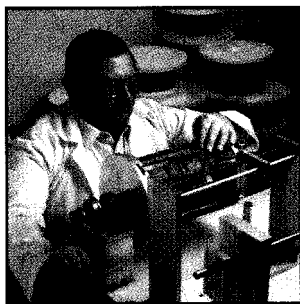


*What sets Restek apart from the competition?*

*Quality and Innovation you can count on!*

### ■ High Quality Fused Silica Tubing

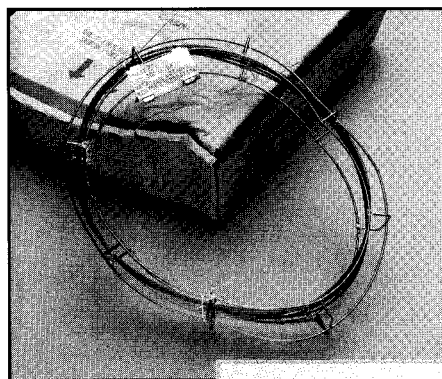


A column's quality is only as good as the materials from which it is manufactured. Restek uses only high quality fused silica tubing for our Rtx capillary columns. We constantly monitor the strength of our tubing by using a manual winding system which assures that every meter of every column is checked. Our tubing suppliers often say, "If our tubing is strong enough for Restek, it's strong enough for anybody."

We don't know if the column in the picture to the right was run over by a truck or crushed beneath a heavy crate during shipping, but we do know it survived! The cage is badly bent and the box is severely deformed. However, the column wasn't broken or damaged in any way. Why? Because we engineered our cage to be a survivor!

### ■ Innovative Cage Design

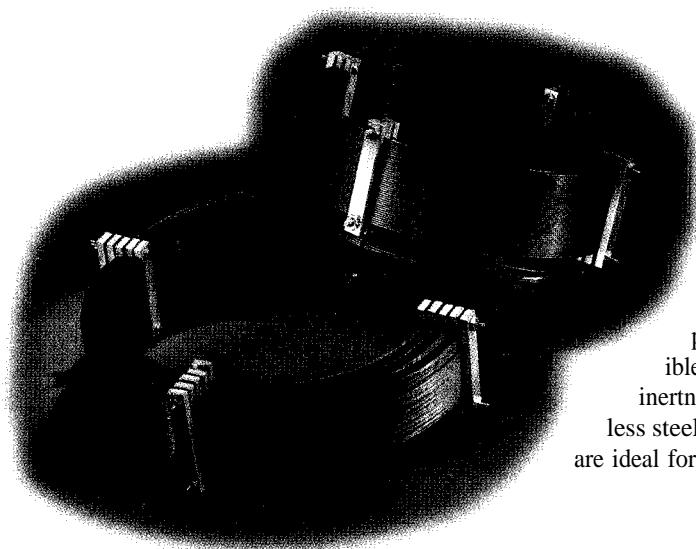
To keep your column safe we have designed a stainless steel cage to completely surround the column. The column is suspended in the cage using high temperature string that acts as a shock absorber. At no time does the fused silica tubing come into contact with the metal support of the cage. Spontaneous breakage can occur when fused silica tubing contacts sharp metal edges on the column cage. Our fused silica column cage is 7.65" (19.4 cm) in diameter and fits into virtually any GC oven.



*Just how strong is Restek's column cage?*

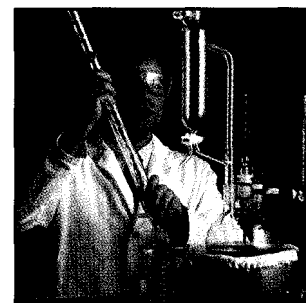
### ■ Unbreakable Metal Capillary Columns

However, we realize that there are some harsh environments or special applications where fused silica tubing may not be the ideal material. For these circumstances Restek offers MXT capillary columns. MXT columns are made from unbreakable, thin wall, stainless steel that has been treated with our SilcosteeP process. This process deposits a submicron layer of flexible fused silica on the inside of the tubing giving it the same inertness as an Rtx column, but with the ruggedness of stainless steel. MXT columns are caged in small diameter coils that are ideal for portable or process GCs.



## ■ High Quality Polymers

In addition to the tubing material, high quality polymers used for deactivation and stationary phases are also necessary for making the world's best capillary columns. All of the polymers that go into Restek's Rx and MXT columns are synthesized to exacting standards in our own laboratory to ensure the highest quality and consistency. Any residual catalyst, which can cause degradation and increased bleed, is removed from the polymer. The polymer is then carefully fractionated to remove low molecular weight fragments. This provides a tight mono-modal distribution and further reduces column bleed. Every polymer is fully characterized to ensure long-term reproducibility. Characterization testing includes Refractive Index (RI), Fournier Transform Infrared Spectroscopy (FTIR), Kovats Retention Indices, % crosslinking, efficiency, and a five-day thermal bake-out to ensure column longevity. Each polymer lot is tracked in an extensive database for future reference and guarantees that the column you buy today will meet the same specifications of the column you bought last week or last year.



## ■ Thorough Testing of Every Column

The final quality assurance test on every Restek capillary column confirms that each column has the necessary inertness and efficiency. Each column is also evaluated for bleed at its maximum operating temperature to ensure that every column exhibits the lowest bleed possible.

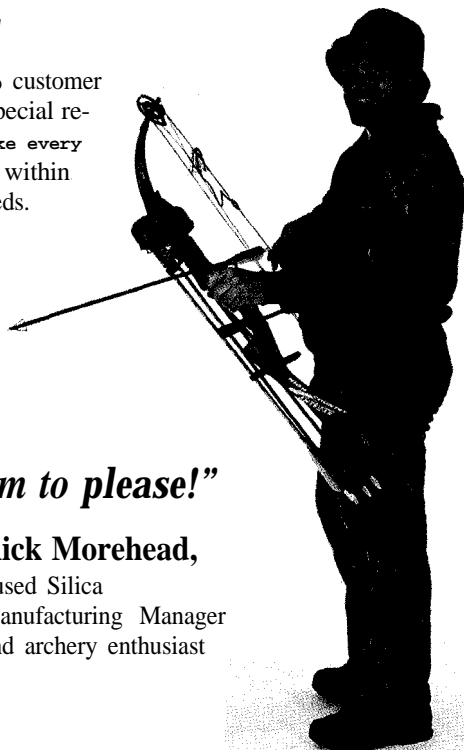


## ■ Functional, Environmentally Safe Packaging

The Restek difference is apparent before the column box is even opened. Instead of a logo or an advertisement on the top of the compact, recyclable corrugated cardboard column box, we've printed a useful Column Service Record. This allows the analyst to easily track column installation and GC maintenance for troubleshooting purposes. By having the column history on hand for instant review, quicker decisions can be made and guesswork eliminated.

## ■ What we can do for you

At Restek we are committed to 100% customer satisfaction in every way. Have a special request? Call us! It is our policy to take every request seriously, and do everything within our power to meet the customers' needs.



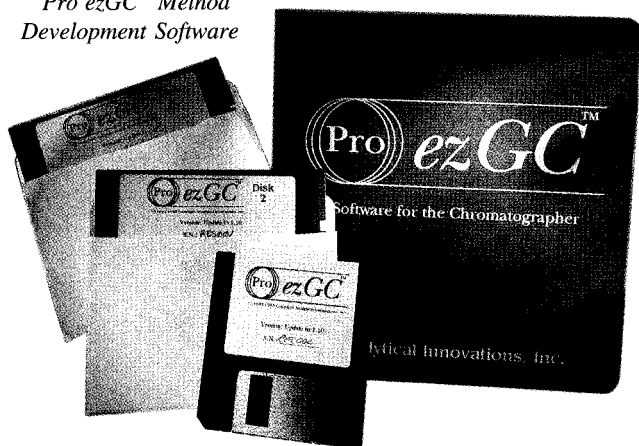
*"We aim to please!"*

**Rick Morehead,**  
Fused Silica  
Manufacturing Manager  
and archery enthusiast

How do I know  
**CLICK COLUMN**  
to use for my  
specific analysis?

Follow Restek's Column  
Selection suggestions or call  
your local distributor for help

Pro ezGC™ Method  
Development Software



### ■ Column Selection

#### ■ How do I know which column to use?

Some analysts do not have the freedom to choose a different type of column because their analytical methods dictate one specific column. Other analysts may keep using the same column because it works, even though it may not be the best choice for their samples. But, how was the current column chosen? Was the column choice determined by careful investigation of all column parameters and subsequent optimization for the specific application? Or, was the column chosen because it happened to be installed in the GC during method development?

Restek offers over 900 different capillary columns. If you do not know exactly which column to choose, selection can be a frustrating hit or miss decision. Trying to determine which column is ideal for your specific analysis can be difficult. This selection guide contains information on column materials and parameters such as stationary phase polarity, internal diameter, film thickness, and column length, that will help you choose the proper column for a particular sample. In addition, it might encourage you to carefully examine whether the column you already use is the best choice, or whether improvements in resolution, speed of analysis, and quantitation could be achieved by using a different type of capillary column.

#### ■ Pro ezGC Method Development Software

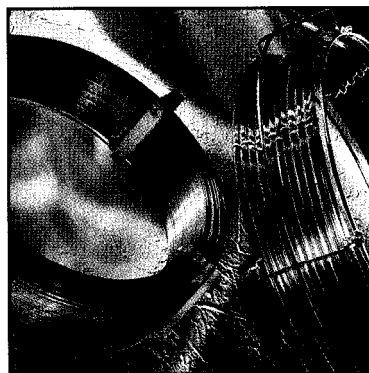
Take the guesswork out of selecting the best column and conditions for your GC analysis with *Pro ezGC* software for Windows. Increase the productivity of your existing gas chromatographs by improving separations and shortening analysis time with optimized temperature and carrier gas programs. *Pro ezGC* will save you time and money by greatly enhancing your productivity and increasing sample throughput. Take advantage of this powerful GC optimization tool today!

**Pro ezGC for Windows ver. 2:** cat.# 21487 ea.

**Pro ezGC (DOS) to Pro ezGC for Windows ver. 2 Upgrade:** cat.# 21486 ea.

#### ■ Column Materials

Both fused silica and stainless steel MXT columns offer a high degree of inertness and excellent flexibility. While the two column materials can service many of the same needs, the advent of MXT columns has expanded the utility of capillary columns. They are resistant to abrasion and scratches and show little risk of spontaneous breakage at any GC operating temperature. They can also be coiled into a smaller diameter to fit into portable field equipment. Under harsh operating conditions, stainless steel MXT columns are the best choice. When breakage is less of a concern (stationary bench top equipment) and it is advantageous to be able to identify non-volatile contamination inside the column, fused silica is the best choice. Fused silica is also much more amenable to the addition of a guard column using a press-tight connector.



#### ■ GC Columns

## Stationary Phase Selectivity

When purchasing a new column, the most important consideration is the stationary phase. There are many different interactions that occur between the analytes and the functional groups of the stationary phase. These interactions contribute more to the overall results of the analysis than any other factor in the column. That is why it is important to understand as much about your column and sample as possible.

Table I shows the chemical structure of most common stationary phases. Changes in selectivity can be observed by using a column with different functional groups as well as increasing the percentage of substitution of those functional groups. The non-polar Rtx-1 phase will preferentially retain non-polar compounds compared to polar compounds such as alcohols. As non-polar methyl units are substituted with polar functionalities such as phenyl and cyanopropyl units, the selectivity of the column shifts towards more polar compounds. In turn, non-polar compounds are retained less as there are less overall methyl units for the non-polar compounds to interact with. The Rtx-200 stationary phase contains trifluoropropyl units which provide high selectivity for analytes containing lone pair electrons, such as nitro and carbonyl groups. Polyethylene glycol columns, such as Stabilwax and Rtx/MXT-WAX, are polar and are highly selective towards polar compounds such as alcohols.

**Table 2**

Comparison of structures, polarities, properties, and uses for each capillary column phase listed in order of increasing polarity.

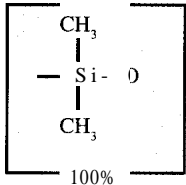
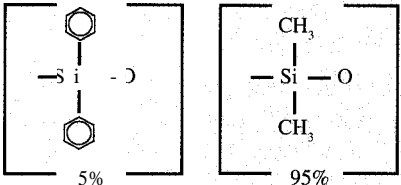
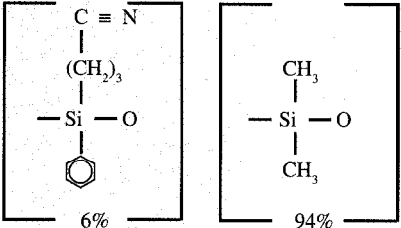
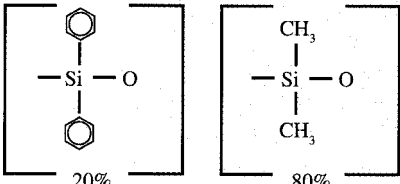
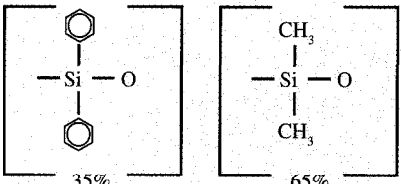
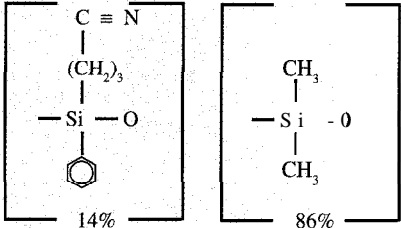
<p>Rtx/MXT-1 100% dimethyl polysiloxane</p>  <p>100%</p> <p><b>Polarity:</b> non-polar <b>Uses:</b> solvents, petroleum products, pharmaceutical samples, waxes</p>	<p>Rtx/MXT/XTI-5 5% diphenyl - 95% dimethyl polysiloxane</p>  <p>5%                      95%</p> <p><b>Polarity:</b> non-polar <b>Uses:</b> flavors, environmental samples, aromatic hydrocarbons</p>	<p>Rtx/MXT-1301, Rtx/MXT-624 6% cyanopropylphenyl 94% dimethyl polysiloxane</p>  <p>6%                      94%</p> <p><b>Polarity:</b> slightly polar <b>Uses:</b> volatile compounds, insecticides, residue solvents in pharmaceutical products</p>
<p>Rtx/MXT-20 20% diphenyl - 80% dimethyl polysiloxane</p>  <p>20%                      80%</p> <p><b>Polarity:</b> slightly polar <b>Uses:</b> volatile compounds, alcohols</p>	<p>Rtx/MXT-35 35% diphenyl - 65% dimethyl polysiloxane</p>  <p>35%                      65%</p> <p><b>Polarity:</b> intermediately polar <b>Uses:</b> pesticides, Aroclors, amines, nitrogen containing herbicides</p>	<p>Rtx/MXT-1701 14% cyanopropylphenyl 86% dimethyl polysiloxane</p>  <p>14%                      86%</p> <p><b>Polarity:</b> intermediately polar <b>Uses:</b> pesticides, Aroclors, alcohols, oxygenates</p>

Table I (cont.) Table I, listing column phase structures, is continued on page 38.

**Table I** (cont.) Table I, listing column phase structures continued from page 38.

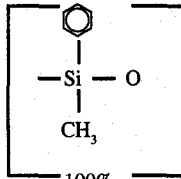
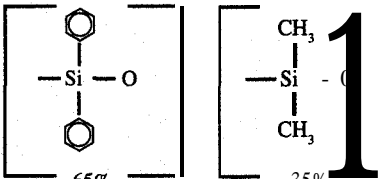
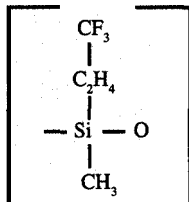
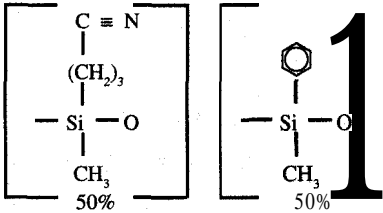
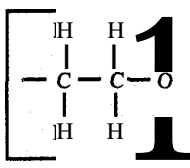
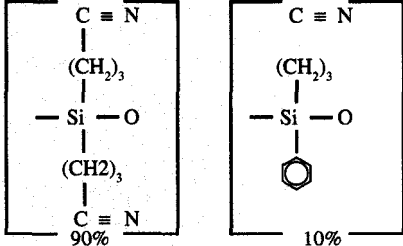
<p>Rtx/XT-50 50% phenyl 50% methyl polysiloxane</p>  <p><b>Polarity:</b> <i>intermediately polar</i> <b>Uses:</b> <i>triglycerides, phthalate esters, steroids, phenols</i></p>	<p>Rtx/MXT-65TG 65% diphenyl - 35% dimethyl polysiloxane</p>  <p><b>Polarity:</b> <i>intermediately polar</i> <b>Uses:</b> <i>triglycerides, rosin acids, free fatty acids</i></p>	<p>RtxYMXT@-200 trifluoropropylmethyl polysiloxane</p>  <p><b>Polarity:</b> <i>selective for lone pair electrons</i> <b>Uses:</b> <i>environmental samples, solvents, Freons, drugs, ketones, alcohols</i></p>
<p>Rtx®-225 50% cyanopropylphenyl 50% phenylmethyl polysiloxane</p>  <p><b>Polarity:</b> <i>polar</i> <b>Uses:</b> <i>FAMES, carbohydrates</i></p>	<p>Stabilwax®/MXT®-WAX Carbowax® PEG</p>  <p><b>Polarity:</b> <i>polar</i> <b>Uses:</b> <i>FAMES, flavors, acids, amines, solvents, xylene isomers</i></p>	<p>Rtx®-2330 90% biscyanopropyl 10% cyanopropylphenyl polysiloxane</p>  <p><b>Polarity:</b> <i>very polar</i> <b>Uses:</b> <i>FAMES, cis/trans &amp; dioxin isomers, rosin acids</i></p>

Table II shows retention indices for the stationary phases shown in Table I. Retention indices are mathematical derivations indicating the elution point of a probe with respect to two hydrocarbons. For example, if the retention index for benzene was 650, then it would elute halfway between C6 (RI=600) and C7 (RI=700).

□ Table 11

The retention indices for each phase illustrate the differences in selectivity for a variety of compounds.

Phase	Benzene	Butanol	Pentanone	Nitropropane
Rtx/MXT- 1	651	651	667	705
Rtx/MXT-5/ XTI-5/Rtx-5MS	667	667	689	743
Rtx/MXT-1301/624	689	729	739	816
Rtx/MXT-20	711	704	740	820
Rtx/MXT-35	746	733	773	867
Rtx/MXT-1701	721	778	784	881
Rtx/MXT-50	778	769	813	921
Rtx/MXT-65TG	794	779	825	938
Rtx/MXT-200	738	758	884	980
Rtx-225	847	937	958	
	963	1158	998	1230



**Rick Morehead**  
Fused Silica  
Manufacturing Manager

## □ Internal Diameter (ID)

When selecting an internal diameter, sample concentration and instrumentation must be considered. If the concentration of the sample exceeds the column's capacity, loss of resolution, poor reproducibility, and peak distortion will result. Table III shows typical column characteristics. Note the limited capacity of narrow bore columns (0.18mm ID <50ng) versus the high capacity of 0.53mm ID columns (2000ng). Also, 0.53mm ID columns are recommended in high flow situations, such as with a purge and trap unit. Conversely, narrow bore columns can be installed directly into a MSD because of the limited flow at optimum linear velocity.

□ **Table 111**

*Typical Column Characteristics*

Column ID	0.18mm	0.25mm	0.32mm	0.53mm
Helium (flow: 20cm/sec.)	0.3cc/min.	0.7cc/min.	1.2cc/min.	2.6cc/min.
Hydrogen (flow: 40cm/sec.)	0.6cc/min.	1.4cc/min.	2.4cc/min.	2.6cc/min.
Sample Capacity	<50ng	50-100ng	400-500ng	1000-2000ng
Trenzahl Values	40	30	25	15
Theoretical Plates/Meter	5300	3300	2700	1600
Effective Plates/Meter	3900	2500	2100	1200

## □ Film Thickness

Film thickness has a direct effect on the retention and elution temperature for each sample compound. Thicker films retain compounds longer by maximizing the amount of time the compounds spend in the stationary phase. Thinner films retain compounds less by minimizing the amount of time the compounds spend in the stationary phase. Therefore, very volatile compounds should be analyzed on thick filmed columns to increase the time the compounds spend in the column and allow them to separate. High molecular weight compounds such as triglycerides must be analyzed on a thin film column. This minimizes the amount of time the analytes stay in the column and provide low bleed at elevated temperatures which are required when analyzing high molecular weight compounds.

Film thickness directly effects phase ratio (beta) which is an important consideration when changing internal diameter. When internal diameter increases, film thickness (df) must increase in order to provide the similar resolution and retention. Table IV shows beta values for common dimensions of columns. Similar values indicate similar elution for different IDs.

- **Table IV**

*Common beta Values*

Column ID	0.10um	0.25um	0.50um	1.00um	1.50um	3.00um	5.00um
0.18mm	450	180	90	45	30	15	9
0.25mm	625	250	125	63	42	21	13
0.32mm	so0	320		80	53	27	16
0.53mm	1325	530	265	128	88	43	27



*Kristi*  
Assistant Supervisor,  
Fused Silica Manufacturing

The following chromatograms show a sample containing low boiling compounds analyzed on a 0.25, 1.0, and 5.0 $\mu$ m column with all other variables held constant. Notice that the 0.25 $\mu$ m column does not resolve butanol from benzene (peaks 1 & 2). The 1.0 $\mu$ m column provides about 80% resolution of this pair. Note that the retention times of the compounds eluting on the 0.25 $\mu$ m column more than double on the 1.0 $\mu$ m column. Now, compare the 5.0 $\mu$ m to the 0.25 and 1.0 $\mu$ m columns. The resolution between butanol and benzene (peaks 1 & 2) is not any better than the 1.0 $\mu$ m column, and the retention times have increased six times over the 0.25 $\mu$ m. For this particular sample, the 1.0 $\mu$ m column is best. The resolution is better than the 0.25 $\mu$ m column and the 5.0 $\mu$ m column does not offer any additional improvements. If our true interest was in resolving the compounds prior to butanol (peak 1), then the 5.0 $\mu$ m column would be the preferred film thickness.

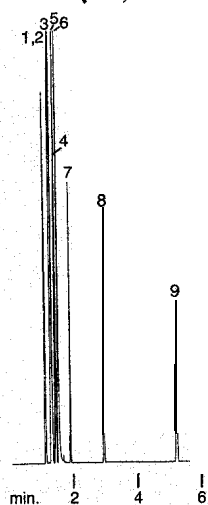
Would you like  
to know more about  
**WHICH COLUMN**  
to use for your  
analyses?

Have one of Restek's chromatography seminars presented in-house. Call your local distributor for information.

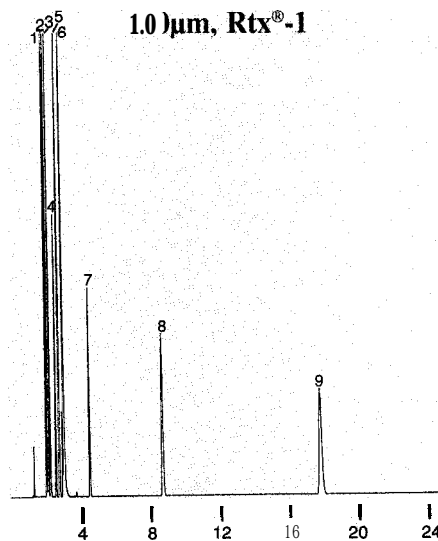
### Film Thickness Effects

A sample containing low boiling components shows the differences in resolution between 0.25, 1.0, and 5.0 $\mu$ m columns. The 1.0 $\mu$ m offers better resolution than the 0.25 $\mu$ m and the 5.0 $\mu$ m does not offer any further improvements for compounds eluting after C6.

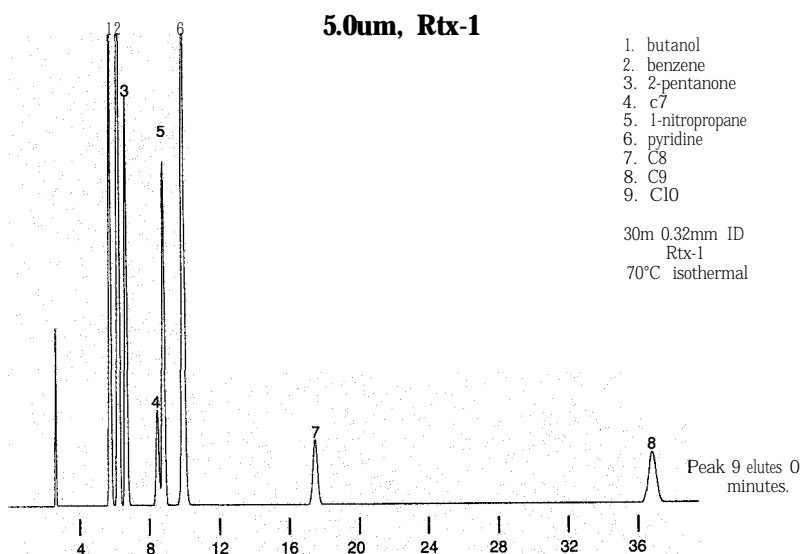
0.25 $\mu$ m, Rtx-1



1.0  $\mu$ m, Rtx®-1



5.0 $\mu$ m, Rtx-1



1. butanol
2. benzene
3. 2-pentanone
4. c7
5. 1-nitropropane
6. pyridine
7. C8
8. C9
9. C10

30m 0.32mm ID  
Rtx-1  
70°C isothermal

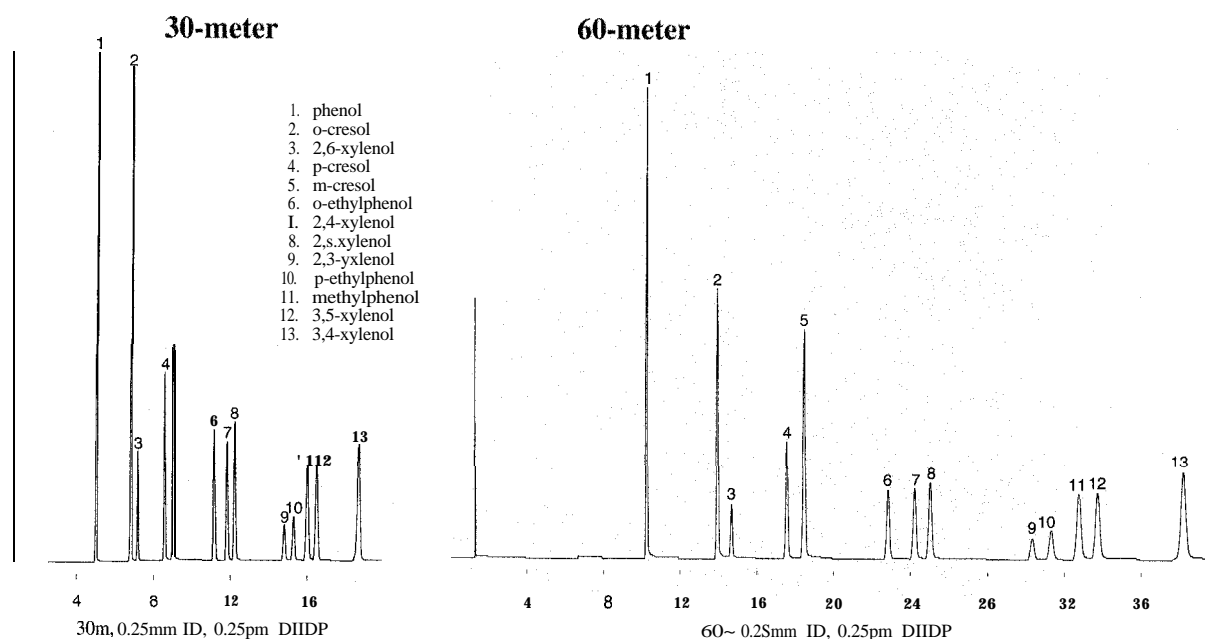
## - Length

Longer columns provide more resolving power, increase analysis times, and cost more. Often an analyst must determine whether the amount of resolution increase is worth the extra time and expense. The benefits of using longer columns differ depending on whether isothermal or temperature programmed analyses are being performed.

For an isothermal analysis, retention time is dependent on length of the column. If the column length is doubled, the analysis time will double as well. However, the increase in resolution is only approximately 40%, since resolution is calculated using the square root of the length.

### isothermal Analysis

When using a 60-meter column in an isothermal analysis, the resolution increases but the analysis time is approximately double that of the 30-meter column.



### LENGTH EFFECTS

Length affects resolution and speed of analysis.

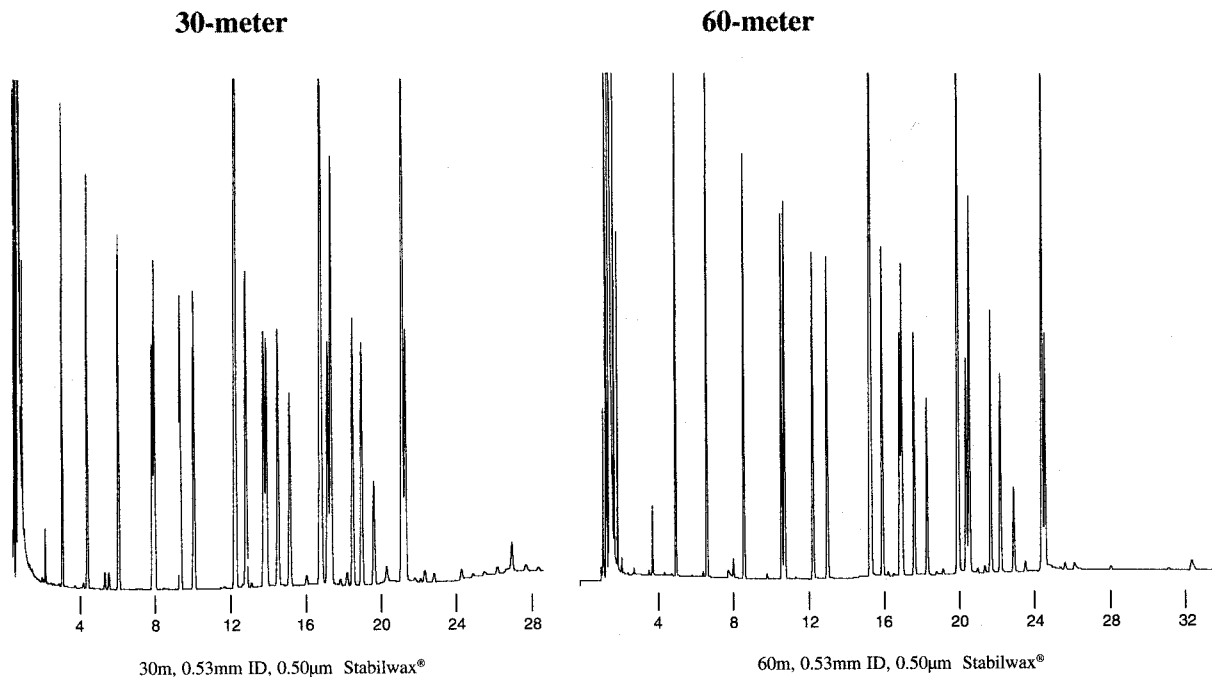
$$\text{Resolution} = \frac{1}{4} \sqrt{\frac{L}{h}} \times \frac{k}{k+1} \times \frac{\alpha-1}{\alpha}$$

L = length  
h = HETP  
k = capacity factor  
α = selectivity

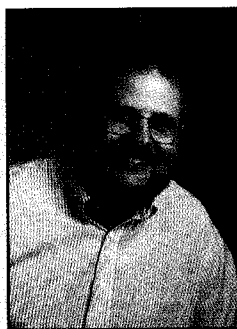
In the case of temperature programmed analyses, retention times are more dependent on temperature than column length. The increase in resolution is the same as an isothermal run, but there is only a marginal increase in analysis time.

### Temperature Programmed Analysis

When using temperature programming, 60-meter columns provide better resolution than 30-meter columns without a significant increase in analysis time.



30 vs. 60m column  
 Bacterial Acid Methyl Esters  
 130°C (hold 2 min.) to 250°C @ 4°C/min.



*Marty Stern*  
*Fused Silica*  
*Manufacturing Chemist*

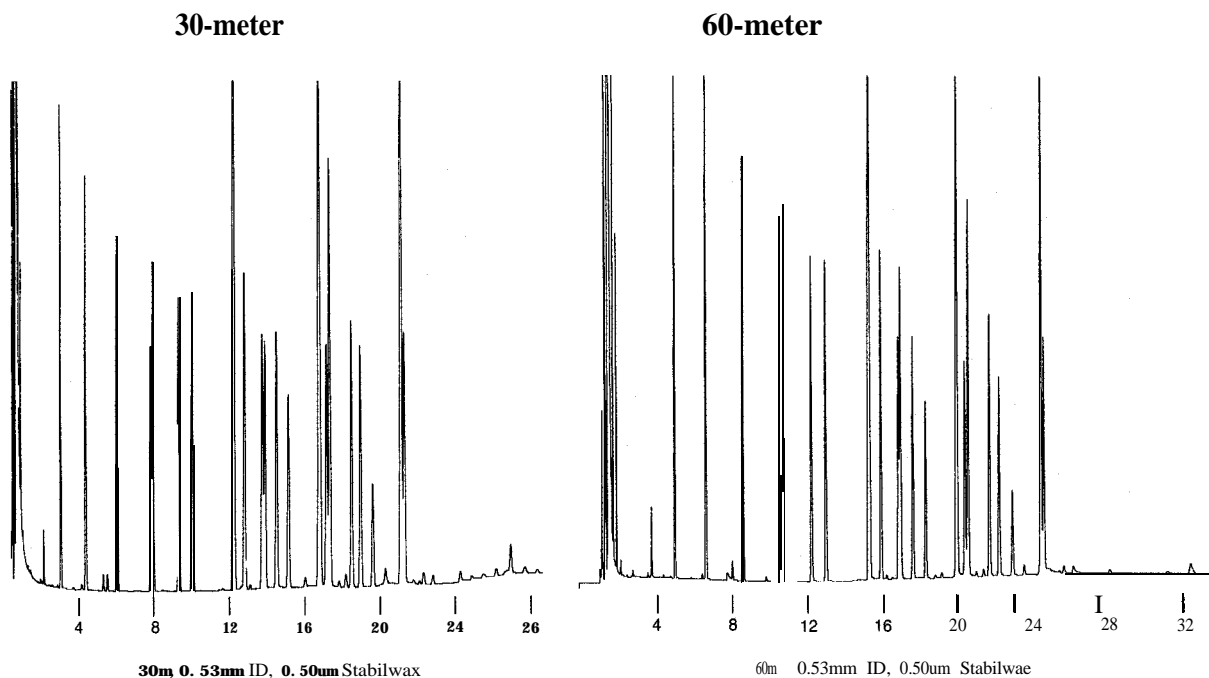


*Bob Paloskey*  
*QA Assistant*  
*Supervisor*

In the case of temperature programmed analyses, retention times are more dependent on temperature than column length. The increase in resolution is the same as an isothermal run, but there is only a marginal increase in analysis time.

## Temperature Programmed Analysis

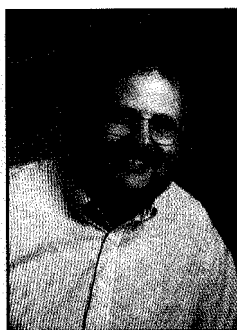
When using temperature programming, 60-meter columns provide better resolution than 30-meter columns without a significant increase in analysis time.



30m 0.53mm ID, 0.50um Stabilwax

60m 0.53mm ID, 0.50um Stabilwax

**30vs. 60m column**  
Bacterial Acid Methyl Esters  
130°C (hold 2 min.) to 250°C @ 4W/min.



*Marty*  
*Fused Silica*  
*Manufacturing Chemist*



*Bob*  
*QA Assistant*  
*Supervisor*

## ■ Custom Phases

We have over 35 custom stationary phases in stock. Over the years, we have developed proprietary phases for specific analyst needs as well as phases written into methods. If you don't see it in the catalog, call us. Put our experienced synthesis group to work for you.

## ■ Custom Column Dimensions

Need a specific film thickness? Locked into a method that uses a 42 meter column? If you need it, we can make it. Restek has shipped lengths from 3 to 150 meters, and film thickness' from .1pm to 10pm. If it is physically possible, we'll try it.

## ■ Special Testing

Set the specifications for your own capillary column. Restek's knowledgeable chemists will prepare a special test mix to evaluate your column and ensure that it meets your specifications. We have provided specially tested columns to environmental testing labs, petrochemical companies, and other chromatographers using test mixtures that address their specific analytical requirements.

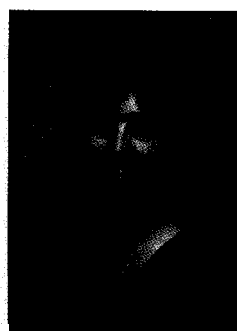
### Custom Phases (currently in stock)

Apolane 87  
 Apiezon' L  
 Butane 1.4 diol Succinate  
 Carbowax 300 (G20)  
 Carbowax 600  
 Carbowax 1000 (G14)  
 Carbowax 8000  
 Carbowax 20M  
 DEGS (G4)  
 DC-550 (G28)  
 DIIDP (G24)  
 Igepal CO-880@  
 OS-124  
 OS-138  
 OV"-202 (G6)  
 OV-275  
 OV-351 (G35)  
 /3p' oxydipropionitrile  
 Rt-2330 (G8)  
 Rt-2340  
 SE@-30 (G1,G2)  
 SE@-54 (G36)  
 Silar@ 5CP  
 Silar@ 9CP (G8)  
 SilaY 10CP  
 SP-1000  
 SP-2401 (G6)  
 Squalane  
 Squalene  
 Superox 20M  
 TCEP  
 Tricresyl phosphate  
 UCON SOHB  
 XE-60  
 W-1150

### Special Tests                      suffix

>90% Coating Efficiency	-001
Benzidines and Phenols	-002
Volatile organics	-004
Hexamethylenediamine	
impurities	-005
Chlorinated pesticides	-006
Morpholine	-007
Free Fatty Acids	-008
Endrin Breakdown	-009
MEA	-010
DEA	-011
Endrin/DDT Breakdown	-012
Methylamines	-013
Ethanolamines	-014
DETA	-015
Mixed Amines	-016
Certified gas concentration	-017
Soybean oil	-018

Chromatographers often say the "common" phases for capillary GC are 100% dimethyl polysiloxane, 5% diphenyl 95% dimethyl polysiloxane, and polyethylene glycol (Waxes). At Restek, we offer four different types of Rtx-1 phases, four different types of Rtx-5 phases, and four different types of wax phases-all tailored to meet the specific needs of the customer. If we don't have what you need, let us know-chances are we will offer it soon.

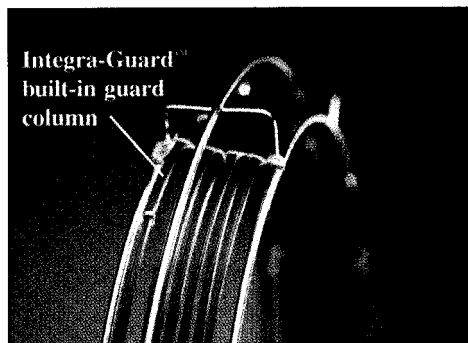


*Cindy Ross*  
**Customer Response Team**  
**Group Leader**

*Guard columns  
WITHOUT press-  
tight connections-*

*protecting your  
analytical column has  
never been this easy!*

**•1 Innovative Integra-Guard Columns**



How many times has it been said about press-fit connectors, "Some people swear by them.. others swear at them"? For many analysts, the art of attaching a guard column to an analytical column is a mystery. Restek's chemists have discovered the solution to this mystery-the most reliable connection is no connection at all! No guard column system is more permanent than one continuous length of tubing containing both the guard column and the analytical column.

Restek now offers a wide variety of Integra-Guard™ capillary columns with a guaranteed leak-free connection! The column is tied using high temperature string with the guard column set apart from the analytical column. The transition area between the columns is the point at which the guard column ends and the analytical column begins. The entire setup is suspended in our unique "crush-free" cage that prevents the column from coming in contact with anything that could damage it.

The Integra-Guard column is so economical that we challenge you to beat our price with that of a conventional connection, even if you assemble it yourself. If you are currently using a guard column or considering one for the future, call your local distributor today and ask about our Integra-Guard columns.

*Ordering is easy. Just add the appropriate suffix number and price to the analytical column's catalog number and price. For example, a 30m, 0.25mm ID, 0.25um Rt@-5 with a 5-meter Integra-Guard column is cat.# 10223-124.*

mm ID	Length	Suffix #
0.25	5m	-124
	10m	-127
0.32	5m	-125
	10m	-128
0.53	5m	-126
	10m	-129

***Restek-bringing you  
breakthroughs in  
column protection!***

**Don McCandless,**  
Marketing Director and  
5th degree black belt in  
Isshinryu karate.

