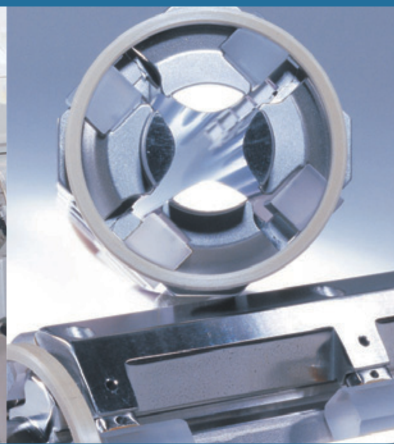
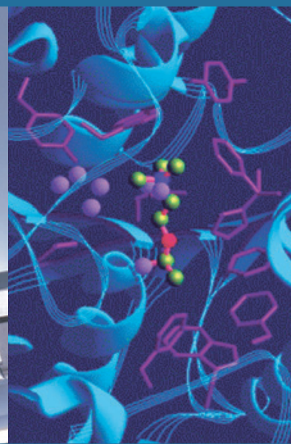
Thermo Fisher Scientific

# DELTA V Plus
## Operating Manual

Revision B - 1184270





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# Übereinstimmungserklärung gemäß ISO/IEC 17050-1:2004

Declaration of conformity according to ISO/IEC 17050-1:2004
Dichiarazione di conformità alla ISO/IEC 17050-1:2004

| | |
|---|---|
| **Name des Herstellers:**<br>manufacturers name<br>nome produttore | Thermo Fisher Scientific |
| **Adresse des Herstellers:**<br>manufacturers address<br>indirizzo produttore | Hanna-Kunath-Strasse 11<br>28199 Bremen<br>Germany |

**erklärt, dass das Produkt**
declares that the following product
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## Delta V plus

**mit den folgenden Produktspezifikationen übereinstimmt:**
complies with the following product specifications
rispetta le seguenti specifiche del prodotto

| | |
|---|---|
| **EMV (Störemissionen):**<br>EMC (emissions)<br>EMC (emissioni) | EN 50081-1; EN 55022 class B |
| **EMV (Störfestigkeit):**<br>EMC (immunity)<br>EMC (immunità) | EN 61000-3-2, -3; EN 61000-4-2, -3, -4, -5, -6, -11; EN 61000-6-2; EN 50204 |
| **Elektrische Sicherheit:**<br>electrical safety<br>sicurezza elettrica | EN 61010-1 |
| **Ergänzende Informationen:**<br>complementary information<br>informazioni complementari | ____________________ |

Dieses Produkt erfüllt die EMV-Richtlinie 89/336/EWG und Niederspannungsrichtlinie 73/23/EWG.
This product complies with EMC directive 89/336/EEC and Low Voltage Directive 73/23/EEC.
Questo produtto rispetta la direttiva 89/336/EEC e la direttiva 73/23/EEC.

**Bremen, Germany, 2. März 2007**

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( Jörg Behrens )

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# Read This First

Welcome to the Thermo Scientific DELTA V Plus system! The DELTA V Plus mass spectrometer is a member of the Thermo Scientific family mass spectrometer (MS) detectors.

## About This Guide

This *DELTA V Plus Operating Manual* describes the modes of operation and principle hardware components of your DELTA V Plus instrument. In addition, this manual provides step-by-step instructions for cleaning and maintaining your instrument.

## Who Uses This Guide

This *DELTA V Plus Operating Manual* is intended for all personnel that need a thorough understanding of the instrument (to perform maintenance or troubleshooting, for example). This manual should be kept near the instrument to be available for quick reference.

## Scope of This Guide

This *DELTA V Plus Operating Manual* includes the following chapters:

- Chapter 1: "Getting Started" describes important basic information in getting familiar and working with the DELTA V Plus mass spectrometer.
- Chapter 2: "Frame" topologically outlines the four sides of the DELTA V Plus mass spectrometer in succession together with their important parts.
- Chapter 3: "Electronic Components Outside the Electronics Cabinet" outlines electronic components that are not located within the electronic cabinet at the rear side of the DELTA V Plus mass spectrometer.
- Chapter 4: "Dual Inlet System" depicts functional units of an optional Dual Inlet system, for example valves, Multiport, Microvolume, Changeover Valve, and Changeover Extension.
- Chapter 5: "Analyzer" describes the analyzer layout, ion source, collector systems, amplifiers, voltage-frequency converters, and the electromagnet.

- Chapter 6: "Operation" describes important operations concerning ion source, magnet, cups, and an optional Dual Inlet system.
- Chapter 7: "Maintenance Operations" provides procedures necessary for maintaining and repairing components of the DELTA V Plus mass spectrometer. Remarks only for Thermo Fisher Scientific field service engineers are given as well.
- Chapter 8: "Diagnosis" outlines diagnostic criteria for operating the DELTA V Plus mass spectrometer.
- Chapter 9: "Spare Parts and Consumables" lists important replaceable parts for the DELTA V Plus mass spectrometer.

# Related Documentation

In addition to this guide, Thermo Fisher Scientific provides the following documents for DELTA V Plus mass spectrometers:

- *DELTA V Series/MAT 253 Preinstallation Requirements Guide*
- *ConFlo IV Operating Manual*
- *GasBench II Operating Manual*
- *Kiel IV Carbonate Device Operating Manual*
- *TC/EA Operating Manual*
- *LC IsoLink Operating Manual*
- *GC IsoLink Operating Manual*
- *LC IsoLink Preinstallation Requirements Guide*

The software also provides Help.

# Contacting Us

There are several ways to contact Thermo Fisher Scientific.

## Assistance

For technical support and ordering information, **visit us on the Web**:

www.thermoscientific.com/ms

Service contact details for customers in Europe are available under:

www.thermoscientific.com/euservicecontact

## Customer Information Service

cis.thermo-bremen.com is the Customer Information Service site aimed at providing instant access to

- Latest software updates
- Manuals, application reports, and brochures

Thermo Fisher Scientific recommends that you register with the site as early as possible. To register, visit register.thermo-bremen.com/form/cis and fill in the registration form. Once your registration has been finalized, you will receive confirmation by e-mail.

## Changes to the Manual

❖ **To suggest changes to this manual**

- Please send your comments (in German or English) to:

  Editors, Technical Documentation
  Thermo Fisher Scientific (Bremen) GmbH
  Hanna-Kunath-Str. 11

  28199 Bremen

  Germany

- Send an e-mail message to the Technical Editor at

  documentation.bremen@thermofisher.com

You are encouraged to report errors or omissions in the text or index. Thank you.

# Typographical Conventions

This section describes typographical conventions that have been established for Thermo Fisher Scientific manuals.

## Data Input

Throughout this manual, the following conventions indicate data input and output via the computer:

- Messages displayed on the screen are represented by capitalizing the initial letter of each word and by italicizing each word.
- Input that you enter by keyboard is identified by quotation marks: single quotes for single characters, double quotes for strings.
- For brevity, expressions such as “choose **File > Directories**” are used rather than “pull down the File menu and choose Directories.”
- Any command enclosed in angle brackets < > represents a single keystroke. For example, “press **<F1>**” means press the key labeled F1.
- Any command that requires pressing two or more keys simultaneously is shown with a plus sign connecting the keys. For example, “press **<Shift>** + **<F1>**” means press and hold the <Shift> key and then press the <F1> key.
- Any button that you click on the screen is represented in bold face letters. For example, “click **Close**”.

## Topic Headings

The following headings are used to show the organization of topics within a chapter:

Chapter 1 Chapter Name

Second Level Topics

Third Level Topics

Fourth Level Topics

# Safety and EMC Information

In accordance with our commitment to customer service and safety, this instrument has satisfied the requirements for the European CE Mark including the Low Voltage Directive.

Designed, manufactured and tested in an ISO9001 registered facility, this instrument has been shipped to you from our manufacturing facility in a safe condition.

This instrument must be used as described in this manual. Any use of this instrument in a manner other than described here may result in instrument damage and/or operator injury.

**Notice on Lifting and Handling of Thermo Scientific Instruments**

For your safety, and in compliance with international regulations, the physical handling of this Thermo Scientific instrument *requires a team effort* for lifting and/or moving the instrument. This instrument is too heavy and/or bulky for one person alone to handle safely.

**Notice on the Proper Use of Thermo Scientific Instruments**

In compliance with international regulations: If this instrument is used in a manner not specified by Thermo Fisher Scientific, the protection provided by the instrument could be impaired.

**Notice on the Susceptibility to Electromagnetic Transmissions**

Your instrument is designed to work in a controlled electromagnetic environment. Do not use radio frequency transmitters, such as mobile phones, in close proximity to the instrument.

## Safety and Special Notices

Make sure you follow the precautionary statements presented in this guide. The safety and other special notices appear different from the main flow of text. Safety and special notices include the following:

**Warning** Warnings highlight hazards to human beings. Each Warning is accompanied by a Warning symbol. ▲

**Caution** Cautions highlight information necessary to protect your instrument from damage. ▲

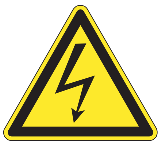
**Note** Notes highlight information that can affect the quality of your data. In addition, notes often contain information that you might need if you are having trouble. ▲

# Identifying Safety Information

This guide contains precautionary statements that can prevent personal injury, instrument damage, and loss of data if properly followed. Warning symbols alert the user to check for hazardous conditions. These appear throughout the manual, where applicable. The most common warning symbols that appear in Thermo Fisher Scientific manuals are shown below.

In addition, every instrument has specific hazards. Be sure to read and comply with all precautions described in this guide. They will help to ensure the safe and long-term use of your system.

**Warning** **General Hazard.** This general symbol indicates that a hazard is present that could result in injuries if it is not avoided.
The source of danger is described in the accompanying text. ▲



**Warning** **Electric Current.** Danger of injury. High voltages capable of causing personal injury are used in the instrument. The instrument must be shut down and disconnected from line power before service is performed. Do not operate the instrument with the top cover off. Do not remove protective covers from PCBs. ▲

**Warning** **Strong Magnetic Field.** Strong magnetic fields are used in the instrument. Keep away from heart pacemakers, computers, credit cards, and any other magnetically sensitive device. Do not bring compressed gas cylinders within close proximity to the instrument. ▲

**Warning** **Hot Surface.** Danger of injury. Treat heated zones with respect. Parts of the instrument might be very hot and might cause severe burns if touched. Allow hot components to cool before servicing them. ▲

**Warning** **Poisonous Gases.** Danger of injury or death. Careless handling of poisonous gases might cause severe personal injury or death. Use appropriate filters and exhaust systems. ▲

**Warning** **Noxious Material.** Danger of injury. Careless handling of noxious material might cause severe personal injury. Wear protective clothing when operating this equipment including insulated gloves and face shield. ▲

**Warning** **Flammable Gases.** Danger of injury. Use care when operating the system in the presence of flammable gases. ▲

## General Safety Precautions

Observe the following safety precautions when you operate or perform service on your instrument:

- The system should be operated by trained personnel only. Read the manuals before starting the system and make sure that you are familiar to the warnings and safety precautions!
- Accurate results can be obtained only if the system is in good condition and properly calibrated.
- Service by the customer should be performed by trained qualified personnel only and should be restricted to servicing mechanical parts! Service on electronic parts should be performed by Thermo Fisher Scientific field service engineers only!
- Before plugging in any of the instrument modules or turning on the power, always make sure that the voltage and fuses are set appropriately for your local line voltage.
- Only use fuses of the type and current rating specified. Do not use repaired fuses and do not short-circuit the fuse holder.
- The supplied power cord must be inserted into a power outlet with a protective earth contact (ground). When using an extension cord, make sure that the cord also has an earth contact.
- Do not change the external or internal grounding connections. Tampering with or disconnecting these connections could endanger you and/or damage the system.
- The instrument is properly grounded in accordance with regulations when shipped. You do not need to make any changes to the electrical connections or to the instrument's chassis to ensure safe operation.
- Never run the system without the housing on. Permanent damage can occur. When leaving the system, make sure that all protective covers and doors are properly connected and closed, and that heated areas are separated and marked to protect for unqualified personnel!

- Do not turn the instrument on if you suspect that it has incurred any kind of electrical damage. Instead, disconnect the power cord and contact a Thermo Fisher Scientific field service engineer for a product evaluation. Do not attempt to use the instrument until it has been evaluated. (Electrical damage may have occurred if the system shows visible signs of damage, or has been transported under severe stress.)

- Damage can also result if the instrument is stored for prolonged periods under unfavorable conditions (for example, subjected to heat, water, etc.).

- Always disconnect the power cord before attempting any type of maintenance.

- Capacitors inside the instrument may still be charged even if the instrument is turned off.

- Never try to repair or replace any component of the system that is not described in this manual without the assistance of your Thermo Fisher Scientific field service engineer.

- Do not place any objects upon the instrument—especially not containers with liquids—unless it is requested by the user documentation. Leaking liquids might get into contact with electronic components and cause a short circuit.

## Safety Advice for Possible Contamination

**Hazardous Material Might Contaminate Certain Parts of Your System During Analysis.**

In order to protect our employees, we ask you to adhere to special precautions when returning parts for exchange or repair.

If hazardous materials have contaminated mass spectrometer parts, Thermo Fisher Scientific can only accept these parts for repair if they have been properly decontaminated. Materials, which due to their structure and the applied concentration might be toxic or which in publications are reported to be toxic, are regarded as hazardous. Materials that will generate synergetic hazardous effects in combination with other present materials are also considered hazardous.

Your signature on the Health and Safety Form confirms that the returned parts have been decontaminated and are free of hazardous materials. Download the form from decon.thermo-bremen.com or order it from the Thermo Fisher Scientific field service engineer.

Parts contaminated by radioisotopes should not be returned to Thermo Fisher Scientific—neither under warranty nor within the exchange part program. If unsure about parts of the system possibly being contaminated by hazardous material, please make sure the Thermo Fisher Scientific field service engineer is informed before the engineer starts working on the system.

# Contents

# Figures

# Tables

# Procedures

# Chapter 1 Getting Started

This chapter describes important basic information in getting familiar and working with the DELTA V Plus mass spectrometer.

It contains the following topics:

# Introduction

This *DELTA V Plus Operating Manual* describes the functions and the fundamental measuring procedures of your DELTA V Plus mass spectrometer. In addition, specific Operating Manuals for the purchased peripherals are supplied.

To obtain a good understanding of the complete system, it is necessary to study this guide before starting up your instrument. A basic knowledge of handling computers and of Isodat 2.5 software is assumed for properly operating the DELTA V Plus mass spectrometer.

To reach a high level of performance with the DELTA V Plus mass spectrometer, we recommend making use of the operator courses we provide at our facilities in Bremen and/or onsite.

## Basic Instrument

The DELTA V Plus mass spectrometer is primarily designated to measure the isotope ratios of H/D, $^{13}C/^{12}C$, $^{15}N/^{14}N$, $^{18}O/^{16}O$, $^{34}S/^{32}S$, $^{37}Cl/^{35}Cl$ and other elements that can be transformed into gaseous substances. The gases used with this type of IRMS are $CO_2$, $H_2$, $N_2$, NO, $N_2O$, $O_2$, $SO_2$, $CH_3Cl$ etc..

The DELTA V Plus mass spectrometer provides a flexible and open platform for the connection of inlet systems and preparation devices. Thermo Scientific-supplied inlet systems are automatically recognized by a “plug and measure” concept. In addition, the system is open for easy connection and control of custom inlet/preparation systems.

For classical applications, the basic instrument can be equipped with a Dual Inlet system. It is of modular design for the adaptation of different inlet modules. This enables a configuration of the instrument tailored to the requirements of the user.

On the sample side can be connected:

- a secondary inlet system for up to 20 samples, that is a Multiport with or without automatic TubeCrackers.
- a Microvolume for very small samples,
- external multisample inlets for separating and purifying samples
- installations for “on-line” coupling to gas chromatographs, Elemental Analyzer, or other peripherals.

The configuration of the inlet systems is described in this guide. Detailed information about other inlet systems such as the “on line” coupling to gas chromatographs or to an Elemental Analyzer is provided in the manual describing the peripheral equipment.

Make yourself familiar with all controls at the front side as well as with all connections and installations on the rear side of your DELTA V Plus mass spectrometer. See Figure 1-1.

**Figure 1-1.** DELTA V Plus IRMS - Front View

## Isodat 2.5

Isodat 2.5 is a software suite for system control, data acquisition and data evaluation that is an integral part of the system architecture.

### System Control

All aspects of the mass spectrometer are controlled by Isodat 2.5, including ion generation, mass separation and ion detection. Control of the ion source allows manual tuning, autotuning, as well as storage and retrieval of ion source parameters.

Different configurations representing different analytical setups can be stored and retrieved. Up to eight simultaneous data acquisition streams are supported.

### Automation

The system is designed to fully automatically execute pre-defined procedures and run sequences of analyses, including customized reporting.

### Open Architecture

Isodat Script Language (ISL) is the tool giving the expert user full access to the mass spectrometer, the inlet systems and additional user-supplied devices. An input-output module allows connection and control of up to five interfaces. Scripts can be developed for customized applications.

### Data Evaluation and Display

Isodat 2.5 provides a comprehensive set of customizable data evaluation routines. Standard report forms are provided according to the application. In addition, reports can be easily customized using Isodat 2.5's Result Workshop.

# Hardware

This section explains hardware-related steps to be performed before any measurement can be started. Refer to your *DELTA V Series/MAT 253 Preinstallation Requirements Guide*.

## First Steps

The following steps are usually performed by a Thermo Fisher Scientific field service engineer:

1. Unpack your IRMS and arrange it at the desired place in your laboratory.

2. Connect your wall outlet or a compressor for compressed air to the compressed air inlet at the rear side of the IRMS (**1** in Figure 2-48) using the blue, transparent tube (8 mm) from the installation package. You need at least 4 bar.

   Usually, the pressure reducer for compressed air, Figure 2-29 and Figure 2-30, is factory-set via the rotary adjusting knob to display 4 bar. To vary the pressure, pull out the rotary adjusting knob or turn it.

3. Lay the waste gas tube (at the output of the pumps) outdoors in order to prevent accumulation of oil mist and perilous gases, for example CO or $H_2$. If available, connect to exhaust vent of your laboratory.

**Warning** **Noxious Material.** Danger of injury. If your system is used to analyze hazardous materials, the effluent from the open-split interface and the exhaust from the rotary pumps must be connected to an adequate exhaust system! ▲

## Power Supply

❖ **To establish power supply for the instrument**

1. Connect your DELTA V Plus IRMS to the power supply.
2. At the rear side of the DELTA V Plus IRMS, five sockets are arranged to connect peripherals, computer equipment etc.. For first tests, the IRMS is checked without any peripheral connected to it. Later, they are connected one at a time.
3. Turn on the IRMS by setting the main switch to position On. The main switch is located at the rear side of DELTA V Plus IRMS.

## Pumping System

Up to two fore pumps are used:

- Pfeiffer “DUO 2.5" for the analyzer
- Pfeiffer “DUO 2.5" for the Dual Inlet system

For detailed information—for example, concerning handling and maintenance—refer to the *Pfeiffer Operating Instructions* of your pumps. Before starting the pumping system, it is assumed that:

- the fore pumps are filled with oil,
- they are connected to the power supply, and
- their gas ballast is shut.

Normally, the fill level of the oil must range between the upper and the lower line, optimally at half height of the level indicator. A total oil exchange is recommended once a year. Refer to the manufacturer’s manual and to www.pfeiffer-vacuum.com.

The gas ballast is shut by turning the switch to position 0. The switch is located sidewise. Refer to the manufacturer’s manual and to www.pfeiffer-vacuum.com.

The Control Panel at the front side, Figure 2-5, shows switches for operating the pumps. The corresponding LEDs are described below.

Turn on the analyzer turbomolecular pump(s) by pressing the "Pumps" switch, **1** in Figure 2-5.

The "Inlet Pump" switch, **6** in Figure 2-5, must only be additionally pressed in case of a Dual Inlet system. If no Dual Inlet system is available, this switch has no function.

- Pump LEDs are yellow, when they are switched on.
- After 15 minutes, the LEDs "Main" (**2** in Figure 2-5) and, if available, "Secondary" (**3** in Figure 2-5) must be green. See Table 2-3.
- If one of the turbomolecular pumps does not reach 80% of the rotation speed after a specific period of time, the pumping system will shut down automatically.
- After 20 minutes, the security threshold should be reached. The ion source can then be switched on.
- Red LEDs "Main", "Secondary" or "Inlet" indicate errors concerning the turbomolecular pumps. For example, after 15 minutes, the security threshold of $\approx 3\times10^{-5}$ mbar has not been reached.

## IRMS-Computer Connection

❖ **To connect the IRMS to the data system computer**

1. To ensure data transfer between IRMS and computer, connect the fiber line to the respective port at the computer's rear side.
2. Connect the other end of the fiber line to the IRMS by inserting the blue plug into the blue connector and the gray plug into the gray connector.
3. To verify whether the quality of the established vacuum is sufficient, use Isodat 2.5.

When connected, Isodat 2.5 is running, and power supply is on, the LED "Connection", **5** in Figure 2-5, will be green.

**Note** If the LED "Connection" (**5** in Figure 2-5) is not green with Isodat 2.5 being started, no connection between IRMS and computer has been established. ▲

## Source Heater

When the source heater (that is the radiation heaters consisting of halogen lamps near the ion source) is turned on, the LED “Heater“ (**8** in Figure 2-5) must be on. Otherwise, one of the heaters might be defective.

**Note** The source heater cannot be switched from outside, but only via Isodat 2.5. See Figure 2-20 on page 2-23. ▲

## Heater of Changeover Valve and/or Needle Valve

Switch on the heater of the Changeover Valve and/or the heater of needle valve (in case of Continuous Flow applications). This helps to prevent water condensation.

## IRMS-Peripheral Connection

❖ **To connect the IRMS to the peripherals**

1. Connect your peripherals to the IRMS using the five equivalent SUB D ports at its rear side. See Figure 2-50 and **1** in Figure 2-51.
2. Establish compressed air supply.
3. Establish the power supply for the peripherals, preferably via the built-in connector, or use an external power supply.
4. Peripherals are identified automatically by a plug and measure concept.
5. If Isodat 2.5 is trying to get access to a peripheral and cannot identify it, an error message occurs.

## Dual Inlet Crimp Adjustment

Crimp adjustment is only important if a Dual Inlet system is available.

❖ **To adjust the crimps**

1. Open the entire Dual Inlet system.
2. Let 50 mbar of $CO_2$ flow into each bellow (“equilibration”).
3. Adjust the crimps for each inlet port until this bellow pressure leads to a signal of 5 V on both sides, that is standard side and sample side. About 10 mbar correspond to 1 V in case of $CO_2$.

Crimp adjustment ensures an approximately constant and slight gas flow. Therefore, gas consumption will be low.

# Software

To use Isodat 2.5 optimally, meet some system requirements. Isodat 2.5 needs certain

- software requirements and
- hardware requirements.

## Software Requirements

It is advantageous if your system meets the recommended requirements:

**Table 1-1.** Software Requirements[a]

| Software requirements (minimal) | Software requirements (recommended) |
|---|---|
| Microsoft™ Windows™ XP (Intel) operating system | Microsoft™ Windows™ XP (Intel) operating system |
| Pentium™ class computer (233 MHz) | Pentium™ class computer (400 MHz or higher) |
| 96 MB RAM | 128 MB RAM (or higher) |
| 100 MB free disk space (only for Isodat 2.5, without backups and result files) | 500 MB free disk space (or higher) |
| Super VGA monitor (resolution 768×1280 pixels) | Super VGA monitor (resolution 1280×1024 pixels) |
| Microsoft™ Windows™ XP supported printer | Microsoft™ Windows™ XP supported printer |

[a] See Figure 2-1 on page 2-2.

## Hardware Requirements

Refer to your *DELTA V Series/MAT 253 Preinstallation Requirements Guide*.

# Chapter 2 Frame

This chapter topologically outlines the four sides of the DELTA V Plus mass spectrometer in succession together with their important parts.

It contains the following topics:

# Front Side

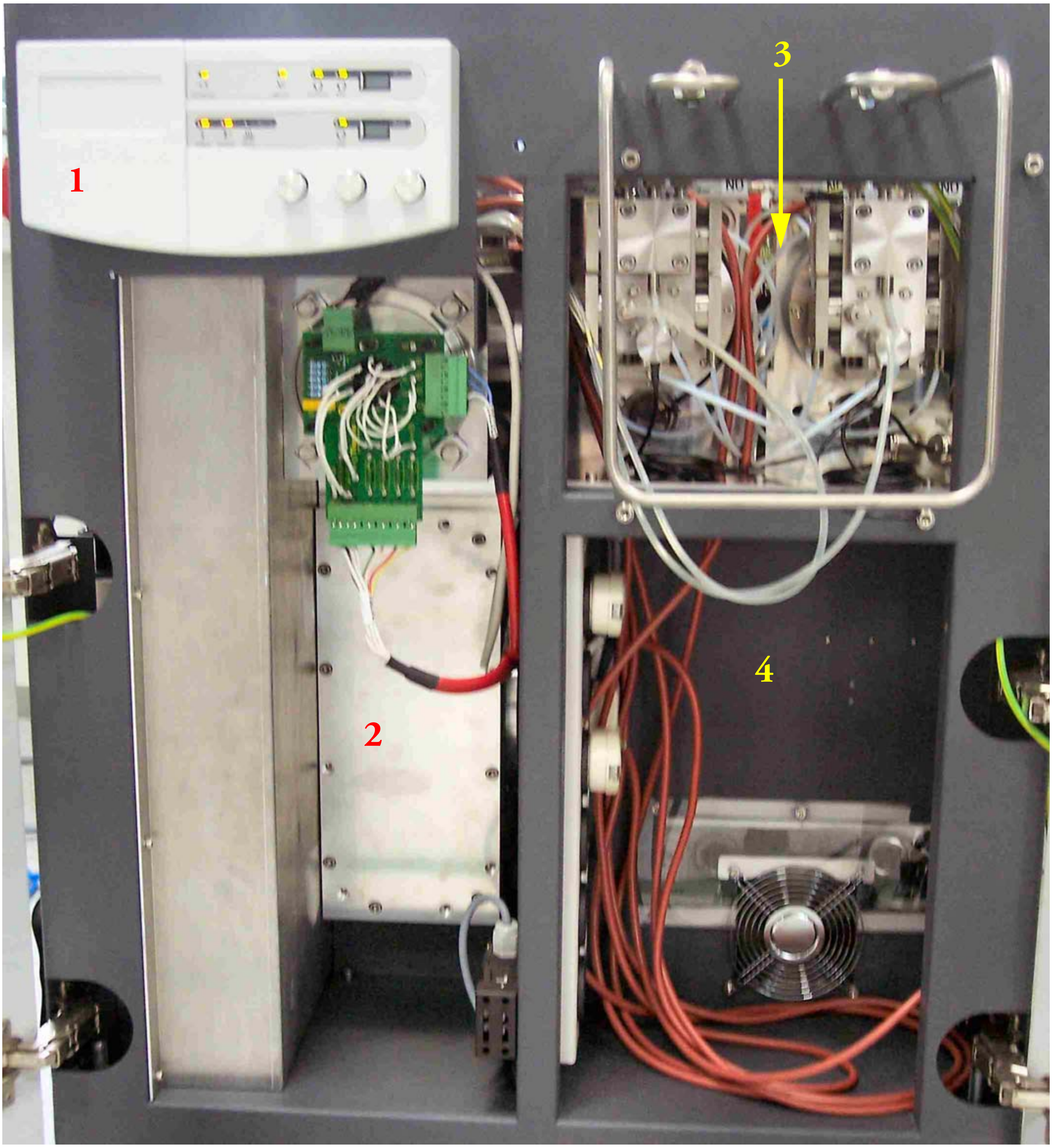



**Figure 2-1.** Cabinets at Front Side

At the front side, you can operate the Control Panel, **1** in Figure 2-1. Additionally, the front side allows access to three different cabinets shown as **2**, **3** and **4** in Figure 2-1. The three cabinets are located behind the three front doors shown in Figure 2-2. Table 2-1 gives an overview.

**Table 2-1.** Cabinets at Front Side[a]

| No. | Access to | Described in Detail at |
|---|---|---|
| 1 | Control Panel | "Control Panel" on page 2-5 |
| 2 | Ion source and amplifiers | "Ion Source" on page 5-7 |
| 3 | Dual Inlet system (optional) | "Dual Inlet System" on page 4-1 |
| 4 | Microvolume and dewar, sockets for heaters, pump inspection (optional) | "Microvolume" on page 4-19 |

[a] See Figure 2-1.

## Front Doors


**Figure 2-2.** DELTA V Plus IRMS - Front Doors

**Table 2-2.** Front Doors of DELTA V Plus IRMS[a]

| Door No. | Comment |
|---|---|
| 2 | Is usually closed and should be opened only by skilled service personnel!<br>Only for Thermo Fisher Scientific field service engineers: Do not grab the door from above, because the Control Panel 1 is located there and thus inhibits access! To open it, unfasten the two M5 socket screws at its edges (one at the bottom and one on top of it) using a socket wrench. Then, grab the door from beneath and pull it out.<br>Gives access to ion source and amplifiers. Access to the ion source is needed, for example for cleaning it during maintenance or for exchanging the filament. Access to amplifiers is needed only in case of an electronic defect.<br>When it is opened, the ion source will be turned off automatically for safety reasons. Conversely, you cannot turn on the ion source (that is, the corresponding LED at the Control Panel stays off), if the door is not properly closed. |
| 3 | In case of a Dual Inlet system, the sample vials together with their supportive brackets are arranged in front of this door.<br>Therefore, it cannot be opened but only hung out (that is removed completely): grasp the door at its top and bottom and then push it away upwards. Hanging it out is especially easy when the lower right door 4 beneath it is open as well.<br>Gives access to the optional Dual Inlet system. If no Dual Inlet system is available, the cabinet may be used as storage space. |
| 4 | May easily be opened by the user by grabbing it from beneath.<br>Gives access to an inspection glass (to control the oil level of the fore pumps), an optional Microvolume together with the related liquid nitrogen container and the socket shelves at the left wall providing various heating elements.<br>If no Microvolume is available, the place behind the door is empty and can be used as storage space to hold spare parts or expendables in readiness (for example a reactor or reactor packing materials, if an Elemental Analyzer is available). |

[a] See Figure 2-2.

## Dimensions of Front Side

Figure 2-3 shows the dimensions of the DELTA V Plus IRMS stand-alone.

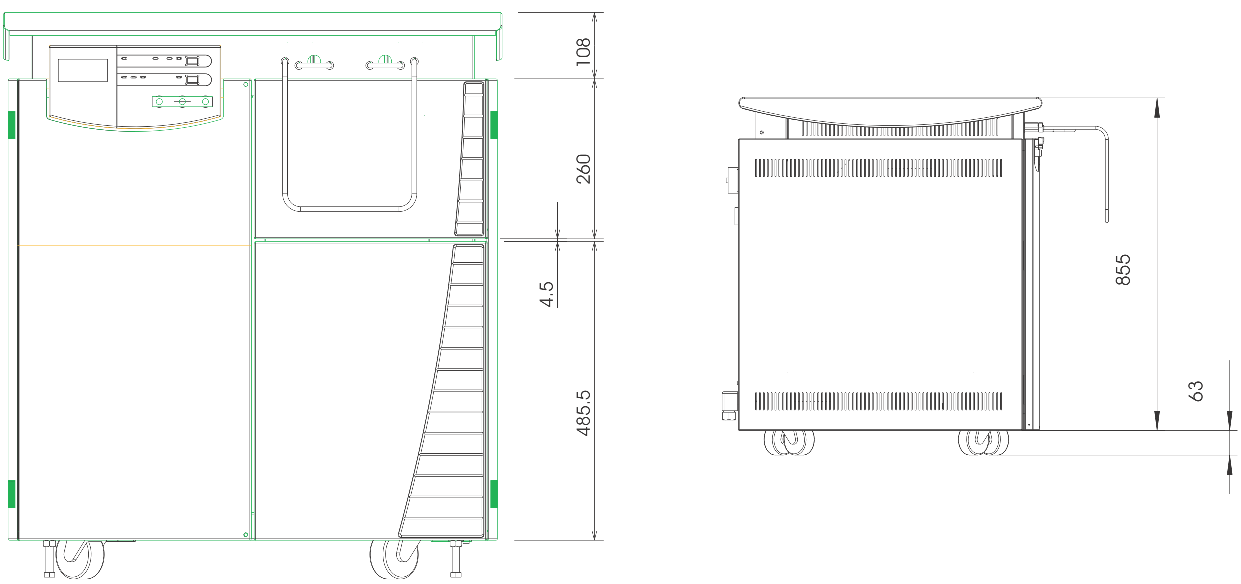



**Figure 2-3.** Dimensions of DELTA V Plus IRMS

Figure 2-4 depicts the dimensions of the DELTA V Plus IRMS together with the optional peripherals table.

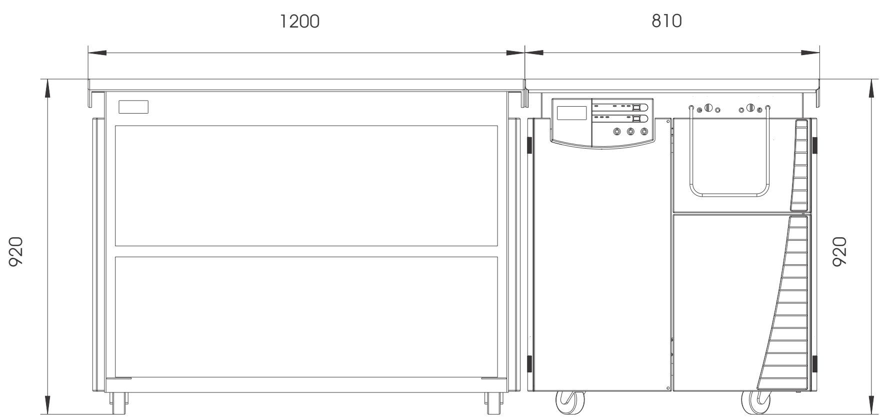



**Figure 2-4.** DELTA V Plus IRMS and Peripherals Table

## Control Panel

The Control Panel, Figure 2-5, is located on top left at the front side. It is divided into two rows with a pump switch and pump-related LEDs each. For the Control Panel board located beneath it, see "Control Panel Board" on page 3-2.

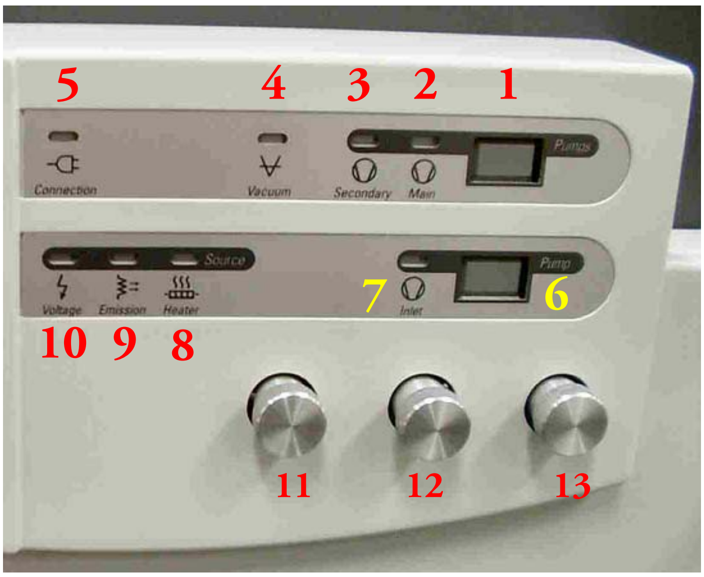



**Figure 2-5.** Control Panel

### Upper Row of Control Panel

**1 Pump**: switch to turn on/off the required analyzer turbomolecular pump (that is, main pump) and the optional analyzer turbomolecular pump (that is, differential pump, if available)

**2 Main**: LED monitors status of required analyzer turbomolecular pump (that is, main pump)

**3 Secondary**: LED monitors status of optional analyzer turbomolecular pump, that is differential pump (if available).

**Table 2-3.** Pump Statuses[a]

| Color of LED | Pump Status |
|---|---|
| yellow | The device has been switched on, but has not yet reached its final operating state. |
| green | The device has reached its final operating state and works properly. |
| red | The pump does not work properly due to a technical problem, defect or whatever kind of error. |
| off (no color) | The device has not yet been turned on, for example the switch to turn on the corresponding pump has not yet been pressed. |

[a] See Figure 2-5.

**4 Vacuum**: LED monitors vacuum quality as summarized in Table 2-4.

**Table 2-4.** Vacuum Statuses[a]

| Color of LED | Vacuum Status |
|---|---|
| off (no color) | Penning gauge is off, because the pumps are off or have not yet reached their final number of revolutions. |
| on | Pumps have reached their final number of revolutions. |
| yellow | Penning gauge is on and works properly, but set point has not been reached yet. |
| green | Pressure has fallen below the set point of Penning gauge. |

[a] See Figure 2-5.

**Note** The ion source can only be switched on when this LED is on! ▲

**5 Connection**: LED monitors power supply and connection to the computer as summarized in Table 2-5.

**Table 2-5.** Power Supply and Connection to Computer[a]

| Color of LED | Power Supply and Connection to Computer |
|---|---|
| off (no color) | No power is available (for example, switched off, fuses, main power cable not plugged in). |
| yellow | Power is available, because main power supply is on and the main switch is at On position. No computer connection or turned off.<br>See Figure 2-44. |
| green | As yellow, but connection to the computer has additionally been established. |

[a] See Figure 2-5.

## Lower Row of Control Panel

6 **Pump**: switch to turn on/off Dual Inlet system turbomolecular pump. If no Dual Inlet system is available, it is inoperable.

7 **Inlet**: LED monitors status of Dual Inlet system turbomolecular pump (if available). If no Dual Inlet system is available, it is inoperable.

**Table 2-6.** Pump Statuses[a]

| Color of LED | Pump Status |
|---|---|
| yellow | The device has been switched on, but has not yet reached its final operating state. |
| green | The device has reached its final operating state and works properly. |
| red | The pump does not work properly due to a technical problem, defect or whatever kind of error. |
| off (no color) | The device has not yet been turned on, for example the switch to turn on the corresponding pump has not yet been pressed. |

[a] See Figure 2-5.

8 **Heater**: LED monitors status of ion source heater, that is of the halogen lamps as radiant heaters as summarized in Table 2-7. It is switched on/off by Isodat 2.5.

**Table 2-7.** Statuses of Ion Source Heater[a]

| Color of LED | Status of Ion Source Heater |
|---|---|
| off (no color) | Ion source heater is switched off or<br>ion source heater is switched on, but not working. |
| green | Ion source heater is switched on. |

[a] See Figure 2-5.

9 **Emission**: LED monitors, whether emission takes place, that is whether the filament is emitting electrons. See Table 2-8.

**Table 2-8.** Statuses of Emission[a]

| Color of LED | Status of Emission |
|---|---|
| off (no color) | The ion source is switched off.<br>It cannot be switched on, because the pumps have not yet reached their final number of revolutions and/or set point of Penning gauge has not been reached. Therefore, vacuum quality is not yet satisfactory. |
| yellow | Vacuum quality is satisfactory, but emission does not take place all the same. For example, the filament has not been switched on or it is out of order. |
| green | All related conditions are in order and therefore emission takes place. |

[a] See Figure 2-5.

**10 Voltage**: LED monitors the status of ion source and of high voltage as summarized in Table 2-9.

**Table 2-9.** Statuses of Ion Source and High Voltage[a]

| Color of LED | Status of Ion Source and High Voltage |
|---|---|
| off (no color) | The ion source is switched off. It cannot be switched on, because the pumps have not yet reached their final number of revolutions and/or set point of Penning gauge has not been reached.<br>Therefore, vacuum quality is not yet satisfactory. |
| yellow | The ion source could be on, but high voltage has not been switched on.<br>For example, vacuum quality is satisfactory, but ion source has been switched off automatically due to a high voltage flashover.<br>For example, all conditions are alright, but ion source has not yet been switched on by the user (must always be done via Isodat 2.5). |

[a] See Figure 2-5.

## Adjusting Knobs for Needle Valve Control

The optional adjusting knobs **11**, **12** and **13** at the Control Panel open and close three equivalent needle valves (more precisely: on/off valves) located at the aluminum-made needle valve heating block close to the ion source. These needle valves are described together with their maintenance at "Needle Valves" on page 7-26.

# Ion Source Cabinet

This section describes the cabinet at the front side that allows access to ion source, amplifiers, and feedthrough. See Figure 2-6 and Table 2-10.

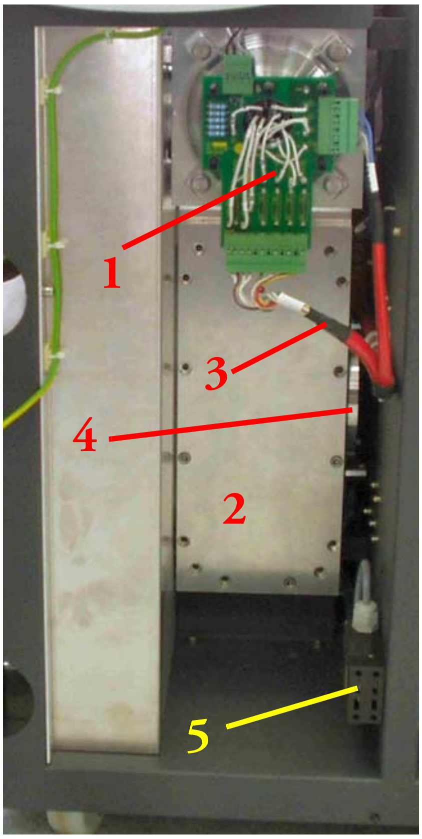



**Figure 2-6.** Ion Source Cabinet

**Table 2-10.** Components of Ion Source Cabinet

| No. | Component | Described in Detail at |
|---|---|---|
| 1 | ion source | "Ion Source" on page 5-7<br>"Ion Source" on page 7-4 |
| 2 | cover plate, shielding<br>- amplifiers,<br>- ground plane amplifier,<br>- ground plane cup and<br>- feedthrough | <br>"Single Amplifiers" on page 7-47<br>"Ground Plane Amplifier" on page 2-11<br>"Ground Plane Cup" on page 2-13<br>Figure 5-12 and Figure 5-16 |
| 3 | ion source supply cable | "Ion Source Supply Cable" on page 2-14 |
| 4 | data logger | "Data Logger" on page 3-3 |
| 5 | safety contact for door | "Safety Contact for Door" on page 2-15 |

## Ion Source

The ion source is directly accessible and can be removed as a whole for maintenance operations. Details about its maintenance are given at "Ion Source" on page 7-4.

## Cover Plate and Amplifiers

If access to the amplifiers is needed, the cover plate **2** can be removed by loosening the screws. It shields up to ten amplifiers as individual electronic boards. No. 1 is the lowermost amplifier, whereas No. 10 is the uppermost one. See their horizontal arrangement below each other in their individual slots in Figure 5-15.

Usually, only three or five out of the five lower ones are equipped and in use. The upper amplifiers, that is No. 6 to No. 10 are optional. They are designated for special purposes requiring more than the five mentioned cups, for example for measurement of air.

The amplifiers are all identical ones, but have different RC combinations according to the individual *m/z* value to be measured. One amplifier can contain at most two RC combinations. A relay allows selecting different RC combinations.

Table 2-11 summarizes the assignment of amplifiers on ground plane cup according to Figure 2-11.

**Table 2-11.** Amplifiers at Ground Plane Cup and *m/z* Values of Cups[a]

| Amplifier No. | m/z |
|---|---|
| 1 | 2 (HD) |
| 2 | 28 ($N_2$), 32 ($O_2$), 44 ($CO_2$), 64 ($SO_2$) |
| 3 | 29 ($N_2$), 33 ($O_2$), 45 ($CO_2$), 66 ($SO_2$) |
| 4 | 30 ($N_2$), 34 ($O_2$), 46 ($CO_2$) |
| 5[b] | 3 (HD) |
| | |
| 6-10 | not pre-set, but arbitrarily configurable[c] |

[a] Example of Universal Triple collector plus HD. See Figure 2-11 and Figure 2-9.

[b] Normally pre-set for HD, but also usable for other gases.

[c] See Figure 6-16.

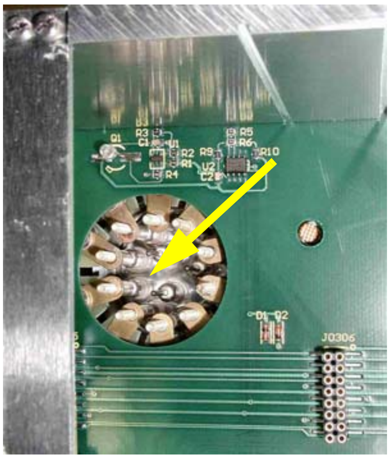


**Figure 2-7.** Cup-to-Amplifier Feedthrough

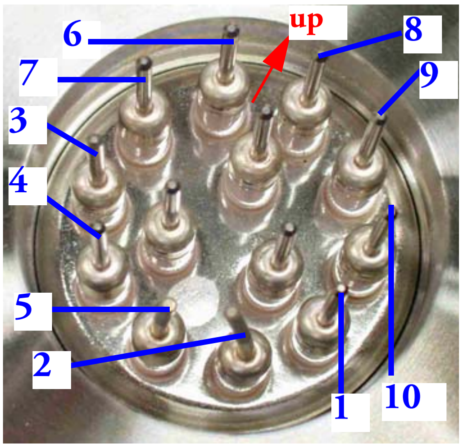



**Figure 2-8.** Feedthrough to Amplifier Number

## Ground Plane Amplifier

Behind the ten amplifiers, the ground plane amplifier, Figure 2-9, is located. This electronic board guarantees their supply voltages and establishes the connection to the data logger.

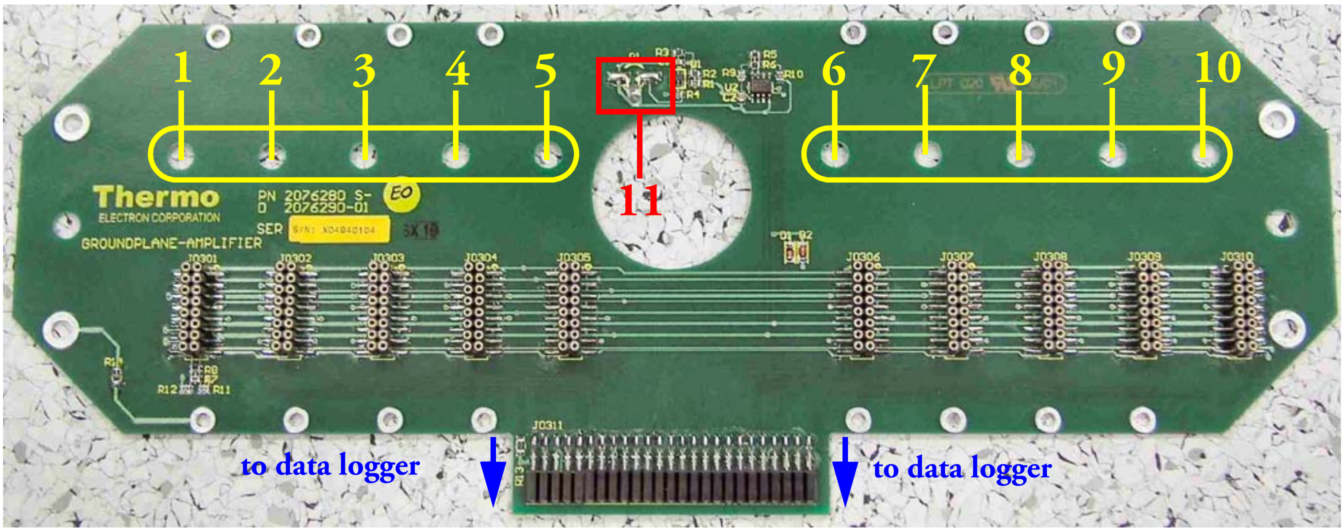



**Figure 2-9.** Ground Plane Amplifier with Amplifier Numbers

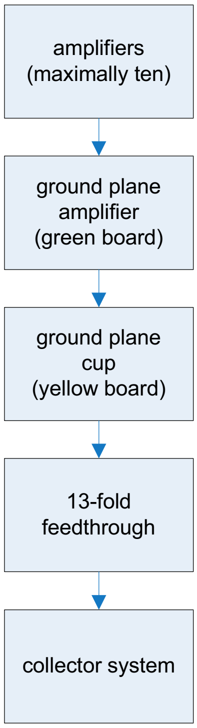
The ten round holes are the transfer points of the measurement signal (gold-made spring contacts) to the ground plane cup, which is arranged below ground plane amplifier.

The ground plane amplifier carries the ten amplifiers and VFCs and connects the amplifiers to the data logger. A photo diode, **11** in Figure 2-9, switches off the supply voltage when the lid of the amplifier housing is removed. It serves as an additional precaution and only works properly when the workplace is sufficiently lit.

**Note** If the ground plane amplifier needs to be removed, first remove the data logger as both are connected to each other by a connector! ▲

**Note** During reinsertion, first insert the ground plane amplifier and then the data logger! ▲

Figure 2-10 schematically displays the arrangement of amplifiers, ground plane amplifier, ground plane cup, 13-fold feedthrough, and collector system.




- The **amplifiers** are stuck onto ground plane amplifier according to Figure 2-9 and Figure 2-11 (the contact springs protrude a little out of ground plane amplifier).
- The **Ground plane amplifier** is arranged directly above **ground plane cup**. See Figure 2-11.
- The ground plane cup is stuck upon the **13-fold feedthrough** by spring contacts. See also Figure 5-12. The maximally ten amplifiers are connected to the 13-fold feedthrough from above.
- Finally, the 13-fold feedthrough is connected to the **collector system** via wires according to **6** in Figure 5-9.

**Figure 2-10.** Ground Plane Amplifier and Ground Plane Cup

Only in case of a Universal Triple collector and an Universal Triple collector plus H/D, the pin positions are predefined. However, depending on the special application, completely different, individual cup configurations may be reasonable, for example

- not all of the ten amplifiers need to be used.
- if several gases or ions are to be measured simultaneously, special collectors may be needed using more than five amplifiers.

  Examples for these particular or combinative applications are:

  - atmospheric measurements, that is $CO_2$, $N_2$, Ar
  - simultaneous measurement of SO/$SO_2$
  - additional measurement of $H_2$, $SF_6$, Kr

**Note** When using more than five amplifiers, a closing plate must be mounted above the uppermost amplifier. It shields magnetic fields and enables switching between amplifiers. Do not remove this closing plate! ▲

## Ground Plane Cup

Below the ground plane amplifier, the ground plane cup is mounted. It is shown in Figure 2-11 and establishes the transfer between 13-fold feedthrough and the ten individual amplifiers. The yellow board is free of lacquer for technical reasons and contains only a few components summarized in Table 2-12.

**Note** On the ground plane cup, springs and contact pins are connected via conducting paths, **f** in Figure 2-9. There are longer and shorter conducting paths: highly sensitive amplifiers have been connected via short conducting paths! ▲

**Table 2-12.** Components of Ground Plane Cup[a]

| Number in Figure 2-11 | Designation |
|---|---|
| a | spring of the contact pin e to the individual amplifier<br>A particular spring presses upon the gold contact of its corresponding amplifier. See 3 in Figure 5-13. |
| b | hole in ground plane cup<br>leads to the 13-fold feedthrough shown in Figure 2-8. |
| c | slit used for insulation<br>Slits guarantee high resistances between the conducting paths and minimize crosstalk. |
| d | screw that fixes the corresponding contact pin e |
| e | contact pin to the 13-fold feedthrough shown in Figure 2-8 |
| f | conducting path<br>is the connection between spring a and contact pin e. |

[a] See Figure 2-11.

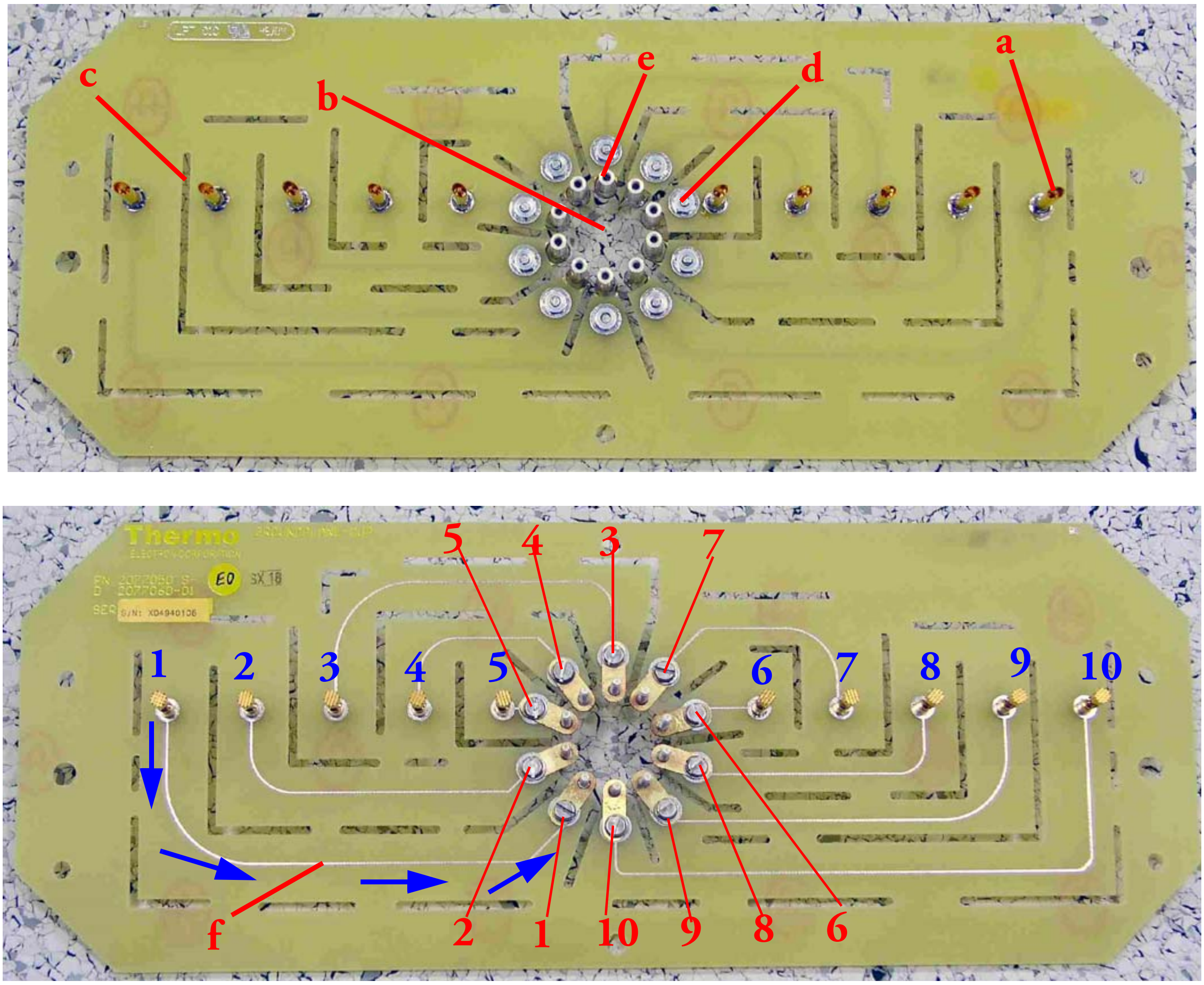



**Figure 2-11.** Ground Plane Cup

## Ion Source Supply Cable

The ion source supply cable, **3** in Figure 2-6, leads to the ion source control board.

## Data Logger

Behind the metallic ring, **4** in Figure 2-6, the data logger is housed. It is accessible from right side panel and is described in detail at "Data Logger" on page 3-3.

## Safety Contact for Door

The safety contact for the door, **5** in Figure 2-6, guarantees that high voltage and emission will both be switched off instantaneously when the door of the ion source cabinet (**2** in Figure 2-2) is opened.

The corresponding two LEDs at the Control Panel will then be off. Operator and ion source will thus be protected from damage.

As soon as the door is closed again, the contact will be re-established. Thereby, the ion source will be supplied again.

**Figure 2-12.** Safety Contact for Door

# Dual Inlet System Cabinet

This section describes the cabinet at the front side that allows access to the Dual Inlet system. See Figure 2-13, **3** in Figure 2-1 and Table 2-13 for the individual components. The Dual Inlet system is an option. If no Dual Inlet system is available, the cabinet is empty.

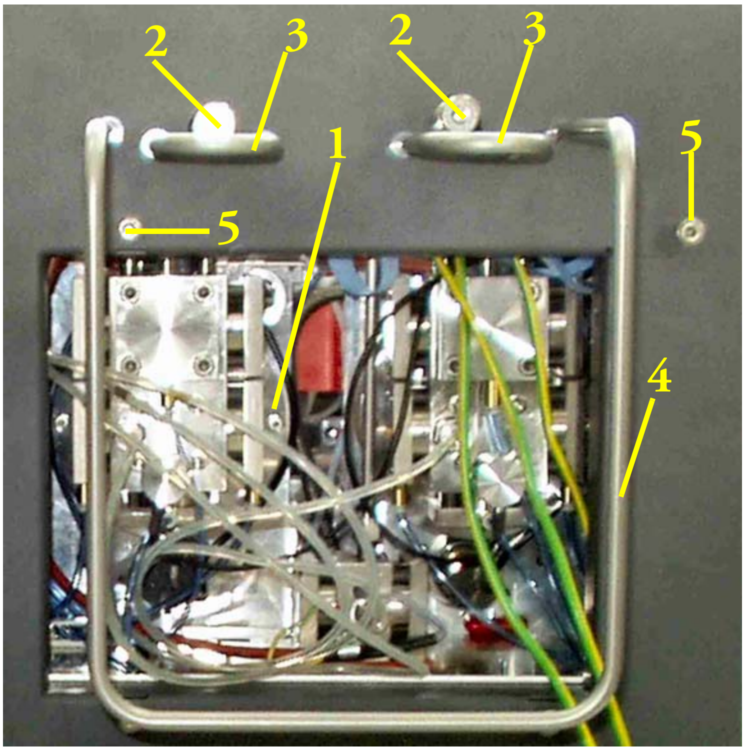



**Figure 2-13.** Dual Inlet System Cabinet

**Table 2-13.** Components of Dual Inlet System Cabinet[a]

| No. | Component | Described in Detail at |
|---|---|---|
| 1 | Dual Inlet system | "Dual Inlet System" on page 4-1 |
| 2 | connection of sample vials (at right and left gas inlet) | "Connection of Sample Vials" on page 2-17 |
| 3 | supportive brackets | "Supportive Brackets" on page 2-17 |
| 4 | protective bracket | "Protective Bracket" on page 2-18 |
| 5 | bolts for panel insertion | "Bolts for Panel Insertion" on page 2-19 |

[a] See Figure 2-13.

## Dual Inlet System

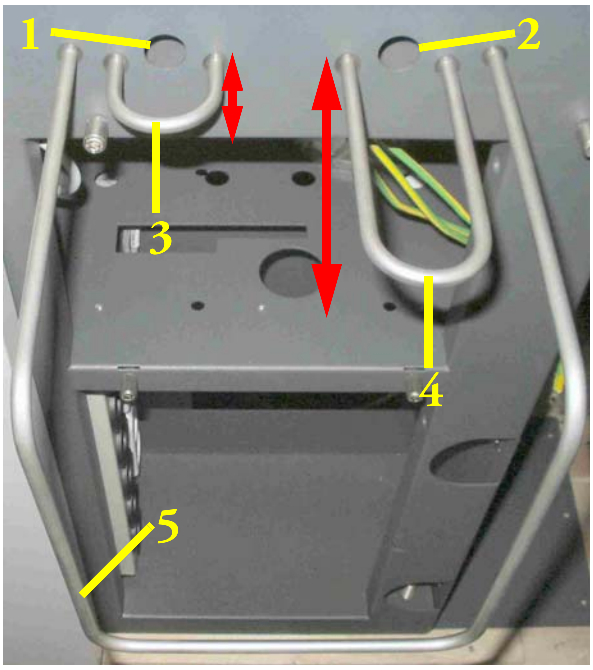
The Dual Inlet system, **1** in Figure 2-13, will be treated in-depth in Chapter 4: "Dual Inlet System" together with its options.

## Connection of Sample Vials

A wide variety of sample vials can be attached at both gas inlets (**2** in Figure 2-13 and **1**, **2** in Figure 2-14). This is possible due to supportive brackets (**3** in Figure 2-13 and **3**, **4** in Figure 2-14).

## Supportive Brackets

The supportive brackets are variable in length. They support the connection between metal and hanging sample vial and relieve it thereby. See Figure 2-15. Thermo Fisher Scientific provides, for example, glass-made sample vials. If no Dual Inlet system is available, the supportive brackets are missing.




Labeled Components: 1=Left gas inlet; 2=Right gas inlet; 3=Supportive bracket for left sample vial variable in length (at minimum length); 4=Supportive bracket for right sample vial variable in length (at maximum length); 5=Protective bracket of Dual Inlet system

**Figure 2-14.** Supportive Brackets - without Sample Vials

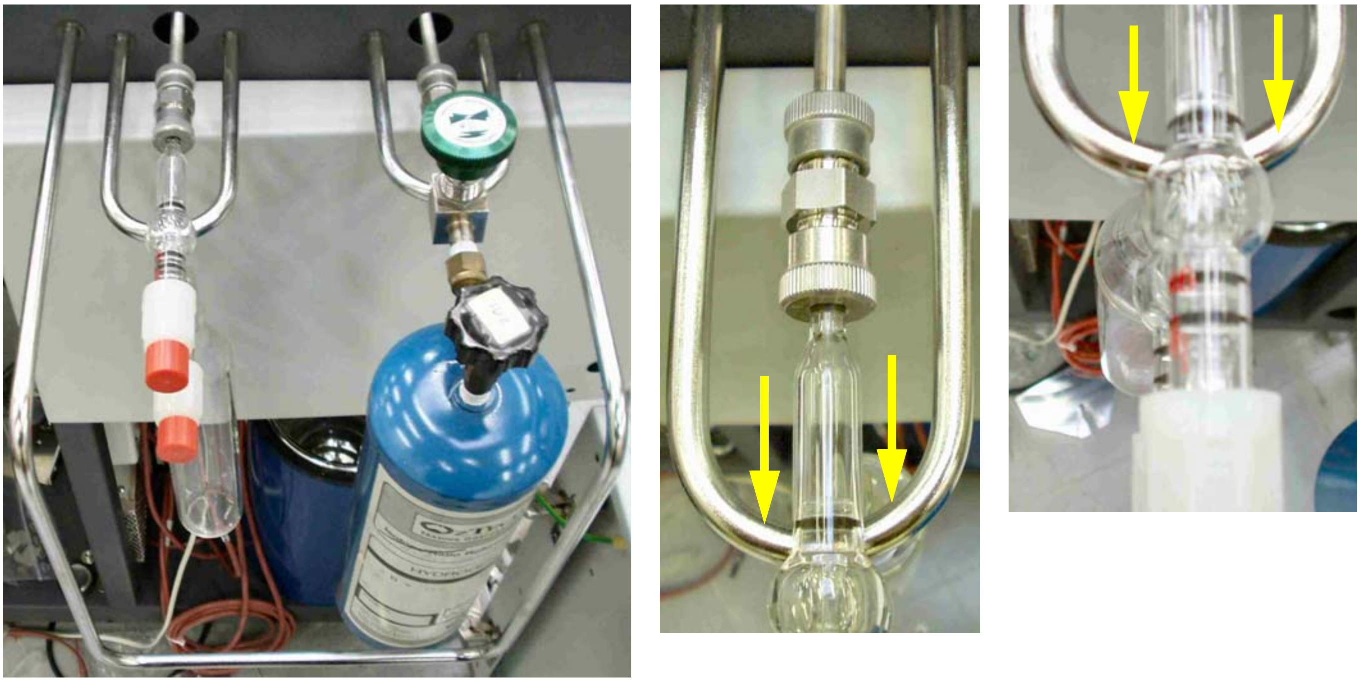


**Figure 2-15.** Supportive Brackets - with Sample Vials Attached

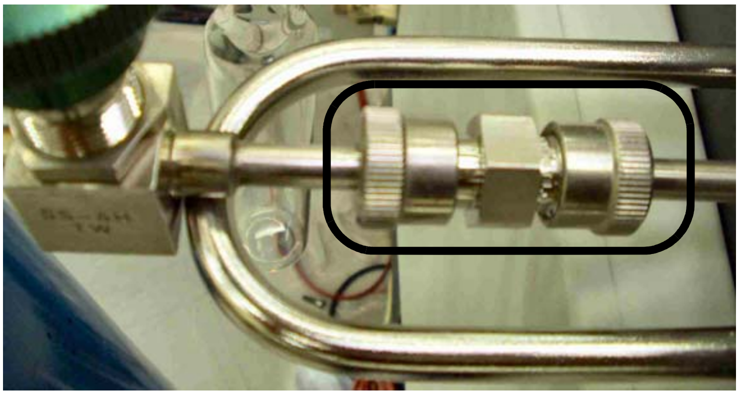


**Figure 2-16.** Screw Connection for Sample Vials

The sample vials are attached to the gas inlets via a screw connection shown in Figure 2-16. These Swagelok-connectors are also used for TubeCracker as displayed as **3** in Figure 4-16.

## Protective Bracket

A protective bracket (**4** in Figure 2-13 and **5** in Figure 2-14) secures the attached sample vials from being broken away, for example when someone operates near them. If no Dual Inlet system is available, the protective bracket is missing.

### Bolts for Panel Insertion

The bolts for panel insertion, **5** in Figure 2-13, allow easily re-inserting panels after they have been removed.

## Microvolume Cabinet

This section describes the cabinet at the front side allowing access to the Microvolume and the parts belonging to it (that is, dewar for liquid nitrogen and Autocool Unit). Furthermore, the sockets for heaters are accessible. The Microvolume cabinet is shown in Figure 2-17 and as **4** in Figure 2-1.

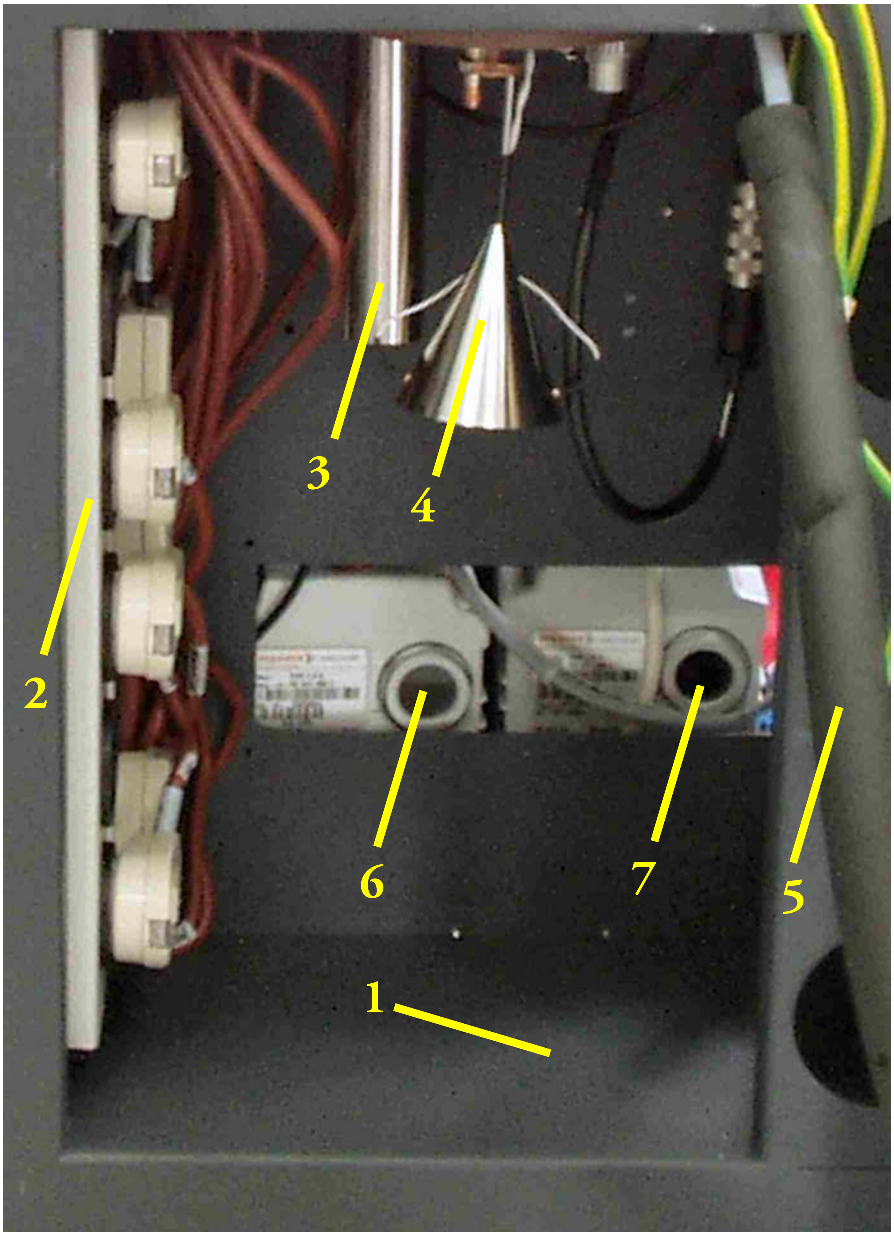



**Figure 2-17.** Microvolume Cabinet

**Table 2-14.** Components of Microvolume Cabinet [a]

| No. | Component | Described in Detail at |
|---|---|---|
| 1 | position of optional Microvolume and Autocool Unit | "Position of Microvolume and Autocool Unit" on page 2-21 |
| 2 | activated sockets and 12 V power supply | "Activated Sockets" on page 2-22 and "12 V Power Supply" on page 2-25 |
| 3 | protective tube for fill level controller | "Protective Tube for Fill Level Controller" on page 4-25 |
| 4 | funnel with integrated heater | "Autocool Unit" on page 4-20 |
| 5 | refill tube for liquid nitrogen | "Refill Tube for Liquid Nitrogen" on page 4-24 |
| 6 | inspection glass of analyzer fore pump | "Inspection Glasses of Both Fore Pumps" on page 2-25 |
| 7 | inspection glass of Dual Inlet system fore pump | "Inspection Glasses of Both Fore Pumps" on page 2-25 |

[a] See Figure 2-17.

## Position of Microvolume and Autocool Unit

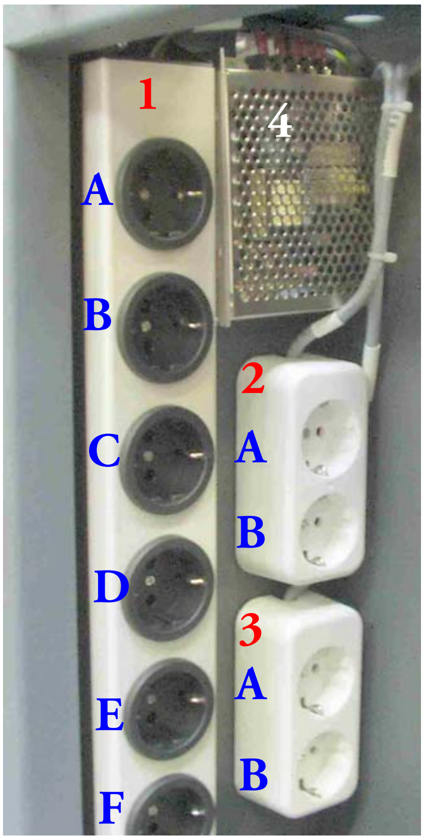
Figure 2-18 shows the dewar **1** containing liquid nitrogen for using a Microvolume. A metallic splash guard **2** protects the activated sockets against liquid nitrogen that may bubble over.


**Figure 2-18.** Position of Microvolume within Microvolume Cabinet

Because Microvolume and Autocool Unit are options of a Dual Inlet system, both will be described in Chapter 4: "Dual Inlet System"; detailed information is given in "Microvolume" on page 4-19 and "Autocool Unit" on page 4-20, respectively.

If no Microvolume is available, the space designated for it (**1** in Figure 2-17) is empty.

## Activated Sockets




1 Group 1 of six equivalent sockets (J1110)

switchable as a group by Isodat 2.5
switchable as individuals manually

2 Group 2 of two equivalent sockets (J1112)

switchable as a group by Isodat 2.5
switchable as individuals manually

3 Group 3 of two equivalent sockets (J1113)

switchable as a group by Isodat 2.5
switchable as individuals manually

4 12 V power supply

S-40-12, 12 V, 3.5 A

**Figure 2-19.** Activated Sockets and 12 V Power Supply

The activated sockets **1**, **2** and **3** in Figure 2-19, are always present. They are controlled by Isodat 2.5 and therefore not switched on all the time.

The activated sockets are **arranged in three groups** of six (J1110), two (J1112) and two (J1113). Accordingly, they provide **three groups of heaters** (and/or heatable valves) with energy. gives an overview.

**Table 2-15.** Assignment of Sockets to Heaters[a]

| Socket No. | Heater of |
|---|---|
| A | Dual Inlet system |
| B | Multiport |
| C | Multiport Extension |
| D | Microvolume |
| E | Trap (125 VA) |
| F | Capillary (185 VA) |
| | |
| A | Needle valve |
| B | Changeover Valve |

**Table 2-15.** Assignment of Sockets to Heaters[a], continued

| Socket No. | Heater of |
|---|---|
| A | Free (for example, for Changeover Extension) |
| B | Free |

[a] See Figure 2-19.

A click on the respective button will turn the individual heater on (green) or off (grey). See polygon in "MS State" window, Figure 2-20.

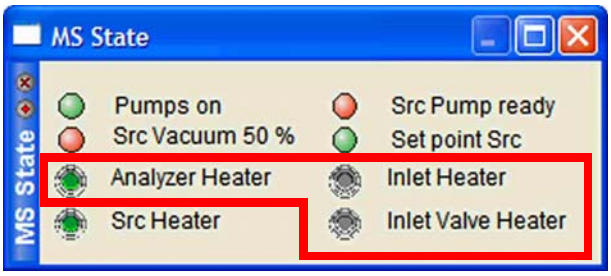



**Figure 2-20.** Controlling Activated Sockets via Isodat 2.5

1. **Analyzer Heater**
   It heats the analyzer block (power of 200 W), has been firmly installed within the analyzer block by screws and is directly connected to the power distribution board. See **7g** in Figure 2-63.

2. **Inlet Heaters**
   They heat components of the Dual Inlet system (for example, Dual Inlet system valve blocks, Changeover Valve, Changeover Extension, Multiport, Microvolume). The inlet heaters are provided with heating energy by arbitrary sockets of socket group **1** in Figure 2-19.

3. **Inlet Valve Heater**
   It can either be switched on or off. Inlet valve heater heats the needle valve where peripherals are connected to (about 80 °C) and Changeover Valve/Changeover Extension as well. It is provided with heating energy by arbitrary sockets of socket group **2** in Figure 2-19.

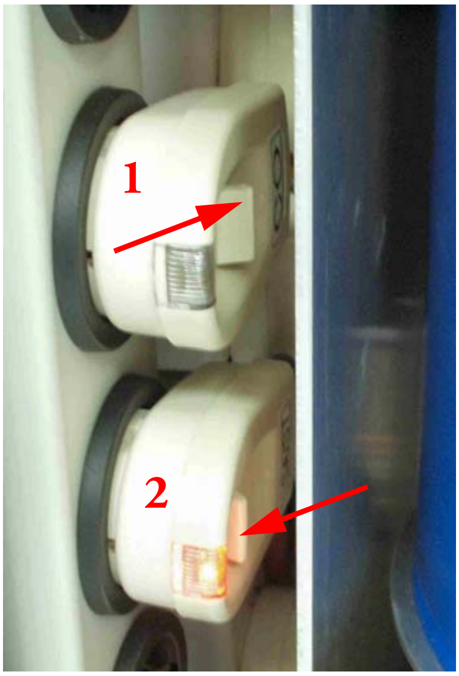
4. **Source Heater (Src Heater)**
   Two serially connected heaters (halogen lamps of 12 V and 35 W nominally; total power of 20 W) heat the ion source. The halogen lamps can either be switched on or off.

**Note** When the source heater is on (off), the LED "Heater" in the lower row of the Control Panel is on (off). See **8** in Figure 2-5. When the source heater is on but the LED "Heater" is off, the lamp is defective. ▲

The activated sockets are also **controlled only as groups** (that is as entire shelves of six, two and two sockets) by Isodat 2.5's Instrument Control.

In addition to this control in groups via Isodat 2.5, you can switch on or switch off **individual** sockets (that is, individual heater elements or valves which are noted at the individual plugs) manually: turn the switch at the corresponding plug up or down. When the integrated lamp at an individual plug is on, the corresponding socket is really activated. See Figure 2-21. Thereby, selected valves can be excluded from being heated.

**Note** To enable manual control, activate the socket via Isodat 2.5 first (that is, the respective button in Figure 2-20 must be green)! ▲




1 socket manually switched off (lamp is off)
socket must be activated in Isodat 2.5 first to get manual access!

2 socket manually switched on (lamp is on)
socket must be activated in Isodat 2.5 first to get manual access!

**Figure 2-21.** Controlling Activated Sockets Manually

Each plug shown in Figure 2-21 is labeled according to the heater it provides with energy (for example, CO for Changeover Valve and Changeover Extension, ST for standard, SA for sample, MV for Microvolume, MP 10 for Multiport 10, MP 20 for Multiport 20, NV for needle valve).

The activated sockets are electronically controlled by relays located at the power distribution board. See Figure 2-63 and **5** in Table 2-28.

## 12 V Power Supply

The 12 V power supply, **3** in Figure 2-19, is located right to the activated sockets and provides the ion source heater with the energy it needs to heat out the ion source. See "Heater Exchange" on page 7-14.

## Inspection Glasses of Both Fore Pumps

Finally, the Microvolume cabinet allows visual access to the inspection glasses of one or two fore pumps, that is analyzer fore pump (left, **6** in Figure 2-17) and Dual Inlet system fore pump (right, **7** in Figure 2-17). Thereby, their oil levels can be checked. For pump maintenance, see "Pumps" on page 7-16.

The fore pumps themselves are described in detail at "Analyzer Fore Pump" on page 2-33 and at "Dual Inlet System Fore Pump" on page 2-34.

# Right Side

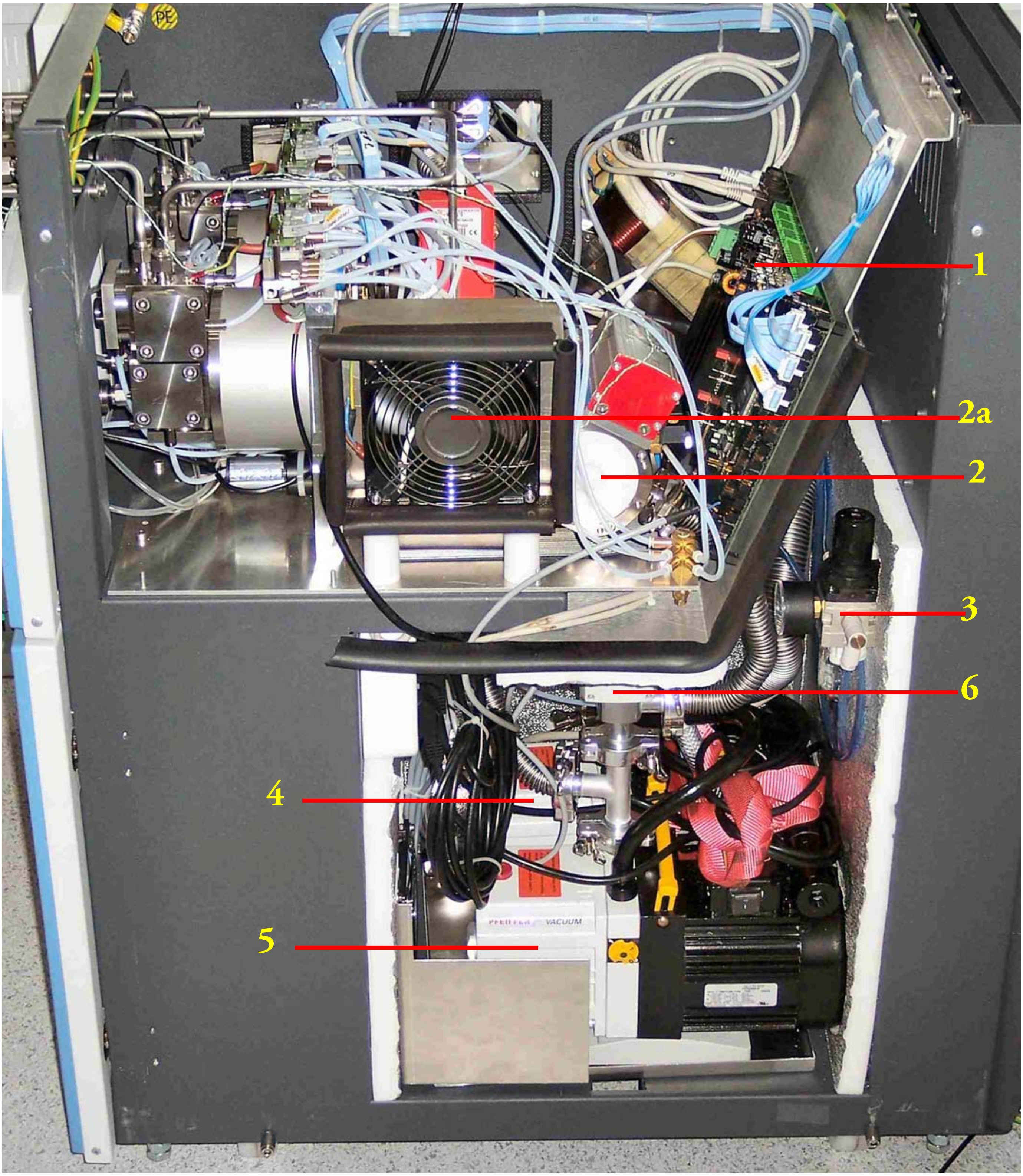



**Figure 2-22.** Right Side of IRMS

**Table 2-16.** Parts Housed on Right Side of IRMS[a]

| No. | Description | Described in Detail at |
|---|---|---|
| 1 | Dual Inlet board (optional) | "Dual Inlet Board" on page 2-28 |
| 2 | Dual Inlet system turbomolecular pump (optional) - with fan 2a | "Dual Inlet System Turbomolecular Pump" on page 2-31 |
| 3 | Pressure reducer for compressed air | "Pressure Reducer for Compressed Air" on page 2-32 |
| 4 | Analyzer fore pump | "Analyzer Fore Pump" on page 2-33 |
| 5 | Dual Inlet system fore pump (optional) | "Dual Inlet System Fore Pump" on page 2-34 |
| 6 | Additional valve (optional) | "Additional Valve" on page 2-35 |

[a] See Figure 2-22.

## Dimensions of Right Side

Figure 2-23 shows the sideways dimensions of the DELTA V Plus IRMS. Both sides of the IRMS are shielded by a metallic side panel.

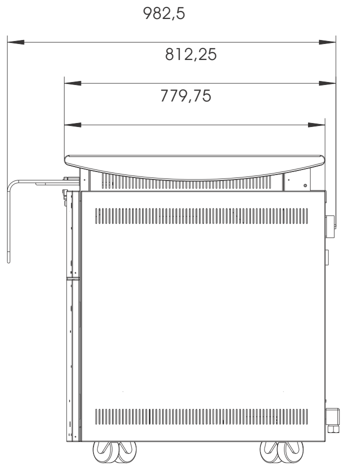



**Figure 2-23.** Dimensions of DELTA V Plus IRMS- Side View

# Right Side Panel

## Mounting and Removing Side Panels

To easily mount the panels, metallic bolts have been arranged on top of the edges of the frame and at their bottom. See Figure 2-24. To remove a side panel, grasp it at its top and bottom (not from aside) and pull it upwards.

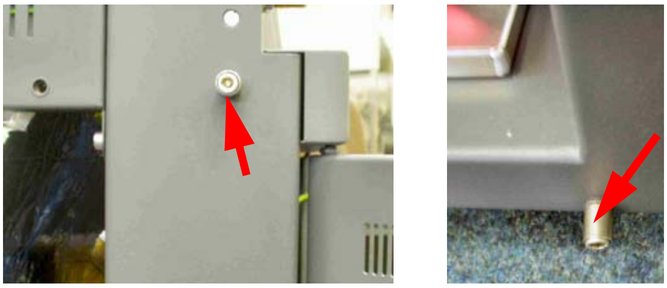


**Figure 2-24.** Bolts at Edges of Frame

**Note** Take care of the green-yellow ground wire which has been stuck onto the side door according to Figure 3-7 and temporarily remove it! ▲

# Dual Inlet Board

## Location

**Note** The Dual Inlet board must be distinguished from the **inlet board** (see “Inlet Board” on page 2-57 and Figure 2-54), which is designated for **external** options and thus located at the rear side of the DELTA V Plus IRMS. ▲

The Dual Inlet Board is located closely to the Dual Inlet system it belongs to. See Figure 2-25 and **1** in Figure 2-22.

## Functions

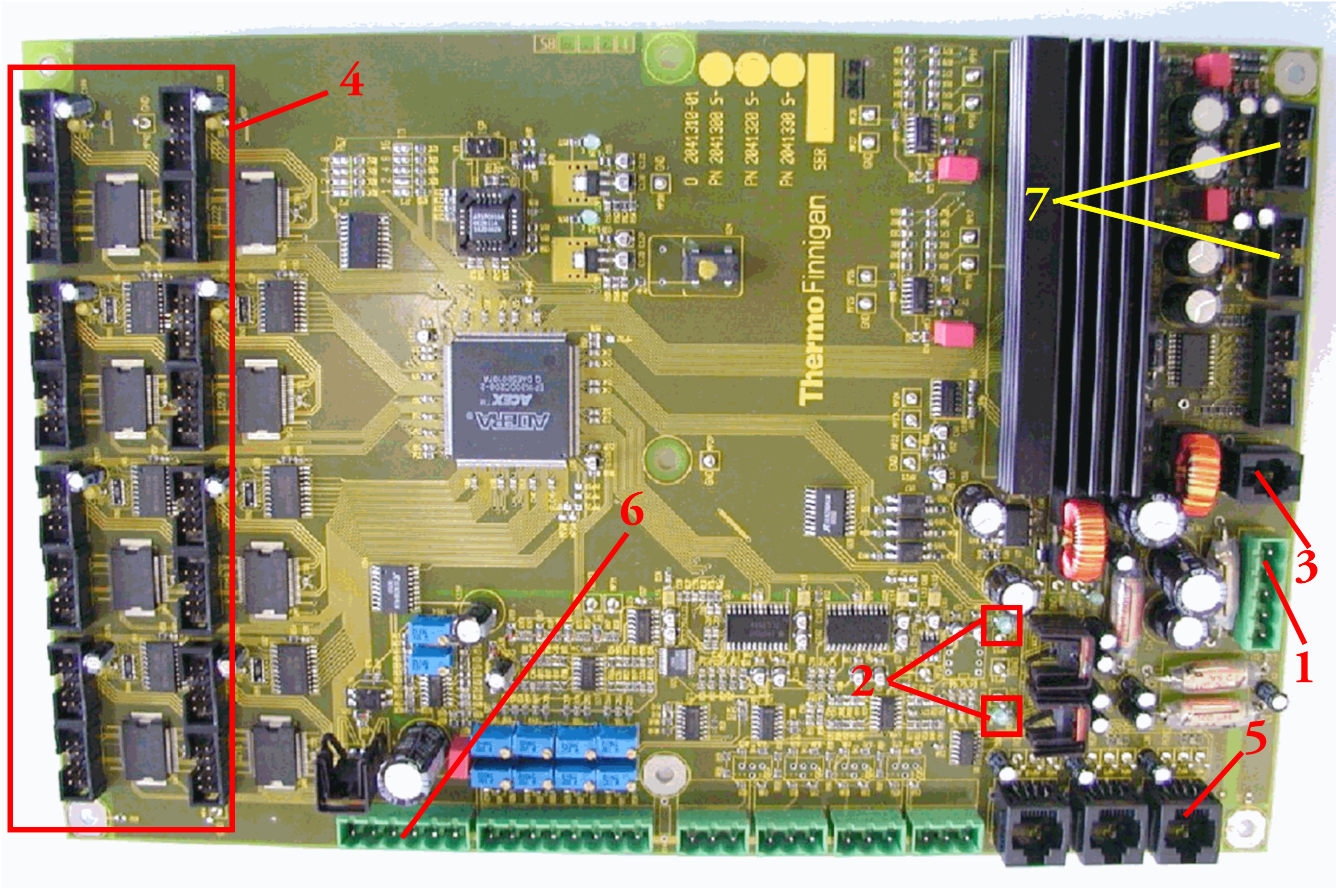
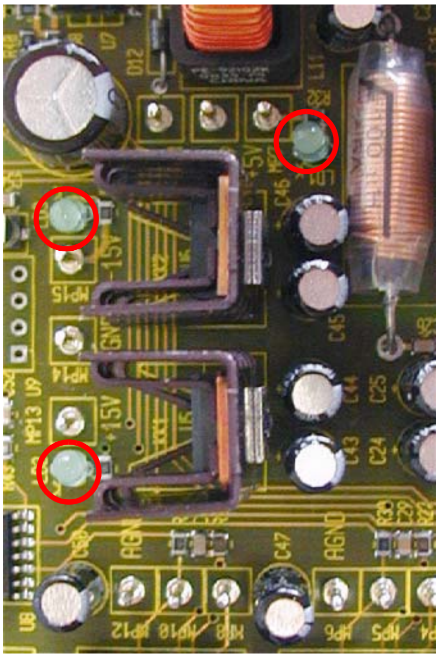



**Figure 2-25.** Dual Inlet Board



LEDs for supply current

See **2** in Figure 2-25.

**Figure 2-26.** LEDs for Supply Current on Dual Inlet Board

The Dual Inlet board controls the Dual Inlet system and its options (**internal** options, for example  Multiport or Microvolume). Therefore, this board is synonymously called **internal inlet board** and missing if no optional Dual Inlet system is available. Dual Inlet board has the functions:

- Control of valve banks
- Connection of three additional vacuum gauges
- Connection of operation device for cooling trap
- Motion control of bellows

**Table 2-17.** Components of Dual Inlet Board[a]

| No. | Description |
|---|---|
| 1 | 24 V power supply |
| 2 | LEDs for supply current.[b] They are on when the supply current is available. |
| 3 | Connection to serial data link |
| 4 | Control of valve banks |
| 5 | Connection to pressure sensors |
| 6 | Connection to Microvolume |
| 7 | Motor Controller[c] |

[a] See Figure 2-25 and Figure 2-26.

[b] See Figure 2-26.

[c] See Figure 2-27.

The connectors J 205 and J 206 are used to connect the bellow motors.

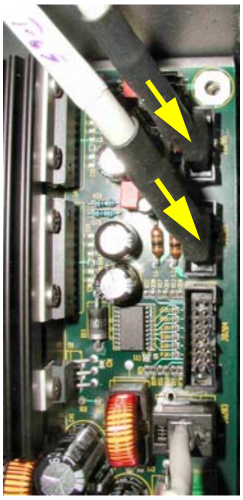


**Figure 2-27.** Connectors for Bellow Motors on Dual Inlet Board

## Dual Inlet System Turbomolecular Pump

The Dual Inlet system turbomolecular pump, **2** in Figure 2-22 and **1** in Figure 2-28, is a TMH 071 P manufactured by Pfeiffer and mounted next to the Dual Inlet board. Table 2-18 summarizes related components.

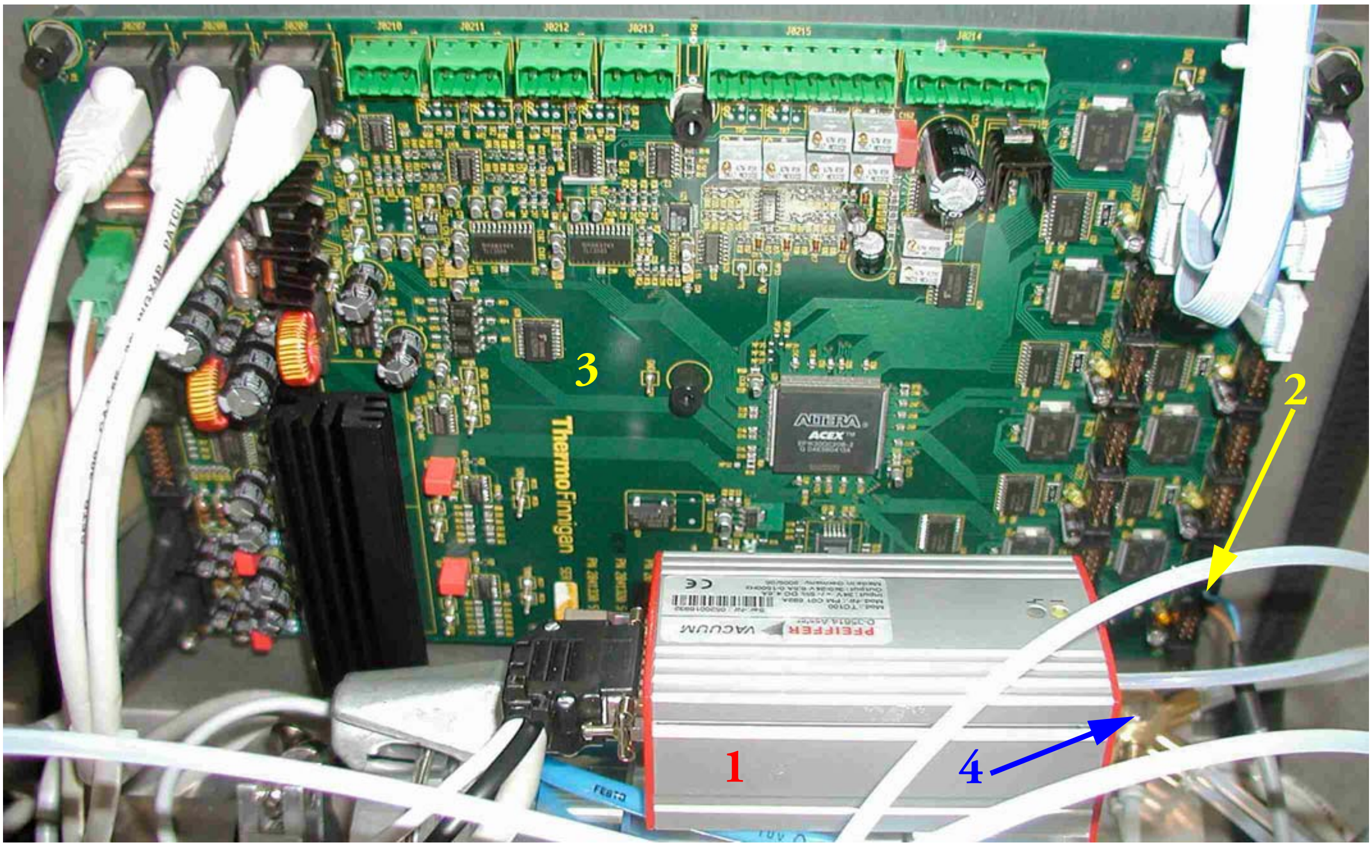



**Figure 2-28.** Dual Inlet System Turbomolecular Pump and Dual Inlet Board

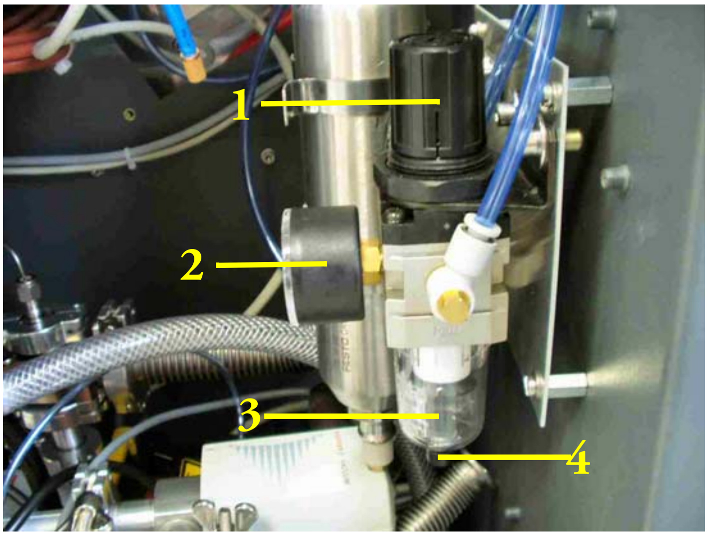
**Table 2-18.** Components Related to Dual Inlet System Turbomolecular Pump[a]

| No. | Component |
|---|---|
| 1 | Dual Inlet system turbomolecular pump |
| 2 | connector from additional valve to J 230 on Dual Inlet board |
| 3 | Dual Inlet board |
| 4 | compressed air distributor |

[a] See Figure 2-28.

To switch this turbomolecular pump on or off, press the appropriate button at the Control Panel. See **6** in Figure 2-5 and **3** in Figure 3-2. If no Dual Inlet system is available, this button is inoperable. The turbomolecular pump is supplied via the power distribution board, Figure 2-63. For maintaining it, see "Turbomolecular Pumps" on page 7-18. For its symbolization in Isodat 2.5, see **8** in Figure 6-29.

## Pressure Reducer for Compressed Air




Labeled Components: 1=rotary adjusting knob; 2=pressure display; 3=oil collection bin; 4=blow-off valve to empty bin

**Figure 2-29.** Pressure Reducer for Compressed Air - Side View

The pressure reducer for compressed air, **3** in Figure 2-22, Figure 2-29, and Figure 2-30, regulates the pressure of the compressed air needed for operating the Dual Inlet system and the peripherals. It has been manufactured by Festo.

**Figure 2-30.** Pressure Reducer for Compressed Air - Front View

For compressed air supply of peripherals at the rear side of the DELTA V Plus IRMS, see "Compressed Air Connections for Peripherals" on page 2-52. For maintenance of the pressure reducer, see "Pressure Reducer for Compressed Air" on page 7-24.

### Adjusting the Pressure Reducer

❖ **To adjust the pressure reducer to a particular pressure value**

1. Pull the rotary adjusting knob **1** upwards to unlock it.
2. Turn the rotary adjusting knob **1** until the desired pressure value is shown at the pressure display **2**. Usually, the pressure reducer must be adjusted to 4 bar.
3. Push the rotary adjusting knob **1** down to lock the pressure reducer at this particular pressure value.

**Note** Thermo Fisher Scientific provides the pressure reducer in the locked state. Therefore, unlock it to adjust the pressure at 4 bar, for example. ▲

### Bin for Oil Collection

If the compressed air contains much oil, it will be collected within a bin **3**, which can be emptied via the blow-off valve **4**.

### Breakdown of Compressed Air Supply

If compressed air pressure decreases or breaks down entirely, an integrated check valve guarantees that the device will still be provided with compressed air of the adjusted pressure for a limited period of time.

## Analyzer Fore Pump

The analyzer fore pump, **4** in Figure 2-22, is mounted at the bottom of the right side next to Dual Inlet system fore pump. See also **2** in Figure 2-31. It is a rotary vane pump, DUO 2.5, manufactured by Pfeiffer, providing pressures of about $10^{-3}$ mbar by a rate of 5 $m^3/h$.

For maintaining it, see "Fore Pumps" on page 7-17. The analyzer fore pump serves two purposes. It acts as a

- **fore** pump for analyzer turbomolecular pump(s)
- **rough** pump for the amplifier housing

After venting the amplifier housing, the rough pump creates a fore vacuum, before it is possible to connect an analyzer turbomolecular pump.

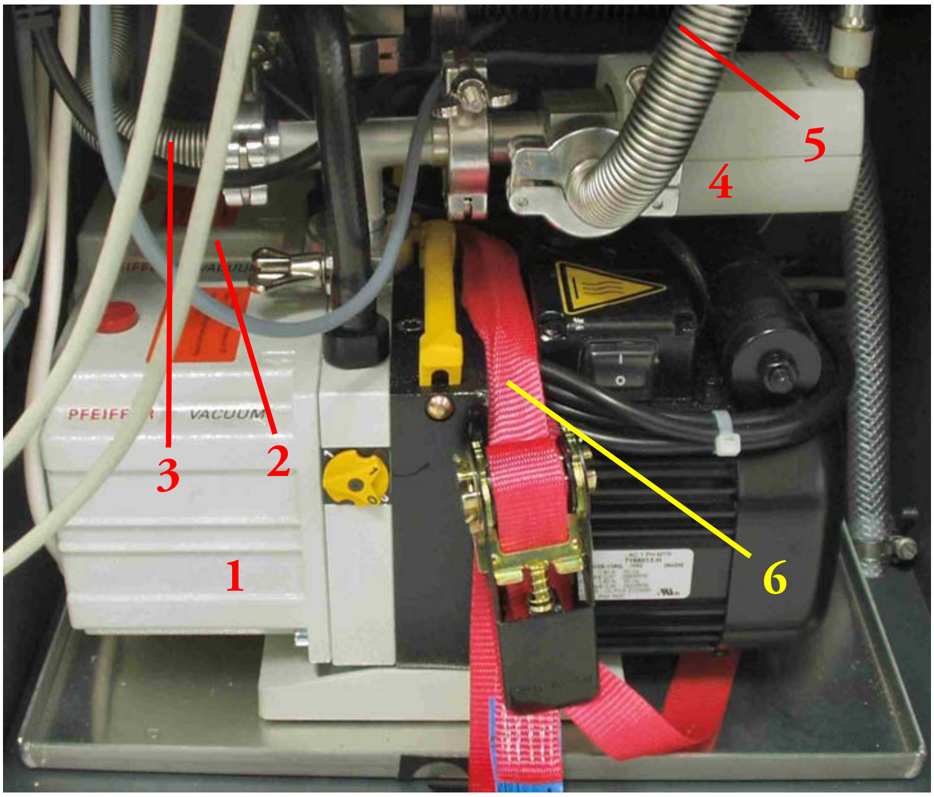
## Dual Inlet System Fore Pump

If a Dual Inlet system is available, the appropriate Dual Inlet system fore pump is placed at the bottom of the right side of the IRMS (**5** in Figure 2-22 and **1** in Figure 2-31). It is a rotary vane pump, DUO 2.5 manufactured by Pfeiffer, as well and thus provides a pressure of about $10^{-3}$ mbar by a rate of 5 $m^3$/h, too.

If no Dual Inlet system is available, the Dual Inlet system fore pump is missing. Next to it, the analyzer fore pump, **2** in Figure 2-31, is located. The Dual Inlet system fore pump serves two purposes:

- **fore pump** for the Dual Inlet system turbomolecular pump
- **rough pump** of the Dual Inlet system (that is, it pumps off considerable gas amounts out of the Dual Inlet system)

For maintaining it, see "Fore Pumps" on page 7-17. For its symbolization in Isodat 2.5, see **7** in Figure 6-29.



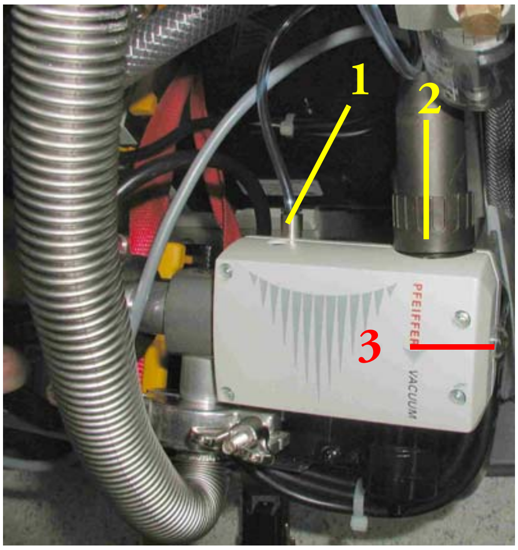

Labeled Components: 1=Dual Inlet system fore pump; 2=Analyzer fore pump; 3=to waste line of Dual Inlet system; 4=Additional valve; 5=to Dual Inlet system turbomolecular pump; 6=Transportation lock of both fore pumps (is removed during normal operation)

**Figure 2-31.** Dual Inlet System Fore Pump with Additional Valve

## Additional Valve

While working as a rough pump, the Dual Inlet system fore pump cannot be used as a fore pump for the turbomolecular pump. The pressure increase at the exit of Dual Inlet system turbomolecular pump would be too large. To avoid excessively high pre-pressures at the Dual Inlet system turbomolecular pump, the additional valve has been implemented (**6** in Figure 2-22 and **4** in Figure 2-31).

It is located upon Dual Inlet system fore pump and controlled automatically via Isodat 2.5 (see **9** in Figure 6-29). As the additional valve belongs to the Dual Inlet system, it is missing, if no such system is available. Figure 2-32 shows its components.

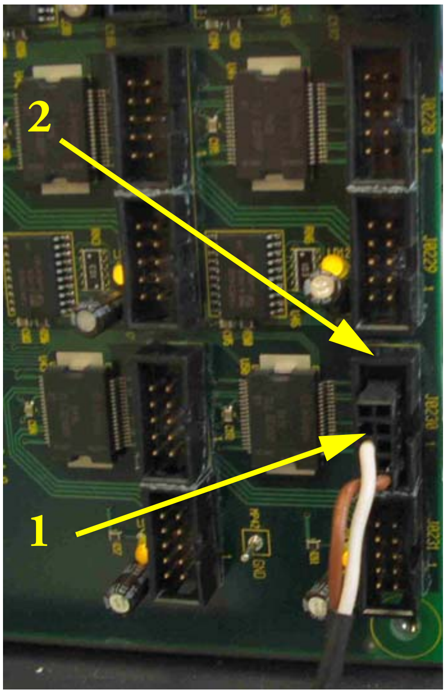



Labeled Components: 1=connector for compressed air; 2=electrical connector leads to J 230 on Dual Inlet board; 3=inspection glass shows whether additional valve is open or closed

**Figure 2-32.** Components of Additional Valve

## Connection to Dual Inlet Board

To accurately open and close the additional valve via Isodat 2.5, the connector of the additional valve **1** must be connected to socket J 230 **2** on the Dual Inlet board.




1 Connector of the additional valve

2 Socket J 230 on Dual Inlet board

**Figure 2-33.** Connecting Additional Valve to Dual Inlet Board

### Additional Valve Closed

While the Dual Inlet system fore pump acts as a rough pump and pumps off large gas amounts, the additional valve is **closed**. The Dual Inlet system turbomolecular pump will then operate without the fore pump. This is possible during a limited period of time.

If no compressed air is available during a longer time, the additional valve will be closed as well. All other valves of the Dual Inlet system will open. Operating the Dual Inlet system is impossible.

If no electrical connection has been established to the Dual Inlet board (the connector of the additional valve has not been stuck into socket J 230 of the Dual Inlet board), the additional valve is open.

### Additional Valve Open

Isodat 2.5 assures time-controlled that the additional valve is **opened** again early enough (that is, before the pressure at the exit of the turbomolecular pump becomes too high). Now, the pump acts as a fore pump again.

**Note** If Dual Inlet system turbomolecular pump does not operate, but instead repeatedly turns off, the additional valve may be closed. ▲

## Transportation Lock of Fore Pumps

Before starting instrument transport, for example in case of a laboratory removal, both fore pumps must be secured by fixing them (transportation lock). Use the provided belt, **6** in Figure 2-31, as a clamping fixture. Thereby, both fore pumps can remain within the instrument during transport. Remove the belt after transport and before operation is started again.

## Fore Pumps Arranged upon Movable Tray

The two fore pumps, are placed together upon a movable tray. Possible leaking pump oil will be collected there. The tray is accessible from outside and can be pulled out or pushed inwards with ease, as the fore pumps are relatively lightweight. See Figure 2-34. Rubber pads below the tray prevent it from rubbing over the bottom of the instrument.

**Figure 2-34.** Movable Tray below Fore Pumps

**Note** Before moving the tray with the fore pumps, remove their connectors! ▲

# Left Side

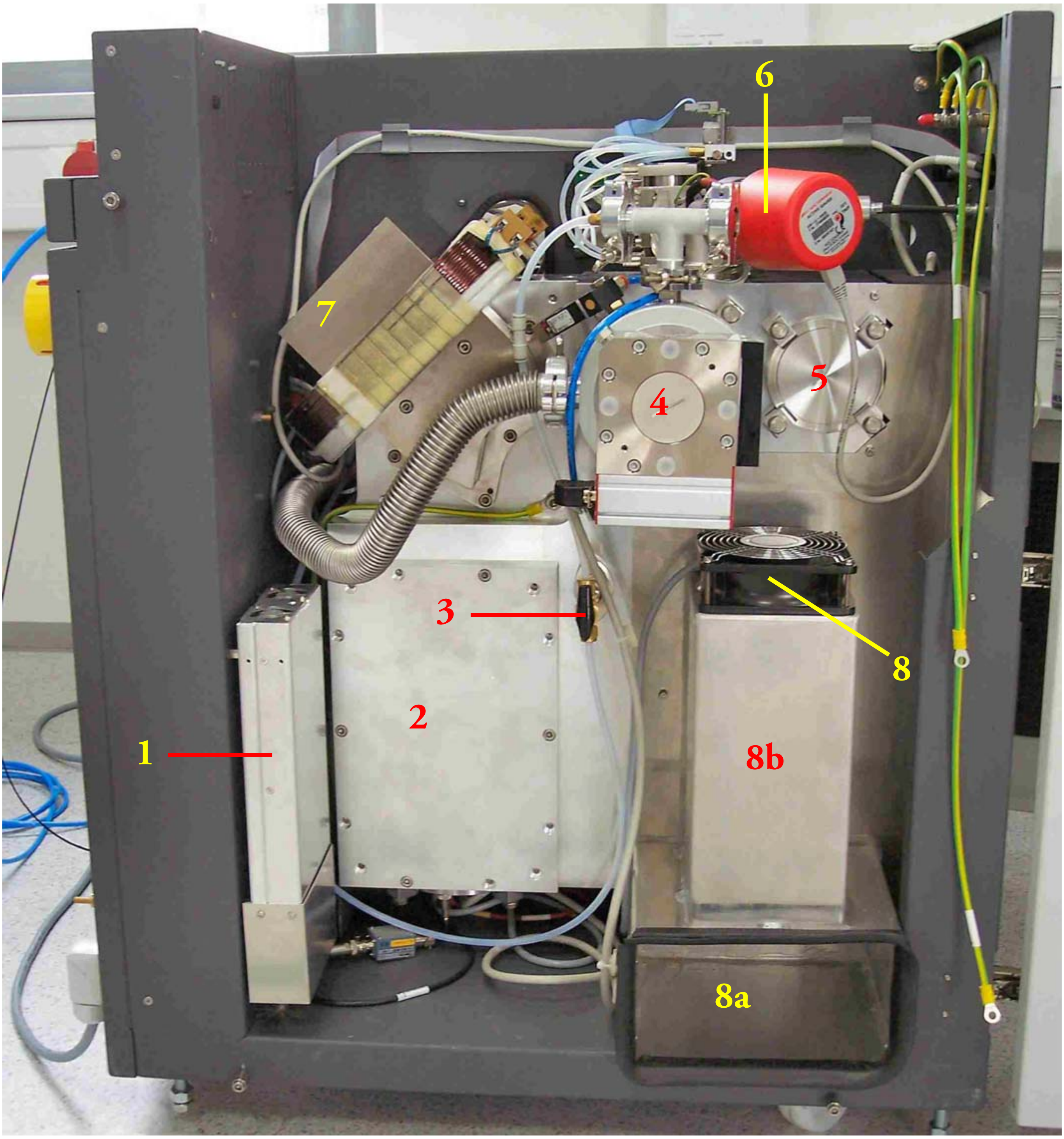



**Figure 2-35.** Left Side of IRMS

Table 2-19 summarizes the components shown in Figure 2-35.

**Table 2-19.** Components of Left Side[a]

| No. | Component | Described in Detail at |
|---|---|---|
| 1 | 24 V power supply | "24 V Power Supply" on page 2-40 |
| 2 | cover plate | "Cover Plate" on page 2-41 |
| 3 | three-way valve | "Three-Way Valve" on page 7-47 |
| 4 | analyzer turbomolecular pump (required) | "Analyzer Turbomolecular Pump (Required)" on page 2-43 |
| 5 | analyzer turbomolecular pump (optional)[b] | "Analyzer Turbomolecular Pump (Optional)" on page 2-43 |
| 6 | Penning gauge | "Penning Gauge" on page 2-44 |
| 7 | magnet | "Magnet" on page 2-45 |
| 8 | fan for turbomolecular pump(s) with "exhaust device" 8a and "chimney" 8b | "Fan for Analyzer Turbomolecular Pump(s)" on page 2-45 |

[a] See Figure 2-35.

[b] Not present in Figure 2-35 (only flange is shown).

## 24 V Power Supply

The main power supply (SP480-24, 24 V, 20 A, 480 W) provides power for the turbomolecular pumps and several electronic boards (for example, inlet board, Dual Inlet board (if available), data logger board, power distribution board)

**Figure 2-36.** 24 V Power Supply

## Cover Plate

Behind the cover plate, **2** in Figure 2-35, the collector system is arranged. The collector system is described in detail at "Collector Systems" on page 5-9.

## Three-Way Valve

The three-way valve is shown in Figure 2-37. Its principle and operation are outlined in detail at "Three-Way Valve" on page 7-47. The three-way valve allows evacuating the amplifier area. Therefore, it can be switched between the four different positions

- Fore Vacuum (FV),
- High Vacuum (HV),
- Vent and
- 0.

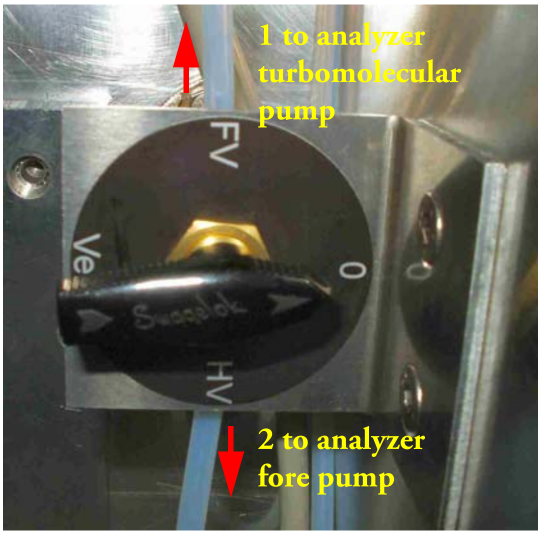



**Figure 2-37.** Four Positions of Three-Way Valve

## Check Valve

A check valve is arranged between three-way valve and analyzer turbomolecular pump. It allows keeping the amplifier area at vacuum while venting the analyzer.


1 to analyzer turbomolecular pump (required)

2 to three-way valve and analyzer fore pump

**Figure 2-38.** Check Valve Near Three-Way Valve

Advantages of the check valve are:

- After the amplifiers have been vented and are now being evacuated again, they take time to become as stable again as during routine operation: namely adsorbed water and gases need time to evaporate and then to be pumped off.
- The low risk that oil exhalations are sucked in and then intrude the amplifier area decreases even further.

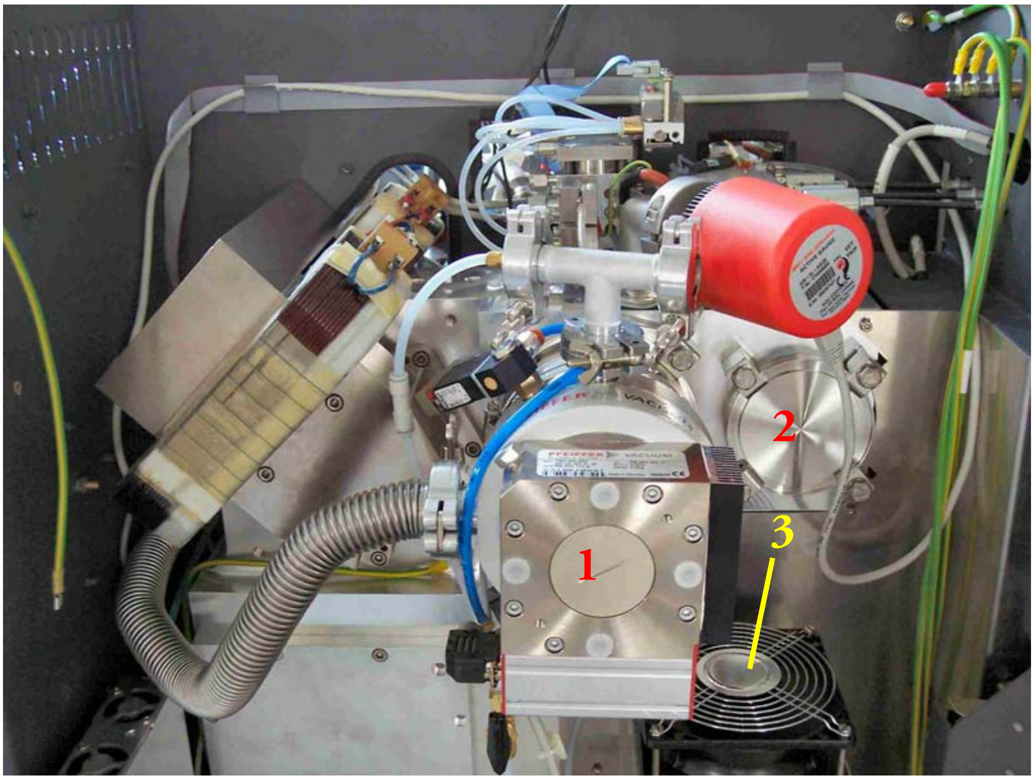
## Connections to Analyzer Pumps

One Teflon tube leads from the three-way valve upward to the analyzer turbomolecular pump (via the check valve near the three-way valve). See **1** in Figure 2-37 and **1** in Figure 2-38.

Another Teflon tube leads from the three-way valve downward to analyzer fore pump. See **2** in Figure 2-37 and **2** in Figure 2-38.

## Analyzer Turbomolecular Pump (Required)

The DELTA V Plus IRMS is equipped with at least one turbomolecular pump, the so-called **main pump**, **4** in Figure 2-35 and **1** in Figure 2-39. This TMH 262 manufactured by Pfeiffer is always required ("standard version"), is usually sufficient, and evacuates the entire analyzer system at a rate of 210 L/s. For maintaining it, see "Turbomolecular Pumps" on page 7-18.




Labeled Components: 1=analyzer turbomolecular pump (required, main pump); 2=analyzer turbomolecular pump (optional[a], differential pump); 3=fan for analyzer turbomolecular pump(s)

**Figure 2-39.** Analyzer Turbomolecular Pumps

[a] Not available in Figure 2-39. Only flange is shown.

## Analyzer Turbomolecular Pump (Optional)

A second analyzer turbomolecular pump, **5** in Figure 2-35 and **2** in Figure 2-39, may be used as a supportive option for the main pump. This TMH 071 P, manufactured by Pfeiffer, evacuates the analyzer at a rate of 60 L/s. Because it pumps the ion source area, the main pump must pump less gas and the analyzer vacuum is improved. Better abundance, peak shape, and improved signal to background ratio at high ion source pressures are thereby obtained.

If available, this **differential pump** is placed right to the main pump. For maintaining it, see "Turbomolecular Pumps" on page 7-18.

It is only used for particular, critical measurements, for example high-end measurements using a Dual Inlet system, when minimal abundance is mandatory.

### Differential Blind

If a differential pump is available, ion source housing and analyzer housing are separated by a metallic differential blind, Figure 2-40. In this case, analyzer area and ion source housing are pumped off each by a pump of their own.

If no differential pump is available, the differential blind must be removed as the main pump alone pumps off both ion source housing and analyzer area. Because the differential blind is attached to the ion source (see upper part of Figure 7-2), dismantle the ion source first and then take away the differential blind.

**Figure 2-40.** Differential Blind

## Penning Gauge

The Penning gauge (**6** in Figure 2-35, Figure 2-41 and Figure 7-26) is an active inverted magnetron gauge combining head and gauge controller in a single compact unit. This high vacuum gauge operates as cold cathode ionization gauge, in which the pressure is measured indirectly as a function of the current which flows in a Townsend discharge maintained in the body tube.

The ionization of the gas in the vacuum system depends on both the pressure and the physical properties of the gas. Therefore, the output signal of the Penning gauge is gas dependent. The output signal voltage to pressure conversion is applied for nitrogen and dry air.

The AIM-XL-NW25 is used (BOCE Product No. D14645000). The measurement range of the similar AIM-S and AIM-SL gauges is $1 \times 10^{-8}$ mbar to $1 \times 10^{-2}$ mbar.

Maintenance and dismantling of Penning gauge are described at "Penning Gauge" on page 7-41. Refer also to the Instruction Manual of Edwards and www.edwardsvacuum.com.


**Figure 2-41.** Penning Gauge - Implemented (Front View)

## Magnet

The magnet, **7** in Figure 2-35, is part of the analyzer and will be described in "Electromagnet" on page 5-21. It is controlled by the magnet current regulator, Figure 2-55, which provides the energy necessary to generate the magnetic field.

## Fan for Analyzer Turbomolecular Pump(s)

A fan, **8** in Figure 2-35, cools both analyzer turbomolecular pumps, that is main pump and differential pump. Air is sucked in via an "exhaust device" **8a** and led through a "chimney" **8b**.

# Rear Side

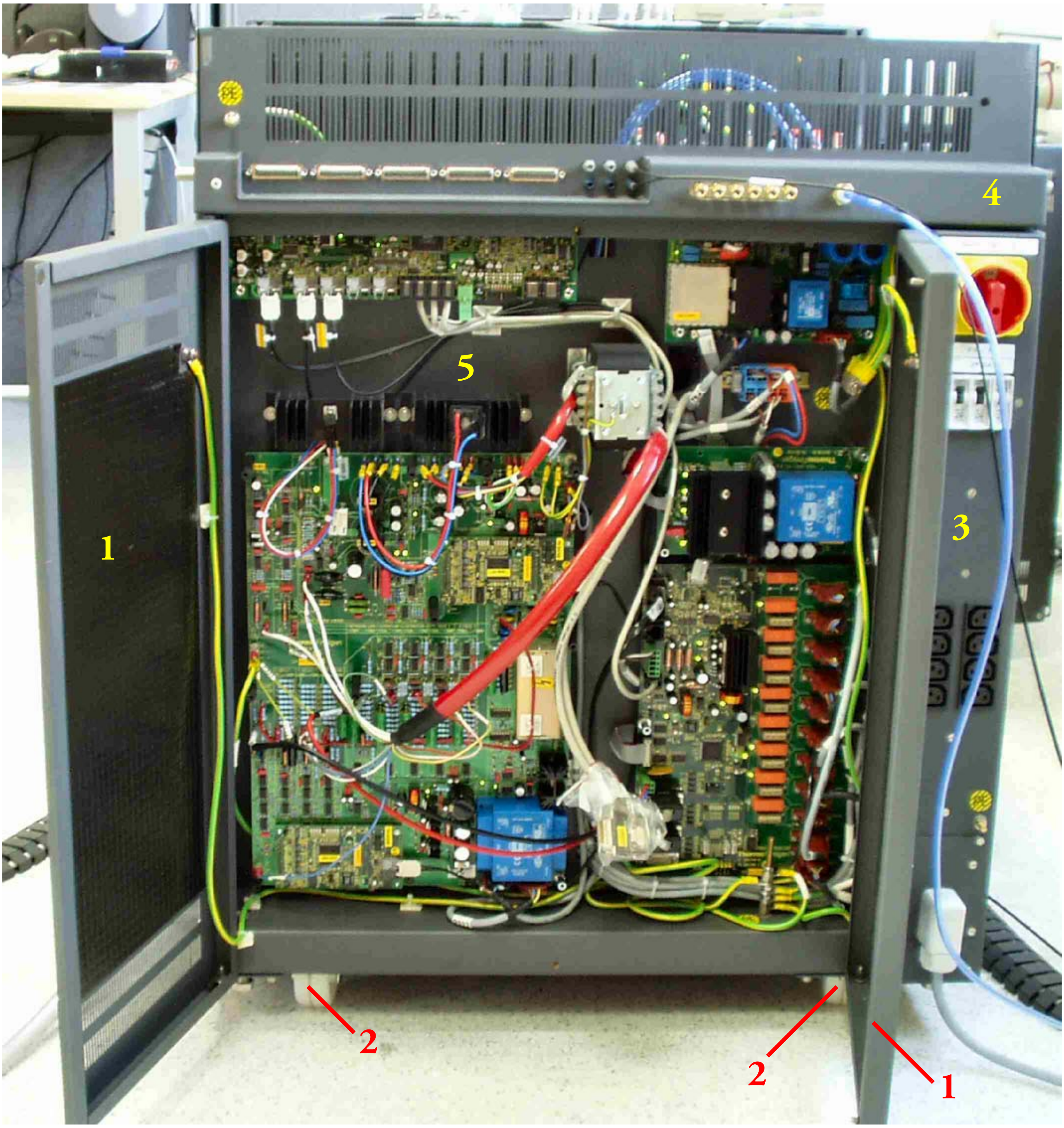



**Figure 2-42.** Rear Side of DELTA V Plus IRMS

Electronic connections and pneumatics are located at the rear side of the DELTA V Plus IRMS. It houses the following components according to Table 2-22.

**Table 2-20.** Components of Rear Side[a]

| No. | Component | Described in Detail at |
|---|---|---|
| 1 | Back doors | "Back Doors" on page 2-47 |
| 2 | Rolls | "Rolls" on page 2-47 |
| 3 | Right faceplate | "Right Faceplate" on page 2-48 |
| 4 | Upper faceplate | "Upper Faceplate" on page 2-51 |
| 5 | Electronics cabinet | "Electronics Cabinet" on page 2-55 |

[a] See Figure 2-42.

## Back Doors

The left and right back doors, **1** in Figure 2-42, give access to the electronics cabinet **6**.

**Note** Keep the back doors closed. The back doors may only be opened by a Thermo Fisher Scientific field service engineer. They cannot be opened without a tool and only in case of severe electronic problems. ▲

## Rolls

### Easily Moving the DELTA V Plus IRMS

The DELTA V Plus IRMS seldom requires lateral access or access from behind. If this is required, the IRMS can easily be rolled out.

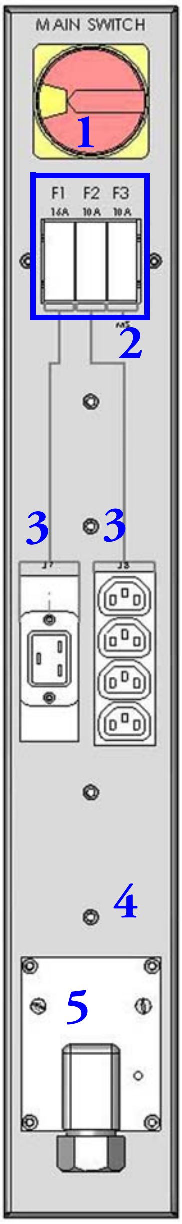
### Arresting the DELTA V Plus IRMS

It is equipped with four rolls, **2** in Figure 2-42, to be located in position. Each roll can be arrested by unscrewing its adjusting screw, but normally you can leave them unarrested during any operation as the rolls bear the weight. Therefore, the DELTA V Plus IRMS will usually not change its position on a flat floor.

Some users may nevertheless want to arrest the rolls to completely fix the DELTA V Plus IRMS, for example because of possible earthquakes or skewness of the laboratory floor. In this case, it is usually sufficient to arrest the two fore rolls by unscrewing their adjusting screws. The two rear rolls may remain unarrested, that is, their adjusting screws may remain screwed in.

## Right Faceplate

The right faceplate and its parts are shown in Figure 2-43 and as **3** in Figure 2-42. It is arranged right to the electronics cabinet and houses the power supply system.




1 main switch

2 fuses (16 A, 10 A, 10 A)

3 1 IEC power socket (16 A) and 4 IEC power sockets (10 A) as power outlets for peripherals

4 PE connector

5 main power cable

**Figure 2-43.** Right Faceplate

## Main Switch

Turning the main switch by 90° allows switching on or off the DELTA V Plus IRMS.

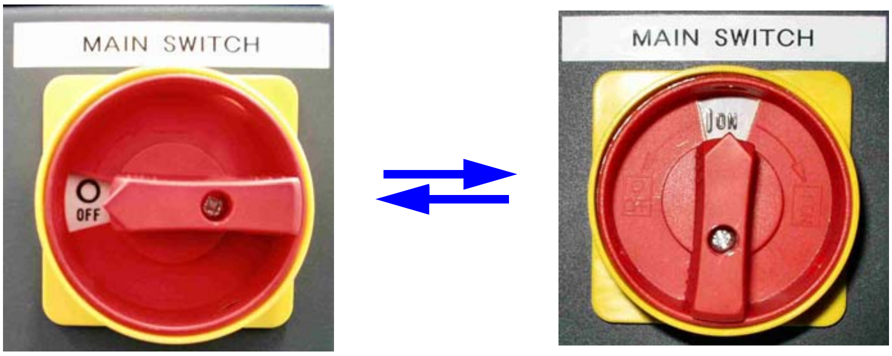



**Figure 2-44.** Positions of Main Switch

## Fuses

Three fuses, F1 (left, 16 A), F2 (middle, 10 A) and F3 (right, 10 A) are available (See Figure 2-45.):

- The **left** one, **F1** (16 A), is designated for a 16 A socket. It is assigned to the left column, **J7**.
- The **middle** one, **F2** (10 A), is designated for connected IRMS peripherals, for example Kiel IV Carbonate Device, GC/TC. It is assigned to the right column **J8**.
- The **right** one, **F3** (10 A), is designated for the DELTA V Plus IRMS itself, that is for its complete electronics.

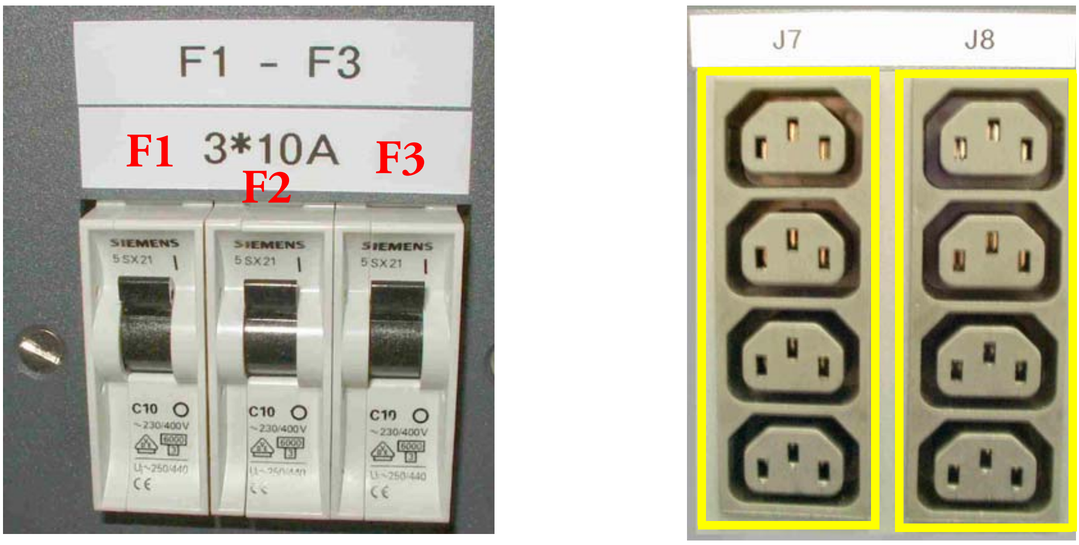



**Figure 2-45.** Fuses (Left) and Sockets (Right)

**Caution** When connecting external peripherals or computer equipment, take care that the overall current does not exceed 10 A or 16 A respectively! If the overall current exceeds these values however, the IRMS will not be turned off as it has a fuse of its own. ▲

**Note** After your computer and IRMS peripherals have been connected, you must switch on the according fuses. Otherwise, operating them will not be possible. ▲

## IEC Power Sockets

Five IEC power sockets which are conform to CE are arranged in two columns offering a single (16 A) and four connectors (10 A each). Each column is fed by a separate circuit with a fuse of its own. See Figure 2-45. The connectors serve as power outlets for peripherals.

## PE Connector

A PE connector (protective earth connector) is shown in the left part of Figure 2-46. If additionally a separate grounded PE system exists in your building, you can connect an extra ground wire here. Electronically, this would imply additional protection for your system. Alternatively, in case of several devices within a system, these can be grounded altogether at the PE connector (thereby establishing a local grounding system).


**Figure 2-46.** PE Connector (Left) and Main Power Cable (Right)

## Main Power Cable

The main power cable (Figure 2-46, right) leads to the socket outlet.

## Upper Faceplate

The upper faceplate is mounted above the electronics cabinet and houses the parts shown in Figure 2-47 and **4** in Figure 2-42.

**Table 2-21.** Components at Upper Faceplate[a]

| No. | Component | Described in Detail at |
|---|---|---|
| 1 | Compressed air inlet | "Compressed Air Inlet" on page 2-51 |
| 2 | Compressed air connections for peripherals | "Compressed Air Connections for Peripherals" on page 2-52 |
| 3 | Connectors for optical fibers | "Connectors for Optical Fibers" on page 2-52 |
| 4 | SUB D connectors | "SUB D Connectors" on page 2-53 |
| 5 | PE connector | "PE Connector" on page 2-50 and "PE Connector" on page 2-54 |

[a] See Figure 2-47.

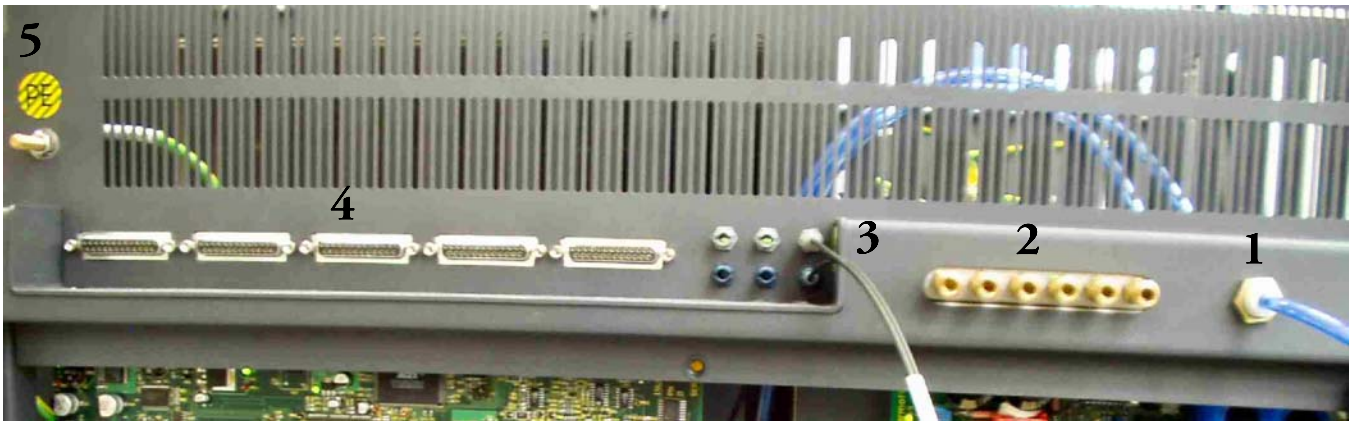



**Figure 2-47.** Electronics Cabinet - Upper Faceplate

### Compressed Air Inlet

Compressed air provided by the distribution unit of your lab enters the DELTA V Plus IRMS at compressed air inlet (**1** in Figure 2-48) via a tube of suited outer diameter, for example 6 mm.


**Figure 2-48.** Compressed Air Inlet and Compressed Air Connections

Simply stick the tube in and leave it there. When you pull out the tube, an internal check valve at the pressure reducer (see Figure 2-29) nevertheless maintains compressed air supply for some seconds. Short-term interruptions of compressed air supply can thus be balanced.

## Compressed Air Connections for Peripherals

External peripherals, that is IRMS peripherals, need compressed air to switch valves and actuators (that is pneumatic lifters, for example at ConFlo III to lift and drop capillaries). Each peripheral, for example LC IsoLink, ConFlo III, Kiel IV Carbonate Device, GasBench II, GC Combustion Interface, PreCon, must be connected to one of the compressed air connections (synonymously called pneumatic connections).

Compressed air passes along the following way within the DELTA V Plus IRMS:

1. It enters the DELTA V Plus IRMS at compressed air inlet **1** in Figure 2-48.
2. It passes to the pressure reducer where the needed pressure is adjusted. See Figure 2-29 and to "Pressure Reducer for Compressed Air" on page 2-32.
3. After leaving the pressure reducer, the compressed air passes to an internal distributor. See **4** in Figure 2-28.
4. Finally, it is led to the six compressed air connections **2** (one for each peripheral) and distributed to maximally six peripherals.

Usually, the compressed air connections are closed. However, when you plug in the suitable coupling of a peripheral, it opens. When you pull out the coupling afterwards, it is closed again. A check valve integrated into each compressed air connection ensures that available compressed air only leaves the DELTA V Plus IRMS, when a peripheral is connected to it.

## Connectors for Optical Fibers

The three connectors for optical fibers are shown in Figure 2-49. Each of the three two-pole connectors (**1**, **2** and **3**) is made up by a pair of a blue and a grey pole. The computer sends signals to the IRMS via the grey pole and receives signals from the IRMS via the blue pole.

- connector **1** leads to the **computer**, whereas
- connector **2** and connector **3** are both designated for at most two IRMS **peripherals** "having an intelligence of their own", and which are therefore connected via optical fibers, for example a Kiel IV Carbonate Device or a Peripheral Controller.

  Analog values, for example temperature values, can thus be continuously adjusted and read back via computer here.

The serial data bus gets signals from the computer via all data lines (that is, via optical fibers and via cables). These signals are consolidated at a distributor on the inlet board (**5**, **6** and **7** in Figure 2-54), before they are distributed starlike to all electronic boards and finally fed back to the computer (bidirectional). See especially **6** in Figure 2-54.

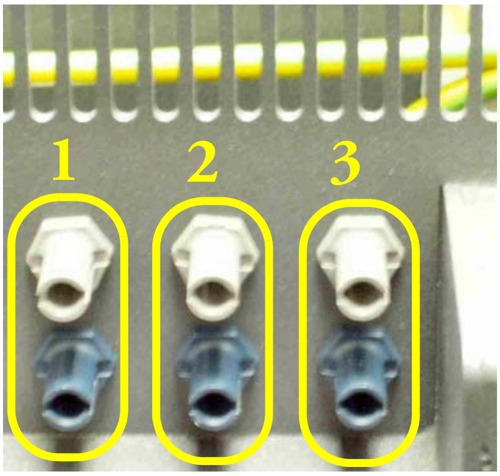



**Figure 2-49.** Three Connectors for Optical Fibers

**Note** Light from extraneous sources, for example sunlight, passes adulterant signals to the IRMS via the connectors for optical fibers. Hence, many channels are read out falsely, for example cup signals or pressure values.

If the Thermo Fisher Scientific field service engineer has once equipped your DELTA V Plus mass spectrometer with connectors for optical fibers, connect peripherals at **2** or **3** in Figure 2-49.

However, if no peripherals are connected, close these unused connectors by plugs. Do not use red plugs, as red light is primarily responsible for signal transmission. ▲

## SUB D Connectors

Five 25-pole SUB D connectors are shown in Figure 2-50. See also **1** in Figure 2-54. External peripherals which have a plug & measure adapter can directly be plugged in here, depicted as **1** in Figure 2-51. Valves of the particular peripheral can thereby be switched on and off. The plug and measure adapter belongs to the cable of the individual peripheral. The plug and measure concept is described in detail at "Plug and Measure Concept" on page 3-7.

Maximum five peripherals can thus be connected to the IRMS. After Isodat 2.5 has read the connections for the first time, the five SUB D connectors are all equivalent ones. For peripherals which do not have a plug and measure adapter (GP Interface, PreCon and LC IsoLink), the same functionality has been integrated within their modified plug.

**Figure 2-50.** SUB D Connectors without Peripheral

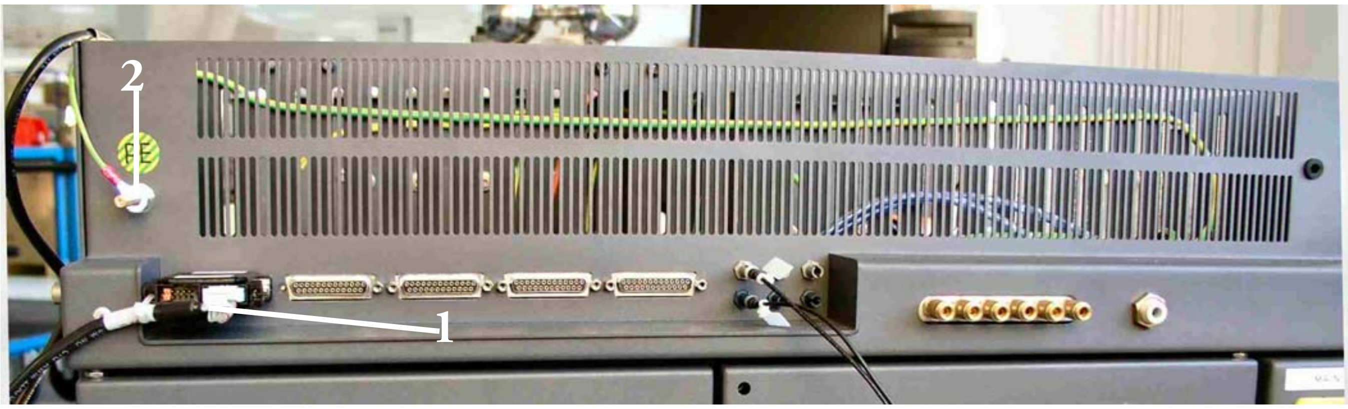



**Figure 2-51.** SUB D Connector with Peripheral

## PE Connector

The cables of the peripherals leading to the SUB D connectors are screened. Their green-yellow lines must be connected to the PE connector shown as **5** in Figure 2-47 and as **2** in Figure 2-51. See "PE Connector" on page 2-50 as well.

This avoids both introducing disturbances from outside and spreading them from inside via the cables (electromagnetic compatibility, EMC).

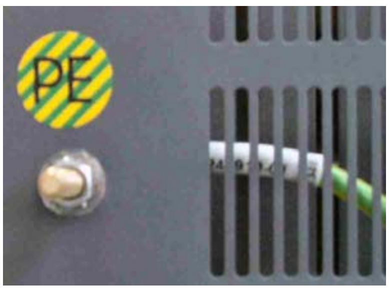



**Figure 2-52.** PE Connector

## Electronics Cabinet

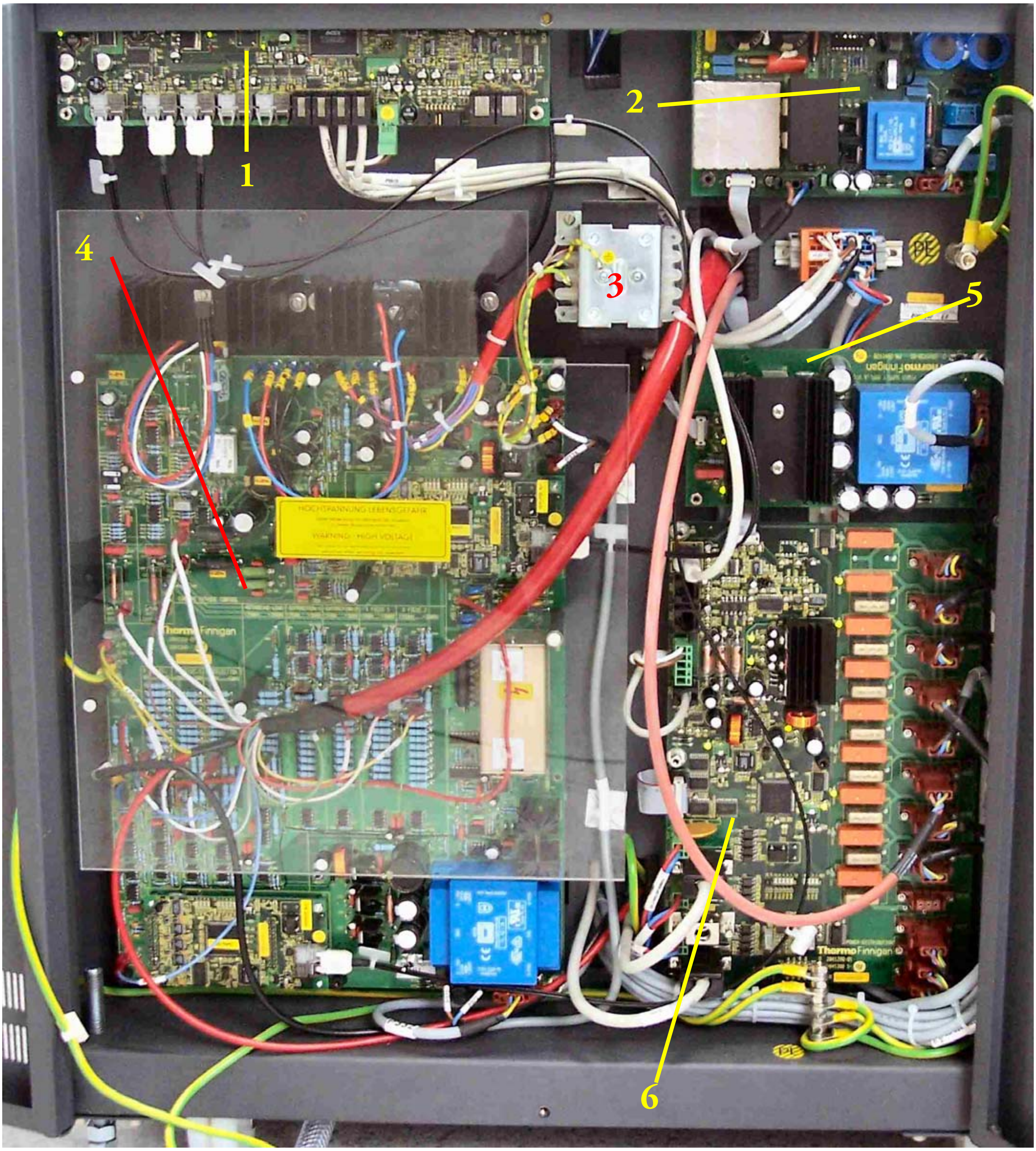



**Figure 2-53.** Electronics Cabinet

## Safety Instructions

The electronics of the DELTA V Plus IRMS contains complicated circuits. Only qualified, skilled electronics engineers should perform servicing.

It is recommended to call for the Thermo Fisher Scientific field service engineer if servicing is required. Before calling, try to localize the defect. A precise description of the defect will ease the repair and reduce costs.

Further, we recommend to use Thermo Scientific spare parts only, because many parts are specially selected. When replacing fuses, only use the correct type.

**Warning** **High Voltage.** Danger of injury. Be careful when removing the protective covers from plugs, cables, and other parts. ▲

**Caution** To assure trouble-free operation of the DELTA V Plus IRMS, the maximum allowable voltage between neutral and ground must be less than 1 V! ▲

**Caution** Opening the electronics cabinet is only allowed for maintenance purposes by qualified personal! ▲

## General Remarks

This section describes the basic structure of the electronic equipment. Various electronic devices are required to carry out the procedures of the DELTA V Plus IRMS:

- Most of the electronic boards are part of the electronics cabinet (Figure 2-53, summarized in Table 2-22) and will be discussed below.
- Other electronic devices are located outside the electronics cabinet. They will be discussed in "Electronic Components Outside the Electronics Cabinet" on page 3-1.

**Table 2-22.** Components of Electronics Cabinet [a]

| No. | Component | Described in Detail at |
|---|---|---|
| 1 | Inlet board | "Inlet Board" on page 2-57 |
| 2 | Magnet current regulator | "Magnet Current Regulator" on page 2-58 |
| 3 | Transformer for ion source control board | "Transformer for Ion Source Control Board" on page 2-60 |
| 4 | Ion source control board | "Ion Source Control Board" on page 2-60 |

**Table 2-22.** Components of Electronics Cabinet, continued[a]

| No. | Component | Described in Detail at |
|---|---|---|
| 5 | Power supply for amplifiers and VFC | "Power Supply for Amplifiers and VFC" on page 2-66 |
| 6 | Power distribution board | "Power Distribution Board" on page 2-67 |

[a] See Figure 2-53.

## Inlet Board

The inlet board, Figure 2-54 and **1** in Figure 2-53, has been designated for **external** options, that is for IRMS peripherals: maximally five IRMS peripherals can directly be plugged into the five 25-pole SUB D connectors, which are easily accessible from outside as described at "SUB D Connectors" on page 2-53.

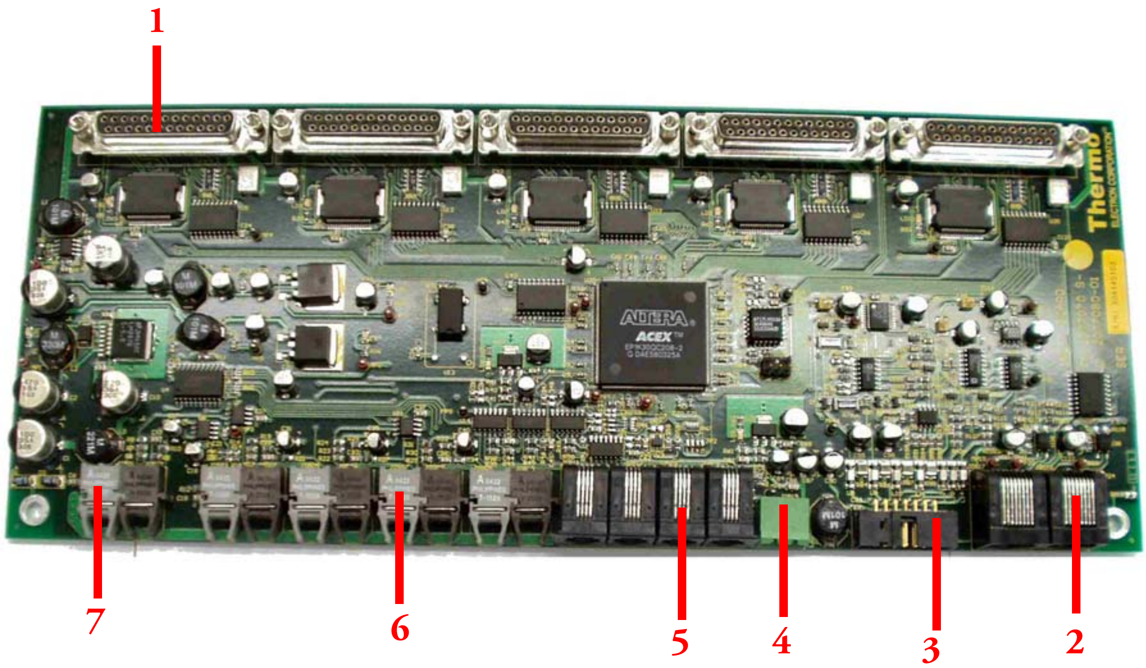



**Figure 2-54.** Inlet Board (for External Options)

**Note** The inlet board, designated for **external** options, must be distinguished from the Dual Inlet board (Figure 2-25), which is used for **internal** options and therefore located near the Dual Inlet system. ▲

Some external peripherals, especially the more complex ones, are not connected to the IRMS via a 25-pole SUB D connector. Instead, they are connected via an optical fiber (for example, a Kiel IV Carbonate Device). See "Connectors for Optical Fibers" on page 2-52.

The connection type depends on the construction history of the individual peripheral. SUB D connectors mainly control devices, which only send digital information, that is on/off information (no analog interface exists outwards). Nevertheless, even the optical fiber-connected peripherals are controlled via the inlet board.

Table 2-23 summarizes important components located on the inlet board.

**Table 2-23.** Components of Inlet Board[a]

| No. | Component |
|---|---|
| 1 | 25-pole SUB D connector (plug and measure connector for an external peripheral)<br>Overall, five equivalent ones exist to connect at most five arbitrary peripherals, for example GasBench II, LC IsoLink. |
| 2 | two connectors for two additional vacuum gauges |
| 3 | connector, which is not used yet (analog inputs and outputs) |
| 4 | 24 V power supply<br>If the inlet board had no power supply, neither the ion source could be controlled nor could any data be acquired. |
| 5 | serial data link cable; four connectors to control at most four internal boards.<br>Momentarily, three of them are occupied by<br>a) power distribution board<br>b) Dual Inlet board<br>c) data logger board,<br>whereas one free connector is not used yet. |
| 6 | four optical fiber connectors (used in pairs for communication with at most four electrically isolated electronic units)<br>Momentarily, they are occupied by<br>a) high-lying ion source potentials<br>b) low-lying potentials of ion source control (for example, X-deflection, Y-deflection)<br>c) an external peripheral,<br>whereas up to two remain unused.<br>serial data link option, for ion source control board and external options<br>(for example, Kiel IV Carbonate Device, Peripheral Controller). |
| 7 | connection to PCI-interface of your computer |

[a] See Figure 2-54.

## Magnet Current Regulator

The magnet current regulator (**2** in Figure 2-53 and Figure 2-55) is located top left of electronics cabinet and controls the magnet: it provides the current required to generate the magnetic field that deflects the ion beam.

The relationship between magnet current and mass number is determined and stored by means of the mass calibration procedure. The computer feeds the information of the specified mass number via the optical bus and the data logger to the microprocessor, which controls the DAC on the power distribution board. Here, this information is converted into an output voltage, which controls the power supply of the magnet current regulator. Table 2-24 summarizes its components.

**Warning High Voltage.** Danger of injury. Parts of magnet current regulator and power distribution board are at 230 V voltage. Never touch this board without safety measures! ▲

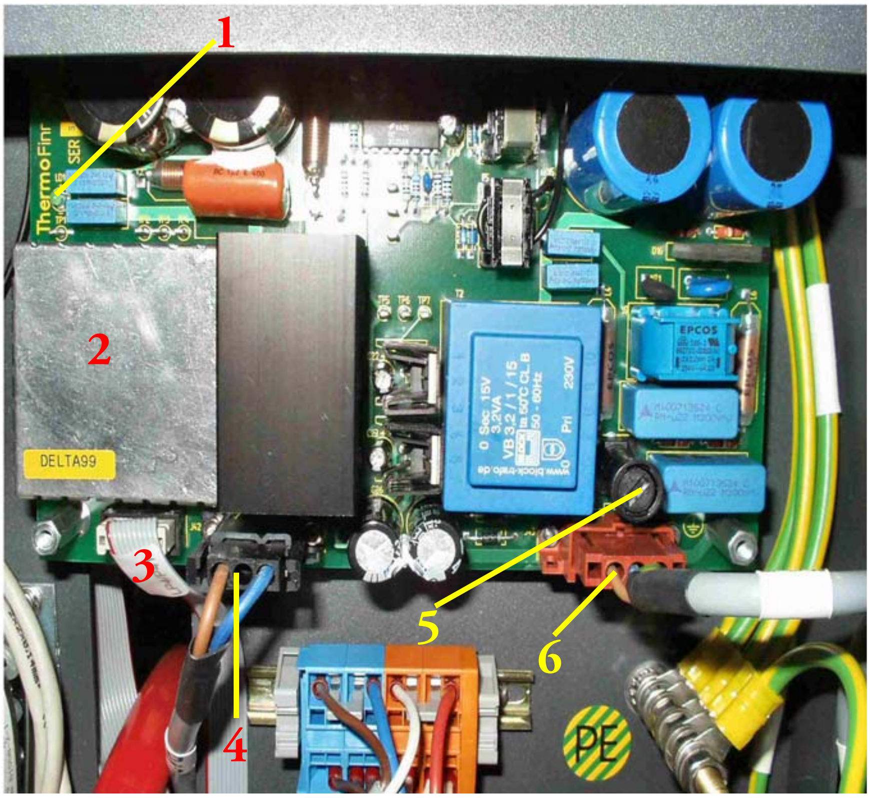



**Figure 2-55.** Magnet Current Regulator

**Table 2-24.** Components of Magnet Current Regulator[a]

| No. | Component |
|---|---|
| 1 | Control LED |
| 2 | Switching box<br>Houses the control electronics of the board.<br>Its metallic lid protects the control electronics against draught.<br>This ensures stability of the magnet current regulator.<br>Contains the switch between a Delta instrument and a MAT 253. |
| 3 | Input (control connection)<br>Comes from power distribution board |

**Table 2-24.** Components of Magnet Current Regulator[a], continued

| No. | Component |
|---|---|
| 4 | Connection to magnet |
| 5 | Normal micro-fuse |
| 6 | Power connection (230 V line in) |

[a] See Figure 2-55.

## Transformer for Ion Source Control Board

The transformer for the ion source control board, Figure 2-56 and **3** in Figure 2-53, is connected to the ion source control board (Figure 2-57) and provides it with the different voltages needed.

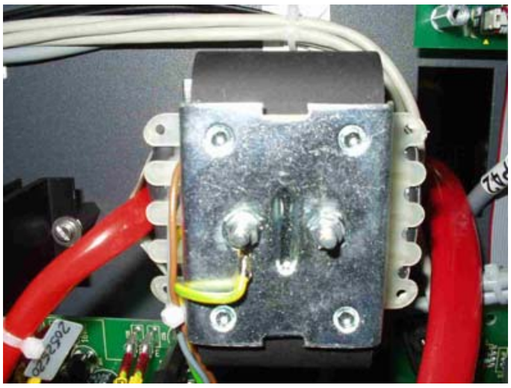
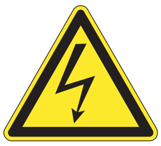


**Figure 2-56.** Transformer for Ion Source Control Board

The transformer belongs to the high-voltage part of the ion source control board. As high voltage is not applied to the transformer's **outside**, it does not need to be shielded by a perspex pane.

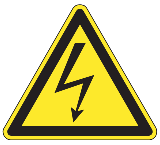


**Warning** **High Voltage.** Danger of injury. At the transformer's **inside,** high voltage of about 3 kV is applied! ▲

## Ion Source Control Board

The ion source control board is synonymously called ion source controller and depicted as Figure 2-57 and as **4** in Figure 2-53. Table 2-25 summarizes major components of ion source control board.

It provides emission control and creates all required potentials (for example, X-focus, deflection) and currents. Via the connection cable **3**, they are led to the ion source. It generates high voltage when the ion source is switched on, thus providing it with power to produce the ions. It also provides the different voltages necessary to focus the generated ions.



**Warning** **High Voltage.** Danger of injury. The major part of the ion source control board is shielded by a perspex pane, as high voltage of maximally about 3 kV is applied! ▲

Even though the ion source is run predominantly at 3 kV, Isodat 2.5 allows adjusting other arbitrary voltages, if necessary. As high voltage is not applied at the lower part of the ion source control board, the perspex pane does not extend entirely downwards.

**Note** Only a Thermo Fisher Scientific field service engineer needs access to the lower part, where the switch to turn off high voltage and the on/off switch to turn it on again are located. ▲

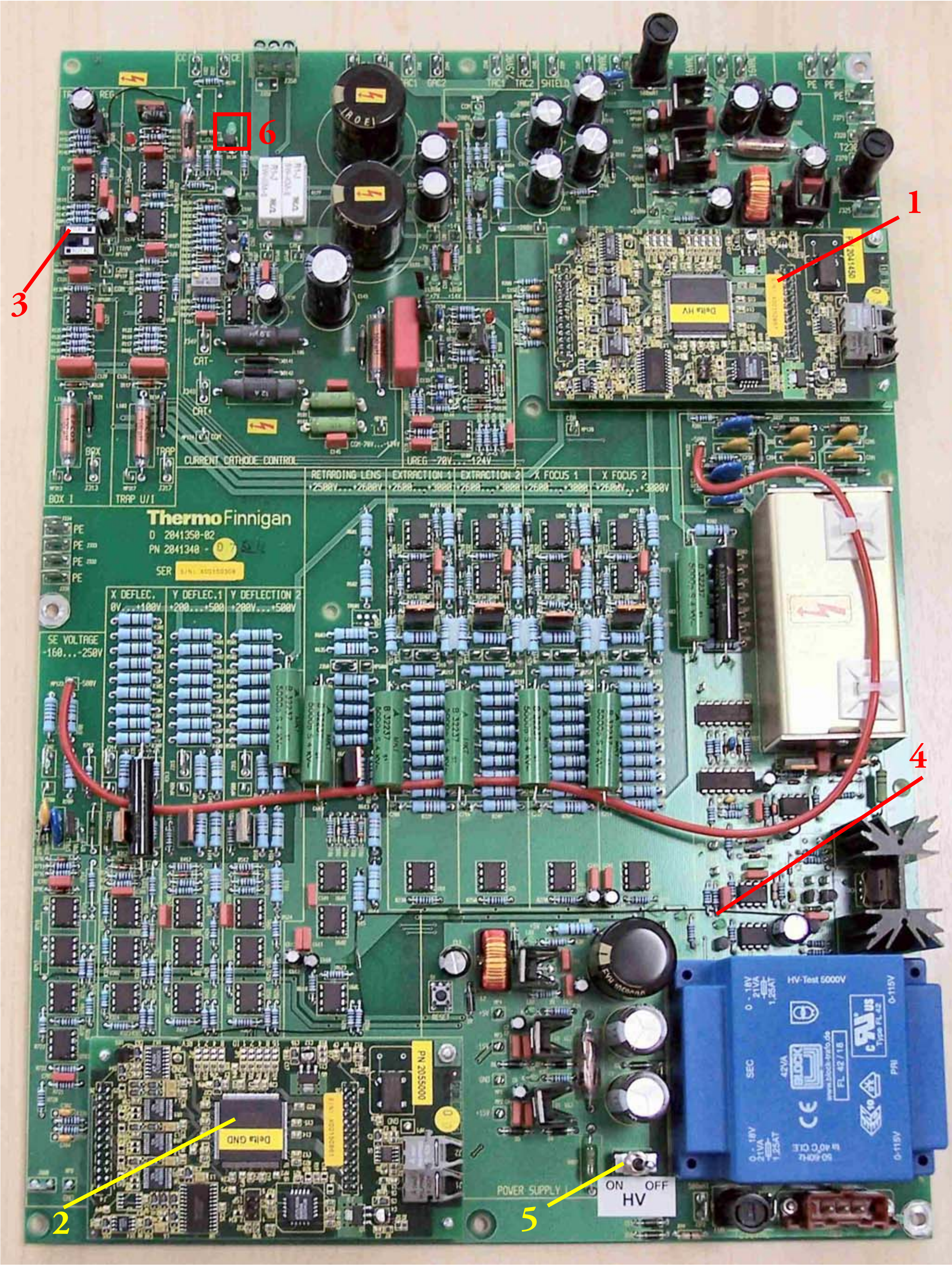



**Figure 2-57.** Ion Source Control Board - Dismantled

**Table 2-25.** Components of Ion Source Control Board[a]

| No. | Component |
|---|---|
| 1 | Bus control board (high voltage) |
| 2 | Bus control board (ground)<br>In case of a DELTA V Plus IRMS, Focus Quad power supply board is arranged below it. |
| 3 | The setting of this switch determines whether only the trap current or also the box current is used for emission control. Should be set to total. |
| 4 | LEDs that indicate proper functioning of high voltage |
| 5 | On/off switch for high voltage |
| 6 | This LED is red if something is functioning improperly, for example if sometimes a short circuit exists between trap and ground. |

[a] See Figure 2-57.

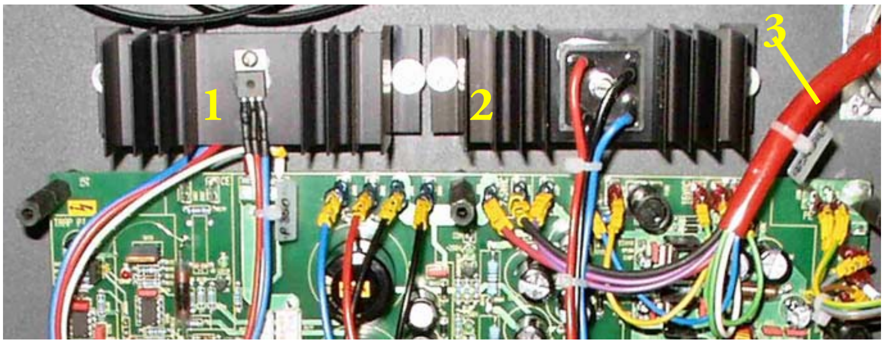



**Figure 2-58.** Upper Part of Ion Source Control Board

Figure 2-58 shows the upper part of the ion source control board.

**Table 2-26.** Components connected to Ion Source Control Board[a]

| No. | Description |
|---|---|
| 1 | Heat sink MOS-FET (also shielded by the perspex pane)<br>Control transistor that controls the cathode current and keeps the electron emission out of the cathode constant. A continuous ion current is thus obtained. |
| 2 | Heat sink diode bridges (also shielded by the perspex pane)<br>Bridge rectifier that rectifies the alternating voltage of the transformer into a direct voltage |
| 3 | Ion source connection cable |

[a] See Figure 2-58.

As universal control units, two bus control boards control the ion source. Both are located on the ion source control board:

- bus control board (ground) and
- bus control board (high voltage)

## Bus Control Board (High Voltage)

The bus control board (high voltage), Figure 2-59 and **1** in Figure 2-57, lies at the adjustable accelerating voltage and is nearly identical to the bus control board (ground). Only the programming of communication flow, voltages and addresses on the boards are different. See "Bus Control Board (Ground)" on page 2-65.

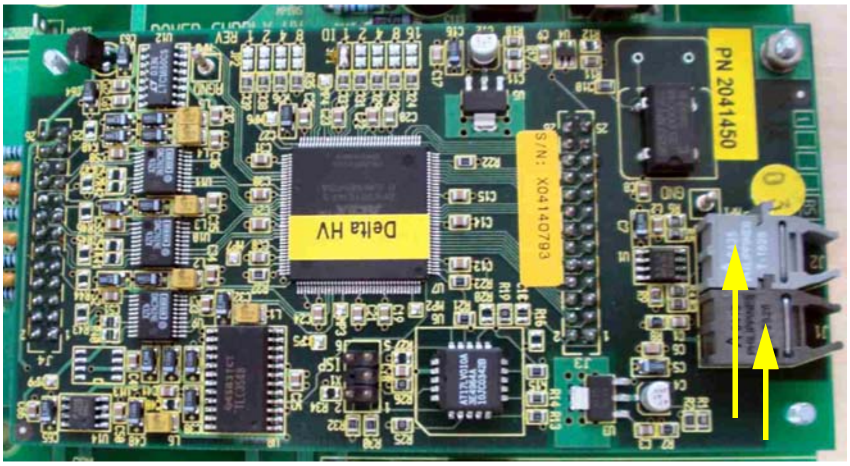


**Figure 2-59.** Bus Control Board (High Voltage)

It controls all high-lying potentials, for example emission control, extraction, X-focus. The arrows in Figure 2-59 point at fiber line connectors to send and receive commands (serial data link). The serial data link provides two ports that are connected to the data logger. One port is dedicated to emission and high-lying potentials, the other one for the low-lying potentials. By using optical fibers instead of metallic conductors, the signals for the two ports are galvanically isolated from the rest of the electronics. This design obviates mutual interferences of the conductors especially in case of line surges.

## Bus Control Board (Ground)

The bus control board (ground) is shown in Figure 2-60 and as **2** in Figure 2-57. It is present in both the DELTA V Advantage and DELTA V Plus IRMS.

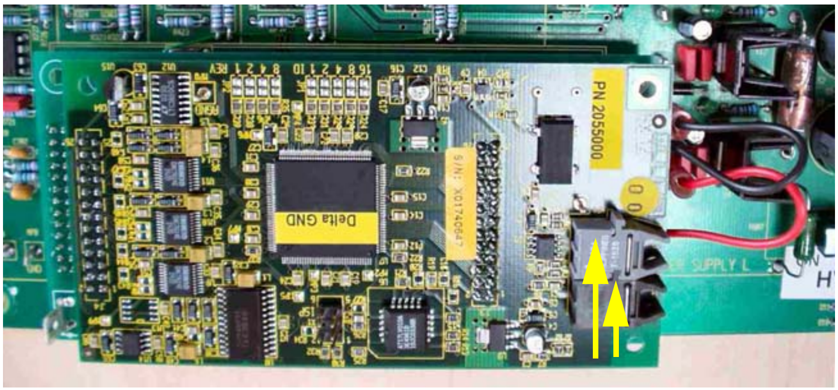


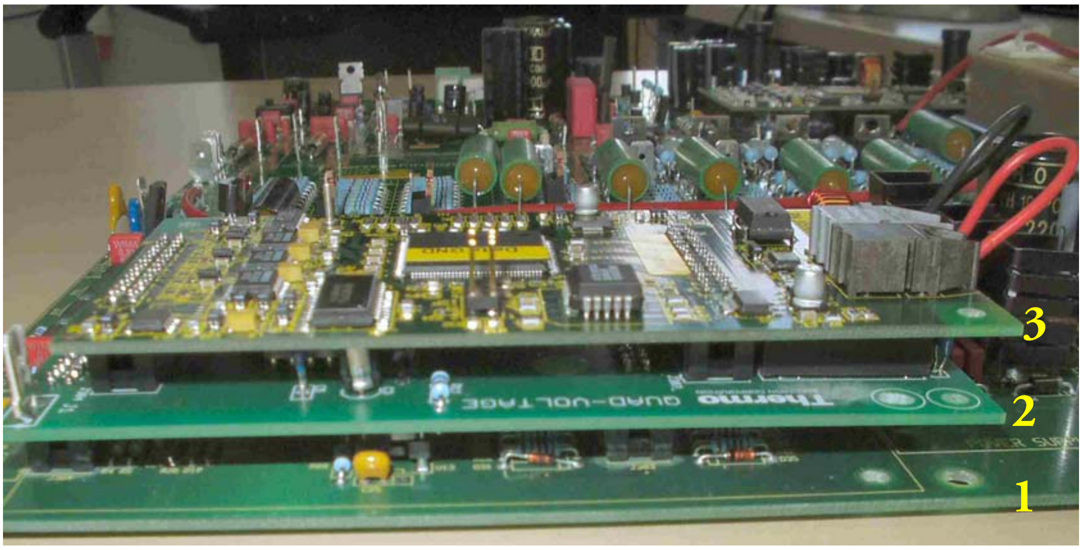

**Figure 2-60.** Arrangement of Bus Control Board (Ground)

The arrows in Figure 2-60 point at fiber line connectors to send and receive commands (serial data link). The bus control board (ground) allows adjusting the accelerating voltage. It controls all low-lying potentials as for example  X-deflection, Y-deflection, SE suppressing, Focus quad (Figure 6-5).

- In case of the DELTA V Advantage IRMS, the Focus Quad power supply board is missing, the bus control board (ground) is arranged directly above the ion source control board.
- In case of the DELTA V Plus IRMS, the Focus Quad power supply board is positioned "piggy-back" between ion source control board and bus control board (ground). See Figure 2-61.

## Focus Quad Power Supply Board

The Focus Quad power supply board is available only in the DELTA V Plus IRMS. As **2** in Figure 2-61, it has been arranged "piggy-back" between ion source control board (below, **1** in Figure 2-61) and bus control board (ground; above, **3** in Figure 2-61).




Labeled Components: 1=Ion source control board; 2=Focus quad power supply board; 3=Bus control board (ground)

**Figure 2-61.** Arrangement of Focus Quad Power Supply Board

The Focus Quad power supply board is missing in the DELTA V Plus IRMS. In this case, the bus control board (ground) is arranged at the same position, but directly above ion source control board.

The Focus Quad power supply board provides a DC voltage between -20 V and +20 V. As with the other lens voltages, the value of the Focus Quad voltage can be adjusted and focused between -100%, 0 and +100% via Isodat 2.5's Instrument Control. As ion focusing is facilitated, the sensitivity of the IRMS increases and the peak shape is enhanced.

## Power Supply for Amplifiers and VFC

The power supply for amplifiers and voltage-frequency converter, **5** in Figure 2-53 and Figure 2-62, is also called 55 V power supply. It provides the different supply voltages for the amplifiers. Table 2-27 summarizes its components.

**Table 2-27.** Components of Power Supply for Amplifiers and VFC[a]

| No. | Component |
|---|---|
| 1 | Voltage output; connection to data logger board |

**Table 2-27.** Components of Power Supply for Amplifiers and VFC[a],

| No. | Component |
|---|---|
| 2 | Heat sink; behind it, the voltage controllers (that is, the control transistors) are located together with a LED. |
| 3 | Power connection (230 V line in) |

[a] See Figure 2-62.

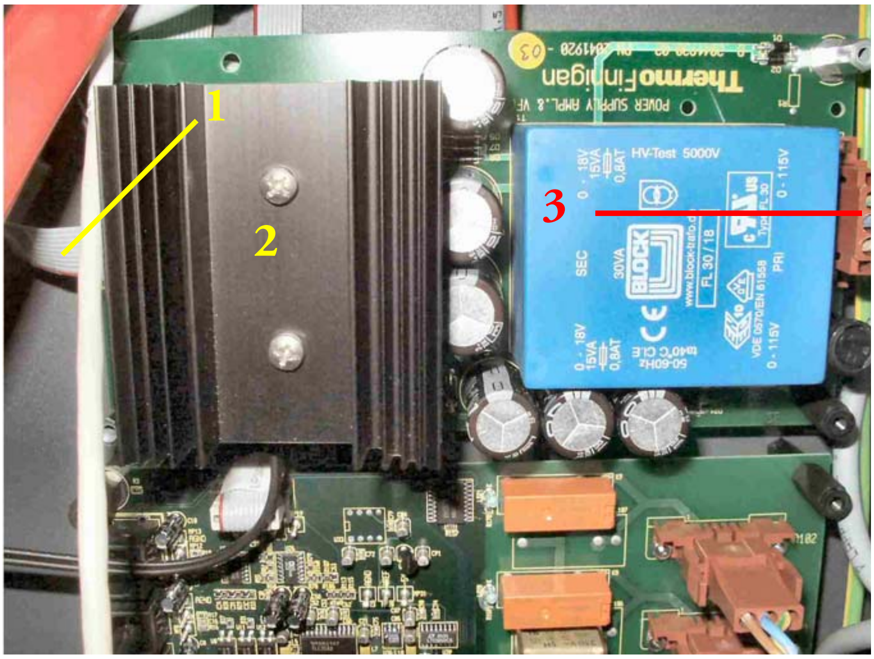



**Figure 2-62.** Power Supply for Amplifiers and VFC

## Power Distribution Board

The power distribution board (synonymously called power distributor, Figure 2-63, and **6** in Figure 2-53) regulates major parts of the IRMS:

- It maintains vacuum safety as it controls fore pumps, turbomolecular pumps and Control Panel.
- It switches the relays of heaters.
- It controls the Penning gauge by reading out its Set Trip: when the pressure falls below Set Trip, the ion source control board will be switched on.
- It controls the magnetic field as follows:

  In order to change the magnetic field, Isodat 2.5 sends a signal along the serial data link cable. This signal will be transformed into a voltage on the power distribution board. This voltage in turn regulates the magnet current regulator. Finally, the magnet current regulator provides the energy that is necessary to create a new magnetic field.

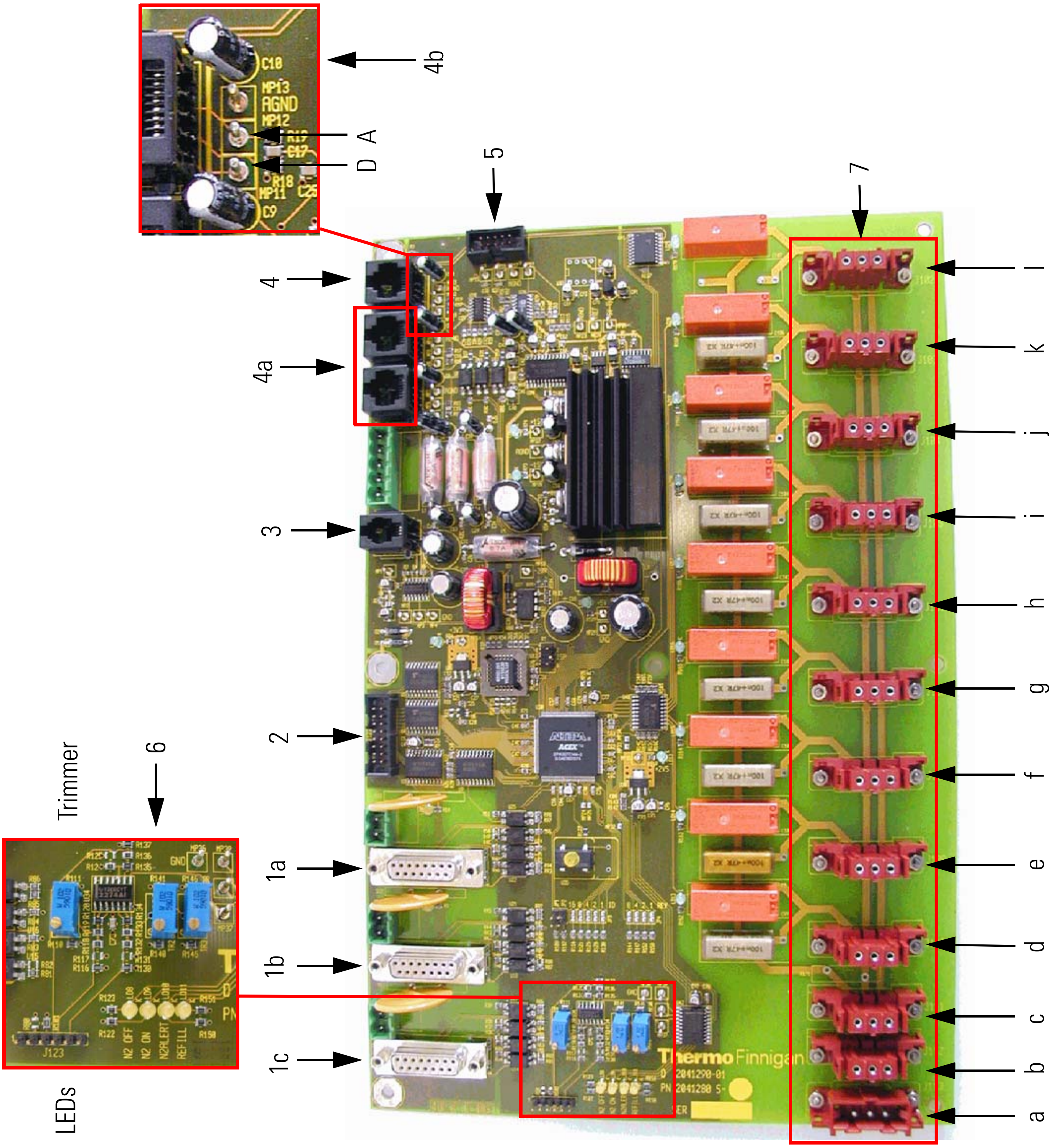



**Figure 2-63.** Power Distribution Board

The components of the power distribution board are summarized in Table 2-28.

**Table 2-28.** Components of Power Distribution Board[a]

| No. | Description |
|---|---|
| 1a | Connection to analyzer turbomolecular pump (required), that is main pump |
| 1b | Connection to analyzer turbomolecular pump (optional), that is differential pump<br>If this optional pump is missing, this connector is shielded by a plug. |
| 1c | Connection to Dual Inlet system turbomolecular pump |
| 2 | Connection to Control Panel |
| 3 | Connection to serial interface |
| 4 | Connection to Penning gauge for high vacuum measurement (important for vacuum security) |
| 4a | Vacuum sensors; additional vacuum gauges can be connected here. Anyway, vacuum security is not affected. |
| 4b | Tapping points for Penning gauge; threshold (D) and actual (A) current values of Penning gauge can be remeasured here. |
| 5 | Connection to magnet current regulator |
| 6 | Controls for refill equipment; the settings of trimmers determine trigger thresholds:<br>LED “N2 OFF” is on when liquid nitrogen has reached maximum level.<br>LED “N2 ON” is on when liquid nitrogen has fallen below minimum level.<br>LED “N2ALERT” is on when liquid nitrogen has reached a critical level.<br>LED “REFILL” is on when refill is switched on. |
| 7 | Connections to all 230 V consumers |
| 7a | Mains from fuse and main switch |
| 7b | to 24 V power supply; not switched |
| 7c | to 55 V power supply (→socket J503); not switched |
| 7d | Refill equipment |
| 7e | Inlet valve heater (→socket J1112) |
| 7f | Ion source control board (→socket J322) |
| 7g | Analyzer heater |
| 7h | Ion source heating |
| 7i | Inlet system heater (→socket J1110) |
| 7j | Inlet pump (→socket J1109) |
| 7k | Pump source & analyzer (→socket J1108) |
| 7l | Source heater (→socket J1113) |

[a] See Figure 2-63.

# Cover Plate

The cover plate is shown together with some dimensions of DELTA V Plus in Figure 2-64 and Figure 2-65. Most external peripherals can be placed upon it.

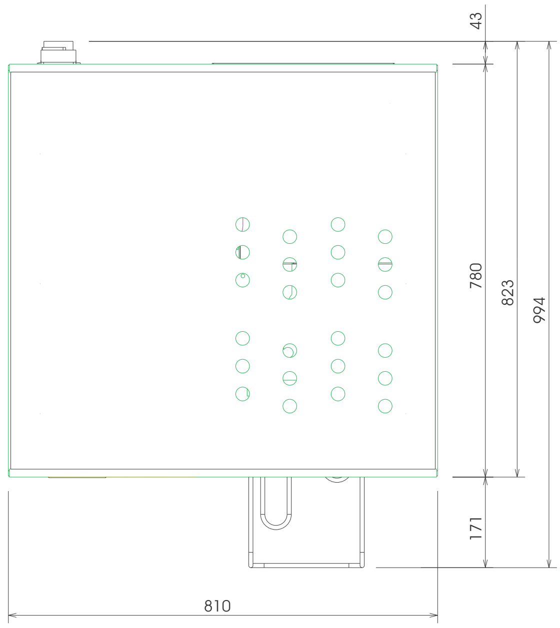



**Figure 2-64.** Cover Plate - Top View with Dimensions

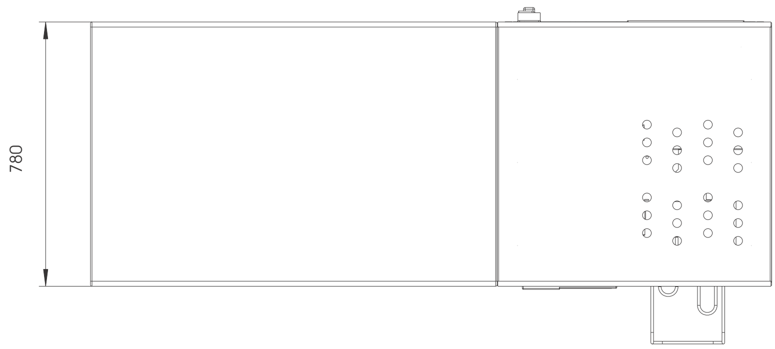



**Figure 2-65.** DELTA V Plus and Peripherals Table - Top View

The removable blind on the left side of the DELTA V Plus IRMS (see "Easy Access via Removable Blind" on page 7-31) allows quick sideways access to for example needle valves and Penning gauge. Thus, the peripheral placed upon the cover plate does not need to be removed in most maintenance cases.

**Warning** **Electric Current.** Danger of injury. Do not remove the cover plate before or during operation or when performing minor servicing, for example at the ion source. Voltages of at least 220 V and temperatures above 60°C are prevalent inside! ▲

**Note** Only in case of maintenance of the Dual Inlet system (for example, a seal must be replaced within it), a Thermo Fisher Scientific field service engineer may remove the cover plate. ▲

Figure 2-66 shows the DELTA V Plus mass spectrometer from above.

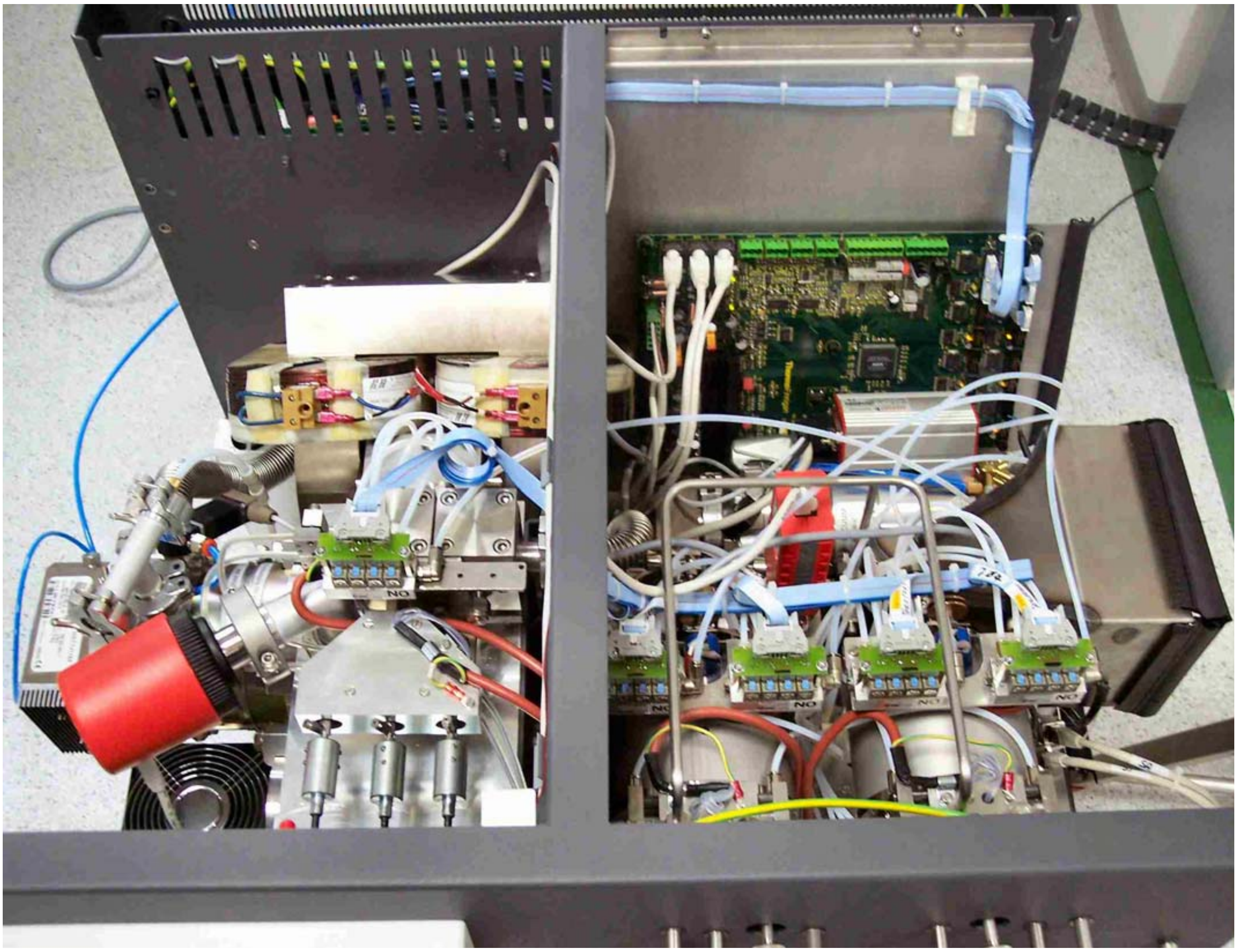


**Figure 2-66.** DELTA V Plus IRMS - Top View without Cover Plate

# Chapter 3 Electronic Components Outside the Electronics Cabinet

This chapter outlines electronic components that are not located within the electronic cabinet at the rear side of the DELTA V Plus mass spectrometer.

It contains the following topics:

# General Remarks

The majority of electronics components of the DELTA V Plus IRMS is located at the electronics cabinet at the rear side of the instrument. See "Electronics Cabinet" on page 2-55.

In this chapter, the remaining electronics components outside the electronics cabinet will be discussed. They are mainly related to data acquisition. Figure 3-1 outlines the communication between your computer and various electronic boards.

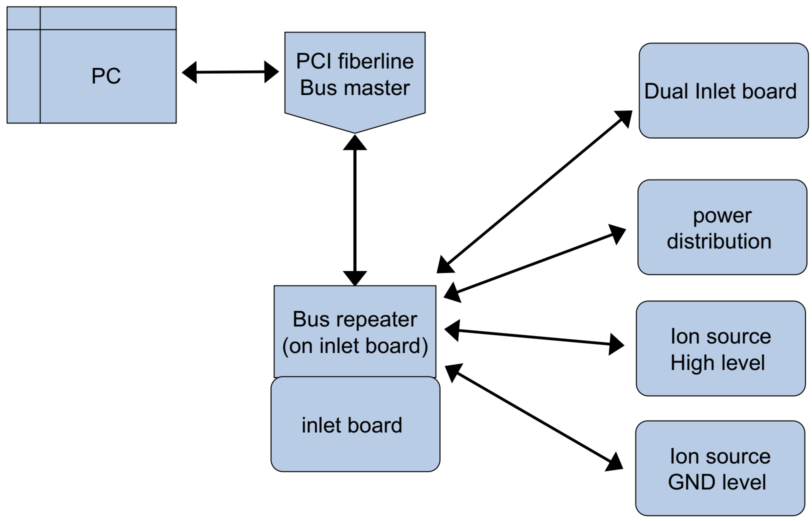



**Figure 3-1.** Communication between Computer and Boards

# Control Panel Board

The Control Panel board, Figure 3-2, is covered by the Control Panel (see "Control Panel" on page 2-5). Therefore, it cannot be seen from outside. Access to it is usually not necessary. It contains the components summarized in Table 3-1.

**Table 3-1.** Components of Control Panel Board[a]

| No. | Component |
|---|---|
| 1 | Several status-reporting LEDs |
| 2 | Upper switch, to turn the pumping system on or off<br>The appropriate LED is located next to it. |
| 3 | Lower switch, to turn Dual Inlet system turbomolecular pump on or off<br>The appropriate LED is located next to it. |
| 4 | Cable, leads to power distribution board |

[a] See Figure 3-2 and see "Control Panel" on page 2-5.

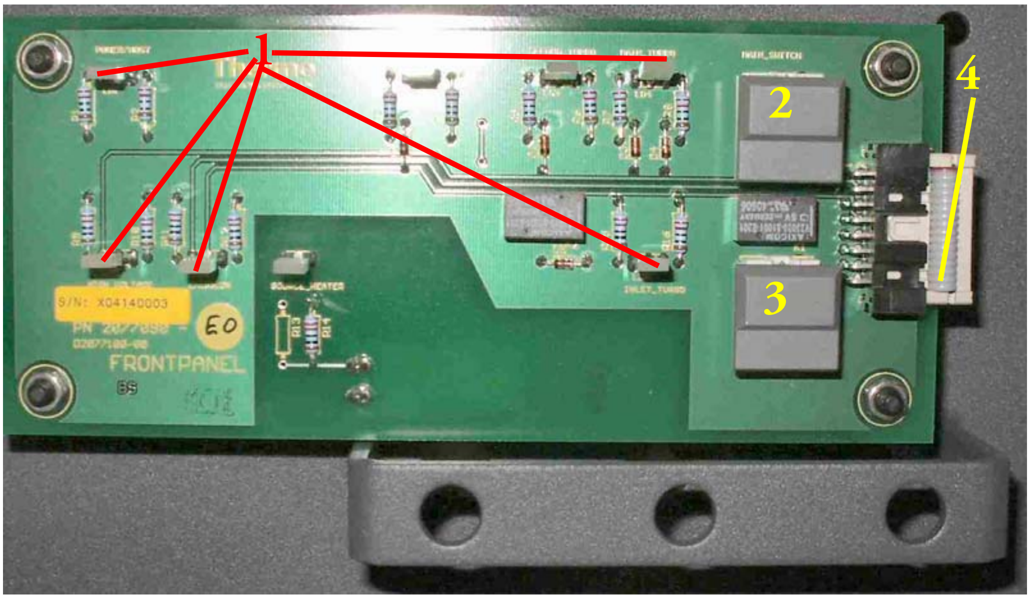



**Figure 3-2.** Control Panel Board

# Data Logger

The data logger is used for recording measurement readings and has been screwed directly upon the analyzer near to the amplifier area so that no interference-prone circuits are needed.

It acts as the vacuum feedthrough towards the fore vacuum of the amplifier area (that is, the vacuum feedthrough has been integrated into the board). Thus, it is the transfer point from ion source control board to the amplifiers. The signal is transmitted from the amplifiers to the data logger. Figure 3-3 and Figure 3-4 show the implemented data logger, whereas Figure 3-5 displays it dismantled.

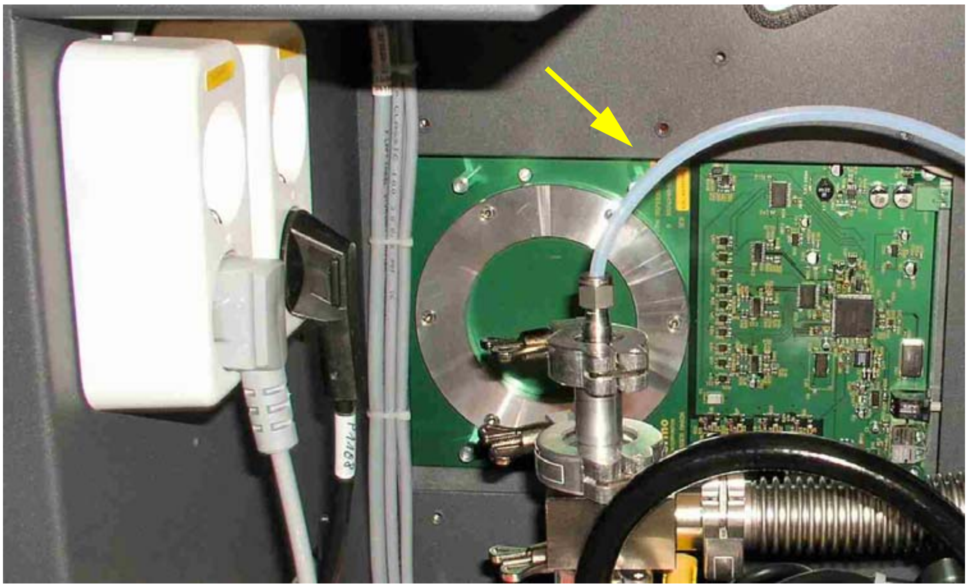
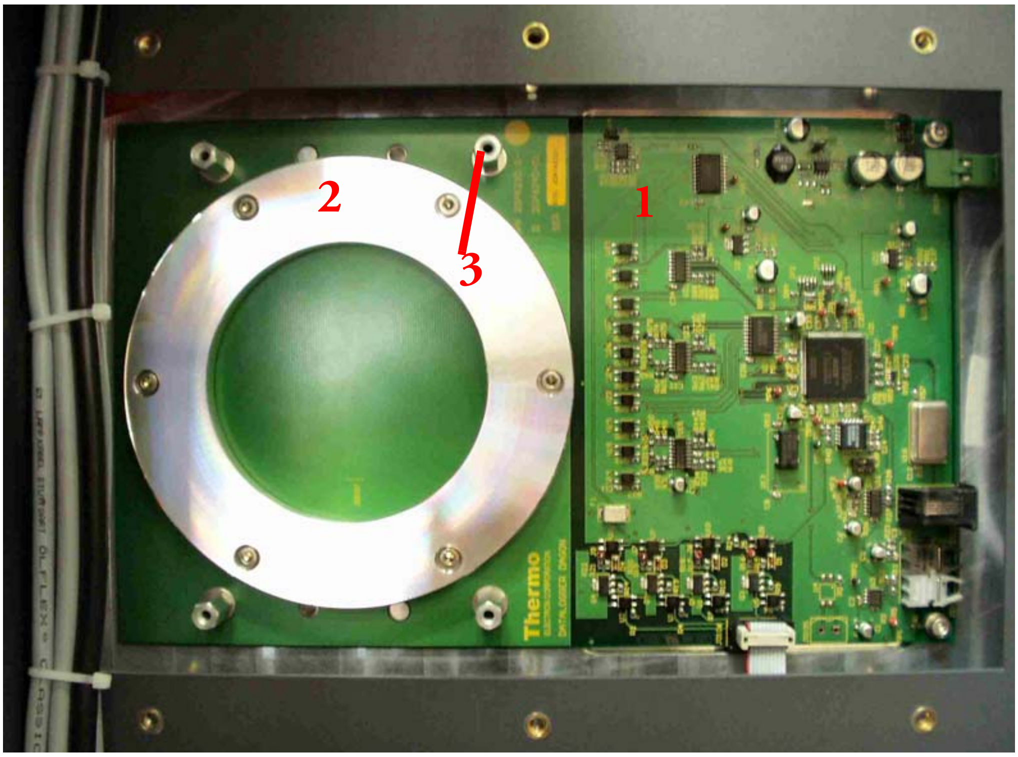


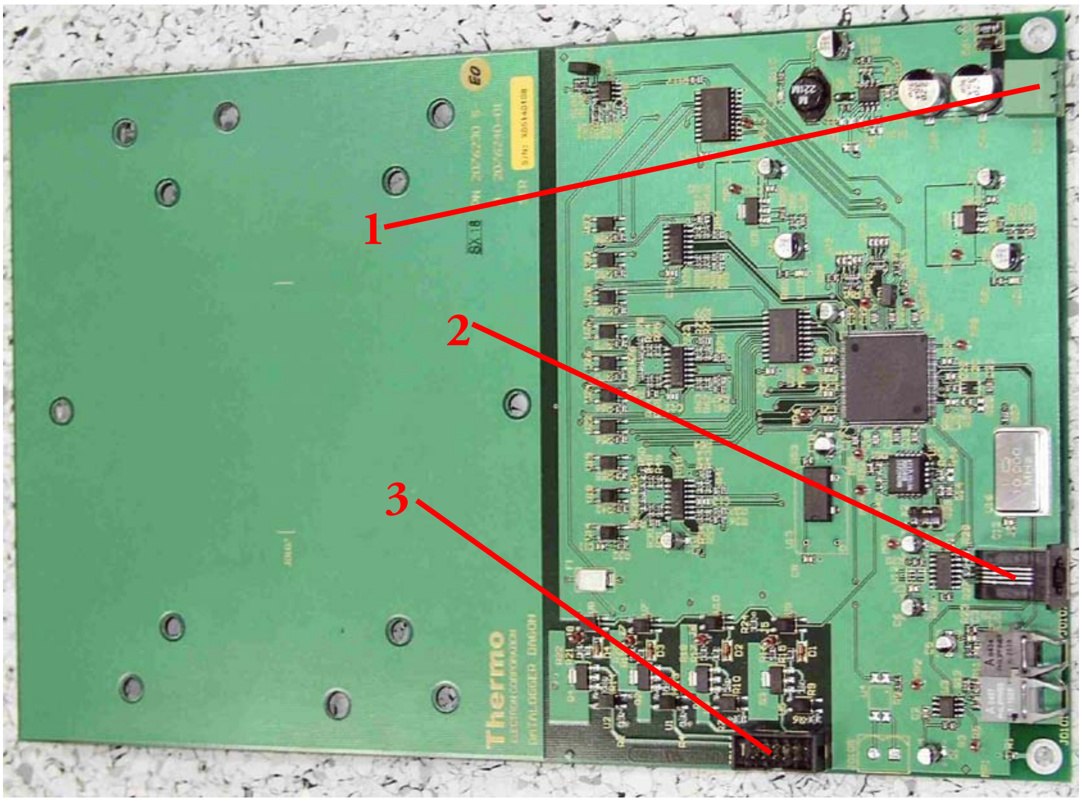
**Figure 3-3.** Data Logger - Implemented (I)




Labeled Components: 1=data logger board; 2=vacuum feedthrough with metallic ring that distributes the pressure; 3=handles for service engineers to pull out data logger

**Figure 3-4.** Data Logger - Implemented (II)

After the data logger has been removed, the Thermo Fisher Scientific field service engineer has access to the ground plane amplifier.




Labeled Components: 1=connector to 24 V power supply; 2=electrical serial data link; 3=connector to 55 V power supply

**Figure 3-5.** Data Logger - Dismantled

**Note** Only service engineers may remove the data logger, for example in case of a electronic defect. To do so, they pull it out at handles **3** in Figure 3-4! ▲

# DEL-PCI Controller

The DEL-PCI controller, Figure 3-6 and Table 3-2, is plugged in a PCI slot of the computer that is delivered with the IRMS. It is connected to the bus controllers in the IRMS via optical fibers. This board is the instrument controller and contains the front-end processor.

**Table 3-2.** Components of DEL-PCI Controller[a]

| No. | Description |
|---|---|
| 1 | Serial data link to IRMS via optical fibers |
| 2 | Connection to PCI slot of computer |

[a] See Figure 3-6.

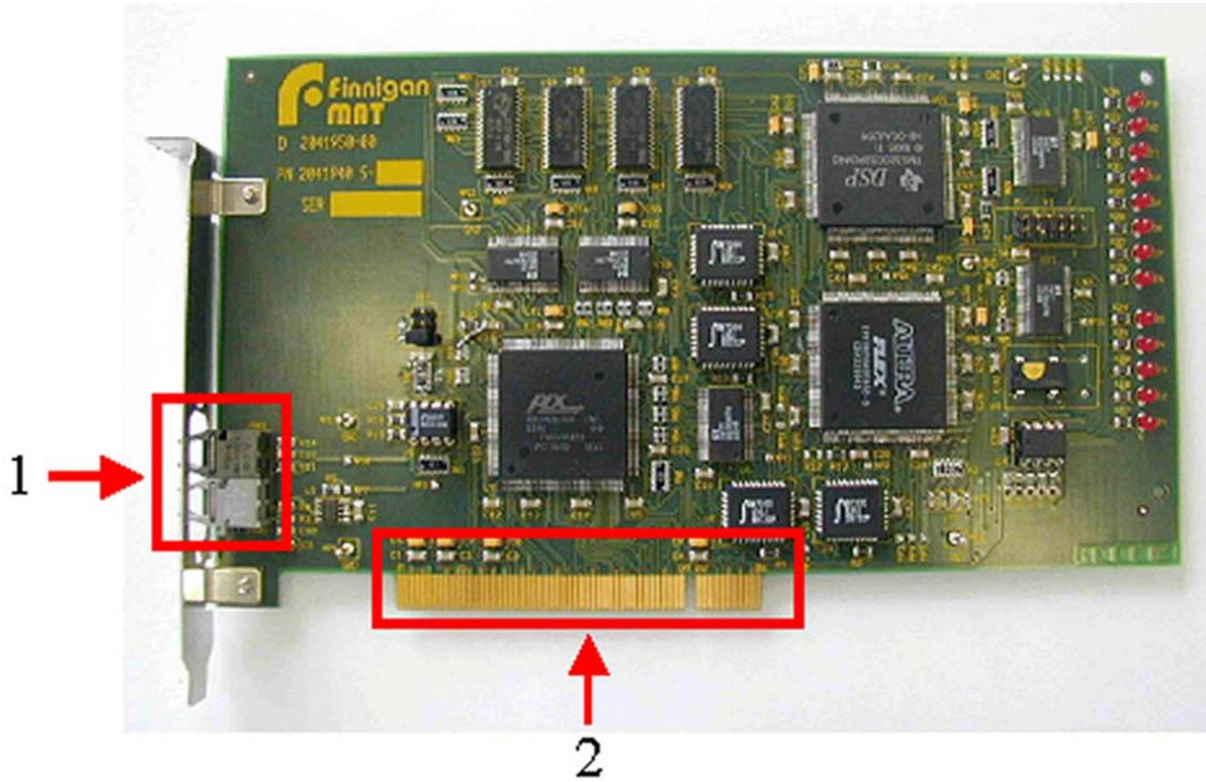



**Figure 3-6.** DEL-PCI Controller

# Grounding of the DELTA V Plus IRMS

A high-frequent radiator nearby the IRMS could adulterate the measurement signal. Conversely, the IRMS could disturb the signals of other highly sensitive devices near to it. Thus, the yellow-green ground wires are merely used for shielding against such high-frequency disturbances into or from the IRMS in accordance with the criteria of electromagnetic compatibility, EMC.

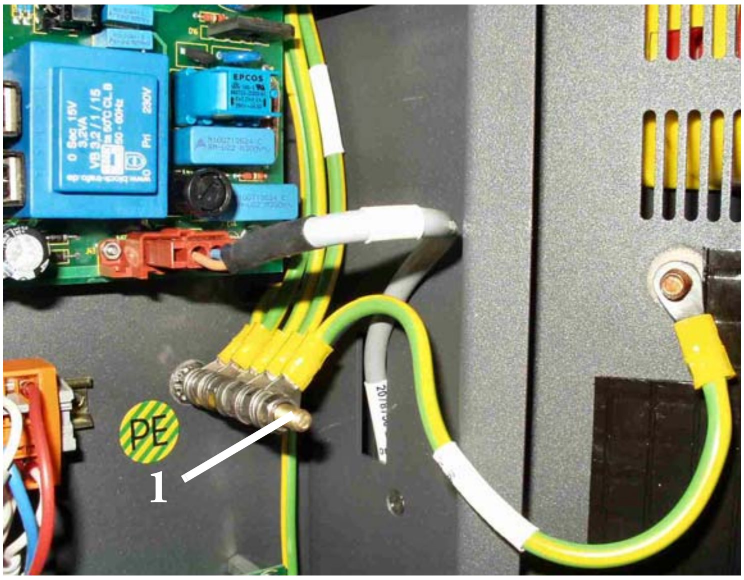



**Figure 3-7.** Ground Wires

**Note** For grounding of the instrument, yellow-green ground wires must be used exclusively! ▲

At several grounding points within the instrument, ground wires are connected to metallic parts with low-impedance. The ground wires will be installed by Thermo Fisher Scientific. See Figure 3-7 as an example. Notice the ground bolt **1** of the electronic cabinet. See also "PE Connector" on page 2-50.

## Plug and Measure Concept

An arbitrary peripheral can be connected to any of the five SUB D connectors, that is up to five peripherals simultaneously. See "SUB D Connectors" on page 2-53.

Each peripheral has its own plug and measure code. This code is encoded either in the cable to the device or in a plug and measure adapter. This is also used for downward compatibility using an old peripheral.

The instrument recognizes the kind of peripheral and the SUB D connector used for it automatically, when a configuration requires this device. Otherwise, for example when the device cable is unplugged accidentally, an error message will be displayed.

## Plug and Measure Adapter

The plug and measure adapter (pnm-adapter, Figure 3-8) is used for connecting peripherals. It is pre-configured at Thermo Fisher Scientific for a defined option, for example ConFlo III). A supplementary reconfiguration by the user is not recommended. The plug and measure adapter is connected to one of the five identical SUB D ports at the rear side of the DELTA V Plus IRMS. The peripheral is then connected to the IRMS via the bottom port of the pnm-adapter.

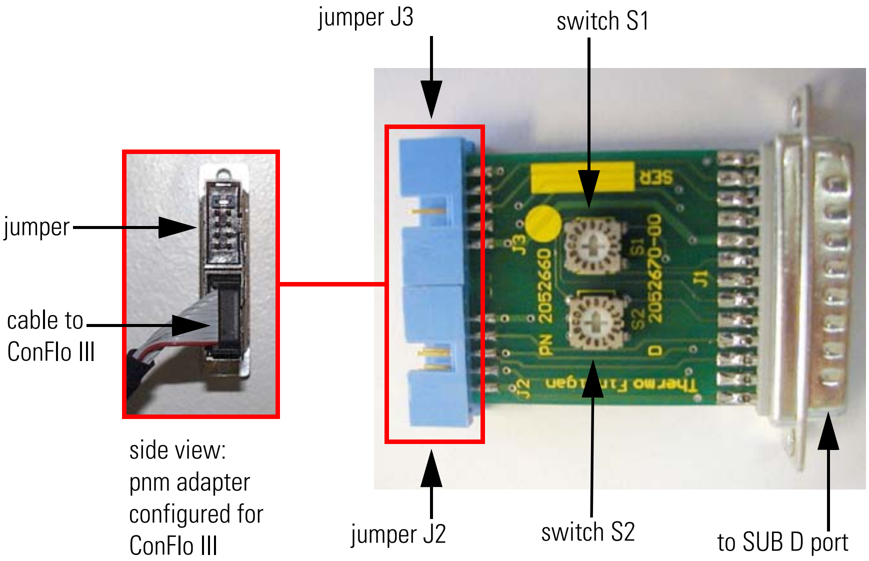



**Figure 3-8.** Plug and Measure Adapter

Peripherals are identified by the settings of the turn switches and the jumpers. The turn switches are used to specify the pnm-ID for the peripheral (for example, for ConFlo III, set S1 to 2). The jumpers are also used to identify the kind of peripheral that is connected to the IRMS. If indicated, the lowest two contacts of the plug socket at the pnm-adapter (either socket J3 or J2) are cut short from outside of the pnm-adapter.

**Note** Some external options are connected to the SUB D ports without using the plug and measure adapter. ▲

## Grounding Cable for Peripherals

Peripherals which are operated by a plug and measure adapter, must be connected to the IRMS by a grounding cable. It is not necessary for peripheral devices, which already run using a new cable (for example, PreCon, GP Interface). The peripheral is connected with a green-yellow PE cable to the IRMS. The grounding contact is a bolt at the right side of the main switch at the lower part of the electronics cabinet.

## Configuration of Plug and Measure Devices

Five SUB D ports are located at the rear side of the instrument. The external option is recognized, because it is encoded with a pnm ID. The electronics recognizes that there is an option connected to a certain port, and which kind of option it is.

**Table 3-3.** Settings for Plug and Measure Devices

| Peripheral | pnm-ID[a] | 2nd ID[b] | Jumper pin 9/10[c] | New cable[d] |
|---|---|---|---|---|
| ConFlo II/III | 0x02 | 0x03 | J3 | |
| GCC II/III | 0x04 | 0x05 | J3 | |
| GasBench II | 0x08 | 0x09 | | |
| PreCon | 0x0A | 0x0B | | Yes |
| MultiInlet | 0x0E | 0x0F | | |
| acid pump | 0x18 | 0x19 | J2 | |
| GC/GP | 0x10 | 0x10 | | Yes |
| Dual Inlet | | | | |
| MP1 | | | | |
| MP2 | | | | |
| TC1 | | | | |
| TC2 | 0x12 | 0x13 | | |

[a] by switches inside the pnm-adapter or by shortcuts inside the cable

[b] if two instruments of the same type are installed

[c] if indicated, the lowest two contacts of the plug socket at the pnm-adapter, that is either socket J3 or J2, are cut short (from the outside of the pnm-adapter).

[d] No pnm-adapter. Instead, it is necessary to exchange the cable.

**Note** The TubeCracker second bank is applied to two ports of the inlet board for external options. Therefore, it has a pnm-number. ▲

## Using Peripherals with another IRMS

The options GasBench, PreCon or TubeCracker are available in two versions:

- one for Delta$^{plus}$XP, Delta$^{plus}$Advantage, or MAT 253
- one for Delta$^{plus}$, Delta$^{plus}$XL, or MAT 252.

Practice has shown that in some laboratories, options are not always connected to the same mass spectrometer, especially the Continuous Flow options like GasBench and PreCon. Depending on the analytical problem, they are sometimes transferred from one mass spectrometer to another. It is possible to switch between the newer generation mass spectrometers (Delta$^{plus}$XP, Delta$^{plus}$Advantage or MAT 253) and the older generation, when the subsequent important guidelines are followed.

- Applying an older peripheral device to a newer generation IRMS

  Use a plug and measure device. In case of PreCon and GP-Interface use a new connection cable.

  – Each option delivered after June 2002 is delivered with the necessary hardware.

  – For older devices, order a plug and measure device or a connection cable.

- Applying a peripheral device ordered with or for a newer generation mass spectrometer to an older generation IRMS

  Connect the connection cable to the driver board.

  – For most peripherals the driver board supplied with the older generation IRMS can be used directly.

  – For peripherals like GasBench, PreCon or TubeCracker it is recommended to order a dedicated driver board.

  Alternatively, a new address can be assigned to the driver board delivered with the older generation IRMS.

**Caution** Never put the plugs of the peripheral connection cable into the wrong socket on the driver board! Serious damage of the driver board may occur, which is not covered by any warranty.
On the other hand, if the jumpers are set to a wrong address, the device cannot be addressed, but nothing will be damaged. ▲

- Applying an option using an IEEE interface (for example, HDO device) delivered with an older generation IRMS to a newer generation IRMS

  Install an additional IEEE interface.

# Chapter 4 Dual Inlet System

This chapter depicts functional units of an optional Dual Inlet system, for example valves, Multiport, Microvolume, Changeover Valve, and Changeover Extension.

It contains the following topics:

# Layout of the Dual Inlet System

Compared to earlier versions, the Dual Inlet system has been modified in some respects. Besides the monolithic construction, its dimensions have been reduced. Figure 4-1 displays a schematic, whereas Figure 4-2 shows its location within the system.

It is controlled by an electronic board of its own, the Dual Inlet board, described at "Dual Inlet Board" on page 2-28.

The Dual Inlet system only needs one fore pump (Dual Inlet system fore pump), which is described at "Dual Inlet System Fore Pump" on page 2-34.

Sample vials and standard vials are mechanically supported and protected as shown in Figure 2-14 to Figure 2-16.

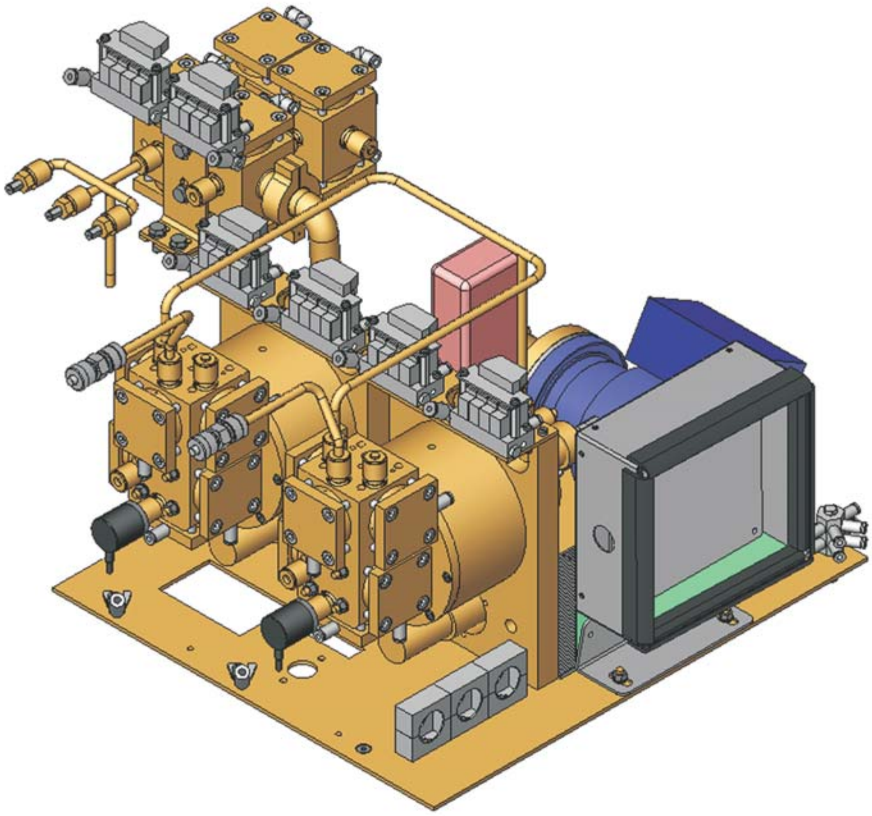


**Figure 4-1.** Schematic of Dual Inlet System - Dismantled

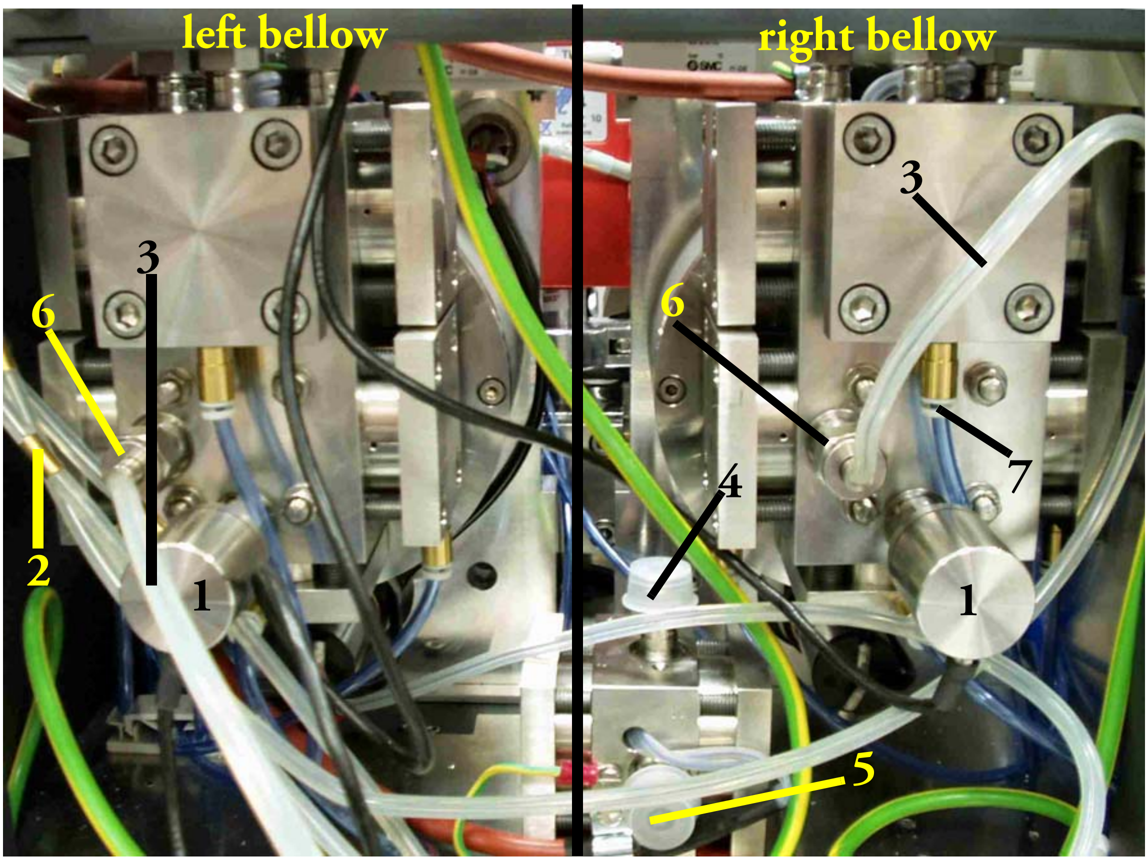



**Figure 4-2.** Dual Inlet System - Front View (behind Upper Door)

**Table 4-1.** Components of Dual Inlet System[a]

| No. | Component |
|---|---|
| 1 | Pressure transducer (one for each bellow)<br>It measures the actual pressure within the individual bellow.<br>See 1 and 2 in Isodat 2.5's Dual Inlet System window, Figure 6-29. |
| 2 | Brass contact in center of capillary for current entry while heating it out (using an alligator crimp and a power supply unit) |
| 3 | Stainless steel capillary<br>It is surrounded by an insulating silicone tube and leads to Changeover Valve. |
| 4 | Connector for a stainless steel capillary that leads to Dual Inlet system<br>It is only available in case of a Microvolume. |
| 5 | Connector for a stainless steel capillary that leads to the Changeover Valve<br>It is only available in case of a Microvolume. |
| 6 | Swagelok connector |
| 7 | Compressed air connector |

[a] See Figure 4-2 and Figure 6-29.

# Principle of the Dual Inlet System

The Dual Inlet system of the DELTA V Plus IRMS has been symmetrically designed and allows alternating measurements of a sample and a standard gas. If the instrument is equipped with a Dual Inlet system, the configuration is identical for sample side and standard side, which enables balanced flow. Each inlet side has two ports and a variable volume (bellow) with the respective inlet capillary leading to the Changeover Valve. For very small samples, a Microvolume with its own capillary is installed.

Before measurements can be performed and results be compared, equal gas conditions—as pressure and flow—must be provided for both sample and standard gas to obtain a balanced ion beam intensity. Pressure adjustment for sample and standard gas is performed in reservoirs (bellows), which are adjustable in volume. These variable volumes are operated by software-controlled bellow motors.

An automated procedure balances the volumes to such an extent that the ion beam intensity of a selected mass attains a preset value. As it is not possible via computer in some cases, balancing of the volumes can also be performed manually. The bellows are adjustable from about 3.5 ml to 40 ml each.

Precise isotope ratio determination via Dual Inlet measurement requires a stable gas flow into the ion source. To obtain this, bellow balancing of both sides is essential. Bellow balancing is called Pressure Adjust in Isodat 2.5 (see "Pressure Adjust" on page 6-31). If sample gas flows into the ion source, an equal amount of a standard gas is evacuated simultaneously by the waste line pump system—or vice versa. The flow conditions thus remain identical during measurement.

Flow conditions are also matched by adjusting the flow resistance through the capillaries to the ion source. The flow resistance is set to equal conditions by crimping the capillaries in front of the inlet port of the Changeover Valve. The crimps of the capillaries are factory-set, but must be set new when a capillary is replaced. How to crimp a capillary to a specific flow resistance is described at "Heating out Capillaries" on page 7-34 and at "Replacing Capillaries" on page 7-37.

The bellows adjust the pressure for larger samples (> 50 bar×µL). Very small samples, as low as 5 bar×µL, can be analyzed using the optional Microvolume. For details, see "Microvolume" on page 4-19.

To avoid any condensation, to remove impurities or to measure $SO_2$, the Dual Inlet system including the Changeover Valve and the ion source can be heated up to 80 °C.

For maintenance of the Dual Inlet system, see "Dual Inlet System" on page 7-25.

## Dual Inlet Device vs. Continuous Flow Device

In Continuous Flow devices, no Dual Inlet system is available. Thus, also the Changeover Valve and the Dual Inlet board are missing.

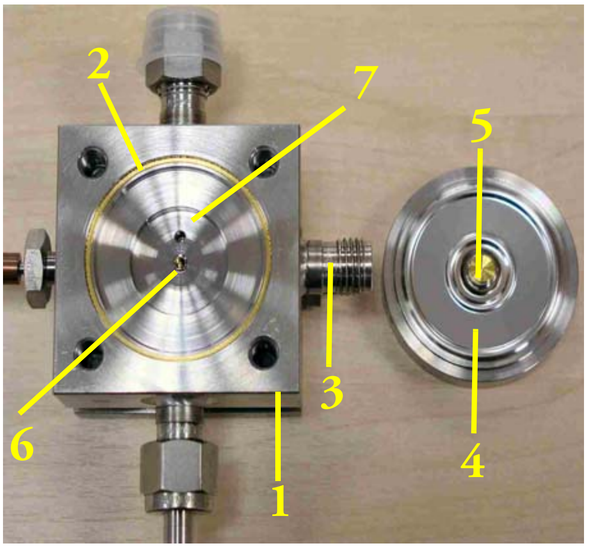
Instead of the Changeover Valve, only the three needle valves are present (in case of Dual Inlet devices as well) and controlled from outside via the Control Panel. See "Needle Valves" on page 7-26. The heating block is the same as in Dual Inlet devices, as well.

# Valves of the Dual Inlet System

The Dual Inlet system is operated by pneumatic valves with a nominal closing pressure of 4 bar. Even though they are all made of stainless steel, after long-term operation they might be worn nevertheless. All the valves base upon the same construction principle. Figure 4-3 shows such a valve with its high-vacuum side opened.

## Parts of a Valve

The stainless steel membrane **4** is turned down by 180° and then laid onto the gold-made gasket **2**, that is with the plunger **5** oriented downwards.




Labeled Components: 1=valve block, made of stainless steel; 2=gasket (gold), seals valve block against stainless steel membrane; 3=Swagelok-connector as gas inlet; laterally welded on the valve block; 4=stainless steel membrane with valve plug that closes the valve (See also Figure 4-11.); 5=plunger, made of gold, fits exactly to the edge; 6=knife, located in center of valve block, also gas exhaust; 7=hole that acts as gas inlet to the valve

**Figure 4-3.** Dual Inlet System Valve


**Figure 4-4.** Parts of Dual Inlet System Valve

The parts of a Dual Inlet system valve are also made of stainless steel. They are depicted in Figure 4-4 and summarized in Table 4-2.

**Table 4-2.** Parts of Dual Inlet System Valve[a]

| No. | Description |
|---|---|
| 1 | Valve block (made of stainless steel) |
| 2 | Stainless steel membrane with valve plug that closes the valve (a sleeve not to be seen in Figure 4-4 is attached to its rear side) |
| 3 | Actuator for compressed air (usually lying within rear side) See "Pneumatic Valves" on page 4-12. |
| 4 | Covering cap |
| 5 | Four screws to fasten covering cap |

[a] See Figure 4-4.

## Arrangement in Valve Blocks

Compressed air is either supplied by an optional compressor attached to the IRMS or by a user supplied pressure air line. The metal valves are equipped with gold gaskets and gold seats acting on knife-edges. Up to six valves are machined into one monoblock, thus considerably reducing the volume in plumbing as well as possible leakage of the installation.

This type of valve block is used throughout all inlet modules. For plumbing the valve blocks are fitted with 1/4" Swagelok-connectors. Compressed air is fed to the pneumatically operated valves by solenoid valves. These are controlled by dedicated electronics linked to the computer via a data bus.

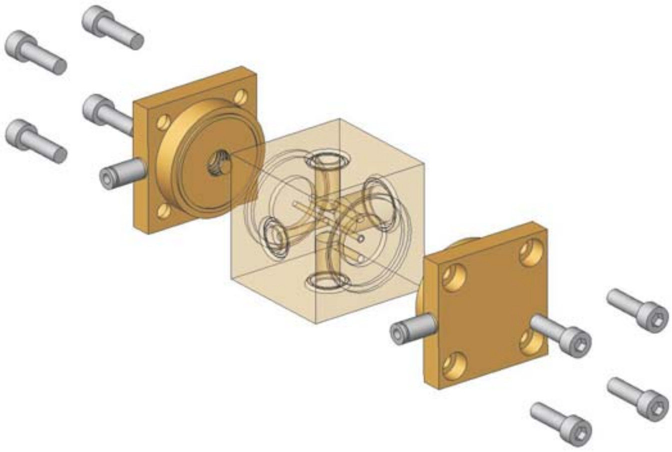
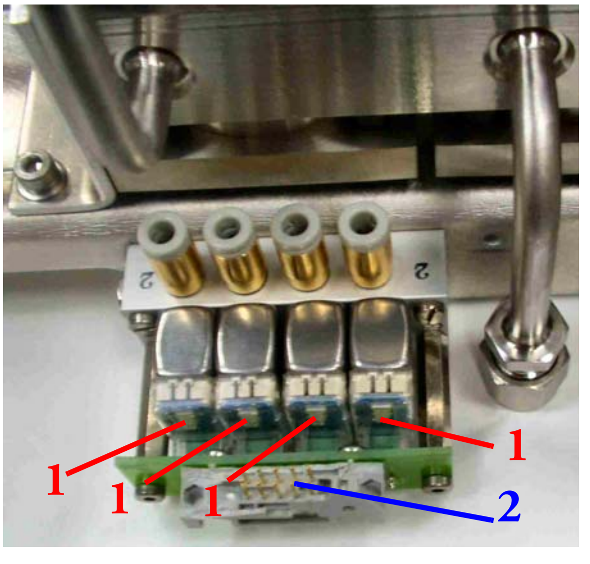


**Figure 4-5.** Double Valve Block

## Manifold Block with Solenoid Valves

Four of the solenoid three-way valves are located on a manifold block. The solenoid valves are operated with a voltage of 24 V. The voltage is supplied by the Dual Inlet board.

The solenoid valves are normally open (with the exception of TubeCracker). The working condition is signaled by a red LED located on the board. The actuators for compressed air transform a signal A into another signal B: they switch an electrical signal generated at the Dual Inlet board into a compressed air signal. Thereby, compressed air is provided which forcefully switches the actual valves.



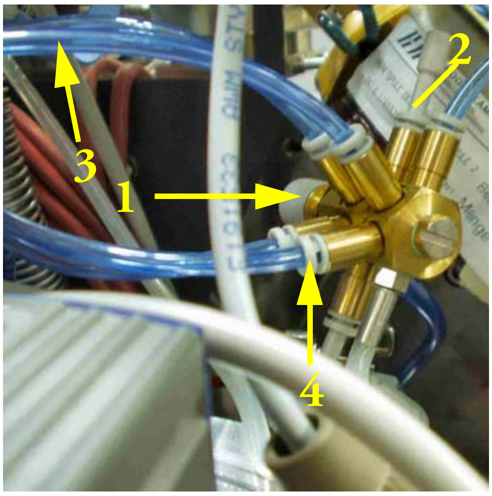

Labeled Components: 1=four LEDs reveal individual switching status (on/off); 2=connector to Dual Inlet board

**Figure 4-6.** Manifold Block with Four Solenoid Valves

**Note** In case of a power failure, all solenoid valves open automatically (exception: TubeCracker, where they close automatically). Thus, the pneumatic valves in the entire Dual Inlet system close avoiding its contamination. ▲

# Compressed Air Distributor

The compressed air distributor, Figure 4-7, is part of the Dual Inlet system. Therefore, it is missing if no Dual Inlet system is available.




Labeled Components: 1=connection where compressed air enters; 2=blind plug; 3=tubings; 4=tubing connections

**Figure 4-7.** Compressed Air Distributor

## Compressed Air Connections

The compressed air connections of the distributor are all equivalent ones. Compressed air enters at **1** in Figure 4-7 and is then distributed to all compressed air valves.

The number of compressed air valves of the system depends on which particular options for the Dual Inlet system are available. If only few compressed air valves must be connected to the compressed air distributor, one or more blind plugs **2** allow closing the unused connections tightly.

# Changeover Valve

The Changeover Valve allows maintaining a continuous, never interrupted flow of gas as it switches between reference gas flow and sample gas flow (in the range of some tens to some hundred mbar×L×$s^{-1}$ each). Alternatingly, one gas flow is continuously led into the ion source (evacuated by analyzer turbomolecular pump), whereas the other gas flow is continuously pumped off by the Dual Inlet system turbomolecular pump.

## Layout of the Changeover Valve

The Changeover Valve consists of a single block attached to the analyzer housing and accepts the coupling of capillaries for sample and standard gas. It is operated automatically by Isodat 2.5 or manually via the monitor display of the inlet schematic.

Figure 4-8 and Figure 4-9 show its layout and position upon the analyzer. Made of two metallic blocks which contain four individual valves each, the Changeover Valve allows repeatedly alternating between sample gas and reference gas. Switch between "**no** gas into the ion source", "gas from the **right** bellow into the ion source" and "gas from the **left** bellow into the ion source".

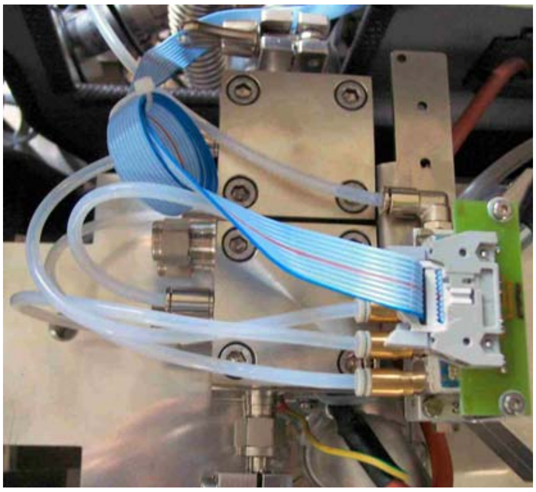


**Figure 4-8.** Changeover Valve

The positions where capillaries can be inserted are displayed as **1** in Figure 4-9, whereas **2** shows the direction towards Dual Inlet system turbomolecular pump.

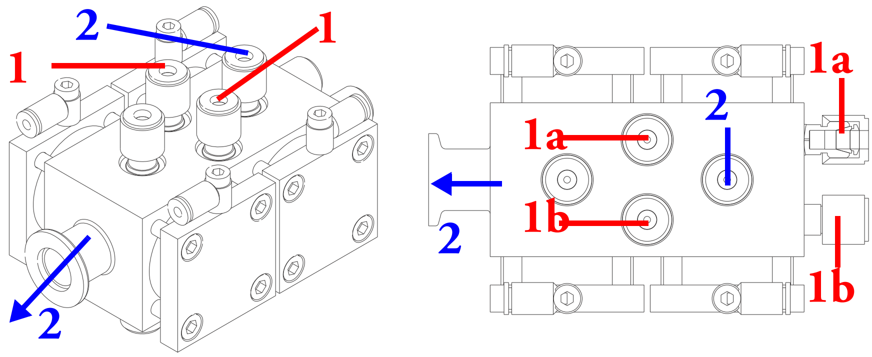



**Figure 4-9.** Schematics of Changeover Valve

**Note** Positions **1a** and **1a** are equivalent. Positions **1b** and **1b** are equivalent as well. At **2**, a needle valve can be connected alternatively. ▲

## Pneumatic Valves

### Layout of the Pneumatic Valves

A cylinder on top is actuated by compressed air. Its gold-made plunger then presses a membrane underneath and thus tightens. Gas transfer is then impossible. When no compressed air is present, the cylinder is not actuated. Its plunger will not press the membrane and thus does not tighten. Gas transfer is possible.

### Parts of a Pneumatic Valve

Figure 4-10 shows the parts of a pneumatic valve.


Labeled Components: 1=sleeve (compressed air plunger moves within it), 2=compressed air plunger; 3=O-ring seal (seals compressed air plunger against sleeve); 4=guide sleeve, made of Pertinax (arranged above O-ring seal)

**Figure 4-10.** Parts of a Pneumatic Valve

### Inserting a Pneumatic Valve

Figure 4-11 shows the pliers **1** to properly insert a pneumatic valve **2**. Hold the pneumatic valve tight by jamming it within the pliers (left in Figure 4-11). Then shove the outer sleeve above the pneumatic valve (right in Figure 4-11).


Labeled Components: 1=pliers to properly insert a pneumatic valve; 2=pneumatic valve; 3=compressed air plunger

**Figure 4-11.** Pliers to Insert a Pneumatic Valve

## Capillary Connections

Figure 4-12 depicts how a stainless steel capillary is connected to the Changeover Valve. **1** are the crimping screws, **2** is the stainless steel capillary with the crimping position **3**.

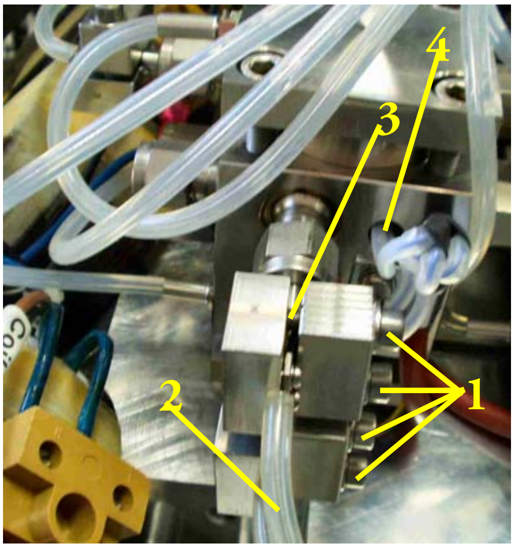



**Figure 4-12.** Capillary Connections at Changeover Valve

At **4**, a heating cartridge is positioned. Several of them are housed within the metal block. They serve to heat out the Changeover Valve and usually need neither to be replaced nor maintained.

# Changeover Extension

The Changeover Extension, Figure 4-13, may be added to the Changeover Valve as an optional extension module. It is almost identical to it and thus has the same function. The Changeover Extension is flanged to the Changeover Valve by 1/4" Swagelok™ connectors and provides two additional inlet ports allowing coupling of further inlet system options, for example a Kiel IV Carbonate Device.

Additional sample gases can be switched via its two ports. External peripherals, for example ConFlo III, can be connected to it instead of connecting them to a needle valve.

**Note** The Changeover Extension can be controlled via Isodat 2.5, whereas a needle valve can only be switched manually. ▲

Thus, the Changeover Extension is advantageous when it is required to switch between various external peripherals automatically.

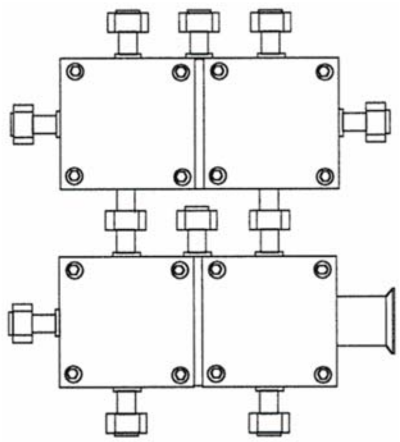


**Figure 4-13.** Changeover Extension Attached to Changeover Valve

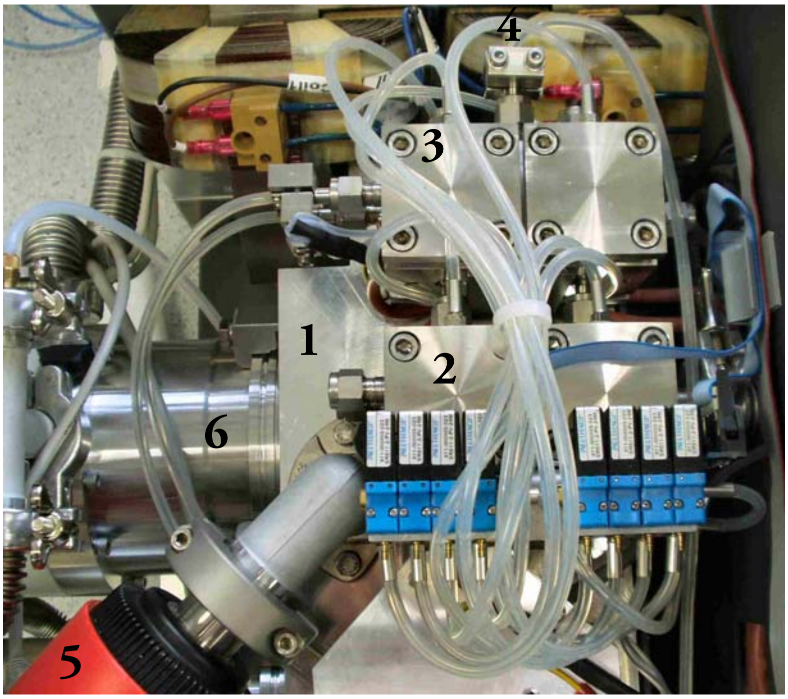



**Figure 4-14.** Changeover Valve and Changeover Extension

Figure 4-14 shows the analyzer **1** in top view together with the Changeover Valve **2** and the Changeover Extension **3**. A Microvolume **4** has been connected to the Changeover Extension. Penning gauge **5** and analyzer turbomolecular pump **6** are also shown.

# Multiport

The Multiport is a sample manifold inlet system consisting of one or two banks of 10 ports each. It may be optionally equipped with a TubeCracker. When using the Multiport as an inlet system, the Multiport is connected directly to the sample side of the Inlet System valve 12 (left inlet port). The valves of the Multiport are operated the same way as the components of the Dual Inlet system, that is automatically by the computer or manually via the monitor display.

If a Dual Inlet system is available, the DELTA V Plus IRMS may additionally contain a Multiport 10 (10 ports) and/or a Multiport Extension (10 ports) each. Thus together, they provide 20 additional ports ("Multiport+Extension").

A Multiport allows easily switching between various inlet ports for gases. The degree of automation is higher than in case of Dual inlet system (see Figure 2-15 on page 2-18): in case of gas change, it is not necessary to repeatedly connect new sample vials at the front side and start measurement manually thereafter. Instead, connect many different sample vials to the Multiport at the same time and then start their automatic successive measurement via Isodat 2.5 only once.

When no Multiport is available, only the two inlet ports of the Dual Inlet system can be used to let gases flow into the system (Figure 2-15). If more than two ports are needed however, a Multiport is required (for example, in case of automatic successive measurement of different gases after their offline-preparation).

## Dismantling the Multiport

Figure 4-15 shows the implemented Multiport (that is Multiport 10) **1** and the implemented Multiport Extension **2** in top view.

**Note** Multiport 10 **1** and Multiport Extension **2** together form "Multiport+Extension". ▲

On the right, both are fastened by socket screws **3**. When dismantling the Multiport, both can easily be removed by using an Allen wrench. On the left, they are simply attached at **4** without screws.

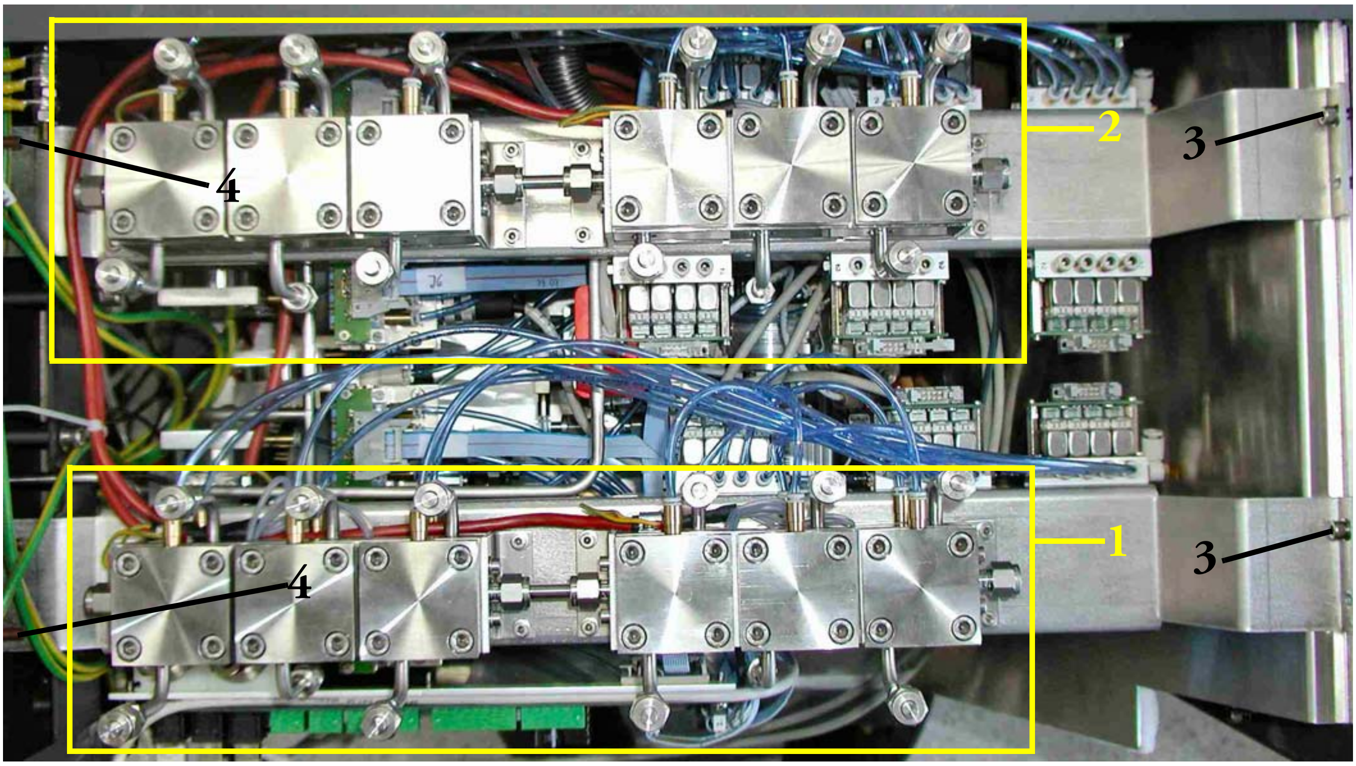



**Figure 4-15.** Multiport - Implemented (Top View)

## TubeCracker

The TubeCracker, Figure 4-16, is an option for the Multiport. After gases have been prepared offline and stored within melted-off glass ampules, the TubeCracker automatically breaks them at a predetermined breaking point. As the TubeCracker is mounted upon a Multiport, the gas enters the system this way. See "Multiport" on page 4-16.

On the left side of Figure 4-16, the TubeCracker is depicted in rest position, that is straight. **1** shows the compressed air tube shoved above the compressed air inlet. Via the connecting piece **2** (protected by a plastic bag), the TubeCracker is mounted onto the Multiport by sticking it into one of its positions.

On either side of TubeCracker, a rubber-sealed Swagelok-connector **3** allows jamming a glass tube of arbitrary length to be cracked. The glass tube sticks out of the TubeCracker, whereas the site of fracture is located inside of it.

**Note** The same Swagelok-connectors are used to connect sample vials at the front side. See Figure 2-16. ▲

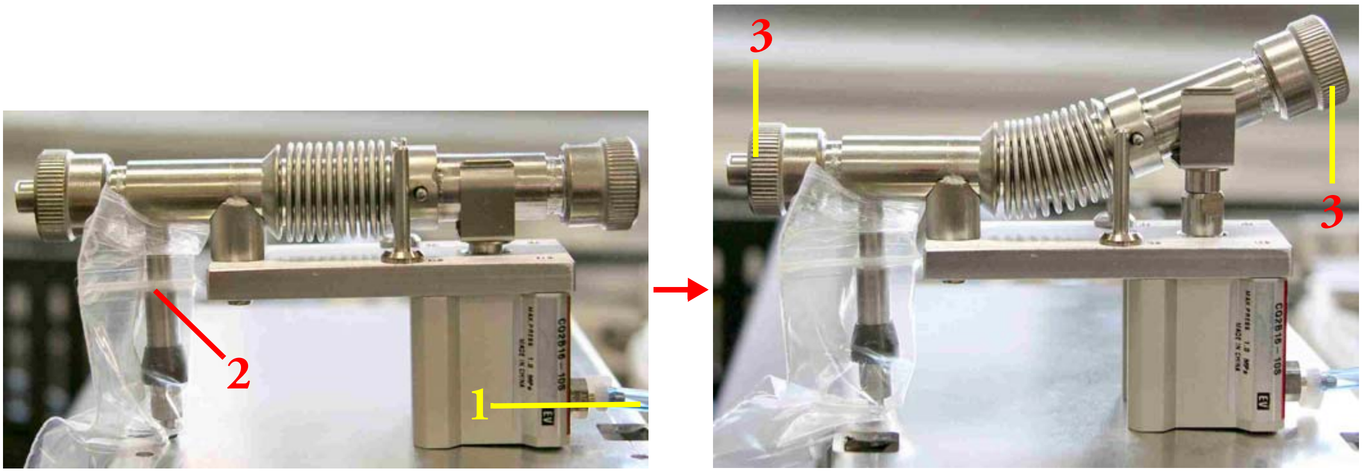



**Figure 4-16.** TubeCracker in Retracted Position

On the right side of Figure 4-16, the TubeCracker is shown in extended position, that is, operated with compressed air. The glass tube that was inserted at **3** in rest position has been cracked.

## Reference Gas Refill

When working with a Multiport inlet system, a reference gas refill may be necessary in order to avoid running out of reference gas during measurements. Reference Refill provides the reference gas supply to the inlet system. Reference Refill is a hardware option. It consists of a metal tank with a manual valve connected via a capillary to one of the inlet ports on the standard side. The capacity of the metal tank amounts to approximately 5 l. See Figure 4-17. With the Reference Refill selected, the standard side of the inlet system is completely pumped out before it is filled again for the next measurement sequence.

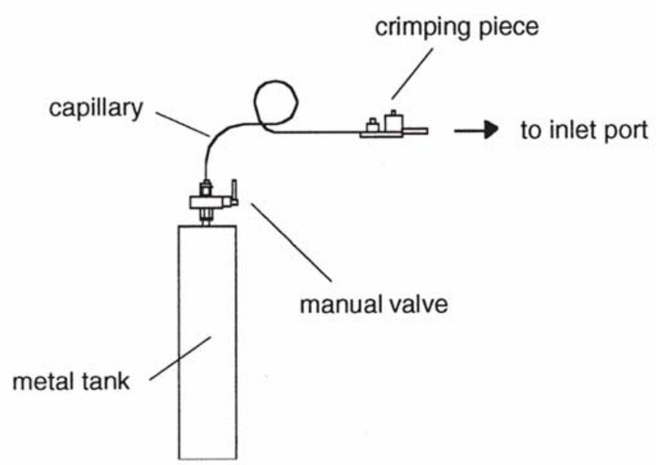



**Figure 4-17.** Reference Gas Refill

# Microvolume

### Safety Warnings

Keep in mind: Safety First! Before operating the device, carefully read these notes as well as the manufacturer's handling instructions. Make sure that only authorized and fully trained operators use this equipment and they are fully conversant with these safety notes.

**Warning** **Low Temperatures.** Danger of injury. The device contains extremely cold liquid gas. Careless handling might cause severe personal injury including frostbite. Only use liquid nitrogen as cooling agent. ▲

**Warning** Wear protective clothing when operating this equipment, including protective gloves and face shield. Do not overfill or tilt the device! Prevent spills. ▲

**Warning** **Suffocation Hazard.** Use the device only in well-ventilated areas. Poor ventilation might cause suffocation. Follow correct First Aid procedures. If gas was inhaled, remove victim to fresh air. If necessary give artificial respiration and seek medical assistance immediately ▲

## Layout and Principle of the Microvolume

The Microvolume or cooling finger as optional inlet module for very small samples may be installed in combination with a Dual Inlet system or a Multiport. In both cases, Microvolume is connected to the left port (valve 12) of Dual Inlet system.

A Microvolume consists of a cooling finger, a valve block, an Autocool Unit and a separate capillary. This capillary leads directly to the Changeover Valve.

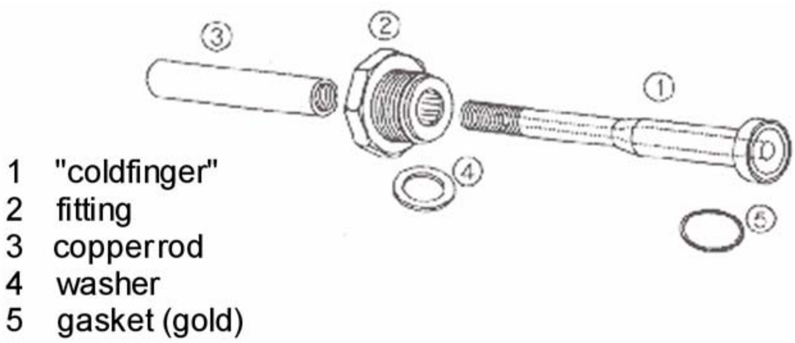



**Figure 4-18.** Microvolume Parts to be Inserted into Autocool Unit

The Microvolume contains two valves, the cooling finger and a pumping device. It is used for smallest sample amounts. The total volume in front of the capillary crimp, that is "cooling finger" volume plus the connections including the capillary, is about 145 µL. Due to the viscous flow conditions, which require a pressure of at least 15 mbar in front of the capillary, a sample of 3 bar×µL to 50 bar×µL must be concentrated into a small volume. The cooling finger volume can be reduced for even smaller samples by inserting small steel spheres. The concentration in a Microvolume is performed by freezing the small sample using liquid nitrogen and expanding it again by subsequent heating.

Two different types of Microvolumes can be used depending on the gas to be measured. For $CO_2$, a smaller Microvolume is used, and for $N_2$ a larger one is required. The larger one contains a molecular sieve to freeze out $N_2$ at liquid nitrogen temperature.

The valves of the Microvolume are operated in the same way as the other components of the Dual Inlet system (automatically via computer or manually via monitor display). Using the Autocool Unit, the temperature can be set individually within a range of about -180 °C and +155 °C.

The sample gas to be measured, for example $CO_2$, will move to the coldest place within the tubing system, that is to the cold cooling finger, where it is frozen out.

Then, the valves are closed, and the Microvolume will be heated. The sample gas will expand and considerably increase the pressure within the small volume. Now, measurement via standard-sample comparison is possible (sample within the small Microvolume; standard within the equally small volume between valve 25, valve 26 and the capillary depicted by the rectangle in Figure 8-1).

## Autocool Unit

The Autocool Unit is an automatic, software-controlled cooling unit superseding the cumbersome manual procedure. It comprises for example the following components: dewar, refill tube for liquid nitrogen, refill valve at liquid nitrogen tank, copper-made cooling cascades, fill level controller with protective tube, funnel with integrated heater.

The temperature of the Autocool Unit, that cools the cooling finger, can be set via Isodat 2.5's Microvolume control (that is via the "Instrument" tab's "Microvolume" part). A temperature range between -180 °C and +155 °C can be covered.

- The time to get from +50 °C down to -180 °C is less than 2 minute.
- The time to get from -180 °C up to +50 °C is about 1 minute.

The Microvolume fits into a thermal contact pipe attached to the lid of a dewar. The dewar contains liquid nitrogen. An electrical heater element, a temperature sensor and a cascade arrangement of three small bowls are fitted to the contact pipe. See Figure 4-19. All parts of the assembly are made of a material of high thermal conductivity and are placed in close thermal contact to each other. Thus, a quick change from one temperature to another is provided. To heat the Microvolume to a defined temperature, the heater element is activated. The heating phase is controlled by the temperature sensor.

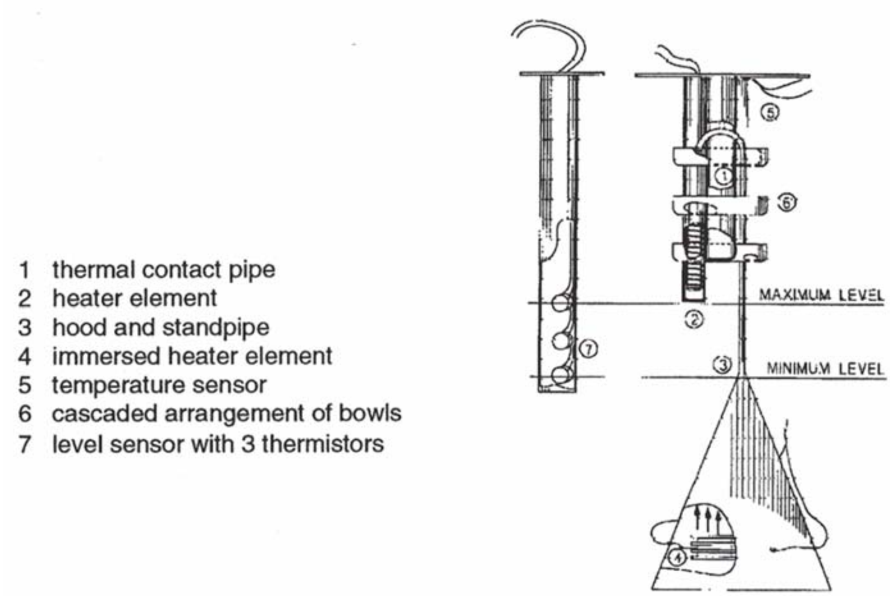



**Figure 4-19.** Schematic of Autocool Unit

To cool the Microvolume, another electrical heater element immersed in liquid nitrogen is activated and causes both evaporation and agitation.

Above the heater element, a funnel-shaped hood of a standpipe is positioned, which leads to the uppermost bowl of the cascaded arrangement. This arrangement enables about one droplet of liquid nitrogen per second to be carried by the stream of evaporated nitrogen.

Small holes in the bottom of the bowls yield a constant trickle of liquid nitrogen back into the dewar, and the continuous flow of liquid nitrogen rapidly cools down the Microvolume. By suitable balancing of the liquid nitrogen flow and heating the Microvolume, any temperature within the range can be obtained.

Due to the very small quantity of liquid nitrogen held in the cascaded bowl arrangement the Microvolume temperature rises very quickly when the immersion heater is switched off and the pipe heater is switched on. A constant liquid nitrogen level in the dewar vessel is maintained by means of the liquid nitrogen refill device.

# Autocool Refill Device

## Safety Warnings

Keep in mind: Safety First! Before operating the device, carefully read these notes as well as the manufacturer's handling instructions. Make sure that only authorized and fully trained operators use this equipment and they are fully conversant with these safety notes.

**Warning** **Low Temperatures.** Danger of injury. The device contains extremely cold liquid gas. Careless handling might cause severe personal injury including frostbite. Only use liquid nitrogen as cooling agent. ▲

**Warning** Wear protective clothing when operating this equipment, including protective gloves and face shield. Do not overfill or tilt the device! Prevent spills. ▲

**Warning** **Suffocation Hazard.** Use the device only in well-ventilated areas. Poor ventilation might cause suffocation. Follow correct First Aid procedures. If gas was inhaled, remove victim to fresh air. If necessary give artificial respiration and seek medical assistance immediately ▲

Maintenance of Autocool Refill device is described at "Autocool Refill Device" on page 7-25.

## General Remarks

Autocool Refill device provides a constant level of liquid $N_2$ in the dewar of Autocool Unit. It consists of a storage dewar of 75 L or 25 L and is equipped with safety devices, valves and pressure gauges required for safely handling liquid $N_2$.

The transfer line to the dewar of the Autocool Unit is controlled by a solenoid refill valve N12. This refill valve N12 is directly connected to the liquid fill and decant valve of the Autocool Refill device.

The Autocool Refill device is activated by a level sensor installed in the dewar of the Autocool Unit. The level sensor consists of three sensing thermistors (see Figure 4-20 and **7** in Figure 4-19), one each for the maximum, the minimum and the alert level. They are Pt 100 resistors, that is resistors of 100 Ω.

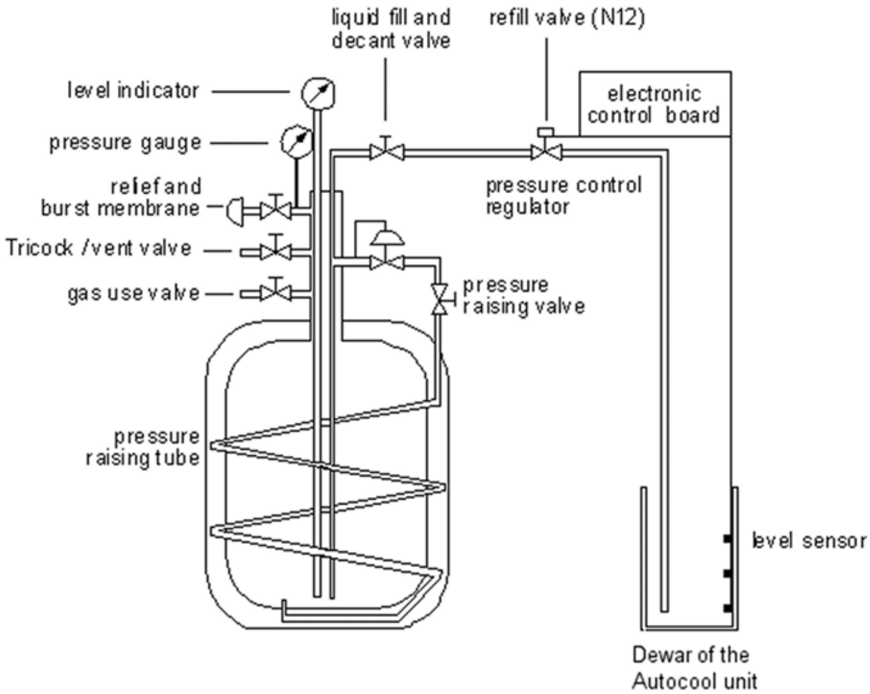



**Figure 4-20.** Schematic of Autocool Refill Device

## Working Principle

The transfer of liquid nitrogen is affected by a pressure build-up in the self-pressurizing dewar of the refill device. The pressure builds up by vaporization of liquid nitrogen in a coiled pressure raising tube located in the dewar's vacuum interspace when the gas vent valve is closed and the pressure-raising valve is opened.

A pressure gauge monitors the pressure. A pressure of 5 psi should be sufficient to transfer liquid nitrogen. A pressure of 10 psi will transfer liquid at about 10 L/min. A higher pressure is not necessary and even squandering.

As soon as a preset pressure is reached, the pressure regulator installed in the circulation cuts the flow through the coiled pressure raising tube. The working pressure can be set to an optimal level using the pressure regulator.

The blow-off valve is set to a limit of about 1.5 bar. An additional burst membrane prevents from building up a dangerous pressure. The gas vent valve allows bleeding excessive pressure, if necessary. The function schematic of the liquid nitrogen refill device is shown in Figure 4-20. The 75 L storage dewar is equipped with a level indicator monitoring liquid nitrogen content.

### Checking Liquid Nitrogen Evaporation Rate

If you suspect that the evaporation rate of the refill device is excessive, note down the decrease of the liquid nitrogen level for some time. To check the loss rate, close the pressure-raising valve and open the Trycock/vent valve. After the contents are fully vented down to atmospheric pressure, measure the boil-off rate using a simple flow meter. The normal boil-off rate for nitrogen is 1 L/min for gas, that is about 2 L of liquid per day.

The reason for a higher rate might be an abnormal cold or frost formation at the lower dished end of the outer casing, which should be removed.

### Refill Tube for Liquid Nitrogen

The refill tube for liquid nitrogen, **5** in Figure 2-17, has been isolated and provides the Microvolume. It is therefore connected to the big liquid nitrogen refill tank. Depending on the fill level in the dewar, a refill valve at the refill tank will be opened or closed. Resistor cascades are monitoring three different fill levels (lower level, middle level and final switch-off) within the dewar.

**Caution** Because it cannot be heated, the cooling finger must never be in contact with liquid nitrogen! The fill level must end sufficiently beneath the cooling finger. ▲

### Operating Instructions

As a quick reference, the arrangement of valves for filling, dispensing and storage of liquid nitrogen is shown below. See Figure 4-20.

**Table 4-3.** Valve Statuses during Operation

| Operation | Liquid Fill and Decant Valve | Gas Use Valve | Pressure-Raising Valve | Trycock/Vent Valve |
|---|---|---|---|---|
| Filling Liquid | open | closed | closed | open |
| Dispensing Liquid | open | closed | open | closed |
| Gas Withdrawal | closed | open | open | closed |
| Storage (Short Term) | closed | closed | open | closed |
| Storage (Long Term) | closed | closed | closed | open |

Before using the Microvolume, check the content of the refill device. If filling is required:

1. Open the Trycock/vent valve and close the pressure-raising valve.

2. Close the gas use valve and fill via the opened liquid fill and decant valve.

After having checked the refill device, first fill the dewar of the Autocool Unit with liquid nitrogen roughly to the required level.

❖ **To enable the automated and computer controlled refill operation**

1. Check the pipe connection leading to the dewar of Autocool Unit.
2. Close the gas vent valve and open the liquid fill and decant valve.
3. Open the pressure-raising valve.

The refill device is now connected to the dewar of the Microvolume via the opened liquid fill and decant valve.

The flow is controlled via the refill valve N12. The pressure-raising valve may be closed when the working pressure is reached, or it may remain open—provided the pressure regulator is set to a suitable working pressure.

## Protective Tube for Fill Level Controller

The fill level controller, **7** in Figure 4-19, is protected by a metallic tube (**3** in Figure 2-17). Otherwise, the fill level controller could repeatedly be switched on or off by swashing liquid nitrogen.

# Chapter 5 Analyzer

This chapter describes the analyzer layout, ion source, collector systems, amplifiers, voltage-frequency converters, and the electromagnet.

It contains the following topics:

# General Remarks

The gaseous sample to be analyzed is fed into the ion source via the inlet system. In the ion source, ions are generated in a high vacuum by the impact of electrons. The ions are then accelerated to energies of up to 3 keV and focused by electrostatic lenses to form a beam.

The ion beam exits the ion source into the magnetic field through a slit with a fixed width of 0.2 mm. It enters the magnetic field boundary at an angle of 26.5° and traverses the 90° magnetic sector field. Part of the ion beam exits at the same angle of 26.5°.

Due to shaping and dimensions of the magnet, not only a focusing in X-direction but also in Y-direction is achieved. The refraction power (X-direction) is half as much as compared to the same magnet without shaping it. The focal length decreases and its value is the same for X- and Y-direction. Consequently, mass dispersion increases compared to the conventional arrangement, where the beam enters and exits the field normal to the boundaries. Thus, the 9 cm radius system has the same mass dispersion as the conventional 18 cm arrangement (where the beam enters and exits the field normal to the boundaries with a sector radius of 18 cm).

The magnetic sector field is generated by an electromagnet with a maximum field strength of 0.75 T. It covers a mass range up to *m/z* = 96 in case of the DELTA V Plus IRMS (*m/z* = 80 for the DELTA V Advantage IRMS) at full accelerating voltage.

The mass setting is achieved by varying magnetic field strength and/or accelerating voltage. The relation between mass number *m/z* of the ions reaching the ion collector and magnetic field strength *H* is given by:

$$\frac{m}{z} = k_M \times H^2$$

with

*z*: number of charges on the ion, where:

$$k_M = \frac{r^2}{2\,\mathrm{U}}$$

with

*r*: nominal radius of ion path (r = 9 cm = const.)

*U*: accelerating voltage

Due to the variable accelerating voltage *U*, $k_{\mathrm{M}}$ is not a constant value as well, but a function of *U*.

*U* and *H* can be varied to allow different species to be analyzed. A speciality of this machine is to allow for fast switches between gas species (jump calibration). During a measurement, *U* and *H* are kept constant to allow for a single gas species to enter the cups.

**Example**: for the special case of $U = 3$ kV, $k_M = 1.35\times10^{-6}$ $m^2/V$ results.

Usually, Universal Triple detectors are used, that is, standard case. The HD collectors are positioned in the housing of the collector systems. Their exit slit width is 2 mm. For the middle cup that is, the narrow one, the resolution below results:

$$\frac{m}{\Delta_m} = 110 \text{ (10\% valley)}$$

In the special case of C, N, O, and S-collectors (in short CNOS collectors), MEMCO detectors are applied. Their collector slit width is 1.4 mm for the middle cup of the Universal Triple collector.

# Layout of the Analyzer

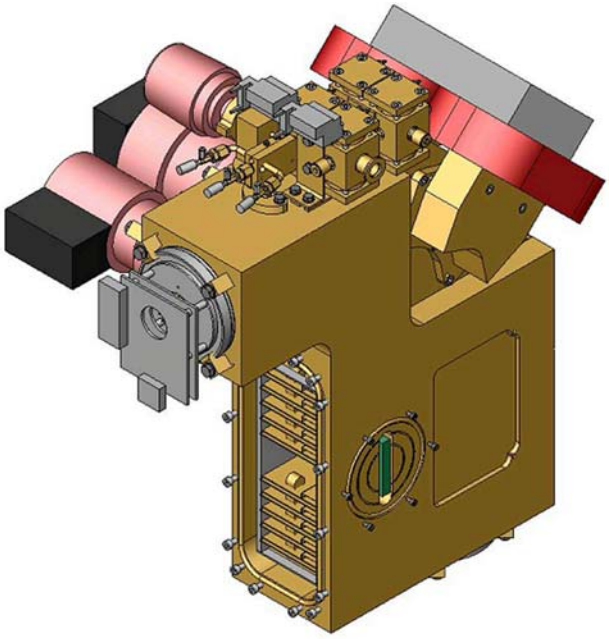
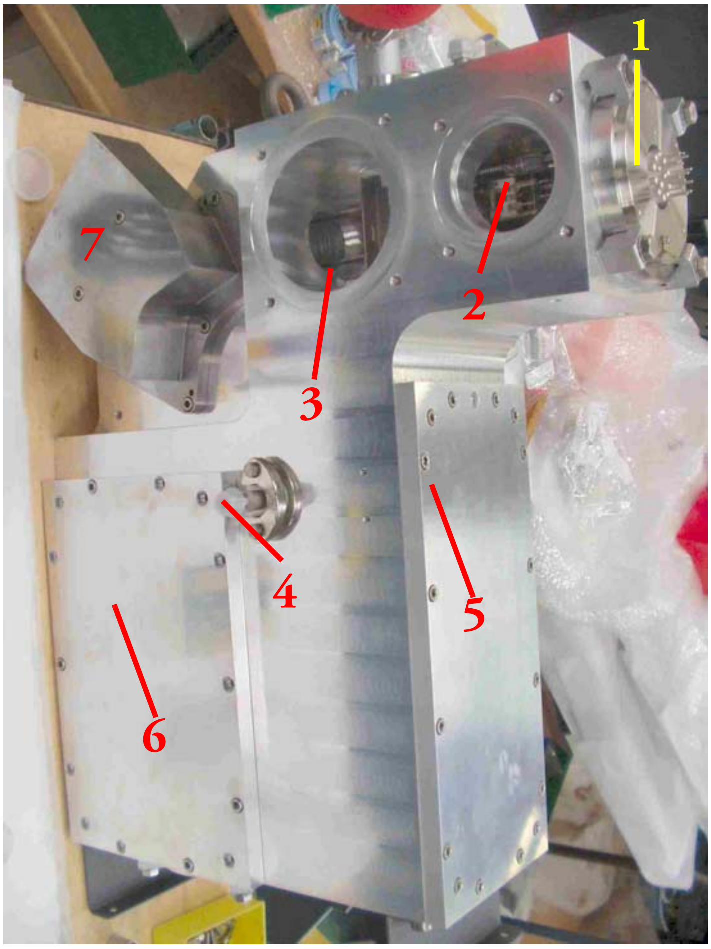


**Figure 5-1.** Schematic of Analyzer

The monolithic analyzer has been milled out of a single aluminum block (monoblock). This increases stability and facilitates evacuation compared to an analyzer consisting of several separated blocks. The dismantled analyzer block is shown in Figure 5-2.

**Caution** When you turn the switch to High Vacuum position (HV) and then turn off the analyzer, the analyzer block stays evacuated. Never try to open it! ▲

**Caution** To avoid damaging of the aluminum-made parts, never use any mechanical tool to force opening of flanges! Instead, after first venting correctly and then loosening the screws, any flange can be easily removed manually. ▲




Labeled Components: 1=ion source flange; 2=position of optional analyzer turbomolecular pump (differential pump); 3=position of required analyzer turbomolecular pump (main pump); 4=fore vacuum connection of amplifier housing; 5=amplifier housing; 6=cup assembly; 7=magnet

**Figure 5-2.** Analyzer Block - Dismantled

## Analyzer Heater

The aluminum-made analyzer is equipped with a heater (power-controlled; 200 W). Turning it on will heat out the analyzer. Substances adsorbed on the aluminum surface, primarily water, but also hydrocarbons (for example, if pump oil has intruded the analyzer in case of an accident), will be desorbed and removed.

Usually, for example after cleaning the ion source, it does not need to be used. After extensive maintenance or service operations however, turning it on will facilitate regaining vacuum: typically, vacuum will first worsen, before it improves. The initial pressure value will be regained or even outreached not until the heater is finally turned off. If no gas has been let in, pressures up to $5 \times 10^{-8}$ mbar can be obtained within the analyzer after heating it out. If the pressure is much too high, peaks will become rounded and skew.

**Note** The heater must always be connected to J107 on the power distribution board. See Figure 2-63. ▲

The “MS State“ window in Isodat 2.5’s Instrument Control is used to turn the analyzer heater on and off. The appropriate temperature will then automatically be reached (maximally about 40 °C to 50 °C). If the analyzer heater is on, mostly the ion source heater should be on as well as then both will increase temperature.

**Note** Isodat 2.5 switches off the analyzer heater after 12 h. This avoids the electronics from damage due to permanent heating. ▲

# Ion Source

The ion source of the DELTA V Plus IRMS is designed for high sensitivity (due to high gas density) and linearity. To ensure high sensitivity, the ion source is of gas tight design. The sample gas enters the ionization chamber through the Changeover Valve or the manually operated needle valve. It leaves it only via small apertures, which are required as a passage for the electron beam and the ions exiting into the analyzer.

The conductivity of these openings is much lower than the pumping speed of the vacuum pumps. Thus, the pressure within the ionization chamber is about 100 times higher than outside, which leads to high ion yields. The ions are generated in the source by electron impact ionization. The ionizing electrons are emitted by a thermionic cathode. The emission current is held constant by the ion source control board See Figure 2-57.

Two small permanent magnets are mounted to the ionization chamber, generating a magnetic field parallel to the electron beam. Due to the magnetic field, the electrons are focused to a defined part of the ionization volume. Thus, the probability to generate an ion with the aid of one single electron increases.

The energy of the ionizing electrons is determined by the potential difference between cathode and ionization chamber. It has a range between 70 eV and 124 eV. The electron beam leaves the ionization chamber via a small opening opposite to the cathode. It is collected in the electron trap, which is held on a positive potential relative to the ionization chamber.

Extraction plates accelerate ions out of the ionization chamber. The following lens system of different lenses focuses the ion beam onto the ion source slit. Mechanical tolerances might cause a slight out-of-axis deflection of the ion beam. Some of the system's lenses are half sections, which are insulated from each other. This construction allows for compensation by applying different potentials to the halves of the lenses.

Using Isodat 2.5, you can set continuous values for the ion accelerating voltage. If it is changed, the lens potentials are changed proportionally with the exception of those of the trap and cathode voltages.

Setting the accelerating voltage to lower values results in an enhancement of the mass range beyond 96 for the DELTA V Plus IRMS (and beyond 80 for the DELTA V Advantage IRMS). For example, a setting to 2.0 kV results in a mass range up to 106 for the DELTA V Advantage IRMS and up to 129 for the DELTA V Plus IRMS.

The ion source is mounted on the front flange for easy maintenance. Correct alignment of the ion source relative to the analyzer tube is achieved by fitting the surface to the analyzer head.

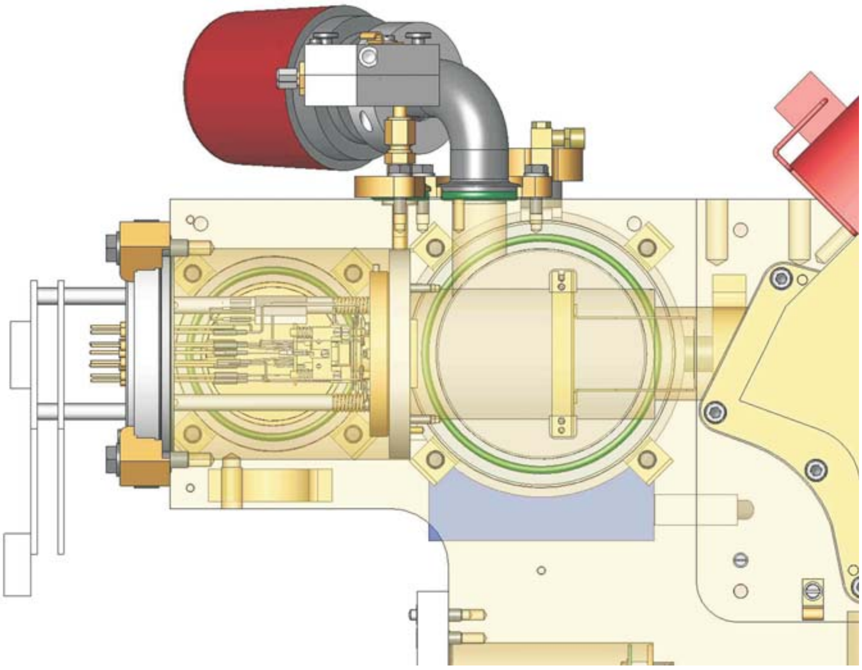


**Figure 5-3.** Coupling of Dual Inlet System to Ion Source

Figure 5-3 depicts how Dual Inlet system is coupled to the ion source. For maintaining the ion source, see "Ion Source" on page 7-4.

# Collector Systems

Several configurations of collector systems for ion detection are available, the MEMCO and the Universal Triple system. It is also possible to install user-tailored collector systems.

The collector system is installed within the collector system housing. For HD isotope analysis, an optional collector system with two Faraday cups and amplifiers is available. The HD collector system is also installed within the collector system housing.

Each collector cup has its own amplifier and the feedback resistor of the amplifier can be matched to the abundance of the isotope to be collected in this cup. Each collector cup and its amplifier are connected to a voltage-to-frequency converter (VFC). Up to ten amplifiers can be used to support up to ten cups. They are allotted to one of the ten counters, so forming a measuring channel as shown in Figure 5-4.

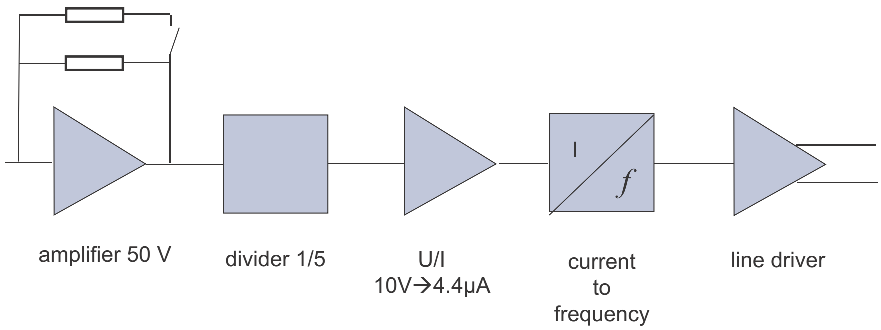



**Figure 5-4.** Components forming a Measuring Channel

The converters transform the analog ion current signals into pulses. These pulses are fed to counters for a preselected integration time. At the end of each integration interval, the computer reads the number of counts and calculates the ion current ratios. See Figure 5-5.

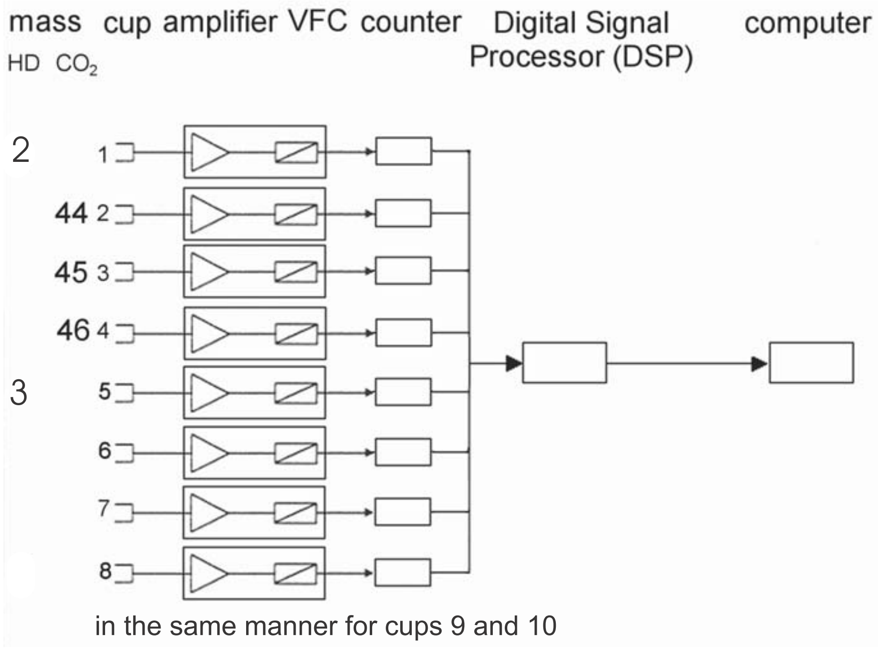



**Figure 5-5.** Function Schematic of Ion Detection System

The collector systems cover the mass range from *m/z* 10 to *m/z* 96 for the DELTA V Plus IRMS (and to *m/z* 80 for the DELTA V Advantage IRMS) at 3 kV accelerating voltage, allowing a resolution of $m/\Delta m = 110$ (10% valley) for both instruments. Owing to high dispersion of the analyzer system, distance between collectors is extremely large, for example approximately 4 mm between *m/z* 44 and *m/z* 45.

It was possible to design the Faraday collectors as deep, shielded buckets with integrated secondary electron suppression shields. See Figure 5-6. Effects that might degrade the ion current measurement are eliminated.

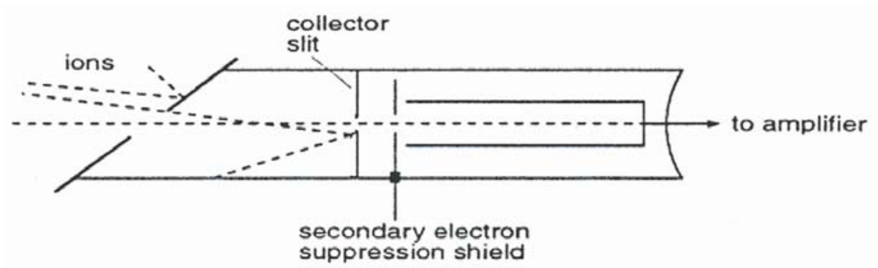



**Figure 5-6.** Layout of a Faraday Collector Cup

In most cases, Universal Triple collectors consisting of a narrow and two wide cups are used. On demand, MEMCO collector system is delivered.

## Universal Triple Collector System

The Universal Triple collector system is suitable for $N_2$, $O_2$, $CO_2$ and $SO_2$ measurement. It consists of one small and two wide, individually shielded deep Faraday cups (Figure 5-7). The Universal Triple collector system can be accessed together with the optional HD collector system during one experiment, for example for background checks.

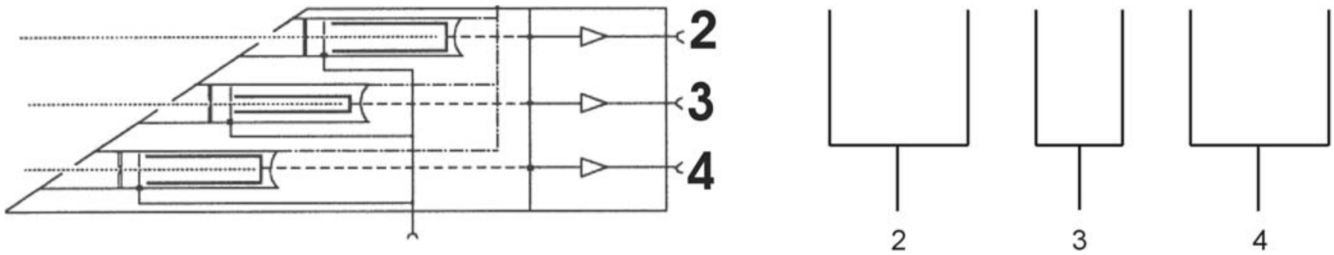



**Figure 5-7.** Schematic of Universal Triple System

**Note** Notice the considerable advantage of the DELTA V Plus IRMS: it offers switchable amplifiers. When switching from one gas to another, the resistors are changed and adjusted via Isodat 2.5 (including high voltage). See Table 5-1. ▲

**Table 5-1.** Cup Assignment of Universal Triple Collector System[a]

| Gas | Cup 2 | Cup 3 | Cup 4 |
|---|---|---|---|
| $N_2$ | 28 | 29 | 30 |
| $O_2$ | 32 | 33 | 34 |
| $CO_2$ | 44 | 45 | 46 |

[a] See Figure 5-7 and Figure 5-8.

| Gas | Collector Arrangements for Masses (m/z) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $H_2$ | 2 | | | | | | | | | 3 |
| $N_2$ | | | 28 | 29 | 30 | | | | | |
| CO | | | 28 | 29 | 30 | | | | | |
| NO | | | 30 | 31 | 32 | | | | | |
| $O_2$ | | | 32 | 33 | 34 | | | | | |
| $CO_2$ | | | 44 | 45 | 46 | | | | | |
| $N_2O$ | | | 4 4 | 45 | 46 | | | | | |
| $SO_2$ | | | 64 | 66 | | | | | | |
| DELTA V Plus - Additional Collector Arrangements | | | | | | | | | | |
| Air | 28 | 29 | 32 | 33 | 34 | 36 | 40 | 44 | 45 | 46 |
| $N_2O$ | 28 | 29 | 30 | 31 | 32 | | | 44 | 45 | 46 |
| CO, $CO_2$ | 28 | 29 | 30 | | | | | 44 | 45 | 46 |
| $N_2$, $CO_2$ | 28 | 29 | 30 | | | | | 44 | 45 | 46 |
| $SO_2$ | | | | | | | | 64 | 65 | 66 |
| SO, $SO_2$ | | | | | 48 | 49 | 50 | 64 | 65 | 66 |
| $CH_3Cl$ | | | | | 50 | 51 | 52 | 53 | | |
| $CH_3Br$ | | | | | | | | | 94 | 96 |
| Ne | 20 | 21 | 22 | | | | | | | |
| Ar | | | | | 36 | 38 | 40 | | | |
| Kr | | | | | | 78 | 80 | 82 | 84 | 86 |

**Figure 5-8.** Collector Arrangements and Masses

## MEMCO Collector System

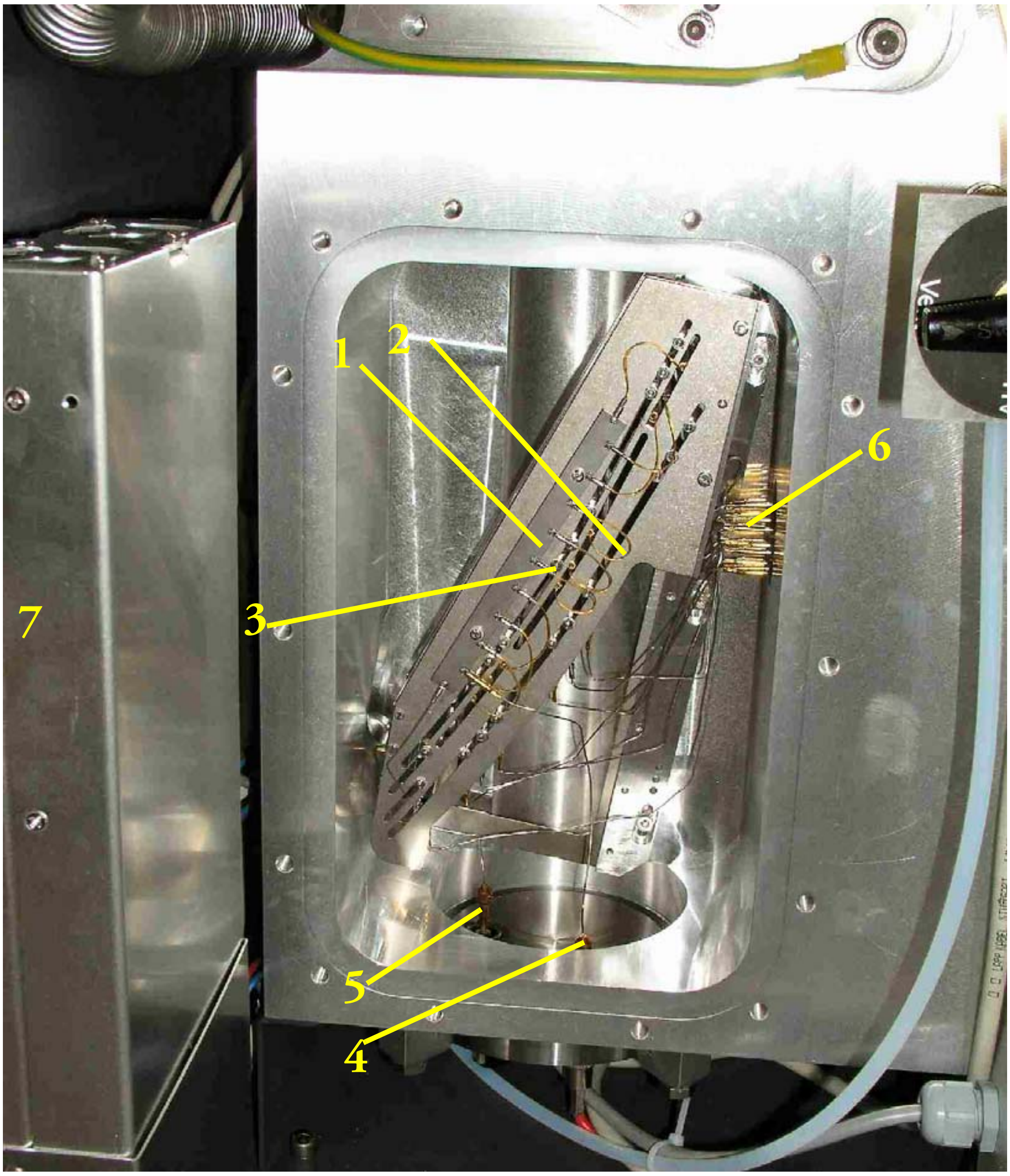
The MEMCO collector system comprises three to six identical cups. The 3-cup version allows simultaneous measurement of two isotope ratios from the same sample, for example $^{13}C/^{12}C$ and $^{18}O/^{16}O$ of $CO_2$.

**Note** Different gases may jointly use one cup in order to reduce the total number of cup measuring channels. ▲

## HD Collector System

The HD collector system is a dual Faraday collector assembly for hydrogen isotope measurement on the same ion path, operating in parallel to the MEMCO or Universal Triple systems. The HD collector is located in the common collector system housing. The collector cups are designed like those of the MEMCO system.

The implemented collector system with its important parts is shown in Figure 5-9. In Figure 5-10 and Figure 5-11 it is shown dismantled and schematically.




1 SE suppression voltage distributor

2 SE wires

3 collectors (arranged below) with retaining screws

4 SE feedthrough

5 feedthrough for retarding voltage

6 feedthrough to amplifiers (and ground plane cup and ground plane amplifier)

See Figure 5-12.

7 24 V power supply

See "24 V Power Supply" on page 2-40.

**Figure 5-9.** Collector - Implemented

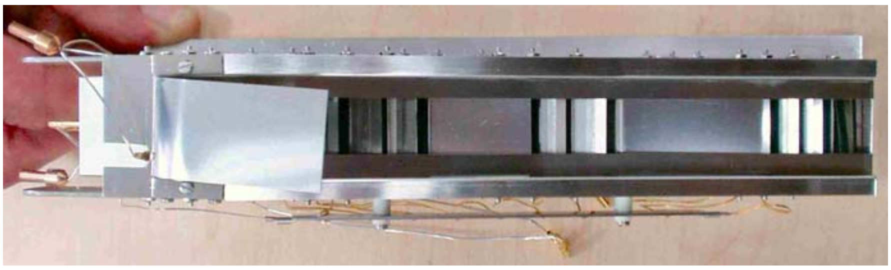
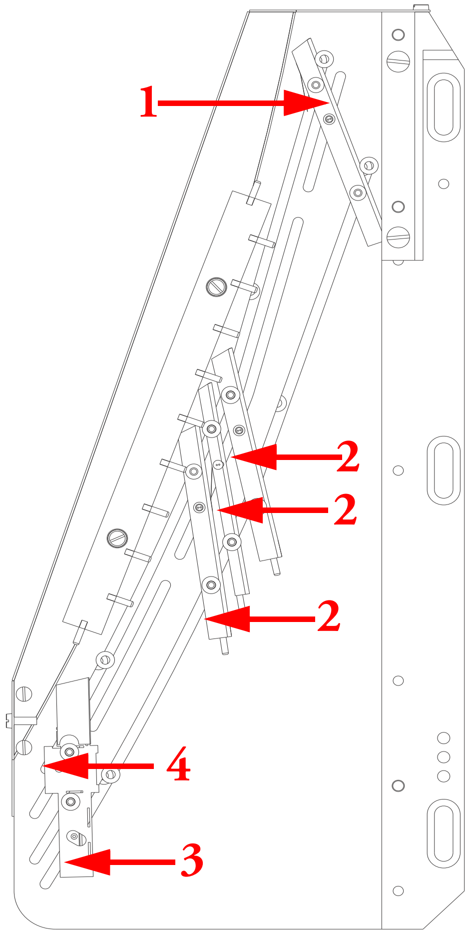


**Figure 5-10.** Collector System - Dismantled - Top View




The collector system consists of the following parts:

1. $H_2$ collector ($m/z = 2$)
2. Universal Triple collector ($m/z = 28$; $m/z = 46$)
3. HD collector ($m/z = 3$)
4. retarding lens connector

**Figure 5-11.** Collector System - Dismantled - Side View

Figure 5-12 shows the assignment of the amplifier numbers (1–10) to the cups. The view is from inside, that is from the cup housing towards the feedthrough. The arrow is directed upwards. The cup for *m/z* 28 is assigned to amplifier No. 2. The cup for *m/z* 29 is assigned to amplifier No. 3. The cup for *m/z* 30 is assigned to amplifier No. 4.

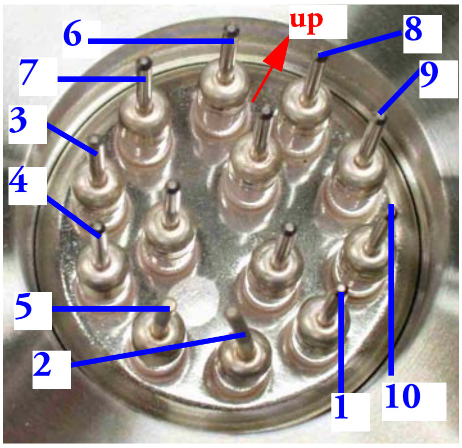



**Figure 5-12.** Feedthrough to Amplifier Number

**Caution** To avoid damaging of the aluminum-made parts, never use any mechanical tool to force opening of flanges! Instead, after first venting correctly and then loosening the screws, any flange can be easily removed manually. ▲

# Amplifiers and VFCs

## Single Amplifier

The DC amplifiers have 100% inverse feedback. Their output voltage (50 V maximum) is the product of the input current and a feedback resistor. The feedback resistor must match the abundance of the isotope to be collected in the respective collector cup. Table 5-2 shows the resistor values to be used for isotopes of different gases.

**Table 5-2.** Resistor Values Matching Natural Abundance of Isotopes[a]

| Gas | m/z | Resistor/Ω | Capacity/pF |
|---|---|---|---|
| $H_2$ | 2 | $1 \times 10^{9}$ | 150 |
| | 3 | $1 \times 10^{12}$ | 2 |
| $N_2$ | 28 | $3 \times 10^{8}$ | 470 |
| | 29 | $3 \times 10^{10}$ | 5 |
| | 30 | $1 \times 10^{11}$ | 2 |
| $O_2$ | 32 | $3 \times 10^{8}$ | 470 |
| | 33 | $1 \times 10^{12}$ | 2 |
| | 34 | $1 \times 10^{11}$ | 2 |
| $CO_2$ | 44 | $3 \times 10^{8}$ | 470 |
| | 45 | $3 \times 10^{10}$ | 5 |
| | 46 | $1 \times 10^{11}$ | 2 |
| $SO_2$ | 64 | $3 \times 10^{8}$ | 470 |
| | 66 | $1 \times 10^{10}$ | 15 |

[a] See Figure 5-13.

The product R×C is approximately a constant equalling the time constant of the amplifier. Usually, it amounts about 0.1–0.2 seconds.

A single, dismantled amplifier is shown in Figure 5-13. For maintenance of single amplifiers and the amplifier area, see “Amplifier Area” on page 7-47.

**Caution** Never touch the surface of the high-impedance resistors, **1** in Figure 5-13! Already a slight touch of a fingertip contaminates the resistors resulting in signal instability. If you nevertheless accidentally once touched them, clean them using methanol. ▲

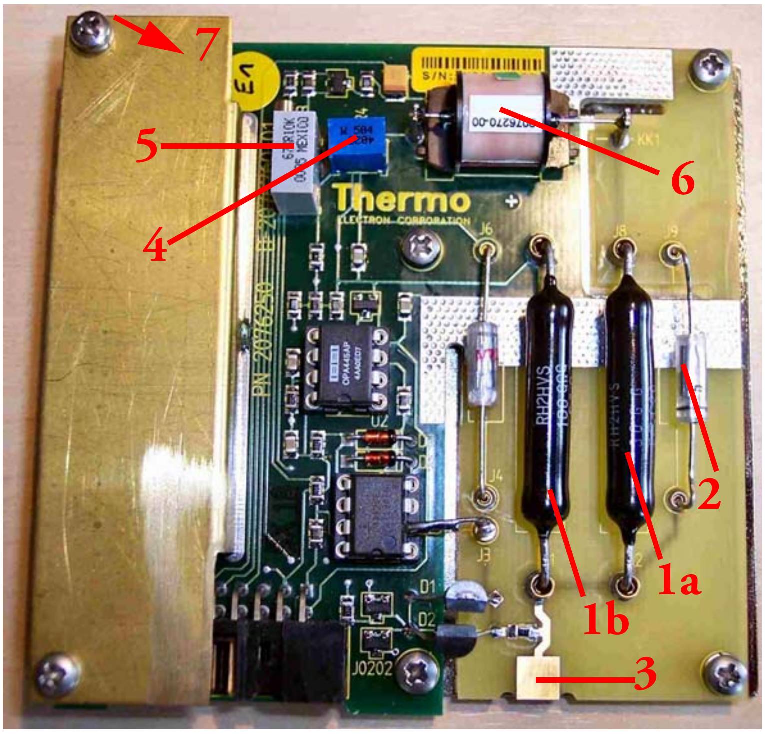



**Figure 5-13.** Single Amplifier - Dismantled

**Table 5-3.** Components of a Single Amplifier[a]

| No. | Designation |
|---|---|
| 1a | High-impedance resistor, for example 30 GΩ or 100 GΩ |
| 1b | Low-impedance resistor, for example 300 MΩ |
| 2 | Capacitor, for example 5 pF |
| 3 | Contact, gold made<br>is the transfer point for the ion current (from cups to amplifier board) |
| 4 | Attenuation potentiometer (see 1 in Figure 5-14)<br>Controls time constant and yields the optimal characteristic of the RC combination as it avoids over- and undershooting. |
| 5 | Offset potentiometer. Controls offset. See 2 in Figure 5-14. Only for factory!<br>When the amplifier was calibrated, the potential was set to 0 V. |
| 6 | Coil for switching between resistors (Reed-contact)<br>Activates or deactivates the parallel array of both resistors (like a relay) |
| 7 | Blue jumper (not to be seen in Figure 5-13, but see 3 in Figure 5-14)<br>Is needed for mounting the amplifier into the amplifier housing according to Figure 5-14 and Figure 5-15. External voltages can be fed in there |

[a] See Figure 5-13.

**Caution** Never change the offset potentiometer **5**! It has already been adjusted by Thermo Fisher Scientific. ▲

A resistor and a capacitor, **1** and **2** in Figure 5-13, form a RC combination. Usually, an amplifier contains one specifically chosen RC combination to accomplish a particular amplification according to the individual measurement problem.

Figure 5-13 however, shows an amplifier with two RC combinations arranged in parallel. The additional RC combination enables switching between amplifiers which is handled by Isodat 2.5.

**Note** The smaller resistor (that is, the one with the lower Ω value) must always be arranged in the outer position. ▲

## Arrangement of Several Amplifiers

Even the amplifier housing is a component of the analyzer block. Space for ten amplifiers offer an increased flexibility concerning simultaneous measurement of several gases. Figure 5-14 shows the arrangement of a single amplifier after it has been inserted into its slot along a guideway.

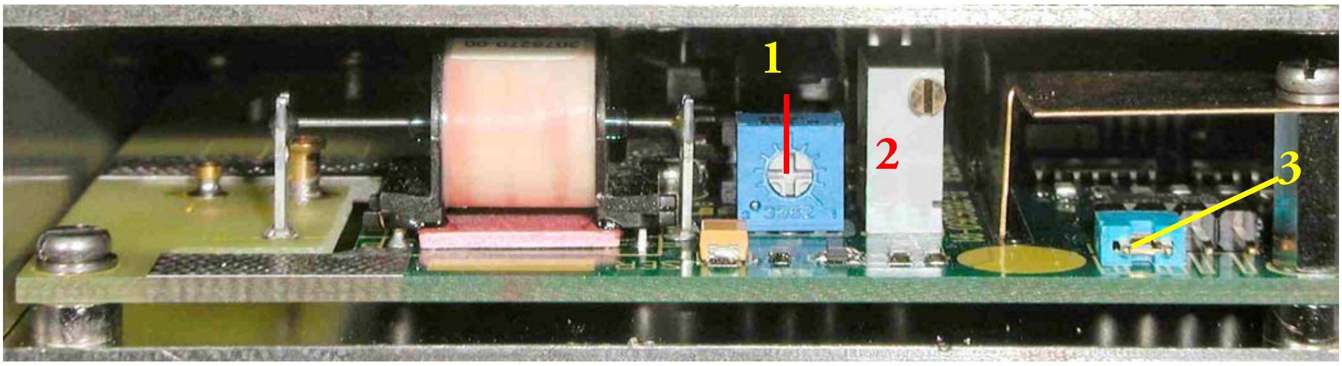



**Figure 5-14.** Arrangement of a Single Amplifier

Figure 5-15 shows how several of those amplifiers are arranged next to each other within their respective slots. The visible green board is amplifier ground plane.

**Note** Below the amplifier ground plane, the yellow board amplifier cup is located. See Figure 2-11. ▲

**Note** When using more than five amplifiers, a closing plate must be mounted above the uppermost amplifier. It shields magnetic fields and enables switching between amplifiers. Do not remove this closing plate! ▲

**1** depicts the contacts to the collectors. **2** are the connectors between amplifier and ground plane. **3** shows the 13-fold feedthrough, which is displayed in detail in Figure 5-16.

Only ten of 13 (1–10) are in use, that is connected to the pins, whereas the three remaining ones stay unconnected. No. 1 and No. 5 are used for HD measurements.

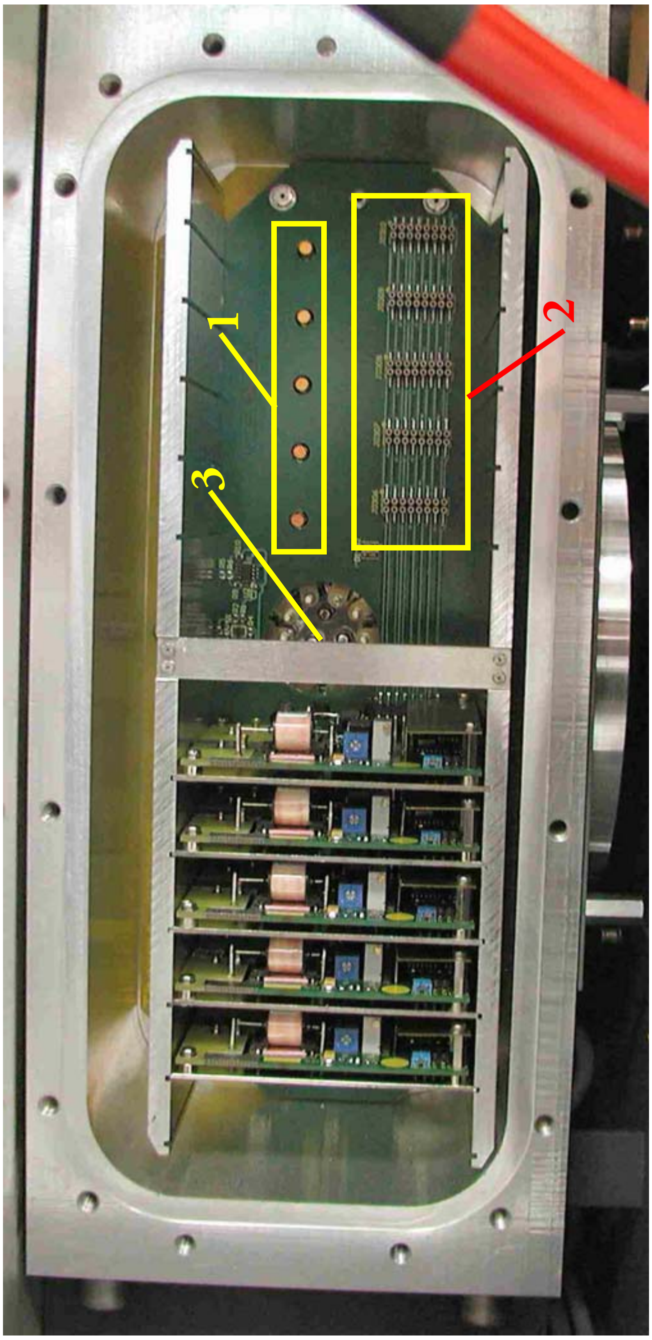



**Figure 5-15.** Arrangement of Several Amplifiers

Figure 5-16 shows the cup-to-amplifier feedthrough (viewed from amplifier side) with part of amplifier ground plane. Especially see **b** in Figure 2-11, but also to Figure 2-9.

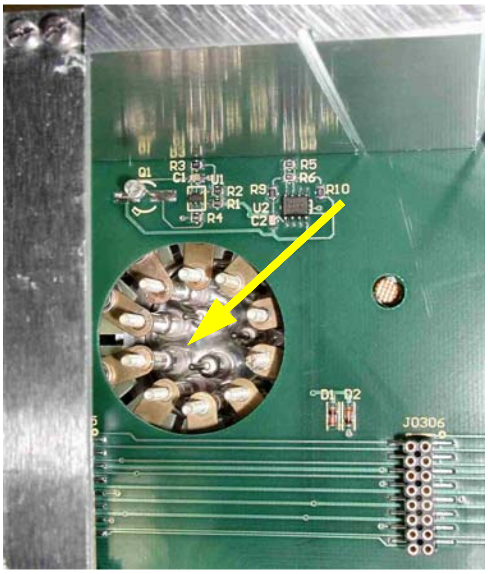



**Figure 5-16.** Cup-to-Amplifier Feedthrough

# Electromagnet

The magnetic field providing the ion deflection is generated by an electromagnet with a maximum field strength of 0.75 T. The selection of the different masses is achieved by changing the magnetic field. In addition, the covered mass range can be extended by continuously varying the accelerating voltage.

The magnet has been directly sealed into the aluminum block behind the analyzer. Therefore, it is fixed and cannot be moved within the analyzer. See arrow in Figure 5-17.

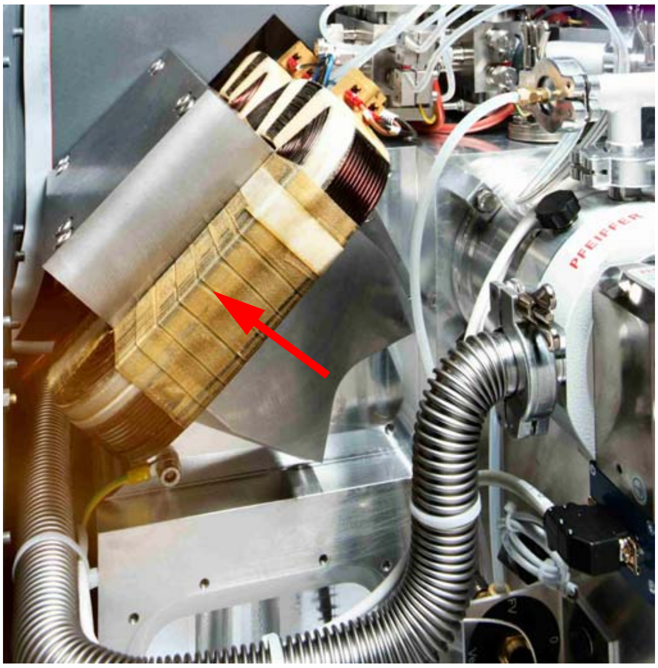



**Figure 5-17.** Position of Magnet behind Analyzer

Its two magnetic coils have been arranged in a shape reminding of spectacles. This shape reduces the stray field and saves space compared to one large magnetic coil.

**Note** Usually, the magnet never needs to be removed. Only in the seldom case of cleaning the surfaces of the magnet (for example, if oil has intruded into the analyzer), the Thermo Fisher Scientific field service engineer removes it. ▲

To do so, the service engineer removes its yoke before. Therefore, the service engineer unscrews the socket screws of the yoke by using an Allen wrench according to Figure 5-18. **1** in Figure 5-18 denote the metal fittings of the removed yoke. The coils, **2** in Figure 5-18, become visible after removing the yoke.

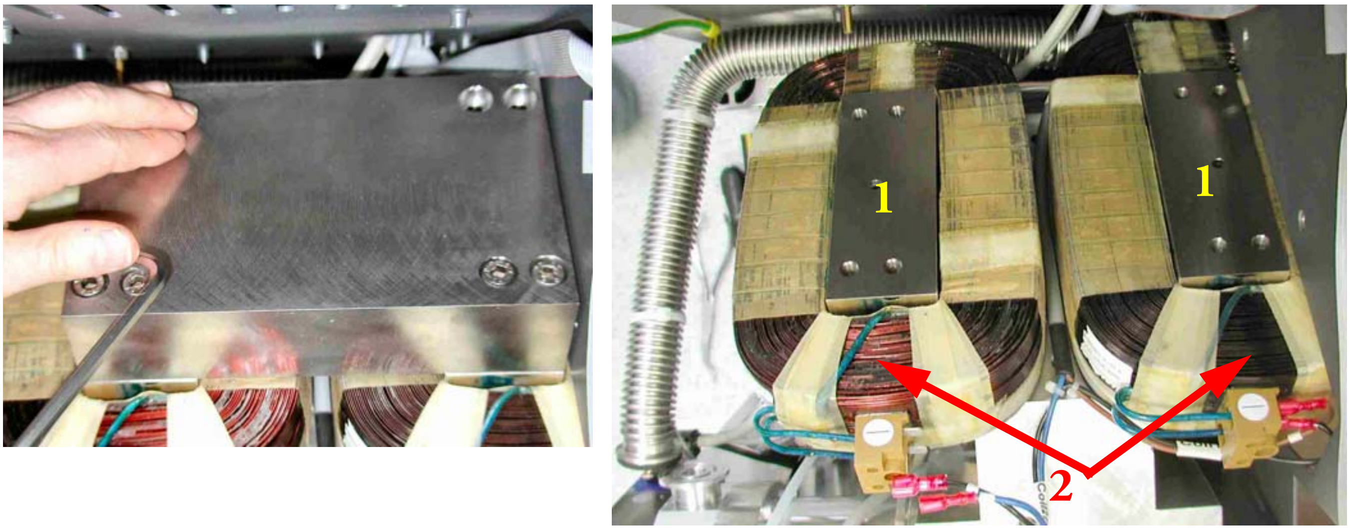
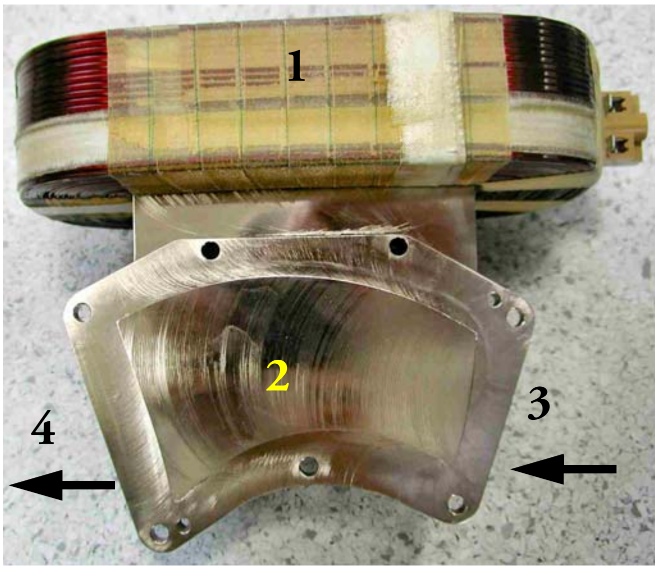



**Figure 5-18.** Yoke Removal and Magnetic Coils




Labeled Components: 1=magnetic coil; 2=pole piece; 3=entry of ion beam; 4=exit of ion beam

**Figure 5-19.** Magnet - Dismantled

**Figure 5-20.** View into Analyzer - One Magnetic Coil Dismantled

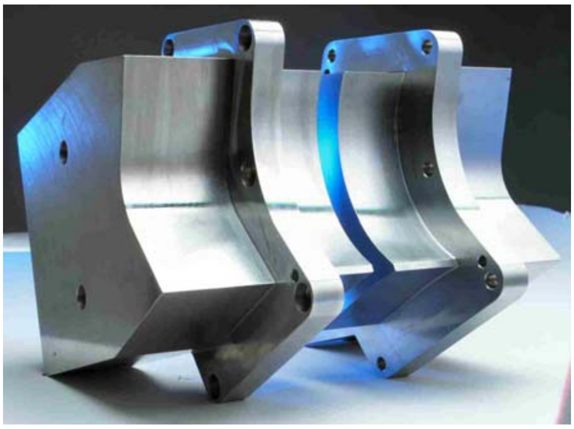


**Figure 5-21.** Pole Piece - Dismantled

**Caution** To avoid damaging of the aluminum-made parts, never use any mechanical tool to force opening of flanges! Instead, after first venting correctly and then loosening the screws, any flange can be easily removed manually. ▲

# Chapter 6 Operation

This chapter describes important operations concerning ion source, magnet, cups, and an optional Dual Inlet system.

It has the following topics:

# Ion Source

## Ion Generation

Ions are formed in the ionization housing from neutral gas atoms by bombardment with electrons. These electrons again are formed on a filament by electric heating. The amount of electrons is determined by the emission current setting ("Emission"). This value can be adjusted between 0 and 1.5 mA. Higher values result in higher cup readings but shorter lifetime of the filament.

The electrons are accelerated towards the ionization volume with a small voltage traditionally called "electron energy", this value can be adjusted between 70 and 150 V. Higher energies yield more ions but may generate multiply charged ionic species that interfere on certain masses (for example, $He^{2+}$ interferes with $H_2$).

After leaving the ionization volume the electrons are collected on an electrode called "trap" with a potential more positive than the ionization volume. This potential can be adjusted between 0 and 40 V. Higher values correspond to higher collection efficiency but also higher energy spread of the ion beam. See Figure 6-1.

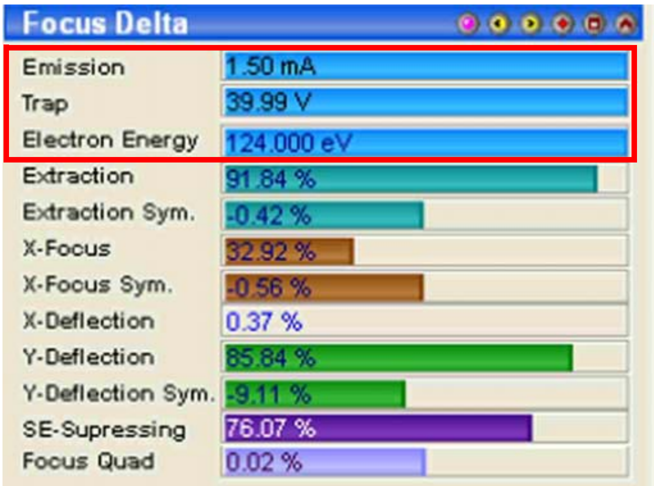



**Figure 6-1.** "Emission Current", "Electron Energy", and "Trap"

## Trap Box and Current

To control the quality of ion generation, two separate electron currents in the source are continuously monitored. See Figure 6-2.

The "box current" is the part of the electron current that hits the ionization housing, whereas the "trap current" is the portion of the electron current that reaches the trap (as intended). The ratio of the two currents should be 0.7 on box versus 0.7 on trap or further in favour for the trap current indicating an effective electron collection.

**Note** Deviations from these values indicate upcoming problems concerning the filament. ▲

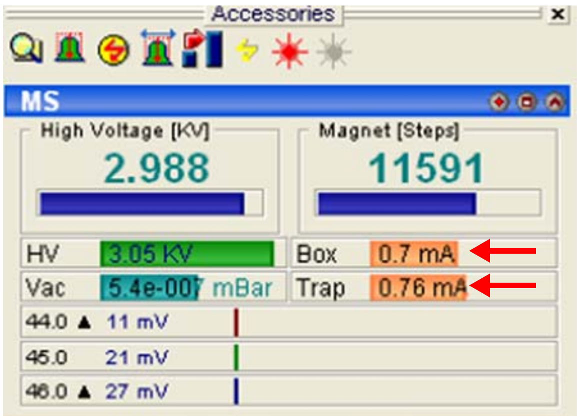



**Figure 6-2.** "Box Current" and "Trap Current"

## Lenses

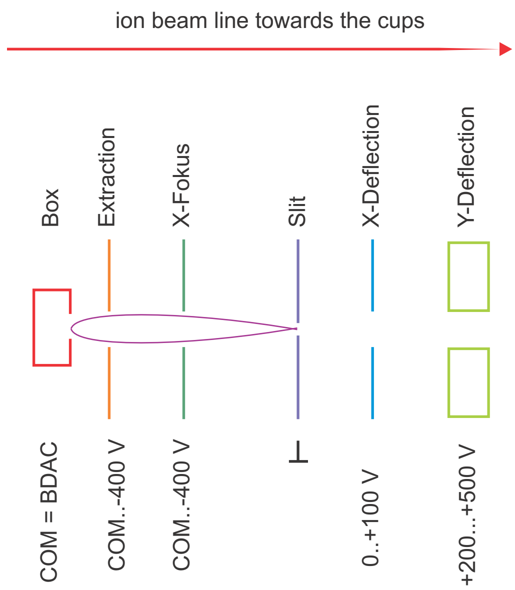



**Figure 6-3.** Lens Arrangement and Ion Source Potentials

The ion source of the DELTA V Plus and DELTA V Advantage IRMS contains four pairs of lenses: two pairs in front of the beam-defining slit and two pairs behind this slit. See Figure 6-3.

The lenses are named starting from the ionization volume Extraction 1 and Extraction 2; X-Focus 1 and X-Focus 2 ; Slit; X-Deflection and Y-Deflection 1 and Y-Deflection 2. Their purpose is to form the ion beam and to guide it through the ion optical system (magnet, flight tubes) towards the cups.

The first two pairs of lenses (Extraction 1 and Extraction 2; X-Focus 1 and X-Focus 2) have the purpose to form an ion beam and produce a focal point in the position of the slit. Thus, these lenses define the beam strength at the point of the slit and further down the beamline towards the cups. They can be adjusted absolutely in voltage, and a voltage difference between the lenses of a pair can be adjusted.

The following X-Deflection and Y-Deflection lenses are used to fine-adjust the complete beam into the flight tube. Thus, their effect is smaller than that of the above mentioned lenses, and larger changes in voltage must be applied to induce an effect on the beam.

As is denoted by the respective names, the X-Deflection lens (unipolar - only one lens plate can be adjusted) is used to move the beam in the plane of magnetic deflection, whilst the Y-Deflection is used to move the beam perpendicular to that plane. The Y-Deflection has an important additional purpose: setting an absolute voltage on these plates causes the beam to change its focal point in the Y-direction (perpendicular to the plane of magnetic deflection).

The DELTA V Plus IRMS additionally contains a quadrupole lens to fine-adjust focal lengths in X-direction and Y-direction.

## High Voltage


Power supply of ion source control board will be switched on.

Thereby, “High Voltage“ and “Emission Current“ will be turned on.


Power supply of ion source control board will be switched off.

Thereby, “High Voltage“ and “Emission Current“ will be turned off.


“High Voltage“ will be reset, for example after a flashover.

"High Voltage" controls the kinetic energy of the ion beam and thus such important ion optical properties as resolution and dispersion.

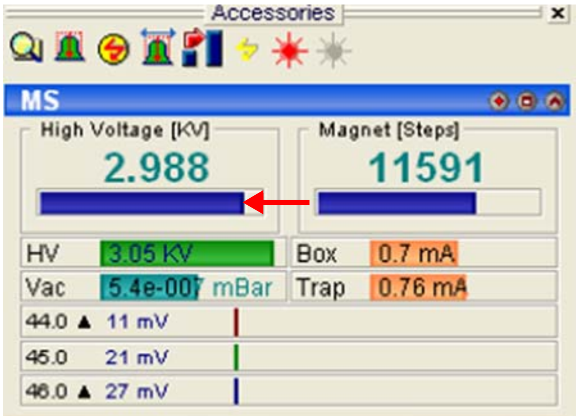



**Figure 6-4.** Changing the Value of "High Voltage"

Increasing "High Voltage" according to Figure 6-4 allows for higher transmission and smaller energy width of the emerging beam. Drawbacks are more frequent sparks and a smaller mass range of the IRMS. See "Electromagnet" on page 5-21.

## Focusing of the IRMS

You can perform focusing either:

- manually or
- using the autofocus (AF).

**Note** If you are not experienced with focusing, we recommend using the autofocus (AF). ▲

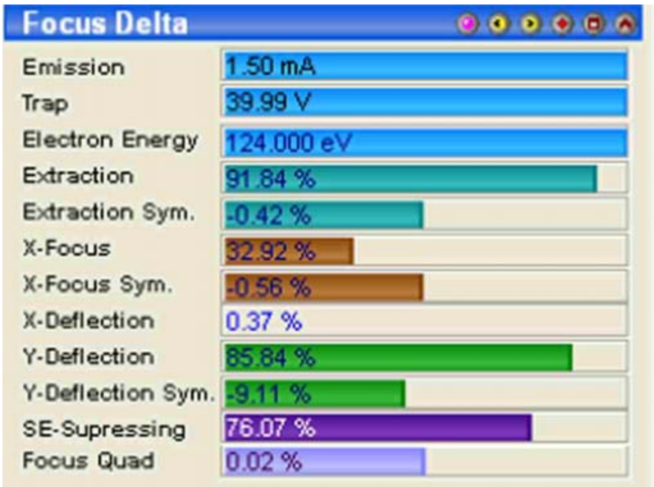
### Manual Focusing

A first type of manual focusing, **intensity** focusing (also called **peak shape** focusing or **sensitivity** focusing) is performed only in case of Dual Inlet measurements. Sensitivity and peak shape are both improved, when the extraction voltage, that is Extraction 1 and Extraction 2, is decreased.

In the vast majority of cases however, the so-called **linearity** focusing is performed as another type of manual focusing. It requires relatively high extraction voltages, that is high values of Extraction 1 and Extraction 2, in order to extract the ions out of the ionization housing. It will be described below.

1. Basic Adjustment of Parameters

Before the first focusing run, the parameters depicted in Figure 6-5 should be preset:




- Set "Emission" to a value between 1 mA and 1.5 mA.
- Set "Trap" to 40 V.
- Set "Electron Energy" to maximum value.
- Set "Extraction" and "Extraction Symmetry" to middle position.
- Set "X-Focus" and "X-Focus Symmetry" to middle position.
- Set "X-Deflection" to a middle position.
- Set "Y-Deflection" and "Y-Deflection Symmetry" to middle position.

**Figure 6-5.** Basic Adjustment of Focusing Parameters

**Note** Do not change the parameter "SE-Suppressing". It is preset to about 80–90%, that is to about 200 V. ▲

**Note** In case of doubt, it is recommended to accept the default parameter values preset by the factory, if you perform manual focusing! ▲

2. Ensure that the intensity signal is monitored on a cup which can be used for peak center (for example, the middle cup of a Universal Triple collector).

   - Be sure that gas, for example $CO_2$, is flowing into the source.

   - If the mass scale is already calibrated, jump to mass (that is *m/z* 45 on the middle cup of a Universal Triple collector).

     Perform a Peak Center.

     If the signal is too low to proceed (that is, below 50 mV), jump to another mass (that is, *m/z* 44 on the middle cup of a Universal Triple collector).

   - If no Mass Calibration is available, perform a Mass Scan.

     Then seek a peak for ion source optimization.

     Afterwards, perform a Mass Scan again.

     Finally, perform a Mass Calibration.

- Switch on "Tune Scan" in Isodat 2.5's Instrument Control module. See Figure 6-6.

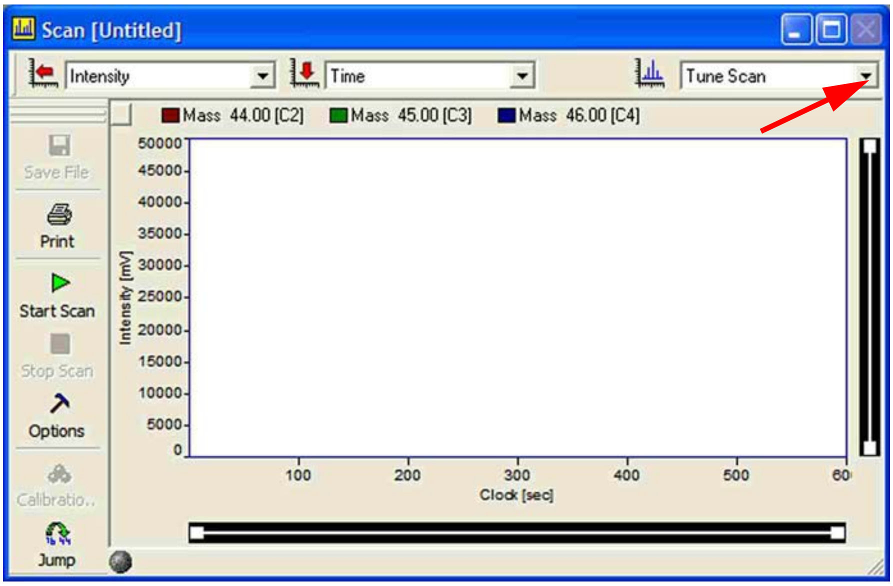



**Figure 6-6.** "Tune Scan" Window in Instrument Control

3. Perform focusing as depicted in Figure 6-7.

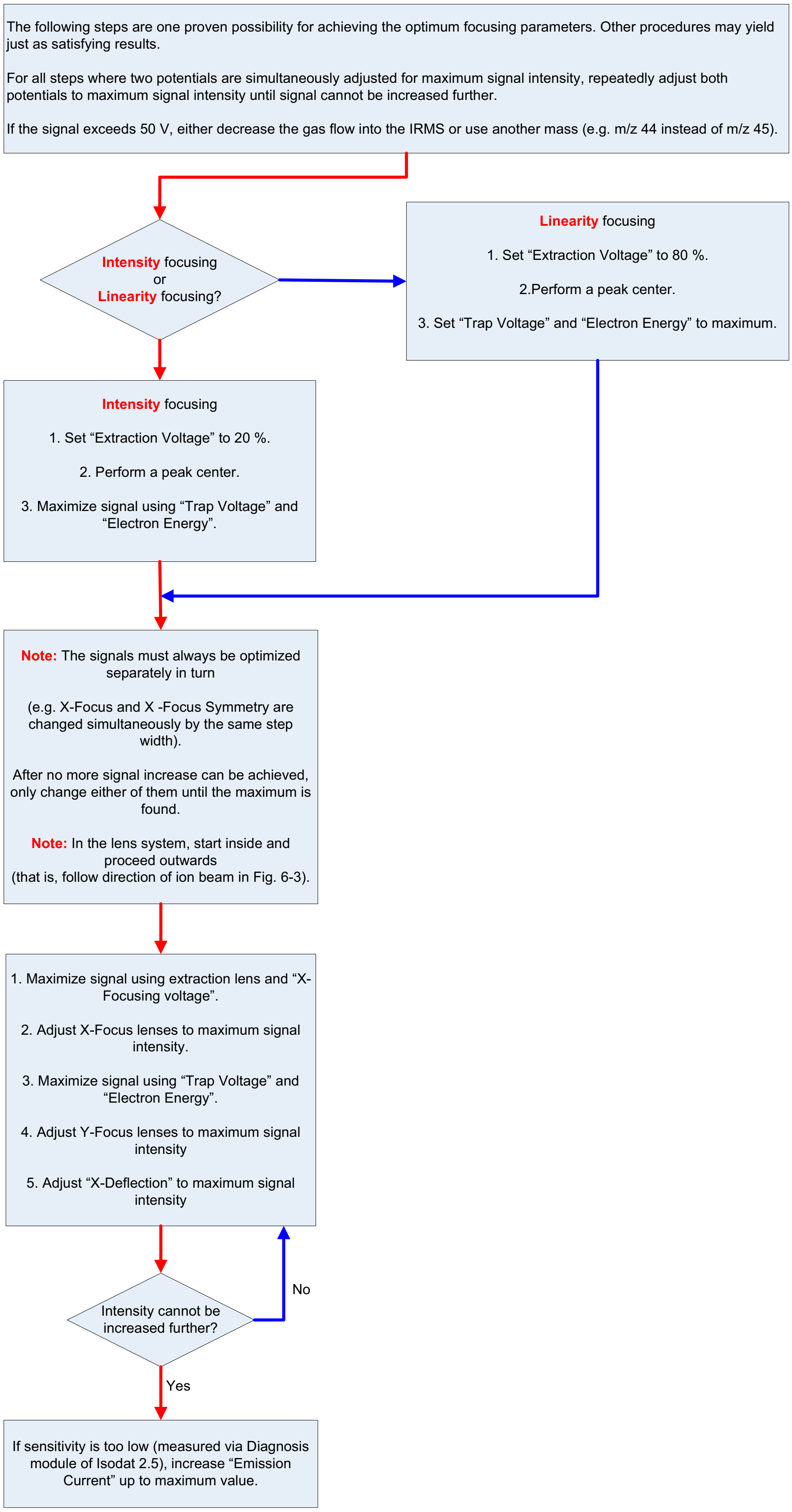



**Figure 6-7.** Focusing

# Magnet

## Universal CNOSH Detector

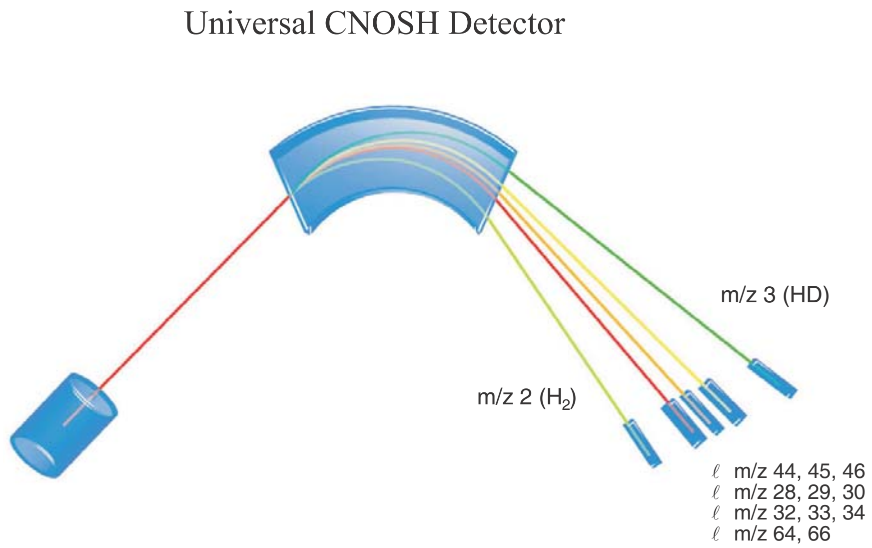



**Figure 6-8.** Universal CNOSH Detector

## DAC Steps and Mass Selection

Individual masses are selected by controlling the current in the magnet at a given high voltage (HV). This can be done by selecting different values for "Magnet" in the "MS" panel. See Figure 6-9.

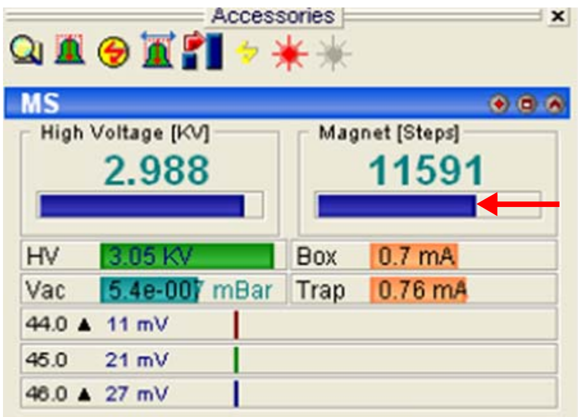



**Figure 6-9.** Selecting a Value for "Magnet"

Alternatively, right-click on one of the cup current readings (for example, 44.0) and select **Jump to Mass**. Then, enter the desired mass to be focused on that cup. See Figure 6-10.

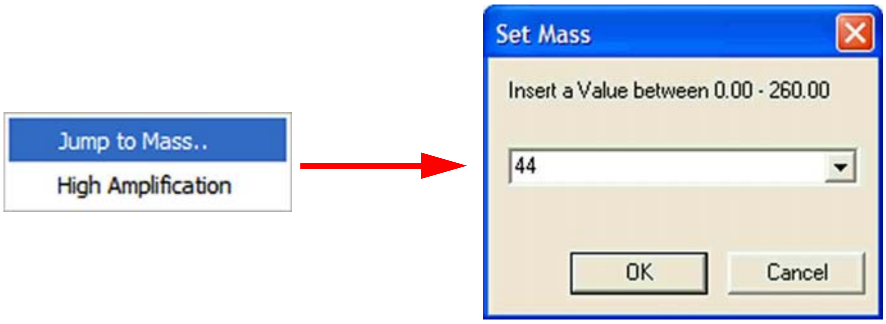



**Figure 6-10.** "Jump to Mass" Command

## Calibration

To determine and store the important relation between magnet current and selected mass, perform a calibration. Therefore, it is required to have a stable signal of $CO_2$ gas from the source, for example.

In case of a Dual Inlet measurement, fill one bellow with gas and open the respective side to the source. In case of a Continuous Flow measurement, inject reference gas into the source.

In Isodat 2.5's Instrument Control, choose **Slow Magnet** on the right side of the "Scan" window. In the pulldown menu left to it, "Magnetic Field" will then be displayed automatically. See arrows in Figure 6-11.


**Figure 6-11.** Selecting Parameters for a Magnetic Field Scan

Start the Magnetic Field Scan with standard parameters (Figure 6-12).

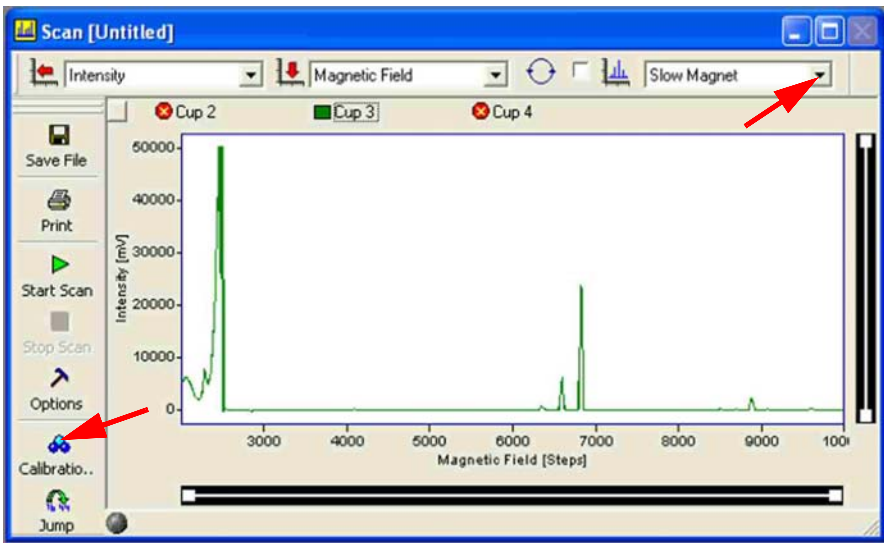
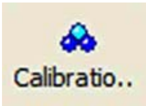



**Figure 6-12.** Magnetic Field Scan




After this has been finished, the **Calibration** button in the left pane of the “Scan“ window becomes active. Click it to perform an automatic calibration.

# Cup Arrangement

## Peak Shapes

The term “peak shape” refers to the ion optical image of the slit on the respective cup. This term is used to denote the quality of the ion optical system as well as the quality of cup alignment.

A peak shape is obtained by electrically or magnetically moving the slit image over the respective cup. Isodat 2.5 offers a standard way of scanning the peak shape via the “Scan” window within Instrument Control module. See Figure 6-13 for selecting the correct parameters for a Peak Shape scan.


**Figure 6-13.** Selecting Parameters for a High Voltage Scan

The individual peak shape of your instrument depends on the selected cup arrangement. Figure 6-14 and Figure 6-15 give an overview of typical applications.

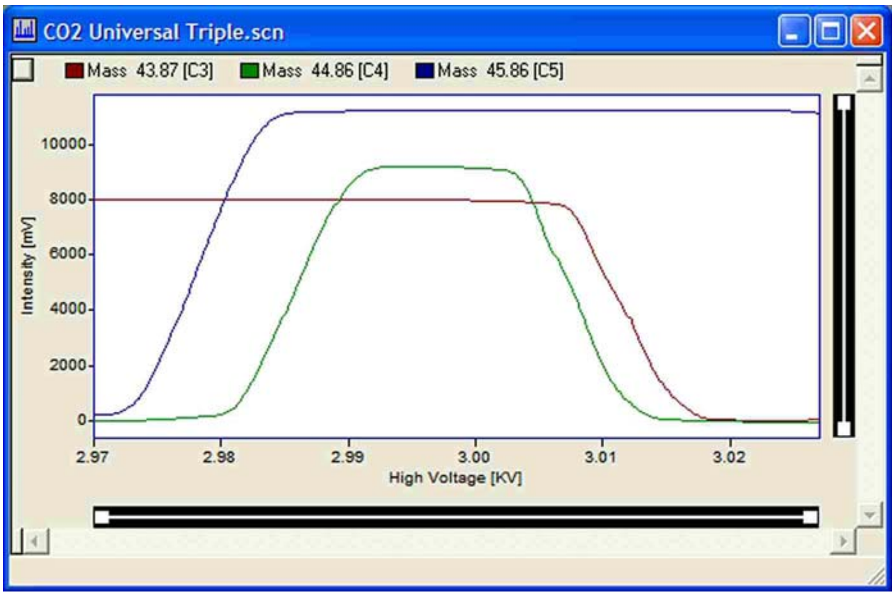



**Figure 6-14.** $CO_2$ Scan Using an Universal Triple Collector

**Note** In the $CO_2$-scan, Figure 6-14, the smallest mass occurs first in the Scan window. The bigger ones appear later. ▲

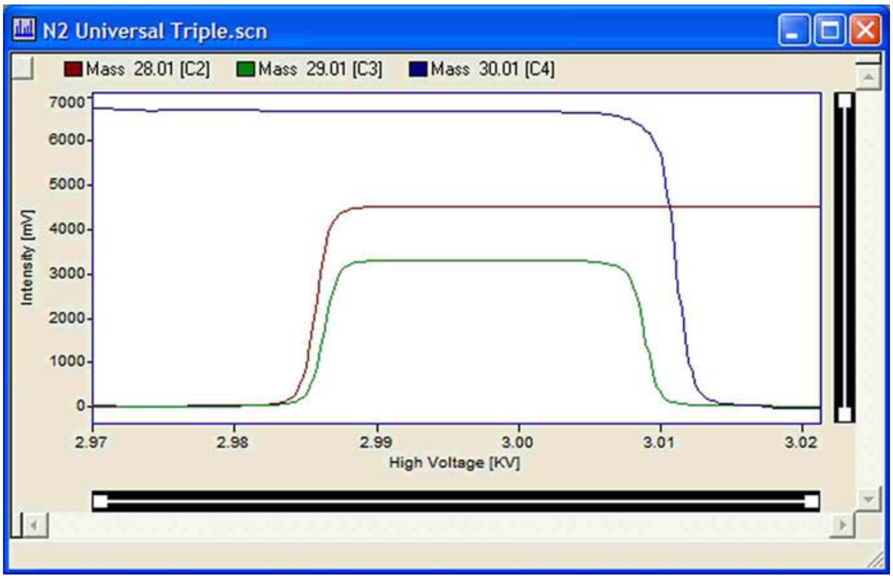



**Figure 6-15.** $N_2$ Scan Using an Universal Triple Collector

**Note** Due to cup geometry and contrary to the $CO_2$-scan, in the $N_2$-scan (Figure 6-15), the biggest mass occurs first. The smaller ones appear later. ▲

As an example for a customized collector arrangement, Figure 6-16 shows a scan of a simultaneous $N_2$-NO-$N_2O$-$CO_2$ measurement.

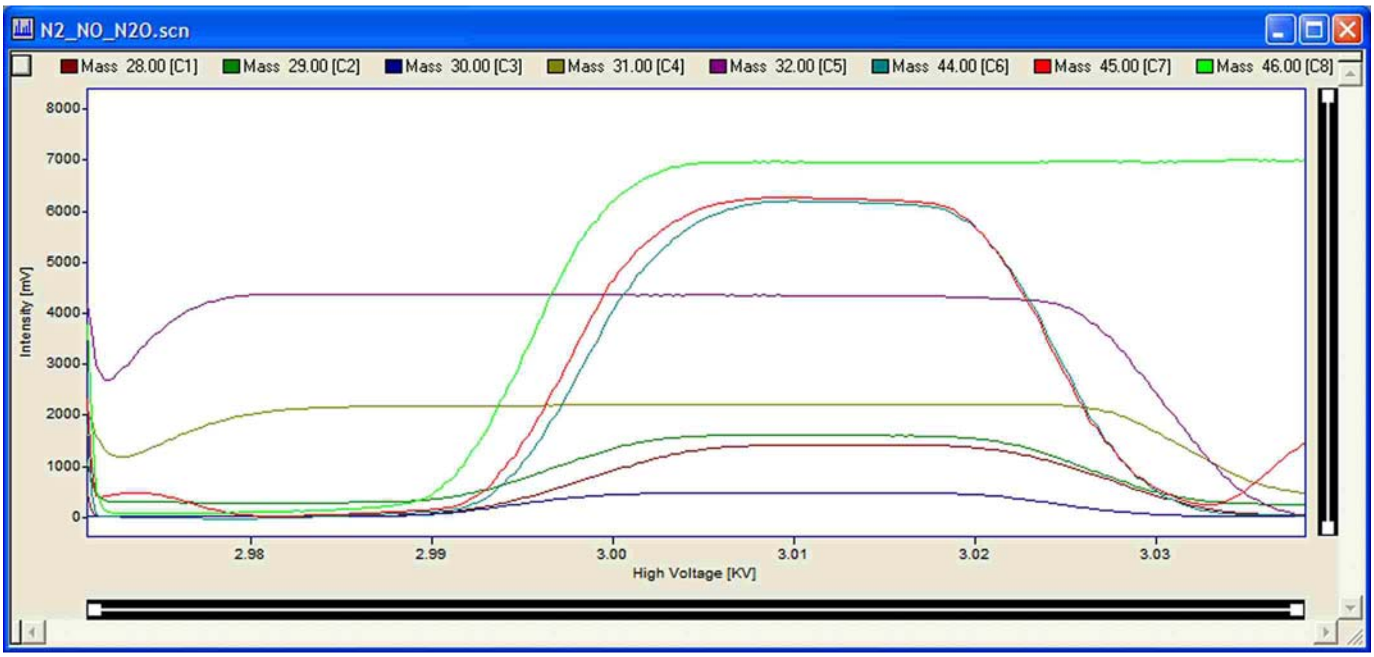



**Figure 6-16.** Scan of a Simultaneous Measurement

## Amplification

The amplifiers of the DELTA V Plus IRMS, Figure 5-13, allow for two settings of amplification factors. They are switched and controlled by the arrows at the cup reading of Figure 6-18 (arrow or no arrow) or via the Gas Configuration. Column **1** in Figure 6-17 refers to the left resistor of Figure 5-13, which is always present. Column **2** alludes to the right resistor of Figure 5-13, which can additionally be switched as an option. This is stored in the Gas Configuration as well.

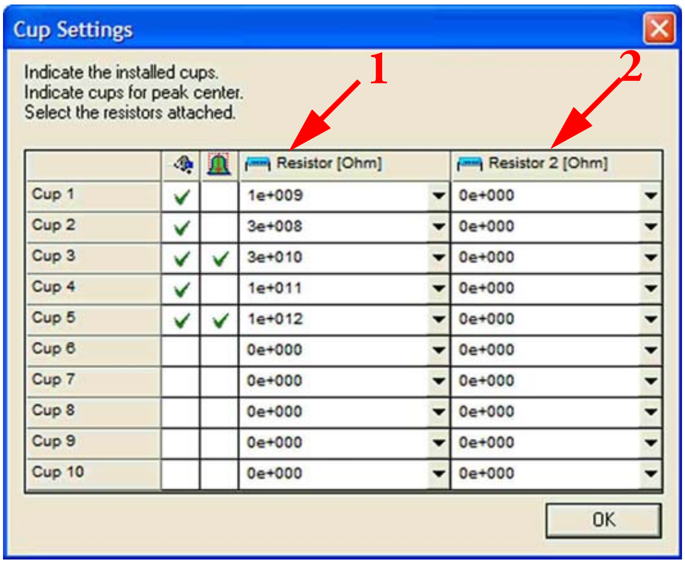



**Figure 6-17.** Two Different Settings of Amplification Factors

The arrows in Figure 6-18 show that the second resistor is switched on as well, that is, first and second resistor are switched in parallel (for example, at *m/z* 44 and *m/z* 46). A missing arrow, for example at *m/z* 45, denotes that only the first resistor is active, whereas the second is not.

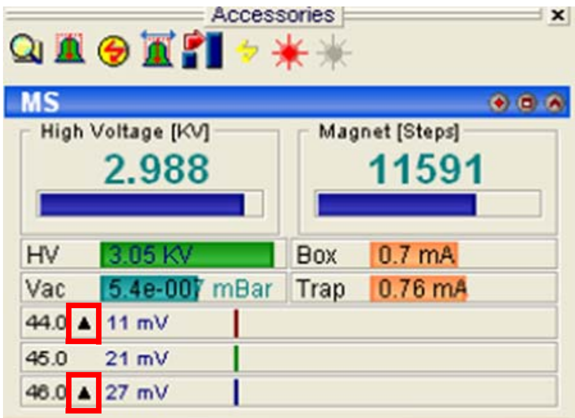
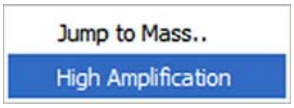



**Figure 6-18.** Parallel Switching of Both Amplifiers




To activate/deactivate the second amplifier, right-click on the mass number. Then mark/unmark “High Amplification“.

## Peak Center


Upon clicking this button on the “Accessories” toolbar, a “Peak Center” will be performed (an electric scan where the physical ion beam is electrically moved across the cup by changing accelerating voltage, Figure 6-22).

The purpose of this procedure is to obtain a value for the statistical center of the ion beam given in HVDAC steps. If no proper peak can be detected (for instance, if the peak is too small or it ends outside the “Scan” window), the function assumes the value -1.

The parameters used for this scan can be preset in the Gas Configuration Editor in Figure 6-20 and Figure 6-21.

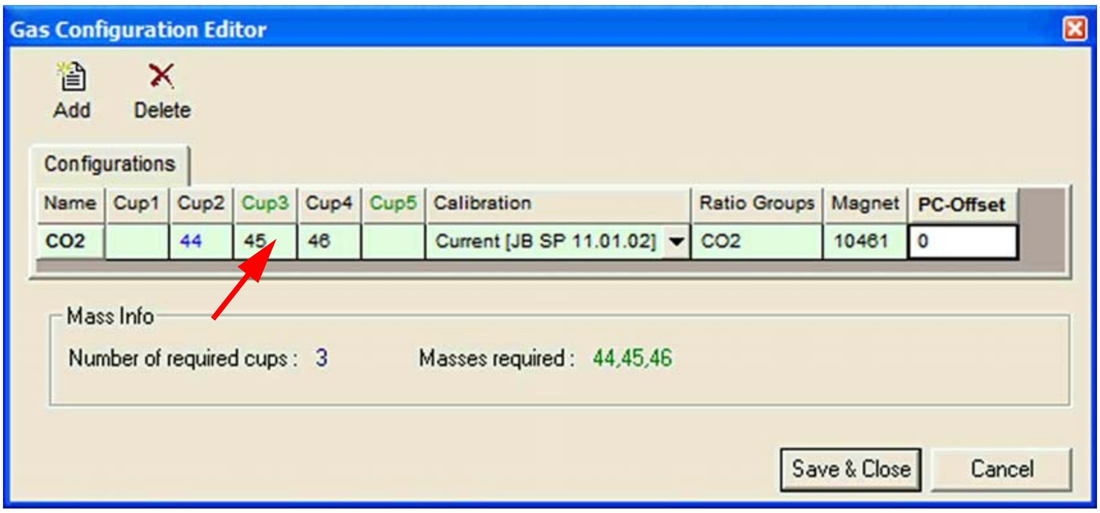
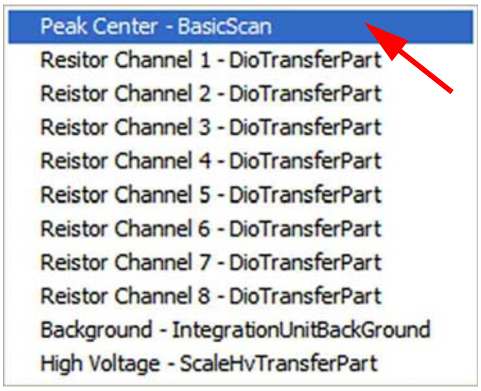



**Figure 6-19.** Presetting Peak Center Parameters




Right-click into an arbitrary column of the actual Gas Configuration. See Figure 6-19.

Select **Peak Center - Basic Scan**.

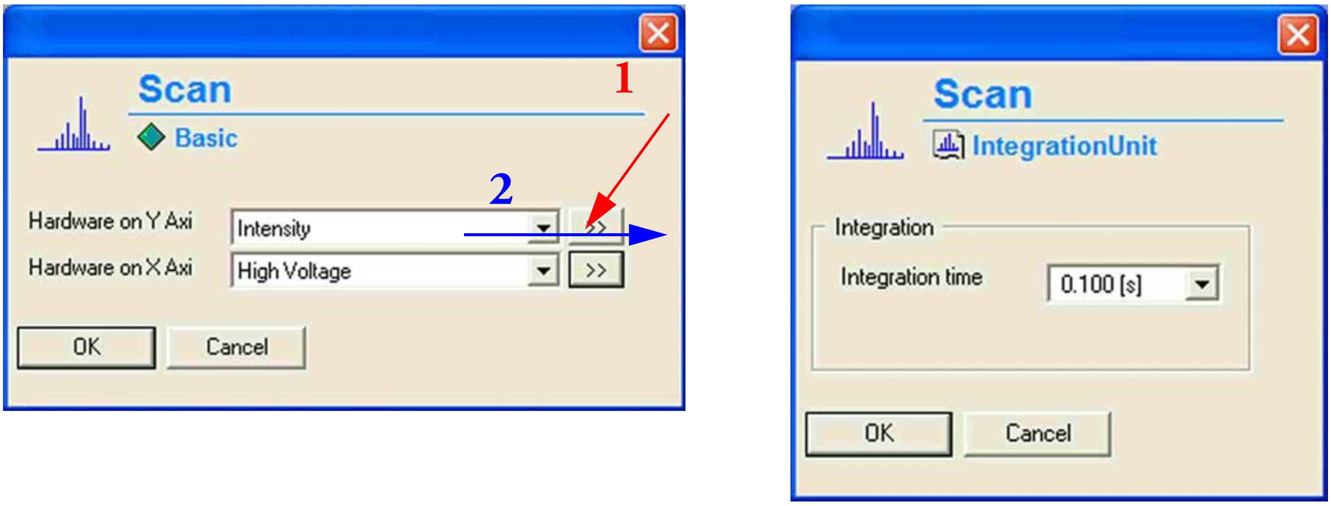
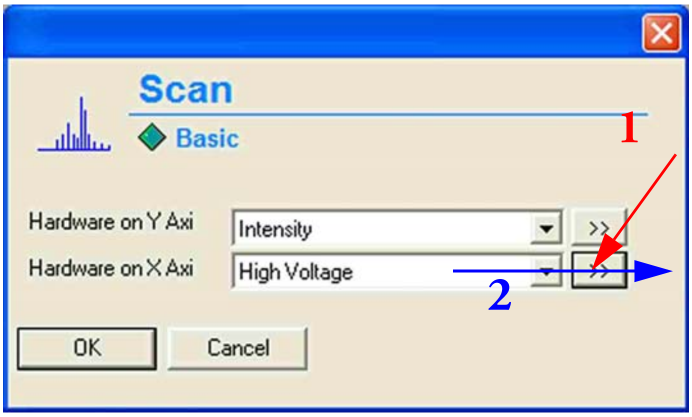



**Figure 6-20.** Presetting Scan Parameters



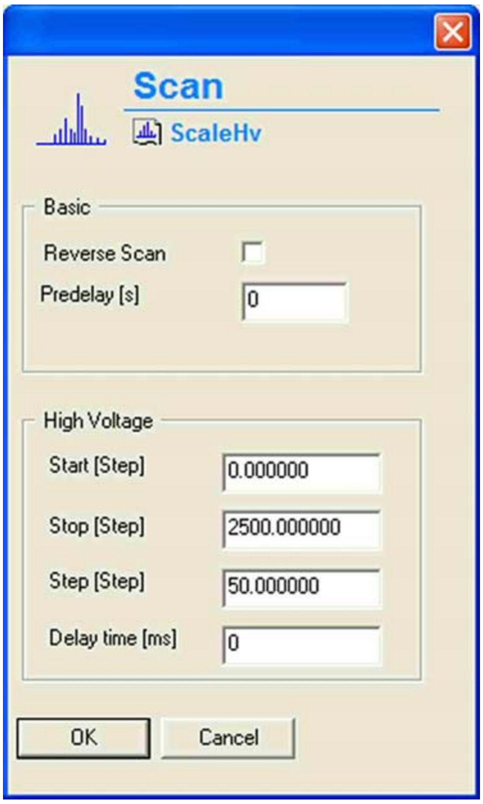




**Figure 6-21.** Presetting Scan Parameters - Continued

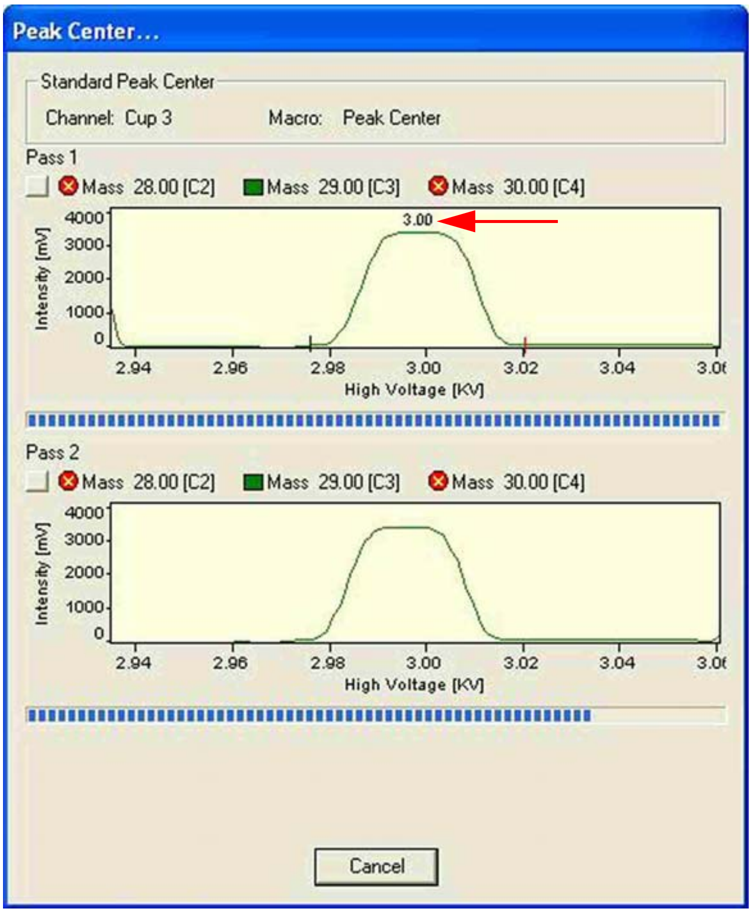



**Figure 6-22.** Peak Center Procedure

The Peak Center value shown at the arrow in Figure 6-22 appears in the Info window, Figure 6-23.

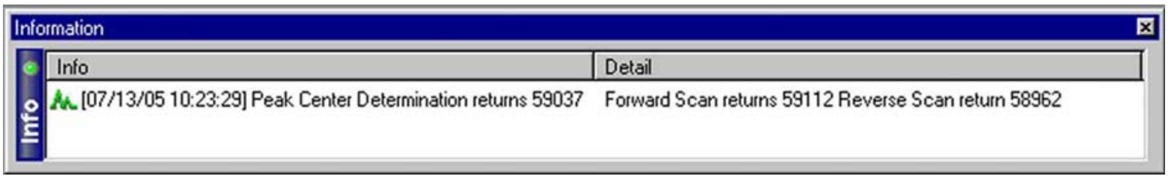



**Figure 6-23.** Peak Center Return Value

## Peak Center Offset

After each Peak Center procedure, the obtained Peak Center value will be corrected by the fixed Peak Center Offset value (given in HVDAC steps). Thus, Peak Center Offset allows adjusting the ion beam on purpose aside the center of the peak (found just before by the Peak Center).

When typing a value into the "PC Offset" cell of the actual Gas Configuration, the "HV Steps" value will be corrected for that value following each Peak Center (may it be called manually or from within an Isodat 2.5 acquisition). Clicking the **Peak Center Offset** button opens a window that allows graphically editing the PC Offset value.

1. First, a Peak Shape Scan is performed according to Figure 6-24.

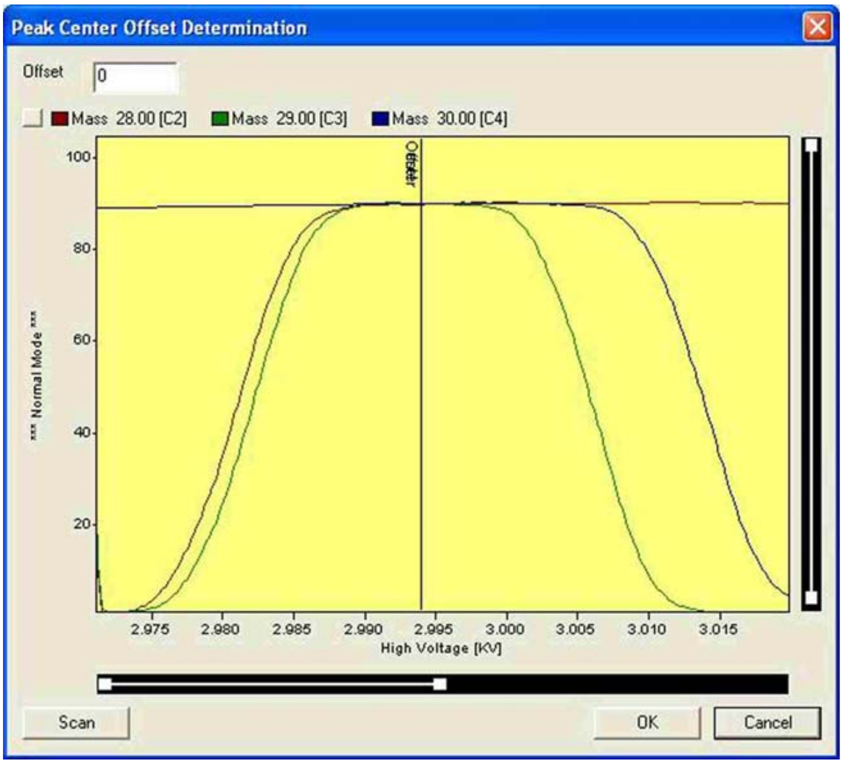



**Figure 6-24.** Peak Center Offset Determination

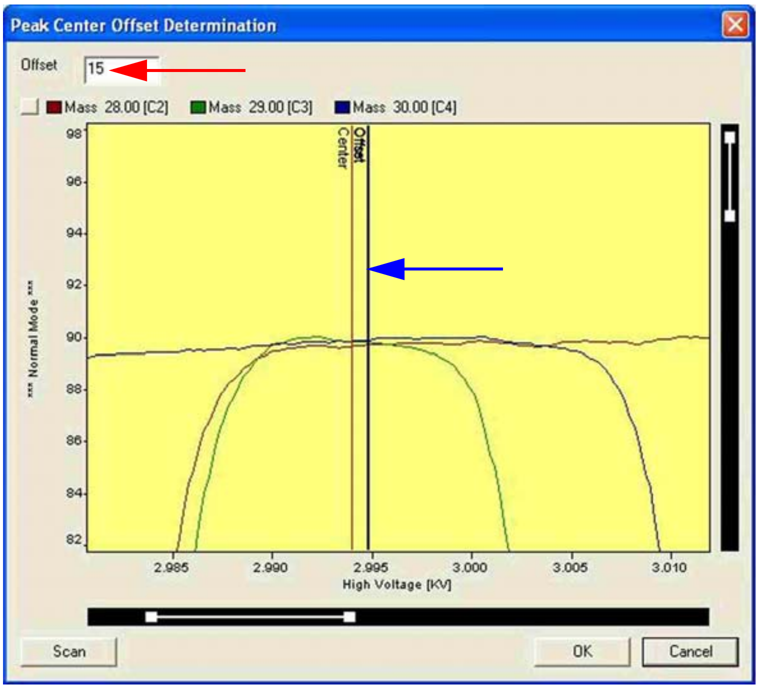
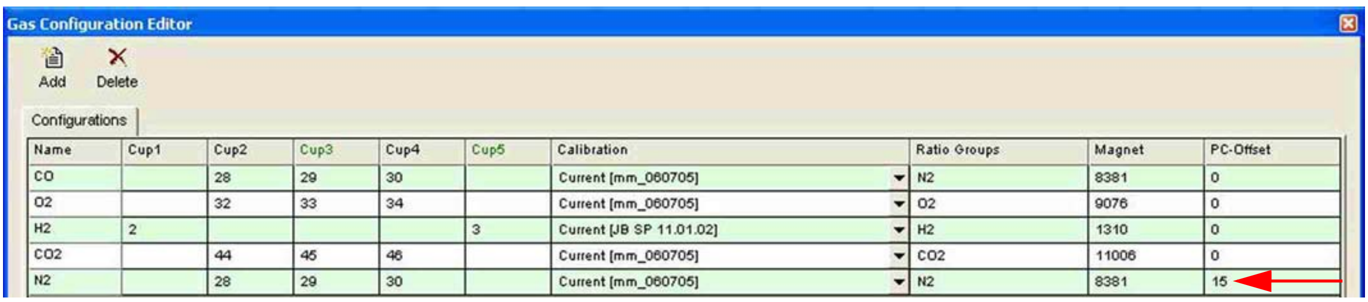



**Figure 6-25.** Adjusting the Desired Peak Center Offset Value

2. Then the desired Peak Center Offset can be adjusted by dragging the bar with the mouse. See Figure 6-25.

3. Confirming by "OK" transfers the Peak Center Offset value chosen above into the respective Gas Configuration.




| Name | Cup1 | Cup2 | Cup3 | Cup4 | Cup5 | Calibration | Ratio Groups | Magnet | PC-Offset |
|---|---|---|---|---|---|---|---|---|---|
| CO | | 28 | 29 | 30 | | Current [mm_060705] | N2 | 8381 | 0 |
| O2 | | 32 | 33 | 34 | | Current [mm_060705] | O2 | 9076 | 0 |
| H2 | 2 | | | | 3 | Current [JB SP 11.01.02] | H2 | 1310 | 0 |
| CO2 | | 44 | 45 | 46 | | Current [mm_060705] | CO2 | 11006 | 0 |
| N2 | | 28 | 29 | 30 | | Current [mm_060705] | N2 | 8381 | 15 |

**Figure 6-26.** Peak Center Offset in Gas Configuration Editor

**Note** Peak Center Offset is especially useful when ratios for such species must be determined that do not match the actual Cup Configuration. ▲

**Note** The parameters used in the Peak Shape scan (Start, Stop and Steps) are stored at "Peak Shape" in the file IsoScanMacro.iso in the folder C:\Finnigan\IsodatNT \Global\Databases. In most cases, it does not need to be edited at all. If in seldom cases editing is necessary however, create a backup before! ▲

# Electronic Offset

**Note** Do not use Electronic Offset for standard applications! ▲


Electronic offset is used to calibrate the counting channels associated with the cup amplifiers. When this function is called, a window, Figure 6-27, opens displaying the actual values of the electronic offsets for all channels.

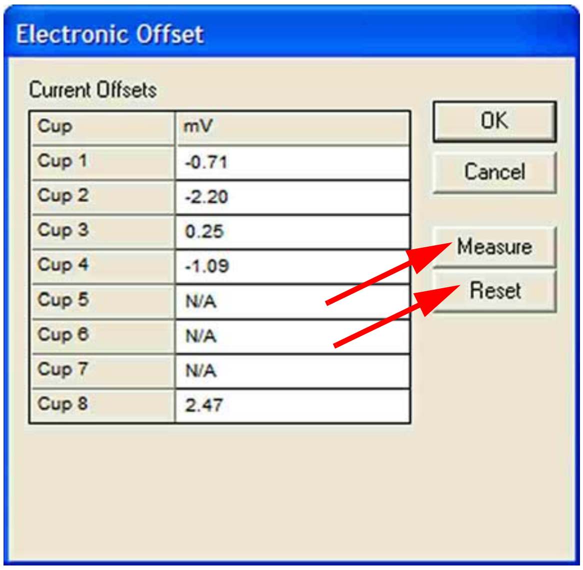



**Figure 6-27.** Actual Values of Electronic Offsets

The window shown in Figure 6-27 allows the user to:

- reset these values to N/A (via **Reset** button) and to
- perform a measurement of the actual counting rate on each amplifier channel (via **Measure** button).


To calibrate the counter zero setting for all channels simultaneously, switch off high voltage. Thereby, Emission will be automatically switched off as well.


Click the **Measure** button.

The base count rate generated by the voltage to frequency counters plus additional electronic noise are measured and stored.

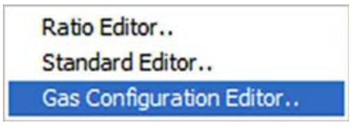
The resulting offset value will now be subtracted from all readings. This results in a zero reading when no current enters the respective cups.

## Gas Configurations

A Gas Configuration is a parameter set that contains all necessary settings to optimally receive ions of all interesting masses of one gas species in the respective cups.

Thus, not only mass to cup dependencies are stored in this parameter set, but also focus settings, the mass calibration, amplifier settings, and Peak Center Offset.


To access the Gas Configuration Editor, click the **Editors** button in Instrument Control module.




Choose **Gas Configuration Editor**.

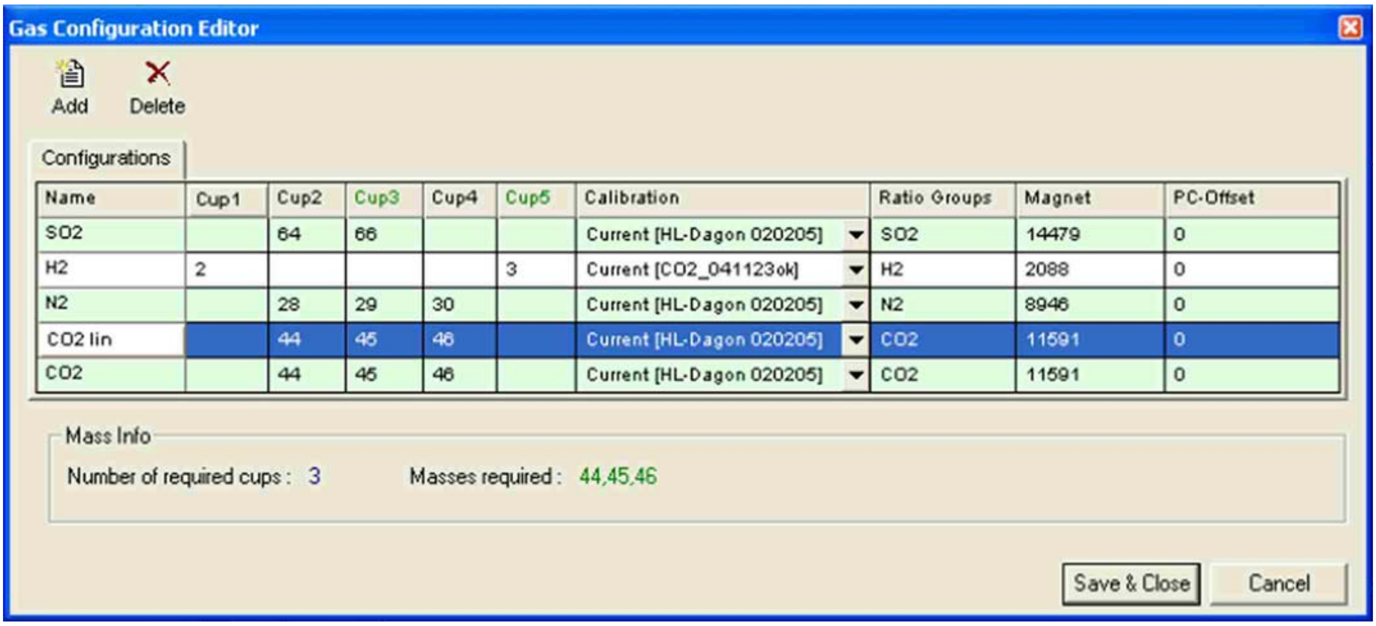



**Figure 6-28.** Gas Configuration Editor

# Dual Inlet System

## Dual Inlet System Window

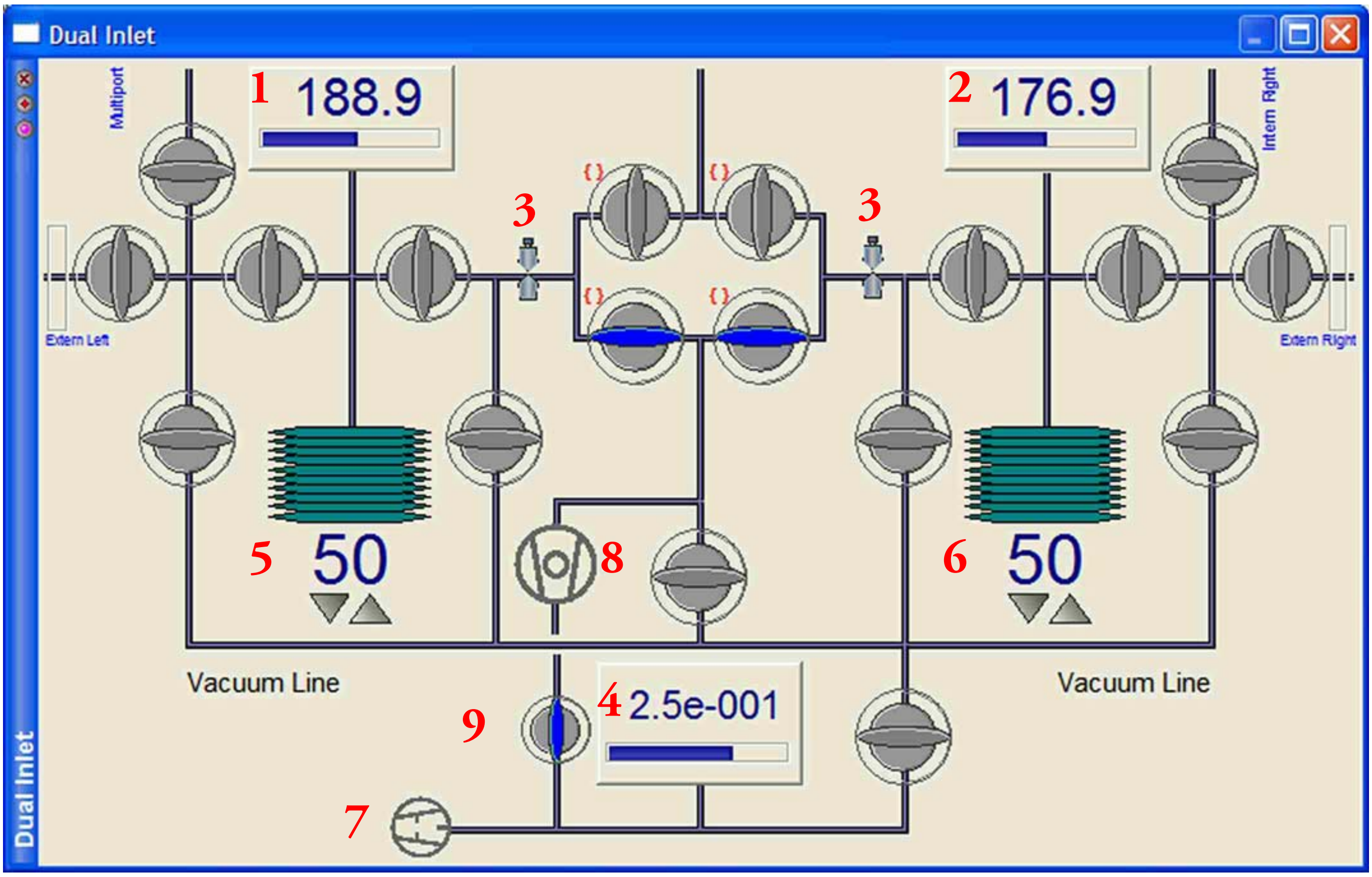



**Figure 6-29.** Dual Inlet System Window

**Table 6-1.** Indications of Dual Inlet System Window[a]

| No. | Indication |
|---|---|
| 1 | actual pressure of left side of Dual Inlet system (in mbar). See pressure transducer, 1 in Figure 4-2. |
| 2 | actual pressure of right side of Dual Inlet system (in mbar). See pressure transducer, 1 in Figure 4-2. |
| 3 | optical reminder of the crimp position of a capillary |
| 4 | actual fore vacuum pressure in mbar; measured by a Pirani gauge (as fore vacuum gauge of Dual Inlet system) |
| 5 | volume proportion of left bellow (in %) |
| 6 | volume proportion of right bellow (in %) |
| 7 | Dual Inlet system fore pump. See "Dual Inlet System Fore Pump" on page 2-34. |
| 8 | Dual Inlet system turbomolecular pump. See "Dual Inlet System Turbomolecular Pump" on page 2-31. |
| 9 | Additional valve. See "Additional Valve" on page 2-35. |

[a] See Figure 6-29 and Figure 4-2.

# Operation of the Changeover Valve

## Switching Positions

The Changeover Valve can be switched to three different positions:

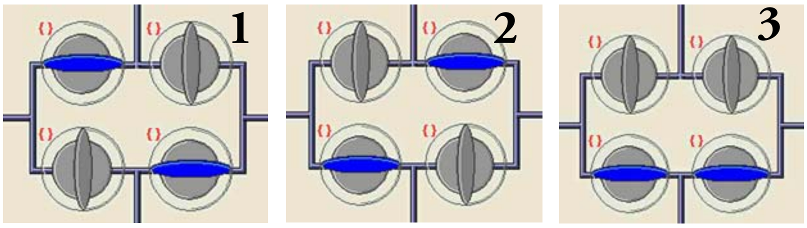



**Figure 6-30.** Switching Positions of Changeover Valve

**Table 6-2.** Switching Positions of Changeover Valve[a]

| No. | Designation | Comment |
|---|---|---|
| 1 | Changeover Left | The left side capillary is opened to the ion source while the right side capillary is opened to Dual Inlet system turbomolecular pump. |
| 2 | Changeover Right | The right side capillary is opened to the ion source while the left side capillary is opened to Dual Inlet system turbomolecular pump. |
| 3 | Changeover Closed | Both capillaries are pumped by Dual Inlet system turbomolecular pump. |

[a] See Figure 6-30.

## Changeover Valve in Dual Inlet Measurement

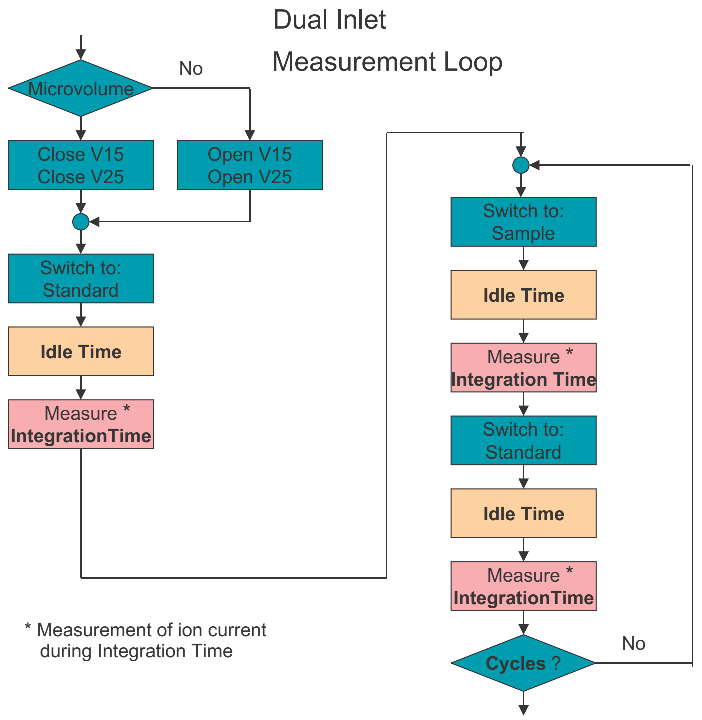



**Figure 6-31.** Dual Inlet Measurement Loop

Usually, the Changeover Valve is controlled by Isodat 2.5 in order to accomplish a Dual Inlet measurement. A flow chart of this basic measurement is shown in Figure 6-31.

Two important time constants can be adjusted in the Dual Inlet method:

- Idle time (Figure 6-32, is "Pre Delay" in Figure 6-31) and
- Integration time (Figure 6-33)

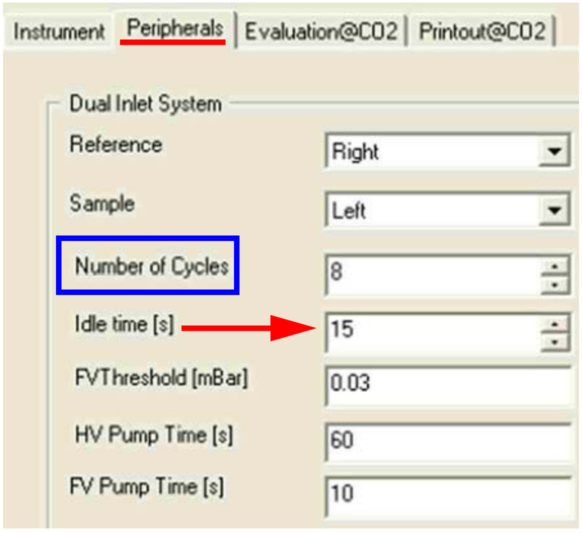



**Figure 6-32.** Setting Idle Time

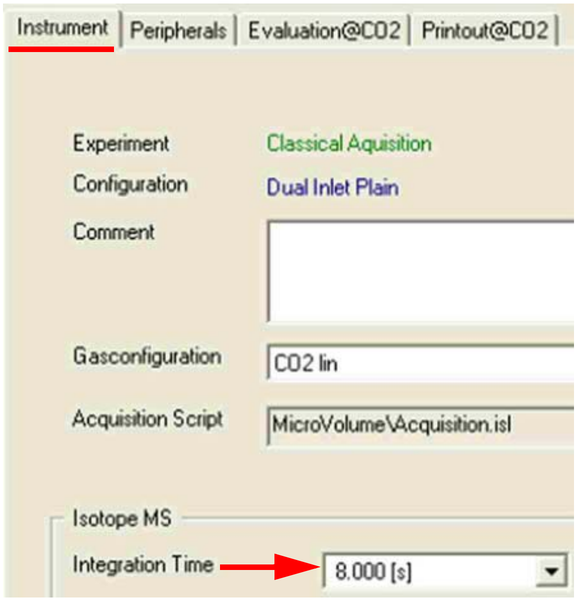



**Figure 6-33.** Setting Integration Time

## Shot Noise Limits of Precision in Dual Inlet Measurements

Figure 6-34 displays how precision (one σ value) varies when integration time and amplitude are changed. Higher amplitudes and longer integration times result in enhanced measurement precision (that is, low standard deviation of the n repetitions with n selected at "Number of Cycles" in Figure 6-32, for example n=8).

Thus, it can be used to select a reasonable integration time for a given measurement and to calculate the precision that can be expected.

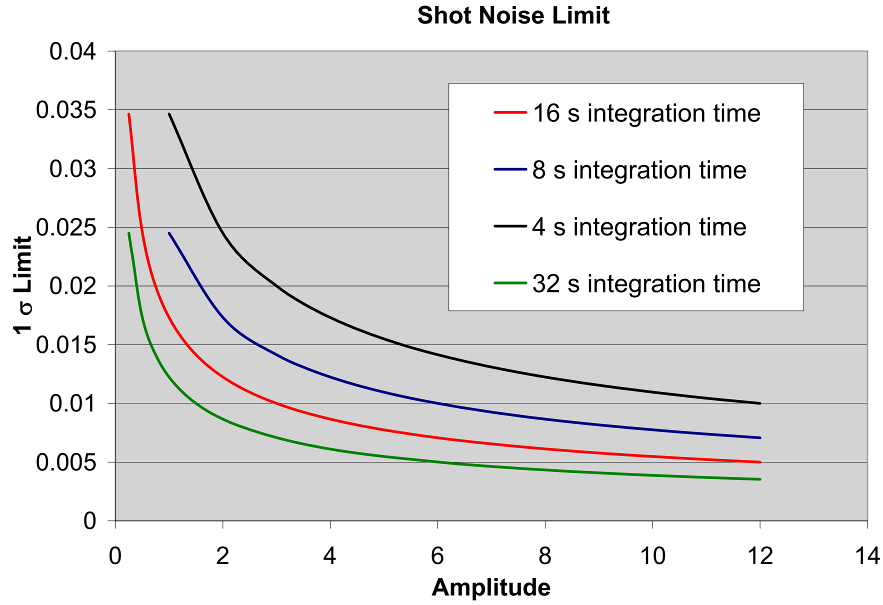



**Figure 6-34.** Shot Noise Limits of Precision

The diagram contains the results of a calculation for the shot noise (statistical noise) on a cup, taking into account the integration time, the resistor of the cup and the signal height in that cup. The sample calculation is taken out for the middle cup and thus is true for $\delta\,^{13}C$. For $\delta\,^{18}O$ roughly multiply the results by 1.4.

The same mathematics is used with the calculations that are contained on the "All Products" CD supplied by our marketing department.

When we talk about precision here, we call it "internal precision". This number is reported as "Standard Deviation" in the output grid. This is **not** the number reported as **"**standard error**"** although in discussion both are often mixed up. The "Standard Error" is a number that is generally smaller because it takes into account the repetitions of the measurement (number of cycles—usually set to 8). The standard error is also reported in the output grid and represents the error in determining the average of a distribution (in our case the average δ value of the n repetitions of individual measurements).

## Operation of the Changeover Extension

The Changeover Extension enhances the capabilities of the standard Changeover Valve by adding two ports usable for two additional peripherals.

## Switching Positions

Similar to the Changeover Valve, the Changeover Valve Extension can be switched to five different positions according to Figure 6-35, Figure 6-36 and Table 6-3:

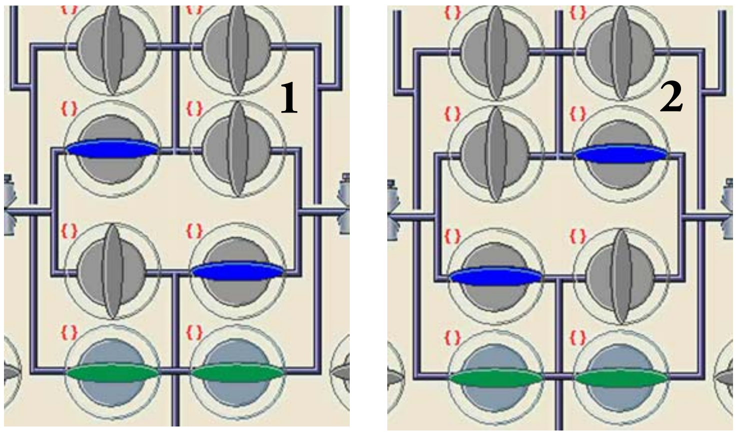



**Figure 6-35.** Positions of Changeover Extension

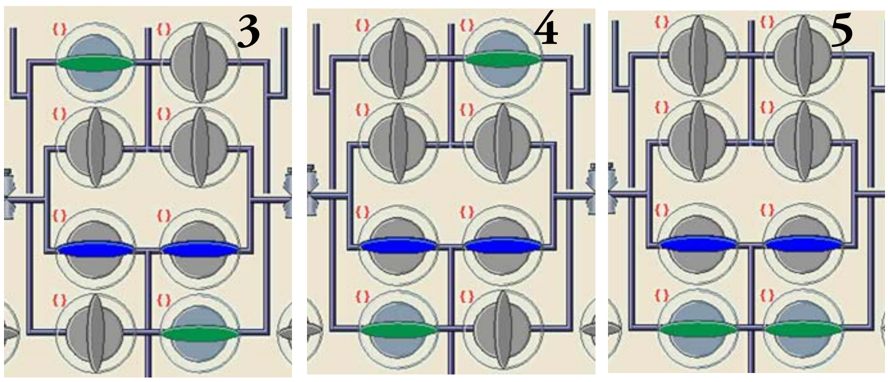



**Figure 6-36.** Positions of Changeover Extension - Continued

**Table 6-3.** Switching Positions of Changeover Extension[a]

| No. | Designation | Comment |
|---|---|---|
| 1 | Changeover Left | The left side capillary is opened to the ion source while the right side capillary is opened to Dual Inlet system turbomolecular pump. |
| 2 | Changeover Right | The right side capillary is opened to the ion source while the left side capillary is opened to Dual Inlet system turbomolecular pump. |
| | | |
| 3 | Changeover Extension Left | The left side capillary of Changeover Extension is opened to the ion source while all other capillaries are opened to Dual Inlet system turbomolecular pump. |
| 4 | Changeover Extension Right | The right side capillary of Changeover Extension is opened to the ion source while all other capillaries are opened to Dual Inlet system turbomolecular pump. |

**Table 6-3.** Switching Positions of Changeover Extension[a], continued

| No. | Designation | Comment |
|---|---|---|
| 5 | Changeover Extension Closed | All capillaries of Changeover Valve and Changeover Extension are pumped by Dual Inlet system turbomolecular pump. |

[a] See Figure 6-35.

## Operation of the Bellows

The purpose of the bellows (that is, variable volumes) is to compress or expand gas samples to adjust proper gas flows for the two capillaries leading to the Changeover Valve.

Prior to a Dual Inlet measurement, a bellow calibration must be performed as follows in two steps. It is presumed, that the ion source has been switched on and focusing has already been performed.

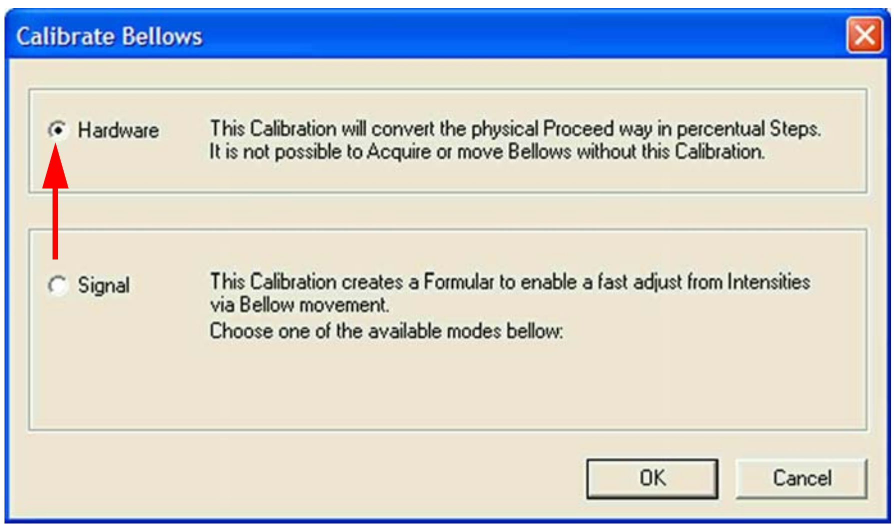
### Hardware Calibration for the First Time

To operate the bellows for the first time, perform a hardware calibration.

❖ **To perform a hardware calibration**

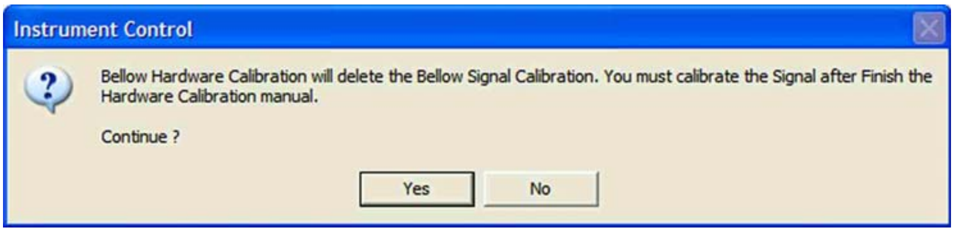
1. On the “Accessories“ toolbar, click the **Calibrate Bellows** icon.


2. Choose **Hardware**.



In hardware calibration, the bellows are opened as far as it will go (that is, to 100%) and closed again (that is, to 0%).

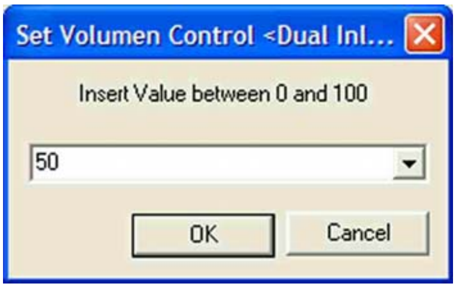
**Note** A hardware calibration deletes a signal calibration. Thus, hardware calibration must always be performed prior to signal calibration! ▲



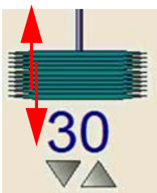


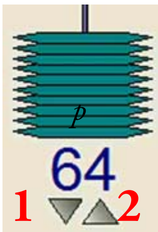
## Later Procedure

Later, simply right-click on the bellow symbol in the Dual Inlet window. Then enter the desired volume ratio in %, for example 50:


Alternatively, click on the bellow symbol and drag your mouse up or down to the desired volume setting:



The arrows **1** and **2** below the values allow an in- or decrease by a single elementary step at the respective bellow motor.

**Note** Clicking on the arrows will not cause an in- or decrease by ±1%, but much less! ▲

## Signal Calibration

Signal calibration establishes a relationship between bellow position and signal on the cups. Since signal calibration needs to set percentage values (25% and 75%) of bellow extension, hardware calibration must always be performed prior to signal calibration.

**Note** Signal calibration requires a signal intensity of at least 3 V! ▲

**Note** If signal calibration has not been performed, the Diagnosis tests cannot be run! ▲

During automated operation, that is if the bellows are controlled via scripts or during acquisition, Isodat 2.5 uses an algorithm that allows direct setting of signal amplitudes. For this to be possible, a signal calibration must be performed.

❖ **To perform a signal calibration**

1. An amount of gas must be let into the bellows, which results in a pressure of about 10 mbar to 20 mbar on each side. This gas amount is necessary to obtain a certain signal intensity. If the gas amount is either too small (for example, < 10 mbar) or too large, warning messages will occur.

2. Close the valves (14 and 24).

3. On the “Accessories“ toolbar, click the **Calibrate Bellows** icon.

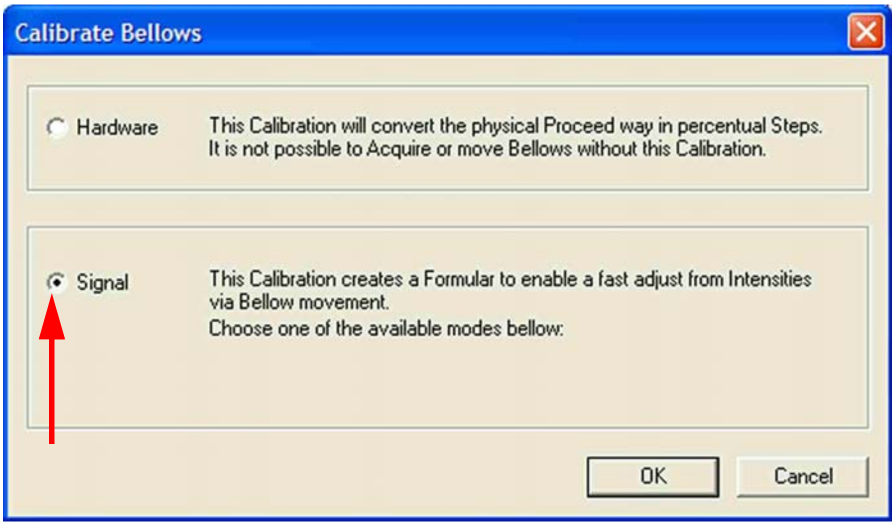



**Figure 6-37.** Signal Calibration of Bellows - Signal

4. Select **Signal**.

The signal intensity of the gas will be measured depending on the bellow volume.

### Pressure Adjust

Only after signal calibration has been successfully performed, an automated pressure adjust can be carried out. During automated operation, a number of parameters are used to control bellow movement.

They are summarized in “Peripherals“ tab of a Dual Inlet method as shown in Figure 6-38.

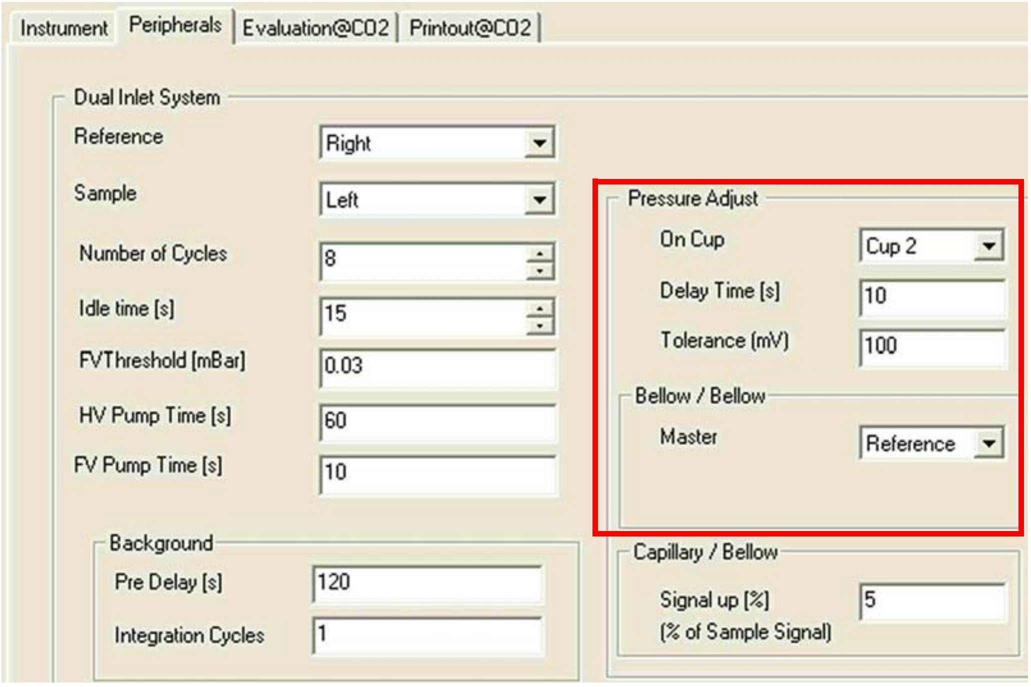



**Figure 6-38.** Parameters for Pressure Adjust

## Combined Multiport-Microvolume Measurement

Whereas a Multiport has no parameters of its own, a Microvolume does have. Figure 6-39 outlines a combined Multiport-Microvolume measurement.

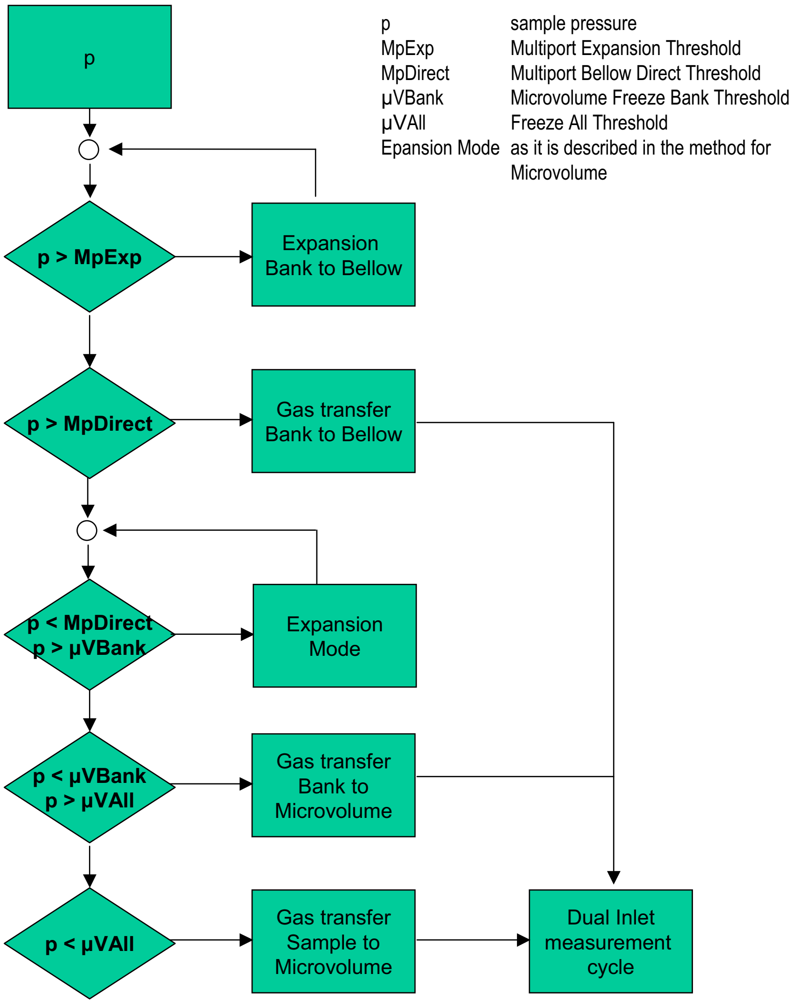



**Figure 6-39.** Combined Multiport-Microvolume Measurement

The sample pressure p is measured. If p is too high to be measured directly with the bellow, the gas will be expanded to the bellow, and the remaining gas will pumped.

## Reference Refill

Reference Refill adds no additional display features that can be used. Instead, if installed, it appears as a part of a Dual Inlet method: in "Instrument" tab, some important parameters of Reference Refill can be preset. See Figure 6-40 and Figure 6-41.


**Figure 6-40.** Presetting of Reference Refill Parameters

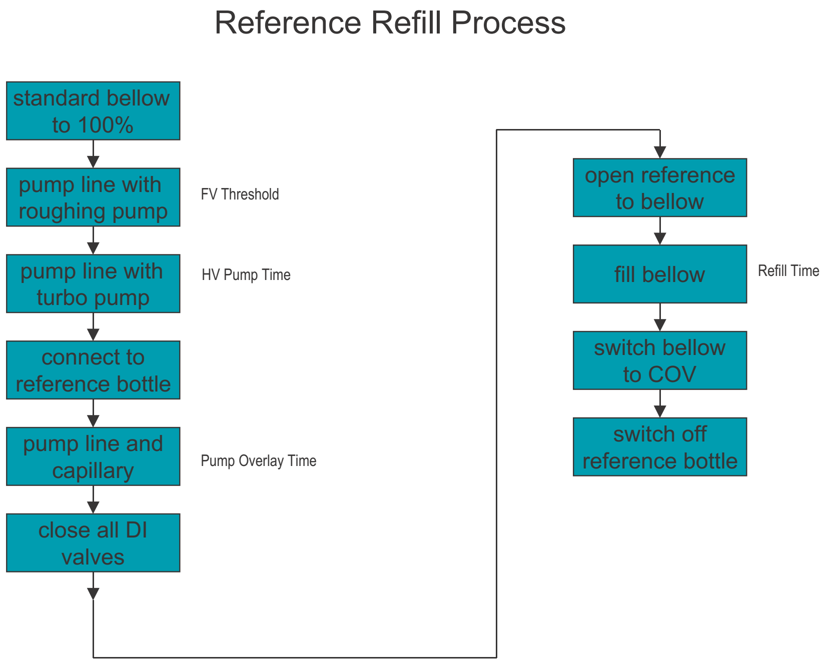



**Figure 6-41.** Reference Refill Process

The Reference Refill parameters occurring in Figure 6-41 are preset in Figure 6-40.

1. First of all, a fore vacuum threshold (“FV Threshold“) can be pre-set that is used while the bellow and adjacent volumes are pumped off.

2. Afterwards, the respective volumes are pumped off using the Dual Inlet turbomolecular pump for “HV Pump Time“.

3. Directly after that, the volumes and the connected Reference Refill volume are pumped off together to avoid that used gas enters the bellows. This is done for “Pump Overlay Time“.

4. Afterwards, the actual refill of the bellows takes place for “Refill Time“.

# Chapter 7 Maintenance Operations

This chapter provides procedures necessary for maintaining and repairing components of the DELTA V Plus mass spectrometer. Remarks only for Thermo Fisher Scientific field service engineers are given as well.

It contains the following topics:

# General Remarks

This chapter contains information required for maintenance and repair of your DELTA V Plus IRMS. Regular maintenance including the functional checks and routines described below is required to maintain trouble-free, continuous operation and to obtain optimum mass spectrometer performance. Some of the measures should only be performed by service engineers. Especially see "Remarks for Service Engineers" on page 7-51.

Table 7-1 summarizes some important maintenance procedures over time.

**Table 7-1.** Some Important Maintenance Operations over Time

| Maintenance Operation | Period |
|---|---|
| - oil exchange of all fore pumps<br>- oil exchange of all turbomolecular pumps<br>- oil level check in bin of pressure reducer for compressed air | annually |
| - oil level check of all fore pumps (via inspection glasses) | quarterly |
| - filament exchange<br>- ion source cleaning[a] | if required |
| - check of halogen lamps | weekly |

[a] When the values of the diagnostic criteria described in "Diagnosis" on page 8-1 can no longer be obtained.

## Basic Rules for Cleaning

**Note** Do not economize with the cleaning agent! Renew the cleaning bath frequently. ▲

To check highly volatile cleaning agents (for example, cyclohexane, acetone), dip a polished metal plate into the bath and take it out again so that as much liquid as possible remains behind on the plate. Preferably, bend the plate to a concave shape. Allow the bath liquid to evaporate. No residuals should be left on the plate. Otherwise, change the bath liquid.

**Note** Use slightly contaminated bath liquids for preliminarily washing severely contaminated parts! Do not rinse with water if using volatile cleaning agents! Rinse with a lot of water if using cleaning agents in aqueous solution! Use warm water, finally rinse with distilled or deionized water! ▲

Dry the parts, which have been rinsed in water, well in a dust free area, preferably in a vacuum drying oven! In the case of drying ovens with forced air circulation, the air must be free of dust. If necessary, wrap the parts loosely in tissue paper and place them in the oven.

Because contaminations on ceramic parts consist of physically adsorbed metal layers, they cannot be removed with volatile cleaning agents.

Using an ultrasonic bath increases the probability of a successful removal of contaminations. Successful removal of contaminations from ceramic parts may not always be possible. In this case, replace these parts by new ones. If new parts are not available, strongly adhering layers can be removed as follows:

- by filing down with a diamond file. After being filed, the parts must be washed. The diamond file can easily be cleaned again with an erasing rubber.
- by annealing at red heat in a propane-oxygen flame. Too high temperature may cause distortion of ceramic parts. Therefore, avoid the white heat range!

**Caution** Do not wash any parts after they have been annealed. Ceramic parts that cannot be disconnected from metal parts must not be annealed! ▲

When re-assembling, do not touch the washed parts with naked hands! Use non-fibrous gloves and clean tools!

In case of difficult assembly jobs, it may be necessary to work without gloves. Then thoroughly wash your hands and remove any fat or grease from the fingertips with a solvent. The parts should then be touched only with degreased fingertips.

To avoid any damage to the skin, rub your fingertips over with a fatty skin cream when the work is completed!

# Ion Source

The ion source is described at "Ion Source" on page 5-7. Maintenance operations at the ion source are probably the most frequently occurring ones.

## Easy Access to the Ion Source

The ion source is quickly and easily accessible. Before starting any maintenance operation, it can easily be dismantled as a whole together with the ion source connector board still attached to it. Only three connectors must be unplugged, not all 13.

The entire unit together with the ion source connector board can then be positioned upright on a work bench for maintenance operations. This secure procedure obviates mistakes, for example related to wiring. See Figure 7-1. Afterwards, the ion source can easily be reinserted as a whole.

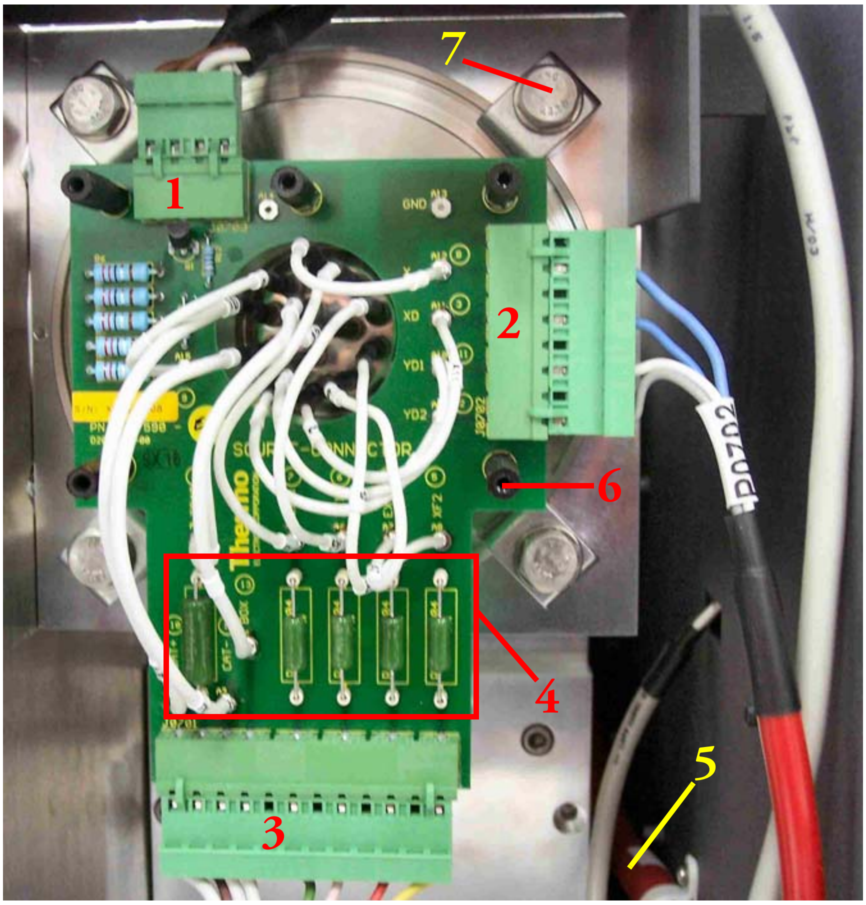
Table 7-2 summarizes important maintenance operations to be performed at the ion source.

**Table 7-2.** Maintenance Operations at Ion Source[a]

| Operation | Described in Detail at |
|---|---|
| Dismantling the ion source | "Dismantling the Ion Source" on page 7-5 |
| Reinserting the ion source | "Reinserting the Ion Source" on page 7-9 |
| Cathode unit exchange | "Cathode Unit Exchange" on page 7-11 |
| Cleaning ion source parts | "Cleaning Ion Source Parts" on page 7-12 |
| Filament exchange | "Filament Exchange" on page 7-12 |
| Heater exchange | "Heater Exchange" on page 7-14 |

[a] See Figure 7-2, Figure 7-3 and Figure 7-4.

## Dismantling the Ion Source




1 connector for ion source heater coming from the 12 V power supply

2 connector for low-lying ion source potentials (that is voltages around ground potential, but less than ca. 500 V) coming from ion source connector cable, 5

3 connector for high-lying ion source potentials, that is for voltages around 3 kV

4 five resistors, attenuating possible flashovers within the ion source, as then only very small currents will flow towards ion source connector board. Thus, possible damage will be minimized.

5 ion source connector cable

6 black screw to turn the ion source upright on your work bench before maintenance operations

7 metallic claw, fastening the flange at the housing

**Figure 7-1.** Ion Source and Ion Source Connector Board

**Note** On the ion source connector board is indicated which electrical connector leads to which lens plate within the ion source. See Figure 6-3 and parts 5, 7, 9, 17, 33 in Table 9-4. The numbers 1–13 of the individual pins of the feedthrough are indicated in Figure 7-5 as well. ▲

When dismantling or inserting the ion source, it might be tedious, error-plagued and damaging (for example, easily breaking ceramics and delicate metal-ceramics transitions) to loosen or connect all 13 connectors individually. Rather, the ion source can much more easily be dismantled as a whole together with the ion source connector board.

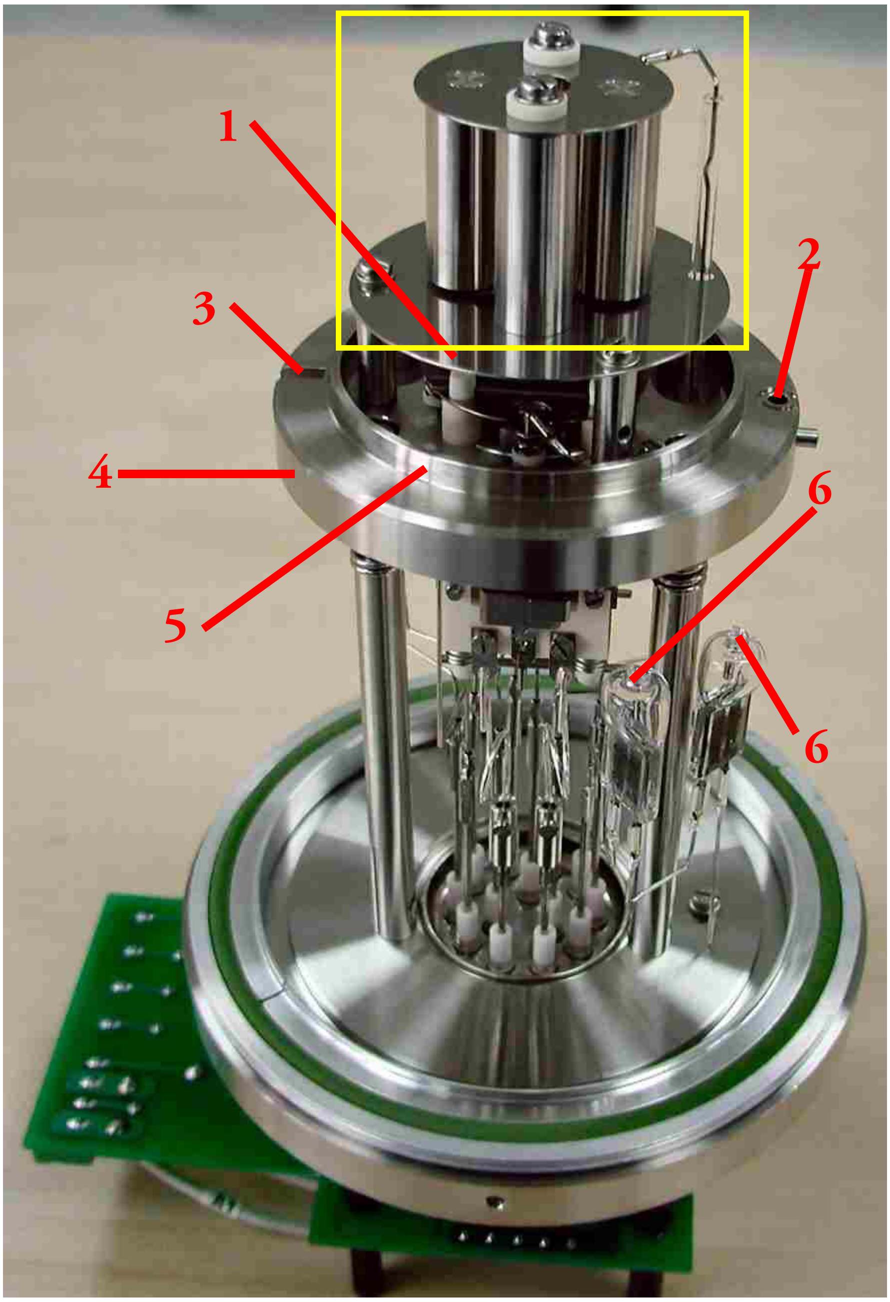
**Caution** To avoid damaging of the aluminum-made parts, never use any mechanical tool to force opening of flanges! Instead, after first venting correctly and then loosening the screws, any flange can be easily removed manually. ▲

### ❖ To dismantle the ion source

1. Switch off the ion source.
2. If available, close Dual Inlet system, that is close Changeover Valve.

**Note** Alternative: after you closed Changeover Valve, the Dual Inlet system can be operated while the rest of the instrument is being vented. This is advantageous for filament exchange, for example. ▲

3. Switch off the pump system of the main instrument, but not necessarily the Dual Inlet turbomolecular pump.
4. Vent the analyzer using dry argon or nitrogen. See "Venting the Amplifier Housing" on page 7-49.
5. Pull out all three green connectors (**1**, **2**, and **3** in Figure 7-1).
6. Loosen all four claws (**7** in Figure 7-1) using a screw wrench.
7. Carefully pull out the ion source as a whole.
8. Position it upon its four screws (**6** in Figure 7-1) on your work bench. Thus, the ion source is upturned vertically (Figure 7-2).




Labeled Components: 1=focus quad[a]; 2=gas inlet into the ion source; 3=slit for guide pin of ion source; 4=supporting surface for ion source; 5=guide ring; 6=two halogen lamps as ion source heaters

**Figure 7-2.** Ion Source - Dismantled

[a] Focus quad is not available in DELTA V Advantage but only in DELTA V Plus.

9. If the ion source shall be removed for a longer period of time, for example for cleaning, close the opening of the analyzer head by suitable means to prevent foreign particles from entering the ion source.

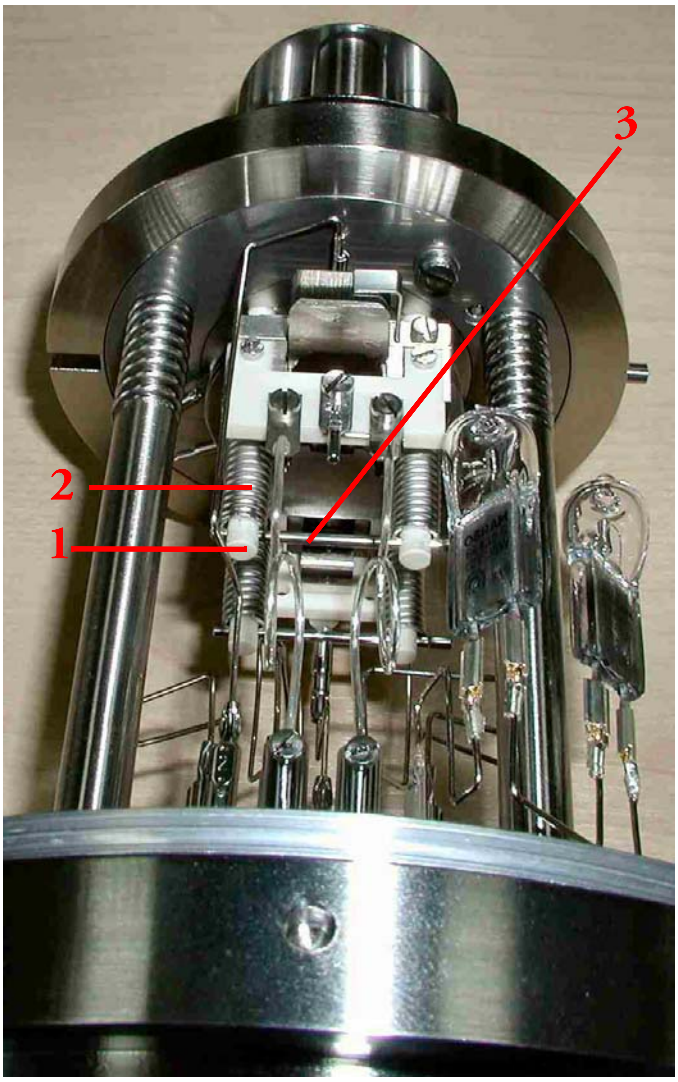
10. Perform ion source maintenance operations. See Figure 7-3.

11. Afterwards, simply insert the ion source again as a whole.

12. Fix the four metallic claws and the three green connectors again.

**Note** Due to the elastic Viton O-ring seal, it is sufficient to fix the four metallic claws slightly. Screwing on them too tight might do damage to the aluminum-made analyzer block. ▲

Figure 7-2 displays the dismantled ion source as a whole. Figure 7-3 shows important mechanical parts.

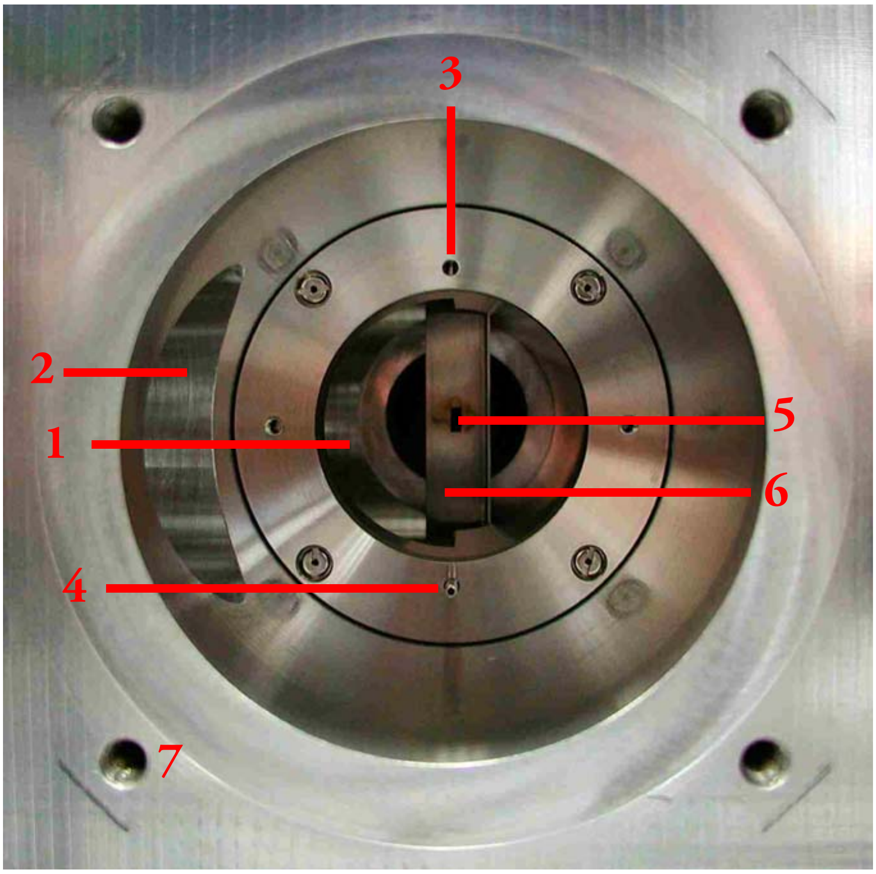



Labeled Components: 1=four ceramic pins; 2=springs (assure mechanical stability); 3=metallic bolts (inserted perpendicularly between the ceramic pins, assure mechanical stability)

**Figure 7-3.** Mechanical Parts of Ion Source - Dismantled

## Reinserting the Ion Source

Figure 7-4 shows the empty ion source housing with its important parts.




Labeled Components: 1=behind it, main pump is placed (required analyzer turbomolecular pump); 2=behind it, differential pump is placed (optional analyzer turbomolecular pump); 3=gas inlet; 4=guide pin of the ion source; 5=aperture; 6=aperture sheet; 7=thread for ion source attachment screw

**Figure 7-4.** Empty Ion Source Housing

**Note Only for service engineers**: the guide pin of the ion source **4** is used for proper alignment of the ion source while reinserting it. The ion source is thereby prevented from being reinserted on-edge.

If the ion source has been reinserted askew, sensitivity worsens. Additionally, Y1 deflection differs markedly from Y2 deflection (asymmetric values, that is, one deflection value is at maximum, whereas the other one is considerably lower). ▲

**Note** In seldom cases, the guide pin may be canted within the ion source. Furthermore, if the ion source is often dismantled and reinserted, the guide pin may fall out completely and get lost.

Therefore, when reinserting the ion source, make sure that the guide pin is still present and not canted. The ion source must be easily movable and not get stuck during reinsertion! ▲

### ❖ To reinsert the ion source

1. Inspect the edge sealing carefully for absence of scratches and lint.
2. Place the edge sealing on the flange of the analyzer head.
3. Insert the ion source into the analyzer head. When inserted, ion source flange and making flange should be aligned in parallel.
4. Press the ion source in the direction of the analyzer and tighten the screw hand tight. Check for short circuits. Afterwards, use a wrench and tighten the screws crosswise within at last two procedures.
5. After exchanging the cathode unit and/or dismantling the ion source, readjust the ion source potentials.

**Only for service engineers**: Figure 7-5 shows the feedthrough of the ion source viewed from inside (left) and outside (right). See also Figure 7-6.

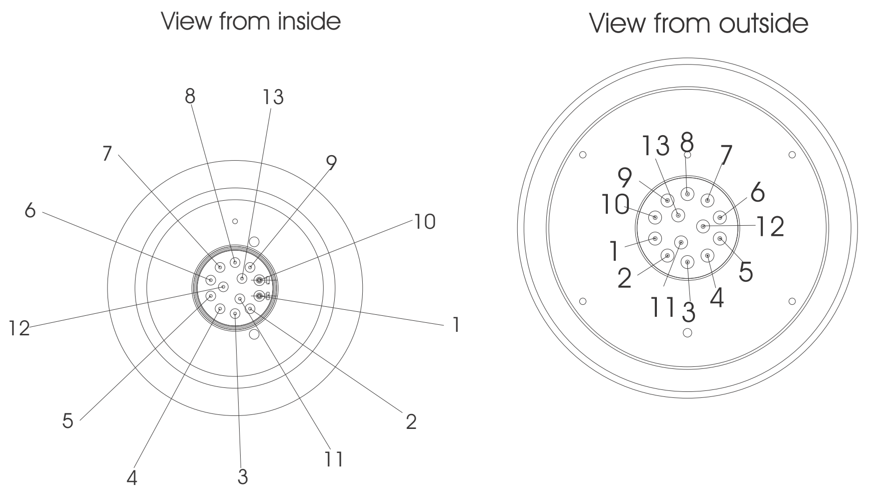



**Figure 7-5.** Feedthrough of Ion Source

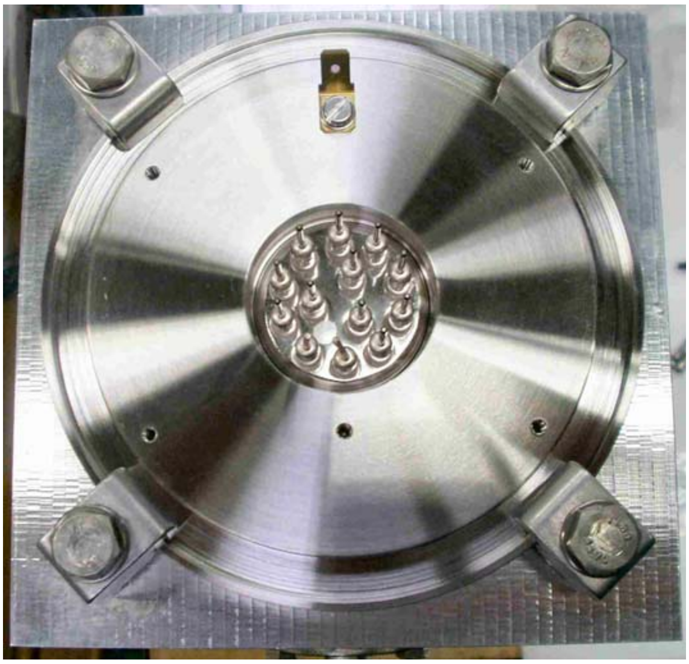


**Figure 7-6.** Ion Source Flange

## Cathode Unit Exchange

**Note** Use lint-free gloves and clean tools for the exchange. ▲

❖ **To exchange the cathode unit**

1. Dismantle the ion source as described at "Dismantling the Ion Source" on page 7-5 and put it onto a work bench upright.
2. Unscrew the cathode unit from the ionization housing and remove the cathode unit.
3. The new unit must fit to the edge of the housing. Afterwards, tighten the screws. See Figure 7-8.
4. Hold the feedthroughs using small pliers and screw on the connection wires.
5. Perform the ion source check.
6. Reinsert the ion source as described at "Reinserting the Ion Source" on page 7-9.

# Cleaning Ion Source Parts

Because the ion source and/or its parts gets dirty by and by, it must be cleaned from time to time. The procedure is taught in a Thermo Fisher Scientific training course. Either send the ion source to Thermo Fisher Scientific or clean it on your own as described below.

## Cleaning Metallic and/or Ceramic Parts

❖ **To clean metallic and/or ceramic parts**

1. Carefully dismantle the ion source. See "Dismantling the Ion Source" on page 7-5.

2. Carefully disassemble the ion source into its components.

3. Grind all contaminated and discolored metal parts with aluminum oxide powder (600 grain) or use a soft emery paper with a 600 grain.

   This mechanical cleaning must be followed by a chemical cleaning:

4. All parts made of stainless steel should be cleaned in a detergent solution at 60 °C for about 1 or 2 hours.

5. All parts must be cleaned within a bath. An ultrasonic bath will improve and accelerate the cleaning procedure:

**Note** Do not use ultrasonic when cleaning the ion source magnet. ▲

   a. Rinse the metallic parts with deionized water.

   b. Remove the residues of water using pure ethanol or acetone.

6. The parts should be dried by a fan or a drying oven to eliminate solvent residuals.

# Filament Exchange

Exchanging the filament due to burn-through is probably the most often occurring maintenance operation concerning the ion source. Buy new ones at Thermo Fisher Scientific.

**Note** Always stock a filament as this facilitates operation around the clock and restricts dead times. We recommend to exchange a filament up to twice a year. However, it is not necessary to replace it after venting the IRMS. ▲

If a filament has burnt through, replace it by a new one. See Figure 7-7, but also Figure 7-1, Figure 7-2 and Figure 7-3.

#### ❖ To replace a filament

1. Open both clamps that hold the silver wires of the filament.

2. Loosen the screws of the filament carrier.

3. Carefully pull out the old filament.

4. To remove the claws cut through the wires using a pair of scissors. See Figure 7-7.

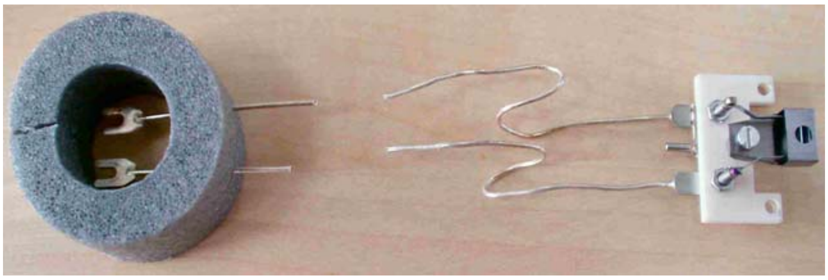


**Figure 7-7.** Filament - Dismantled

5. When inserting the new filament, carefully push the filament carrier along both guide tracks (one for up/down and one for left/right).

   See arrows in Figure 7-8 and then in Figure 7-9 for proper adjustment of the edges. This ensures that the filament will fit correctly later on.

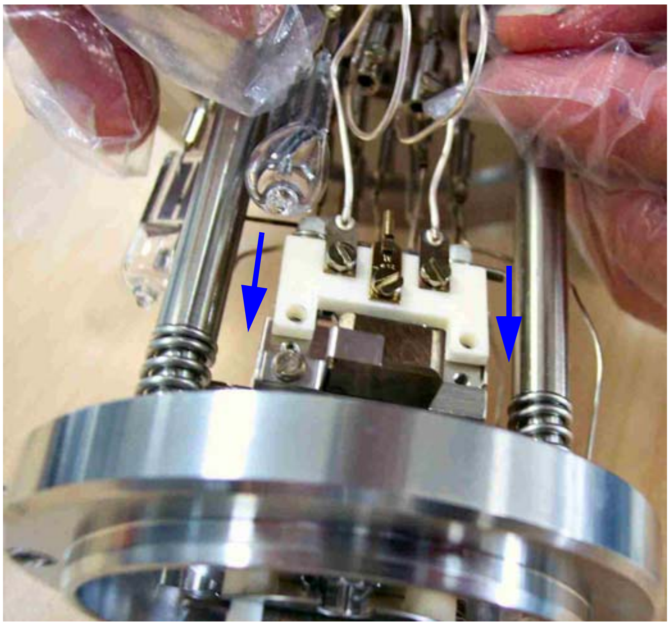


**Figure 7-8.** Pushing Filament Carrier along Guide Tracks

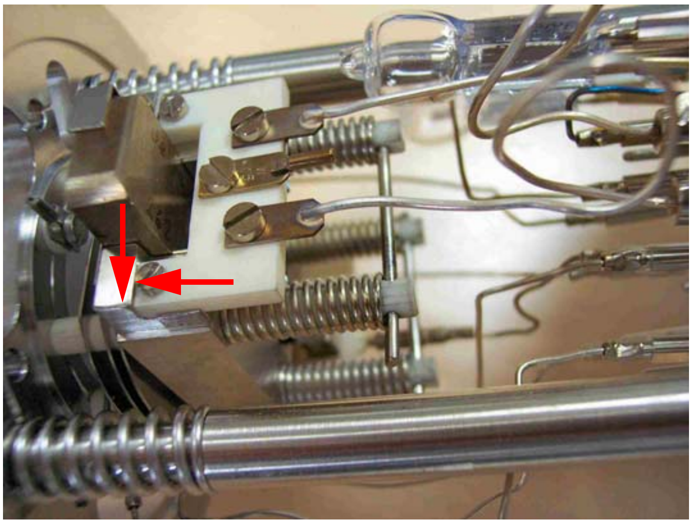


**Figure 7-9.** Proper Adjustment at Edges

## Heater Exchange

It may be advantageous to replace even the heaters when the filament is being exchanged. As ion source heaters, two commercial halogen lamps of 12 V each are used. We recommend using "Osram Starlite" halogen lamps (No. 64432 S of 35 W, 12 V and GY 6.35), which are of high quality and durability. Take a look at them in the product catalog at www.osram.com.

**Note** The halogen lamps may not imply an infrared protection, as those mainly would emit visible light and their heating power would thus be decreased. Halogen lamps **without** an infrared protection however, emit more infrared radiation and are therefore better suited as heaters. ▲

They are provided with energy by the 12 V power supply (see "12 V Power Supply" on page 2-25) and are run with undervoltage to drastically increase their lifetime. Figure 7-10 displays the connection scheme of the halogen lamps (pin 9 in Figure 7-1).

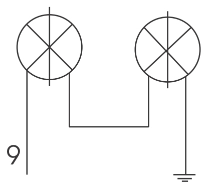



**Figure 7-10.** Connection Scheme of Halogen Lamps

**Note** If the halogen lamps are waggling, press their spring contacts carefully together using little pliers. ▲

## Apertures

The aperture limits the width of the ion beam and guides it. Thus, the beam can be focused and finally hits the magnet accurately. The DELTA V Plus and DELTA V Advantage IRMS are equipped with different apertures. Figure 7-11 (left) shows the aperture of the DELTA V Advantage IRMS, whereas Figure 7-11 (right) and Figure 7-12 depict the aperture of the DELTA V Plus IRMS. In Figure 7-12, the analyzer turbomolecular pump has been removed before.

**Figure 7-11.** Dismantled Apertures

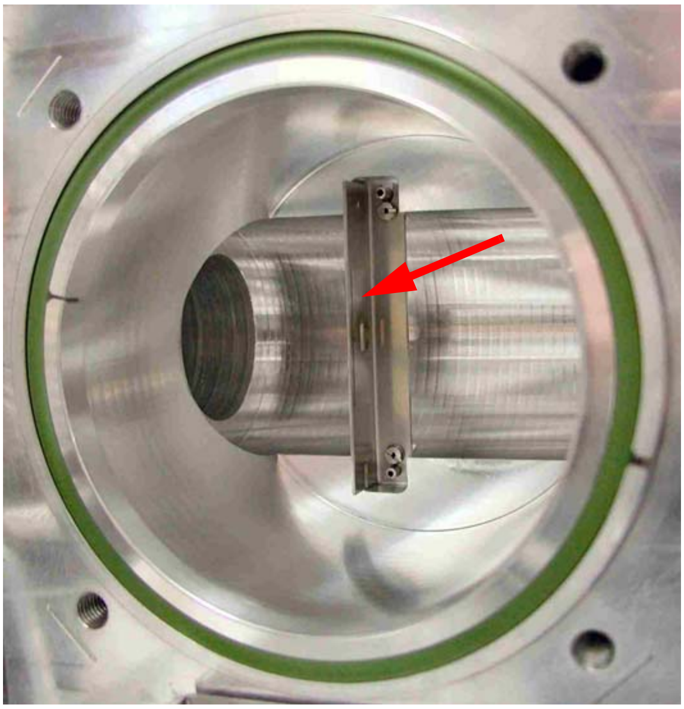


**Figure 7-12.** Aperture of DELTA V Plus - Implemented

# Pumps

The DELTA V Plus IRMS is equipped either with or without a differential pumping system. The high vacuum status of the pumping system is monitored by a Penning gauge attached to the left side of the ion source housing. The fore vacuum is controlled by a Pirani gauge located at the Dual Inlet system.

The DELTA V Plus IRMS is equipped with up to three **analyzer pumps** manufactured by Pfeiffer:

- a **fore** pump (rotary vane pump DUO 2.5)
- two **turbomolecular** pumps (a required **main** pump TMH 261 and an optional **differential** pump TMH 071 P)

Furthermore, two **Dual Inlet system pumps** manufactured by Pfeiffer are in use:

- Dual Inlet system **fore** pump (rotary vane pump DUO 2.5)
- Dual Inlet system **turbomolecular** pump (TMH 071 P)

All pumps in use are summarized in Table 7-3.

**Table 7-3.** Pumps Used in DELTA V Plus IRMS

| Function | Pump Name of Pfeiffer |
|---|---|
| analyzer fore pump | DUO 2.5 |
| analyzer turbomolecular pump (required) main pump | TMH 261 |
| analyzer turbomolecular pump (optional) differential pump | TMH 071 P |
| | |
| Dual Inlet system fore pump | DUO 2.5 |
| Dual Inlet system turbomolecular pump | TMH 071 P |

All pumps are comfortably accessible from aside: **turbomolecular** pumps are accessible from the left side and **fore** pumps from the right.

However, when this is not possible due to narrowness, screw in the adjusting screws and then simply pull the IRMS forward. Now, you can exchange pump oil or perform other maintenance operations. Afterwards, simply push the IRMS backwards again. Thus, these operations are space-saving.

**Note** Pump oil of turbomolecular pumps and fore pumps should both be **exchanged** once a year. Because the DELTA V Plus IRMS must be vented before, we recommend performing this exchange as part of an overall check of all pumps. ▲

## Fore Pumps

The analyzer fore pump is described at "Analyzer Fore Pump" on page 2-33, whereas information about the Dual Inlet system fore pump is given in "Dual Inlet System Fore Pump" on page 2-34.

For all maintenance operations at the fore pumps, refer to the manufacturer's manual and to www.pfeiffer-vacuum.com.

### Oil Level Check

**Check** the oil levels of both fore pumps quarterly by looking at their inspection glasses.

**Note** The oil levels must not drop below a certain level! On the other hand, do not fill in more oil than is indicated by the calibration mark! ▲

If they are too low, fill in a sufficient but not too big amount of new oil.

### Oil Exchange

**Note** To vent the instrument as seldom as possible, **empty** and **exchange** the oil of both fore pumps and turbomolecular pumps simultaneously within one session once a year. ▲

**Note Filling in** new oil (in case of too low oil levels) is even possible during the pumps are running. It is not necessary to vent the fore pumps. Before you **empty** and **exchange** old oil however, the fore pumps must be vented! ▲

**Warning** **Health Hazard.** Hazardous compounds introduced into the system may be dissolved in the pumps oil. Accordingly, use only locally-approved containers and procedures for waste oil disposal! Note that contaminated pumps must be emptied and decontaminated before they are sent back to Thermo Fisher Scientific for repair or exchange! ▲

### Heat Removal

The fore pumps produce heat, which must be dissipated. The entire area is therefore lined extensively by thermal insulation mats to prevent other parts of the instrument from being heated as well. Furthermore, warm ascending air can leave the instrument via a chimney. See Figure 7-13.

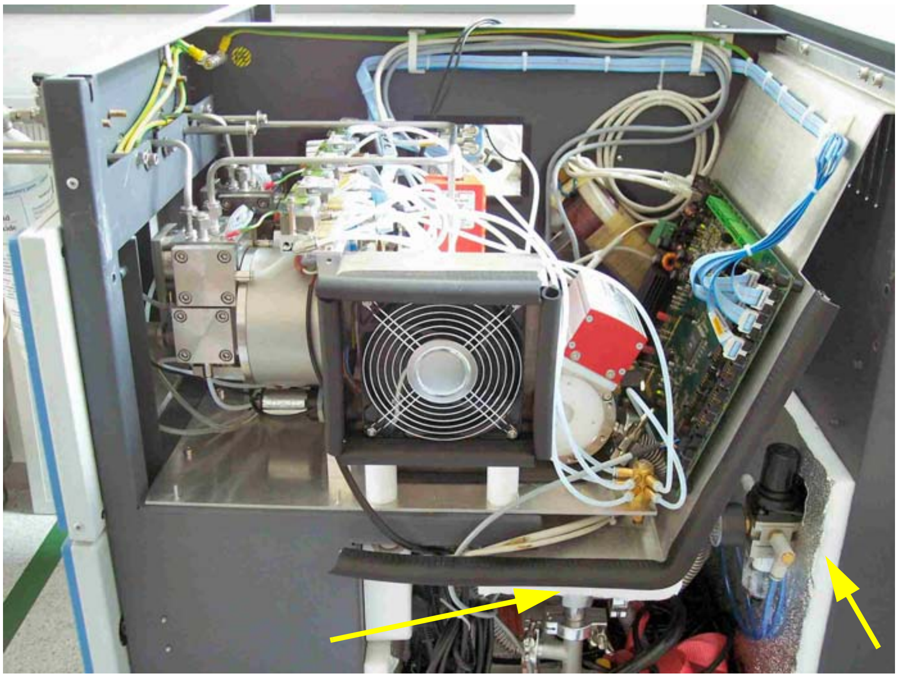


**Figure 7-13.** Thermal Insulation Mats and Chimney

### Exhaust Gas Removal

The exhaust gases of both fore pumps contain pump oil vapor and must be removed. The exhaust tube leaves the IRMS underneath its back doors and is led either outwards or to the exhaust gas equipment.

## Turbomolecular Pumps

The **analyzer** turbomolecular pumps are described at "Analyzer Turbomolecular Pump (Required)" on page 2-43 and "Analyzer Turbomolecular Pump (Optional)" on page 2-43.

Detailed information about the **Dual Inlet system** turbomolecular pump is given in "Dual Inlet System Turbomolecular Pump" on page 2-31. For all maintenance operations at the turbomolecular pumps, refer to the manufacturer's manual and to www.pfeiffer-vacuum.com.

### Working Principle

The turbomolecular pumps work completely mechanically by rotor disks imparting momentum to the gas molecules. Baffles or cryogenic traps are not necessary for retention of pump fluid vapors.

The vacuum system is roughed by rotary pumps through the turbomolecular pumps. Furthermore, the turbomolecular pumps are started at atmospheric pressure. Hence, this arrangement also obviates the need for a high vacuum pump valve. Thus, the rated capacity of pump speed is available without restriction at the connecting flange of the source housing.

Because the molecular pump principle works in the molecular flow region only, the turbomolecular pumps require a fore pump. This pump is roughing the vacuum system through the turbomolecular pump down to the upper limit of the turbomolecular pump operating range.

The turbomolecular pumps installed in the instrument are air-cooled. In case of a mains failure there is a delayed venting provided by a venting valve. When starting the turbomolecular pump, the venting valve is closed immediately. After stopping (by mains failure or switch-off), delayed venting is performed. The vent valve remains open until the next start cycle of the electronic unit. In absence of current, the valve is open.

Each turbomolecular pump has an integrated control electronics and power supply. The pumps are started with the switches on the control panel. In addition to the LEDs on the control panel, several LEDs for error indication are directly attached to the turbomolecular pumps. For type of error, details regarding function and design of the turbomolecular pumps, refer to the Operating Manual of the pump manufacturer.

## LEDs at Bottom Side

At the bottom side of each turbomolecular pump, two LEDs are located, which elaborately reveal the working status. For details, refer to the manufacturer’s manual. Both LEDs can easily be monitored by holding a white piece of paper slantingly beneath the pump. See Figure 7-14.


**Figure 7-14.** LEDs at Bottom Side of Turbomolecular Pump

## Oil Exchange

For a description of the oil exchange of an **analyzer** turbomolecular pump, refer to the manufacturer's manual. Even the **Dual Inlet system** turbomolecular pump has been mounted in a way facilitating direct access to it, for example for maintenance operations, oil level control, oil exchange or other maintenance operations. For details, refer to the manufacturer's manual.

## Fixing the Analyzer Turbomolecular Pumps

Due to the elastic Viton™ O-ring seal, it is sufficient to fix the metallic claws of both analyzer turbomolecular pumps slightly. Screwing on the metallic claws too tight might do damage to the aluminum-made analyzer block.

## Magnetic Screen and Heat Sinks

As it might be damaged by the magnetic stray field, the required analyzer turbomolecular pump (that is, the main pump) needs a magnetic screen.

To drastically increase lifetime during operation at elevated temperatures, both analyzer turbomolecular pumps are protected by heat sinks mounted upon them. See Figure 7-15.


**Figure 7-15.** Heat Sinks Mounted on Analyzer Turbomolecular Pumps

# Vacuum System

The main reasons of troubles with the vacuum system are

- leaks and
- contaminations.

**Caution Be careful when servicing the vacuum system!** Abrupt opening to atmospheric pressure might damage filaments, multipliers, heaters, slits and other sensitive parts! ▲

## Leaks

Leaks may be caused:

- if flange connections and/or sealings are improperly treated during service operations.
- accidentally during cooling down periods after baking.
- if heavily treated sealing components are worn out.

As leak detection is rather time-consuming, make sure that flange connections are carefully and properly assembled during service. Additionally, watch the pressure during cooling down after baking. If necessary, retighten the flanges.

### Detection of Leaks

Two different methods are recommended for leak detection:

- Mass spectrometric leak detection can be applied if the leak permits IRMS operation (p ~$6 \times 10^{-4}$ mbar). Use a container with a suitable test gas, for example argon. Connect the reducing valve to a PVC tube and the open end of the tube to a fine capillary, for example glass or metal tubing. Using a sensitive cup, set the IRMS to the Ar peak, that is to *m/z* 40, and blow a fine argon beam onto those parts, where leaks are suspected.
- For leak detection in the forevacuum section, or if the pressure is too high for IRMS operation: use a small washing bottle with ethanol and spray a fine ethanol beam onto those connections where a leak is suspected. When hitting the leak, the pressure, after a short time of delay, will first decrease and afterwards increase rapidly. Use the Penning gauge for pressure reading.

**Warning** **Explosion Hazard.** Ethanol vapors are explosive. Do not smoke or handle with open fire! During leak detection ventilate the laboratory carefully. ▲

## Contaminations

Contaminations may be caused by:

- water vapor stemming from the sample preparation devices.
- using improper elastomer gaskets, especially at elevated temperatures. We recommend ordering spare gaskets from Thermo Scientific only.
- introducing solvents, which weren't removed carefully after cleaning.

The final pressure should be checked daily. About 24 hours after start, without sample inflow, the pressure should be in the $10^{-8}$ mbar range.

**Caution** Never use silicon greases or silicon oils! Silicon layers lead to surface charges and are difficult to eliminate. ▲

## Flanges with Viton Gaskets

When changing the Viton™ gasket, do not use other materials. The Viton used must be of good and preheated quality. For this reason, we recommend to order spare gaskets from Thermo Scientific only. Before using the gasket, ensure that sealing surfaces and gasket are clean and that the gasket surfaces are not injured. For cleaning, wipe the gasket with clean paper.

**Note** Do not use vacuum grease, and do not clean Viton™ gaskets with solvents. Viton must not be operated at temperatures above 150 °C. ▲

## Cleaning Vacuum Components

For general remarks, see "Basic Rules for Cleaning" on page 7-2. Cleaning the parts of the ion source is described in "Cleaning Ion Source Parts" on page 7-12.

For cleaning parts of the fore vacuum region, many different methods are known. We recommend using cyclohexane as solvent. The best cleaning is obtained by using a hot ultrasonic bath. Observe the following recommendations:

- Use pure solvents only.

- When cleaning with solvents, use a hood.
- Pay attention to your country's safety regulations.
- After cleaning, dry the parts carefully.
- Do not touch the cleaned parts with your fingers. Use lint-free gloves instead.

# Pressure Reducer for Compressed Air

The pressure reducer for compressed air is described in detail at "Pressure Reducer for Compressed Air" on page 2-32. The compressed air may contain much oil. It will be collected within a bin, which can be emptied via a blow-off valve. See **3** and **4** in Figure 2-29.

**Note** Check the oil level of the bin once a year. Exchange it if it contains oil. Drain the condensate and clean the filter if required. ▲

## Removing Tubings from Tubing Connections

❖ **To remove tubings from tubing connections**

1. Switch off compressed air.

2. Push the grey plastic ring towards the brass part of the compressed air distributor using an open-ended spanner. (See for example, **4** in Figure 4-7 on page 4-10 and Figure 2-29 on page 2-32). The manufacturer SMC provides an alternative tool for doing this. At the same time, pull the tubing out.

## Inserting Tubings into Tubing Connections

❖ **To insert tubings into tubing connections**

1. Switch off compressed air.

2. Stick the tubings into the tubing connections until limit stop. (See for example, **4** in Figure 4-7 on page 4-10 and Figure 2-29 on page 2-32.)

3. Redraw the tubings a little bit.

# Dual Inlet System

The Dual Inlet system and its parts are described in depth in "Dual Inlet System" on page 4-1.

## Autocool Refill Device

Hardly any routine maintenance is required for Autocool Refill device. However, the components of the refill device should be regularly checked for damage or possible freeze-up. If it is necessary to dry and clean items or to replace them, make sure that they are thoroughly degreased and dried, as moisture or lubricants will freeze at cryogenic temperatures. Do not use thread-sealing compounds. Use PTFE tape, for example Teflon® or other approved oxygen-safe compounds instead.

Occasionally, the pressure should be increased up to the relief valve setting to ensure satisfactory functioning of this safety device.

❖ **To set the pressure control regulator**

1. Loosen the hexagon locking nut below adjusting screw.
2. Rotate the adjusting screw counter-clockwise to set to zero.
3. Close vent valve and liquid valve and open the pressure building valve.
4. Rotate the adjusting screw clockwise to increase vessel pressure until gas escapes through vent hole. Rotate the adjusting screw counter-clockwise again until the gas stops escaping through the vent hole.
5. The pressure is now set. Tighten the locking nut to prevent further rotation or tampering of the adjusting screw.

# Needle Valves

Up to three equivalent needle valves (stainless steel on/off valve SMOV-1 manufactured bey SGE; SGE Part No. 1236283) are used for peripherals control and are themselves controlled by Isodat 2.5. They are located at the aluminum-made needle valve heating block close to the ion source.

Nevertheless, they are easily accessible from outside via the Control Panel as up to three adjusting knobs (**11**, **12** and **13** in Figure 2-5) open and close them. Thus, it is not necessary to manually tamper with the instrument's inside.

By turning the adjusting knobs, the needle valves are switched on or off. Thereby, gas transfer (that is transfer of the mixture of helium and sample gas) from a peripheral to the ion source is enabled or disabled.

Any arbitrary peripheral can be connected to any of the three needle valves (for example, GasBench II, LC IsoLink, ConFlo III or GC-Combustion Interface). When a peripheral is not used, keep the corresponding needle valve closed. Open it to use the peripheral for measurements.

**Note** Even though up to three peripherals can simultaneously be connected, only one should be active and controlled by its adjusting knob at a time. Furthermore, do not apply too high gas pressures to the ion source! ▲

For maintaining the stainless steel on/off valve SMOV-1, refer to SGE's documentation at www.sge.com.

## Opening and Closing the Needle Valves

**Note** Open and close needle valves with caution: turn adjusting knobs sensitively! To open a needle valve, turn the corresponding adjusting knob only one or maximally two revolutions counterclockwise! ▲

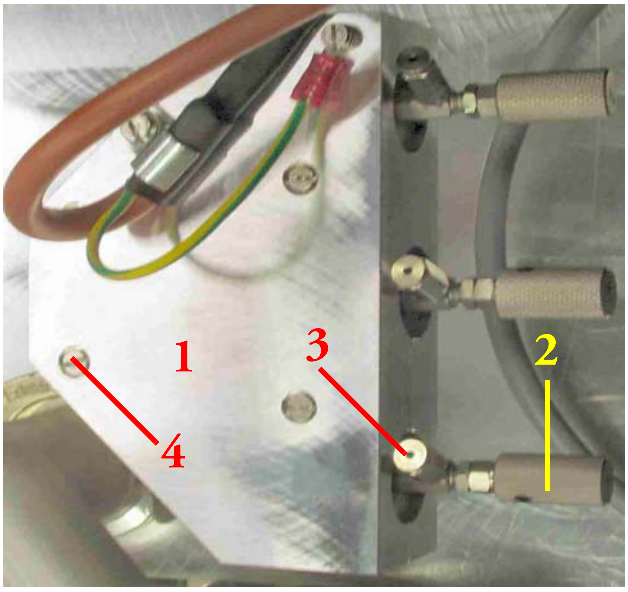
**Caution** If you turn an adjusting knob on too far, leaks may result. In extreme cases, the needle valve might be totally unscrewed from the Swagelok connector, which leads to venting of the analyzer! ▲

Turning the adjusting knob one or maximally two revolutions clockwise will close the corresponding needle valve again.

## Needle Valve Heating Block

The needle valve heating block, Figure 7-16, is the same for Dual Inlet devices and Continuous Flow devices. It contains a heating cartridge to uniformly heat the needle valves either during specific operational time intervals or during entire operation. This keeps them clean, particularly water-free. Temperature is about 60–80°C but below 100°C.

**Warning** **Hot Surface.** Danger of injury. Temperatures of about 75 °C or above may be reached at the metallic surface of valves that are heated out. Do not touch any surface of a valve you are heating out! ▲




Labeled Components: 1=needle valve heating block; 2=needle valve; 3=connector for fused silica capillary of peripheral; 4=knurled head screw

**Figure 7-16.** Heating Block for Needle Valves

Figure 7-17 shows the heating block for needle valves together with the movable shafts **1**, which allow compensating differences in length and are direct connections to the three adjusting knobs at the Control Panel.

The cylindrical connectors **2** for the needle valves are fixable by two screws each.

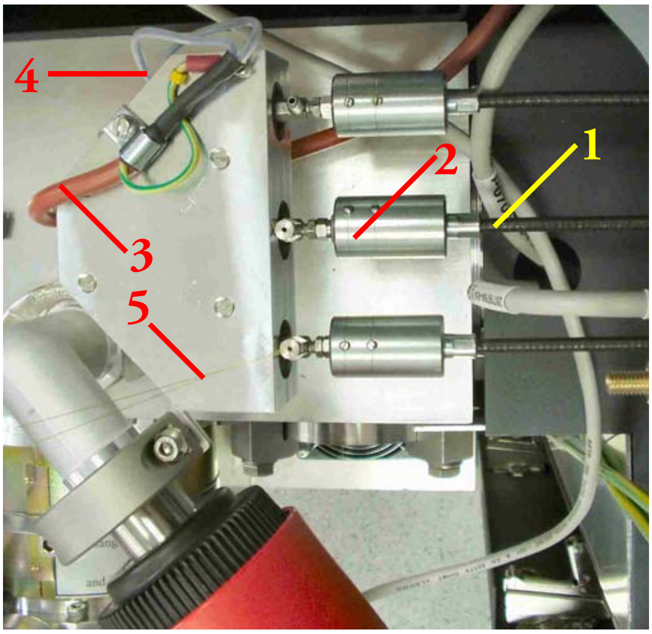
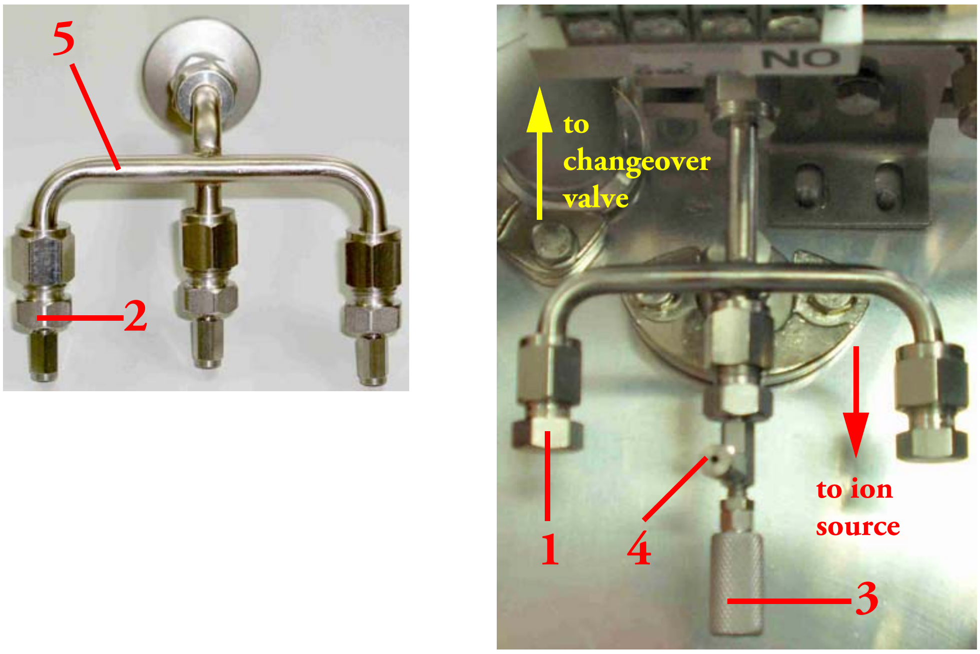



**Figure 7-17.** Heating Block for Needle Valves - with Movable Shaft

**3** is the cable between heating cartridge and activated sockets at Microvolume cabinet. **4** shows the heating cartridge inside the heating block. **5** depicts fused silica capillaries of a connected peripheral.

### Removing Needle Valve Heating Block

If you need access to the needle valves for maintenance operations, you can remove the heating block **1** in Figure 7-16. Therefore, loosen the knurled head screws **4**.




Labeled Components: 1=locking cap; 2=union; 3=valve knob[a]; 4=nut; 5=manifold

**Figure 7-18.** Inlet Distributor

[a] is connected to its adjusting knob of Control Panel, 11-13 in Figure 2-5.

After removing the needle valve heating block, only the inlet distributor, Figure 7-18, remains. It establishes the connection to ion source and Changeover Valve.

## Leaks at the Needle Valves

Needle valves might become leaky by and by. For maintaining the stainless steel on/off valve SMOV-1, refer to SGE's documentation at www.sge.com.

## Connecting a New Peripheral

Depending on your measurement type, connecting another peripheral might become necessary.

❖ **To connect a new peripheral**

1. Switch off the instrument.
2. Vent the instrument.
3. Carefully remove the needle valve heating block. See "Removing Needle Valve Heating Block" on page 7-28.

**Warning** **Hot Surface.** Danger of injury. The needle valve heating block may be hot! ▲

4. Remove the locking cap **1** shown in Figure 7-18 on page 7-29.

5. Screw the union to the manifold (shown as **2** and **5** in Figure 7-18).

6. Screw on the new needle valve as shown as **3** in Figure 7-18.

7. Remove the nut **4** shown in Figure 7-18.

**Note** To avoid unscrewing of the entire valve, hold a screw wrench against it! ▲

8. Insert the ferrule with the two capillaries coming from the peripheral into the nut **4** in Figure 7-18.

9. Carefully stick the capillaries through until they touch the ground at the valve.

10. Begin to tighten the nut until the capillaries are no longer movable within the ferrule.

11. Open the ferrule a little and pull back the capillaries a bit.

**Note** When pulling back the capillaries a bit, mark this position by a small piece of adhesive tape. ▲

12. Carefully tighten the nut again.

13. Connect the new peripheral to a SUB D connector (**4** in Figure 2-47) and to a compressed air connector (**2** in Figure 2-47) at the rear side of the IRMS.

14. Finally, switch on the IRMS again.

## Heating out a Needle Valve

After you have connected the new peripheral, heat out the corresponding needle valve.

❖ **To heat the needle valve**

1. Mount the needle valve heating block again.

2. Switch it on.

Additionally, see “Needle Valve Heating Block” on page 7-27.

# Stainless Steel Capillaries

All stainless steel capillaries have a central brass contact for the current entry brass contact and are surrounded by an insulating silicone tube. They are used to connect:

- Changeover Valve to Dual Inlet system
  See **1** and **6** in Figure 7-22.
- Changeover Valve to Kiel IV Carbonate Device (if available)
- Changeover Valve to Microvolume (if available)
  See **1** and **2** in Figure 7-22.

**Caution** Take care that hot stainless steel capillaries never touch plastics parts during and after they are heated out! ▲

## Easy Access via Removable Blind

The capillaries have been arranged in a way that allows easily accessing them from outside after removing the blind on the **left** side. It is shown in Figure 7-19 and can easily be removed even under running operations. Taking it away makes the removal of peripherals arranged upon the cover plate and of the cover plate itself unnecessary.

Thereby, removing the blind allows quick sideways access to for example needle valves (when connecting a new peripheral by screwing on a new needle valve, or for maintaining them) and to the Penning gauge.

**Note** We explicitly recommend removing the blind for easy access inwards. Thus, for normal maintenance operations, the cover plate does not need to be removed, but only for more complex ones. ▲

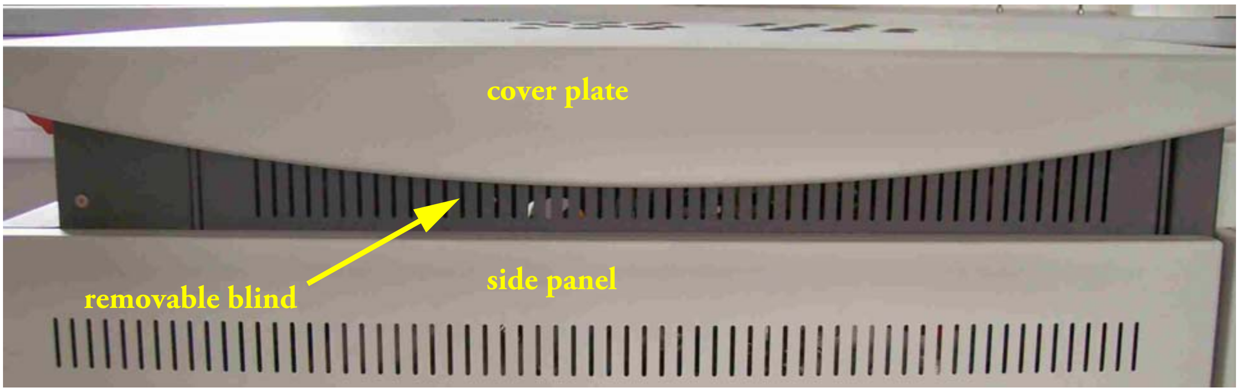



**Figure 7-19.** Removable Blind

## Removing the Blind

❖ **To remove the blind**

1. Remove the left side panel (by grasping it at its top and at its bottom and then lifting it up and out).

2. Unscrew the two screws located on the left and right side.

3. Grasp behind the blind and pull it outwards.

4. If you need more space, pull away the electronics cylinder of the Penning gauge, **1** in Figure 7-29 as is described there.

## Capillary Throughput

Mostly, throughput of fused silica capillaries, but also of stainless steel capillaries is concerned here. Two mechanisms have been realized to lead both types of capillaries from the DELTA V Plus IRMS towards the peripherals positioned outside of it. This allows arranging and connecting your peripherals rather flexibly and furthermore saves capillary length:

- capillary throughput via blinds with slits
- capillary throughput via guide tube

### Capillary Throughput via Blinds with Slits

On the left side, an easily removable blind with slits at both ends is located (see “Easy Access via Removable Blind” on page 7-31). At the right side, another blind with slits at both ends is arranged as well. However, it cannot be removed as easy as the blind on the left side.

The slits are used as throughput for capillaries according to Figure 7-20. Thereby, the capillaries may stay connected even when the blind is removed.

Depending on the peripheral to be connected, different slits are used (1. right side vs. left side and 2. rear slits vs. front slits):

- Generally, the **rear** slits are used in case of all peripherals except Kiel IV Carbonate Device, that is they are more often than the front slits.

- Furthermore, the slits on the **left** side are in use more often than those on the right side. This keeps the distance between capillaries, which are restricted in length, and analyzer smallest in the usual case of a peripheral positioned left to the IRMS.

- A Kiel IV Carbonate Device as peripheral will be placed besides the IRMS. Its stainless steel capillary will be led mostly through the front slits.

**Note** Any other peripheral however will be placed on top of the IRMS, that is upon its cover plate. The capillaries will then be led out preferably via the **left rear** slits. This is also valid in case of several peripherals, which are not placed on top but left to it. ▲

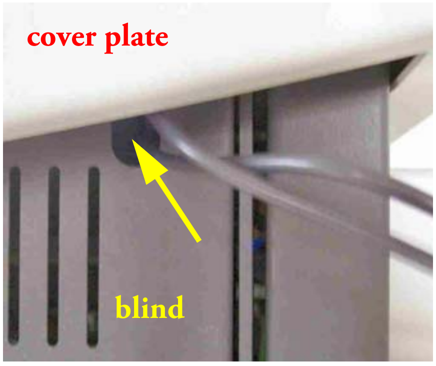



**Figure 7-20.** Capillary Throughput via Blinds with Slits

### Capillary Throughput via Guide Tube

Top right at the rear side, a hollow guide tube made of plastic is arranged between the two outer walls of the IRMS as shown in Figure 7-21. Within the guide tube, capillaries can be led out towards the external peripherals. The guide tube inhibits contact between capillaries and electronics.

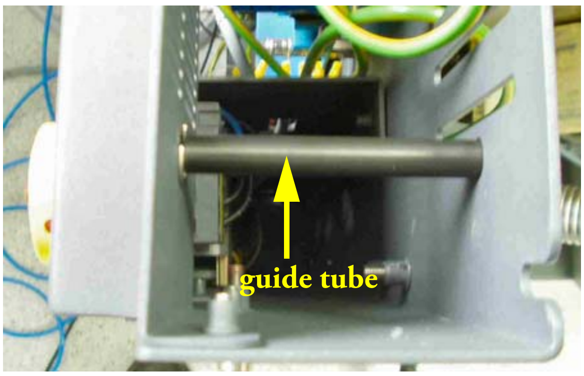
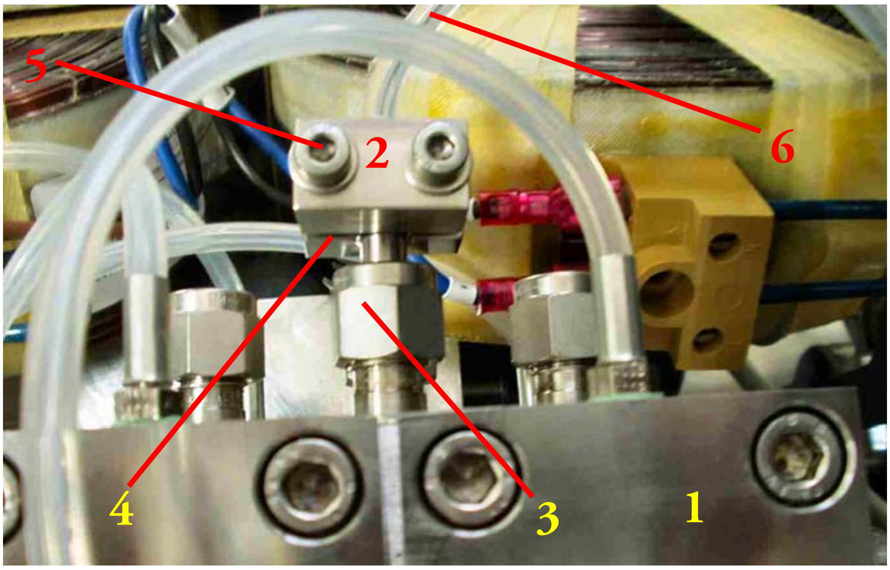



**Figure 7-21.** Capillary Throughput via Guide Tube

## Crimping Capillaries

This section is of importance only, if a Dual Inlet system is available. The defined crimping position allows precisely adjusting the diameter of stainless steel capillaries. See **4** and **5** in Figure 7-22. To change the diameter, fasten or unfasten the crimping screws, where the capillaries enter Changeover Valve.

**Note** If a Dual Inlet system is available, the flow through both capillaries should be the same for measurements.
To achieve this, first switch between both bellows and adjust the same pressure in both of them. Then fasten or unfasten the crimping screws until the flow in both capillaries is identical. Usually, this has already been performed by your Thermo Fisher Scientific field service engineer. ▲

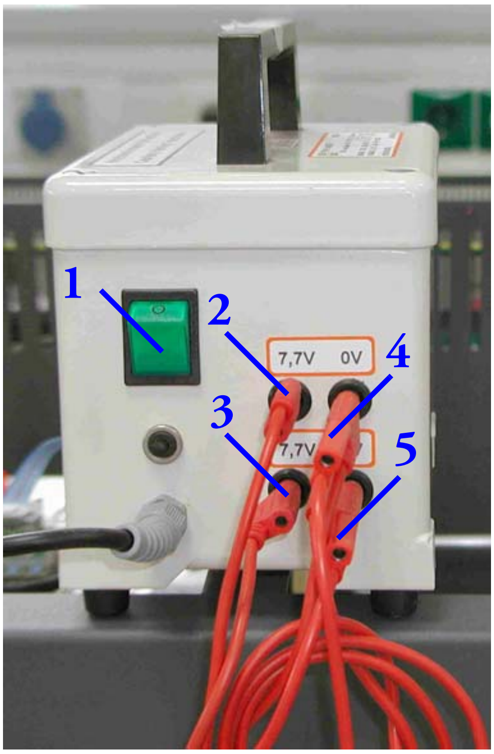



Labeled Components: 1=Changeover Valve; 2=crimp device; 3=Swagelok fitting 1/4" to Changeover Valve; 4=crimping position; 5=crimping screws; 6=stainless steel capillary from bellow or peripheral

**Figure 7-22.** Connecting a Microvolume to Changeover Valve

## Heating out Capillaries

We recommend heating out stainless steel capillaries, when they are contaminated (for example, by impurities or water). They conduct electric current quite well. As power supply unit, the capillary heating transformer, Figure 7-23, provides the necessary energy.




Labeled Components: 1=main switch (on/off); 2=input of 7.7 V (12 A); 3=input of 7.7 V (12 A); 4=input of 0 V; 5=input of 0 V

**Figure 7-23.** Capillary Heating Transformer

**Note** The heating process can be regulated via Isodat 2.5. ISL scripts can be used to create time programs for it. ▲

### ❖ To heat out a stainless steel capillary

1. Before heating the capillary itself, the surrounding of the capillary must be heated to approximately 80 °C for about 30–60 minutes, that is, the valves of the inlet system (incl. the valves of a Multiport, if in use), the Changeover Valve, the ion source and the analyzer housing.

   During the heating period, all valves must be open. Swagelok connectors should be heated separately for a short while using a flame or a heat gun.

2. Enable gas transfer through the capillaries to be heated out, that is let $CO_2$ flow through them during the entire process.

   Thereby, impurities within the capillaries, for example water, will be continuously transported to the waste line together with the gas and removed by the waste line pump (the Dual Inlet system must be closed).

3. Connect both 0 V inputs of the capillary heating transformer (for example, **4** in Figure 7-23) to the banana jack. See **1** in Figure 7-24.

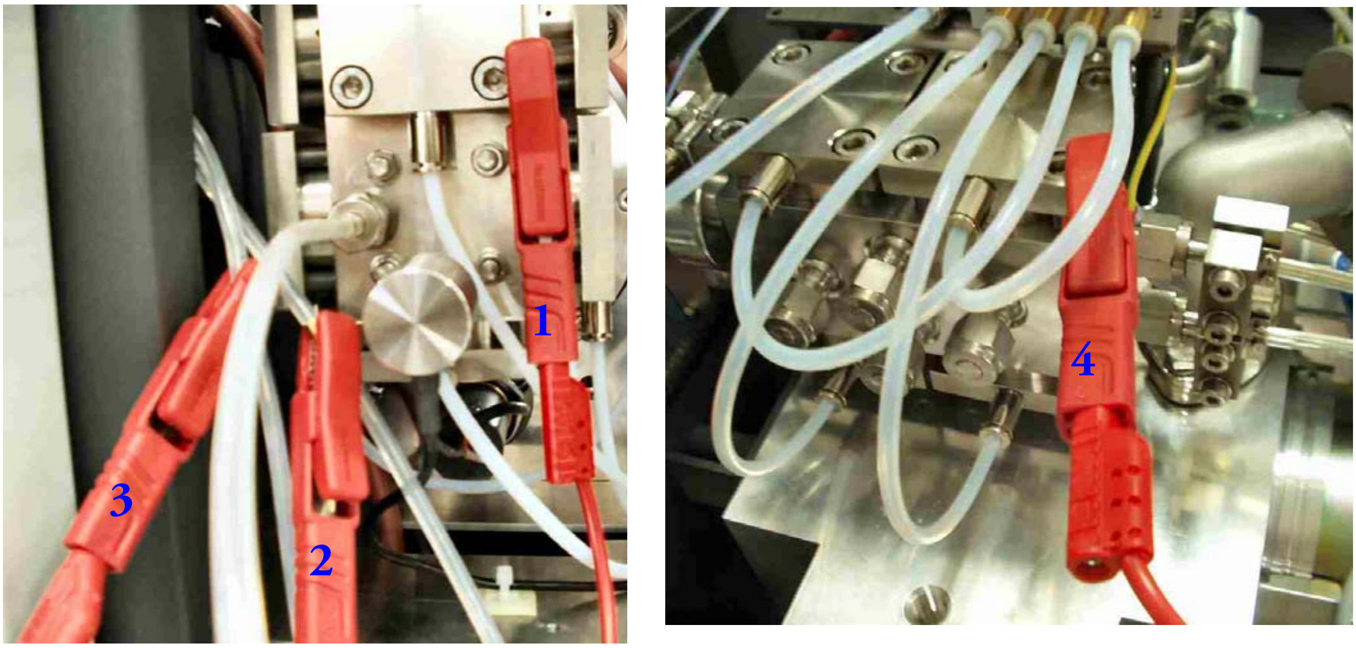



**Figure 7-24.** Fixing Alligator Crimps to Capillaries

4. Connect one 7.7 V input of capillary heating transformer (positive pole, for example **2** in Figure 7-23) to the brass contact in center of one capillary (for example, **2** in Figure 7-24).

5. Connect the other 7.7 V input of capillary heating transformer (positive pole, for example **3** in Figure 7-23) to the brass contact in center of the other capillary (for example, **3** in Figure 7-24).

**Note** After the capillary has been wired make sure, the capillary (with or without insulation) has no contact to any plastic surface of tubes, housings, cables etc. to avoid melting or smoldering caused by a hot capillary. ▲

6. Turn on the capillary heating transformer by pressing its main switch, **1** in Figure 7-23. An electric current will flow from the brass contact in center of the capillary to both ends and heat it out.

7. The heating phase should be controlled by monitoring signal intensity of $H_2O$ (*m/z* 18, measured on the channel for *m/z* 45).

8. Heat out the capillaries for half an hour while $CO_2$ continuously passes through them.

9. It is recommended to heat also the crimped part of the capillary separately for a few minutes using a flame or a heat gun.

**Note** Before removing the upper crimp block mark the parts of the crimping device to avoid mismatch when reassembling. ▲

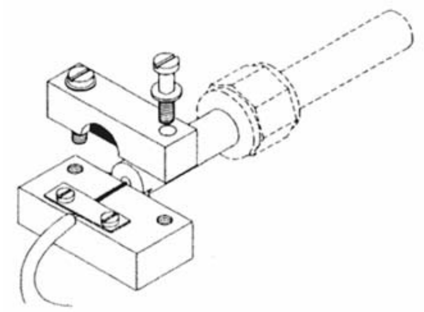


**Figure 7-25.** Crimping Device at the End of a Capillary

10. When fitting the crimp block again, make sure the capillary is exactly placed in the grove of the base and the die of the upper block in the crimp of the capillary. After heating the capillary, the flow resistance of the crimp has to be checked and reset to 1 V per 10 mbar if required. See "Replacing Capillaries" on page 7-37.

    During the start phase of heating, signal intensity increases but decreases and stabilizes later. The best results of decontaminating capillaries are achieved by heating for approximately 6 to 8 hours. With stabilized signal intensity lower than the first signal, a successful decontamination can be assumed. The result can be checked by a zero-measurement, that is measuring the same gas on sample and standard side.

## Replacing Capillaries

Replacement of an inlet capillary may become necessary in case of contamination or mechanical damage. After replacement, the flow rate of the new capillary has to be set by crimping. The crimping device consists of two metal blocks. The base is attached to the end piece of the new capillary, which has to be fitted to the Changeover Valve. The second block, to be bolted on top of the base block, holds a metal pin in a spacing, which will squeeze the capillary when bolting the two blocks together.

❖ **To replace a capillary**

1. Make sure that all valves are closed before venting the surrounding area of the capillary, which is to be exchanged.

2. Vent the parts of the inlet system and the Changeover Valve, which are connected by the capillary.

3. Loosen the Swagelok™ fittings holding both end pieces of the capillary to be exchanged. New capillaries are delivered with close

ends. Use a diamond file to cut a capillary end at opposite sides before breaking off the tip. Then smoothen the end of the capillary.

4. Fasten the end pieces of the new capillary with the Swagelok connectors. The end piece with the crimp block has to be connected to the Changeover Valve. Fasten the upper crimp block loosely onto the base with the capillary.

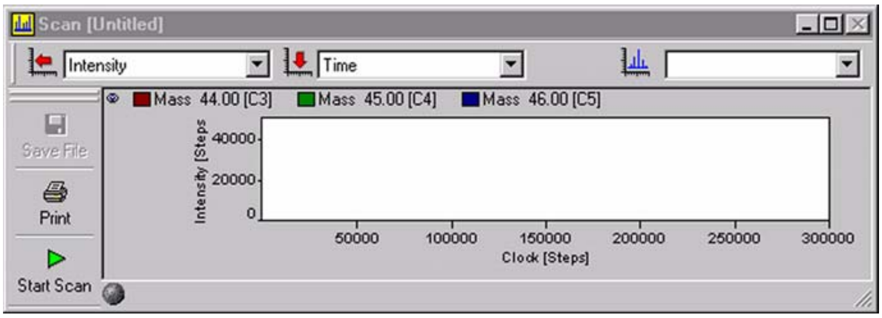
## Adjusting Capillaries

Each time a capillary has been replaced (see "Replacing Capillaries" on page 7-37), the flow through it must be adjusted. It is reasonable to do this from time to time even if no capillary has been replaced.

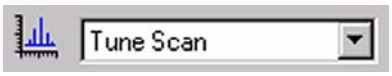
❖ **To adjust the capillaries**

1. Pump out the Dual Inlet system.
2. Let a proper amount of $CO_2$ flow into the Dual Inlet system, so that the storage reservoir pressure is about 20 mbar on both capillary sides.
3. Start Isodat 2.5's Instrument Control.


4. Activate the "Scan" window by a click on its frame.




5. Select **Tune Scan**.




6. Click the **Start Scan** button.


7. Tighten the screws of the crimp block carefully and squeeze the capillary until the output signal reaches 1 V per 10 mbar with $CO_2$ used for measurement.

8. After crimping the capillary must be heated. See "Heating out Capillaries" on page 7-34.

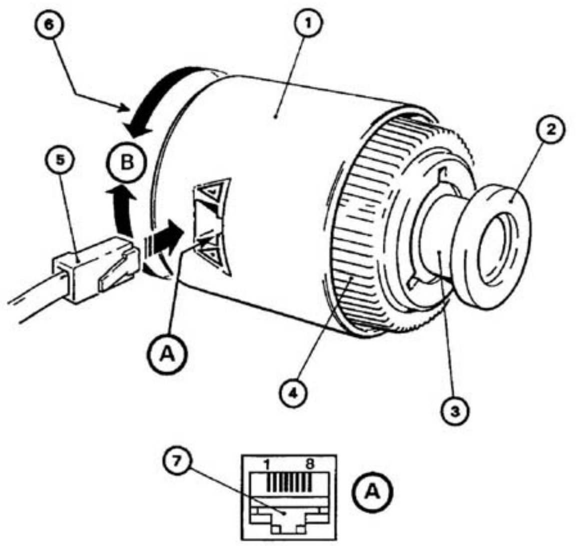
# Fused Silica Capillaries

Fused silica capillaries are used to connect Continuous Flow peripherals to the DELTA V Plus IRMS.

**Note** Fused silica capillaries are fragile although their stability has been increased by a polyimide coating! ▲

# Penning Gauge

The principle of the Penning gauge is described at “Penning Gauge” on page 2-44. Figure 7-26 depicts its parts schematically.




Labeled Components: 1=end cap; 2=vacuum flange; 3=body tube; 4=magnet housing; 5=cable connector plug; 6=set point potentiometer; 7=Penning gauge connector socket

**Figure 7-26.** Schematic of Penning Gauge

## Starting Problems of Penning Gauge

If the Penning gauge does not spark during an evacuation, it might have got dirty by and by. See “Cleaning the Penning Gauge” on page 7-42.

**Note** To put the Penning gauge into operation again rough and ready, simply pull away its electronics cylinder (without venting the system) and stick it on again as shown in Figure 7-27.
Alternatively, let slightly more gas flow into the ion source in order to start the Penning gauge again. ▲

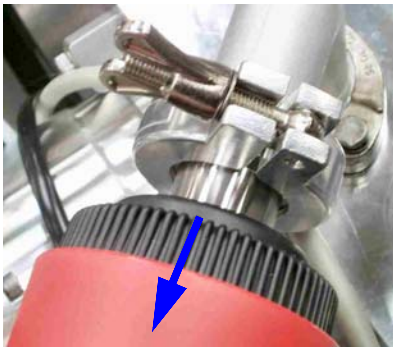
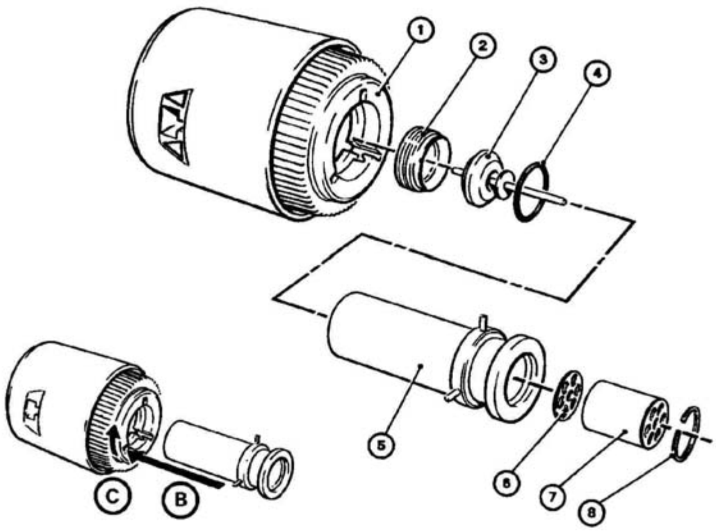


**Figure 7-27.** Pulling Away Electronics Cylinder of Penning Gauge

## Cleaning the Penning Gauge

If the provisional procedure described above at "Starting Problems of Penning Gauge" on page 7-41 does not put the Penning gauge into operation again, it must be cleaned. A contaminated Penning gauge may read out wrong pressures. Its design allows you to easily clean cathode tube, cathode plate and anode assembly that predominantly may get dirty. See **7**, **6**, **3** in Figure 7-28 or **3**, **4**, **7** in Figure 7-29. From time to time, proceed as follows:




Labeled Components: 1=magnet housing; 2=collar; 3=anode assembly; 4=O-ring seal; 5=body tube; 6=cathode plate; 7=cathode tube; 8=circlip

**Figure 7-28.** Parts of Penning Gauge - Schematic


Labeled Components: 1=electronics cylinder; 2=needle-nosed pliers; 3=cathode tube; 4=cathode plate; 5=circlip; 6=collar; 7=anode assembly; 8=O-ring seal; 9=body tube

**Figure 7-29.** Dismantled Parts of Penning Gauge

## Replacing the Penning Gauge

**Caution High Voltage.** Danger of injury. High voltages about 3 kV are generated inside the Penning gauge. Be careful! ▲

❖ **To replace the Penning gauge**

1. Disconnect the cable from the Penning gauge.
   See arrow at **1** in Figure 7-29!
2. Pull away the electronics cylinder of the Penning gauge.
   See also "Removing the Blind" on page 7-32.
3. Turn the body tube anti-clockwise (when viewed from the vacuum flange) to unlock the bayonet fitting.
4. Vent the system.
5. Remove the body tube from the vacuum system.

6. Clean the body tube as described at "Cleaning the Body Tube" on page 7-44.

### Cleaning the Body Tube

❖ **To clean the body tube**

1. After replacing the Penning gauge as shown at "Replacing the Penning Gauge" on page 7-43, unscrew the collar, **6** in Figure 7-29, using needle-nosed pliers **2**.
2. Insert the needle-nosed pliers into both eyelets of the circlip (**5** in Figure 7-28, see arrows) and pull it out.
3. Remove dirt on the metal parts (predominantly **7**, **6**, **3** in Figure 7-28 or **3**, **4**, **7** in Figure 7-29) using fine sandpaper or $Al_2O_3$.

**Note** After you exchanged the Penning gauge, adjust its set point ("Set Trip") anew as described in "Adjusting the Set Point" on page 7-45. ▲

## Control via Power Distribution Board

The Penning gauge is controlled via the Power Distribution board. See Figure 2-63 and **4** in Figure 2-63. Three measurement points (MP 13, MP 12 and MP 11) relevant for the Penning gauge are located on this board and shown as **1**, **2** and **3** in Figure 7-30:

- the value between ground (GND, that is MP 13) and MP 11 is the set point, for example $1 \times 10^{-5}$ mbar.

  When the pressure falls below the set point, vacuum is considered to be sufficient. The Penning gauge enables electronics and Isodat 2.5 then, so that ion source and high voltage can be switched on.

  However, when the actual pressure exceeds the set point, security mechanisms become active. The Penning gauge induces shutdown of ion source and high voltage.

  The set point must be adjusted according to Figure 2-41 and "Adjusting the Set Point" on page 7-45, for example $1 \times 10^{-5}$ mbar.

- the value between ground (GND, that is MP 13) and MP 12 is the actual voltage value in V read out by the Penning gauge. This output voltage represents a pressure (the actual vacuum status) and can be checked on the power distribution board. See Figure 7-30.

As various types of Penning gauges possess a voltage-pressure characteristic of their own, this measured voltage value is converted into its appropriate pressure value by Isodat 2.5 (for example, $1 \times 10^{-5}$ mbar may correspond to 6.8 V for a particular type of Penning gauge).

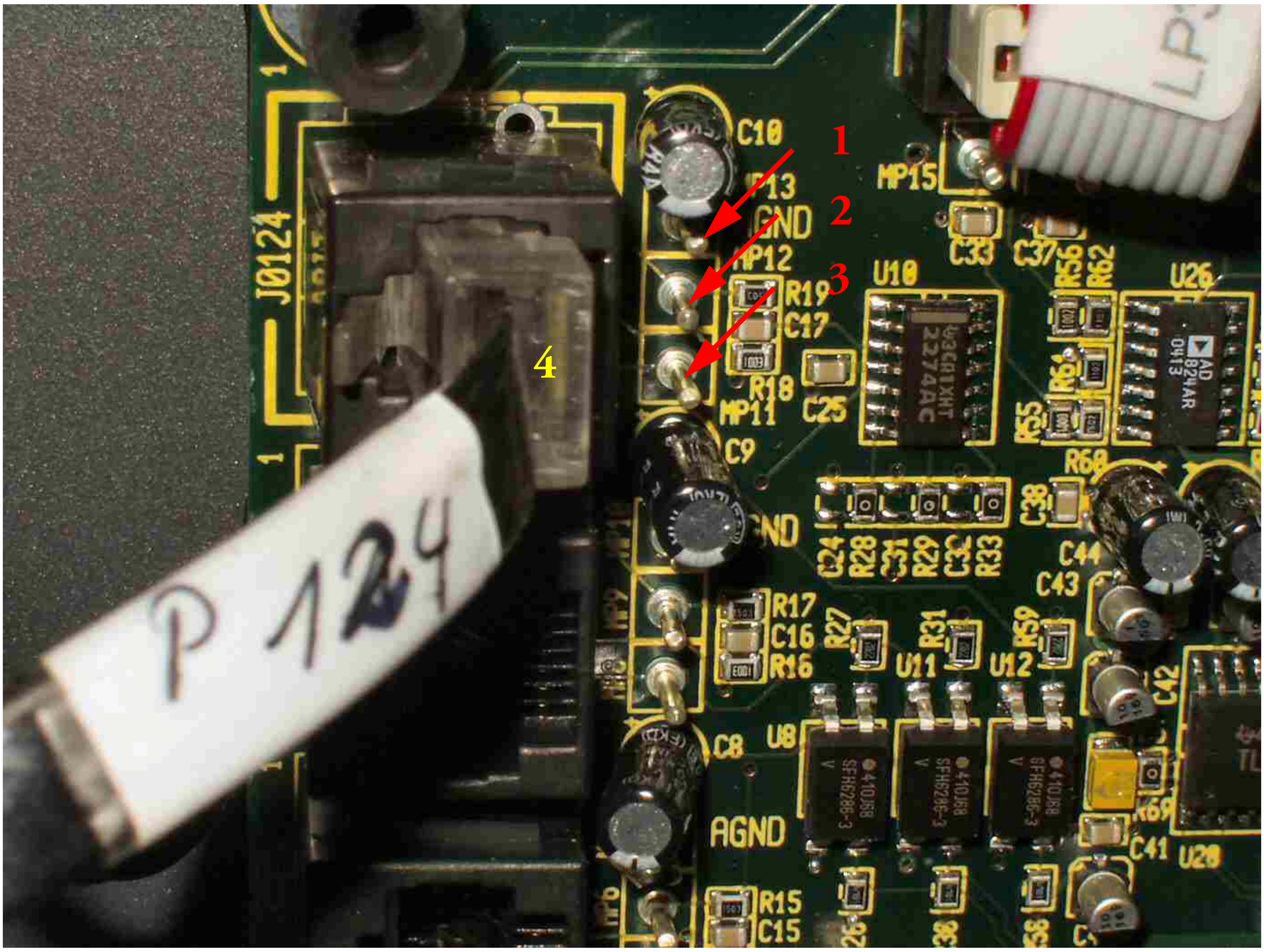



**Figure 7-30.** Measurement Points on Power Distribution Board

## Adjusting the Set Point

The set point of the Penning gauge (Set Trip) is the particular voltage at which the set point output signal goes on. Thermo Fisher Scientific has adjusted it once and it usually does not need to be adjusted again.

In the very rare case of defective electronics of the Penning gauge or if you bought a new electronics for it at Edwards, adjust its set point.

### ❖ To adjust the set point of the Penning gauge

1. With the aid of a fine screwdriver, turn the set point potentiometer (accessible through an access hole in the end-cap of the Penning gauge):

   Turn it clockwise to increase the voltage. Turn it anti-clockwise to decrease the voltage. See arrow in Figure 2-41.

2. Simultaneously measure the set point as the voltage between pins MP 11 and MP 13 on the power distribution board. See Figure 7-31.

3. Adjust the set point to 6.8 V.

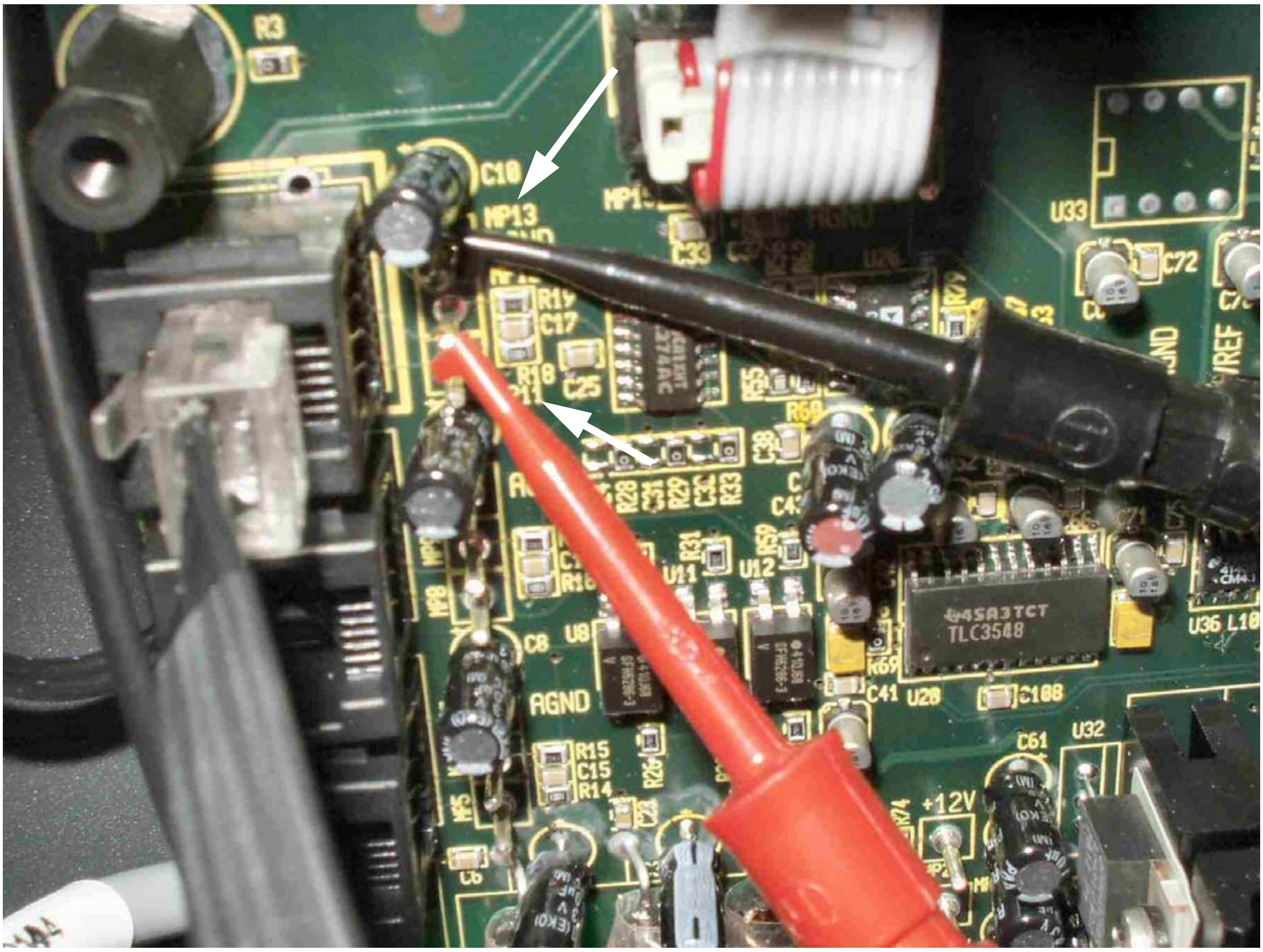



**Figure 7-31.** Voltage Measurement at Power Distribution Board

# Amplifier Area

## Single Amplifiers

Single amplifiers are described at "Single Amplifier" on page 5-16. The arrangement of several amplifiers is shown in "Arrangement of Several Amplifiers" on page 5-18.

Access to the amplifier area is needed extremely seldom. When capacitors or resistors at the amplifiers cause problems, they must eventually be exchanged. For example, fingerprints on the resistor may cause a rather noisy signal. Dismantle the resistor and carefully wipe it with pure ethanol. See Figure 5-14 and to **1** in Figure 5-13.

**Caution** Neither touch an amplifier nor its electronic parts, for example resistors, by hands! This electronic equipment is highly sensitive. ▲

**Caution** The blue potentiometer ("jumper") is used only by aThermo Fisher Scientific field service engineer to adjust the time constant. However, even as a service engineer, do not touch the white potentiometer as it regulates the offset! ▲

**Caution** An amplifier can be damaged when it is exchanged while power supply is switched on! ▲

## Three-Way Valve

The three-way valve, (Figure 7-32; see also "Three-Way Valve" on page 2-41) allows evacuating the amplifier area to the mbar range. Evacuation provides thermal insulation and leads to a stable signal due to elimination of cosmic radiation.

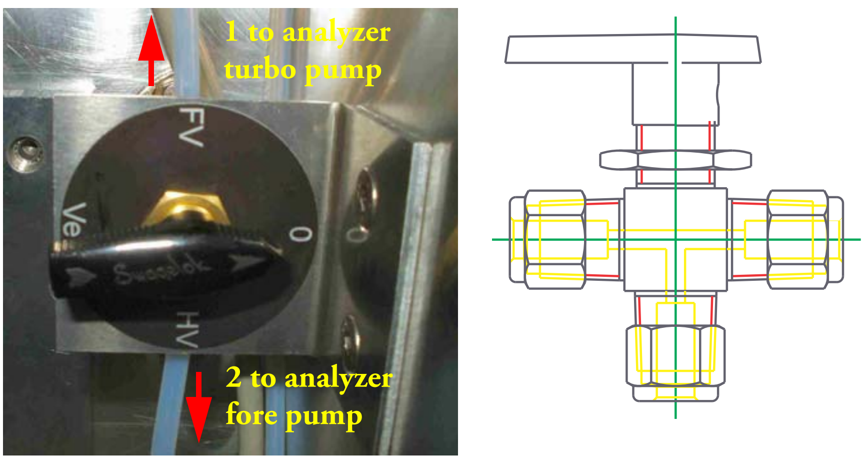



**Figure 7-32.** Switching Positions and Layout of Three-Way Valve

**Table 7-4.** Switching Positions of Three-Way Valve[a]

| Switching Position | Designation |
|---|---|
| 0 | Off |
| FV | Amplifier area will be connected to fore vacuum. |
| HV | Amplifier area will be connected to fore vacuum. |
| Vent | Amplifier area will be vented. |

[a] See Figure 7-32.

At its bottom, the three-way valve contains a punched sheet plate (diameter of hole: 0.15 mm). An O-ring seal is positioned on the sheet plate. The white Teflon™ tube leading to analyzer fore pump is arranged upon the O-ring seal. The Teflon tube is equipped with a supporting sheath on its inside. On the outside, the usual Swagelok™-cone is arranged. See Figure 7-32.

**Note** When mounting the Teflon tube on the right side, cram it in tightly before and during you screw it in! Thereby, the Teflon tube indeed seals up against the O-ring seal. ▲

## Evacuating the Amplifier Housing with an Evacuated Analyzer

The amplifier housing can be evacuated without affecting the analyzer vacuum.

**Caution** Turn off the ion source to prevent the filament from any damage. ▲

❖ **To evacuate the amplifier housing**

1. Switch the three-way valve to FV position.
2. Wait for 2 hours but not longer than 4 hours! This long time period is necessary because pumping the amplifier housing proceeds along a considerably narrow restriction.

**Note** If the analyzer turbomolecular pumps are shut down, turn them on again via their switches. If then the turbomolecular pumps are shut down again, probably a leak is present at the amplifier area or the seal fits improperly due to impurities. ▲

3. Switch the three-way valve to HV position.

### Evacuating the Amplifier Housing with a Vented Analyzer

When evacuating amplifier housing with **vented** analyzer, simply switch the three-way valve to HV position and evacuate the analyzer.

### Venting the Amplifier Housing

**Note** The amplifier area will not be vented automatically when the IRMS is vented! ▲

To vent even the amplifier area, turn the three-way valve to Vent position.

## Accessing the Amplifier Area

**Caution** To avoid damaging of the aluminum-made parts, never use any mechanical tool to force opening of flanges! Instead, after first venting correctly and then loosening the screws, any flange can be easily removed manually. ▲

The lid cannot be removed before. After venting however, it can easily be removed by loosening the screws.

If you sometimes need access to the amplifier area for maintenance operations, vent the amplifiers before as described above by turning the switch to Vent position. See "Venting the Amplifier Housing" on page 7-49.

# Differences between DELTA V Plus IRMS and DELTA V Advantage IRMS

Table 7-5 summarizes differences between the DELTA V Plus IRMS and the DELTA V Advantage IRMS.

**Table 7-5.** Differences between DELTA V Plus and DELTA V Advantage

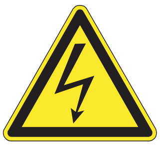
| Feature | DELTA V Advantage | DELTA V Plus |
|---|---|---|
| Focus Quad and Focus Quad power supply board | No Focus Quad exists.<br>No Focus Quad power supply board is needed. | Focus Quad exists.<br>Focus Quad power supply board is needed to control it.<br>See "Focus Quad Power Supply Board" on page 2-66. |
| Aperture | Aperture equipped with an additional bracket<br>See "Apertures" on page 7-15 and Figure 7-11. | Aperture is shorter as the bracket is missing.<br>See "Apertures" on page 7-15, Figure 7-11 and Figure 7-12. |
| Sensitivity and ion beam dimension | Ion beam is narrower. Focal depth is satisfactory to hit the cups.<br>Therefore, no focus quad is necessary to improve focusing.<br>Thus, sensitivity is lower than with DELTA V Plus IRMS<br>(about 1500 molecules per ion) | Ion beam is wider.<br>Therefore, a focus quad is necessary to later on focus the ion beam on the cups again.<br>Thus, sensitivity is higher than with DELTA V Advantage IRMS<br>(about 900 molecules per ion) |

**Note** In case of the DELTA V Plus IRMS, the ion beam is wider. The focus quad allows utilizing a larger portion of the original ion beam coming from the ion source, therefore increasing peak shape, sensitivity and resolution. ▲

# Remarks for Service Engineers

Because the DELTA V Plus IRMS contains elaborate and expensive components, only qualified and skilled personnel should perform servicing. We recommend calling Thermo Scientific service, if there are any uncertainties or if difficulties arise. It is further recommended to use original Thermo Scientific spare parts only. Notice that many adjustments can be made only by using special tools and instruments, which are not supplied with the system. See the references within this guide.

Before starting maintenance and repair, read the appropriate chapters of this guide. Before calling Thermo Scientific service, try to localize the defect! A precise description of the defect will ease repair and reduce costs.



**Warning** **High Voltage.** Danger of injury. Some parts of the DELTA V Plus IRMS are at high voltage! Therefore, opening the electronics cabinet is only allowed for maintenance purposes by qualified service personnel. ▲

**Caution** When replacing fuses, only use the correct types! ▲

**Caution** Be careful when servicing the vacuum system. Abrupt opening to atmosphere might destroy the filament or damage the collector system and other expensive parts. ▲

**Note** When working with solvents and sample residuals, consider your regional safety instructions! ▲

## Safety Rules

Thermo Scientific mass spectrometers are frequently used for analysis of noxious materials. In these cases, usually certain parts of the system will be contaminated. To protect health of our employees we ask you for some special precautions when returning those parts for exchange or repair.

Mass spectrometer parts that have been contaminated by hazardous materials we can accept only if they have been decontaminated prior to return. Hazardous materials are those materials listed up on the MAK list (Maximale Arbeitsplatzkonzentration) and on the EPA (Environmental Protection Agency) priority list.

Additionally such materials are enclosed which due to their structure and the applied concentration might be toxic or which in publication are reported to be toxic. Finally, such materials are concerned which in combination with other present materials will generate synergetic hazardous effects.

Take care that pumps and all other parts which had been in contact to hazardous materials, will be properly decontaminated prior to return to Thermo Fisher Scientific.
Parts contaminated by radioisotopes are not subject to return to Thermo Fisher Scientific neither under warranty nor under the exchange part program.

**Note** When returning parts to Thermo Fisher Scientific, the use of our Health and Safety Form is obligatory. Your signature on the Health and Safety Form confirms that the returned parts have been decontaminated and are free of hazardous materials. Download the form from decon.thermo-bremen.com or order it from the Thermo Fisher Scientific field service engineer. ▲

# Chapter 8 Diagnosis

This chapter outlines diagnostic criteria for operating the DELTA V Plus mass spectrometer.

It has the following topics:

# Checking Performance Data

Thermo Scientific has developed several test routines to check the performance data of DELTA V Plus.

For user's convenience, Diagnosis module covering these test routines is included in Isodat 2.5. Notice that operating some of the test routines requires technical knowledge of the instrument's internals. In addition, successful execution of some of the tests depends upon instrument preconditions.

When running the test routines, a highly sensitive focusing of your instrument will lead to the best specifications results. Diagnosis module contains the following test routines:

- Absolute Sensitivity
- Abundance
- Amplifier Test
- Compression Factor
- Linearity
- Peak Flatness
- Relative Sensitivity
- Resolution
- Signal Stability
- System Stability

**Note** Reference gas for all performance data is $CO_2$. Make sure to have properly filled $CO_2$ reservoirs attached to the inlet system before starting Diagnosis module. ▲

Table 8-1 summarizes values for some of the Diagnosis parameters which are measured in the Diagnosis module of Isodat 2.5.

**Table 8-1.** Values of Diagnosis Parameters

| Diagnosis Parameter | DELTA V Advantage | DELTA V Plus |
|---|---|---|
| Absolute Sensitivity | 1200 molecules/ion (sensitivity focusing) | 800 molecules/ion (sensitivity focusing) |
| | 1500 molecules/ion (linearity focusing) | 1100 molecules/ion (linearity focusing) |
| Amplifier Test | 0.005 (for R = $3\times10^8$ Ω) | 0.005 (for R = $3\times10^8$ Ω) |
| | 0.02 (for R = $1\times10^9$ Ω) | 0.02 (for R = $1\times10^9$ Ω) |

**Table 8-1.** Values of Diagnosis Parameters, continued

| Diagnosis Parameter | DELTA V Advantage | DELTA V Plus |
|---|---|---|
| | 0.03 (for R = $3\times10^{10}\ \Omega$)<br>0.06 (for R = $1\times10^{11}\ \Omega$)<br>0.3 (for R = $1\times10^{12}\ \Omega$) | 0.03 (for R = $3\times10^{10}\ \Omega$)<br>0.06 (for R = $1\times10^{11}\ \Omega$)<br>0.3 (for R = $1\times10^{12}\ \Omega$) |
| Linearity | 0.066 ‰/nA (for $CO_2$; $^{13}C$)<br>0.066 ‰/nA (for $CO_2$; $^{18}O$) | 0.066 ‰/nA (for $CO_2$; $^{13}C$)<br>0.066 ‰/nA (for $CO_2$; $^{18}O$) |
| Resolution | 110 | 110 |
| Signal Stability | $3\times10^{-4}$<br>(Dual Inlet applications)<br>$3\times10^{-3}$<br>(Continuous Flow applications) | $3\times10^{-4}$<br>(Dual Inlet applications)<br>$3\times10^{-3}$<br>(Continuous Flow applications) |
| System Stability | 10 ppm | 10 ppm |

Table 8-2 summarizes some more important parameters.

**Table 8-2.** Values of Other Important Parameters

| Parameter | DELTA V Advantage | DELTA V Plus |
|---|---|---|
| End vacuum | $1\times10^{-7}$ mbar<br>(without differential pump)<br>$7\times10^{-8}$ mbar<br>(with differential pump) | $1\times10^{-7}$ mbar<br>(without differential pump)<br>$7\times10^{-8}$ mbar<br>(with differential pump) |
| Mass range | 1-80 Da | 1-96 Da |
| Noise | < 50 dB(A) | < 50 dB(A) |
| $H_3$ factor | 10 ppm/nA | 10 ppm/nA |
| Stability of $H_3$ factor | 0.03 ppm/nA/h | 0.03 ppm/nA/h |

# Absolute Sensitivity

**Note** Testing Absolute Sensitivity requires a Dual Inlet system. ▲

Absolute Sensitivity is defined as the number of molecules needed to generate an ion, which is then registered at the collector (for example, one ion of *m/z* 44 at the corresponding collector cup). It is thus dimensionless and measured in molecules per ion.

Based on a defined volume, the ion current is determined during a defined time period as a function of sample consumption (that is, sample loss). The small, defined volume is located between valve 25 of the inlet system and the inlet capillary. It amounts to approximately 145 µL.

Integrating the ion current over time yields the number of ions. From the signal drop during measurement the number of molecules necessary to generate this ion amount is calculated. To obtain Absolute Sensitivity, the number of molecules is divided by the number of ions.

Positively charged ions are produced in the ion source by electron bombardment. This electron impact (EI) ionization is described by:

$$AB + e^{-} \rightarrow AB^{+} + 2e^{-}$$ (ionization)

$$AB + e^{-} \rightarrow A^{+} + B + 2e^{-}$$ (ionization and dissociation)

Definition of Absolute Sensitivity *AS* (in molecules/ion):

$$AS = \frac{\Delta n_{gas}}{n_{\text{ion}}}$$

where:

$\Delta n_{gas}$:sample gas consumption

$n_{\text{ion}}$:number of detected ions

The number of consumed sample molecules $\Delta n_{gas}$ is calculated via the ideal gas law:

$$\Delta p \cdot v = \Delta n_{gas} \cdot R \cdot T$$

where:

*R*: universal gas constant

*T*: temperature

*Δp*: pressure difference

$\Delta n_{gas}$:number of consumed sample molecules

$V$: volume (here 250 µL)

The amount of detected ions $n_{ion}$ in the collector cup can be calculated via the electrons needed to neutralize the positive ions:

$$Q = \int_{t_1}^{t_2} I \, dt$$

where:

$Q$: charge
$I$: intensity
$t$: time

## Principle of Testing Absolute Sensitivity

1. Measurement starts determining pressure and intensity.

2. The volume is reduced to the defined volume of 145 µL that is enclosed between valve 25, valve 26 and the capillary by closing valve 25 of Dual Inlet system. See rectangle in Figure 8-1.

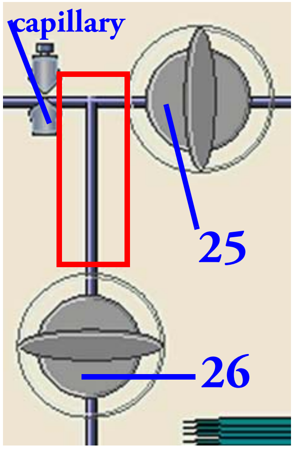



**Figure 8-1.** Defined Volume Enclosed between Valves and Capillary

The system is in a waiting position until start pressure and intensity are reached.

3. The ion current is measured for the preset time, for example 500 s.

**Note** Absolute Sensitivity should be about 1500 molecules $CO_2$ per mass 44 at the collector cup. ▲

# Abundance

**Note** Testing Abundance requires a Dual Inlet system. ▲

Abundance denotes the contribution of a mass to a neighbor mass, for example the amount of ions for *m/z* 44 falling into the *m/z* 45 cup. Thus, the intensity of a mass (for example, *m/z* 44) is compared to the intensity of the neighboring peak (for example, *m/z* 45).

In case of $CO_2$, the amount of ion current of mass 44 falling into the *m/z* 45 cup is divided by the ion current of *m/z* 44 into the *m/z* 44 cup.

Measured as ratio of two ion currents it is dimensionless and quoted in % or ppm. It should not exceed $2 \times 10^{-6}$ for a DELTA V Plus IRMS with Dual Inlet system. The Abundance test is performed with $CO_2$, and the device must be calibrated. Peak center is performed on cup 3, that is, the narrow cup (middle cup of Universal Triple collector) before measurement starts.

## Principle of Testing Abundance

1. Signal height, that is intensity on *m/z* 44 is determined in the appropriate collector cup, for example cup 3.
2. The background signal on *m/z* 45 is measured (that is, electronic noise with no gas) from *m/z* 44 to *m/z* 45.5.
3. With $CO_2$ as sample gas high voltage (HV) is scanned from *m/z* 44 to *m/z* 45.5, and the intensities are measured on the neighboring cup of *m/z* 45 (for example cup 4, with bigger resistor value in order to keep the signal in the detection range).
4. The abundance (of *m/z* 44 onto *m/z* 45) from the signal to the left and to the right of *m/z* 45 peak is extrapolated.
5. The abundance is calculated as described above.

## Sources of Error

- Resistor values are not configured correctly.
- Due to electrons on the left and on the right side of the peak, a negative signal may result. This problem can be overcome by manual adjustment.

# Amplifier Test

The Amplifier Test checks the ion detection performance of the IRMS with no ions present. Thus, it informs about the background noise of electronic devices.

The amplifier baseline must be determined without an interfering signal. Thus, the ion source is switched off before measurement starts (that is, the ion current equals zero). The signal intensity of every cup is individually measured at least 200 times for 300 seconds integration time. Finally, mean and standard deviation are calculated.

# Compression Factor

**Note** Testing Compression Factor requires a Dual Inlet system. ▲

Compression Factor is only important in case of a Dual Inlet system as it measures bellow compression. Defined as an intensity ratio, it is dimensionless [mV/mV]:

$$Comp = \frac{Int_{end}}{Int_{start}}$$

where:

$Int_{end}$:Intensity at the end of measurement

$Int_{start}$:Intensity at measurement start

The Compression Factor determines the dynamic range of the two bellows informing about their tightness and linearity. The ion signal (that is, intensity) is measured at different bellow compressions: an intensity vs. volume diagram results. The standard deviation around the signal's mean is calculated.

**Note** The bellows must be calibrated before performing the test. ▲

To test this parameter, the peak intensity for a mass (for example, *m/z* 44) is measured starting at the maximum (that is, 100%) down to the minimum (that is, 0%). A minimum death volume of about 3 mL is still remaining at 0% volume. A certain level (for example, 200 mV) serves as starting point of the measurement. The signal for the bellow expanded to maximum should be at this level. If this is not the case, the inlet system is expanded and pumped automatically until the reference level is reached.

**Note** The Compression Factors should be about the same for both bellows: at least 1:10 or higher. ▲

# Linearity

At Linearity test, synonymously called Ratio Linearity, signal linearity is checked vs. beam intensity (that is, intensity of main ion current) over a range of varying signals. Signal intensity is measured, and the isotope ratios are displayed vs. beam intensity. Linearity is calculated as slope of the regression line [‰/V]. The ratios are monitored between 2 V and 8 V in 1 V steps. For each data point, the background is subtracted.

## Source of Error

Resistor values are not configured correctly.

# Peak Flatness

As slope of the peak plateau, Peak Flatness reflects the quality of the ion stream. A correction is necessary to eliminate effects of descending peak plateau with increasing high voltage. This is done by measuring the peak twice—first with increasing and then with decreasing high voltage. The resulting peak represents the mean values of both runs. The measured intensity is a function of the acceleration voltage (that is, ion energy). Therefore, during a high voltage scan the intensity is slightly affected by this effect. To overcome this an “energy correction” is performed. The ion intensity on top of the peak (that is, at a parameterized mass range around the center) is measured. Peak Flatness can be determined for different gases and different collector cups (for example, for a $CO_2$-peak at *m/z* 45 at cup 2).

Two results are obtained:

- maximal intensity deviation divided by the intensity
- slope of the regression line [1/Da]

# Relative Sensitivity

Relative Sensitivity, $S_{rel}$, describes the dependency of signal intensity (that is, ion current) on the ion source pressure and is thus given in A/mbar:

$$S_{rel} = \frac{1}{0,69} \cdot \frac{1}{\Delta p} \cdot \frac{U}{R}$$

where:

*U*: voltage measured at amplifier of collector cup (for example cup 3, $m/z$ 44)

*R*: resistor value (for example, $3 \times 10^8\ \Omega$ for $m/z$ 44). This value is the same for $N_2$ and $CO_2$ as reference gases. It must be changed in special cases only.

$\Delta p$:pressure difference between a measurement with and without reference gas.

0.69:correction factor for $CO_2$. The ion gauge is calibrated with $N_2$, however, which has a different ionizing probability. The correction factor takes this into account. To calculate it, intensities (that is, ion currents) and pressures are measured with and without reference gas.

**Note** Two different Relative Sensitivity values exist depending on whether the instrument is equipped with a differential pumping system or not. The difference is due to different pressure readings at the same flow. The Absolute Sensitivity (given in molecules/ion) however, is the same. ▲

After a cycle of, for example, three measurements and calculations of Relative Sensitivity a mean value is displayed. This value should be about 0.2 A/mbar for a standard system and about 0.5 A/mbar in case of a differentially pumped system. They depend on the pumping capacity of the turbomolecular pumps. Each cup, that is each mass, is characterized by a Relative Sensitivity value of its own.

Different values of Relative Sensitivities can only be compared, if pumping speed, conductance, location of the ion gauge etc. are identical. Therefore, it is senseless to compare different types of instruments.

## Sources of Error

- Resistor values are not configured correctly.
- Relative Sensitivity depends on the accuracy of the high vacuum pressure gauge's accuracy, which is limited.

# Resolution

Resolution describes the masses, which can be separated from each other (that is, the minimal relative distance between two masses, which can be resolved). Different definitions of resolution are used in mass spectrometry. The 10% valley definition, commonly used for double focusing sector field mass spectrometers, means according to Figure 8-2:

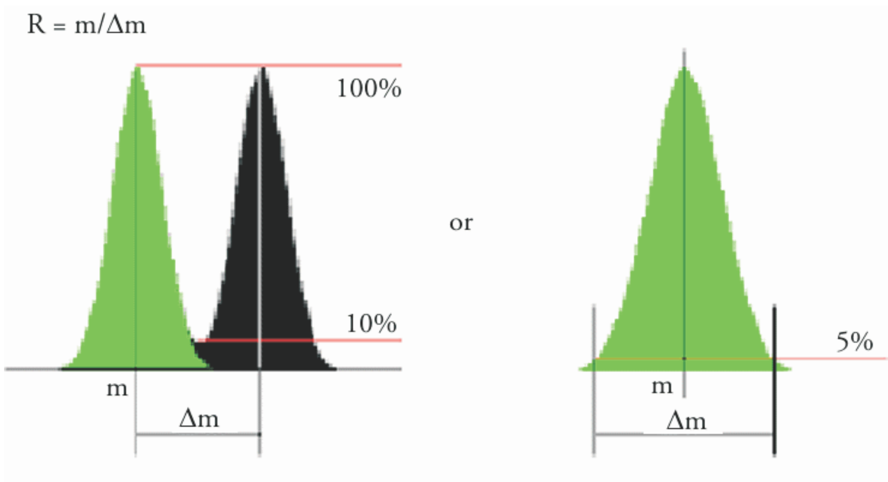



**Figure 8-2.** 10% Valley Definition of Resolution

Resolution can be defined as:

- mass divided by the mass difference of two neighboring peaks, if the valley between peaks drops to 10% of the peak height, or as
- mass divided by the peak width (in Da) at 5% of peak height

According to the 10% valley definition, it is dimensionless ( in m/Δm):

$$R = \frac{m}{\Delta m}$$

where:

*R*: resolution

*m*: mass of the respective isotope

$\Delta m$:mass difference between neighboring peaks

In **Dual** Peak mode, the distance between Peak Centers of two neighboring peaks is measured [Da]. The peak width of one peak is measured at 5% peak height.

In **Single** Peak mode, the distance between neighboring peaks is set to 1 Da. In both modes, Resolution can be calculated as follows (the mass difference is usually 1 Da):

$$R = \frac{m}{\Delta m} \cdot \frac{a}{b}$$

where:

*a*: distance between peak centers

*b*: peak width of the isotope of interest

When determining Resolution, choose an intensity focusing (see "Focusing of the IRMS" on page 6-5). Use the narrowest cup available (that is, usually cup 3 in the middle of the Universal Triple collector; *m/z* 45).

## Example

For a resolution of 88 and *m/z* 44, a peak with a distance of (44/88) Da = 0.5 Da could be resolved using the 10% criterion.

Start mass and end mass of the magnetic field scan can be edited. In case of $CO_2$, the mass ranges from about 43 to 45.5. The magnet steps values referring to *m/z* 44 and *m/z* 45 are determined and Resolution is calculated.

# Signal Stability

Signal Stability describes intensity peak height stability. Intensity on top of the peak is measured for a limited period of time, for example 5 minutes. Notice the similarity to the System Stability, but here, the stability is not measured at the peak flank, but at the peak center. Signal Stability should be $\sim 2 \times 10^{-4}$ for 5 min.

Two results are obtained:

- Slope of the regression line (normalized by the intensity)
- Standard deviation of the regression line (normalized by the intensity)

**Note** Testing Signal Stability requires a signal of 3 V or more! ▲

## Sources of Error

- The slope is usually due to gas consumption during measurement. However, it should be checked, if an unusual result is obtained.
- Instabilities of the emission may cause an unstable signal although a stable high voltage and magnetic field are given.
- Pressure fluctuations (check oil of the fore pumps!) or temperature fluctuations particularly at the crimps

# System Stability

System Stability informs about high voltage stability and thus magnetic field stability. Already small variations of high voltage or magnetic field dramatically influence signal intensity: They cause peak shifts. The fluctuations of high voltage or the magnetic field strength are measured at the peak flank, because they exert a much higher impact on peak intensity at the flank than on top. The System Stability test comprises the following steps:

- Peak center and peak flanks are determined.
- Magnetic field is set to 50% of peak height (at peak flank).
- Signal intensity (that is high voltage fluctuation) at the peak flank is measured for a defined period of time, for example 15 minutes.
- A new peak center procedure takes place.

Calculation of System Stability [$min^{-1}$] and Relative Mass Drift [$min^{-1}$] (either electronic or to magnetic drift) using the slope of the peak flank.

**Note** Testing System Stability requires a signal of 3 V or more! ▲

Two results are obtained:

- Slope of relative mass drift vs. time (time drift)
- Standard deviation of this slope (scatter of the mass)

A value of $5\times10^{-4}$ measured over a period of 15 minutes reflects a good System Stability.

# Chapter 9 Spare Parts and Consumables

This chapter lists important replaceable parts for the DELTA V Plus mass spectrometer.

It contains the following topics:

# General Remarks

According to Table 9-1, the following units will be depicted in respect of their respective spare parts and consumables in this chapter:

**Table 9-1.** Spare Parts and Consumables of Several Units

| Unit | Part No. | Depicted in Detail at |
|---|---|---|
| Pump System | no own part number | "Pump System" on page 9-4 |
| Analyzer | 115 9000 | "Analyzer" on page 9-12 |
| Ion Source | 115 8000 | "Ion Source" on page 9-16 |
| Compressed Air Supply | 115 8690 | "Compressed Air Supply" on page 9-19 |
| Changeover Valve | 108 2630 | "Changeover Valve" on page 9-20 |
| Bellows | 108 2681 | "Bellows" on page 9-22 |
| Microvolume | 108 2900 | "Microvolume" on page 9-23 |
| Pump Module | 116 8470 | "Pump Module" on page 9-24 |
| Multiport | 108 3200 | "Multiport" on page 9-25 |
| TubeCracker | 108 2840 | "TubeCracker" on page 9-26 |
| Autocool Unit | 049 3661 | "Autocool Unit" on page 9-27 |
| Sample Vials | different part numbers | "Sample Vials" on page 9-28 |

# Electronics

Table 9-2 summarizes important electronic parts.

**Table 9-2.** Spare Parts and Consumables - Electronics

| Quantity | Designation | Part No. |
|---|---|---|
| 1 | DEL-PCI controller | 204 1940 |
| 6 m | optical fiber between computer and IRMS, duplex | 205 2590 |
| 1 | main power supply cable | 207 8870 |
| 1 | power distribution board | 204 1280 |
| 1 | ion source control board | 204 1340 |
| 1 | bus control board (ground)[a] | 205 5000 |
| 1 | bus control board (high voltage)[a] | 204 1450 |
| 1 | transformer[a] | 205 2520 |
| 1 | heat sink MOS-FET[a] | 207 9690 |
| 1 | heat sink diode bridges[a] | 207 8830 |
| 1 | magnet current regulator | 205 6680 |
| 1 | power supply for amplifier and VFC | 204 1920 |
| 1 | inlet board | 207 7070 |
| 1 | switching power supply SP480-24, 24 V/20 A | 207 7660 |

**Table 9-2.** Spare Parts and Consumables - Electronics, continued

| Quantity | Designation | Part No. |
|---|---|---|
| 1 | control panel board | 207 7090 |
| 1 | ion source connector board | 207 7590 |
| 1 | switching power supply S-40-12, 12 V/3.5 A | 207 7680 |
| 1 | data logger | 207 6230 |
| 1 | ground plane cup | 207 7050 |
| 1 | ground plane amplifier | 207 6280 |
| 1 | amplifier | 207 6250 |
| 1 | RC combination, 300 MΩ, 470 pF | 205 3170 |
| 1 | RC combination, 30 GΩ, 5 pF | 205 3200 |
| 1 | RC combination, 100 GΩ, 2 pF | 205 3210 |
| 1.2 m | optical fiber, duplex, crossed | 207 9770 |
| 0.8 m | optical fiber, duplex, crossed | 207 9780 |
| 0.6 m | optical fiber, simplex, duplex | 207 9790 |
| 0.5 m | optical fiber, simplex, duplex | 208 0250 |

[a] directly connected to ion source control board

# Pump System

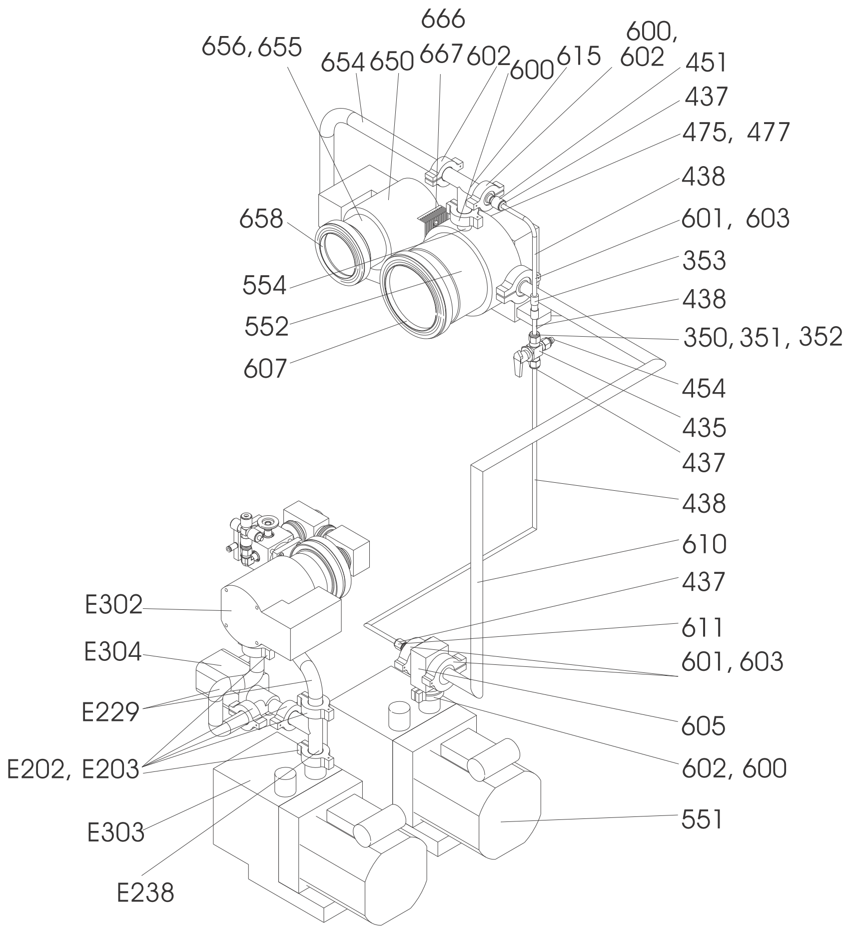



**Figure 9-1.** Pump System (no Part No. of its Own)

The pump system, Figure 9-1, is a part of the basic unit (Part No. 116 6000). It has no Part No. of its own because it comprises sub-units summarized in Table 9-3. These will now be presented successively.

**Table 9-3.** Sub-Units of Pump System[a]

| Designation | Part No. | Parts in Figure 9-1 | Parts Listed in |
|---|---|---|---|
| Vacuum Kit | 118 8090 | 600 - 649 | Table 9-4 |
| Pump Kit | 118 8600 | 550 - 599 | Table 9-5 |
| Mounting Parts | 115 8510 | 400 - 499 | Table 9-6 |
| Vacuum Kit of Amplifier | 118 4370 | 300 - 349 | Table 9-7 |
| Differential Pump module[b] | 117 5730 | 650 - 699 | Table 9-8 |
| Pumps and Devices of Dual Inlet system[c] | 118 8880 | E300 - 349 | Table 9-9 |
| Mounting Kit for Dual Inlet system[c] | 118 2710 | E200 - 299 | Table 9-10 |

[a] See Figure 9-1.

[b] Only if optional differential pump module is available.

[c] Only if optional Dual Inlet system (Part No. 117 9990) is available.

## Vacuum Kit

The Vacuum Kit has the Part No. 118 8090.

**Table 9-4.** Spare Parts and Consumables of Vacuum Kit[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 600 | 6 | centering ring, NW 16, Viton | 052 2140 |
| 601 | 3 | centering ring, NW 25, Viton | 052 2150 |
| 602 | 2 | tension ring, NW10/16, KF | 052 1830 |
| 603 | 3 | tension ring, NW20/25, KF DIN 28403 | 052 1560 |
| 604 | 20 | claw, DN63-100 ISO | 102 8380 |
| 605 | 1 | reducer T-piece, KF NW25/25/16 | 112 7820 |
| 606 | 2 | gas inlet, KF Swagelok adapter | 115 8460 |
| 607 | 3 | sealing ring, NW 100 ISO, aluminum/Viton | 055 3070 |
| 608 | 1 | sealing ring, NW 63 ISO, aluminum/Viton | 055 4060 |
| 609 | 1 | blank flange, DN16 | 115 8400 |
| 610 | 1 | metal tube, KF NW 25×1000 | 053 4230 |
| 611 | 1 | adapter, KF25-1/4” | 118 7690 |
| 612 | 2 | O-ring seal, 120×5, Viton | 116 5560 |
| 613 | 2 | O-ring seal, 250×5, Viton | 115 8370 |
| 614 | 1 | O-ring seal, 110×5, Viton | 108 7610 |
| 616 | 1 | elbow pipe, KF NW25 | 052 2190 |
| 617 | 1 | edge seal, aluminum, DN 20/25 | 055 2930 |
| 618 | 1 | KF-outer centering ring and inner thrust ring, DN40 | 116 8960 |
| 619 | 1 | O-ring seal, 107,2×5,3, aluminum/Viton | 065 1980 |
| 620 | 1 | tension ring, NW20/25 | 047 2500 |

[a] See Figure 9-1.

## Pump Kit

The Pump Kit has the Part No. 118 8600.

**Table 9-5.** Spare Parts and Consumables of Pump Kit[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 551 | 1 | rotary vane pump, DUO 2.5 | 109 5950 |
| 552 | 1 | turbo pump, TMH 262 | 114 1600 |

**Table 9-5.** Spare Parts and Consumables of Pump Kit[a], continued

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 553 | 1 | LP3/turbo pump, cable | 205 0730 |
| 554 | 1 | adapter TMH-064, KF-NW16 | 108 8390 |

[a] See Figure 9-1.

# Mounting Parts

The mounting parts are summarized at Part No. 115 8510.

**Table 9-6.** Spare Parts and Consumables - Mounting Parts[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 400 | 1 | label “Thermo” 3,14”×1,43” | 117 9110 |
| 401 | 40 | cylinder head screw, M6×16, DIN 912, A4 | 045 3100 |
| 402 | 2 | disc 6.4, DIN 125, A2 | 047 0060 |
| 403 | 30 | blind cap, 26 mm | 108 6670 |
| 404 | 2 | blind cap, 18 mm | 108 6680 |
| 405 | 1 | screw, M4 ×20, DIN 84, A4 | 045 0490 |
| 405 | 8 | feedthrough, 26 mm | 108 6700 |
| 406 | 1 | disc 4.3, DIN 125, A4 | 047 0040 |
| 407 | 1 | spring washer, B 4, DIN 127 | 047 0540 |
| 408 | 1 | lock washer, J 4,3, DIN 6797, A2 | 047 1990 |
| 409 | 2 | hexagon nut, M 4, DIN 934, A4 | 046 0220 |
| 410 | 1 | PE label “ground wire“, round | 202 6340 |
| 411 | 2 | bolt, 3×16, DIN7, A4 | 048 0130 |
| 412 | 3 | screw M 4 ×20, DIN 912, A4 | 045 3450 |
| 413 | 14 | cylindrical head screw M6×16, DIN 912, A4 | 045 3100 |
| 414 | 6 | cylindrical head screw M8×20, DIN 912, A4 | 045 1880 |
| 415 | 2 | bolt, 2×12, DIN7, A4 | 048 0070 |
| 416 | 2 | cylindrical head screw M2×16, DIN 84, A4 | 045 5400 |
| 417 | 4 | screw M4×20, DIN 84, A4 | 045 0490 |
| 418 | 3 | bolt, 3×10, DIN7, A4 | 048 0110 |
| 419 | 3 | screw M 5×10, DIN 912, A4 | 045 3590 |
| 420 | 6 | cylindrical head screw M 4×16, DIN 912, A4 | 045 3290 |
| 421 | 2 | disc 5.3, DIN 125, A2 | 047 0050 |
| 422 | 2 | screw M 5×12, DIN 84, A2 | 045 0590 |
| 423 | 48 | lock washer J 6.4, DIN 6797, A2 | 047 1030 |
| 423 | 1 | bolt 5×32, DIN 7, A4 | 117 5970 |
| 424 | 4 | disc 10,5, DIN 125, A2 | 047 0880 |

**Table 9-6.** Spare Parts and Consumables - Mounting Parts[a], continued

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 425 | 4 | screw M 10×25, DIN 933, A2 | 078 3360 |
| 426 | 4 | disc 5,3, DIN 433-1.4301 | 047 0200 |
| 427 | 4 | screw M 5×12, DIN 84, A2 | 045 0590 |
| 428 | 2 | roller M 5 ×20 | 047 1130 |
| 429 | 14 | disc 5.3, DIN 125, A2 | 047 0050 |
| 430 | 10 | screw M 5×8, DIN 84 A2 | 045 0570 |
| 431 | 4 | screw M 5×12, DIN84  A2 | 045 0590 |
| 432 | 4 | screw M 8×50, DIN 933, A4 | 045 3520 |
| 433 | 4 | disc 8.4, DIN 125, A2 | 047 0070 |
| 434 | 1 | adapter TMH-064, KF-NW16 | 108 8390 |
| 435 | 1 | 3-port valve | 112 2300 |
| 436 | 1 | label "Amplifier" | 118 9150 |
| 437 | 3 | supporting sleeve for tube, ID = 4 m | 104 9620 |
| 438 | 2 m | tube 4×1, Teflon | 069 0280 |
| 439 | 16 | screw M 8×35, DIN 931, A4 | 045 4400 |
| 440 | 16 | disc 8.4, DIN 125, A2 | 047 0070 |
| 441 | 1 | tube screwing, M5 | 052 1320 |
| 442 | 4 | bolt 5×14, DIN7, A 4 | 048 0210 |
| 443 | 4 | screw M 6 ×70, DIN 912, A4 | 115 8810 |
| 444 | 10 | hexagon head screw, M 6×20, DIN 933 | 045 3510 |
| 445 | 14 | disc 6.4, DIN 125, A2 | 047 0060 |
| 446 | 4 | screw M 5×10, DIN 84, A2 | 045 0580 |
| 447 | 2 | sealing ring for M5 screwing, turbo pump | 115 7780 |
| 448 | 2 | tube screwing, M5 | 052 1320 |
| 449 | 7 | disc 4.3, DIN 125, A4 | 047 0040 |
| 450 | 0.5 m | tube 2×1, PTFE | 109 1650 |
| 451 | 2 | small flange, NW 16, M5 | 112 7830 |
| 452 | 2 | flange clamp, KF16 | 114 5860 |
| 453 | 1 | flange clamp, DN25KF | 104 2030 |
| 454 | 1 | tube section,1/4" with cone lug | 100 3940 |
| 455 | 4 | screw M 8×45, DIN 931, A4 | 045 3370 |
| 456 | 8 | screw M 8×65, DIN 912, A4 | 115 8730 |
| 457 | 2 | bolt 6×14, DIN7, 5.8 | 115 7070 |
| 458 | 3 | cap | 118 8270 |
| 459 | 3 | cap, machined | 118 8280 |
| 460 | 2 | protective grating LZ30-4; fan type 9956 | 118 1170 |

**Table 9-6.** Spare Parts and Consumables - Mounting Parts[a], continued

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 461 | 6 | distance bolt M4×8, SW7, stainless steel | 116 5650 |
| 462 | 2 | bolt 6×20, DIN7, A4 | 048 0640 |
| 463 | 4 | claw DN 10-50, with screw | 102 7301 |
| 464 | 6 | screw M4×8 | 053 2180 |
| 465 | 1 | disc 3,2, DIN 125, A4 | 047 0030 |
| 466 | 1 | screw M3 ×4, DIN 84 , A4 | 045 0740 |
| 467 | 1 | clamp 1× 6, DIN 72571 | 037 0030 |
| 468 | 1 | cylindrical screw M4×8, DIN 84, A4 | 045 0790 |
| 469 | 2 | knurled head screw M3×20, DIN 464-A2 | 118 6500 |
| 470 | 2 m | tube 4×1, Teflon | 069 0280 |
| 471 | 2 | clamp belt with ratchet | 109 0270 |
| 472 | 5 m | tube 13×3.5, PVC | 069 0720 |
| 473 | 2 | tube clamp, 12-20 mm, W4 | 100 5970 |
| 474 | 1 | tube coupling, 12-8 | 118 8460 |
| 475 | 1 | heat sink TMH 262 | 118 8790 |
| 476 | 1 | gasket, gold, 6,3 | 055 1010 |
| 477 | 2 | screw M4×10, DIN 912, A4 | 045 1820 |

[a] See Figure 9-1.

## Vacuum Kit of Amplifier

The Vacuum kit of amplifier has the Part No. 118 4370.

**Table 9-7.** Spare Parts and Consumables of Vacuum Kit of Amplifier[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 350 | 1 | blind, 0.15 mm | 118 4380 |
| 351 | 4 | supporting sleeve for tube, ID = 4 m | 104 9620 |
| 352 | 1 | O-ring seal, 3.18×1.57, Viton | 055 4410 |
| 353 | 1 | return valve, tube AD 6-tube AD 6 | 115 0330 |

[a] See Figure 9-1.

## Differential Pump Module

The differential pump module is on option and has the Part No. 117 5730.

**Table 9-8.** Spare Parts and Consumables of Differential Pump Module[a]

| Pos No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 650 | 1 | turbo pump TMH 071 P | 114 1500 |
| 651 | 1 | LP3/turbo pump, cable | 205 0730 |
| 652 | 3 | centering ring, NW16, Viton | 052 2140 |
| 653 | 3 | tension ring, NW10/16 KF | 052 1830 |
| 654 | 1 | metal tube, KF NW 16×500 | 053 4500 |
| 655 | 1 | shielding TPH | 115 2920 |
| 656 | 2 | label for shielding | 115 5970 |
| 657 | 1 | sealing ring for connection KF 16, turbo pump | 115 7790 |
| 658 | 1 | sealing ring NW 63 ISO, aluminum/Viton | 055 4060 |
| 659 | 1 | ion source cover 1 | 118 5050 |
| 660 | 1 | ion source cover 2 | 118 5060 |
| 661 | 3 | disc 3.2, DIN 433, A4 | 047 0210 |
| 662 | 3 | disc 8.4, DIN 125, A2 | 047 0070 |
| 663 | 3 | screw M 3×8, DIN 84, A4 | 045 0760 |
| 664 | 3 | disc 3.2, DIN 433, A4 | 047 0210 |
| 665 | 3 | hexagon nut M 3, DIN 934, A4 | 046 0610 |
| 666 | 1 | heat sink, TMH 071 P | 118 8810 |
| 667 | 2 | screw M 4×10, DIN 912, A4 | 045 1820 |
| 668 | 1 | t-piece NW 16, aluminum | 095 3460 |

[a] See Figure 9-1.

## Pumps and Devices of Dual Inlet System

If the optional Dual Inlet system (Part No. 117 9990) is available, the pumps and devices summarized at Part No. 118 8880 and shown in Table 9-9 are provided.

**Table 9-9.** Pumps and Devices of Dual Inlet System[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 301 | 1 | turbo pump TMH 071 P | 114 1500 |
| 302 | 1 | LP3/turbo pump, cable | 205 0730 |
| 303 | 1 | rotary vane pump DUO 2.5 | 109 5950 |
| 304 | 1 | angle valve, pneumatically operated | 117 5960 |
| 305 | 1 | Pirani APG-M DN16KF | 102 7320 |
| 307 | 1 | flood valve, 24 V | 108 4890 |
| 310 | 1 | Pump Kit for Dual Inlet Module | 118 8870 |

[a] Only if optional Dual Inlet system (Part No. 117 9990) is available. See Figure 9-1.

## Mounting Kit for Dual Inlet System

If the optional Dual Inlet system (Part No. 117 9990) is available, the parts shown in Table 9-10 are provided. They are summarized as Mounting Kit for Dual Inlet system at Part No. 118 2710.

**Table 9-10.** Mounting Kit of Dual Inlet System[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 200 | 3 | centering ring NW25, Viton | 052 2150 |
| 201 | 3 | tension ring NW20/25KF, DIN 28403 | 052 1560 |
| 202 | 8 | tension ring NW10/16, KF | 052 1830 |
| 203 | 8 | centering ring NW16, Viton | 052 2140 |
| 204 | 1 | sealing ring NW63 ISO, aluminum/Viton | 055 4060 |
| 205 | 1 | t-reducer, TRS 8-12-8 | 117 9790 |
| 206 | 2 m | tube, 9×3, black, PVC | 104 9540 |
| 207 | 5 | valve cluster, 4-fold | 117 5780 |
| 208 | 1 | blind plug, M5 | 052 1950 |
| 209 | 8 | plug connection, KQ2S | 117 7150 |
| 210 | 1 | compressed air distributor, 9-fold, M5 | 106 8410 |
| 211 | 1 m | tube, 6×4×1, type K 310 | 069 0740 |
| 212 | 1 | L-plug connection, R1/8a>tube AD6, KQ2V | 117 7110 |
| 213 | 4 | screw M 8×20, DIN 933, A4 | 045 2260 |
| 214 | 4 | screw M 6×12, DIN 933, A4 | 045 2230 |
| 215 | 8 | screw M 5×10, DIN 84-A2 | 045 0580 |

**Table 9-10.** Mounting Kit of Dual Inlet System[a], continued

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 218 | 2 | nut M 6, DIN 934, A4 | 046 0520 |
| 219 | 12 | disc 8.4, DIN 125, A2 | 047 0070 |
| 220 | 10 | disc 6.4, DIN 125, A2 | 047 0060 |
| 221 | 11 | disc 5.3, DIN 125, A2 | 047 0050 |
| 222 | 15 | disc 4.3, DIN 125, A4 | 047 0040 |
| 224 | 1 | sheet, Kit for Dual Inlet system | 119 0950 |
| 225 | 7 | distance bolt M4×5, SW7 Ms, nickel-plated | 116 8550 |
| 226 | 6 | screw M 5×10, DIN 7991-A2 | 116 8620 |
| 227 | 1 | elbow piece, KF DN 25 | 116 5720 |
| 228 | 1 | reducer t-piece, KF-NW25/16/25 | 116 5730 |
| 229 | 3 | metal tube, KF NW16×250 | 052 4260 |
| 231 | 30 | disc 3.2, DIN 433, A4 | 047 0210 |
| 232 | 12 | screw M 3×20, DIN 84, A4 | 045 4660 |
| 233 | 14 | hexagonal nut M 3, DIN 934, A4 | 046 0610 |
| 234 | 1 | metal tube, NW 25×500 KF | 053 4180 |
| 237 | 5 m | Teflon tube, AD = 4 mm | 118 7730 |
| 238 | 1 | t-piece NW16, aluminum | 095 3460 |
| 239 | 11 | cylindrical screw M 4×8, DIN 84, A4 | 045 0790 |
| 240 | 8 | screw M 6×16, DIN 933, A4 | 045 2240 |
| 241 | 4 | lock washer B 8, DIN 127 | 047 0570 |
| 242 | 1 | nut M 5, DIN 934, A2 | 046 0590 |
| 243 | 4 | cylindrical head screw M 4×10, DIN 84, A4 | 045 0800 |
| 244 | 4 | hexagonal nut M 4, DIN 934, A4 | 046 0220 |
| 245 | 0.5 m | tube 6×1, PU, blue, transparent | 117 7190 |
| 246 | 6 | L-plug connection, KQ2VS | 117 7320 |

[a] Only if optional Dual Inlet system (Part No. 117 9990) is available. See Figure 9-1.

# Analyzer

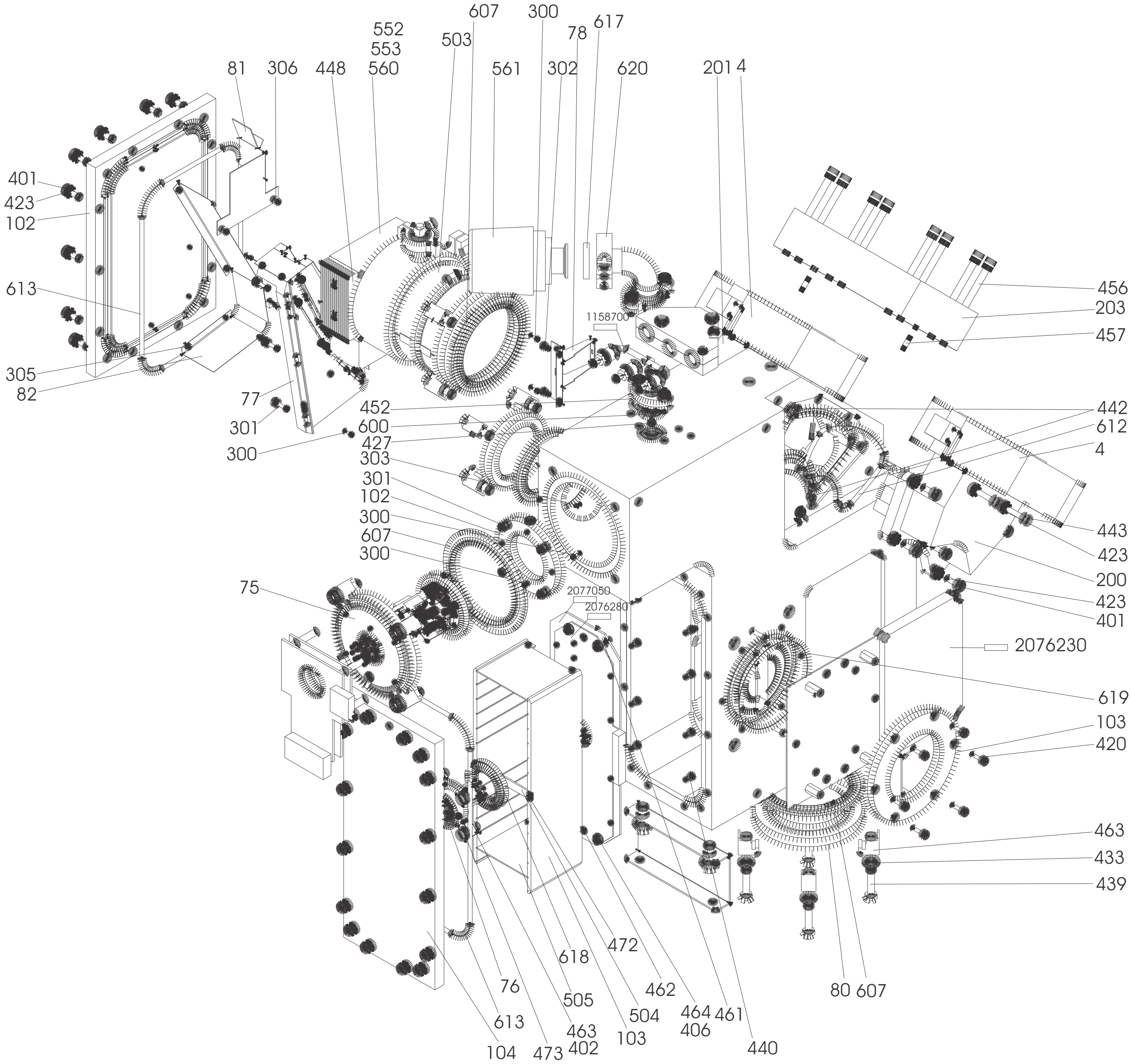



**Figure 9-2.** Analyzer (Part No. 115 9000)

The parts of the analyzer occurring in Figure 9-2 are not merged into one all-embracing parts list. Rather, the analyzer parts belong to various sub-units. Each sub-unit has a parts list of its own according to Table 9-11.

**Table 9-11.** Sub-Units of Analyzer[a]

| Designation | Part No. | Parts in Figure 9-2 | Parts Listed in |
|---|---|---|---|
| Mechanical Kit of Basic Unit | 115 8300 | 75-99 | Table 9-12 |
| Analyzer Kit | 118 8580 | 100-149 | Table 9-13 |
| Magnet Kit | 118 8560 | 200-249 | Table 9-14 |
| Mounting Parts (Vacuum) | 115 8310 | 300-349 | Table 9-15 |
| Vacuum Kit of Amplifier | 118 4370 | 350-399 | Table 9-7 |
| Mounting Parts | 115 8510 | 400-499 | Table 9-6 |
| Mounting Kit | 116 9500 | 500-549 | Table 9-16 |
| Pumps and Devices | 115 8530 | 550-599 | Table 9-17 |
| Vacuum Kit | 118 8090 | 600-649 | Table 9-4 |
| Differential Pump Module | 117 5730 | 650-699 | Table 9-8 |

[a] See Figure 9-2.

## Mechanical Kit of Basic Unit

The mechanical kit of basic unit, Part No. 115 8300, comprises the parts 75-99 in Figure 9-2. The most important of them are summarized in Table 9-12.

**Table 9-12.** Spare Parts and Consumables of Mechanical Kit of Basic Unit[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 75 | 1 | ion source with flange | 115 8230 |
| 76 | 1 | 13-fold feedthrough | 116 8270 |
| 77 | 1 | collector | 115 8160 |
| 78 | 1 | aperture | 115 8500 |
| 79 | 1 | mounting parts (vacuum) | 115 8310 |
| 80 | 1 | collector flange, welded | 117 9000 |
| 81 | 1 | scraper | 118 8390 |
| 82 | 1 | shielding plate, lid | 115 8440 |
| 83 | 1 | vacuum kit of amplifier | 118 4370 |

[a] See Figure 9-2.

## Analyzer Kit

The analyzer kit, Part No. 118 8580, comprises the parts 100-149 in Figure 9-2. The most important of them are summarized in Table 9-13.

**Table 9-13.** Spare Parts and Consumables of Analyzer Kit[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 100 | 1 | lower part of heating block | 116 9540 |
| 101 | 1 | upper part of heating block | 116 9550 |
| 102 | 1 | lid of collector | 115 8380 |
| 102 | 1 | inlet ring of ion source | 115 8450 |
| 103 | 2 | board fitting of amplifier | 116 5630 |
| 103 | 1 | flange | 116 5700 |
| 104 | 1 | amplifier lid | 116 5530 |
| 105 | 1 | flange K JB 095 063 000 | 065 2620 |

[a] See Figure 9-2.

## Magnet Kit

The magnet kit, Part No. 118 8560, comprises the parts 200-249 in Figure 9-2. The most important of them are summarized in Table 9-14.

**Table 9-14.** Spare Parts and Consumables of Magnet Kit[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 200 | 1 | magnetic core (lower part) | 115 7030 |
| 201 | 1 | magnetic core (upper part) | 115 7040 |
| 203 | 1 | magnet plate | 115 7020 |

[a] See Figure 9-2.

## Mounting Parts (Vacuum)

The mounting parts (vacuum), Part No. 115 8310, comprises the parts 300-349 in Figure 9-2. The most important ones are summarized in Table 9-15.

**Table 9-15.** Spare Parts and Consumables - Mounting Parts (Vacuum)[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 300 | 8 | bolt 3×10, penetrated | 057 4970 |
| 301 | 7 | screw M4×16, DIN 912 A4 | 116 0060 |
| 302 | 2 | screw M3×6, drilled | 114 3460 |
| 303 | 1 | bolt 2×5, DIN 7 | 118 4100 |
| 305 | 4 | screw M2×4, DIN 84 A4, penetrated | 117 7250 |
| 306 | 2 | screw M 4 ×8, DIN 84 | 048 3200 |

[a] SeeFigure 9-2.

## Vacuum Kit of Amplifier

The vacuum kit of amplifier, Part No. 116 9500, comprises the parts 350-399 in Figure 9-2. The most important of them have already been summarized in Table 9-7.

## Mounting Parts

The mounting parts, Part No. 115 8510, comprises the parts 400-499 in Figure 9-2. They have already been summarized in Table 9-6.

## Mounting Kit

The mounting kit, Part No. 116 9500, comprises the parts 500-549 in Figure 9-2. The most important of them are summarized in Table 9-16.

**Table 9-16.** Spare Parts and Consumables of Mounting Kit[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 500 | 1 | overlay panel | 119 1430 |
| 501 | 1 | cover 1 | 118 1100 |
| 502 | 1 | cover 2 | 118 1110 |
| 503 | 1 | shielding TMH 262, complete | 118 6340 |
| 504 | 1 | stiffener | 116 5640 |
| 505 | 2 | shielding plate of amplifier | 116 5660 |

[a] See Figure 9-2.

## Pumps and Devices

The pumps and devices, Part No. 115 8530, comprises the parts 550-599 in Figure 9-2. The most important of them are summarized in Table 9-17.

**Table 9-17.** Spare Parts and Consumables - Pumps and Devices[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 550 | 1 | pump kit (Pfeiffer) | 118 8600 |
| 551 | 1 | rotary vane pump DUO 2.5 | 109 5950 |
| 552 | 1 | turbo pump TMH 262 | 114 1600 |
| 553 | 1 | LP3/turbo pump, cable | 205 0730 |

[a] See Figure 9-2.

## Vacuum Kit

The vacuum kit, Part No. 118 8090, comprises the parts 600-649 in Figure 9-2. They have already been summarized in Table 9-4.

## Differential Pump Module

The differential pump module, Part No. 117 5730, comprises the parts 650-699 in Figure 9-2. They have already been summarized in Table 9-8.

# Ion Source

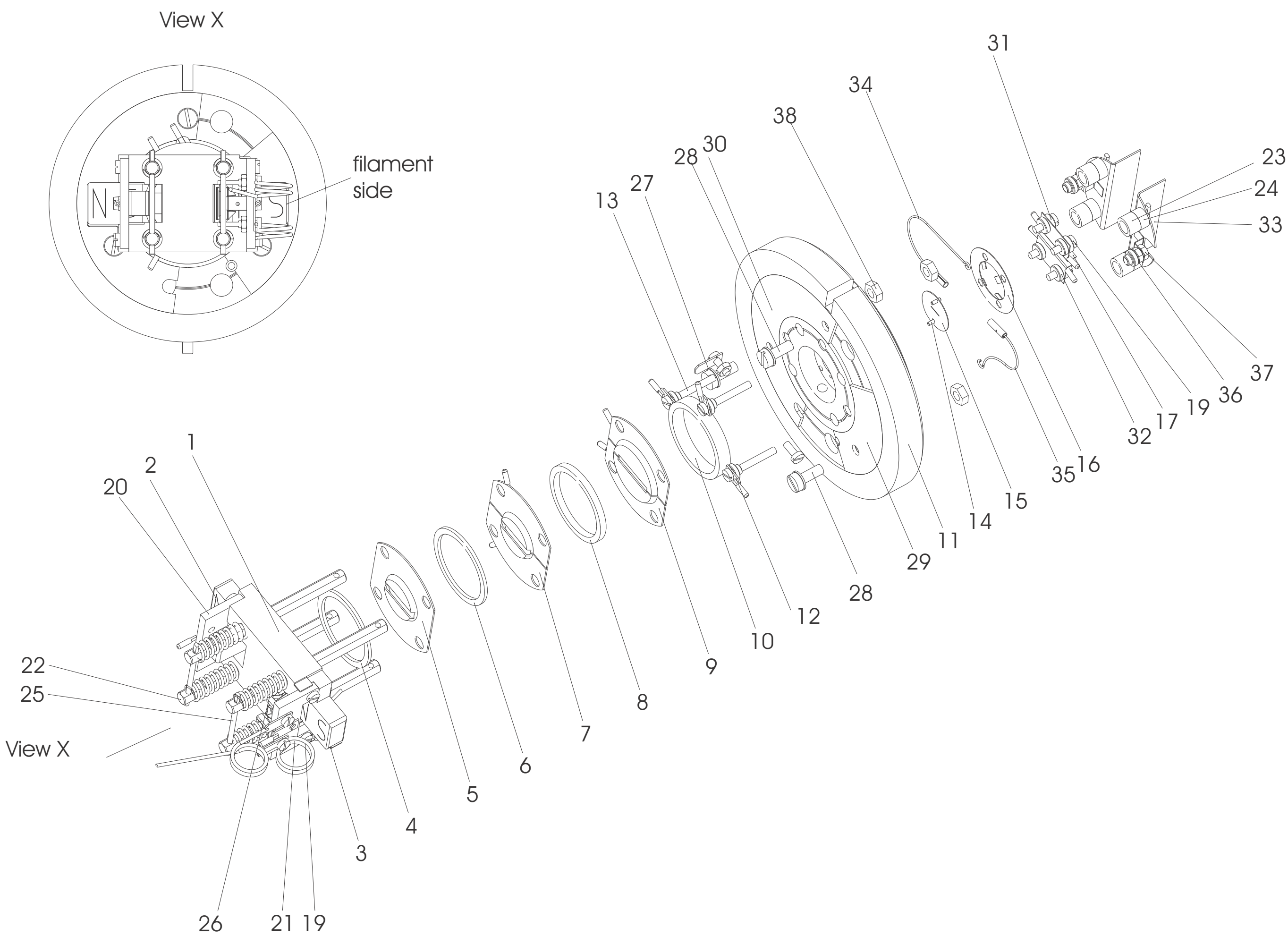



**Figure 9-3.** Ion Source (Part No. 115 8000)

Depending on the type of your IRMS (that is, DELTA V Plus or DELTA V Advantage) and the availability of a differential pump (that is, present or not), four different combinations concerning the ion source are possible. They are shown in Table 9-18.

The particular combination used in your IRMS is indicated by an adhesive label in the left cabinet of the front side. See **2** in Figure 2-1. Refer also to “Differential Blind” on page 2-44.

**Note** When ordering an ion source, do not omit the prefix EX shown in the “Part No.“ column of Table 9-18! ▲

**Table 9-18.** Combinations Concerning the Ion Source

| Ion Source Type | Part. No |
|---|---|
| ion source with flange - DELTA V Advantage plus differential pump | EX119 1750 |
| ion source with flange - DELTA V Plus plus differential pump | EX119 1760 |
| ion source with flange - DELTA V Advantage without differential pump | EX115 8230 |
| ion source with flange - DELTA V Plus without differential pump | EX119 1400 |

Table 9-19 shows spare parts and consumables of any ion source.

**Table 9-19.** Spare Parts and Consumables of Ion Source[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 1 | 1 | ionization housing | 111 9480 |
| 2 | 1 | magnet (rod-shaped) | 057 9300 |
| 3 | 2 | spring | 074 2380 |
| 4 | 1 | distance ring | 102 8160 |
| 5 | 1 | extraction plate 1 | 102 8040 |
| 6 | 1 | distance ring, 24,8×21×1 | 056 0010 |
| 7 | 1 | extraction plate 2 | 058 2460 |
| 8 | 1 | distance ring, 24,8×21×2, quartz glass | 106 7910 |
| 9 | 1 | lens, complete | 058 2440 |
| 10 | 1 | distance ring, 24,8×21×4, quartz glass | 106 7920 |
| 11 | 1 | base plate of ion source | 115 8220 |
| 12 | 3 | contact tongue for M 2 | 081 0170 |
| 13 | 3 | cylinder head screw, M 2×16, DIN 84, A4 | 045 5400 |
| 14 | 2 | cylindrical pin, 1×3, A4 | 111 9430 |
| 15 | 1 | ion source slit, 0,2, tantalum | 112 0940 |
| 16 | 1 | spring | 111 8040 |
| 17 | 2 | R-deflection | 050 2060 |
| 18 | 1 | pin, 3×6, DIN7, A4 | 048 0100 |
| 19 | 11 | screw, M2×6, DIN 84, A4, head 3 mm | 045 3650 |
| 20 | 1 | electron collector | 074 2600 |
| 21[b] | 1 | cathode, tungsten | 102 7920 |
| 22 | 4 | column | 102 7480 |
| 23[b] | 4 | distance tube, 6×4,1×4, ceramics | 056 0710 |
| 24[b] | 4 | distance tube, 6×4,2×3, ceramics | 056 0150 |
| 25 | 4 | pin, long | 102 6730 |
| 26 | 4 | pressure spring, i.d. = 4,2, LO = 12 | 102 8920 |
| 27 | 3 | disc 3,2, DIN 433, A4 | 047 0210 |
| 28 | 3 | screw M3×8, DIN 84 A4 | 045 0760 |

**Table 9-19.** Spare Parts and Consumables of Ion Source[a], continued

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 29 | 1 | ion source cover, faceplate 1 | 118 5050 |
| 30 | 1 | ion source cover, faceplate 2 | 118 5060 |
| 31[b] | 4 | distance tube, 5×3,2×1,5, ceramics | 056 1650 |
| 32[b] | 10 | bush, ceramics | 048 5280 |
| 33 | 2 | Z-deflection | 116 6220 |
| 34 | 1 | line, ion source | 118 5420 |
| 35 | 1 | line 9 | 118 8060 |
| 36 | 8 | disc 2,2, DIN 433, A4 | 047 2090 |
| 37 | 6 | hexagon nut, M 2, DIN 934, A4 | 046 0210 |
| 38 | 3 | hexagon nut, M 3, DIN 934, A4 | 046 0610 |

[a] See Figure 9-3.

[b] These parts frequently break. We recommend to provide for replacements before the ion source is opened.

# Compressed Air Supply

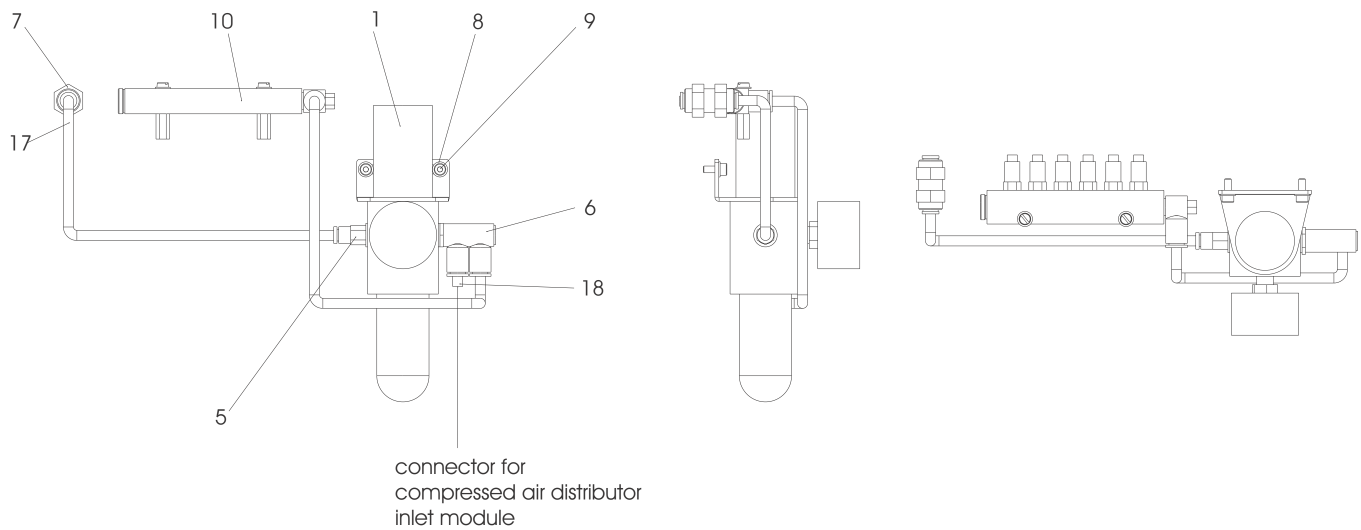



**Figure 9-4.** Compressed Air Supply (Part No. 115 8690)

**Table 9-20.** Spare Parts and Consumables of Compressed Air Supply[a]

| Pos. No. | Quantity | Designation | Part No |
|---|---|---|---|
| 1 | 1 | maintenance unit, LFR-1/8"S | 052 1630 |
| 2 | 1 | return valve, tube AD6-R1/4"a | 117 7160 |
| 3 | 1 | plug-in connector, 2-fold, R1/8"a>tube AD6, KQ2 | 118 5610 |

**Table 9-20.** Spare Parts and Consumables of Compressed Air Supply[a],

| Pos. No. | Quantity | Designation | Part No |
|---|---|---|---|
| 4 | 1 | Schott plug-in connector, tube AD6>tube AD6, KQ2E | 117 7200 |
| 5 | 2 | disc 4.3, according to DIN 125, A4 | 047 0040 |
| 6 | 2 | screw M 4×10, DIN 912, A4 | 045 1820 |
| 7 | 1 | compressed air distributor | 117 7070 |
| 8 | 6 m | tube, 6×1, PU, blue, transparent | 117 7190 |
| 10 | 1 | plug, KQ2P-06 | 118 5620 |

[a] See Figure 9-4.

# Changeover Valve

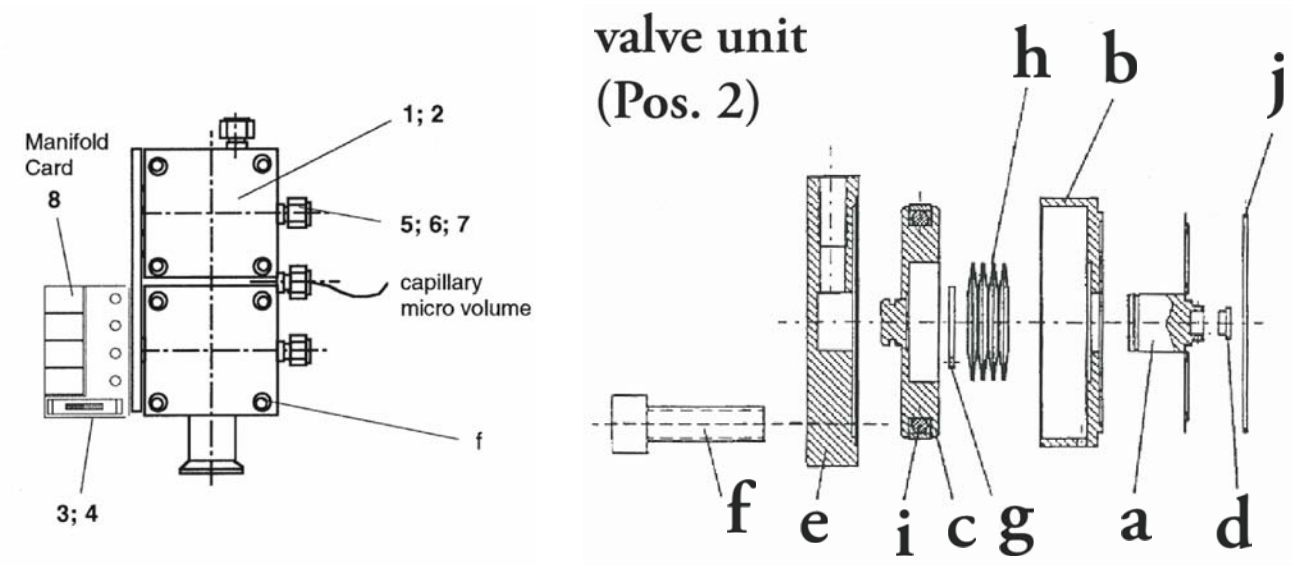



**Figure 9-5.** Changeover Valve (Part No. 108 2630)

**Table 9-21.** Spare Parts and Consumables of Changeover Valve[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 1 | 1 | valve body | 108 2620 |
| 2 | 4 | valve unit | 065 3001 |
| a | 1 | membrane | 065 3010 |
| b | 1 | pressure unit | 065 3050 |
| c | 1 | piston | 065 3030 |
| d | 1 | stamp, gold | 065 3041 |
| e | 1 | cover | 065 3060 |
| f | 4 | screw; M 6 x 20 | 045 3420 |

**Table 9-21.** Spare Parts and Consumables of Changeover Valve[a],

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| g | 1 | guard ring; 10 x 1 | 047 3430 |
| h | 8 | plate spring; 20 x 10.2 x 0.4 | 043 1570 |
| i | 1 | jacket ring | 055 3140 |
| j | 1 | gasket; gold, 38 | 054 5270 |
| k | 1 | lithium fat | 079 1140 |
| 3 | 4 | connecting fitting | 070 3780 |
| 4 | 4 | gasket | 050 5260 |
| 5 | 8 | cap nut | 052 1160 |
| 6 | 8 | front ferrule | 079 2800 |
| 7 | 8 | back ferrule | 079 2810 |
| 8 | 1 | manifold card | 108 3241 |

[a] See Figure 9-5.

# Bellows

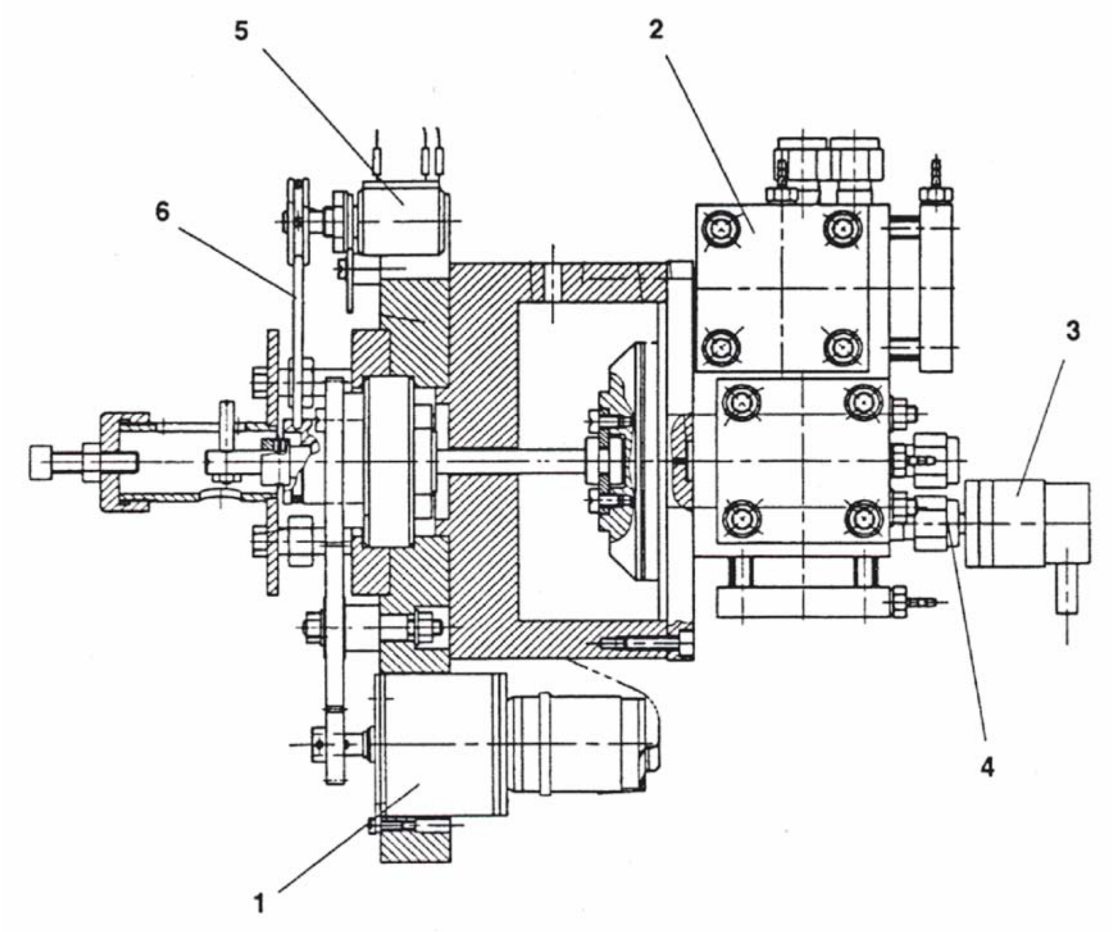



**Figure 9-6.** Bellow (Part No. 108 2681)

**Table 9-22.** Spare Parts and Consumables of Bellows[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 1 | 1 | motor, complete | 070 3330 |
| 2 | 1 | valve unit | 108 2670 |
| 3 | 1 | manometer | 101 6802 |
| 4 | 1 | capillary | 067 1182 |
| 5 | 1 | potentiometer | 070 3540 |
| 6 | 1 | O ring seal | 055 3180 |
| 7 | 1 | limit stop | 070 3610 |
| 8 | 1 | bellows unit, small | 070 3310 |

[a] See Figure 9-6.

# Microvolume

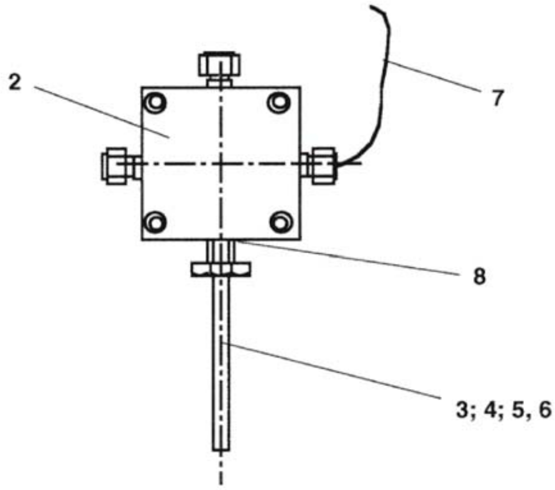



**Figure 9-7.** Microvolume (Part No. 108 2900)

**Table 9-23.** Spare Parts and Consumables of Microvolume[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 2 | 1 | valve | 106 8970 |
| 3 | 1 | cold finger; $CO_2$ | 078 3330 |
| 4 | 1 | cold finger; $N_2$ | 078 3340 |
| 5 | 1 | cooling plate; $CO_2$ | 041 2300 |
| 6 | 1 | cooling plate; $N_2$ | 058 3290 |
| 7 | 1 | capillary tube, heatable | 067 1182 |
| 8 | 1 | gasket; gold; 6.3 | 055 1010 |

[a] See Figure 9-7.

# Pump Module

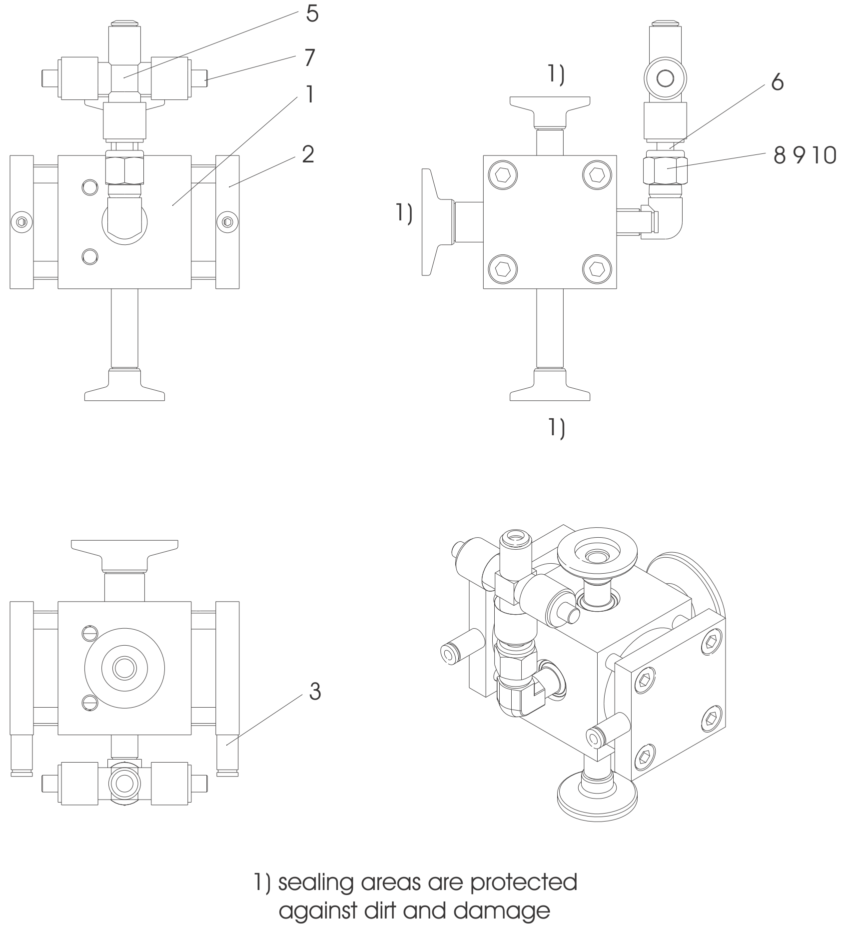



**Figure 9-8.** Pump Module (Part No. 116 8470)

**Table 9-24.** Spare Parts and Consumables of Pump Module[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 1 | 1 | valve | 116 8480 |
| 2 | 2 | valve unit | 065 3001 |
| 3 | 2 | plug-in connector, M5a>tube, AD4 mm (KQ2S) | 117 7150 |
| 5 | 1 | cross piece, 400-4 SS 1/4" | 052 3530 |
| 6 | 1 | tube section,1/4" with cone lug | 100 3940 |
| 7 | 2 | blind plug, 1/4" | 079 2710 |
| 8 | 5 | union nut 402, 1/4", stainless steel | 052 1160 |
| 9 | 4 | cone V. 1/4", into Swagelok | 079 2800 |
| 10 | 4 | cone R. 1/4", into Swagelok | 079 2810 |

[a] See Figure 9-8.

# Multiport

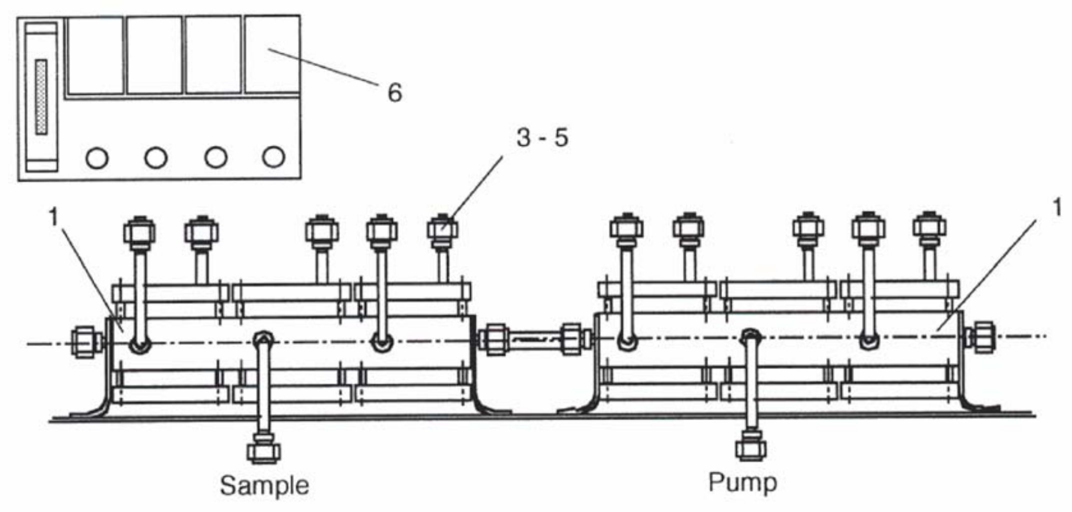



**Figure 9-9.** Multiport (Part No. 108 3200)

**Table 9-25.** Spare Parts and Consumables of Multiport[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 1 | 2 | valve block | 106 8770 |
| 2 | 1 | manometer | 101 6801 |
| 3 | 5 | nut | 052 1160 |
| 4 | 5 | front ferrule | 079 2800 |
| 5 | 5 | back ferrule | 079 2810 |
| 6 | 3 | manifold card | 108 3241 |
| 7 | 5 m | silicon tube | 101 5830 |

[a] See Figure 9-9. Pos. 2 and 7 are not shown therein.

# TubeCracker

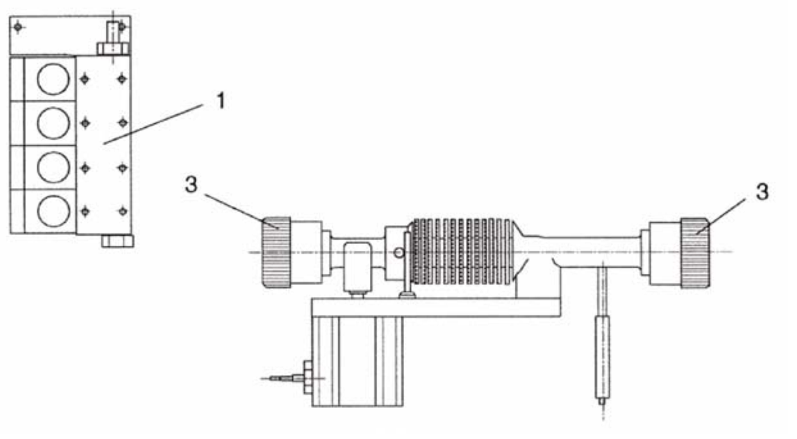



**Figure 9-10.** TubeCracker (Part No. 108 2840)

**Table 9-26.** Spare Parts and Consumables of TubeCracker[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 1 | 3 | manifold card | 109 7750 |
| 2 | 5 m | silicon tube | 101 5830 |
| 3 | 2 | O-ring seal | 055 2180 |

[a] See Figure 9-10. Pos 2 is not shown therein.

# Autocool Unit

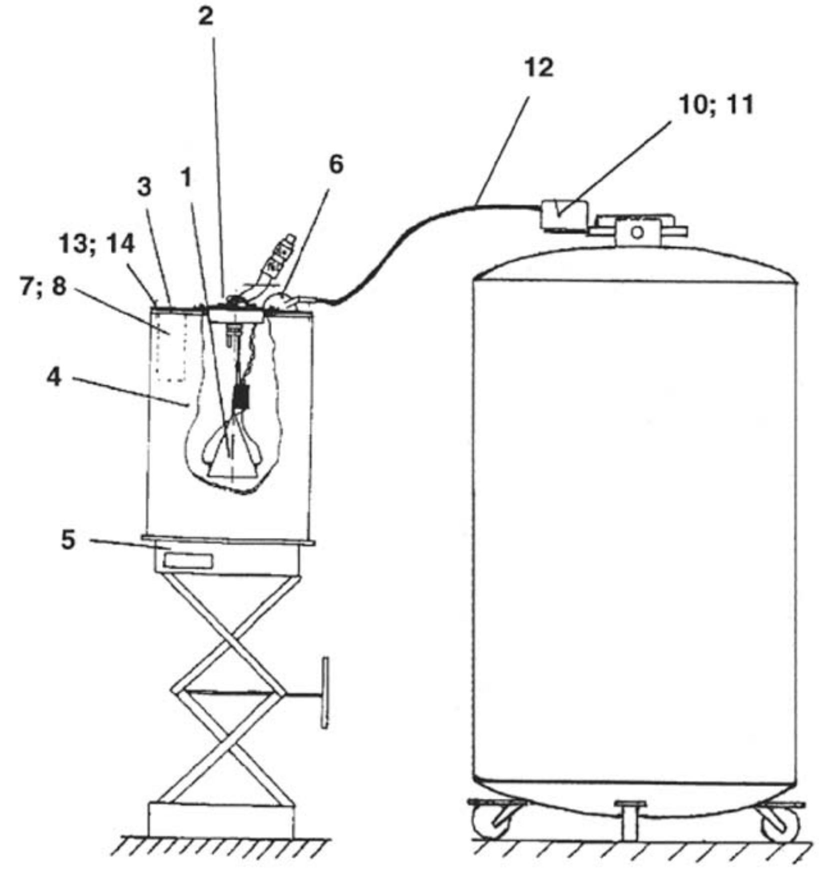



**Figure 9-11.** Autocool Unit (Part No. 049 3661)

**Table 9-27.** Spare Parts and Consumables of Autocool Unit[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 1 | 1 | cooling unit | 079 2400 |
| 2 | 1 | blank flange | 059 7380 |
| 3 | 1 | cover | 059 6530 |
| 4 | 1 | insulating case | 054 2830 |
| 5 | 1 | lifting device | 060 9260 |
| 6 | 1 | filler cap | 112 8230 |
| 7 | 1 | sleeve | 075 4850 |
| 8 | 1 | insert | 075 4710 |
| 9 | 1 | refill device | 039 5441 |
| 10 | 1 | magnet valve; for LN2 | 041 4130 |
| 11 | 1 | manifold; for LN2 | 048 2610 |
| 12 | 1 | tube for refill box | 059 9610 |
| 13 | 1 | screw; M 4 x 10 | 045 088 |

**Table 9-27.** Spare Parts and Consumables of Autocool Unit[a], continued

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 14 | 4 | nut; M 4 | 046 0220 |
| 15 | 2 | screw; M 4 x 25 | 045 0500 |
| 16 | 1 | connection cable for trap | 025 3791 |
| 17 | 1 | container; 75 l; for LN2 | 079 4700 |

[a] See Figure 9-11.

# Sample Vials

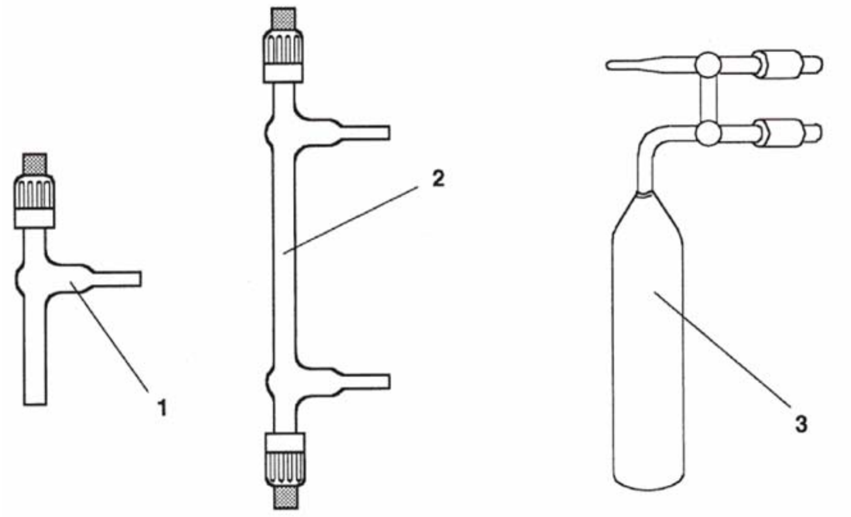



**Figure 9-12.** Sample Vials

**Table 9-28.** Spare Parts and Consumables Concerning Sample Vials[a]

| Pos. No. | Quantity | Designation | Part No. |
|---|---|---|---|
| 1 | 1 | sample vial; 5 ml | 100 3560 |
| 2 | 1 | sample vial; 10 ml | 100 3840 |
| 3 | 1 | sample vial; 200 ml | 025 4650 |

[a] See Figure 9-12.

# Glossary

This section lists and defines terms used in this manual. It also includes acronyms, metric prefixes, symbols, and abbreviations.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

## A

**A** ampere

**ac** alternating current

**ADC** analog-to-digital converter

**AP** acquisition processor

**API** atmospheric pressure ionization

**ASCII** American Standard Code for Information Interchange

## B

**b** bit

**B** byte (8 b)

**baud rate** data transmission speed in events per second

**BEST** Brightly Enhanced Sample Transfer

**BF** backflush

## C

**°C** degrees Celsius

**CE** European conformity. Mandatory European marking for certain product groups to indicate conformity with essential health and safety requirements set out in European Directives.

**cfm** cubic feet per minute

**CI** chemical ionization

**CID** collision-induced dissociation

**cm** centimeter

**$cm^3$** cubic centimeter

**Continuous-Flow (CF)** Automated preparation device and mass spectrometer in which sample analysis is conducted in a continuous stream of helium carrier gas.

**CPU** central processing unit (of a computer)

**CRC** cyclic redundancy check

**CRM** consecutive reaction monitoring

**CSIA** Compound Specific Isotope Analysis

**<Ctrl>** control key on the terminal keyboard

## D

**d** depth

**Da** dalton

**DAC** digital-to-analog converter

**dc** direct current

**driver** A device-specific control program that enables a computer to work with a particular device.

**DS** data system

**DSP** digital signal processor

**DSQ™** Dual Stage Quadrupole

See also ITQ™.

**Dual Inlet (DI)** Inlet method in which a pure gas sample is admitted into an isotope ratio mass spectrometer (IRMS) by a variable volume bellows. A reference gas is admitted into the IRMS via a second variable volume bellows. The bellows are balanced to provide sample and reference signal responses of equal intensity.

## E

**ECD** Electron Capture Detector

**EI** electron ionization

**Elemental Analyzer (EA)** Automated sample preparation instrument in which samples are automatically converted into pure gases for isotope ratio analysis. An elemental analyzer contains the following elements: (i) furnace for combustion, reduction or pyrolysis of sample material; (ii) chemical traps for analyte gas purification; (iii) gas chromatography for time separation of these analyte gases.

**EMBL** European Molecular Biology Laboratory

**<Enter>** Enter key on the terminal keyboard

**ESD** electrostatic discharge

**ESI** electrospray ionization

**eV** electron volt

## F

**f** femto ($10^{-15}$)

**°F** degrees Fahrenheit

**FID** Flame Ionization Detector

**FM** flow meter

**forepump** The pump that evacuates the foreline. A rotary-vane pump is a type of forepump.

**ft** foot

**FTP** file transfer protocol

**FWHM** Full Width at Half Maximum

## G

**g** gram

**G** Gauss; giga ($10^9$)

**GC** gas chromatograph; gas chromatography

**GC/MS** gas chromatograph/mass spectrometer

**GISP** Greenland Ice Sheet Precipitation. International reference standard for hydrogen and oxygen isotopes.

See also SLAP and VSMOW.

**GLT** Glass Lined Tubing

**GUI** graphical user interface

## H

**h** hour

***h*** height

**HF** high flow

**HOT OC** High Oven Temperature Cold On-Column

**HPLC** High Performance Liquid Chromatography. Standalone liquid chromatography system (or inlet for mass spectrometry detector).

**HTC** High Temperature Conversion

**HV** high voltage

**Hz** hertz (cycles per second)

## I

**IAEA** International Atomic Energy Agency

**ICIS™** Interactive Chemical Information System

**ICL™** Instrument Control Language™

**ICP** inductively coupled plasma

**ICP-OES** inductively coupled plasma optical emission spectroscopy

**ID** inside diameter

**IEC** International Electrotechnical Commission

**IEEE** Institute of Electrical and Electronics Engineers

**in.** inch

**I/O** input/output

**ion optics** Focuses and transmits ions from the ion source to the mass analyzer.

**ion source** A device that converts samples to gas-phase ions.

**irm** isotope ratio monitoring

**IRMS** isotope ratio mass spectrometer

**ITQ™** Ion Trap Quadrupole

See also DSQ™.

## K

**k** kilo ($10^3$, 1000)

**K** kilo ($2^{10}$, 1024)

**KEGG** Kyoto Encyclopedia of Genes and Genomes

**kg** kilogram

## L

***l*** length

**L** liter

**LAN** local area network

**lb** pound

**LC** Liquid chromatography. A process that separates a chemical mixture carried by liquid into components as a result of differential distribution of the solutes as they flow around or over a stationary or solid phase.

**LC/MS** liquid chromatograph / mass spectrometer

**LED** light-emitting diode

**LF** low flow

**log file** A text file, with a .log file extension, that is used to store lists of information.

**LVSL** Large Volume Splitless Injector

**µ** micro ($10^{-6}$)

## M

**m** meter

**m** milli ($10^{-3}$)

**M** mega ($10^6$)

**$M^+$** molecular ion

**MB** Megabyte (1 048 576 bytes)

**$MH^+$** protonated molecular ion

**min** minute

**mL** milliliter

**mm** millimeter

**MP** measuring point

**MS** mass spectrometer; mass spectrometry

**MS** $MS^n$ power: where n = 1

**MS/MS** $MS^n$ power: where n = 2

**$MS^n$** $MS^n$ power: where n = 1 through 10

**MTBE** methyl tert-butyl ether

**MVFC** multifunctional valve cluster

***m/z*** Mass-to-charge ratio. An abbreviation used to denote the quantity formed by dividing the mass of an ion (in u) by the number of charges carried by the ion. For example, for the ion $C_7H_7^{2+}$, *m/z*=45.5.

## N

**n** nano ($10^{-9}$)

**Natural Abundance** The concentration of isotopes as found in nature.

**NCBI** National Center for Biotechnology Information (USA)

**NIST** National Institute of Standards and Technology (USA)

**noise** Any random disturbance that obscures the clarity of a signal

**NPD** nitrogen/phosphorous detector

## O

**OC** On-Column

**OD** outside diameter

**OS** open split

**Ω** ohm

**outlier** A calibration data point that does not appear to correlate to other calibration data points within experimental error.

## P

**p** pico ($10^{-12}$)

**Pa** pascal

**PCB** printed circuit board

**PDD** Pulsed Discharge Detector

**PE** protective earth

**PEEK** polyether ether ketone

**PID** proportional/integral/differential

**P/N** part number

**P/P** peak-to-peak voltage

**ppm** parts per million

**psig** pounds per square inch, gauge

**PTV** Programmable Temperature Vaporizing

## R

**RAM** random access memory

**relative standard deviation** A measure of the dispersion of a group of measurements relative to the mean of the group. Relative standard deviation is expressed as a percentage of the average value. The percent relative standard deviation is calculated as:

$$\%\,RSD = 100 \cdot \frac{SD}{\bar{x}}$$

where SD is the standard deviation and $\bar{X}$ is the sample mean.

**RF** radio frequency

**RMS** root mean square

**ROM** read-only memory

**rotary-vane pump** A mechanical vacuum pump that establishes the vacuum necessary for the proper operation of the turbomolecular pump. (Also called a roughing pump or forepump.)

**RS-232** An accepted industry standard for serial communication connections. This Recommended Standard (RS) defines the specific lines and signal characteristics used by serial communications controllers to standardize the transmission of serial data between devices.

## S

**s** second

**serial port** An input/output location (channel) for serial data transmission.

**SIM** selected ion monitoring

**SLAP** Standard Light Antarctic Precipitation; international reference standard for hydrogen and oxygen isotopes.

See also VSMOW.

**SPME** Solid Phase Micro Extraction

**SRM** selected reaction monitoring

**standard deviation** In statistics, the standard deviation SD is a measure of the dispersion of a group of measurements. For example, masses, times, or intensities. Standard deviation is calculated as follows:

$$\sigma = SD = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

See also relative standard deviation.

## T

**TCD** Thermal Conductivity Detector

**TCP/IP** transmission control protocol / Internet protocol

**TIC** total ion current

**Torr** A unit of pressure, equal to 1 mm of mercury and 133.32 Pa.

**turbomolecular pump** A vacuum pump that provides a high vacuum for the mass spectrometer and detector system.

## U

**u** atomic mass unit

**UHV** ultra high vacuum

## V

**V** volt

**V AC** volts alternating current

**V DC** volts direct current

**VFC** voltage-frequency converter

**vol** volume

**VCDT** Vienna Canyon Diablo Troilite; international reference standard for sulfur isotopes.

**VPDB** Vienna Pee Dee Belemnite; international reference standard for carbon and oxygen isotopes.

**VSMOW** Vienna Standard Mean Ocean Water; international reference standard for hydrogen and oxygen isotopes.

See also SLAP.

## W

**w** width

**W** watt

**WEEE** European Union Waste Electrical and Electronic Equipment Directive. Provides guidelines for disposal of electronic waste.

# Index

## Numerics



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