USER MANUAL

Release: IMS 5000-1.01e, March 2003

Draeger IMS 5000
Ion Mobility Spectrometer

Draeger Safety AG & Co. KGaA
Volmerstraße 7b
12489 Berlin, Germany

Tel.: 030 6392-2091
Fax: 030 6392-2090
www.draeger.com

3. Declaration of conformity

Dräger SAFETY

Konformitätserklärung
Declaration of Conformity
Déclaration de Conformité

Wir We Nous	Dräger Safety AG & Co KGaA
Anschrift Address Adresse	Volmerstraße 7B, 12489 Berlin Germany

erklären in alleiniger Verantwortung, dass das Produkt
declare under our sole responsibility, that the product
déclarons sous notre seule responsabilité, que le produit

Bezeichnung Name Nom	**Ionenmobilitätsspektrometer** **Ion Mobility Spectrometer**
Typ, Modell, Artikel-Nr., Größe Type, Model, Article No., Size Type, Modèle, Mod.d'Article, Taille	**Draeger IMS 5000**

mit den Anforderungen der Normen und Richtlinien
fulfils the requirements of the standard and regulations of the directive
satisfait aux exigences des normes et directives

72/23/EWG	Niederspannungsrichtlinie
DIN EN 61010	Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte
EN 50270/4.99	Elektromagnetische Verträglichkeit Prüfung Störaussendung Prüfung Störfestigkeit

und den angezogenen Prüfberichten übereinstimmt und damit den Bestimmungen entspricht.
and the taken test reports and therfore corresponds to the regulations of the directive.
et les rapports d'essais notifiés et, ainsi, correspond aux règlement de la directive.

Berlin, den

Ort und Datum der Ausstellung Place and date of issue Leu et date d'etablissement	Name und Unterschrift des Befugten Name and signature of authorised person Nom et signature de la personne autorisee

Dräger Safety AG & Co. KGaA
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Telefax +49 451 8 82-20 80
Telex 2 6 807-0
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Sitz der Gesellschaft: Lübeck
Handelsregister:
Amtsgericht Lübeck HRB 4097

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Konto-Nr. 371072500
BLZ 230 800 40
Swift-Code DRES DE FF 230
Landesbank Schleswig-Holstein, Kiel
Konto-Nr. 7053002780
BLZ 210 500 00
Swift-Code KILADE 22

Deutsche Bank AG, Lübeck
Konto-Nr. 030210900
BLZ 230 707 00
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Commerzbank AG, Lübeck
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Vorsitzender des Aufsichtsrats:
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Geschäftsführung
Dräger Safety Verwaltungs AG
Vorstand:
Prof. Dr.-Ing. Albert Jugel (Vors.)
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Dräger Safety Verwaltungs AG
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Prof. Dr.-Ing. Albert Jugel (Vors.)
Thomas Holzgreve

4. Bauartzulassung (Document of technical compliance)

Senatsverwaltung für Gesundheit und Soziales

Berlin

Senatsverwaltung für Gesundheit und Soziales, Oranienstr. 106, 10969 Berlin

Zulassungsschein B - 04 / 98

I.

Gemäß § 22 Abs. 1 in Verbindung mit Anlage VI Nr. 1 der Strahlenschutzverordnung (StrlSchV) vom 13. Oktober 1976 in der Neufassung der Bekanntmachung vom 30. Juni 1989 wird dem

Institut für Umwelttechnologie GmbH (I.U.T.)
Rudower Chaussee 5
12489 Berlin-Adlershof

die Zulassung der Bauart für die nachstehend beschriebene Vorrichtung erteilt:

Gegenstand:	Ionenmobilitätsspektrometer
Firmenbezeichnung:	Gasspurenmonitor in den Ausführungen: 1. Beta - IMS mit Gasprobenschleife 2. Beta - IMS mit Membrankammer
Hersteller und Antragsteller:	Institut für Umwelttechnologie GmbH (I.U.T.) Rudower Chaussee 5 12489 Berlin-Adlershof
Radioaktiver Stoff:	Tritium
Aktivität:	Maximal 4,44 GBq
Hersteller:	Chlopin Radiuminstitut 2. Murinsky Avennue Z8 194021 St. Petersburg / Rußland zusammen mit dem Antragsteller
Quellenbezeichnung:	1. I.M.S. mit Gasprobenschleife: H-3-001/96 2. I.M.S. mit Membrankammer. H-3-050/96
Verwendungszweck:	Nachweis von Gasspuren in Luft
Befristung:	Die Zulassung ist befristet bis zum 01. Juni 2008.

II.

Zulassungsbestandteile:

1. Antrag dem Institut für Umwelttechnologie GmbH (I.U.T.) vom 20.06.1997.
2. Prüfschein der Physikalsch-Technischen Bundesanstalt Nr. 6.52 - R 244 vom 11.05.1998

3. Bauartzeichnungen:
   RID3.50-02:00 vom 11.04.1997 (Driftzelle), RID4.schbet :1 vom 24.04.1997 (Gasprobenschleife), Kennz.-Nr. 6.52-R 244/3 (Membrankammer), RID4.12-05:00/1 vom 24.04.1997 Kennz.-Nr. 6.52-R 244/1 (Kreislauffilter), RID 3.57-2:04 vom 21.04.1997 (Tritium-Strahlenquelle).

III.

Wesentliche Merkmale der Vorrichtung

Die Ionenmobilitätsspektrometer mit Gasprobenschleife und Membrankammer dienen der Gasspurenanalyse in Luft. Moleküle der zu untersuchenden Gase werden mit der Umgebungsluft angesaugt und gelangen entweder dosiert durch eine Gasprobenschleife mit Ventilsteuerung oder mittels Diffusion durch eine Membrane in die Driftzelle, wo sie durch die β-Strahlung der Tritiumquelle ionisiert und aufgrund unterschiedlicher Driftgeschwindigkeiten in einem elektrischen Feld analysiert werden.

Der radioaktive Stoff Tritium (H-3) ist in Zwischengitterplätze einer 0,5 µm dicken Titanschicht eingelagert, die auf einer 2 mm dicken Scheibe aus Edelstahl 1.4301 von 10 mm Durchmesser aufgedampft ist. Auf diese Titanschicht sind als Schutzschichten zwei weitere Schichten aus Silizium (0,1 µm) und Aluminium (0,5 µm) aufgedampft. Die schwache β-Strahlung des Tritiums wird von allen Teilen des Ionenmobilitätsspektrometers absorbiert, so daß nur die aus dem Gerät austretende Abluft für den Strahlenschutz von Bedeutung ist.

Zur Absorption von Tritium, das aus dem Strahler freigesetzt wird, dient eine Filterpatrone, die aus zwei Schichten Molekularsieben mit einer dazwischenliegenden Schicht aus Katalysatormaterial aufgebaut ist. Dieser Filter muß nach einer vom Hersteller angegebenen Betriebsdauer ausgewechselt werden.

Weitere Einzelheiten gehen aus den in der Physikalsch-Technischen Bundesanstalt (PTB) hinterlegten Unterlagen hervor.

Prüfung der Bauart:

Mit Prüfschein Nr. 6.52 - R 244 vom 11.05.1998 hat die Physikalisch-Technische Bundesanstalt (PTB) bestätigt, daß das Strahlenschutzziel der Anlage VI Nr. 1 für das vorstehend beschriebene Ionenmobilitätsspektrometer erreicht ist. Obwohl die in den beiden Ionenmobilitätsspektrometern eingebauten Tritium-Strahler wegen der zwar geringen Abgabe von Tritium mit der Abluft streng genommen nicht der Definition „umschlossene radioaktive Stoffe" im Sinne der Strahlenschutzverordnung genügen, werden sie für diese Bauartzulassung dennoch als quasi umschlossene radioaktive Stoffe behandelt.

Prüfergebnis:

1. Die Aktivitäten der in den Ionenmobilitätsspektrometern befindlichen radioaktiven Stoffe betragen weniger als das 10^6 -fache der Freigrenze der Anlage IV, Tabelle IV 1, Spalte 4 der Strahlenschutzverordnung.

   Die Ortsdosisleistung in 10 cm Abstand von der berührbaren Oberfläche der Ionenmobilitätsspektrometer (IMS-Gerät) beträgt weniger als 10 µSv/h.
2. Bei betriebsmäßiger Beanspruchung der Ionenmobilitätsspektrometer treten bei dem IMS-Gerät mit Gasprobenschleife nicht mehr als 20 Bq/Tag und bei dem IMS-Gerät mit Membranfilter nicht mehr als 8 kBq/Tag an Tritium mit der Abluft aus.

IV.

Auflagen:

Die Zulassung wird gemäß § 24 StrlSchV mit folgenden Auflagen verbunden:

1. Jedes Ionenmobilitätsspektrometer muß deutlich sichtbar und dauerhaft mit dem Bauartzeichen B - 04 / 98 und dem Strahlenzeichen gekennzeichnet sein. Außerdem sind das Radionuklid und die Aktivität (Tritium: 4,44 GBq) anzugeben.
2. Vor der Auslieferung ist jedes Ionenmobilitätsspektrometer einer Qualitätskontrolle (Abnahmeprüfung) daraufhin zu unterziehen, ob es bezüglich der für den Strahlenschutz wesentlichen Merkmale dieser Bauartzulassung entspricht.
3. Das Ergebnis der Qualitätskontrolle ist in einer Prüfliste aufzuzeichnen, die folgende Angaben enthalten soll:
   - Laufende Fabrikations-Nummer,
   - Max. Ortsdosisleistung in 10 cm Abstand von der Oberfläche der Ionenmobilitätsspektrometer,
   - Ergebnis der Kontaminationsprüfung (Wischtest),
   - Prüfdatum,
   - Unterschrift des für die Abnahmeprüfung Verantwortlichen.
4. Zur Überwachung der Qalitätskontrolle wird das Institut für Strahlenschutz und Qualitätssicherung GmbH (ISQ), Kyllmannstr. 12b, 12203 Berlin bestimmt.
5. Jedem Erwerber eines der vorgenannten und zugelassenen IMS-Geräte ist ein Abdruck des Zulassungsscheines auszuhändigen, auf dem das Ergebnis der Qualitätskontrolle bestätigt ist. Außerdem ist jedem IMS-Gerät eine Betriebsanleitung in deutscher Sprache beizufügen, in der insbesondere auf die dem Strahlenschutz dienenden Maßnahmen und die Pflichten des Betreibers hingewiesen wird.
6. Die zur Reduzierung der mit der Abluft entweichenden Tritiumaktivität in den IMS-Geräten eingebauten Filter sind vom Hersteller oder von einer von ihm autorisierten Firma spätestens halbjährlich auszutauschen. Eine entsprechende Verpflichtung muß im Kauf- oder Überlassungsvertrag enthalten sein.

V.

Pflichten des Inhabers einer zugelassenen Vorrichtung:

1. Ein Abdruck dieses Zulassungsscheines und die Betriebsanleitung sind bei der zugelassenen Vorrichtung bereitzuhalten und der Aufsichtsbehörde auf Verlangen vorzulegen.
2. Auf die Pflichten des Inhabers der Vorrichtung nach § 4 Abs. 1, § 27 und § 79 StrlSchV wird besonders hingewiesen.

Berlin, den 27. Mai 1998

Senatsverwaltung für Gesundheit und Soziales
Im Auftrag

Dr. Scheffler

Ergebnis der Qualitätskontrolle

Geräte-Nr.	
Typ	IMS 5000
Quellennummer	
Ortsdosisleistung	
Wischtest	
Prüfdatum	

Verantwortlicher:

Senatsverwaltung für Arbeit,
Soziales und Frauen

Berlin

Senatsverwaltung für Arbeit, Soziales und Frauen, Oranienstrasse 106, 10969 Berlin

1. Nachtrag zum Zulassungsschein B - 04/98

Gemäß § 23 der Strahlenschutzverordnung (StrlSchV) vom 13. Oktober 1976 in der Fassung der Bekanntmachung vom 30. Juni 1989 (BGBl. I S. 1321; ber. S. 1926) zuletzt geändert durch 4. VO zur Änderung der StrlSchV vom 18.08.1997 (BGBl. I S. 2113) wird auf Antrag des Zulassungsinhabers vom 11. Februar 2000 die erteilte Bauartzulassung B - 04/98 vom 27. Mai 1998 aufgrund der Umbenennung der Anschrift wie folgt geändert:

Zulassungsinhaber und Hersteller des Ionenmobilitätsspektrometers (Gasspurmonitor):

Institut für Umwelttechnologien GmbH (I.U.T.)
Volmerstr. 9 B
12489 Berlin

Soweit durch diesen Bescheid nicht geändert, gelten die im Zulassungsschein B-04/98 vom 27. Mai 1998 aufgeführten Zulassungstatbestände, Merkmale, Auflagen und Hinweise unverändert fort.

Wenn nicht rechtzeitig eine Verlängerung der Befristung nach § 23 Abs. 2 StrlSchV beantragt wird, ist der Zulassungsschein mit Fristablauf der Zulassungsbehörde unaufgefordert zurückzusenden.

Rechtsbehelfsbelehrung

Gegen diesen Bescheid ist die Klage vor dem Verwaltungsgericht zulässig. Sie ist innerhalb eines Monats nach Zustellung dieses Bescheides beim Verwaltungsgericht Berlin. Kirchstr. 7, 10557 Berlin, schriftlich oder zur Niederschrift des Urkundsbeamten einzulegen; der Klageschrift soll eine Abschrift beigefügt werden. Die Klage ist gegen das Land Berlin, vertreten durch die Senatsverwaltung für Arbeit, Soziales und Frauen, zu richten.

Es wird darauf hingewiesen, dass bei schriftlicher Klageeinlegung die Klagefrist nur dann gewahrt ist, wenn die Klage innerhalb dieser Frist beim Verwaltungsgericht eingegangen ist.

Berlin, den 09. März 2000

Im Auftrag

Beih

5. Manufacturers test certificate

Dräger SAFETY

1. Electrical components	
2. Gas system	
3. Calibration	
Temperature (°C)	
Flow in (ml/min)	
Relative Humidity (%)	
Substance	
Range (ppb)	
MDC (ppb)	
Alert (ppb)	

Berlin, den

Place and date of issue

Name and signature of authorized person

Dräger Safety AG & Co. KGaA
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Handelsregister:
Amtsgericht Lübeck HRB 4097

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Dräger Safety Verwaltungs AG
Vorstand:
Prof. Dr.-Ing. Albert Jugel (Vors.)
Thomas Holzgreve

6. Abbrivations and technical terms

Abbrivations and technical terms	Meaning
Dimer	complex of two identical molecules
IMS	Ion Mobility Spectrometer
FWHM	full width at half maximum
LED	light emitting diode
MDC	minimal detectable concentration
Monomer	single molecule
n/a	not available
ppb	parts per billion (10^{-9})
ppm	parts per million (10^{-6})
RIP	Reaction Ion Peak
SPS	memory programmable control
$T_{Monomer, Dimer, RIP}$	drift time of monomer, dimer or reaction ions
UV	ultaviolett (radiation)
VDC	Volt, direct current
ß	beta radiation (fast electrons)
ß(-)	ionization by a tritium radiation source, negative mode
ß(+)	ionization by a tritium radiation source, positive mode

CONTENTS

A Safety regulations

1. Power supply

The power supply is +24 VDC.

2. Use of the correct fuse

Please use attached fuses only. Otherwise the device may be destroyed.

3. Do not remove front or backside panels

Within the IMS high voltages up to 2 kV are used. Touching inner parts of the device is dangerous.

4. Operation in explosive atmosphere

If you would like to use the IMS in an explosive atmosphere, please order a protected version. The standard version is not equipped for this case.

5. Electrical overload

Never use voltages, which are not specified for this device.

6. Gas flow

Ambient air is soaked into the device continuously with a flow rate of 200 ml/min. In case of integration of the IMS into other gas systems this gas flow must be kept. Otherwise the gas inlet system may be destroyed.

7. Use of dust filter

The IMS is equipped with a dust filter. This polypropylene filter with a teflon membran protects the device against liquids and dust.

8. Grounding

If the device is not operated in a grounded rack, please connect a grounded wire to the voltage input socket (see page 16, item 19).

9. Circulation filter replacement

The circulation filter must be replaced at least every 6 months by the Draeger Service or an authorized contractor.

10. Radioactive radiation source

Within the IMS cell a weak radioactive radiation source is used (see attachment XII/2). The radiation cannot penetrate the walls of the IMS cell. Do

not open the IMS cell. According to the German regulation for radiation protection (StrlSchV from 2001/07/26) all owners of an IMS are obliged

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- to keep a copy of the document of technical compliance (Bauartzulassung) and the user manual close to the device,
- not to modify the device in a way that its radiation protection is changed,
- not to use the device if it is worn out, broken or destroyed,
- to take the device of service if the technical compliance is revoked.

§ 71 StrlSchV
to announce the loss of the device.

B Description of the Draeger IMS

I. Introduction

Obtaining a Draeger IMS you have got a high-tech device, which can detect a variety of toxic gases and vapours in ambient air and meets the increasing demands of emission and immission control. It can be used as a control station in industrial environments as well as an analyser for the detection of environmental pollutions and for searching of toxic compounds.

The physical principle is based on the different drift velocities of positive and negative ions in a homogeneous electric field at atmospheric pressure. Ambient air arrives at an ion source and is ionized there. A weak radioactive radiation serves as ion source. Complex positive ions like $NH_4^+, NO^+, (H_2O)_n H^+$ are produced and originate the so called reaction ion peak (RIP^+) in the recorded spectrum. The negative reaction ion peak RIP^- is related to ions like O_2^- and $(H_2O)^-$ which are always present.

In case that the ambient air contains hydrocarbons or a phosphororganic or halocarbon compound M, charge transfer reactions take place

$$RIP^+ + M \rightarrow RIP + M^+ \quad \text{(positive mode)},$$
$$RIP^- + M \rightarrow RIP + M^- \quad \text{(negative mode)}.$$

Electric pulses applied to a shutter grid (see Fig. 2) push the ions into the drift region of the IMS cell. In a homogeneous electric field the ions move with different drift velocities due to their mobilities. They arrive at different times - their individual drift time - at the collector electrode and cause an ion current. So, a specific molecular ion can be identified by its drift time. The ion current is proportional to the concentration of the compound M.

The ion current is amplified and digitalized. The data are processed by a 32 bit microprocessor. The concentrations of up to 16 compounds can be visualized on a alphanumerically display. The whole spectrum can be monitored by a PC or oscilloscope.

II. Components of the IMS

The basic components of the IMS are shown schematically in Fig. 1.

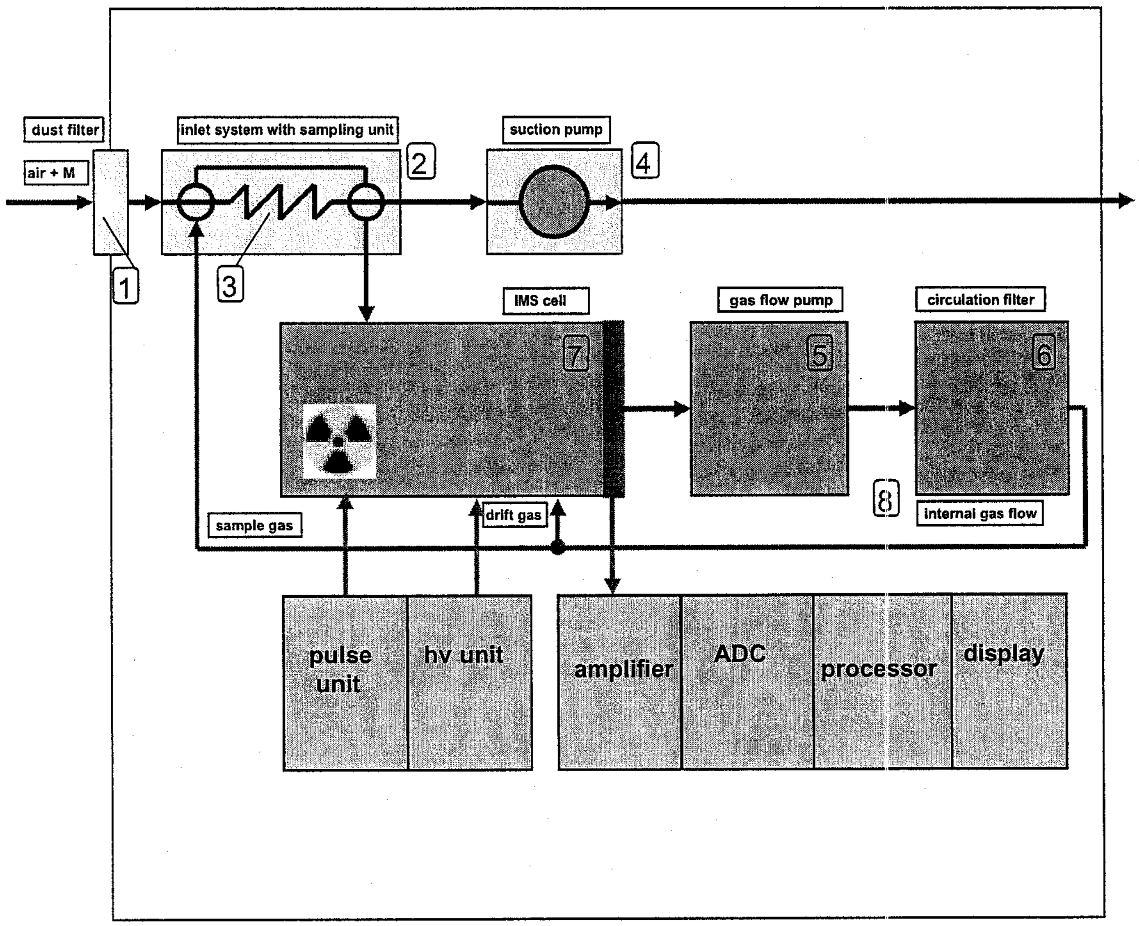


Figure 1:

1 dust filter
2 inlet system with sampling unit
3 sampling loop
4 suction pump
5 gas flow pump
6 circulation filter
7 IMS cell
8 internal gas flow

1. Gas system

1.1. Inlet system

Ambient air containing a compound M is continuously soaked by a pump (4) through a dust filter (1) into the sampling loop (0,5 cm^3) of the inlet system (2) and leaves the systems at the gas exit. The sampling loop (3) is periodically moved into the internal gas flow (8), which passes the ionization source within the IMS cell (7). The sampling frequency is controlled by the processor and can be varied in a wide range.

1.2. Internal gas flow

The IMS has an internal air flow. By means of a pump (5) dry air is supplied as drift gas (400 ml/min) and as a sample gas flow (50 ml/min), which transports the sample from the inlet system to the ionization source. After passing the IMS cell both gas streams enter the circulation filter (6). Here, water vapour and analysed compounds are absorbed.

1.3. Circulation filter

The circulation filter can absorb water vapour in the order of 10 % of its own mass. If humidity in the internal air flow increases above 10 ppm, the resolution of the spectrometer decreases. If the IMS operates continuously the circulation filter has to be changed after 6 months of operation. It will be regenerated by Draeger.

2. IMS cell

In Fig. 2 the IMS cell is shown schematically.

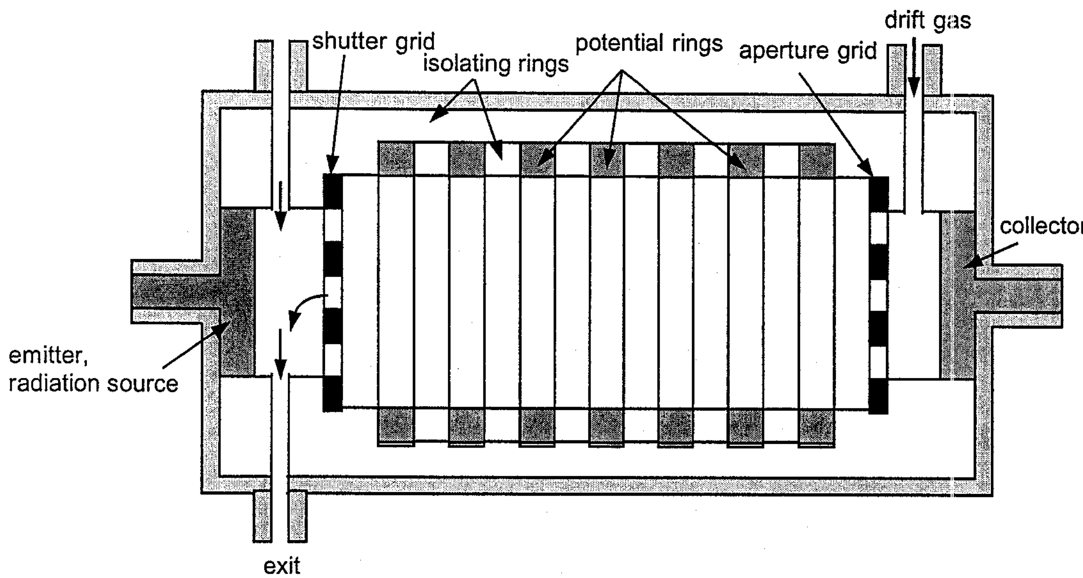


Figure 2:

2.1. Radiation source

The radiation source consists of a stainless steel disc, on which a titanium layer is fixed containing tritium with a radiation activity of 5...500 MBq. This layer is shielded twice by silicium dioxide and aluminium layers.

The radiation source serves as one of the electrodes of the IMS cell and causes ionization in the adjacent gas layer . The shutter grid separates the ionization space from the drift region.

2.2. Drift tube

The drift tube is a cylinder of 5 cm length and 10 mm diameter. The design uses potential rings alternating with insulating ones. The electric field is 400 Volts/cm. The collector electrode at the right end of the drift tube is protected by an aperture grid and connected directly to the amplifier. The IMS cell, the internal gas loop, and the circulation filter are designed as a compact unit. Special materials guarantee a safe electrical function.

3. Electrical components

3.1. *Amplifier*

The ion current is amplified by an impedance transformer. Its time constant is about 50 µs, the gain is $5 \cdot 10^9$ V/A.

3.2. *Pulse unit*

The pulse width at the shutter grid is about 60 µs, the pulse height 400 V. Such pulses allow to push 30-40 % of the produced ions into the drift cell. Resolution and sensitivity are enhanced by this special pulse regime.

3.3. *A/D-Converter*

The analog signal at the amplifier output can be directly displayed on an oscilloscope. Each IMS is equipped with two BNC connectors for viewing the signal and the trigger pulse. Afterwards the analog spectrum is digitalized with high resolution.

3.4. *Microprocessor*

All electronic units of the device are controlled by a 32 bit Motorola processor. The following functions are available in data processing:

- signal accumulation,
- subtraction of spectra,
- choice of 16 time windows (in the regions of interest) for compounds to be identified,
- determination of the peak height's in the time windows as a measure for concentration,
- entering of calibration data.

3.5. *Data output ports*

- Alphanumerical display,
- analog outputs (BNC connectors), digital output (RS 232),
- current loops for 8 time windows in the 4-20 mA range.

III. Applications

In accordance with the ion-molecule reactions mentioned above the charge transfer between "air" ions and molecules M depends on the proton or electron affinity of the compound M. The larger the affinity the lower is the detectable concentration of this compound.

Ions are identified by their mobilities. Ion mobilities depend on various molecular parameters: mass, charge, charge distribution, cross section, structure, bonds etc. Generally, ion mobility depends on gas temperature and pressure.

The exact identification of a compound M is only possible if its ions lead to a separate peak in the spectrum. Important application fields for selected compounds are given below:

Off-gases:	Cl_2, NH_3, HCN, NO_X, SO_2, HCl
Aldehydes:	Formaldehyde, Acetaldehyde
Halogens and halogenated hydrocarbons:	J_2, Br_2, Cl_2, F_2, Methylchloride, Chlorobenzene, Phosgene, (Chloromethyl)methylether, Dichlorethen, etc.
Isocyanates and precursors:	Toluene 2,4-diisocyanate, Toluene 2,4-diamine, Phosgene, Chlorine
Nitrocompounds:	DNT, TNT and other explosives
Chemical warfare agents:	Soman, Sarin, Tabun, VX, Mustard, N-Mustard, Lewisite, HCN
Aromates:	Toluene, Xylene, Phenol, Aniline, Ethylbenzene
Solvents:	Acetone, Methanol, Ethanol, Phenol, Acrylonitrile, Dimethylether, Ethylacetate, Butylacetate
Microelectronic compounds:	Diborane, Phosphine, Arsine
Bad smalls:	H_2S, Mercaptans, Amines

The drift times for selected compounds are listed in attachment XII/1.

IV. Resolution of the IMS

The resolution R of a drift cell is defined as the ratio of the ion drift time divided by the peak width (FWHM). Peak width is the most important parameter. It depends on the width of the shutter pulse, on the diffusion and repulsion of ions during the drift, and on the space charge distribution too. The resolution improves with increasing electric field strength. Draeger designed three types of IMS cells with various resolution. Their parameters are listed in the table:

Type	year of design	R	drift tube length
IUT-25	1993	25	2,5 cm
IUT-50	1995	50	5,0 cm
IUT-100	1996	100	10,0 cm

The IUT-50 cell is used in the Draeger systems. It may be equipped with radioactive or photoionization sources. Optionally, the IMS may be equipped with a special gas separation column. This so called GC-IMS produces 3-dimensional spectra with more analytical information.

The quality of an IMS cell can be easily checked from the structure of the reaction ion peaks which in reality consists of several peaks (Fig. 3).

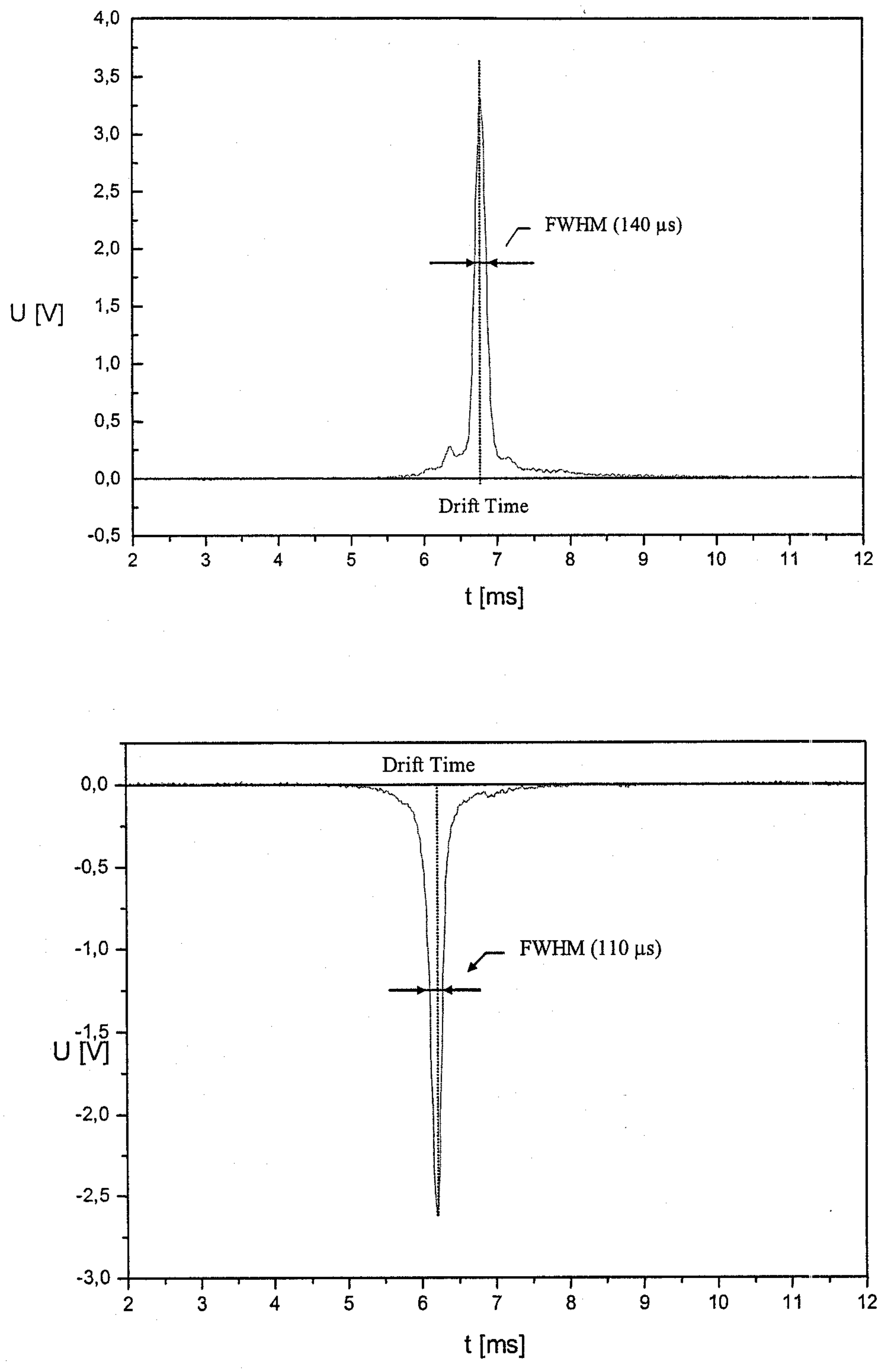


Figure 3: Typical reaction ion peaks for positive and negative modes respectively

V. Minimal Detectable Concentration (MDC)

The detection of a chemical compound is limited by the fluctuation of the ion current at the collector. Generally, a signal is still detectable if the signal amplitude is equal to the 3σ-value of the ion current fluctuations. The MDCs of the Draeger IMS are calculated in this way. Concentrations are given as parts per billion (ppb) or parts per million (ppm) respectively. These dimensionless concentrations can easily be transferred into mass per volume concentrations like microgram or milligram per cubic meter. For example, the maximal allowed HCN-concentration at working places is

$$MAK(hydrocyanic\ acid) = 10\frac{ml}{m^3} = 11\frac{mg}{m^3} = 11\frac{\cdot 22{,}4}{M \cdot 10^3 \cdot 1000} = 9\,ppm = 9000\,ppb\,.$$

VI. Interferences and how to avoid them

When mixtures of chemical compounds enter the ionization source, cross interferences may occur. The peak(s) of each compound may change because of interactions between different ions. There are many analytical situations in which interferences do not play an important rule. That is, for example, the case if one or several compounds with large affinities have to be detected among others with weak affinities. The problem to detect a compound with weak proton affinity in a matrix of compounds with large affinities can be solved only by means of an additional gas separation column. So, for example, the determination of benzene becomes possible in presence of high toluene concentrations.

VII. Overloading of the IMS

The input concentration of an IMS typically ranges from 1 ppb up to some ppm. Overloading by high concentrations must be avoided.

As mentioned above, the IMS operation requests low water vapour concentrations in the internal air flow, usually below 10 ppm. The sampling of very wet gases will shorten the lifetime of the circulation filter and hence of the device.

C Operation instructions

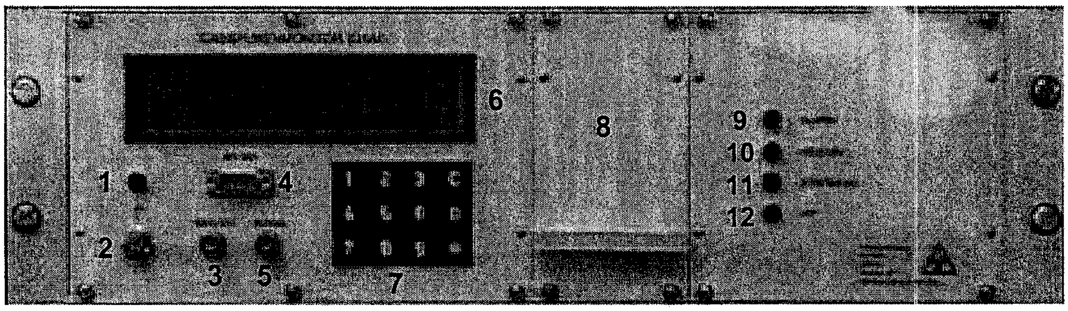
VIII. Technical data

1.	Dimensions	350 x 480 x 130 cm^3
2.	Mass	10 kg
3.	Gases, Sensitivities	see attachments XII/1 and XII/5
4.	Display and Signal Output	alphanumerically display for selected compounds and their concentrations in ppb BNC connector (oscilloscope) RS 232 (PC) current loops 4-20 mA (attachment XII/5)
5.	Alarms	optical, per definition (attachment XII/5)
6.	Concentration Range	1000 x MDC
7.	Ready for Operation	1 hour after power is switched on
8.	Reaction Time	several seconds
9.	Dead Time	120 s
10.	Operation Temperature	0 - 50 °C
11.	Humidity	0 - 90 % relative humidity
12.	Power Supply	+24 VDC
13.	Power Consumption	24 W
14.	Ionization Source	see attachment XII/2
15.	Data storage	flash card, 3240 values in two blocks

IX. Control elements

The most important control elements on the front and backside panels are:

Front panel:

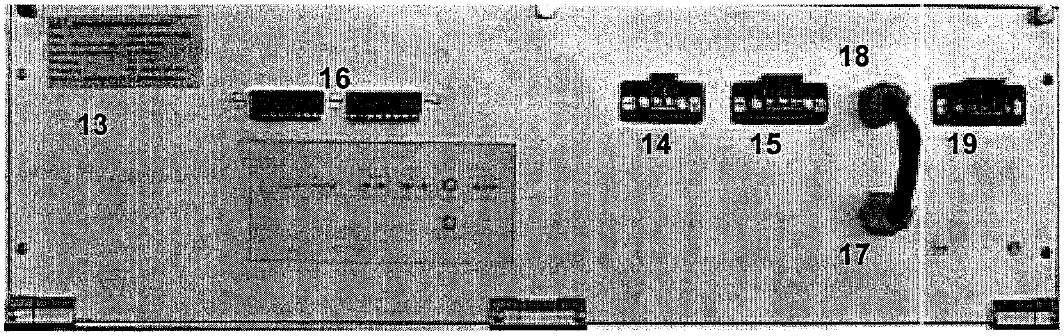


1	Control LED for power supply
2	Power button
3	Trigger output (oszilloscope)
4	RS 232 interface
5	Signal output (oszilloscope)
6	Alphanumerical display
7	Keyboard
8	Circulation filter unit
9	Control LED alarm
10	Control LED heater
11	Control LED flow (suction pump in Fig. 1)
12	Control LED RIP

The control elements on the keyboard are:

button C:	Start/Enter
button *:	Stop/Escape
button 1:	Selection of operation modes
buttons 1-4:	Display of configuration parameters

Backside panel:



13 Model designation
14 +24 VDC trigger input for SPS (remote sampling control)
15 Relay control for operation failure
16 8 current loops, 4–20 mA (+24 VDC)
17 Gas outlet
18 Gas inlet
19 +24 VDC power socket

X. Start of operation

In accordance with designation of the control elements in chapter IX!

When power is switched on the gas flow pump (5 in Fig. 1) and the processor are started. The processor is checking all positions of the start procedure, which are displayed. After 15 s the first „select script"-picture is displayed:

Select Script	1 Select
New: CLEANING	C Start
Run: CLEANING	* Config

It shows the current running mode (Run: CLEANING), which always flushes, and a new possible operation mode (New: CLEANING). If button **1** is pressed in sequence all operation modes, defined in accordance with users requests, are shown one after another. If button **C** is pressed the new operation mode is activated. If button ***** is pressed a submenue shows the different configuration parameters

- Configuration Data (battery, pressure, temperature),
- Configuration Scan,
- Configuration Script,
- Configuration Intern.

1. Selection and start of the operation modes

Push button **1** to select and button **C** to activate the desired operation mode. The following modes may appear one after another:

CLEANING	cleaning of the IMS cell
n_key1_15	manually executable mode (negative) sampling time: 15 s sampling: button **1** display: Substance 1, Substance 2, ..., RIP
n_aut_120	automatic sampling mode (negative) sampling time: 120 s display: Substance 1, Substance 2, ..., RIP
n_trg_120	externally triggerable mode (negative) sampling time: 120 s sampling: external trigger signal +24 VDC on (19) display: Substance 1, Substance 2, ..., RIP
p_key1_15	manually executable mode (positive) sampling time: 15 s sampling: button **1** display: Substance 1, Substance 2, ..., RIP
p_aut_120	automatic sampling mode (positive) sampling time: 120 s display: Substance 1, Substance 2, ..., RIP
Test_20mA	test of output current loops 1-8: 20mA display: 8x 20 mA
Test_AHSR	test of alarm-, heater-, flow- and RIP-failure relay display: AHSR_Test
SpeedClean	enhanced cleaning of the IMS cell

The mode n_key1_15 starts automatically 80 s after switch on.

2. Detailed discussion of operation steps

Start the device by pushing the power button. After 15 seconds the following picture is displayed:

picture 1:

Select Script	1 Select
New: CLEANING	C Start
Run: CLEANING	* Config

The device runs in the cleaning mode. The high voltage and sampling are not activated. **Push button C**. The next picture on display appears

No Windows defined

The device is still in the cleaning mode. **Push button** *. Picture 1 appears again.

Select Script	1 Select
New: CLEANING	C Start
Run: CLEANING	* Config

Push button 1. The mode n_key1_15 is selected.

picture 2:

Select Script	1 Select
New: n_key1_15	C Start
Run: CLEANING	* Config

Push button C to start this mode **(after 60 s it start automatically)**. Negative high voltage is switched on. Sampling of ambient air starts. A measurement can be performed each 15 s by pushing **button 1**. The display shows the compounds in ppb:

Substance 1	0.0	→	0.0
Substance 2	0.0	→	0.0
RIP	0.0	→	60.2

The mode works if the 'RIP' digits change from 0.0 into numbers.
In case of substance detection the digits 0.0 for Substance 1 or/and Substance 2 change into numbers too and the corresponding current output loops are activated (4-20 mA).
Push button *. Picture 2 appears again, high voltage and sampling are switched off.

Select Script	1 Select
New: n_key1_15	C Start
Run: CLEANING	* Config

Pushing button 1 leads to the other operating modes.
Pushing button C starts the selected operating mode (after 60 s it starts automatically)

3. Stop of operation

- The operation mode has to be finished by pushing **button** *.
- For transportation and storage switch power off.

The device should be **ALWAYS** switched on.

4. Data storage

All measured values are written to the internal flash card of the device. For a sampling time of 120 s the measured data of the last 120 h are stored. They will be maintained in case of switching power off. For data readout use the installed IMS Software GSM Reader as follows:

- switch the device on,
- connect device and PC with the cable,
- open the GSMReader program on PC,
    - press button "Connect device",
    - press button "Read data",
    - press button "Store your data" and create a filename.

XI. Troubleshooting

Before a service call is released, malfunctions should be identified or located:

1. No display illumination after „power on“

a) **Cause:** no power supply
Action: connect the device to +24 VDC

2. Display illumination after „power on“, shutting down of the device, acoustical signal “beep”

a) **Cause:** power consumption is too high
Action: min. 24 V/1A

3. Operation modes can not selected by pushing button 1

Cause: bad connection, dysfunction of the data evaluation
Action: new start

4. RIP values (reaction ion peak) < 3 are displayed, LED RIP (see page 15) is on

a) **Cause:** moisture break trough
Action: call Draeger service for circulation filter change

b) **Cause:** dysfunction of the gas flow pump (Fig. 1)
Action: call Draeger service

c) **Cause:** high voltage is not switched on
Action: restart the mode

d) **Cause:** high voltage is broken
Action: call Draeger service

e) **Cause:** concentration of compounds in the IMS cell are too high
Action: wait

If points a-e do not help please call the Draeger service.

5. RIP values (reaction ion peak) > 3 are displayed, the test substance does not cause a signal, LED flow (see page 15) is on

Cause: gas flow through the entrance system is stopped
Action: substitute the dust filter, check the pump (4) of the entrance system, check the magnetic valves

If no improvements are reached, call the Draeger service.

XII. Attachements

1. Table of selected chemical compounds

Compound	$\frac{T_{Monomer}}{T_{RIP}}$	$\frac{T_{Dimer}}{T_{RIP}}$	other peaks	MDC (ppb)	Ionization
Alcohols					
Butanol	1.19	1.41	1.68	10	β(+)
Cresol	1.14			10	β(+)
Cyclohexanol	1.28	1.35	1.58	10	β(+)
Ethanol	1.06	1.15		10	β(+)
Heptanol	1.42	1.81		10	β(+)
Methanol	0.97	1.03		20	β(+)
Tetrahydrofurfurylalcohol	1.16	1.43		10	β(+)
Alcanes					
Cyclohexane	1.04	1.09	1.13	50	β(+)
Heptane	1.12			50	β(+)
Isooctane	1.03	1.11	1.16	50	β(+)
Nonane	1.55			50	β(+)
Aldehyde					
Butylaldehyde	1.13	1.22	1.30	10	β(+)
Formaldehyde	0.99			10	β(+)
Heptylaldehyde	1.35	1.72		10	β(+)
Propionaldehyde	1.04	1.16	1.33	10	β(+)
Amines					
Amphetamine	1.13	1.67		1	β(+)
Diaminobutane	1.1	1.30		10	β(+)
Diaminobutane	1.34	1.75		10	β(-)
Diaminopropane	1.26			10	β(+)
Diaminopropane	1.34	1.75	0.93	10	β(-)
Dimethylformamide	1.04	1.26		1	β(+)
1,1-Dimethylhydrazine	1.24			1	β(+)
Dimethylurea	0.91	0.94	1.10	1	β(+)
Hexamethylentetramine	0.96	1.17		10	β(+)
Hexylamine	1.21	1.60	0.92	1	β(+)
Hydrazine	1.04	1.14		10	β(-)
Methylhydrazine	1.24			1	β(-)
Methylhydrazine	0.85	0.92	1.05	1	β(+)
Nicotine	1.38	2.12		2	β(+)
Nonafluorobutylamine	1.44			1	β(-)
Aromates					
Benzene	0.96			5	UV
Chlorophenol	1.33	1.69		10	β(-)
Cumene	1.15	1.17		5	UV
Dimethoxybenzene	1.16	1.29	1.61	10	β(+)
Ethylbenzene	1.20	1.60		5	β(+)
Iodobenzene	0.95			10	β(-)
Nitrobenzene	1.26	1.55		10	β(-)
Phenol	1.27			10	β(-)
p-Xylene	1.08			5	UV
Toluene	1.02			5	UV

Compound	$\frac{T_{Monomer}}{T_{RIP}}$	$\frac{T_{Dimer}}{T_{RIP}}$	other peaks	MDC (ppb)	Ionization
Carbon acids					
Acetic acid	1.06	1.17		10	β(+) (β(-)
Formic acid	1.13	1.20			β(-)
Esters					
Ammoniumacetate	0.85	0.91	0.95	1	β(+)
Ethylacetate	1.11	1.36		1	β(+)
Ethylacetoacetate	1.18	1.39	1.62	1	β(+)
Phthalic acid diethylester	1.05	1.15		1	β(+)
Phthalic acid dibutylester	1.19	1.40		1	β(+)
Phthalic acid dioctylester	1.11	1.28	1.36	1	β(+)
Ethers					
Diethylether	1.08	1.25		1	β(+)
Divinylether	1.20	1.69	1.75	1	β(+)
Halogenated Hydrocarbons					
Amylchloride	0.91	0.98	1.04		β(-)
Amylchloride	1.29	1.75			β(+)
Chlorbromomethane	0.93	1.03	1.50		β(-)
Chloroacetonitrile	0.91	0.98	1.14		β(-)
Chlorotrimethylsilane	1.21	1.36			β(-)
Chlorodimethylether	0.82			5	β(-)
Dichlorethane	0.91	0.98		5	β(-)
Dibromethane	0.93	0.96	1.05		β(-)
Dibromobutane	0.93	0.96	1.05		β(-)
Dibromomethane	0.93	0.96	1.05		β(-)
Dibromopropane	0.93	0.96	1.05		β(-)
Isobutylchloride	0.91	0.96	1.34		β(-)
n-Butylchloride	0.91	0.98	1.04		β(-)
Methylchlorid	0.82			1000	β(-)
Trichlorethylene	0.93	0.96	1.44		β(-)
Trichlorfluoromethane	0.97	1.03			β(-)
Vinylchloride (VC)	1.20			100	UV
Ketons					
Acetone	1.12			1	β(+)
Acetophenone	1.20	1.58		1	β(+)
Acetylacetone	1.12	1.44	1.46		β(+)
Acetylacetone	1.05	1.26			β(-)
Benzophenone	1.36	1.95			β(+)
Cumene	1.15	1.17			UV, ß(+)
Ethylmethylketone	1.07	1.27		1	β(+)
Hexanone	1.21	1.53			β(+)
Phosphororganic compounds					
Malathion	1.13	1.37			β(+)
Tributylphosphite	1.19	1.41	1.56	1	β(+)
Tricresylphosphate	1.69	2.49		3	β(+)
Pyridine					
Pyridine	1.02	1.27		10	β(+)
2-Dimethylpyridine	1.67	1.40		10	β(+)

Compound	$\frac{T_{Monomer}}{T_{RIP}}$	$\frac{T_{Dimer}}{T_{RIP}}$	other peaks	MDC (ppb)	Ionization
Others					
Acroleine	1,13				β(+)
Ammonia	0,90	0,85		1	β(+)
Arsine (with modified grid)	1.03	1.16		10	UV
Dibutylsulfite	1.32	1.84			β(+)
Carbon disulfide	0,96			5	β(-)
Chlorine	0,95			10	β(+)
Diborane	0,94			10	β(-)
Ethylenoxid	1,04	1.25		100	ß(+)
Hydrochloric acid	0,91			25	β(-)
Hydrocyanic acid	0,92			5	β(-)
Hydrogen sulfide	0,93			10	β(-)
Nitric oxide	0,95			50	β(-)
Nitrogen dioxide	0,90			5	β(-)
Phosgene low	0,87	0,96		0,5	β(-)
high				100	
Phosphine	n/a			n/a	n/a
Sulfur dioxide	1,04			10	β(-)
Sulfur hexafluoride	1,13			10	β(+)
tert-Dibutylmalonate	1.04	1.27			β(+)

Remarks:

1) MDCs are valid for compounds in synthetical air at 20 °C.
2) Other compounds may be measured on request.

2. Source certificate

Certificate

for the Tritium source of the IMS-device

IMS type :	ARTB-0001 *X* gas sample loop chamber with membrane
Designation of source:	H-3, No.- 015 / 00
Type of source:	quasi-sealed radioactive source (look at the document of technical compliance B - 04/98 (Bauartzulassung)
Activity:	925 MBq; 20 MBq; 50 MBq; 4,4 GBq
Reference time:	04.06.2002
Decay/Radiochemistry:	no radioactive product of decay; inactive ^3He is produced.
Type of radiation:	β^- - emission
Energy of radiation:	average energy 5,68 keV maximum energy 18,70 keV
Half lifetime:	12,4 years 10 days biological as ^3H_2O
H-3 Radiation constant (dose rate, bremsstrahlung)	9,9 10^{-9} mSv h^{-1} GBq^{-1} at a distance of 1 m
Factor of equivalent dose:	< 0,1 mSv cm^2 h^{-1} kBq^{-1}
Radiation absorption:	air: 1 mm, water: 1 µm, tissue: 6 µm
Location of the source:	fixed inside the IMS-device. The source is safe against contact, it can not be touched from outside.
Dose rate of the device:	< 1 µSv h^{-1} at a distance of 0,1 m from the touchable surface of the device.
Description of the source:	If necessary, the construction of the source can be examined with the technical drawing No. RID3.57-02:04 at the I.U.T. Ltd. The Tritium is bonded as Titanium titride and sealed with oxides of Silicon and Aluminium.

20.03.2003 / M. Leonhardt
Date / sign