cat. # 31206 (ea.)

4,000µg/mL each in methylene chloride, 1mL/ampul
cat. # 31006 (ea.)

B/N Surrogate Mix (4/89 SOW)

2-fluorobiphenyl | *p*-terphenyl-d14
nitrobenzene-d5

1,000µg/mL each in methylene chloride, 1mL/ampul
cat. # 31024 (ea.)

5,000µg/mL each in methylene chloride, 1mL/ampul
cat. # 31062 (ea.)

5,000µg/mL each in methylene chloride, 5mL/ampul
cat. # 31086 (ea.)

5,000µg/mL each in methylene chloride, 10mL/ampul
cat. # 33028 (ea.)

Acid Surrogate Mix (4/89 SOW)

2-fluorophenol | 2,4,6-tribromophenol
phenol-d6

2,000µg/mL each in methanol, 1mL/ampul
cat. # 31025 (ea.)

10,000µg/mL each in methanol, 1mL/ampul
cat. # 31063 (ea.)

10,000µg/mL each in methanol, 5mL/ampul
cat. # 31087 (ea.)

10,000µg/mL each in methylene chloride, 10mL/ampul
cat. # 33029 (ea.)

GC/MS Tuning Mixture

benzidine | DFTPP
4,4'-DDT | pentachlorophenol

1,000µg/mL each in methylene chloride, 1mL/ampul
cat. # 31615 (ea.)

605 Benzidines Calibration Mix

benzidine | 3,3'-dichlorobenzidine

2,000µg/mL each in methanol, 1mL/ampul
cat. # 31030 (ea.)

2,000µg/mL each in methylene chloride, 1mL/ampul
cat. # 31834 (ea.)

8270 Matrix Spike Mix (76 components)

200µg/mL each in methanol:methylene chloride (80:20), 5mL/ampul
cat. # 31687 (ea.)

8270 MegaMix® (76 components)

1,000µg/mL each in methylene chloride, 1mL/ampul, •
cat. # 31850 (ea.)

• Refer to figure for compound list

Inert Sample Path Increases Accuracy

Injection port liners are designed in many configurations, four of which are commonly used for semivolatiles analysis: the single gooseneck, double gooseneck, cyclo double gooseneck, and the Drilled Uniliner®. While all four liner types are used for 8270 analysis, we recommend the Drilled Uniliner® when using constant flow, and the cyclo double gooseneck with pressure pulse conditions.

Liners shown are for Agilent instruments; liners for other instrument brands also are available. For a complete list of liners and seals refer to our catalog or website.

Gooseneck Splitless (4mm)

4.0 ID 6.5 OD x 78.5 20799 5 pk.

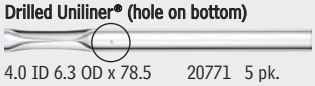
Cyclo Double Gooseneck (4mm)

4.0 ID 6.5 OD x 78.5 20896 5 pk.

Double Gooseneck Splitless (4mm)

4.0 ID 6.5 OD x 78.5 20785 5 pk.

Drilled Uniliner® (hole on bottom)



4.0 ID 6.3 OD x 78.5 20771 5 pk.

The Drilled Uniliner® is the most inert liner because the metal injection port outside the glass liner does not contact the sample path – the sample is virtually "funneled" into the column. Also, when using the Drilled Uniliner® inlet seals do not need to be replaced – a savings in maintenance cost and time. The cyclo double gooseneck liner is recommended with pressure pulse conditions. Its corkscrew type sample path enhances sample vaporization and helps prevent sample contact with metal surfaces below the liner. When using a gooseneck type liner, however, routinely replacing the inlet seal below the liner is critical. Gold plated and Siltek® treated liners and seals both ensure an inert sample path, however, Siltek® treated surfaces are more resistant to abrasion during cleaning.

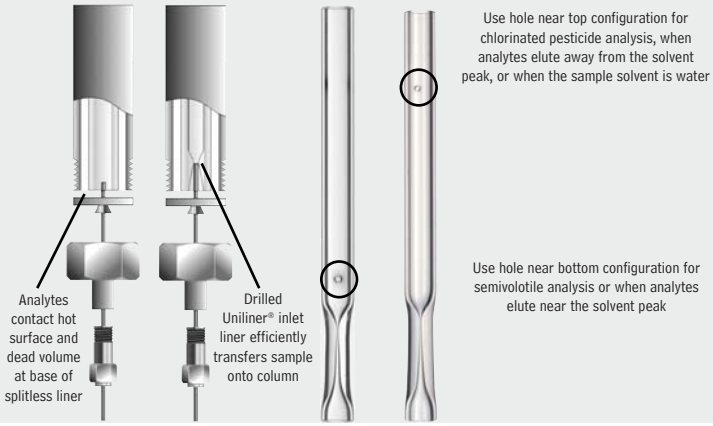
0.8mm ID Dual Vespel® Ring Inlet Seal

Siltek® Treated	21242	2-pk.
Stainless Steel	21238	2-pk.
Gold Plated	21240	2-pk.

restek **innovation**!

The Drilled Uniliner®

The Drilled Uniliner® provides the most inert sample pathway of all inlet liners for splitless injection techniques. This liner connects directly to the column, eliminating contact between the active compounds and active metal surfaces in the injector, and ensuring an inert sample pathway for analyte transfer from the injection port to the column.



Organochlorine Pesticides and PCB

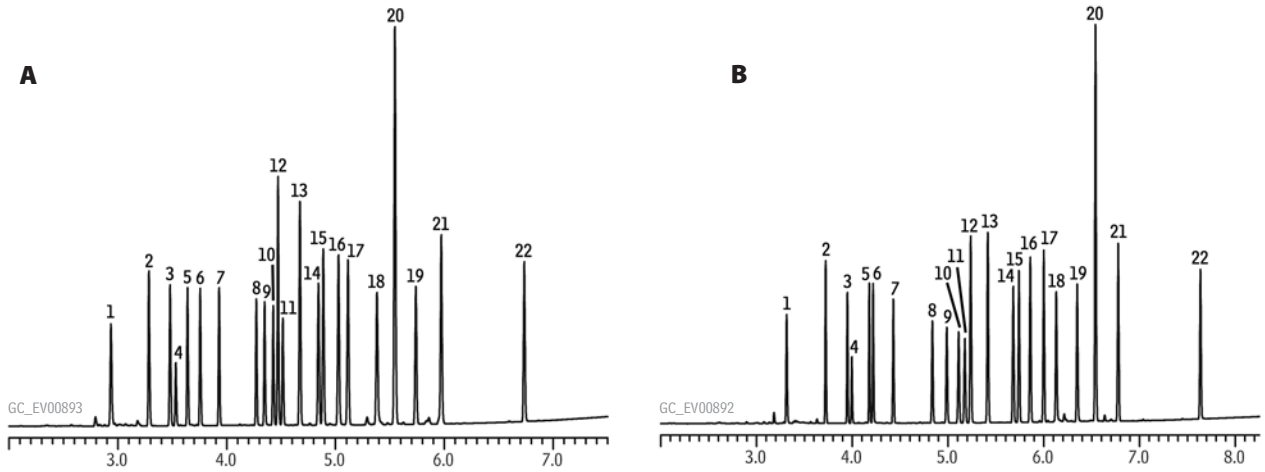
In organochlorine pesticide analysis, careful consideration of the instrument set-up and column choice can greatly improve sample throughput – reducing costs and saving time. The most critical aspects of the inlet system are inertness and efficiency of target analyte transfer to the analytical column. For pesticide and PCB analysis we recommend the Drilled Uniliner® for its unsurpassed inertness (see page 5).

In the analysis shown, 20m x 0.18mm ID Rtx®-CLPesticides and Rtx®-CLPesticides2 primary and confirmation columns were used. We connected a 5m x 0.53mm guard column to the dual analytical columns, using a SeCure™ "Y" connector kit. These columns have been specifically designed to resolve the chlorinated pesticides when used in parallel under the same temperature program and inlet backpressure. As shown in Figure 1, all the organochlorine pesticide compounds are baseline resolved in less than 8 minutes.

Figure 1 Organochlorine pesticides on Rtx®-CLPesticides and Rtx®-CLPesticides2 columns.

5%Column:	**A:** Rtx®-CLPesticides, 20m, 0.18mm ID, 0.18µm (cat.# 42102) and **B:** Rtx®-CLPesticides2, 20m, 0.18mm ID,0.14µm (cat.# 42302) with 5m x 0.53mm ID intermediate-polarity deactivated guard tubing (cat.# 10045), connected using SeCure™ "Y" Connector Kit (cat.# 20276) with Universal "Y" Press-Tight® Connector
Sample:	Organochlorine Pesticide Mix AB #2 (cat.# 32292), 8-80µg/mL each component in hexane/toluene, Pesticide Surrogate Mix (cat.# 32000), 200µg/mL each component in acetone
Inj.:	0.5µL splitless (hold 0.75 min.), 2mm single gooseneck inlet liner (cat.# 20796)
Inj. temp.:	250°C
Carrier gas:	helium, constant flow
Linear velocity:	20cm/sec. @ 140°C
Oven temp.:	140°C (hold 1 min.) to 250°C @ 35°C/min. (hold 1 min.) to 330°C @ 35°C/min. (hold 3 min.)
Det.:	ECD @ 350°C

1. 2,4,5,6-tetrachloro-m-xylene (surr.)
2. α-BHC
3. γ-BHC
4. β-BHC
5. δ-BHC
6. heptachlor
7. aldrin
8. heptachlor epoxide
9. γ-chlordane
10. α-chlordane
11. endosulfan I
12. 4,4' DDE
13. dieldrin
14. endrin
15. 4,4' DDD
16. endosulfan II
17. 4,4' DDT
18. endrin aldehyde
19. endosulfan sulfate
20. methoxychlor
21. endrin ketone
22. decachlorobiphenyl (surr.)



Recommended Columns

Rtx®-CLPesticides Columns (fused silica)

ID	df (µm)	temp. limits	length	cat. #
0.18mm	0.18	-60 to 310/330°C	20-Meter	42102
0.25mm	0.25	-60 to 320/340°C	30-Meter	11123
0.32mm	0.50	-60 to 320/340°C	30-Meter	11139
0.53mm	0.50	-60 to 300/320°C	30-Meter	11140

Rtx®-CLPesticides2 Columns (fused silica)

ID	df (µm)	temp. limits	length	cat. #
0.18mm	0.14	-60 to 310/330°C	20-Meter	42302
0.25mm	0.20	-60 to 320/340°C	30-Meter	11323
0.32mm	0.50	-60 to 320/340°C	30-Meter	11325
0.53mm	0.42	-60 to 300/320°C	30-Meter	11340

Analytical Reference Materials

Organochlorine Pesticide Mix AB #1

(20 components)

aldrin	dieldrin
α-BHC	endosulfan I
β-BHC	endosulfan II
δ-BHC	endosulfan sulfate
γ-BHC (lindane)	endrin
α-chlordane	endrin aldehyde
γ-chlordane	endrin ketone
4,4'-DDD	heptachlor
4,4'-DDE	heptachlor epoxide (B)
4,4'-DDT	methoxychlor

200μg/mL each in hexane:toluene (1:1), 1mL/ampul
cat. # 32291 (ea.)

Organochlorine Pesticide Mix AB # 3

(20 components)
same listing as Organochlorine Pesticide Mix AB #1, shown above.

2,000μg/mL each in hexane:toluene (1:1), 1mL/ampul
cat. # 32415 (ea.)

Pesticide Surrogate Mix

decachlorobiphenyl 2,4,5,6-tetrachloro-*m*-xylene
200μg/mL each in acetone, 1mL/ampul
cat. # 32000 (ea.)

Pesticide Surrogate Mix

decachlorobiphenyl 200μg/mL
2,4,5,6-tetrachloro-*m*-xylene 100
In P&T methanol, 1mL/ampul
cat. # 32453 (ea.)

Organochlorine Pesticide System Evaluation Mix

4,4'-DDT 200μg/mL endrin 100μg/mL
In MTBE, 1mL/ampul
cat. # 32417 (ea.)

508.1 GC Degradation Check Mix

4,4'-DDT endrin
100μg/mL each in ethyl acetate, 1mL/ampul
cat. # 32093 (ea.)

Technical Chlordane, Toxaphene Solutions

Compound	cat.# (ea.)
1,000μg/mL in hexane, 1mL/ampul	
chlordane (technical)	32021
toxaphene	32005
2,000μg/mL in methanol, 1mL/ampul	
chlordane (technical)	32016
toxaphene	32015
5,000μg/mL in isooctane, 1mL/ampul	
chlordane (technical)	32072
toxaphene	32071

also **available**

Aroclor® Solutions!
Visit our website, see our newest catalog, or call your Restek representative for details.

Increase Sample Throughput Using Dual Analytical Columns and a "Y" Connector Union

Most laboratories need to confirm the compound identification obtained on one column with a second column of different selectivity. This is best achieved by making a single injection onto a guard column which is connected to two analytical columns, using a "Y" splitter. This allows data to be collected from both columns simultaneously, allowing samples to be processed without waiting for the confirmation result.

Rtx®-CLPesticides Column Kits

0.25mm ID Rtx®-CLPesticides Kit cat.# 11199 (kit),

Includes:	cat.#
30m, 0.25mm ID, 0.25μm Rtx®-CLPesticides Column	11123
30m, 0.25mm ID, 0.20μm Rtx®-CLPesticides2 Column	11323
Universal Angled "Y" Press-Tight® Connector	20403
5m, 0.25mm ID Siltek® Guard Column	10026

0.32mm ID Rtx®-CLPesticides Kit cat.# 11198 (kit),

Includes:	cat.#
30m, 0.32mm ID, 0.50μm Rtx®-CLPesticides Column	11139
30m, 0.32mm ID, 0.25μm Rtx®-CLPesticides2 Column	11324
Universal Angled "Y" Press-Tight® Connector	20403
5m, 0.32mm ID Siltek® Guard Column	10027

0.53mm ID Rtx®-CLPesticides Kit cat.# 11197 (kit),

Includes:	cat.#
30m, 0.53mm ID, 0.50μm Rtx®-CLPesticides Column	11140
30m, 0.53mm ID, 0.42μm Rtx®-CLPesticides2 Column	11340
Universal Angled "Y" Press-Tight® Connector	20403
5m, 0.53mm ID IP Deactivated Guard Column	10045

"Y" connectors

"Y" connectors are available in both metal and glass. Glass connectors offer the best chromatography, but are prone to leaks. To eliminate leaks we developed the SeCure™ "Y" connector, which takes advantage of our Press-Tight® connector and adds mechanical strength to hold the columns in place. A second connector, the MXT™ "Y"-Union, is available for fused silica columns.

SeCure™ "Y" - The most secure connector available!

Kits include: SeCure™ "Y" connector body, 3 knurled nuts, "Y" Universal Press-Tight® union, 3 ferrules.

Ferrules Fit Column ID	qty.	cat.#
0.25/0.28mm	kit	20276
0.32mm	kit	20277
0.45/0.53mm	kit	20278

MXT™ "Y"-Union Connector Kits for Fused Silica Columns

Each kit contains the MXT™ union, three 1/32-inch nuts and three one-piece fused silica adaptors.

Description	qty.	cat.#
For 0.25mm ID Fused Silica Columns	kit	21389
For 0.32mm ID Fused Silica Columns	kit	21388
For 0.53mm ID Fused Silica Columns	kit	21387

Volatile Organic Compounds in Air

One of the most widely used VOC methods for ambient air monitoring specifies sample collection with a specially prepared stainless steel canister, followed by GC/MS analysis. Restek can support all facets of your air monitoring program – from state-of-the-art sampling equipment to high quality analytical reference standards.

An inert canister surface is critical to obtaining accurate sample results. Restek offers a complete line of TO-Cans™ (Summa® canisters) which are electropolished and extensively cleaned prior to shipping to ensure a high-quality passivated surface for improved analyte stability. No weld marks on the spheres further reduce the occurrence of active sites. For reactive compounds, such as sulfur-containing components, a SilcoCan™ is your best canister choice. SilcoCan™ canisters are deactivated with Siltek® surface treatment resulting in exceptional inertness and maximum sample stability, even for low level sulfur compounds.

Optional gauge

- Quickly confirm vacuum or pressure inside canister.
- Monitor pressure changes.
- Fully protected by canister frame.
- Can be heated to 90°C during cleaning.

Siltek® tee

High-quality vacuum gauge

Enhanced valve and canister bracket
Canister holder and valve bracket protect canister, tube stub, and valve.

2-3 Port high quality valve
Metal-to-metal seal, 2/3 turn with stainless steel diaphragm.

We consider your TO-Cans™ and SilcoCans™ to be an investment and offer check-ups and reconditioning when needed.

Serial-controlled label
For quick, sure identification.

TO-Can™ Air Monitoring Canisters

Optimized for US EPA Methods TO-14 and TO-15, and ASTM D5466

Description	qty.	cat.#
6L Volume*		
TO-Can™ Canister, 1/4" Valve	ea.	24174
TO-Can™ Canister with Gauge, 1/4" Valve	ea.	24178
TO-Can™ Canister with No Valve	ea.	22096

SilcoCan™ Air Monitoring Canisters

Ideal for low-level reactive sulfur (1-20ppb), TO-14, or TO-15 compounds

Description	qty.	cat.#
6L Volume*		
SilcoCan™ Canister, 1/4" Valve	ea.	24182
SilcoCan™ Canister, Siltek® Treated 1/4" Valve	ea.	24182-650
SilcoCan™ Canister with Gauge, 1/4" Valve	ea.	24142
SilcoCan™ Canister with Gauge, Siltek® Treated 1/4" Valve	ea.	24142-650
SilcoCan™ Canister with No Valve	ea.	22092
Replacement 1/4" Valves for Air Monitoring Canisters		
1/4" Replacement Valve (2-port)	ea.	24145
1/4" Siltek® Replacement Valve (2-port)	ea.	24144
1/4" Replacement Valve (3-port)	ea.	24147
1/4" Siltek® Replacement Valve (3-port)	ea.	24146

Restek canisters are originally equipped with high-quality Parker Hannifin diaphragm valves. Each valve is helium leak-tested to 4 x 10^{-9}cc/sec. The all-stainless steel construction eliminates contamination and withstands temperatures from -100°C to 250°C. Compression outlet fitting, indicator plate to display open or closed position, 1/4" inlet and outlet.

All configurations also available in 1L, 3L, and 15L volumes.

Recommended Columns

Rxi™-1ms Columns (fused silica)

(Crossbond® 100% dimethyl polysiloxane)

ID	df (µm)	temp. limits	length	cat. #
0.32mm	1.00	-60 to 330/350°C	60-Meter	13357

Analytical Reference Materials

TO-15 62 Component Mix (62 components)

Cylinder Construction:	aluminum
Cylinder Size:	8 x 24 cm.
Volume/Pressure:	104 liters of gas @ 1800psig
Cylinder Fitting:	CGA-180 outlet
Weight:	1.5 lbs./0.7 kg

acetone
benzene
benzyl chloride*
bromodichloromethane
bromoform
bromomethane
1,3-butadiene
2-butanone (MEK)
carbon disulfide*
carbon tetrachloride
chlorobenzene
chloroethane
chloroform
chloromethane
cyclohexane
dibromochloromethane
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
1,1-dichloroethane
1,2-dichloroethane
1,1-dichloroethene
cis-1,2-dichloroethene
trans-1,2-dichloroethene
1,2-dichloropropane
cis-1,3-dichloropropene
trans-1,3-dichloropropene
1,4-dioxane
ethanol*
ethyl acetate
ethyl benzene
ethylene dibromide (1,2-dibromoethane)
4-ethyltoluene
trichlorofluoromethane (Freon® 11)
dichlorodifluoromethane (Freon® 12)
1,1,2-trichloro-1,2,2-trifluoroethane (Freon® 113)
1,2-dichlorotetrafluoroethane (Freon® 114)
heptane
hexachloro-1,3-butadiene
hexane
2-hexanone (MBK)
4-methyl-2-pentanone (MIBK)
methylene chloride
methyl *tert*-butyl ether (MTBE)
2-propanol
propylene
styrene
1,1,2,2-tetrachloroethane
tetrachloroethene
tetrahydrofuran
toluene
1,2,4-trichlorobenzene
1,1,1-trichloroethane
1,1,2-trichloroethane
trichloroethene
1,2,4-trimethylbenzene
1,3,5-trimethylbenzene
vinyl acetate
vinyl chloride
m-xylene
o-xylene
p-xylene

In nitrogen, 104 liters @ 1800psig

1ppm	cat. # 34436 (ea.)
100ppb	cat. # 34437 (ea.)

*Stability of this compound cannot be guaranteed.

TO-14A Internal Standard/Tuning Mix

Cylinder Construction:	aluminum
Cylinder Size:	8 x 24 cm.
Volume/Pressure:	104 liters of gas @ 1800psig
Cylinder Fitting:	CGA-180 outlet
Weight:	1.5 lbs./0.7 kg

bromochloromethane
1-bromo-4-fluorobenzene (4-bromofluorobenzene)
chlorobenzene-d5
1,4-difluorobenzene

In nitrogen, 104 liters @ 1800psig

1ppm	cat. # 34408 (ea.)
100ppb	cat. # 34425 (ea.)

Simplify Sampling, Increase Accuracy & Efficiency

Air Canister Heating Jacket

Our heating jackets can help you prepare your canisters for sampling faster and more efficiently. The jacket's novel design ensures complete cleaning by heating the canister and valve together and prevents condensation, ensuring more accurate results. Two temperature settings, 75ºC and 150ºC. Fits all canisters up to 6L in size.

Description	qty.	cat.#
Air Canister Heating Jacket	ea.	24123

*Not CE certified.

The ultimate in controlled heating, for reliably cleaning your air canisters!

Passive Air Sampling Kits

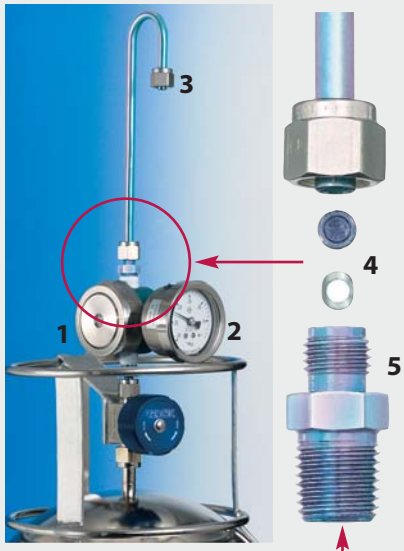
Our passive sampling kits include all hardware required for field sampling (except the canister) and assemble easily. Our kit was designed to reduce the number of potential leak sites and is available in seven flow ranges, and in stainless steel or with Siltek® surface treatment. Individual parts are also available.

1. Veriflo™ SC423XL flow controller
This flow controller is the heart of the sampling train. It is a high-quality device designed to maintain a constant mass flow as the pressure changes from 30" Hg to 5" Hg (we recommend you stop sampling at or before 5" Hg of vacuum). All wetted parts of the flow controller can be Siltek® treated.

2. Stainless steel vacuum gauge
Fitted to the flow controller, the gauge monitors canister vacuum change during sampling.

3. ¼-inch Siltek® sample inlet
The 0.3m x ¼-inch tubing includes a stainless steel nut on the inlet end, to prevent water droplets from accumulating at the edge of the tubing, where they could be pulled into the sampling train.

4. 2-micron frit filter and washer
Located prior to the critical orifice to prevent airborne particles from clogging the critical orifice. Replaceable. Available in stainless steel, or Siltek® treated for optimum inertness.



All fitting connections are ¼" tube, except where noted.

¼" NPT

See our catalog for other canister volumes and sampling times.

5. Interchangeable critical orifice
An interchangeable ruby critical orifice allows you to control the flow with very high precision. To select the correct critical orifice for your sample, see table below. Available in stainless steel, or Siltek® treated for optimum inertness.

Sampling Time 6 Liter	Flow (sccm)	Orifice size	Siltek® Treated Sampling Kits*	Stainless Steel Sampling Kits*
125 hour	0.5–2	0.0008"	24217	24216
24 hour	2–4	0.0012"	24160	24165
12 hour	4–8	0.0016"	24161	24166
8 hour	8–20	0.0020"	24162	24167
3 hour	20–40	0.0030"	24163	24168
1.5 hour	40–80	0.0060"	24164	24169
0.5 hour	80–350	0.0090"	22101	22100

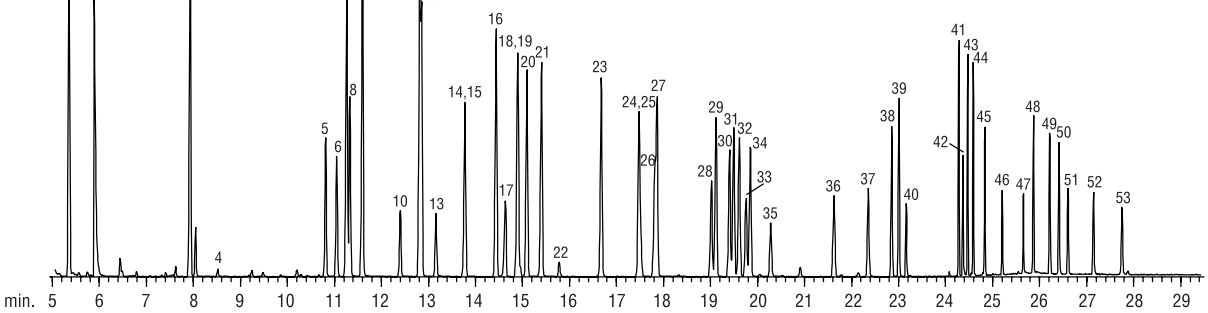
*Air sampling canisters sold separately. Available in 400cc, 1L, 3L, 6L, and 15L volumes.

Organophosphorus Pesticides

Organophosphorus pesticides (OPPs) are commonly used as insecticides, fungicides, and herbicides. Due to their widespread use however, they have become an environmental concern. We reccommend the Rtx®-OPPesticides2 column for separating organophosphorus pesticides (OPP). Separation is improved, and analysis time is significantly reduced, compared to other columns. The extended upper temperature limit of this phase (330°C) allows analysts to bake out high molecular weight contamination typically associated with pesticide samples. The low bleed column is a perfect match for sensitive detection systems.

Figure 1 Organophosphorus pesticides on an Rtx®-OPPesticides2 column.

1. dichlorvos
2. hexamethylphosphoramide
3. mevinphos
4. trichlorfon
5. TEPP
6. demeton-O
7. thionazin
8. tributyl phosphate (IS)
9. ethoprop
10. naled
11. sulfotepp
12. phorate
13. dicrotophos
14. demeton-S
15. monocrotophos
16. terbufos
17. dimethoate
18. dioxathion
19. fonophos
20. diazinon
21. disulfoton
22. phosphamidon isomer
23. dichlorofenthion
24. chlorpyrifos methyl
25. phosphamidon
26. parathion-methyl
27. ronnel
28. fenitrothion
29. aspon
30. malathion
31. chlorpyrifos
32. trichloronate
33. parathion-ethyl
34. fenthion
35. merphos
36. chlorfenvinphos
37. crotoxyphos
38. stirofos
39. tokuthion
40. merphos oxone (breakdown product)
41. ethion
42. fensulfothion
43 bolstar
44. carbophenothion
45. famphur
46. triphenyl phosphate (SS)
47. EPN
48. phosmet
49. leptophos
50. tri-*o*-cresyl phosphate
51. azinphos-methyl
52. azinphos-ethyl
53. coumaphos



GC_EV00602

Column:	Rtx®-OPPesticides2, 30m, 0.25mm ID, 0.25µm (cat.# 11243)	Inj. temp.:	250°C
Sample:	US EPA Method 8141A Custom Standard Mix 1µL 100ppm (100ng on column) Triphenylphosphate Standard (cat.# 32281) Tributylphosphate Standard (cat.# 32280) 8140/8141 OP Pesticides Calibration Mix A (cat.# 32277) 8141 OP Pesticides Calibration Mix B (cat.# 32278) *Custom Mixes: Call Restek for Information*	Carrier gas:	helium, constant flow
		Flow rate:	1.0mL/min.
		Oven temp.:	80°C (hold 0.5 min.) to 140°C @ 20°C/min. to 210°C @ 4°C/min. (hold 1 min.) to 280°C @ 30°C (hold 5 min.)
		Det:	MS
Inj.:	1.0µL splitless (hold 0.4 min.), 4mm double gooseneck inlet liner (cat.# 20785)	Transfer line temp.:	280°C
		Scan range:	35-400amu
		Ionization:	EI

Recommended Columns

Rtx®-OPPesticides2 Columns (fused silica)

ID	df (µm)	temp. limits	length	cat. #
0.18mm	0.20	-20 to 310/330°C	20-Meter	11244
0.25mm	0.25	-20 to 310/330°C	30-Meter	11243
0.32mm	0.32	-20 to 310/330°C	30-Meter	11241
0.53mm	0.50	-20 to 310/330°C	30-Meter	11242

Sample Preparation

CarboPrep™ Cartridges

SPE Cartridge	Tube Volume, Bed Weight	qty.	cat#
CarboPrep™ 90	3mL, 250mg	50-pk.	26091
CarboPrep™ 90	6mL, 500mg	30-pk.	26092

Excellent for Pesticide Residue Cleanup!

Carbamates by HPLC

Carbamates are widely used insecticides that pose a health risk as endocrine disruptors. Our Ultra Carbamate column, in a 50mm length, separates common carbamates in less than 10 minutes (Figure 1), significantly less than the time required by traditional C18 columns. In addition to the best column choice for the analysis, we offer reference mixes for Method 531 carbamates, a performance check mix, and the specified internal standard, 4-bromo-3,5-dimethylphenyl-N-methylcarbamate (BDMC).

Figure 1 Carbamate pesticides on an Ultra Carbamate column.

Peak List:
1. aldicarb sulfone
2. aldicarb sulfoxide
3. oxamyl
4. methomyl
5. 3-hydroxycarbofuran
6. aldicarb
7. propoxur
8. carbofuran
9. carbaryl
10. methiocarb
11. 4-bromo-3,5-dimethylcarbamate

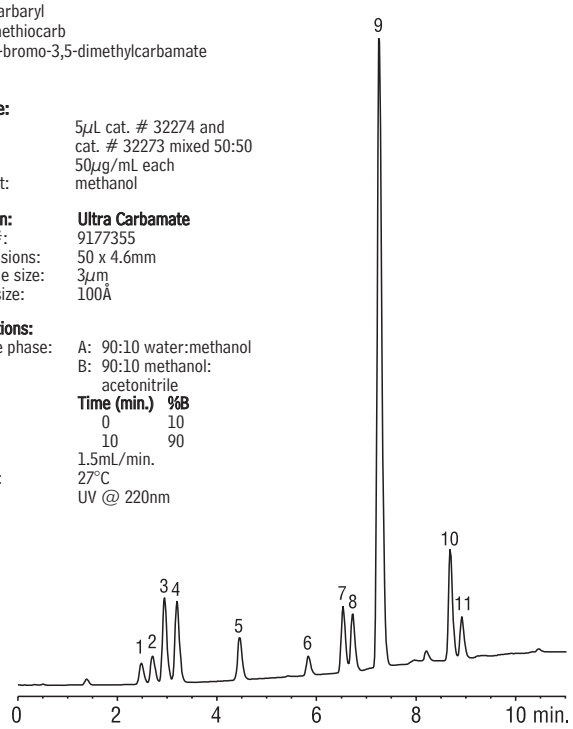
Sample:
Inj.: 5µL cat. # 32274 and cat. # 32273 mixed 50:50
Conc.: 50µg/mL each
Solvent: methanol

Column: Ultra Carbamate
Cat. #: 9177355
Dimensions: 50 x 4.6mm
Particle size: 3µm
Pore size: 100Å

Conditions:
Mobile phase: A: 90:10 water:methanol
B: 90:10 methanol: acetonitrile

Time (min.)	%B
0	10
10	90

Flow: 1.5mL/min.
Temp.: 27°C
Det.: UV @ 220nm



LC_0225

free literature

Simple, Sensitive HPLC/UV Analysis for Paraquat and Diquat

These highly charged quaternary amines are poorly retained on alkyl stationary phases. Using only acetonitrile, water, and a solvation-blocking reagent, our separation system alters the interactions among analyte, mobile phase, and stationary phase, and promotes solubility of the analytes in the stationary phase. In our system, the detection limit is 6ppb for either herbicide, and the analysis is completed in less than 10 minutes. An optimized solid phase extraction cartridge concentrates the herbicides for the analysis.

Lit. cat. # 580006

Recommended Columns

Ultra Carbamate Columns

Physical Characteristics:

particle size: 3µm or 5µm, spherical
pore size: 100Å
pH range: 2.5 to 7.5
temperature limit: 80°C

3µm Column	cat. #
50mm (2.1mm ID)	9177352
50mm (4.6mm ID)	9177355
5µm Column	**cat. #**
250mm (4.6mm ID)	9177575

*For post-column derivatization / fluorescence detection applications for a 4.6mm ID column the total system dead volume, including the post-column reactor, must be less than 650µL. For standard post-column reactor systems, we recommend a 250 x 4.6mm, 5µm column. Call Restek technical service for more information.

ordering note
For guard cartridges for these columns, visit our website at www.restek.com.

Analytical Reference Materials

531.1 Carbamate Pesticide Calibration Mixture

(10 components)

aldicarb
aldicarb sulfone
aldicarb sulfoxide
carbaryl (Sevin®)
carbofuran
3-hydroxycarbofuran
methiocarb
methomyl
oxamyl
propoxur (Baygon®)

100µg/mL each in methanol, 1mL/ampul
cat. # 32273 (ea.)

531.2 Carbamate Pesticide Calibration Mixture

(11 components)

aldicarb
aldicarb sulfone
aldicarb sulfoxide
carbaryl (Sevin®)
carbofuran
3-hydroxycarbofuran
methiocarb
methomyl
1-naphthol
oxamyl
propoxur (Baygon®)

100µg/mL in acetonitrile, 1mL/ampul
cat. # 32435 (ea.)

Internal Standard

4-bromo-3,5-dimethylphenyl-N-methylcarbamate (BDMC)
100µg/mL in methanol, 1mL/ampul
cat. # 32274 (ea.)

531.1 Performance Check Mix

aldicarb sulfoxide	100µg/mL	3-hydroxycarbofuran	2
BDMC	10	methiocarb	20

In methanol, 1mL/ampul
cat. # 32275 (ea.)

Polyaromatic Hydrocarbons (PAHs) by HPLC

Most HPLC PAH methods recommend using a C18 column with fluorescence and/or UV/VIS detection. Our Pinnacle™ II PAH columns have a highly reproducible modified alkyl phase on Restek manufactured silica, specifically developed for this application. Figure 1 shows the analysis of 16 target PAHs in less than 18 minutes, and Figure 2 shows a separation of 20 target PAHs and related compounds, in less than 6 minutes, using a 5cm column.

Figure 1 Baseline separation of 16 PAHs in less than 18 minutes on a Pinnacle™ II PAH column.

Sample:
Inj.: 5µL
Solvent: 1:9 methylene chloride:acetonitrile

Column: Pinnacle™ II PAH (Cat. # 9219563)
150mm x 3.2mm ID

Conditions:
Mobile phase: A: water, B: acetonitrile

Time (min.)	%B
0	40
7	60
11	100
17.9	100
18	40

Flow: 1.2 mL/min.
Temp.: ambient
Det.: UV @ 254nm

Peak List:	Conc. (µg/mL)
1. naphthalene	100
2. acenaphthylene	100
3. acenaphthene	100
4. fluorene	100
5. phenanthrene	50
6. anthracene	100
7. fluoranthene	50
8. pyrene	50
9. benzo(a)anthracene	50
10. chrysene	50
11. benzo(b)fluoranthene	50
12. benzo(k)fluoranthene	50
13. benzo(a)pyrene	50
14. dibenzo(a,h)anthracene	50
15. benzo(ghi)perylene	50
16. indeno(1,2,3-cd)pyrene	50

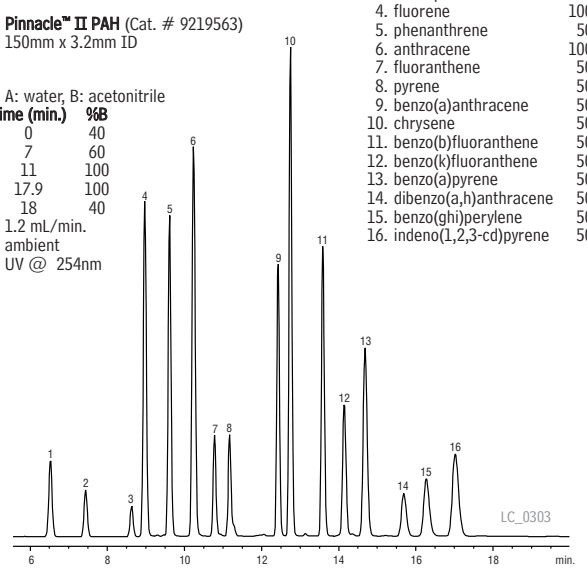


Figure 2 Fast, efficient separation of 20 target PAHs and related compounds using a 5cm Pinnacle™ II PAH column.

Sample:
Inj.: 5µL
Conc.: 5-10ppm each
Sample diluent: methylene chloride:acetonitrile (1:9 v/v)

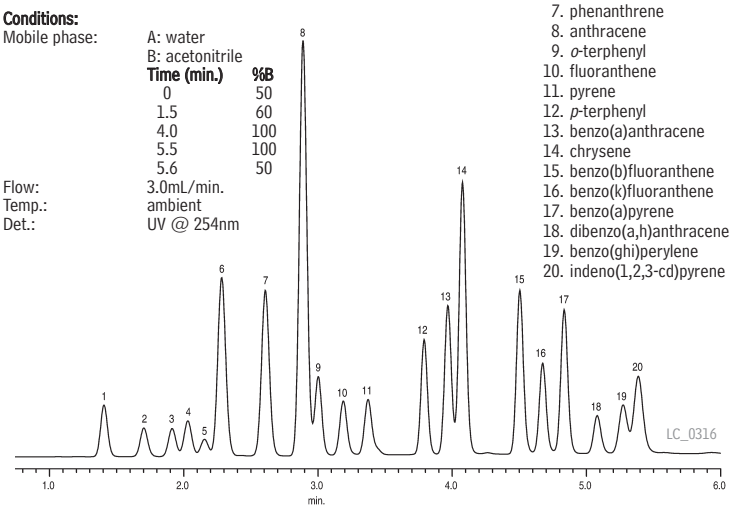
Column: Pinnacle™ II PAH (Cat. # 9219555)
50mm x 4.6mm ID

Conditions:
Mobile phase: A: water
B: acetonitrile

Time (min.)	%B
0	50
1.5	60
4.0	100
5.5	100
5.6	50

Flow: 3.0mL/min.
Temp.: ambient
Det.: UV @ 254nm

Peak List:
1. naphthalene
2. acenaphthylene
3. 1-methylnaphthalene
4. 2-methylnaphthalene
5. acenaphthene
6. fluorene
7. phenanthrene
8. anthracene
9. *o*-terphenyl
10. fluoranthene
11. pyrene
12. *p*-terphenyl
13. benzo(a)anthracene
14. chrysene
15. benzo(b)fluoranthene
16. benzo(k)fluoranthene
17. benzo(a)pyrene
18. dibenzo(a,h)anthracene
19. benzo(ghi)perylene
20. indeno(1,2,3-cd)pyrene



Recommended Columns

Pinnacle™ II PAH Columns

Physical Characteristics:

particle size: 5µm, spherical
pore size: 110Å
endcap: fully endcapped
pH range: 2.5 to 10
temperature limit: 80°C

5µm Column	cat. #
50 x 2.1mm	9219552
50 x 3.2mm	9219553
150 x 3.2mm	9219563
50 x 4.6mm	9219555
150 x 4.6mm	9219565
10 x 2.1mm	921950212
10 x 4.0mm	921950210
20 x 2.1mm	921950222
20 x 4.0mm	921950220

ordering note
For guard cartridges for these columns, visit our website at **www.restek.com**.

Analytical Reference Materials

EPA Method 8310 PAH Mixture (18 components)

acenaphthene
acenaphthylene
anthracene
benzo(a)anthracene
benzo(a)pyrene
benzo(b)fluoranthene
benzo(ghi)perylene
benzo(k)fluoranthene
chrysene
dibenzo(a,h)anthracene
fluoranthene
fluorene
indeno(1,2,3-cd)pyrene
1-methylnaphthalene
2-methylnaphthalene
naphthalene
phenanthrene
pyrene

500µg/mL each in acetonitrile, 1mL/ampul
cat. # 31841 (ea.)

EPA Method 8310 Quality Control Check

(18 components)

acenaphthene	100µg/mL	dibenzo(a,h)anthracene	10
acenaphthylene	100	fluoranthene	10
anthracene	100	fluorene	100
benzo(a)anthracene	10	indeno(1,2,3-cd)pyrene	10
benzo(a)pyrene	10	1-methylnaphthalene	100
benzo(b)fluoranthene	10	2-methylnaphthalene	100
benzo(ghi)perylene	10	naphthalene	100
benzo(k)fluoranthene	5	phenanthrene	100
chrysene	10	pyrene	10

In acetonitrile, 1mL/ampul
cat. # 31843 (ea.)

EPA Method 8310 Surrogate Standard

decafluorobiphenyl
1,000µg/mL in acetonitrile, 1mL/ampul
cat. # 31842 (ea.)

free literature

Environmental Flyer
HPLC analyses described in this 8-page publication include carbamates, carbonyls, explosives, paraquat/diquat, phenoxyacid herbicides, and polyaromatic hydrocarbons.

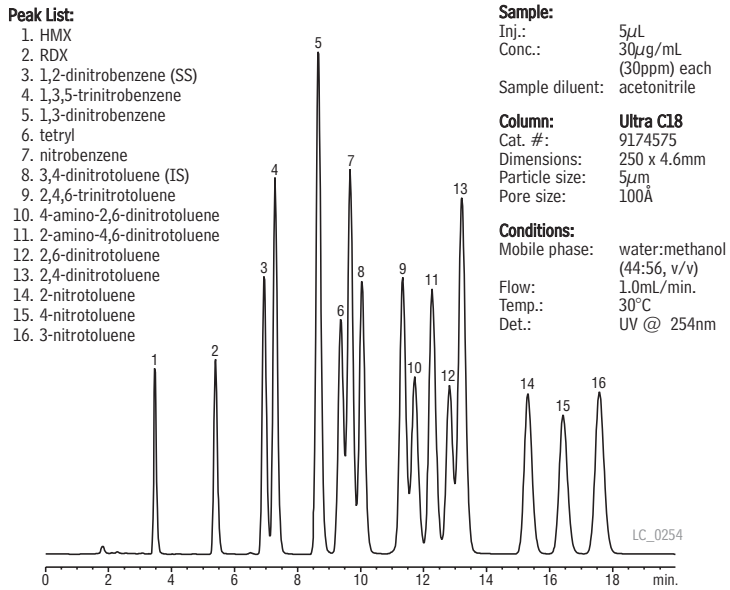
Lit. cat. # 59741A

Explosives by HPLC

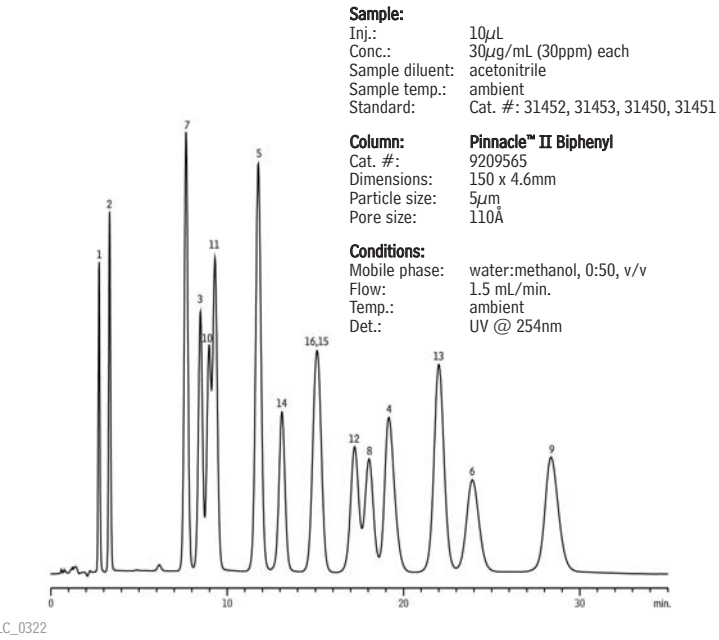
Common methods for quantifying explosives call for reversed phase HPLC with UV detection, using a primary column and a confirmation column. While cyano phases typically have been used for the confirmation column, resolution of the target explosive compounds is poor. The Pinnacle™ II Biphenyl column provides excellent resolution of Method 8330 explosives, as shown in Figure 1, and selectivity is markedly different from C18 phases, making the Pinnacle™ II Biphenyl column an ideal confirmation column. If a cyano phase must be used for confirmation, we recommend a Pinnacle™ II Cyano column.

Figure 1 An outstanding column pair for explosives analysis.

For superior performance, use an Ultra C18 primary column...



...coupled with a Pinnacle II™ Biphenyl column.



Recommended Columns

Ultra C18 Columns (USP L1)

Physical Characteristics:

particle size: 3µm or 5µm, spherical
pore size: 100Å
carbon load: 20%
endcap: fully endcapped
pH range: 2.5 to 7.5
temperature limit: 80°C

5µm Column, 4.6mm	cat. #
150mm	9174565
250mm	9174575

Pinnacle™ II Biphenyl Columns (USP L11)

Physical Characteristics:

particle size: 5µm, spherical
pore size: 110Å
endcap: yes
pH range: 2.5 to 7.5
temperature limit: 80°C

5µm Column, 4.6mm	cat. #
150mm	9209565
250mm	9209575

ordering note
For guard cartridges for these columns, visit our website at **www.restek.com**.

Analytical Reference Materials

Nitroaromatics and Nitramine Explosives by HPLC (14 components)

1,3-dinitrobenzene
2-amino-4,6-dinitrotoluene
4-amino-2,6-dinitrotoluene
2,4-dinitrotoluene
2,6-dinitrotoluene
HMX
nitrobenzene
2-nitrotoluene
3-nitrotoluene
4-nitrotoluene
RDX
tetryl
1,3,5-trinitrobenzene
2,4,6-trinitrotoluene

1,000µg/mL each in acetonitrile, 1mL/ampul
cat. # 33905 (ea.)

8095 Internal Standard

3,4-dinitrotoluene
1,000µg/mL in methanol, 1mL/ampul
cat. # 31452 (ea.)

8330 Surrogate

1,2-dinitrobenzene
1,000µg/mL in methanol, 1mL/ampul
cat. # 31453 (ea.)

free literature

HPLC Analysis of Trace-Level Explosives Using Pinnacle II™ C18 and Cyano Columns
Pinnacle II™ C18 reversed phase columns and Pinnacle II™ Cyano normal phase columns are effective primary and confirmation columns for analyzing explosives according to US EPA Method 8330A. Analytical conditions and example chromatograms are presented in this 2-page note. Per recommendation in the method, the same mobile phase is used for the primary and confirmation analysis.

Lit. cat. # 59361

Environmental Essentials

COLUMN INSTALLS THIS END

Direct Injection Liners - What's a drilled uniliner? See page 5.

Description	ID*/OD & Length (mm)	cat.# ea.	cat.# 5-pk.
DI Liners for Agilent 5890 & 6890 GCs (For 0.25/0.32/0.53mm ID Columns)			
Drilled Uniliner® ▲	4.0 ID 6.3 OD x 78.5	21054	21055
Siltek® Drilled Uniliner® ▲	4.0 ID 6.3 OD x 78.5	21054-214.1	21055-214.5
Drilled Uniliner® ▼	4.0 ID 6.3 OD x 78.5	20756	20771
Double Gooseneck Drilled Uniliner® ▲	4.0 ID 6.3 OD x 78.5	20508	20509
Double Gooseneck Drilled Uniliner® ▼	4.0 ID 6.3 OD x 78.5	20954	20989
Siltek® 1mm Drilled Uniliner® ▲	1.0 ID 6.3 OD x 78.5	21390-214.1	21391-214.5
DI Liners for Varian 1177 GCs (For 0.25/0.32/0.53mm ID Columns)			
Drilled Uniliner® ▲	4.0 ID 6.3 OD x 78.5	21470	21471
Drilled Uniliner® ▼	4.0 ID 6.3 OD x 78.5	21468	21469
DI Liners for Shimadzu 17A, 2010, and 2014 GCs (For 0.32/0.53mm ID Columns)			
Open-top Drilled Uniliner® ▲	3.5 ID 5.0 OD x 95	21285	21286
Open-top Drilled Uniliner® ▼	3.5 ID 5.0 OD x 95	21287	21288
Gooseneck Drilled Uniliner® ▲	3.5 ID 5.0 OD x 95	21289	21290
Gooseneck Drilled Uniliner® ▼	3.5 ID 5.0 OD x 95	21291	21292
DI Liners for PerkinElmer GCs (For 0.32/0.53mm ID Columns)			
Auto SYS™ Drilled Uniliner® ▲	4.0 ID 6.2 OD x 92.1	20819	20822
Auto SYS™ Drilled Uniliner® ▼	4.0 ID 6.2 OD x 92.1	21293	21294
Auto SYS™ Gooseneck Drilled Uniliner® ▲	4.0 ID 6.2 OD x 92.1	21295	21296
Auto SYS™ Gooseneck Drilled Uniliner® ▼	4.0 ID 6.2 OD x 92.1	21297	21298
Direct Injection Liners for Thermo Electron TRACE™ & Focus SSL (0.32 & 0.53mm ID columns)			
Drilled Uniliner® ▲	5.0 ID 8.0 OD x 105	22411	22412
Drilled Uniliner® ▼	5.0 ID 8.0 OD x 105	22413	22414

*Nominal ID at syringe needle expulsion point. ▲ Hole on top. ▼ Hole on bottom.

O-Rings

	Max. temp.	qty.	cat.#
A) Viton® O-Rings for Agilent GCs			
	250°C	25-pk.	20377
B) Graphite O-rings for Agilent & Varian split liners (6.35mm ID)			
	450°C	10-pk.	20296
B) Graphite O-rings for Agilent & Varian splitless liners (6.5mm ID)			
	450°C	10-pk.	20298
C) 5mm Graphite Liner Seals for Varian 1078/1079 GCs			
	450°C	10-pk.	22683
D) Viton® O-Rings for Shimadzu 17A, 2010, and 2014 GCs			
	250°C	10-pk.	21477
E) Graphite O-Rings for Shimadzu 17A, 2010, & 2014 Split Liners			
	450°C	5-pk.	20243
E) Graphite O-Rings for Shimadzu 17A, 2010, & 2014 Splitless Liners			
	450°C	5-pk.	20244
F) Silicone O-Rings for PerkinElmer Auto SYS™ GCs			
	250°C	10-pk.	20262
G) Viton® O-Rings for PerkinElmer PSS			
	250°C	10-pk.	20366
H) Inlet Liner Seals for TRACE™ PTV			
	450°C	2-pk.	21392
I) Graphite Sealing Ring for TRACE™ and Focus SSL Instruments			
	450°C	ea.	21898
I) Graphite Sealing Rings for TRACE™ and Focus SSL Instruments			
	450°C	2-pk.	21899

Restek Septa

- Precision molding assures consistent, accurate fit.
- Ready to use.
- Do not adhere to hot metal surfaces.
- Packaged in non-contaminating glass jars.

Septum Diameter	25-pk.	50-pk.	100-pk.
Thermolite® Septa			
5mm (3/16")	27120	27121	27122
6mm (1/4")	27123	27124	27125
7mm	27126	27127	27128
8mm	27129	27130	27131
9mm	27132	27133	27134
9.5mm (3/8")	27135	27136	27137
10mm	27138	27139	27140
11mm (7/16")	27141	27142	27143
11.5mm	27144	27145	27146
12.5mm (1/2")	27147	27148	27149
17mm	27150	27151	27152
Shimadzu Plug	27153	27154	27155
IceBlue™ Septa			
9mm		27156	27157
9.5mm (3/8")		27158	27159
10mm		27160	27161
11mm (7/16")		27162	27163
11.5mm		27164	27165
12.5mm (1/2")		27166	27167
17mm		27168	27169
Shimadzu Plug		27170	27171
BTO® Septa			
5mm CenterGuide™		27100	27101
6mm (1/4")		27102	27103
9mm CenterGuide™		27104	27105
9.5mm (3/8")		27106	27107
10mm		27108	27109
11mm (7/16") CenterGuide™		27110	27111
11.5mm CenterGuide™		27112	27113
12.5mm (1/2") CenterGuide™		27114	27115
17mm CenterGuide™		27116	27117
Shimadzu Plug		27118	27119

Thermolite® Septa
- Usable to 340°C inlet temperature.
- Excellent puncturability.

IceBlue™ Septa
- Usable to 250°C inlet temperature.
- General-purpose septa.
- Excellent puncturability.
- Ideal for SPME.

BTO® Septa
- CenterGuide™ design—requires less force for initial penetration.
- Usable to 400°C inlet temperature.
- Each batch GC-FID tested.
- Bleed and temperature optimized; ideal for demanding GC and GC/MS applications.

Dual Vespel® Ring Inlet Seals - Eliminates the need for a washer!

0.8mm ID Dual Vespel® Ring Inlet Seal	2-pk.	10-pk.
Siltek® Treated	21242	21243
Gold-Plated	21240	21241
Stainless Steel	21238	21239
1.2mm ID Dual Vespel® Ring Inlet Seal	**2-pk.**	**10-pk.**
Siltek® Treated	21248	21249
Gold-Plated	21246	21247
Stainless Steel	21244	21245

Replacement Inlet Seals with Washers

Single-Column Installation, 0.8mm Opening*		0.25/0.32mm ID Dual-Column Installation, 1.2mm Opening		0.53mm ID Dual-Column Installation (1/16-inch opening)	
2-pk.	10-pk.	2-pk.	10-pk.	2-pk.	10-pk.
Stainless Steel Inlet Seal					
21315	21316	20390	20391	20392	20393
Gold-Plated Inlet Seal					
21317	21318	21305	21306	—	—
Siltek® Treated Inlet Seal					
21319	21320	21307	21308	—	—

*0.8mm ID stainless steel inlet seal is similar to Agilent part #18740-20880, 0.8mm ID gold-plated inlet seal is similar to Agilent part #18740-20885.

HANDY septum size chart

Instrument	Septum Diameter (mm)
Agilent (HP)	
5880A, 5890, 6890, 6850, PTV	11
5700, 5880	9.5/10
On-Column Injection	5
Thermo Electron	
TRACE™ GC	17
GCQ w/TRACE™, PTV	17
8000 series	17
Finnigan (TMQ)	
GC 9001	9.5
GCQ	9.5
QCQ™	9.5
TRACE™ 2000	9.5
Gow-Mac	
6890 series	11
All other models	9.5
PerkinElmer	
Sigma series	11
900,990	11
8000 series	11
Auto SYS™	11
Auto SYS™ XL	11
Pye/Unicam	
All models	7
Shimadzu	
All models	Plug
SRI	
All models	Plug
Tracor	
540	11.5
550,560	9.5
220,222	12.5
Varian	
Injector type:	
Packed column	9.5/10
Split/splitless	
1078/1079	10/11
1177	9
1075/1077	11

septum handling tips

- Handle septa carefully, to prevent contamination.
- Minimize bleed—use preconditioned, low-bleed septa.
- Follow septum and instrument manufacturers' recommendations.

Restek Trademarks:
CarboPrep, Crossbond, IceBlue, MegaMix, MXT, Pinnacle, Press-Tight, Rtx, Rxi, SeCure, SilcoCan, Silcosteel, Siltek, Sulfinert, Thermolite, TO-Can, Uniliner.

Other Trademarks:
BTO (Chromatography Research Supplies, Inc.), Freon, Vespel, Viton (E.I. du Pont de Nemours & Co., Inc.), QCQ (Finnigan Corp.), SUMMA (Moletrics), Auto SYS (Perkin-Elmer), Baygon (S.C. Johnson & Son, Inc.), TRACE (Thermo Scientific), Sevin (Union Carbide Corp.), Veriflo (Veriflo Corp.)

Analyze Seven EPA Methods on One GC Column Pair!

Pesticides, PCBs, Herbicides, and More on Rtx®-CLPesticides & Rtx®-CLPesticides2 Columns

- Reduce downtime by running multiple methods on a single column set.
- Speed up analysis time without sacrificing resolution.
- Restek's unique column selectivity assures optimal separations.

www.restek.com

Innovative Chromatography Solutions

RESTEK

CHROMalytic TECHnology Pty Ltd +61(0)3 9762 2034

Australian Distributors
Importers & Manufacurers
www.chromtech.net.au

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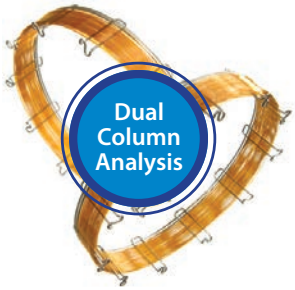
Save Time and Money—Use One Column Pair for Seven EPA Methods



Analyze Pesticides, PCBs, Herbicides, and More on Rtx®-CLPesticides & Rtx®-CLPesticides2 Columns

Get fast separations without sacrificing resolution by using Restek's proprietary Rtx®-CLPesticides and Rtx®-CLPesticides2 columns for multiple environmental methods. Instead of changing columns between GC-ECD methods, you can save time by analyzing chlorinated pesticides, PCBs, herbicides, and other halogenated compounds on a single column set using an Agilent µ-ECD. As shown in the applications in this brochure, Rtx®-CLPesticides and Rtx®-CLPesticides2 columns have a unique selectivity and are ideal for multiple GC-ECD methods. Compare them to your current column set (Table I) and you'll see the Restek advantage!

Table I: Rtx®-CLPesticides columns offer the best overall performance for organochlorine pesticide analysis, as well as many other GC-ECD methods (0.32 mm ID columns).

Method Compound List	Column Pair	Analysis Time (min)	Coelutions	Restek Advantage
8081B (Organochlorine pesticides)	Rtx-CLPesticides / Rtx-CLPesticides2	7 / 7	0 / 0	• Increase sample throughput with 7 min analyses and baseline resolution.
	DB-CLP1 / DB-CLP2	7 / 8	0 / 1	
	ZB-MR1 / ZB-MR2	10 / 9	0 / 0	
8081B (extended) (Organochlorine pesticides)	Rtx-CLPesticides / Rtx-CLPesticides2	24 / 23	1 / 2	• Best balance of speed and selectivity. • All compounds are resolved on at least one column.
	DB-CLP1 / DB-CLP2	27 / 29	0 / 3	
	ZB-MR1 / ZB-MR2	NDP / 16	NDP / 3	
8082A (Polychlorinated biphenyls [PCBs], Aroclors)	Rtx-CLPesticides / Rtx-CLPesticides2	7 / 7	n/a	• Fast PCB analysis times.
	DB-CLP1 / DB-CLP2	6 / 7	n/a	
	ZB-MR1 / ZB-MR2	24 / 21	n/a	
8151A (Chlorinated herbicides)	Rtx-CLPesticides / Rtx-CLPesticides2	13 / 13	1 / 0	• More elution order changes improve confidence in confirmational results.
	DB-CLP1 / DB-CLP2	13 / 13	0 / 0	
	ZB-MR1 / ZB-MR2	16 / 15	1 / 1	
504.1 (EDB, DBCP, TCP)	Rtx-CLPesticides / Rtx-CLPesticides2	6 / 6	0 / 0	• Reliably separate analytes from trihalomethane interferences.
	DB-CLP1 / DB-CLP2	6 / 6	0 / 0	
	ZB-MR1 / ZB-MR2	NDP	NDP	
505 (Organohalide pesticides)	Rtx-CLPesticides / Rtx-CLPesticides2	18 / 18.5	1 / 1	• All compounds resolved on at least one column.
	DB-CLP1 / DB-CLP2	14 / 14	0 / 1	
	ZB-MR1 / ZB-MR2	35 / 36	1 / 2	
508.1 (Chlorinated pesticides, herbicides, organohalides)	Rtx-CLPesticides / Rtx-CLPesticides2	23.5 / 24	2 / 2	• Good balance of speed and resolution.
	DB-CLP1 / DB-CLP2	21 / 23	0 / 3	
	ZB-MR1 / ZB-MR2	18 / 17	2 / 4	
552.2 (Haloacetic acids, dalapon)	Rtx-CLPesticides / Rtx-CLPesticides2	12 / 12	0 / 0	• No coelutions—get accurate results for compounds that coelute on other columns.
	DB-CLP1 / DB-CLP2	8 / 9	1 / 1	
	ZB-MR1 / ZB-MR2	NDP / 10	NDP / 1	

Comparison based on published competitor data. All columns tested were 0.32 mm ID. NDP = no data published

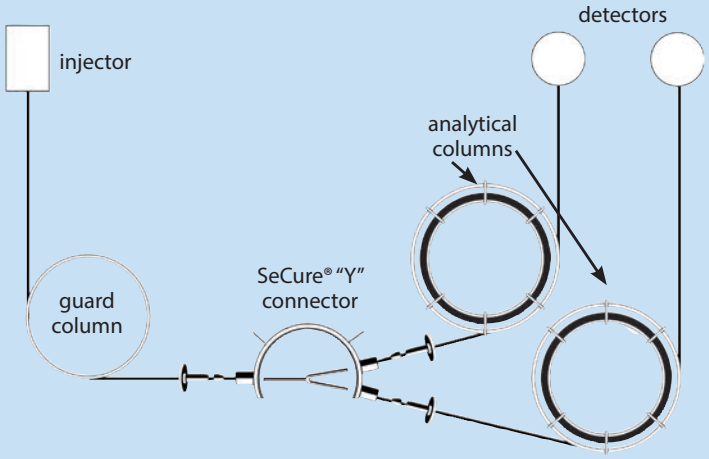
NOTE: Analyzing dirty or derivatized samples can contaminate your column. Restek does not recommend analyzing trace-level pesticide samples following derivatized samples (e.g., Methods 8151A and 552.2) without first performing inlet maintenance. Standard steps include trimming the guard column and changing the inlet liner, o-ring, seal, and septum.

Achieve Optimal Results with Our Parallel Dual-Column Setup

Rtx®-CLPesticides and Rtx®-CLPesticides2 columns are designed for organochlorine pesticide analysis using a parallel dual-column setup that provides both fast analyses and reduced downtime. The stationary phase film thicknesses and optimized run conditions allow rapid analysis without sacrificing column capacity, meaning faster sample throughput for your laboratory. Parallel dual-column analysis saves time because data for primary and confirmation analyses are obtained from a single injection. In addition, injection port maintenance is reduced because only one injector is used. Once the sample passes through a single guard column, it is split on to two analytical columns which are attached using a "Y" connector (Figure 1). Parallel dual-column analysis using Rtx®-CLPesticides and Rtx®-CLPesticides2 columns offers many advantages including:

- **Method-compliant results in half the time**
  Parallel dual-column analysis provides simultaneous acquisition of primary and confirmation data using columns with different selectivities.
- **Reduced contamination**
  Guard column traps nonvolatile residue, protecting the analytical columns.
- **Consistent performance**
  Resolution and relative retention times are unaffected by maintenance since the guard column can be trimmed instead of the analytical columns.
- **Enhanced reproducibility**
  Using a single inlet and "Y" connector results in consistent vaporization and on-column amounts.

Figure 1: Perform parallel dual-column analysis using a single injector and guard column with split flow onto two analytical columns.

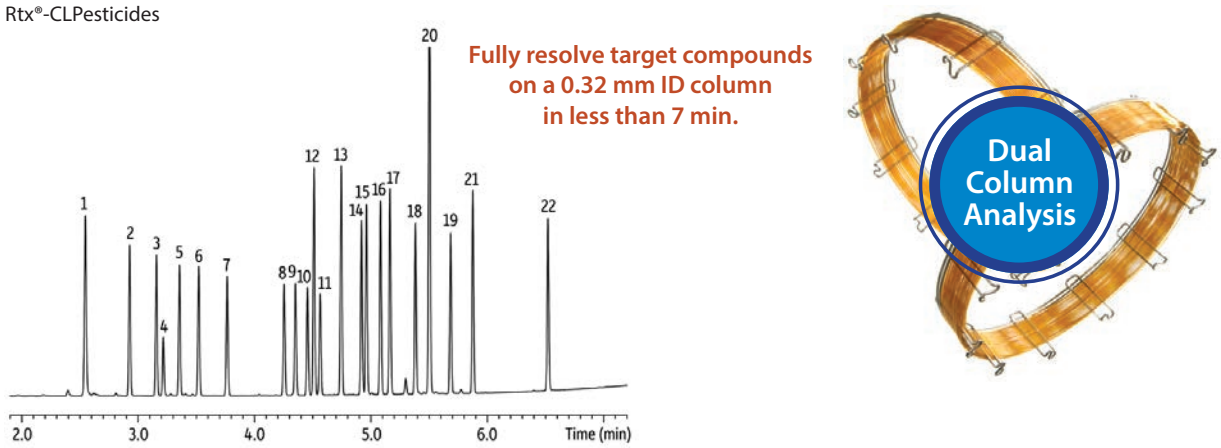


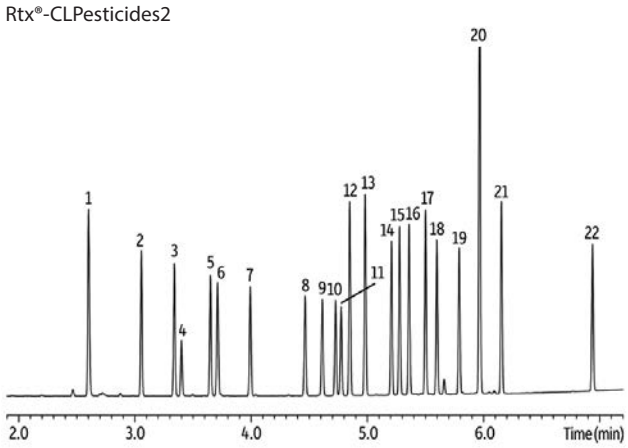
In addition to organochlorine pesticide analysis, parallel dual-column analysis using the Rtx®-CLPesticides and Rtx®-CLPesticides2 columns is an effective approach for several other environmental ECD methods. As detailed on the following pages, this column pair provides excellent results for analysis time and resolution of critical compounds for seven EPA methods: 8081B (organochlorine pesticides); 8082A (PCBs/Aroclors); 8151A (chlorinated herbicides); 504.1 (EDB, DBCP, and TCP); 505 (organohalide pesticides); 508.1 (chlorinated pesticides, herbicides, and organohalides); and 552.2 (haloacetic acids and dalapon).

EPA Method 8081B: Organochlorine Pesticide Analysis

Organochlorine pesticides emerged in the 1940s, but are no longer used today due to their persistence in the environment. However, they still are monitored in water, soil, and other samples. EPA Method 8081B is widely used for organochlorine pesticide analysis in a variety of difficult sample matrices. The selectivity of the Rtx®-CLPesticides column set was originally tuned for Method 8081 and Method 8081B, which provide an excellent example of the performance of the column pair (Figure 2). All compounds are fully resolved in just seven minutes using standard 0.32 mm columns and an Agilent µ-ECD for analysis. (Analysis times reflect simultaneous parallel dual-column analysis.) Fast analysis times translate into high sample throughput, which is an important consideration for environmental labs. In addition, several elution order changes are observed, filling the confirmational requirements of the method.

Figure 2: Cut analysis time in half for organochlorine pesticide analysis (Method 8081B) using Rtx®-CLPesticides columns and a µ-ECD.





Peaks

1. 2,4,5,6-Tetrachloro-*m*-xylene (SS)
2. α-BHC
3. γ-BHC
4. β-BHC
5. δ-BHC
6. Heptachlor
7. Aldrin
8. Heptachlor epoxide (isomer B)
9. *trans*-Chlordane*
10. *cis*-Chlordane*
11. Endosulfan I
12. 4,4'-DDE
13. Dieldrin
14. Endrin
15. 4,4'-DDD
16. Endosulfan II
17. 4,4'-DDT
18. Endrin aldehyde
19. Endosulfan sulfate
20. Methoxychlor
21. Endrin ketone
22. Decachlorobiphenyl (SS)

* For information regarding the nomenclature used for *cis*-chlordane and *trans*-chlordane, visit www.restek.com/chlordane-notice

Columns: Rtx®-CLPesticides 30 m, 0.32 mm ID, 0.32 µm (cat.# 11141) and Rtx®-CLPesticides2 30 m, 0.32 mm ID, 0.25 µm (cat.# 11324) using Rxi® guard column 5 m, 0.32 mm ID (cat.# 10039) with deactivated universal "Y" Press-Tight® connector (cat.# 20405-261); **Sample**: Organochlorine pesticide mix AB #2 (cat.# 32292) Pesticide surrogate mix, EPA 8080, 8081 (cat.# 32000); **Injection:** Inj. Vol.: 1 µL splitless (hold 0.3 min), Liner: Splitless taper (4 mm) (cat.# 20799), Inj. Temp.: 250 °C, **Oven:** Oven Temp: 120 °C to 200 °C at 45 °C/min to 230 °C at 15 °C/min to 330 °C at 30 °C/min (hold 2 min); **Carrier Gas:** He; **Detector**: µ-ECD @ 330 °C;

Notes:
Instrument was operated in constant flow mode. Linear velocity: 60 cm/sec @ 120 °C.
This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

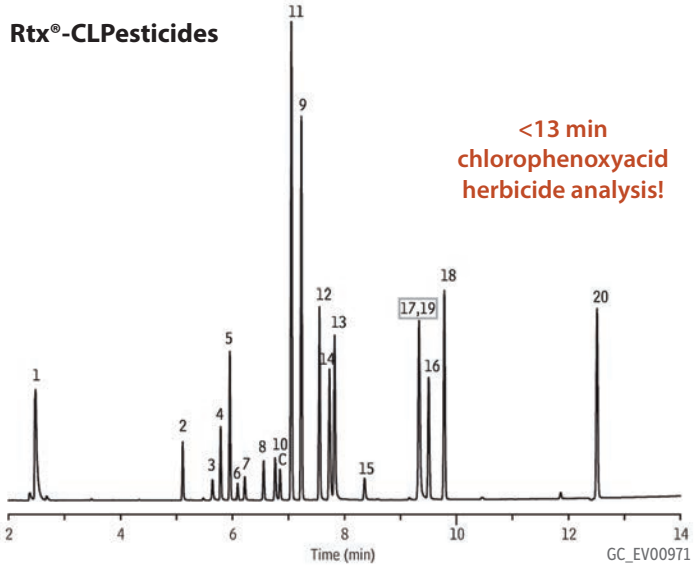
EPA Method 8151A: Chlorinated Herbicide Analysis

Today, many modern herbicides are designed to selectively kill specific types of vegetation. Even though these herbicides are not environmentally persistent and degrade in less than one year, EPA Method 8151A was developed for chlorinated herbicide analysis in wastewater and soil matrices. The most commonly used compounds targeted in this method are the chlorophenoxy herbicides. Of these herbicides, (2,4-dicholorophenoxy)acetic acid, also known as 2,4-D, is the most widely used and widely monitored herbicide worldwide.

According to Method 8151A, samples containing the target herbicides are analyzed using a parallel dual-column confirmation setup and an ECD, the recommended method of detection. Because of this, many laboratories acquire chlorinated herbicides on the same instrument setup used for chlorinated pesticide and PCB analyses. The Rtx®-CLPesticides and Rtx®-CLPesticides2 column pair also perform exceptionally well for chlorinated herbicide analysis; in fact, all 17 target compounds in EPA Method 8151A can be determined in just 13 minutes using these columns. One pair of compounds (bentazon and picloram methyl esters) coelutes on the Rtx®-CLPesticides column, but these compounds are fully resolved on the Rtx®-CLPesticides2 column. And, due to the difference in selectivity of the columns, several elution order changes occur filling the confirmational requirement of the method (Figure 3).

Figure 3: Excellent resolution of chlorinated herbicides on the Rtx®-CLPesticides/Rtx®-CLPesticides2 column pair.

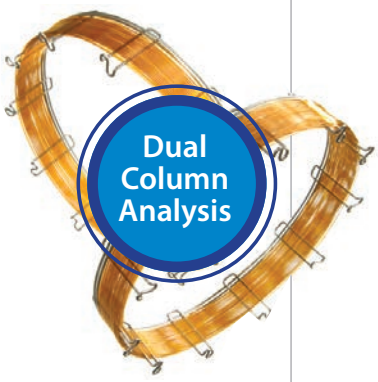
Rtx®-CLPesticides



Peaks

1. Dalapon methyl ester
2. 3,5-Dichlorobenzoic acid methyl ester (SS)
3. 4-Nitroanisole
4. DCAA methyl ester (SS)
5. Dicamba methyl ester
6. MCPP methyl ester
7. MCPA Methyl ester
8. Dichlorprop, methyl ester
9. 4,4'-DBOB (IS)
10. 2,4-D methyl ester
11. Pentachloroanisole
12. 2,4,5-TP, methyl ester
13. 2,4,5-T methyl ester
14. Chloramben, methyl ester
15. 2,4-DB methyl ester
16. Dinoseb methyl ester
17. Bentazon methyl ester
18. DCPA
19. Pichloram methyl ester
20. Acifluorfen methyl ester

C. contaminant



Columns Rtx®-CLPesticides2 30 m, 0.32 mm ID, 0.25 µm (cat.# 11324) and Rtx®-CLPesticides 30 m, 0.32 mm ID, 0.32 µm (cat.# 11141) using Rxi® deactivated guard column 5 m, 0.32 mm ID (cat.# 10039) with universal "Y" Press-Tight® connector (cat.# 20405-261)

Sample 200 ng/mL herbicide mix #1 (cat.# 32055)
1,000 ng/mL dalapon methyl ester (cat.# 32057)
20,000 ng/mL herbicide mix #3 (cat.# 32059)
200 ng/mL herbicide mix #4 (cat.# 32062)
250 ng/mL 4,4'-dibromooctafluorobiphenyl (cat.# 32053)
400 ng/mL 2,4-dichlorophenyl acetic acid methyl ester (cat.# 32050)

Diluent: Hexane

Injection

Inj. Vol.: 1.0 µL splitless (hold 0.75 min)
Liner: Cyclo double taper (4 mm) (cat.# 20895)
Inj. Temp.: 250 °C

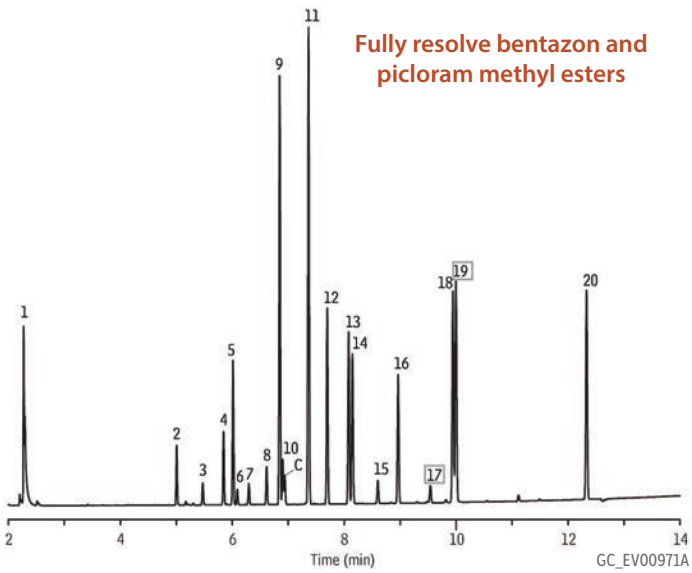
Oven

Oven Temp: 70 °C (hold 0.5 min) to 190 °C at 25 °C/min (hold 1 min) to 300 °C at 11 °C/min (hold 5 min)

Carrier Gas He, constant pressure
Linear Velocity: 36 cm/sec @ 70 °C
Detector µ-ECD @ 325 °C
Instrument Agilent/HP6890 GC
Notes This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

Analyzing dirty or derivatized samples can contaminate your column. Restek does not recommend analyzing trace-level pesticide samples following derivatized samples (e.g., Methods 8151A and 552.2) without first performing inlet maintenance. Standard steps include trimming the guard column and changing the inlet liner, seal, and septum.

Rtx®-CLPesticides2



EPA Method 8082A: PCB Analysis

Polychlorinated biphenyls (PCBs) are a group of industrial organochlorine chemicals that were used extensively as coolant fluids in transformers and capacitors. Later they were used as plasticizers, de-inking solvents, heat transfer fluids in machinery, and also as waterproofing agents, among other uses. PCBs are chemically inert liquids that are difficult to burn. Because they are very persistent in the environment, bioaccumulate in living systems, and some are toxic (i.e., coplanar PCBs), they are a major environmental concern.

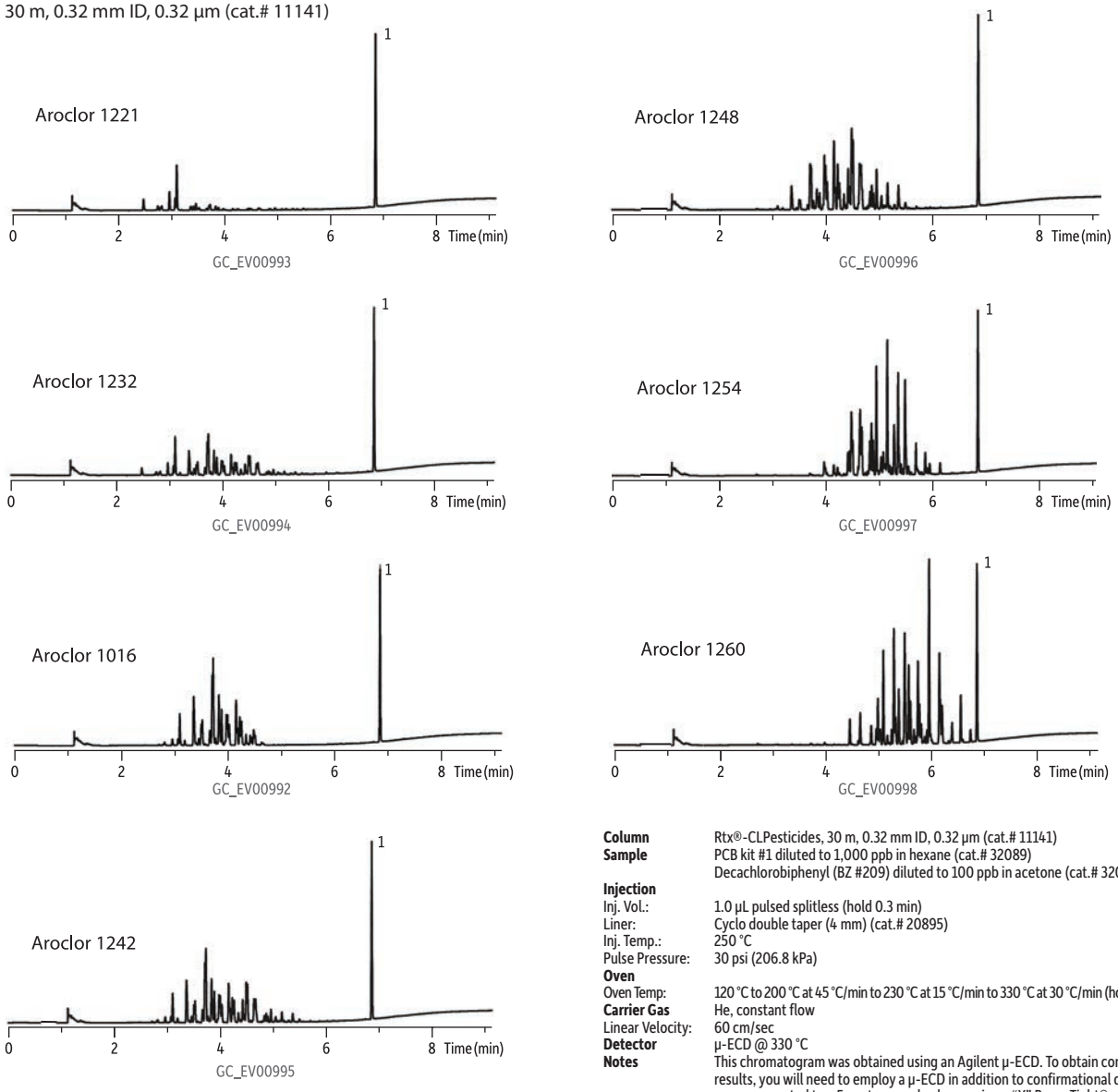
EPA Method 8082A details how Aroclor mixtures and PCB congeners are to be analyzed in a parallel dual-column confirmation setup. When choosing columns, it is important to select stationary phases that have low bleed and high thermal stability. This allows the columns to be held at high temperature at the end of each analysis to prevent carryover from one injection to the next. Because many instruments used for PCB analysis also may be used for pesticide and herbicide analyses, the column pair of choice is the Rtx®-CLPesticides and Rtx®-CLPesticides2 columns. This column set provides low bleed, high thermal stability, and is designed for primary column analysis and secondary column confirmation.

Figure 4: Aroclor analysis on the Rtx®CLPesticides column.

Rtx®-CLPesticides

30 m, 0.32 mm ID, 0.32 µm (cat.# 11141)

Peaks
1. Decachlorobiphenyl (DCB)



Column	Rtx®-CLPesticides, 30 m, 0.32 mm ID, 0.32 µm (cat.# 11141)
Sample	PCB kit #1 diluted to 1,000 ppb in hexane (cat.# 32089) Decachlorobiphenyl (BZ #209) diluted to 100 ppb in acetone (cat.# 32029)
Injection	
Inj. Vol.:	1.0 µL pulsed splitless (hold 0.3 min)
Liner:	Cyclo double taper (4 mm) (cat.# 20895)
Inj. Temp.:	250 °C
Pulse Pressure:	30 psi (206.8 kPa)
Oven	
Oven Temp:	120 °C to 200 °C at 45 °C/min to 230 °C at 15 °C/min to 330 °C at 30 °C/min (hold 2 min)
Carrier Gas	He, constant flow
Linear Velocity:	60 cm/sec
Detector	µ-ECD @ 330 °C
Notes	This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

For Aroclor mixture analysis under EPA 8082A, individual Aroclor mixes are required to be analyzed as standards, then the sample extract chromatograms are compared to the standards to qualitatively identify the Aroclor mixtures. Once identification has been made, quantification can be performed by selecting five of the largest peaks, treating them as individual compounds, and then reporting the average concentration. Figures 4 and 5 show the individual Aroclor mixes and the differences among them.

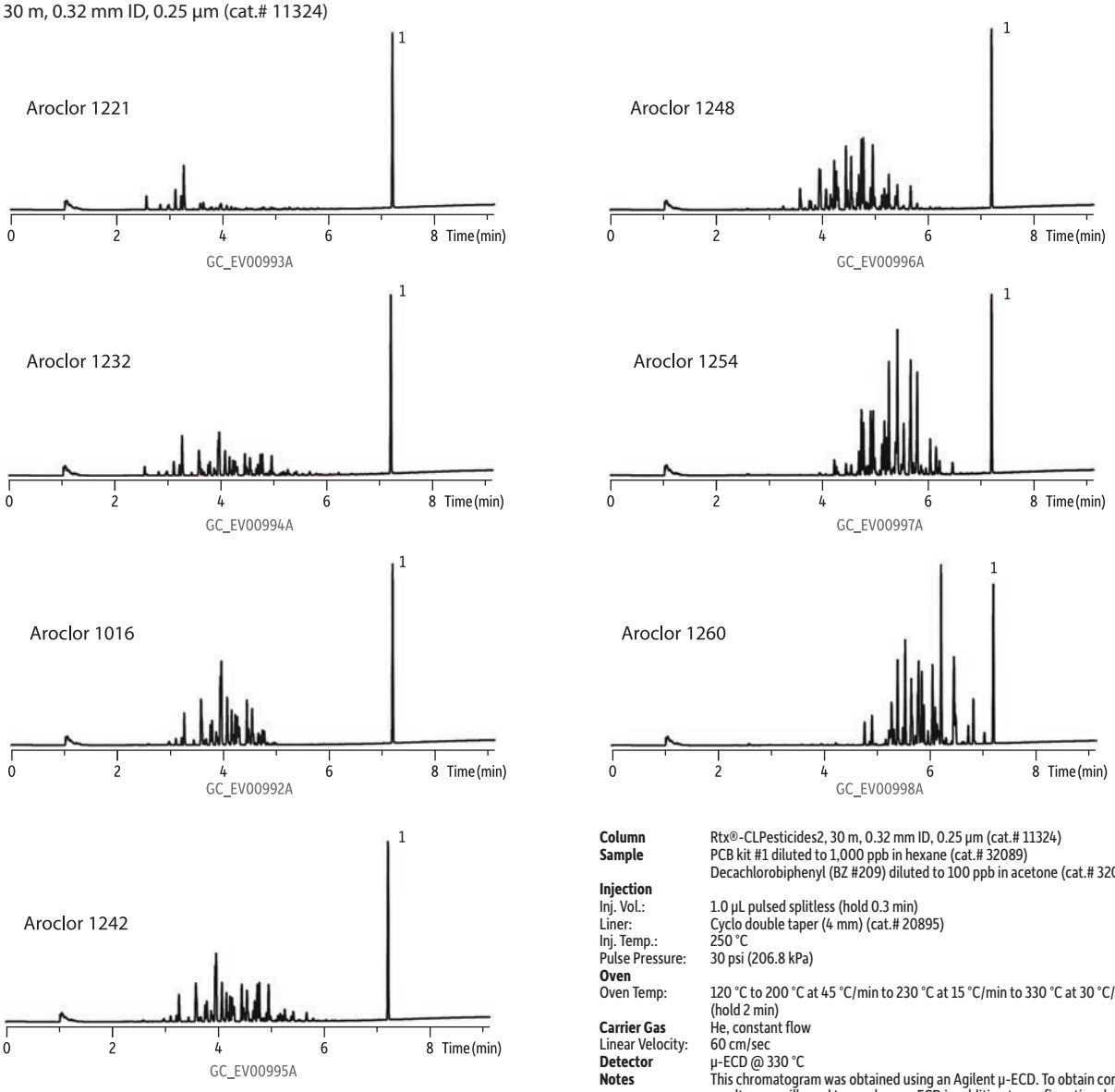
When analyzing for PCB congeners using Method 8082A, each peak is to be treated as an individual component and a standard curve is made for each of the congeners of interest. Note that while many laboratories are interested in the analysis of PCBs by congener, most do not need, or desire, to analyze all 209.

Figure 5: Aroclor analysis on the Rtx®CLPesticides2 column.

Rtx®-CLPesticides2

30 m, 0.32 mm ID, 0.25 µm (cat.# 11324)

Peaks
1. Decachlorobiphenyl (DCB)



Column	Rtx®-CLPesticides2, 30 m, 0.32 mm ID, 0.25 µm (cat.# 11324)
Sample	PCB kit #1 diluted to 1,000 ppb in hexane (cat.# 32089) Decachlorobiphenyl (BZ #209) diluted to 100 ppb in acetone (cat.# 32029)
Injection	
Inj. Vol.:	1.0 µL pulsed splitless (hold 0.3 min)
Liner:	Cyclo double taper (4 mm) (cat.# 20895)
Inj. Temp.:	250 °C
Pulse Pressure:	30 psi (206.8 kPa)
Oven	
Oven Temp:	120 °C to 200 °C at 45 °C/min to 230 °C at 15 °C/min to 330 °C at 30 °C/min (hold 2 min)
Carrier Gas	He, constant flow
Linear Velocity:	60 cm/sec
Detector	µ-ECD @ 330 °C
Notes	This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

EPA Method 504.1: EDB, DBCP, TCP Analysis

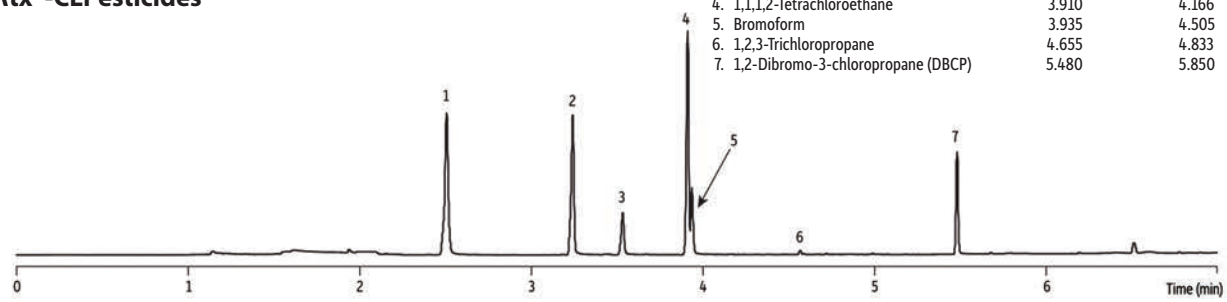
EPA Method 504.1 is a common test performed by environmental laboratories for the analysis of 1,2-dibromoethane (EDB), 1,2-dibromo-3-chloropropane (DBCP), and 1,2,3-trichloropropane (TCP) in drinking water. This method uses parallel dual-column gas chromatography with electron capture detection (GC-ECD), the same instrument setup that is used for the analysis of chlorinated pesticides and herbicides. Thus, when selecting a set of capillary columns for EDB, DBCP, TCP analysis, it is advantageous that they work well for a number of different methods.

The Rtx®-CLPesticides and the Rtx®-CLPesticides2 columns provide excellent separation for the compounds listed in Method 504.1, as well as for analytes in several other drinking water methods. Figure 6 shows the analysis of the Method 504.1 target compounds on these columns connected in parallel using a glass 'Y' Press-Tight® connector. This configuration is important to ensure that both the primary and confirmation column analyses are performed simultaneously under the same conditions and using the same injection port. Method 504.1 requires that EDB, DBCP, and TCP be fully resolved from the common interference compounds (e.g., chloroform, bromodichloromethane, chlorodibromomethane, 1,1,1,2-tetrachloroethane, and bromoform). The Rtx®- CLPesticides2 columns fully resolved these compounds. Note that the coelution of 1,1,1,2-tetrachloroethane and bromoform is between two interference compounds; it does not affect the identification or quantification of EDB, DBCP, or TCP.

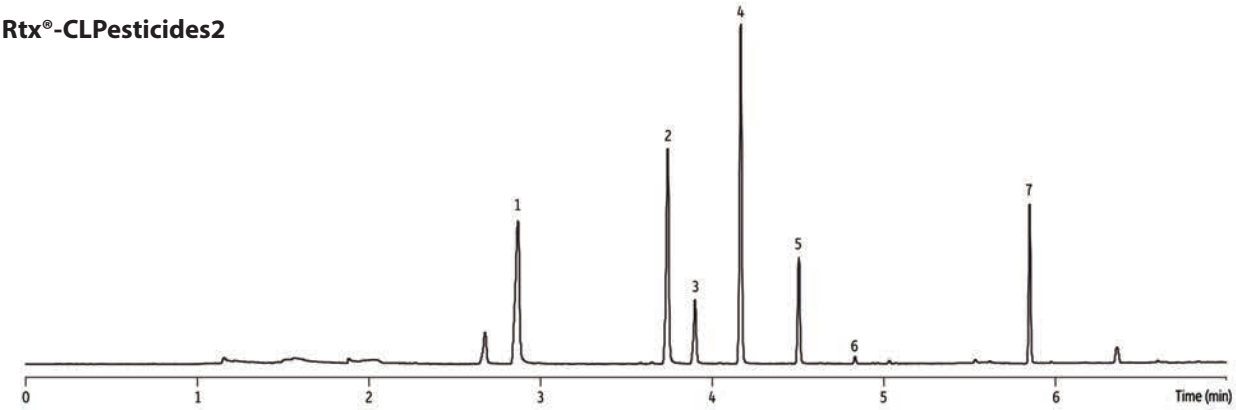
Figure 6: EDB, DBCP, and TCP analysis on Rtx®-CLPesticides and Rtx®-CLPesticides2 columns according to EPA Method 504.1

Peaks	CLP t_R (min)	CLP2 t_R (min)
1. Bromodichloromethane	2.504	2.866
2. Chlorodibromomethane	3.239	3.740
3. 1,2-Dibromoethane (EDB)	3.531	3.899
4. 1,1,1,2-Tetrachloroethane	3.910	4.166
5. Bromoform	3.935	4.505
6. 1,2,3-Trichloropropane	4.655	4.833
7. 1,2-Dibromo-3-chloropropane (DBCP)	5.480	5.850

Rtx®-CLPesticides



Rtx®-CLPesticides2



GC_EV1227

Dual Column Analysis

Columns: Rtx®-CLPesticides2 30 m, 0.32 mm ID, 0.25 µm (cat.# 11324) and Rtx®-CLPesticides 30 m, 0.32 mm ID, 0.32 µm (cat.# 11141) using Rxi® guard column 5 m, 0.32 mm ID (cat.# 10039) with Universal "Y" Press-Tight® connector (cat.# 20405); **Sample**: Dibromochloromethane (chlorodibromochloromethane) (cat.# 30271); Bromodichloromethane (cat.# 30251); 504.1 calibration mix (cat.# 30239); 1,1,1,2-tetrachloroethane (cat.# 30411); Bromoform (cat.# 30252); Diluent: *n*-Hexane; Conc.: 10 ng/mL; **Injection:** Inj. Vol.: 2 µL splitless (hold 0.50 min); Liner: Sky® 4 mm single taper inlet liner w/wool (cat.# 23303.1); Inj. Temp.: 200 °C; Purge Flow: 50 mL/min; **Oven:** Oven Temp: 30 °C (hold 2.0 min) to 220 °C at 30 °C/min; **Carrier Gas**: He, constant flow; Flow Rate: 5.0 mL/min; Linear Velocity: 60 cm/sec; **Detector**: µ-ECD @ 220 °C; Make-up Gas Flow Rate: 50 mL/min; Make-up Gas Type: He; Data Rate: 50 Hz; **Instrument:** Agilent/HP6890 GC; **Notes**: This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual-columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

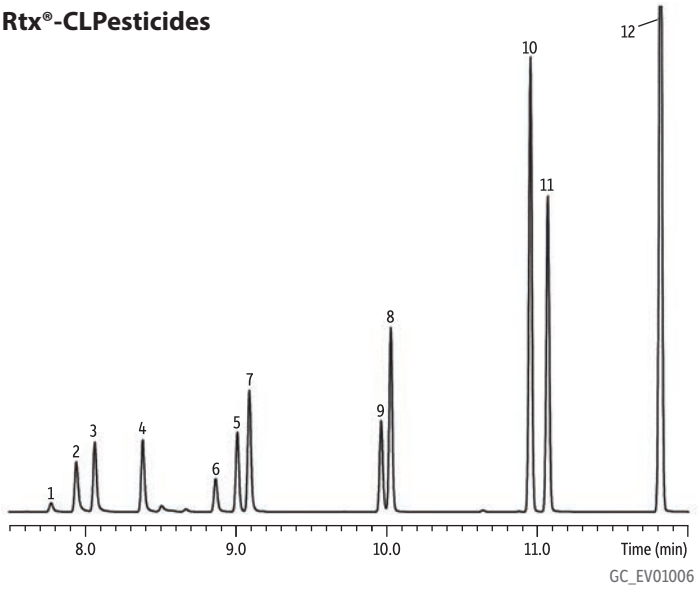
EPA Method 552.2: Haloacetic Acid Analysis

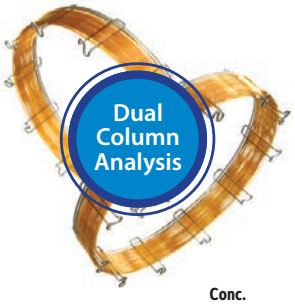
Haloacetic acids are a byproduct of chlorinated disinfection of drinking water. Historically, there has been some concern that these analytes may represent a chronic risk to human health, and toxicological evidence suggests that some of them are possible human carcinogens. Elevated levels of haloacetic acids in drinking water could pose acute human risk because of their corrosive nature. Using Method 552.2 and an appropriate GC column set, such as the Rtx®- CLPesticides and the Rtx®-CLPesticides2 columns, environmental chemists can achieve accurate analysis of haloacetic acids and dalapon.

Haloacetic acid analysis can be performed on a variety of GC column phases. However, an important criterion for column selection is the degree of resolution between the methylated haloacetic acid compounds and known interference compounds like bromoform. Bromoform may be present due to the partial decarboxylation of tribromoacetic acid that can occur during a methylation step that uses acidic methanol. As shown in Figure 7, the Rtx®-CLPesticides and Rtx®-CLPesticides2 columns provide the necessary resolution for this GC-ECD analysis in less than 12 minutes, using the same instrument setup as several other EPA methods.

Figure 7: Dalapon and haloacetic acid analysis by Method 552.2 on an Rtx®-CLPesticides column set.

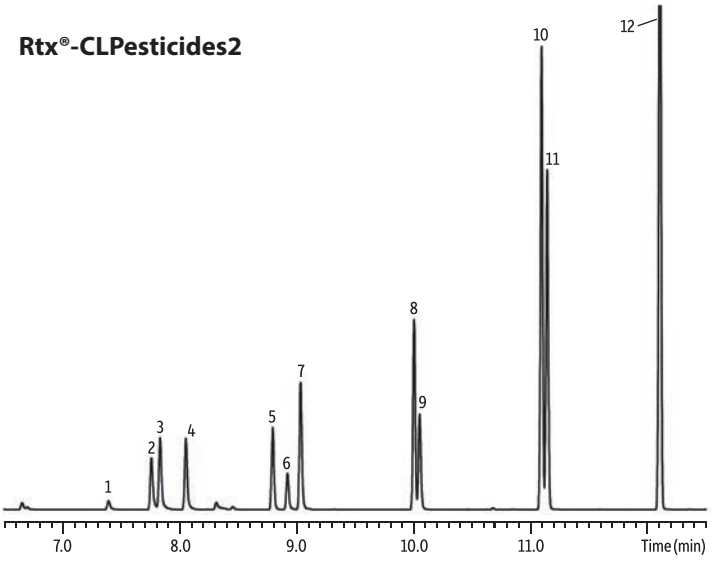
Rtx®-CLPesticides





	Peaks	Conc. (µg/mL)
1.	Methyl monochloroacetate	1.2
2.	Methyl monobromoacetate	0.8
3.	Methyl dichloroacetate	1.2
4.	Dalapon methyl ester	2
5.	Methyl trichloroacetate	0.4
6.	1,2,3-Trichloropropane (IS)	4
7.	Methyl bromo(chloro)acetate	0.8
8.	Methyl bromodichloroacetate	0.8
9.	Methyl dibromoacetate	0.4
10.	Methyl chlorodibromoacetate	2
11.	Methyl 2,3-dibromopropionate (SS)	2
12.	Methyl tribromoacetate	4

Rtx®-CLPesticides2



Columns	Rtx®-CLPesticides2 30 m, 0.32 mm ID, 0.25 µm (cat.# 11324) and Rtx®-CLPesticides 30 m, 0.32 mm ID, 0.32 µm (cat.# 11141) using Rxi® guard column 5 m, 0.32 mm ID (cat.# 10039) with deactivated universal "Y" Press-Tight® connector (cat.# 20405-261)
Sample	Haloacetic acid methyl ester mix #2 (cat.# 31647) Dalapon methyl ester (cat.# 32057) Methyl-2,3-dibromopropionate (cat.# 31656) 1,2,3-Trichloropropane (cat.# 31648)
Diluent:	Methyl *tert*-butyl ether (MTBE)
Injection	
Inj. Vol.:	1.0 µL splitless (hold 0.75 min)
Liner:	Cyclo double taper (4 mm) (cat.# 20896)
Inj. Temp.:	250 °C
Oven	
Oven Temp:	35 °C (hold 4 min) to 250 °C at 15 °C/min (hold 5 min)
Carrier Gas	He, constant flow
Linear Velocity:	25 cm/sec
Detector	µ-ECD @ 300 °C
Notes	This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual columns connected to a 5-meter guard column using a "Y" Press-Tight® connector. Analyzing dirty or derivatized samples can contaminate your column. Restek does not recommend analyzing trace-level pesticide samples following derivatized samples (e.g., Methods 8151A and 552.2) without first performing inlet maintenance. Standard steps include trimming the guard column and changing the inlet liner, seal, and septum.

RESTEK

EPA Method 505: Organohalide Pesticide Analysis and EPA Method 508.1: Chlorinated Pesticide, Chlorinated Herbicide, and Organohalide Analysis

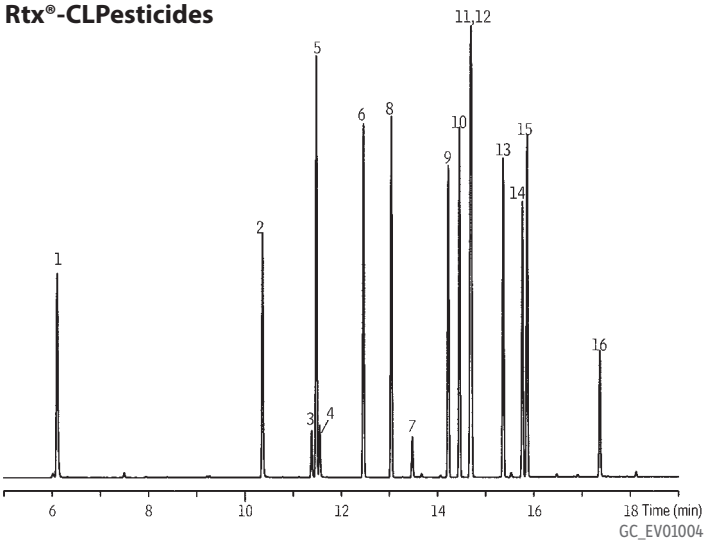
With the advent of modern agriculture and its vast selection of chemical pest control measures, the farming community has made significant increases in productivity and efficiency. Crop yield per acre is extremely high, due in part to the role of pesticides and herbicides in mitigating the devastating effects of many plant and insect pests. However, the use of these chemicals can have drawbacks, including surface and ground water contamination. EPA Methods 505 and 508.1 are used for chlorinated pesticide, chlorinated herbicide, and organohalide analysis in drinking and ground water. The Rtx®-CLPesticides and Rtx®-CLPesticides2 column set also works well for the analysis of compounds in these methods because the columns are highly selective for analytes that contain electronegative substituents. The optimized parallel dual-column method shown here satisfies method requirements in very fast analysis times, which improves sample throughput (Table II, Figures 8 and 9).

Table II: Rtx®-CLPesticides and Rtx®-CLPesticides2 columns easily pass Method 508.1 performance criteria.

Test/Requirement	Analyte	Concentration (ppb)	Rtx®-CLPesticides2	Rtx®-CLPesticides
Inertness (breakdown <20%)	endrin	50	0.9%	1.4%
Inertness (breakdown <20%)	4,4'-DDT	100	1.0%	1.1%
Sensitivity (S/N>3)	chlorpyrifos	2	12.0	6.2
Chromatographic performance (0.8<PGF<1.15)	DCPA	50	1.03	1.06
Column performance (resolution>0.50)	delta-BHC/ chlorothalonil	40/50	9.9	26.8

Figure 8: Organohalide pesticide analysis (Method 505) on Rtx®-CLPesticides and Rtx®-CLPesticides2 columns.

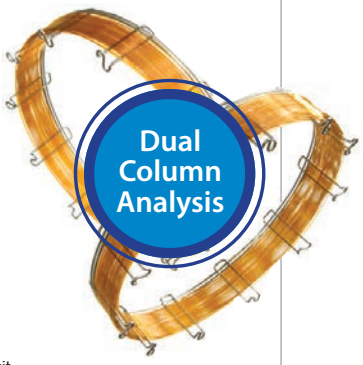
Rtx®-CLPesticides



Peaks

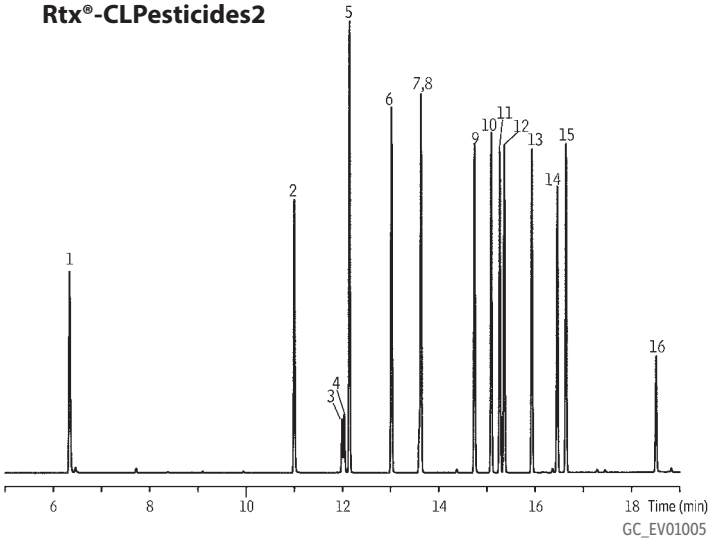
1. Hexachlorocyclopentadiene
2. Hexachlorobenzene
3. Simazine
4. Atrazine
5. γ-BHC
6. Heptachlor
7. Alachlor
8. Aldrin
9. Heptachlor epoxide
10. *trans*-Chlordane*
11. *trans*-Nonachlor
12. *cis*-Chlordane*
13. Dieldrin
14. Endrin
15. *cis*-Nonachlor
16. Methoxychlor

* For information regarding the nomenclature used for *cis*-chlordane and *trans*-chlordane, visit www.restek.com/chlordane-notice



Columns Rtx®-CLPesticides 30 m, 0.32 mm ID, 0.32 µm (cat.# 11141) and Rtx®-CLPesticides2 30 m, 0.32 mm ID, 0.25 µm (cat.# 11324) using Rxi® guard column 5 m, 0.32 mm ID (cat.# 10039) with deactivated universal "Y" Press-Tight® connector (cat.# 20405-261)
Sample 200 ng/mL 505 organohalide pesticide mix (cat.# 32024)
4.2 µg/mL simazine (cat.# 32236)
4.2 µg/mL atrazine (cat.# 32208)
Diluent: Methanol
Injection
Inj. Vol.: 2 µL splitless (hold 0.75 min)
Liner: Cyclo double taper (4 mm) (cat.# 20896)
Inj. Temp.: 250 °C
Oven
Oven Temp: 90 °C (hold 1 min) to 310 °C at 10 °C/min (hold 5 min)
Carrier Gas He, constant flow
Linear Velocity: 40 cm/sec
Detector µ-ECD @ 325 °C
Instrument Agilent/HP6890 GC
Notes This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

Rtx®-CLPesticides2



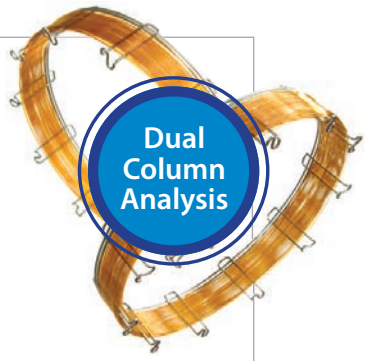
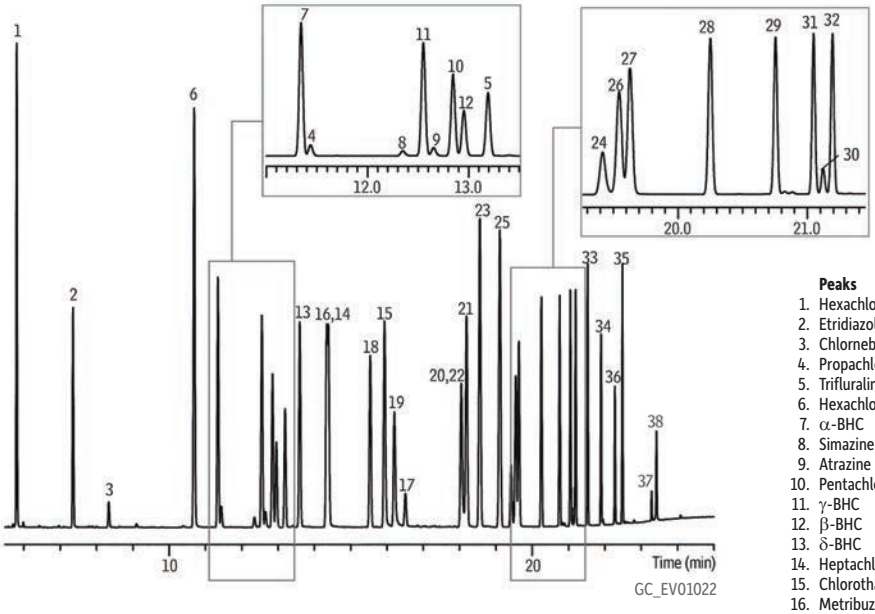


Figure 9: 24-minute analysis of Method 508.1 chlorinated pesticides, herbicides, and organohalides using Rtx®-CLPesticides columns and a µ-ECD.

Rtx®-CLPesticides

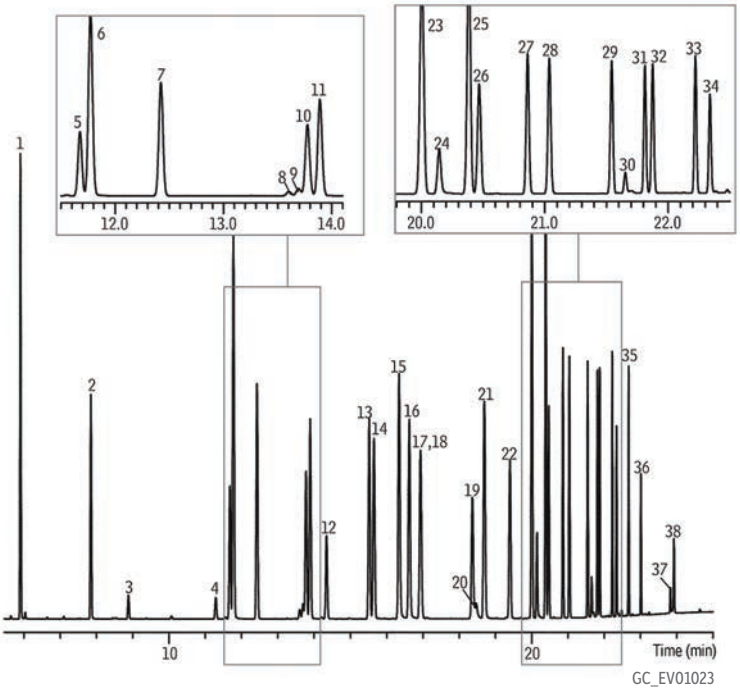


Peaks

1. Hexachlorocyclopentadiene
2. Etridiazole
3. Chlorneb
4. Propachlor
5. Trifluralin
6. Hexachlorobenzene
7. α-BHC
8. Simazine
9. Atrazine
10. Pentachloronitrobenzene (IS)
11. γ-BHC
12. β-BHC
13. δ-BHC
14. Heptachlor
15. Chlorothalonil
16. Metribuzin
17. Alachlor
18. Aldrin
19. 4,4'-Dibromobiphenyl (SS)
20. Metachlor
21. DCPA
22. Heptachlor epoxide
23. *trans*-Chlordane
24. Cyanazine
25. *cis*-Chlordane
26. Endosulfan I
27. 4,4'-DDE
28. Dieldrin
29. Endrin
30. Chlorobenzilate
31. 4,4'-DDD
32. Endosulfan II
33. 4,4'-DDT
34. Endrin aldehyde
35. Endosulfan sulfate
36. Methoxychlor
37. *cis*-Permethrin
38. *trans*-Permethrin

* For information regarding the nomenclature used for *cis*-chlordane and *trans*-chlordane, visit www.restek.com/chlordane-notice

Rtx®-CLPesticides2



Columns	Rtx®-CLPesticides2 30 m, 0.32 mm ID, 0.25 µm (cat.# 11324) and Rtx®-CLPesticides 30 m, 0.32 mm ID, 0.32 µm (cat.# 11141) using Rxi® guard column 5 m, 0.32 mm ID (cat.# 10039) with deactivated universal "Y" Press-Tight® connector (cat.# 20405-261)
Sample	50 ng/mL 508.1 calibration mix #1 (cat.# 32094) 100 ng/mL 508.1 calibration mix #2 (cat.# 32095) 100 ng/mL 508.1 calibration mix #3 (cat.# 32096) 50 ng/mL pentachloronitrobenzene (cat.# 32091) 250 ng/mL 4,4'-dibromobiphenyl (cat.# 32092) 500 ng/mL atrazine (cat.# 32208) 500 ng/mL simazine (cat.# 32236)
Diluent:	Ethyl acetate
Injection	
Inj. Vol.:	2 µL splitless (hold 0.75 min)
Liner:	Cyclo double taper (4 mm) (cat.# 20896)
Inj. Temp.:	250 °C
Oven	
Oven Temp:	80 °C (hold 0.5 min) to 155 °C at 19 °C/min (hold 1 min) to 210 °C at 4 °C/min to 310 °C at 25 °C/min (hold 0.5 min)
Carrier Gas	He, constant flow
Linear Velocity:	26 cm/sec
Detector	µ-ECD @ 325 °C
Notes	This chromatogram was obtained using an Agilent µ-ECD. To obtain comparable results, you will need to employ a µ-ECD in addition to confirmational dual columns connected to a 5-meter guard column using a "Y" Press-Tight® connector.

Get Set for Parallel Dual-Column Analysis!

Analytical Columns

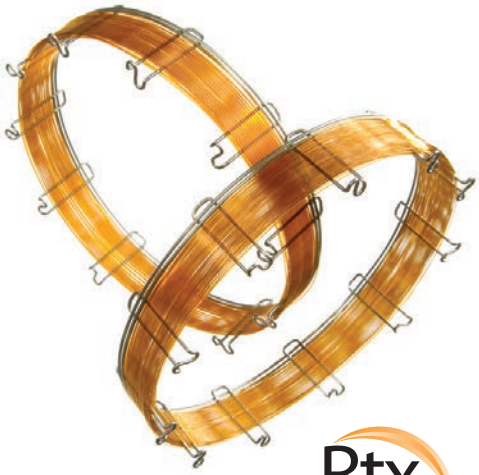
Improved resolution and faster analysis times, compared to 1701 or phenyl phases, make the Rtx®-CLPesticides/Rtx®-CLPesticides2 column pair ideal for analyzing chlorinated pesticides, PCBs as Aroclors, and chlorinated herbicides. These columns offer alternate selectivity, meeting method requirements for elution order changes and relative retention time shifts. Column bleed is low, allowing high boiling point contaminants to be heated off of the column, which extends column lifetime.

Rtx®-CLPesticides Columns (fused silica)
(proprietary Crossbond® phases)

ID	df	temp. limits	15-Meter	20-Meter	30-Meter	60-Meter
0.18 mm	0.18 µm	-60 to 320/340 °C		42102		
0.25 mm	0.25 µm	-60 to 320/340 °C	11120		11123	11126
0.32 mm	0.32 µm	-60 to 320/340 °C			11141	
	0.50 µm	-60 to 320/340 °C	11136		11139	
0.53 mm	0.50 µm	-60 to 300/320 °C	11137		11140	

Rtx®-CLPesticides2 Columns (fused silica)
(proprietary Crossbond® phases)

ID	df	temp. limits	10-Meter	15-Meter	20-Meter	30-Meter	60-Meter
0.18 mm	0.14 µm	-60 to 320/330 °C	42301		42302		
0.25 mm	0.20 µm	-60 to 320/340 °C				11323	11326
0.32 mm	0.25 µm	-60 to 320/340 °C		11321		11324	
	0.50 µm	-60 to 320/340 °C				11325	
0.53 mm	0.42 µm	-60 to 300/320 °C		11337		11340	



Rtx GCColumns

Rtx®-CLPesticides Column Kit (0.32 mm ID)
(Note: Columns are not preconnected in this kit.)
Rtx-CLPesticides Kit (0.32 mm ID) **cat.# 11196 (kit)**

Includes:	cat.#
30 m, 0.32 mm ID, 0.32 µm Rtx-CLPesticides Column Column	11141
30 m, 0.32 mm ID, 0.25 µm Rtx-CLPesticides2 Column Column	11324
Universal Angled "Y" Press-Tight Connector, Deactivated	20403-261
5 m, 0.32 mm ID Siltek Guard Column	10027

Rtx®-CLPesticides Column Kit (0.53 mm ID)
(Note: Columns are not preconnected in this kit.)
Rtx-CLPesticides Kit (0.53 mm ID) **cat.# 11197 (kit)**

Includes:	cat.#
30 m, 0.53 mm ID, 0.50 µm Rtx-CLPesticides Column Column	11140
30 m, 0.53 mm ID, 0.42 µm Rtx-CLPesticides2 Column Column	11340
Universal Angled "Y" Press-Tight Connector, Deactivated	20403-261
5 m, 0.53 mm ID IP Deactivated Guard Column	10045

0.25 mm ID columns are also available at **www.restek.com**

Save Money, Buy a Kit!

Purchase one of these recommended combinations of guard and analytical columns and save money.

Connectors

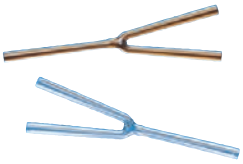
The best chromatography for parallel dual-column analysis is obtained using the universal "Y" Press-Tight® connector. The internal design of the taper allows the column to seal to the glass surface and minimizes dead volume. To strengthen this connection, Restek developed the SeCure® "Y" connector, which uses a C-clamp to hold the columns in place, assuring a reliable connection.

The MXT®-Union connectors are an alternative connector system that uses special ferrules designed to eliminate dead volume. The MXT®-Union is made of stainless steel and is deactivated with Siltek® treatment, making an inert sample pathway. The special ferrules used to make the connection are designed to eliminate the dead volume when installing the columns.

Universal "Y" Press-Tight® Connectors

An alternative method of performing dual-column confirmational analyses!

Description	ea.	3-pk.
Universal "Y" Press-Tight Connector, Deactivated	20405-261	20406-261



SeCure® "Y" Connector Kits

Kits include: SeCure® "Y" connector body, three knurled nuts, universal "Y" Press-Tight® union, three ferrules.

Description	Ferrules Fit Column ID	qty.	cat.#
SeCure "Y" Connector Kit	0.18/0.25/0.28 mm	kit	20276
SeCure "Y" Connector Kit	0.32 mm	kit	20277
SeCure "Y" Connector Kit	0.45/0.53 mm	kit	20278
Knurled Nut		3-pk.	20279

The SeCure® "Y" connector's open design allows visual confirmation of the seal.

Graphite Ferrules for SeCure® "Y" Connectors

Buy extra to keep spares on hand.

Ferrule ID	Fits Column ID	qty.	Graphite
0.4 mm	0.10/0.15/0.18/0.25/0.28 mm	10-pk.	20200
0.4 mm	0.10/0.15/0.18/0.25/0.28 mm	50-pk.	20227
0.5 mm	0.32 mm	10-pk.	20201
0.5 mm	0.32 mm	50-pk.	20228
0.8 mm	0.45/0.53 mm	10-pk.	20202
0.8 mm	0.45/0.53 mm	50-pk.	20224

MXT® "Y"-Union Connector Kits for Fused Silica Columns

Each kit contains the MXT® union; three 1/32-inch nuts; and three, one-piece, fused silica adaptors.

Description	qty.	cat.#
For 0.25 mm ID Fused Silica Columns	kit	21389
For 0.32 mm ID Fused Silica Columns	kit	21388
For 0.53 mm ID Fused Silica Columns	kit	21387

Get Set for Parallel Dual-Column Analysis!

Inlet Liners

The Rtx®-CLPesticides and Rtx®-CLPesticides2 column pair will work with both split or splitless injection techniques and any liner geometry. Various inlet liners are used for pesticide analysis; the four most common are the single taper, double taper, cyclo double taper, and the drilled Uniliner® inlet liner.

The drilled Uniliner® inlet liner provides the most inert sample pathway and eliminates injection port discrimination because the sample is funneled directly onto the column without contacting the metal injection port. Using a drilled Uniliner® inlet liner eliminates the need to replace the inlet seal at the bottom of the injection port, substantially reducing maintenance time and expense.

The tapered liners are also commonly used for pesticide analysis and work best with pressure pulsing conditions. The best tapered liner to use with pressure pulsing is the cyclo double taper. This liner has a screw-type sample pathway which collects nonvolatile material at the beginning of the screws and offers more surface area to vaporize the sample prior to reaching the entrance of the column.

Liners for Splitless Injection with Agilent GCs:

Sky® 4.0 mm ID Single Taper Inlet Liner

ID x OD x Length	qty.	cat.#
Single Taper, Sky Technology, Borosilicate Glass		
4.0 mm x 6.5 mm x 78.5 mm	ea.	23302.1
4.0 mm x 6.5 mm x 78.5 mm	5-pk.	23302.5
4.0 mm x 6.5 mm x 78.5 mm	25-pk.	23302.25

Sky® 4.0 mm ID Single Taper Inlet Liner w/ Wool

ID x OD x Length	qty.	cat.#
Single Taper, Sky Technology, Wool, Borosilicate Glass		
4.0 mm x 6.5 mm x 78.5 mm	ea.	23303.1
4.0 mm x 6.5 mm x 78.5 mm	5-pk.	23303.5
4.0 mm x 6.5 mm x 78.5 mm	25-pk.	23303.25

Sky® 4.0 mm ID Double Taper Inlet Liner

ID x OD x Length	qty.	cat.#
Double Taper, Sky Technology, Borosilicate Glass		
4.0 mm x 6.5 mm x 78.5 mm	ea.	23308.1
4.0 mm x 6.5 mm x 78.5 mm	5-pk.	23308.5
4.0 mm x 6.5 mm x 78.5 mm	25-pk.	23308.25

Sky® 4.0 mm ID Cyclo Double Taper Inlet Liner

ID x OD x Length	qty.	cat.#
Cyclo Double Taper, Sky Technology, Borosilicate Glass		
4.0 mm x 6.5 mm x 78.5 mm	ea.	23310.1
4.0 mm x 6.5 mm x 78.5 mm	5-pk.	23310.5
4.0 mm x 6.5 mm x 78.5 mm	25-pk.	23310.25

Sky® 4.0 mm ID Drilled Uniliner® Inlet Liner with Hole near Top

ID x OD x Length	qty.	cat.#
Drilled Uniliner (hole near top), Sky Technology, Borosilicate Glass		
4.0 mm x 6.3 mm x 78.5 mm	ea.	23311.1
4.0 mm x 6.3 mm x 78.5 mm	5-pk.	23311.5
4.0 mm x 6.3 mm x 78.5 mm	25-pk.	23311.25

Liners for Split Injection with Agilent GCs

Sky® 4.0 mm ID Precision® Inlet Liner w/ Wool

ID x OD x Length	qty.	cat.#
Precision, Sky Technology, Borosilicate Glass with Quartz Wool		
4.0 mm x 6.3 mm x 78.5 mm	ea.	23305.1
4.0 mm x 6.3 mm x 78.5 mm	5-pk.	23305.5
4.0 mm x 6.3 mm x 78.5 mm	25-pk.	23305.25

Dual Vespel® Ring Inlet Seals

Washerless, leak-tight seals for Agilent GCs

0.8 mm ID Dual Vespel Ring Inlet Seal	2-pk.	10-pk.	50-pk.
Gold-Plated	21240	21241	23418
Siltek-Treated	21242	21243	23419
1.2 mm ID Dual Vespel Ring Inlet Seal	**2-pk.**	**10-pk.**	
Gold-Plated	21246	21247	
Siltek-Treated	21248	21249	

Patented.

21240 21248

Restek Recommended!

Sample Preparation

Resprep® SPE Cartridges (Normal Phase)

Hydrophilic (polar) adsorbents used to extract hydrophilic analytes from nonpolar matrices, such as organic solvents (e.g., polar contaminants from sample extracts).

	3 mL/500 mg (50-pk.)	6 mL/500 mg (30-pk.)	6 mL/1,000 mg (30-pk.)	15 mL/2 g (15-pk.)
Florisil (EPA SW 846 methods and CLP protocols)	24031 24032*	26086**	24034 26085**	26228
Silica (EPA SW 846 methods)	24035 24036*		24038	

*PTFE frits **Glass tubes with PTFE frits

All cartridges are manufactured using high-olyethylene frits unless otherwise noted.

Resprep® CarboPrep® SPE Cartridges

SPE Cartridge	Tube Volume, Bed Weight	qty.	cat.#
CarboPrep 90	3 mL, 250 mg	50-pk.	26091
CarboPrep 90	6 mL, 500 mg	30-pk.	26092

Excellent for Pesticide Residue Cleanup!

Reference Standards

Organochlorine Pesticide Mix AB #1

(20 components)

aldrin	dieldrin
α-BHC	endosulfan I
β-BHC	endosulfan II
δ-BHC	endosulfan sulfate
γ-BHC (lindane)	endrin
cis-chlordane	endrin aldehyde
trans-chlordane	endrin ketone
4,4'-DDD	heptachlor
4,4'-DDE	heptachlor epoxide (isomer B)
4,4'-DDT	methoxychlor

200 µg/mL each in hexane:toluene (1:1), 1 mL/ampul

cat.# 32291 (ea.)

Organochlorine Pesticide Mix AB #2

(20 components)

aldrin	8 µg/mL	dieldrin	16
α-BHC	8	endosulfan I	8
β-BHC	8	endosulfan II	16
δ-BHC	8	endosulfan sulfate	16
γ-BHC (lindane)	8	endrin	16
cis-chlordane	8	endrin aldehyde	16
trans-chlordane	8	endrin ketone	16
4,4'-DDD	16	heptachlor	8
4,4'-DDE	16	heptachlor epoxide (isomer B)	8
4,4'-DDT	16	methoxychlor	80

In hexane:toluene (1:1), 1 mL/ampul

cat.# 32292 (ea.)

Organochlorine Pesticide System Evaluation Mix (2 components)

4,4'-DDT	200 µg/mL
endrin	100 µg/mL

In methyl *tert*-butyl ether, 1 mL/ampul

cat.# 32417 (ea.)

Pesticide Surrogate Mix (2 components)

decachlorobiphenyl
2,4,5,6-tetrachloro-*m*-xylene

200 µg/mL each in acetone, 1 mL/ampul

cat.# 32000 (ea.)

200 µg/mL each in acetone, 5 mL/ampul

cat.# 32457 (ea.)

Organochlorine Pesticide Resolution Check Mix (with surrogates) (22 components)

aldrin	10 µg/mL	endosulfan I	10
α-BHC	10	endosulfan II	20
β-BHC	10	endosulfan sulfate	20
δ-BHC	10	endrin	20
γ-BHC (lindane)	10	endrin aldehyde	20
cis-chlordane	10	endrin ketone	20
trans-chlordane	10	heptachlor	10
decachlorobiphenyl (SS)	20	heptachlor epoxide (isomer B)	10
dieldrin	20	methoxychlor	100
4,4'-DDD	20	2,4,5,6-tetrachloro-*m*-xylene (SS)	10
4,4'-DDE	20		
4,4'-DDT	20		

In hexane:toluene (90:10), 1 mL/ampul

cat.# 32454 (ea.)

Aroclor Solutions

Volume is 1 mL/ampul. Concentration is µg/mL unless otherwise noted.

Compound	CAS #	Solvent	Conc.	cat.#
Aroclor 1016	12674-11-2	H	1,000	32006
Aroclor 1221	11104-28-2	H	1,000	32007
Aroclor 1232	11141-16-5	H	1,000	32008
Aroclor 1242	53469-21-9	H	1,000	32009
Aroclor 1248	12672-29-6	H	1,000	32010
Aroclor 1254	11097-69-1	H	1,000	32011
Aroclor 1260	11096-82-5	H	1,000	32012
Aroclor 1262	37324-23-5	H	1,000	32409
Aroclor 1268	11100-14-4	H	1,000	32410

H = hexane

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Restek Offers a Full Line of Certified Reference Materials

www.restek.com/iso

Visit **www.restek.com** for more products and resources for environmental labs!

Dynamic Duo (Restek Leak Detector and ProFLOW 6000 Flowmeter)

Protect your instrument and improve data quality with this powerful pair from Restek. Checking for leaks and verifying flows before you start helps you avoid costly problems later.

Description	qty.	cat.#
Dynamic Duo Combo Pack (Restek Leak Detector and ProFLOW 6000 Flowmeter)	kit	22654
Related Products and Accessories		
Leak Detector With Hard-Sided Carrying Case and Universal Charger Set (U.S., UK, European, Australian)	ea.	22655
Small Probe Adaptor for Leak Detector	ea.	22658
Restek ProFLOW 6000 Electronic Flowmeter With Hard-Sided Carrying Case	ea.	22656
Soft-Sided Storage Case for Leak Detector or ProFLOW 6000 Flowmeter	ea.	22657

Restek's New Leak Detector

Redesigned and better than ever, our new leak detector is an essential tool for trouble-shooting and routine maintenance of your gas chromatograph. Don't risk damaging your system or losing sensitivity; check for leaks often and protect your GC column and instrument with a Restek leak detector!

Leak Detector Specifications:

Detectable Gases:	Helium, nitrogen, argon, carbon dioxide, hydrogen
Battery:	Rechargeable lithium ion internal battery pack (12 hours normal operation)
Operating Temp. Range:	32–120 °F (0–48 °C)
Humidity Range:	0–97%
Warranty:	One year
Certifications:	CE, Ex, Japan
Compliance:	WEEE, RoHS

Limits of Detection

These gases can be detected with the Restek electronic leak detector at the following leak rates:

Minimum Detectable Gas Limits and Indicating LED Color:

- Helium, 1.0 x 10^{-5}, red LED
- Hydrogen*, 1.0 x 10^{-5}, red LED
- Nitrogen, 1.4 x 10^{-3}, yellow LED
- Argon, 1.0 x 10^{-4}, yellow LED
- Carbon dioxide, 1.0 x 10^{-4}, yellow LED

Gas detection limits measured in atm cc/sec.

ProFLOW 6000 Flowmeter

With its wide range of capabilities, the ProFLOW 6000 flowmeter simplifies gas flow measurement in the lab. Real-time measurements can be made for various types of flow paths, including continually changing gas types.

Flowmeter Specifications:

Type of Flowmeter:	Volumetric
Battery:	2-AA
Operating Temp. Range:	32–120 °F (0–48 °C)
Warranty:	One year
Certifications:	CE, Ex
Compliance:	WEEE, RoHS

Patented.

Optional Accessories

22657

Soft-Side Carry/Storage Case
Ideal for storing your leak detector or flowmeter in smaller spaces such as a tool box.

22658

Small Probe Adaptor for Leak Detector
Verify hard-to-reach leaks using the small probe adaptor.

Order today at www.restek.com

RESTEK®

Lit. Cat.# EVBR1013C-UNV

www.restek.com

2006/07 Edition

CLINICAL/ FORENSICS

Products & Applications for GC & HPLC

Introduction

In the clinical and forensic markets, chromatography encompasses a wide range of application areas, including:

- hospital & forensic toxicology
- drugs of abuse
- alcohol & driving
- workplace drug testing (illicit drugs)
- drug abuse in sports (steroids, stimulants, analgesics, hormones, diuretics, narcotics)
- therapeutic drug monitoring (prescription drugs)
- natural toxins (hallucinogenic mushrooms)
- pesticide poisoning
- volatile substance abuse (adhesives, dry cleaning/degreasing agents, hydrocarbon fuels, solvents, paint strippers/thinners, vasodilators)
- solid drug identification

Example chromatograms for a variety of these applications, obtained using Restek GC and HPLC columns and accessories, are illustrated in this guide.

Throughout this guide you also will find references to application notes that detail specific analyses, technical guides that explain various analytical techniques, product information pieces that highlight aspects of our products, and reference books that offer detailed information on topics from sample preparation to chromatographic methods. All Restek publications are available free on request; order by contacting our Technical Service Department, our Customer Service Department, or your Restek distributor by e-mail, telephone, or fax, and providing the literature catalog numbers for the publications you want. For fastest access, you can review and download these publications from our website. For prices for reference books, refer to our general catalog or website - or simply call our Customer Service Department.

Kristi Sellers
Clinical/Forensic
Innovations Chemist

Kristi brings 18 years of experience in GC and 4 years of experience in HPLC to her role as our principal clinical and forensic applications chemist. She holds a B.S. in chemistry from Lock Haven University, Lock Haven, PA.

E-mail: kristi.sellers@restek.com
Phone: 800-356-1688 or 814-353-1300, ext. 2150

three **simple** words...

Plus 1
Exceeding your expectations in everything we do.

Innovation
Turning visions into reality™.

Execution
On-time delivery of products and services.

Restek's vision is to be the company that chromatographers trust by providing the highest quality, most innovative products and services throughout the world.

We will soon reach our goal of 100% employee ownership.
As owners, our success depends on your success.

Table of Contents:

Arson Accelerants

Arson Accelerants

Analyses of fire debris for accelerants commonly are performed on non-polar columns, like the Rtx®-1 column. Thick film columns give better resolution for the low boiling point compounds that are components of gasoline. Thinner film columns provide better resolution and shorter analysis times for higher molecular weight compounds in diesel fuels. However, by choosing the appropriate column dimensions and analytical parameters, a wide range of petroleum products can be tested for on a single column.

Accelerants in fire debris are identified through chromatographic pattern comparison. Accelerants and that have been exposed to high heat exhibit a "weathered" pattern. Large proportions of the lower boiling components in any accelerant will have disappeared in samples that have undergone severe weathering. We have an extensive line of petroleum products that have been weathered to various stages of weight loss to aid in the identification of accelerants in fire debris.

free literature

Weathered Petroleum Analytical Reference Materials

lit. cat.# 59215

Fire Debris Analysis

lit. cat.# 59574

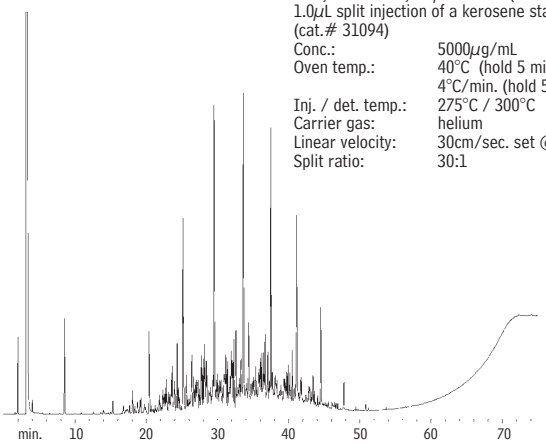
Call Restek at 800-356-1688 or 814-353-1300, ext. 5, or contact your Restek representative, to request your free copy!

Kerosene
Rtx®-1

GC

30m, 0.32mm ID, 1.5µm Rtx®-1 (cat.# 10169)
1.0µL split injection of a kerosene standard (cat.# 31094)

Conc.:	5000µg/mL
Oven temp.:	40°C (hold 5 min.) to 300°C @ 4°C/min. (hold 5 min.)
Inj. / det. temp.:	275°C / 300°C
Carrier gas:	helium
Linear velocity:	30cm/sec. set @ 40°C
Split ratio:	30:1



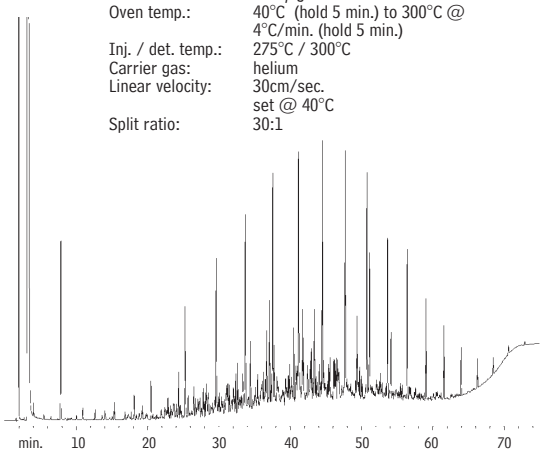
GC_MS00274

Diesel Fuel
Rtx®-1

GC

30m, 0.32mm ID, 1.5µm Rtx®-1 (cat.# 10169)
1.0µL split injection of a diesel fuel #2 standard (cat.# 31093)

Conc.:	5000µg/mL
Oven temp.:	40°C (hold 5 min.) to 300°C @ 4°C/min. (hold 5 min.)
Inj. / det. temp.:	275°C / 300°C
Carrier gas:	helium
Linear velocity:	30cm/sec. set @ 40°C
Split ratio:	30:1



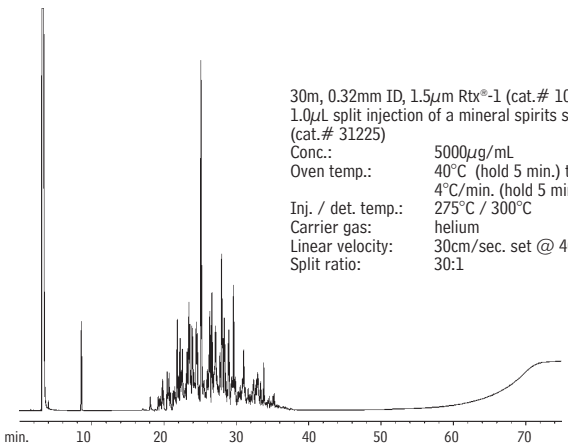
GC_MS00275

Mineral Spirits
Rtx®-1

GC

30m, 0.32mm ID, 1.5µm Rtx®-1 (cat.# 10169)
1.0µL split injection of a mineral spirits standard (cat.# 31225)

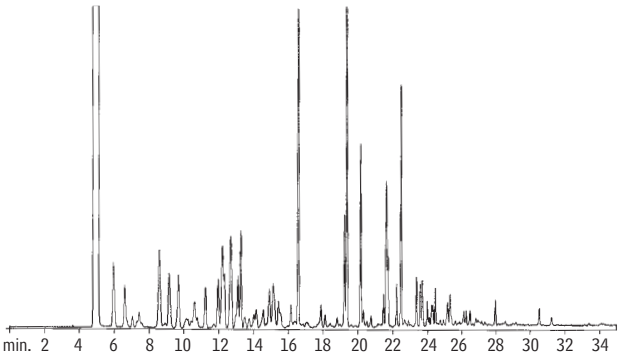
Conc.:	5000µg/mL
Oven temp.:	40°C (hold 5 min.) to 300°C @ 4°C/min. (hold 5 min.)
Inj. / det. temp.:	275°C / 300°C
Carrier gas:	helium
Linear velocity:	30cm/sec. set @ 40°C
Split ratio:	30:1



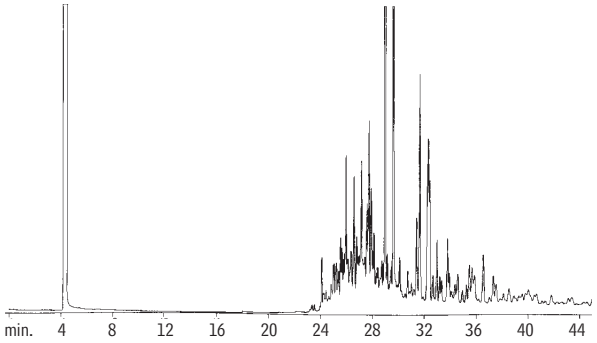
Unleaded Gasoline
Rtx®-1

GC

Unweathered



99% Weathered

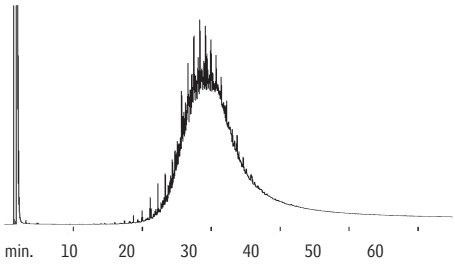


GC_MS00270

30m, 0.53mm ID, 1.50µm Rtx®-1 (cat.# 10170)
Oven temp.: 40°C (hold 3 min.) to 75°C @ 15°C/min. to 275°C @ 20°C/min. (hold 5 min.)
Inj./det. temp.: 250°C/285°C
Carrier gas: hydrogen
Linear velocity: 50cm/sec. set @ 40°C
FID sensitivity: 4.10 x 10⁻⁹ AFS
Split ratio: 30:1

Motor Oil
Rtx®-5

GC

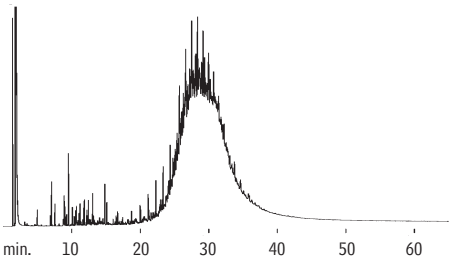


GC_MS00272

30m, 0.53mm ID, 1.0µm Rtx®-5 (cat.# 10255)
1.0µL split injection of Motor Oil Composite Standard (cat.# 31464)*
Conc.: 50,000ppm
Oven temp.: 40°C (hold 2 min.) to 330°C @ 10°C/min. (hold 60 min.)
Inj./det. temp.: 300/330°C
Carrier gas: hydrogen
Linear velocity: 41cm/sec.
Split ratio: 3:1

*Prepared from an equal volume blend of 5w30, 10w30, 10w40, and 20w50 motor oil, precisely weighed to produce a mixture at 50,000µg/mL in methylene chloride.

Motor Oil (Used)
Rtx®-5



GC_MS00273

30m, 0.25mm ID, 0.25µm Rtx®-5 (cat.# 10223)
1.0µL split injection of Used Motor Oil Composite Standard (cat.# 31465)*
Conc.: 50,000ppm
Oven temp.: 40°C to 340°C @ 10°C/min. (hold 15 min.)
Inj./det. temp.: 250/340°C
Carrier gas: hydrogen
Linear velocity: 40cm/sec.
Split ratio: 15:1

*Prepared from an equal volume blend from five gasoline powered vehicles, precisely weighed to produce a mixture at 50,000µg/mL in methylene chloride.

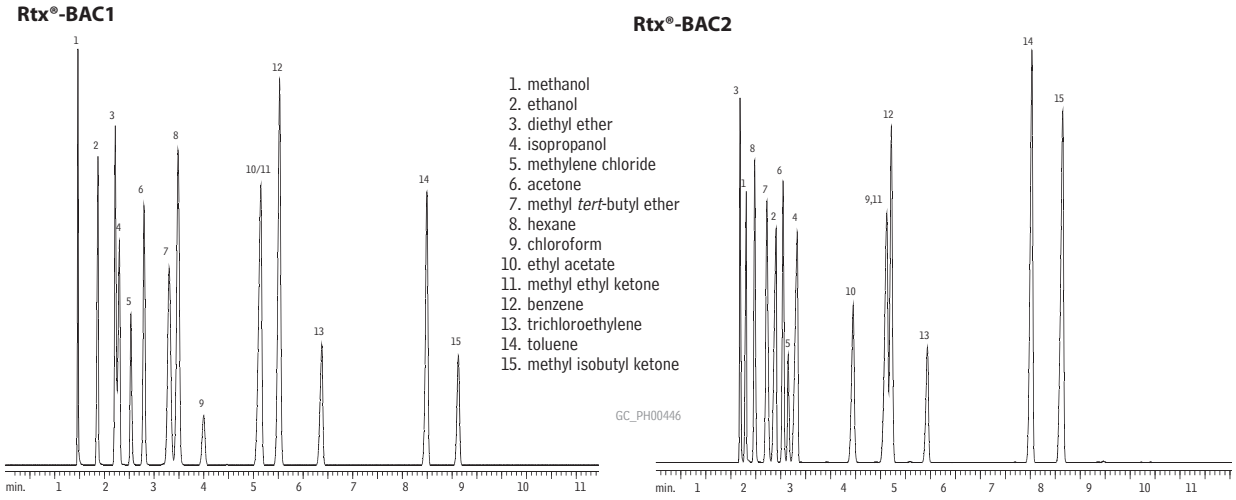
Abused Inhalants; Anesthetics

Abused Inhalants/ Anesthetics

Inhalant abuse can be detected during screening of whole blood, serum, or urine samples, using headspace (GC) with flame ionization detection (FID). Here, we used a GC equipped with an automated headspace sampler that simultaneously introduces a sample into two analytical columns. A dual-column configuration provides screening and confirmational data from the same injection. We used an Rtx®-BAC1 column (30m, 0.53mm ID, 3.00µm df) and an Rtx®-BAC2 column (30m, 0.53mm ID, 2.00µm df)—columns typically used in combination as a screening and confirmation column set for blood alcohol analysis. A useful extension of blood alcohol analysis using this column set is the detection of other volatile organic compounds (VOCs), such as those in inhalants and anesthetics.

Abused Inhalants
Rtx®-BAC1 & Rtx®-BAC2

GC



30m, 0.32mm ID, 1.80µm Rtx®-BAC1 (cat.# 18003)
30m, 0.32mm ID, 1.20µm Rtx®-BAC2 (cat.# 18002)

Oven temp.:	40°C (hold 4 min.) to 120°C @ 10°C/min.
Carrier gas:	helium
Linear velocity:	50cm/sec.
Detector:	FID

Sample:	250µL headspace
Transfer line temp.:	125°C
Sample loop temp.:	125°C
Vial temp.:	70°C

Acknowledgement: Analyses performed using a Tekmar 7000 Headspace Autosampler on loan courtesy of Tekmar-Dohrmann.

for **more** info

GC Analysis of Commonly Abused Inhalants in Blood, Using Rtx®-BAC1 and Rtx®-BAC2 Columns

lit. cat.# 59548

A Technical Guide for Static Headspace Analysis, Using GC

lit. cat.# 59895A

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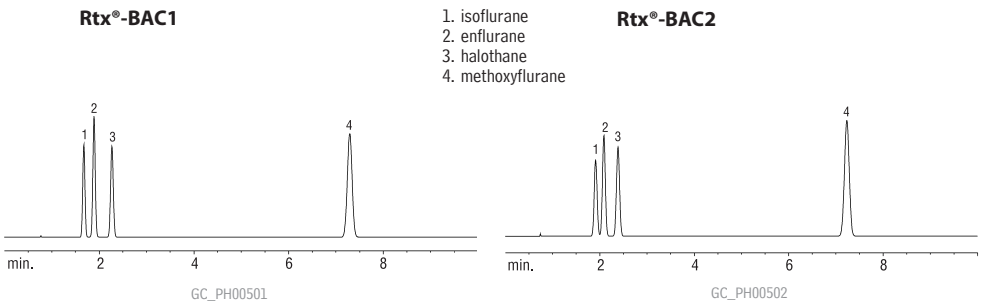
Abused Anesthetics
Rtx®-BAC1 & Rtx®-BAC2

GC

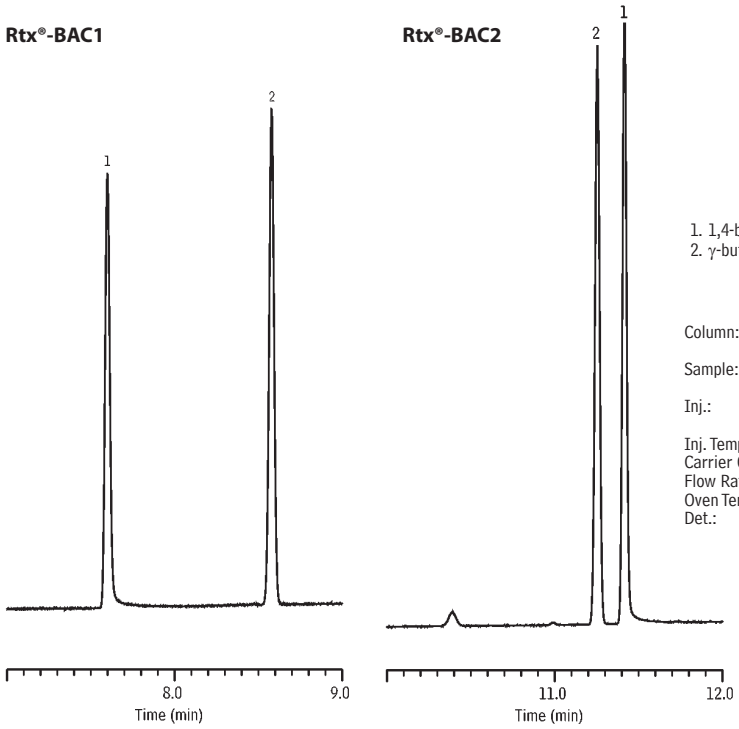


30m, 0.53mm ID, 3.0µm Rtx®-BAC1 (cat.# 18001)
30m, 0.53mm ID, 2.0µm Rtx®-BAC2 (cat.# 18000)
1.0mL headspace sample

Oven temp.:	40°C (hold 5 min.) to 240°C @ 5°C/min.
Inj. & det. temp.:	240°C
Carrier gas:	helium
Linear velocity:	65cm/sec.

GC

γ-butyrolactone & 1,4-butanediol
Rtx®-BAC1 & Rtx®-BAC2

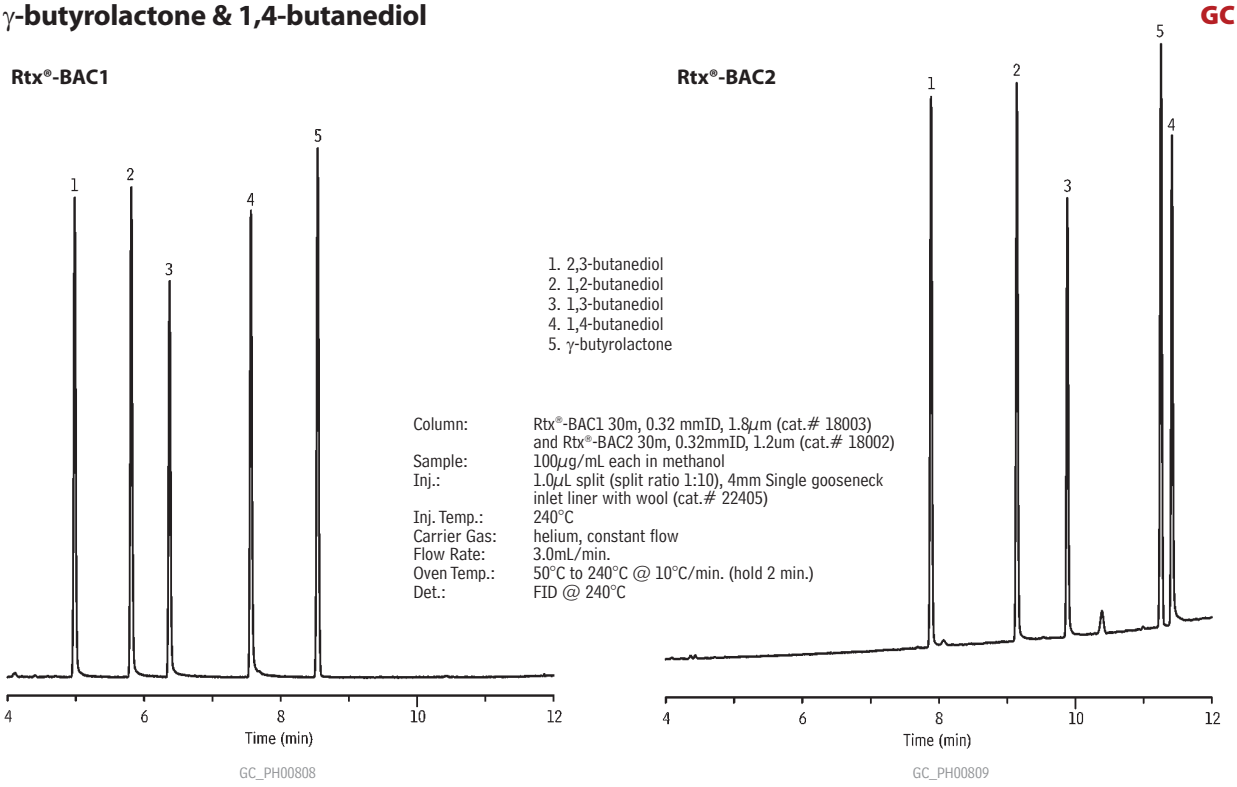


1. 1,4-butanediol
2. γ-butyrolactone

Column:	Rtx®-BAC1 30m, 0.32 mm ID, 1.8μm (cat.# 18003) and Rtx®-BAC2 30m, 0.32 mmID, 1.2μm (cat.# 18002)
Sample:	100μg/mL each γ-butyrolactone (GBL) and 1, 4-butanediol in methanol
Inj.:	1.0μL split (split ratio 1:10), 4mm single gooseneck inlet liner with wool (cat. # 22405)
Inj. Temp.:	240°C
Carrier Gas:	helium, constant flow
Flow Rate:	3.0mL/min.
Oven Temp.:	50°C to 240°C @ 10°C/min. (hold 2 min.)
Det.:	FID @ 240°C

GC

γ-butyrolactone & 1,4-butanediol



1. 2,3-butanediol
2. 1,2-butanediol
3. 1,3-butanediol
4. 1,4-butanediol
5. γ-butyrolactone

Column:	Rtx®-BAC1 30m, 0.32 mmID, 1.8μm (cat.# 18003) and Rtx®-BAC2 30m, 0.32mmID, 1.2um (cat.# 18002)
Sample:	100μg/mL each in methanol
Inj.:	1.0μL split (split ratio 1:10), 4mm Single gooseneck inlet liner with wool (cat.# 22405)
Inj. Temp.:	240°C
Carrier Gas:	helium, constant flow
Flow Rate:	3.0mL/min.
Oven Temp.:	50°C to 240°C @ 10°C/min. (hold 2 min.)
Det.:	FID @ 240°C

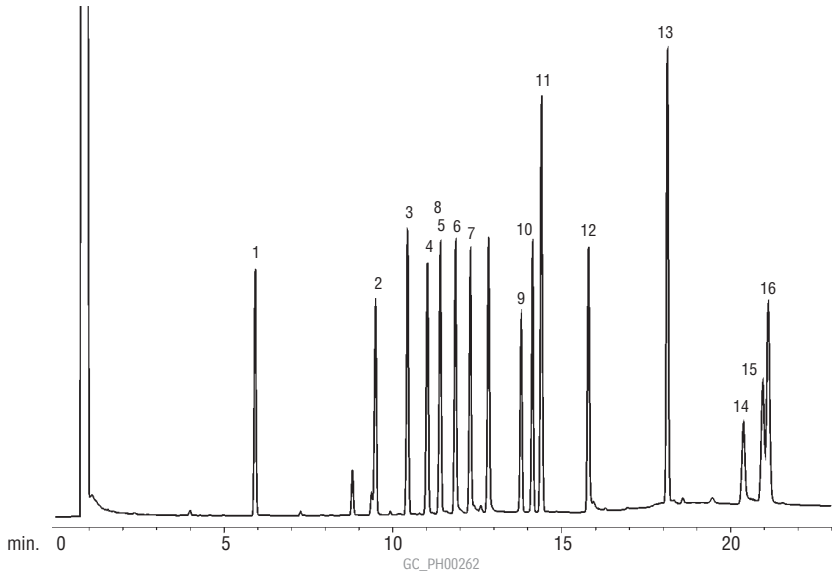
Barbiturates

These acidic and neutral drugs normally are analyzed in their underivatized forms. Symmetric peaks and baseline resolution for many compounds can be achieved by using intermediate polarity Restek columns, Rtx®-35 and Rtx®-1701. In drug overdose or drug abuse testing, these two columns can be used in combination, in dual column analysis for screening and tentatively confirming the presence or absence of specific compounds. Differences in polarity for each stationary phase produce shifts in retention time and elution order. High thermal stability and low column bleed allow these drugs to be detected by FID with on-column concentrations in the low nanogram range. When analyzing underivatized barbiturates, a deactivated inlet liner should be used in the injection port to prevent adsorption onto the surface of the liner. Liners should be changed frequently to prevent the accumulation of non-volatile contamination.

To avert injection port adsorption problems, barbiturates also can be analyzed by gas chromatography in their derivatized forms. They can be derivitized on-column, using methylating reagents like TMAH or TMPAH.

GC

Barbiturates (Underivitized)
Rtx®-35

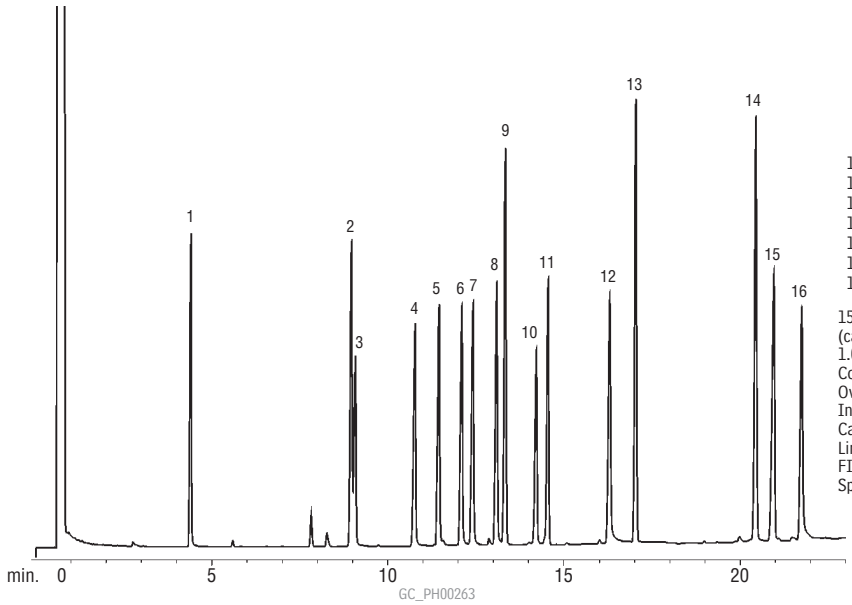


1. ethosuximide
2. barbital
3. methyprylon
4. aprobarbital
5. butalbital
6. amobarbital
7. pentobarbital
8. secobarbital
9. meprobamate
10. carisoprodal
11. glutethimide
12. phenobarbital
13. methaqualone
14. primidone
15. carbamazepine
16. diphenylhydantoin

30m, 0.53mm ID, 1.0µm Rtx®-35 (cat.# 10455)
1.0µL splitless injection

Conc.:	50µg/mL
Oven temp.:	100°C to 280°C @ 10°C/min. (hold 5 min.)
Inj. & det. temp.:	250°C/ 275°C
Carrier gas:	helium
Linear velocity:	40cm/sec. set @ 100°C
FID sensitivity:	5.12 x 10^{-10} AFS
Splitless hold time:	0.5 min.

Barbiturates (Underivatized)
Rtx®-1701



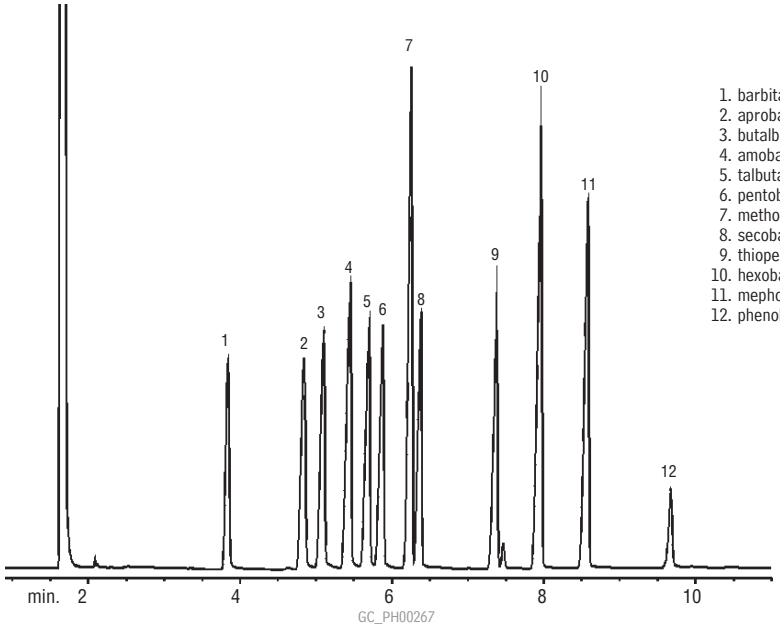
1. ethosuximide
2. methyprylon
3. barbital
4. aprobarbital
5. butalbital
6. amobarbital
7. pentobarbital
8. secobarbital
9. glutethimide
10. meprobamate
11. carisoprodal
12. phenobarbital
13. methaqualone
14. carbamazepine
15. primidone
16. diphenylhydantoin

15m, 0.53mm ID, 0.50µm Rtx®-1701
(cat.# 12037)
1.0µL splitless injection

Conc.:	50µg/mL
Oven temp.:	100°C to 280°C @ 7°C/min.
Inj. / det. temp.:	250°C / 275°C
Carrier gas:	helium
Linear velocity:	40cm/sec. set @ 100°C
FID sensitivity:	5.12 x 10^{-10} AFS
Splitless hold time:	0.5 min.

Barbiturates (Underivatized)
Rtx®-35

GC



1. barbital
2. aprobarbital
3. butalbital
4. amobarbital
5. talbutal
6. pentobarbital
7. methohexital
8. secobarbital
9. thiopental
10. hexobarbital
11. mephobarbital
12. phenobarbital

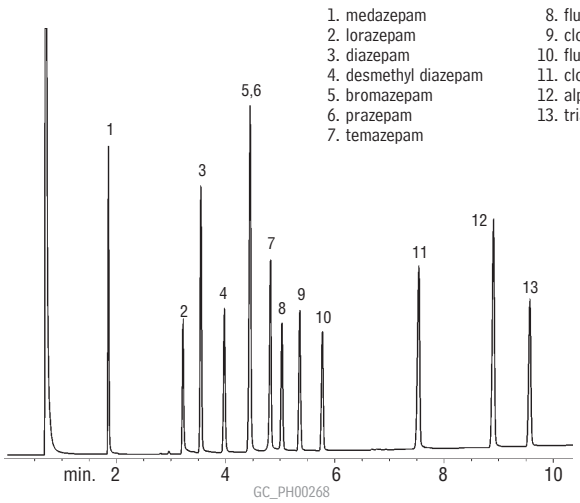
30m, 0.32mm ID, 0.50µm Rtx®-35 (cat.# 10439)
1.0µL split injection of barbiturates

Oven temp.:	210°C (hold 2 min.) to 300°C @ 7°C/min. (hold 2 min.)
Inj. & det. temp.:	300°C
Carrier gas:	helium
Linear velocity:	35cm/sec. set @ 210°C
FID sensitivity:	5.12 x 10^{-10} AFS
Split vent:	30:1

Benzodiazepines (Underivatized)
Rtx®-200

GC

1. medazepam
2. lorazepam
3. diazepam
4. desmethyl diazepam
5. bromazepam
6. prazepam
7. temazepam
8. flurazepam
9. clobazam
10. flunitrazepam
11. clonazepam
12. alprazolam
13. triazolam



15m, 0.32mm ID, 0.25µm Rtx®-200 (cat.# 15021)
1.0µL split injection of benzodiazepines

Conc.:	15ng/component
Oven temp.:	225°C to 325°C @ 8°C/min.
Inj. / det. temp.:	250°C / 320°C
Carrier gas:	helium
Linear velocity:	35cm/sec. set @ 225°C
FID sensitivity:	5.12 x 10^{-10} AFS
Split ratio:	60:1

Benzodiazepines

The Rtx®-200 stationary phase provides excellent resolution and peak shape for benzodiazepines. The unique selectivity of the Rtx®-200 trifluoropropyl methyl polymer helps to resolve this group of compounds, which are very closely related structurally. The high thermal stability of the stationary phase provides a stable baseline at high temperature, to facilitate analysis of picogram quantities of these materials.

free literature

Barbituate Analysis

lit. cat.# 59575

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Basic Drugs (Mixed)

Mixed Basic Drugs

Many basic compounds can be screened for in any given analysis, using a single Restek column. Our bonded polysiloxane stationary phases exhibit low column bleed and high thermal stability while offering a variety of compositions that yield selective retention for specific analytes. Screening and confirmation for individual drugs can be performed simultaneously by using two dissimilar stationary phases in a dual column configuration.

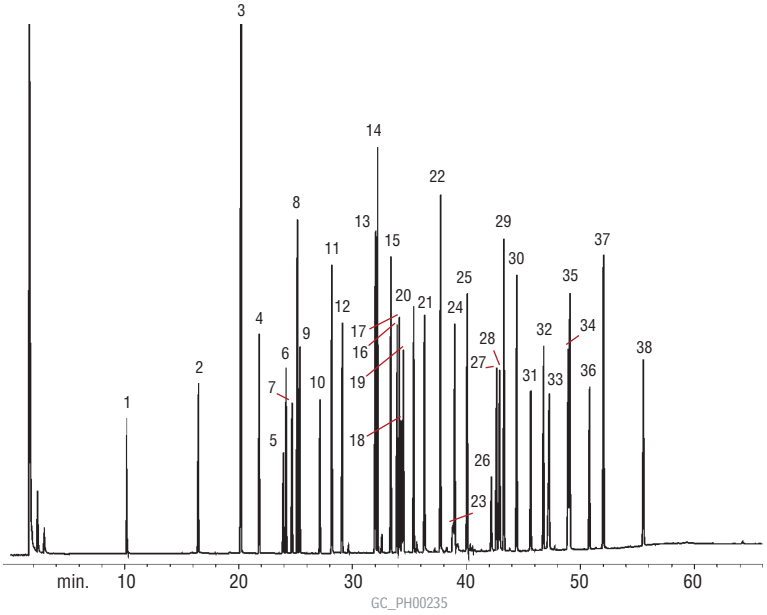
Rtx®-5 and Rtx®-35 phases are 5% and 35% phenyl/methyl polysiloxanes, respectively. The Rtx®-5 column has been used as the primary analytical column by many laboratories and can resolve all 38 compounds in this mixture of basic drugs in less than 60 minutes. The higher phenyl content of the Rtx®-35 phase increases its polarity and retention of more polar compounds, resulting in several elution order and retention time shifts. Under the same conditions used for the Rtx®-5 column, the Rtx®-35 column also resolves all 38 basic drugs, with the exception of pyrilamine and bupivacaine.

Rtx®-200 is a trifluoropropyl polysiloxane that exhibits unique selectivity for compounds with lone pairs of electrons. This column displays very different retention times and elution orders in comparison to the Rtx®-5 or Rtx®-35 column. Under the same analytical conditions, several coelutions occur with the Rtx®-200 column, including: cotinine/caffeine, bupivacaine/chlorpromazine, bromazepam/prazepam, and flurazepam/papaverine.

Because all three columns can be operated under the same temperature program conditions, simultaneous dual column confirmation analysis can be accomplished by using either an Rtx®-35 column or an Rtx®-200 column in conjunction with an Rtx®-5 column. This increases qualitative and quantitative reliability without sacrificing analysis time.

Mixed Basic Drugs (Underivatized)
Rtx®-5

GC



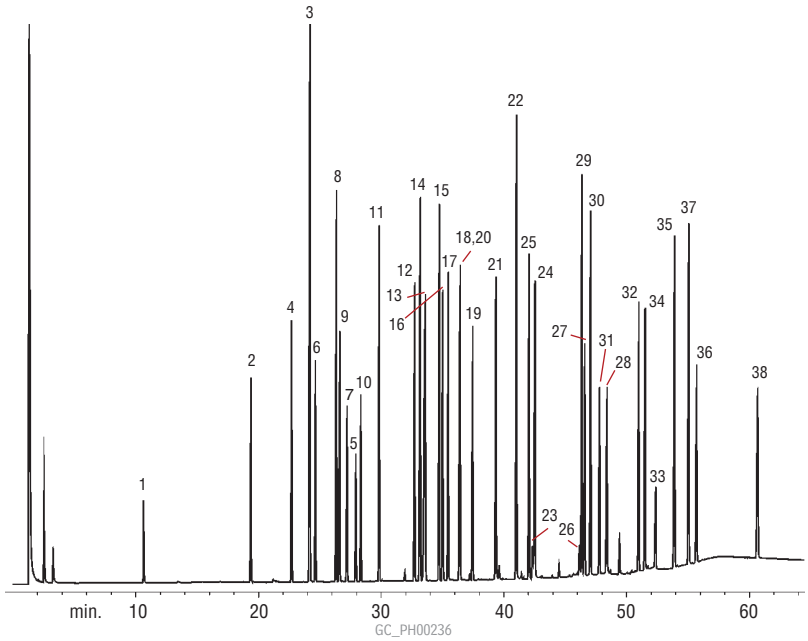
1. nicotine
2. benzocaine
3. cotinine
4. meperidine
5. caffeine
6. benzphetamine
7. ketamine
8. diphenhydramine
9. lidocaine
10. phenyltoloxamine
11. tripelennamine
12. phenothiazine
13. dextromethorphan
14. methadone
15. amitriptyline
16. trimipramine
17. tetracaine
18. pyrilamine
19. medazepam
20. bupivacaine
21. scopolamine
22. codeine
23. morphine
24. diazepam
25. chlorpromazine
26. temazepam
27. flunitrazepam
28. bromazepam
29. prazepam
30. acetopromazine
31. flurazepam
32. papaverine
33. clonazepam
34. haloperidol
35. alprazolam
36. triazolam
37. thioridazine
38. trazodone

30m, 0.25mm ID, 0.25µm Rtx®-5 (cat.# 10223)
1.0µL split injection of a basic drug sample.

Conc.:	1000ng/µL
Oven temp.:	100°C to 325°C @ 4°C/min. (hold 10 min.)
Inj. / det. temp.:	250°C / 320°C
Carrier gas:	helium
Linear velocity:	30cm/sec. set @ 100°C
FID sensitivity:	1.28 x 10^{-10} AFS
Split ratio:	50:1

GC

Mixed Basic Drugs (Underivatized)
Rtx®-35

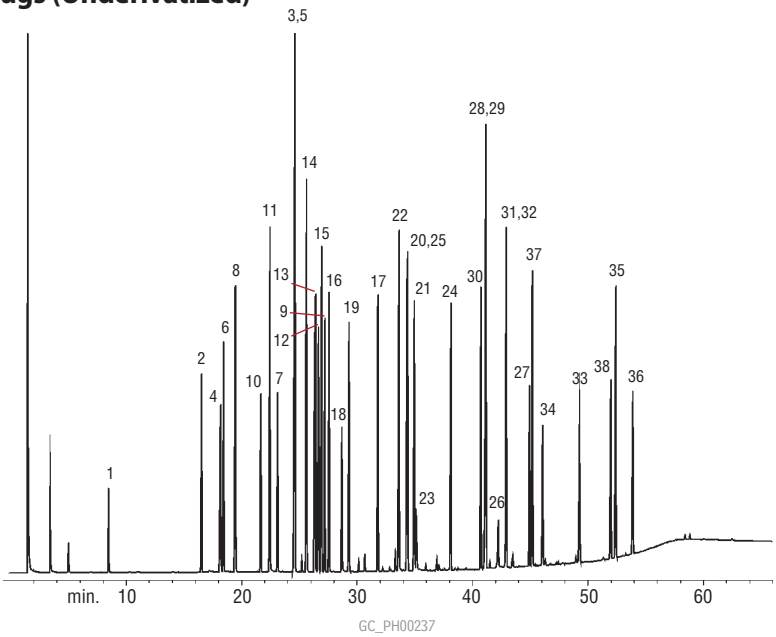


30m, 0.25mm ID, 0.25µm Rtx®-35 (cat.# 10423)
1.0µL split injection of a basic drug mix (1mg/mL)

Conc.:	1000ng/µL
Oven temp.:	100°C to 325°C @ 4°C/min. (hold 10 min.)
Inj. / det. temp.:	250°C / 320°C
Carrier gas:	helium
Linear velocity:	30cm/sec. set @ 100°C
FID sensitivity:	1.28 x 10^{-10} AFS
Split ratio:	50:1

1. nicotine
2. benzocaine
3. cotinine
4. meperidine
5. caffeine
6. benzphetamine
7. ketamine
8. diphenhydramine
9. lidocaine
10. phenyltoloxamine
11. tripelennamine
12. phenothiazine
13. dextromethorphan
14. methadone
15. amitriptyline
16. trimipramine
17. tetracaine
18. pyrilamine
19. medazepam
20. bupivacaine
21. scopolamine
22. codeine
23. morphine
24. diazepam
25. chlorpromazine
26. temazepam
27. flunitrazepam
28. bromazepam
29. prazepam
30. acetopromazine
31. flurazepam
32. papaverine
33. clonazepam
34. haloperidol
35. alprazolam
36. triazolam
37. thioridazine
38. trazodone

Mixed Basic Drugs (Underivatized)
Rtx®-200



30m, 0.25mm ID, 0.25µm Rtx®-200 (cat.# 15023)
1.0µL split injection of a basic drug mix (1mg/mL)

Conc.:	1000ng/µL
Oven temp.:	100°C to 325°C @ 4°C/min. (hold 10 min.)
Inj. / det. temp.:	250°C / 320°C
Carrier gas:	helium
Linear velocity:	30cm/sec. set @ 100°C
FID sensitivity:	1.28 x 10^{-10} AFS
Split ratio:	50:1

Blood Alcohol

Blood Alcohol

Resolution and analysis time are two critical factors to consider when developing an assay for ethanol and other volatiles in biological samples. We have developed two stationary phases specifically for blood alcohol analysis; each has the ability to baseline resolve all of the low molecular weight alcohols and their metabolites. Elution order of this analyte set differs on the two stationary phases, enabling screening and confirmation of volatile compounds to be performed with one injection. These columns also were designed for maximum sample throughput, with total analysis time under 3.5 minutes for an isothermal run. In addition to blood alcohol analysis, these columns can be used to test whole blood, serum, or urine for volatile compounds, using temperature programming.

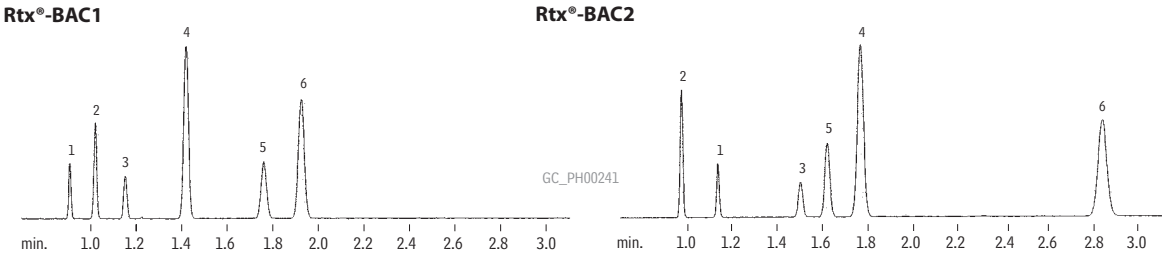
Blood Alcohol
Rtx®-BAC1 & Rtx®-BAC2 (0.32mm ID Columns)

GC

	Conc. w/v
1. methanol	0.1%
2. acetaldehyde	0.2%
3. ethanol	0.2%
4. isopropanol	0.1%
5. acetone	0.01%
6. *n*-propanol	0.1%

30m, 0.32mm ID, 1.8µm Rtx®-BAC1 (cat.# 18003)
30m, 0.32mm ID, 1.2µm Rtx®-BAC2 (cat.# 18002)
Dual-column analysis using a two-hole ferrule.
1.0mL headspace sample of a blood alcohol mix in water

Oven temp.:	40°C
Inj. temp.:	200°C
Carrier gas:	helium
Sample equilibration:	70°C, 15 min.
Vial pressure:	30psi
Vial pressurization time:	0.15 min.
Vial sampling time:	0.01 min.
Transfer line:	0.32mm ID Hydroguard™ fused silica tubing
Transfer line temp.:	200°C
Injection port sleeve:	2mm ID
Split flow:	20mL/min.

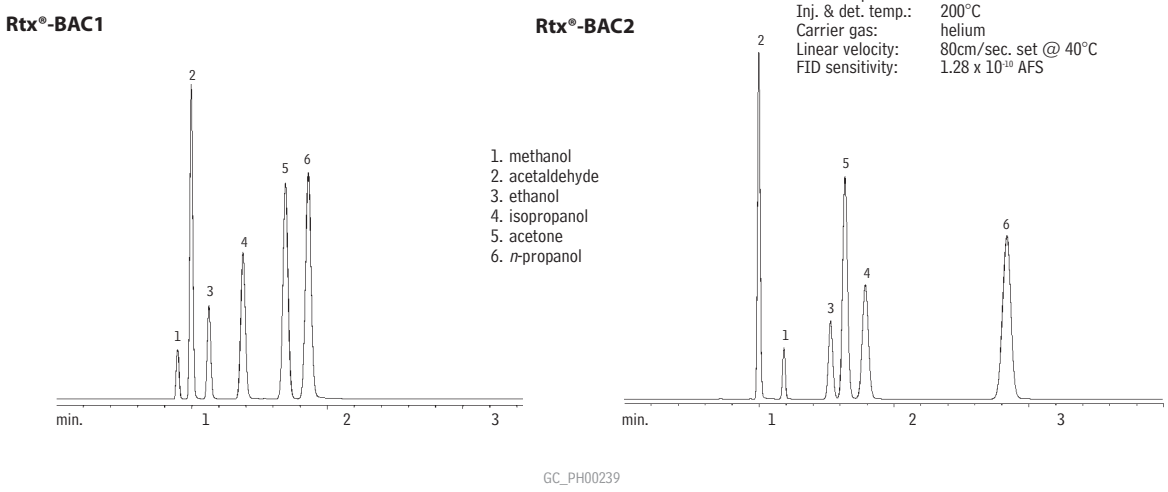


Blood Alcohol
Rtx®-BAC1 & Rtx®-BAC2 (0.53mm ID columns)

GC

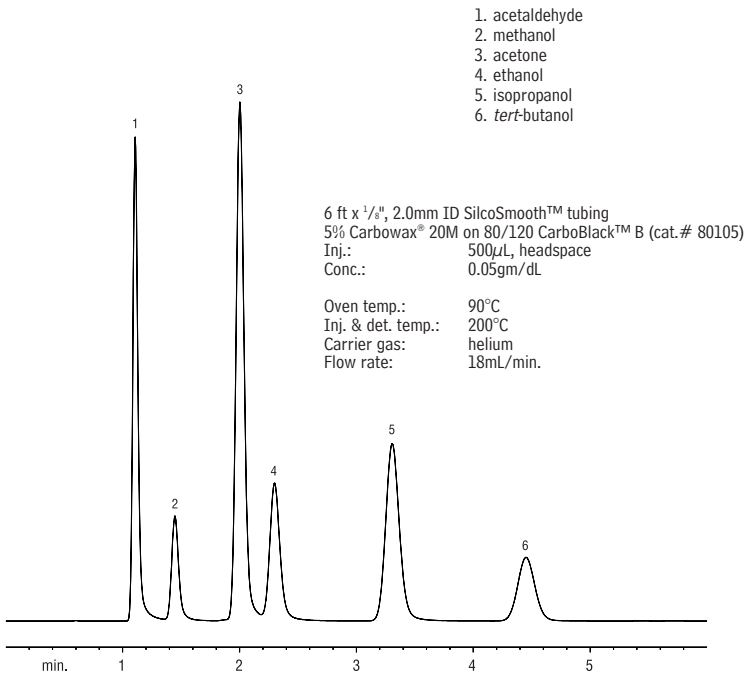
30m, 0.53mm ID, 3.0µm Rtx®-BAC1 (cat.# 18001)
30m, 0.53mm ID, 2.0µm Rtx®-BAC2 (cat.# 18000)
1.0mL headspace sample of a blood alcohol mix in water

Sample conc.:	0.1% per compound
Oven temp.:	40°C
Inj. & det. temp.:	200°C
Carrier gas:	helium
Linear velocity:	80cm/sec. set @ 40°C
FID sensitivity:	1.28 x 10^{-10} AFS



Blood Alcohol
5% Carbowax® 20M on 80/120 CarboBlack™ B

GC



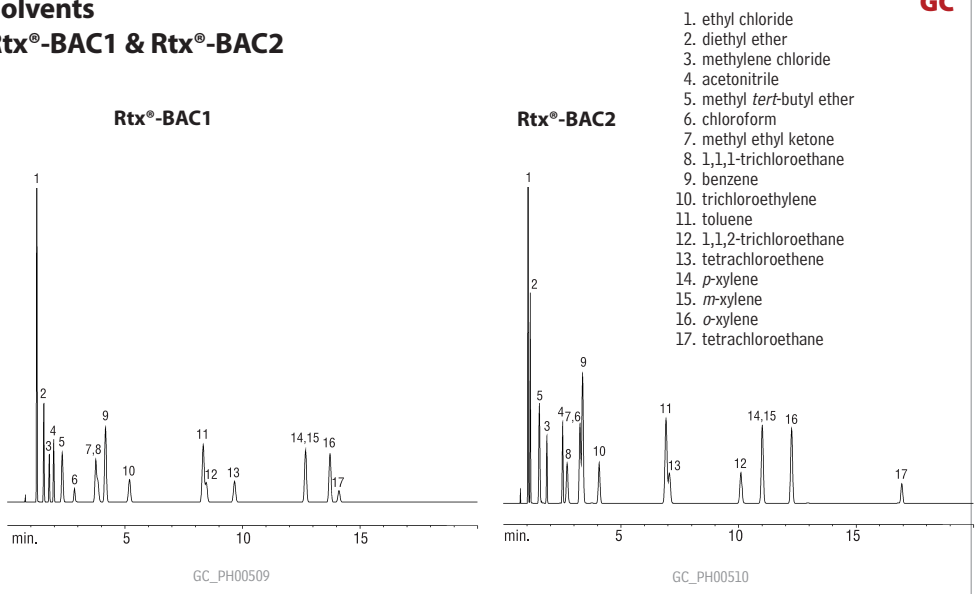
did you **know**?

Our Technical Service Department is staffed with more than 35 experienced chemists on rotating shifts from various departments. Whether your chromatography problem is simple or complex, call Restek's Technical Service Team at 1-800-356-1688 (ext. 4), or your Restek representative, and we will do everything we can to help you find a solution.

CLINICAL/FORENSICS

Solvents
Rtx®-BAC1 & Rtx®-BAC2

GC



30m, 0.53mm ID, 3.0µm Rtx®-BAC1 (cat.# 18001)
30m, 0.53mm ID, 2.0µm Rtx®-BAC2 (cat.# 18000)
1.0mL headspace sample
Oven temp.: 40°C (hold 5 min.) to 240°C @ 5°C/min.
Inj. & det. temp.: 240°C
Carrier gas: helium
Linear velocity: 65cm/sec.

free literature

Ethanol Analytical Reference Standards for Blood Alcohol Testing

lit. cat.# 59382

Dual-Column Confermation GC Analysis of Blood Alcohols Using Rtx®-BAC1 and Rtx®-BAC2 Columns Optimized for the Perkin Elmer HS 40 Headspace Autosampler

lit. cat.# 59598

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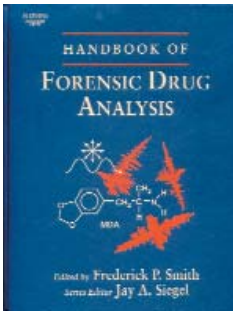
Cannabinoids; Opiates

Cannabinoids

Analysis of cannabinoids includes screening for parent compounds as well as metabolites of the active constituents in marijuana. Derivatization is commonly employed to help improve peak shape and resolution. Derivatization also can aid in the identification of specific cannabinoids by GC/MS by producing unique high mass ion fragments. Columns with low bleed and high thermal stability are required for trace level analysis. Low polarity columns, like the Rtx®-5 column, provide sufficient resolution for derivatized cannabinoids without extending the run time unnecessarily.

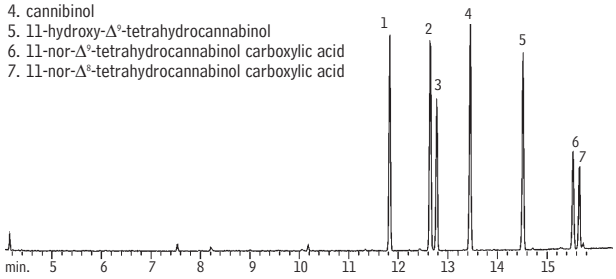


Handbook of Forensic Drug Analysis
cat.# 23055 (ea.)

Cannabinoids (TMS Derivatives)
Rtx®-5

GC

1. cannabidiol
2. Δ^8-tetrahydrocannabinol
3. Δ^9-tetrahydrocannabinol
4. cannibinol
5. 11-hydroxy-Δ^9-tetrahydrocannabinol
6. 11-nor-Δ^9-tetrahydrocannabinol carboxylic acid
7. 11-nor-Δ^8-tetrahydrocannabinol carboxylic acid



GC_PH00253

15m, 0.25mm ID, 0.25µm Rtx®-5 (cat.# 10220)
1.0µL splitless injection of cannabinoids

Conc.:	100µg/mL
Oven temp.:	50°C (hold 0.5 min.) to 225°C @ 30°C/min., to 325°C @ 10°C/min.
Inj. temp.:	225°C
Interface temp.:	320°C
Det.:	MSD
Ionization:	EI
Carrier gas:	helium
Scan range:	40-500 AMU
Linear velocity:	40cm/sec. set @ 50°C
Splitless hold time:	0.75 min.

Opiates

Opiates are comprised of a multiple ring structure, substituted at various sites, producing compounds with different degrees of potency. When substitution is with a hydroxyl group, derivatization prior to analysis by GC is necessary to improve peak shape and response. Derivatization also can aid in the identification of opiates during GC/MS analysis by forming unique high mass ion fragments. An Rtx®-5 column can efficiently separate trimethylsilyl or fluoroacyl derivatives of the opiates.

free literature

Opiate Analysis

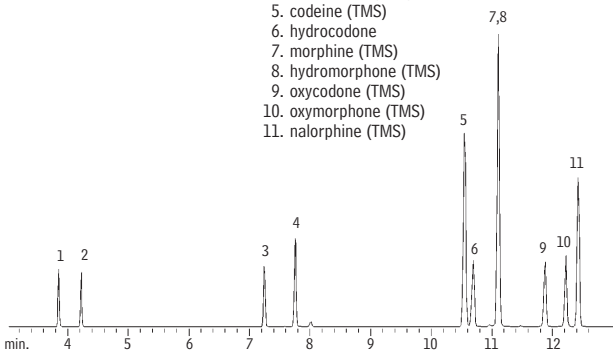
lit. cat.# 59576

Call Restek at 800-356-1688 or 814-353-1300, ext. 5, or contact your Restek representative, to request your free copy!

Opiates (TMS Derivatives)
Rtx®-5

GC

1. meperidine
2. alphaprodine
3. methadone
4. levorphanol (TMS)
5. codeine (TMS)
6. hydrocodone
7. morphine (TMS)
8. hydromorphone (TMS)
9. oxycodone (TMS)
10. oxymorphone (TMS)
11. nalorphine (TMS)



GC_PH00233

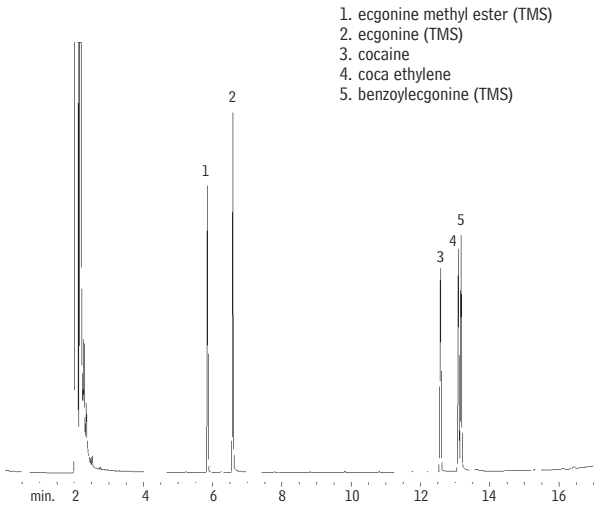
30m, 0.25mm ID, 0.25µm Rtx®-5 (cat.# 10223)
2.0µL split injection of opiates

Conc:	2000ng/µL
Oven temp.:	200°C to 325°C @ 7°C/min.
Inj. / det. temp.:	250°C / 300°C
Det. type:	MS
Ionization:	EI
Carrier gas:	helium
Mode:	full scan
Linear velocity:	30cm/sec. set @ 200°C
Split ratio:	50:1

Cocaine

Benzoylecgonine is the major metabolite found in urine after cocaine abuse. Monitoring for benzoylecgonine is required in the testing protocol established by the Department of Health and Human Services and the National Institute on Drug Abuse. Benzoylecgonine and other cocaine metabolites should be derivatized prior to analysis. Parent cocaine and its derivatized metabolites can be analyzed together on an Rtx®-5 column with good peak shape and resolution. The analysis also can be accomplished by HPLC.

Cocaine & Metabolites (TMS Derivatives) — GC
Rtx®-5



30m, 0.25mm ID, 0.25µm Rtx®-5 (cat.# 10223)
1.0µL split injection of cocaine and cocaine metabolites

Oven temp.:	150°C to 320°C @ 10°C/min.
Inj. / det. temp.:	250°C / 300°C
Carrier gas:	helium
Linear velocity:	30cm/sec. set @ 50°C
FID sensitivity:	2.56 x 10^{-10} AFS
Split ratio:	30:1

Cocaine and Ecgonine Methyl Ester — HPLC
Allure™ PFP Propyl

Peak List:
1. EME (ecgonine methyl ester)
2. COC (cocaine)

Sample:

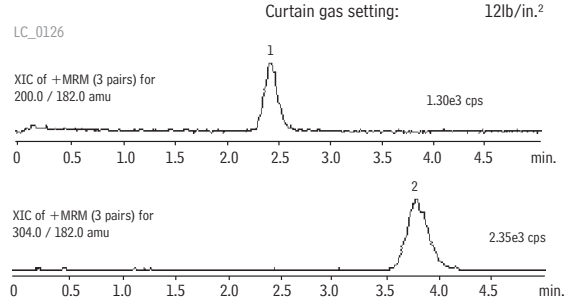
Inj.:	10µL
Conc.:	1µg/mL
Solvent:	water
Temp.:	4°C

Column: Allure™ PFP Propyl

Cat. #:	9169532
Dimensions:	30 x 2.1mm
Particle size:	5µm
Pore size:	60Å

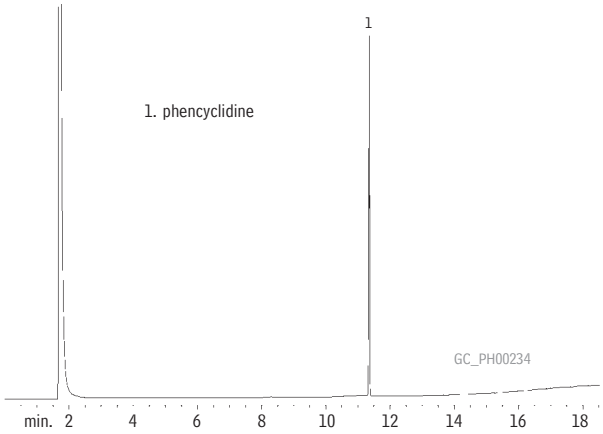
Conditions:

Mobile phase:	5mM ammonium formate, pH 3.0: acetonitrile (10:90, v/v)
Flow:	0.6mL/min.
Column temp.:	ambient
Det.:	PE/Sciex API 3000
Interface:	turbo ion spray, ESI
Interface temp.:	150°C
Ion mode:	positive
ESI probe voltage:	5000V
Orifice:	+ 71V
Ring:	+ 265V
Collision gas:	nitrogen
Collision gas pressure:	2.2 mTorr
Collision gas energy:	28 eV (COC) 26 eV (EME)
Electron multiplier:	2100 volts
Auxilary gas flow:	7000cc/min.
Nebulizer gas setting:	15lb/in.²
Curtain gas setting:	12lb/in.²



Data Courtesy of Shane Needham, Pfizer Inc.

Phencyclidine (PCP) — GC
Rtx®-5



30m, 0.25mm ID, 0.25µm Rtx®-5 (cat.# 10223)
1.0µL split injection of phencyclidine

Conc.:	1000ng/µL
Oven temp.:	50°C (hold 1 min.) to 250°C @ 25°C/min., then to 325°C @ 10°C/min. (hold 2 min.)
Inj. / det. temp.:	250°C / 325°C
Carrier gas:	helium
Linear velocity:	30cm/sec. set @ 50°C
FID sensitivity:	2.56 x 10^{-10} AFS
Split ratio:	30:1

Phencyclidine

Phencyclidine can be screened for using immunoassay techniques. However, prior to reporting positive results, the presence of phencyclidine should be confirmed by an alternative chemical test. Phencyclidine easily can be chromatographed on phenylmethyl stationary phases like Rtx®-5. Low picogram amounts of the drug can be detected by NPD or GC/MS.

free literature

HPLC Column Selection Guide

lit. cat.# 59454B

Allure™ PFP Propyl and Ultra PFP Columns Provide Improved Analyses of Basic Compounds

lit. cat.# 59118A

Call Restek at 800-356-1688 or 814-353-1300, ext. 5, or contact your Restek representative, to request your free copy!

Glycols

Ethylene Glycol

Ethylene glycol, a major component of automotive antifreeze products, is a poison to humans and animals. It can be analyzed by GC on an Rtx®-BAC1, Rtx®-BAC2, or Stabilwax® column.

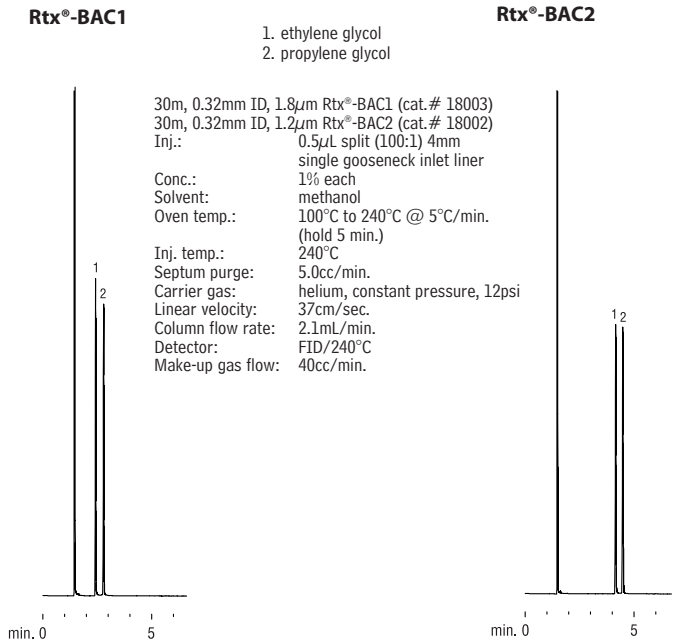
GC

Glycols
Rtx®-BAC1 & Rtx®-BAC2

1. ethylene glycol
2. propylene glycol

30m, 0.32mm ID, 1.8µm Rtx®-BAC1 (cat.# 18003)
30m, 0.32mm ID, 1.2µm Rtx®-BAC2 (cat.# 18002)

Inj.:	0.5µL split (100:1) 4mm single gooseneck inlet liner
Conc.:	1% each
Solvent:	methanol
Oven temp.:	100°C to 240°C @ 5°C/min. (hold 5 min.)
Inj. temp.:	240°C
Septum purge:	5.0cc/min.
Carrier gas:	helium, constant pressure, 12psi
Linear velocity:	37cm/sec.
Column flow rate:	2.1mL/min.
Detector:	FID/240°C
Make-up gas flow:	40cc/min.



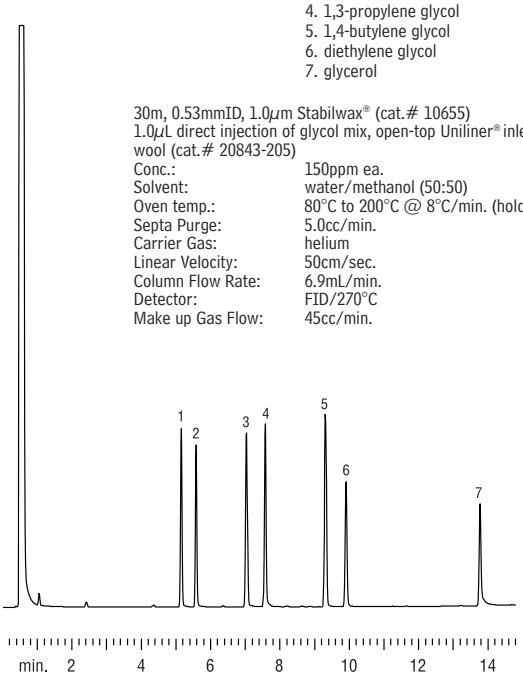
GC_EV00474

Glycols
Stabilwax®

1. 1,2-propylene glycol
2. ethylene glycol
3. 1,3-butylene glycol
4. 1,3-propylene glycol
5. 1,4-butylene glycol
6. diethylene glycol
7. glycerol

30m, 0.53mmID, 1.0µm Stabilwax® (cat.# 10655)
1.0µL direct injection of glycol mix, open-top Uniliner® inlet liner without wool (cat.# 20843-205)

Conc.:	150ppm ea.
Solvent:	water/methanol (50:50)
Oven temp.:	80°C to 200°C @ 8°C/min. (hold 10 min.)
Septa Purge:	5.0cc/min.
Carrier Gas:	helium
Linear Velocity:	50cm/sec.
Column Flow Rate:	6.9mL/min.
Detector:	FID/270°C
Make up Gas Flow:	45cc/min.



GC_EV00476

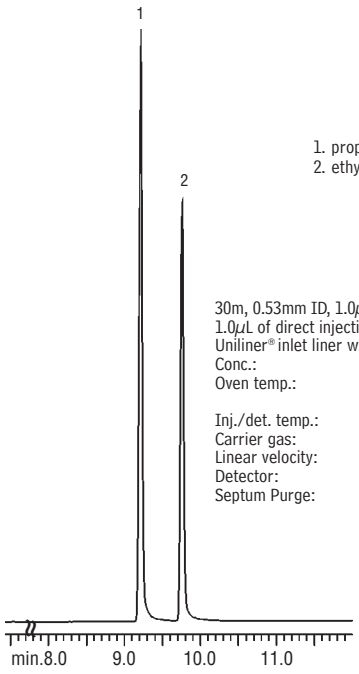
GC

Glycols
Stabilwax®

1. propylene glycol
2. ethylene glycol

30m, 0.53mm ID, 1.0µm Stabilwax® (cat.# 10655)
1.0µL of direct injection of glycols in water. Open-top Uniliner® inlet liner without wool (cat.# 20843-205).

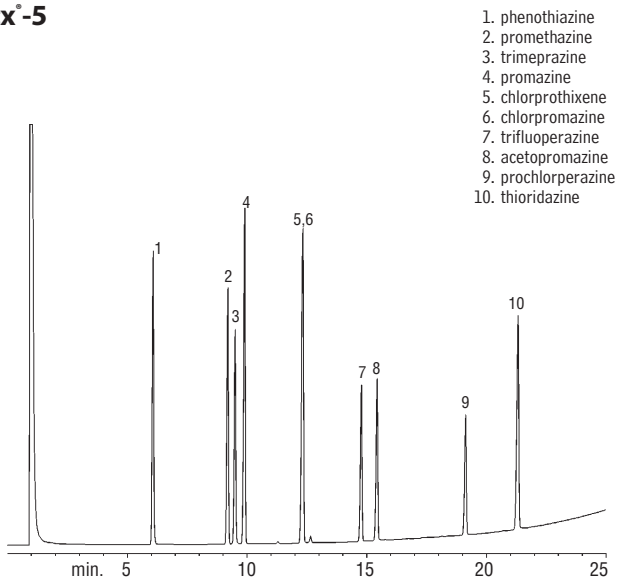
Conc.:	100ppm
Oven temp.:	80°C (hold 1 min.) to 200°C @ 8°C/min. (hold 5 min.)
Inj./det. temp.:	225°C/250°C
Carrier gas:	helium
Linear velocity:	50cm/sec.
Detector:	FID
Septum Purge:	5.0cc/min.



GC_EV00546

Phenothiazines (Underivatized)
Rtx®-5

GC



GC_PH00269

15m, 0.32mm ID, 0.50µm Rtx®-5 (cat.# 10236)
1.0µL split injection of phenothiazines
Conc.: 2000ng/µL

Oven temp.: 200°C to 325°C @ 5°C/min.
Inj. / det. temp.: 250°C / 315°C
Carrier gas: helium
Linear velocity: 25cm/sec. set @ 200°C
FID sensitivity: 2.56 x 10^{-10} AFS
Split ratio: 30:1

Phenothiazines

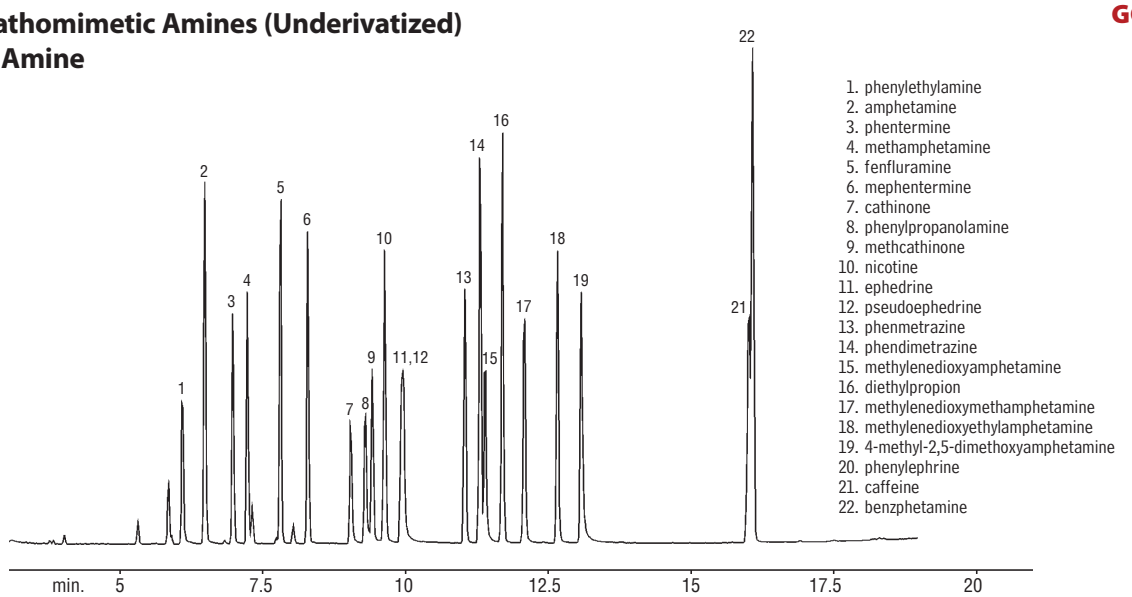
Phenothiazines are high molecular weight compounds based on a three ring structure. When analyzing phenothiazines by gas chromatography, retention times are typically long with elution temperatures at or near the maximum operating temperature of the column. Using shorter columns will help to reduce the effective elution temperature and overall analysis time.

Sympathomimetic Amines

Sympathomimetic amine drugs include both controlled and non-controlled substances based on phenylethylamine, with various functional groups substituted at key positions on the molecule. Active hydrogens on the amine portion of the molecule necessitate derivatization to improve peak shape and response. Acylating reagents have been used to produce less polar and less reactive compounds that chromatograph well on low polarity stationary phases like Rtx®-5. A carefully chosen derivatizing reagent can produce differences in relative retention time for specific compounds and help to resolve coelutions. Identification by GC/MS can be improved by using a reagent that produces unique high mass ion fragments. Deactivated vials, glassware and inlet liners should be used to maintain consistent recovery during sample preparation and analysis.

Sympathomimetic Amines (Underivatized)
Rtx®-5 Amine

GC



GC_PH00438

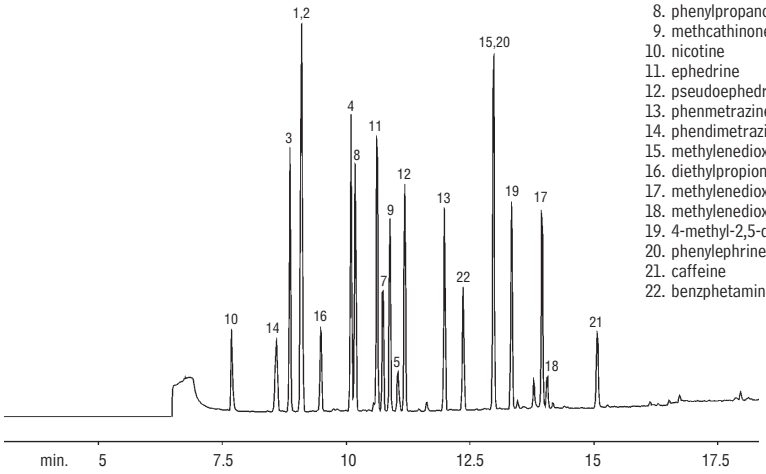
30m, 0.25mm ID, 0.50µm Rtx®-5 Amine (cat.# 12338)
split mode, split vent flow rate 45mL/min.
Oven temp.: 100°C to 310°C @ 10°C/min.

Varian 3400 GC coupled with Varian Saturn 2000 MS detector
Mass spectroscopy data collected using a scan range of 40 amu through 600 amu.
Ionization performed in the EI Auto mode.

GC

Sympathomimetic Amines (Derivatized)
Rtx®-200

1. phenylethylamine
2. amphetamine
3. phentermine
4. methamphetamine
5. fenfluramine
6. mephentermine
7. cathinone
8. phenylpropanolamine
9. methcathinone
10. nicotine
11. ephedrine
12. pseudoephedrine
13. phenmetrazine
14. phendimetrazine
15. methylenedioxyamphetamine
16. diethylpropion
17. methylenedioxymethamphetamine
18. methylenedioxyethylamphetamine
19. 4-methyl-2,5-dimethoxyamphetamine
20. phenylephrine
21. caffeine
22. benzphetamine



GC_PH00439

30m, 0.25mm ID, 0.50µm Rtx®-200 (cat.# 15038)
split mode, split vent flow rate 45mL/min.
Oven temp.: 100°C to 310°C @ 10°C/min.

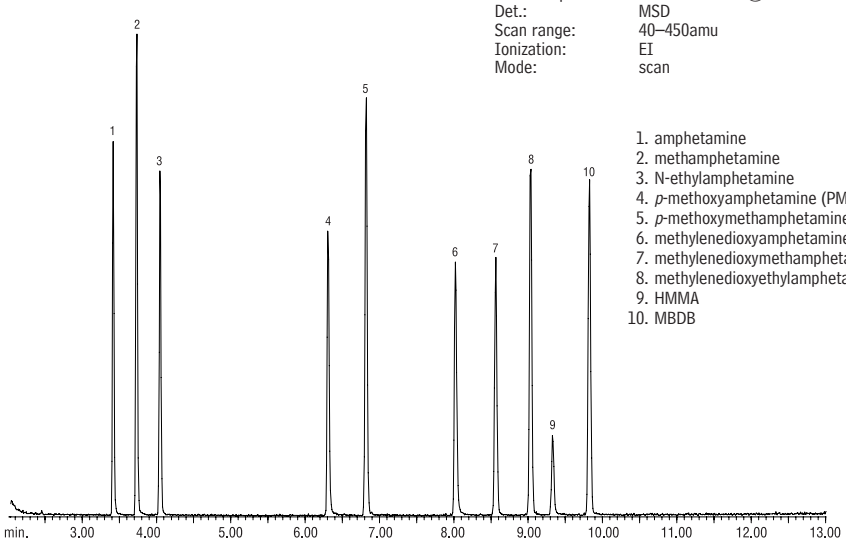
Varian 3400 GC coupled with Varian Saturn 2000 MS detector
Mass spectroscopy data collected using a scan range of 40 amu through 600 amu.
Ionization performed in the EI Auto mode.

Sympathomimetic Amines (Underivatized)
Rtx®-35 Amine

Rtx®-35 Amine 30m, 0.25mm ID, 0.50µm (cat.# 11338)
1.0µL split injection of underivatized sympathomimetic amines

Conc.	1000ng/µL
Inj. temp:	250°C
Carrier gas:	helium
Linear velocity:	30cm/sec.
Oven temp.:	150°C to 240°C @ 7°C/min.
Det.:	MSD
Scan range:	40–450amu
Ionization:	EI
Mode:	scan

1. amphetamine
2. methamphetamine
3. N-ethylamphetamine
4. *p*-methoxyamphetamine (PMA)
5. *p*-methoxymethamphetamine (PMMA)
6. methylenedioxyamphetamine (MDA)
7. methylenedioxymethamphetamine (MDMA)
8. methylenedioxyethylamphetamine (MDEA)
9. HMMA
10. MBDB



GC_PH00574

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High Performance Silica Products

lit. cat.# 59901

Operating Hints for Using Split/Splitless Injectors

lit. cat.# 59880A

Improved GC Analysis of Basic Organic Compounds Using Base Deactivated Columns & Liners.

lit. cat.# 59108

Genuine Restek Replacement Parts for Agilent GCs

lit. cat.# 59627E

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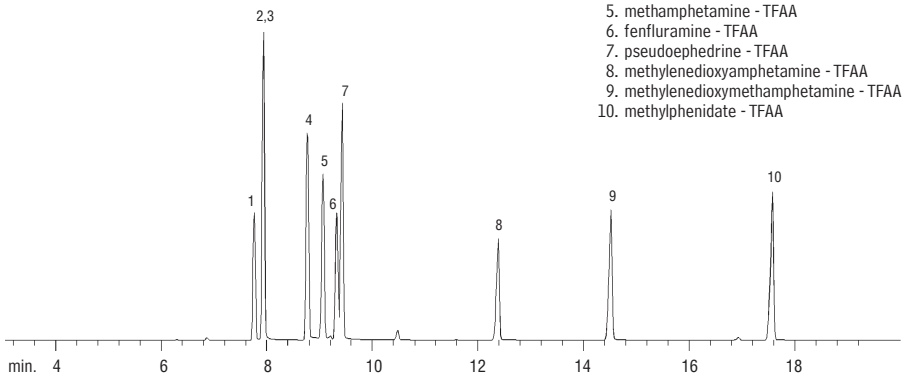
GC

Sympathomimetic Amines (TFAA Derivatives)
Rtx®-5

1. amphetamine - TFAA
2. phentermine - TFAA
3. phenylpropanolamine - TFAA
4. ephedrine - TFAA
5. methamphetamine - TFAA
6. fenfluramine - TFAA
7. pseudoephedrine - TFAA
8. methylenedioxyamphetamine - TFAA
9. methylenedioxymethamphetamine - TFAA
10. methylphenidate - TFAA



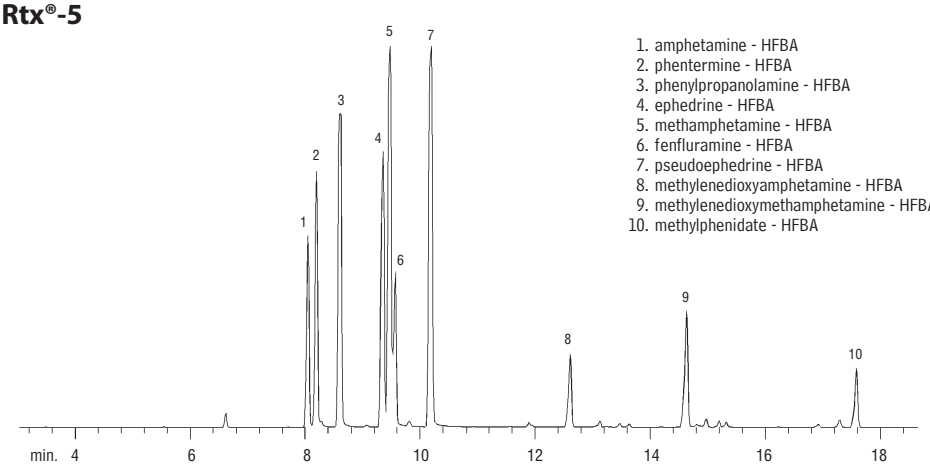
GC_PH00251

30m, 0.25mm ID, 0.25µm Rtx®-5 (cat.# 10223)
1.0µL splitless injection of derivatized sympathomimetic amines

Conc.:	approximately 2.5ng/µL
Oven temp.:	40°C (hold 1 min.) to 150°C @ 30°C/min., to 300°C @ 5°C/min.
Inj. temp.:	225°C
Interface temp.:	275°C
Det.:	MSD
Ionization:	EI
Carrier gas:	helium
Linear velocity:	20cm/sec. set @ 100°C
Splitless hold time:	1 min.

Sympathomimetic Amines (HFBA Derivatives)
Rtx®-5

1. amphetamine - HFBA
2. phentermine - HFBA
3. phenylpropanolamine - HFBA
4. ephedrine - HFBA
5. methamphetamine - HFBA
6. fenfluramine - HFBA
7. pseudoephedrine - HFBA
8. methylenedioxyamphetamine - HFBA
9. methylenedioxymethamphetamine - HFBA
10. methylphenidate - HFBA



GC_PH00252

30m, 0.25mm ID, 0.25µm Rtx®-5 (cat.# 10223)
1.0µL splitless injection of sympathomimetic amines

Conc.:	approximately 2.5ng/µL.
Oven temp.:	40°C (hold 1 min.) to 150°C @ 30°C/min., to 300°C @ 5°C/min.
Inj. temp.:	225°C
Interface temp.:	275°C
Det.:	MSD
Ionization:	EI
Carrier gas:	helium
Linear velocity:	20cm/sec. set @ 100°C
Splitless hold time:	1 min.

CLINICAL/FORENSICS

free literature

GC Column Installation

lit. cat.# 59668A

USP Column Cross-Reference Chart

lit. cat.# 59253

Call Restek at 800-356-1688 or 814-353-1300, ext. 5, or contact your Restek representative, to request your free copy!

Analgesic Formulations

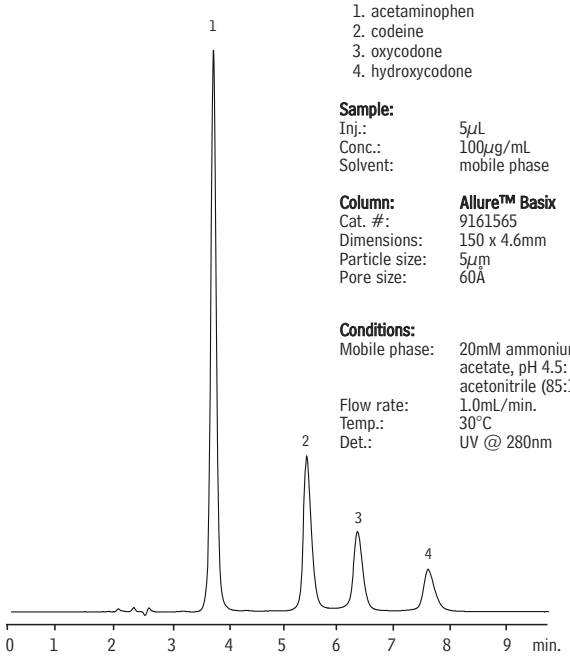
Analgesics

Popular components for multi-active analgesic formulations include aspirin, salicylic acid, salicylamide, acetaminophen, ibuprofen, naproxen, guaifenesin, codeine, oxycodone, hydrocodone, and caffeine. Many of these compounds can be analyzed simultaneously using high performance liquid chromatography (HPLC), thereby improving laboratory efficiency and productivity. With the selection of the proper LC phase, separation becomes a simple and manageable task that does not rely upon extensive preparation procedures or use of ion pairing agents, which often are described in pharmaceutical compenda.

Ultra C18, Ultra Phenyl, and Allure™ Basix HPLC column phases separate mixtures of these pharmaceuticals in a productive and cost effective manner. The selective chemistries of these phases provide powerful separation mechanisms.

Acetaminophen and Narcotic Analgesics
Allure™ Basix

HPLC



Peak List:
1. acetaminophen
2. codeine
3. oxycodone
4. hydroxycodone

Sample:
Inj.: 5µL
Conc.: 100µg/mL
Solvent: mobile phase

Column: **Allure™ Basix**
Cat. #: 9161565
Dimensions: 150 x 4.6mm
Particle size: 5µm
Pore size: 60Å

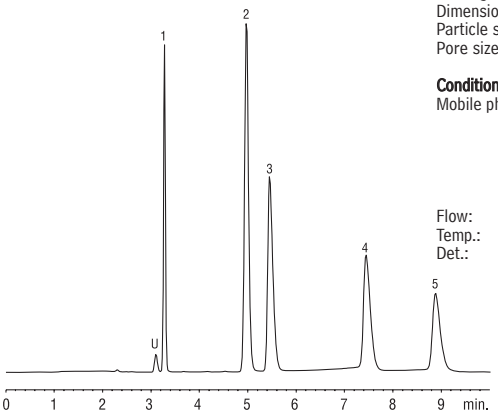
Conditions:
Mobile phase: 20mM ammonium acetate, pH 4.5: acetonitrile (85:15, v/v)
Flow rate: 1.0mL/min.
Temp.: 30°C
Det.: UV @ 280nm

LC_0082

Acetaminophen and Narcotic Analgesics
Ultra C18

HPLC

Peak List:	Conc. (µg/mL)	Ret. Time (min.)	Tailing	Resolution
U. unknown	unknown	3.1	NA	NA
1. morphine sulfate	204	3.3	1.0	1.8
2. acetaminophen	92	5.0	1.1	14.1
3. codeine phosphate	216	5.5	1.4	2.6
4. oxycodone HCl	206	7.5	1.4	8.5
5. hydrocodone bitartrate	218	8.9	1.4	5.0



Sample:
Inj.: 4.0µL
Sample: raw material mix
Solvent: mobile phase

Column: **Ultra C18**
Catalog #: 9174575
Dimensions: 250 x 4.6mm
Particle size: 5µm
Pore size: 100Å

Conditions:
Mobile phase: A: 10mm potassium phosphate, pH 2.8
B: acetonitrile: methanol (90:10 v/v) (85A:15B, v/v)
Flow: 1.0mL/min.
Temp.: 27°C
Det.: UV @ 235nm

LC_0218

free literature

Improved HPLC Analysis of Analgesics

lit. cat.# 59511A

Genuine Restek Replacement Parts for HPLC Systems

lit. cat.# 59012A

HPLC Tech Tips Wall Chart

lit. cat.# 59894A

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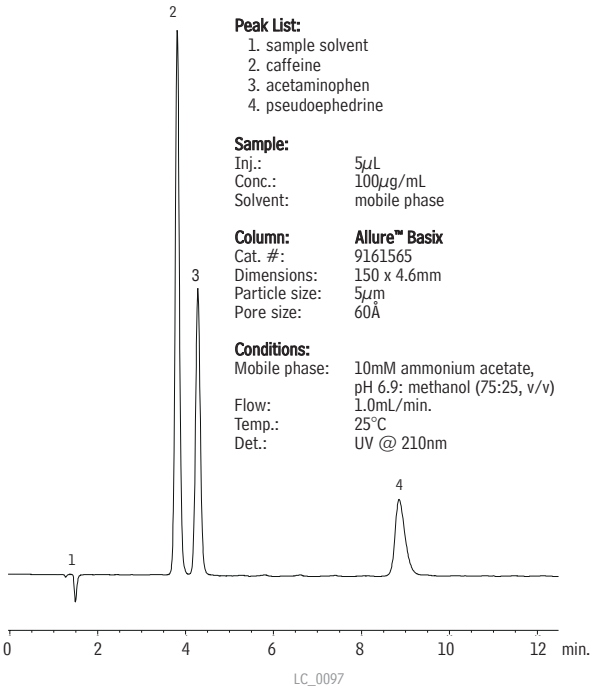
Acetaminophen (Analgesic), Pseudoephedrine (Decongestant), and Caffeine (Stimulant)
Allure™ Basix



Peak List:
1. sample solvent
2. caffeine
3. acetaminophen
4. pseudoephedrine

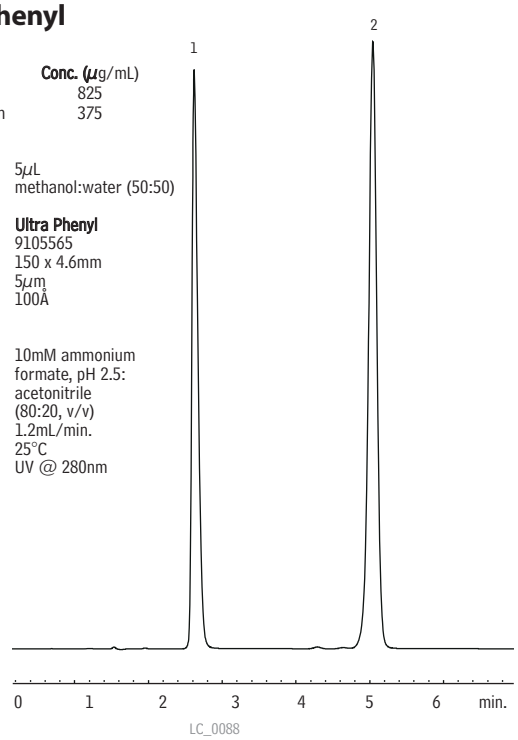
Sample:
Inj.: 5µL
Conc.: 100µg/mL
Solvent: mobile phase

Column: Allure™ Basix
Cat. #: 9161565
Dimensions: 150 x 4.6mm
Particle size: 5µm
Pore size: 60Å

Conditions:
Mobile phase: 10mM ammonium acetate, pH 6.9: methanol (75:25, v/v)
Flow: 1.0mL/min.
Temp.: 25°C
Det.: UV @ 210nm

Guaifenesin (Expectorant/Antitussive) and Codeine (Narcotic Analgesic)
Ultra Phenyl

HPLC



Peak List: Conc. (µg/mL)
1. codeine 825
2. guaifenesin 375

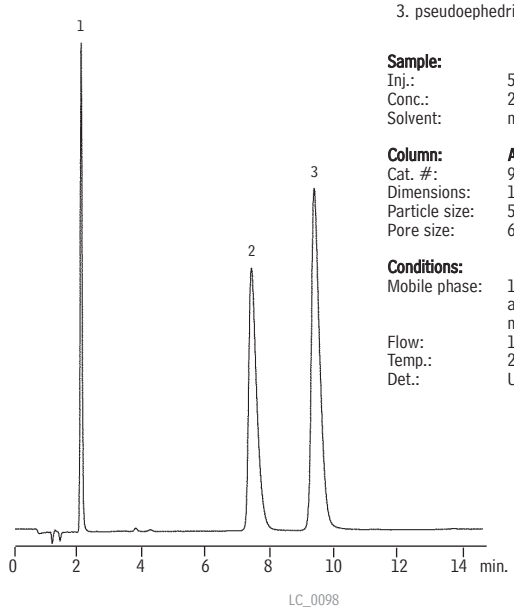
Sample:
Inj.: 5µL
Solvent: methanol:water (50:50)

Column: Ultra Phenyl
Cat. #: 9105565
Dimensions: 150 x 4.6mm
Particle size: 5µm
Pore size: 100Å

Conditions:
Mobile phase: 10mM ammonium formate, pH 2.5: acetonitrile (80:20, v/v)
Flow rate: 1.2mL/min.
Temp.: 25°C
Det.: UV @ 280nm

Ibuprofen (Analgesic) and Pseudoephedrine (Decongestant)
Allure™ Basix

HPLC



Peak List:
1. uracil
2. ibuprofen
3. pseudoephedrine

Sample:
Inj.: 5µL
Conc.: 200µg/mL
Solvent: mobile phase

Column: Allure™ Basix
Cat. #: 9161565
Dimensions: 150 x 4.6mm
Particle size: 5µm
Pore size: 60Å

Conditions:
Mobile phase: 10mM ammonium acetate, pH 6.9: methanol (75:25, v/v)
Flow: 1.0mL/min.
Temp.: 25°C
Det.: UV @ 210nm

free literature

HPLC Columns & Accessories (catalog)

lit. cat.# 59241B

Analysis of Narcotics & Narcotic/Acetaminophen Admixtures: What to do When Compendium Methods Don't Work

lit. cat.# 59453

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Antidepressants (Tricyclic)

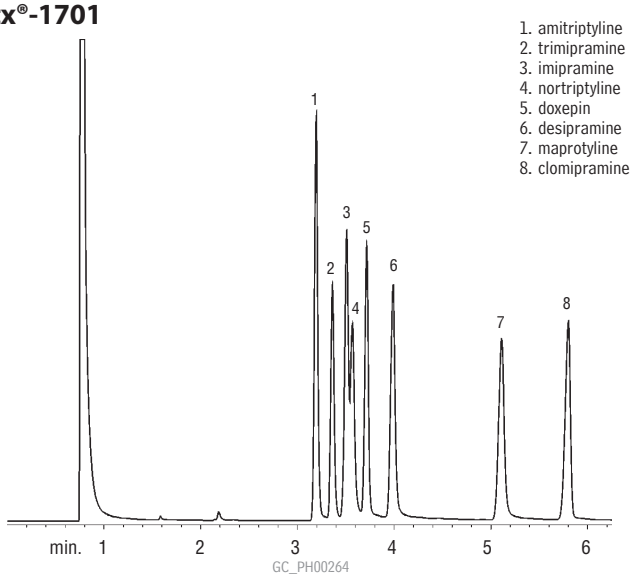
Tricylic Antidepressants

Antidepressants are similar to phenothiazines in structure except that the center ring is seven membered instead of six, and does not contain sulfur. Short GC columns operated at elevated temperatures produce the best separations in the shortest time. Rtx®-1701 columns provide a unique selectivity for the antidepressants, performing the separation isothermally in less than six minutes.

Tricylic antidepressants also are rapidly separated on an HPLC column specially developed for basic compounds: Allure™ Basix.

Antidepressants (Basic Drugs) Rtx®-1701

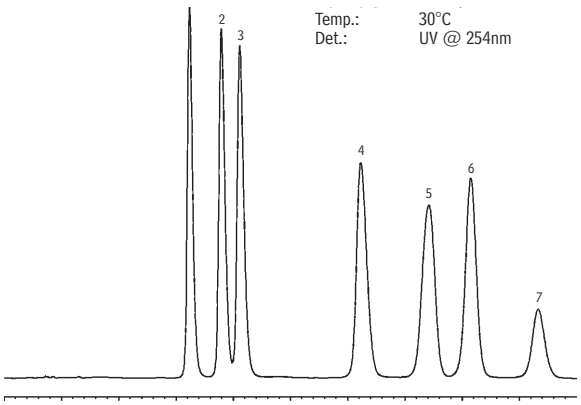
GC



15m, 0.25mm ID, 0.25µm Rtx®-1701 (cat.# 12020)
1.0µL split injection of antidepressants

Conc.:	25ng/component
Oven temp.:	225°C
Inj. / det. temp.:	250°C / 260°C
Carrier gas:	helium
Linear velocity:	30cm/sec. set @ 225°C
FID sensitivity:	2.56 x 10^{-10} AFS
Split ratio:	40:1

HPLC



Antidepressants (Basic Drugs) Allure™ Basix (LC/MS)

HPLC

Peak List:
1. desipramine
2. trimipramine

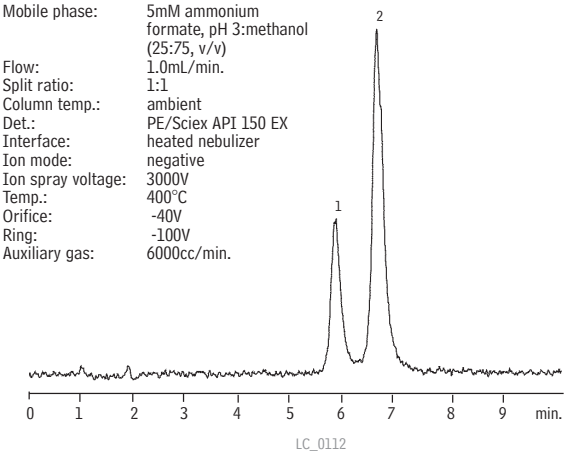
Sample:

Inj.:	10µL
Conc.:	10µg/mL
Solvent:	water:methanol (1:1, v/v)

Column:	**Allure™ Basix**
Cat. #:	9161565
Dimensions:	150 x 4.6mm
Particle size:	5µm
Pore size:	60Å

Conditions:

Mobile phase:	5mM ammonium formate, pH 3:methanol (25:75, v/v)
Flow:	1.0mL/min.
Split ratio:	1:1
Column temp.:	ambient
Det.:	PE/Sciex API 150 EX
Interface:	heated nebulizer
Ion mode:	negative
Ion spray voltage:	3000V
Temp.:	400°C
Orifice:	-40V
Ring:	-100V
Auxiliary gas:	6000cc/min.



Antidepressants
Ultra IBD

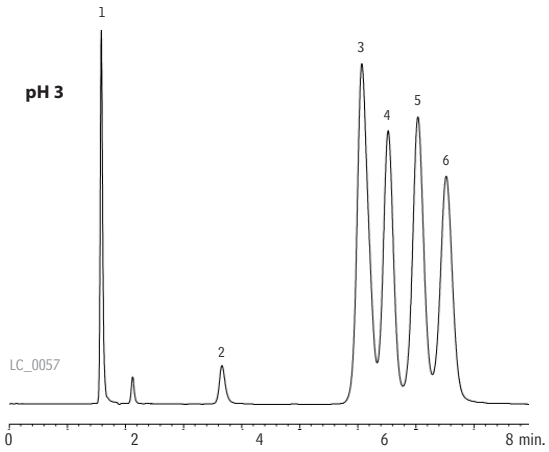
HPLC

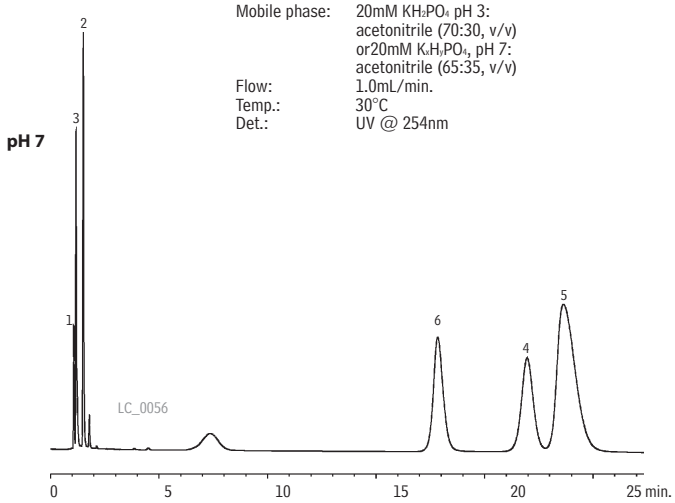
Peak List:	Conc. (µg/mL)
1. uracil	5
2. maleate	5
3. benzoic acid	50
4. nortriptyline	50
5. amitriptyline	50
6. trimipramine	50

Sample:
Inj.: 10µL
Solvent: mobile phase

Column: Ultra IBD
Cat. #: 9175565
Dimensions: 150 x 4.6mm
Particle size: 5µm
Pore size: 100Å

Conditions:
Mobile phase: 20mM KH_2PO_4 pH 3: acetonitrile (70:30, v/v) or20mM $K_2H_2PO_4$, pH 7: acetonitrile (65:35, v/v)
Flow: 1.0mL/min.
Temp.: 30°C
Det.: UV @ 254nm





Anithistamines

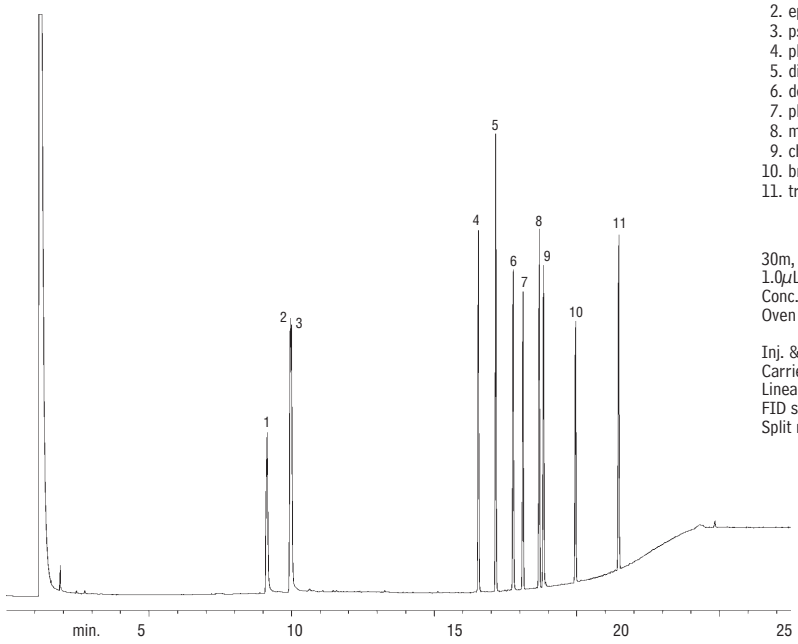
Antihistamines and decongestants are common ingredients in over-the-counter cold medications. Many include amine functional groups and are classified as basic compounds. Our Rtx®-5 Amine column is specially designed for basic compounds: antihistamines and other compounds that tail or are adsorbed on poorly deactivated columns exhibit excellent peak shape and better response on an Rtx®-5 Amine column.

Antihistamines (Underivatized)
Rtx®-5 Amine

GC

1. phenylpropanolamine
2. ephedrine
3. pseudoephedrine
4. pheniramine
5. diphenhydramine
6. doxylamine
7. phenyltoloxamine
8. methapyrilene
9. chlorpheniramine
10. brompheniramine
11. triprolidine

30m, 0.32mm ID, 1.0µm Rtx®-5 Amine (cat.# 12354)
1.0µL split injection of antihistamines.
Conc.: 1000ng/µL
Oven temp.: 130°C (hold 5 min.) to 305°C @ 10°C/min. (hold 5 min.)
Inj. & det. temp.: 305°C
Carrier gas: hydrogen
Linear velocity: 43cm/sec. set @ 130°C
FID sensitivity: 6.4 x 10^{-11} AFS
Split ratio: 50:1



Antiepileptics

Antiepileptics

Laboratories that perform therapeutic drug monitoring tests analyze antiepilepticc (anti-convulsant) drugs using either GC or HPLC because immunoassays do not exhibit linearity and show cross reactivities in the toxic range. Common antiepileptics are resolved using an Rtx®-20 or Rtx®-1701 GC column.

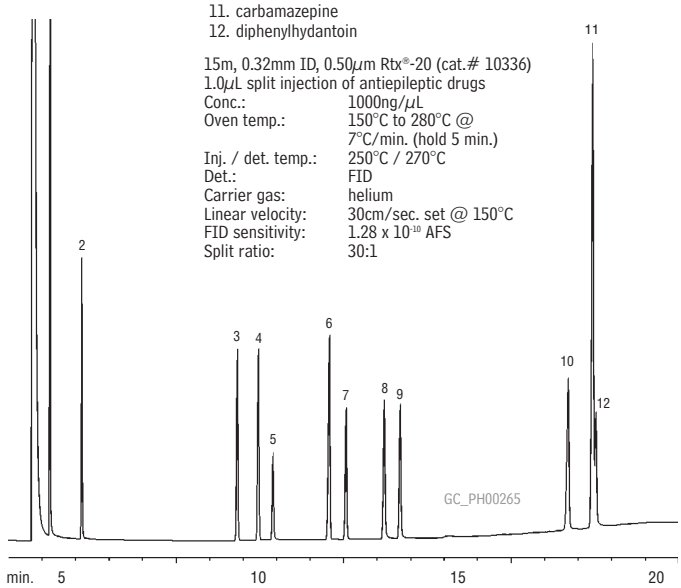
Antiepileptics (Underivatized) Rtx®-20

GC

1. valproic acid
2. ethosuximide
3. methsuximide
4. phensuximide
5. desmethyl methsuximide
6. mephenytoin
7. ethotoin
8. PEMA
9. phenobarbital
10. primidone
11. carbamazepine
12. diphenylhydantoin

15m, 0.32mm ID, 0.50µm Rtx®-20 (cat.# 10336)
1.0µL split injection of antiepileptic drugs

Conc.:	1000ng/µL
Oven temp.:	150°C to 280°C @ 7°C/min. (hold 5 min.)
Inj. / det. temp.:	250°C / 270°C
Det.:	FID
Carrier gas:	helium
Linear velocity:	30cm/sec. set @ 150°C
FID sensitivity:	1.28 x 10^{-10} AFS
Split ratio:	30:1



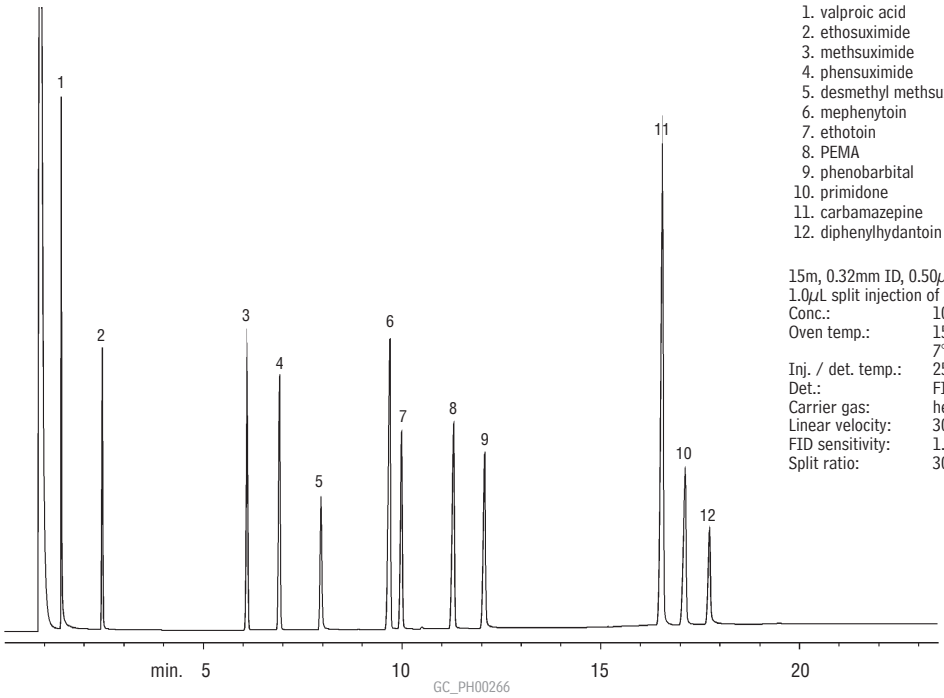
Antiepileptics (Underivatized) Rtx®-1701

GC

1. valproic acid
2. ethosuximide
3. methsuximide
4. phensuximide
5. desmethyl methsuximide
6. mephenytoin
7. ethotoin
8. PEMA
9. phenobarbital
10. primidone
11. carbamazepine
12. diphenylhydantoin

15m, 0.32mm ID, 0.50µm Rtx®-1701 (cat.# 12036)
1.0µL split injection of antiepileptic drugs

Conc.:	1000ng/µL
Oven temp.:	150°C to 280°C @ 7°C/min. (hold 5 min.)
Inj. / det. temp.:	250°C / 270°C
Det.:	FID
Carrier gas:	helium
Linear velocity:	30cm/sec. set @ 150°C
FID sensitivity:	1.28 x 10^{-10} AFS
Split ratio:	30:1



Atenolol (Antiarrhythmic) Allure™ Basix

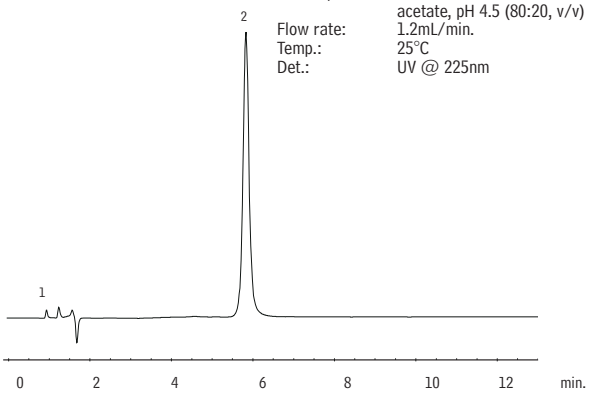
HPLC

Peak List:
1. uracil (marker)
2. atenolol

Sample:
Inj.: 1µL
Conc.: 1mg/mL
Solvent: water:methanol (7:3, v/v)

Column: Allure™ Basix
Cat. #: 9161565
Dimensions: 150 x 4.6mm
Particle size: 5µm
Pore size: 60Å

Conditions:
Mobile phase: acetonitrile:20mM ammonium acetate, pH 4.5 (80:20, v/v)
Flow rate: 1.2mL/min.
Temp.: 25°C
Det.: UV @ 225nm



LC_0072

Triamterene and Hydrochlorothiazide (Antiarrhythmics) Allure™ Basix

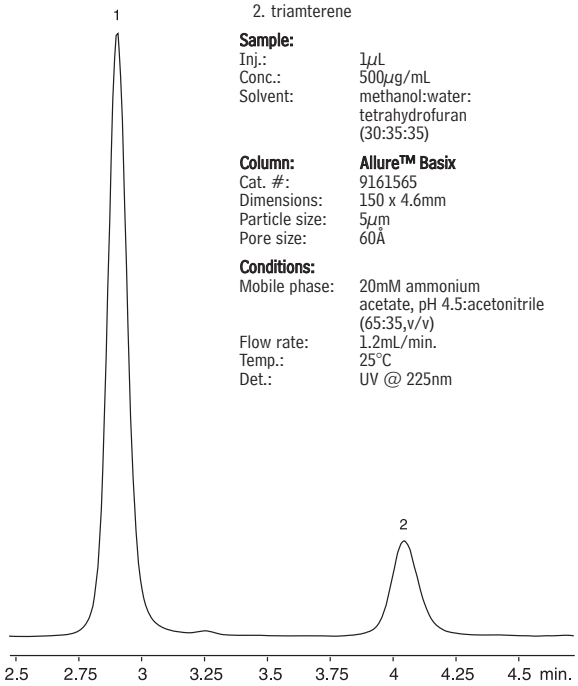
HPLC

Peak List:
1. hydrochlorothiazide
2. triamterene

Sample:
Inj.: 1µL
Conc.: 500µg/mL
Solvent: methanol:water: tetrahydrofuran (30:35:35)

Column: Allure™ Basix
Cat. #: 9161565
Dimensions: 150 x 4.6mm
Particle size: 5µm
Pore size: 60Å

Conditions:
Mobile phase: 20mM ammonium acetate, pH 4.5:acetonitrile (65:35,v/v)
Flow rate: 1.2mL/min.
Temp.: 25°C
Det.: UV @ 225nm



LC_0086

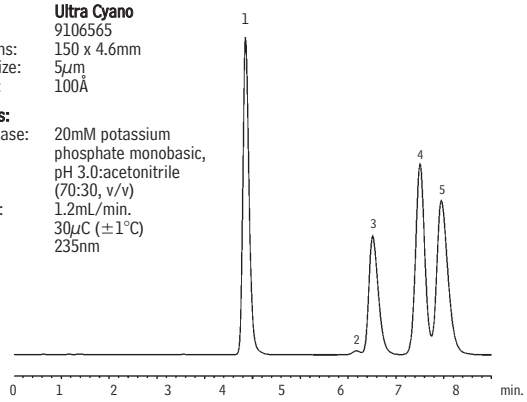
Calcium Channel Blockers (Antiarrhythmics) Ultra Cyano

Peak List:
1. diltiazem
2. nifedipine impurity
3. verapamil
4. nifedipine
5. nicardipine

Sample:
Inj.: 5µL
Conc.: 100mg/mL
Solvent: acetonitrile:water (1:1)

Column: Ultra Cyano
Cat. #: 9106565
Dimensions: 150 x 4.6mm
Particle size: 5µm
Pore size: 100Å

Conditions:
Mobile phase: 20mM potassium phosphate monobasic, pH 3.0:acetonitrile (70:30, v/v)
Flow rate: 1.2mL/min.
Temp.: 30µC (±1°C)
Det.: 235nm



LC_0062

Digitalis Extracts/Derivatives Ultra PFP Propyl Cartridge Column (Fast LC)

HPLC

Peak List:	Conc.	Ret. Time (min.)
1. digoxigenin	100µg/mL	0.40
2. gitoxigenin	100µg/mL	0.80
3. digoxin	100µg/mL	1.10
4. gitoxin	~10µg/mL	2.20
5. digitoxin	100µg/mL	2.60

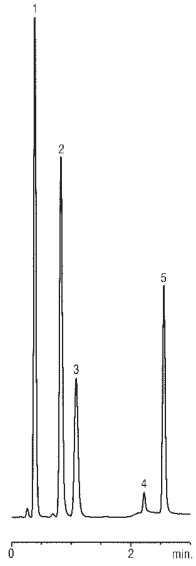
Sample:
Inj.: 10µL
Solvent: water:acetonitrile (80:20 v/v)

Column: Ultra PFP Propyl (Custom)
Dimensions: 30 x 4.0mm
Particle size: 3µm
Pore size: 100Å

Conditions:
Mobile phase: A: water
B: acetonitrile

Time (min.)	%B
0.0	20
1.5	20
1.51	35
3.0	35
3.1	20

Flow: 2.0mL/min.
Temp.: 27°C
Det.: UV @ 230nm



LC_0250

Cardiac Medications; CNS Depressants (Sedatives)

Cardiac Medications

Several classes of medications are used to decrease high blood pressure, control arrhythmias (abnormal heart rhythms), and treat congestive heart failure. These medications include beta antagonists, ACE inhibitors, diuretics, and calcium channel blockers. HPLC is the preferred technique for analyzing many of these compounds. Selecting the appropriate analytical column is critical, because many of the basic compounds tail badly on poorly deactivated HPLC phases. Restek's fully end-capped Allure™ Basix, Allure™ PFP Propyl, Ultra PFP, and Ultra Cyano phases can use the basic nature of these compounds to achieve separation without peak tailing.

free literature

Analyzing Cardiac Medications by HPLC

lit. cat.# 59151

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Metoprolol (Antiarrhythmic) Allure™ Basix

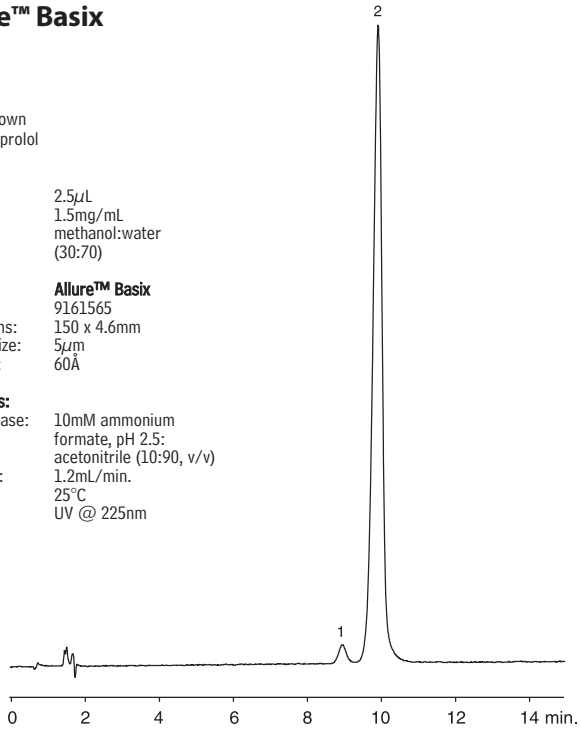
HPLC

Peak List:
1. unknown
2. metoprolol

Sample:
Inj.: 2.5µL
Conc.: 1.5mg/mL
Solvent: methanol:water (30:70)

Column: Allure™ Basix
Cat. #: 9161565
Dimensions: 150 x 4.6mm
Particle size: 5µm
Pore size: 60Å

Conditions:
Mobile phase: 10mM ammonium formate, pH 2.5: acetonitrile (10:90, v/v)
Flow rate: 1.2mL/min.
Temp.: 25°C
Det.: UV @ 225nm



LC_0090

Sedatives

Sedatives are CNS (central nervous system) depressants. They have been identified as contributors in impaired driving cases, and have been used in greyhound racing and horseracing to decrease an animal's speed. CNS depressants can be analyzed by HPLC on an Allure™ Basix column.

free literature

HPLC Analysis of Basic Pharmaceutical Compounds on an Ultra Cyano Phase

lit. cat.# 59545

Call Restek at 800-356-1688 or 814-353-1300, ext. 5, or contact your Restek representative, to request your free copy!

Alprazolam and Lorazepam (Sedatives) Allure™ Basix

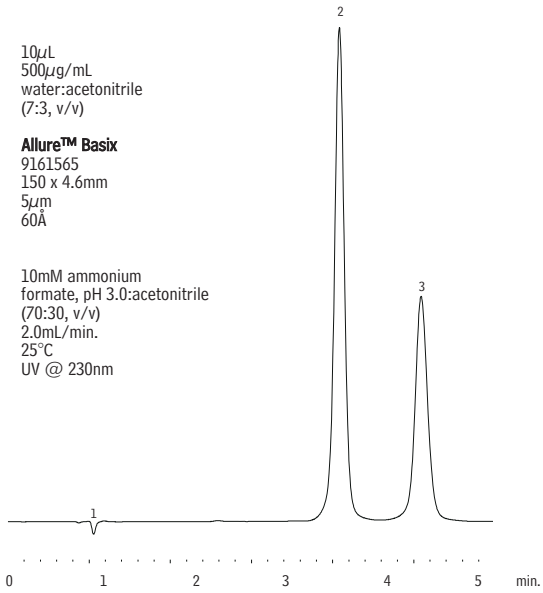
HPLC

Peak List:
1. toluene (marker)
2. lorazepam
3. alprazolam

Sample:
Inj.: 10µL
Conc.: 500µg/mL
Solvent: water:acetonitrile (7:3, v/v)

Column: Allure™ Basix
Cat. #: 9161565
Dimensions: 150 x 4.6mm
Particle size: 5µm
Pore size: 60Å

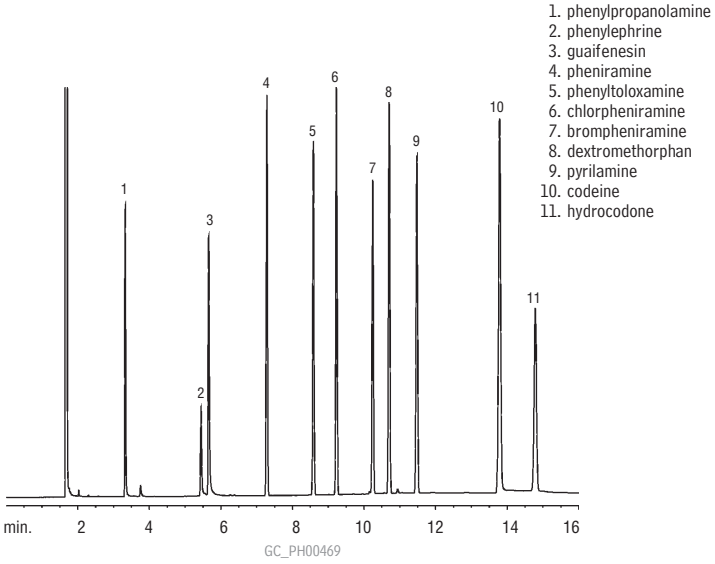
Conditions:
Mobile phase: 10mM ammonium formate, pH 3.0:acetonitrile (70:30, v/v)
Flow rate: 2.0mL/min.
Temp.: 25°C
Det.: UV @ 230nm



LC_0078

Cold Medications (Underivatized)
Rtx®-5 Amine

GC



30m, 0.53mm ID, 1.0µm Rtx®-5 Amine (cat.# 12355)

Oven temp.:	175°C to 280°C @ 10°/min. (hold 5.5 min.)
Inj./det. temp.:	250°C/280°C
Carrier gas:	helium
Linear velocity:	40cm/sec.
Sample size:	1µL
Split vent flow:	88mL/min.
Split ratio:	20:1

Cold & Sinus Medications

Cold and sinus medications can be analyzed for phenylpropanolamine using a simple extraction procedure followed by GC analysis. An Rtx®-5 Amine or Rtx®-35 Amine column provides excellent resolution of all the compounds commonly found in most cold medications. Phenylpropanolamine is separated easily from the other compounds. All target analytes exhibit good peak shape, even when in the free base form. Additionally, the analysis is complete in less than 15 minutes, which allows quick turn-around of multiple samples.

free literature

GC Analysis of Phenylpropanolamine in Cold Medications, Using an Rtx®-5Amine Column

lit. cat.# 59339

Call Restek at 800-356-1688 or 814-353-1300, ext. 5, or contact your Restek representative, to request your free copy!

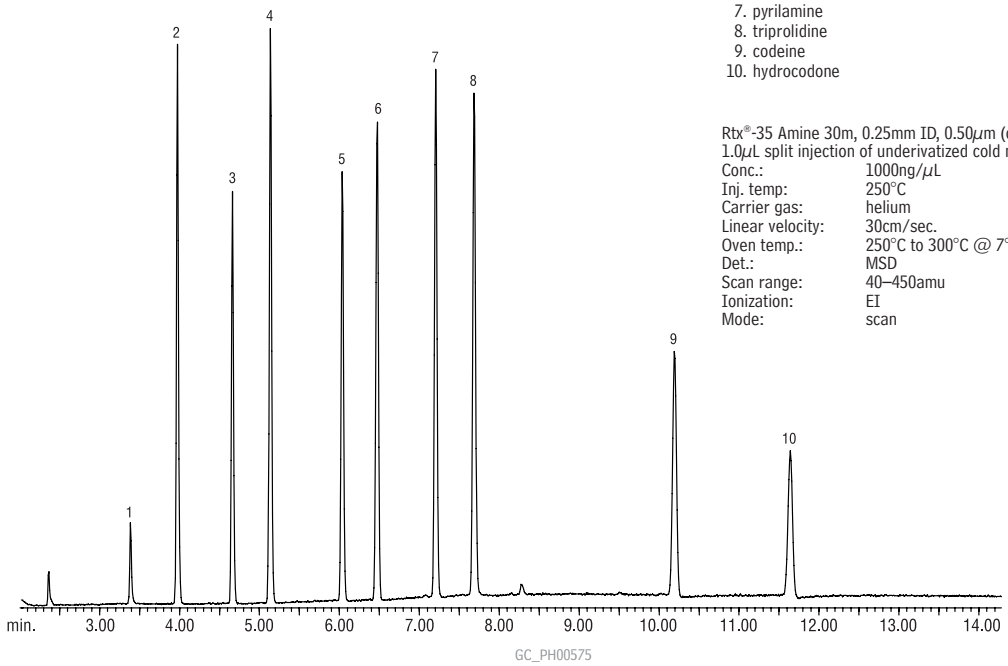
Cold Medications (Underivatized)
Rtx®-35 Amine

GC

1. guaifenesin
2. pheniramine
3. phenyltoloxamine
4. chlorpheniramine
5. brompheniramine
6. dextromethorphan
7. pyrilamine
8. triprolidine
9. codeine
10. hydrocodone

Rtx®-35 Amine 30m, 0.25mm ID, 0.50µm (cat.# 11338)
1.0µL split injection of underivatized cold medicines

Conc.:	1000ng/µL
Inj. temp:	250°C
Carrier gas:	helium
Linear velocity:	30cm/sec.
Oven temp.:	250°C to 300°C @ 7°C/min. (hold 7 min.)
Det.:	MSD
Scan range:	40–450amu
Ionization:	EI
Mode:	scan



Steroids

Anabolic steroids can be analyzed as TMS-derivatized or as underivatized compounds. In either case, this analysis is usually done at high temperature by GC. Analysis time can be reduced through the use of thin film GC columns. Lower polarity GC columns will help to reduce the effective elution temperature. Rtx®-5 columns provide sufficient selectivity to resolve many anabolic steroids, and have the stability necessary to withstand the high temperatures needed.

Allure™ Biphenyl columns are an excellent choice for steroid analyses. Through π-π interactions with double bonds in the steroid ring structure, the biphenyl stationary phase greatly improves selectivity, relative to alkyl phases (e.g., C18). For example analyses, request the free Applications Note listed below.

Steroids also can be analyzed by HPLC on an octadecylsilyl (C18) stationary phase. Specially developed for HPLC/MS. Allure™ C18 columns increase the sensitivity of the analysis by allowing higher concentrations of organic content in the mobile phase.

free literature

Improved HPLC Analysis of Steroids, Using Restek's Unique Allure™ Biphenyl Column

lit. cat.# 580020

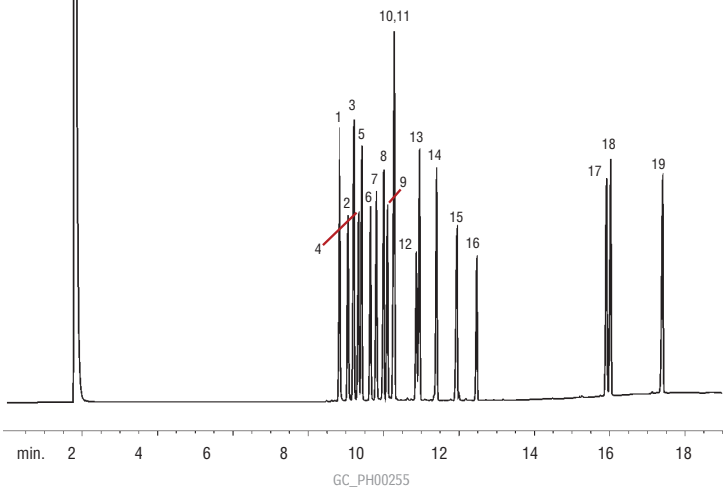
Call Restek at 800-356-1688 or 814-353-1300, ext. 5, or contact your Restek representative, to request your free copy!

Steroids, Anabolic (Underivatized)
Rtx®-5

GC

30m, 0.25mm ID, 0.10µm Rtx®-5 (cat.# 10208)
0.5µL split injection of anabolic steroids

Conc.:	1000ng/µL
Oven temp.:	180°C to 340°C @ 10°C/min. (hold 3 min.)
Inj. / det. temp.:	280°C / 340°C
Carrier gas:	helium
Linear velocity:	35cm/sec. set @ 180°C
FID sensitivity:	1.28 x 10^{-10} AFS
Split ratio:	50:1



1. 5-androstene-3β,17β-diol
2. 17α-methyl-5-androstene-3β,17β-diol
3. 5α-androstan-17β-ol-3-one
4. 19-nortestosterone
5. 17α-methylandrostan-17β-ol-3-one
6. mesterolone
7. testosterone
8. 17α-methyltestosterone
9. 1-dehydrotestosterone
10. 1-dehydro-17α-methyltestosterone
11. bolasterone
12. oxymethalone
13. 19-nortestosterone-17-propionate
14. testosterone propionate
15. fluoxymesterone
16. 4-chlorotestosterone-17-acetate
17. testosterone-17β-cypionate
18. 1-dehydrotestosterone benzoate
19. 1-dehydrotestosterone undecylenate

Corticosteroids
Allure™ C18 vs. Conventional C18 (LC/MS)

HPLC

Conventional C18

water:methanol (40:60, v/v)
3324.0 cps

Allure™ C18

water:methanol (33:67, v/v)
4191.1 cps

12% increase in organic = 26% increase in LC/MS sensitivity

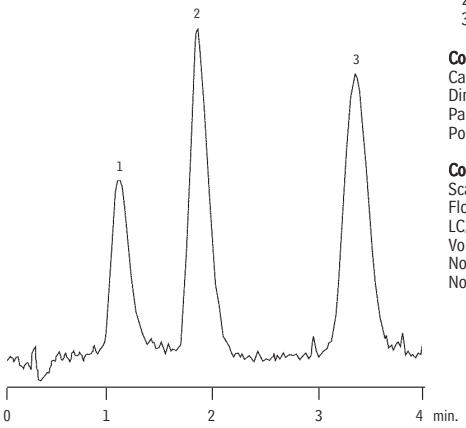
Peak List:
1. deoxycorticosterone (DCC) acetate
2. DCC glucoside
3. DCC

Column:

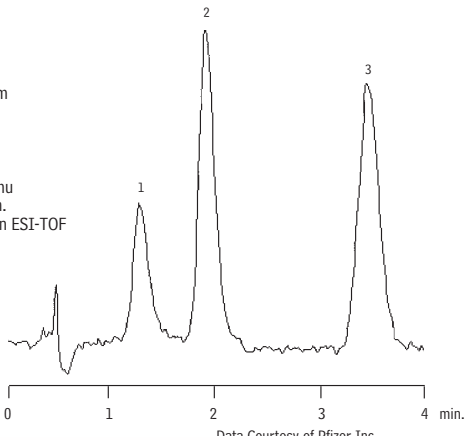
Cat. #:	9164552
Dimensions:	50 x 2.1mm
Particle size:	5µm
Pore size:	60Å

Conditions:

Scan range:	320-520amu
Flow rate:	0.4mL/min.
LC/MS Interface:	positive ion ESI-TOF
Voltage:	3800V
Nozzle temp.:	160V
Nozzle volt.:	190V



LC_0111



Data Courtesy of Pfizer Inc.

Corticosteroids Ultra C18

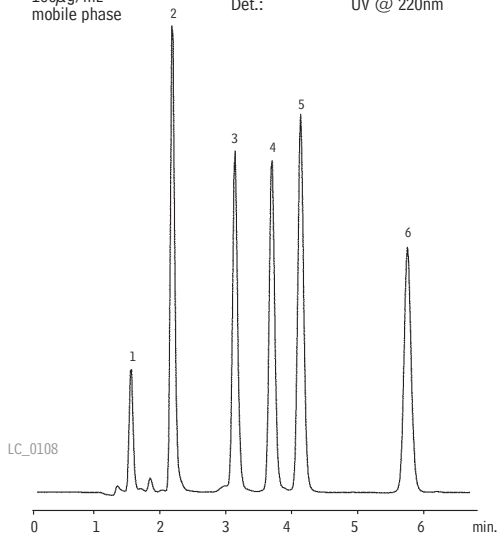
HPLC

Peak List:
1. uracil
2. triamcinolone
3. hydrocortisone
4. dexamethasone
5. corticosterone
6. deoxycorticosterone

Sample:
Inj.: 5µL
Conc.: 100µg/mL
Solvent: mobile phase

Column: Ultra C18
Cat. #: 9174565
Dimensions: 150 x 4.6mm
Particle size: 5µm
Pore size: 100Å

Conditions:
Mobile phase: water:methanol (30:70, v/v)
Flow: 1.0mL/min.
Temp.: 30°C
Det.: UV @ 220nm



Corticosteroids Pinnacle™ II Phenyl

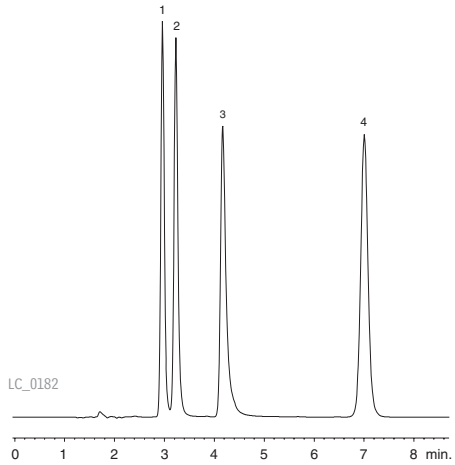
HPLC

Peak List:
1. hydrocortisone
2. cortisone
3. corticosterone
4. cortisone acetate

Sample:
Inj.: 5µL
Conc.: 200µg/mL each
Solvent: methanol

Column: Pinnacle™ II Phenyl
Cat. #: 9215565
Dimensions: 150 x 4.6mm
Particle size: 5µm
Pore size: 110Å

Conditions:
Mobile phase: water:methanol (60:40 v/v)
Flow: 1.0mL/min.
Temp.: ambient
Det.: UV @ 254nm



Corticosteroids Allure™ Biphenyl

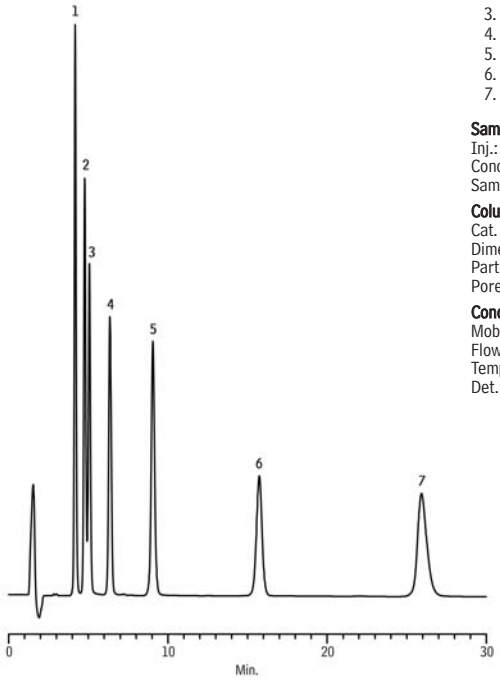
HPLC

Peak List	Ret. Time (min.)
1. hydrocortisone	4.19
2. prednisone	4.79
3. cortisone	5.08
4. dexamethasone	6.37
5. corticosterone	9.01
6. cortisone acetate	15.75
7. desoxycorticosterone	25.94

Sample:
Inj.: 5µL
Conc.: 100µg/mL each component
Sample diluent: methanol

Column: Allure™ Biphenyl
Cat. #: 9166565
Dimensions: 150 x 4.6 mm
Particle size: 5µm
Pore size: 60Å

Conditions:
Mobile phase: water:acetonitrile, 60:40
Flow: 1mL/min.
Temp.: ambient
Det.: UV @ 254 nm



LC_PH0330

Chiral Drugs

Chiral Drugs

In many instances stereochemical properties of chiral drugs are the controlling factor concerning activity. One enantiomer might provide a biological function, the other might be inactive or might exhibit another functionality, which could result in side effects. In some cases, one optical isomer might be harmful. Enantiomeric separation of these compounds for accurate interpretation of drug tests, is easily achieved on Rt-βDEXcst™ and Rt-βDEXsm™ chiral capillary GC columns.

free literature

A Guide to the Analysis of Chiral Compounds by GC

lit. cat.# 59889

Call Restek at 800-356-1688 or 814-353-1300, ext. 5, or contact your Restek representative, to request your free copy!

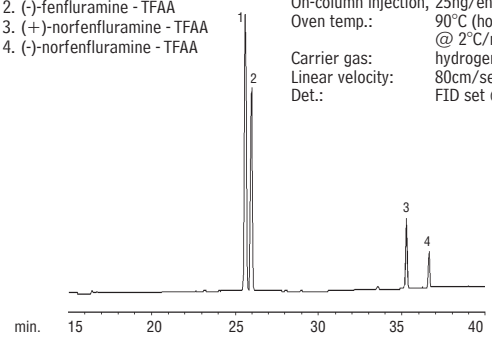
Fenafluramine (TFAA Derivative)

GC

Rt-βDEXcst™

1. (+)-fenfluramine - TFAA
2. (-)-fenfluramine - TFAA
3. (+)-norfenfluramine - TFAA
4. (-)-norfenfluramine - TFAA

30m, 0.32mm ID, 0.25µm
Rt-βDEXcst™ (cat.# 13102)
On-column injection, 25ng/enantiomer
Oven temp.: 90°C (hold 1 min.) to 200°C @ 2°C/min. (hold 3 min.)
Carrier gas: hydrogen
Linear velocity: 80cm/sec. set @ 60°C
Det.: FID set @ 220°C



GC_PH00244

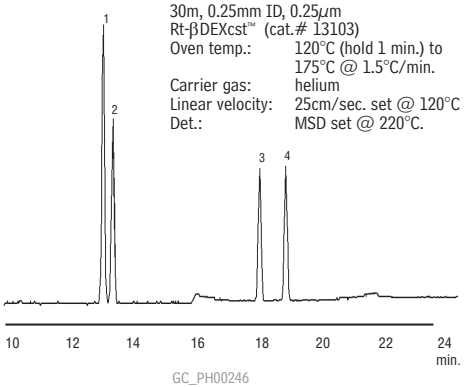
Amphetamine & Methamphetamine (TFAA Derivatives)

GC

Rt-βDEXcst™

1. (+)methamphetamine - TFAA
2. (-)methamphetamine - TFAA
3. (+)amphetamine - TFAA
4. (-)amphetamine - TFAA

30m, 0.25mm ID, 0.25µm
Rt-βDEXcst™ (cat.# 13103)
Oven temp.: 120°C (hold 1 min.) to 175°C @ 1.5°C/min.
Carrier gas: helium
Linear velocity: 25cm/sec. set @ 120°C
Det.: MSD set @ 220°C.



GC_PH00246

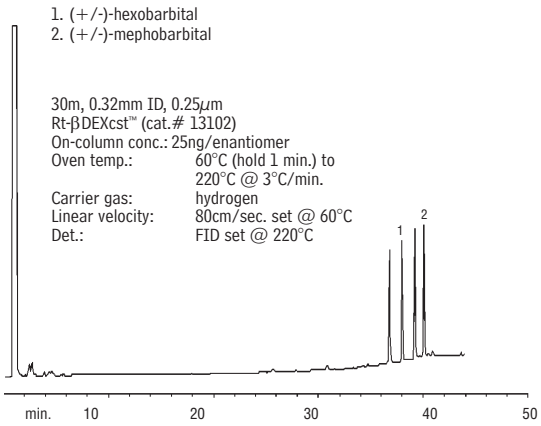
Barbiturates (Underivatized)

GC

Rt-βDEXcst™

1. (+/-)-hexobarbital
2. (+/-)-mephobarbital

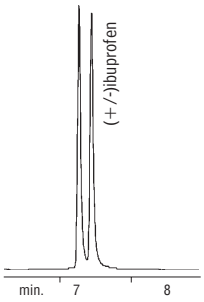
30m, 0.32mm ID, 0.25µm
Rt-βDEXcst™ (cat.# 13102)
On-column conc.: 25ng/enantiomer
Oven temp.: 60°C (hold 1 min.) to 220°C @ 3°C/min.
Carrier gas: hydrogen
Linear velocity: 80cm/sec. set @ 60°C
Det.: FID set @ 220°C



GC_PH00245

Ibuprofen (Underivatized)

Rt-βDEXsm™



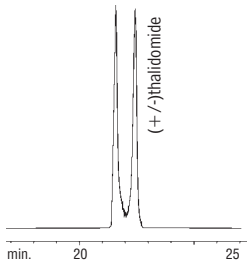
GC_PH00242

30m, 0.32mm ID, 0.25µm Rt-βDEXsm™ (cat.# 13104)
On-column injection
Conc.: 125ng each enantiomer
Oven temp.: 175°C to 200°C @ 2°C/min.
Inj./det. temp.: 200°C/230°C
Carrier gas: helium
Linear velocity: 60cm/sec.
Det.: GC-FID
Split ratio: 13:1 using cup splitter liner (cat.# 20709)

Thalidomide (Underivatized)

GC

Rt-βDEXcst™



GC_PH00243

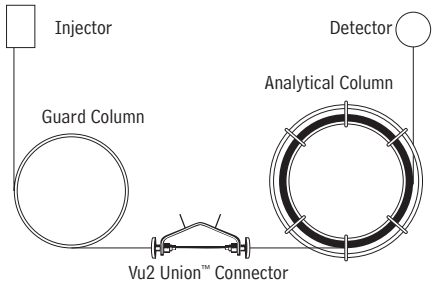
30m, 0.32mm ID, 0.25µm Rt-βDEXcst™ (cat.# 13102)
On-column injection
Conc.: approximately 15ng each enantiomer
Oven temp.: 200°C to 230°C @ 1°C/min.
Inj./det. temp.: 200°C/230°C
Carrier gas: hydrogen
Linear velocity: 80cm/sec.
Detector type: GC/FID
Split ratio: 13:1 using cup splitter liner (cat.# 20709)

What is a guard column?

A capillary GC guard column is a short length of deactivated, uncoated fused silica or MXT® stainless steel tubing that is connected to the inlet end of the analytical column (Figure 1). The guard column traps nonvolatile residues and prevents them from collecting at the inlet of the analytical column, with important benefits:

- Increased column lifetime (more injections).
- Prevents peak splitting during splitless analysis.
- Improved analyte focusing.

Figure 1 A guard column connected to an analytical column



Contaminants that accumulate within the analytical column can adsorb active compounds, reduce resolution, and cause poor peak symmetry. Packed inlet liners remove only a portion of the non-volatile contaminants in samples. When this contamination begins to affect sample analysis, a section (15-30cm) of the analytical column must be removed to restore performance. Each time a section of the analytical column is removed, retention times change and some resolution is lost, eventually resulting in a need to replace the column. By removing contaminated loops from the guard column instead of the analytical column, the inertness and length of the analytical column remain intact, so retention times and resolution do not change. The amount of time the sample spends in the guard column is minimal because there is no stationary phase.

did you know?

We test our guard columns/ transfer lines with the Grob test mix to ensure high inertness.

What type of guard column should be used?

It is important to match the polarity of the sample solvent and the polarity of the surface deactivation in the guard column. Intermediate Polarity (IP) guard columns allow most common solvents (methylene chloride, hexane, isooctane, toluene) to easily wet and create a uniform film on the tubing surface. A polar-deactivated guard column is necessary to allow more polar solvents such as methanol or water to wet the tubing surface. Polar-deactivated guard columns are not resistant to water vaporization, which occurs when liquid water is injected onto the tubing, and rapidly vaporizes (such as in steam cleaning). Hydroguard™ deactivation is an alternative for direct aqueous injections. However, a Hydroguard™-deactivated guard column will not allow polar solvents to wet the tubing surface, and may cause beading of the solvent if the oven temperature is 20°C below the solvent boiling point. Siltek® deactivation creates a highly inert surface for very active compounds such as chlorinated pesticides. Base-deactivated guard columns reduce adsorption and tailing for amines and other basic compounds.

please note

For superior inertness, try our Siltek® guard columns!

How is a guard column connected to the analytical column?

The most common connector is the Press-Tight® connector. In addition, Restek offers Vu-Union®, Vu2-Union™, and Gerstel GRAPHPACK® connectors for attaching guard columns. MXT® unions are available for connecting stainless steel MXT® columns and guard columns. See our general catalog, or website, for information about these connectors.

for more info

Having trouble making a leak-free connection? Try our "built in" Integra-Guard™ columns!

See page 30 for details.

Intermediate-Polarity Deactivated Guard Columns/Transfer Lines

- Useful for a wide range of applications.
- Use with most common solvents.
- Maximum temperature: 325°C

Fused Silica

Nominal ID	Nominal OD	1-Meter	5-Meter	5-Meter/6-pk.
0.18mm	0.37 ± 0.04mm	10102	10046	
0.25mm	0.37 ± 0.04mm		10043	10043-600
0.32mm	0.45 ± 0.04mm		10044	10044-600
0.53mm	0.69 ± 0.05mm		10045	10045-600

Capillary GC Columns: Guard Columns

Siltek®-Deactivated Guard Columns/Transfer Lines

- Revolutionary deactivation process for superior inertness.
- Minimize bleed.
- Analyze active samples accurately; ideal for chlorinated pesticide analysis (reduces endrin breakdown to less than 1%).
- Maximum temperature: 380°C.

Fused Silica

Nominal ID	Nominal OD	5-Meter	10-Meter
0.25mm	0.37 ± 0.04mm	10026	10036
0.32mm	0.45 ± 0.04mm	10027	10037
0.53mm	0.69 ± 0.05mm	10028	10038

Base-Deactivated Guard Columns

- Excellent inertness for basic compounds.
- Recommended for use with Rtx®-5 Amine, Rtx®-35Amine, and Stabilwax®-DB capillary columns.
- Tested with basic amine test mix.
- Batch test chromatogram included.
- Maximum temperature: 315°C.

Chemists using guard columns in analyses of basic compounds frequently observe peak tailing and low recovery, because conventionally deactivated tubing surfaces can be adsorptive to basic compounds. Restek offers both base-deactivated columns and base-deactivated guard columns for completely inert sample pathways.

Fused Silica

Nominal ID	Nominal OD	5-Meter	5-Meter/6-pk.
0.25mm	0.37 ± 0.04mm	10000	10000-600
0.32mm	0.45 ± 0.04mm	10001	10001-600
0.53mm	0.69 ± 0.05mm	10002	10002-600

Innovative Integra-Guard™ Columns

restek
innovation!

Integra-Guard™ Columns: guard columns WITHOUT connections—protecting your analytical column has never been this easy!

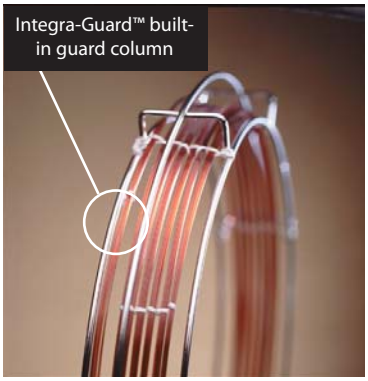
For analysts who find it inconvenient to make a leak-free connection between the guard column and the analytical column, Restek offers Integra-Guard™ columns. These innovative columns incorporate both guard column and analytical column in a continuous length of tubing, eliminating the connection and all connection-associated problems! The guard column section is tied separately from the analytical column, using high-temperature string. The column is suspended in our unique "crush-free" cage, which protects the column from damage.

Restek offers a wide variety of Integra-Guard™ capillary columns, listed in the figure below. The Integra-Guard™ column is so economical that we challenge you to compare our price against that of a conventional connection, even if you assemble it yourself. If you are currently using a guard column, or are considering using one, call today and ask about Integra-Guard™ columns.

Ordering is simple. Just add the appropriate suffix number and price to the analytical column's catalog number and price. For example, a 30m, 0.25mm ID, 0.25µm Rtx®-5 column with a 5-meter Integra-Guard™ column is cat.# 10223-124.

ID	Length	Suffix #
0.25mm	5m	-124
	10m	-127
0.32mm	5m	-125
	10m	-128
0.53mm	5m	-126
	10m	-129

Phases currently available as Integra-Guard™ columns



Rtx®-1
Rtx®-1MS
Rtx®-5
Rtx®-5MS
Rtx®-5Sil MS
XTI®-5
Rtx®-1301
Rtx®-624
Rtx®-1701
Rtx®-Volatiles
Rtx®-20
Rtx®-35
Rtx®-35MS
Rtx®-BAC 1 & 2
Stabilwax®

Available for all phases listed, for columns with 0.25 to 0.53mm ID and lengths to 75 meters.

Rxi™-1ms (nonpolar phase, Crossbond® 100% dimethyl polysiloxane)

- General purpose columns for drugs of abuse, essential oils, hydrocarbons, pesticides, PCB congeners or (e.g.) Aroclor® mixes, sulfur compounds, amines, solvent impurities, simulated distillation, oxygenates, gasoline range organics (GRO), refinery gases.
- Temperature range: -60°C to 330/350°C (bleed tested temperature/maximum operating temperature).
- Low bleed - improved signal to noise ratio, for better sensitivity and mass spectral integrity.
- Equivalent to USP G2 phase.

new **column** technology**!**

Rxi™-1ms (fused silica)

(Crossbond® 100% dimethyl polysiloxane)

ID	df (µm)	temp. limits	15-Meter	30-Meter	60-Meter	
0.25mm	0.25	-60 to 330/350°C	13320	13323	13326	
	0.50	-60 to 330/350°C	13335	13338	13341	
	1.00	-60 to 330/350°C	13350	13353	13356	
0.32mm	0.25	-60 to 330/350°C	13321	13324	13327	
	0.50	-60 to 330/350°C	13336	13339	13342	
	1.00	-60 to 330/350°C	13351	13354	13357	
0.53mm	0.50	-60 to 330/350°C	13337	13340		
	1.00	-60 to 330/350°C	13352	13355		
	1.50	-60 to 330/350°C	13367	13370		
ID	**df (µm)**	**temp. limits**	**12-Meter**	**20-Meter**	**25-Meter**	**50-Meter**
0.18mm	0.18	-60 to 330/350°C		13302		
0.20mm	0.33	-60 to 330/350°C	13397		13398	13399

did you **know**?

Our Technical Service Department is staffed with more than 35 experienced chemists on rotating shifts from various departments. Whether your chromatography problem is simple or complex, call Restek's Technical Service Team at 1-800-356-1688 (ext. 4), or contact your Restek representative, and we will do everything we can to help you find a solution.

Similar **Phases**

DB-1, DB-1ms, HP-1, HP-1ms, Ultra-1, SPB-1, Equity-1

Rtx®-1MS (fused silica)

(Crossbond® 100% dimethyl polysiloxane)

ID	df (µm)	temp. limits	15-Meter	30-Meter
0.25mm	0.10	-60 to 330/350°C	11605	11608
	0.25	-60 to 330/350°C	11620	11623
	0.50	-60 to 330/350°C	11635	11638
0.32mm	0.10	-60 to 330/350°C	11606	11609
	0.25	-60 to 330/350°C	11621	11624
	0.50	-60 to 330/350°C	11636	11639
0.53mm	1.00	-60 to 320/340°C	11652	11655
	1.50	-60 to 310/330°C	11667	11670

Similar **Phases**

DB-1, DB-1MS, HP-1, HP-1MS, Ultra-1, SPB-1, Equity-1, MDN-1

Rtx®-20 (low/mid-polarity phase; Crossbond® 80% dimethyl / 20% diphenyl polysiloxane)

- General purpose columns for volatile compounds, flavor compounds, alcoholic beverages.
- Temperature range: -20°C to 320°C.
- Equivalent to USP G28, G32 phases.

Rtx®-20 (fused silica)

(Crossbond® 80% dimethyl/20% diphenyl polysiloxane)

ID	df (µm)	temp. limits*	15-Meter	30-Meter	60-Meter	105-Meter
0.25mm	0.25	-20 to 300/320°C	10320	10323	10326	10329
	0.50	-20 to 290/310°C	10335	10338	10341	10344
	1.00	-20 to 280/300°C	10350	10353	10356	10359
0.32mm	0.25	-20 to 300/320°C	10321	10324	10327	10330
	0.50	-20 to 290/310°C	10336	10339	10342	10345
	1.00	-20 to 280/300°C	10351	10354	10357	10360
0.53mm	0.50	-20 to 260/280°C	10337	10340	10343	
	1.00	-20 to 260/280°C	10352	10355	10358	

*Maximum temperatures listed are for 15- and 30-meter lengths. Longer lengths may have a slightly reduced maximum temperature.

Similar **Phases**

SPB-20

Capillary GC Columns

Similar Phases

DB-5, HP-5, HP-5ms, Ultra-2, SPB-5, Equity-5

Rxi™-5ms (low-polarity phase, Crossbond® 5% diphenyl / 95% dimethyl polysiloxane)

- General purpose columns for semivolatiles, phenols, amines, residual solvents, drugs of abuse, pesticides, PCB congeners or (e.g.) Aroclor® mixes, solvent impurities.
- Temperature range: -60°C to 330/350°C (bleed tested temperature/maximum operating temperature).
- Low bleed - improved signal to noise ratio, for better sensitivity and mass spectral integrity.
- Equivalent to USP G27 phase.

new **column** technology!

Rxi™-5ms (fused silica)
(Crossbond® 5% diphenyl / 95% dimethyl polysiloxane)

ID	df (µm)	temp. limits	15-Meter	30-Meter	60-Meter
0.25mm	0.25	-60 to 330/350°C	13420	13423	13426
	0.50	-60 to 330/350°C	13435	13438	
	1.00	-60 to 330/350°C	13450	13453	13456
0.32mm	0.25	-60 to 330/350°C	13421	13424	
	0.50	-60 to 330/350°C	13436	13439	
	1.00	-60 to 330/350°C	13451	13454	13457
0.53mm	0.25	-60 to 330/350°C	13422	13425	
	0.50	-60 to 330/350°C	13437	13440	
	1.00	-60 to 330/350°C	13452	13455	
	1.50	-60 to 330/350°C	13467	13470	

ID	df (µm)	temp. limits	12-Meter	20-Meter	25-Meter	50-Meter
0.18mm	0.18	-60 to 330/350°C		13402		
	0.36	-60 to 330/350°C		13411		
0.20mm	0.33	-60 to 330/350°C	13497		13498	13499

also available

Custom lengths and film thicknesses are available. Call technical service at **800-356-1688 (ext. 4)**, or contact your Restek representative.

Rtx®-5MS (fused silica)
(Crossbond® 5% diphenyl / 95% dimethyl polysiloxane)

ID	df (µm)	temp. limits	15-Meter	30-Meter	60-Meter
0.25mm	0.10	-60 to 330/350°C	12605	12608	12611
	0.25	-60 to 330/350°C	12620	12623	12626
	0.50	-60 to 330/350°C	12635	12638	12641
0.32mm	0.25	-60 to 330/350°C	12621	12624	12627
	0.50	-60 to 330/350°C	12636	12639	12642
0.53mm	0.50	-60 to 320/340°C	12637	12640	
	1.00	-60 to 320/340°C	12652	12655	

Similar Phases

DB-5, HP-5, HP-5MS, Ultra-2, SPB-5, Equity-5, MDN-5
DB-5MS is equivalent to Rtx®-5Sil MS

Rtx®-5 Amine (low-polarity phase; Crossbond® 5% diphenyl / 95% dimethyl polysiloxane)

- Application-specific columns for amines and other basic compounds, including alkylamines, diamines, triamines, ethanolamines, and nitrogen-containing heterocyclics.
- Stable to 315°C.

Active basic compounds that previously required derivatization or another analytical technique can be analyzed on the Rtx®-5 Amine column. The tubing surface is chemically altered to reduce tailing of basic compounds, eliminating the need for column priming. Breakthrough technology also allows the analysis of neutral compounds, adsorptive compounds with oxygen groups susceptible to hydrogen bonding, and even mildly acidic compounds such as phenols.

Thorough testing of each Rtx®-5 Amine column ensures that every column exceeds the requirements for analyzing ppm levels of amines, without priming. The temperature program/bleed profile for each column is measured to ensure low bleed at maximum operating temperature. Rtx®-5 Amine columns are bonded and can be rejuvenated by solvent rinsing.

Rtx®-5 Amine (fused silica)
(Crossbond® 5% diphenyl/95% dimethyl polysiloxane)

ID	df (µm)	temp. limits	15-Meter	30-Meter
0.25mm	0.50	-60 to 300/315°C	12335	12338
	1.00	-60 to 300/315°C	12350	12353
0.32mm	1.00	-60 to 300/315°C	12351	12354
	1.50	-60 to 290/305°C	12366	12369
0.53mm	1.00	-60 to 290/305°C	12352	12355
	3.00	-60 to 280/295°C	12382	12385

Similar Phases

PTA-5

Rtx®-1701 (mid-polarity phase; Crossbond® 14% cyanopropylphenyl / 86% dimethyl polysiloxane)

- General purpose columns for alcohols, oxygenates, PCB congeners or (e.g.) Aroclor® mixes, pesticides.
- Temperature range: -20°C to 280°C.
- Equivalent to USP G46 phase.

Rtx®-1701 (fused silica)

(Crossbond® 14% cyanopropylphenyl/86% dimethyl polysiloxane)

ID	df (µm)	temp. limits*	15-Meter	30-Meter	60-Meter	105-Meter
0.25mm	0.25	-20 to 280°C	12020	12023	12026	12029
	0.50	-20 to 270/280°C	12035	12038	12041	12044
0.32mm	0.25	-20 to 280°C	12021	12024	12027	12030
	0.50	-20 to 270/280°C	12036	12039	12042	12045
0.53mm	0.50	-20 to 260/270°C	12037	12040	12043	
	1.00	-20 to 250/270°C	12052	12055	12058	

Similar **Phases**

DB-1701, HP-1701, SPB-1701

CLINICAL/FORENSICS

Rtx®-35/Rtx®-35MS (mid-polarity phase; Crossbond® 35% diphenyl / 65% dimethyl polysiloxane)

- General purpose columns for organochlorine pesticides, PCB congeners or (e.g.) Aroclor® mixes, herbicides, pharmaceuticals, sterols, rosin acids, phthalate esters.
- Temperature range: 0°C to 320°C.
- Equivalent to USP G42 phase.

Rtx®-35 (fused silica)

(Crossbond® 35% diphenyl/65% dimethyl polysiloxane)

ID	df (µm)	temp. limits*	15-Meter	30-Meter	60-Meter	105-Meter
0.25mm	0.25	0 to 320°C	10420	10423	10426	10429
	0.50	0 to 310°C	10435	10438	10441	10444
0.32mm	0.25	0 to 320°C	10421	10424	10427	10430
	0.50	0 to 310°C	10436	10439	10442	10445
0.53mm	0.50	0 to 300°C	10437	10440	10443	
	1.00	0 to 290°C	10452	10455	10458	

Similar **Phases**

DB-35, HP-35, SPB-35, SPB-608

Rtx®-35MS (fused silica)

(Crossbond® 35% diphenyl / 65% dimethyl polysiloxane)

ID	df (µm)	temp. limits	15-Meter	30-Meter
0.25mm	0.10	-20 to 320°C	14605	14608
	0.25	-20 to 320/340°C	14620	14623
0.32mm	0.10	-20 to 320/340°C	14606	14609
	0.25	-20 to 320/340°C	14621	14624
0.53mm	0.50	-20 to 300/320°C	14637	14640
	1.00	-20 to 290°C	14652	14655

Rtx®-35 Amine (mid-polarity phase; Crossbond® 35% diphenyl / 65% dimethyl polysiloxane)

- Application-specific columns for amines and other basic compounds, including alkylamines, diamines, triamines, ethanolamines, and nitrogen-containing heterocyclics.
- Stable to 310°C.

Active basic compounds that otherwise require derivatization can be analyzed on an Rtx®-35 Amine column. The tubing surface is chemically altered to reduce tailing of basic compounds, eliminating the need for column priming. An Rtx-35® Amine column is ideal for a wide variety of basic compounds, but also is suitable for neutral compounds, adsorptive compounds with oxygen groups susceptible to hydrogen bonding, or even weakly acidic compounds such as phenols. Every Rtx®-5 Amine column is tested to ensure that it exceeds the requirements for analyzing ppm levels of amines, without priming, and to ensure low bleed at maximum operating temperature.

Rtx®-35 Amine (fused silica)

(Crossbond® 35% diphenyl/65% dimethyl polysiloxane)

ID	df (µm)	temp. limits	15-Meter	30-Meter
0.25mm	0.50	0 to 290/310°C	11335	11338
	1.00	0 to 280/300°C	11350	11353
0.32mm	1.00	0 to 280/300°C	11351	11354
	1.50	0 to 270/290°C	11366	11369
0.53mm	1.00	0 to 260/280°C	11352	11355
	3.00	0 to 240/260°C	11382	11385

*Maximum temperatures listed are for 15- and 30-meter lengths. Longer lengths may have a slightly reduced maximum temperature.

Capillary GC Columns

Similar **Phases**

DB-200, DB-210

Rtx®-200/Rtx®-200MS (mid-polarity phase; Crossbond® trifluoropropylmethyl polysiloxane)

- General purpose columns for solvents, Freon® fluorocarbons, alcohols, ketones, silanes, glycols. Excellent confirmation column, with an Rtx®-5 column, for phenols, nitrosamines, organochlorine pesticides, chlorinated hydrocarbons, chlorophenoxy herbicides.
- Temperature range: -20°C to 340°C.
- Equivalent to USP G6 phase.

Rtx®-200 (fused silica)
(Crossbond® trifluoropropylmethyl polysiloxane)

ID	df (µm)	temp. limits*	15-Meter	30-Meter	60-Meter	105-Meter
0.25mm	0.25	-20 to 320/340°C	15020	15023	15026	15029
	0.50	-20 to 310/330°C	15035	15038	15041	15044
0.32mm	0.25	-20 to 320/340°C	15021	15024	15027	15030
	0.50	-20 to 310/330°C	15036	15039	15042	15045
0.53mm	0.50	-20 to 300/320°C	15037	15040	15043	
	1.00	-20 to 290/310°C	15052	15055	15058	

also **available**

Custom lengths and film thicknesses are available. Call technical service at **800-356-1688 (ext. 4)**, or contact your Restek representative.

Rtx®-200MS (fused silica)
(Crossbond® trifluoropropylmethyl polysiloxane)

ID	df (µm)	temp. limits	15-Meter	30-Meter
0.25mm	0.10	-20 to 320/340°C	15605	15608
	0.25	-20 to 320/340°C	15620	15623
0.32mm	0.10	-20 to 320/340°C	15606	15609
	0.25	-20 to 320/340°C	15621	15624
0.53mm	0.50	-20 to 300/320°C	15637	15640

*Maximum temperatures listed are for 15- and 30-meter lengths. Longer lengths may have a slightly reduced maximum temperature.

Similar **Phases**

DB-WAX, DB-WAXetr, HP-Wax, HP-Innowax, Supelcowax 10

Stabilwax® (polar phase; Crossbond® Carbowax® polyethylene glycol)

- General purpose columns for FAMEs, flavor compounds, essential oils, amines, solvents, xylene isomers, US EPA Method 603 (acrolein/acrylonitrile).
- Resistant to oxidative damage.
- Temperature range: 40°C to 250°C.
- Equivalent to USP G14, G15, G16, G20, G39 phases.

Stabilwax® (fused silica)
(Crossbond® Carbowax® polyethylene glycol—provides oxidation resistance)

ID	df (µm)	temp. limits	15-Meter	30-Meter	30-Meter 6/pk.	60-Meter
0.25mm	0.25	40 to 250°C	10620	10623		10626
	0.50	40 to 250°C	10635	10638		10641
0.32mm	0.25	40 to 250°C	10621	10624		10627
	0.50	40 to 250°C	10636	10639		10642
0.53mm	0.50	40 to 250°C	10637	10640		10643
	1.00	40 to 240/250°C	10652	10655	10655-600	10658

Rtx®-Wax (polar phase; Crossbond® Carbowax® polyethylene glycol)
- General purpose columns for FAMEs, solvents, BTEX aromatics, flavor compounds.
- Temperature range: 20°C to 250°C.
- Equivalent to USP G14, G15, G16, G20, G39 phases.

Rtx®-Wax (fused silica)
(Crossbond® Carbowax® polyethylene glycol)

ID	df (µm)	temp. limits*	15-Meter	30-Meter	60-Meter
0.25mm	0.25	20 to 250°C	12420	12423	12426
	0.50	20 to 250°C	12435	12438	12441
0.32mm	0.25	20 to 250°C	12421	12424	12427
	0.50	20 to 250°C	12436	12439	12442
	1.00	20 to 240/250°C	12451	12454	12457
0.53mm	0.50	20 to 250°C	12437	12440	12443
	1.00	20 to 240/250°C	12452	12455	12458

*Maximum temperatures listed are for 15- and 30-meter lengths. Longer lengths may have a slightly reduced maximum temperature.

Similar **Phases**

DB-WAX, HP-Wax

Rtx®-G27 & Rtx®-G43
- Application-specific columns, designed for analysis of residual solvents in pharmaceutical products.
- Meet all requirements of USP 467.
- Integra-Guard™ guard+analytical column eliminates connecting problems and leaks.
- Rtx®-G27 thermally stable to 290°C; Rtx®-G43 thermally stable to 240°C.

Some USP 467 methods require the use of a guard column. Our Integra-Guard™ integrated guard column system makes this an easy task.

Rtx®-G27 (fused silica with 5-meter Integra-Guard™)
(Crossbond® 5% diphenyl/95% dimethyl polysiloxane)

ID	df (µm)	temp. limits	30-Meter with 5-Meter, 0.53mm ID Integra-Guard™ Column
0.53mm	5.00	-60 to 270/290°C	10279-126

Rtx®-G43 (fused silica with 5-meter Integra-Guard™)
(Crossbond® 6% cyanopropylphenyl/94% dimethyl polysiloxane)

ID	df (µm)	temp. limits	30-Meter with 5-Meter, 0.53mm ID Integra-Guard™ Column
0.53mm	3.00	-20 to 240°C	16085-126

Rtx®-BAC1/Rtx®-BAC2 (proprietary Crossbond® phase)
- Application-specific columns for blood alcohol analysis, achieving baseline resolution in less than 3 minutes. Also excellent for abused inhalant anesthetics, γ-hydroxybutyrate (GHB) / γ-butyrolactone (GBL), glycols, and common industrial solvents.
- Rtx®-BAC2 confirmation column provides four elution order changes under the same conditions.
- Rtx®-BAC1 stable to 260°C, Rtx®-BAC2 stable to 240°C.

These columns achieve baseline separation of all blood alcohol compounds in blood, breath, or urine in less than 3 minutes, under isothermal conditions. Isothermal analysis increases productivity by eliminating the need for oven cycling. Confirmation is easily achieved with this tandem set because there are four elution order changes between the two columns.

Rtx®-BAC1 (fused silica)

ID	df (µm)	temp. limits	30-Meter
0.32mm	1.80	-20 to 240/260°C	18003
0.53mm	3.00	-20 to 240/260°C	18001

Rtx®-BAC2 (fused silica)

ID	df (µm)	temp. limits	30-Meter
0.32mm	1.20	-20 to 240/260°C	18002
0.53mm	2.00	-20 to 240/260°C	18000

Cyclodextrin Columns for Analyzing Many Chiral Compounds

By adding β or γ cyclodextrin to our bonded Rtx®-1701 stationary phase, we greatly enhance overall utility and column lifetime for our chiral columns, compared to columns that have pure cyclodextrin stationary phases. Separations of more than one hundred chiral compounds have been achieved using our unique DEX columns, and our columns continue to demonstrate stability after hundreds of temperature program cycles. Refer to the applications section of this catalog for example applications, or call our Technical Service chemists or your Restek representative for assistance in matching a column to your chiral analysis.

Rt-βDEXm™ (fused silica)

(permethylated beta cyclodextrin doped into 14% cyanopropylphenyl/86% dimethyl polysiloxane)

ID	df (µm)	temp. limits	30-Meter
0.25mm	0.25	40 to 230°C	13100
0.32mm	0.25	40 to 230°C	13101

Uses: General purpose chiral phase with many published applications.

Rt-βDEXsm™ (fused silica)

(2,3-di-O-methyl-6-O-*tert*-butyl dimethylsilyl beta cyclodextrin doped into 14% cyanopropylphenyl/86% dimethyl polysiloxane)

ID	df (µm)	temp. limits	30-Meter
0.25mm	0.25	40 to 230°C	13105
0.32mm	0.25	40 to 230°C	13104

Uses: Excellent column for most chiral compounds found in essential oils.

Rt-βDEXse™ (fused silica)

(2,3-di-O-ethyl-6-O-*tert*-butyl dimethylsilyl beta cyclodextrin doped into 14% cyanopropylphenyl/86% dimethyl polysiloxane)

ID	df (µm)	temp. limits	30-Meter
0.25mm	0.25	40 to 230°C	13107
0.32mm	0.25	40 to 230°C	13106

Uses: Similar in performance to Rt-βDEXsm™ but provides better resolution for limonene, linalool, linalyl acetate, ethyl-2-methylbutyrate, 2,3-butane diol, and styrene oxides.

Rt-βDEXsp™ (fused silica)

(2,3-di-O-propyl-6-O-*tert*-butyl dimethylsilyl beta cyclodextrin doped into 14% cyanopropylphenyl/86% dimethyl polysiloxane)

ID	df (µm)	temp. limits	30-Meter
0.25mm	0.25	40 to 230°C	13111
0.32mm	0.25	40 to 230°C	13110

Uses: Often useful in dual-column configurations, with the Rt-βDEXsm™ column, for complex enantiomeric separations.

Rt-βDEXsa™ (fused silica)

(2,3-di-acetoxy-6-O-*tert*-butyl dimethylsilyl beta cyclodextrin doped into 14% cyanopropylphenyl/86% dimethyl polysiloxane)

ID	df (µm)	temp. limits	30-Meter
0.25mm	0.25	40 to 230°C	13109
0.32mm	0.25	40 to 230°C	13108

Uses: Unique selectivity for esters and lactones, and other fruit flavor components.

Rt-βDEXcst™ (fused silica)

(Proprietary cyclodextrin material doped into 14% cyanopropylphenyl/86% dimethyl polysiloxane)

ID	df (µm)	temp. limits	30-Meter
0.25mm	0.25	40 to 230°C	13103
0.32mm	0.25	40 to 230°C	13102

Uses: Proprietary stationary phase, developed specifically for the fragrance industry. Also used for pharmaceutical applications.

Rt-γDEXsa™ (fused silica)

(2,3-di-acetoxy-6-O-*tert*-butyl dimethylsilyl gamma cyclodextrin doped into 14% cyanopropylphenyl/86% dimethyl polysiloxane)

ID	df (µm)	temp. limits	30-Meter
0.25mm	0.25	40 to 230°C	13113
0.32mm	0.25	40 to 230°C	13112

Uses: Larger organic molecules. Also useful for flavor compounds in fruit juices.

CarboBlack™ Solid Supports

Graphitized carbon black offers unique selectivity for alcohols, with very little adsorption. Two types of CarboBlack™ supports are available, CarboBlack™ B and CarboBlack™ C. CarboBlack™ B support, with its higher surface area, can hold up to a 10% loading of a non-silicone liquid phase. CarboBlack™ C support can hold up to a 1% loading of a non-silicone liquid phase. Many Carbowax® 20M-loaded CarboBlack™ packings are available. CarboBlack™ packings are treated with KOH or picric acid for basic or acidic compounds, and special alcoholic beverage loadings are available. CarboBlack™ supports provide resolution and retention similar to Carbopack™ and Carbograph™ supports.

for **more** info

Blood alcohol analysis on a CarboBlack™ B packed column is shown on **page 11**.

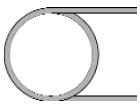
		Stainless Steel Tubing				SilcoSmooth™ Tubing**			
On CarboBlack™ B	Mesh	L (ft.)	OD (in.)	ID (mm)	cat.#*	L (m)	OD (in.)	ID (mm)	cat.#*
5% Carbowax® 20M	80/120	—	—	—	—	2	1/8	2	80105-
5% Carbowax® 20M	60/80	6	1/8	2.1	88012-	1.8	1/8	2	80106-
6.6% Carbowax® 20M	80/120	6	1/8	2.1	80451-	2	1/8	2	80107-
4% Carbowax® 20M/ 0.8% KOH	60/80	—	—	—	—	2	1/8	2	80116-
1% Rt-1000	60/80	8	1/8	2.1	88013-	2.4	1/8	2	80206-
1% Rt-1000	60/80	6	1/8	2.1	80452-	2	1/8	2	80207-
3% Rt-1500	80/120	10	1/8	2.1	80453-	3.05	1/8	2	80211-
1% Rt-1510	60/80	10	1/8	2.1	80454-	3.05	1/8	2	80216-
1.5% XE-60/1% H_3PO_4	60/80	6	1/8	2.1	80455-	1.8	1/8	2	80305-

		Nickel 200 Tubing			
On CarboBlack™ B	Mesh	L (m)	OD (in.)	ID (mm)	cat.#*
5% Krytox (Ni 200 tubing)	60/80	3.05	1/8	2.1	80127-

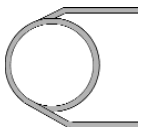
		Stainless Steel Tubing				SilcoSmooth™ Tubing**			
On CarboBlack™ C	Mesh	L (ft.)	OD (in.)	ID (mm)	cat.#*	L (m)	OD (in.)	ID (mm)	cat.#*
0.2% Carbowax® 1500	60/80	6	1/8	2.1	80456-	2	1/8	2	80121-
0.2% Carbowax® 1500	80/100	6	1/8	2.1	80457-	2	1/8	2	80122-
0.1% Rt-1000	80/100	6	1/8	2.1	80458-	1.8	1/8	2	80205-
0.19% picric acid	80/100	6	1/8	2.1	80459-	2	1/8	2	80311-
0.3% Carbowax® 20M/0.1% H_3PO_4	60/80	2.5	3/16	3.2	80460-	0.75	3/16	3.2	80111-

*Please add configuration suffix number to cat.# when ordering.
**Silcosteel®-deactivated stainless steel.

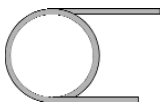
Column Configurations



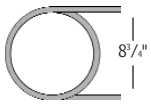
General Configuration
Suffix -800



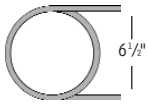
Agilent 5880, 5890, 5987, 6890:
Suffix -810



Varian 3700, Vista Series, FID:
Suffix -820



PE 900-3920 Sigma 1,2,3:
Suffix -830



PE Auto System 8300, 8400, 8700 (Not On-Column):
Suffix -840

Note: Initial 2" of column will be empty, to accommodate a needle. For a completely filled column add suffix -901.

See our general catalog for custom configurations

Chromosorb® Diatomaceous Earth Supports

Restek offers the full line of Chromosorb® solid supports that are specially sieved to remove fines and ensure tight particle distribution. Choosing the appropriate support will depend on your application. Need assistance? Call Technical Service at 800-356-1688 or 814-353-1300, ext. 4, or contact your Restek representative for more information.

Chromosorb® P (used to prepare Silcoport™ P)

Chromosorb® P support is manufactured from hard firebrick, making it a rugged material. This support is available acid washed (AW), non-acid washed (NAW), and traditional dimethyldichlorosilane (DMDCS) treated. Chromosorb® P support can hold up to 30 weight% of liquid stationary phase, making it the highest loading support available.

Chromosorb® W (used to prepare Silcoport™ W and Silcoport™ BW)

Chromosorb® W support is a flux-calcinated diatomite. This solid support is very fragile but offers the highest inertness of all diatomaceous earth supports. It can be prepared with up to 25 weight% of liquid stationary phase. Chromosorb® W support is available in AW, NAW, and DMDCS, or treated with Restek's proprietary (Silcoport™) deactivation. Chromosorb® W-HP is an acid washed, silanized version of Chromosorb® W.

Chromosorb® G

Chromosorb® G support is the hardest support available and has the lowest surface area of all the diatomaceous earth supports. Chromosorb® G support is available as AW, NAW, and DMDCS-treated. It can hold up to 10 weight% of liquid stationary phase.

Chromosorb® T

Chromosorb® T support is made from Teflon® and is an extremely inert solid support.

Call Restek at 800-356-1688 or 814-353-1300, ext. 3, or contact your Restek representative for quotes on any Chromosorb® material. Some of the popular Chromosorb®-based stock columns and packings available are:

Chromosorb®-Based Packed Columns

	Stainless Steel Tubing				SilcoSmooth™ Tubing**			
On 100/120 Silcoport™ W***	L (ft.)	OD (in.)	ID (mm)	cat.#*	L (m)	OD (in.)	ID (mm)	cat.#*
3% Rt-101	6	1/8	2.1	80461-	2	1/8	2	80400-
3% Rt-2100	6	1/8	2.1	80462-	2	1/8	2	80420-
5% Rt-1200/1.75% Bentone 34	6	1/8	2.1	80463-	2	1/8	2	80125-
5% Rt-1200/5% Bentone 34	6	1/8	2.1	80464-	2	1/8	2	80129-

		Stainless Steel Tubing				SilcoSmooth™ Tubing**			
On Chromosorb® PAW	Mesh	L (ft.)	OD (in.)	ID (mm)	cat.#*	L (m)	OD (in.)	ID (mm)	cat.#*
10% TCEP		8	1/8	2.1	80465-	2.5	1/8	2	80126-
23% Rt-1700	80/100	30	1/8	2.1	80466-	9.2	1/8	2	80128-

*Please add configuration suffix number to cat.# when ordering. See page 37.
**Silcosteel®-deactivated stainless steel.
***Modified version of Chromosorb® W; highest inertness, most consistent performance.

Searching for a product?
www.restek.com

COLUMN INSTALLS THIS END

Splitless Liners for Agilent/Finnigan GCs	Benefits/Uses	ID*/OD & Length (mm)	Similar to Agilent part #	cat.# ea.	5-pk.	25-pk.
4mm Splitless	trace samples >2µL	4.0 ID 6.5 OD x 78.5	210-3003 (ea.) 210-3003-5 (5-pk.)	20772	20773	20774
Siltek® 4mm Splitless	trace samples >2µL	4.0 ID 6.5 OD x 78.5	—	20772-214.1	20773-214.5	20774-214.25
4mm Splitless w/ Wool	trace samples >2µL	4.0 ID 6.5 OD x 78.5	19251-60540 (ea.) 5183-4691 (5-pk.) 5183-4692 (25-pk.)	22400	22401	22402
Gooseneck Splitless (4mm)†	trace samples >2µL	4.0 ID 6.5 OD x 78.5	5181-3316 (ea.) 5183-4695 (5-pk.) 5183-4696 (25-pk.)	20798	20799	20800
Siltek® Gooseneck Splitless (4mm)†	trace samples >2µL	4.0 ID 6.5 OD x 78.5	—	20798-214.1	20799-214.5	20800-214.25
Gooseneck Splitless (4mm) w/ Wool†	trace samples >2µL	4.0 ID 6.5 OD x 78.5	5062-3587 (ea.) 5183-4693 (5-pk.) 5183-4694 (25-pk.)	22405	22406	22407
Siltek® Gooseneck Splitless (4mm) w/ Wool†	trace samples >2µL	4.0 ID 6.5 OD x 78.5	—	22405-213.1	22406-213.5	22407-213.25

Splitless Liners for Shimadzu GCs	Benefits/Uses:	ID*/OD & Length (mm)	Similar to Shimadzu part #	cat.# ea.	5-pk.	25-pk.
17A & 2010 Double Gooseneck	reduces backflash and catalytic decomposition	3.5 ID 5.0 OD x 95	—	20958	20959	20960
17A & 2010 Single Gooseneck	reduces backflash, also operates in DI mode	3.5 ID 5.0 OD x 95	221-41599-00	20961	20962	20963

Split/Splitless Liners for Shimadzu GCs	Benefits/Uses:	ID*/OD & Length (mm)	Similar to Shimadzu part #	cat.# ea.	5-pk.	25-pk.
17A & 2010 Split/Splitless w/ Wool	universal, for most common analyses	3.5 ID 5.0 OD x 95	221-41444-00	20955	20956	20957
Siltek® 17A & 2010 Split/Splitless w/ Wool	universal, for most common analyses	3.5 ID 5.0 OD x 95	—	20955-213.1	20956-213.5	20957-213.25

Liners for Varian 1177 GCs	Benefits/Uses:	ID*/OD & Length (mm)	Similar to Varian part #	cat.# ea.	5-pk.	25-pk.
Gooseneck Splitless (4mm)	trace samples <2µL	4.0 ID 6.5 OD x 78.5	39-26119-27	21896	21897	—
Siltek® Gooseneck Splitless (4mm)	trace samples <2µL	4.0 ID 6.5 OD x 78.5	—	21896-214.1	21897-214.5	—
Gooseneck Splitless (4mm) w/ Wool	trace samples <2µL	4.0 ID 6.5 OD x 78.5	39-26119-36	21896-200.1	21897-200.5	—
Siltek® Gooseneck Splitless (4mm) w/ Wool	trace samples <2µL	4.0 ID 6.5 OD x 78.5	—	21896-213.1	21897-213.5	—

Splitless Liners for PerkinElmer GCs	Benefits/Uses:	ID*/OD & Length (mm)	Similar to PE part #	cat.# ea.	5-pk.	25-pk.
Auto SYS™ Splitless w/ Wool (2mm ID)	trace samples	2.0 ID 6.2 OD x 92.1	N6101372	20829	20830	20831
Siltek® Auto SYS™ Splitless w/ Wool (2mm ID)	trace samples	2.0 ID 6.2 OD x 92.1	—	20829-213.1	20830-213.5	20831-213.25
Auto SYS™ Double Gooseneck	trace, active samples up to 4µL	4.0 ID 6.2 OD x 92.1	—	20853	20854	—

Splitless Liners for Thermo Finnigan 8000 & TRACE™ Series GCs	Benefits/Uses:	ID*/OD & Length (mm)	Similar to TF part #	cat.# ea.	5-pk.	25-pk.
Splitless (3mm ID)	trace samples	3.0 ID 8.0 OD x 105	453 20032	20942	20943	20944
Siltek® Splitless (3mm ID)	trace samples	3.0 ID 8.0 OD x 105	—	20942-214.1	20943-214.5	20944-214.25
Splitless (5mm ID)	trace samples	5.0 ID 8.0 OD x 105	453 20033	20945	20946	20947

*Nominal ID at syringe needle expulsion point.
†Use this liner for increased sensitivity.

All liners are 100% deactivated

All liners are shipped intermediate polarity (IP) deactivated unless otherwise requested.

GC Accessories

septum sizes

Reference Chart

Instrument	Septum Size (mm)
Agilent (HP)	
5880A, 5890, 6890, 6850, PTV	11
5700, 5880	9.5/10
On-Column Injection	5
CE Instruments (TMQ)	
TRACE™ GC	17
Finnigan (TMQ)	
GC 9001	9.5
GCQ9.5	
GCQ w/TRACE™, PTV	17
QCQ™9.5	
TRACE™ 2000	9.5
Fisons/Carlo Erba (TMQ)	
8000 series	17
Gow-Mac	
6890 series	11
All other models	9.5
PerkinElmer	
Sigma series	11
900,990	11
8000 series	11
Auto SYS	11
Auto SYS XL	11
Pye/Unicam	
All models	7
Shimadzu	
All models	Plug
SRI	
All models	Plug
Tracor	
540 11.5	
550,560	9.5
220,222	12.5
Varian	
Injector type:	
Packed column	9.5/10
Split/splitless 1078/1079	10/11
1177 9	
1075/1077	11

for more info

To see our complete selections of septa, ferrules, and other consumables for GC, please request our current catalog, or visit our website.

save money!

Buy ferrules in 50-packs!

Thermolite® Septa

- Usable to 340°C inlet temperature.
- Each batch tested with FIDs, ECDs, and MSDs to ensure lowest bleed.
- Excellent puncturability.
- Preconditioned and ready to use.
- Do not adhere to hot metal surfaces.
- Packaged in non-contaminating glass jars.

Septum Diameter	25-pk.	50-pk.	100-pk.
5mm (3/16")	20351	20352	20353
6mm (1/4")	20355	20356	20357
7mm	20381	20382	20383
8mm	20370	20371	—
9mm	20354	20358	20362
9.5mm (3/8")	20359	20360	20361
10mm	20378	20379	20380
11mm (7/16")	20363	20364	20365
11.5mm	22385	22386	22387
12.5mm (1/2")	20367	20368	20369
17mm	20384	20385	20386
Shimadzu Plug	20372	20373	20374

Measure your old septum here (size in mm)

5 7 9 9.5 10 11 11.5 12.5 17

Vespel® Ferrules

- 100% high-temperature polyimide.
- Stable to 350°C.
- Durable, leak-tight.

Graphite Ferrules

- High-purity, high-density graphite.
- Smoother surface and cleaner edges than conventional graphite ferrules.
- Contain no binders that can off-gas or adsorb analytes.
- Stable to 450°C.

Vespel®/Graphite Ferrules

- 60%/40% Vespel®/graphite blend, offering the best combination of sealing and ease of workability.
- Seal with minimal torque, reusable, and preferred for vacuum and high-pressure uses.
- Stable to 400°C.
- Recommended for mass spec transfer lines.

Capillary Ferrules—For 1/16-Inch Compression-Type Fittings

Ferrule ID	Fits Column ID	qty.	Vespel®	Graphite	Vespel®/Graphite
0.3mm	≤ 0.20μμ	10-pk.	22213	20233	20275
0.4mm	0.25/0.28mm	10-pk.	22214	20200	20211
0.4mm	0.25/0.28mm	50-pk.	—	20227	20229
0.5mm	0.28/0.32mm	10-pk.	22215	20201	20212
0.5mm	0.28/0.32mm	50-pk.	—	20228	20231
0.6mm	0.28mm**	10-pk.	—	—	20232
0.8mm	0.45/0.53mm	10-pk.	22216	20202	20213
0.8mm	0.45/0.53mm	50-pk.	—	20224	20230
1.0mm	0.75mm*	10-pk.	22217	21058	24912
1.2mm	0.75mm	10-pk.	22218	—	—
1.6mm	1.00mm*	10-pk.	—	21060	—

*For micropacked columns.
**For 0.28mm MXT® columns.

Viton® O-Rings for Agilent GCs

- Fit split (6.3mm OD) or splitless (6.5mm OD) liners.

Description	Max. temp.	Similar to Agilent part #	qty.	cat.#
Viton® O-Rings for Agilent GCs	250°C	5180-4182	25-pk.	20377

Graphite O-Rings for Agilent and Varian 1177 GCs

- Excellent thermal stability at injection port temperatures up to 450°C!

Description	Max. temp.	Similar to Agilent part #	Restek cat.# 10-pk.	50-pk.
Graphite O-rings for split liners (6.35mm ID)	450°C	5180-4168	20296	20297
Graphite O-rings for splitless liners (6.5mm ID)	450°C	5180-4173	20298	20299

Liner Seals for Varian 1078/1079

Description	Max. temp.	Similar to Varian part #	qty.	cat.#
5mm Graphite Liner Seals for Varian 1078/1079 GCs	450°C	392611919 392534201	10-pk.	22683

Viton® O-Rings for PerkinElmer Auto SYS™ GCs

Graphite O-Rings for PerkinElmer Auto SYS™ XL PSS

Description	Max. temp.	Similar to PE part #	qty.	cat.#
Graphite O-Rings for PerkinElmer Auto SYS™ XL PSS	450°C	N610-1751	10-pk.	21475
Graphite O-Rings for PerkinElmer Auto SYS™ XL PSS	450°C	N610-1751	25-pk.	21476

Viton® O-Rings for PerkinElmer PSS

Description	Max. temp.	Similar to PE part #	qty.	cat.#
Viton® O-Rings for PerkinElmer PSS	250°C	N6101747	10-pk.	20366

Graphite O-Rings for Shimadzu 17A and 2010 GCs

Description	Max. temp.	Similar to Shimadzu part #	qty.	cat.#
Graphite O-Rings for Split Liners	450°C	221-48393-91	5-pk.	20243
Graphite O-Rings for Splitless Liners	450°C	221-47222-91	5-pk.	20244

Viton® O-Rings for Shimadzu 17A and 2010 GCs

Description	Max. temp.	Similar to Shimadzu part #	qty.	cat.#
Viton® O-Rings for Shimadzu 17A and 2010 GCs	250°C	036-11203-84	10-pk.	21477

Septum Puller

- Keep several on hand in your laboratory—can be used in many different ways.
- Use hooked end for removing septa and O-rings; pointed end works well for removing stuck ferrules or fragments.

Description	qty.	cat.#
Septum Puller	ea.	20117

Inlet Liner Removal Tool

- Easily remove liner from injector—no more burned fingers.
- Made from high-temperature silicone.
- Won't chip or crack the liner.

Description	qty.	cat.#
Inlet Liner Removal Tool	3-pk.	20181

Leak Detector

- Reliable thermal conductivity leak detector—every analyst should have one.
- Compact, portable, ergonomic design—easy to hold and operate.
- Sensitive—detects helium or hydrogen at $1x10^{-4}$ cc/sec*.
- Fast results—responds to leaks in less than 2 seconds, zeros with the touch of a button.
- Built-in rechargeable battery—charging adaptor included.

In continuing our efforts to provide chromatographers with the best available columns, tools, and accessories, we have enhanced our popular Restek Electronic Leak Detector. New features include internal battery charge capability, a low-battery indicator, a battery charge indicator light, yellow lights to signal a nitrogen leak, a repositioned on/off switch, to eliminate accidentally powering on the unit, and a new probe tip design that prevents debris from entering the unit. The new leak detector retains the microchip technology that enables high sensitivity in a compact unit, the autozero feature that allows instantaneous zeroing with the touch of a button, and the ergonomic design that puts all controls at your fingertips, for maximum ease of use.

The new Restek Electronic Leak Detector is the affordable solution for detecting helium, hydrogen, or nitrogen leaks in your GC system. Leaks can cause detector noise and baseline instability, waste carrier gas, and shorten column lifetimes. The leak detector responds in less than 2 seconds to leaks of gases with thermal conductivities different from air, indicating leaks with both an audible alarm and an LED readout. The leak detector detects minute gas leaks that can go undetected by liquid leak detectors. And, remember—you should never use liquid leak detectors on a capillary system, because liquids drawn into the system through the leaks will contaminate the system.

Description	qty.	cat.#
Leak Detector with 110Volt Battery Charger	ea.	22451
Leak Detector with 220Volt European Battery Charger	ea.	22451-EUR
Leak Detector with 220Volt UK Battery Charger	ea.	22451-UK

Caution: The Restek Electronic Leak Detector is NOT designed for determining leaks of combustible gases. A combustible gas detector should be used for determining combustible gas leaks in possibly hazardous conditions.

*Sensitivity measured using helium.

for more info

Restek offers an extensive line of GC and HPLC columns, accessories, and replacement parts. Call to request one of these catalogs for a full listing of products or visit us on the web at www.restek.com

GC Replacement Parts for Agilent GCs, Lit. Cat. #59627E

2006 General Catalog Lit. Cat. #580021

Leak Detector Accessory Kit

The kit includes an adaptor fitting that fits over the probe assembly to detect leaks in hard-to-reach locations, and a mounting bracket that can be affixed to the wall or GC.

Verify pinpoint leaks with the adaptor fitting.

Leak Detector is easily accessed when stored in the mounting bracket.

Description	qty.	cat.#
Leak Detector Accessory Kit (adaptor fitting for probe, mounting bracket)	kit	22453

Press-Tight® Connectors

- Fit column ODs from 0.33–0.74mm (Restek 0.1mm–0.53mm ID).
- Made from inert fused silica.
- Deactivated Press-Tight® connectors are ideal for better recovery of polar and non-polar compounds.

Universal Press-Tight® Connectors

- Connect a guard column to an analytical column.
- Repair a broken column.
- Connect a column outlet to a transfer line.

Description	5-pk.	25-pk.	100-pk.
Universal Press-Tight® Connectors	20400	20401	20402
Deactivated, Universal Press-Tight® Connectors	20429	20430	20431

Universal Angled Press-Tight® Connectors

- Angle approximates the curvature of a capillary column, reduces strain on column-end connections.

Description	5-pk.	25-pk.	100-pk.
Universal Angled Press-Tight® Connectors	20446	20447	20448
Deactivated Universal Angled Press-Tight® Connectors	20446-261	20447-261	20448-261

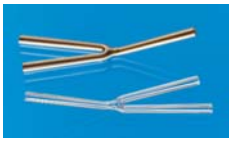
Universal "Y" Press-Tight® Connectors

- Split sample flow onto two columns.
- Split a single column flow to two detectors—perform confirmation analysis with a single injection.

Description	ea.	3-pk.
Universal "Y" Press-Tight® Connector	20405	20406
Deactivated Universal "Y" Press-Tight® Connector	20405-261	20406-261

Universal Angled "Y" Press-Tight® Connectors

- Angle approximates the curvature of a capillary column, reduces strain on column-end connections.



Description	ea.	3-pk.
Universal Angled "Y" Press-Tight® Connector	20403	20404
Deactivated Universal Angled "Y" Press-Tight® Connector	20403-261	20404-261

MXT®-Union Connector Kits for Fused Silica Columns

- Low-dead-volume, leak-tight connection.
- Reusable; use to oven temperatures of 350°C.
- Siltek® treatment ensures maximum inertness.
- Ideal for connecting a guard column or transfer line to an analytical column.

These MXT® connectors can be used with fused silica tubing, as well as with metal tubing, because a Valcon polyimide 1/32-inch one-piece fused silica adaptor allows a capillary column to slide into the adaptor and be locked in place simply by loosening and tightening the fitting.

MXT®-Union Connector Kits for Fused Silica Columns

Each kit contains the MXT® union, two 1/32-inch nuts and two one-piece fused silica adaptors.

Description	qty.	cat.#
For 0.25mm ID Fused Silica Columns	kit	21386
For 0.32mm ID Fused Silica Columns	kit	21385
For 0.53mm ID Fused Silica Columns	kit	21384

MXT® "Y"-Union Connector Kits for Fused Silica Columns

Each kit contains the MXT® union, three 1/32-inch nuts and three one-piece fused silica adaptors.

Description	qty.	cat.#
For 0.25mm ID Fused Silica Columns	kit	21389
For 0.32mm ID Fused Silica Columns	kit	21388
For 0.53mm ID Fused Silica Columns	kit	21387

1/32-Inch Replacement Nut

Description	qty.	cat.#
1/32" Replacement Nut	5-pk	20389

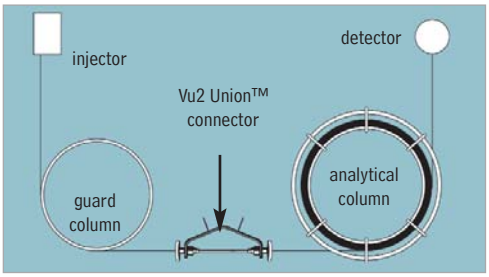
GC Accessories

Vu2 Union™ Connectors

- Connect a guard column to an analytical column.
- Connect a column to a transfer line.
- Connect two columns in series.
- Repair a broken column.

Our Vu2 Union™ connector combines the simplicity of a Press-Tight® union with the strength of a metal union. The columns cannot unexpectedly disconnect, even at temperatures as high as 400°C.

A guard column connected to an analytical column by a Vu2 Union™ connector.

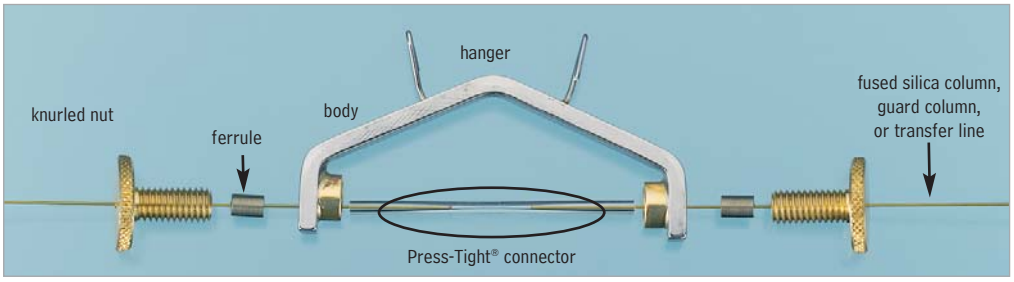


Secure, reliable column-to-column connections!

How does a Vu2 Union™ connector work?
A Press-Tight® union in the Vu2 Union™ connector joins the fused silica ends together; the ferrule and knurled nut at each end of the connector hold the tubing in place via a secondary seal between the ferrule and the Press-Tight® union. Each knurled nut applies independent pressure to each ferrule, to make a leak-tight seal with the column end. These ultra-strong connections will not unexpectedly disconnect under temperature changes, vibrations, or other stresses normally encountered in GC analyses. The open design allows visual confirmation of the seal between the column and the Press-Tight® union, to ensure confidence in the connection. Hang the connector from the column cage, to minimize stress on the connections.

Who will benefit from using Vu2 Union™ connectors?
Any analyst using guard columns, transfer lines, or restrictor tubing, performing a dual-column analysis with columns connected in series, or seeking to repair a broken column will find Vu2 Union™ connectors the simple, reliable, easy-to-use solution to their connection needs.

The Vu2 Union™ connector's open design allows visual confirmation of the seal; secondary seals ensure a leak-tight connection.



for **more** info
See **page 43** for Universal Press-Tight® Connectors.

Kits include: Vu2 Union™ body, 2 knurled nuts, 2 Press-Tight® unions, and 4 ferrules

Description	Ferrules Fit Column ID	qty.	cat.#
Vu2 Union™ Connector Kit	0.10/0.15mm	kit	22220
Vu2 Union™ Connector Kit	0.18/0.28mm	kit	21105
Vu2 Union™ Connector Kit	0.32mm	kit	21106
Vu2 Union™ Connector Kit	0.45/0.53mm	kit	21107
Knurled nut		2-pk.	21108

NOTE: Not recommended for GC column-to-MS connections—use the Vacuum Vu-Union® (see our general catalog, or website).

Graphite Ferrules for Vu2 Union™ Connectors

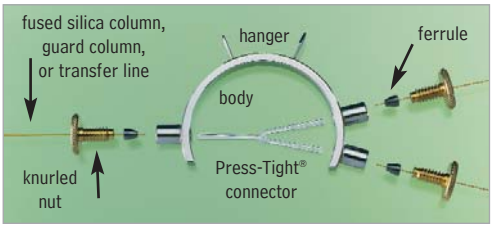
- High-purity, high-density graphite.
- Stable to 450°C.
- No binders that can off-gas or adsorb analytes.
- Smooth surface and clean edges.

Ferrule ID	Fits Column ID	Graphite 2-pk.	Graphite 10-pk.
0.3mm	0.10/0.15mm	22221	22222
0.4mm	0.18/0.28mm	20280	20281
0.5mm	0.32mm	20282	20283
0.8mm	0.45/0.53mm	20284	20285

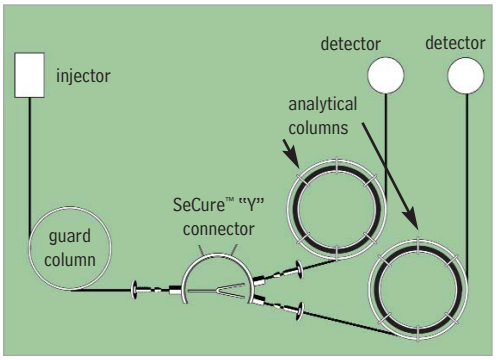
SeCure™ "Y" Connector Kits

- Connect two analytical columns to a transfer line or guard column.
- Use standard "Y" Press-Tight® connectors and 1/16" graphite ferrules.
- Reliable seal integrity, will not unexpectedly disconnect during temperature-programmed analyses.
- Open design allows visual confirmation of the seal for added confidence in the connection.

Combine the simplicity of a "Y" Press-Tight® connector with the strength of a metal union. The ferrules and knurled nuts hold the fused silica tubing in place, which prevents the tubing from unexpectedly disconnecting, even at temperatures as high as 400°C.



The SeCure™ "Y" Connector's open design allows visual confirmation of the seal; secondary seals ensure a leak-tight connection.



The SeCure™ "Y" connector allows dual-column confirmational analysis with a single injection—one of the connector's many uses.

Kits include: SeCure™ "Y" connector body, 3 knurled nuts, "Y" Universal Press-Tight® union, 3 ferrules.

Description	Ferrules Fit Column ID	qty.	cat.#
SeCure™ "Y" Connector Kit	0.25/0.28mm	kit	20276
SeCure™ "Y" Connector Kit	0.28/0.32mm	kit	20277
SeCure™ "Y" Connector Kit	0.45/0.53mm	kit	20278
Knurled nut		3-pk.	20279

for **more** info
See **page 43** for Universal "Y" Press-Tight® Connectors.

Graphite Ferrules for SeCure™ "Y" Connectors

- High-purity, high-density graphite.
- Stable to 450°C.
- No binders that can off-gas or adsorb analytes.
- Smooth surface and clean edges.

Ferrule ID	Fits Column ID	Graphite 10-pk.	Graphite 50-pk.
0.4mm	0.25/0.28mm	20200	20227
0.5mm	0.28/0.32mm	20201	20228
0.8mm	0.45/0.53mm	20202	20224

Kit installs easily, without special tools or plumbing.

restek
innovation!

Change columns in minutes—without venting!

EZ No-Vent™ GC Column-Mass Spectrometer Connector

- Change GC/MS columns in minutes without venting—100µm transfer line throttles vacuum and prevents MS venting.
- Easy to install and maintain—no special tools or plumbing required.
- Gold-plated body for inertness.
- Deactivated transfer line keeps analytes focused; high-temperature polyimide ferrules eliminate leaks at the problematic transfer line fitting.
- Lower cost than other "no-vent" fittings.
- Available for Agilent GCs with 5971/5972 or 5973 GC/MS and Varian Saturn 2000 Series Mass Spectrometers.

We designed the EZ No-Vent™ GC column-mass spectrometer connector to be simple and easy to use. After studying user feedback concerning our EZ-Vent™ 2000 connector, we re-engineered the connector fitting for even better performance. A critical orifice in the EZ No-Vent™ connector minimizes the amount of oxygen allowed into the MS source, eliminating the need for purge gas and enabling you to skip the lengthy vent and pump-down cycle otherwise required when you make a column change. This can save nearly a day of downtime with each column change. The EZ No-Vent™ connector easily attaches to the MS source without special tools or extra plumbing. Figure 1 shows the internal structure of the connector.

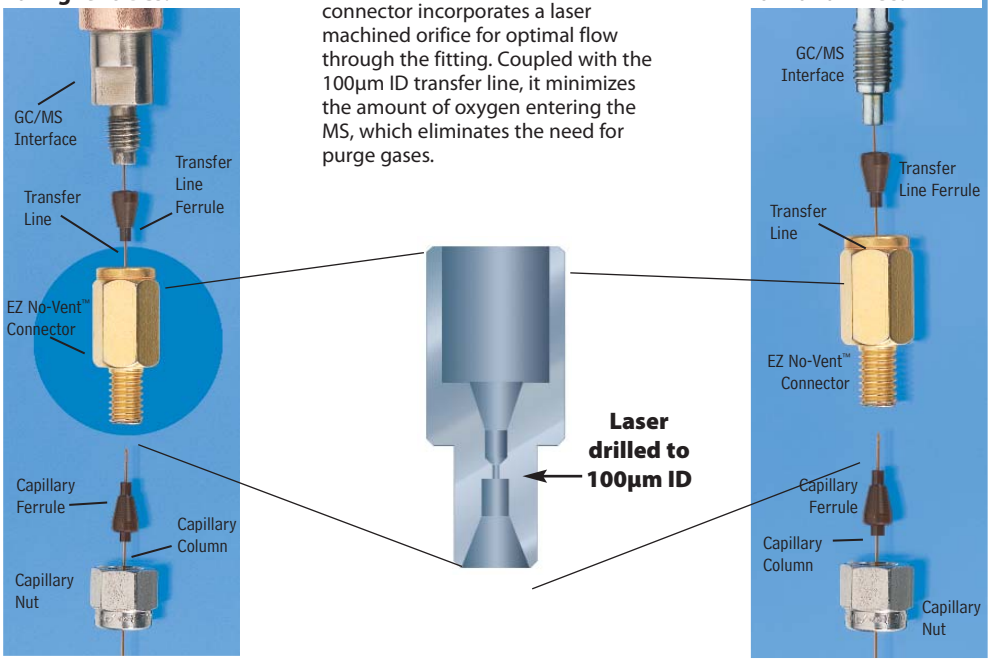


Figure 1 The EZ No-Vent™ connector incorporates a laser machined orifice for optimal flow through the fitting. Coupled with the 100µm ID transfer line, it minimizes the amount of oxygen entering the MS, which eliminates the need for purge gases.

Description	qty.	cat.#
EZ No-Vent™ Connector Kit for Agilent 5971/5972 and 5973 GC/MS Kit includes: EZ No-Vent™ Connector, two 0.4mm ID ferrules for capillary column, two 0.4mm ID ferrules for transfer line, 100µm deactivated transfer line (3 ft.), column plug, column nut.	kit	21323
EZ No-Vent™ Connector Kit for Varian Saturn 2000 Series MSs Kit includes: EZ No-Vent™ Connector, two 0.4mm ID ferrules for capillary column, two 0.4mm ID ferrules for transfer line, 100µm deactivated transfer line (3 ft.), column plug, column nut.	kit	22423
Replacement ferrules for connecting capillary column to EZ No-Vent™:		
0.4mm ID	2-pk.	21015
0.5mm ID	2-pk.	21016
Replacement ferrules for connecting transfer line to EZ No-Vent™: 0.4mm ID	2-pk.	21043
Replacement 100µm deactivated transfer line	3 ft.	21018
Replacement EZ No-Vent™ Column Nut	5-pk.	21900
Replacement EZ No-Vent™ Plug	2-pk.	21915
Open-End Wrenches ($^1/_4$" x $^5/_{16}$")	2-pk.	20110

Choosing a Stationary Phase

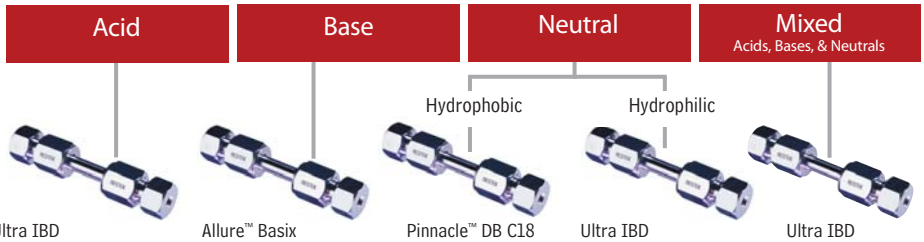
Identifying the appropriate stationary phase for your separation is the most critical step of column selection. The choice of stationary phase should be based on sample solubility and on chemical differences among the sample compounds that can be exploited to separate the analytes of interest (Figure 1).

Sample hydrophobicity also is a major determinant of the separation mode (reversed phase or normal phase). In reversed phase separations, the mobile phase is more polar than the stationary phase, which is traditionally a straight alkyl chain, most often octadecylsilyl, C18 (ODS). The majority of HPLC analyses are performed in reversed phase mode because most analytes of interest can be dissolved in mixtures of water and/or a polar organic solvent such as methanol or acetonitrile.

In normal phase separations, the mobile phase is less polar than the stationary phase (e.g., when bare silica is the stationary phase and hexane with a modifier is the mobile phase). The normal phase mode is used primarily when the reversed phase mode cannot be used, because reversed phase separations generally are more robust, reproducible, and versatile. Note that a stationary phase incorporating both polar and nonpolar functionality can be used in either reversed phase or normal phase mode. Cyano phases (e.g., Ultra, Pinnacle™ DB, or Pinnacle™ II cyano columns) commonly are used in either reversed phase or normal phase mode. Ultra IBD and Allure™ Basix columns also can be used for either reversed phase or normal phase separations. Allure™ PFP Propyl and Ultra PFP columns also display dual functionality.

Choose the best stationary phase for your application based on analyte functionality.

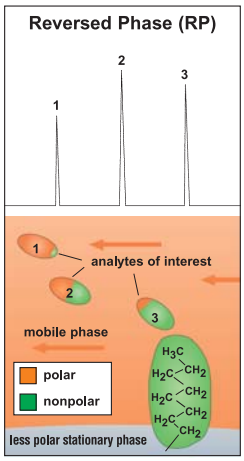
Analyte Functional Group

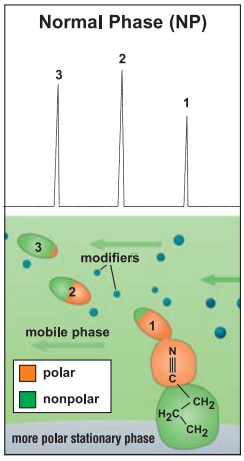


Acid	Base	Neutral: Hydrophobic	Neutral: Hydrophilic	Mixed (Acids, Bases, & Neutrals)
Ultra IBD	Allure™ Basix	Pinnacle™ DB C18	Ultra IBD	Ultra IBD
Ultra Aqueous C18	Allure™ PFP Propyl	Ultra C18	Ultra Aqueous C18	Allure™ Basix
Allure™ Aqueous C18	Ultra IBD	Pinnacle™ II C18	Allure™ Aqueous C18	
Allure™ Organic Acids	Ultra PFP	Allure™ C18	Allure™ Organic Acids	
	Pinnacle™ DB Cyano	Ultra C8		
	Ultra Cyano	Pinnacle™ II C8		
	Ultra Amino	Pinnacle™ II Phenyl		
	Pinnacle™ II Amino	Viva C18		
		Allure™ Biphenyl		

Figure 1
Choice of stationary phase is dependent upon polarity of the sample.

Non-polar analytes are more attracted to the less polar stationary phase. Polar analytes are more strongly retained by the more polar stationary phase.





Pinnacle™ II Phenyl (USP L11)

Physical Characteristics:

particle size: 3µm or 5µm, spherical
pore size: 110Å
carbon load: 6%
endcap: fully endcapped
pH range: 2.5 to 10
temperature limit: 80°C

Chromatographic Properties:

The Pinnacle™ II Phenyl phase offers unique selectivity versus traditional alkyl chain phases, especially for aromatic compounds.

To order a 2.1mm, 3.2mm, or 4.6mm ID column with a Trident™ Integral Inlet Fitting, add "-700" to the catalog number for the column.

Example: 100mm x 4.6mm ID Ultra C18 column with Trident™ Integral Inlet Fitting: 9174315-700
Nominal additional charge

For guard cartridges for these columns, see page 52.

Allure™ C18 (USP L1)
Excellent Columns for LC/MS and ELSD

Physical Characteristics:

particle size: 3µm or 5µm, spherical
pore size: 60Å
carbon load: 27%
endcap: fully endcapped
pH range: 2.5 to 7.5
temperature limit: 80°C

Chromatographic Properties:

Most retentive phase for hydrophobic and slightly polar analytes due to large surface area of the base silica and high-density bondings. High-purity packings exhibit excellent peak shapes for a wide range of compounds.

Length	1.0mm ID cat.#	2.1mm ID cat.#	3.2mm ID cat.#	4.6mm ID cat.#
3µm Columns				
30mm	9164331	9164332	9164333	9164335
50mm	9164351	9164352	9164353	9164355
100mm	9164311	9164312	9164313	9164315
5µm Columns				
30mm	9164531	9164532	9164533	9164535
50mm	9164551	9164552	9164553	9164555
100mm	9164511	9164512	9164513	9164515
150mm	9164561	9164562	9164563	9164565

Allure™ Basix (USP L10)
Excellent Columns for LC/MS and ELSD

Physical Characteristics:

particle size: 3µm or 5µm, spherical
pore size: 60Å
carbon load: 12%
endcap: fully endcapped
pH range: 2.5 to 7.5
temperature limit: 80°C

Chromatographic Properties:

Highly retentive propyl cyano phase. Excellent choice for analytes containing amine group functionality.

Length	1.0mm ID cat.#	2.1mm ID cat.#	3.2mm ID cat.#	4.6mm ID cat.#
3µm Columns				
30mm	9161331	9161332	9161333	9161335
50mm	9161351	9161352	9161353	9161355
100mm	9161311	9161312	9161313	9161315
5µm Columns				
30mm	9161531	9161532	9161533	9161535
50mm	9161551	9161552	9161553	9161555
100mm	9161511	9161512	9161513	9161515
150mm	9161561	9161562	9161563	9161565

did you **know**?

Our Technical Service Department is staffed with more than 35 experienced chemists on rotating shifts from various departments. Whether your chromatography problem is simple or complex, call Restek's Technical Service Team at 1-800-356-1688 (ext. 4), or your Restek representative, and we will do everything we can to help you find a solution.

Allure™ Biphenyl

Physical Characteristics:

particle size: 3µm or 5µm, spherical
pore size: 60Å
carbon load: 23%
endcap: yes
pH range: 2.5 to 7.5
temperature limit: 80°C

Chromatographic Properties:

Highly retentive and selective phase for aromatic compounds. Increased retention over phenyl phases; uses high-purity, Type B silica.

Length	1.0mm ID cat.#	2.1mm ID cat.#	3.2mm ID cat.#	4.6mm ID cat.#
5µm Columns				
30mm	9166531	9166532	9166533	9166535
50mm	9166551	9166552	9166553	9166555
100mm	9166511	9166512	9166513	9166515
150mm	9166561	9166562	9166563	9166565
200mm	9166521	9166522	9166523	9166525
250mm	9166571	9166572	9166573	9166575

Allure™ PFP Propyl
Excellent Columns for LC/MS and ELSD

Physical Characteristics:

particle size: 3µm or 5µm, spherical
pore size: 60Å
carbon load: 17%
endcap: fully endcapped
pH range: 2.5 to 7.5
temperature limit: 80°C

Chromatographic Properties:

A pentafluorophenyl phase with a propyl spacer. Highly retentive for basic analytes. An excellent phase for separating nucleosides, nucleotides, purines, pyrimidines, halogenated compounds, β-blockers, and tricyclic antidepressants.

Length	1.0mm ID cat.#	2.1mm ID cat.#	3.2mm ID cat.#	4.6mm ID cat.#
3µm Columns				
30mm	9169331	9169332	9169333	9169335
50mm	9169351	9169352	9169353	9169355
100mm	9169311	9169312	9169313	9169315
5µm Columns				
30mm	9169531	9169532	9169533	9169535
50mm	9169551	9169552	9169553	9169555
100mm	9169511	9169512	9169513	9169515
150mm	9169561	9169562	9169563	9169565

Ultra C18 (USP L1)

Physical Characteristics:

particle size: 3µm or 5µm, spherical
pore size: 100Å
carbon load: 20%
endcap: fully endcapped
pH range: 2.5 to 7.5
temperature limit: 80°C

Chromatographic Properties:

A retentive, high-purity packing that exhibits excellent peak shape for a wide range of compounds. Excellent general-purpose reversed phase column.

Length	1.0mm ID cat.#	2.1mm ID cat.#	3.2mm ID cat.#	4.0mm ID cat.#	4.6mm ID cat.#
3µm Columns					
30mm	9174331	9174332	9174333	—	9174335
50mm	9174351	9174352	9174353	—	9174355
100mm	9174311	9174312	9174313	—	9174315
5µm Columns					
30mm	9174531	9174532	9174533	—	9174535
50mm	9174551	9174552	9174553	—	9174555
100mm	9174511	9174512	9174513	9174514	9174515
150mm	9174561	9174562	9174563	9174564	9174565
250mm	9174571	9174572	9174573	—	9174575

for more info

Restek offers an extensive line of GC and HPLC columns, accessories, and replacement parts. Call to request our general catalog, or our HPLC products catalog, for a full listing of products, or visit us on the web at www.restek.com

To order a 2.1mm, 3.2mm, or 4.6mm ID column with a Trident™ Integral Inlet Fitting, add "-700" to the catalog number for the column.

Example: 100mm x 4.6mm ID Ultra C18 column with Trident™ Integral Inlet Fitting: 9174315-700
Nominal additional charge

For guard cartridges for these columns, see page 52.

Ultra Aqueous C18 (USP L1)

Physical Characteristics:

particle size: 3µm or 5µm, spherical
pore size: 100Å
endcap: no
pH range: 2.5 to 7.5
temperature limit: 80°C

Chromatographic Properties:

Highly retentive and selective for reversed phase separations of polar analytes. Highly base deactivated. Compatible with highly aqueous (up to 100%) mobile phases.

Length	1.0mm ID cat.#	2.1mm ID cat.#	3.2mm ID cat.#	4.6mm ID cat.#
3µm Columns				
30mm	9178331	9178332	9178333	9178335
50mm	9178351	9178352	9178353	9178355
100mm	9178311	9178312	9178313	9178315
5µm Columns				
30mm	9178531	9178532	9178533	9178535
50mm	9178551	9178552	9178553	9178555
100mm	9178511	9178512	9178513	9178515
150mm	9178561	9178562	9178563	9178565
250mm	9178571	9178572	9178573	9178575

free literature

HPLC Analysis of Vitamins

lit. cat.# 59181

Analyze Polar Compounds by Reversed Phase HPLC Using Ultra Aqueous C18 Columns

lit. cat.# 59177

Call Restek at 800-356-1688 or 814-353-1300, ext. 5, or contact your Restek representative, to request your free copy!

Ultra IBD
Specialized Columns for Mixed Polar and Nonpolar Compounds

Physical Characteristics:

particle size: 3µm or 5µm, spherical
pore size: 100Å
carbon load: 12%
endcap: no
pH range: 2.5 to 7.5
temperature limit: 80°C

Chromatographic Properties:

An intrinsically base-deactivated (IBD) phase, containing a polar group within, or intrinsic to, the hydrocarbon bonded phase. Unique selectivity and a high level of base deactivation, while reducing or eliminating the need for mobile phase additives.

Length	1.0mm ID cat.#	2.1mm ID cat.#	3.2mm ID cat.#	4.6mm ID cat.#
3µm Columns				
30mm	9175331	9175332	9175333	9175335
50mm	9175351	9175352	9175353	9175355
100mm	9175311	9175312	9175313	9175315
5µm Columns				
30mm	9175531	9175532	9175533	9175535
50mm	9175551	9175552	9175553	9175555
100mm	9175511	9175512	9175513	9175515
150mm	9175561	9175562	9175563	9175565

free literature

Excellent LC/MS Separation of Penicillins and Cephalosporins Using Ultra IBD Columns

lit. cat.# 59133

Analyze Nucleotides, Nucleosides, Purines, and Pyrimidines Simultaneously with the Ultra IBD Column

lit. cat.# 59141

The Ultra IBD Column Allows HPLC Separation of Polar and Non-Polar Analytes from the Same Sample

lit. cat.# 59512

Call Restek at 800-356-1688 or 814-353-1300, ext. 5, or contact your Restek representative, to request your free copy!

To order a 2.1mm, 3.2mm, or 4.6mm ID column with a Trident™ Integral Inlet Fitting, add "-700" to the catalog number for the column.

Example: 100mm x 4.6mm ID Ultra C18 column with Trident™ Integral Inlet Fitting: 9174315-700
Nominal additional charge

Also order the appropriate XG-XF fitting - see page 52.

For guard cartridges for these columns, see page 52.

Ultra Cyano (USP L10)

Physical Characteristics:

particle size: 3µm or 5µm, spherical
pore size: 100Å
carbon load: 8%
endcap: fully endcapped
pH range: 2.5 to 7.5
temperature limit: 80°C

Chromatographic Properties:

High-purity cyano phase with few silanol sites. Often a better choice than C18 phases for basic pharmaceuticals, especially regarding peak shape and selectivity. Cyano phases are more rugged than bare silica for normal phase analyses because they are less sensitive to small amounts of water present in the mobile phase.

Length	1.0mm ID cat.#	2.1mm ID cat.#	3.2mm ID cat.#	4.6mm ID cat.#
3µm Columns				
30mm	9106331	9106332	9106333	9106335
50mm	9106351	9106352	9106353	9106355
100mm	9106311	9106312	9106313	9106315
5µm Columns				
30mm	9106531	9106532	9106533	9106535
50mm	9106551	9106552	9106553	9106555
100mm	9106511	9106512	9106513	9106515
150mm	9106561	9106562	9106563	9106565

Ultra Phenyl (USP L11)

Physical Characteristics:

particle size: 3µm or 5µm, spherical
pore size: 100Å
carbon load: 10%
endcap: fully endcapped
pH range: 2.5 to 7.5
temperature limit: 80°C

Chromatographic Properties:

High-purity, highly retentive, base-deactivated phase with alternative selectivity to straight chain hydrocarbon phases, especially for aromatic analytes.

Length	1.0mm ID cat.#	2.1mm ID cat.#	3.2mm ID cat.#	4.6mm ID cat.#
3µm Columns				
30mm	9105331	9105332	9105333	9105335
50mm	9105351	9105352	9105353	9105355
100mm	9105311	9105312	9105313	9105315
5µm Columns				
30mm	9105531	9105532	9105533	9105535
50mm	9105551	9105552	9105553	9105555
100mm	9105511	9105512	9105513	9105515
150mm	9105561	9105562	9105563	9105565
200mm	9105521	9105522	9105523	9105525
250mm	9105571	9105572	9105573	9105575

Trident™ Direct provides three levels of protection

Trident™ Direct high-pressure filter
Protection against particulate matter.

Trident™ Direct 10mm guard cartridge holder with filter
Protection against particulate matter and moderate protection against irreversibly adsorbed compounds.

Trident™ Direct 20mm guard cartridge holder with filter
Protection against particulate matter and maximum protection gainst irreversibly adsorbed compounds.

Trident™ Direct Guard Column System

Easy to Use, Low Dead Volume—The Ultimate Combination of Convenience and Column Protection

The system offers three levels of protection and guard cartridges in four dimensions, with a variety of bonded phases to match your analytical column. The economical, leak-free cartridge design provides an unprecedented combination of convenience, economy, and reliability. The foundation of the Trident™ Direct system is a reusable direct connect holder that easily attaches to any HPLC column using CPI- or Waters®-style end fittings.* The system is available in configurations to match different protection level needs: in-line filter, in-line filter with holder for 10mm guard cartridge, and in-line filter with holder for 20mm guard cartridge. The guard cartridges are available in 2.1 and 4.0mm ID and are interchangeable within the appropriate length holder.

Description	qty.	cat.#
High-pressure filter	ea.	25082
10mm guard cartridge holder without filter	ea.	25083
10mm guard cartridge holder with filter	ea.	25084
20mm guard cartridge holder without filter	ea.	25085
20mm guard cartridge holder with filter	ea.	25086
Connection tip for Waters®-style end fittings	ea.	25088
PEEK® tip standard fittings	ea.	25087
Replacement cap frits: 4mm, 2.0μm	5-pk.	25022
Replacement cap frits: 4mm, 0.5μm	5-pk.	25023
Replacement cap frits: 2mm, 2.0μm	5-pk.	25057

*The standard PEEK® tip in Trident™ Direct systems is compatible with Parker®, Upchurch®, Valco®, and other CPI-style fittings. To use Trident™ Direct systems with Waters®-style end fittings, replace the tip with cat.# 25088.

10 & 20mm Guard Cartridges

Guard Cartridges	3-pk. (10 x 2.1mm)	3-pk. (10 x 4.0mm)	2-pk. (20 x 2.1mm)	2-pk. (20 x 4.0mm)
Allure™ Basix	916150212	916150210	916150222	916150220
Allure™ C18	916450212	916450210	916450222	916450220
Allure™ PFP Propyl	916950212	916950210	916950222	916950220
Pinnacle™ II Phenyl	921550212	921550210	921550222	921550220
Ultra Aqueous C18	917850212	917850210	917850222	917850220
Ultra C18	917450212	917450210	917450222	917450220
Ultra Cyano	910650212	910650210	910650222	910650220
Ultra IBD	917550212	917550210	917550222	917550220
Ultra Phenyl	910550212	910550210	910550222	910550220

Genuine Restek Replacement Parts for Agilent HPLC Systems

Description	Model #	Similar to Agilent part #	qty.	cat.#
Preventive Maintenance Kit (Includes: rotor seal, needle seat, needle assembly, seat cap)	1050	01078-68721	kit	25259
Autosampler Preventive Maintenance Kit (Includes: rotor seal, needle assembly, needle seat)	1100	G1313-68709	kit	25271
Pump Maintenance Kit (Includes: PTFE frit, outlet cap, active inlet cartridge, gold disk seal, 2 piston seals, glass solvent filter)	1050 & 1100	G1311-68710	kit	25270
Outlet Ball Valve, Binary Pump	1100	G1312-60012	ea.	25267
Outlet Ball Valve	1050 & 1100	G1311-60012	ea.	25276
Sieves for Outlet Valve	1050 & 1100	5063-6505	10-pk.	25266
Check Valve Cartridge Assembly	1090	79835-67101	ea.	25344
Piston Seals, Teflon® w/Graphite	1050 & 1100	5063-6589	2-pk.	22482
Piston Seals, Teflon® w/Graphite	1050 & 1100	5063-6589	10-pk.	22483
Piston Seals (Black)	1090	5062-2494	4-pk.	25347
Seal Wash Kit, Binary Pump (4 seals, 4 gaskets)	1100	—	kit	25268
Seal Wash Kit (2 seals, 2 gaskets)	1100	—	kit	25269
Wash Seal	1050 & 1100	0905-1175	ea.	25277
Sapphire Piston	1050 & 1100	5063-6586	ea.	25273
Sapphire Piston	1090	6980-0672	ea.	25345
Needle Seat	1050	79846-67101	ea.	25258
Needle Seat	1090	79846-67101	ea.	25348
Needle Seat Assembly	1100	G1313-87101	ea.	25265
Needle Assembly	1100	G1313-87201	ea.	25278
Rotor Seal (not for use with 7125 injection valve)	1050	0101-0626	ea.	25272
Rotor Seal	1100	0100-1853	ea.	25275
Rotor Seal (Rheodyne®-style)	1090	0101-0623	ea.	25349
Frits, PTFE	1050 & 1100	01018-22707	5-pk.	25466
Seal, Gold Disk (outlet)	1050 & 1100	5001-3707	ea.	25467
Detector Lamp, 1090 DA, 1050 VW/DA/MWD	1090, 1050	79883-60002	ea.	25260
Lamp, DAD G1315A, G1365A	1100	2140-0590	ea.	25261
Lamp, VWD G1314A	1100	G1314-60100	ea.	25262
8453 Deuterium Lamp	—	2140-0605	ea.	25263
G1321 Fluorescence Detector Flash Lamp	—	2140-0600	ea.	25264
Lamp, DAD Long Life Deuterium (2000 hours)	1100	5181-1530	ea.	25399

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for **more** info

Genuine Restek Replacement Parts for HPLC Systems

lit. cat.# 59012A

Call Restek at 800-356-1688 or 814-353-1300, ext. 5, or contact your Restek representative, to request your free copy!

Genuine Restek Replacement Parts for Thermo Separation HPLC Systems

Description	Model #	Similar to TSP/SP part #	qty.	cat.#
Inlet Check Valve Assembly	SP8800 & P-Series Pumps	A3495-010	ea.	25474
Outlet Check Valve Assembly	SP8800 Series Pumps	A3490-010	ea.	25475
Piston	SP8800 & P-Series Pumps	A3102-010	ea.	25476
Back-up Seal	SP8800 & P-Series Pumps	A2963-010	ea.	25477
Plunger Seal, Gold Superseal	SP8800 & P-Series Pumps	A2962-010	ea.	25478
Check Valve and Transducer Assembly	P-Series Pumps	A3990-010	ea.	25479
Kel-F® Washer	P-Series Pumps	A2973-010	ea.	25480
Rotor Seal Assembly, Rheodyne® 7010	TSP AS100, 300, 1000, 3000, 3500, 8875, and 8880 Autosamplers	7010-039	ea.	25481
Syringe Assembly, 250µL	TSP AS100, 300, 1000, 3000, 3500, 8875, and 8880 Autosamplers	A3588-020	ea.	25482
Syringe, 500µL	TSP AS100, 300, 1000, 3000, 3500, 8875, and 8880 Autosamplers	A3588-010	ea.	25483
Lamp, UV	Linear UV-200, 203, 204, 205, 206, and UV 100, 150, 1000, and 2000 Detectors	9551-0023	ea.	25484

Description	Model #	Similar to TSP part #	qty.	cat.#
Check Valve Cartridge	LDC Constametric Pumps	900946	ea.	25485
Sapphire Plunger	LDC Constametric Pumps	801306	ea.	25486
Plunger Seal Kit, Gold	LDC Constametric Pumps	31-36-00754	ea.	25487
Plunger Seal, Black	LDC Constametric Pumps	206129001	ea.	25488
Plunger Seal, Gold	LDC Constametric Pumps	206156001	ea.	25489
Lamp, Deuterium	LDC SM-I, II, III, 3000, 3100, 3100X, and 4000 Detectors	108035	ea.	25490
Lamp, Deuterium Pre-aligned	LDC 3200 and 4100 Detectors	900918001	ea.	25491

did you **know**?

We also offer Genuine Restek Replacement Parts for Beckman, Hitachi, PerkinElmer, and Shimadzu systems. Please refer to our current catalog - or visit our website.

Genuine Restek Replacement Parts for Waters HPLC Systems

Description	Model #	Similar to Waters part #	qty.	cat.#
Preventative Maintenance Kit Includes: sparge diffuser, filter insert, compression screws, SS ferrule, battery for 2690/717, 250µL WISP™ syringe, seal wash plunger seal kits (2), wash tube seal kits (4), 2690 seal pack rebuild kit (steel bodies not included), 2690 head plunger seal kits (2), solvent reservoir 20µm filters (4), Alliance® check valve cartridges (2), Alliance® plunger assemblies (2), 2690 face seals (4)	Alliance® 2690, 2695	WAT270944	kit	25143
Preventative Maintenance Kit Includes: PerformancePLUS™ cartridges (2), sparge diffusers (4), Super Seals™ (2), solvent reservoir 20µm filters (2), sapphire plungers (2), reference valve rebuild kit, inlet manifold kit	600 Pump	WAT052675	kit	25144
Preventative Maintenance Kit Includes: 717 seal pack with needle, filter insert, 250µL WISP™ syringe	717 Autosampler	WAT052669	kit	25145
Preventative Maintenance Kit Includes: 616/326/625 plunger assemblies (2), pump seal kit, sparge diffusers (4), solvent reservoir 20µm filters (4), 616 cartridge assemblies (4)	616 Pump	WAT052672	kit	25146
Inlet Check Valve Assembly	M6KA, 501, 510, 515, 590, 600E	33679, 25214	ea.	25360
Inlet Check Valve Housing	M6KA, 501, 510, 515, 590, 600E	25203	ea.	25361
Inlet Check Valve Rebuild Kit	M6KA, 501, 510, 515, 590, 600E	60495	2-pk.	25362
Outlet Check Valve Assembly (Actuator Style)	M6KA, 501, 510, 515, 590, 600E	25030	ea.	25363
Outlet Check Valve Housing (Actuator Style)	M6KA, 501, 510, 515, 590, 600E	25212	ea.	25364
Outlet Check Valve Rebuild Kit (Actuator Style)	M6KA, 501, 510, 515, 590, 600E	26016	2-pk.	25365
Outlet Check Valve Assembly (Ball & Seat Style)	M6KA, 501, 510, 515, 590, 600E	25216	ea.	25366
Outlet Check Valve Housing (Ball & Seat Style)	M6KA, 501, 510, 515, 590, 600E	25207	ea.	25367
Outlet Check Valve Rebuild Kit (Ball & Seat Style)	M6KA, 501, 510, 515, 590, 600E	26014	2-pk.	25368
Inlet Check Valve Assembly, 225µL (Extended Flow)	M6KA, 501, 510, 515, 590, 600E	60307	ea.	25369
PerformancePLUS™ Check Valve Cartridge	M6KA, 501, 510, 515, 590, 600E	700000254	2-pk.	25370
Check Valve Rebuild Kit (Extended Flow)	M6KA, 501, 510, 515, 590, 600E	88223	2-pk.	25371
PerformancePLUS™ Check Valve Housing	M6KA, 501, 510, 515, 590, 600E	—	ea.	25372
Check Valve Cartridges	Alliance®	WAT270941	2-pk.	25373
Super Seal™ for Analytical Heads	M6KA, 501, 510, 515, 590, 600E	22946, 22934	ea.	25374
Plunger Seal, Gold for Analytical Heads*	M6KA, 501, 510, 515, 590, 600E	22934	ea.	25375
Plunger Seal, Black for graphite-filled Teflon®	M6KA, 501, 510, 515, 590, 600E	26613	ea.	25378
Plunger Seal, Black for EF Heads	510, 590, 600E	26644	ea.	25379
Plunger Seal, Gold for EF Heads	510, 590, 600E	26644	ea.	25380
Seal Wash Plunger Seal	Alliance®	WAT271018	2-pk.	25386
Head Plunger Seal Kit	Alliance®	WAT270938	2-pk.	25387
Head Plunger Seal Kit (Black)	Alliance®	WAT271066	2-pk.	25388
Insert Seal Parts Kit	M6KA, 501, 510, 515, 590, 600E	60012	kit	25389
Sapphire Plunger	M6KA, 510, 590, 600	25656	ea.	25381
Sapphire Plunger (Extended Flow)	510, 590, 600E	60304	ea.	25382
Sapphire Plunger	M45, M501	26524	ea.	25383
Sapphire Plunger	M515	WAT207069	ea.	25384
Sapphire Plunger	616, 625, 626	31788	ea.	25420
Sapphire Plunger	Alliance®	WAT270959	ea.	25385
Single Solvent Inlet Manifold	600E	60034, 60042	ea.	25390
Pressure Transducer	M6KA, 501, 510, 515, 590, 600E	60328	ea.	25391
Draw-Off Tube Assembly	M6KA, 501, 510, 515, 590, 600E	25470	ea.	25392
1/16" Stainless Steel TEE	M6KA, 501, 510, 515, 590, 600E	75215	ea.	25411
Inlet Manifold Kit	M45, 501, 510, 590, 600E	60448	kit	25412
Ferrule, Stainless Steel	515	22330	ea.	25417
Gradient Proportioning Valve, 9Volt	600E	34423	ea.	25418
Gradient Proportioning Valve, 12Volt	600E	62037	ea.	25419
Wash Face Seal	Alliance® 2690	WAT271017	ea.	25428
Wash Tube Seal Kit	Alliance® 2690	WAT270940	4-pk.	25429
Proportioning Valve	Alliance® 2690	WAT270927	ea.	25430

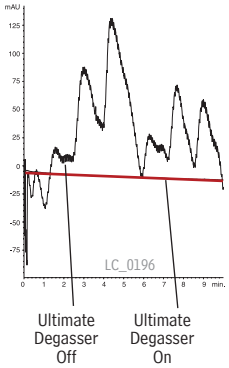
*Ultra-high molecular weight polyethylene (UHMWPE).

Mobile Phase Degasser

Dissolved oxygen can cause flow rate instability and increased baseline noise. Also, it has a quenching effect on fluorescence detection and increases the background of UV detectors. Dissolved gases can out-gas in the HPLC system, forming bubbles in check valves, at connections, or in detector flow cells.

In-line vacuum degassing is more effective at removing dissolved gas from mobile phases than sonication or helium sparging. Most in-line degassers withdraw gas across a gas-permeable PTFE tubing membrane, but the Degasys Ultimate Degasser uses tubing composed of an amorphous fluoropolymer that is 200 to 300 times more gas permeable than PTFE. This translates into the ability to use shorter tubing for removing dissolved gas. This new material also has better tubular burst strength than PTFE. To prevent cross contamination, each channel on this Degasys unit is individually encased within its own vacuum chamber.

Degasys Ultimate Degasser provides highly stable baselines



Mobile Phase: water:methanol 50:50
Flow: 1.0 mL/min.
Det.: UV @ 210nm

Specifications:

Residual Oxygen[1]	Pressure Loss[1]	Internal Volume	Wetted Parts	Max Flow Rate
0.9ppm	0.24psi	500µL	Teflon® AF	7mL/min./channel
			PTFE	
			ETFE	
			PPS	

[1] At a flow rate of 1mL/min.

Description	qty.	cat.#
110V Mobile Phase Degasser (4 Channel, 7mL/min./channel)	ea.	25189
220V Mobile Phase Degasser (4 Channel, 7mL/min./channel)	ea.	25194

Not recommended for use with fluorinated mobile phases, including mobile phases containing TFA.

Solvent Debubbler

Bubbles in an HPLC system can cause check valve malfunctions and pump cavitation, seriously affecting pump performance. The debubbler removes bubbles from the fluid stream before it enters the pump. The gas/liquid interface is easily visible through the translucent wall of the device. Loosening the airtight cap releases the trapped gas. The debubbler is fitted with a bracket and universal connecting tips.

Description	qty.	cat.#
Solvent Debubbler with Bracket	ea.	25014

Sidewinder™ Column Heater

- Easy to set up!
- Operation range: 5°C above ambient to 85°C, ±1°C.
- Lightweight, compact design fits in small spaces.
- Column holder can be placed in any orientation.

This unique design completely encloses any HPLC analytical column up to 25cm in length. Two lengths of heater jackets are available: the short column holder accommodates columns up to 10cm in length, while the long column holder holds columns up to 25cm in length. The control module provides optimum heating performance, accuracy to within 1°C, and stability to within 0.1°C. The new Sidewinder™ controller has fast 10Hz sampling for improved responsiveness. Power requirements: 24V control unit for maximum stability; RS232 control allows external programming.

Description	qty.	cat.#
Temperature Control Module and Long Column Holder, 25cm Holder	ea.	26516
Temperature Control Module and Short Column Holder, 10cm Holder	ea.	26517

Sidewinder™ Heater/Cooler Temperature Control Module

- Operation range: 5 - 55°C, ±0.2°C.
- Ability to program multiple temperature points.
- Accommodates columns up to 30cm in length and 7.8mm ID.
- Compact design.

The Sidewinder™ heater/cooler unit has a doubly insulated cover to maintain the programmed temperature to within 0.2°C. The 24V control unit provides maximum stability and rapid equilibration times; RS232 control allows external programming.

Description	qty.	cat.#
Sidewinder™ Heater/Cooler Temperature Control Module	ea.	26518

All Sidewinder™ temperature control products carry the value recognized CE mark. Each unit meets the demanding electromagnetic emission standards of the new European Union Directives, United States standards, and Canadian standards.

High-Pressure Frit-Type In-Line Filters

Restek's high-pressure in-line filter is a stand-alone version of the Trident™ column protection system. The filter is specifically designed for ease of use, low dead-volume, and flexibility. The filter has a replaceable, PEEK® encapsulated 316 stainless steel frit with a surface area of 12mm². The standard frit shipped with the filter has a 2.0µm porosity; however, it may be replaced with an optional 0.5µm porosity frit. Use of this filter can greatly extend column life, thereby reducing costs and saving maintenance time. Tubing OD 1/16"; Connectors–CPI

Description	Porosity	qty.	cat.#
Frit-Type In-Line Filter	2.0µm	ea.	25041
Replacement cap frits: 4mm	0.5µm	5-pk.	25023
Replacement cap frits: 4mm	2.0µm	5-pk.	25022

High-Pressure Cup-Type In-Line Filters

High-pressure cup-type filters can be used in fluid streams operating to 15,000psi. The cup-shaped filter elements have a large (2.5 cm²) surface area to give long operating lifetime. Mounted in screw-type adapters, they are easily removed for cleaning. Normally, backflushing and cleaning in an ultrasonic bath with an appropriate solvent will restore them. If they become permanently clogged, replacement elements are available.

Housings and all wetted parts are type 316 stainless steel. Filters are packaged with appropriate gland nuts and ferrules. A bulkhead type is available for thru-panel mounting. Tubing OD 1/16"; Connectors–CPI

Description	Porosity	qty.	cat.#
Cup-Type In-Line Filter	0.5µm	ea.	25000
Cup-Type In-Line Filter	2.0µm	ea.	25001
Replacement Filter Elements & Seals	0.5µm	2-pk.	25002
Replacement Filter Elements & Seals	2.0µm	2-pk.	25003

Low-Pressure Slip-On Inlet Filter for Mobile Phase Reservoir

A type 316 stainless steel tip with a Tefzel® collar seals to a corrosion-resistant type 316 stainless steel filter element. The slip-on filter easily attaches to the pump inlet line, without the use of wrenches. The universal tip accommodates standard Teflon® tubing inner diameters. The cylindrical filter is standard 10µm porosity. 1/8" OD (fits Altex, ISCO, LDC, Varian, Waters, PerkinElmer, and other pumps)

Description	qty.	cat.#
Slip-on Inlet Filter	ea.	25008

Low-Pressure CPI Inlet Filter for Mobile Phase Reservoir

A type 316 stainless steel knurled cap and Tefzel® CPI ferrule seals to 1/8" OD Teflon® tubing when finger-tightened onto the precision-machined filter holder. The filter element is replaceable. Standard 10µm porosity protects delicate pump components from particles but introduces very little pressure drop. 1/8" OD. May be used as a helium sparging diffuser.

Description	qty.	cat.#
CPI Inlet Filter	ea.	25009
Replacement Elements: 10µm filter	2-pk.	25010

Mobile Phase Spargers and Filters

These helium spargers offer an inexpensive way to prepare and maintain mobile phases free of dissolved gas. They are made from 316 stainless steel and PEEK® and are compatible with most solvents.

Description	qty.	cat.#
Sparge Filter: 2µm	ea.	25311
Inlet Filter: 10µm	ea.	25312
Inlet Filter: 20µm	ea.	25313

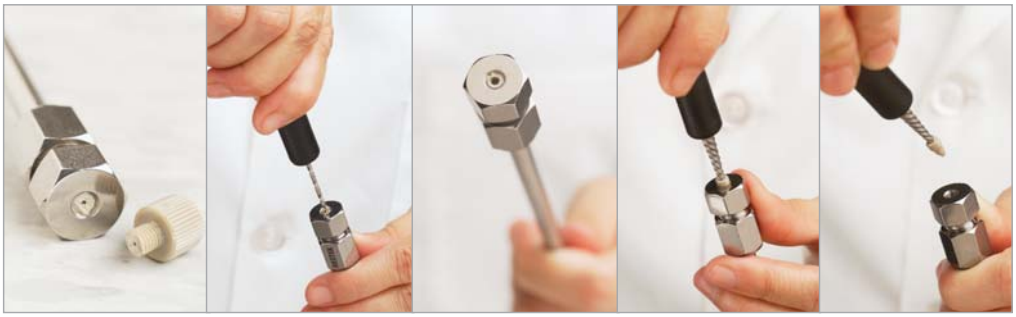
pinnacle™ II **hplc** columns

Developed using Restek silica. We strictly control the quality of raw material, phase bonding, and column packing. You'll be impressed with our column-to-column reproducibility!

For more information and applications, request the Pinnacle™ II Column flyer. (lit. cat. #59281)

PEEK® Fitting Extractor

Drill into the broken fitting, then screw the extractor into the fitting and remove it easily.



Description	qty.	cat.#
PEEK® Fitting Extractor	ea.	25325

PEEK® Union Connector

Allows you to quickly and reliably connect two pieces of 1/16-inch tubing. 0.3mm union bore. End fittings included.

Description	qty.	cat.#
PEEK® Union Connector 1/16"	2-pk.	25323

Zero-Dead-Volume Internal Union

Restek is pleased to offer a selected line of Valco® fittings for connecting fused silica or 1/16- or 1/8-inch metal tubing. For over 30 years, Valco® Instrument Co. has been the leading designer and manufacturer of valves and fittings for precision analytical instrumentation. Valco® fittings have been designed for the specific demands of instrumentation and manufactured with the tight tolerances and premium quality that analysts require. If you don't see the Valco® fitting you need, please request special ordering information.

Ends of tubing seat squarely at bottoms of fitting details. 300 series stainless steel. For 1/16-inch OD tubing. Stainless steel ferrules included.

Description	Union Bore	Valco® #	qty.	cat.#
Internal Union	0.15mm	ZU1XC	ea.	20147
Internal Union	0.25mm	ZU1C	ea.	20148
Internal Union	0.75mm	ZU1	ea.	20149
Internal Union	1/16"	ZU1T	ea.	20150

Universal 10-32 PEEK® Column Connectors and Plugs

Universal PEEK® Connectors allow easy installation of all 1/16-inch tubing, including stainless steel.

Description	qty.	cat.#
PEEK® Column Connector (beige, round body)	10-pk.	25015
PEEK® Column Plug (black)	10-pk.	25016
PEEK® Fingertight Fittings (blue, flat-sided)	10-pk.	25324

Rheodyne® Style Nut and Ferrule

Replacement long nut for connecting stainless steel tubing to a Rheodyne® 6-port valve or other Rheodyne® part.

Description	qty.	cat.#
1/16" Rheodyne® Style Nut	10-pk.	25095
1/16" Rheodyne® Style Ferrule	10-pk.	25096

Crimp-Top Vials, Snap Seal™ Style (12 x 32mm, 11mm Crimp)

Description	100-pk.	1000-pk.
2.0mL Clear Glass Vial w/White Graduated Marking Spot*	24383	24384
2.0mL Amber Glass Vial w/White Graduated Marking Spot*	24385	24386
2.0mL Clear Glass Vial without Graduated Marking Spot	21152	21153

11mm Aluminum Crimp Seals with Septa

Description	100-pk.	500-pk.	1000-pk.
Silver Seal, PTFE/Natural Rubber Septum	21174	—	21175
Blue Seal, PTFE/Natural Rubber Septum	24351	—	24352
Green Seal, PTFE/Natural Rubber Septum	24353	—	24354
Red Seal, PTFE/Natural Rubber Septum	24355	—	24356
Yellow Seal, PTFE/Natural Rubber Septum	24357	—	24358
Mixed Colors, PTFE/Natural Rubber Septum	—	21724	—
Silver Seal, PTFE/Silicone Septum	24359	—	24360
Blue Seal, PTFE/Silicone Septum	24361	—	24362
Green Seal, PTFE/Silicone Septum	24363	—	24364
Red Seal, PTFE/Silicone Septum	24365	—	24366
Yellow Seal, PTFE/Silicone Septum	24367	—	24368
Mixed Colors, PTFE/Silicone Septum	—	21725	—
Silver Seal, PTFE/Silicone/PTFE Septum**	24369	—	24370

Convenience Kits: Vials, Caps, & Septa

Vials packaged in a clear-lid tray. Caps with septa packaged in a plastic bag.

Description	100-pk.	1000-pk.
2.0mL Clear Vial, **deactivated**, PTFE/Natural Rubber Seal†	24671	24672
2.0mL Amber Vial, **deactivated**, PTFE/Natural Rubber Seal†	24673	24674
2.0mL Clear Vial, untreated, PTFE/Natural Rubber Seal	21196	21197
2.0mL Amber Vial, untreated, PTFE/Natural Rubber Seal	21198	21199
2.0mL Clear Vial, untreated, PTFE/Silicone Seal	24646	24647
2.0mL Amber Vial, untreated, PTFE/Silicone Seal	24648	24649

Glass, Flat Bottom Insert w/ID Ring

Glass, Limited Volume Insert with Bottom Spring

Limited Volume Inserts for 2mL Crimp-Top & Short-Cap, Screw-Thread Vials

Description	100-pk.	1000-pk.
50µL Glass, Polypropylene, Bottom Spring	24513	21782
250µL Glass, Big Mouth Insert w/ Bottom Spring	21776	21777
250µL Glass, Big Mouth Insert w/ Glass Flange (Step™ design)‡‡	24516	21779
350µL Glass, Flat Bottom Insert	21780	24517
350µL Glass, Flat Bottom Insert w/ ID Ring	24692	24693
250µL Polypropylene, Bottom Spring	24518	—
250µL Polypropylene, Top Flange	24519	—
250µL Polypropylene, No Spring	24520	—

6.0mL Headspace Vial with PTFE/Silicone Seal

Headspace Autosampler Vials*

Description	100-pk.	1000-pk.
a) 6mL Clear Vial	21166	21167
b) 10mL Clear Vial, Flat Bottom	24683	24684
c) 10mL Clear Vial, Rounded Bottom	21164	21165
d) 20mL Clear Vial, Flat Bottom	24685	24686
e) 20mL Clear Vial, Rounded Bottom	21162	21163
f) 27mL Clear Vial	21160	21161

Silver Seal with PTFE/Gray Butyl Rubber Septum

20mm Aluminum Seals w/Septa, Assembled

Description	100-pk.	1000-pk.
Silver Seal w/ PTFE/Gray Butyl Rubber	21761	21762
Silver Seal w/ PTFE/Silicone	21763	21764
Pressure Release Silver Seal w/ PTFE/Gray Butyl Rubber Septum <125°C	21765	21766
Pressure Release Silver Seal w/ PTFE/Silicone Septum >125°C	21767	21768

*Colored marking spots available on request in blue, green, rust, or yellow (1000 packs only).
**Individual colored seals available on request.
†Silcote™ CL7 deactivation.
‡Not to be used with 9mm screw-thread vials.

Standard Micro-Liter Syringes for Agilent 7673, 7683, and 6850 Autosamplers

- Hamilton and SGE syringes are designed and tested to meet critical autosampler performance.
- SGE manufactures autosampler syringes for every major GC instrument company.
- Needle point styles are designed to withstand multiple, fast injections through a septum.

Hamilton Syringes

Volume	Needle Term.	Needle Gauge	Needle Length	Point Style	Hamilton Model	Hamilton cat.#	qty.	Restek cat.#
5µL	ASN	23s	1.71"	Agilent	75	87990	6-pk.	20170
5µL	ASN	26s	1.71"	Agilent	75	87989	6-pk.	21230
5µL	ASN	23s–26s	1.71"	Agilent	75	87994	6-pk.	24594
10µL	ASN	23s	1.71"	Agilent	701	80390*	6-pk.	20169
10µL	ASN	26s	1.71"	Agilent	701	80389	6-pk.	24599
10µL	ASN	23s–26s	1.71"	Agilent	701	80391	6-pk.	24600

SGE Syringes

Volume	Needle Term.	Needle Gauge	Needle Length	Point Style	SGE Model	SGE cat.#	qty.	Restek cat.#
5µL	F	23	42mm	Cone	SK-5F-HP-0.63	001814	6-pk.	24783
5µL	F	26	42mm	Cone	SK-5F-HP-0.47	001804	6-pk.	24782
5µL	F	23-26s	42mm	Cone	SK-5F-HP-0.63/0.47	001822	6-pk.	21214
10µL	F	23	42mm	Cone	SK-10F-HP-0.63	002814	6-pk.	24787
10µL	F	26	42mm	Cone	SK-10F-HP-0.47	002804	6-pk.	24786
10µL	F	23–26s	42mm	Cone	SK-10F-HP-0.63/0.47	002822	6-pk.	21215

*Designated by Agilent as #80397.

23s—Single Gauge Needle
- Most popular gauge for Agilent 7673.
- Best for Merlin Microseal® septum and standard septum-equipped GCs.
- For packed column injection ports.
- For split/splitless injection ports.

26s—Single Gauge Needle
- For on-column injection ports.
- For split/splitless injection ports.

23s-26s—Dual Gauge (tapered)
- Durability of a 23s gauge needle.
- Ability of a 26s gauge needle to perform split/splitless and on-column injections.

Guide to Needle Termination Codes

Hamilton:
(ASN) Autosampler Cemented Needle

SGE:
(F) Fixed Needle

Syringes for Agilent 1090 & 1100 LC Autosamplers

25µL, 1/4-32 UNEF Thread

SGE Syringes

Volume	SGE Model	SGE cat.#	qty.	Restek cat.#
25µL	25D-HP1090-GT	003670	ea.	22290
250µL	250D-HP1090-GT	006670	ea.	22291

ordering note

Hamilton and SGE syringes are in stock and available for same-day shipment.

Syringes for Waters WISP® LC Autosamplers

250µL, 1/4-28 UNF Thread

SGE Syringes

Volume	SGE Model	SGE cat.#	qty.	Restek cat.#
25µL	25D-WISP	003990	ea.	22293
250µL	250D-WISP	006690	ea.	22294

Sample Preparation

All cartridges are polypropylene and have polyethylene frits unless otherwise noted.

Resprep™ SPE Cartridges: Normal Phase

Hydrophilic (polar) adsorbents used to extract hydrophilic analytes from nonpolar matrices, such as organic solvents (e.g., polar contaminants from sample extracts).

	3mL/200mg (50-pk.)	3mL/500mg (50-pk.)	6mL/500mg (30-pk.)	6mL/1000mg (30-pk.)
Florisil®	—	24031	—	24034
(EPA SW 846 methods and CLP protocols)	—	24032*	26086**	26085**
Silica (EPA SW 846 methods)	—	24035	—	24038
	—	24036*	—	—
Cyanopropyl (endcapped)	26048	26049	—	—

*Teflon® frits

**Glass tubes with Teflon® frits

Strong Anion Exchange (SAX)
Strong Cation Exchange (SCX)
Weak Anion Exchange (WAX)
Weak Cation Exchange (WCX)

Resprep™ SPE Cartridges: Ion Exchange Phases

Ionized adsorbents used to extract positively- or negatively-charged analytes from aqueous matrices (e.g., tricyclic antidepressants from plasma).

	1mL/100mg (100-pk.)	3mL/200mg (50-pk.)	3mL/500mg (50-pk.)	6mL/500mg (30-pk.)	6mL/1000mg (30-pk.)
SAX, quaternary amine	26054	—	26055	—	—
SCX, propyl	26056	—	26057	—	—
SCX, benzene	—	26058	—	26059	26060
WAX, amino, primary amine	26050	26051	26052	26053	—
WCX, carboxylic acid	26061	—	26062	—	—

Syringe Filters

- Nylon - PTFE - PVDF membranes.
- 13mm or 25mm diameter.
- 0.22µm or 0.45µm porosity.
- Color coded for easy identification.
- 100 filters, reusable storage container.

Excellent syringe filters—great prices!

	Size	Porosity	qty.	cat.#
Nylon	13mm	0.22µm	100-pk.	26146
	13mm	0.45µm	100-pk.	26147
	25mm	0.22µm	100-pk.	26148
	25mm	0.45µm	100-pk.	26149
PTFE (polytetrafluoroethylene)	13mm	0.22µm	100-pk.	26142
	13mm	0.45µm	100-pk.	26143
	25mm	0.22µm	100-pk.	26144
	25mm	0.45µm	100-pk.	26145
PVDF (polyvinyldifluoride)	13mm	0.22µm	100-pk.	26150
	13mm	0.45µm	100-pk.	26151
	25mm	0.22µm	100-pk.	26152
	25mm	0.45µm	100-pk.	26153

Resprep™ SPE Cartridges: Bonded Reversed Phases

Hydrophobic (nonpolar) adsorbents, used to extract hydrophobic analytes from polar matrices (e.g., pesticides from water).

	1mL 100mg (100-pk)	3mL 200mg (50-pk.)	3mL 500mg (50-pk.)	6mL 500mg (30-pk.)	6mL 1000mg (30-pk.)	20mL 5g (20-pk.)	60mL 10g (16-pk.)
C18 (high load, endcapped)	26030	26031	24050	24052	24051	26034	26035
C8 (high load, endcapped)	26036	26037	26038	26039	26040	—	—
C2 (endcapped)	26041	26042	—	—	—	—	—
Cyclohexyl (endcapped)	—	—	—	—	26043	—	—

Specialty SPE Cartridges

These cartridges have been specifically designed to provide consistent and reproducible results for the method stated.

Description	Applications	Tube Volume, Bed Weight	qty.	cat.#
Drug Prep I	Acidic, basic, and/or neutral drugs. Mixed-mode hydrophobic and ion exchange sites provide selective, reproducible extraction of biological samples containing therapeutic or illegal drugs.	3mL, 200mg	50-pk.	26044
		10mL, 200mg	50-pk.	26045
Drug Prep II	Extraction of THCA from biological samples. Copolymeric anion exchange sites provide selective, reproducible extraction of THCA from urine.	3mL, 200mg	50-pk.	26046
		10mL, 200mg	50-pk.	26047

Exempted Drug of Abuse Reference Materials

1,000µg/mL in P&T methanol (*except where noted), 1mL/ampul

Compound	Individual cat.#
Benzodiazepines	
alprazolam	34042
bromazepam	34043
chlordiazepoxide	34044
clobazam	34045
clonazepam	34046
diazepam	34047
flunitrazepam	34049
flurazepam	34050
lorazepam	34051
nitrazepam	34053
oxazepam	34054
prazepam	34055
temazepam	34056
triazolam	34057
Cocaine & Metabolites	
cocaine	34015
benzoylecgonine	34016
ecgonine	34017
ecgonine methyl ester	34018
Methadone & Metabolites	
methadone	34005
Amphetamines & Metabolites	
d-amphetamine	34020
(+)methamphetamine	34021
Opiates & Metabolites	
codeine	34000
hydrocodone	34002
hydromorphone	34063
morphine	34006
oxycodone	34007
oxymorphone	34065
Cannabinoid & Metabolites	
cannabidiol	34011
cannabinol	34010
Barbiturates	
amobarbital	34028
aprobarbital	34029
barbital	34030
butabarbital	34031
butalbital	34032
DL-glutethimide	34058
hexobarbital	34033
mephobarbital	34034
methohexital	34035
pentobarbital	34036
phenobarbital	34037
secobarbital	34038
talbutal	34039
thiamylal	34040
thiopental	34041
Other	
benzphetamine	34022
cocaethylene*	34066
fenfluramine	34023
levorphanol	34003
meperidine	34004
meprobamate	34059
methaqualone	34064
methyprylon	34060
pentazocine	34062
phencyclidine	34027
phendimetrazine	34025
phenmetrazine	34026
phentermine	34024
dextro-propoxyphene	34008
thebaine	34009

*1,000µg/mL in acetonitrile.
No datapacks available.

Single-Component Explosives Solutions

These materials support nitroaromatic, nitramine, and nitroester analyses by GC-ECD (Method 8095[1,2]. Compounds listed are explosives, manufacturing intermediates or degradation products. Method 8095 includes Method 8330 target compounds, plus 3,5-dinitroaniline, nitroglycerin, and pentaerythritol tetranitrate (PETN). Method 8095 mixtures contain the additional components at concentration ratios appropriate for ECD.

Compound Packaged 1mL/ampul	CAS#	Solvent Code	Solvent Concentration	Individual cat.#
2-amino-4,6-dinitrotoluene	35572-78-2	ACN	1,000	31670
4-amino-2,6-dinitrotoluene	19406-51-0	ACN	1,000	31671
3,5-dinitroaniline	618-87-1	ACN	1,000	31661
1,3-dinitrobenzene	99-65-0	ACN	1,000	31662
2,4-dinitrotoluene	121-14-2	ACN	1,000	31663
2,6-dinitrotoluene	606-20-2	ACN	1,000	31664
EGDN	628-96-6	M	1,000	31601
HMX	2691-41-0	ACN	1,000	31665
nitrobenzene	99-95-3	ACN	1,000	31657
nitroglycerin	55-63-0	M	1,000	31498
nitroguanidine	556-88-7	M	1,000	31602
2-nitrotoluene	88-72-2	ACN	1,000	31659
3-nitrotoluene	99-08-1	ACN	1,000	31660
4-nitrotoluene	99-99-0	ACN	1,000	31658
PETN	78-11-5	M	1,000	31600
picric acid	88-89-1	M	1,000	31499
propylene glycol dinitrate (PGDN)	6423-43-4	M	1,000	31821
RDX	121-84-4	ACN	1,000	31666
tetryl	479-45-8	ACN	1,000	31667
1,3,5-trinitrobenzene	99-35-4	ACN	1,000	31668
2,4,6-trinitrotoluene	118-96-7	ACN	1,000	31669

ACN=acetonitrile
M = methanol

References (Not available from Restek.)

[1]US Environmental Protection Agency. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.* SW-846, Proposed Draft Update IVB, Office of Solid Waste, Washington, DC, 1999.
[2]M. E. Walsh, T. Ranney, J. Chromatogr. Sci., Vol. 36, pp. 406-416, August 1998.

CLINICAL/FORENSICS

free data packs

Restek offers free downloadable data packs for analytical reference material products.
Just visit our website at **www.restek.com/datapacks**. Enter the catalog number and lot number for the product you ordered and obtain a printable pdf file.

Single Source Weathered Petrochemical Standards

These solutions are prepared from a single source (one refinery) product. The weathered materials indicate the percent weight loss from the original material. Samples of regular and premium grade unleaded gasoline were collected, then blended in equal volumes.

There are four general types of mineral spirits, classified according to boiling point range (BPR):

- Type I (Stoddard solvent) BPR 149–182°C
- Type II (high flash point) BPR 177–196°C
- Type III (odorless) BPR 149–196°C
- Type IV (low dry point) BPR 149–174°C

The mineral spirit solutions listed below were prepared from an equal volume blend of Type I, II, and III mineral spirits.

Compound	cat.# (ea.)
5,000µg/mL in P&T methanol, 1mL/ampul	
unleaded gasoline: unweathered	30096
unleaded gasoline: 25% weathered	30097
unleaded gasoline: 50% weathered	30098
unleaded gasoline: 75% weathered	30099
unleaded gasoline: 99% weathered	30436
5,000µg/mL in methylene chloride, 1mL/ampul	
kerosene: unweathered	31229
kerosene: 25% weathered	31230
kerosene: 50% weathered	31231
kerosene: 75% weathered	31232
5,000µg/mL in methylene chloride, 1mL/ampul	
diesel fuel #2: unweathered	31233
diesel fuel #2: 25% weathered	31234
diesel fuel #2: 50% weathered	31235
diesel fuel #2: 75% weathered	31236
5,000µg/mL in methylene chloride, 1mL/ampul	
mineral spirits: unweathered	31225
mineral spirits: 25% weathered	31226
mineral spirits: 50% weathered	31227
mineral spirits: 75% weathered	31228
50,000µg/mL in methylene chloride, 1mL/ampul	
mineral spirits: unweathered	31260
mineral spirits: unweathered (5mL/ampul)	31261

please note

We can custom prepare weathered accelerants for fire debris analysis.

Please complete the custom reference material request form on **page 64, or online.**

We'll be glad to work with you!

Stoddard Solvent Standard

10,000µg/mL in P&T methanol, 1mL/ampul
cat. # 30487 (ea.)

Weathered Gasoline Kit

kit

30096: Unleaded Gasoline Standard
30097: Unleaded Gas Standard: 25% Weathered
30098: Unleaded Gas Standard: 50% Weathered
30099: Unleaded Gas Standard: 75% Weathered

Contains 1mL each of these mixtures.
cat. # 30100 (kit)

Weathered Gasoline Kit #2

kit

30096: Unleaded Gasoline Standard
30097: Unleaded Gas Standard: 25% Weathered
30098: Unleaded Gas Standard: 50% Weathered
30099: Unleaded Gas Standard: 75% Weathered
30436: Unleaded Gas Standard: 99% Weathered

Contains 1mL each of these mixtures.
cat. # 30437 (kit)

Weathered Kerosene Kit

kit

31229: Kerosene Standard
31230: Kerosene Standard: 25% Weathered
31231: Kerosene Standard: 50% Weathered
31232: Kerosene Standard: 75% Weathered

Contains 1mL each of these mixtures.
cat. # 31238 (kit)

Weathered Diesel Fuel #2 Kit

kit

31233: Diesel Fuel #2 Standard
31234: Diesel Fuel #2 Standard: 25% Weathered
31235: Diesel Fuel #2 Standard: 50% Weathered
31236: Diesel Fuel #2 Standard: 75% Weathered

Contains 1mL each of these mixtures.
cat. # 31239 (kit)

Weathered Mineral Spirits Kit

kit

31225: Mineral Spirits Standard
31226: Mineral Spirits Standard: 25% Weathered
31227: Mineral Spirits Standard: 50% Weathered
31228: Mineral Spirits Standard: 75% Weathered

Contains 1mL each of these mixtures.
cat. # 31237 (kit)

ASTM E1387-95 and E1618-97 Fire Debris Analysis

These materials also can be used for underground storage tank monitoring.

E1387-95 Column Resolution Check Mix

(13 components)

n-hexane (C6)
n-octane (C8)
n-decane (C10)
n-dodecane (C12)
n-tetradecane (C14)
n-hexadecane (C16)
n-octadecane (C18)
n-eicosane (C20)
2-ethyltoluene
3-ethyltoluene
toluene
1,2,4-trimethylbenzene
p-xylene

2,000µg/mL each in methylene chloride, 1mL/ampul
cat. # 31224 (ea.)

E1618-97 Test Mix (13 components)

Components in this mix (0.5µL/mL or 0.05% volume/volume each) are at 10X the concentration of the final test solution specified in ASTM 1618 and ASTM 1387.

n-hexane (C6)
n-octane (C8)
n-decane (C10)
n-dodecane (C12)
n-tetradecane (C14)
n-hexadecane (C16)
n-octadecane (C18)
n-eicosane (C20)
2-ethyltoluene
3-ethyltoluene
toluene
1,2,4-trimethylbenzene
p-xylene

0.05% volume/volume each in methylene chloride, 1mL/ampul
cat. # 31613 (ea.)

Glycols Standard

ethylene glycol
propylene glycol

50,000µg/mL each in DI water, 1mL/ampul
cat. # 30471 (ea.)

Blood Alcohol Standards

We have developed eleven calibration mixtures for performing multi-point instrument calibrations so that laboratories can construct calibration curves. The data pack includes a Certificate of Analysis, raw material testing results, statistical QA results, analytical balance printout, and gravimetric weight of each analyte. Ethanol in these mixes is National Institute of Standards and Technology (NIST)-traceable.

Compound	qty.	cat.#
0.015g/dL forensic ethanol solution		
1mL/ampul	5-pk.	36232
1mL/ampul	10-pk.	36332
5mL/ampul	ea.	36240
20mL/ampul	ea.	36248
0.02g/dL forensic ethanol solution		
1mL/ampul	5-pk.	36233
1mL/ampul	10-pk.	36333
5mL/ampul	ea.	36241
20mL/ampul	ea.	36249
0.025g/dL forensic ethanol solution		
1mL/ampul	5-pk.	36234
1mL/ampul	10-pk.	36334
5mL/ampul	ea.	36242
20mL/ampul	ea.	36250
0.04g/dL forensic ethanol solution		
1mL/ampul	5-pk.	36235
1mL/ampul	10-pk.	36335
5mL/ampul	ea.	36243
20mL/ampul	ea.	36251
0.05g/dL forensic ethanol solution		
1mL/ampul	5-pk.	36257
1mL/ampul	10-pk.	36259
5mL/ampul	ea.	36258
20mL/ampul	ea.	36260
0.08g/dL forensic ethanol solution		
1mL/ampul	5-pk.	36262
1mL/ampul	10-pk.	36264
5mL/ampul	ea.	36263
20mL/ampul	ea.	36265
0.1g/dL forensic ethanol solution		
1mL/ampul	5-pk.	36236
1mL/ampul	10-pk.	36336
5mL/ampul	ea.	36244
20mL/ampul	ea.	36252
0.15g/dL forensic ethanol solution		
1mL/ampul	5-pk.	36237
1mL/ampul	10-pk.	36337
5mL/ampul	ea.	36245
20mL/ampul	ea.	36253
0.2g/dL forensic ethanol solution		
1mL/ampul	5-pk.	36238
1mL/ampul	10-pk.	36338
5mL/ampul	ea.	36246
20mL/ampul	ea.	36254
0.3g/dL forensic ethanol solution		
1mL/ampul	5-pk.	36239
1mL/ampul	10-pk.	36339
5mL/ampul	ea.	36247
20mL/ampul	ea.	36255
0.4g/dL forensic ethanol solution		
1mL/ampul	5-pk.	36266
1mL/ampul	10-pk.	36268
5mL/ampul	ea.	36267
20mL/ampul	ea.	36269

Blood Alcohol Mix Resolution Control Standard

(8 components)

Use our Resolution Control Standard to verify the retention time for each compound normally included in a blood alcohol test, and to verify that the compounds are resolved from and do not interfere with one another. Concentration of ethanol is NIST-traceable.

acetaldehyde	ethyl acetate
acetone	isopropanol
acetonitrile	methanol
ethanol (NIST certified value)	methyl ethyl ketone

0.100g/dL each in water, 1mL/ampul

cat. # 36256 (ea.)

Bank Dye Standard (MAAQ)

Restek offers this qualitative standard to help investigators in municipal police stations and criminal laboratories fight crime.

1-N-(methylamino)anthraquinone (MAAQ)

100μg/mL in methylene chloride, 1mL/ampul

cat. # 31823 (ea.)

No data pack available.

Column Test Mixes

Routine analysis using these products can assist in determining the need to perform column and/or system maintenance.

Grob Test Mix (Capillary GC)

*n*C10-FAME	0.42mg/mL
*n*C11-FAME	0.42
*n*C12-FAME	0.41
2,3-butanediol	0.53
dicyclohexylamine	0.31
2,6-dimethylaniline	0.32
2,6-dimethylphenol	0.32
2-ethylhexanoic acid	0.38
nonanal	0.40
1-octanol	0.36
undecane	0.29
decane	0.28

In methylene chloride, 1mL/ampul

cat. # 35000 (ea.)

No data pack available.

HPLC Reversed Phase Test Mix #1

benzene	0.50
3.00mg/mL	biphenyl
uracil 0.02	0.06
naphthalene	

In methanol:water (75:25), 1mL/ampul

cat. # 35005 (ea.)

No data pack available.

HPLC Normal Phase Test Mix #1

benzene	benzyl alcohol
1.00mg/mL	3.00
benzaldehyde	4-methoxybenzyl alcohol
0.04	2.00

In hexane, 1mL/ampul

cat. # 35004 (ea.)

No data pack available.

did you **know**?

Our Rtx®-BAC1 and Rtx®-BAC2 columns can resolve a blood alcohol sample in less than 3 minutes. We continually improve analysis methods and develop innovative products for clinical/forensic applications. If you have any questions about methods or products, please contact our Technical Service Team at: support@restek.com or contact your Restek representative.

Custom Reference Materials Request Form

Take these eight steps to create the right solution:

1. Mixture Description: _____

2. Solvent: _____

3. Number of Components: _____

4. Volume per ampul (select): 1mL, 2mL, 5mL, 10mL or other _____mL

5. Quantity of ampuls: _____

6. Testing and documentation that best meets your requirements:

- ❍ Gravimetric Documentation: Lot Sheet with balance printout attached.
- ❍ Qualitative Documentation: Certificate of Composition, Chromatogram, and Gravimetric Documentation.
- ❍ Quantitative Documentation: Certificate of Analysis and Data Pack.

7. Compound(s): (list or attach sheet; include CAS number)

Compound 01:	_____	Concentration: _____
Compound 02:	_____	Concentration: _____
Compound 03:	_____	Concentration: _____
Compound 04:	_____	Concentration: _____
Compound 05:	_____	Concentration: _____
Compound 06:	_____	Concentration: _____
Compound 07:	_____	Concentration: _____
Compound 08:	_____	Concentration: _____
Compound 09:	_____	Concentration: _____
Compound 10:	_____	Concentration: _____
Compound 11:	_____	Concentration: _____
Compound 12:	_____	Concentration: _____
Compound 13:	_____	Concentration: _____
Compound 14:	_____	Concentration: _____
Compound 15:	_____	Concentration: _____
Compound 16:	_____	Concentration: _____
Compound 17:	_____	Concentration: _____
Compound 18:	_____	Concentration: _____
Compound 19:	_____	Concentration: _____
Compound 20:	_____	Concentration: _____

8. Concentration Units

❍ mg/mL ❍ µg/mL ❍ ng/mL ❍ vol./wt. % ❍ wt./wt. % ❍ other _____

Contact Information:

Name: _____ Date: _____

Company/Location: _____

_____

Phone #: _____ FAX #: _____

E-mail: _____

International Customers

Contact Your Restek Representative.

ALL mixtures are produced in accordance with our ISO 9001:2000 registration.
Analytical balances are calibrated daily at seven mass levels using NIST traceable weights.
ALL raw materials used are a minimum of 97% pure unless otherwise specified.