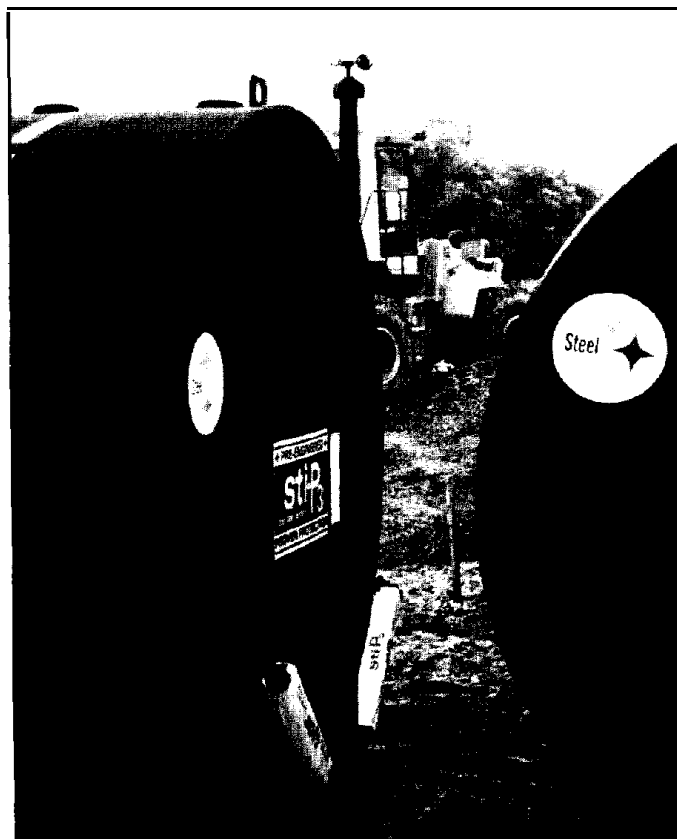


# Guide for the Analysis of Petroleum Hydrocarbons in Soil and Water



**This guide presents:**

- An overview of methods for underground storage tank monitoring.
- Suggestions for sample screening.
- Hints for GRO and DRO analysis.
- Common problems associated with these methods.
- Weathered petroleum standard recommendations for more accurate identification.
- A listing of columns and standards for GRO and DRO analysis.

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**I**t is estimated that there are over 1.5 million underground storage tanks in the United States. Over 10% of these tanks have had confirmed leaks. The potential for leaks from the other 90% has created a serious environmental problem. The US EPA in conjunction with the American Petroleum Institute (API), has drafted a method for monitoring leaks from underground storage tanks'. In addition, many states have developed methods for monitoring leaks from underground storage tanks. A summary of state by state soil and ground water cleanup standards, including recommended methods, were compiled in the December 1993 *Soils* magazine'.

Since petroleum products are the most common materials stored in underground tanks, many of the methods involve the analysis of Total Petroleum Hydrocarbons (TPH). TPH can further be broken down into Gasoline Range Organics (GRO) and Diesel Range Organics (DRO). Since the boiling point distribution differs significantly for these two ranges of petroleum products, two very different methods are employed to monitor for these contaminants. This guide was developed to assist the analyst in selecting the correct method and solve many of the common problems encountered with these methods.

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## Screening for TPH and Hydrocarbon Range

Before analyzing a water or soil extract specifically for gasoline range or diesel range petroleum hydrocarbons it is advantageous to screen the sample. One purpose of the screening analysis is to determine the approximate concentration of the contamination. Although the calibration range for GRO and DRO analysis can be over 5 orders of magnitude, some samples may be highly contaminated and exceed the normal calibration range. Analysis of soil and water samples without prior screening, may result in contamination of the chromatographic system. Contamination from high concentration samples can be particularly troublesome; because, carry over to subsequent analyses will produce erroneously high values. Screening of samples for petroleum hydrocarbons can be performed on a non-critical GC instrument. An old packed column GC, equipped with an FID, can be set aside for this purpose.

Before screening samples, the gas chromatograph is calibrated using a standard containing individual hydrocarbons found in gasoline, diesel and motor oil. Figure 1 is an example of this analysis. From the retention times of these individual hydrocarbons, the retention time windows for gasoline and diesel are determined. Although states differ in the specific components used to **define** these windows, Restek's retention time standard (cat.# 3 1200) is suitable for establishing times according to most methods.

A typical screening analysis of petroleum hydrocarbons in soil and water is shown in Figure 2. This sample has been spiked with weathered gasoline, a composite diesel and a small amount of motor oil. The fingerprints for each hydrocarbon group are clearly visible in this chromatogram. Since many samples contain high molecular weight hydrocarbons, the column used for screening should be capable of operation at high temperatures. The XTI<sup>®</sup>-5 column (cat.# 12255) is a good choice for screening since it can be operated continuously at 325°C, and conditioned as high as 360°C to bake out high molecular weight contamination.

1. EPA UST Workgroup American Petroleum Institute, February 1992.
2. Oliver, Kostecki, and Calabrese, *Soils*, December 1993.

Figure I - A mixture of C6 to C40 hydrocarbons is used to correlate retention time and carbon number ranges.

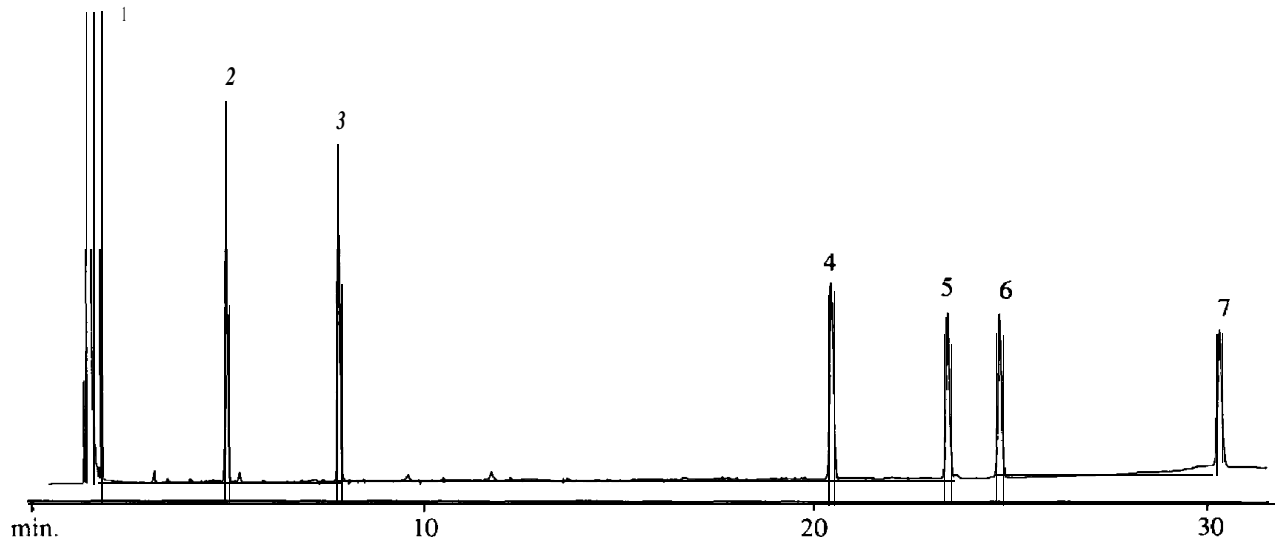
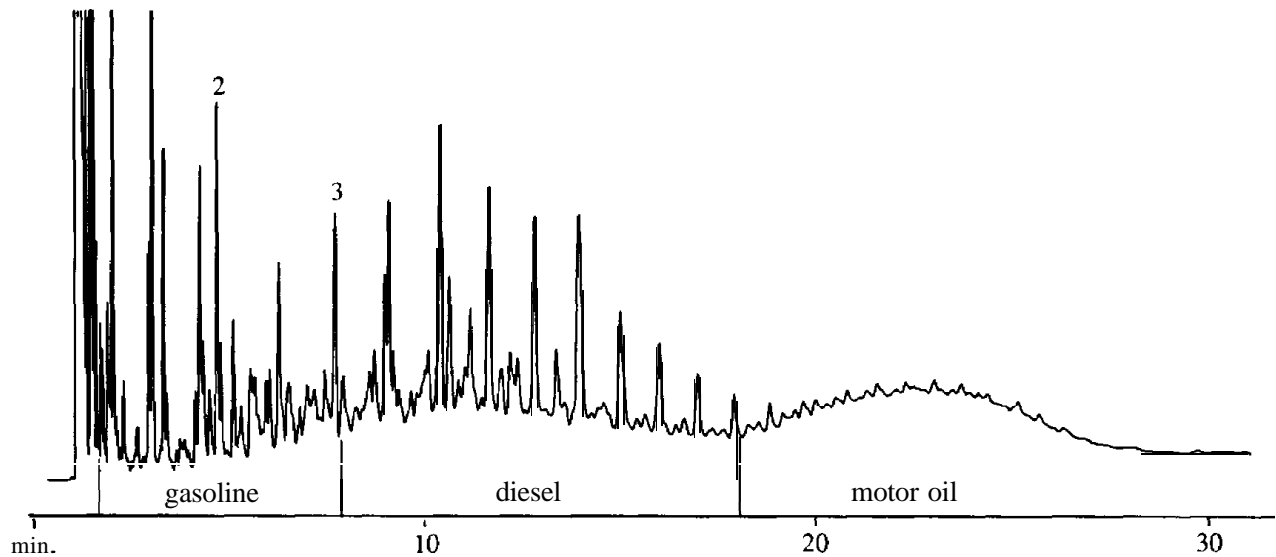


Figure 2 - The **fingerprints** for each hydrocarbon group are clearly visible in this analysis of petroleum hydrocarbons in soil and water which has been spiked with weathered gasoline, diesel and motor oil.



**Peak List and Run Conditions for Figures 1 - 2**

COMPOUNDS	
1	hexane (C6)
2	decane (C10)
3	dodecane (C12)
4	tetracosane (C24)
5	octacosane (C28)
6	triacontane (C30)
7	tetracontane (C40)

Column: 30111, 0.53mm ID, 1.0um XTI<sup>®</sup>-5 (cat.# 12255)  
 Conc.: 50ng/ml Figure 1 (cat.# 31200)  
 500ng/ul Figure 2  
 Oven temp.: 40°C (hold 1 min.) to 325°C 10°C/min. (hold 10 min.)  
 Inj/det. temp.: 280°C/10°C\*  
 Carrier gas: helium @50cm/~sec.  
 FID sens.: 8 x 10<sup>-11</sup> AFS

\* High injection port temperatures are necessary to ensure complete sample transfer.

## Analysis of Gasoline Range Organics (GRO)

Gasoline is a complex mixture, containing in excess of 400 individual hydrocarbon compounds; consisting of saturates, olefins, and aromatics. BTEX (benzene, toluene, ethyl benzene, and xylenes) are the most commonly analyzed compounds that indicate the presence of gasoline contamination. GRO analysis is accomplished by using modified EPA methods for the analysis of volatile organic pollutants. These methods employ a purge and trap sample concentrator, a wide bore capillary column, and both photo ionization (PID) and flame ionization (FID) detectors for the analysis of TPH and BTEX. A purge and trap system is used to extract and concentrate the more volatile gasoline components from water and soil prior to introduction into the gas chromatograph. The sampling procedure for water is similar to the one specified in EPA Method 602'. For soils, a methanol extract is added to the purge vessel containing a volume of water as specified in EPA Method 80204. The FID responds to all hydrocarbon species in the complex gasoline sample and is used to detect the total volatile hydrocarbons. A PID, when operated with a 10.2 or 10.0 eV lamp, yields more specific response to aromatic and other unsaturated hydrocarbons present in gasoline and is used to quantitate BTEX.

A wide range of columns can be used for GRO analysis, depending upon the requirements specified in each state's analytical procedure. In general, the column, operating under the conditions of the method, must meet some minimum requirements for retention and resolution. If BTEXs are to be determined, the column must resolve these aromatics from the other hydrocarbons. Since the three xylene isomers are reported as a total, it is not necessary to separate them. The resolution between ethyl

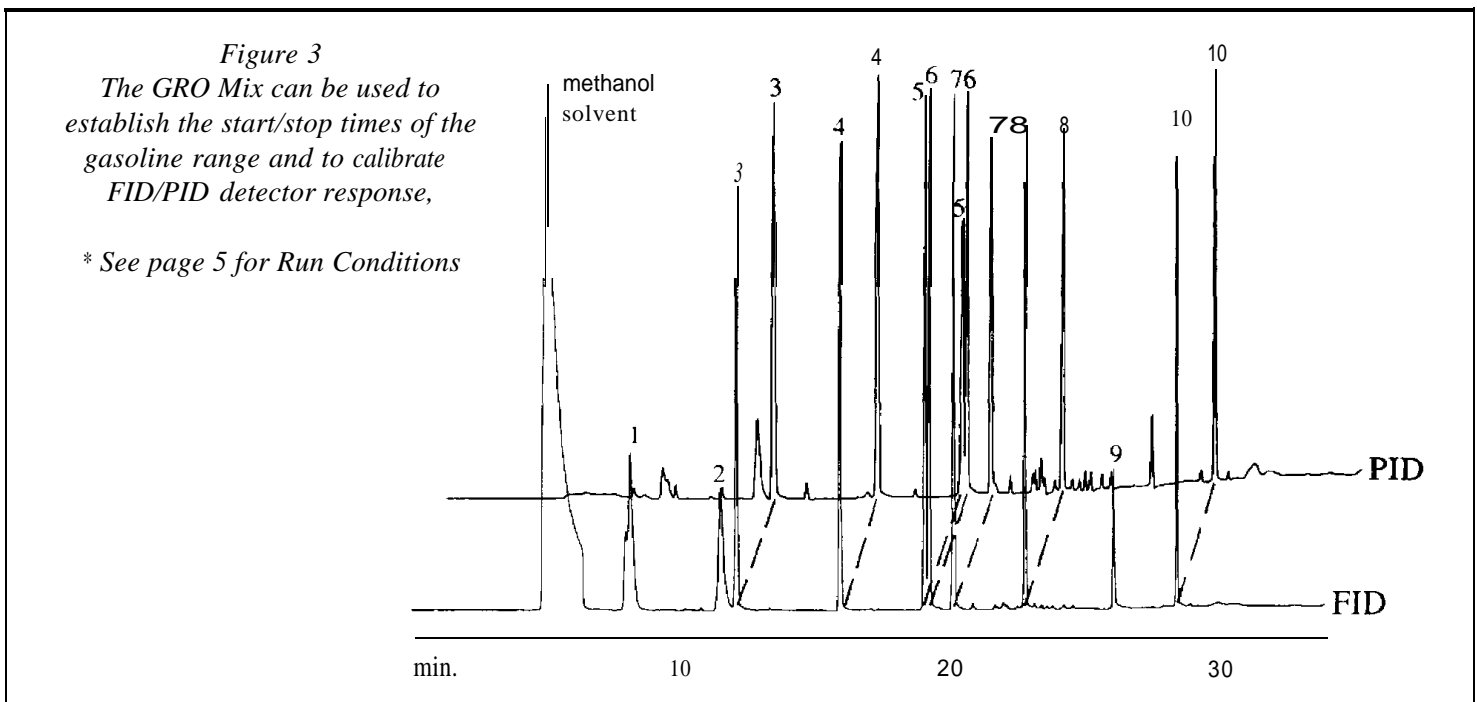
benzene and m-, p-xylene is typically the most difficult separation to obtain. Since the same chromatographic method is normally used for both water and soils, the column must also resolve gasoline from the methanol solvent peak. States may differ on which hydrocarbon is used to define the beginning and end of the gasoline compounds to be measured, so the requirements of the column will vary. The 105 meter Rtx"-502.2 column (cat.# 10910) is a good choice for most methods because it resolves 3-methyl pentane from methanol without sub-ambient oven temperatures and provides excellent resolution of ethyl benzene from m- and p-xylene (see Figure 3).

### Determining Gasoline Retention Range and Calibrating Response

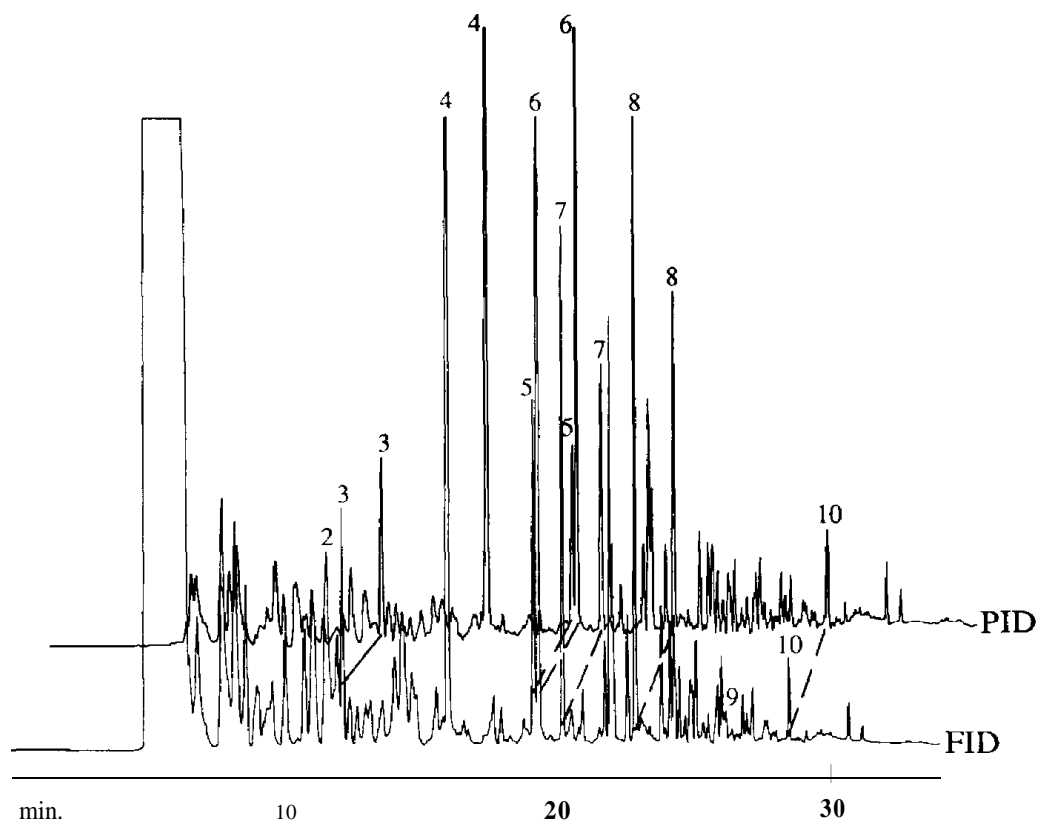
Hydrocarbon calibration standards serve two purposes in TPH/BTEX analysis. Since the reporting of TPH requires the summation of the total gasoline area, the standard must contain the first and last components defining the retention time range. Individual states differ on the compounds defining the retention time range for gasoline. Figure 3 shows a chromatogram of Restek's GRO Mix (cat.# 30069) plus dodecane. Dodecane was added to the standard since some states define the upper limit of the GRO range using naphthalene, while other states use dodecane.\*

\* Custom CRO standards are available with dodecane already added to comply with some state regulations.

3. Federal Register 1984 Vol. 49, No. 209; USEPA Method 602 (Purgeable Aromatics).
4. USEPA, SW-846 Test Method5 for Evaluating Solid Waste, 3rd Edition.



**Figure 4** - The unleaded composite gasoline standard is representative of GRO samples.



**Peak List and Run Conditions for Figures 3 - 4**

COMPOUNDS	
1	3-methylpentane
2	2,2,4-trimethylpentane (isooctane)
3	benzene
4	toluene
5	ethylbenzene
6	m-xylene
7	o-xylene
8	1,2,4-trimethylbenzene
9	dodecane
10	naphthalene

**Fig. 3)** 105m, 0.53mm ID, 3.0µm Rtx®-502.2 (cat.# 10910)

**Sample:** GRO Mix (cat.# 30069) + dodecane\*

**Concentration:** 200ppb each in 5ml of H<sub>2</sub>O

**Fig. 4)** 105m, 0.53mm ID, 3.0µm Rtx®-502.2 (cat.# 10910)

**Sample:** Unleaded Gasoline Composite Standard (cat.# 30081)

**Concentration:** 5ppm in 5ml of H<sub>2</sub>O

**Oven temp.:** 40°C (hold 1 min.) to 100°C @ 5°C/min., then to 240°C @ 8°C/min. (hold 8 min.)

**Inj. 1 det. temp.:** 200°C/250°C

**Carrier gas:** helium (10cc/min.)

**FID sensitivity:** 16 X 10<sup>-11</sup> AFS

**Trap:** Tenax, Siiica Gel, Charcoal

**Purge:** 12 min. @ 40cc/min.

**Desorb) preheat:** 175°C **Desorb temp.:** 180°C

**Desorb) time:** 2 min. **Desorb flow:** 10cc/min.

\* Custom GRO standards are available with dodecane already added to comply with some state regulations.

The detector must be calibrated for the aromatic hydrocarbons (BTEX) and for the entire gasoline range (TPH). Since BTEX is made up of individual components, the calibration is straightforward. However, for TPH calibration there are two possible procedures. One procedure is to analyze a mixture of individual hydrocarbons covering the gasoline range (Figure 3) and calculate an average response factor from the response of each individual component. This calibration standard should be representative of the different types of hydrocarbons in gasoline.

States recommending this method of calibration will specify the hydrocarbon components to be used. The other procedure for calibrating TPH response is to analyze a quantitative standard containing one or more gasolines. In theory, a composite will be more representative of the gasoline present in a wide range of samples to be analyzed. An example of a chromatogram generated from Restek's composite gasoline standard (cat.# 30081) appears in Figure 4.

## Sample Analysis and Evaluating Method Performance

Once the retention time range and response factors are determined, it is good practice to perform an analysis of a spiked soil or water to determine the analyte recovery and method repeatability. For TPH, the Restek composite gasoline (cat.# 30081) allows more precise calibration of a wide range of gasolines. To calculate BTEX recovery, an aromatic standard mixture (cat.# 30051) should be used. It is best to calibrate BTEX from a mixture of aromatics because the exact concentration of BTEX in the gasoline standard is not easily determined. The addition of an internal standard and surrogate to the samples prior to analysis will usually increase the precision of the results, especially for BTEX. Internal and surrogate standards that have been used successfully include a,a,a-trifluorotoluene, 1-chloro-4-fluorobenzene, 4-bromofluorobenzene and

1-chlorooctane (see page 12 for a complete list of GRO surrogate & internal standards).

Although GRO methods differ between states, the basic procedures are similar. The capillary column frequently recommended for TPH and BTEX analysis is a 105 meter, 0.53mm ID, 3.0um Rtx"-502.2 (cat.# 10910). System calibration can be accomplished with either mixtures of individual hydrocarbons or composite gasoline standards. Analysts should refer to their specific methods for analytical and calibration procedures. If you have questions about which GRO standards to use or which columns work best, contact Restek's technical service department at (800) 356 1688 (ext. 4).

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## Analysis of Diesel Range Organics

DRO (Diesel Range Organics) methods are designed to measure the concentration of mid-range petroleum products such as diesel fuel, home heating oil, gas oil, jet fuel, mineral spirits and kerosene in the range of C10-C28 hydrocarbons in water and soil. As in GRO analysis, many states have adopted their own testing methodology for measuring DRO. The typical DRO analytical method involves a solvent extraction with methylene chloride and Kuderna-Danish concentration of the extract. One microliter of the extract is then injected onto a 0.53mm ID capillary column and the resolved components are monitored using a flame ionization detector (FID). Water samples are extracted as specified in SW-846 Method 3510 (separatory funnel liquid/liquid extraction) or Method 3520 (continuous liquid/liquid extraction)<sup>4</sup>. Soil samples are extracted using Method 3550 (sonication)<sup>4</sup>. The FID responds to all hydrocarbon species and is used to detect the total petroleum hydrocarbons (TPH). A wide range of columns can be used for DRO analysis, depending upon the requirements specified in each state's analytical procedure. In general, the column, operating under the conditions of the method, must meet some minimum requirements for retention and resolution. Due to the higher hydrocarbon range and GC oven temperatures required for DRO analysis, either a 30 meter, 0.53mm ID, 1.0um Rtx"-5 (cat.# 10255), MXT"-5 (cat.# 70255), or XTI"-5 (cat.# 12255) column is an excellent choice to meet the resolution and performance requirements of the methods.

To determine TPH, the sum of the area within a range of hydrocarbons is used. States may differ on which hydrocarbons are used to define the beginning and end of the diesel compounds to be measured, but typically begin with C10 to C12 and end with C24 to C28. Integration begins 0.1 minutes before the retention time of the first hydrocarbon marker and ends 0.1 minutes after the last hydrocarbon

marker in the component standard. Most methods have specific performance requirements. Examples of method performance requirements include:

1. The beginning hydrocarbon must be completely resolved from the solvent peak.
2. Internal and surrogate standards must be resolved from the hydrocarbons.

Most methods also employ a discrimination check to test for molecular weight discrimination. When analyzing such a wide range of hydrocarbons, molecular weight discrimination of the later eluting hydrocarbons is a common problem. Discrimination occurs when a larger fraction of the more volatile hydrocarbons enter the column in proportion to the heavier hydrocarbons. Splitless injections tend to be more discriminatory compared to direct injections. Therefore, direct injection is a better technique for DRO analysis. Request Restek's **Guide to Direct/On-column Flash Vaporization Injection** for more details.

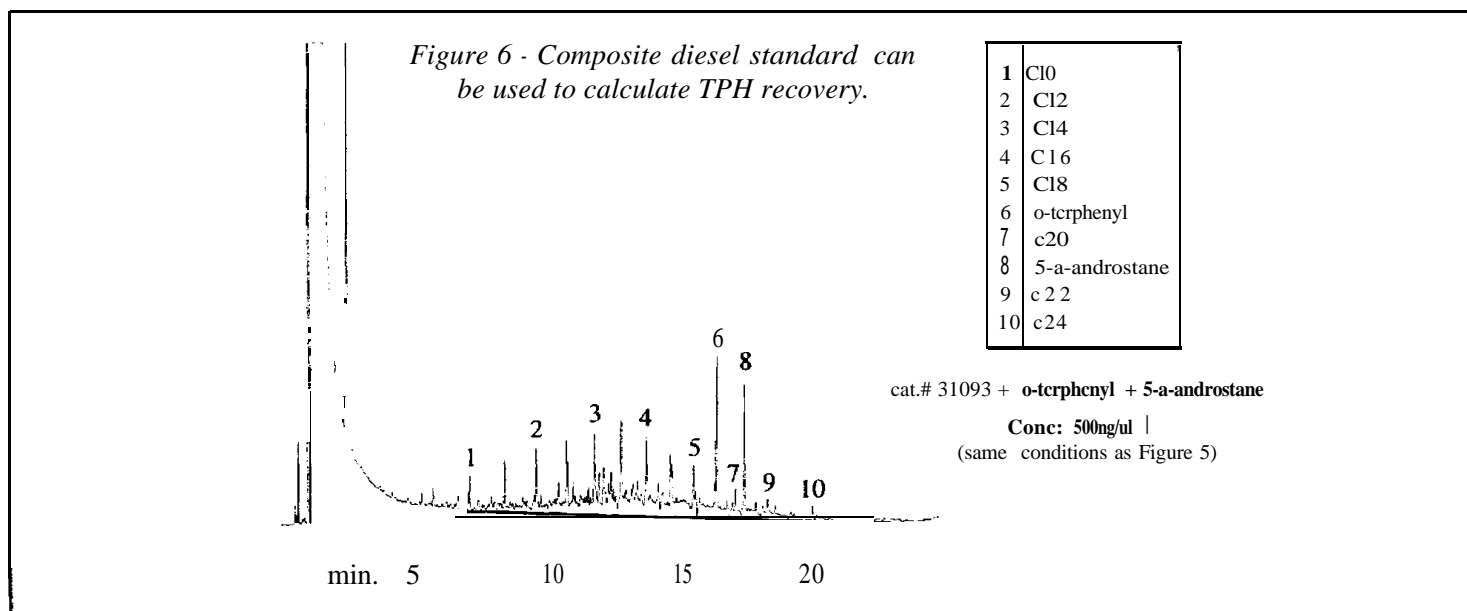
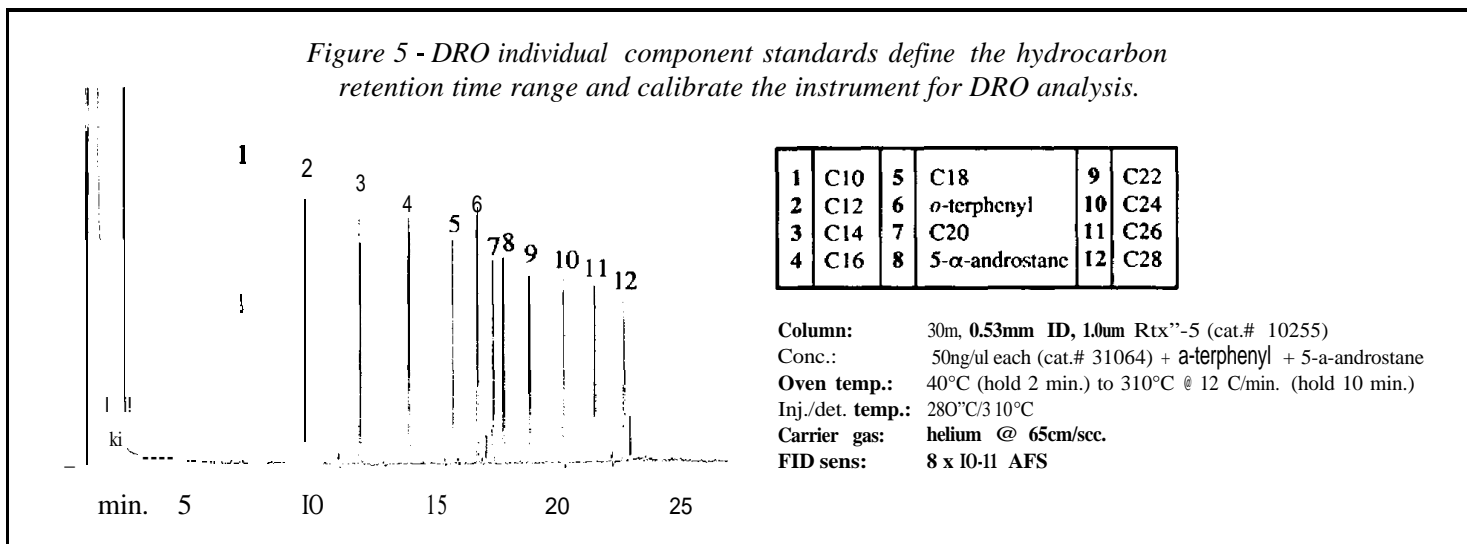
## Determining Diesel Retention Range and Calibrating Response

Since reporting TPH requires the summation of all chromatographic peaks eluting between the first and last component specified in the method, the calibration standard must contain the components defining the retention time range. Individual states differ on which compounds to use in defining the retention time range for diesel. Figure 5 shows a chromatogram of Restek's DRO individual component standard (cat.# 31064). This standard is used to determine the beginning and ending retention times of the diesel range and is also used to calculate an average response factor by dividing the total area of all components by the total amount injected.

Confirmation of TPH response is achieved by analyzing a quantitative standard containing one or more diesel fuels. A composite diesel standard was developed to be represen-

tative of diesels present in a wide range of samples to be analyzed. An example of a chromatogram generated from Restek's DRO composite diesel standard (cat.# 31093) is shown in Figure 6. Once the beginning and ending

retention times and response factors from the individual components have been defined, the total area of the composite standard is used to calculate the recovery for a spiked standard.



## Common Problems Encountered with Lust Analysis:

### High Recoveries

Several factors can contribute to erroneously high recoveries when performing GRO or DRO analyses. Each of these problems can result in reporting higher concentrations than were actually present in the samples. The most common factors are:

1. Interferences from solvents, oils or other high molecular weight compounds
2. Carry over and memory effects
3. Column bleed
4. Molecular weight discrimination

A common problem encountered in both GRO or DRO analysis is the presence of interfering compounds in the

chromatographic analysis. GRO interferences can be caused by organic solvents and other non-hydrocarbon contamination present in the samples. Sources of interferences for DRO analyses can occur from the presence of high molecular weight contaminants, such as phenols, phthalates, lubricating oils or motor oils that were also extracted during the liquid/liquid extraction step.

Figure 7 shows a chromatogram of a DRO sample that contains motor oil contamination. Most DRO samples contain hydrocarbons in the C10 to C28 range. From Figure 7, it appears that motor oil contamination is present with a hydrocarbon range beginning near C20 and overlapping beyond C28. If an analyst was to sum the area

Figure 7 - High molecular weight motor oil contamination commonly causes high DRO recovery.

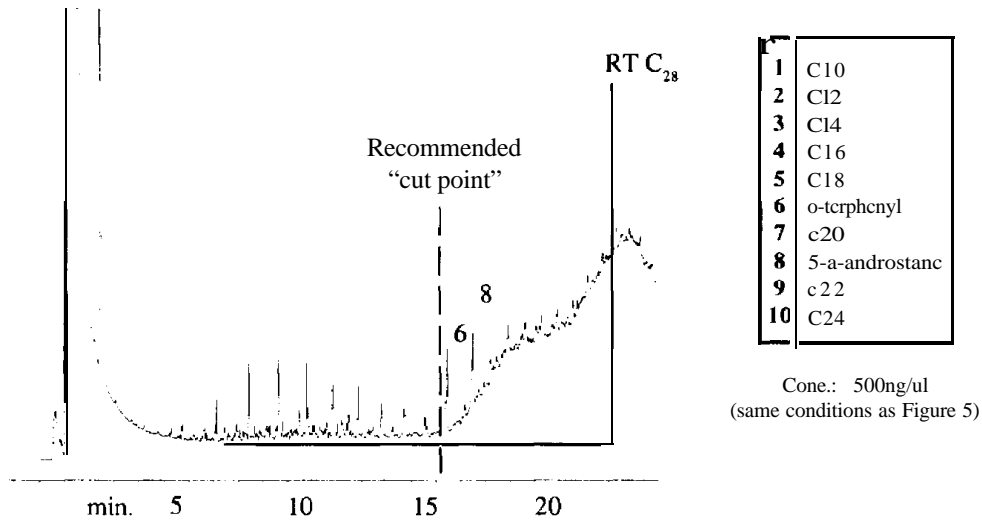
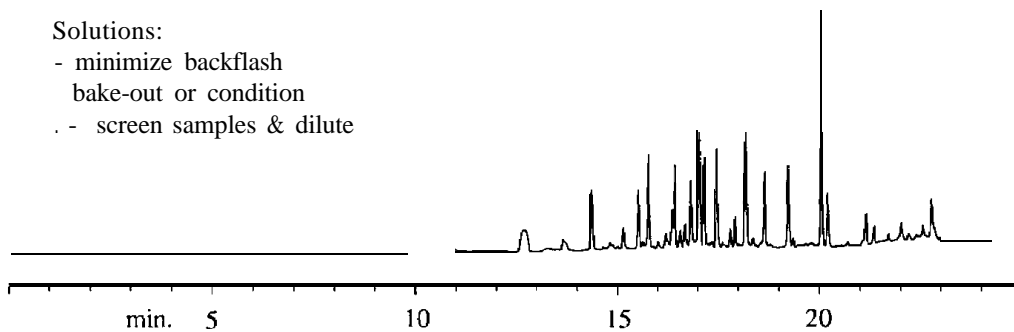


Figure 8 - Residual hydrocarbon contamination in the injector and pneumatics yields artifact peaks.

- Solutions:
- minimize backflash
  - bake-out or condition
  - screen samples & dilute



from the defined retention time marker of C10 to C28, an erroneously high DRO value would result. In the case of motor oil contamination, the analyst is required to make a judgment call, recognize the patterns of diesel fuel and motor oil, and determine a “cut point” for the DRO range.

Carry over or memory effects from highly contaminated samples is also a common problem with both GRO and DRO analyses. It is typically caused when sample residue is left behind after injecting a highly concentrated sample or from high molecular weight contaminants extracted during sample preparation. Figure 8 shows an example of carry over from a previous injection of high molecular weight hydrocarbons. When running samples, always establish a sequence that injects from low to high concentration. To insure that part of the sample has not been left behind in the injector, increase the injection port temperature to between 280°C and 300°C. If a highly contaminated sample has been analyzed, make a blank run after the sample to bake-out any potential contaminants. In cases of extreme contamination, the column may have to be rinsed and the inlet sleeve cleaned (see Restek’s *Fused Silica Capillary Column Instruction Guide* for more details). To avoid carry over, prescreening the samples on

a separate GC prior to sample preparation is recommended. Overloading the instrument with hydrocarbon contaminants can be minimized by diluting highly contaminated samples to keep them within the linear range of the method.

High recoveries can also be caused by changes in the baseline due to column bleed. Column bleed can result in high DRO recovery since the background area under the diesel is increased when programming the GC oven to the higher temperatures required for DRO analysis. To minimize high recoveries from column bleed always thoroughly condition new columns for 18 hours at their maximum operating temperature. Make sure oxygen purifiers are functioning and the system is leak free while conditioning columns at elevated temperatures, or column damage will occur. (To avoid contamination of the lamp window, do not connect the column to a PID when conditioning a capillary column for the first time). Column conditioning is also recommended when re-installing the column into the GC. Also, perform a blank run prior to analysis to determine the true baseline. This true baseline can be subtracted from the DRO analysis to compensate for the additional area caused from column bleed.

Another cause of high recovery in DRO analysis is mass discrimination of high molecular weight hydrocarbons causing a low average response factor. Mass discrimination occurs from poor volatility in the injection port and/or syringe needle discrimination. Since splitless injections are more prone to mass discrimination, it is recommended that DRO analysis be performed in the direct injection mode. A significant reduction in discrimination can be achieved by switching from splitless to direct injection. (For more information on minimizing injection discrimination, request a copy of Restek's *Guide to Direct/On-column Flash Vaporization Injection*). Since discrimination can also occur in the syringe needle, it is recommended that a solvent flush technique be used for DRO analysis. Solvent flush can be accomplished by first taking a small plug of methylene chloride into the syringe, followed by a small air gap, and then finally the sample. When the plunger is depressed, the plug of solvent will help wash any remaining sample out of the needle, minimizing any discrimination.

### Low Recoveries

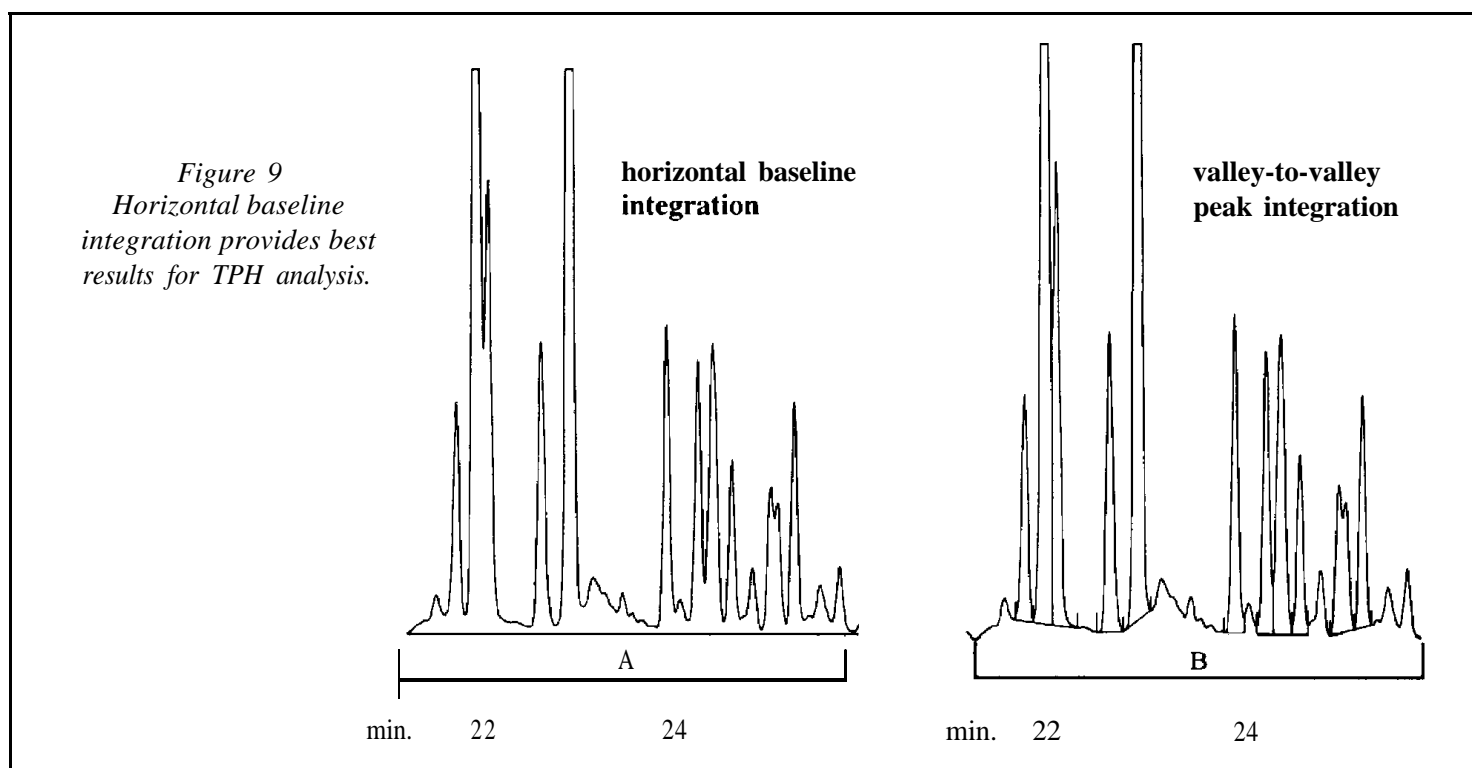
Another common problem encountered with both GRO and DRO analysis is low recoveries. This is most frequently observed when response factor calibration is based upon a hydrocarbon component standard as opposed to a composite gasoline or diesel standard. This occurs because the actual components from the hydrocarbon contamination may exceed the start and stop integration points established from the hydrocarbon component standard.

Low recoveries can also be caused by errors in integration. Since petroleum products are made up from complex

mixtures of hydrocarbons, often the column cannot resolve all the components. For GRO analysis this problem is minimized since the analysis is accomplished on a 105 meter Rtx"-502.2 column and most of the components are resolved. However, baseline resolution of diesel oils is not chromatographically feasible. This results in a characteristic rising baseline underneath the resolved hydrocarbon components as shown in Figure 6. Figure 9 shows the difference between baselines obtained using horizontal baseline integration (A) and valley-to-valley peak integration (B) modes. The area resulting from the valley-to-valley peak integration will give low recoveries because part of the baseline area is excluded from the calculation. For best results with TPH analysis, the baseline should be determined at the beginning and end of the analysis, and a horizontal hold applied between these two points.

### Calibrating for the Effects of Weathering

Since petroleum products can degrade due to volatility and microbial activity, often the samples analyzed do not closely resemble the original starting materials. These changes in the sample composition can lead to misidentification of the type of material involved. Therefore, artificially weathered petroleum products can be useful in minimizing identification errors since they can closely resemble actual environmental samples. Figure 10 shows the difference between an unweathered gasoline sample and one that was artificially weathered to a 50% weight loss. Much of the light end of the gasoline was lost due to the weathering process. Figure 11 shows a similar effect between an unweathered diesel oil and one that was

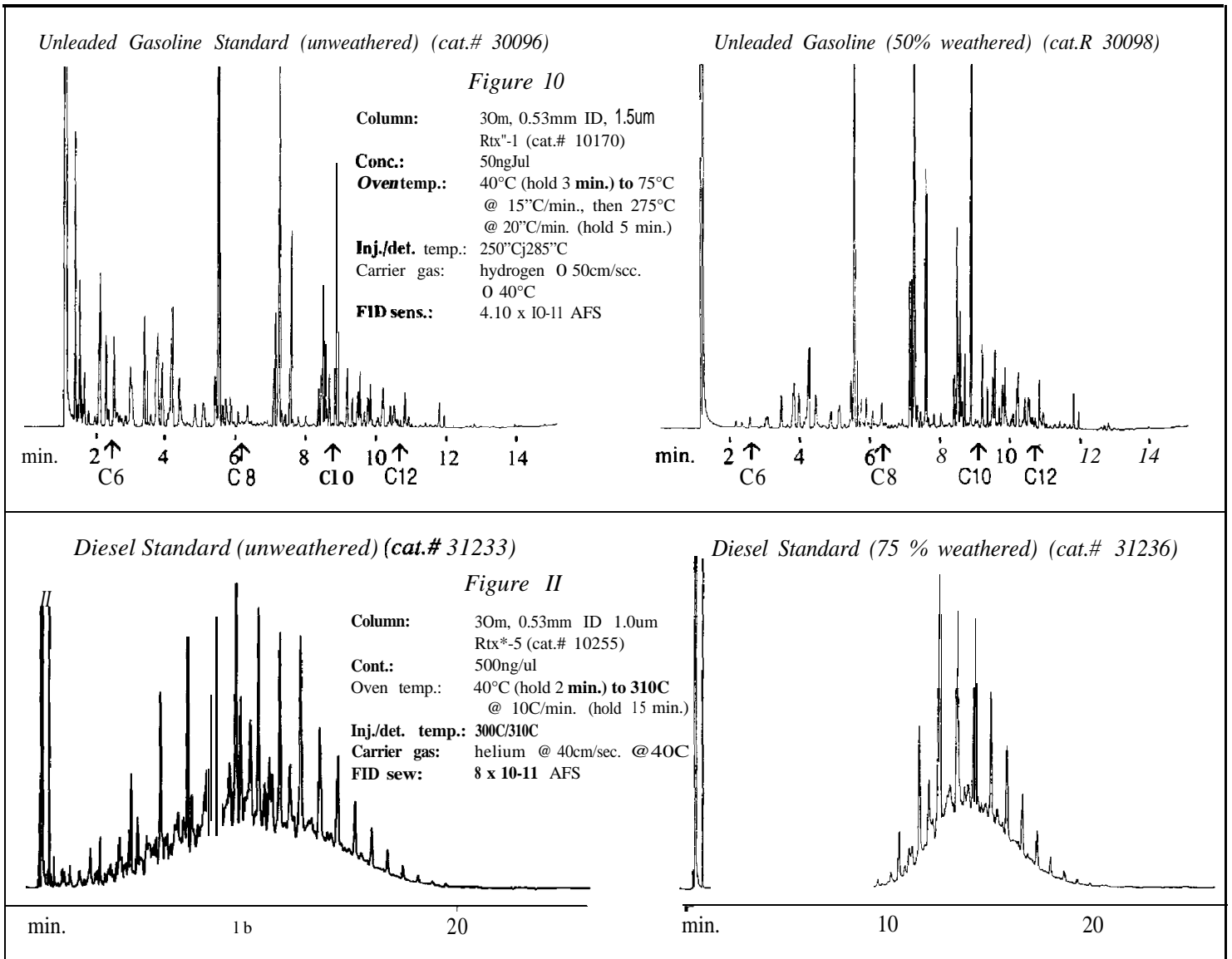


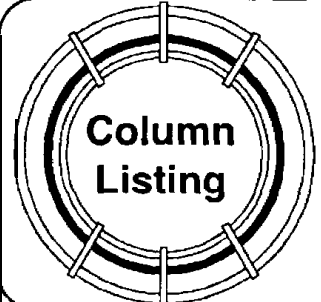
artificially weathered to a 75 % weight loss. (A complete listing of weathered petroleum products is shown on page 14). Calibration with weathered standards will increase

quantitative accuracy for field samples exposed to environmental weathering.

## Summary

Petroleum contamination of soil and groundwater from leaking underground storage tanks is a serious environmental problem. A growing number of environmental laboratories are now commonly performing GRO and DRO analyses. Due to the complex nature of petroleum products, the analysis for these materials in environmental samples pose many problems to the analyst. The lack of universally accepted methods for GRO and DRO analyses adds further difficulties to labs that are analyzing samples from several different states. This guide has given the analyst more information about GRO and DRO analyses and has made recommendations that will improve analytical accuracy.



	Column Use	Columns	Catalog Number	List Price
	Screening	30m, 0.53mm ID, <b>1.0µm</b>	12255	
		MXP-5: 30m, 0.53mm ID, 1.0µm	70255	
	CR0 and BTEX	Rtx <sup>®</sup> - 502.2: 105m, 0.53mm ID, 3.0µm	10910	
MXT <sup>®</sup> -502.2: 105m, 0.53mm ID, 3.0µm		70910		
DRO	Rtx@-5: 30m, 0.53mm ID, 1.0µm	10255		
	XTP-5: 30m, <b>0.53mm</b> ID, 1.0µm	12255		
	MXT <sup>®</sup> -5: 30m, 0.53mm ID, 1.0µm	<b>70255</b>		

# UST Monitoring Standards

## Standards for Screening

### Retention Time Standard

This hydrocarbon mixture may be used during initial screening of the samples to determine retention time windows for each petroleum product type. It is generally accepted that gasoline elutes in the window from C6 to C10 (or C12). Diesel fuel elutes in the window from C10 (or C12) to C24 (or C28). Retention above C24 (or C28) would indicate oil or lubricant contamination.

### LUST Retention Time Standard

hexanc (C6)	decane (C10)
dodecanc (C12)	tetracosane (C24)
octacosanc (C28)	triacontane (C30)
tetracontanc (C40)	
25-g/ml each in 1ml methylene chloride.	
Cat.# 31200	ea.
31200-500	ea. w/data pack
<b>31200-510</b>	<b>5pk.</b>
<b>31200-520</b>	<b>5pk. w/data pack</b>
<b>31300</b>	<b>10pk. w/data pack</b>

## Standards for GRO Analysis

### PVOC Mix

benzenc	ethylbenzenc
tolucnc	o-xylenc
m-xylenc	methyl-t-butyl ether
1,2,4-trimethylbenzenc	
1,3,5-trimethylbenzenc	
1000ug/ml each in 1 ml P&T grade methanol	
Cat.# 30070	ea.
30070-500	ea. w/data pack
<b>30070-510</b>	<b>5pk.</b>
<b>30070-520</b>	<b>5pk. w/data pack</b>
<b>30170</b>	<b>10pk. w/data pack</b>

### PVOC Mix (CA Method)

benzenc	ethylbenzenc
tolucnc	cl-xylenc
m-xylenc	methyl-t-butylether
1000ug/ml each in 1ml P&T grade methanol	
Cat.# 30071	ea.
<b>30071-500</b>	<b>ea. w/data pack</b>
<b>30071-510</b>	<b>5pk.</b>
<b>30071-520</b>	<b>5pk. w/data pack</b>
<b>30171</b>	<b>10pk. w/data pack</b>

### Revised PVOC/GRO Mix (WISC)

methyl-t-butyl ether	benzenc
tolucnc	ethylbenzenc
o-xylenc	p-xylenc
naphthalenc	1,2,4-trimethylbenzenc
1,3,5-trimethylbenzenc	m-xylene
1000-g/ml each in 1ml P&T grade methanol	
Cat.# 30095	ea.
30095-500	ea. w/data pack
<b>30095-510</b>	<b>5pk.</b>
<b>30095-520</b>	<b>5pk. w/data pack</b>
<b>30195</b>	<b>10pk. w/data pack</b>

### GRO Mix

3methylpentanc	
benzenc	
tolucnc	
ethylbenzenc	
m-xylenc	
o-xylenc	
naphthalenc	
1,2,4-trimethylbenzenc	
2,2,4-trimethylpentanc (isooctanc)	
1000ug/ml each in 1ml P&T grade methanol	
Cat.# 30069	ea.
<b>30069-500</b>	<b>ea. w/data pack</b>
<b>30069-510</b>	<b>5pk.</b>
<b>30069-520</b>	<b>5pk. w/data pack</b>
<b>30169</b>	<b>10pk. w/data pack</b>

### GRO Mix (EPA)

2-methylpentanc	1500ug/ml
2,2,4-trimethylpentanc (isooctanc)	1500
tolucnc	1500
1,2,4-trimethylbenzenc	1000
nr-xylenc	1000
cl-xylenc	1000
heptanc	500
benzenc	500
ethylbenzenc	500
In 1ml P&T grade methanol	
Cat.# 30065	ea.
<b>30065-500</b>	<b>ea. w/data pack</b>
<b>30065-510</b>	<b>5pk.</b>
<b>30065-520</b>	<b>5pk. w/data pack</b>
<b>30165</b>	<b>10pk. w/data pack</b>

### BTEX Standard

benzenc	tolucnc
ethylbenzenc	o-xylene
m-xylenc	p-xylene
200pg/ml each in 1ml P&T grade methanol	
Cat.# 30051	ea.
30051-500	ea. w/data pack
<b>30051-510</b>	<b>5pk.</b>
<b>30051-520</b>	<b>5pk. w/data pack</b>
<b>30151</b>	<b>10pk w/data pack</b>

## Unleaded Gasoline Composite

Samples of regular and premium grade unleaded gasoline were each collected from three different sources (six samples total). Equal volumes of each were blended to form a composite unleaded gasoline sample. The composite blend was then used to produce the standard listed.

### Unleaded Gasoline Composite Standard

2500ug/ml in 1 ml P&T grade methanol	
Cat.# 30081	ea.
<b>30081-500</b>	<b>ea. w/data pack</b>
<b>30081-510</b>	<b>5pk</b>
<b>30081-520</b>	<b>5pk. w/data pack</b>
<b>30181</b>	<b>11 pk. w/data pack</b>

### Aviation Gas Standard

This material is a 100 octane low lead fuel currently used in piston type aircraft.

2500ug/ml in 1 ml P&T grade methanol.	
Cat.# 30094	ea.
<b>30094-500</b>	<b>ea. w/data pack</b>
<b>30094-510</b>	<b>5pk.</b>
<b>30094-520</b>	<b>5pk. w/data pack</b>
<b>30194</b>	<b>10pk. w/data pack</b>

For additional details on these or other mixes, call (800) 356-1688 for chemical standards.

## Gasoline Surrogate & Internal Standards

State requirements for the use of surrogate and internal standards during sample preparation/extraction of gasoline contaminated water and soil vary. These compounds have been identified in several state methods:

2500ug/ml in 1ml P&T grade methanol	Individual	Individual w/data pat k	5pk.	5pk. w/data pack	10pk. w/data pack
4-bromofluorobenzene Standard	30067	30067-500	30067-510	30067-520	30167
a,a,a-trifluorotoluene Standard	30068	30068-500	30068-510	30068-520	30168

10,000ug/ml in 1ml P&T grade methanol	Individual	Individual w/data pat k	5pk.	5pk. w/data pack	10pk. w/data pack
4-bromofluorobenzene	30082	30082-500	30082-510	30082-520	30182
a,a,a-trifluorotoluene	30083	30083-500	30083-510	30083-520	30183
1-chlorooctane	30084	30084-500	30084-510	30084-520	30184

Recommended Internal standard (PID) for EPA GRO method:

2500ug/ml in 1ml P&T grade methanol	Individual	Individual w/data pack	5pk.	5pk. w/data pack	10pk. w/data pack
1-chloro-4-fluorobenzene Std.	30066	30066-500	30066-510	30066-520	30166 \$225

## Standards for DRO Analysis

### DRO Mix (EPA/WBC)

decane (C10)	dodecane (C12)
tetradecane (C14)	hexadecane (C16)
octadecane (C18)	
cicosane (C20)	
docosane (C22)	
tetracosane (C24)	
hexacosane (C26)	
octacosane (C28)	

2000ug/ml each in 1ml methylene chloride.

Cat.# 31064	ea.
31064-500	ea. w/data pack
31064-510	5pk.
31064-520	5pk. w/data pack
31164	10pk. w/data pack

### DRO Mix (Ten#Miss)

decane (C 10)	undecane (C 11)
dodecane (C 12)	tridecane (C 13)
tetradecane (C 14)	pentadecane (C 15)
hexadecane (C 16)	heptadecane (C 17)
octadecane (C 18)	nonadecane (C 19)
cicosane (C20)	hencicosane (C21)
docosane (C22)	tricosane (C23)
tetracosane (C24)	pentacosane (C25)

1000ug/ml each in 1ml methylene chloride.

Cat.# 3121	ea.
31214-500	ea. w/data pack
31214-510	5pk.
31214-520	5pk. w/data pack
31314	10pk. w/data pack

Restek stocks composite standards to meet many state mandates. If the product you require is not listed, call our chemical standards department at (800) 356-4688 for a custom quote.

## Composite Standards

Samples of diesel fuel and kerosene fuel were each collected from three different sources. Equal volumes of each were blended to form a composite standard.

### Diesel Fuel #2 Composite Standard

5000ug/ml in 1ml methylene chloride.

Cat.# 31093	ea.
31093-500	ea. w/data pack
31093-510	5pk.
31093-520	5pk. w/data pack
31193	10pk. w/data pack

### Kerosene Fuel Composite Standard

5000ug/ml in 1ml methylene chloride.

Cat.# 31094	ea.
31094-500	ea. w/data pack
31094-510	5pk.
31094-520	5pk. w/data pack
31194	10pk. w/data pack



To order tollfree, call (800) 356-1688 ext.3).

## Standards for DRO Analysis (cont.)

### Jet Fuel A Standard

Commercial Jet Fuel A

5000ug/ml in 1ml methylene chloride.

<b>Cat# 31215</b>	<b>ea.</b>
<b>31215500</b>	<b>ea. w/data pack</b>
<b>31215-510</b>	<b>5pk.</b>
<b>31215-420</b>	<b>5pk. w/data pack</b>
<b>31315</b>	<b>10pk. w/data pack</b>

### Fuel Oil #4 Standard

Fuel Oil #4 is typically used in limited application where preheating of the fuel prior to burning cannot be utilized. The fuel is a blend of distillate (Fuel Oil #2) and residual (Fuel Oil #6) to meet ASTM viscosity specifications. This Fuel Oil #4 had a kinematic viscosity of 2.1.9 at 38°C (100°F). Kinematic viscosity measurement is performed using ASTM D-445.

5000ug/ml in 1 ml methylene chloride.

<b>Cat.# 31216</b>	<b>ea.</b>
<b>31216-500</b>	<b>ea. w/data pack</b>
<b>31216410</b>	<b>5pk.</b>
<b>31216-520</b>	<b>5pk. w/data pack</b>
<b>31316</b>	<b>10pk. w/data pack</b>

### Fuel Oil 45 Standard

Fuel Oil #5 is also typically used in applications where little or no preheating of the fuel prior to burning is utilized. A blend of distillate and residual, this Fuel Oil #5 had a kinematic viscosity of 106.5 at 38°C (100° F) using ASTM D-445.

5000ug/ml in 1ml methylene chloride.

<b>Cat.# 31217</b>	<b>ea.</b>
<b>31217-500</b>	<b>ea. w/data pack</b>
<b>31217-510</b>	<b>5pk.</b>
<b>31217-520</b>	<b>5pk. w/data pack</b>
<b>31317</b>	<b>10pk. w/data pack</b>

### Fuel oil #6 Standard

This oil, also called Bunker C or residual, is a black viscous fuel. Applications where it may be used all require the ability to preheat the fuel prior to pumping and burning.

5000ug/ml in 1ml methylene chloride.

<b>Cat.# 31218</b>	<b>ea.</b>
<b>31218-500</b>	<b>ea. w/data pack</b>
<b>31218-510</b>	<b>5pk.</b>
<b>31218-520</b>	<b>5pk. w/data pack</b>
<b>31318</b>	<b>10pk. w/data pack</b>

## Military Fuel Standards

With the mandated clean-up of military sites, the need for standards of these types has increased. The two most common aviation fuel types used today in the military are JP-4 and JP-5. The two standards listed are available from materials received from Army stocks.

### JP-4 Military Fuel Standard

5000ug/ml in 1 ml methylene chloride.

<b>Cat.# 31219</b>	<b>ea.</b>
<b>31219-500</b>	<b>ea. w/data pack</b>
<b>31219-510</b>	<b>5pk.</b>
<b>31219-520</b>	<b>5pk. w/data pack</b>
<b>31319</b>	<b>10pk. w/data pack</b>

### JP-5 Military Fuel Standard

5000ug/ml in 1 ml methylene chloride.

<b>Cat.# 31220</b>	<b>ea.</b>
<b>31220-500</b>	<b>ea. w/data pack</b>
<b>31220-510</b>	<b>5pk.</b>
<b>31220-520</b>	<b>5pk. w/data pack</b>
<b>31320</b>	<b>10pk. w/data pack</b>

## Diesel Surrogate 4% Internal Standards

10,000ug/ml in 1ml methylene chloride	Individual	Individual w/data pack	5pk.	5pk. w/data pack	10pk. w/data pack
p-terphenyl	31095	31095-500	31095-510	31095-520	31195
24-fluorobiphen	31096	31096-500	31096-510	31096-520	31196
o-terphenyl	31097	31097-500	31097-510	31097-520	31197
1-chlorooctadecane	31098	31098-500	31098-510	31098-520	31198

Recommended internal standard:

2000ug/ml in 1ml methylene chloride	Individual	Individual w/data pack	5pk.	5pk. w/data pack	10pk. w/data pack
5-a-androstane Standard	31065	31065-500	31065-510	31065-520	31165

20000ug/ml in 1ml acetone	Individual	Individual w/data pack	5pk.	5pk. w/data pack	10pk. w/data pack
o-terphenyl Standard	31066	31066-500	31066-510	31066-520	31166

## Weathered Petrochemical Standards

Restek is now offering as stock products, weathered petrochemical products to improve analytical accuracy. All of these standards are prepared from commercially acquired materials. The material is then weathered in the laboratory based upon a specific weight loss from the original weight of starting material. While we cannot duplicate all environmental factors, these standards may be useful in identification of the type of petrochemical detected.

### Unleaded Gasoline

These standards are prepared from a *single source (one refinery) product*. Samples of regular and premium grade unleaded gasoline were collected, then blended in equal volumes. The weathered materials indicate the percent weight loss from original starting material. These standards are prepared at 5000ug/ml in purge & trap grade methanol, 1ml per ampul.

#### Unleaded Gasoline Standard - (unweathered)

Cat&	<b>30096</b>	ea.
	<b>30096-500</b>	ea. w/data pack
	30096-510	5pk.
	30096-520	5pk. w/data pack
	30196	10pk. w/data pack

#### Unleaded Gas Standard - 25 % Weathered

Cat.#	30097	\$25 ea.
	30097-500	\$35 ea. w/data pack
	30097-5 10	\$112.50 Spk.
	30097-520	\$125 5pk. w/data pack
	30197	\$225 10pk. w/data pack

#### Unleaded Gas Standard - 50% Weathered

Cat.#	30098	ea.
	30098-500	ea. w/data pack
	30098-510	5pk.
	30098-520	5pk. w/data pack
	30198	10pk. w/data pack

#### Unleaded Gas Standard - 75% Weathered

Cat.#	30099	\$25 ea.
	30099-500	\$35 ea. w/data pack
	30099-5 10	\$112.50 Spk.
	30099-520	\$125 5pk. w/data pack
	30199	\$225 10pk. w/data pack

#### Weathered Gasoline Kit

Contains 1ml each of catalog #'s:

Cat.#	30096	Unleaded Gasoline Std.
	30097	Unleaded Gas Standard - 25 % Weathered
	30098	Unleaded Gas Standard - 50% Weathered
	30099	Unleaded Gas Standard - 75 % Weathered

30100	Weathered Gasoline Kit: \$85
30100-500	Weathered Gasoline Kit w/data pack:

### Diesel Fuel #2

These standards are prepared from a *single source (one refinery) product*. The weathered materials indicate the percent weight loss from original starting material. These standards are prepared at 5000ug/ml in methylene chloride, 1ml per ampul.

#### Diesel Fuel #2 Standard - (unweathered)

Cat.#	31233	ea.
	31233-500	ea. w/data pack
	31233-510	Spk.
	31233-520	5pk. w/data pack
	31333	10pk. w/data pack

#### Diesel Fuel #2 Standard - 25% Weathered

Cat.#	31234	ea.
	31234-500	ea. w/data pack
	31234-510	5pk.
	31234-520	5pk. w/data pack
	31334	10pk. w/data pack

#### Diesel Fuel #2 Standard - 50% Weathered

Cat.+!	31235	ea.
	31235-500	ea. w/data pack
	31235-510	5pk.
	31235-520	5pk. w/data pack
	313.7	10 pk. w/data pack

#### Diesel Fuel #2 Standard - 75% Weathered

Cat.#	31236	ea.
	3 1236-500	ea. w/data pack
	<b>31236-510</b>	<b>\$5k</b>
	3 1236-520	5pk. w/data pack
	31336	10pk. w/data pack

#### Weathered Diesel Fuel #2 Kit

Contains 1 ml each of catalog #'s:

Cat.#	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

31239	Weathered Diesel Fuel #2 Kit:
31239-500	Weathered Diesel Fuel #2 Kit w/data pack:

## Kerosene

These standards are prepared from a single source (one *refinery*) *product*. The weathered materials indicate the percent weight loss from original starting material. These standards are prepared at 5000ug/ml in methylene chloride, 1ml per ampul.

### *Kerosene Standard - (unweathered)*

Cat.# 31229	ea.
31229-500	ea. w/data pack
31229610	5pk.
31229620	5pk. w/data pack
31329	10pk. w/data pack

### *Kerosene Standard - 25% Weathered*

Cat.# 31230	ea.
31230-500	ea. w/data pack
31230-510	5pk.
31230-520	5pk. w/data pack
31330	10pk. w/data pack

### *Kerosene Standard - 50% Weathered*

Cat& 31231	ea.
31231-500	ea. w/data pack
31231-610	5pk.
31231-620	5pk. w/data pack
31331	10pk. w/data pack

### *Kerosene Standard - 75% Weathered*

Cat.+/ 31232	ea.
31232-500	ea. w/data pack
31232-510	5pk.
31232-520	5pk. w/data pack
31332	10pk. w/data pack

### *Weathered Kerosene Kit*

Contains 1 ml each of catalog #'s:

Cat.# 31229	Kerosene Standard
31230	Kerosene Standard - 25% Weathered
31231	Kerosene Standard - 50 % Weathered
31232	Kerosene Standard - 75% Weathered

31238	Weathered Kerosene Kit:
31238-500	Weat hered Kerosene Kit w/ data pack:

## Fuel Oil Degradation Test

Subsurface degradation of fuel oil spills can be estimated by examining the ratio of C17/pristane and C18/phytane<sup>1</sup>. The state of Massachusetts requires that these two ratios be reported in their UST program. To assist in identifying these four compounds from the complex fuel oil analysis, we are now offering a product that contains these compounds for retention time determination.

<sup>1</sup> "Interpretation of Gas Chromatographic Data in Subsurface Hydrocarbon Investigations", R. Senn and M. Johnson, *Ground Water Monitoring Review*, Winter 1987.

### *Fuel Oil Degradation Mix*

heptadecane  
octadecane  
pristane (2,6,10,14-tetramethylpentadecane)  
phytane (2,6,10,14-tetramethylhexadecane)

Prepared at 2000ug/ml each in 1ml methylene chloride, 1ml per ampul.

Cat.# 31240	ea.
31240-500	ea. w/data pack
31240-510	5pk.
31240-520	5pk. w/data pack
31340	10pk. w/data pack

Additional calibration, internal standards/surrogate, and weathered petroleum mixtures are available as custom products. For more information on custom TPH mixtures, please contact Restek's chemical standard group at

(800) 356-4688.



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