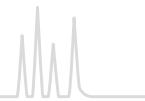
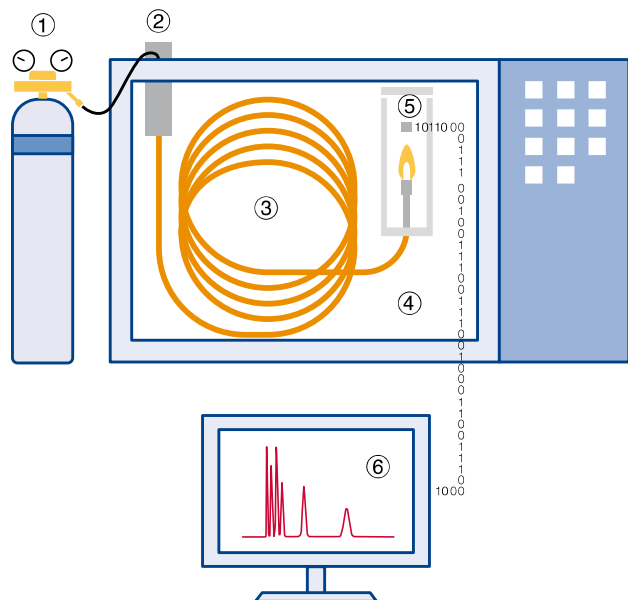


## Contents

|  |     |
|--|-----|
| Basics.....  | 300 |
| USP listing.....                                     | 302 |
| Additional information for GC columns.....           | 303 |
| Separation properties of OPTIMA® phases.....         | 305 |
| Summary of MN phases for GC.....                     | 306 |
| OPTIMA® · nonpolar capillary columns.....            | 310 |
| OPTIMA® · weakly polar capillary columns.....        | 314 |
| OPTIMA® δ · phases with autoselectivity.....         | 318 |
| OPTIMA® · medium polar capillary columns.....        | 321 |
| OPTIMA® · polar capillary columns.....               | 328 |
| PERMABOND® capillary columns.....                    | 336 |
| Special GC columns overview.....                     | 339 |
| Capillary columns for Fast GC.....                   | 340 |
| Capillary columns for enantiomer separation.....     | 342 |
| Capillary columns for biodiesel analysis.....        | 346 |
| Capillary columns for triglyceride analysis.....     | 348 |
| Capillary columns for high temperature GC.....       | 349 |
| Capillary columns for amine separation.....          | 350 |
| Capillary columns for hydrocarbons.....              | 352 |
| Capillary columns for silane · DEG.....              | 354 |
| Fused silica capillaries.....                        | 355 |
| Reagents / methods for derivatization.....           | 357 |
| Reagents / methods for acylation.....                | 359 |
| Reagents / methods for alkylation / methylation..... | 361 |
| Reagents / methods for silylation.....               | 362 |
| Derivatization procedures.....                       | 367 |
| Test mixtures for GC capillary columns.....          | 368 |
| Ferrules for capillary columns.....                  | 370 |
| Septa for capillary column.....                      | 371 |
| Accessories for capillary columns.....               | 372 |
| General accessories.....                             | 373 |



## The GC system



### Configuration of a gas chromatograph

- ① Gas supply: carrier gas and - if necessary - detector gases e.g., for FID detector
- ② Sample injector: During direct injection, the sample is applied to the column without touching any other parts made from glass or metal (on-column injection). During indirect injection, the sample is brought into an evaporator and is then transferred onto the column either completely, or partially (split technique). Both techniques allow working at low temperatures, high temperatures and the use of temperature programming.
- ③ Capillary column: the heart of the GC system
- ④ Temperature-controlled oven
- ⑤ Detector: indicates a substance by generating an electrical signal (response). Some detectors are specific for certain classes of substances or for certain elements (e.g., P, N).
- ⑥ Data station for configuration of a gas chromatograph

### The separation process

Chromatographic separation is achieved through continuous distribution of each sample component between the mobile and the stationary phase:

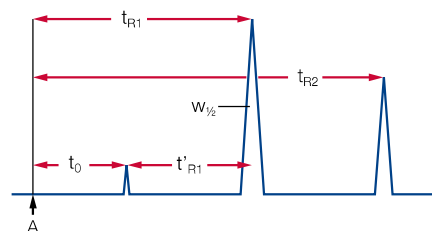
In GC, the mobile phase is always a gas, mostly either He, N<sub>2</sub> or H<sub>2</sub>.

The stationary phase is often a viscous, gum-like liquid adhered to the inner wall of a capillary column (WCOT = Wall Coated Open Tubular).

Transport of the components occurs exclusively in the mobile phase, while separation only takes place in the stationary phase. The quality of a separation (resolution) depends on the residence time of the components within the stationary phase and on the rate of interactions. The type of interaction between component and phase (selectivity) is determined by the functional groups of the stationary phase. The polarity of the phase is a function of its substituents.

### The chromatogram

A chromatogram consists of a base line and a number of peaks. The area of a peak allows quantitative determinations:



A: starting point of a chromatogram = time of injection of a dissolved solute

A component can be identified by its retention time (qualitative determination):

$$t_{Ri} = t_0 + t'_{Ri}$$

$t_0$ : dead time = residence time of a solute in the mobile phase (time required by a component to migrate through the chromatographic system without any interaction with the stationary phase)

$t_{Ri}$ : retention time = time interval between peak *i* and the point of injection

$t'_{Ri}$ : net retention time = difference between total retention time and dead time  $t_0$ . It indicates how long a substance stays in the stationary phase.

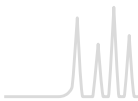
Other terms characterizing a separation:

$k'_i$ : retention factor: a measure for the position of a sample peak in the chromatogram. The retention factor is specific for a given compound and constant under constant conditions.

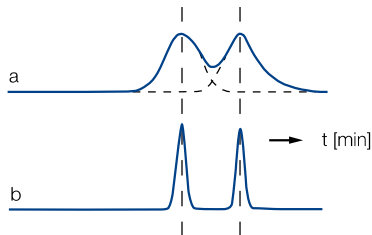
$$k'_i = \frac{t_{Ri} - t_0}{t_0}$$

$\alpha$ : relative retention, also called separation factor or selectivity coefficient, is the ratio of two capacity factors. The reference substance is always in the denominator.

$$\alpha = \frac{k'_2}{k'_1}$$



The relative retention does not provide any information on the quality of a separation. For equal values of  $\alpha$  two very broad peaks may overlap (as shown in a), or may be completely resolved (as in b), if they are accordingly narrow.



R: resolution: a measure for the quality of a separation, taking ( $w_{1/2}$ ) into account according to:

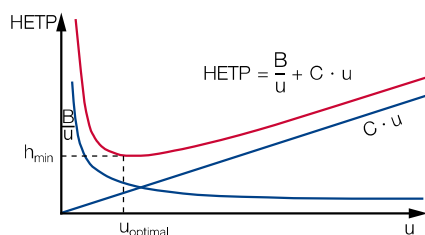
$$R = 1.18 \cdot \frac{t_{R2} - t_{R1}}{(w_{1/2})_2 + (w_{1/2})_1}$$

N: number of theoretical plates: characterizes the quality of a column (should be determined for  $k' > 5$ ). The height equivalent to a theoretical plate ( $h$ , HETP) is calculated by dividing the length  $L$  of the column by the number of theoretical plates  $N$ . The smaller this value the more efficient the column.

$$N = 5.54 \cdot \frac{(t_{Ri})}{(w_{1/2})} \quad h = \text{HETP} = \frac{L}{N}$$

The Golay equation shows how the plate height  $h$  depends on the flow velocity  $u$ :

B: molecular axial diffusion; B is a function of the diffusion coefficient of the component in the respective carrier gas



C: resistance to mass transfer

In practice often higher velocities than  $u_{opt}$  are chosen, if separation efficiency is sufficient. Higher carrier velocities mean shorter retention times.

### Parameters characterizing a capillary column

| OPTIMA® 5 | 1.0 $\mu\text{m}$ film | 30 m x | 0.32 mm ID |
|-----------|------------------------|--------|------------|
| A         | B                      | C      | D          |

#### A. Stationary phase

Different chemical structures of stationary phases are responsible for the type of interaction (selectivity) between the phase and the analytes. The stationary phase also limits the temperature range for chromatography. For a detailed summary of MN phases for GC please see the following chapter.

#### B. Film thickness

MACHEREY-NAGEL offers ranges from 0.1 to 5.0  $\mu\text{m}$ . The standard film thickness is 0.25  $\mu\text{m}$ . Thin films (0.1–0.2  $\mu\text{m}$ ) are very well suited for high-boiling, temperature-sensitive or almost contemporaneously eluting substances.

Increasing the film thickness will increase the capacity, the retention for low-boiling substances and the inertness of the column. This is especially helpful for samples with a broad range of concentrations, or the separation of volatile polar substances.

A better coverage of the column wall by a thicker film and a reduced column surface due to a shorter column have a positive impact on the separation of very active substrates, that may cause noticeable tailing when they come in contact with non-coated spots of the column wall.

Thick films, however, always mean more stationary phase in the column, hence increased column bleeding. Therefore, maximum operating temperatures for thick-film columns are reduced. In addition, thick-film columns may have a lesser separating capacity.

#### C. Column length

The separating efficiency (better the number of plates  $N$ ) of a column is directly proportional to its length. Most routine separations are carried out on 25 or 30 m columns, while more complex samples may require 50 or 60 m. 10 m columns are common for Fast GC (see page 340).

#### D. Inner diameter (ID)

The lower the ID, the higher is the theoretically possible number of plates per meter.

0.1–0.2 mm ID:

for high resolution and short retention times at low carrier gas flow

0.25 mm ID:

for analysis of complex mixtures

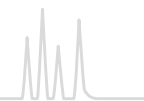
0.32 mm ID:

for routine analysis with short retention times, but increased capacity

0.53 mm ID:

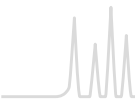
for rapid separations with inert surface and highest capacity





## USP listing of MN GC phases

| Code        | Specifications   | MN GC phases           | Page |
|-------------|--|------------------------|------|
| USP G1 / G2 | dimethylpolysiloxane oil   | OPTIMA® 1              | 310  |
|             |  | OPTIMA® 1 MS           | 312  |
|             |  | OPTIMA® 1 MS Accent    | 312  |
|             |  | OPTIMA® 1-TG           | 348  |
|             |  | PERMABOND® SE-30       | 336  |
|             |  | PERMABOND® P-100       | 352  |
| USP G3      | 50 % phenyl - 50 % methylpolysiloxane  | OPTIMA® 17             | 327  |
|             |  | OPTIMA® 17 MS          | 328  |
|             |  | OPTIMA® 17-TG          | 348  |
| USP G6      | trifluoropropylmethylpolysiloxane  | OPTIMA® 210            | 329  |
| USP G7      | 50 % 3-cyanopropyl - 50 % phenylmethylpolysiloxane   | OPTIMA® 225            | 330  |
| USP G16     | polyethylene glycol (average molecular weight ~ 15 000); high molecular weight compound of polyethylene glycol and diepoxide | OPTIMA® WAX            | 332  |
|             |  | OPTIMA WAXplus®        | 333  |
|             |  | PERMABOND® CW 20 M     | 337  |
|             |  | PERMABOND® CW 20 M-DEG | 354  |
|             |  | FS-CW 20 M-AM          | 351  |
| USP G19     | 25 % phenyl – 25 % cyanopropyl – 50 % methylsiloxane   | OPTIMA® 225            | 330  |
| USP G25     | high molecular weight compound of polyethylene glycol and diepoxide, which is esterified with terephthalic acid              | OPTIMA® FFAP           | 334  |
|             |  | OPTIMA® FFAPplus       | 335  |
|             |  | PERMABOND® FFAP        | 338  |
| USP G27     | 5 % phenyl – 95 % methylpolysiloxane   | OPTIMA® 5              | 314  |
|             |  | OPTIMA® 5 Amine        | 350  |
|             |  | OPTIMA® 5 HT           | 349  |
|             |  | OPTIMA® 5 MS           | 315  |
|             |  | OPTIMA® 5 MS Accent    | 316  |
|             |  | PERMABOND® SE-52       | 336  |
| USP G28     | 25 % phenyl – 75 % methylpolysiloxane  | OPTIMA® 35 MS          | 326  |
| USP G32     | 20 % phenylmethyl – 80 % dimethylpolysiloxane  | OPTIMA® 35 MS          | 326  |
| USP G35     | high molecular weight compound of polyethylene glycol and diepoxide, which is esterified with nitroterephthalic acid         | OPTIMA® FFAP           | 334  |
|             |  | OPTIMA® FFAPplus       | 335  |
|             |  | PERMABOND® FFAP        | 338  |
| USP G36     | 1 % vinyl – 5 % phenylmethylpolysiloxane   | OPTIMA® 5              | 314  |
|             |  | OPTIMA® 5 Amine        | 350  |
|             |  | OPTIMA® 5 HT           | 349  |
|             |  | OPTIMA® 5 MS           | 315  |
|             |  | OPTIMA® 5 MS Accent    | 316  |
|             |  | PERMABOND® SE-54 HKW   | 352  |
| USP G38     | dimethylpolysiloxane oil   | OPTIMA® 1              | 310  |
|             |  | OPTIMA® 1 MS           | 312  |
|             |  | OPTIMA® 1 MS Accent    | 312  |
|             |  | OPTIMA® 1-TG           | 348  |
|             |  | PERMABOND® SE-30       | 336  |
|             |  | PERMABOND® P-100       | 352  |
| USP G42     | 35 % phenyl – 65 % dimethylpolysiloxane  | OPTIMA® 35 MS          | 326  |
| USP G43     | 6 % cyanopropylphenyl – 94 % dimethylpolysiloxane  | OPTIMA® 1301           | 321  |
|             |  | OPTIMA® 1301 MS        | 322  |
|             |  | OPTIMA® 624            | 323  |
|             |  | OPTIMA® 624 LB         | 323  |
| USP G46     | 14 % cyanopropylphenyl – 86 % methylpolysiloxane   | OPTIMA® 1701           | 324  |
|             |  | OPTIMA® 1701 MS        | 325  |
| USP G49     | proprietary derivatized phenyl groups on a polysiloxane backbone   | OPTIMA® δ-3            | 319  |

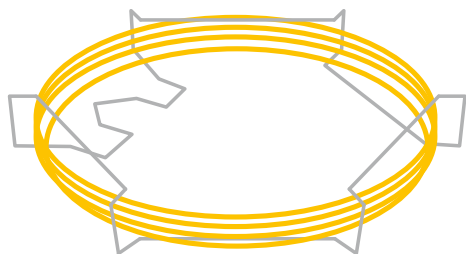


# Additional information for GC columns



## Scope of delivery

Each column is individually tested and supplied with test certificate and test chromatogram, but without fittings or ferrules. Columns have fused ends or are sealed with septa, to protect them from atmospheric oxygen. Further more an instruction leaflet is enclosed.



**OPTIMA 5 MS**

Columns data  
 REF: 726 600.30  
 Part No.: 69634

Length: 30 m  
 ID: 0.25 mm  
 Phase: 5% Ph. 95% MS

Test conditions  
 Column: OPTIMA 5 MS  
 Carrier gas: He  
 Temperature program: 40°C (10 min) → 100°C (1 min) → 10°C/min → 250°C (10 min)

Quality specifications - Test results

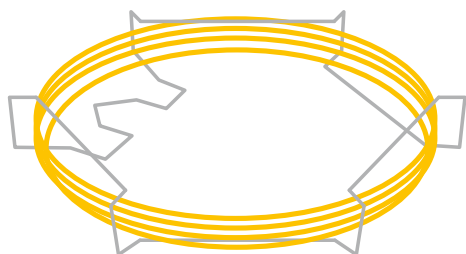
| Parameter       | Value   | Unit     |
|-----------------|---------|----------|
| Efficiency      | 1000000 | plates/m |
| Resolution      | 1.05    | plates/m |
| Reproducibility | 0.15    | %        |

MACHEREY-NAGEL logo and contact information.

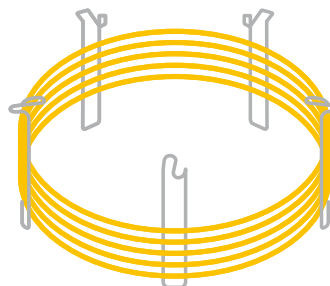


## GC cages

The standard size of a GC cage is 7 inches. On request, all columns can be supplied on a 5 inch (13 cm) cage e.g., for the Agilent GC 6850. To order, please add an E at the end of the REF number (e.g., 726470.30E)



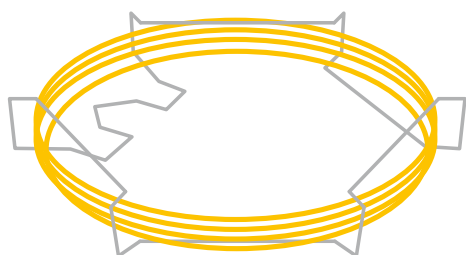
7 inches standard size e.g., REF 726600.30



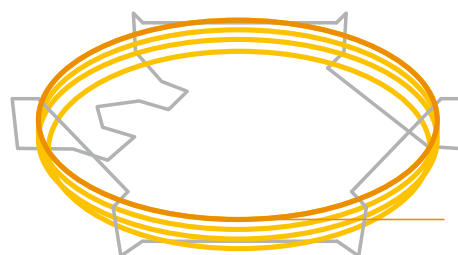
5 inches special cage e.g., REF 726600.30E

## Integrated guard column

To prolong column life, even at highly contaminated or matrix-containing samples, MN offers the option to add an integrated guard column. All capillary columns are available with a 10 m guard column with respective deactivation. To order, please add V1 at the end of the REF number (e.g., 726600.30V1). Guard column combinations with other lengths, IDs or different deactivation are available on request.

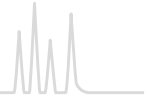


Without integrated guard column e.g., REF 726600.30



With integrated guard column e.g., REF 726600.30V1



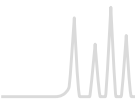


## MACHEREY-NAGEL derivatization reagents

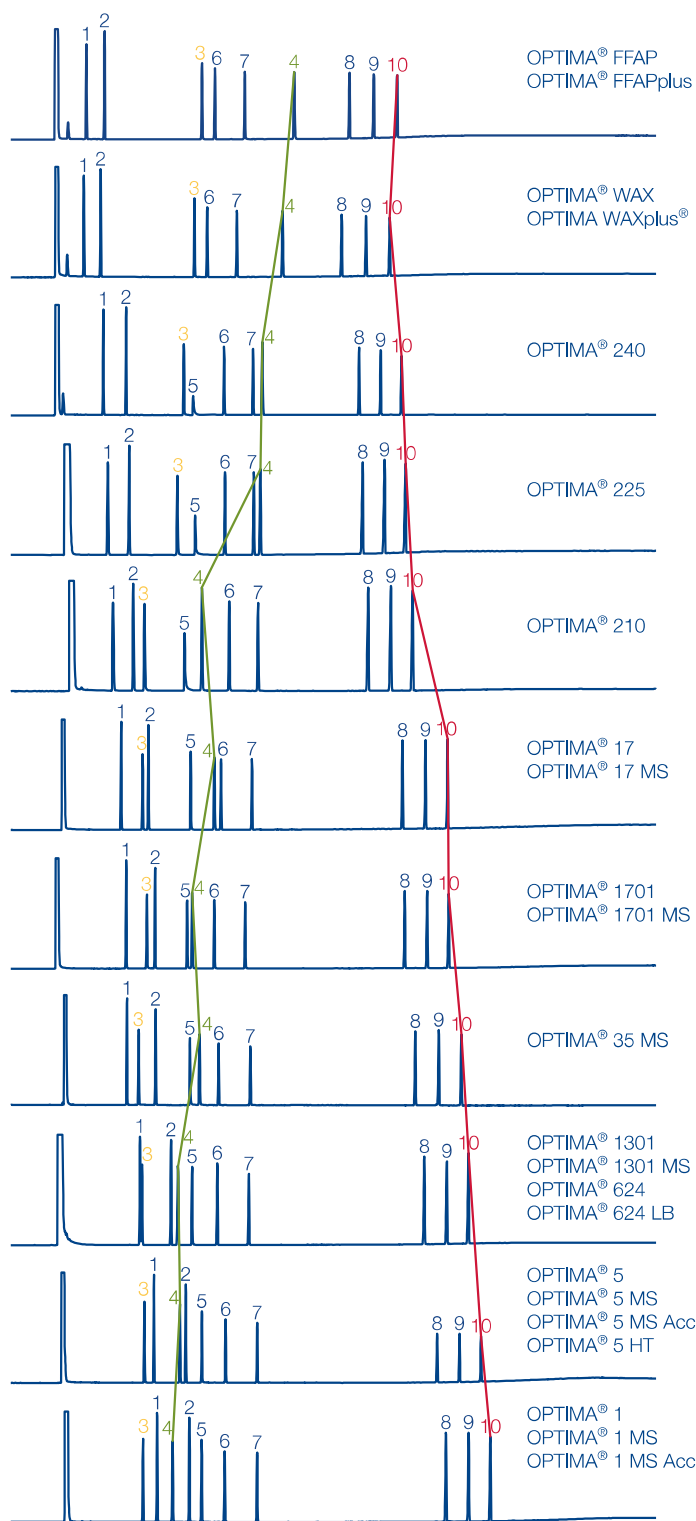
### Purpose of derivatization

- Improved volatility, better thermal stability or a lower limit of detection in gas chromatography
- Prerequisite: quantitative, rapid and reproducible formation of only one derivative
- Halogen atoms inserted by derivatization (e.g., trifluoroacetates) for specific detection (ECD) with the advantage of high sensitivity
- Influence of elution orders and fragmentation patterns in MS by a specific derivatization
- We provide reagents for
  - Silylation
  - Alkylation (methylation)
  - Acylation
- For 1 x 10 mL, 1 x 50 mL and 6 x 50 mL also as screw neck vial
- Product range from page 357 onwards





# Separation properties of OPTIMA<sup>®</sup> phases



increasing polarity

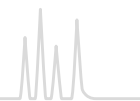
- Peaks:
- 1. Undecane
  - 2. Dodecane
  - 3. Octanol
  - 4. Dimethylaniline
  - 5. Decylamine
  - 6. Methyl decanoate
  - 7. Methyl undecanoate
  - 8. Henicosane
  - 9. Docosane
  - 10. Tricosane

All columns: 0,25 µm film, 30 m x 0,25 mm ID  
 Sample: MN OPTIMA<sup>®</sup> test mixture (REF 722316)  
 Injection: 1,0 µL, split 15 mL/min  
 Carrier gas: 0,80 bar He  
 Temperature: 80 °C T<sub>max</sub> (isothermal), 8 °C/min (20 min T<sub>max</sub>)  
 Detector: FID 260–280 °C





# Summary of MN phases for GC



## Overview of OPTIMA<sup>®</sup> MN phases

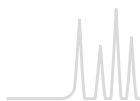
| Phase                           | Composition  | Page | Relative polarity <sup>①</sup> | Maximum temperature <sup>②</sup> |
|---------------------------------|--|------|--------------------------------|----------------------------------|
| OPTIMA <sup>®</sup> 1           |  | 310  |                                |                                  |
| OPTIMA <sup>®</sup> 1 MS        | 100 % dimethylpolysiloxane   | 312  |                                | 340/360 °C                       |
| OPTIMA <sup>®</sup> 1 MS Accent |  | 312  |                                |                                  |
| OPTIMA <sup>®</sup> 5           | 5 % phenyl – 95 % methylpolysiloxane   | 314  |                                | 340/360 °C                       |
| OPTIMA <sup>®</sup> 5 MS        | 5 % diphenyl – 95 % dimethylpolysiloxane   | 315  |                                | 340/360 °C                       |
| OPTIMA <sup>®</sup> 5 MS Accent | silarylene phase with selectivity similar to 5 % diphenyl – 95 % dimethylpolysiloxane                      | 316  |                                | 340/360 °C                       |
| OPTIMA <sup>®</sup> XLB         | silarylene phase like above, optimized silarylene content for low bleeding                                 | 317  |                                | 340/360 °C                       |
| OPTIMA <sup>®</sup> δ-3         | phase with autoselectivity <sup>④</sup>  | 319  |                                | 340/360 °C                       |
| OPTIMA <sup>®</sup> δ-6         | phase with autoselectivity <sup>④</sup>  | 320  |                                | 340/360 °C                       |
| OPTIMA <sup>®</sup> 1301        | 6 % cyanopropylphenyl – 94 % dimethylpolysiloxane  | 321  |                                | 300/320 °C                       |
| OPTIMA <sup>®</sup> 1301 MS     | silarylene phase with low bleeding: polarity similar to 6 % cyanopropylphenyl – 94 % dimethylpolysiloxane  | 322  |                                | 300/320 °C                       |
| OPTIMA <sup>®</sup> 624         | 6 % cyanopropylphenyl – 94 % dimethylpolysiloxane  | 323  |                                |                                  |
| OPTIMA <sup>®</sup> 624 LB      | like above, phase with low bleeding  | 323  |                                | 280/300 °C                       |
| OPTIMA <sup>®</sup> 1701        | 14 % cyanopropylphenyl – 86 % dimethylpolysiloxane   | 324  |                                | 280/300 °C                       |
| OPTIMA <sup>®</sup> 1701 MS     | silarylene phase with low bleeding: polarity similar to 14 % cyanopropylphenyl – 86 % dimethylpolysiloxane | 325  |                                | 280/300 °C                       |

<sup>①</sup> = nonpolar, = polar

<sup>②</sup> First temperature (long term temperature) for isothermal operation, second value for the max. temperature (short term temperature) in a temperature program. Please note that for details refer to the description of individual phases.

<sup>③</sup> Phases which provide a similar selectivity based on chemical and physical properties <sup>④</sup> See description on page 318

GC columns for special separations can be found from page 339 onwards.



# Summary of MN phases for GC

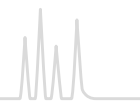


| Structure  | USP           | Similar phases <sup>③</sup>  |
|--|---------------|--|
| $\left[ \begin{array}{c} \text{CH}_3 \\   \\ \text{O}-\text{Si} \\   \\ \text{CH}_3 \end{array} \right]_n$   | G1 / G2 / G38 | PERMABOND <sup>®</sup> SE-30, OV-1, DB-1, SE-30, HP-1, SPB <sup>™</sup> -1, CP-Sil 5 CB, Rtx <sup>®</sup> -1, 007-1, BP1, MDN-1, AT <sup>™</sup> -1, ZB-1, OV-101<br><br>5 % diphenyl – 95 % dimethylpolysiloxane          |
| $\left[ \begin{array}{c} \text{CH}_3 \\   \\ \text{O}-\text{Si} \\   \\ \text{C}_6\text{H}_5 \end{array} \right]_m \left[ \begin{array}{c} \text{CH}_3 \\   \\ \text{O}-\text{Si} \\   \\ \text{CH}_3 \end{array} \right]_n$   | G27 / G36     | PERMABOND <sup>®</sup> SE-52, SE-54, SE-52, HP-5, SPB <sup>™</sup> -5, CP-Sil 8, Rtx <sup>®</sup> -5, 007-5, BP5, MDN-5, AT <sup>™</sup> -5, ZB-5  |
| $\left[ \begin{array}{c} \text{C}_6\text{H}_5 \\   \\ \text{O}-\text{Si} \\   \\ \text{C}_6\text{H}_5 \end{array} \right]_m \left[ \begin{array}{c} \text{CH}_3 \\   \\ \text{O}-\text{Si} \\   \\ \text{CH}_3 \end{array} \right]_n$  | G27 / G36     | DB-5, DB-5MS, HP-5MS, Ultra-2, Equity <sup>™</sup> -5, CP-Sil 8CB low bleed/MS, Rxi <sup>®</sup> -5MS, Rtx <sup>®</sup> -5SIL-MS, Rtx <sup>®</sup> -5MS, 007-5MS, BPX <sup>™</sup> 5, MDN-5S, AT <sup>™</sup> -5MS, VF-5MS |
| $\left[ \begin{array}{c} \text{CH}_3 \quad \text{CH}_3 \\   \quad   \\ \text{Si}-\text{C}_6\text{H}_4-\text{Si}-\text{O} \\   \quad   \\ \text{CH}_3 \quad \text{CH}_3 \end{array} \right]_n \left[ \begin{array}{c} \text{CH}_3 \\   \\ \text{Si}-\text{O} \\   \\ \text{CH}_3 \end{array} \right]_o$   | G27 / G36     |  |
| $\left[ \begin{array}{c} \text{CH}_3 \quad \text{CH}_3 \\   \quad   \\ \text{Si}-\text{C}_6\text{H}_4-\text{Si}-\text{O} \\   \quad   \\ \text{CH}_3 \quad \text{CH}_3 \end{array} \right]_n \left[ \begin{array}{c} \text{CH}_3 \\   \\ \text{Si}-\text{O} \\   \\ \text{CH}_3 \end{array} \right]_o$   | -             | DB-XLB, Rxi <sup>®</sup> -XLB, Rtx <sup>®</sup> -XLB, MDN-12, VF-XMS   |
| see description page 318   | G49           | no similar phases  |
| see description page 318   | -             | no similar phases  |
| $\left[ \begin{array}{c} \text{C}_6\text{H}_5 \\   \\ \text{O}-\text{Si} \\   \\ \text{NC}-(\text{CH}_2)_3 \end{array} \right]_m \left[ \begin{array}{c} \text{CH}_3 \\   \\ \text{O}-\text{Si} \\   \\ \text{CH}_3 \end{array} \right]_n$   | G43           | HP-1301, DB-1301, SPB <sup>™</sup> -1301, Rtx <sup>®</sup> -1301, CP-1301, 007-1301  |
| $\left[ \begin{array}{c} \text{NC}-(\text{CH}_2)_3 \\   \\ \text{Si}-\text{O} \\   \\ \text{NC}-(\text{CH}_2)_3 \end{array} \right]_m \left[ \begin{array}{c} \text{CH}_3 \quad \text{CH}_3 \\   \quad   \\ \text{Si}-\text{C}_6\text{H}_4-\text{Si}-\text{O} \\   \quad   \\ \text{CH}_3 \quad \text{CH}_3 \end{array} \right]_{2m} \left[ \begin{array}{c} \text{CH}_3 \\   \\ \text{Si}-\text{O} \\   \\ \text{CH}_3 \end{array} \right]_n$ | G43           | VF-1301ms, Rxi <sup>®</sup> -1301SIL MS, TG-1301MS   |
| $\left[ \begin{array}{c} \text{C}_6\text{H}_5 \\   \\ \text{O}-\text{Si} \\   \\ \text{NC}-(\text{CH}_2)_3 \end{array} \right]_m \left[ \begin{array}{c} \text{CH}_3 \\   \\ \text{O}-\text{Si} \\   \\ \text{CH}_3 \end{array} \right]_n$   | G43           | HP-624, HP-VOC, DB-624, DB-VRX, SPB <sup>™</sup> -624, CP-624, Rtx <sup>®</sup> -624, Rtx <sup>®</sup> -Volatiles, 007-624, BP624, VOCOL   |
| $\left[ \begin{array}{c} \text{C}_6\text{H}_5 \\   \\ \text{O}-\text{Si} \\   \\ \text{NC}-(\text{CH}_2)_3 \end{array} \right]_m \left[ \begin{array}{c} \text{CH}_3 \\   \\ \text{O}-\text{Si} \\   \\ \text{CH}_3 \end{array} \right]_n$   | G46           | OV-1701, DB-1701, CP-Sil 19 CB, HP-1701, Rtx <sup>®</sup> -1701, SPB <sup>™</sup> -1701, 007-1701, BP10, ZB-1701   |
| $\left[ \begin{array}{c} \text{NC}-(\text{CH}_2)_3 \\   \\ \text{Si}-\text{O} \\   \\ \text{NC}-(\text{CH}_2)_3 \end{array} \right]_m \left[ \begin{array}{c} \text{CH}_3 \quad \text{CH}_3 \\   \quad   \\ \text{Si}-\text{C}_6\text{H}_4-\text{Si}-\text{O} \\   \quad   \\ \text{CH}_3 \quad \text{CH}_3 \end{array} \right]_{2m} \left[ \begin{array}{c} \text{CH}_3 \\   \\ \text{Si}-\text{O} \\   \\ \text{CH}_3 \end{array} \right]_n$ | G46           | VF-1701ms, TG-1701MS, OV-1701, DB-1701, HP-1701, Rtx <sup>®</sup> -1701, SPB <sup>™</sup> -1701, CP Sil 19 CB, 007-1701, BP10, ZB-1701   |

at for columns with 0,53 mm ID and for columns with thicker films temperature limits are generally lower.



# Summary of MN phases for GC



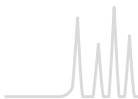
| Phase            | Composition  | Page | Relative polarity <sup>①</sup> | Maximum temperature <sup>②</sup> |
|------------------|--|------|--------------------------------|----------------------------------|
| OPTIMA® 35 MS    | silarylene phase with selectivity similar to 35 % diphenyl – 65 % dimethylpolysiloxane | 326  |                                | 360/370 °C                       |
| OPTIMA® 17       | phenylmethylpolysiloxane, 50 % phenyl  | 327  |                                | 320/340 °C                       |
| OPTIMA® 17 MS    | silarylene phase with selectivity similar to 50 % phenyl – 50 % methylpolysiloxane     | 328  |                                | 340/360 °C                       |
| OPTIMA® 210      | trifluoropropylmethylpolysiloxane (50 % trifluoropropyl)                               | 329  |                                | 260/280 °C                       |
| OPTIMA® 225      | 50 % cyanopropylmethyl – 50 % phenylmethylpolysiloxane                                 | 330  |                                | 260/280 °C                       |
| OPTIMA® 240      | 33 % cyanopropylmethyl – 67 % dimethylpolysiloxane                                     | 331  |                                | 260/280 °C                       |
| OPTIMA® WAX      | polyethylene glycol 20 000 Da  | 332  |                                | 240/250 °C                       |
| OPTIMA WAXplus®  | polyethylene glycol with optimized cross-linking                                       | 333  |                                | 260/270 °C                       |
| OPTIMA® FFAP     | polyethylene glycol 2-nitroterephthalate   | 334  |                                | 250/260 °C                       |
| OPTIMA® FFAPplus | polyethylene glycol 2-nitroterephthalate with optimized cross-linking                  | 335  |                                | 250/260 °C                       |

<sup>①</sup> = nonpolar, = polar

<sup>②</sup> First temperature (long term temperature) for isothermal operation, second value for the max. temperature (short term temperature) in a temperature program. Please note that for details refer to the description of individual phases.

<sup>③</sup> Phases which provide a similar selectivity based on chemical and physical properties

GC columns for special separations can be found from page 339 onwards.



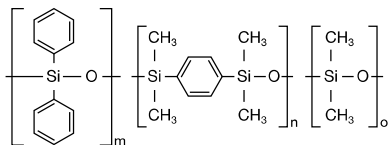
# Summary of MN phases for GC



Structure

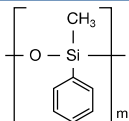
USP

Similar phases <sup>®</sup>



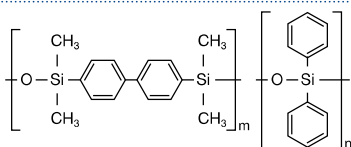
G28 / G32 / G42

DB-35 MS, HP-35, SPB<sup>™</sup>-35, Rxi<sup>®</sup>-35SIL MS, Rtx-35, 007-35, BPX<sup>™</sup>-35, MDN-35, AT<sup>™</sup>-35 MS, ZB-35, OV-11, VF-35 MS



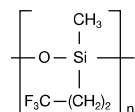
G3

OV-17, DB-17, HP-50+, HP-17, SPB<sup>™</sup>-50, SP-2250, Rxi<sup>®</sup>-17, Rtx<sup>®</sup>-50, CP-Sil 24 CB, 007-17, ZB-50



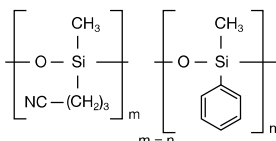
G3

OV-17, AT<sup>™</sup>-50, BPX<sup>™</sup>-50, DB-17, DB-17ms, HP-50+, HP-17, SPB<sup>™</sup>-50, SPB<sup>™</sup>-17, SP-2250, Rtx<sup>®</sup>-50, CP-Sil 24 CB, 007-17, VF-17ms, ZB-50



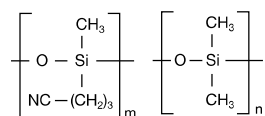
G6

OV-210, DB-210, Rtx<sup>®</sup>-200, 007-210



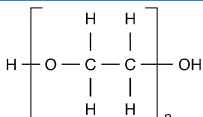
G7 / G19

DB-225, HP-225, OV-225, Rtx<sup>®</sup>-225, CP-Sil 43, 007-225, BP225



-

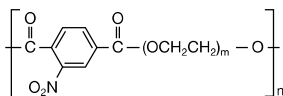
no similar phases



G16

PERMABOND<sup>®</sup> CW 20 M, DB-Wax, Supelcowax, HP-Wax, HP-INNOWAX, Rtx-Wax, CP-Wax 52 CB, Stabilwax, 007-CW, BP20, AT-Wax, ZB-Wax

DB-Wax, Supelcowax, HP-Wax, HP-INNOWAX, Rtx-Wax, CP-Wax 52 CB, Stabilwax, 007-CW, BP20, AT-Wax, ZB-Wax



G35 / G25

PERMABOND<sup>®</sup> FFAP, DB-FFAP, HP-FFAP, CP-Wax 58 FFAP CB, 007-FFAP, CP-FFAP CB, Nukol<sup>™</sup>, AT-1000, SPB-1000, BP21, OV-351

DB-FFAP, HP-FFAP, CP-SIL 58 CB, 007-FFAP, CP-FFAP CB, Nukol<sup>™</sup>

hat for columns with 0.53 mm ID and for columns with thicker films temperature limits are generally lower.



## OPTIMA<sup>®</sup> 1 100 % dimethylpolysiloxane · USP G1 / G2 / G38

### ★ Key features

- Nonpolar phase
- Structure see page 307

### ✓ Recommended application

- Separation of components according to boiling points
- Thick film columns  $\geq 3 \mu\text{m}$  film are especially recommended for solvent analysis.

### ✍ Temperature

- Columns with 0.1–0.32 mm ID and films  $< 3 \mu\text{m}$ :  
 $T_{\text{max}}$  340 °C (long-term temperature),  
 $T_{\text{max}}$  360 °C (short-term max. temperature in a temperature program)
- 0.53 mm ID, films  $< 3 \mu\text{m}$ :  
 $T_{\text{max}}$  320 and 340 °C, resp.
- Thick film columns with films  $\geq 3 \mu\text{m}$ :  
max. temperatures 300 and 320 °C, resp.

### Similar phases

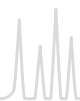
- PERMABOND<sup>®</sup> SE-30 (see page 336), OV-1, DB-1, SE-30, HP-1, SPB<sup>™</sup>-1, CP-Sil 5 CB, Rtx<sup>®</sup>-1, 007-1, BP1, MDN-1, AT<sup>™</sup>-1, ZB-1, OV-101

## Ordering information

### OPTIMA<sup>®</sup> 1

|                         | Length →<br>10 m | 12 m      | 15 m      | 20 m      | 25 m      | 30 m      | 50 m      | 60 m      |
|-------------------------|------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 0.1 mm ID (0.4 mm OD)   |                  |           |           |           |           |           |           |           |
| 0.10 $\mu\text{m}$ film | 726024.10        |           |           | 726024.20 |           |           |           |           |
| 0.40 $\mu\text{m}$ film |                  |           |           | 726025.20 |           |           |           |           |
| 0.2 mm ID (0.4 mm OD)   |                  |           |           |           |           |           |           |           |
| 0.10 $\mu\text{m}$ film |                  |           |           |           | 726832.25 |           |           |           |
| 0.20 $\mu\text{m}$ film |                  | 726834.12 |           |           | 726834.25 |           | 726834.50 |           |
| 0.35 $\mu\text{m}$ film |                  | 726837.12 |           |           | 726837.25 |           | 726837.50 |           |
| 0.50 $\mu\text{m}$ film |                  |           |           |           |           |           | 726839.50 |           |
| 0.25 mm ID (0.4 mm OD)  |                  |           |           |           |           |           |           |           |
| 0.10 $\mu\text{m}$ film | 726038.10        |           | 726038.15 |           | 726038.25 | 726038.30 |           | 726038.60 |
| 0.25 $\mu\text{m}$ film | 726050.10        |           | 726050.15 |           | 726050.25 | 726050.30 | 726050.50 | 726050.60 |
| 0.50 $\mu\text{m}$ film | 726081.10        |           |           |           | 726081.25 | 726081.30 | 726081.50 | 726081.60 |
| 1.00 $\mu\text{m}$ film |                  |           |           |           | 726802.25 | 726802.30 | 726802.50 | 726802.60 |
| 0.32 mm ID (0.5 mm OD)  |                  |           |           |           |           |           |           |           |
| 0.10 $\mu\text{m}$ film | 726301.10        |           |           |           | 726301.25 | 726301.30 | 726301.50 | 726301.60 |
| 0.25 $\mu\text{m}$ film | 726302.10        |           | 726302.15 |           | 726302.25 | 726302.30 | 726302.50 | 726302.60 |
| 0.35 $\mu\text{m}$ film |                  |           |           |           | 726821.25 | 726821.30 | 726821.50 | 726821.60 |
| 0.50 $\mu\text{m}$ film | 726304.10        |           |           |           | 726304.25 | 726304.30 | 726304.50 | 726304.60 |
| 1.00 $\mu\text{m}$ film | 726323.10        |           | 726323.15 |           | 726323.25 | 726323.30 | 726323.50 | 726323.60 |
| 3.00 $\mu\text{m}$ film |                  |           |           |           | 726805.25 | 726805.30 | 726805.50 | 726805.60 |
| 5.00 $\mu\text{m}$ film | 726931.10        |           |           |           | 726931.25 | 726931.30 | 726931.50 |           |
| 0.53 mm ID (0.8 mm OD)  |                  |           |           |           |           |           |           |           |
| 0.50 $\mu\text{m}$ film |                  |           | 726519.15 |           | 726519.25 | 726519.30 |           |           |
| 1.00 $\mu\text{m}$ film | 726529.10        |           | 726529.15 |           | 726529.25 | 726529.30 |           |           |
| 2.00 $\mu\text{m}$ film | 726521.10        |           |           |           | 726521.25 | 726521.30 | 726521.50 |           |
| 5.00 $\mu\text{m}$ film | 726926.10        |           |           |           | 726926.25 | 726926.30 | 726926.50 |           |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.



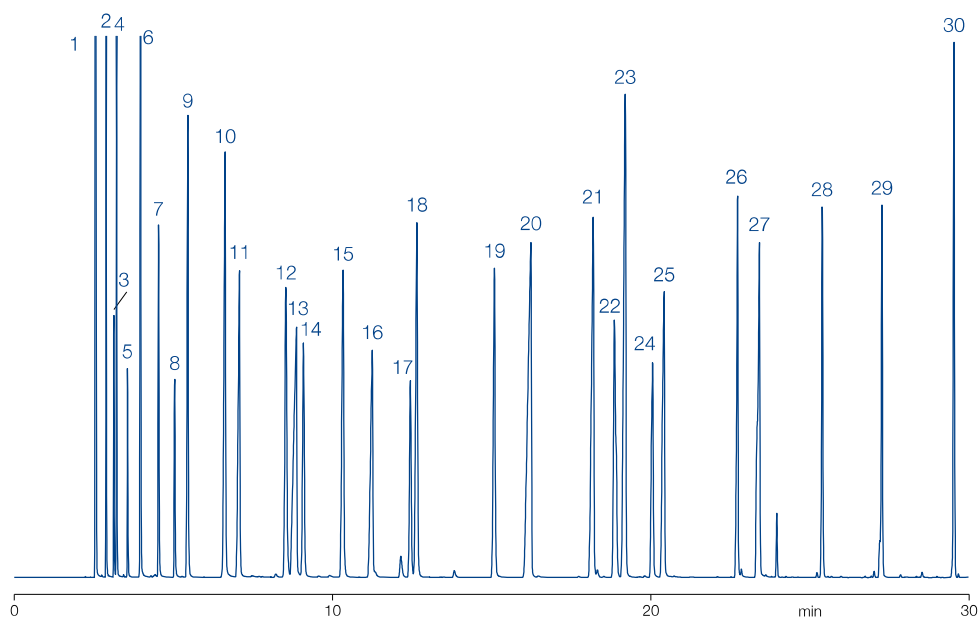
## Solvent analysis

MN Appl. No. 201390

Column: OPTIMA<sup>®</sup> 1, 60 m x 0.32 mm ID, 1.0 µm film  
Sample: solvent mixture, courtesy of J. Lutz, Alcan Rorschach, Switzerland  
Injection: 0.4 µL, split 1:60  
Carrier gas: H<sub>2</sub>, 120 kPa  
Temperature: 50 °C (9 min) → 90 °C, 4 °C/min → 280 °C (2 min), 14 °C/min  
Detector: FID 300 °C

### Peaks:

- |                                    |                            |
|------------------------------------|----------------------------|
| 1. Methanol                        | 26. Heptanol               |
| 2. Ethanol                         | 27. Ethyl diglycol         |
| 3. Acetone                         | 28. Butyl diglycol         |
| 4. 2-Propanol                      | 29. Butyl glycol acetate   |
| 5. Methyl acetate                  | 30. Butyl diglycol acetate |
| 6. <i>n</i> -Propanol              |                            |
| 7. Methyl ethyl ketone             |                            |
| 8. Ethyl acetate                   |                            |
| 9. Isobutanol                      |                            |
| 10. <i>n</i> -Butanol              |                            |
| 11. 1-Methoxy-2-propanol           |                            |
| 12. Isooctane                      |                            |
| 13. Ethyl glycol                   |                            |
| 14. Isoheptane                     |                            |
| 15. Methyl isobutyl ketone         |                            |
| 16. 1-Ethoxy-2-propanol            |                            |
| 17. Toluene                        |                            |
| 18. Isobutyl acetate               |                            |
| 19. Butyl acetate                  |                            |
| 20. 4-Hydroxy-4-methyl-2-pentanone |                            |
| 21. 1-Methoxy-2-propyl acetate     |                            |
| 22. Xylene                         |                            |
| 23. Cyclohexanone                  |                            |
| 24. Ethyl glycol acetate           |                            |
| 25. Butyl glycol                   |                            |





# OPTIMA® · nonpolar capillary columns



## OPTIMA® 1 MS 100 % dimethylpolysiloxane · USP G1 / G2 / G38

### ★ Key features

- Selectivity identical to OPTIMA® 1, Phase with low bleeding
- Structure see page 307

### ✓ Recommended application

- GC/MS and ECD, general analysis at trace level

### ✍ Temperature

- T<sub>max</sub> 340 °C (long-term temperature), T<sub>max</sub> 360 °C (short-term max. temperature in a temperature program)

### Similar phases

- Ultra-1, DB-1MS, HP-1MS, Rxi®-1MS, Rtx®-1MS, Equity™-1, AT™-1MS, VF-1MS, CP-Sil 5 CB MS

## Ordering information

### OPTIMA® 1 MS

|                        | Length →  |           |           |           |           |           |
|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
|                        | 12 m      | 15 m      | 25 m      | 30 m      | 50 m      | 60 m      |
| 0.2 mm ID (0.4 mm OD)  |           |           |           |           |           |           |
| 0.20 µm film           |           |           | 726201.25 |           | 726201.50 |           |
| 0.35 µm film           | 726203.12 |           |           |           |           |           |
| 0.25 mm ID (0.4 mm OD) |           |           |           |           |           |           |
| 0.25 µm film           |           | 726205.15 |           | 726205.30 |           | 726205.60 |
| 0.32 mm ID (0.5 mm OD) |           |           |           |           |           |           |
| 0.25 µm film           |           |           |           | 726202.30 |           | 726202.60 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.

## OPTIMA® 1 MS Accent 100 % dimethylpolysiloxane · USP G1 / G2 / G38

### ★ Key features

- Selectivity identical to OPTIMA® 1, nonpolar phase
- Lowest column bleed
- Solvent rinsing for removal of impurities applicable
- Increased sensitivity due to an unmatched low background level
- Structure see page 307

### ✓ Recommended application

- Ideal for ion trap and quadrupole MS detectors
- Perfect inertness for basic compounds
- All-round phase for environmental analysis, trace analysis, EPA methods, pesticides, PCB, food and drug analysis

### ✍ Temperature

- T<sub>max</sub> 340 °C (long-term temperature), T<sub>max</sub> 360 °C (short-term max. temperature in a temperature program)

### Similar phases

- Ultra-1, DB-1MS, HP-1MS, Rxi®-1MS, Rtx®-1MS, Equity™-1, AT™-1MS, VF-1MS, CP-Sil 5 CB MS



# OPTIMA® · nonpolar capillary columns



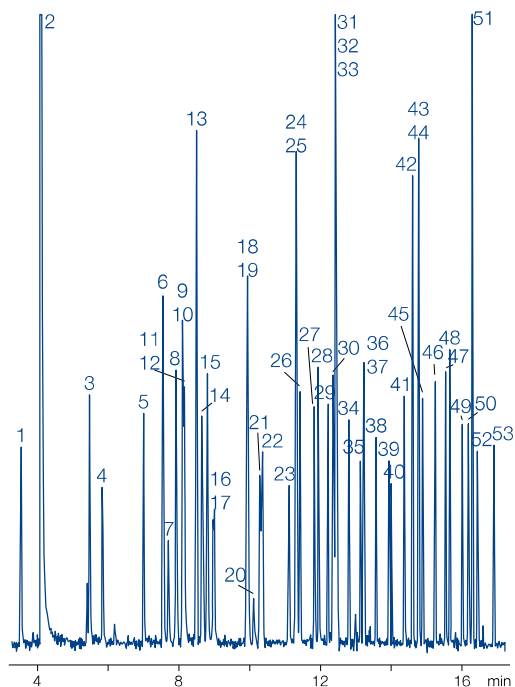
## EPA 8140/8141/8141 A Organophosphorus pesticides

MN Appl. No. 213030

Column: OPTIMA® 1 MS Accent, 30 m x 0.32 mm ID, 0.50 µm film  
 Sample: 0.2 µg/mL in hexane,  
 8140/8141 OP pesticides calibration mix A  
 and 8141 OP pesticides calibration mix B;  
 IS triphenyl phosphate and tributyl phosphate  
 Injection: 250 °C, splitless (hold 1 min)  
 Carrier gas: He, 1 mL/min, constant pressure  
 Temperature: 100 °C → 180 °C, 10 °C/min (2 min) → 300 °C, 18 °C/min (3 min)  
 Detector: FPD (Flame Photometric Detector), 280 °C

### Peaks:

|                                 |                         |                                     |
|---------------------------------|-------------------------|-------------------------------------|
| 1. Dichlorvos                   | 19. Fonophos            | 38. Stirofos                        |
| 2. Hexamethylphospho-<br>ramide | 20. Phosphamidon isomer | 39. Tokuthion                       |
| 3. Mevinphos                    | 21. Diazinon            | 40. Merphos oxidation<br>product    |
| 4. Trichlorfon                  | 22. Disulfoton          | 41. Fensulfothion                   |
| 5. TEPP                         | 23. Phosphamidon        | 42. Famphur                         |
| 6. Thionazin                    | 24. Dichlorofenthion    | 43. Ethion                          |
| 7. Demeton-O                    | 25. Parathion-methyl    | 44. Bolstar                         |
| 8. Ethoprop                     | 26. Chlorpyrifos-methyl | 45. Carbophenothion                 |
| 9. Tributyl phosphate (IS)      | 27. Ronnel              | 46. Triphenyl phosphate (IS)        |
| 10. Dicrotophos                 | 28. Fenitrothion        | 47. Phosmet                         |
| 11. Monocrotophos               | 29. Malathion           | 48. EPN                             |
| 12. Naled                       | 30. Fenthion            | 49. Azinphos-methyl                 |
| 13. Sulfotepp                   | 31. Aspon               | 50. Leptophos                       |
| 14. Phorate                     | 32. Parathion-ethyl     | 51. Tri- <i>o</i> -cresyl phosphate |
| 15. Dimethoate                  | 33. Chlorpyrifos        | 52. Azinphos-ethyl                  |
| 16. Demeton-S                   | 34. Trichloronate       | 53. Coumaphos                       |
| 17. Dioxathion                  | 35. Chlorfenvinphos     |                                     |
| 18. Terbufos                    | 36. Merphos             |                                     |
|                                 | 37. Crotoxyphos         |                                     |



### Ordering information

#### OPTIMA® 1 MS Accent

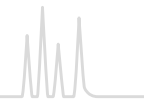
|                        | Length →  |           |           |           |           |
|------------------------|-----------|-----------|-----------|-----------|-----------|
|                        | 15 m      | 25 m      | 30 m      | 50 m      | 60 m      |
| 0.2 mm ID (0.4 mm OD)  |           |           |           |           |           |
| 0.20 µm film           |           | 725801.25 |           | 725801.50 |           |
| 0.25 mm ID (0.4 mm OD) |           |           |           |           |           |
| 0.25 µm film           | 725805.15 |           | 725805.30 |           | 725805.60 |
| 0.50 µm film           |           |           | 725806.30 |           | 725806.60 |
| 0.32 mm ID (0.5 mm OD) |           |           |           |           |           |
| 0.25 µm film           |           |           | 725802.30 |           | 725802.60 |
| 0.50 µm film           |           |           | 725807.30 |           | 725807.60 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.





# OPTIMA<sup>®</sup> · weakly polar capillary columns



## OPTIMA<sup>®</sup> 5 5 % phenyl – 95 % methylpolysiloxane · USP G27 / G36

### ★ Key features

- Nonpolar phase
- Structure see page 307

### ✓ Recommended application

- Standard phase with large range of application

### ✍ Temperature

- Columns with 0.1–0.32 mm ID and films < 3 µm:  
T<sub>max</sub> 340 °C (long-term temperature),  
T<sub>max</sub> 360 °C (short-term max. temperature in a temperature program)
- 0.53 mm ID, films < 3 µm:  
T<sub>max</sub> 320 and 340 °C, resp.
- Thick film columns with films ≥ 3 µm:  
max. temperatures 300 and 320 °C, resp.

### Similar phases

- PERMABOND<sup>®</sup> SE-52 (see page 336), SE-54, SE-52, HP-5, SPB<sup>™</sup>-5, CP-Sil 8, Rtx<sup>®</sup>-5, 007-5, BP5, MDN-5, AT<sup>™</sup>-5, ZB-5

## Ordering information

### OPTIMA<sup>®</sup> 5

|                        | Length →  |           |           |           |           |           |
|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
|                        | 10 m      | 15 m      | 25 m      | 30 m      | 50 m      | 60 m      |
| 0.1 mm ID (0.4 mm OD)  |           |           |           |           |           |           |
| 0.10 µm film           | 726846.10 |           |           |           |           |           |
| 0.2 mm ID (0.4 mm OD)  |           |           |           |           |           |           |
| 0.10 µm film           | 726854.25 |           |           |           |           |           |
| 0.20 µm film           | 726857.25 |           |           |           |           |           |
| 0.35 µm film           | 726860.25 |           |           |           |           |           |
| 0.50 µm film           | 726863.25 |           |           |           |           |           |
| 0.25 mm ID (0.4 mm OD) |           |           |           |           |           |           |
| 0.10 µm film           | 726911.25 |           |           |           |           |           |
| 0.25 µm film           | 726056.10 | 726056.15 | 726056.25 | 726056.30 | 726056.50 | 726056.60 |
| 0.35 µm film           | 726623.25 |           |           |           |           |           |
| 0.50 µm film           | 726099.25 |           |           |           |           |           |
| 1.00 µm film           | 726807.25 |           |           |           |           |           |
| 0.32 mm ID (0.5 mm OD) |           |           |           |           |           |           |
| 0.10 µm film           | 726313.10 | 726313.15 | 726313.25 | 726313.30 | 726313.50 | 726313.60 |
| 0.25 µm film           | 726314.15 |           |           |           |           |           |
| 0.35 µm film           | 726628.25 |           |           |           |           |           |
| 0.50 µm film           | 726316.25 |           |           |           |           |           |
| 1.00 µm film           | 726325.15 |           |           |           |           |           |
| 3.00 µm film           | 726809.25 |           |           |           |           |           |
| 5.00 µm film           | 726934.15 |           |           |           |           |           |
| 0.53 mm ID (0.8 mm OD) |           |           |           |           |           |           |
| 0.50 µm film           | 726523.10 |           |           |           |           |           |
| 1.00 µm film           | 726541.10 |           |           |           |           |           |
| 2.00 µm film           | 726525.10 |           |           |           |           |           |
| 5.00 µm film           | 726916.10 |           |           |           |           |           |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)



# OPTIMA<sup>®</sup> · weakly polar capillary columns



## OPTIMA<sup>®</sup> 5 MS 5 % diphenyl – 95 % dimethylpolysiloxane · USP G27 / G36

### ★ Key features

- Selectivity identical to OPTIMA<sup>®</sup> 5
- Phase with low bleeding
- Structure see page 307

### ✓ Recommended application

- GC/MS and ECD, applications and general analysis at trace level
- Perfect inertness for basic compounds

### ✍ Temperature

- T<sub>max</sub> 340 °C (long-term temperature), T<sub>max</sub> 360 °C (short-term max. temperature in a temperature program)

### Similar phases

- DB-5, DB-5MS, HP-5MS, Ultra-2, Equity<sup>™</sup>-5, CP-Sil 8CB low bleed/MS, Rxi<sup>®</sup>-5MS, Rtx<sup>®</sup>-5SIL-MS, Rtx<sup>®</sup>-5MS, 007-5MS, BPX<sup>™</sup>5, MDN-5S, AT<sup>™</sup>-5MS, VF-5MS

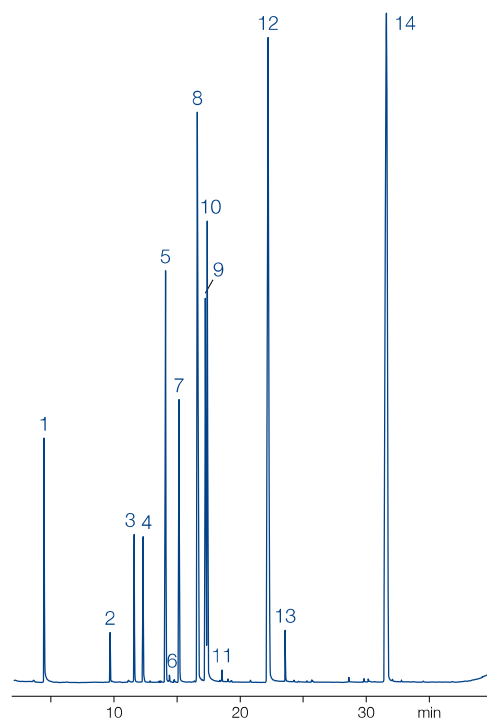
### Analysis of various phenols

MN Appl. No. 210110

Column: OPTIMA<sup>®</sup> 5 MS, 30 m x 0.25 mm ID, 0.25 µm film  
 Sample: 5 ppm of each compound except *N*-*i*-propylaniline (9.4 ppm)  
 Methode: SPME  
 Temperature: 40 °C (2 min) → 240 °C, 6 °C/min → 320 °C, 20 °C/min  
 Detector: MSD

#### Peaks:

1. Toluene-D<sub>8</sub>
2. Phenol
3. 2-Methylphenol (o-Cresol)
4. Nitrobenzene-D<sub>5</sub>
5. *N*-*i*-Propylaniline
6. 2,4-Dichlorophenol
7. 4-Chlorophenol
8. 4-Bromo-2-chlorophenol
9. 3-Bromophenol
10. 4-Chloro-3-methylphenol
11. 2,4-Dibromophenol
12. 2-Hydroxybiphenyl
13. 2-Cyclohexylphenol
14. Hexafluorobisphenol A



Courtesy of Riedel-de-Haën, Seelze, Germany

### Ordering information

#### OPTIMA<sup>®</sup> 5 MS

|                        | Length →  |           |           |           |           |           |
|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
|                        | 12 m      | 15 m      | 25 m      | 30 m      | 50 m      | 60 m      |
| 0,2 mm ID (0,4 mm OD)  |           |           |           |           |           |           |
| 0,20 µm film           | 726210,12 |           | 726210,25 |           | 726210,50 |           |
| 0,35 µm film           | 726215,12 |           | 726215,25 |           | 726215,50 |           |
| 0,25 mm ID (0,4 mm OD) |           |           |           |           |           |           |
| 0,25 µm film           |           | 726220,15 |           | 726220,30 |           | 726220,60 |
| 0,50 µm film           |           |           |           | 726225,30 |           | 726225,60 |
| 1,00 µm film           |           |           |           | 726226,30 |           | 726226,60 |
| 0,32 mm ID (0,5 mm OD) |           |           |           |           |           |           |
| 0,25 µm film           |           |           |           | 726211,30 |           |           |
| 0,50 µm film           |           |           |           | 726213,30 |           |           |
| 1,00 µm film           |           |           | 726212,25 |           | 726212,50 | 726212,60 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.



# OPTIMA® · weakly polar capillary columns



## OPTIMA® 5 MS Accent silarylene phase · USP G27 / G36

### ★ Key features

- Chemically bonded, cross-linked silarylene phase with polarity similar to a 5 % diphenyl - 95 % dimethylpolysiloxane phase
- Lowest column bleed, nonpolar phase, solvent rinsing for removal of impurities applicable
- Structure see page 307

### ✓ Recommended application

- Ideal for ion trap and quadrupole MS detectors
- Perfect inertness for basic compounds
- All-round phase for environmental analysis, trace analysis, EPA methods, pesticides, PCB, food and drug analysis

### ✍ Temperature

- $T_{max}$  340 °C (long-term temperature),  $T_{max}$  360 °C (short-term max. temperature in a temperature program)
- Film thickness > 0.5 µm:  
 $T_{max}$  320 and 340 °C, resp.

### Similar phases

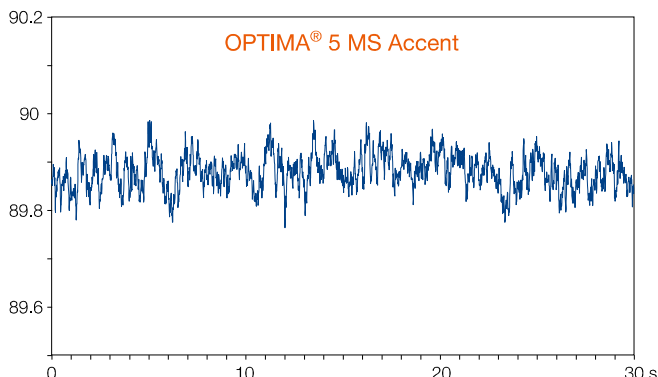
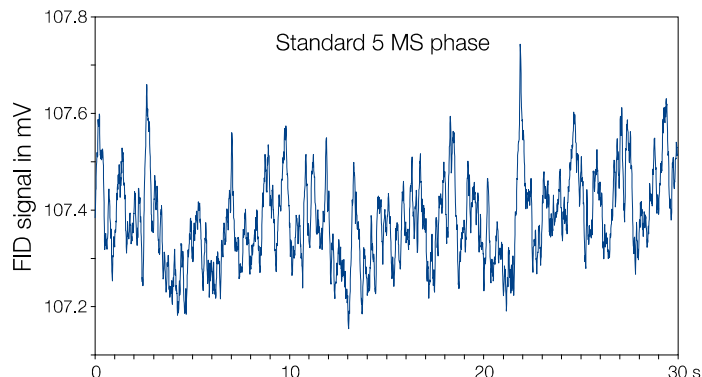
- DB-5, DB-5MS, HP-5MS, Ultra-2, Equity™-5, CP-Sil 8CB low bleed/MS, Rxi®-5MS, Rtx®-5SIL-MS, Rtx®-5MS, 007-5MS, BPX™5, MDN-5S, AT™-5MS, VF-5MS

### Increased sensitivity due to an unmatched low background level

The bleed comparison test of OPTIMA® 5 MS Accent with a conventional 5 MS phase shows the outstanding performance of the silarylene phase.

The unmatched low background level of the OPTIMA® 5 MS Accent, which is approximately three times lower compared to a 5 MS brand column, provides significantly increased sensitivity and allows its application in trace analysis particularly of high-boiling compounds.

### Background noise at 340 °C

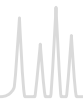


### Ordering information

#### OPTIMA® 5 MS Accent

|                        | Length →  |           |           |           |           |           |
|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
|                        | 12 m      | 15 m      | 25 m      | 30 m      | 50 m      | 60 m      |
| 0.2 mm ID (0.4 mm OD)  |           |           |           |           |           |           |
| 0.20 µm film           |           |           | 725810,25 |           | 725810,50 |           |
| 0.35 µm film           | 725815,12 |           |           |           | 725815,50 |           |
| 0.25 mm ID (0.4 mm OD) |           |           |           |           |           |           |
| 0.25 µm film           |           | 725820,15 |           | 725820,30 |           | 725820,60 |
| 0.50 µm film           |           |           |           | 725825,30 |           | 725825,60 |
| 1.00 µm film           |           |           |           | 725826,30 |           | 725826,60 |
| 0.32 mm ID (0.5 mm OD) |           |           |           |           |           |           |
| 0.25 µm film           |           |           |           | 725811,30 |           | 725811,60 |
| 0.50 µm film           |           |           |           | 725813,30 |           |           |
| 1.00 µm film           |           |           | 725812,25 |           |           | 725812,60 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.



# OPTIMA® · weakly polar capillary columns



## OPTIMA® XLB silarylene phase

### ★ Key features

- Chemically bonded, cross-linked silarylene phase, optimized silarylene content for lowest column bleed, nonpolar phase, perfect inertness for basic compounds, solvent rinsing for removal of impurities applicable
- Structure see page 307

### ✓ Recommended application

- Ideal for ion trap and quadrupole MS detectors, ultra low bleed phase, highly selective for environmental and trace analysis, pesticides, recommended phase for PCB separations

### ✍ Temperature

- T<sub>max</sub> 340 °C (long-term temperature), T<sub>max</sub> 360 °C (short-term max. temperature in a temperature program)

### Similar phases

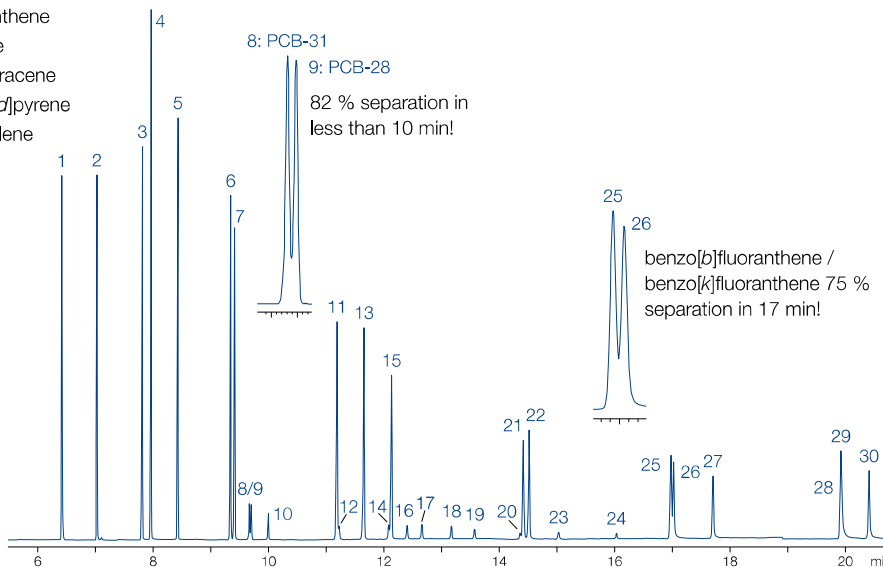
- DB-XLB, Rxi®-XLB, Rtx®-XLB, MDN-12, VF-XMS

### Rapid separation of PCB and PAH

MN Appl. No. 212920

Column: OPTIMA® XLB, 30 m x 0.25 mm ID, 0.25 µm film  
 Injection: 1 µL, Standard 0.005 ng/µL, 250 °C, pulsed, splitless, pulse 1.38 bar in 1 min  
 Carrier gas: 60 mL/min He  
 Temperature: 40 °C (2 min) → 240 °C (2 min), 30 °C/min → 340 °C (5 min), 10 °C/min  
 Detektion: MS source 230 °C, interface 280 °C, quadrupole 150 °C

- Peaks:
- |                          |                            |
|--------------------------|----------------------------|
| 1. Naphthalene           | 21. Benz[a]anthracene      |
| 2. 2-Methylnaphthalene   | 22. Chrysene               |
| 3. Acenaphthylene        | 23. PCB-169                |
| 4. Acenaphthene          | 24. PCB-194                |
| 5. Fluorene              | 25. Benzo[b]fluoranthene   |
| 6. Phenanthrene          | 26. Benzo[k]fluoranthene   |
| 7. Anthracene            | 27. Benzo[a]pyrene         |
| 8. PCB-31                | 28. Dibenz[ah]anthracene   |
| 9. PCB-28                | 29. Indeno[1,2,3-cd]pyrene |
| 10. PCB-52               | 30. Benzo[ghi]perylene     |
| 11. Fluoranthene         |                            |
| 12. PCB-101              |                            |
| 13. Pyrene               |                            |
| 14. PCB-77               |                            |
| 15. 2-Methylfluoranthene |                            |
| 16. PCB-118              |                            |
| 17. PCB-153              |                            |
| 18. PCB-138              |                            |
| 19. PCB-126              |                            |
| 20. PCB-180              |                            |



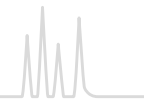
Courtesy of Centre d'Analyses de Recherche, Lab. d'Hydrologie, 65400 Illkirch, France

### Ordering information

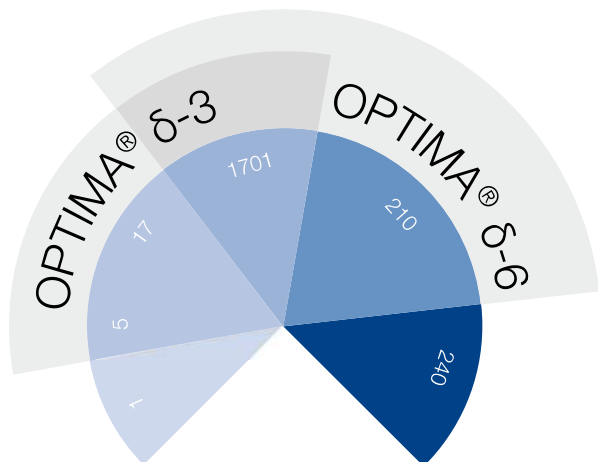
#### OPTIMA® XLB

|                        | Length →  |           |
|------------------------|-----------|-----------|
|                        | 30 m      | 60 m      |
| 0.25 mm ID (0.4 mm OD) |           |           |
| 0.25 µm film           | 725850.30 | 725850.60 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.



## Range of polarities covered by OPTIMA<sup>®</sup> $\delta$ phases



All stationary GC phases can be classified by their polarities. While the selectivity of common GC phases is generally determined by permanent dipole-dipole interactions, OPTIMA<sup>®</sup>  $\delta$ -3 and OPTIMA<sup>®</sup>  $\delta$ -6 show an additional feature. Large, polarizable groups in the polymer chain of the stationary phase enable the analyte to induce a further dipole moment that increases

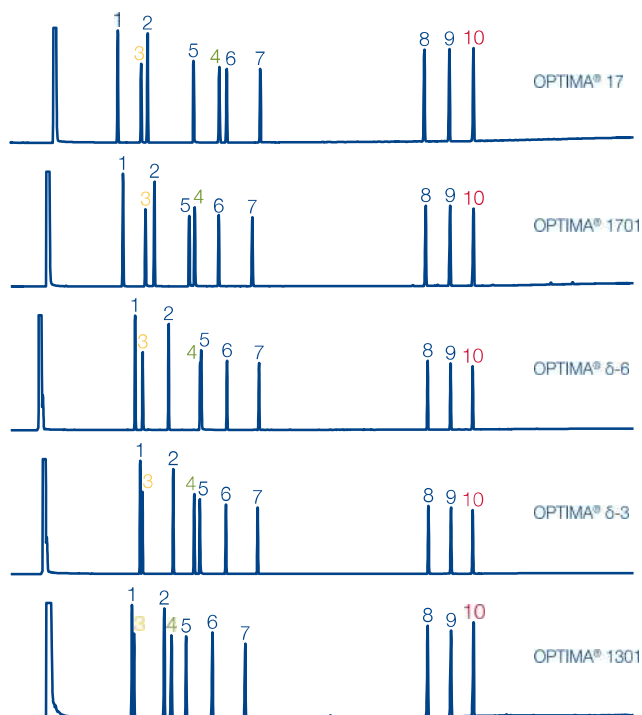
with the polarity of said analyte. We call this phenomenon “Autoselectivity”, because the column adjusts itself to the polarity of the analyte. The implemented polymers consist of cross-linked polysiloxanes with a defined composition and an extremely narrow distribution of molecular weight.

OPTIMA<sup>®</sup>  $\delta$  phases cover broad ranges of polarities. Compared with conventional phases, OPTIMA<sup>®</sup>  $\delta$ -3 polarity ranges from approximately the nonpolar OPTIMA<sup>®</sup> 5 to the midpolar OPTIMA<sup>®</sup> 1701, while for OPTIMA<sup>®</sup>  $\delta$ -6 the polarity covers a range from about the midpolar OPTIMA<sup>®</sup> 17 to the polar OPTIMA<sup>®</sup> 210.

OPTIMA<sup>®</sup>  $\delta$  phases show high temperature limits (340 / 360 °C), as well as low bleed levels, which makes them ideal for the use with mass selective (MSD) or phosphorus/nitrogen detectors (PND) in the field of environmental trace analysis.

Isomeric phenols, such as chloro- and nitrophenols, are difficult to analyze with standard GC phases (e.g., OPTIMA<sup>®</sup> 5 or OPTIMA<sup>®</sup> 17) because of co-elutions. The autoselective OPTIMA<sup>®</sup>  $\delta$ -3 is able to separate all 22 phenols due to stronger interactions occurring with more polar molecules, because polar analytes induce a dipole moment in the phase of the OPTIMA<sup>®</sup>  $\delta$ -3 (see chromatogram page 319).

## Separation characteristics of OPTIMA<sup>®</sup> $\delta$ phases



Conditions and peaks (see page 305)

### Key features of OPTIMA<sup>®</sup> $\delta$ phases

- Wide range of application due to autoselectivity
- Outstanding thermal stability similar to nonpolar phases
- Low bleed levels
- Medium polar without CN groups

Ordering information about OPTIMA<sup>®</sup>  $\delta$  phases can be found on page 319 and page 320.



## OPTIMA<sup>®</sup> δ-3 polysiloxane phase with autoselectivity · USP G49

### ★ Key features

- Medium polar without CN groups
- Autoselectivity resulting in a polarity range from approximately the nonpolar OPTIMA<sup>®</sup> 5 to the midpolar OPTIMA<sup>®</sup> 1701 (see page 318)
- Analytes determine the polarity of the phase

### ✓ Recommended application

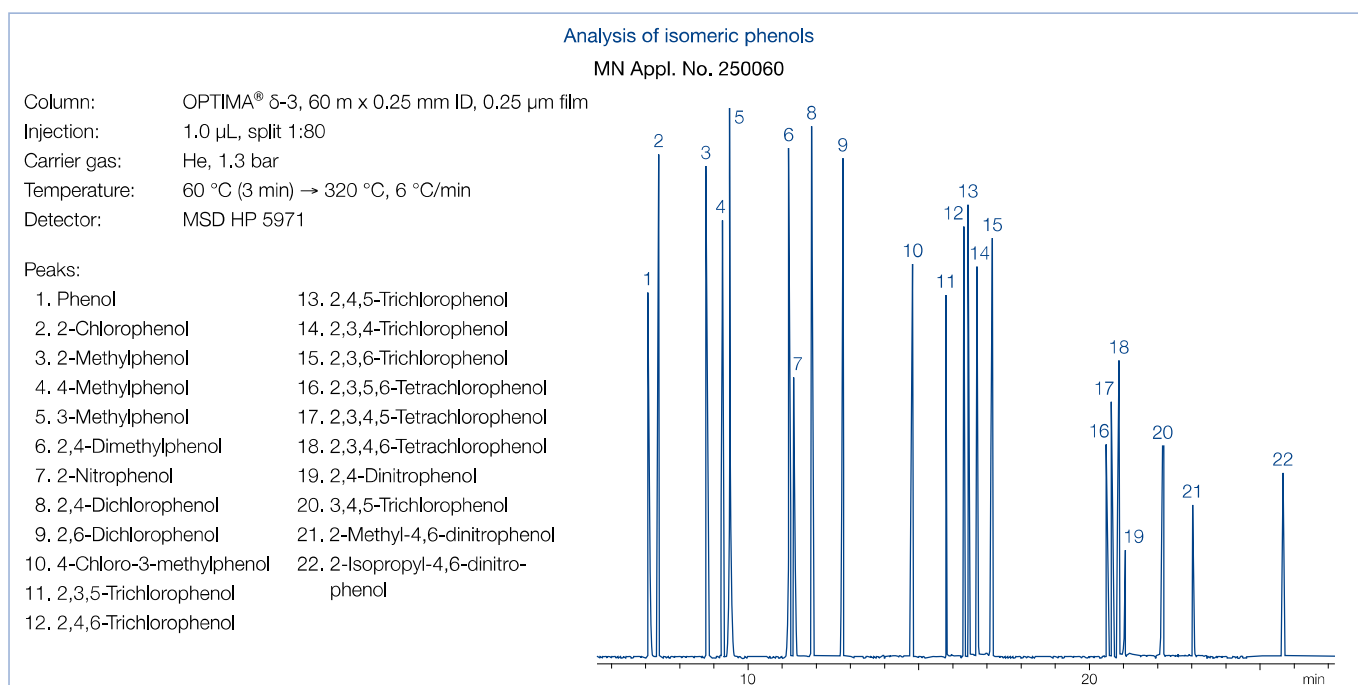
- Ideal for MSD and PND detectors

### ✍ Temperature

- 0.1–0.32 mm ID:  
T<sub>max</sub> 340 °C (long-term temperature),  
T<sub>max</sub> 360 °C (short-term max. temperature in a temperature program)
- 0.53 mm ID:  
T<sub>max</sub> 320 and 340 °C, resp.

### Similar phases

- Exclusive from MN



### Ordering information

#### OPTIMA<sup>®</sup> δ-3

|                        | Length →  |           |           |           |           |           |
|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
|                        | 10 m      | 20 m      | 25 m      | 30 m      | 50 m      | 60 m      |
| 0.1 mm ID (0.4 mm OD)  |           |           |           |           |           |           |
| 0.10 μm film           | 726410.10 | 726410.20 |           |           |           |           |
| 0.2 mm ID (0.4 mm OD)  |           |           |           |           |           |           |
| 0.20 μm film           |           |           | 726400.25 |           | 726400.50 |           |
| 0.25 mm ID (0.4 mm OD) |           |           |           |           |           |           |
| 0.25 μm film           |           |           |           | 726420.30 |           | 726420.60 |
| 0.50 μm film           |           |           |           | 726421.30 |           |           |
| 0.32 mm ID (0.5 mm OD) |           |           |           |           |           |           |
| 0.25 μm film           |           |           |           | 726440.30 |           | 726440.60 |
| 0.35 μm film           |           |           |           | 726441.30 |           | 726441.60 |
| 1.00 μm film           |           |           |           | 726442.30 |           | 726442.60 |
| 0.53 mm ID (0.8 mm OD) |           |           |           |           |           |           |
| 1.00 μm film           |           |           |           | 726443.30 |           |           |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.



# OPTIMA<sup>®</sup> δ · phases with autoselectivity



## OPTIMA<sup>®</sup> δ-6 polysiloxane phase with autoselectivity

### ★ Key features

- Medium polar without CN groups  
Autoselectivity resulting in a polarity range from approximately the midpolar OPTIMA<sup>®</sup> 17 to the polar OPTIMA<sup>®</sup> 210 (see page 318)
- Analytes determine the polarity of the phase

### ✓ Recommended application

- Ideal for MSD and PND detectors

### ✍ Temperature

- 0.1–0.32 mm ID:  
T<sub>max</sub> 340 °C (long-term temperature),  
T<sub>max</sub> 360 °C (short-term max. temperature in a temperature program)
- 0.53 mm ID:  
T<sub>max</sub> 320 and 340 °C, resp.

### Similar phases

- Exclusive from MN

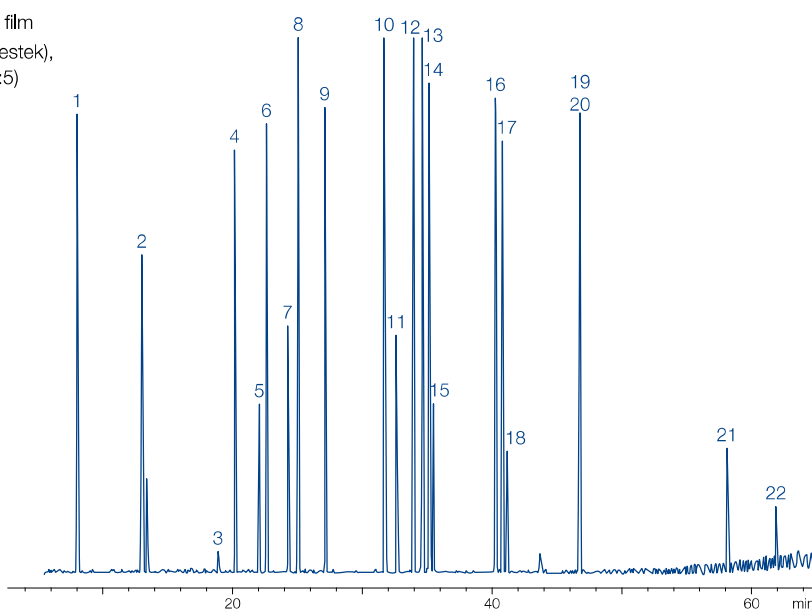
### Separation of organophosphorus pesticides (EPA 8140 / 8141)

MN Appl. No. 250420

Column: OPTIMA<sup>®</sup> δ-6, 50 m x 0.2 mm ID, 0.2 µm film  
 Sample: EPA 8140 OP pesticide calibration mix (Restek),  
 200 µg/mL each in hexane – acetone (95:5)  
 Injection: 1 µL, split 1:30  
 Carrier gas: 2.0 bar He  
 Temperature: 150 °C → 300 °C (10 min), 2.5 °C/min  
 Detector: MSD HP 5971

#### Peaks:

- |                      |                               |
|----------------------|-------------------------------|
| 1. Dichlorvos        | 13. Trichloronate             |
| 2. Mevinphos         | 14. Fenthion                  |
| 3. Demeton-S         | 15. Merphos                   |
| 4. Ethoprop          | 16. Stirofos                  |
| 5. Naled             | 17. Tokuthion                 |
| 6. Phorate           | 18. Merphos oxidation product |
| 7. Demeton-O         | 19. Fensulfothion             |
| 8. Diazinon          | 20. Bolstar                   |
| 9. Disulfoton        | 21. Azinphos-methyl           |
| 10. Ronnel           | 22. Coumaphos                 |
| 11. Parathion-methyl |                               |
| 12. Chlorpyrifos     |                               |

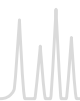


### Ordering information

#### OPTIMA<sup>®</sup> δ-6

|                        | Length →  |           |           |           |           |
|------------------------|-----------|-----------|-----------|-----------|-----------|
|                        | 10 m      | 25 m      | 30 m      | 50 m      | 60 m      |
| 0.1 mm ID (0.4 mm OD)  |           |           |           |           |           |
| 0.10 µm film           | 726490.10 |           |           |           |           |
| 0.2 mm ID (0.4 mm OD)  |           |           |           |           |           |
| 0.20 µm film           |           | 726465.25 |           | 726465.50 |           |
| 0.25 mm ID (0.4 mm OD) |           |           |           |           |           |
| 0.25 µm film           |           |           | 726470.30 |           | 726470.60 |
| 0.32 mm ID (0.5 mm OD) |           |           |           |           |           |
| 0.25 µm film           |           |           | 726480.30 |           | 726480.60 |
| 0.35 µm film           |           |           | 726481.30 |           | 726481.60 |
| 1.00 µm film           |           |           | 726482.30 |           | 726482.60 |
| 0.53 mm ID (0.8 mm OD) |           |           |           |           |           |
| 1.00 µm film           |           |           | 726483.30 |           |           |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.



## OPTIMA<sup>®</sup> 1301 6 % cyanopropyl-phenyl – 94 % dimethylpolysiloxane · USP G43

### ★ Key features

- Midpolar phase
- Structure see page 307

### ✓ Recommended application

- Pesticide analysis
- For corresponding columns with higher film thickness see OPTIMA<sup>®</sup> 624

### ✍ Temperature

- T<sub>max</sub> 300 °C (long-term temperature),  
T<sub>max</sub> 320 °C (short-term max. temperature in a temperature program)

### Similar phases

- HP-1301, DB-1301, SPB<sup>TM</sup>-1301, Rtx<sup>®</sup>-1301, CP-1301, 007-1301

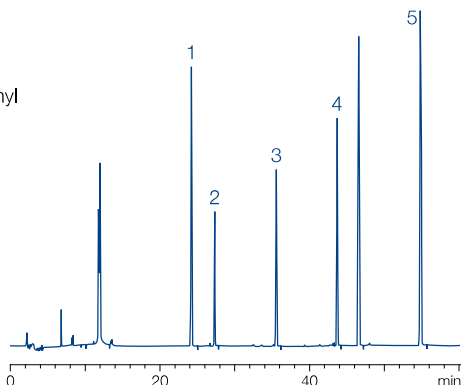
#### Analysis of a pesticide mixture

MN Appl. No. 210620

Column: OPTIMA<sup>®</sup> 1301, 60 m x 0.25 mm ID, 0.25 µm film  
 Injection: 3 µL (0.1 ng/µL), 80 °C (1 min) → 250 °C (1 min)  
 pulsed splitless  
 Carrier gas: He, 54 mL/min  
 Temperature: 80 °C (2 min) → 190 °C,  
 20 °C/min (12 min) → 240 °C,  
 2 °C/min (23 min) → 260 °C, 10 °C/min (20 min)  
 Detector: ECD

Peaks :

1. Propyzamide
2. Vinclozolin
3. Bromophos-ethyl
4. 2,4-DDT
5. Bromopropylate



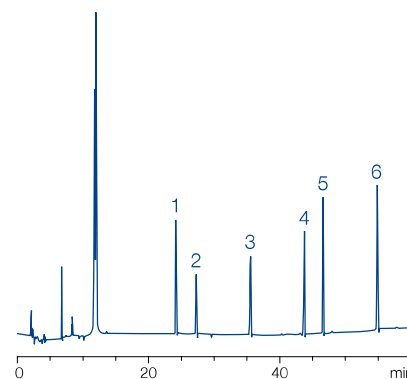
#### Analysis of a PCB mixture

MN Appl. No. 210650

Column: OPTIMA<sup>®</sup> 1301, 60 m x 0.25 mm ID, 0.25 µm film  
 Injection: 3 µL (0.1 ng/µL), 80 °C (1 min) → 250 °C (1 min)  
 pulsed splitless  
 Carrier gas: He, 54 mL/min  
 Temperature: 80 °C (2 min) → 190 °C,  
 20 °C/min (12 min) → 240 °C,  
 2 °C/min (23 min) → 260 °C, 10 °C/min (20 min)  
 Detector: ECD

Peaks :

1. PCB-28
2. PCB-52
3. PCB-128
4. PCB-153
5. PCB-138
6. PCB-180



### Ordering information

#### OPTIMA<sup>®</sup> 1301

|                        | Length →  |           |           |           |
|------------------------|-----------|-----------|-----------|-----------|
|                        | 25 m      | 30 m      | 50 m      | 60 m      |
| 0.25 mm ID (0.4 mm OD) |           |           |           |           |
| 0.25 µm film           | 726771.25 | 726771.30 | 726771.50 | 726771.60 |
| 0.32 mm ID (0.5 mm OD) |           |           |           |           |
| 0.25 µm film           | 726777.25 | 726777.30 |           | 726777.60 |
| 1.00 µm film           |           | 726780.30 | 726780.50 | 726780.60 |
| 0.53 mm ID (0.8 mm OD) |           |           |           |           |
| 1.00 µm film           | 726783.25 |           |           |           |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)





# OPTIMA® · medium polar capillary columns



## OPTIMA® 1301 MS 6 % cyanopropyl-phenyl – 94 % dimethylpolysiloxane · USP G43

### ★ Key features

- Chemically bonded, cross-linked silarylene phase with selectivity similar to 6 % cyanopropyl-phenyl – 94 % dimethylpolysiloxane, symmetric substituted cyanopropylsilanes and integrated phenyl rings (silarylene)
- Midpolar phase with very low bleed
- Perfect deactivation
- Structure see page 307

### ✓ Recommended application

- Specially suitable for sophisticated environmental analysis (e.g., EPA methods for PAHs, PCBs and pesticides)
- 100 % ion trap and quadrupol MS compatibility

### ✍ Temperature

- T<sub>max</sub> 300 °C (long-term temperature), T<sub>max</sub> 320 °C (short-term max. temperature in a temperature program)

### Similar phases

- VF-1301ms, Rxi®-1301Sil MS, TG-1301MS

### Ordering information

#### OPTIMA® 1301 MS

|                        | Length →  |           |
|------------------------|-----------|-----------|
|                        | 30 m      | 60 m      |
| 0.25 mm ID (0.4 mm OD) |           |           |
| 0.25 µm film           | 726640.30 | 726640.60 |
| 0.32 mm ID (0.5 mm OD) |           |           |
| 0.25 µm film           | 726641.30 | 726641.60 |
| 1.00 µm film           | 726642.30 | 726642.60 |
| 0.53 mm ID (0.8 mm OD) |           |           |
| 1.00 µm film           | 726643.30 | 726643.60 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.



# OPTIMA<sup>®</sup> · medium polar capillary columns



## OPTIMA<sup>®</sup> 624 6 % cyanopropyl-phenyl – 94 % dimethylpolysiloxane · USP G43

### ★ Key features

- Midpolar phase
- Structure see page 307

### ✓ Recommended application

- Environmental analysis
- For corresponding columns with lower film thickness see OPTIMA<sup>®</sup> 1301

### ✍ Temperature

- T<sub>max</sub> 280 °C (long-term temperature), T<sub>max</sub> 300 °C (short-term max. temperature in a temperature program)

### Similar phases

- HP-624, HP-VOC, DB-624, DB-VRX, SPB<sup>™</sup>-624, CP-624, Rtx<sup>®</sup>-624, Rtx<sup>®</sup>-Volatiles, 007-624, BP624, VOCOL

## OPTIMA<sup>®</sup> 624 LB 6 % cyanopropyl-phenyl – 94 % dimethylpolysiloxane

### ★ Key features

- Midpolar phase with low bleeding
- Structure see page 307

### ✓ Recommended application

- Halogenated hydrocarbons, volatiles, aromatic compounds, solvents etc.

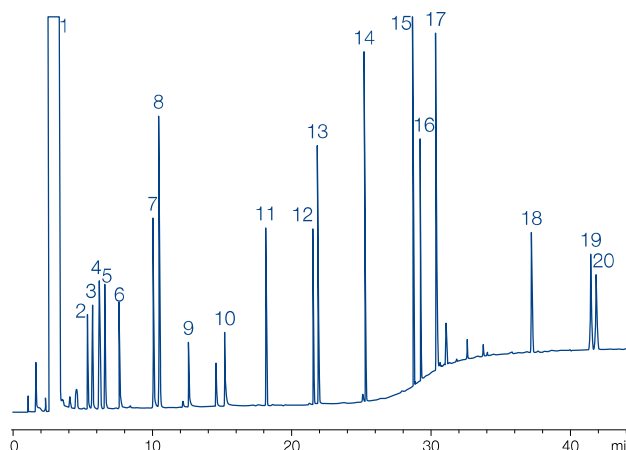
### Solvents and semi-volatiles

MN Appl. No. 212520

Column: OPTIMA<sup>®</sup> 624 LB, 30 m x 0.32 mm ID, 1.8 µm film; retention gap Phe-Sil 0.5 m x 0.53 mm  
 Injection: 1 µL (10 ppm per substance in acetone), cold on-column  
 Carrier gas: 1.1 bar He  
 Temperature: 45 °C (3 min) → 150 °C (6 °C/min) → 300 °C (18 °C/min), 20 min 300 °C  
 Detector: FID 280 °C

### Peaks:

- |                       |                                       |
|-----------------------|---------------------------------------|
| 1. Acetone            | 11. Decane                            |
| 2. Ethyl acetate      | 12. 1-Octanol                         |
| 3. Tetrahydrofuran    | 13. Acetophenone                      |
| 4. Cyclohexane        | 14. Butyrophenone                     |
| 5. 2-Methyl-2-butanol | 15. Heptanophenone                    |
| 6. 1-Butanol          | 16. 5-Methoxyindole                   |
| 7. Pyridine           | 17. Dibenzylamine                     |
| 8. Toluene            | 18. Methyl eicosanoate                |
| 9. Dimethylformamide  | 19. Methyl <i>cis</i> -13-docosanoate |
| 10. Dimethylsulfoxide | 20. Methyl docosanoate                |



### Ordering information

|                                  | Length →  |           |           |           |
|----------------------------------|-----------|-----------|-----------|-----------|
|                                  | 25 m      | 30 m      | 50 m      | 60 m      |
| <b>OPTIMA<sup>®</sup> 624</b>    |           |           |           |           |
| 0.2 mm ID (0.4 mm OD)            |           |           |           |           |
| 1.10 µm film                     | 726784.25 |           |           |           |
| 0.25 mm ID (0.4 mm OD)           |           |           |           |           |
| 1.40 µm film                     | 726785.25 | 726785.30 | 726785.50 | 726785.60 |
| 0.32 mm ID (0.5 mm OD)           |           |           |           |           |
| 1.80 µm film                     | 726787.25 | 726787.30 | 726787.50 | 726787.60 |
| 0.53 mm ID (0.8 mm OD)           |           |           |           |           |
| 3.00 µm film                     | 726789.25 | 726789.30 |           |           |
| <b>OPTIMA<sup>®</sup> 624 LB</b> |           |           |           |           |
| 0.32 mm ID (0.5 mm OD)           |           |           |           |           |
| 1.80 µm film                     |           | 726786.30 | 726786.50 |           |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.



# OPTIMA<sup>®</sup> · medium polar capillary columns



## OPTIMA<sup>®</sup> 1701 14 % cyanopropyl-phenyl – 86 % dimethylpolysiloxane · USP G46

### ★ Key features

- Midpolar phase, special selectivity due to high cyanopropyl content
- Structure see page 307

### ✓ Recommended application

- Reference column for structure identification, e.g., in combination with OPTIMA<sup>®</sup> 5
- Film thickness ≥ 1 µm for solvent analysis

### ✍ Temperature

- T<sub>max</sub> 280 °C (long-term temperature), T<sub>max</sub> 300 °C (short-term max. temperature in a temperature program)
- 0.53 mm ID: T<sub>max</sub> 280 and 300 °C, resp.

### Similar phases

- OV-1701, DB-1701, CP-Sil 19 CB, HP-1701, Rtx<sup>®</sup>-1701, SPB<sup>™</sup>-1701, 007-1701, BP10, ZB-1701

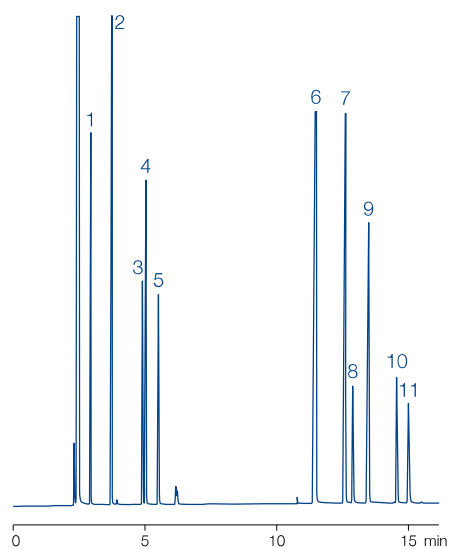
### Analysis of aromatic hydrocarbons

MN Appl. No. 200400

Column: OPTIMA<sup>®</sup> 1701, 25 m x 0.32 mm ID, 0.25 µm film  
 Injection: 1 µL, split 1:40  
 Carrier gas: 0.6 bar N<sub>2</sub>  
 Temperature: 60 °C → 120 °C, 4 °C/min  
 Detector: FID 260 °C

#### Peaks:

1. Benzene
2. Toluene
3. Ethylbenzene
4. *p*-Xylene
5. *o*-Xylene
6. Phenol
7. 2-Methylphenol
8. 2,6-Dimethylphenol
9. 4-Methylphenol
10. 2,4-Dimethylphenol
11. 2,4,6-Trimethylphenol



### Ordering information

#### OPTIMA<sup>®</sup> 1701

|                        | Length →  |           |           |           |           |           |
|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
|                        | 10 m      | 15 m      | 25 m      | 30 m      | 50 m      | 60 m      |
| 0.2 mm ID (0.4 mm OD)  |           |           |           |           |           |           |
| 0.20 µm film           |           |           | 726841.25 |           | 726841.50 |           |
| 0.25 mm ID (0.4 mm OD) |           |           |           |           |           |           |
| 0.25 µm film           | 726058.10 | 726058.15 | 726058.25 | 726058.30 | 726058.50 | 726058.60 |
| 0.50 µm film           |           |           |           | 726064.30 |           | 726064.60 |
| 1.00 µm film           |           |           |           | 726965.30 |           |           |
| 0.32 mm ID (0.5 mm OD) |           |           |           |           |           |           |
| 0.25 µm film           | 726318.10 | 726318.15 | 726318.25 | 726318.30 | 726318.50 | 726318.60 |
| 0.35 µm film           |           |           | 726824.25 | 726824.30 | 726824.50 | 726824.60 |
| 0.50 µm film           |           |           | 726320.25 | 726320.30 | 726320.50 | 726320.60 |
| 1.00 µm film           |           |           | 726929.25 | 726929.30 | 726929.50 | 726929.60 |
| 0.53 mm ID (0.8 mm OD) |           |           |           |           |           |           |
| 1.00 µm film           | 726545.10 | 726545.15 | 726545.25 | 726545.30 |           |           |
| 2.00 µm film           |           | 726735.15 | 726735.25 | 726735.30 | 726735.50 |           |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)



## OPTIMA<sup>®</sup> 1701 MS silarylene phase · USP G46

### ★ Key features

- Chemically bonded, cross-linked silarylene phase with selectivity similar to 14 % cyanopropyl-phenyl – 86 % dimethylpolysiloxane, symmetric substituted cyanopropylsilanes and integrated phenyl rings (silarylene)
- Midpolar phase with very low bleed
- Perfect deactivation
- Structure see page 307

### ✓ Recommended application

- Environmental analysis (e.g., PAHs, PCBs, pesticides)
- Reference column for structure identification, e.g., in combination with OPTIMA<sup>®</sup> 5 MS
- 100 % ion trap and quadrupole MS compatibility

### ✍ Temperature

- T<sub>max</sub> 280 °C (long-term temperature), T<sub>max</sub> 300 °C (short-term max. temperature in a temperature program)

### Similar phases

- VF-1701ms, TG-1701MS, OV-1701, DB-1701, HP-1701, Rtx<sup>®</sup>-1701, SPB<sup>™</sup>-1701, CP Sil 19 CB, 007-1701, BP10, ZB-1701

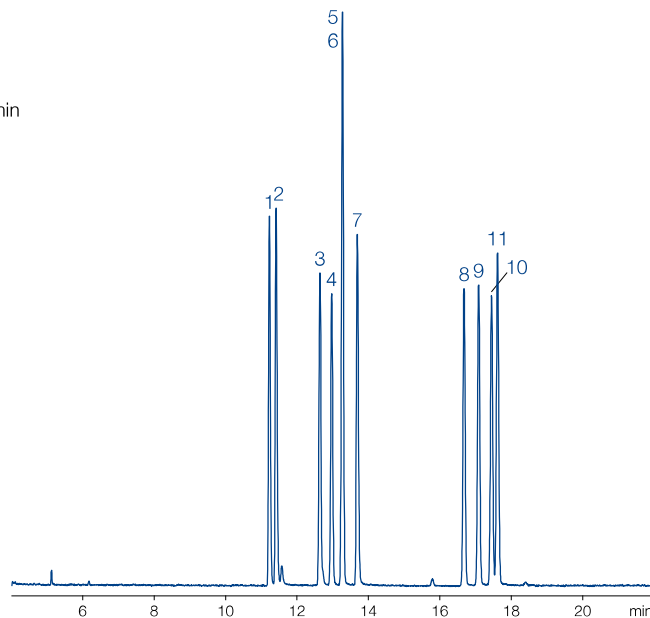
### Separation of triazine pesticides (EPA 619)

MN Appl. No. 215080

Column: OPTIMA<sup>®</sup> 1701 MS, 30 m x 0.25 mm ID, 0.25 µm film  
 Injection: 1 µL, 250 °C, split 1:100  
 Carrier gas: 42 cm/s He  
 Temperature: 160 °C (1 min) → 180 °C, 15 °C/min → 220 °C, 2 °C/min  
 Detector: MSD

#### Peaks:

1. Prometon
2. Atraton
3. Propazine
4. Atrazine
5. Simazine
6. Terbutylazine
7. Secbumeton
8. Prometryn
9. Ametryn
10. Simetryn
11. Terbutryn



### Ordering information

#### OPTIMA<sup>®</sup> 1701 MS

|                        | Length →  |           |
|------------------------|-----------|-----------|
|                        | 30 m      | 60 m      |
| 0.25 mm ID (0.4 mm OD) |           |           |
| 0.25 µm film           | 726630.30 | 726630.60 |
| 0.50 µm film           | 726631.30 | 726631.60 |
| 1.00 µm film           | 726632.30 | 726632.60 |
| 0.32 mm ID (0.5 mm OD) |           |           |
| 0.25 µm film           | 726633.30 | 726633.60 |
| 0.50 µm film           | 726634.30 | 726634.60 |
| 1.00 µm film           | 726635.30 | 726635.60 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.



# OPTIMA® · medium polar capillary columns



## OPTIMA® 35 MS silarylene phase · USP G42 / close equivalent to USP G28 / G32

### ★ Key features

- Chemically bonded cross-linked silarylene phase with selectivity similar to 35 % phenyl – 65 % methyl polysiloxane, midpolar phase, polymer without CN groups
- Very low column bleeding
- Structure see page 309

### ✓ Recommended application

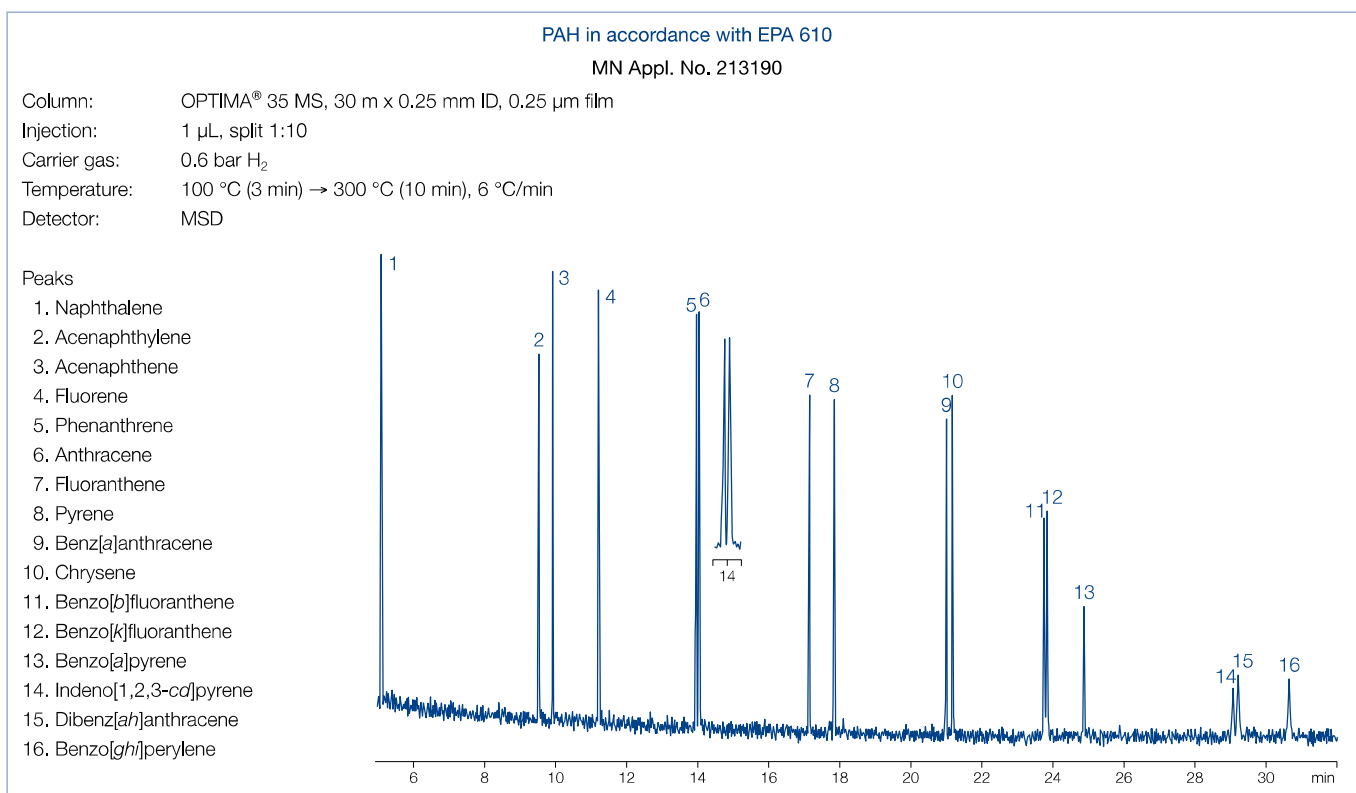
- Ideal for ion trap detectors
- Optimum column for confirmation of analytical results in combination with a 1 MS or 5 MS
- All-round phase for environmental analysis, ultra trace analysis, EPA methods, pesticides, PCB, food and drug analysis

### ✍ Temperature

- T<sub>max</sub> 360 °C (long-term temperature), T<sub>max</sub> 370 °C (short-term max. temperature in a temperature program)

### Similar phases

- DB-35 MS, HP-35, SPB™-35, Rxi®-35SIL MS, Rtx-35, 007-35, BPX™-35, MDN-35, AT™-35 MS, ZB-35, OV-11, VF-35 MS



### Ordering information

#### OPTIMA® 35 MS

|                        | Length →  |           |
|------------------------|-----------|-----------|
|                        | 30 m      | 60 m      |
| 0.25 mm ID (0.4 mm OD) |           |           |
| 0.25 µm film           | 726154.30 | 726154.60 |
| 0.32 mm ID (0.5 mm OD) |           |           |
| 0.25 µm film           | 726157.30 | 726157.60 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)



## OPTIMA<sup>®</sup> 17 phenylmethylpolysiloxane (50 % phenyl) · USP G3

### ★ Key features

- Midpolar phase
- Structure see page 309

### ✓ Recommended application

- Steroids, pesticide, drug analysis

### ✍ Temperature

- T<sub>max</sub> 320 °C (long-term temperature), T<sub>max</sub> 340 °C (short-term max. temperature in a temperature program)
- 0.53 mm ID: T<sub>max</sub> 300 and 320 °C resp.

### Similar phases

- OV-17, DB-17, HP-50+, HP-17, SPB<sup>™</sup>-50, SP-2250, Rxi<sup>®</sup>-17, Rtx<sup>®</sup>-50, CP-Sil 24 CB, 007-17, ZB-50

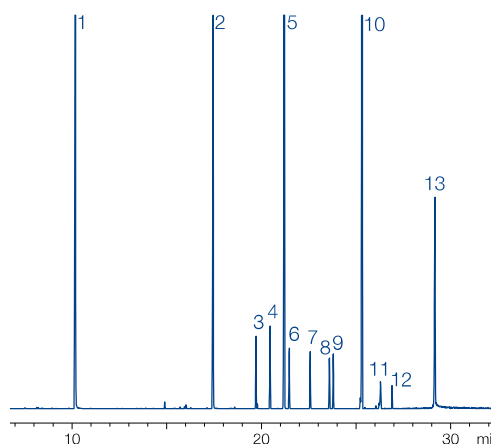
### Analysis of pesticides

MN Appl. No. 200930

Column: OPTIMA<sup>®</sup> 17, 25 m x 0.2 mm ID, 0.20 µm film  
 Sample: pesticides, standard of the cantonal laboratory Schaffhausen (Switzerland), 0.1 mg/mL or 0.01 mg/mL each  
 Injection: 1.0 µL, 3 s without split  
 Carrier gas: He, 25 cm/s  
 Temperature: 100 °C (3 min), 8 °C/min → 250 °C, 10 °C/min → 320 °C  
 Detector: MSD HP 5971

#### Peaks:

- |                  |                     |
|------------------|---------------------|
| 1. Dichlorphos   | 8. Captan           |
| 2. Naled         | 9. Folpet           |
| 3. Vinclozolin   | 10. Carbophenothion |
| 4. Chlorthalonil | 11. Iprodion        |
| 5. Chlorpyrifos  | 12. Captafol        |
| 6. Dichlofluamid | 13. Coumaphos       |
| 7. Procymidon    |                     |



### Ordering information

#### OPTIMA<sup>®</sup> 17

|                        | Length →  |      |           |      |           |      |           |  |           |  |           |  |
|------------------------|-----------|------|-----------|------|-----------|------|-----------|--|-----------|--|-----------|--|
|                        | 10 m      | 12 m | 15 m      | 25 m | 30 m      | 50 m | 60 m      |  |           |  |           |  |
| 0.1 mm ID (0.4 mm OD)  |           |      |           |      |           |      |           |  |           |  |           |  |
| 0.10 µm film           | 726848.10 |      |           |      |           |      |           |  |           |  |           |  |
| 0.2 mm ID (0.4 mm OD)  |           |      |           |      |           |      |           |  |           |  |           |  |
| 0.20 µm film           | 726065.12 |      | 726065.25 |      | 726065.50 |      |           |  |           |  |           |  |
| 0.50 µm film           |           |      | 726066.25 |      | 726066.50 |      |           |  |           |  |           |  |
| 0.25 mm ID (0.4 mm OD) |           |      |           |      |           |      |           |  |           |  |           |  |
| 0.15 µm film           |           |      | 726742.25 |      | 726742.30 |      | 726742.50 |  | 726742.60 |  |           |  |
| 0.25 µm film           |           |      | 726022.15 |      | 726022.25 |      | 726022.30 |  | 726022.50 |  | 726022.60 |  |
| 0.50 µm film           |           |      | 726067.25 |      | 726067.30 |      | 726067.50 |  | 726067.60 |  |           |  |
| 0.32 mm ID (0.5 mm OD) |           |      |           |      |           |      |           |  |           |  |           |  |
| 0.15 µm film           |           |      |           |      | 726755.30 |      |           |  |           |  |           |  |
| 0.25 µm film           |           |      | 726351.25 |      | 726351.30 |      | 726351.50 |  | 726351.60 |  |           |  |
| 0.35 µm film           |           |      | 726757.25 |      | 726757.30 |      | 726757.50 |  | 726757.60 |  |           |  |
| 0.50 µm film           |           |      | 726744.25 |      | 726744.30 |      | 726744.50 |  | 726744.60 |  |           |  |
| 0.53 mm ID (0.8 mm OD) |           |      |           |      |           |      |           |  |           |  |           |  |
| 1.00 µm film           | 726747.10 |      | 726747.15 |      | 726747.25 |      | 726747.30 |  |           |  |           |  |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.



## OPTIMA<sup>®</sup> 17 MS silarylene phase · USP G3

### ★ Key features

- Medium polar silarylene phase with selectivity analogue to 50 % phenyl – 50 % methylpolysiloxane, no CN groups in the polymer
- Structure see page 309

### ✓ Recommended application

- Ideal for ion trap detectors
- Optimum reference column in combination with a 1 MS or 5 MS
- All-round phase for environmental analysis, ultra-trace analysis, EPA methods, pesticide, PCBs, food and drug analysis

### ✍ Temperature

- T<sub>max</sub> 340 °C (long-term temperature),
- T<sub>max</sub> 360 °C (short-term max. temperature in a temperature program)

### Similar phases

- OV-17, AT<sup>™</sup>-50, BPX<sup>™</sup>-50, DB-17, DB-17ms, HP-50+, HP-17, SPB<sup>™</sup>-50, SPB<sup>™</sup>-17, SP-2250, Rtx<sup>®</sup>-50, CP-Sil 24 CB, 007-17, VF-17ms, ZB-50

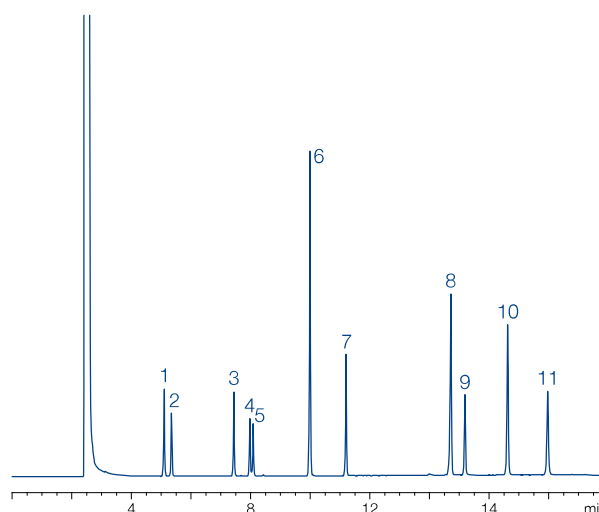
### Analysis of phenols

MN Appl. No. 213600

Column: OPTIMA<sup>®</sup> 17 MS, 30 m x 0.25 mm ID, 0.25 µm film  
 Sample: phenol mix 604  
 Injection: 1.0 µL, 230 °C, split 1:30  
 Carrier gas: 0.8 bar He  
 Temperature: 100 °C, 10 °C/min → 250 °C  
 Detector: FID 280 °C

#### Peaks:

1. Phenol
2. 2-Chlorophenol
3. 2,4-Dimethylphenol
4. 2-Nitrophenol
5. 2,4-Dichlorophenol
6. 4-Chloro-3-methylphenol
7. 2,4,6-Trichlorophenol
8. 4-Nitrophenol
9. 2,4-Dinitrophenol
10. 2-Methyl-4,6-dinitrophenol
11. Pentachlorophenol



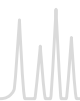
### Ordering information

#### OPTIMA<sup>®</sup> 17 MS

|                        | Length →<br>30 m | 60 m      |
|------------------------|------------------|-----------|
| 0.25 mm ID (0.4 mm OD) |                  |           |
| 0.25 µm film           | 726162.30        | 726162.60 |
| 0.32 mm ID (0.5 mm OD) |                  |           |
| 0.25 µm film           | 726165.30        | 726165.60 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)



## OPTIMA<sup>®</sup> 210 trifluoropropyl-methylpolysiloxane (50 % trifluoropropyl) · close equivalent to USP G6

### ★ Key features

- Midpolar phase
- Structure see page 309

### ✓ Recommended application

- Environmental analysis, especially for *o*-, *m*- and *p*-substituted aromatic hydrocarbons

### ✍ Temperature

- T<sub>max</sub> 260 °C (long-term temperature),  
T<sub>max</sub> 280 °C (short-term max. temperature in a temperature program)

### Similar phases

- OV-210, DB-210, Rtx<sup>®</sup>-200, 007-210

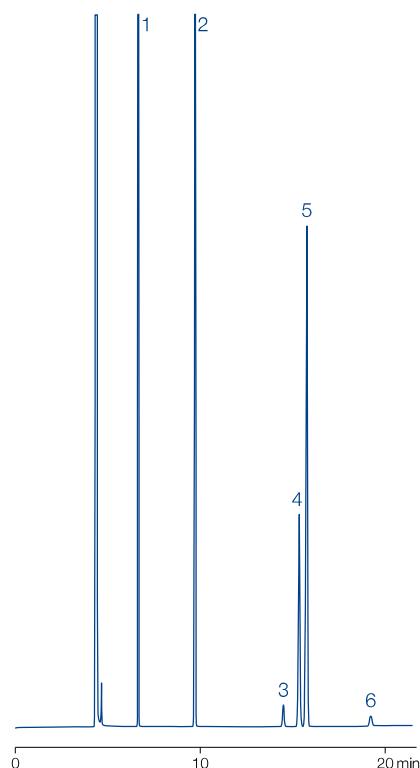
### Aromatic hydrocarbons (BTX)

MN Appl. No. 200230

Column: OPTIMA<sup>®</sup> 210, 50 m x 0.25 mm ID, 0.5 µm film  
 Injection: 0.5 µL, split 105 mL/min  
 Carrier gas: 130 kPa N<sub>2</sub> (1.1 mL/min)  
 Temperature: 50 °C  
 Detector: FID 250 °C

#### Peaks:

1. Benzene
2. Toluene
3. Ethylbenzene
4. *p*-Xylene
5. *m*-Xylene
6. *o*-Xylene



### Ordering information

#### OPTIMA<sup>®</sup> 210

|                        | Length →  |           |           |           |           |
|------------------------|-----------|-----------|-----------|-----------|-----------|
|                        | 15 m      | 25 m      | 30 m      | 50 m      | 60 m      |
| 0.25 mm ID (0.4 mm OD) |           |           |           |           |           |
| 0.25 µm film           | 726871.15 | 726871.25 | 726871.30 | 726871.50 | 726871.60 |
| 0.50 µm film           |           |           | 726874.30 | 726874.50 | 726874.60 |
| 0.32 mm ID (0.5 mm OD) |           |           |           |           |           |
| 0.25 µm film           | 726877.15 |           | 726877.30 | 726877.50 | 726877.60 |
| 0.50 µm film           |           | 726880.25 | 726880.30 | 726880.50 | 726880.60 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.





# OPTIMA® · polar capillary columns



**OPTIMA® 225** 50 % cyanopropyl-methyl – 50 % phenylmethylpolysiloxane · close equivalent to USP G7/G19

### ★ Key features

- Midpolar phase
- Structure see page 309

### ✓ Recommended application

- Fatty acid analysis

### ✍ Temperature

- T<sub>max</sub> 260 °C (long-term temperature),
- T<sub>max</sub> 280 °C (short-term max. temperature in a temperature program)

### Similar phases

- OV-210, DB-210, Rtx®-200, 007-210

### Analysis of FAME in porcine fat

MN Appl. No. 210060

Column: OPTIMA® 225, 25 m x 0.32 mm ID, 0.25 µm film

Injection: 1 µL, split 1:40

Carrier gas: 60 kPa H<sub>2</sub>

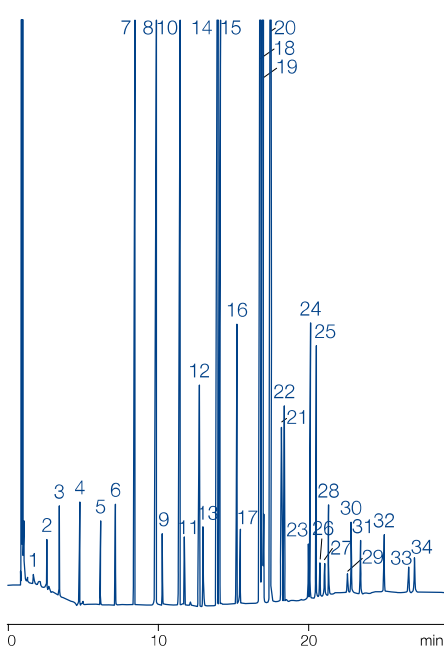
Temperature: 50 °C (2 min) → 125 °C, 30 °C/min → 160 °C, 5 °C/min → 180 °C, 20 °C/min → 200 °C, 3 °C/min → 220 °C, 20 °C/min (10 min)

Detector: FID 260 °C

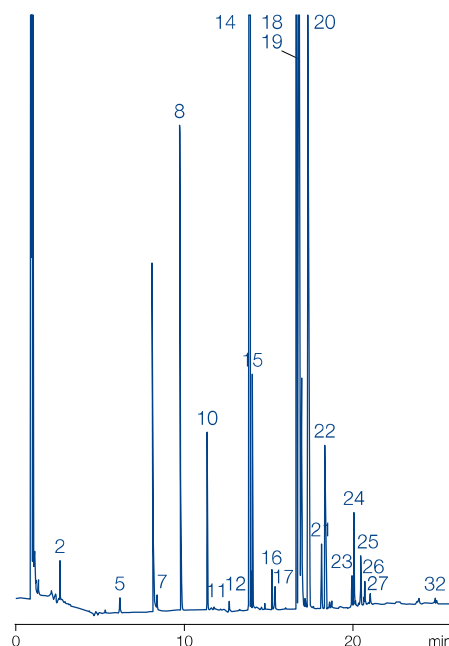
### Peaks:

- |           |           |
|-----------|-----------|
| 1. C4:0   | 18. C18:0 |
| 2. C5:0   | 19. C18:1 |
| 3. C6:0   | 20. C18:2 |
| 4. C8:0   | 21. C18:3 |
| 5. C10:0  | 22. C19:0 |
| 6. C11:0  | 23. C20:0 |
| 7. C12:0  | 24. C20:1 |
| 8. C13:0  | 25. C20:2 |
| 9. C13:1  | 26. C20:4 |
| 10. C14:0 | 27. C20:3 |
| 11. C14:1 | 28. C20:5 |
| 12. C15:0 | 29. C22:0 |
| 13. C15:1 | 30. C22:1 |
| 14. C16:0 | 31. C22:2 |
| 15. C16:1 | 32. C22:6 |
| 16. C17:0 | 33. C24:0 |
| 17. C17:1 | 34. C24:1 |

### FAME Standard



### FAME in porcine fat



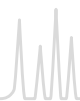
Courtesy of Dr. Bantleon, Mr. Leusche, Mr. Hagemann, VFG-Labor, Versmold, Germany

### Ordering information

#### OPTIMA® 225

| Length →               | Length →  |           |           |           |           |           |
|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
|                        | 10 m      | 15 m      | 25 m      | 30 m      | 50 m      | 60 m      |
| 0.1 mm ID (0.4 mm OD)  |           |           |           |           |           |           |
| 0.10 µm film           | 726080.10 |           |           |           |           |           |
| 0.25 mm ID (0.4 mm OD) |           |           |           |           |           |           |
| 0.25 µm film           | 726118.15 | 726118.15 | 726118.25 | 726118.30 | 726118.50 | 726118.60 |
| 0.32 mm ID (0.5 mm OD) |           |           |           |           |           |           |
| 0.25 µm film           |           |           | 726352.25 | 726352.30 | 726352.50 | 726352.60 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.



## OPTIMA<sup>®</sup> 240 33 % cyanopropyl-methyl – 67 % dimethylpolysiloxane

### ★ Key features

- Midpolar phase
- Structure see page 309

### ✓ Recommended application

- FAMES, dioxins

### ✍ Temperature

- T<sub>max</sub> 260 °C (long-term temperature),  
T<sub>max</sub> 280 °C (short-term max. temperature in a temperature program)

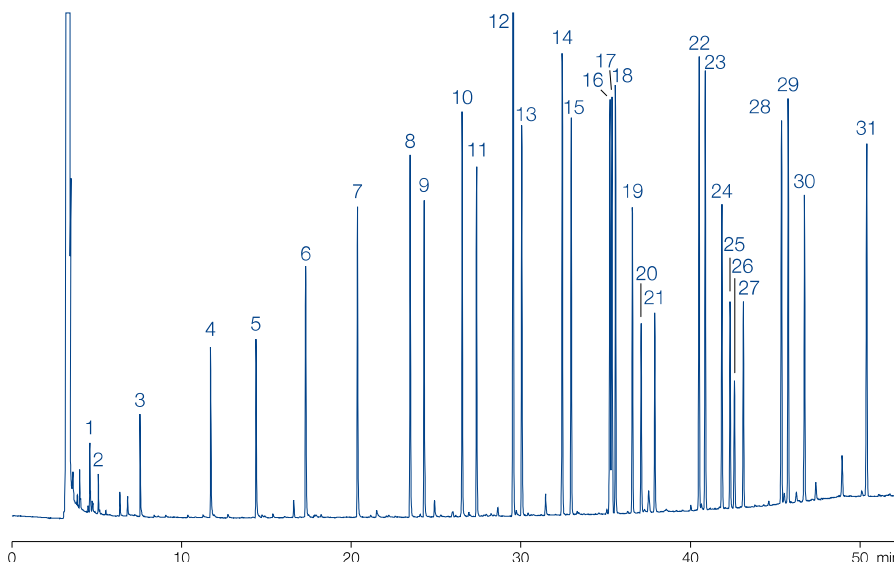
### Fatty acid methyl esters *cis/trans* C18:1 (FAME)

MN Appl. No. 201620

Column: OPTIMA<sup>®</sup> 240, 60 m x 0.25 mm ID, 0.25 µm film  
 Sample: FAME mixture  
 Injection: 1.0 µL, split 1:25  
 Carrier gas: 150 kPa H<sub>2</sub>  
 Temperature: 80 °C → 120 °C, 20 °C/min → 260 °C (10 min), 3 °C/min  
 Detector: FID 280 °C

#### Peaks:

- |                         |                       |
|-------------------------|-----------------------|
| 1. C4:0                 | 18. <i>cis</i> -C18:1 |
| 2. C5:0                 | 19. C18:2             |
| 3. C8:0                 | 20. C18:3             |
| 4. C10:0                | 21. C18:3             |
| 5. C11:0                | 22. C20:0             |
| 6. C12:0                | 23. C20:1             |
| 7. C13:0                | 24. C20:2             |
| 8. C14:0                | 25. C20:3             |
| 9. C14:1                | 26. C20:4             |
| 10. C15:0               | 27. C20:3             |
| 11. C15:1               | 28. C22:0             |
| 12. C16:0               | 29. C22:1             |
| 13. C16:1               | 30. C22:3             |
| 14. C17:0               | 31. C24:1             |
| 15. C17:1               |                       |
| 16. C18:0               |                       |
| 17. <i>trans</i> -C18:1 |                       |



### Ordering information

#### OPTIMA<sup>®</sup> 240

|                        | Length →  |           |           |           |
|------------------------|-----------|-----------|-----------|-----------|
|                        | 25 m      | 30 m      | 50 m      | 60 m      |
| 0.25 mm ID (0.4 mm OD) |           |           |           |           |
| 0.25 µm film           |           | 726089.30 | 726089.50 | 726089.60 |
| 0.50 µm film           |           | 726090.30 |           | 726090.60 |
| 0.32 mm ID (0.5 mm OD) |           |           |           |           |
| 0.25 µm film           | 726091.25 | 726091.30 | 726091.50 | 726091.60 |
| 0.35 µm film           |           | 726095.30 |           | 726095.60 |
| 0.50 µm film           |           | 726096.30 |           | 726096.60 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)



## OPTIMA® WAX polyethylene glycol 20 000 Da · USP G16

### ★ Key features

- Polar phase
- Structure see page 309

### ✓ Recommended application

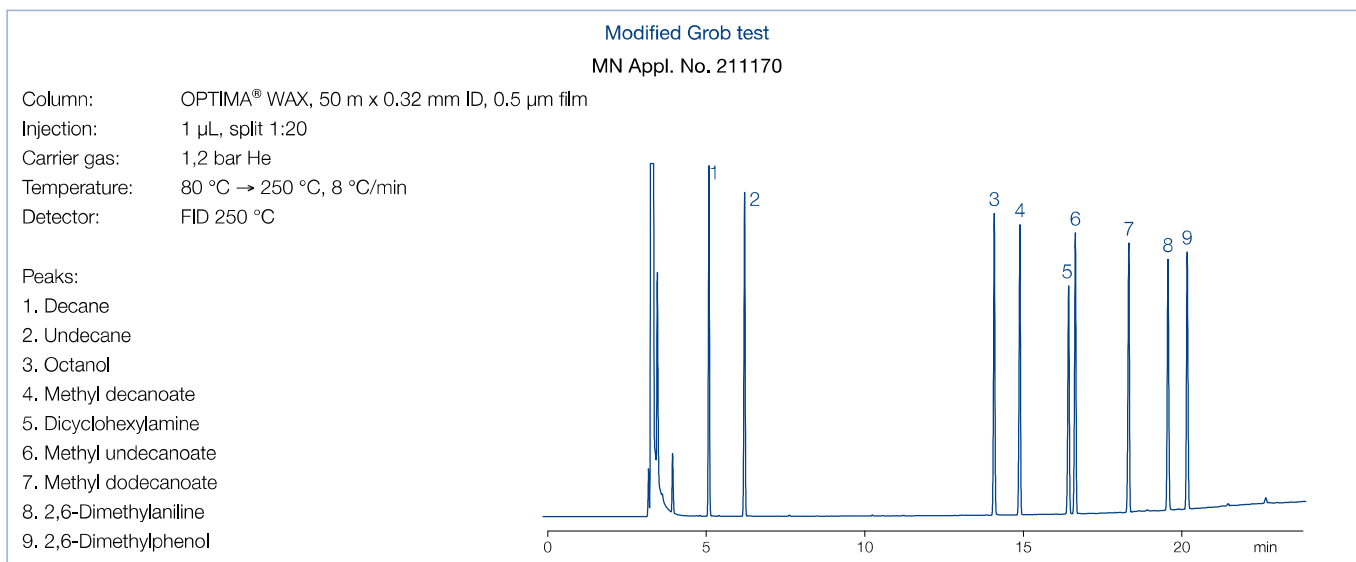
- Solvent analysis and alcohols, suitable for aqueous solutions

### ✍ Temperature

- T<sub>max</sub> 240 °C (long-term temperature), T<sub>max</sub> 250 °C (short-term max. temperature in a temperature program)
- 0.53 mm ID: T<sub>max</sub> 220 and 240 °C resp.

### Similar phases

- PERMABOND® CW 20 M (see page 337), DB-Wax, Supelcowax, HP-Wax, HP-INNOWAX, Rtx-Wax, CP-Wax 52 CB, Stabilwax, 007-CW, BP20, AT-Wax, ZB-Wax



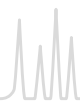
### Ordering information

#### OPTIMA® WAX

|                        | Length →  |           |           |           |
|------------------------|-----------|-----------|-----------|-----------|
|                        | 25 m      | 30 m      | 50 m      | 60 m      |
| 0.25 mm ID (0.4 mm OD) |           |           |           |           |
| 0.25 µm film           | 726600.25 | 726600.30 | 726600.50 | 726600.60 |
| 0.32 mm ID (0.5 mm OD) |           |           |           |           |
| 0.25 µm film           | 726321.25 | 726321.30 | 726321.50 | 726321.60 |
| 0.50 µm film           | 726296.25 | 726296.30 | 726296.50 | 726296.60 |
| 0.53 mm ID (0.8 mm OD) |           |           |           |           |
| 1.00 µm film           | 726549.25 | 726549.30 |           |           |
| 2.00 µm film           |           | 726548.30 |           |           |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)



## OPTIMA WAXplus<sup>®</sup> cross-linked polyethylene glycol · USP G16

### ★ Key features

- Polar phase with improved cross-linking for lower column bleed and better temperature stability
- Structure see page 309

### ✓ Recommended application

- Broad range of application, e.g., for solvents and alcohols, suitable for aqueous solutions

### ✍ Temperature

- T<sub>max</sub> 260 °C (long-term temperature), T<sub>max</sub> 270 °C (short-term max. temperature in a temperature program)

### Similar phases

- DB-Wax, Supelcowax, HP-Wax, HP-INNOWAX, Rtx-Wax, CP-Wax 52 CB, Stabilwax, 007-CW, BP20, AT-Wax, ZB-Wax

### Alcohols

MN Appl. No. 214160

Column: OPTIMA WAXplus<sup>®</sup>, 30 m x 0.25 mm ID, 0.5 µm film

Injection: 0.1 µL, split 1:80

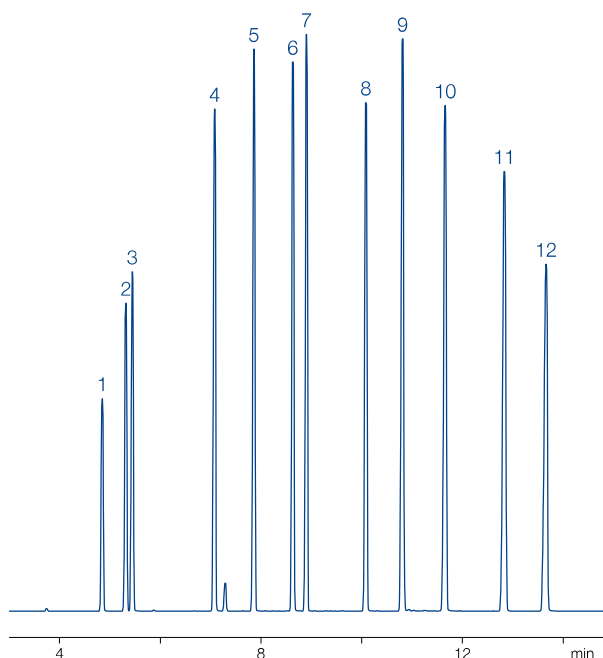
Carrier gas: 1.3 bar He

Temperature: 40 °C → 260 °C, 12 °C/min (15 min)

Detector: FID 260 °C

#### Peaks:

1. Methanol
2. 2-Propanol
3. Ethanol
4. 1-Propanol
5. 2-Methyl-1-propanol
6. 1-Butanol
7. 4-Methyl-2-pentanol
8. 1-Pentanol
9. 2-Methyl-1-pentanol
10. 1-Hexanol
11. Cyclohexanol
12. 1-Heptanol

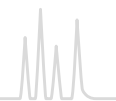


### Ordering information

#### OPTIMA WAXplus<sup>®</sup>

|                        | Length →  |           |
|------------------------|-----------|-----------|
|                        | 30 m      | 60 m      |
| 0.25 mm ID (0.4 mm OD) |           |           |
| 0.25 µm film           | 726380.30 | 726380.60 |
| 0.50 µm film           | 726381.30 | 726381.60 |
| 0.32 mm ID (0.5 mm OD) |           |           |
| 0.25 µm film           | 726382.30 | 726382.60 |
| 0.50 µm film           | 726383.30 | 726383.60 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.



## OPTIMA<sup>®</sup> FFAP polyethylene glycol 2-nitroterephthalate · USP G35 / close equivalent to USP G25

### ★ Key features

- Polar phase (FFAP = Free Fatty Acid Phase)
- Structure see page 309

### ✓ Recommended application

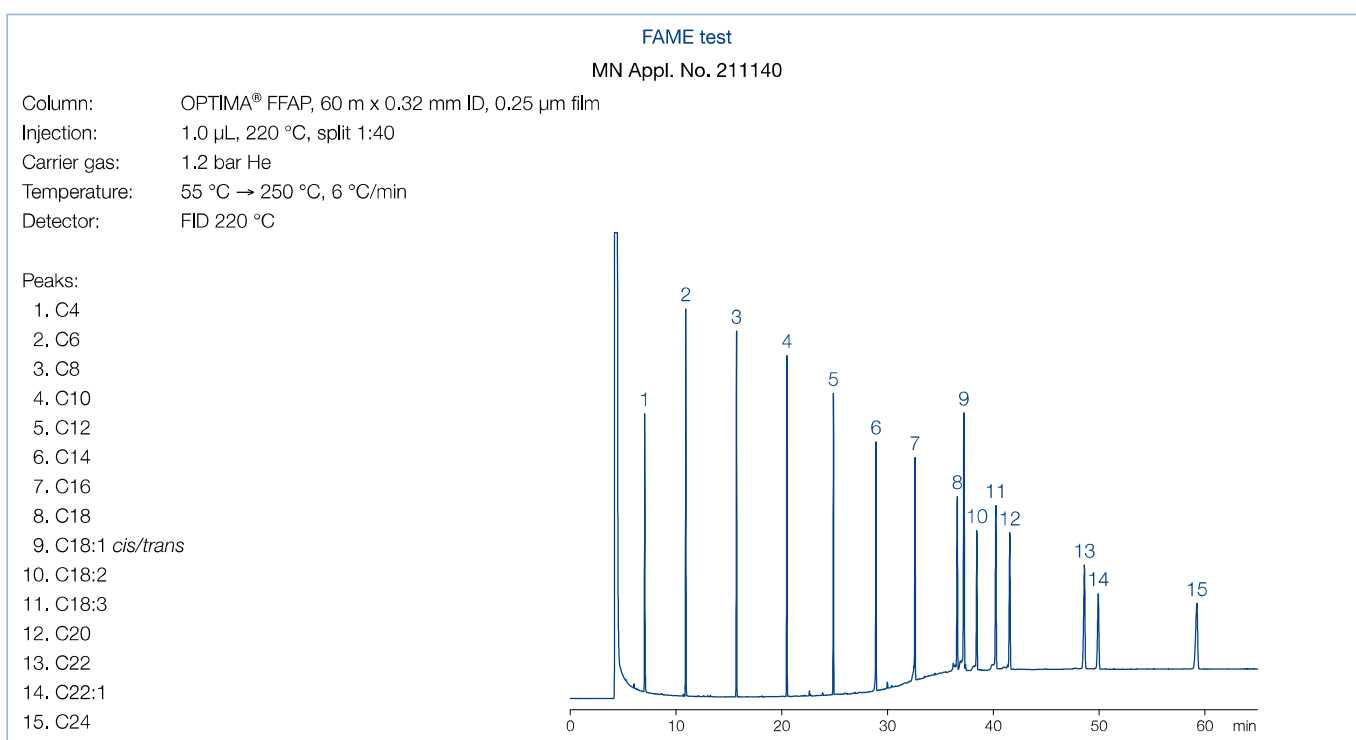
- Fatty acid methyl esters (FAMES), free carboxylic acids

### ✍ Temperature

- 0.10–0.32 mm ID:
  - $T_{\max}$  250 °C (long-term temperature),
  - $T_{\max}$  260 °C (short-term max. temperature in a temperature program)
- 0.53 mm ID:  $T_{\max}$  220 and 240 °C, resp.

### Similar phases

- PERMABOND<sup>®</sup> FFAP (see page 338), DB-FFAP, HP-FFAP, CP-Wax 58 FFAP CB, 007-FFAP, CP-FFAP CB, Nukol<sup>™</sup>, AT-1000, SPB-1000, BP21, OV-351



### Ordering information

#### OPTIMA<sup>®</sup> FFAP

|                        | Length →  |           |           |           |           |
|------------------------|-----------|-----------|-----------|-----------|-----------|
|                        | 10 m      | 25 m      | 30 m      | 50 m      | 60 m      |
| 0.1 mm ID (0.4 mm OD)  |           |           |           |           |           |
| 0.10 µm film           | 726180.10 |           |           |           |           |
| 0.25 mm ID (0.4 mm OD) |           |           |           |           |           |
| 0.25 µm film           |           | 726116.25 | 726116.30 | 726116.50 | 726116.60 |
| 0.32 mm ID (0.5 mm OD) |           |           |           |           |           |
| 0.25 µm film           |           | 726341.25 | 726341.30 | 726341.50 | 726341.60 |
| 0.50 µm film           |           | 726344.25 | 726344.30 | 726344.50 |           |
| 0.53 mm ID (0.8 mm OD) |           |           |           |           |           |
| 0.50 µm film           |           |           | 726345.30 |           |           |
| 1.00 µm film           |           | 726346.25 |           |           |           |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.



## OPTIMA<sup>®</sup> FFAPplus polyethylene glycol 2-nitroterephthalate · USP G35 / close equivalent to G25

### ★ Key features

- Polar phase
- Structure see page 309

### ✓ Recommended application

- FAMES, free carboxylic acids

### ✍ Temperature

- T<sub>max</sub> 250 °C (long-term temperature),  
T<sub>max</sub> 260 °C (short-term max. temperature in a temperature program)

### Similar phases

- DB-FFAP, HP-FFAP, CP-SIL 58 CB, 007-FFAP, CP-FFAP CB, Nukol™

### FAMES from biodiesel

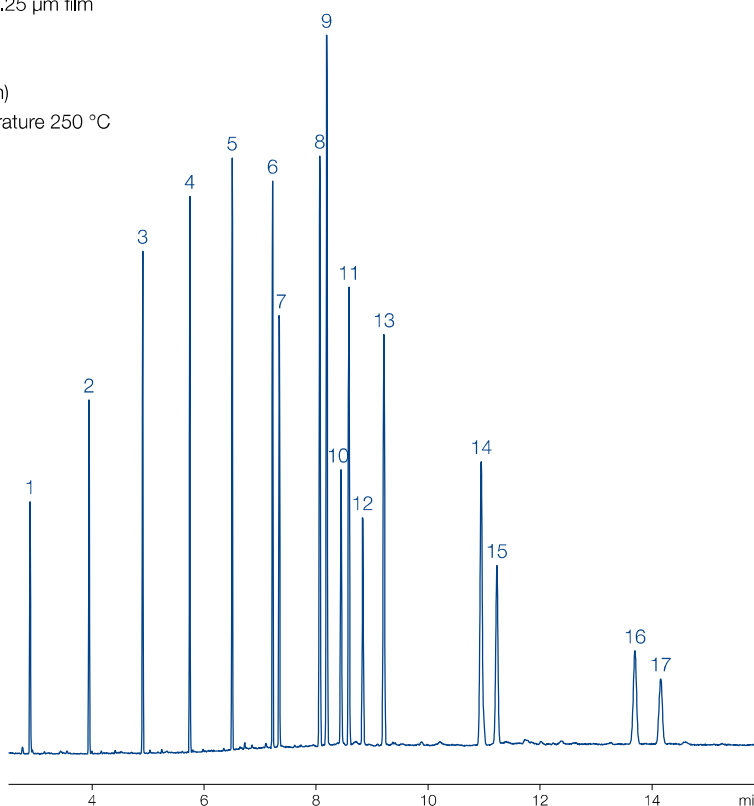
MN Appl. No. 214590

Column: OPTIMA<sup>®</sup> FFAPplus, 30 m x 0.25 mm ID, 0.25 µm film  
 Injection: 1 µL, 260 °C, split 1:15  
 Carrier gas: 40 cm/s He  
 Temperature: 70 °C (1 min) → 240 °C, 30 °C/min (10 min)  
 Detector: MS-EI, ion source 200 °C, interface temperature 250 °C

#### Peaks:

#### Methyl esters of:

1. Caproic acid (C6:0)
2. Caprylic acid (C8:0)
3. Capric acid (C10:0)
4. Lauric acid (C12:0)
5. Myristic acid (C14:0)
6. Palmitic acid (C16:0)
7. Palmitoleic acid (C16:1)
8. Stearic acid (C18:0)
9. Oleic acid (C18:1 *cis*)
10. Linoleic acid (C18:2 *cis*)
11. Nonadecanoic acid (C19:0)
12. Linolenic acid (C18:3)
13. Arachidic acid (C20:0)
14. Behenic acid (C22:0)
15. Erucic acid (C22:1 *cis*)
16. Lignoceric acid (C24:0)
17. Nervonic acid (C24:1 *cis*)



### Ordering information

#### OPTIMA<sup>®</sup> FFAPplus

|                        | Length →  |           |
|------------------------|-----------|-----------|
|                        | 30 m      | 60 m      |
| 0.25 mm ID (0.4 mm OD) |           |           |
| 0.25 µm film           | 726241.30 | 726241.60 |
| 0.50 µm film           | 726242.30 | 726242.60 |
| 0.32 mm ID (0.5 mm OD) |           |           |
| 0.25 µm film           | 726243.30 | 726243.60 |
| 0.50 µm film           | 726246.30 | 726246.60 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)



## PERMABOND<sup>®</sup> SE-30 100 % dimethylpolysiloxane · USP G1 / G2 / G38

### ★ Key features

- Nonpolar phase

### ✎ Temperature

- T<sub>max</sub> 300 °C (long-term temperature),
- T<sub>max</sub> 320 °C (short-term max. temperature in a temperature program)

### Similar phases

- OPTIMA<sup>®</sup> 1 (see page 310)

### Ordering information

#### PERMABOND<sup>®</sup> SE-30

|                        | Length →  |           |
|------------------------|-----------|-----------|
|                        | 25 m      | 50 m      |
| 0,25 mm ID (0,4 mm OD) |           |           |
| 0,25 µm film           | 723052,25 | 723052,50 |
| 0,32 mm ID (0,5 mm OD) |           |           |
| 0,25 µm film           | 723306,25 |           |
| 0,50 µm film           |           | 723308,50 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.

## PERMABOND<sup>®</sup> SE-52 5 % phenyl – 95 % dimethylpolysiloxane · USP G27

### ★ Key features

- Nonpolar phase

### ✎ Temperature

- T<sub>max</sub> 300 °C (long-term temperature),
- T<sub>max</sub> 320 °C (short-term max. temperature in a temperature program)

### Similar phases

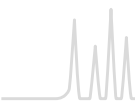
- OPTIMA<sup>®</sup> 5 (see page 314)

### Ordering information

#### PERMABOND<sup>®</sup> SE-52

|                        | Length →  |
|------------------------|-----------|
|                        | 25 m      |
| 0,25 mm ID (0,4 mm OD) |           |
| 0,25 µm film           | 723054,25 |
| 0,32 mm ID (0,5 mm OD) |           |
| 0,25 µm film           | 723310,25 |
| 0,50 µm film           | 723312,25 |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.



# PERMABOND<sup>®</sup> capillary columns



## PERMABOND<sup>®</sup> CW 20 M polyethylene glycol 20 000 Dalton · USP G16

### ★ Key features

- Polar phase

### ✓ Recommended application

- Solvent analysis and alcohols, suitable for aqueous solutions

### ✍ Temperature

- 0.1–0.32 mm ID:  
 $T_{\max}$  220 °C (long-term temperature),  
 $T_{\max}$  240 °C (short-term max. temperature in a temperature program)
- 0.53 mm ID:  $T_{\max}$  200 and 220 °C, resp.

### Similar phases

- See OPTIMA<sup>®</sup> WAX (see page 332)

## Ordering information

### PERMABOND<sup>®</sup> CW 20 M

|                        | Length →  |           |           |           |           |
|------------------------|-----------|-----------|-----------|-----------|-----------|
|                        | 10 m      | 25 m      | 30 m      | 50 m      | 60 m      |
| 0.1 mm ID (0.4 mm OD)  |           |           |           |           |           |
| 0.10 µm film           | 723064.10 |           |           |           |           |
| 0.25 mm ID (0.4 mm OD) |           |           |           |           |           |
| 0.25 µm film           | 723060.10 | 723060.25 | 723060.30 | 723060.50 | 723060.60 |
| 0.32 mm ID (0.5 mm OD) |           |           |           |           |           |
| 0.25 µm film           | 723321.10 | 723321.25 | 723321.30 | 723321.50 | 723321.60 |
| 0.35 µm film           | 723827.10 | 723827.25 |           | 723827.50 |           |
| 0.50 µm film           | 723296.10 | 723296.25 | 723296.30 | 723296.50 | 723296.60 |
| 0.53 mm ID (0.8 mm OD) |           |           |           |           |           |
| 0.50 µm film           | 723515.10 | 723515.25 |           |           |           |
| 1.00 µm film           | 723549.10 | 723549.25 | 723549.30 |           |           |
| 2.00 µm film           | 723517.10 | 723517.25 | 723517.30 |           |           |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)





# PERMABOND<sup>®</sup> capillary columns



## PERMABOND<sup>®</sup> FFAP polyethylene glycol 2-nitroterephthalate · USP G35 / close equivalent to G25

### ★ Key features

- Polar phase

### ✓ Recommended application

- FAMES, free carboxylic acids

### ✍ Temperature

- 0.1–0.32 mm ID:
  - T<sub>max</sub> 220 °C (long-term temperature),
  - T<sub>max</sub> 240 °C (short-term max. temperature in a temperature program)
- 0.53 mm ID: T<sub>max</sub> 200 and 220 °C, resp.

### Similar phases

- See OPTIMA<sup>®</sup> FFAP (see page 334)

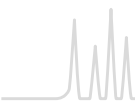
## Ordering information

### PERMABOND<sup>®</sup> FFAP

|                        | Length →<br>10 m | 20 m      | 25 m      | 30 m      | 50 m      | 60 m      |
|------------------------|------------------|-----------|-----------|-----------|-----------|-----------|
| 0.1 mm ID (0.4 mm OD)  |                  |           |           |           |           |           |
| 0.10 µm film           | 723180.10        | 723180.20 |           |           |           |           |
| 0.25 µm film           | 723181.10        |           |           |           |           |           |
| 0.25 mm ID (0.4 mm OD) |                  |           |           |           |           |           |
| 0.10 µm film           |                  |           | 723936.25 |           | 723936.50 |           |
| 0.25 µm film           | 723116.10        |           | 723116.25 | 723116.30 | 723116.50 | 723116.60 |
| 0.32 mm ID (0.5 mm OD) |                  |           |           |           |           |           |
| 0.10 µm film           |                  |           | 723356.25 |           | 723356.50 |           |
| 0.25 µm film           |                  |           | 723341.25 | 723341.30 | 723341.50 | 723341.60 |
| 0.35 µm film           | 723830.10        |           | 723830.25 |           | 723830.50 |           |
| 0.50 µm film           | 723344.10        |           | 723344.25 | 723344.30 | 723344.50 | 723344.60 |
| 0.53 mm ID (0.8 mm OD) |                  |           |           |           |           |           |
| 1.00 µm film           | 723555.10        |           | 723555.25 |           | 723555.50 |           |

In addition to this standard program we will be happy to supply columns custom-made to your specifications. Information about scope of delivery, special cages and integrated guard columns see additional information for GC columns on page 303.

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)



## Capillary columns for special GC separations

Certain analytical separations can be accomplished more easily with chromatographic columns, that have been especially developed for that task, compared with standard columns. The

following table summarizes our program of GC speciality capillaries, the individual columns will be described in detail on the following pages.

| Overview  |   |      |
|---|---|------|
| Separation/special application                              | Recommended capillary column  | Page |
| Fast GC column with 0.10 mm ID                              | OPTIMA® 1, OPTIMA® 5, OPTIMA® δ-3, OPTIMA® δ-6<br>OPTIMA® 17, OPTIMA® 225, OPTIMA® FFAP<br>PERMABOND® CW 20 M, PERMABOND® FFAP                        | 340  |
| Enantiomer separation cyclodextrin phases                   | FS-LIPODEX® A, FS-LIPODEX® B, FS-LIPODEX® C<br>FS-LIPODEX® D, FS-LIPODEX® E, FS-LIPODEX® G  | 342  |
|   | FS-HYDRODEX β-PM, FS-HYDRODEX β-3 P,<br>FS-HYDRODEX β-6TBDM, FS-HYDRODEX β-6TBDE,<br>FS-HYDRODEX β-6TBDE, FS-HYDRODEX β-TBDAc,<br>FS-HYDRODEX γ-DIMOM | 344  |
| Biodiesel   |   |      |
| Methanol analysis   | OPTIMA® BioDiesel M   | 346  |
| FAME analysis   | OPTIMA® BioDiesel F   | 346  |
| Glycerol and triglycerides                                  | OPTIMA® BioDiesel G   | 346  |
| Triglycerides   |   |      |
|   | OPTIMA® 1-TG  | 348  |
|   | OPTIMA® 17-TG   | 348  |
| High temperature GC   |   |      |
|   | OPTIMA® 5 HT  | 349  |
| Amines  |   |      |
| Polyfunctional amines                                       | OPTIMA® 5 Amine   | 350  |
| Amine separations   | FS-CW 20 M-AM   | 351  |
| Petrochemical products (complex hydrocarbon mixtures)       |   |      |
|   | PERMABOND® P-100  | 352  |
| Environmental analysis of volatile halogenated hydrocarbons |   |      |
|   | PERMABOND® SE-54 HKW  | 352  |
| Silanes (monomeric, e.g., chlorosilanes)                    |   |      |
|   | PERMABOND® Silane   | 354  |
| Diethylene glycol, e.g., for the quality control of wine    |   |      |
|   | PERMABOND® CW 20 M-DEG  | 354  |



## Fast GC

### ★ Key features

- Decreased column diameters, high heating rates and decreased column lengths for faster GC separations with high resolution efficiency
- Small inner diameters combined with very fast temperature programs can reduce the analysis time by up to 80 %
- High sensitivity detectors with small volume and very short response time, as well as very rapid data acquisition and processing
- Small inner diameters result in high column inlet pressures and a lower volume flow of the mobile phase: very fast injection of very small samples against a high pressure
- Amount of sample, which can be injected, is limited by the inner diameter and the thin film

### ✍ Temperature

- High heating rates place special demands on stationary phases. OPTIMA® columns meet exactly this requirement: very low bleeding, long lifetimes, even for continuous high heating rates

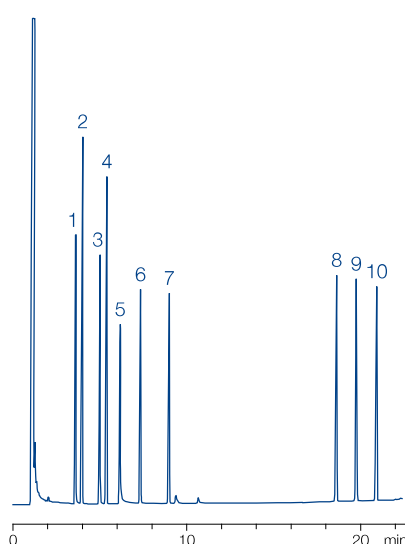
Comparison of a separation on a 50 m standard capillary with separation on a 10 m fast GC column  
MN Appl. No. 211260

Peaks:

1. Octanol
2. Undecane
3. Dimethylaniline
4. Dodecane
5. Decylamine
6. Methyl decanoate
7. Methyl undecanoate
8. Henicosane
9. Docosane
10. Tricosane

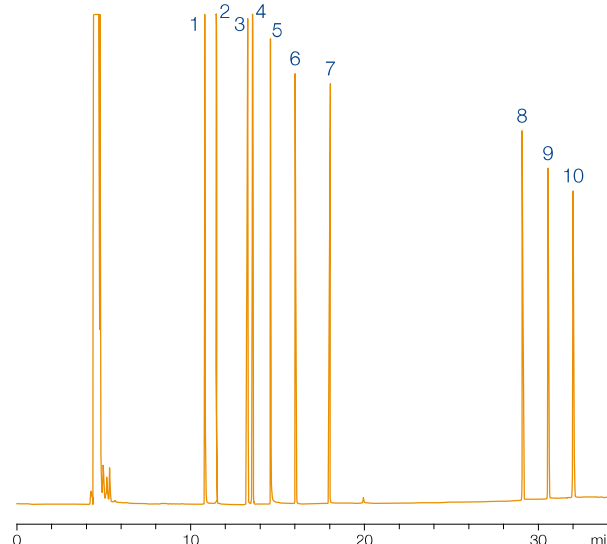
#### A) Fast GC column

Column: OPTIMA® 5, 10 m x 0.1 mm ID,  
0.1 µm film  
Injection 1 µL, split 1:40,  
Carrier gas 0.75 bar He



#### B) standard GC column

Column: OPTIMA® 5, 50 m x 0.25 mm ID,  
0.25 µm film  
Injection 1 µL, split 1:35,  
Carrier gas 1.5 bar He

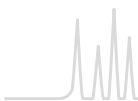


Both separations:

Temperature: 80 °C → 320 °C (10 min), 8 °C/min

Detector: FID

While maintaining the temperature program and halving the pressure a time saving of 30 % results with identical separation efficiency.



# Capillary columns for Fast GC



| Ordering information |                     |         |                     |            |            |
|----------------------|---------------------|---------|---------------------|------------|------------|
| Columns for Fast GC  |                     |         |                     |            |            |
| Phase                | Maximum temperature | ID [mm] | Film thickness [µm] | REF (10 m) | REF (20 m) |
| OPTIMA® 1            | 340/360 °C          | 0.10    | 0.10                | 726024.10  | 726024.20  |
|                      |                     | 0.10    | 0.40                |            | 726025.20  |
| OPTIMA® 5            | 340/360 °C          | 0.10    | 0.10                | 726846.10  |            |
| OPTIMA® δ-3          | 340/360 °C          | 0.10    | 0.10                | 726410.10  | 726410.20  |
| OPTIMA® δ-6          | 340/360 °C          | 0.10    | 0.10                | 726490.10  |            |
| OPTIMA® 17           | 320/340 °C          | 0.10    | 0.10                | 726848.10  |            |
| OPTIMA® 225          | 260/280 °C          | 0.10    | 0.10                | 726080.10  |            |
| OPTIMA® FFAP         | 250/260 °C          | 0.10    | 0.10                | 726180.10  |            |
| PERMABOND® CW 20 M   | 220/240 °C          | 0.10    | 0.10                | 723064.10  |            |
| PERMABOND® FFAP      | 220/240 °C          | 0.10    | 0.10                | 723180.10  | 723180.20  |
|                      |                     | 0.10    | 0.25                | 723181.10  |            |
| OPTIMA® 5 Amine      | 300/320 °C          | 0.10    | 0.40                | 726361.10  |            |
| FS-CW 20 M-AM        | 220/240 °C          | 0.10    | 0.25                | 733111.10  |            |
| FS-LIPODEX® E        | 200/220 °C          | 0.10    | 0.10                | 723382.10  |            |
| FS-HYDRODEX β-6TBDM  | 230/250 °C          | 0.10    | 0.10                | 723383.10  |            |

In addition to this standard program, all MN GC phases can be custom-made as fast GC columns

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)



## LIPODEX® cyclodextrin phases for enantiomer separation

### ★ Key features

- Base material: cyclic oligosaccharides consisting of six ( $\alpha$ -cyclodextrin), seven ( $\beta$ -cyclodextrin) or eight ( $\gamma$ -cyclodextrin) glucose units bonded through 1,4-linkages
- Regioselective alkylation and / or acylation of the hydroxyl groups leads to lipophilic phases with varying enantioselectivity, which are well suited for GC enantiomer analysis
- Important advantage: many compounds can be analyzed without derivatization (however, for certain substances enantioselectivity can be favorably influenced by formation of derivatives)

### ✔ Recommended application

- A large number of separations have been achieved, however, it is not possible to make a general prediction, which phase could solve a given separation task. Even for compounds with small structural differences or within homologous series the enantiodifferentiation can be quite different. The following table shows typical applications.

### Note:

- Water as solvent is strictly forbidden for all cyclodextrin phases
- Dry the sample with our CHROMAFIX® Dry ( $\text{Na}_2\text{SO}_4$ ) cartridges (see page 61)
- Use suitable nonpolar solvent

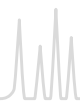
| Phase      | Cyclodextrin derivate                               | T <sub>max</sub> [°C] | Recommended application  |
|------------|---|-----------------------|--|
| LIPODEX® A | hexakis-(2,3,6-tri-O-pentyl)- $\alpha$ -CD          | 200 / 220             | carbohydrates, polyols, diols, hydroxycarboxylic acid esters, (epoxy-) alcohols, glycerol derivatives, spiroacetals, ketones, alkyl halides                                      |
| LIPODEX® B | hexakis-(2,6-di-O-pentyl-3-O-acetyl)- $\alpha$ -CD  | 200 / 220             | lactones, diols (cyclic carbonates), aminols, aldols (O-TFA), glycerol derivatives (cyclic carbonates)   |
| LIPODEX® C | heptakis-(2,3,6-tri-O-pentyl)- $\beta$ -CD          | 200 / 220             | Alcohols, cyanhydrins, olefins, hydroxycarboxylic acid esters, alkyl halides   |
| LIPODEX® D | heptakis-(2,6-di-O-pentyl-3-O-acetyl)- $\beta$ -CD  | 200 / 220             | aminols (TFA), $\beta$ -amino acid esters, trans-cycloalkane-1,2-diols, trans-cycloalkane-1,2-diols, trans-cycloalkane-1,3-diols (TFA)   |
| LIPODEX® E | octakis-(2,6-di-O-pentyl-3-O-butyryl)- $\gamma$ -CD | 200 / 220             | $\alpha$ -amino acids, $\alpha$ - and $\beta$ -hydroxycarboxylic acid esters, alcohols (TFA), diols (TFA), ketones, pheromones (cyclic acetals), amines, alkyl halides, lactones |
| LIPODEX® G | octakis-(2,3-di-O-pentyl-6-O-methyl)- $\gamma$ -CD  | 220 / 240             | menthol isomers, ketones, alcohols, carboxylic acid esters, terpenes   |

### Ordering information

#### LIPODEX®

|               | Length → | 10 m       | 25 m       | 50 m       |
|---------------|----------|------------|------------|------------|
|               |          | 0,10 mm ID | 0,25 mm ID | 0,25 mm ID |
| FS-LIPODEX® A |          |            | 723360.25  | 723360.50  |
| FS-LIPODEX® B |          |            | 723362.25  | 723362.50  |
| FS-LIPODEX® C |          |            | 723364.25  | 723364.50  |
| FS-LIPODEX® D |          |            | 723366.25  | 723366.50  |
| FS-LIPODEX® E |          | 723382.10  | 723368.25  | 723368.50  |
| FS-LIPODEX® G |          |            | 723379.25  | 723379.50  |

All columns with 0,4 mm OD



## Enantiomer separation of amino acid methyl esters (TFA)

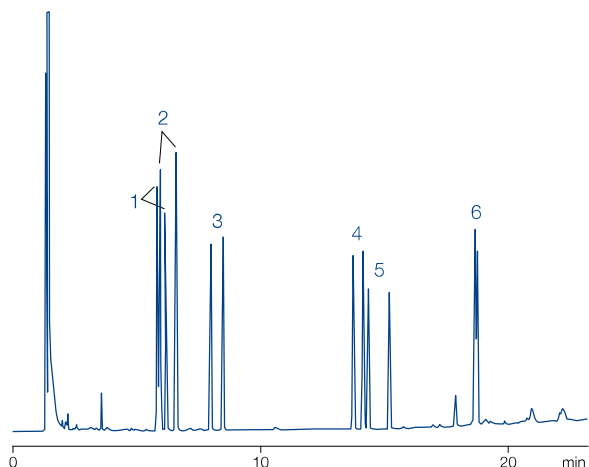
MN Appl. No. 202592

Column: FS-LIPODEX® E, 25 m x 0.25 mm ID  
Injection: 1 µL, split ~ 1: 100  
Carrier gas: 60 kPa H<sub>2</sub>  
Temperature: 90 → 190 °C, 4 °C/min  
Detector: FID 250 °C

### Peaks:

(D is eluted before L except for proline: L before D)

1. Alanine
2. Valine
3. Leucine
4. Proline
5. Aspartic acid
6. Phenylalanine



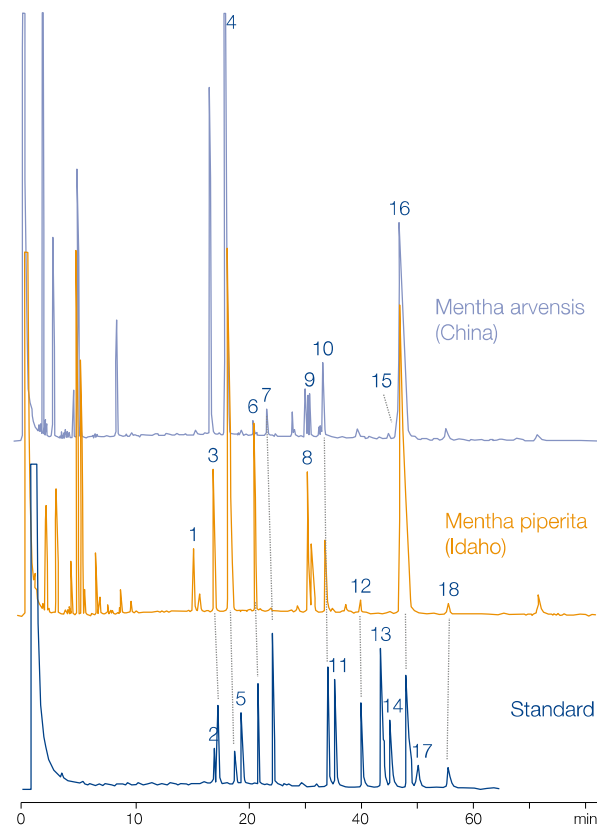
## Separation of chiral constituents of peppermint oil

MN Appl. No. 250410

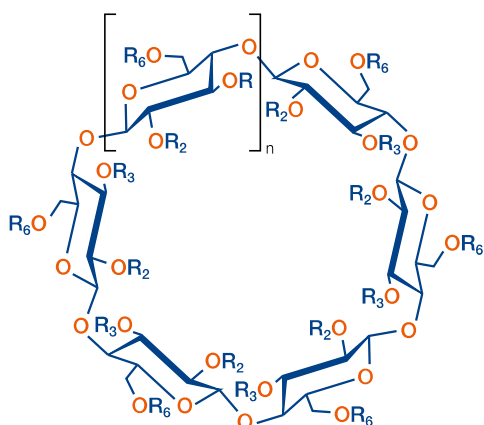
W.A. König et al., High Resol. Chromatogr. 20 (1997) 55–61  
Column: FS-LIPODEX® G, 25 m x 0.25 mm ID  
Carrier gas: 50 kPa H<sub>2</sub>  
Temperature: 75 °C, isothermal  
Detector: FID

### Peaks:

- |                               |                       |
|-------------------------------|-----------------------|
| 1. (+)-trans-Sabinene hydrate | 10. (+)-Neomenthol    |
| 2. (+)-Menthone               | 11. (-)-Neomenthol    |
| 3. (+)-Isomenthone            | 12. (+)-Neoisomenthol |
| 4. (-)-Menthone               | 13. (+)-Menthol       |
| 5. (-)-Isomenthone            | 14. (-)-Neoisomenthol |
| 6. (+)-Menthofuran            | 15. (+)-Piperitone    |
| 7. (-)-Isopulegol             | 16. (-)-Menthol       |
| 8. (-)-Menthyl acetate        | 17. (+)-Isomenthol    |
| 9. (+)-Pulegone               | 18. (-)-Isomenthol    |



## Cyclodextrin derivatives



Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)



## HYDRODEX cyclodextrin phases for enantiomer separation

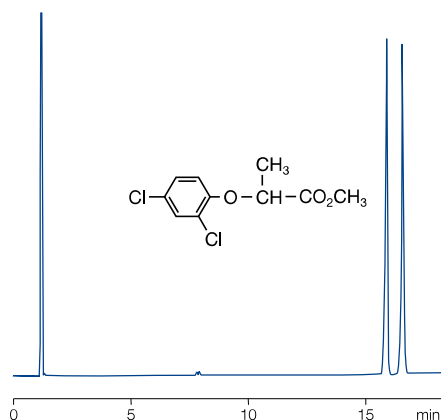
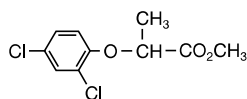
### Recommended application

- Cyclodextrin derivatives (see page 343) with high melting point: for GC enantiomer separation diluted with polysiloxanes

#### Enantiomer separation of dichlorprop methyl ester

MN Appl. No. 202542

Column: FS-HYDRODEX β-3P, 25 m x 0.25 mm ID  
 Injection: 0.1 μL (~1 % in CH<sub>2</sub>Cl<sub>2</sub>), split 130 mL/min  
 Carrier gas: 60 kPa H<sub>2</sub> (1.9 mL/min)  
 Temperature: 160 °C  
 Detector: FID 250 °C



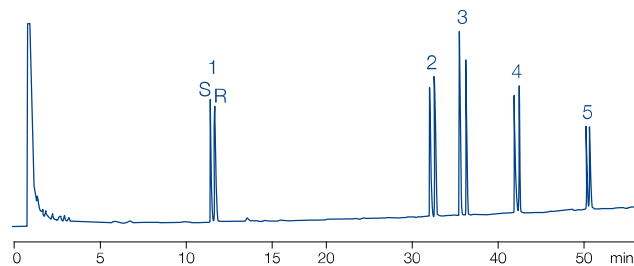
#### Separation of isomeric antiinflammatory drugs

MN Appl. No. 210150

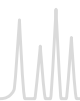
Courtesy of Prof. W.A. König, Hamburg, Germany  
 Column: FS-HYDRODEX β-6TBDM, 25 m x 0.25 mm ID  
 Carrier gas: He  
 Temperature: 135 °C → 200 °C, 1 °C/min  
 Detector: FID

Peaks:

1. Ibuprofen
2. Flurbiprofen
3. Fenoprofen
4. Naproxen
5. Ketoprofen



| Phase            | Cyclodextrin derivative<br>(diluted with optimized polysiloxane) | T <sub>max</sub> [°C] | Recommended application  |
|------------------|--|-----------------------|--|
| HYDRODEX β-PM    | heptakis-(2,3,6-tri-O-methyl)-β-CD                               | 230 / 250             | hydroxycarboxylic acid esters, alcohols, diols, olefins, lactones, acetals   |
| HYDRODEX β-3P    | heptakis-(2,6-di-O-methyl-3-O-pentyl)-β-CD                       | 230 / 250             | terpenes, dienes, allenes, terpene alcohols, 1,2-epoxyalkanes, carboxylic acids (esters), hydroxycarboxylic acid esters, pharmaceuticals, pesticides |
| HYDRODEX β-6TBDM | heptakis-(2,3-di-O-methyl-6-O-t-butyl-dimethyl-silyl)-β-CD       | 230 / 250             | γ-lactones, cyclopentanones, terpenes, esters, tartrates   |
| HYDRODEX β-6TBDE | heptakis-(2,3-di-O-ethyl-6-O-t-butyl-dimethyl-silyl)-β-CD        | 230 / 250             | essential oils   |
| HYDRODEX β-TBDAC | heptakis-(2,3-di-O-acetyl-6-O-t-butyl-dimethyl-silyl)-β-CD       | 220 / 240             | alcohols, esters, ketones, aldehydes, δ-lactones   |
| HYDRODEX γ-TBDAC | octakis-(2,3-di-O-acetyl-6-O-t-butyl-dimethyl-silyl)-γ-CD        | 220 / 240             | cyclic ketones, aromatic ketones, oxiranes, aromatic esters, aromatic amides   |
| HYDRODEX γ-DIMOM | octakis-(2,3-di-O-methoxymethyl-6-O-t-butyl-dimethyl-silyl)-γ-CD | 220 / 240             | ketones, terpenes, cyclic ethers, alcohols, amines   |



# Capillary columns for enantiomer separation



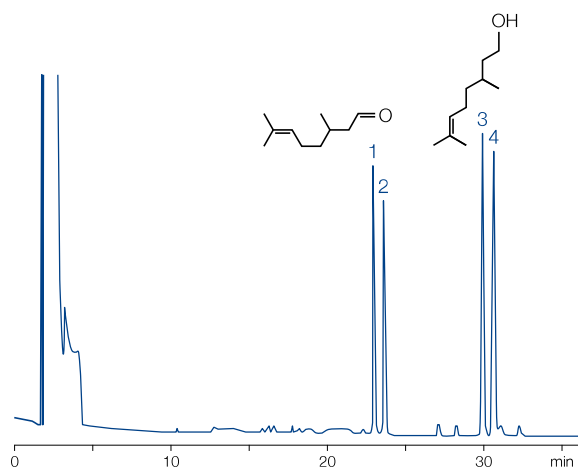
## Separation of (R/S) citronellol + citronellal

MN Appl. No. 212440

Column: FS-HYDRODEX  $\beta$ -TBDAC, 50 m x 0.25 mm ID  
 Injection: 1  $\mu$ L, 1:1000 in CH<sub>2</sub>Cl<sub>2</sub>, split 25 mL/min  
 Carrier gas: 1.5 bar H<sub>2</sub>  
 Temperature: 100 °C  
 Detector: FID 220 °C

### Peaks:

1. (R)/(S)-Citronellal
2. (S)/(R)-Citronellal
3. (S)-Citronellol
4. (R)-Citronellol



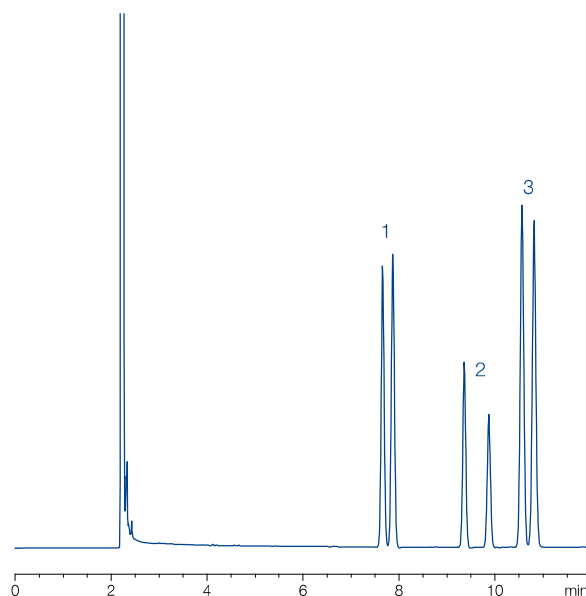
## Separation of essential oils

MN Appl. No. 212980 / 212990 / 213000

Column: FS-HYDRODEX  $\gamma$ -TBDAC, 50 m x 0.25 mm ID  
 Injektor: 220 °C  
 Carrier gas: 1.2 bar H<sub>2</sub>  
 Temperature: 125 °C  
 Detector: FID 220 °C

### Peaks:

1. Fenchone (1.5 mg/mL)
2. Menthone (0.5 mg/mL)
3. Menthol (2 mg/mL)



## Ordering information

### HYDRODEX

| Length →                    | 10 m<br>0,10 mm ID | 25 m<br>0,25 mm ID | 50 m<br>0,25 mm ID |
|-----------------------------|--------------------|--------------------|--------------------|
| FS-HYDRODEX $\beta$ -PM     |                    | 723370,25          | 723370,50          |
| FS-HYDRODEX $\beta$ -3P     |                    | 723358,25          | 723358,50          |
| FS-HYDRODEX $\beta$ -6TBDM  | 723383,10          | 723381,25          | 723381,50          |
| FS-HYDRODEX $\beta$ -6TBDE  |                    | 723386,25          |                    |
| FS-HYDRODEX $\beta$ -TBDAC  |                    | 723384,25          | 723384,50          |
| FS-HYDRODEX $\gamma$ -TBDAC |                    | 723387,25          | 723387,50          |
| FS-HYDRODEX $\gamma$ -DIMOM |                    | 723388,25          | 723388,50          |
| All columns with 0,4 mm OD  |                    |                    |                    |

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)





## OPTIMA® BioDiesel for the analysis of biodiesel (DIN EN 14214 / ASTM D 6751)

### OPTIMA® BioDiesel M for analysis of methanol in accordance with DIN EN 14110

#### ★ Key features

- The methanol content in biodiesel as specified in DIN EN 14110 must not exceed 0.2 %. The column OPTIMA® BioDiesel M allows the GC headspace analysis of the methanol content in biodiesel in the concentration range from 0.01 to 0.5 % with 2-propanol as internal standard.

#### ✍ Temperature

- T<sub>max</sub> 340 °C (long-term temperature),  
T<sub>max</sub> 360 °C (short-term max. temperature in a temperature program)

#### Similar phases

- Select™ Biodiesel for Methanol, Trace TR-BioDiesel (M)

## OPTIMA® BioDiesel F for analysis of FAMES in accordance with DIN EN 14103:2011

#### ★ Key features

- The analysis of biodiesel requires separation of typical FAMES between myristic acid (C<sub>14</sub>) and nervonic acid (C<sub>24:1</sub>) methyl esters. This analysis is possible on OPTIMA® BioDiesel F in only 22 min. Additionally, linolenic acid methyl ester can be determined due to the good resolution. The extended standard DIN EN 14103:2011 also covers smaller FAMES starting from C<sub>6</sub> (see application 214510 on opposite page). Change of the internal standard from C<sub>17</sub> to C<sub>19</sub> also allows the analysis of animal fats.

#### ✍ Temperature

- T<sub>max</sub> 240 °C (long-term temperature),  
T<sub>max</sub> 250 °C (short-term max. temperature in a temperature program)

#### Similar phases

- Select™ Biodiesel for FAME, Trace TR-BioDiesel (F)

## OPTIMA® BioDiesel G for analysis of glycerol and glycerides in accordance with DIN EN 14105

#### ★ Key features

- The capillary column OPTIMA® BioDiesel G allows determination of free glycerol and residues of mono-, di- and triglycerides in FAMES intended as additives for mineral oils. The procedure can be applied for FAMES from rapeseed oil, sunflower oil and soy bean oil. Glycerol as well as mono- and diglycerides are derivatized to more volatile substances by addition of MSTFA in the presence of pyridine (see page 363).

#### ✍ Temperature

- T<sub>max</sub> 380 °C (long-term temperature),  
T<sub>max</sub> 400 °C (short-term max. temperature in a temperature program)

#### Similar phases

- Select™ Biodiesel for Glycerides, Trace TR-BioDiesel (G), MET-Biodiesel



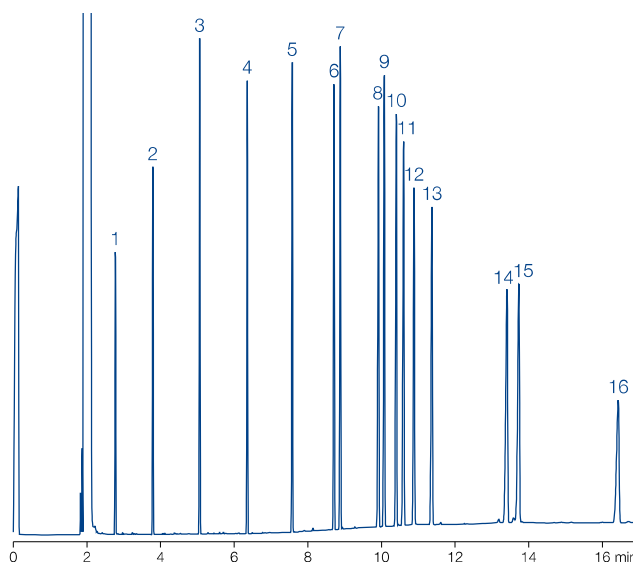
## Analysis of FAMES from biodiesel in accordance with DIN EN 14103:2011

MN Appl. No. 214510

Column: OPTIMA® BioDiesel F, 30 m x 0.25 mm ID  
 Sample: 50 µg/mL each in dichloromethane  
 Injection: 10 µL, 250 °C, split 1:20  
 Carrier gas: 1.2 bar He  
 Temperature: 80 °C → 250 °C (8.5 min), 20 °C/min  
 Detector: FID 260 °C

### Peaks:

- |          |                     |
|----------|---------------------|
| 1. C6:0  | 9. C18:1            |
| 2. C8:0  | 10. C18:2           |
| 3. C10:0 | 11. C19:0, int. st. |
| 4. C12:0 | 12. C18:3           |
| 5. C14:0 | 13. C20:0           |
| 6. C16:0 | 14. C22:0           |
| 7. C16:1 | 15. C22:1           |
| 8. C18:0 | 16. C24:0           |



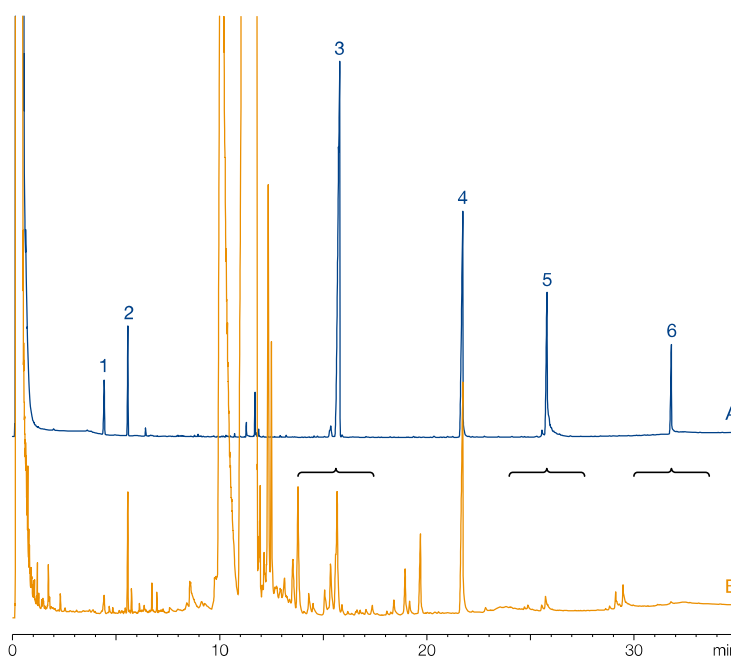
## Analysis of glycerol and glycerides from biodiesel

MN Appl. No. 213640

Column: OPTIMA® BioDiesel G,  
10 m x 0,25 mm ID  
 Sample: A) standard in *n*-heptane  
B) biodiesel  
 Injection: 2 µL, 350 °C,  
CIS (15 °C → 350 °C, 12 °C/s)  
 Carrier gas: 0.8 bar H<sub>2</sub>, split 1: 2.6  
 Temperature: 50 °C (3.5 min) → 180 °C, 15 °C/min  
→ 280 °C, 7 °C/min  
→ 370 °C (10 min), 10 °C/min  
 Detector: FID 380 °C

### Peaks:

- Glycerol (TMS)
- Butanetriol (TMS), IS
- Monoolein = glycerol monooleate (TMS)  
+ monoacylglycerides
- Tricaprin (glycerol tricaprinate), IS
- Dirolein = glycerol dioleate (TMS)  
+ diacylglycerides
- Triolein = glycerol trioleate  
+ triacylglycerides



## Ordering information

### OPTIMA® BioDiesel

|   | Length →<br>10 m | 30 m      |
|---|------------------|-----------|
| OPTIMA® BioDiesel M<br>0.32 mm ID (0.5 mm OD) |                  | 726905.30 |
| OPTIMA® BioDiesel F<br>0.25 mm ID (0.4 mm OD) |                  | 726900.30 |
| OPTIMA® BioDiesel G<br>0.25 mm ID (0.4 mm OD) | 726903.10        |           |



# Capillary columns for triglyceride analysis



## OPTIMA® 1-TG · 17-TG for triglyceride analysis · USP G1 / G2 / G38 (1-TG) · USP G3 (17-TG)

### ★ Key features

- Short capillary columns (max. 25 m and 0.32 mm ID) with low-bleeding stationary phases thermally stable with optimized deactivation

### ✓ Recommended application

- OPTIMA® 1-TG  
100 % dimethylpolysiloxane offers separation according to carbon number
- OPTIMA® 17-TG  
phenyl-methyl-polysiloxane (50 % phenyl) for separation according to degree of unsaturation

### ✍ Temperature

- T<sub>max</sub> 370 °C (both phases)

### Similar phases der OPTIMA® 1-TG:

- SPB-1 TG, DB-1 HT, 400-1 HT, HT-5

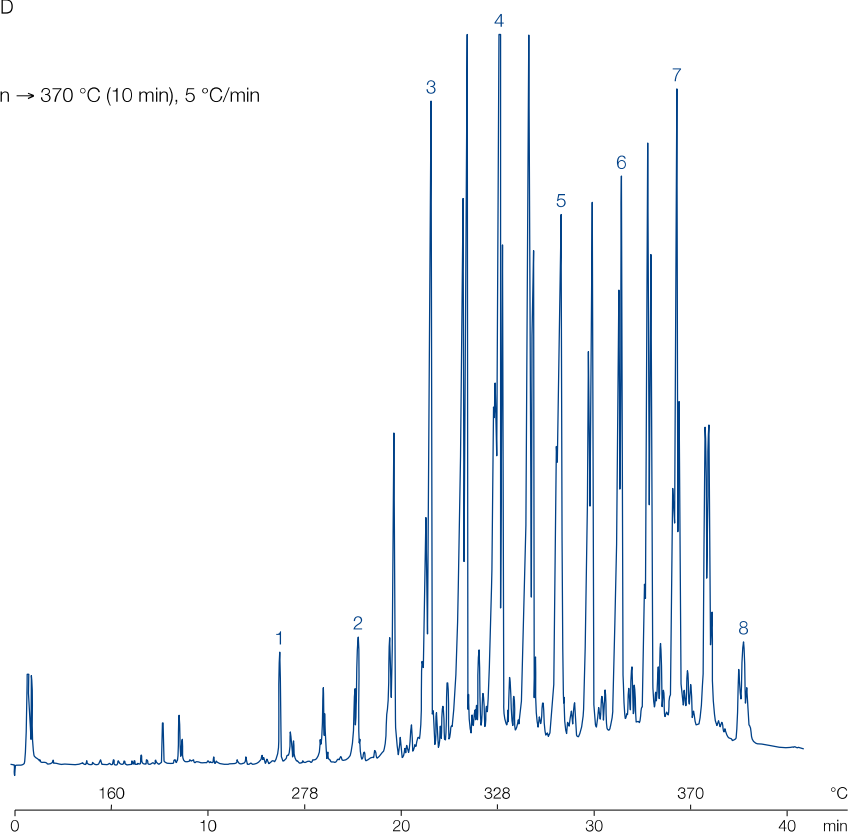
### Triglycerides (from butter)

MN Appl. No. 201790

Column: OPTIMA® 1-TG, 25 m x 0.32 mm ID  
 Injection: 0.5 µL  
 Carrier gas: 80 kPa H<sub>2</sub>  
 Temperature: 80 °C (1 min) → 250 °C, 20 °C/min → 370 °C (10 min), 5 °C/min  
 Detector: FID 380 °C

### Peaks:

1. Cholesterol
2. T-30
3. T-34
4. T-38
5. T-42
6. T-46
7. T-50
8. T-54



### Ordering information

#### OPTIMA® 1-TG · OPTIMA® 17-TG

|                        | Length →  |           |
|------------------------|-----------|-----------|
|                        | 10 m      | 25 m      |
| <b>OPTIMA® 1-TG</b>    |           |           |
| 0.25 mm ID (0.4 mm OD) | 726133.10 | 726133.25 |
| 0.32 mm ID (0.5 mm OD) | 726132.10 | 726132.25 |
| <b>OPTIMA® 17-TG</b>   |           |           |
| 0.32 mm ID (0.5 mm OD) | 726131.10 | 726131.25 |



# Capillary columns for high temperature GC



## OPTIMA® 5 HT for high temperature GC · USP G27 / G36

### ★ Key features

- Chemically bonded, cross-linked silylene phase with polarity similar to a 5 % diphenyl - 95 % dimethylpolysiloxane phase
- Nonpolar phase, low bleeding

### ✓ Recommended application

- Ideal for MS detectors, can be rinsed with solvents
- For simulated distillation, hydrocarbon, fuel and oil analysis, high-boiling analytes

### ✍ Temperature

- T<sub>max</sub> 380 °C (long-term temperature), T<sub>max</sub> 400 °C (short-term max. temperature in a temperature program)

### Similar phases

- DB-5HT, VF-5HT, HT-5, XTI-5HT, ZB-5HT

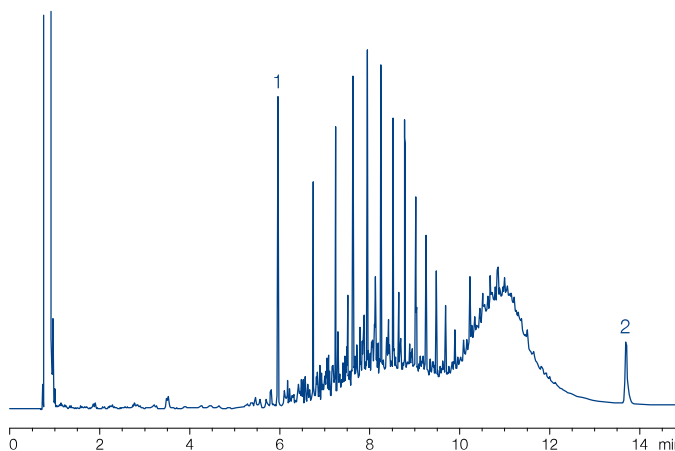
### Separation of motor oil / mineral oil (type A + B), rapid determination in accordance with DIN H-53 / ISO DIS

MN Appl. No. 213400

Column: OPTIMA® 5 HT, 15 m x 0.32 mm ID, 0.25 µm film  
 Sample: mineral oil type A + B (hydrocarbon index kit acc. to EN ISO 9377-2) in hexane  
 Injection: 1 µL, splitless, 300 °C  
 Carrier gas: 0.6 bar He  
 Temperature: 40 °C (5 min) → 390 °C, 50 °C/min  
 Detector: FID 280 °C

#### Peaks:

1. Decane (C10)
2. Tetracontane (C40)



### Ordering information

#### OPTIMA® 5 HT

|                        | Length →  |           |
|------------------------|-----------|-----------|
|                        | 15 m      | 30 m      |
| 0.25 mm ID (0.4 mm OD) |           |           |
| 0.10 µm film           | 726102.15 | 726102.30 |
| 0.25 µm film           | 726106.15 | 726106.30 |
| 0.32 mm ID (0.5 mm OD) |           |           |
| 0.10 µm film           | 726104.15 | 726104.30 |
| 0.25 µm film           | 726108.15 | 726108.30 |

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)



# Capillary columns for amine separation



## OPTIMA® 5 Amine special column for analysis of amines · USP G27 / G36

### ★ Key features

- Nonpolar phase
- Improved linearity for analysis of active components at trace levels: no amine absorptions even for aliphatic and aromatic amines at concentrations of 100 pg/peak
- Tested with the OPTIMA® Amine test mixture (REF 722317), which contains, amongst others, diethanolamine and propanol-pyridine (this test mixture is supplied with each column)

### ✓ Recommended application

- Especially deactivated for the analysis of polyfunctional amines such as ethanolamines, amino-functionalized diols and similar compounds, which are important base materials in industrial chemistry, and show strong tailing on standard-deactivated columns

### ✍ Temperature

- T<sub>max</sub> 300 °C (long-term temperature), T<sub>max</sub> 320 °C (short-term max. temperature in a temperature program)

### Similar phases

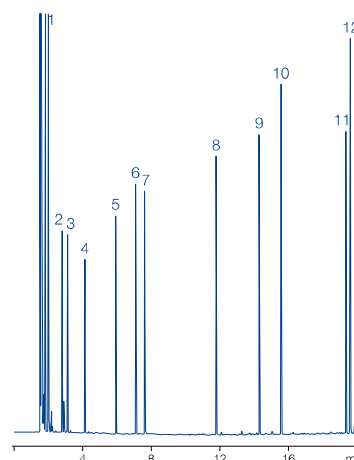
- Rtx®-5 Amine, PTA-5

### Separation of secondary and tertiary amines MN Appl. No. 210280

Column: OPTIMA® 5 Amine, 30 m x 0.25 mm ID, 1.0 µm film  
 Injection: 1 µL, split 1:100  
 Carrier gas: 0.6 bar H<sub>2</sub>  
 Temperature: 100 °C (3 min) → 280 °C, 10 °C/min  
 Detector: FID 280 °C

#### Peaks:

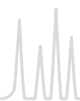
- |                               |                               |
|-------------------------------|-------------------------------|
| 1. Diethylamine               | 7. Di-isobutylamine           |
| 2. Di-isopropylamine          | 8. Tri- <i>n</i> -butylamine  |
| 3. Triethylamine              | 9. Di-isohexylamine           |
| 4. Di- <i>n</i> -propylamine  | 10. Dicyclohexylamine         |
| 5. Di- <i>n</i> -butylamine   | 11. Dibenzylamine             |
| 6. Tri- <i>n</i> -propylamine | 12. Tri- <i>n</i> -hexylamine |



### Ordering information

#### OPTIMA® 5 Amine

|                        | Length →  |           |           |
|------------------------|-----------|-----------|-----------|
|                        | 10 m      | 25 m      | 30 m      |
| 0.1 mm ID (0.4 mm OD)  |           |           |           |
| 0.40 µm film           | 726361.10 |           |           |
| 0.2 mm ID (0.4 mm OD)  |           |           |           |
| 0.35 µm film           |           | 726355.25 |           |
| 0.25 mm ID (0.4 mm OD) |           |           |           |
| 0.50 µm film           |           |           | 726354.30 |
| 1.00 µm film           |           |           | 726358.30 |
| 0.32 mm ID (0.5 mm OD) |           |           |           |
| 0.25 µm film           |           |           | 726360.30 |
| 1.00 µm film           |           |           | 726353.30 |
| 1.50 µm film           |           |           | 726356.30 |
| 0.53 mm ID (0.8 mm OD) |           |           |           |
| 1.00 µm film           |           |           | 726359.30 |
| 3.00 µm film           |           |           | 726357.30 |



# Capillary columns for amine separation



## FS-CW 20 M-AM polyethylene glycol 20 000, non-immobilized · USP G16

### ★ Key features

- Polyethylene glycol, basic for amine separations

### ✎ Temperature

- $T_{\max}$  220 °C (long-term temperature),
- $T_{\max}$  240 °C (short-term max. temperature in a temperature program)

### Similar phases

- Carbowax™ Amine, CP-Wax 51, CAM, Stabilwax® DB

### Ordering information

#### FS-CW 20 M-AM

|  | Length →<br>10 m | 25 m      | 50 m      |
|--|------------------|-----------|-----------|
| 0.1 mm ID (0.4 mm OD)<br>0.25 µm film  | 733111.10        |           |           |
| 0.25 mm ID (0.4 mm OD)<br>0.25 µm film |                  | 733110.25 | 733110.50 |
| 0.32 mm ID (0.5 mm OD)<br>0.25 µm film |                  | 733299.25 | 733299.50 |
| 0.35 µm film                           |                  |           | 733442.50 |
| 0.53 mm ID (0.8 mm OD)<br>1.00 µm film |                  | 733551.25 |           |

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)



## MACHEREY-NAGEL CHROMAFIL® syringe filters

### Ideal for the filtration of GC, HPLC and UHPLC sample solutions

- Diverse membrane types and filter sizes for a variety of applications
- Optimal flow geometry because of star-shaped distribution device
- Lowest content of extractable substances
- Luer lock inlet, Luer outlet
- Prefiltration of solvents protects sensitive instrument parts and chromatography columns from solid contamination and increases their lifetime.

Find CHROMAFIL® products from page 81 onwards.





# Capillary columns for hydrocarbons



## PERMABOND® P-100 for analysis of petrochemical products · USP G1 / G2 / G38

### ★ Key features

- Extra long column with nonpolar dimethylpolysiloxane phase

### ✓ Recommended application

- High resolution and sufficient capacity for analysis of complex mixtures of hydrocarbons

### ✍ Temperature

- T<sub>max</sub> 300 °C (long-term temperature), T<sub>max</sub> 320 °C (short-term max. temperature in a temperature program)

### Ordering information

#### PERMABOND® P-100

|                        | Length →<br>100 m |
|------------------------|-------------------|
| 0.25 mm ID (0.4 mm OD) |                   |
| 0.50 µm film           | 723890.100        |

## PERMABOND® SE-54-HKW for volatile halogenated hydrocarbons · USP G36

### ✓ Recommended application

- SE-54 optimized for volatile halogenated hydrocarbons

### ✍ Temperature

- T<sub>max</sub> 300 °C (long-term temperature), T<sub>max</sub> 320 °C (short-term max. temperature in a temperature program)

For the analysis of halogenated hydrocarbons, we recommend our optimized column PERMABOND® SE-54-HKW at 25 or 50 m length with our approved polysiloxane phase SE-54.

As an alternative, or to verify analytical results, the OPTIMA® 624 has proven itself as advantageous, especially for the determination of 1,1,2-trichlorotrifluoroethane (F 113) along with dichloromethane.

Both phases are also suited for the determination of vinyl chloride as well as for the separation of cis/trans isomers of 1,2-dichloroethene. The high film thickness secures a high capacity and an outstanding resolution. For GC/MS coupling, we recommend OPTIMA® 624 LB or OPTIMA® 624 with 0.2 or 0.25 mm ID

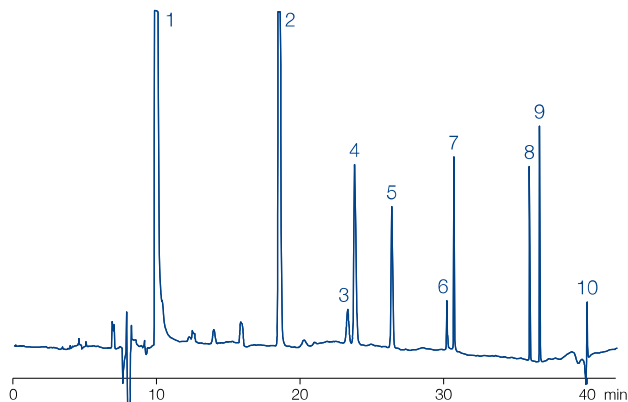
### Volatile halogenated hydrocarbons

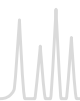
MN Appl. No. 212480

Column: PERMABOND® SE-54-HKW, 50 m x 0.32 mm ID  
 Injection: 1 µL, split ~ 1:30  
 Carrier gas: 0.9 bar He  
 Temperature: 35 °C (25 min) → 160 °C (5 min), 10 °C/min  
 Detector: ECD 300 °C

#### Peaks:

1. Dichloromethane (795 ng/mL)
2. Trichloromethane (75 ng/mL)
3. 1,1,1-Trichloroethane (67 ng/mL)
4. 1,2-Dichloroethane (100 ng/mL)
5. Tetrachloromethane (15.9 ng/mL)
6. Trichloroethene (14.6 ng/mL)
7. Bromodichloromethane (20 ng/mL)
8. Dibromochloromethane (122 ng/mL)
9. Tetrachloroethene (81 ng/mL)
10. Tribromomethane (28.9 ng/mL)





# Capillary columns for hydrocarbons



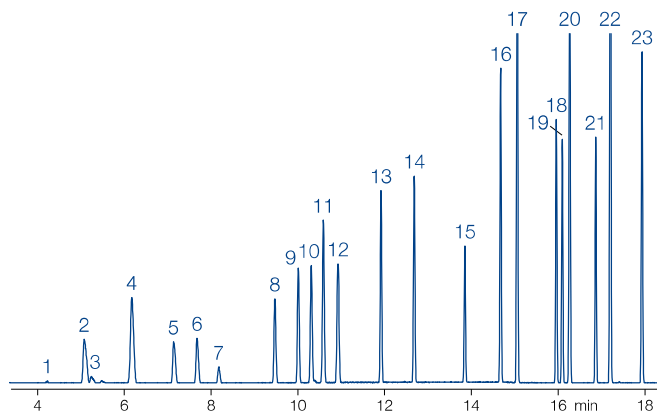
## Volatile halogenated hydrocarbons and BTX

MN Appl. No. 200160

Column: OPTIMA® 624, 50 m x 0.25 mm ID, 1.40 µm film  
 Injection: 1 µL, split 50 mL/min  
 Carrier gas: 0.9 mL/min He (constant flow)  
 Temperature: 40 °C (5 min) → 160 °C, 10 °C/min  
 Detector: MSD 5971

### Peaks:

- |   |                                   |
|---|-----------------------------------|
| 1. Vinyl chloride                         | 12. 1,2-Dichloroethane + benzene  |
| 2. Trichlorofluoromethane (F 11)          | 13. Trichloroethene               |
| 3. Pentane                                | 14. Bromodichloromethane          |
| 4. 1,1,2-Trichlorotrifluoroethane (F 113) | 15. Toluene                       |
| 5. Dichloromethane                        | 16. Tetrachloroethene             |
| 6. <i>trans</i> -1,2-Dichloroethene       | 17. Dibromochloromethane          |
| 7. Hexane                                 | 18. Chlorobenzene                 |
| 8. <i>cis</i> -1,2-Dichloroethene         | 19. Ethylbenzene                  |
| 9. Trichloromethane                       | 20. <i>m</i> - + <i>p</i> -Xylene |
| 10. 1,1,1-Trichloroethane                 | 21. <i>o</i> -Xylene              |
| 11. Tetrachloromethane                    | 22. Tribromomethane               |
|   | 23. Bromobenzene                  |



### Ordering information

#### PERMABOND® SE-54-HKW

|                        | Length →  |           |
|------------------------|-----------|-----------|
|                        | 25 m      | 50 m      |
| 0.32 mm ID (0.5 mm OD) |           |           |
| 1.80 µm film           | 723945.25 | 723945.50 |

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)





## PERMABOND® Silane for silane analysis

### ✓ Recommended application

- Developed especially for the analysis of monomeric silanes and chlorosilanes (not for the separation of trimethylsilyl derivatives)
- Also suited for the separation of dimeric siloxanes and silazanes

### ✎ Temperature

- 0.32 mm ID:  $T_{max}$  260 °C (long-term temperature),  $T_{max}$  280 °C (short-term max. temperature in a temperature program)
- 0.53 mm ID:  $T_{max}$  240 and 260 °C, resp.

## Ordering information

### PERMABOND® Silane

|                        | Length →<br>25 m | 50 m      |
|------------------------|------------------|-----------|
| 0.32 mm ID (0.5 mm OD) |                  | 723409.50 |
| 0.53 mm ID (0.8 mm OD) | 723411.25        |           |

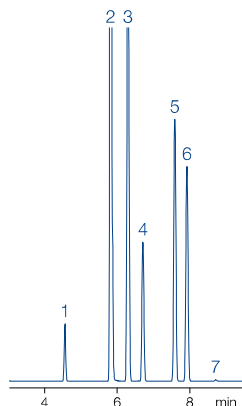
### Chloromethylsilanes

MN Appl. No. 200090

Column: PERMABOND® Silane, 50 m x 0.32 mm ID  
 Injection: 0.5 µL gas, split 80 mL/min  
 Carrier gas: 1 mL/min He (constant flow)  
 Temperature: 50 °C → 100 °C, 5 °C/min  
 Detector: MSD 5971

#### Peaks:

1. Tetramethylsilane
2. Dichloromethane
3. Tetrachlorosilane
4. Chlorotrimethylsilane
5. Methyltrichlorosilane
6. Dichlorodimethylsilane
7. Hexamethyldisiloxane



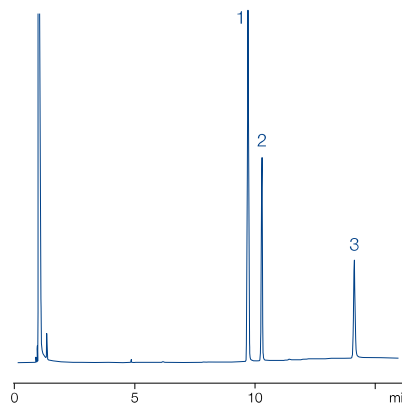
### Diethylene glycol standard in wine

MN Appl. No. 201500

Column: PERMABOND® CW 20 M-DEG,  
 25 m x 0.25 mm ID  
 Injection: 0.5 µL, split ~1:40  
 Carrier gas: 1.2 bar N<sub>2</sub>  
 Temperature: 80 °C → 200 °C, 10 °C/min  
 Detector: FID 260 °C

#### Peaks:

- DEG standard
1. 1,4-Butanediol
  2. Diethylene glycol
  3. Glycerol



## PERMABOND® CW 20 M-DEG for determination of diethylene glycol · USP G16

### ★ Key features

- Polyethylene glycol 20 000 (diethylene glycol tested)

### ✓ Recommended application

- Determination of diethylene glycol (DEG), e.g., for the quality control of wine

### ✎ Temperature

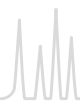
- $T_{max}$  220 °C (long-term temperature),  $T_{max}$  240 °C (short-term max. temperature in a temperature program)

## Ordering information

### PERMABOND® CW 20 M-DEG

|                        | Length →<br>25 m |
|------------------------|------------------|
| 0.25 mm ID (0.4 mm OD) |                  |
| 0.25 µm film           | 723063.25        |
| 0.32 mm ID (0.5 mm OD) |                  |
| 0.25 µm film           | 723327.25        |

Further applications can be found online in our application database at [www.mn-net.com/apps](http://www.mn-net.com/apps)



## Untreated capillaries

### ✓ Recommended application

- Capillary electrophoresis
- Preparation of capillary columns
- Capillary LC applications

### Ordering information

#### Untreated capillaries

|                                 | Length → 1 m<br>Pack of 3 | 10 m<br>Pack of 1 | 25 m<br>Pack of 1 |
|---------------------------------|---------------------------|-------------------|-------------------|
| Capillaries for electrophoresis |                           |                   |                   |
| 0.025 mm ID (0.4 mm OD)         | 723793.1                  | 723793.2          |                   |
| 0.05 mm ID (0.4 mm OD)          | 723790.1                  | 723790.2          |                   |
| 0.075 mm ID (0.4 mm OD)         | 723791.1                  | 723791.2          |                   |
| 0.10 mm ID (0.4 mm OD)          | 723792.1                  | 723792.2          |                   |
| Untreated capillaries           |                           |                   |                   |
| 0.20 mm ID (0.4 mm OD)          |                           | 723148.10         | 723148.25         |
| 0.25 mm ID (0.4 mm OD)          |                           | 723101.10         | 723101.25         |
| 0.32 mm ID (0.5 mm OD)          |                           | 723151.10         | 723151.25         |
| 0.53 mm ID (0.8 mm OD)          |                           | 723501.10         | 723501.25         |

Untreated capillaries are supplied without cage.

## Deactivated capillary columns precolumns / guard columns

### ✓ Recommended application

- As precolumns / guard columns, whenever a larger contamination capacity is required
- Preparation of capillary columns

### Ordering information

#### Deactivated capillary columns

|  | Length →<br>10 m | 25 m      |
|--|------------------|-----------|
| Methyl-Sil deactivated ( $T_{max}$ 320 °C) |                  |           |
| 0.25 mm ID (0.4 mm OD)                     | 723106.10        | 723106.25 |
| 0.32 mm ID (0.5 mm OD)                     | 723346.10        | 723346.25 |
| 0.53 mm ID (0.8 mm OD)                     | 723558.10        | 723558.25 |
| Phenyl-Sil deactivated ( $T_{max}$ 320 °C) |                  |           |
| 0.25 mm ID (0.4 mm OD)                     | 723108.10        | 723108.25 |
| 0.32 mm ID (0.5 mm OD)                     | 723348.10        | 723348.25 |
| 0.53 mm ID (0.8 mm OD)                     | 723560.10        | 723560.25 |
| CW deactivated ( $T_{max}$ 250 °C)         |                  |           |
| 0.25 mm ID (0.4 mm OD)                     | 723105.10        | 723105.25 |
| 0.32 mm ID (0.5 mm OD)                     | 723349.10        | 723349.25 |
| 0.53 mm ID (0.8 mm OD)                     | 723562.10        | 723562.25 |

Untreated capillaries are supplied without cage.

For a considerably longer lifetime, even for contaminated or matrix-containing samples, MN offers the option of integrated precolumns. All capillary columns are available with a 10 m guard column with matched deactivation. For ordering, please add V1 at the end of the REF number. Guard column combinations with other lengths, IDs or different deactivation are available on request.



## Retention gaps

### ★ Key features

- The retention gap technique in combination with on-column injection allows to concentrate a large sample volume in the capillary column.
- Choice of the retention gap depends on the solvent used: the flooded zone after injection should be between 20–30 cm/μL
- Me-Sil retention gap:  
only for use with *n*-hexane and diethyl ether
- Phe-Sil retention gap:  
for all solvents except methanol and water
- CW retention gap:  
for all solvents and especially for methanol and water

### ✎ Temperature

- $T_{\max}$  250 °C (CW retention gaps),  
 $T_{\max}$  320 °C (Me-Sil and Phe-Sil retention gaps)

### Note:

- Calculation example: length of flooded zone ~ 20–30 cm/μL, retention gap 10 m x 0.32 mm ID, capillary column: 25 m x 0.32 mm ID, max. injection volume ~ 30–50 μL
- A retention gap must be inert without any noticeable retention: Me-Sil retention gaps are more inert than Phe-Sil, while Phe-Sil is less susceptible to contamination
- Retention gaps can also be used as transfer lines or precolumns (contamination capacity about 5–10 μg).

## Ordering information

### Retention gaps

|   | Length →  |           |
|---|-----------|-----------|
|   | 10 m      | 25 m      |
| Me-Sil retention gaps ( $T_{\max}$ 320 °C)  |           |           |
| 0.25 mm ID (0.4 mm OD)                      | 723706.10 | 723706.25 |
| 0.32 mm ID (0.5 mm OD)                      | 723707.10 | 723707.25 |
| 0.53 mm ID (0.8 mm OD)                      | 723708.10 | 723708.25 |
| Phe-Sil retention gaps ( $T_{\max}$ 320 °C) |           |           |
| 0.25 mm ID (0.4 mm OD)                      | 723709.10 | 723709.25 |
| 0.32 mm ID (0.5 mm OD)                      | 723710.10 | 723710.25 |
| 0.53 mm ID (0.8 mm OD)                      | 723711.10 | 723711.25 |
| CW retention gaps ( $T_{\max}$ 250 °C)      |           |           |
| 0.25 mm ID (0.4 mm OD)                      | 723712.10 | 723712.25 |
| 0.32 mm ID (0.5 mm OD)                      | 723713.10 | 723713.25 |
| 0.53 mm ID (0.8 mm OD)                      | 723714.10 | 723714.25 |

Retention gaps are supplied without cage.

For a considerably longer lifetime, even for contaminated or matrix-containing samples, MN offers the option of integrated precolumns. All capillary columns are available with a 10 m guard column with matched deactivation. For ordering, please add V1 at the end of the REF number. Guard column combinations with other lengths, IDs or different deactivation are available on request.



## Derivatization reagents

### ★ Key features

- Derivatization reagents:  
To improve volatility, increase thermal stability or to achieve a lower limit of detection in gas chromatography
- Prerequisite: quantitative, rapid and reproducible formation of only one derivative
- Halogen atoms inserted by derivatization, e.g., trifluoroacetates, allow the specific detection in an ECD with the advantage of high sensitivity.
- Specific derivatizations may influence elution orders and fragmentation patterns in a MS
- We provide reagents for
  - acylation
  - alkylation (methylation)
  - silylation
- For 1 x 10 mL, 1 x 50 mL and 6 x 50 mL also available with screw closure

## Ordering information

### Derivatization method development kits\*

| Designation  | Contents of the kit                         | REF    |
|--|---|--------|
| Which type of derivatization is suited best for your sample (alkylation, acylation or silylation)? | 2 x 1 mL each of TMSH, MSTFA, MBTFA         | 701952 |
| <b>Acylation kit</b>   |   |        |
| Which is the proper reagent for acylation?   | 2 x 1 mL each of MBTFA, TFAA, MBHFBA        | 701950 |
| <b>Alkylation kit</b>  |   |        |
| Which is the proper reagent for methylation?   | 3 x 1 mL each of TMSH, DMF-DMA              | 701951 |
| <b>Silylation kit</b>  |   |        |
| Which is the proper reagent for silylation?  | 2 x 1 mL each of MSTFA, BSTFA, TSIM, MSHFBA | 701953 |

\* These products contain harmful substances which must be specially labeled as hazardous. For detailed information please see SDS.

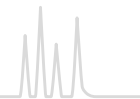
## Selection guide for derivatization of important functional groups in GC

| Function                                       | Method          | Derivative                | Recommended reagents   |
|--|-----------------|---------------------------|--|
| alcohols, phenols<br>R'OH                      | silylation      | R'O-TMS                   | BSA, MSTFA, MSHFBA, TSIM, SILYL-2110, SILYL-21, SILYL-1139       |
| sterically hindered                            | acylation       | R'O-CO-R                  | TFAA, HFBA, MBTFA, MBHFBA  |
|  | alkylation      | R'O-R                     | TMSH   |
| amines<br>primary, secondary<br>hydrochlorides | silylation      | R'O-TMS                   | TSIM, BSTFA, SILYL-991   |
|  | silylation      | R'-NR''-TMS               | BSA, MSTFA, MSHFBA, SILYL-991                                    |
| amides   | acylation       | R'-NR''-CO-R              | TFAA, HFBA, MBTFA, MBHFBA  |
|  | silylation      | R'-NH-CO-R                | MSTFA  |
| amino acids                                    | silylation      | R'-CH(NH-TMS)-CO-O-TMS    | BSA, BSTFA, MSTFA, MSHFBA  |
|  | alkylation (a)  | R'-CH(NH-CO-R)-CO-O-R     | a) MeOH/TMCS, TMSH   |
|  | + acylation (b) |                           | b) TFAA, HFBA, MBTFA, MBHFBA                                     |
| Carboxylic acids<br>(fatty acids)              | silylation      | R'-CO-O-TMS               | BSA, MSTFA, MSHFBA, TMCS, TSIM, SILYL-2110, SILYL-21, Silyl-1139 |
|  | alkylation      | R'-CO-O-R                 | DMF-DMA, MeOH/TMCS (1 M), TMSH                                   |
| salts  | silylation      | R'-CO-O-TMS               | TMCS   |
|  | silylation      | susceptible to hydrolysis |  |
| carbohydrates                                  | silylation      |                           | MSTFA, TSIM, HMDS, SILYL-1139                                    |
|  | acylation       |                           | TFAA, MBTFA  |
| steroids                                       | silylation      |                           | BSA, TSIM  |
|  | acylation       |                           | TFAA, MBTFA, HFBA, MBHFBA  |

These products contain harmful substances which must be specially labeled as hazardous. For detailed information please see SDS.

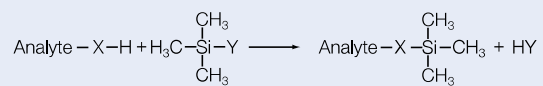
Due to their purpose, derivatization reagents are very reactive substances. For this reason, they should be stored cool and protected from moisture. For easy access with a syringe, our derivatization reagents are supplied in vials with crimp caps (exception DMCS and TMCS with screw closure). Vials with pierced sealing disks have limited stability and should be used soon.

The derivatization procedures can be found on page 367.



## General reaction mechanisms

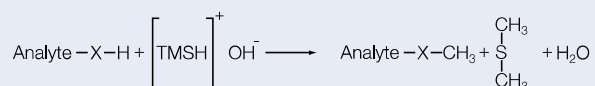
### Silylation



X = e.g., O, S, COO, etc.

Y = rest of silylation reagents

### Alkylation (Methylation) · example TMSH



X = e.g., O, S, COO, etc.

### Acylation



X = e.g., O, S, NH, etc.

Y = rest of acylation reagents



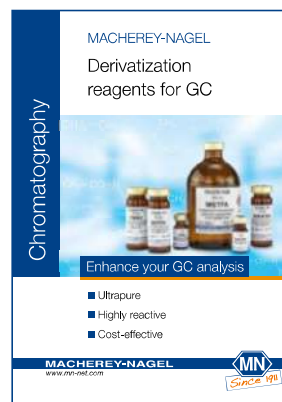
## MACHEREY-NAGEL

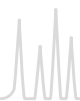
### derivatization reagents for GC

#### Content of brochure

- Product range for acylation, alkylation and silylation reagents
- Protocols for derivatization
- Diverse tips and hints

Order now your derivatization brochure KATEN200144





## Acylation reagents

### Acyl halides

#### ★ Key features

- By-product of acylation with acyl halides: corresponding hydrohalic acids excess of reagent and acid have to be removed or trapped by a suitable base (e.g., pyridine)
- Pentafluorobenzoyl chloride  
PFBC:  $C_6F_5-CO-Cl$   
M 230.52 g/mol, Bp 158–159 °C (760 mm Hg),  
Density  $d_{20}^{20}/4^{\circ} = 1.601$

### Anhydrides

#### ★ Key features

- By-products of acylation with anhydrides: corresponding acids excess reagent and the acid formed are to be removed
- Trifluoroacetic acid anhydride TFAA:  $CF_3-CO-O-CO-CF_3$   
M 210.04 g/mol, Bp 39.5–40.5 °C (760 mm Hg),  
Density  $d_{20}^{20}/4^{\circ} = 1.490$
- Heptafluorobutyric acid anhydride  
HFBA:  $C_3F_7-CO-O-CO-C_3F_7$   
M 410.06 g/mol, Bp 106–107 °C (760 mm Hg),  
Density  $d_{20}^{20}/4^{\circ} = 1.665$

### Bisacylamides

#### ★ Key features

- By-products: corresponding neutral acylamides: high volatility
- Easily removed; due to the neutral conditions and their favorable chromatographic characteristics, the removal of surplus bisacylamides and their by-products is often not necessary. Therefore, the sample preparation is much easier.
- *N*-methyl-bis(trifluoroacetamide)  
MBTFA:  $CF_3-CO-N(CH_3)-CO-CF_3$   
M 223.08 g/mol, Kp 123–124 °C (760 mm Hg),  
Density  $d_{20}^{20}/4^{\circ} = 1.55$
- *N*-methyl-bis(heptafluorobutyramide)  
MBHFBA:  $C_3F_7-CO-N(CH_3)-CO-C_3F_7$   
M 423.1 g/mol, Kp 165–166 °C (760 mm Hg),  
Density  $d_{20}^{20}/4^{\circ} = 1.673$



## Methods for acylation

### Acylation with fluorinated acid anhydrides (TFAA, HFBA)

- Applicable for alcohols, phenols, carboxylic acids, amines, amino acids and steroids, stable derivatives for FID or ECD detection
- Procedure see page 367 or online at [www.mn-net.com/apps](http://www.mn-net.com/apps)  
TFAA: MN Appl. Nr. 213041  
HFBA: MN Appl. Nr. 213042

### Acylation with fluorinated acid amides (MBTFA, MBHFBA)

- Recommended for alcohols, primary and secondary amines as well as for thiols under mild, neutral conditions
- MBTFA also forms very volatile derivatives with carbohydrates [17].
- Procedure see page 367 or online at [www.mn-net.com/apps](http://www.mn-net.com/apps)  
MBTFA: MN Appl. Nr. 213051  
MBHFBA: MN Appl. Nr. 21305

### Ordering information

#### Acylation reagents\*

| Substance | Packing unit |            |            |            |
|-----------|--------------|------------|------------|------------|
|           | 10 x 1 mL    | 20 x 1 mL  | 1 x 10 mL  | 5 x 10 mL  |
| HFBA      |              | 701110.201 | 701110.110 | 701110.510 |
| MBTFA     |              | 701410.201 | 701410.110 | 701410.510 |
| MBHFBA    | 701420.101   | 701420.201 |            |            |
| PFBC      | 701120.101   |            |            |            |
| TFAA      |              |            | 701130.110 | 701130.510 |

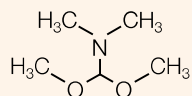
\* These products contain harmful substances which must be specially labeled as hazardous. For detailed information please see SDS.

On request for 1 x 10 mL, 1 x 50 mL and 6 x 50 mL also available with screw closure.



## Alkylation / methylation reagents

### DMF-DMA *N,N*-dimethylformamide dimethylacetal

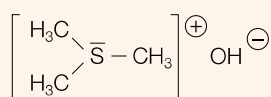


- M 119.17 g/mol,  
Kp 106–107 °C (760 mm Hg),  
Density d<sub>20°/4°</sub> = 0.897

#### ★ Key features

- Methylation reagents

### TMSH (0.2 mol/L in methanol) Trimethylsulfonium hydroxide



- M 94.06 g/mol

#### ★ Key features

- Methylation reagents

## Methods for alkylation / methylation

### Methylation with TMSH

- Suited for free acids, chlorophenoxy-carboxylic acids, their salts and derivatives as well as for phenols and chlorophenols [18]
- The great advantage is the simplification of the sample preparation. Lipids or triglycerides can be converted to the corresponding fatty acid methyl esters (FAMES) by simple transesterification.
- This reaction is very elegant and convenient, because it is only necessary to add the reagent (0.2 mol/L in methanol) to the sample solution. Removal of surplus reagent is not required, since at 250 °C inside the injector of the gas chromatograph, TMSH will pyrolyze solely to volatile methanol and dimethylsulfide. Due to high reactivity, a complete conversion is usually obtained at ambient temperature. Heating (e.g., 10 min at 100 °C) in a closed sample vial may be necessary, however.
- Procedure see page 367 or online at [www.mn-net.com/apps](http://www.mn-net.com/apps)  
MN Appl. Nr. 213060

### Methylation with DMF-DMA

- Applicable for fatty acids, primary amines and (partially) amino acids, under formation of *N*-dimethyl-aminomethylene amino acid methyl esters [19]
- Since DMF-DMA is a poor solvent, it is essential to use a mixture of DMF-DMA with pyridine, THF, acetone (barbiturates) or another solvent.
- Procedure see page 367 or online at [www.mn-net.com/apps](http://www.mn-net.com/apps)  
MN Appl. Nr. 213070

### Methylation with methanol – TMCS (1 M)

- Suited for the esterification of free carboxylic acids and the transesterification of glycerides. Formation of HCl catalyzes the reaction. TMCS, resp. silyl ethers remove the water and thus drive the reaction to completion. The mixture should be freshly prepared.
- Procedure see page 367 or online at [www.mn-net.com/apps](http://www.mn-net.com/apps)  
MN Appl. Nr. 213080

For GC separation of FAMES from natural butter fat after derivatization with TMSH see Appl. 201680 at [www.mn-net.com/apps](http://www.mn-net.com/apps)

## Ordering information

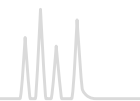
### Alkylation reagents\*

| Substance | Packing unit |            |            |            |
|-----------|--------------|------------|------------|------------|
|           | 10 x 1 mL    | 20 x 1 mL  | 1 x 10 mL  | 5 x 10 mL  |
| DMF-DMA   |              | 701430.201 | 701430.110 |            |
| TMSH      | 701520.101   | 701520.201 | 701520.110 | 701520.510 |

\* These products contain harmful substances which must be specially labeled as hazardous. For detailed information please see SDS.

On request for 1 x 10 mL, 1 x 50 mL and 6 x 50 mL also available with screw closure.





## Silylation reagents

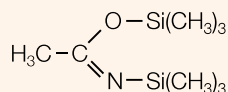
The most common form of silylation in GC is the replacing of active hydrogen atoms with a trimethylsilyl group (TMS derivative). Less frequently, trialkylsilyl groups or dimethylsilyl groups with longer alkyl chains are also in use. The alkylsilyl group increases volatility and enhances thermal stability of the sample.

Silylation can be catalyzed either acidic by addition of TMCS or basic by addition of pyridine or TSIM (e.g., for sterically hindered functionalities like tert. alcohols).

Reactivity of silylation reagents (acc. to M. Donike): TMS amide (e.g., BSA, MSTFA) > TMS amine = TSIM > Enol-O-TMS ether > S-TMS ether > O-TMS ether > TMS-O-TMS

Stability of the TMS derivatives: O-TMS ether > S-TMS ether > Enol-O-TMS ether > TMS amine > TMS amide

### BSA *N,O*-bis-trimethylsilyl-acetamide



- M 203.4 g/mol,  
Bp 71–73 °C (35 mm Hg),  
Density  $d_{20^\circ/4^\circ} = 0.832$

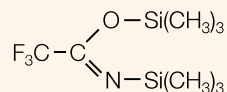
#### ★ Key features

- Strong silylation reagent
- Not recommended for use with carbohydrates or very low molecular weight compounds
- Good solvent for polar compounds, but frequently used in combination with a solvent (pyridine, DMF etc.) or with other silylation reagents. Dissolved in DMF, BSA is the prime derivatization reagent for phenols.

#### ✓ Recommended application

- Alcohols, amines, carboxylic acids, phenols, steroids, biogenic amines and alkaloids are derivatized to stable TMS derivatives

### BSTFA *N,O*-bis-trimethylsilyl-trifluoroacetamide



- M 257.4 g/mol,  
Bp 40 °C (12 mm Hg),  
Density  $d_{20^\circ/4^\circ} = 0.961$

#### ★ Key features

- Powerful trimethylsilyl donor with approx. the same donor strength as the nonfluorinated analog BSA
- Advantage of BSTFA over BSA: greater volatility of its reaction products, particularly useful for GC analysis of low boiling TMS amino acids

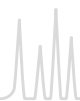
- BSTFA is nonpolar (less polar than MSTFA) and can be mixed with acetonitrile for improved solubility. For the silylation of fatty acid amides, hindered hydroxyl groups and other difficult to silylate compounds, e.g., secondary alcohols and amines, we recommend BSTFA + 1 % trimethylchlorosilane (TMCS), available under the designation SILYL-991 (see page 366).

### Silylation with BSA, BSTFA or SILYL-991 (BSTFA + 1 % TMCS)

- Procedure see page 367 or online at [www.mn-net.com/apps](http://www.mn-net.com/apps)  
BSA MN Appl. Nr. 213091  
BSTFA MN Appl. Nr. 213092  
SILYL-991 MN Appl. Nr. 213093

### Silylation with BSA in combination with other silylation reagents

- Procedure see page 367 or online at [www.mn-net.com/apps](http://www.mn-net.com/apps)  
MN Appl. Nr. 213100



## Ordering information

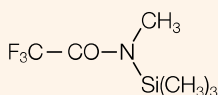
### Silylation reagents\*

| Substance                        | Packing unit |            |            |            |             |
|----------------------------------|--------------|------------|------------|------------|-------------|
|                                  | 20 x 1 mL    | 1 x 10 mL  | 5 x 10 mL  | 1 x 50 mL  | 1 x 100 mL  |
| BSA                              |              | 701210.110 | 701210.510 | 701210.150 |             |
| BSTFA                            | 701220.201   | 701220.110 | 701220.510 |            |             |
| SILYL-991 –(BSTFA – TMCS (99:1)) | 701490.201   |            |            | 701490.150 | 701490.1100 |

\* These products contain harmful substances which must be specially labeled as hazardous. For detailed information please see SDS.

On request for 1 x 10 mL, 1 x 50 mL and 6 x 50 mL also available with screw closure.

## MSTFA *N*-methyl-*N*-trimethylsilyl-trifluoroacetamide



• M 199.1 g/mol,  
Bp 70 °C (75 mm Hg),  
Density d<sub>20°/4°</sub> = 1.11

### ★ Key features

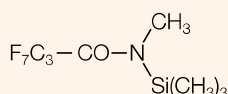
- The most volatile trimethylsilyl amide available, very strong TMS donor which does not cause noticeable FID fouling even during long-time measuring series

### ✓ Recommended application

- Carboxylic acids, hydroxy and ketocarboxylic acids, amino acids, amines, alcohols, polyalcohols, sugars, mercaptans and similar compounds with active hydrogen atoms. Even amine hydrochlorides can be silylated directly.

- The addition of protic solvents in submolar quantities, e.g., TFA for extremely polar compounds (hydrochlorides) or pyridine for carbohydrates), can improve the already good dissolving power of MSTFA.
- Advantages: complete conversion with high reaction rates, even without a catalyst (1–2 % TMCS or TSIM); the by-product of the reaction (*N*-methyltrifluoroacetamide) shows a high volatility and a short retention time

## MSHFBA *N*-methyl-*N*-trimethylsilyl-heptafluorobutyramide



• M 299.1 g/mol,  
Bp 148 °C (760 mm Hg)

### ★ Key features

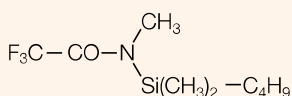
- Similar to MSTFA in reactivity and chromatography
- Either applied alone or in combination with a catalyst (TMCS, TSIM) or another silylation reagent with or without solvent; the by-product *N*-methylheptafluorobutyric amide has a lower retention time than the silylating reagent

### ✓ Recommended application

- Carboxylic acids, alcohols, phenols, primary and secondary amines and amino acids

- Especially useful for flame ionization detection due to the large ratio of fluorine to silicon of 7:1, since degradation of the surplus MSHFBA does not produce SiO<sub>2</sub> but volatile, non-corrosive silicon compounds

## MBDSTFA *N*-methyl-*N*-*tert*-butyldimethylsilyl-trifluoroacetamide



• M 241.3 g/mol,  
Bp 170 °C (760 mm Hg),  
Density d<sub>20°/4°</sub> = 1.121

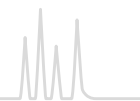
### ★ Key features

- Silylation reagent that donates a *tert*-butyldimethylsilyl group (TBDMS) for derivatizing active hydrogen atoms in hydroxyl, carboxyl and thiol groups as well as primary and secondary amines
- Fast reactions (typically 5–20 min) with high yields (> 96 %), by-products are neutral volatiles

- TBDMS ethers are 10<sup>4</sup> times more stable than the corresponding TMS ethers
- Due to the large protecting group, chromatographic retention times are longer. This may have a beneficial impact on some separations. The high concentration of M<sup>+</sup>-57 ions is an interesting topic for GC/MS.



# Reagents / methods for silylation



## Silylation with MSTFA, MSHFBA or MBDSTFA

· Procedure see page 367 or online at [www.mn-net.com/apps](http://www.mn-net.com/apps)

MSTFA MN Appl. Nr. 213111 · MSHFBA MN Appl. Nr. 213112 · MBDSTFA MN Appl. Nr. 213113

### Ordering information

#### Silylation reagents\*

| Substance | Packing unit |            |            |            |             |            |             |              |
|-----------|--------------|------------|------------|------------|-------------|------------|-------------|--------------|
|           | 10 x 1 mL    | 20 x 1 mL  | 1 x 10 mL  | 5 x 10 mL  | 1 x 100 mL  | 6 x 50 mL  | 6 x 100 mL  | 12 x 100 mL  |
| MSTFA     |              | 701270.201 | 701270.110 | 701270.510 | 701270.1100 | 701270.650 | 701270.6100 | 701270.12100 |
| MSHFBA    |              | 701260.201 | 701260.110 | 701260.510 | 701260.1100 |            | 701260.6100 |              |
| MBDSTFA   | 701440.101   | 701440.201 |            |            |             |            |             |              |

\* These products contain harmful substances which must be specially labeled as hazardous. For detailed information please see SDS.

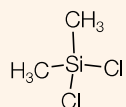
On request for 1 x 10 mL, 1 x 50 mL and 6 x 50 mL also available with screw closure.



Ultrapure derivatization reagents for acylation, alkylation and silylation.



## DMCS Dimethyldichlorosilane

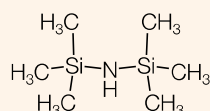


- M 129.06 g/mol,  
Bp 70 °C (760 mm Hg),  
Density d<sub>20°/4°</sub> = 1.07

### ★ Key features

- Used to form dimethylsilyl (DMS) derivatives
- DMS derivatives are much more susceptible to hydrolysis than TMS derivatives, it is therefore vital to have strictly anhydrous conditions during the conversion.

## HMDS Hexamethyldisilazane

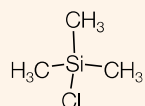


- M 161.4 g/mol,  
Bp 126 °C (760 mm Hg),  
Density d<sub>20°/4°</sub> = 0.7742

### ★ Key features

- Weak TMS donor; used as a sole reagent, it is slow and not very effective.
- Aprotic solvents like acetonitrile, pyridine, dimethylformamide, carbon disulfide and dimethylacetamide recommend themselves for use with HMDS.
- With catalytic quantities, e.g., 1 % of, or as a mixture with TMCS (2:1, v/v; SILYL-21 and SILYL-2110) it is perfectly suited for a quick and quantitative trimethylsilylation of organic compounds.

## TMCS Trimethylchlorosilane

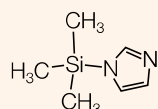


- M 108.7 g/mol,  
Bp 57 °C (760 mm Hg),  
Density d<sub>20°/4°</sub> = 0.8580

### ★ Key features

- Often used as a catalyst with other trimethylsilyl reagents
- As a sole reagent, it can be used to prepare TMS derivatives of organic acids.

## TSIM N-trimethylsilyl-imidazole



- M 140.3 g/mol,  
Bp 94–96 °C (760 mm Hg),  
Density d<sub>20°/4°</sub> = 0.961

### ★ Key features

- Strongest hydroxyl silylator
- It is remarkable that TSIM reacts quickly and smooth with hydroxyl (even tert. OH) and carboxyl groups, but not with amines. Hence it is especially suited for multiple derivatizations, when compounds with various functional groups are to be derivatized in different ways (e.g., -O-TMS, -N-HFB derivatives of catecholamines).

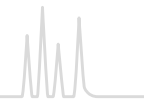
### ✓ Recommended application

- Alcohols, phenols, organic acids, steroids, hormones, glycols, nucleotides, narcotics
- Reagent of choice for carbohydrates and most steroids (even strongly hindered steroids)

### Silylation with TSIM or SILYL-1139 (TSIM – pyridine 11:39)

- Procedure see page 367 or online at [www.mn-net.com/apps](http://www.mn-net.com/apps)

TSIM: MN Appl. Nr. 213121  
SILYL-1139: MN Appl. Nr. 213122



| Ordering information |              |            |            |            |
|----------------------|--------------|------------|------------|------------|
| Silylation reagents* |              |            |            |            |
| Substance            | Packing unit |            |            |            |
|                      | 20 x 1 mL    | 1 x 10 mL  | 5 x 10 mL  | 6 x 50 mL  |
| DMCS                 |              |            |            | 701230,650 |
| HMDS                 |              |            | 701240,510 | 701240,650 |
| TMCS                 | 701280,201   |            |            | 701280,650 |
| TSIM                 | 701310,201   | 701310,110 | 701310,510 |            |

\* These products contain harmful substances which must be specially labeled as hazardous. For detailed information please see SDS.  
On request for 1 x 10 mL, 1 x 50 mL and 6 x 50 mL also available with screw closure.

| Ordering information             |                                 |              |            |            |            |             |
|----------------------------------|---------------------------------|--------------|------------|------------|------------|-------------|
| Reagent mixtures for silylation* |                                 |              |            |            |            |             |
| Mixture                          | Composition                     | Packing unit |            |            |            |             |
|                                  |                                 | 20 x 1 mL    | 1 x 10 mL  | 5 x 10 mL  | 1 x 50 mL  | 1 x 100 mL  |
| SILYL-271                        | BSA - HMDS - TSIM (2:7:1)       | 701450,201   | 701450,110 | 701450,510 |            |             |
| SILYL-1139                       | TSIM - Pyridine (11:39)         | 701460,201   |            |            |            |             |
| SILYL-21                         | HMDS - TMCS (2:1)               | 701470,201   |            |            |            |             |
| SILYL-2110                       | HMDS - TMCS - Pyridine (2:1:10) | 701480,201   |            |            |            |             |
| SILYL-991                        | BSTFA - TMCS (99:1)             | 701490,201   |            |            | 701490,150 | 701490,1100 |

\* These products contain harmful substances which must be specially labeled as hazardous. For detailed information please see SDS.  
On request for 1 x 10 mL, 1 x 50 mL and 6 x 50 mL also available with screw closure.

Due to their purpose, derivatization reagents are very reactive substances. For this reason, they should be stored cool and protected from moisture. For easy access with a syringe, our derivatization reagents are supplied in vials with crimp caps (exception DMCS and TMCS with screw closure). Vials with pierced sealing disks have limited stability and should be used soon.

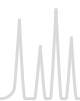
## Silylation with SILYL-21 or SILYL-2110

- Recommended applications: sugars, glycols, sterically unhindered alcohols, carboxylic acids, acids in urine, hydroxy fatty acids, nucleotides, steroids, vitamin D, xanthone derivatives
- Procedure see page 367 or online at [www.mn-net.com/apps](http://www.mn-net.com/apps)  
SILYL-21 MN Appl. Nr. 213131  
SILYL-2110 MN Appl. Nr. 213132

## O-trimethylsilylation with MSTFA followed by N-trifluoroacetylation with MBTF

- Procedure see page 367 or online at [www.mn-net.com/apps](http://www.mn-net.com/apps)  
MSTFA/MBTFA MN Appl. Nr. 213140





## Acylation

### with fluorinated acid anhydrides · TFAA MN Appl. No. 213041 · HFBA MN Appl. No. 213042

Dissolve 0.1 to 1 mg sample in 0.1 mL solvent, add 0.1 mL of the anhydride and heat to 60–70 °C for 1–2 h. If the sample needs not be concentrated prior to the analysis and if there is no danger of catalytically induced side reactions, pyridine is used as solvent. The reaction solution can be injected directly into the gas chromatograph. Otherwise, use a volatile solvent and evaporate solvent, excess reagent and free acid in a stream of nitrogen. Dissolve residue in 50 µL hexane, chloroform etc. and inject aliquot portions.

### with fluorinated acid amides · MBTFA MN Appl. No. 213051 · MBHFBA MN Appl. No. 213052

Add 0.5 mL MBTFA or MBHFBA to about 2 mg sample. If there is no reaction at ambient temperature, heat the reaction mixture to 120 °C. Compounds difficult to dissolve, can be trifluoroacetylated in suitable solvent mixtures. It is recommended to use a ratio of solvent to MBTFA or MBHFBA of 4:1. The reaction mixture is chromatographed directly.

## Alkylation (Methylation)

### with TMSH · MN Appl. No. 213060

Dissolve 100 mg sample (e.g., butter) in 5 mL of a solvent (e.g., *tert.*-butyl methyl ether). Add 50 µL reagent to 100 µL of this solution. The mixture is injected directly. The temperature of the injector must be at least 250 °C.

### with DMF-DMA · MN Appl. No. 213070

Add 1 mL of a mixture of DMF-DMA and pyridine (1:1) to 1–50 mg fatty acids. The sample can be injected as soon as a clear solution has formed. It is recommended, however, to heat the solution to 60–100 °C for 10–15 min.

### with methanol – TMCS · MN Appl. No. 213080

Add 1 mL methanol – TMCS to about 50 mg carboxylic acid or glyceride and heat. Then evaporate in a stream of nitrogen and dissolve again for injection in, e.g., *n*-heptane.

## Silylation

### with BSA, BSTFA oder SILYL-991 (BSTFA + 1 % TMCS)

#### BSA MN Appl. No. 213091 · BSTFA MN Appl. No. 213092 SILYL-991 MN Appl. No. 213093

Add 0.5 mL of the silylation reagent to 1–10 mg sample; if necessary, add some solvent (normally pyridine or DMF [dimethylformamide]). Heat to 60–80 °C for 20 min to increase the reaction rate. 1–2 drops of TMCS (trimethylchlorosilane) or TSM will also speed up the reaction.

### with BSA in combination with other silylation reagents · MN Appl. No. 213100

BSA alone silylates all sterically unhindered hydroxyl groups of the steroid skeleton; addition of TMCS will enable reaction of moderately hindered OH groups (reaction time 3–6 h at 60 °C). After addition of TSM even strongly hindered hydroxyl groups will react (reaction time 6–24 h at 60 °C).

### with MSTFA, MSHFBA or MBDSTFA

#### MSTFA MN Appl. No. 213111 · MSHFBA MN Appl. No. 213112 · MBDSTFA MN Appl. No. 213113

Dissolve 10–15 mg sample in 0.8 mL solvent, then add 0.2 mL of the silylation reagent. The reaction mixture can be heated to 60–70 °C for up to 1 h and can be analyzed directly. If TFA is used as a solvent, proceed as follows [20]: dissolve 1–2 mg sample in 100 µL TFA. Dropwise add 0.9 mL of the silylating reagent. After cooling the sample can be chromatographed directly.

### with TSM or SILYL-1139 (TSM – pyridine 11:39) · TSM MN Appl. No. 213121 · SILYL-1139 MN Appl. No. 213122

Dissolve 10–15 mg sample in 0.8 mL solvent, then add 0.2 mL of the silylation reagent. The reaction mixture can be heated to 60–70 °C for up to 1 hour and can be analyzed directly. Recommended solvent pyridine. When using SILYL-1139, the presence of water does not interfere.

### with SILYL-21 or SILYL-2110 · SILYL-21 MN Appl. No. 213131 · SILYL-2110 MN Appl. No. 213132

Carefully add SILYL-21 or SILYL-2110 to 1–10 mg of the sample. Precipitated ammonium chloride does not interfere. If the sample should not dissolve within 5 min, heat to 75–85 °C. If no mutarotation is to be expected, you may dissolve the sugar in warm pyridine first and then add the silylation reagent. In some cases it may be advantageous to use a different solvent instead of pyridine. For derivatization of 3-ketosteroids we recommend to use DMF (dimethylformamide)

### O-trimethylsilylation with MSTFA followed by *N*-trifluoroacetylation with MBTFA · MN Appl. No. 213140

Completely silylate 2 mg of the sample with 0.3 mL MSTFA, e.g., as described on page 363. After addition of 0.3 mL MBTFA the *N*-trimethylsilyl group is replaced by the *N*-trifluoroacetyl group. The mixture can be analyzed directly.



## Test mixtures

### ★ Key features

- Test mixtures for GC capillary columns to control the performance of fused silica capillary columns and the GC system

## Ordering information

### Test mixtures\*

| Designation  |  | Pack of | REF    |
|--|--|---------|--------|
| Activity test mixture (FA-TMS test according to Donike) in MSTFA/ <i>n</i> -hexane (1 + 4) | 1 mg/mL each of TMS capric acid (C10), TMS myristic acid (C14), TMS stearic acid (C18), TMS behenic acid (C22), hexadecane (C16), eicosane (C20), tetracosane (C24), octacosane (C28)  | 1 mL    | 722307 |
| Grob test mixture (modified) in <i>n</i> -hexane   | (in mg/mL) <i>n</i> -decane (~ 2.8), <i>n</i> -undecane (~ 2.9), <i>n</i> -octanol (~ 3.6), 2,6-dimethylphenol (~ 3.2), 2,6-dimethylaniline (~ 3.2), methyl decanoate (~ 4.2), dicyclohexylamine (~ 3.1), methyl undecanoate (~ 4.2), methyl dodecanoate (~ 4.1) | 1 mL    | 722310 |
| MN OPTIMA® test mixture in pentane   | 0.1 % each of undecane, dodecane, octanol, dimethylaniline, decylamine, methyl decanoate, methyl undecanoate, heneicosane, docosane, tricosane (chromatograms see page 305)  | 1 mL    | 722316 |
| MN OPTIMA® amine test mixture in ethanol   | 0.2 % diisobutylamine, 1 % diethanolamine, 0.2 % 2,6-dimethylaniline, 0.2 % <i>o</i> -propanol-pyridine, 0.2 % dicyclohexylamine, 0.2 % dibenzylamine  | 1 mL    | 722317 |
| FAME test mixture in hexane  | 0.1 % each of FAMEs C4, C6, C8, C10, C12, C14, C16, C18, C18:1 cis, C18:1 trans, C18:2, C18:3, C20, C22, C22:1, C24 (chromatogram see page 334)  | 1 mL    | 722320 |

\* These products contain harmful substances which must be specially labeled as hazardous. For detailed information please see SDS.

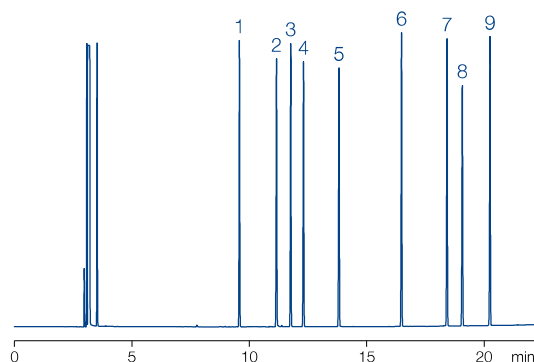
### Grob test mixture (modified) (REF 722310)

MN Appl. No. 211250

Column: OPTIMA® 5, 50 m x 0.25 mm ID, 1.0 µm film  
Injection: 1 µL, split 1:40, 280 °C  
Carrier gas: 1.5 bar H<sub>2</sub>  
Temperature: 80 °C → 280 °C (10 min), 8 °C/min  
Detector: FID 280 °C

#### Peaks:

1. *n*-Decane
2. 1-Octanol
3. *n*-Undecane
4. 2,6-Dimethylphenol
5. 2,6-Dimethylaniline
6. Methyl decanoate
7. Methyl undecanoate
8. Dicyclohexylamine
9. Methyl dodecanoate





# Test mixtures for GC capillary columns

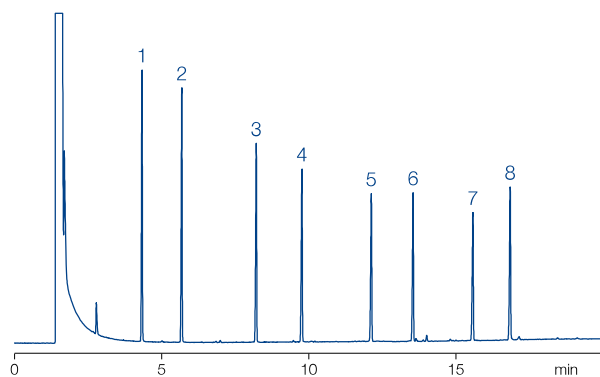
## Activity test mixture (REF 722307)

MN Appl. No. 211240

Column: OPTIMA® 5, 25 m x 0.32 mm ID, 1.0 µm film  
Injection: 1 µL, split 1:40, 300 °C  
Carrier gas: 0.6 bar H<sub>2</sub>  
Temperature: 150 °C → 300 °C (8 min), 10 °C/min  
Detector: FID 300 °C

### Peaks:

1. TMS capric acid (C<sub>10</sub>)
2. Hexadecane (C<sub>16</sub>)
3. TMS myristic acid (C<sub>14</sub>)
4. Eicosane (C<sub>20</sub>)
5. TMS stearic acid (C<sub>18</sub>)
6. Tetracosane (C<sub>24</sub>)
7. TMS behenic acid (C<sub>22</sub>)
8. Octacosane (C<sub>28</sub>)



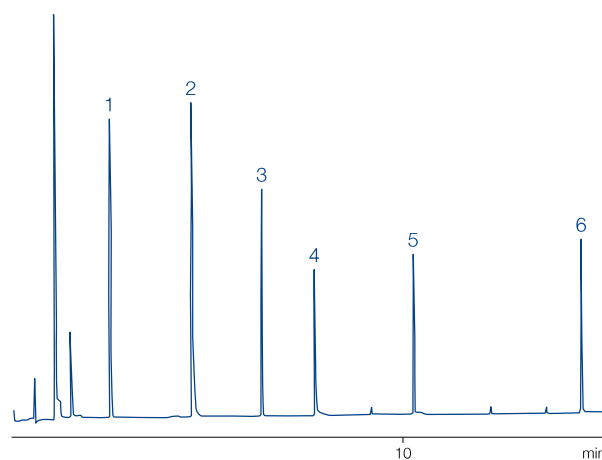
## OPTIMA® Amine test mixture (REF 722317)

MN Appl. No. 250020

Column: OPTIMA® 5 Amine, 30 m x 0.32 mm ID, 1.5 µm film  
Injection: 1 µL, split 1:40  
Carrier gas: 0.6 bar H<sub>2</sub>  
Temperature: 100 °C → 280 °C, 10 °C/min  
Detector: FID 280 °C

### Peaks:

1. Diisobutylamine
2. Diethanolamine
3. 2,6-Dimethylaniline
4. o-Propanol-pyridine
5. Dicyclohexylamine
6. Dibenzylamine







## Ferrules

### ★ Key features

- Graphite ferrules provide the highest temperature stability (up to 450 °C). They are reusable, if handled with care. We also offer 1/16" graphite ferrules specially designed for Carlo Erba / Fisons or for Agilent gas chromatographs.
- Vespel ferrules with 40 % graphite. Temperature-stable up to 400 °C and reusable.

## Ordering information

### Ferrules

| Bore (= column OD)                                       | Graphite | Vespel<br>+40 % Graphite |
|--|----------|--------------------------|
| T <sub>max</sub> →                                       | 450 °C   | 400 °C                   |
| 1/16" ferrules   |          |                          |
| 0,4 mm   |          | 706246                   |
| 0,5 mm   | 708308   |                          |
| 1/16" ferrules for Carlo Erba (Fisons) instruments       |          |                          |
| 0,8 mm   | 708340   |                          |
| 1/16" ferrules for Hewlett-Packard (Agilent) instruments |          |                          |
| 0,4 mm   | 708353   |                          |
| 0,5 mm   | 708354   |                          |
| 0,8 mm   | 708355   |                          |
| 1/8" ferrules  |          |                          |
| no bore  | 708341   |                          |
| 1/4" ferrules  |          |                          |
| no bore  | 708344   |                          |
| 0,4 mm   | 708345   |                          |
| 0,5 mm   | 708346   |                          |



## Injection Port Septa blister pack for cleanliness and easily handling

### ★ Key features

- BTO septa for highest demands in GC and GC-MS
  - pierced, soft – CenterGuide™
- AG3 septa with higher durability than BTO
  - pierced, hard – CenterGuide™
- Marathon Septa with extreme durability for > 400 injections
  - pierced – CenterGuide™

### Ordering information

#### Injection port septa

| Septum grade | BTO septa   | AG3 septa   | Marathon septa  |        |
|--------------|---|---|---|--------|
|              |  |  |  |        |
| OD           |   |   |   |        |
|              | $T_{max}$   |   |   |        |
| 9 mm         | 400 °C  | 702646  | 702656  | 702660 |
| 11 mm        | 400 °C  | 702647  | 702657  | 702661 |
| 11,5 mm      | 400 °C  | 702648  | 702658  | 702662 |
| Shimadzu®    | 300 °C  | 702649  | 702659  | 702663 |
|              | Pack of   | 25  | 25  | 25     |





## Standard Septa in classical plastic container

### ★ Key features

- Standard septa (ST) beige silicone, 60° shore A, 4 mm
- High temperature septa (HT) red non-bleeding silicone, 60° shore A, 3 mm (320 °C max.)
- Silicone septa soft, transparent
- Silicone / PTFE septa white silicone, one side coated with grey PTFE, 3 mm

### Ordering information

#### Classical septa

| Septum grade | Standard septa (ST)   | High temperature septa (HT)   | Silicone septa   | Silicone septa / PTFE   |
|--------------|---|---|--|---|
|              |  |  |  |  |
| OD           |   |   |  |   |
| 9 mm         | 702609  | 702619  | 702602   |   |
| 10 mm        | 702610  | 702620  |  | 702625  |
| 11 mm        | 702611  | 702621  | 702604   | 702626  |
| 12 mm        | 702612  | 702622  | 702605   | 702627  |
| 13 mm        | 702613  | 702623  | 702606   | 702628  |
| 17 mm        |   | 702632  |  |   |
|              | Pack of   | 50  | 50   | 50  |



## Connectors for capillary GC columns

### ★ Key features

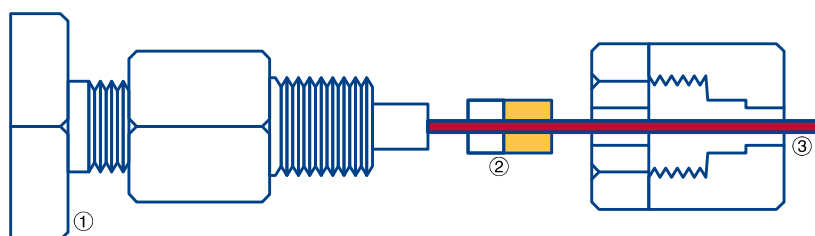
• Glass connectors for fused silica capillary columns from 0.2 to 0.53 mm ID: manufactured from deactivated glass with slightly tapered inner diameter; used to join two fused silica capillaries of equal or different diameters. Advantages compared to stainless steel fittings are easy connection without tools, optical control during connection, negligible heat capacity and no dead volume.

• Graphseal ferrules for capillary columns: a stainless steel ferrule filled with graphite – the ideal sealing material for capillaries. The capillary is mounted on a 1/16" exit (detector, injector etc.), with the appropriate ferrule, a nut (with slit) and an adapter (see table below).

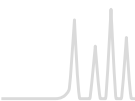
### Ordering information

#### Connectors for capillary GC columns

| Description                              | Pack of       | REF    |
|--|---------------|--------|
| Graphseal ferrules for capillary columns |               |        |
| 0,4 mm bore                              | 10 ferrules   | 708337 |
| 0,5 mm bore                              | 10 ferrules   | 708318 |
| 0,8 mm bore                              | 10 ferrules   | 708319 |
| Universal capillary glass connectors     |               |        |
| linear                                   | 5 connectors  | 707971 |
| linear                                   | 10 connectors | 707972 |
| Y splitter                               | 1 connector   | 707973 |



- ① 1/16" exit
- ② Graphseal ferrule
- ③ Capillary



## Tools and general accessories for GC

### ★ Key features

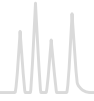
- Magnifying lens with scale: an essential tool for any laboratory. In capillary GC it is often important to inspect column integrity or check cut ends of capillaries. When closing a column by melting the magnifying lens can be used to check whether the column is really closed or whether an open channel has been formed in the sealed end. Our lens provides 8fold magnification and is supplied with a scale as pictured in the figure below. The space between lines is equivalent to 1/10 mm.
- Diamond file: a useful tool for cutting capillaries and smoothing ends of capillaries. Square capillary ends are especially important for butt connections (e.g., in Valco unions).
- Glass wool, quartz wool and glass fiber wadding are used for, e.g., GC liners, packed GC columns etc.

### Ordering information

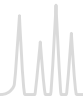
#### Tools and general accessories

| Description  | Pack of  | REF |        |
|--|--|-----|--------|
| Tools for capillary GC   |  |     |        |
| Diamond file   | for cutting capillaries and straightening capillary ends | 1   | 708300 |
| Magnifying lens with scale                                       | magnification 8x   | 1   | 706296 |
| PTFE tape for sealing, reels 12 m long, 12 mm wide, 0.1 mm thick |  |     |        |
| Glass wool   |  |     |        |
| Glass wool, long fibers, DMCS treated, for packed GC columns     | 50 g   |     | 706201 |
| Glass fiber wadding silanized, very fine fibers                  | 25 g   |     | 718002 |
| Quartz wool, very fine fibers                                    | 25 g   |     | 718587 |

# Index of reference numbers



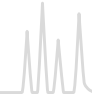
| REF          | Page     | REF       | Page     | REF         | Page               | REF      | Page     |
|--------------|----------|-----------|----------|-------------|--------------------|----------|----------|
| 531011       | 295      | 702001    | 111      | 702054      | 124                | 702128   | 130      |
| 701110.110   | 360      | 702002    | 101      | 702055      | 125                | 702129   | 130      |
| 701110.201   | 360      | 702004    | 102, 120 | 702056      | 129                | 70213    | 102, 120 |
| 701110.510   | 360      | 702005    | 102, 109 | 702057      | 130                | 70213.2  | 102, 120 |
| 701120.101   | 360      | 702006    | 105      | 702058      | 132                | 702130   | 132      |
| 701130.110   | 360      | 702007    | 105      | 702059      | 132                | 702131   | 131      |
| 701130.510   | 360      | 702008    | 105      | 70206.36    | 127                | 702132   | 131      |
| 701210.110   | 363      | 702009    | 105      | 702060      | 132                | 702133   | 131      |
| 701210.150   | 363      | 702010    | 105      | 702061      | 132                | 702134   | 111, 114 |
| 701210.510   | 363      | 702011    | 108      | 702062      | 132                | 702135   | 105      |
| 701220.110   | 363      | 702012    | 108      | 702063      | 115                | 702136   | 125      |
| 701220.201   | 363      | 702013    | 108      | 702063.2080 | 115                | 702141   | 111      |
| 701220.510   | 363      | 702014    | 111      | 702064      | 115                | 702144   | 130      |
| 701230.650   | 366      | 702015    | 111      | 702065      | 112                | 702145   | 129      |
| 701240.510   | 366      | 702016    | 111      | 702066      | 103, 120           | 702146   | 112      |
| 701240.650   | 366      | 702017    | 124      | 702067      | 103                | 702147   | 106      |
| 701260.110   | 364      | 702018    | 124      | 702068      | 103, 120           | 702148   | 107      |
| 701260.1100  | 364      | 702019    | 123      | 702069      | 103                | 702155   | 106      |
| 701260.201   | 364      | 70201CG   | 109      | 702070      | 103                | 70214CG  | 109      |
| 701260.510   | 364      | 70201HP   | 110      | 702071      | 129                | 70215.36 | 126      |
| 701260.6100  | 364      | 70201HP.2 | 110      | 702072      | 125                | 702158   | 106      |
| 701270.110   | 364      | 70202.1   | 124      | 702073      | 132                | 702159   | 106      |
| 701270.1100  | 364      | 702020    | 126      | 702074      | 131                | 70216.36 | 126      |
| 701270.12100 | 364      | 702021    | 131      | 702075      | 110                | 702160   | 106      |
| 701270.201   | 364      | 702022    | 131      | 702076      | 110                | 702161   | 106      |
| 701270.510   | 364      | 702023    | 131      | 702077      | 104, 108, 110, 114 | 702162   | 106      |
| 701270.6100  | 364      | 702024    | 131      | 702078      | 104, 120           | 702163   | 106      |
| 701270.650   | 364      | 702025    | 101      | 702079      | 104, 120           | 702164   | 106      |
| 701280.201   | 366      | 702026    | 105      | 70208.36    | 128                | 702165   | 106      |
| 701280.650   | 366      | 702027    | 105      | 702080      | 106                | 702168   | 132      |
| 701310.110   | 366      | 702028    | 105      | 702081      | 106                | 70217.36 | 127      |
| 701310.201   | 366      | 702029    | 106      | 702082      | 106                | 702170   | 115      |
| 701310.510   | 366      | 70203     | 118      | 702083      | 106                | 702172   | 105      |
| 701410.110   | 360      | 702030    | 106      | 702084      | 106                | 702173   | 111, 114 |
| 701410.201   | 360      | 702031    | 106      | 702085      | 106                | 702174   | 111, 114 |
| 701410.510   | 360      | 702032    | 106, 120 | 702086      | 127                | 702175   | 112      |
| 701420.101   | 360      | 702033    | 106, 120 | 702088      | 105                | 702176   | 115      |
| 701420.201   | 360      | 702034    | 106, 120 | 702089.1    | 128                | 702177   | 105      |
| 701430.110   | 361      | 702035    | 106      | 702091      | 129                | 702178   | 105      |
| 701430.201   | 361      | 702036    | 106      | 702093      | 129                | 702179   | 105      |
| 701440.101   | 364      | 702037    | 106      | 702094      | 129                | 702180   | 121      |
| 701440.201   | 364      | 702038    | 106      | 702096      | 121                | 702181   | 122      |
| 701450.110   | 366      | 702039    | 106      | 702097      | 121                | 702201   | 107      |
| 701450.201   | 366      | 70204.36  | 126      | 702098      | 122                | 702202   | 107      |
| 701450.510   | 366      | 702040    | 106      | 702099      | 122                | 702203   | 107      |
| 701460.201   | 366      | 702041    | 107      | 70210.36    | 128                | 702204   | 107      |
| 701470.201   | 366      | 702042    | 107      | 702100      | 128                | 702205   | 107      |
| 701480.201   | 366      | 702043    | 107      | 702101      | 130                | 702206   | 107      |
| 701490.1100  | 363, 366 | 702044    | 108      | 702101HP    | 113                | 702207   | 107      |
| 701490.150   | 363, 366 | 702045    | 108      | 702102      | 132                | 702208   | 107      |
| 701490.201   | 363, 366 | 702046    | 108      | 702103      | 119, 121           | 702209   | 107      |
| 701520.101   | 361      | 702047    | 108      | 702104      | 121                | 702211   | 107      |
| 701520.110   | 361      | 702048    | 108      | 702105      | 122                | 702212   | 107      |
| 701520.201   | 361      | 702049    | 108      | 702106      | 122                | 702213   | 107      |
| 701520.510   | 361      | 70205.36  | 126      | 702107      | 106                | 702214   | 107      |
| 701950       | 357      | 702050    | 119      | 702109      | 106                | 702215   | 112      |
| 701951       | 357      | 702051    | 119, 121 | 702110      | 125                | 702216   | 112      |
| 701952       | 357      | 702052    | 119, 121 | 702112      | 129                | 702217   | 112      |
| 701953       | 357      | 702053    | 119      |             |                    | 702218   | 112      |



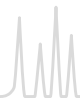
# Index of reference numbers

| REF      | Page     | REF     | Page             | REF         | Page                  | REF      | Page     |
|----------|----------|---------|------------------|-------------|-----------------------|----------|----------|
| 702219   | 112      | 70240   | 130              | 70267       | 130                   | 702827   | 125      |
| 702221   | 112      | 702401  | 111, 115         | 70269       | 130                   | 702829   | 129      |
| 702222   | 112      | 70242   | 130              | 702709      | 114                   | 70283    | 101      |
| 702223   | 112      | 702437  | 103              | 70271       | 123                   | 702833   | 129      |
| 702224   | 112      | 70245   | 103              | 702710      | 115                   | 702834   | 129      |
| 702225   | 115      | 70248   | 103              | 702710.1    | 115                   | 702835   | 129      |
| 702226   | 107      | 702481  | 103              | 702710.2080 | 115                   | 702836   | 129      |
| 702227   | 115      | 70249   | 103              | 702712      | 114                   | 702837   | 129      |
| 702228   | 115      | 70250   | 103              | 702713      | 114                   | 702838   | 129      |
| 702229   | 115      | 702500  | 104              | 702714      | 114                   | 70284    | 112      |
| 702231   | 115      | 702502  | 116, 133         | 702716      | 104, 108,<br>110, 114 | 70285    | 121      |
| 702232   | 115      | 702504  | 118, 133         | 702717.2    | 115                   | 702857   | 107      |
| 702233   | 115      | 70251   | 101              | 702717.2080 | 115                   | 702858   | 107      |
| 702234   | 115      | 702514  | 116, 133         | 702718      | 115                   | 702859   | 113      |
| 702235   | 115      | 702515  | 118, 133         | 702718.1    | 115                   | 70286    | 101      |
| 702236   | 115      | 702516  | 125, 126,<br>133 | 702718.2080 | 115                   | 702860   | 102      |
| 702237   | 115      | 702517  | 131, 133         | 702719      | 115                   | 702863   | 107      |
| 702238   | 103      | 70252.1 | 101              | 70272       | 123                   | 702864   | 107      |
| 702244   | 107      | 70254   | 127              | 70272       | 123                   | 702865   | 132      |
| 702246   | 103      | 702540  | 127              | 70273       | 123                   | 702866   | 125      |
| 702247   | 103      | 702541  | 127              | 702730      | 111                   | 702867   | 113      |
| 702248   | 103      | 702541  | 127              | 702730.1    | 111                   | 702867   | 113      |
| 702249   | 103      | 70256   | 111              | 702730.2    | 111                   | 702873   | 107      |
| 702251   | 103      | 70257   | 118              | 702730.3    | 111                   | 702874   | 107      |
| 702253   | 112      | 70260   | 119              | 702731      | 115                   | 702877   | 132      |
| 702254   | 112      | 702602  | 371              | 702732      | 106                   | 702878   | 101      |
| 702261   | 127      | 702604  | 371              | 702732      | 106                   | 702879   | 112      |
| 702263   | 127      | 702605  | 371              | 70274       | 123                   | 70288    | 111      |
| 702263.2 | 127      | 702606  | 371              | 70275       | 123                   | 70288.1  | 111      |
| 702282   | 104, 120 | 702609  | 371              | 70277       | 130                   | 70288.2  | 111      |
| 702283   | 104, 120 | 70261   | 103              | 702773      | 129                   | 70288.3  | 111      |
| 702284   | 104, 120 | 702610  | 371              | 702774      | 129                   | 702881   | 113      |
| 702286   | 106      | 702611  | 371              | 702775      | 129                   | 702885   | 110      |
| 702287   | 106      | 702612  | 371              | 702775      | 129                   | 702888   | 111      |
| 702287.1 | 106      | 702613  | 371              | 70278       | 130                   | 70289    | 101      |
| 702288   | 106      | 702619  | 371              | 702780      | 130                   | 702891   | 111      |
| 702288.1 | 106      | 70262   | 112              | 70279       | 130                   | 702892   | 110      |
| 702292   | 119      | 70262   | 112              | 702791      | 132                   | 702892   | 110      |
| 702293   | 104, 120 | 702620  | 371              | 702799      | 129                   | 702893   | 102, 120 |
| 70231    | 111      | 702621  | 371              | 702800      | 101                   | 702904   | 130      |
| 70231.1  | 111      | 702622  | 371              | 702801      | 112                   | 702917   | 126      |
| 70231.2  | 111      | 702623  | 371              | 702802      | 118                   | 702918   | 126      |
| 70231.3  | 111      | 702625  | 371              | 702803      | 118                   | 702924   | 126      |
| 70231.4  | 111      | 702626  | 371              | 702804      | 129                   | 702926   | 119      |
| 702311   | 121      | 702627  | 371              | 702805      | 130                   | 702927   | 129      |
| 70232    | 118      | 702628  | 371              | 702807      | 124                   | 702928   | 129      |
| 70233    | 130      | 702628  | 371              | 702808      | 129                   | 702928.9 | 129      |
| 702334   | 111, 114 | 702632  | 371              | 702808      | 129                   | 702929   | 129      |
| 702335   | 105      | 702646  | 371              | 702809      | 111, 114              | 702931   | 130      |
| 70234    | 129      | 702647  | 371              | 702813      | 104, 108,<br>110, 114 | 702931.1 | 130      |
| 70234.8  | 129      | 702648  | 371              | 702818      | 104, 108,<br>110, 114 | 702962   | 119, 121 |
| 70234.9  | 129      | 702649  | 371              | 702818.1    | 104, 108,<br>110, 114 | 702963   | 119      |
| 70234.10 | 129      | 702656  | 371              | 70282       | 101                   | 702966   | 119      |
| 70235    | 130      | 702657  | 371              | 702823      | 111                   | 702968   | 102, 109 |
| 70236    | 130      | 702658  | 371              | 702824      | 102, 109              | 702968.1 | 102, 109 |
| 70236.1  | 130      | 702659  | 371              | 702825      | 104, 108,<br>110, 114 | 702972   | 119      |
| 70237    | 129      | 70266   | 130              | 702826      | 125                   | 702973   | 119, 121 |
| 70238    | 130      | 702660  | 371              | 702826.2    | 125                   | 702974   | 119      |
| 70239    | 111      | 702661  | 371              |             |                       | 702974.1 | 102      |
|          |          | 702662  | 371              |             |                       | 702981   | 125      |
|          |          | 702663  | 371              |             |                       | 702995   | 112      |

# Index of reference numbers



| REF         | Page | REF         | Page | REF         | Page | REF         | Page    |
|-------------|------|-------------|------|-------------|------|-------------|---------|
| 702995.1    | 112  | 711018.100  | 258  | 711350.100  | 257  | 711890.10   | 257     |
| 702995.2    | 112  | 711018.1000 | 258  | 711360.10   | 257  | 711890.100  | 257     |
| 702995.3    | 112  | 711019.100  | 258  | 711360.100  | 257  | 711991.10   | 257     |
| 702D20TB    | 130  | 711019.1000 | 258  | 711370.10   | 257  | 711991.100  | 257     |
| 706201      | 373  | 711020.10   | 257  | 711370.100  | 257  | 711992.10   | 257     |
| 706246      | 370  | 711020.100  | 257  | 711380.10   | 257  | 711992.100  | 257     |
| 706290      | 254  | 711021.100  | 258  | 711380.100  | 257  | 713550.0100 | 256     |
| 706296      | 373  | 711021.1000 | 258  | 711390.10   | 257  | 713550.1    | 256     |
| 706512      | 373  | 711022.100  | 258  | 711390.100  | 257  | 713551.0100 | 256     |
| 707971      | 372  | 711022.1000 | 258  | 711420.10   | 257  | 713551.1    | 256     |
| 707972      | 372  | 711023.100  | 258  | 711420.100  | 257  | 713600.0100 | 256     |
| 707973      | 372  | 711023.1000 | 258  | 711430.10   | 257  | 713600.1    | 256     |
| 708300      | 373  | 711024.100  | 258  | 711430.100  | 257  | 713601.0100 | 256     |
| 708308      | 370  | 711024.1000 | 258  | 711470.100  | 258  | 713601.1    | 256     |
| 708318      | 372  | 711025.100  | 258  | 711470.1000 | 258  | 713610.0100 | 256     |
| 708319      | 372  | 711025.1000 | 258  | 711480.100  | 258  | 713610.1    | 256     |
| 708337      | 372  | 711026.100  | 258  | 711480.1000 | 258  | 713611.0100 | 256     |
| 708340      | 370  | 711026.1000 | 258  | 711490.100  | 258  | 713611.1    | 256     |
| 708341      | 370  | 711027.100  | 258  | 711490.1000 | 258  | 713615.0100 | 256     |
| 708344      | 370  | 711027.1000 | 258  | 711500.100  | 258  | 713615.1    | 256     |
| 708345      | 370  | 711028.100  | 258  | 711500.1000 | 258  | 713618.0100 | 256     |
| 708346      | 370  | 711028.1000 | 258  | 711510.10   | 257  | 713618.1    | 256     |
| 708353      | 370  | 711029.100  | 258  | 711510.100  | 257  | 713620.0100 | 256     |
| 708354      | 370  | 711029.1000 | 258  | 711520.10   | 257  | 713620.1    | 256     |
| 708355      | 370  | 711031.100  | 258  | 711520.100  | 257  | 713621.0100 | 256     |
| 711001.1000 | 259  | 711031.1000 | 258  | 711530.10   | 257  | 713621.1    | 256     |
| 711001.5000 | 259  | 711032.100  | 258  | 711530.100  | 257  | 713630.0100 | 256     |
| 711002.1000 | 259  | 711032.1000 | 258  | 711540.1000 | 259  | 713630.1    | 256     |
| 711002.5000 | 259  | 711033.1000 | 259  | 711540.5000 | 259  | 713631.0100 | 256     |
| 711003.1000 | 259  | 711033.5000 | 259  | 711550.1000 | 259  | 713631.1    | 256     |
| 711003.5000 | 259  | 711034.1000 | 259  | 711550.5000 | 259  | 713831.0100 | 256     |
| 711004.100  | 259  | 711034.5000 | 259  | 711560.10   | 257  | 713831.1    | 256     |
| 711004.1000 | 259  | 711035.100  | 259  | 711560.100  | 257  | 713832.0100 | 256     |
| 711005.100  | 259  | 711035.1000 | 259  | 711570.10   | 257  | 713832.1    | 256     |
| 711005.1000 | 259  | 711036.100  | 259  | 711570.100  | 257  | 718002      | 79, 373 |
| 711006.100  | 259  | 711036.1000 | 259  | 711580.10   | 257  | 718582      | 254     |
| 711006.1000 | 259  | 711037.1000 | 259  | 711580.100  | 257  | 718583      | 254     |
| 711007.100  | 258  | 711037.5000 | 259  | 711590.100  | 258  | 718584      | 254     |
| 711007.1000 | 258  | 711240.1000 | 259  | 711590.1000 | 258  | 718587      | 373     |
| 711008.100  | 258  | 711240.5000 | 259  | 711600.10   | 257  | 718637      | 254     |
| 711008.1000 | 258  | 711250.1000 | 259  | 711600.100  | 257  | 718755      | 255     |
| 711009.100  | 258  | 711250.5000 | 259  | 711610.100  | 259  | 718760      | 255     |
| 711009.1000 | 258  | 711260.1000 | 259  | 711610.1000 | 259  | 718761      | 255     |
| 711010.10   | 257  | 711260.5000 | 259  | 711620.100  | 259  | 718762      | 255     |
| 711010.100  | 257  | 711270.1000 | 259  | 711620.1000 | 259  | 718763      | 255     |
| 711011.100  | 258  | 711270.5000 | 259  | 711630.100  | 259  | 718765      | 255     |
| 711011.1000 | 258  | 711280.10   | 257  | 711630.1000 | 259  | 718766      | 255     |
| 711012.100  | 258  | 711280.100  | 257  | 711680.10   | 257  | 718767      | 255     |
| 711012.1000 | 258  | 711300.10   | 257  | 711680.100  | 257  | 718768      | 255     |
| 711013.100  | 258  | 711300.100  | 257  | 711690.100  | 258  | 718769      | 255     |
| 711013.1000 | 258  | 711310.10   | 257  | 711690.1000 | 258  | 718770      | 255     |
| 711014.100  | 258  | 711310.100  | 257  | 711700.100  | 258  | 718771      | 255     |
| 711014.1000 | 258  | 711320.10   | 257  | 711700.1000 | 258  | 718772      | 255     |
| 711015.100  | 258  | 711320.100  | 257  | 711710.10   | 257  | 718775      | 255     |
| 711015.1000 | 258  | 711330.10   | 257  | 711710.100  | 257  | 718966      | 251     |
| 711016.100  | 258  | 711330.100  | 257  | 711720.100  | 258  | 718967      | 251     |
| 711016.1000 | 258  | 711340.10   | 257  | 711720.1000 | 258  | 718968      | 251     |
| 711017.100  | 258  | 711340.100  | 257  | 711730.100  | 258  | 718969      | 251     |
| 711017.1000 | 258  | 711350.10   | 257  | 711730.1000 | 258  | 718970      | 251     |

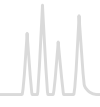


# Index of reference numbers

| REF       | Page | REF         | Page | REF       | Page | REF       | Page |
|-----------|------|-------------|------|-----------|------|-----------|------|
| 718971    | 251  | 720018.46   | 215  | 720120.46 | 214  | 720841.46 | 214  |
| 718975    | 253  | 720019.40   | 220  | 720124.40 | 232  | 720905.40 | 246  |
| 718976    | 253  | 720019.46   | 220  | 720125.40 | 232  | 720923.30 | 229  |
| 718977    | 253  | 720022.40   | 217  | 720127.40 | 232  | 720923.40 | 229  |
| 718978    | 253  | 720022.46   | 217  | 720133.40 | 214  | 720935.40 | 215  |
| 719402    | 249  | 720023.40   | 215  | 720133.46 | 214  | 720935.46 | 215  |
| 719403    | 249  | 720023.46   | 215  | 720140.46 | 215  | 720936.40 | 215  |
| 719404    | 249  | 720024.40   | 222  | 720141.40 | 214  | 720936.46 | 215  |
| 719405    | 249  | 720024.46   | 222  | 720141.46 | 214  | 720949.46 | 214  |
| 719406    | 249  | 720025.46   | 221  | 720143.46 | 220  | 720951.46 | 215  |
| 719409    | 249  | 720028.46   | 223  | 720149.40 | 215  | 720956.46 | 220  |
| 719410    | 249  | 720029.46   | 223  | 720149.46 | 215  | 720989.46 | 223  |
| 719411    | 249  | 720040.40   | 215  | 720150.40 | 214  | 720990.46 | 217  |
| 719412    | 249  | 720040.46   | 215  | 720150.46 | 214  | 720994.46 | 221  |
| 719413    | 249  | 720041.40   | 215  | 720165.46 | 217  | 720996.40 | 223  |
| 719414    | 249  | 720041.46   | 215  | 720170.40 | 216  | 720996.46 | 223  |
| 719418    | 249  | 720042.40   | 215  | 720170.46 | 216  | 721020.30 | 221  |
| 719454    | 245  | 720043.40   | 215  | 720174.46 | 216  | 721022.30 | 214  |
| 719455    | 245  | 720043.46   | 215  | 720175.40 | 216  | 721024.30 | 223  |
| 719456    | 245  | 720046.40   | 234  | 720175.46 | 216  | 721025.30 | 223  |
| 719459    | 245  | 720050.40   | 217  | 720182.46 | 223  | 721030.30 | 219  |
| 719460    | 245  | 720050.46   | 217  | 720183.46 | 223  | 721039.30 | 222  |
| 719469    | 240  | 720051.40   | 215  | 720191.40 | 215  | 721061.30 | 217  |
| 719475    | 240  | 720051.46   | 215  | 720191.46 | 215  | 721070.30 | 215  |
| 719489    | 254  | 720052.40   | 217  | 720193.46 | 215  | 721071.30 | 218  |
| 719501    | 248  | 720052.46   | 217  | 720194.46 | 218  | 721072.30 | 215  |
| 719520    | 245  | 720055.40   | 215  | 720196.40 | 218  | 721073.30 | 215  |
| 719530    | 248  | 720055.46   | 215  | 720196.46 | 218  | 721074.20 | 214  |
| 719531    | 248  | 720057.40   | 222  | 720205.40 | 222  | 721074.30 | 214  |
| 719532    | 248  | 720057.46   | 222  | 720205.46 | 222  | 721075.30 | 215  |
| 719533    | 230  | 720059.40   | 219  | 720214.46 | 217  | 721078.30 | 222  |
| 719534    | 248  | 720059.46   | 219  | 720231.40 | 243  | 721083.30 | 219  |
| 719535    | 248  | 720062.46   | 217  | 720245.40 | 243  | 721085.30 | 216  |
| 719536    | 248  | 720065.40   | 216  | 720252.40 | 244  | 721093.30 | 217  |
| 719537    | 248  | 720065.46   | 216  | 720258.40 | 244  | 721095.30 | 217  |
| 719538    | 250  | 720071.40   | 217  | 720280.40 | 215  | 721096.30 | 217  |
| 719539    | 250  | 720071.46   | 217  | 720280.46 | 215  | 721119.30 | 243  |
| 719540    | 240  | 720074.46   | 216  | 720294.46 | 215  | 721133.30 | 215  |
| 719542    | 245  | 720077.46   | 216  | 720296.40 | 215  | 721137.30 | 220  |
| 719543    | 230  | 720081.40   | 235  | 720296.46 | 215  | 721142.30 | 220  |
| 719570    | 247  | 720088.40   | 236  | 720305.46 | 215  | 721155.30 | 221  |
| 719571    | 247  | 720089.46   | 219  | 720350.40 | 236  | 721157.30 | 216  |
| 719574    | 247  | 720090.40   | 222  | 720430.40 | 215  | 721158.30 | 221  |
| 719575    | 247  | 720090.46   | 222  | 720430.46 | 215  | 721167.30 | 224  |
| 719600    | 240  | 720093.46   | 224  | 720431.40 | 215  | 721168.20 | 229  |
| 720001.40 | 217  | 720094.40   | 230  | 720431.46 | 215  | 721168.30 | 229  |
| 720001.46 | 217  | 720095.46   | 221  | 720432.46 | 215  | 721169.30 | 230  |
| 720002.20 | 214  | 720095.46RP | 221  | 720445.46 | 233  | 721170.30 | 246  |
| 720002.30 | 214  | 720096.46   | 219  | 720450.46 | 233  | 721171.30 | 232  |
| 720002.40 | 214  | 720097.40   | 223  | 720451.46 | 233  | 721176.30 | 232  |
| 720002.46 | 214  | 720097.46   | 223  | 720471.46 | 215  | 721178.30 | 232  |
| 720013.40 | 217  | 720098.46   | 214  | 720472.40 | 215  | 721185.30 | 233  |
| 720013.46 | 217  | 720099.46   | 224  | 720472.46 | 215  | 721186.30 | 233  |
| 720014.20 | 214  | 720110.46   | 215  | 720701.46 | 215  | 721188.30 | 235  |
| 720014.30 | 214  | 720117.20   | 229  | 720709.46 | 223  | 721190.30 | 236  |
| 720014.40 | 214  | 720117.30   | 229  | 720730.46 | 215  | 721194.30 | 217  |
| 720014.46 | 214  | 720117.40   | 229  | 720735.46 | 217  | 721196.30 | 215  |
| 720017.46 | 217  | 720117.46   | 229  | 720740.46 | 215  | 721402.30 | 234  |
| 720018.40 | 215  | 720120.40   | 214  | 720752.40 | 232  | 721469.30 | 232  |



# Index of reference numbers

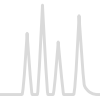


| REF       | Page     | REF       | Page     | REF        | Page     | REF       | Page     |
|-----------|----------|-----------|----------|------------|----------|-----------|----------|
| 721473.30 | 214      | 723327.25 | 354      | 723555.50  | 338      | 725812.25 | 316      |
| 721518.30 | 224      | 723341.25 | 338      | 723558.10  | 355      | 725812.60 | 316      |
| 721567.30 | 244      | 723341.30 | 338      | 723558.25  | 355      | 725813.30 | 316      |
| 721649.30 | 215      | 723341.50 | 338      | 723560.10  | 355      | 725815.12 | 316      |
| 721823    | 247      | 723341.60 | 338      | 723560.25  | 355      | 725815.50 | 316      |
| 721916.30 | 219      | 723344.10 | 338      | 723562.10  | 355      | 725820.15 | 316      |
| 721920    | 232      | 723344.25 | 338      | 723562.25  | 355      | 725820.30 | 316      |
| 721924.30 | 244      | 723344.30 | 338      | 723706.10  | 356      | 725820.60 | 316      |
| 722307    | 368      | 723344.50 | 338      | 723706.25  | 356      | 725825.30 | 316      |
| 722310    | 368      | 723344.60 | 338      | 723707.10  | 356      | 725825.60 | 316      |
| 722316    | 368      | 723346.10 | 355      | 723707.25  | 356      | 725826.30 | 316      |
| 722317    | 368      | 723346.25 | 355      | 723708.10  | 356      | 725826.60 | 316      |
| 722320    | 368      | 723348.10 | 355      | 723708.25  | 356      | 725850.30 | 317      |
| 722393    | 229      | 723348.25 | 355      | 723709.10  | 356      | 725850.60 | 317      |
| 722394    | 147      | 723349.10 | 355      | 723709.25  | 356      | 726022.15 | 327      |
| 723052.25 | 336      | 723349.25 | 355      | 723710.10  | 356      | 726022.25 | 327      |
| 723052.50 | 336      | 723356.25 | 338      | 723710.25  | 356      | 726022.30 | 327      |
| 723054.25 | 336      | 723356.50 | 338      | 723711.10  | 356      | 726022.50 | 327      |
| 723060.10 | 337      | 723358.25 | 345      | 723711.25  | 356      | 726022.60 | 327      |
| 723060.25 | 337      | 723358.50 | 345      | 723712.10  | 356      | 726024.10 | 310, 341 |
| 723060.30 | 337      | 723360.25 | 342      | 723712.25  | 356      | 726024.20 | 310, 341 |
| 723060.50 | 337      | 723360.50 | 342      | 723713.10  | 356      | 726025.20 | 310, 341 |
| 723060.60 | 337      | 723362.25 | 342      | 723713.25  | 356      | 726038.10 | 310      |
| 723063.25 | 354      | 723362.50 | 342      | 723714.10  | 356      | 726038.15 | 310      |
| 723064.10 | 337, 341 | 723364.25 | 342      | 723714.25  | 356      | 726038.25 | 310      |
| 723101.10 | 355      | 723364.50 | 342      | 723790.1   | 355      | 726038.30 | 310      |
| 723101.25 | 355      | 723366.25 | 342      | 723790.2   | 355      | 726038.60 | 310      |
| 723105.10 | 355      | 723366.50 | 342      | 723791.1   | 355      | 726050.10 | 310      |
| 723105.25 | 355      | 723368.25 | 342      | 723791.2   | 355      | 726050.15 | 310      |
| 723106.10 | 355      | 723368.50 | 342      | 723792.1   | 355      | 726050.25 | 310      |
| 723106.25 | 355      | 723370.25 | 345      | 723792.2   | 355      | 726050.30 | 310      |
| 723108.10 | 355      | 723370.50 | 345      | 723793.1   | 355      | 726050.50 | 310      |
| 723108.25 | 355      | 723379.25 | 342      | 723793.2   | 355      | 726050.60 | 310      |
| 723116.10 | 338      | 723379.50 | 342      | 723827.10  | 337      | 726056.10 | 314      |
| 723116.25 | 338      | 723381.25 | 345      | 723827.25  | 337      | 726056.15 | 314      |
| 723116.30 | 338      | 723381.50 | 345      | 723827.50  | 337      | 726056.25 | 314      |
| 723116.50 | 338      | 723382.10 | 341, 342 | 723830.10  | 338      | 726056.30 | 314      |
| 723116.60 | 338      | 723383.10 | 341, 345 | 723830.25  | 338      | 726056.50 | 314      |
| 723148.10 | 355      | 723384.25 | 345      | 723830.50  | 338      | 726056.60 | 314      |
| 723148.25 | 355      | 723384.50 | 345      | 723890.100 | 352      | 726058.10 | 324      |
| 723151.10 | 355      | 723386.25 | 345      | 723936.25  | 338      | 726058.15 | 324      |
| 723151.25 | 355      | 723387.25 | 345      | 723936.50  | 338      | 726058.25 | 324      |
| 723180.10 | 338, 341 | 723387.50 | 345      | 723945.25  | 353      | 726058.30 | 324      |
| 723180.20 | 338, 341 | 723388.25 | 345      | 723945.50  | 353      | 726058.50 | 324      |
| 723181.10 | 338, 341 | 723388.50 | 345      | 725801.25  | 313      | 726058.60 | 324      |
| 723296.10 | 337      | 723409.50 | 354      | 725801.50  | 313      | 726064.30 | 324      |
| 723296.25 | 337      | 723411.25 | 354      | 725802.30  | 313      | 726064.60 | 324      |
| 723296.30 | 337      | 723501.10 | 355      | 725802.60  | 313      | 726065.12 | 327      |
| 723296.50 | 337      | 723501.25 | 355      | 725805.15  | 313      | 726065.25 | 327      |
| 723296.60 | 337      | 723515.10 | 337      | 725805.30  | 313      | 726065.50 | 327      |
| 723306.25 | 336      | 723515.25 | 337      | 725805.60  | 313, 315 | 726066.25 | 327      |
| 723308.50 | 336      | 723517.10 | 337      | 725806.30  | 313      | 726066.50 | 327      |
| 723310.25 | 336      | 723517.25 | 337      | 725806.60  | 313      | 726067.25 | 327      |
| 723312.25 | 336      | 723517.30 | 337      | 725807.30  | 313      | 726067.30 | 327      |
| 723321.10 | 337      | 723549.10 | 337      | 725807.60  | 313      | 726067.50 | 327      |
| 723321.25 | 337      | 723549.25 | 337      | 725810.25  | 316      | 726067.60 | 327      |
| 723321.30 | 337      | 723549.30 | 337      | 725810.50  | 316      | 726080.10 | 330, 341 |
| 723321.50 | 337      | 723555.10 | 338      | 725811.30  | 316      | 726081.10 | 310      |
| 723321.60 | 337      | 723555.25 | 338      | 725811.60  | 316      | 726081.25 | 310      |

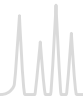
# Index of reference numbers

| REF       | Page     | REF       | Page | REF       | Page     | REF       | Page     |
|-----------|----------|-----------|------|-----------|----------|-----------|----------|
| 726081.30 | 310      | 726205.60 | 312  | 726316.30 | 314      | 726382.60 | 333      |
| 726081.50 | 310      | 726210.12 | 315  | 726316.50 | 314      | 726383.30 | 333      |
| 726081.60 | 310      | 726210.25 | 315  | 726316.60 | 314      | 726383.60 | 333      |
| 726089.30 | 331      | 726210.50 | 315  | 726318.10 | 324      | 726400.25 | 319      |
| 726089.50 | 331      | 726211.30 | 315  | 726318.15 | 324      | 726400.50 | 319      |
| 726089.60 | 331      | 726212.25 | 315  | 726318.25 | 324      | 726410.10 | 319, 341 |
| 726090.30 | 331      | 726212.50 | 315  | 726318.30 | 324      | 726410.20 | 319, 341 |
| 726090.60 | 331      | 726212.60 | 315  | 726318.50 | 324      | 726420.30 | 319      |
| 726091.25 | 331      | 726213.30 | 315  | 726318.60 | 324      | 726420.60 | 319      |
| 726091.30 | 331      | 726215.12 | 315  | 726320.25 | 324      | 726421.30 | 319      |
| 726091.50 | 331      | 726215.25 | 315  | 726320.30 | 324      | 726440.30 | 319      |
| 726091.60 | 331      | 726215.50 | 315  | 726320.50 | 324      | 726440.60 | 319      |
| 726095.30 | 331      | 726220.15 | 315  | 726320.60 | 324      | 726441.30 | 319      |
| 726095.60 | 331      | 726220.30 | 315  | 726321.25 | 332      | 726441.60 | 319      |
| 726096.30 | 331      | 726220.60 | 315  | 726321.30 | 332      | 726442.30 | 319      |
| 726096.60 | 331      | 726225.30 | 315  | 726321.50 | 332      | 726442.60 | 319      |
| 726099.25 | 314      | 726225.60 | 315  | 726321.60 | 332      | 726443.30 | 319      |
| 726099.30 | 314      | 726226.30 | 315  | 726323.10 | 310      | 726465.25 | 320      |
| 726099.50 | 314      | 726226.60 | 315  | 726323.15 | 310      | 726465.50 | 320      |
| 726099.60 | 314      | 726241.30 | 335  | 726323.25 | 310      | 726470.30 | 320      |
| 726102.15 | 349      | 726241.60 | 335  | 726323.30 | 310      | 726470.60 | 320      |
| 726102.30 | 349      | 726242.30 | 335  | 726323.50 | 310      | 726480.30 | 320      |
| 726104.15 | 349      | 726242.60 | 335  | 726323.60 | 310      | 726480.60 | 320      |
| 726104.30 | 349      | 726243.30 | 335  | 726325.15 | 314      | 726481.30 | 320      |
| 726106.15 | 349      | 726243.60 | 335  | 726325.25 | 314      | 726481.60 | 320      |
| 726106.30 | 349      | 726246.30 | 335  | 726325.30 | 314      | 726482.30 | 320      |
| 726108.15 | 349      | 726246.60 | 335  | 726325.50 | 314      | 726482.60 | 320      |
| 726108.30 | 349      | 726296.25 | 332  | 726325.60 | 314      | 726483.30 | 320      |
| 726116.25 | 334      | 726296.30 | 332  | 726341.25 | 334      | 726490.10 | 320, 341 |
| 726116.30 | 334      | 726296.50 | 332  | 726341.30 | 334      | 726519.15 | 310      |
| 726116.50 | 334      | 726296.60 | 332  | 726341.50 | 334      | 726519.25 | 310      |
| 726116.60 | 334      | 726301.10 | 310  | 726341.60 | 334      | 726519.30 | 310      |
| 726118.15 | 330      | 726301.25 | 310  | 726344.25 | 334      | 726521.10 | 310      |
| 726118.25 | 330      | 726301.30 | 310  | 726344.30 | 334      | 726521.25 | 310      |
| 726118.30 | 330      | 726301.50 | 310  | 726344.50 | 334      | 726521.30 | 310      |
| 726118.50 | 330      | 726301.60 | 310  | 726345.30 | 334      | 726521.50 | 310      |
| 726118.60 | 330      | 726302.10 | 310  | 726346.25 | 334      | 726523.10 | 314      |
| 726131.10 | 348      | 726302.15 | 310  | 726351.25 | 327      | 726523.25 | 314      |
| 726131.25 | 348      | 726302.25 | 310  | 726351.30 | 327      | 726523.30 | 314      |
| 726132.10 | 348      | 726302.30 | 310  | 726351.50 | 327      | 726525.10 | 314      |
| 726132.25 | 348      | 726302.50 | 310  | 726351.60 | 327      | 726525.25 | 314      |
| 726133.10 | 348      | 726302.60 | 310  | 726352.25 | 330      | 726525.30 | 314      |
| 726133.25 | 348      | 726304.10 | 310  | 726352.30 | 330      | 726525.50 | 314      |
| 726154.30 | 326      | 726304.25 | 310  | 726352.50 | 330      | 726525.60 | 314      |
| 726154.60 | 326      | 726304.30 | 310  | 726352.60 | 330      | 726529.10 | 310      |
| 726157.30 | 326      | 726304.50 | 310  | 726353.30 | 350      | 726529.15 | 310      |
| 726157.60 | 326      | 726304.60 | 310  | 726354.30 | 350      | 726529.25 | 310      |
| 726162.30 | 328      | 726313.10 | 314  | 726355.25 | 350      | 726529.30 | 310      |
| 726162.60 | 328      | 726313.15 | 314  | 726356.30 | 350      | 726541.10 | 314      |
| 726165.30 | 328      | 726313.25 | 314  | 726357.30 | 350      | 726541.15 | 314      |
| 726165.60 | 328      | 726313.30 | 314  | 726358.30 | 350      | 726541.25 | 314      |
| 726180.10 | 334, 341 | 726313.50 | 314  | 726359.30 | 350      | 726541.30 | 314      |
| 726201.25 | 312      | 726313.60 | 314  | 726360.30 | 350      | 726545.10 | 324      |
| 726201.50 | 312      | 726314.15 | 314  | 726361.10 | 341, 350 | 726545.15 | 324      |
| 726202.30 | 312      | 726314.25 | 314  | 726380.30 | 333      | 726545.25 | 324      |
| 726202.60 | 312      | 726314.30 | 314  | 726380.60 | 333      | 726545.30 | 324      |
| 726203.12 | 312      | 726314.50 | 314  | 726381.30 | 333      | 726548.30 | 332      |
| 726205.15 | 312      | 726314.60 | 314  | 726381.60 | 333      | 726549.25 | 332      |
| 726205.30 | 312      | 726316.25 | 314  | 726382.30 | 333      | 726549.30 | 332      |

# Index of reference numbers



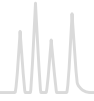
| REF       | Page | REF       | Page     | REF       | Page | REF        | Page |
|-----------|------|-----------|----------|-----------|------|------------|------|
| 726600.25 | 332  | 726777.60 | 321      | 726863.25 | 314  | 727450     | 79   |
| 726600.30 | 332  | 726780.30 | 321      | 726863.50 | 314  | 727451     | 79   |
| 726600.50 | 332  | 726780.50 | 321      | 726871.15 | 329  | 728031.20  | 225  |
| 726600.60 | 332  | 726780.60 | 321      | 726871.25 | 329  | 728031.30  | 225  |
| 726623.25 | 314  | 726783.25 | 321      | 726871.30 | 329  | 728031.40  | 225  |
| 726623.30 | 314  | 726784.25 | 323      | 726871.50 | 329  | 728031.46  | 225  |
| 726623.50 | 314  | 726785.25 | 323      | 726871.60 | 329  | 728032.20  | 225  |
| 726623.60 | 314  | 726785.30 | 323      | 726874.30 | 329  | 728032.30  | 225  |
| 726628.25 | 314  | 726785.50 | 323      | 726874.50 | 329  | 728032.40  | 225  |
| 726628.30 | 314  | 726785.60 | 323      | 726874.60 | 329  | 728032.46  | 225  |
| 726628.50 | 314  | 726786.30 | 323      | 726877.15 | 329  | 728033.46  | 225  |
| 726628.60 | 314  | 726786.50 | 323      | 726877.30 | 329  | 728034.20  | 225  |
| 726630.30 | 325  | 726787.25 | 323      | 726877.50 | 329  | 728034.30  | 225  |
| 726630.60 | 325  | 726787.30 | 323      | 726877.60 | 329  | 728034.40  | 225  |
| 726631.30 | 325  | 726787.50 | 323      | 726880.25 | 329  | 728034.46  | 225  |
| 726631.60 | 325  | 726787.60 | 323      | 726880.30 | 329  | 728035.20  | 225  |
| 726632.30 | 325  | 726789.25 | 323      | 726880.50 | 329  | 728035.30  | 225  |
| 726632.60 | 325  | 726789.30 | 323      | 726880.60 | 329  | 728035.40  | 225  |
| 726633.30 | 325  | 726802.25 | 310      | 726900.30 | 347  | 728035.46  | 225  |
| 726633.60 | 325  | 726802.30 | 310      | 726903.10 | 347  | 728036.46  | 225  |
| 726634.30 | 325  | 726802.50 | 310      | 726905.30 | 347  | 728037.20  | 225  |
| 726634.60 | 325  | 726802.60 | 310      | 726911.25 | 314  | 728037.30  | 225  |
| 726635.30 | 325  | 726805.25 | 310      | 726911.30 | 314  | 728037.40  | 225  |
| 726635.60 | 325  | 726805.30 | 310      | 726911.50 | 314  | 728037.46  | 225  |
| 726640.30 | 322  | 726805.50 | 310      | 726911.60 | 314  | 728038.20  | 225  |
| 726640.60 | 322  | 726805.60 | 310      | 726916.10 | 314  | 728038.30  | 225  |
| 726641.30 | 322  | 726807.25 | 314      | 726916.25 | 314  | 728038.40  | 225  |
| 726641.60 | 322  | 726807.30 | 314      | 726916.30 | 314  | 728038.46  | 225  |
| 726642.30 | 322  | 726807.50 | 314      | 726916.50 | 314  | 728039.46  | 225  |
| 726642.60 | 322  | 726807.60 | 314      | 726926.10 | 310  | 728053.30  | 225  |
| 726643.30 | 322  | 726809.25 | 314      | 726926.25 | 310  | 728053.40  | 225  |
| 726643.60 | 322  | 726809.30 | 314      | 726926.30 | 310  | 728054.30  | 225  |
| 726735.15 | 324  | 726809.50 | 314      | 726926.50 | 310  | 728054.40  | 225  |
| 726735.25 | 324  | 726809.60 | 314      | 726929.25 | 324  | 728055.30  | 225  |
| 726735.30 | 324  | 726821.25 | 310      | 726929.30 | 324  | 728055.40  | 225  |
| 726735.50 | 324  | 726821.30 | 310      | 726929.50 | 324  | 728777.20  | 251  |
| 726742.25 | 327  | 726821.50 | 310      | 726929.60 | 324  | 728777.30  | 251  |
| 726742.30 | 327  | 726821.60 | 310      | 726931.10 | 310  | 728778.20  | 251  |
| 726742.50 | 327  | 726824.25 | 324      | 726931.25 | 310  | 728778.30  | 251  |
| 726742.60 | 327  | 726824.30 | 324      | 726931.30 | 310  | 729004     | 89   |
| 726744.25 | 327  | 726824.50 | 324      | 726931.50 | 310  | 729004.400 | 89   |
| 726744.30 | 327  | 726824.60 | 324      | 726934.15 | 314  | 729006     | 89   |
| 726744.50 | 327  | 726832.25 | 310      | 726934.25 | 314  | 729006.400 | 89   |
| 726744.60 | 327  | 726834.12 | 310      | 726934.30 | 314  | 729007     | 88   |
| 726747.10 | 327  | 726834.25 | 310      | 726934.50 | 314  | 729007.400 | 88   |
| 726747.15 | 327  | 726834.50 | 310      | 726965.30 | 324  | 729008     | 88   |
| 726747.25 | 327  | 726837.12 | 310      | 727400    | 79   | 729009     | 88   |
| 726747.30 | 327  | 726837.25 | 310      | 727401    | 79   | 729010     | 90   |
| 726755.30 | 327  | 726837.50 | 310      | 727402    | 79   | 729011     | 90   |
| 726757.25 | 327  | 726839.50 | 310      | 727403    | 79   | 729012     | 90   |
| 726757.30 | 327  | 726841.25 | 324      | 727404    | 79   | 729012.400 | 90   |
| 726757.50 | 327  | 726841.50 | 324      | 727405    | 79   | 729013     | 90   |
| 726757.60 | 327  | 726846.10 | 314, 341 | 727406    | 79   | 729013.400 | 90   |
| 726771.25 | 321  | 726848.10 | 327, 341 | 727407    | 79   | 729014     | 88   |
| 726771.30 | 321  | 726854.25 | 314      | 727420    | 79   | 729015     | 88   |
| 726771.50 | 321  | 726857.25 | 314      | 727421    | 79   | 729020     | 86   |
| 726771.60 | 321  | 726857.50 | 314      | 727422    | 79   | 729020.400 | 86   |
| 726777.25 | 321  | 726860.25 | 314      | 727423    | 79   | 729021     | 86   |
| 726777.30 | 321  | 726860.50 | 314      | 727424    | 79   | 729021.400 | 86   |



# Index of reference numbers

| REF        | Page | REF        | Page | REF        | Page | REF        | Page |
|------------|------|------------|------|------------|------|------------|------|
| 729022     | 86   | 729226     | 89   | 730014.250 | 32   | 730084     | 38   |
| 729023     | 86   | 729226.400 | 89   | 730014G    | 32   | 730085     | 56   |
| 729024     | 89   | 729227     | 89   | 730015     | 32   | 730085.250 | 56   |
| 729025     | 89   | 729227.400 | 89   | 730015.250 | 32   | 730085G    | 56   |
| 729026     | 89   | 729228     | 91   | 730015ASP  | 68   | 730100.4   | 67   |
| 729026.400 | 89   | 729228.400 | 91   | 730015G    | 32   | 730101     | 67   |
| 729027     | 89   | 729229     | 86   | 730016     | 32   | 730102     | 67   |
| 729027.400 | 89   | 729229.400 | 86   | 730017     | 43   | 730103     | 67   |
| 729028     | 91   | 729230     | 87   | 730018     | 32   | 730104.4   | 67   |
| 729028.400 | 91   | 729230.400 | 87   | 730020     | 43   | 730105     | 67   |
| 729030     | 87   | 729231     | 87   | 730020G    | 43   | 730106     | 66   |
| 729030.400 | 87   | 729231.400 | 87   | 730021     | 35   | 730107     | 39   |
| 729031     | 87   | 729234     | 91   | 730022     | 35   | 730107.250 | 39   |
| 729031.400 | 87   | 729236     | 87   | 730023     | 35   | 730107G    | 39   |
| 729032     | 85   | 729237     | 87   | 730024     | 35   | 730108     | 30   |
| 729032.400 | 85   | 729240     | 90   | 730024G    | 35   | 730108.250 | 30   |
| 729033     | 85   | 729241     | 90   | 730026     | 67   | 730108G    | 30   |
| 729033.400 | 85   | 729241.400 | 90   | 730028     | 33   | 730109     | 54   |
| 729034     | 91   | 729242     | 90   | 730031     | 40   | 730111     | 30   |
| 729036     | 87   | 729243     | 91   | 730033     | 40   | 730111.AOX | 51   |
| 729037     | 87   | 729244     | 91   | 730033.250 | 40   | 730111G    | 30   |
| 729039     | 85   | 729245     | 88   | 730033G    | 40   | 730112     | 52   |
| 729039.400 | 85   | 729246     | 88   | 730034     | 67   | 730117     | 30   |
| 729043     | 91   | 729246.400 | 88   | 730049     | 25   | 730118     | 30   |
| 729044     | 91   | 729247     | 88   | 730049P45  | 25   | 730118G    | 30   |
| 729048     | 90   | 729248     | 90   | 730051     | 41   | 730119     | 30   |
| 729049     | 90   | 729249     | 90   | 730053     | 41   | 730119.AOX | 51   |
| 729050     | 85   | 729254     | 89   | 730061     | 41   | 730125     | 56   |
| 729050.400 | 85   | 729255     | 89   | 730063     | 41   | 730126     | 44   |
| 729051     | 85   | 729256     | 88   | 730068.320 | 94   | 730127     | 44   |
| 729051.400 | 85   | 729257     | 88   | 730068.345 | 94   | 730130     | 33   |
| 729054     | 89   | 729258     | 92   | 730068.620 | 94   | 730132     | 55   |
| 729055     | 89   | 730001     | 33   | 730068.645 | 94   | 730132.250 | 55   |
| 729100     | 92   | 730002     | 33   | 730070     | 39   | 730134     | 35   |
| 729101     | 92   | 730003     | 33   | 730070G    | 39   | 730135     | 52   |
| 729102     | 92   | 730003.250 | 33   | 730071     | 39   | 730135.250 | 52   |
| 729204     | 89   | 730003G    | 33   | 730071ASP  | 68   | 730135G    | 52   |
| 729204.400 | 89   | 730004     | 33   | 730072     | 39   | 730139     | 43   |
| 729205     | 88   | 730004.250 | 33   | 730073     | 39   | 730139G    | 43   |
| 729205.400 | 88   | 730004G    | 33   | 730073.250 | 39   | 730141     | 32   |
| 729206     | 89   | 730005     | 33   | 730073ASP  | 68   | 730149     | 54   |
| 729207     | 88   | 730005.250 | 33   | 730073G    | 39   | 730149.250 | 54   |
| 729207.400 | 88   | 730005G    | 33   | 730073MPS  | 68   | 730149G    | 54   |
| 729208     | 88   | 730007     | 44   | 730075     | 39   | 730150     | 65   |
| 729209     | 88   | 730008     | 33   | 730075.250 | 39   | 730151     | 65   |
| 729212     | 90   | 730009     | 33   | 730075ASP  | 68   | 730152     | 66   |
| 729212.400 | 90   | 730010     | 32   | 730075G    | 39   | 730153     | 66   |
| 729213     | 90   | 730011     | 32   | 730075MPS  | 68   | 730154     | 66   |
| 729213.400 | 90   | 730011ASP  | 68   | 730076     | 45   | 730157     | 66   |
| 729218     | 91   | 730011MPS  | 68   | 730077     | 45   | 730158     | 67   |
| 729218.400 | 91   | 730012     | 32   | 730077.250 | 45   | 730159     | 67   |
| 729219     | 91   | 730012G    | 32   | 730078     | 46   | 730160     | 67   |
| 729219.400 | 91   | 730012MPS  | 68   | 730079     | 46   | 730161     | 67   |
| 729220     | 86   | 730013     | 32   | 730079.250 | 46   | 730162     | 67   |
| 729220.400 | 86   | 730013.250 | 32   | 730081     | 44   | 730163     | 67   |
| 729221     | 86   | 730013ASP  | 68   | 730082     | 44   | 730164     | 67   |
| 729221.400 | 86   | 730013G    | 32   | 730082.250 | 44   | 730165     | 60   |
| 729222     | 86   | 730013MPS  | 68   | 730082G    | 44   | 730166     | 51   |
| 729223     | 86   | 730014     | 32   | 730083     | 38   | 730166G    | 51   |

# Index of reference numbers

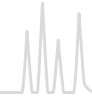


| REF         | Page | REF      | Page | REF         | Page | REF          | Page |
|-------------|------|----------|------|-------------|------|--------------|------|
| 730167      | 60   | 730295   | 34   | 730444      | 37   | 730595.50000 | 64   |
| 730168      | 48   | 730296   | 34   | 730446      | 43   | 730596       | 42   |
| 730168.250  | 48   | 730296G  | 34   | 730447      | 43   | 730601       | 35   |
| 730169      | 36   | 730297   | 34   | 730452      | 43   | 730602       | 33   |
| 730171      | 67   | 730297G  | 34   | 730453      | 43   | 730603       | 40   |
| 730172      | 67   | 730298   | 34   | 730455      | 43   | 730605       | 41   |
| 730173      | 65   | 730298G  | 34   | 730457      | 44   | 730606       | 38   |
| 730174      | 65   | 730299   | 34   | 730460      | 47   | 730607       | 41   |
| 730175      | 65   | 730299G  | 34   | 730462      | 47   | 730608       | 39   |
| 730176      | 65   | 730300   | 34   | 730464      | 47   | 730609       | 45   |
| 730177      | 65   | 730300G  | 34   | 730466      | 43   | 730610       | 46   |
| 730178      | 65   | 730301   | 34   | 730467      | 43   | 730611       | 32   |
| 730179      | 66   | 730302   | 34   | 730473      | 39   | 730612       | 33   |
| 730180      | 40   | 730310   | 31   | 730474      | 67   | 730613       | 32   |
| 730180G     | 40   | 730315   | 50   | 730475      | 67   | 730615       | 30   |
| 730183.12   | 66   | 730322   | 46   | 730482      | 47   | 730616       | 51   |
| 730184.12   | 66   | 730323   | 46   | 730483      | 47   | 730618       | 52   |
| 730185      | 66   | 730344   | 31   | 730484      | 47   | 730618G      | 52   |
| 730187      | 66   | 730349   | 18   | 730487      | 64   | 730619       | 54   |
| 730188      | 66   | 730350.4 | 67   | 730487.250  | 64   | 730620       | 52   |
| 730189.1    | 66   | 730351   | 67   | 730489      | 64   | 730620G      | 52   |
| 730189.12   | 66   | 730355   | 67   | 730490      | 18   | 730622       | 44   |
| 730191      | 67   | 730356   | 67   | 730491      | 18   | 730626       | 40   |
| 730192      | 67   | 730360   | 65   | 730494      | 18   | 730626G      | 40   |
| 730194      | 66   | 730365   | 65   | 730496      | 18   | 730628       | 34   |
| 730197      | 18   | 730366   | 66   | 730501      | 64   | 730629       | 47   |
| 730199      | 18   | 730376   | 31   | 730502      | 64   | 730630       | 47   |
| 730205      | 18   | 730377   | 31   | 730505      | 64   | 730631       | 37   |
| 730206      | 18   | 730378   | 31   | 730506      | 64   | 730640       | 43   |
| 730207      | 18   | 730380   | 67   | 730507      | 64   | 730641       | 43   |
| 730208      | 18   | 730381   | 67   | 730507.100  | 64   | 730642       | 43   |
| 730209      | 18   | 730382   | 67   | 730508      | 64   | 730643       | 42   |
| 730212      | 45   | 730384   | 44   | 730509      | 64   | 730648       | 59   |
| 730214      | 39   | 730385   | 67   | 730517.3100 | 94   | 730651       | 36   |
| 730214G     | 39   | 730386   | 66   | 730517.6100 | 94   | 730652       | 36   |
| 730214MPS   | 68   | 730387   | 66   | 730533      | 60   | 730653       | 59   |
| 730217      | 39   | 730388   | 67   | 730561      | 59   | 730653.20    | 59   |
| 730221      | 36   | 730389   | 67   | 730562      | 59   | 730657       | 59   |
| 730225      | 36   | 730394   | 31   | 730564      | 66   | 730658       | 59   |
| 730227      | 36   | 730396   | 31   | 730566      | 67   | 730660       | 44   |
| 730230      | 67   | 730400   | 33   | 730570.320  | 94   | 730661       | 29   |
| 730233      | 66   | 730402   | 33   | 730570.345  | 94   | 730666       | 77   |
| 730235      | 55   | 730403   | 33   | 730570.620  | 94   | 730667       | 77   |
| 730238      | 44   | 730404   | 32   | 730570.645  | 94   | 730680       | 49   |
| 730238G     | 44   | 730405   | 32   | 730578.320  | 94   | 730681       | 48   |
| 730239      | 44   | 730406   | 39   | 730578.345  | 94   | 730682       | 48   |
| 730239G     | 44   | 730409   | 36   | 730578.620  | 94   | 730683       | 49   |
| 730243      | 66   | 730410   | 36   | 730578.645  | 94   | 730684       | 48   |
| 730249      | 53   | 730411   | 38   | 730579.320  | 94   | 730685       | 49   |
| 730249G     | 53   | 730413   | 40   | 730579.345  | 94   | 730686       | 49   |
| 730249G.250 | 53   | 730417   | 41   | 730579.620  | 94   | 730690       | 31   |
| 730250      | 43   | 730418   | 41   | 730579.645  | 94   | 730692       | 31   |
| 730259      | 32   | 730420   | 41   | 730585      | 64   | 730693       | 31   |
| 730261      | 33   | 730421   | 41   | 730586      | 64   | 730703       | 61   |
| 730269      | 32   | 730425   | 45   | 730593      | 42   | 730710       | 62   |
| 730275      | 45   | 730426   | 46   | 730594      | 42   | 730712       | 62   |
| 730280      | 30   | 730429   | 43   | 730595.500  | 64   | 730714       | 62   |
| 730288      | 18   | 730442   | 37   | 730595.1000 | 64   | 730716       | 62   |
| 730294      | 34   | 730443   | 37   | 730595.5000 | 64   | 730718       | 62   |

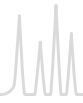
# Index of reference numbers

| REF        | Page | REF        | Page | REF    | Page | REF      | Page |
|------------|------|------------|------|--------|------|----------|------|
| 730720     | 62   | 730915     | 77   | 731773 | 28   | 732083   | 45   |
| 730722     | 62   | 730931     | 24   | 731774 | 27   | 732088   | 46   |
| 730723     | 18   | 730931.250 | 24   | 731775 | 27   | 732091   | 43   |
| 730724     | 62   | 730931MPS  | 68   | 731776 | 27   | 732108   | 30   |
| 730726     | 18   | 730931P45  | 24   | 731801 | 33   | 732130   | 24   |
| 730727     | 26   | 730934     | 24   | 731802 | 33   | 732131   | 24   |
| 730727P45  | 26   | 730934P45  | 24   | 731803 | 33   | 732132   | 24   |
| 730728     | 28   | 730935     | 24   | 731804 | 32   | 732168   | 48   |
| 730728P45  | 28   | 730935MPS  | 68   | 731805 | 32   | 732205   | 43   |
| 730729     | 28   | 730935P45  | 24   | 731806 | 32   | 732210   | 43   |
| 730729P45  | 28   | 730936     | 24   | 731808 | 35   | 732295   | 34   |
| 730730     | 62   | 730936P45  | 24   | 731813 | 40   | 732472   | 29   |
| 730731     | 27   | 730937     | 24   | 731828 | 39   | 732482   | 47   |
| 730731P45  | 27   | 730938     | 24   | 731829 | 39   | 732500   | 67   |
| 730732     | 62   | 730938.250 | 24   | 731830 | 39   | 732501   | 67   |
| 730733     | 27   | 730939     | 24   | 731831 | 45   | 732681   | 49   |
| 730733P45  | 27   | 730939.250 | 24   | 731832 | 45   | 732800   | 75   |
| 730734     | 62   | 730939MPS  | 68   | 731833 | 45   | 732801   | 75   |
| 730735     | 27   | 730940     | 24   | 731834 | 46   | 732802   | 75   |
| 730735P45  | 27   | 730941     | 24   | 731835 | 46   | 732803   | 75   |
| 730736     | 62   | 730950     | 26   | 731836 | 46   | 732804   | 75   |
| 730737     | 27   | 730950P45  | 26   | 731839 | 30   | 732805   | 75   |
| 730738     | 62   | 730951     | 26   | 731840 | 30   | 732806   | 75   |
| 730739     | 27   | 730951P45  | 26   | 731841 | 30   | 732807   | 75   |
| 730739P45  | 27   | 730952     | 25   | 731844 | 43   | 732808   | 75   |
| 730740     | 62   | 730952P45  | 25   | 731845 | 43   | 732809   | 75   |
| 730741     | 27   | 730953     | 25   | 731848 | 44   | 732810   | 75   |
| 730742     | 62   | 730954     | 26   | 731849 | 44   | 732811   | 75   |
| 730743     | 27   | 730955     | 25   | 731851 | 44   | 732812   | 75   |
| 730744     | 28   | 730956     | 25   | 731852 | 61   | 732813   | 75   |
| 730745     | 28   | 730956P45  | 25   | 731853 | 61   | 732814   | 75   |
| 730747     | 28   | 730957     | 25   | 731854 | 61   | 732815   | 75   |
| 730747P45  | 28   | 730958     | 26   | 731860 | 31   | 732816   | 75   |
| 730748     | 28   | 730966     | 26   | 731861 | 31   | 732817   | 75   |
| 730748P45  | 28   | 730968     | 26   | 731862 | 31   | 732818   | 75   |
| 730749     | 28   | 730968P45  | 26   | 731863 | 31   | 732819   | 75   |
| 730751     | 29   | 730969     | 25   | 731865 | 31   | 732850   | 75   |
| 730752     | 29   | 730969P45  | 25   | 731866 | 31   | 732903   | 78   |
| 730753     | 29   | 730970     | 59   | 731867 | 31   | 732960   | 76   |
| 730754     | 29   | 730971     | 59   | 731868 | 31   | 732961   | 76   |
| 730754.250 | 29   | 730972     | 59   | 731870 | 31   | 732962   | 76   |
| 730755     | 29   | 730973     | 59   | 731871 | 31   | 732963   | 76   |
| 730755.250 | 29   | 730974     | 59   | 731875 | 31   | 732964   | 76   |
| 730756     | 29   | 730975     | 59   | 731877 | 31   | 732965   | 76   |
| 730757     | 29   | 730990     | 66   | 731883 | 18   | 732966   | 76   |
| 730758     | 29   | 730996.2   | 59   | 731884 | 18   | 732967   | 76   |
| 730759     | 29   | 731730     | 34   | 731885 | 18   | 732980   | 76   |
| 730765     | 31   | 731731     | 34   | 731886 | 18   | 732980FE | 76   |
| 730798     | 78   | 731732     | 34   | 731888 | 18   | 732981   | 76   |
| 730880     | 77   | 731740     | 36   | 731909 | 31   | 732981FE | 76   |
| 730881     | 77   | 731741     | 36   | 732002 | 33   | 732982   | 76   |
| 730884     | 77   | 731755     | 25   | 732012 | 32   | 732982FE | 76   |
| 730885     | 77   | 731756     | 25   | 732013 | 32   | 732983   | 76   |
| 730886     | 77   | 731757     | 25   | 732019 | 67   | 732983FE | 76   |
| 730887     | 77   | 731768     | 26   | 732020 | 67   | 732984   | 76   |
| 730888     | 77   | 731769     | 26   | 732023 | 35   | 732984FE | 76   |
| 730890     | 77   | 731770     | 26   | 732033 | 40   | 732985   | 76   |
| 730891     | 77   | 731771     | 28   | 732072 | 39   | 732985FE | 76   |
| 730892     | 77   | 731772     | 28   | 732073 | 39   | 732986   | 76   |

# Index of reference numbers



| REF         | Page          | REF         | Page   | REF       | Page | REF       | Page |
|-------------|---------------|-------------|--------|-----------|------|-----------|------|
| 732986FE    | 76            | 738141.100M | 45     | 760035.46 | 183  | 760081.30 | 160  |
| 732987      | 76            | 738161.100M | 48     | 760046.46 | 182  | 760081.40 | 160  |
| 732987FE    | 76            | 738251.100M | 43     | 760050.20 | 182  | 760081.46 | 160  |
| 733110.25   | 351           | 738252.100M | 43     | 760050.30 | 182  | 760082.20 | 160  |
| 733110.50   | 351           | 738253.100M | 43     | 760050.40 | 182  | 760082.30 | 160  |
| 733111.10   | 341, 351      | 738294.100M | 34     | 760050.46 | 182  | 760082.40 | 160  |
| 733299.25   | 351           | 738520.025M | 29     | 760051.20 | 182  | 760082.46 | 160  |
| 733299.50   | 351           | 738520.050M | 29     | 760051.30 | 182  | 760083.20 | 160  |
| 733442.50   | 351           | 738520.100M | 29     | 760051.40 | 182  | 760083.30 | 160  |
| 733551.25   | 351           | 738530.010M | 24     | 760051.46 | 182  | 760083.40 | 160  |
| 735111      | 113, 134      | 738530.025M | 24     | 760052.20 | 182  | 760083.46 | 160  |
| 735113      | 118, 134      | 738530.050M | 24     | 760052.30 | 182  | 760084.20 | 160  |
| 735120      | 128, 134      | 738530.100M | 24     | 760052.40 | 182  | 760084.30 | 160  |
| 735126      | 101, 134      | 738630.M    | 70, 95 | 760052.46 | 182  | 760084.40 | 160  |
| 735132      | 128, 134      | 738637      | 70     | 760053.20 | 182  | 760084.46 | 160  |
| 735133      | 118, 134      | 738638      | 70     | 760053.30 | 182  | 760086.46 | 160  |
| 735208      | 101, 134      | 738639.M    | 70     | 760053.40 | 182  | 760100.20 | 161  |
| 735211      | 113, 134      | 738645      | 70     | 760053.46 | 182  | 760100.30 | 161  |
| 735220      | 128, 134      | 738650.5    | 70     | 760054.20 | 182  | 760100.40 | 161  |
| 735311      | 113, 134      | 738651      | 70     | 760054.30 | 182  | 760100.46 | 161  |
| 735320      | 128, 134      | 738652      | 70     | 760054.40 | 182  | 760101.20 | 161  |
| 735408      | 101, 134      | 738655.2M   | 95     | 760054.46 | 182  | 760101.30 | 161  |
| 735500      | 113, 128, 135 | 738655.M    | 95     | 760059.20 | 183  | 760101.40 | 161  |
| 735501      | 113, 128, 135 | 738656.M    | 95     | 760059.30 | 183  | 760101.46 | 161  |
| 735511      | 113, 135      | 738657.M    | 95     | 760059.40 | 183  | 760102.20 | 161  |
| 735520      | 128, 135      | 738658.M    | 95     | 760059.46 | 183  | 760102.30 | 161  |
| 735611      | 113, 135      | 738659.M    | 95     | 760060.20 | 183  | 760102.40 | 161  |
| 735620      | 128, 135      | 738660.M    | 95     | 760060.30 | 183  | 760102.46 | 161  |
| 735700      | 113, 128, 135 | 738661.M    | 95     | 760060.40 | 183  | 760103.20 | 161  |
| 735711      | 113, 135      | 738662.M    | 95     | 760060.46 | 183  | 760103.30 | 161  |
| 735720      | 128, 135      | 738663.M    | 95     | 760061.46 | 183  | 760103.40 | 161  |
| 735811      | 113, 135      | 738680.100M | 49     | 760062.20 | 183  | 760103.46 | 161  |
| 735820      | 128, 135      | 738702.030M | 61     | 760062.30 | 183  | 760104.20 | 161  |
| 735911      | 113, 134      | 738770.M    | 95     | 760062.40 | 183  | 760104.30 | 161  |
| 735911.20   | 113, 128, 134 | 738771.M    | 95     | 760062.46 | 183  | 760104.40 | 161  |
| 735913      | 118, 134      | 760001.20   | 183    | 760063.20 | 183  | 760104.46 | 161  |
| 735920      | 128, 134      | 760001.30   | 183    | 760063.30 | 183  | 760106.46 | 161  |
| 736400.40   | 239           | 760001.40   | 183    | 760063.40 | 183  | 760149.40 | 187  |
| 736596.40   | 239           | 760001.46   | 183    | 760063.46 | 183  | 760149.46 | 187  |
| 736597.100  | 239           | 760002.20   | 183    | 760064.46 | 183  | 760150.40 | 187  |
| 736598      | 239           | 760002.30   | 183    | 760071.20 | 160  | 760150.46 | 187  |
| 736599.100  | 239           | 760002.40   | 183    | 760075.20 | 160  | 760151.40 | 187  |
| 736601      | 239           | 760002.46   | 183    | 760076.20 | 160  | 760151.46 | 187  |
| 736602.100  | 239           | 760004.20   | 183    | 760076.30 | 160  | 760152.40 | 187  |
| 738001.025M | 33            | 760004.30   | 183    | 760076.40 | 160  | 760152.46 | 187  |
| 738001.100M | 33            | 760004.40   | 183    | 760076.46 | 160  | 760153.40 | 187  |
| 738011.025M | 32            | 760004.46   | 183    | 760078.20 | 160  | 760153.46 | 187  |
| 738011.050M | 32            | 760007.40   | 190    | 760078.30 | 160  | 760154.46 | 187  |
| 738011.100M | 32            | 760007.46   | 190    | 760078.40 | 160  | 760156.40 | 187  |
| 738021.100M | 35            | 760008.20   | 183    | 760078.46 | 160  | 760156.46 | 187  |
| 738031.100M | 40            | 760008.30   | 183    | 760079.20 | 160  | 760157.20 | 187  |
| 738071.100M | 39            | 760008.40   | 183    | 760079.30 | 160  | 760157.30 | 187  |
| 738101.100M | 46            | 760008.46   | 183    | 760079.40 | 160  | 760159.20 | 187  |
| 738111.100M | 30            | 760012.46   | 190    | 760079.46 | 160  | 760170.46 | 190  |
| 738131.150M | 64            | 760013.20   | 183    | 760080.20 | 160  | 760172.46 | 190  |
|             |               | 760013.30   | 183    | 760080.30 | 160  | 760173.46 | 190  |
|             |               | 760013.40   | 183    | 760080.40 | 160  | 760183.20 | 242  |
|             |               | 760013.46   | 183    | 760080.46 | 160  | 760183.30 | 242  |
|             |               | 760023.46   | 190    | 760081.20 | 160  | 760183.40 | 242  |



# Index of reference numbers

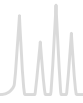
| REF       | Page | REF       | Page | REF       | Page | REF       | Page |
|-----------|------|-----------|------|-----------|------|-----------|------|
| 760183.46 | 242  | 760262.20 | 167  | 760316.40 | 180  | 760410.30 | 165  |
| 760184.20 | 242  | 760262.30 | 167  | 760316.46 | 180  | 760410.40 | 165  |
| 760184.30 | 242  | 760262.40 | 167  | 760321.20 | 179  | 760410.46 | 165  |
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| 760184.46 | 242  | 760263.20 | 167  | 760321.40 | 179  | 760412.30 | 165  |
| 760185.20 | 242  | 760263.30 | 167  | 760321.46 | 179  | 760412.40 | 165  |
| 760185.30 | 242  | 760263.40 | 167  | 760322.46 | 179  | 760412.46 | 165  |
| 760185.40 | 242  | 760263.46 | 167  | 760323.20 | 179  | 760413.20 | 165  |
| 760185.46 | 242  | 760264.20 | 167  | 760323.30 | 179  | 760413.30 | 165  |
| 760186.20 | 242  | 760264.30 | 167  | 760323.40 | 179  | 760413.40 | 165  |
| 760186.30 | 242  | 760264.40 | 167  | 760323.46 | 179  | 760413.46 | 165  |
| 760186.40 | 242  | 760264.46 | 167  | 760324.20 | 179  | 760414.20 | 165  |
| 760186.46 | 242  | 760271.20 | 167  | 760324.30 | 179  | 760414.30 | 165  |
| 760193.20 | 242  | 760271.30 | 167  | 760324.40 | 179  | 760414.40 | 165  |
| 760193.30 | 242  | 760271.40 | 167  | 760324.46 | 179  | 760414.46 | 165  |
| 760193.40 | 242  | 760271.46 | 167  | 760325.20 | 179  | 760415.20 | 165  |
| 760193.46 | 242  | 760272.20 | 167  | 760325.30 | 179  | 760415.30 | 165  |
| 760194.20 | 242  | 760272.30 | 167  | 760325.40 | 179  | 760415.40 | 165  |
| 760194.30 | 242  | 760272.40 | 167  | 760325.46 | 179  | 760415.46 | 165  |
| 760194.40 | 242  | 760272.46 | 167  | 760326.20 | 179  | 760416.46 | 165  |
| 760194.46 | 242  | 760273.20 | 167  | 760326.30 | 179  | 760431.20 | 175  |
| 760195.20 | 242  | 760273.30 | 167  | 760326.40 | 179  | 760431.30 | 175  |
| 760195.30 | 242  | 760273.40 | 167  | 760326.46 | 179  | 760431.40 | 175  |
| 760195.40 | 242  | 760273.46 | 167  | 760396.20 | 165  | 760431.46 | 175  |
| 760195.46 | 242  | 760274.20 | 167  | 760397.46 | 165  | 760433.20 | 175  |
| 760196.20 | 242  | 760275.20 | 167  | 760400.20 | 165  | 760433.30 | 175  |
| 760196.30 | 242  | 760301.20 | 179  | 760400.30 | 165  | 760433.40 | 175  |
| 760196.40 | 242  | 760301.30 | 179  | 760400.40 | 165  | 760433.46 | 175  |
| 760196.46 | 242  | 760301.40 | 179  | 760400.46 | 165  | 760435.20 | 175  |
| 760200.20 | 167  | 760301.46 | 179  | 760401.20 | 165  | 760436.20 | 175  |
| 760200.30 | 167  | 760304.20 | 179  | 760401.30 | 165  | 760436.30 | 175  |
| 760200.40 | 167  | 760305.20 | 179  | 760401.40 | 165  | 760436.40 | 175  |
| 760200.46 | 167  | 760305.30 | 179  | 760401.46 | 165  | 760436.46 | 175  |
| 760201.20 | 167  | 760305.40 | 179  | 760402.20 | 165  | 760438.20 | 175  |
| 760201.30 | 167  | 760305.46 | 179  | 760402.30 | 165  | 760443.20 | 175  |
| 760201.40 | 167  | 760306.20 | 179  | 760402.40 | 165  | 760443.30 | 175  |
| 760201.46 | 167  | 760306.30 | 179  | 760402.46 | 165  | 760443.40 | 175  |
| 760202.20 | 167  | 760306.40 | 179  | 760403.20 | 165  | 760443.46 | 175  |
| 760202.30 | 167  | 760306.46 | 179  | 760403.30 | 165  | 760445.46 | 175  |
| 760202.40 | 167  | 760308.20 | 179  | 760403.40 | 165  | 760446.20 | 175  |
| 760202.46 | 167  | 760311.20 | 180  | 760403.46 | 165  | 760446.30 | 175  |
| 760203.20 | 167  | 760311.30 | 180  | 760404.20 | 165  | 760446.40 | 175  |
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| 760203.46 | 167  | 760312.46 | 180  | 760404.46 | 165  | 760447.30 | 175  |
| 760204.20 | 167  | 760313.20 | 180  | 760405.20 | 165  | 760447.40 | 175  |
| 760204.30 | 167  | 760313.30 | 180  | 760405.30 | 165  | 760447.46 | 175  |
| 760204.40 | 167  | 760313.40 | 180  | 760405.40 | 165  | 760448.20 | 175  |
| 760204.46 | 167  | 760313.46 | 180  | 760405.46 | 165  | 760448.30 | 175  |
| 760205.46 | 167  | 760314.20 | 180  | 760406.20 | 165  | 760448.40 | 175  |
| 760259.46 | 167  | 760314.30 | 180  | 760406.30 | 165  | 760448.46 | 175  |
| 760260.20 | 167  | 760314.40 | 180  | 760406.40 | 165  | 760449.20 | 175  |
| 760260.30 | 167  | 760314.46 | 180  | 760406.46 | 165  | 760449.30 | 175  |
| 760260.40 | 167  | 760315.20 | 180  | 760407.20 | 165  | 760449.40 | 175  |
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| 760261.20 | 167  | 760315.40 | 180  | 760407.40 | 165  | 760453.20 | 175  |
| 760261.30 | 167  | 760315.46 | 180  | 760407.46 | 165  | 760453.30 | 175  |
| 760261.40 | 167  | 760316.20 | 180  | 760409.20 | 165  | 760453.40 | 175  |
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# Index of reference numbers



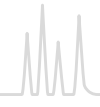
| REF       | Page | REF       | Page | REF       | Page | REF       | Page |
|-----------|------|-----------|------|-----------|------|-----------|------|
| 760455.46 | 175  | 760486.40 | 169  | 760552.46 | 185  | 760588.40 | 171  |
| 760456.20 | 175  | 760486.46 | 169  | 760553.20 | 185  | 760588.46 | 171  |
| 760456.30 | 175  | 760487.20 | 169  | 760553.30 | 185  | 760589.20 | 171  |
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| 760456.46 | 175  | 760487.40 | 169  | 760553.46 | 185  | 760589.40 | 171  |
| 760457.20 | 175  | 760487.46 | 169  | 760554.20 | 185  | 760589.46 | 171  |
| 760457.30 | 175  | 760488.20 | 169  | 760554.30 | 185  | 760591.20 | 163  |
| 760457.40 | 175  | 760488.30 | 169  | 760554.40 | 185  | 760591.30 | 163  |
| 760457.46 | 175  | 760488.40 | 169  | 760554.46 | 185  | 760591.40 | 163  |
| 760458.20 | 175  | 760488.46 | 169  | 760561.20 | 171  | 760591.46 | 163  |
| 760458.30 | 175  | 760489.20 | 169  | 760561.30 | 171  | 760593.20 | 163  |
| 760458.40 | 175  | 760489.30 | 169  | 760561.40 | 171  | 760593.30 | 163  |
| 760458.46 | 175  | 760489.40 | 169  | 760561.46 | 171  | 760593.40 | 163  |
| 760459.20 | 175  | 760489.46 | 169  | 760563.20 | 171  | 760593.46 | 163  |
| 760459.30 | 175  | 760521.20 | 185  | 760563.30 | 171  | 760595.20 | 163  |
| 760459.40 | 175  | 760521.30 | 185  | 760563.40 | 171  | 760596.20 | 163  |
| 760459.46 | 175  | 760521.40 | 185  | 760563.46 | 171  | 760596.30 | 163  |
| 760461.20 | 169  | 760521.46 | 185  | 760565.20 | 171  | 760596.40 | 163  |
| 760461.30 | 169  | 760523.20 | 185  | 760566.20 | 171  | 760596.46 | 163  |
| 760461.40 | 169  | 760523.30 | 185  | 760566.30 | 171  | 760598.20 | 163  |
| 760461.46 | 169  | 760523.40 | 185  | 760566.40 | 171  | 760603.20 | 163  |
| 760463.20 | 169  | 760523.46 | 185  | 760566.46 | 171  | 760603.30 | 163  |
| 760463.30 | 169  | 760525.20 | 185  | 760568.20 | 171  | 760603.40 | 163  |
| 760463.40 | 169  | 760526.20 | 185  | 760573.20 | 171  | 760603.46 | 163  |
| 760463.46 | 169  | 760526.30 | 185  | 760573.30 | 171  | 760605.46 | 163  |
| 760465.20 | 169  | 760526.40 | 185  | 760573.40 | 171  | 760606.20 | 163  |
| 760466.20 | 169  | 760526.46 | 185  | 760573.46 | 171  | 760606.30 | 163  |
| 760466.30 | 169  | 760528.20 | 185  | 760575.46 | 171  | 760606.40 | 163  |
| 760466.40 | 169  | 760530.20 | 185  | 760576.20 | 171  | 760606.46 | 163  |
| 760466.46 | 169  | 760530.30 | 185  | 760576.30 | 171  | 760607.20 | 163  |
| 760468.20 | 169  | 760530.40 | 185  | 760576.40 | 171  | 760607.30 | 163  |
| 760473.20 | 169  | 760530.46 | 185  | 760576.46 | 171  | 760607.40 | 163  |
| 760473.30 | 169  | 760531.20 | 185  | 760577.20 | 171  | 760607.46 | 163  |
| 760473.40 | 169  | 760531.30 | 185  | 760577.30 | 171  | 760608.20 | 163  |
| 760473.46 | 169  | 760531.40 | 185  | 760577.40 | 171  | 760608.30 | 163  |
| 760475.46 | 169  | 760531.46 | 185  | 760577.46 | 171  | 760608.40 | 163  |
| 760476.20 | 169  | 760532.20 | 185  | 760578.20 | 171  | 760608.46 | 163  |
| 760476.30 | 169  | 760532.30 | 185  | 760578.30 | 171  | 760609.20 | 163  |
| 760476.40 | 169  | 760532.40 | 185  | 760578.40 | 171  | 760609.30 | 163  |
| 760476.46 | 169  | 760532.46 | 185  | 760578.46 | 171  | 760609.40 | 163  |
| 760477.20 | 169  | 760533.20 | 185  | 760579.20 | 171  | 760609.46 | 163  |
| 760477.30 | 169  | 760533.30 | 185  | 760579.30 | 171  | 760613.20 | 163  |
| 760477.40 | 169  | 760533.40 | 185  | 760579.40 | 171  | 760613.30 | 163  |
| 760477.46 | 169  | 760533.46 | 185  | 760579.46 | 171  | 760613.40 | 163  |
| 760478.20 | 169  | 760534.20 | 185  | 760583.20 | 171  | 760613.46 | 163  |
| 760478.30 | 169  | 760534.30 | 185  | 760583.30 | 171  | 760615.46 | 163  |
| 760478.40 | 169  | 760534.40 | 185  | 760583.40 | 171  | 760616.20 | 163  |
| 760478.46 | 169  | 760534.46 | 185  | 760583.46 | 171  | 760616.30 | 163  |
| 760479.20 | 169  | 760550.20 | 185  | 760585.46 | 171  | 760616.40 | 163  |
| 760479.30 | 169  | 760550.30 | 185  | 760586.20 | 171  | 760616.46 | 163  |
| 760479.40 | 169  | 760550.40 | 185  | 760586.30 | 171  | 760617.20 | 163  |
| 760479.46 | 169  | 760550.46 | 185  | 760586.40 | 171  | 760617.30 | 163  |
| 760483.20 | 169  | 760551.20 | 185  | 760586.46 | 171  | 760617.40 | 163  |
| 760483.30 | 169  | 760551.30 | 185  | 760587.20 | 171  | 760617.46 | 163  |
| 760483.40 | 169  | 760551.40 | 185  | 760587.30 | 171  | 760618.20 | 163  |
| 760483.46 | 169  | 760551.46 | 185  | 760587.40 | 171  | 760618.30 | 163  |
| 760485.46 | 169  | 760552.20 | 185  | 760587.46 | 171  | 760618.40 | 163  |
| 760486.20 | 169  | 760552.30 | 185  | 760588.20 | 171  | 760618.46 | 163  |
| 760486.30 | 169  | 760552.40 | 185  | 760588.30 | 171  | 760619.20 | 163  |



# Index of reference numbers

| REF       | Page | REF       | Page | REF       | Page | REF       | Page |
|-----------|------|-----------|------|-----------|------|-----------|------|
| 760619.30 | 163  | 760739.46 | 189  | 760802.30 | 177  | 761910.20 | 165  |
| 760619.40 | 163  | 760740.20 | 189  | 760802.40 | 177  | 761910.30 | 165  |
| 760619.46 | 163  | 760741.20 | 189  | 760802.46 | 177  | 761911.20 | 165  |
| 760620.20 | 173  | 760742.46 | 189  | 760803.20 | 177  | 761911.30 | 165  |
| 760620.30 | 173  | 760749.46 | 161  | 760803.30 | 177  | 761912.20 | 165  |
| 760620.40 | 173  | 760750.20 | 161  | 760803.40 | 177  | 761912.30 | 165  |
| 760620.46 | 173  | 760750.30 | 161  | 760803.46 | 177  | 761915.20 | 167  |
| 760621.20 | 173  | 760750.40 | 161  | 760805.20 | 177  | 761915.30 | 167  |
| 760621.30 | 173  | 760750.46 | 161  | 760805.30 | 177  | 761916.20 | 167  |
| 760621.40 | 173  | 760751.20 | 161  | 760805.40 | 177  | 761916.30 | 167  |
| 760621.46 | 173  | 760751.30 | 161  | 760805.46 | 177  | 761917.20 | 167  |
| 760622.20 | 173  | 760751.40 | 161  | 760806.20 | 177  | 761917.30 | 167  |
| 760622.30 | 173  | 760751.46 | 161  | 760806.30 | 177  | 761920.20 | 177  |
| 760622.40 | 173  | 760752.20 | 161  | 760806.40 | 177  | 761920.30 | 177  |
| 760622.46 | 173  | 760752.30 | 161  | 760806.46 | 177  | 761921.20 | 177  |
| 760623.20 | 173  | 760752.40 | 161  | 760807.20 | 177  | 761921.30 | 177  |
| 760623.30 | 173  | 760752.46 | 161  | 760807.30 | 177  | 761922.20 | 177  |
| 760623.40 | 173  | 760753.20 | 161  | 760807.40 | 177  | 761922.30 | 177  |
| 760623.46 | 173  | 760753.30 | 161  | 760807.46 | 177  | 761925.20 | 179  |
| 760624.20 | 173  | 760753.40 | 161  | 760808.20 | 177  | 761925.30 | 179  |
| 760624.30 | 173  | 760753.46 | 161  | 760808.30 | 177  | 761926.20 | 179  |
| 760624.40 | 173  | 760754.20 | 161  | 760808.40 | 177  | 761926.30 | 179  |
| 760624.46 | 173  | 760754.30 | 161  | 760808.46 | 177  | 761927.20 | 180  |
| 760625.20 | 173  | 760754.40 | 161  | 760809.20 | 177  | 761927.30 | 180  |
| 760625.30 | 173  | 760754.46 | 161  | 760809.30 | 177  | 761931.20 | 182  |
| 760625.40 | 173  | 760755.20 | 161  | 760809.40 | 177  | 761931.30 | 182  |
| 760625.46 | 173  | 760755.30 | 161  | 760809.46 | 177  | 761932.20 | 183  |
| 760700.20 | 183  | 760755.40 | 161  | 760812.20 | 177  | 761932.30 | 183  |
| 760700.30 | 183  | 760755.46 | 161  | 760812.30 | 177  | 761936.20 | 183  |
| 760700.40 | 183  | 760756.20 | 161  | 760812.40 | 177  | 761936.30 | 183  |
| 760700.46 | 183  | 760756.30 | 161  | 760812.46 | 177  | 761937.20 | 183  |
| 760701.20 | 183  | 760756.40 | 161  | 760813.46 | 177  | 761937.30 | 183  |
| 760701.30 | 183  | 760756.46 | 161  | 760815.46 | 177  | 761941.20 | 187  |
| 760701.40 | 183  | 760757.20 | 161  | 760821.20 | 177  | 761941.30 | 187  |
| 760701.46 | 183  | 760757.30 | 161  | 760821.30 | 177  | 761943.30 | 187  |
| 760702.46 | 183  | 760757.40 | 161  | 760821.40 | 177  | 761944.30 | 187  |
| 760703.20 | 183  | 760757.46 | 161  | 760821.46 | 177  | 761951.20 | 189  |
| 760703.30 | 183  | 760759.20 | 161  | 760822.20 | 177  | 761951.30 | 189  |
| 760703.40 | 183  | 760760.20 | 161  | 760822.30 | 177  | 761952.30 | 189  |
| 760703.46 | 183  | 760773.20 | 227  | 760822.40 | 177  | 761953.20 | 189  |
| 760704.20 | 183  | 760773.30 | 227  | 760822.46 | 177  | 761953.30 | 189  |
| 760704.30 | 183  | 760773.40 | 227  | 760823.20 | 177  | 761960.20 | 185  |
| 760704.40 | 183  | 760783.30 | 227  | 760823.30 | 177  | 761960.30 | 185  |
| 760704.46 | 183  | 760783.40 | 227  | 760823.40 | 177  | 761961.20 | 185  |
| 760706.46 | 183  | 760784.30 | 227  | 760823.46 | 177  | 761961.30 | 185  |
| 760720.40 | 189  | 760784.40 | 227  | 760824.20 | 177  | 761962.20 | 185  |
| 760720.46 | 189  | 760785.30 | 227  | 760825.20 | 177  | 761962.30 | 185  |
| 760721.46 | 189  | 760785.40 | 227  | 761810.20 | 173  | 761966.30 | 190  |
| 760722.40 | 189  | 760786.30 | 227  | 761810.30 | 173  | 761967.30 | 190  |
| 760722.46 | 189  | 760786.40 | 227  | 761901.20 | 160  | 761970.20 | 227  |
| 760730.20 | 189  | 760800.20 | 177  | 761901.30 | 160  | 761970.30 | 227  |
| 760730.30 | 189  | 760800.30 | 177  | 761902.20 | 160  | 761971.30 | 227  |
| 760730.40 | 189  | 760800.40 | 177  | 761902.30 | 160  | 761975.20 | 175  |
| 760730.46 | 189  | 760800.46 | 177  | 761903.20 | 161  | 761975.30 | 175  |
| 760731.46 | 189  | 760801.20 | 177  | 761903.30 | 161  | 761976.20 | 175  |
| 760732.20 | 189  | 760801.30 | 177  | 761905.20 | 161  | 761976.30 | 175  |
| 760732.30 | 189  | 760801.40 | 177  | 761905.30 | 161  | 761977.20 | 175  |
| 760732.40 | 189  | 760801.46 | 177  | 761907.20 | 161  | 761977.30 | 175  |
| 760732.46 | 189  | 760802.20 | 177  | 761907.30 | 161  | 761980.20 | 169  |

# Index of reference numbers



| REF        | Page | REF        | Page     | REF        | Page | REF        | Page |
|------------|------|------------|----------|------------|------|------------|------|
| 761980.30  | 169  | 762081.210 | 161      | 762273.210 | 167  | 762556.320 | 180  |
| 761981.20  | 169  | 762082.210 | 161      | 762291.160 | 167  | 762556.400 | 180  |
| 761981.30  | 169  | 762090.160 | 183      | 762291.80  | 167  | 762556.500 | 180  |
| 761982.20  | 169  | 762090.80  | 183      | 762293.320 | 167  | 762561.100 | 180  |
| 761982.30  | 169  | 762092.160 | 183      | 762302.100 | 183  | 762561.210 | 180  |
| 761985.20  | 171  | 762092.80  | 183      | 762302.210 | 183  | 762563.210 | 180  |
| 761985.30  | 171  | 762094.160 | 190      | 762303.400 | 183  | 762563.320 | 180  |
| 761986.20  | 171  | 762094.80  | 190      | 762311.320 | 183  | 762563.500 | 180  |
| 761986.30  | 171  | 762097.160 | 161      | 762311.500 | 183  | 762564.100 | 180  |
| 761987.20  | 171  | 762097.80  | 161      | 762321.320 | 183  | 762564.210 | 180  |
| 761987.30  | 171  | 762100.400 | 161      | 762330.320 | 190  | 762565.320 | 180  |
| 761988.20  | 242  | 762103.100 | 161      | 762350.100 | 163  | 762565.400 | 180  |
| 761988.30  | 242  | 762103.210 | 161      | 762350.210 | 163  | 762565.500 | 180  |
| 761989.20  | 242  | 762109.100 | 161      | 762351.100 | 163  | 762566.100 | 180  |
| 761989.30  | 242  | 762109.210 | 161      | 762351.210 | 163  | 762566.210 | 180  |
| 761990.20  | 163  | 762113.100 | 161      | 762352.400 | 163  | 762566.320 | 180  |
| 761990.30  | 163  | 762113.210 | 161      | 762353.100 | 163  | 762566.400 | 180  |
| 761991.20  | 163  | 762113.320 | 161      | 762353.210 | 163  | 762566.500 | 180  |
| 761991.30  | 163  | 762113.400 | 161      | 762353.320 | 163  | 762571.100 | 180  |
| 761992.20  | 163  | 762160.160 | 161      | 762353.400 | 163  | 762571.210 | 180  |
| 761992.30  | 163  | 762160.80  | 161      | 762354.160 | 163  | 762573.210 | 180  |
| 762003.100 | 183  | 762163.320 | 161      | 762354.80  | 163  | 762573.320 | 180  |
| 762003.210 | 183  | 762210.100 | 171, 175 | 762355.320 | 163  | 762573.500 | 180  |
| 762007.100 | 190  | 762210.210 | 171, 175 | 762371.400 | 177  | 762574.100 | 180  |
| 762007.210 | 190  | 762211.100 | 171, 175 | 762372.100 | 177  | 762574.210 | 180  |
| 762007.400 | 190  | 762211.210 | 171, 175 | 762372.210 | 177  | 762575.320 | 180  |
| 762010.100 | 183  | 762212.400 | 171, 175 | 762373.100 | 177  | 762575.400 | 180  |
| 762010.210 | 183  | 762213.100 | 171, 175 | 762373.210 | 177  | 762575.500 | 180  |
| 762010.320 | 183  | 762213.210 | 171, 175 | 762373.320 | 177  | 762576.100 | 180  |
| 762010.400 | 183  | 762213.320 | 171, 175 | 762373.400 | 177  | 762576.210 | 180  |
| 762010.500 | 183  | 762213.400 | 171, 175 | 762375.100 | 177  | 762576.320 | 180  |
| 762011.100 | 183  | 762214.160 | 175      | 762375.210 | 177  | 762576.400 | 180  |
| 762011.210 | 183  | 762214.80  | 175      | 762390.160 | 177  | 762576.500 | 180  |
| 762022.100 | 183  | 762216.320 | 175      | 762390.80  | 177  | 762591.160 | 180  |
| 762022.210 | 183  | 762220.100 | 169      | 762392.320 | 177  | 762591.80  | 180  |
| 762022.320 | 183  | 762220.210 | 169      | 762403.100 | 165  | 762592.320 | 180  |
| 762022.400 | 183  | 762221.100 | 169      | 762403.210 | 165  | 762592.500 | 180  |
| 762027.400 | 183  | 762221.210 | 169      | 762403.320 | 165  | 763132.20  | 201  |
| 762029.100 | 183  | 762222.400 | 169      | 762403.400 | 165  | 763132.30  | 201  |
| 762029.210 | 183  | 762223.100 | 169      | 762404.100 | 165  | 763132.40  | 201  |
| 762061.100 | 183  | 762223.210 | 169      | 762404.210 | 165  | 763132.46  | 201  |
| 762061.210 | 183  | 762223.320 | 169      | 762405.100 | 165  | 763134.20  | 201  |
| 762062.100 | 183  | 762223.400 | 169      | 762405.210 | 165  | 763134.30  | 201  |
| 762062.210 | 183  | 762224.160 | 169      | 762406.400 | 165  | 763134.40  | 201  |
| 762062.320 | 183  | 762224.80  | 169      | 762420.160 | 165  | 763134.46  | 201  |
| 762062.400 | 183  | 762226.320 | 169      | 762420.80  | 165  | 763136.20  | 201  |
| 762070.100 | 161  | 762234.160 | 171      | 762422.320 | 165  | 763136.30  | 201  |
| 762070.210 | 161  | 762234.80  | 171      | 762551.100 | 180  | 763136.40  | 201  |
| 762071.100 | 161  | 762236.320 | 171      | 762551.210 | 180  | 763136.46  | 201  |
| 762071.210 | 161  | 762250.210 | 161      | 762553.210 | 180  | 763138.20  | 201  |
| 762072.100 | 183  | 762250.400 | 161      | 762553.320 | 180  | 763138.30  | 201  |
| 762072.210 | 183  | 762269.400 | 167      | 762553.500 | 180  | 763152.20  | 201  |
| 762075.400 | 190  | 762271.100 | 167      | 762554.100 | 180  | 763152.30  | 201  |
| 762077.100 | 190  | 762271.210 | 167      | 762554.210 | 180  | 763152.40  | 201  |
| 762077.210 | 190  | 762272.100 | 167      | 762555.320 | 180  | 763152.46  | 201  |
| 762078.100 | 190  | 762272.210 | 167      | 762555.400 | 180  | 763154.20  | 201  |
| 762078.210 | 190  | 762272.320 | 167      | 762555.500 | 180  | 763154.30  | 201  |
| 762079.400 | 183  | 762272.400 | 167      | 762556.100 | 180  | 763154.40  | 201  |
| 762081.100 | 161  | 762273.100 | 167      | 762556.210 | 180  | 763154.46  | 201  |

# Index of reference numbers

| REF       | Page | REF       | Page | REF        | Page | REF        | Page |
|-----------|------|-----------|------|------------|------|------------|------|
| 763156.20 | 201  | 763532.46 | 207  | 808013     | 289  | 811073     | 284  |
| 763156.30 | 201  | 763534.20 | 207  | 808023     | 289  | 811074     | 284  |
| 763156.40 | 201  | 763534.30 | 207  | 808033     | 289  | 811075     | 284  |
| 763156.46 | 201  | 763534.40 | 207  | 808043     | 289  | 811081     | 284  |
| 763157.20 | 201  | 763534.46 | 207  | 808053     | 289  | 811082     | 284  |
| 763157.30 | 201  | 763536.20 | 207  | 808063     | 289  | 811111     | 286  |
| 763157.40 | 201  | 763536.30 | 207  | 808072     | 289  | 811112     | 286  |
| 763157.46 | 201  | 763536.40 | 207  | 808073     | 289  | 811115     | 285  |
| 763158.20 | 201  | 763536.46 | 207  | 809011     | 276  | 811116     | 285  |
| 763158.30 | 201  | 763538.20 | 207  | 809012     | 276  | 811120     | 287  |
| 763232.20 | 203  | 763538.30 | 207  | 809013     | 276  | 812003     | 277  |
| 763232.30 | 203  | 763732.20 | 205  | 809017     | 276  | 812004     | 277  |
| 763232.40 | 203  | 763732.30 | 205  | 809017.200 | 276  | 812005     | 277  |
| 763232.46 | 203  | 763732.40 | 205  | 809020     | 276  | 812005.200 | 277  |
| 763234.20 | 203  | 763732.46 | 205  | 809021     | 276  | 812006     | 277  |
| 763234.30 | 203  | 763734.20 | 205  | 809022     | 276  | 812007     | 277  |
| 763234.40 | 203  | 763734.30 | 205  | 809023     | 276  | 812008     | 277  |
| 763234.46 | 203  | 763734.40 | 205  | 809027     | 276  | 812010     | 282  |
| 763236.20 | 203  | 763734.46 | 205  | 809027.200 | 276  | 812011     | 282  |
| 763236.30 | 203  | 763736.20 | 205  | 809028.100 | 276  | 812013     | 282  |
| 763236.40 | 203  | 763736.30 | 205  | 809033     | 292  | 812014     | 282  |
| 763236.46 | 203  | 763736.40 | 205  | 809043     | 292  | 814000     | 269  |
| 763238.20 | 203  | 763736.46 | 205  | 809051     | 276  | 814001     | 269  |
| 763238.30 | 203  | 763738.20 | 205  | 809053     | 276  | 814002     | 269  |
| 763252.20 | 203  | 763738.30 | 205  | 809061     | 276  | 814003     | 269  |
| 763252.30 | 203  | 801011    | 289  | 809063     | 276  | 814011     | 269  |
| 763252.40 | 203  | 801013    | 289  | 809073     | 276  | 814012     | 269  |
| 763252.46 | 203  | 801022    | 289  | 809083     | 276  | 814013     | 269  |
| 763254.20 | 203  | 801023    | 289  | 809121     | 276  | 814018     | 295  |
| 763254.30 | 203  | 801033    | 290  | 809122     | 276  | 814019     | 295  |
| 763254.40 | 203  | 801053    | 290  | 809123     | 276  | 814021     | 295  |
| 763254.46 | 203  | 801063    | 290  | 810012     | 279  | 814022     | 295  |
| 763256.20 | 203  | 801113    | 289  | 810013     | 279  | 814023     | 295  |
| 763256.30 | 203  | 801123    | 289  | 810022     | 279  | 814024     | 295  |
| 763256.40 | 203  | 802021    | 288  | 810023     | 279  | 814025     | 271  |
| 763256.46 | 203  | 802022    | 288  | 810043     | 293  | 814026     | 271  |
| 763257.20 | 203  | 802023    | 288  | 810053     | 293  | 814027     | 271  |
| 763257.30 | 203  | 803012    | 290  | 810063     | 292  | 814028     | 271  |
| 763257.40 | 203  | 803013    | 290  | 810123     | 279  | 814029     | 269  |
| 763257.46 | 203  | 803022    | 290  | 811011     | 281  | 814030     | 295  |
| 763258.20 | 203  | 803023    | 290  | 811012     | 281  | 814100     | 271  |
| 763258.30 | 203  | 804022    | 291  | 811013     | 281  | 814101     | 295  |
| 763332.20 | 209  | 804023    | 291  | 811021     | 281  | 814102     | 295  |
| 763332.30 | 209  | 805012    | 276  | 811022     | 281  | 814103     | 295  |
| 763332.40 | 209  | 805013    | 276  | 811023     | 281  | 814104     | 295  |
| 763332.46 | 209  | 805014    | 276  | 811032     | 279  | 814200     | 271  |
| 763334.20 | 209  | 805017    | 276  | 811042     | 279  | 814201     | 271  |
| 763334.30 | 209  | 805021    | 276  | 811051     | 292  | 814202     | 271  |
| 763334.40 | 209  | 805022    | 276  | 811052     | 283  | 814203     | 296  |
| 763334.46 | 209  | 805023    | 276  | 811054     | 283  | 814204     | 271  |
| 763336.20 | 209  | 805024    | 276  | 811055     | 291  | 814205     | 271  |
| 763336.30 | 209  | 805032    | 276  | 811056     | 291  | 814206     | 296  |
| 763336.40 | 209  | 805901    | 276  | 811057     | 291  | 814300     | 271  |
| 763336.46 | 209  | 805902    | 276  | 811058     | 291  | 814301     | 271  |
| 763338.20 | 209  | 806013    | 293  | 811059     | 291  | 814302     | 296  |
| 763338.30 | 209  | 806023    | 293  | 811062     | 283  | 814400     | 271  |
| 763532.20 | 207  | 807021    | 288  | 811064     | 283  | 814401     | 296  |
| 763532.30 | 207  | 807023    | 288  | 811071     | 284  | 814402     | 296  |
| 763532.40 | 207  | 807033    | 288  | 811072     | 284  | 814403     | 296  |