Table of Contents

CHAPTER 1
GENERAL INFORMATION

About This Manual 5
Safety
General Safety Considerations 5
Product Related Safety Precautions 6
ESD Protection 7
Version Information 7
Related Manuals 8
Trademarks 8
Warranty 9

CHAPTER 2
PRODUCT AND SYSTEM COMPONENT OVERVIEW

Ozone Documentation 11
Introduction to RS92 Ozonesonde 11
Radiosonde 13
Digital Ozonesonde Interface Card (OIF92) 14
RSA921 Digital Interface Kit 15
RSA922 Digital Interface Kit 15

Equipment and Materials Needed for Sounding Preparations 15
Expendables and Spare Parts 16
Ozone Sounding Start-Up Kit 16
Ozonizer / Test Unit TSC-1 18
Air Flow Meter 19
Ozone Destruction Filter 21
Pump Test Unit 22
Ozone Chemicals 24
Set of Laboratory Ware 24
Other Equipment & Materials 25
Balance 25
Thermometer 25
Power Supply 26
Protection Gloves 26

CHAPTER 3
SOUNDING OPERATION

First Preparation Steps 27
Sounding of the Ozonesonde 28
Ozone Sounding Step-by-step 28
Work Area 28
Connect OIF92 and RS92 Radiosonde 29
Connect Radiosonde Holder ...............................................31
Connect Ozone Sensor and OIF92.....................................32
Conducting a Ground Check...............................................39
Preparing Radiosonde and Ground Equipment ..............40
Ozonesonde Construction...................................................41
SPC-6A and EN-SCI Ozonesonde Construction ...........41
Brewer-Mast Model 730-10 Ozonesonde Construction .45
Rigging Preparations...........................................................51
Checklist for Flight Preparations ........................................ 54

CHAPTER 4
SENSOR MEASUREMENT USING INTERFACE UNIT OIF92...........55
OIF92 Interface Block Diagram .............................................55
Ozone current measurement...............................................57
Temperature Measurement..................................................59
Temperature Sensor ..........................................................59
Resistance Measurement ....................................................59
Resistance to Temperature Calculation .............................61
Temperature Rise Caused by Measurement Current
Power Loss in NTC Thermistor .........................................63
Third and Fourth Channels Voltage Measurement .............64
Calculation of Voltages......................................................64
Calibration of Channels 3 and 4.......................................65
Input Resistance...............................................................65
For Double Pole Measurements ........................................66
Generation of Brewer-Mast Cell Potential Voltage ..........67

CHAPTER 5
OZONE CALCULATION ..............................................................................69
Averaging and Eliminating Irrelevant Measuring Results..69
Ozone Partial Pressure Calculation ........................................70
Ozone Sensor Operating Principle ....................................70
Ozone Sensor reactions .......................................................71
Calculation of Local Ozone Values .....................................72
Background current correction (IBG) .................................73
Pumping Time for 100 ml of Air (t) ..................................74
Measured Airflow Temperature (TP) ..............................74
Pump Efficiency Correction (Cef) ......................................74
Additional correction factor (CRef) ....................................76
Total Ozone Calculation ........................................................76
Total Ozone from Sounding ................................................76
Residual Ozone (Total Ozone after Balloon Burst) .............78
Ozone in µg/m³ ..................................................................78

CHAPTER 6
TECHNICAL DATA ......................................................................................81
Accuracy of the Ozonesonde Measurement ....................81
Performance Review Literature ...........................................82

CHAPTER 7
VAISALA HELPDESK..............................................................85
List of Tables

Table 1 Manual Revisions ................................................................. 7
Table 2 Related Manuals ................................................................. 8
Table 3 Ozone Sounding Start-Up Kit ............................................... 17
Table 4 Equipment Required .......................................................... 19
Table 5 Equipment Required .......................................................... 21
Table 6 Equipment Required .......................................................... 22
Table 7 Required Chemicals ............................................................. 24
Table 8 Laboratory Ware Needed ..................................................... 25
Table 9 R-T Table for Thermistor 10K3A542I .................................... 62
Table 10 Ozone Partial Pressure Correction Factors ......................... 75
Table 11 Performance Review Literature ......................................... 82
CHAPTER 1
GENERAL INFORMATION

About This Manual

This manual provides information for assembling and operating the digital Vaisala Radiosonde RS92 with one of the following ozone sensors:

- Science Pump Corporation (SPC) Model ECC-6A, ECC ozone sensor
- EN-SCI Corporation Model Z, ECC ozone sensor
- Mast Dev. Corp. Model 730-10, Brewer-Mast ozone sensor

Safety

General Safety Considerations

Throughout the manual, important safety considerations are highlighted as follows:

<table>
<thead>
<tr>
<th>WARNING</th>
<th>Warning alerts you to a serious hazard. If you do not read and follow instructions very carefully at this point, there is a risk of injury or even death.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAUTION</td>
<td>Caution warns you of a potential hazard. If you do not read and follow instructions carefully at this point, the product could be damaged or important data could be lost.</td>
</tr>
</tbody>
</table>
Product Related Safety Precautions

The RS92 Ozonesonde has been tested for safety and approved as shipped from the factory. Note the following precautions:

**WARNING** Conduct soundings in a safe environment and in accordance with all applicable restrictions and regulations.

**WARNING** Do not use the radiosonde in an area with power lines or other obstructions overhead. Make sure that you check the area for such obstructions before using.

**WARNING** Do not use the radiosonde without consultation and cooperation with local and other applicable aviation authorities.

**WARNING** Do not modify the unit in any way, except as instructed in the manual.

**WARNING** Do not use the radiosonde for any purpose other than for soundings.
ESD Protection

Electrostatic Discharge (ESD) can cause immediate or latent damage to electronic circuits. Vaisala products are adequately protected against ESD for their intended use. However, it is possible to damage the product by delivering electrostatic discharges when touching, removing, or inserting any objects inside the equipment housing.

To make sure you are not delivering high static voltages yourself:

- Handle ESD sensitive components on a properly grounded and protected ESD workbench. When this is not possible, ground yourself to the equipment chassis before touching the boards. Ground yourself with a wrist strap and a resistive connection cord.

  **CAUTION**
  Touch a conductive part of the equipment chassis with your other hand before touching the boards.

- Always hold the boards by the edges and avoid touching the component contacts.

Version Information

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Manual Revisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Code</td>
<td>Description</td>
</tr>
<tr>
<td>M210547EN</td>
<td>This manual</td>
</tr>
</tbody>
</table>
Related Manuals

<table>
<thead>
<tr>
<th>Manual Code</th>
<th>Manual Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>M210295EN</td>
<td>RS92-SGP Digital Radiosonde User Guide</td>
</tr>
<tr>
<td>M210502EN</td>
<td>RS92-AGP Digital Radiosonde User Guide</td>
</tr>
<tr>
<td>M210548EN</td>
<td>RS92-BGP Digital Radiosonde User Guide</td>
</tr>
<tr>
<td>M210329EN</td>
<td>Ground Check Unit GC25 User's Guide</td>
</tr>
<tr>
<td>SPC TSC-1 © SPC</td>
<td>Science Pump Corporation Operator’s Manual Ozonizer Test Unit Model TSC-1</td>
</tr>
<tr>
<td>M210605EN</td>
<td>Instruction Manual EN-SCI Corporation Model Z ECC-O3-Sondes © EN-SCI</td>
</tr>
<tr>
<td>M210606EN</td>
<td>Flight preparation Instruction for the Model 730-8 Ozoneondes © Mast Dev. Corp.</td>
</tr>
<tr>
<td>M210490EN</td>
<td>MW31 DigiCORA III Special Sensors manual</td>
</tr>
<tr>
<td>M210220EN</td>
<td>MW21 DigiCORA III Special Sensors manual</td>
</tr>
<tr>
<td>M210179EN</td>
<td>Metgraph Ozoneonde SPC Data Handler</td>
</tr>
</tbody>
</table>

Trademarks

Microsoft, Windows, and Windows NT are registered trademarks of Microsoft Corporation in U.S. and/or other countries.
Warranty

For certain products Vaisala normally gives a limited one-year warranty. Please observe that any such warranty may not be valid in case of damage due to normal wear and tear, exceptional operating conditions, negligent handling or installation, or unauthorized modifications. Please see the applicable supply contract or Conditions of Sale for details of the warranty for each product.

For radiosonde warranty information, refer to the radiosonde manual. Vaisala follows the warranty instructions of individual ozone sensor manufacturers. Please see manufacturer documentation for details.
This page intentionally left blank.
CHAPTER 2

PRODUCT AND SYSTEM COMPONENT OVERVIEW

Ozone Documentation

This manual describes in detail

- The preparation of the ozone sensor with digital Vaisala RS92 Radiosonde and digital interface in conjunction with the manuals of ozone sensor manufacturers. Please see Related Manuals on page 8.

- The description of flight preparations for launching the ozonesonde and rigging.

- The description of the sounding system setup.

Vaisala ozone sounding software features are described in detail in the applicable manuals.

All these manuals are provided in the ozone documentation. Please refer to Related Manuals on page 8 for further details.

Introduction to RS92 Ozonesonde

This manual describes the construction and handling of ozone sensor with Vaisala RS92 radiosonde.

The Vaisala RS92 Ozonesonde consists of an ozone sensor unit, an ozone sensor interface, and a radiosonde.
The ozone sensor unit is one of following:

- Science Pump Corporation (SPC) Model ECC-6A, ECC ozone sensor
- EN-SCI Corporation Model Z, ECC ozone sensor
- Mast Dev. Corp. Model 730-10, Brewer-Mast ozone sensor

All these sensors are based on chemical reaction cells. Two sensors are electrochemical concentration cell (ECC) type sensors and one is one cell sensor driven by non-chemical potential. Air is sampled flow (by using a pump) which goes to reaction cell, in which the sampled ozone reacts in solution, and the current developed in the reaction is detected and measured. The ozone sensor units are thoroughly discussed in the manuals of sensor manufacturers (Please see Related Manuals on page 8) and publications listed in Performance Review Literature on page 82.

In summary, sensors produce ozone concentration related current, which is measured by using a interface.

![Figure 1 RS92 Digital Ozonesonde with SPC ECC-6A](image)

The following numbers refer to Figure 1 above:

1. Ozone sensor
2. RS92 Radiosonde
3. Ozonesonde Interface Card OIF92
The following numbers refer to Figure 1 above:

4 Ozone sensor styrofoam casing

The ozone sensor unit is thoroughly discussed in the manuals of the individual sensor manufacturers. The main parts of the SPC ECC-6A ozone sensors are seen in Figure 2 below. The EN-SCI Model Z ozone sensor is similar to the SPC sensor.

Figure 2 SPC ECC-6A Ozone Sensor Parts

The following numbers refer to Figure 2 above.

1. Gas sampling pump
2. Ozone sensor cathode
3. Ozone sensor anode
4. Wires for interface
5. Motor
6. Air intake tube
7. Connector for pump battery

Radiosonde

The RS92 Digital Radiosonde family (RS92-SGP, RS92-AGP, or RS92-BGP) can be used with the digital interface OIF92. No special radiosonde types are required.

The RS92 Analog Radiosonde family includes special radiosonde types, the E-type radiosondes, specifically for ozone sounding. Models RS92-KE or RS92-KLE are used for analog interfacing.
The digital Vaisala Radiosondes RS92 radiosondes use digital interfacing (OIF92) with two dedicated channels (ozone sensor current and temperature) and have two additional voltage measurement channels for other purposes. Digital interfacing is available in different kits: RSA921 kit is used with ECC-type sensors produced by Science Pump Corporation model ECC6A or EN-SCI Corporation Model Z. The RSA922 kit is used with MAST Corp. Model 730-10 (Brewer-Mast type sensor). See Figure 3 below, the thermistor, connections for the radiosonde, and ozone sensor are displayed. Also notice the interface label on the rear side of the card with the coefficients needed in the calculations.

**Figure 3**  
OIF92 Interface Connections for Integrated Thermistor, Radiosonde and Ozone Sensor

The following numbers refer to Figure 3 above:

1. Thermistor
The following numbers refer to Figure 3 above:

2. Connector for radiosonde
3. Connections for ozone sensor

RSA921 Digital Interface Kit

The RSA921 kit is used with the Vaisala RS92 digital radiosonde family and with ECC-type sensors produced by Science Pump Corporation (model ECC6A) or EN-SCI Corporation (Model Z). The Kit contains following items:

1. Vaisala digital ozone interface card OIF92.
2. Interface fastening screws, spacers, and nuts (3 pcs. of each for each OIF92).
3. RSU Detainer for the radiosonde unwinder (RSU911).
4. RS92 Radiosonde holder with 2 screws.
5. RSU Stabilizer (used with parachute or radar reflector).

RSA922 Digital Interface Kit

The RSA922 Digital Interface Kit is used with Vaisala RS92 digital radiosonde family and with Mast Dev. Corp. Model 730-10, Brewer-Mast type ozone sensor. The kit contains all the items included in the RSA921 Kit, with the addition of the following factory-assembled components:

- Cell potential adjustment 0.410V ±20% trimmer
- Brewer-Mast sensor connection pin to OIF92

Equipment and Materials Needed for Sounding Preparations

There are several items needed for the preparation of the ozonesonde for flight. The following list is valid when using the SPC ECC-6A ozone sensor. However, this list and related equipment are also applicable to the EN-SCI Model Z as well as the Mast Dev. Corp. Model 730-10. Some sensor manufacturers also have their own startup kits. Note that these kits may not necessarily include all the required
items for conducting an ozone sounding. For more details, please refer to the sensor manufacturer manuals.

Expendables and Spare Parts

After the foundation of an ozone sounding site the availability of expendables and spare parts must be checked. It is recommended that a list of these items is made. A large variety of spare parts are available from Vaisala.

The list of expendables includes at least:

- Radiosondes, interfaces, ozonesondes
- Sounding accessories (for example, balloons)
- Ozone solution chemicals
- Syringes, needles
- Protection gloves
- Triple distilled or ion changed water

Ozone Sounding Start-Up Kit

Vaisala part number 13196OS.

The following list is valid when using the SPC ECC-6A ozone sensor. However, this list and related equipment are also applicable to the EN-SCI Model Z as well as the Mast Dev. Corp. Model 730-10. Some sensor manufacturers also have their own startup kits. Note that these kits may not necessarily include all the required items for conducting an ozone sounding. For more details, please refer to the sensor manufacturer manuals.

Vaisala Ozone Sounding Start-up Kit is used when starting a new ozone sounding site. It includes materials and equipment for sounding preparations. Detailed descriptions of these items are provided in Table 3 on page 17.
Table 3  Ozone Sounding Start-Up Kit

<table>
<thead>
<tr>
<th>Pcs</th>
<th>Item</th>
<th>Vaisala Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Air flow meter</td>
<td>13196 OS</td>
</tr>
<tr>
<td>1</td>
<td>Ozone destruction filter</td>
<td>13197 OS</td>
</tr>
<tr>
<td>1</td>
<td>Pump test unit</td>
<td>12785 OS</td>
</tr>
<tr>
<td>1</td>
<td>Set of laboratory ware</td>
<td>13198 OS</td>
</tr>
<tr>
<td>1</td>
<td>Ozone chemicals</td>
<td>13199 OS</td>
</tr>
<tr>
<td>1</td>
<td>Balance</td>
<td>12771</td>
</tr>
<tr>
<td>1</td>
<td>Ozonizer/Test Unit TSC-1</td>
<td>12768</td>
</tr>
<tr>
<td>1</td>
<td>Power supply</td>
<td>12767</td>
</tr>
<tr>
<td>1</td>
<td>Power cable for RS80</td>
<td>15838ZZ</td>
</tr>
<tr>
<td>1</td>
<td>Ozone extension cable for OIF11</td>
<td>12640ZZ</td>
</tr>
<tr>
<td>1</td>
<td>Ozonesonde documentation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(includes several manuals)</td>
<td></td>
</tr>
</tbody>
</table>

Notes and considerations on the ozone sounding start-up kit items can be found in the following sections.

1. The preparation start-up kit delivered by SPC (see Operator’s Manual for Model 6A ECC Ozonesonde) differs from the Vaisala start-up kit.

2. The preparation start-up kit delivered by EN-SCI (Instruction manual EN-SCI Corporation Model Z ECC-O3-sondes or product brochure) differs from the Vaisala start-up kit.

3. Triple distilled water and some other chemicals are not delivered as they are easily available locally.

4. Ozonesonde documentation contains several manuals. Refer to section Ozone Documentation on page 11 for further details.

5. Additionally, ground equipment documentation, the RS92 Radiosonde User’s Guide as well as the Ground Check Unit GC25 User's Guide, are needed to conduct a successful sounding. Please see Related Manuals on page 8. Storage bag handling, battery activation, tuning the radiosonde frequency, conducting a ground check, and many other details not covered in this manual are explained in the radiosonde and ground check unit documentation. These documents are not included in the startup kit as they include normal sounding system operation information.
A necessary basic instrument for the preparations is the Science Pump Corporation Model TSC-1 Ozonizer / Test Unit (or similar equipment).

The model TSC-1 Ozonizer / Test Unit has been designed for conditioning ECC ozonesondes with ozone and for checking the performance of the sondes prior to balloon release.

The Ozonizer / Test Unit and its operation is described in more detail in the SPC Operator's Manual for Model 6A ECC Ozonesonde and in the SPC Operator's Manual for Model TSC-1 Ozonizer / Test Unit.

The following spare parts are available for TSC-1:

- Internal Ozone Filter, OTU-17. Vaisala part number 18960.
- Other spare parts mentioned in the TSC-1 manual are also available.
Air Flow Meter

Vaisala part number 13196OS.

The equipment required for the Air Flow meter is presented in Table 4 below. Also refer to Figure 5 on page 20.

<table>
<thead>
<tr>
<th>Item Required</th>
<th>Vaisala Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air flow meter tube. Burette with filling tube, capacity 100 ml</td>
<td>12733</td>
</tr>
<tr>
<td>Rubber bulb, capacity approximately from 50 to 80 ml</td>
<td>12734</td>
</tr>
<tr>
<td>Burette stand with two bossheads and two clamps</td>
<td>12730 (stand), 12732 (bosshead), 12728 (clamp)</td>
</tr>
<tr>
<td>Stop-watch, accuracy at least 0.1 s</td>
<td>12764</td>
</tr>
<tr>
<td>Connector tube 1: soft silicon tube approximately 5 cm long, inner diameter 6 mm, outer diameter 10 mm</td>
<td>12642OS (set of tubes)</td>
</tr>
<tr>
<td>Connector tube 2: soft vinyl tube approximately 60 cm long, I.D. 1/8&quot; (3.2 mm), O.D. 1/4&quot; (6.4 mm)</td>
<td>12642OS (set of tubes)</td>
</tr>
<tr>
<td>Connector tube 3: soft silicon tube approximately 2 cm long, inner diameter 2 mm, outer diameter 4 mm</td>
<td>12642OS (set of tubes)</td>
</tr>
<tr>
<td>Dishwashing liquid: Add about one teaspoon of dishwashing liquid and one teaspoon of glycerol to 1 dl of water</td>
<td></td>
</tr>
</tbody>
</table>

Arrange the apparatus as shown in Figure 5 on page 20. Below is a description of the air flow measurement procedure.

1. Fill the rubber bulb and burette with soap solution almost up to the filling tube of the burette.
2. Connect the apparatus to the sensor cathode air exhaust tube. This is done by slipping the connector tube 3 of the apparatus over the short Teflon tube protruding from the top plug of the sensor cathode chamber.
3. With the sonde air pump operating, squeeze the rubber bulb slightly to cause several soap bubbles to rise up the burette. Repeat the process several times, until bubbles reach the top of the burette without breaking.
4. Now form one bubble, and using a stop-watch determine the time \( t \) required for the bubble to rise from 0 to 100 ml up the flow meter tube. Repeat the measurement several times to obtain a mean value. Record the result in the Preparations on the Day of Release checklist.
Figure 5  Apparatus for Measurement of Ozonesonde Air Flow Rate

The following numbers refer to Figure 5 above:

1. Stand
2. Bosshead
3. Connector tube 1
4. Rubber bulb
5. Flow meter tube
6. Clamp
7. Connector tube 2
8. Dishwashing liquid
9. Connector tube 3

**NOTE**

When air flow is being measured, the sensor should be charged with the sensing solution.
Ozone Destruction Filter

Vaisala part number 13197OS.

The following parts are required for the ozone destruction filter (see Table 5 below).

Table 5  
Equipment Required

<table>
<thead>
<tr>
<th>Item Required</th>
<th>Vaisala Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozone filter: Mine Safety Appliances Company chemical cartridge filled with</td>
<td>12769 (1 pc)</td>
</tr>
<tr>
<td>granular catalyst to decompose ozone. Delivered by MSA as a single cartridge</td>
<td></td>
</tr>
<tr>
<td>(part no. 463532) or as a 10 pcs set (part no. 466204).</td>
<td></td>
</tr>
<tr>
<td>Particle filter: Mine Safety Appliances Company ultra filter cartridge.</td>
<td>12770 (1 pc)</td>
</tr>
<tr>
<td>Delivered by MSA as a single cartridge (part no. 814922) or a 10 pcs slot</td>
<td></td>
</tr>
<tr>
<td>(part no. 815175)</td>
<td></td>
</tr>
<tr>
<td>Funnel, 75 mm in diam., tube diam. 8 mm, glass</td>
<td>12725</td>
</tr>
<tr>
<td>Connector tube 1: soft silicon tube approximately 5 cm long, inner diameter</td>
<td>12642OS (set of</td>
</tr>
<tr>
<td>6 mm, outer diameter 10 mm</td>
<td>tubes)</td>
</tr>
<tr>
<td>Connector tube 2: soft vinyl tube approximately 60 cm long, I.D. 1/8&quot; (3.2</td>
<td>12642OS (set of</td>
</tr>
<tr>
<td>mm), O.D. 1/4&quot; (6.4 mm)</td>
<td>tubes)</td>
</tr>
<tr>
<td>Connector tube 3: soft silicon tube approximately 2 cm long, inner diameter</td>
<td>12642OS (set of</td>
</tr>
<tr>
<td>2 mm, outer diameter 4 mm</td>
<td>tubes)</td>
</tr>
<tr>
<td>Connector tube 4: Cut a piece of tubing from the ECC sensor air intake tube</td>
<td>17348S (by the</td>
</tr>
<tr>
<td>(2 cm) or order separately.</td>
<td>meter) or SPC</td>
</tr>
<tr>
<td>Electrical tape (Nitto 15)</td>
<td>12524</td>
</tr>
</tbody>
</table>

Assemble the components as shown in Figure 6 below.

![Figure 6 Ozone Destruction Filter](image)
The following numbers refer to Figure 6 on page 21:

1. Catalyst
2. Ultra Fiber
3. Funnel
4. Connector tube 1
5. Connector tube 2
6. Connector tube 3
7. Tape together with electrical tape

Pump Test Unit

Vaisala part number 12785OS.

Equipment needed for the pump test unit are presented in Table 6 below.

<table>
<thead>
<tr>
<th>Item Required</th>
<th>Vaisala Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum/pressure gauge and connection screw. Range -1... 1.5 Bar, division 0.05 Bar. Includes connection parts for measurement gauge to tubing.</td>
<td>15240</td>
</tr>
<tr>
<td>Locking nut</td>
<td></td>
</tr>
<tr>
<td>Connector tube 1: soft vinyl tube approximately 60 cm long, I.D. 1/8&quot; (3.2 mm), O.D. 1/4&quot; (6.4 mm)</td>
<td>12642OS (set of tubes)</td>
</tr>
<tr>
<td>Connector tube 2: soft silicon tube approximately 2 cm long, inner diameter 2 mm, outer diameter 4 mm</td>
<td>12642OS (set of tubes)</td>
</tr>
<tr>
<td>Connection tube 3: cut a piece of tubing from EEC sensor air inlet tubes to approximately 3 cm long or order separately</td>
<td>17348S (by the meter) or SPC spare part No. OTU-19</td>
</tr>
</tbody>
</table>

Set up the apparatus as shown in Figure 7 on page 23.
Figure 7 Vacuum / Pressure Gauge

The following numbers refer to Figure 7 above:

1. Gauge and connection screw
2. Locking nut
3. Connector tube 1
4. Connector tube 2
5. Connector tube 3

How to set up the pump test unit is described in detail below.

1. Insert connector tube 1 into the locking nut.
2. Push the tube over the tip of the connection screw on the gauge.
3. Gently tighten the locking nut over the connector tube onto the gauge.

**NOTE**

Be careful when attaching connector tube 1 to the connection screw tip. Be sure to tighten the locking nut gently to avoid damaging or tearing the connection tube.

The condition of the connection tube can be checked by opening the locking nut.

4. Insert connector tube 2 into connector tube 1 by at least 5 mm.
5. Finally, insert the connector tube 3 into connector tube 2 by at least 1 cm.
Ozone Chemicals

Vaisala part number 13199OS.

The chemicals used must be very pure, at least Pro Analysis quality.

Table 7  Required Chemicals

<table>
<thead>
<tr>
<th>Chemical Required</th>
<th>Amount</th>
<th>Vaisala Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>KI</td>
<td>1 kg</td>
<td>12743</td>
</tr>
<tr>
<td>KBr</td>
<td>0.5 kg</td>
<td>12744</td>
</tr>
<tr>
<td>NaH2PO4·H2O</td>
<td>0.5 kg</td>
<td>12741</td>
</tr>
<tr>
<td>Na2HPO4·12H2O (or Na2HPO4·7H2O)</td>
<td>0.5 kg</td>
<td>12742</td>
</tr>
<tr>
<td>Methanol (CH3OH)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Glycerol</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Acetone</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Set of Laboratory Ware

Vaisala part number 13198OS.

Bottles and glassware are needed, for example, for preparing and storing sensing solutions, and for sensor cleaning. The following set is useful and easily obtained from any laboratory ware dealer. The set can also be ordered from Vaisala by referring to the part numbers.
Table 8  Laboratory Ware Needed

<table>
<thead>
<tr>
<th>Item</th>
<th>Type</th>
<th>Vaisala Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beakers (Pyrex glass)</td>
<td>1 pc, volume 250 ml, (subdivision 50 ml)</td>
<td>12721</td>
</tr>
<tr>
<td></td>
<td>1 pc, volume 50 ml</td>
<td>12720</td>
</tr>
<tr>
<td>Cylinder (Pyrex glass)</td>
<td>1 pc, volume 100 ml, (subdivision 1 ml)</td>
<td>12722</td>
</tr>
<tr>
<td>Volumetric flasks with stoppers (Pyrex glass)</td>
<td>1 pc, volume 1000 ml</td>
<td>12724</td>
</tr>
<tr>
<td></td>
<td>1 pc, volume 500 ml</td>
<td>214857</td>
</tr>
<tr>
<td></td>
<td>1 pc, volume 100 ml</td>
<td>12723</td>
</tr>
<tr>
<td>Bottles with stoppers (preferably colored glass)</td>
<td>2 pcs, volume 1000 ml</td>
<td>12738 + 12740</td>
</tr>
<tr>
<td></td>
<td>2 pcs, volume 100 ml</td>
<td>12739 + 12740</td>
</tr>
<tr>
<td>Funnels</td>
<td>2 pcs, mouth diameter 75 mm, pipe 10 mm, for liquids, glass</td>
<td>12725</td>
</tr>
<tr>
<td></td>
<td>1 pc, mouth diameter 65 mm, pipe 10 mm, for powder, polypropylene</td>
<td></td>
</tr>
<tr>
<td>Spatulas</td>
<td>3 pcs, polypropylene or steel</td>
<td>12729</td>
</tr>
<tr>
<td>Basins (polypropylene or glass)</td>
<td>2 pcs, for powder weighing</td>
<td>12727</td>
</tr>
<tr>
<td>Syringes with needle</td>
<td>Disposable; total volume 3 ml, division. 0.1 ml (at least 0.5 ml). Plastic (teflon)</td>
<td>12736</td>
</tr>
<tr>
<td></td>
<td>2 pcs, Syringe</td>
<td>12737</td>
</tr>
<tr>
<td></td>
<td>2 pcs, Syringe needle</td>
<td></td>
</tr>
<tr>
<td>Thermometer</td>
<td>1 pc, for room temperatures</td>
<td>HST12</td>
</tr>
</tbody>
</table>

Other Equipment & Materials

Balance

The balance must fulfill the following requirements:

- Measurement range must be 0 to 500 g.
- Required accuracy is 0.01 g.

Vaisala part number 12771.

Thermometer

A thermometer is needed for air temperature measurement. It can be a mercury thermometer or an electrical thermometer.
The thermometer must be capable of measuring normal room temperatures, a suitable measurement range is between -2 and +50 °C. The recommended thermometer subdivision is 0.1 or 0.2 °C.

Vaisala part number HST12 (radiosonde GC thermometer HST12).

**Power Supply**

A power supply rated at 5 to 18 VDC, 300 mA, is required for the ozone pump motor. Please refer to the manufacturer's manual for details.

The Vaisala Radiosonde RS92 is powered by the ground check equipment (GC25 or FSD25), however at times there may be a need for flexibility. Buy connector of the battery from local dealer or the use the radiosonde battery connector (spare part) and make a power cable to be used. Power supply of 9 VDC can be used for the RS92 Radiosonde.

Vaisala part number 12767.

**Protection Gloves**

Use lint-free gloves to avoid dust and other contaminants. Gloves must be lint-free, made of an artificial fabric or plastic. You can obtain disposable gloves from Vaisala by referring to part number 12735.
CHAPTER 3
SOUNDING OPERATION

This chapter explains the sounding operation in detail using a digital Vaisala radiosonde RS92 and an ozone sensor.

Steps concerning only the ozone sensor are described further in the ozone sensor manuals of manufacturers. Please see Related Manuals on page 8 for further information.

First Preparation Steps

The preparations can be divided into three main steps:

1. Preparations 3 days to 1 week prior to release
2. Preparations on the day of release
3. Sounding of the ozonesonde

Steps 1 and 2 only concern the ozone sensor, and they are described further in the ozone sensor manuals.

The preparations should preferably be done at temperatures between +20 to +30 °C.

CAUTION

The chemicals involved in ozone sounding can be harmful and must be handled with proper care. To ensure your working safety, take all the necessary cautions, before beginning the preparations for flight. Read the sensor manuals carefully. Follow local laboratory work practice, regulations and waste management guidelines.
Sounding of the Ozonesonde

Radiosonde preparation instructions are provided in the User’s Guide for RS92. Battery activation, tuning the radiosonde frequency, conducting a ground check, and many other details not covered in this manual, are explained in the radiosonde documentation. Please see Related Manuals on page 8 for further information.

Ground equipment instructions, for example for DigiCORA III and the Ground Check Unit GC25, are also available separately. Please see Related Manuals on page 8 for further information.

This procedure is meant to be carried out without any remarkable breaks (over 2 hours).

**NOTE**

To avoid contamination, observe the following precautions:

- Work in a clean environment with clean hands.
- Never operate the pump without the ozone destruction filter.
- Do not use the sensor loaded with solutions if the sensor is not connected to a powered interface (or the anode and cathode wires are connected). Do not touch anode or cathode materials.

Ozone Sounding Step-by-step

A detailed description of how to connect the parts of the ozonesonde together is provided in the following, so that the ozonesonde can be launched successfully.

**Work Area**

The first task is to place the individual parts on a table to enable a smooth operation.

Place the GC25 close to the ozonizer on the left side of the ozonizer. The RS92 radiosonde will be powered from The GC25 during ozonesonde preparations. There should be enough free space (min 500 * 500 mm) in front of the ozonizer.
Connect OIF92 and RS92 Radiosonde

Connect the interface OIF92 to the RS92 radiosonde as described below.

1. Take the radiosonde out of its storage bag, as described in the RS92 user's manual.
2. Connect the interface to the sonde, as follows:

**WARNING**  When connecting the interface, be careful with the transmitter antenna. It is recommended you hold the antenna securely under your hand to hold the sonde RS92 when connecting the interface to the radiosonde.
Figure 8  OIF92 Interface Cable and Connector Pins Inside Radiosonde

The following numbers refer to Figure 8 above:

1. Ferrite ring
2. Connector for radiosonde
3. Connector pins (located inside radiosonde)

a. Check that none of the pins on the interface connector are deformed.
b. Push the interface connector to the interface connector pins located inside the radiosonde firmly. Keep the side marked with red color of the interface cable facing the outside casing wall of the radiosonde.
c. Keep the Ferrite ring close to the radiosonde.
Connect Radiosonde Holder

The correct way to connect the radiosonde holder is described in detail below.

1. First, connect the radiosonde holder screws to the flight box.
2. Bend the holder arms as show in Figure 9 below.

![Figure 9 Radiosonde Holder, Bent Arms, and Screws](image)

NOTE

Screw the sonde holder to the styrofoam box, attach the top of the holder 5 to 10 mm below the upper edge (for ECC sensors) as shown in Figure 10 on page 32. The holder should be 20 mm from the top when using the Mast-Keystone sensor.
NOTE

Be careful not to use too much force when tightening the screws into place as the styrox material is soft.

**Connect Ozone Sensor and OIF92**

1. Remove the ozone sensor system from the polystyrene box.
2. Remove the interface calibration coefficient sheets taped on the rear side of the interface and tape it onto the Preparations Just Before (0-2 h) Release list, on page 100 of this manual. Note that the interface has the same label (e.g. B3) as the calibration coefficient sheet.
3. Screw the screw spacers (2 pcs.) onto the ozone sensor as seen in Figure 11 on page 33. Both of the ECC sensors have similar locations. When using Brewer-Mast sensor interface OIF92 is not connected to sensor body.
Figure 11  Screw Spacers Attached into SPC ECC-6A

| CAUTION | Keep the sensor in the upright position. There is liquid inside the sensor. |

4. Finally, screw the interface to these 2 spacers as seen in Figure 12 on page 34.
5. Connect the ozone sensor wires to the Interface OIF92 card. Below, the procedures for the SPC and EN-SCI sensors are described in detail.

   - For SPC sensor: The white wire (from anode) is connected to the terminal at the corner of the interface card (marked with W) and the blue wire (from cathode) to the other terminal (marked with B). For details, see Appendix A on page 89.

   - For EN-SCI sensor: There is a straight pin header connector. The blue wire to the right side and the white to the left side. See Figure 13 on page 35. Refer to Appendix A on page 89 for details.
Figure 13 EN-SCI Model Z Ozone Sensor Cables

- For **Mast Dev. Corp.** Model 730-10 sensor the connectors can be seen in Appendix A on page 89.
  a. Pin (of the sensor connector) to the hole on the corner (same as in ECC-6A. marked with W)
  b. Hole (of the sensor connector) to the pin 7.5 mm above connection mentioned above. (It fits mechanical well)

6. Insert the thermistor into the hole in the pump base of the ozonesonde, by pushing the thermistor hose into the hole as shown in Figure 14 on page 36.
7. In the SPC sensor the hole is below the air outlet tube of the pump. In the EN-SCI sensor, the temp measuring hole is on the opposite side of the pump (and is connected through the chassis).
NOTE

The Mast Dev. Corp. does not have a special location for the thermistor. Therefore with the Mast Dev. Corp. sensor the thermistor measuring head needs to be taped on the gas inlet-tube as shown in Figure 16 below or left hanging in the air as indicated by the circle in Figure 17 on page 38.

Figure 16  Thermistor Taped on Gas Inlet-Tube
8. If Mast Dev. Corp. Model 730-10 ozone sensor is used, a factory-assembled cell potential trimmer component (included in the RSA922 kit) can be seen on the OIF92 board. Sensor connection pins are not symmetrical. Refer to Figure 18 on page 39.
Conducting a Ground Check

At this stage it is recommended to conduct a ground check on the RS92 radiosonde with the GC25.

Set the radiosonde into the Ground Check Unit GC25 as described in the GC25 user manual. Turn on the GC25.

**NOTE**

With the Mast Dev. Corp. sensor it is now possible to measure and adjust the cell backward potential by measuring the voltage from the sensor connector to wanted value (0.410+-20%) volts.

- Remove the sensor connector from the interface.
- Measure the backward potential.
- Adjust it by turning the potentiometer.
- Connect the sensor back to the interface.
With all ozone sensors:

1. Connect the ozone destruction filter to the ozone sensor.
2. Connect the ozone sensor pump to its power supply with the voltage mentioned in the sensor manual. Switch the pump power ON.

**CAUTION**

Do not use the sensor loaded (pump-powered) with solutions if the sensor is not connected to a powered interface (or anode and cathode wires connected together).

Refer to the GC25 manual for details on conducting a ground check.

**Preparing Radiosonde and Ground Equipment**

Start to follow the instructions in the radiosonde RS92 and Ground Check Unit GC25 User's Guides and ground equipment manual. Please see Related Manuals on page 8 for further information.

Be sure to select the **correct interface during ground equipment use**. Give the ozone sensor and interface calibration data when asked by the ground equipment to do so.

Before typing the background current for oxygen correction the ozonesonde must have pumped room air through the ozone destruction filter for **at least 10 minutes** or more, until a steady state is reached.

Follow the ground equipment procedure. When the ground equipment is ready for sonde release:

1. Turn off the ozonesonde (always first turn off the ozone pump then the GC25) and cover the measuring boom with the boom shield.
2. Remove the ozone destruction filter.
3. Activate the sensor pump battery as described in the sensor manuals. Activate the radiosonde battery according to instructions for radiosonde battery activation. See the Vaisala RS92-series radiosondes manual for more detailed information.
NOTE

Note that ozone sensors may also use water-activated batteries which have their own separate activation instructions.

Ozonesonde Construction

NOTE

These tasks should be completed just before launch.

There is limited sounding time due to battery capacity. Construction of the ozonesonde should not exceed 20 minutes.

Detailed capacity information of the sonde battery is available in the RS92 radiosonde data sheets. The interface OIF92 reduces the battery operating time by approximately 2 to 4%. Take care that the sounding preparation time and the sounding time (while the sonde is powered from the battery) do not exceed the time, which is specified in RS92 datasheets.

SPC-6A and EN-SCI Ozonesonde Construction

1. Connect the radiosonde battery.
2. Put the ozonesonde back into the styrofoam box.
3. Set the radiosonde into its holder. The first steps are shown in Figure 19 on page 42. Insert the lower arm of the holder inside the connector location (3) and then place the support rod (2) into hole (1) in the radiosonde case.
4. To finally secure the radiosonde into the holder, assemble the two upper holder arms (1) into place (2) as shown in Figure 20 below.

5. Secure the intake tube by taping the tube to the styrofoam box.
6. Be sure that the wires for sensor battery connector are led through the groove in the styrofoam.

7. Close the cover of the flight box and tape the seam between the cover and body of the box. Do not tape the hanging strings. Do not tape over the air outlet and air intake tube to allow the measuring gas to move in and out of the sensor box.

**NOTE**

With the SPC ECC-6A sensor: Balance the sonde payload by moving the string knot located on the bottom of styrox case, and secure it with a piece of tape.
Figure 22  Attaching the Ozonesonde Cover and Radiosonde with SPC ECC-6A

The following numbers refer to Figure 22 above:

1. Strings
2. RS92 Digital Radiosonde with GPS antenna
3. Tape (seal around the cover with tape). Do not tape over air outlet and air intake tube.
4. Battery connection
In the following illustration, the EN-SCI Model Z sensor is shown ready for flight.

![Diagram of EN-SCI Model Z sensor]

**Figure 23** EN-SCI Model Z Ozone Sonde

**Brewer-Mast Model 730-10 Ozonesonde Construction**

When using the Mast-Keystone Model 730-10 Brewer-Mast ozonesonde, use the Mast assembly kit shown in Figure 24 below.

![Diagram of Brewer-Mast Assembly Kit]

**Figure 24** Brewer-Mast Assembly Kit

The following numbers refer to Figure 24 above:

1. Hanger string
2. Battery wire connection shields
3. Tube used with needle and syringe to remove solution from the sensor
4. Support tube for air intake tube
1. First assemble the metal hanger and radiosonde holder as shown in Figure 25 below.

![Figure 25 Mast Assembly](image)

2. Then assemble the air intake support tube into tube.

3. Next, assemble the hanger string as shown in Figure 26 below.

![Figure 26 Hanger String](image)

4. Close the covers and be careful of the wires. Open the air flow outlet by manually removing a piece of styrofoam. Refer to Figure 27 on page 47 and the number 1, indicating the air flow outlet to be opened.
5. Tighten the hanger string, tie a knot to the metal holder and shield with tape as shown in Figure 28 on page 48.

**NOTE**

When using the Mast Dev. Corp. Model 730-10 Brewer-Mast ozonesonde, be careful not to close the air outlet hole.
6. The ozone sensors may also use water-activated batteries and which have their own activation instructions. Activate the ozonesonde pump battery now.

The wet battery is placed into the hole in the box and the hole is sealed with tape (see the following Note).

Similar to the location of the SPC ECC-6A (as shown in Figure 30 on page 50) battery the for water-activated battery, place the battery into EN-SCI Model Z sensor housing. If a lithium battery is used it is assembled into sensor compartment. See the EN-SCI instruction manual for details. The Mast Dev. Corp. sensor also has a similar battery compartment as the ECC-sensors, see Figure 28 above for details. The pump motor wire is equipped with 9 V battery connector. Now 13 V water-activated battery is used. Cut the connector off and make a connection by winding the wires together (same color wires connected to each other) and protect the connections with shields. Alternatively two 9 V alkaline batteries (6LR61) when connected in parallel can be used. In this case, batteries are assembled inside the styrofoam case. Note that there is a risk of battery capacity failure in this case. See the following figure with alkaline batteries.
NOTE
Leave the battery connector outside and do not connect it at this stage.

NOTE
Leave the bottom edge of the ventilation hole free (do not tape over) for improved battery ventilation. Otherwise, when sealed, this can degenerate the battery performance resulting in early sounding interruption due to a lack of battery capacity.
NOTE

At this point, it is recommended that the overall functioning of the system is checked. Reconnect the ozone destruction filter to sensor intake tube. Connect the pump battery for a while and check that ground equipment the monitored values (ozone and PTU) are in order. Then disconnect the pump battery and the destruction filter.

Knot to balloon unwinder string
Seal the cover with tape
Battery connection
Battery compartment closed with tape, leave small opening for battery fumes

Figure 30  The Ozoneonde RS92 (with SPC ECC-6A)
**Rigging Preparations**

Before you begin, look at the general instructions and various rigging options presented in the RS92 radiosonde User's Guide.

Rigging construction depends on the ozone sensor type and if one of the following are used:

- Radar reflector
- Parachute

1. Connect the RSU Stabilizer to the RSU921 Unwinder and prepare balloon string connection if using parachute or radar reflector, as shown in Figure 31 below.

   If neither a parachute or a radar reflector is used in the sounding proceed to Step 2.

2. Assemble the unwinder detainer to the RS92 Unwinder by pressing the detainer head into the RS92 Unwinder.

![Figure 31 Assembly of RSU Stabilizer](image)
Figure 32  Assembly of Detainer to Unwinder

3. Then continue rigging by making the Unwinder and string connection.

Figure 33  Connect RS92 Unwinder to Styrox Box String for SPC Ozonesonde ECC-6A

Figure 34  Close-up of Connection
NOTE

When EN-SCI Model Z ozonesonde is used, the Unwinder string is firmly attached to the ring hanger, see Figure 23 on page 45.

NOTE

When Mast Dev. Corp. Model 730-10 ozonesonde is used, the Unwinder string is firmly attached to the ring of the metal rod hanger, see Figure 28 on page 48.

4. If a parachute or a radar reflector is not used connect the RSU921 Unwinder to the balloon as shown in Figure 35 below.

For other rigging options, see the related radiosonde User's Guide for further details.

![Figure 35 RSU921 Unwinder Connected Directly to Balloon](image)

5. Take the ozonesonde out when rigging is almost completed and connect the ozonesonde battery wires approximately 5 to 10 minutes prior to launch.

6. Check that data is coming through to the ground equipment. Launch the ozonesonde as in an ordinary sounding, for details refer to radiosonde User's Guide.
Checklist for Flight Preparations

Use the check list to guide and rationalize your work. Copy your check list from Appendix C on page 97. Store these check lists in your flight data files for possible later use.
Chapter 4 __________________________________ Sensor Measurement Using Interface Unit OIF92

CHAPTER 4
SENSOR MEASUREMENT USING INTERFACE UNIT OIF92

This chapter describes sensor measurement with the interface unit OIF92.

OIF92 Interface Block Diagram

The ozone sensor current and the temperature of the ozone / air in the pump have to be measured in order to determine ozone concentration. The measurement principle is described in the figure below.

Figure 36 Interface Principle
The ozone sensor current is converted to voltage by a current-to-voltage converter. The temperature of the ozonesonde pump is measured with a thermistor. The voltage channel has an amplifier. The fourth channel is similar to the voltage channel; this channel can be used to measure voltage or optional to create a driving potential for the ozone measuring cell used with the Mast ozone sensor (Model 730-10).

There is a four to one multiplexer in the interface OIF92. Four independent channels can be read. Measuring is controlled by the RS92 radiosonde. Therefore the measuring interval is also defined by the sonde. The measuring cycle of the radiosonde RS92-AGP is 0.5 s. So all sensors (PTU + add-on sensors) will be recorded twice a second. With the radiosonde RS92-SGP the measuring interval is 1 s. With this sonde all the sensors will be read once a second.

This A/D converter is an accurate 16-bit switched capacitor successive approximation Analog to Digital converter. It refers the measured voltage to a reference voltage. The result of the ADC follows following equation:

\[
\text{ADC}_{\text{out}} = \frac{V_{\text{in}}}{V_{\text{ref}}} \times 2^{16}
\]

The lowest value that the ADC sends is 0 and the highest is \(2^{16}-1\) (FFFF in hexadecimal number format). In other words with all \(V_{\text{in}}\) negative values the output will be cut to 0 (underflow) and with all \(V_{\text{in}}\) values above \(V_{\text{ref}}\) the output value will be limited to \(2^{16}-1\). The reference voltage \(V_{\text{ref}}\) for the ADC is about 4.1 V.

The interface is calibrated and temperature dependence is measured during product manufacturing. See the calibration label example Figure 37 on page 57. The temperature dependence correction algorithm is described in detail below. The mathematics are using calibration coefficients, which are printed on a paper taped on the rear side of the interface OIF92. The temperature correction is operating only in the temperature range mentioned in the OIF92 datasheets. Outside of the normal operating temperature the interface is operating with remarkable reduced accuracy. The components of the interface are operating from -40 to +85°C. Outside of these temperatures the interface may not operate at all.
**Ozone current measurement**

The current to voltage converter converts the ozone measuring current to a voltage signal. The conversion resistor is about 200 kΩ. From this conversion resistance value and the voltage reference value ($V_{ref}$) the typical gain coefficient can be counted. In other words the relation between the raw data (analog digital conversion result) measured current can be counted as follows:

$$I_{ozone} = \frac{V_{ref}}{200 \, \text{kΩ}} \times \frac{\text{ADCout}}{2^{16}}$$

Because the values of all the components are not exact, the exact gain ($V_{ref}/200 \, \text{kΩ}$) is measured during product manufacturing. The measured value is called the reference current ($I_{ref}$) and it's value at 0 °C ($I_{ref, 0C}$) is printed on a paper taped on the rear side of the interface (OIF92). The reference currents typical value is slightly over 20 µA.

$$\frac{V_{ref}}{200\Omega} = I_{ref}$$

The reference current has temperature dependence, because all the components used in the interface have temperature dependence. This temperature dependence is corrected by two temperature coefficients:

$$I_{ref, linear\_temp\_coeff}$$ /The linear temperature correction coefficient of the reference current. The typical absolute value is 40*10^{-6} /°C (50 ppm/°C), given individuals printed on the interface board label.
The quadratic temperature correction coefficient of the reference current. The typical absolute value is $5 \times 10^{-6} \degree C^2$ (10 ppm/°C²), given individually printed on the interface board label.

The base value of the reference current is the value of the reference current at 0 °C:

$I_{\text{ref}_0 C}$ /Reference current μA at 0 °C is individually given printed on the interface board label.

Current value of $I_{\text{ref}}$ is calculated now

$$I_{\text{ref}} = I_{\text{ref}_0 C} \times (1 + I_{\text{ref_linear_temp_coeff}} \times T_{\text{NTC}} + I_{\text{ref_quadratic_temp_coeff}} \times T_{\text{NTC}} ^2)$$

$T_{\text{NTC}}$ / The temperature measured by the NTC thermistor in °C

This temperature $T_{\text{NTC}}$ is the temperature of the ozone pump, measuring inlet gas temperature. The temperature difference between the interface card and ozone pump is quite small and thereby it's value can be used in the above $I_{\text{ref}}$ calculation.

In case of temperature differences, between the electronic board of OIF92 and the thermistor head, there will occur also a measuring error in the current measurement. This error can be estimated from calibration coefficients for a known temperature difference. The error is typical 40 ppm (parts per million) of the reading for each degree (°C) of temperature difference. E.g. if 5 μA is measured and there is 5 °C difference between the board and the thermistor head, there will be $5 \times 40 \times 10^{-6} \times 5 \mu A = 1 \, nA$ typical error due to the temperature difference. In the ozone sounding these size of temperature differences can only exist if outside air can be blown into the ozone sensor box (the box is not taped or sealed well).

The measurement electronic of the interface OIF92 refers all measurement to ground (0V), which is used also as the other power supply for the electronics. The electronic is not able to measure reliable voltage values very close to the ground. This problem is bypassed by offering a small offset voltage (∼33 mV) to the current to voltage converter.

With the temperature corrected reference current and the offset voltage an equation binding the analog to digital convert value and the ozone sensor current:
\[ I_{\text{ozone}} = I_{\text{ref}} \times (Ozone\_ADC\_reading - I_{\text{offset}}) / 2^{16} \]

Calculates the ozone current;

This is the result of the ozone current measurement.

**Ozone\_ADC\_reading** /this is the value that the interface AD-converted reads from the

Ozone channel (channel 0); possible values are 0..65535 (0..FFFFH)

**I_{\text{offset}}** / The analog to digital convert result, if no current is applied. (The small offset voltage (33 mV) is applied in the ADC input). The nominal value is 533. The individual value is given as printed on the interface board label. See Figure 37 on page 57.

The current to voltage converter is based on one of the most accurate commercial operational amplifier. For instance the input offset voltage (error) is less than 100 µV (typical 2..3 µV). This offset voltage applies over the measuring cell. This corresponds about 0.5 nA (maximum) in ozone measuring current. The offset current (= leak from the ozone current) of the current to voltage converter is remarkable less than 1 nA; 50 pA in normal operation temperatures.

**Temperature Measurement**

**Temperature Sensor**

The temperature is measured with a temperature depended resistor; 10 kΩ NTC-thermistor (negative temperature coefficient resistor). The resistance of the thermistor increases with decreasing of the temperature of the device. The specification values of the sensor is given in Table 9 on page 62.

**Resistance Measurement**

The resistance is measured with the following principal:
Thermistor measurement

The thermistor resistance is \( R_{ntc} \).

We can write a formula for the measured voltage:

\[
V_{ntc} = V_{ref} \times R_{ntc} / (R_{ntc} + R_{ref})
\]

This voltage is read by the ADC, which compares the measured voltage with the reference voltage \( V_{ref} \). The ADC converts the voltage to a 16-bit number as mentioned in previous chapter:

\[
ADC_{out} = \frac{Vin}{V_{ref}} \times 2^{16}
\]

So final signal out of OIF92 is as following:

\[
ADC_{ntc} = \frac{R_{ntc} \times 2^{16}}{R_{ntc} + R_{ref}}
\]

We can now get:

\[
R_{ntc} = \frac{ADC_{ntc}}{2^{16} - ADC_{ntc}} \times R_{ref}
\]

From this equation it is seen that the resistance measurement or the temperature measurement does not depend on the reference voltage. The resistance measurement depends only on the reference resistor. The reference resistor (\( R_{ref} \)) nominal value is 20 k\( \Omega \).

The error of using nominal value of \( R_{ref} \) is eliminated by using the calibrated value of thermistor at 25 \( ^\circ \)C (\( R_{ntc} - 25 \) \( ^\circ \)C) given individually printed on the interface board value. See Figure 37 on page 57. Calculation of temperature is explained in the following pages.
Please remark that the factor \( \frac{R_{ntc}}{R_{ntc} + R_{ref}} \) is with any \( R_{ntc} \) values always between 0 and 1. The ADCntc will always be inside the measuring range \( 0 \ldots 65535 \). Therefore there is no upper nor lower limit for the thermistor measuring range. Of course there are some limits from the material point of few. Somewhere above 100 °C the isolation of the thermistor melts. The highest dynamic and the most accurate measurement are at resistance values close to \( R_{ref} \). The measuring dynamic and the accuracy decrease in both directions from the \( R_{ref} \) resistance value.

The accuracy of the thermistor measurement is specified in a certain measuring range as seen in the datasheets of the interface. Outside of measuring range the accuracy and the measuring dynamic decreases smoothly. The interface is able to measure temperatures between or below -40 °C or up to about 100 °C. Sure if the temperature of the interface OIF92 is out of the operation range of the electronic specification (\(< -40 ^\circ C \) or \( > +85 ^\circ C \)) the electronic may not operate.

**Resistance to Temperature Calculation**

The resistance of the used NTC thermistor for each temperature is defined on the data sheet of the component, see also the following table.
Table 9  R-T Table for Thermistor 10K3A542I

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Relative Resistance to 10 kΩ</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 50</td>
<td>66.782</td>
</tr>
<tr>
<td>- 40</td>
<td>33.5668</td>
</tr>
<tr>
<td>- 30</td>
<td>17.6682</td>
</tr>
<tr>
<td>-20</td>
<td>9.6976</td>
</tr>
<tr>
<td>-10</td>
<td>5.5298</td>
</tr>
<tr>
<td>0</td>
<td>3.2651</td>
</tr>
<tr>
<td>+10</td>
<td>1.9904</td>
</tr>
<tr>
<td>+15</td>
<td>1.5714</td>
</tr>
<tr>
<td>+ 20</td>
<td>1.2494</td>
</tr>
<tr>
<td>+ 25</td>
<td>1.000</td>
</tr>
<tr>
<td>+ 30</td>
<td>0.8056</td>
</tr>
<tr>
<td>+ 40</td>
<td>0.5325</td>
</tr>
<tr>
<td>+ 50</td>
<td>0.3601</td>
</tr>
<tr>
<td>+ 60</td>
<td>0.2487</td>
</tr>
<tr>
<td>+ 70</td>
<td>0.1752</td>
</tr>
<tr>
<td>+ 80</td>
<td>0.1256</td>
</tr>
<tr>
<td>+ 90</td>
<td>0.0916</td>
</tr>
</tbody>
</table>

In calculation of thermistor temperature (T\text{NTC}), the calibrated value of \(R_{\text{NTC-25} °C}\) is used. The value is given as printed on the interface board label in Ω. See Figure 37 on page 57.

As seen the resistance temperature curve is badly nonlinear. Rather the resistance changes exponential depended on temperature. Actual the physics behind the resistance temperature behavior tells that the amount of free electrons in the thermistor depends mainly exponential on temperature.

Based on the physics of the thermistor it is recommended to count the temperature values from the resistance values between the points mentioned in the R-T table using a logarithm (resistance) -linear (temperature) approximation from Table 9 above.

A sample calculation clarifies the calculation procedure:

If the measured resistance value (\(R_{\text{NTC}}\)) is 14 kΩ and the calibrated value of \(R_{\text{NTC-25} °C}\) from the interface board label (in Ω) is for example:

\[
= 10014,7 \, \Omega
\]

\[
= 10,0147 \, k\Omega
\]

First divide \(R_{\text{NTC}}\) by \(R_{\text{NTC-25} °C}\) to get the relative resistance (calibrated value):
\[ \frac{R_{NTC}}{R_{NTC-25^\circ C}} = 1.397945 \]

We see from Table 9 on page 62 that the temperature is between 15 and 20 °C. We want to find out what is the temperature, when the relative resistance is 1.397945 (and the resistance 14 kΩ).

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Relative Resistance to 10 kΩ</th>
<th>( \log(\text{Relative Resistance}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 15</td>
<td>1.5714</td>
<td>0.196287</td>
</tr>
<tr>
<td>+ 20</td>
<td>1.2494</td>
<td>0.096702</td>
</tr>
<tr>
<td>to be found out (( T_{NTC} ))</td>
<td>1.397945</td>
<td>0.145490</td>
</tr>
</tbody>
</table>

The measured temperature \( (T_{NTC}) \) can be found out by a normal linear approximation from the logarithm of the relative resistance and the temperature:

\[ T_{NTC} = 15 \, ^\circ C + 5 \, ^\circ C \times \frac{0.145490 - 0.196287}{0.096702 - 0.196287} = 17.55 \, ^\circ C \]

**Temperature Rise Caused by Measurement Current Power Loss in NTC Thermistor**

It is not possible to measure a resistance without a current flowing through the resistance. This current inside the measuring resistance heats the thermistor a little. The heating power can be counted from the equation:

\[ P_{heat} = R_{ntc} \times I^2 \]

This heat increase creates a measuring error if not corrected (as we do). The error decreases by decreasing the measuring current. But with decreasing of measuring power the measuring noise increases. The measuring accuracy is optimized by selecting the \( R_{ref} \) (20 kΩ) and the reference voltage \( V_{ref}(\sim 4.1V) \).

The measuring current and generated heat can be counted from the measuring principle (picture above).

<table>
<thead>
<tr>
<th>Temperature</th>
<th>NTC heating power/mW</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10</td>
<td>0.16</td>
</tr>
<tr>
<td>0</td>
<td>0.19</td>
</tr>
<tr>
<td>10</td>
<td>0.2</td>
</tr>
<tr>
<td>20</td>
<td>0.19</td>
</tr>
<tr>
<td>30</td>
<td>0.17</td>
</tr>
<tr>
<td>40</td>
<td>0.13</td>
</tr>
<tr>
<td>Temperature</td>
<td>NTC heating power/mW</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>50</td>
<td>0.10</td>
</tr>
<tr>
<td>60</td>
<td>0.08</td>
</tr>
</tbody>
</table>

This power will cause the temperature uncorrected to rise by about 0.1 °C, if not compensated.

An equal power is used during (calibration of the interface) therefore this temperature rise is taken in account when calibration coefficients of the interface are used with the interface OIF92.

## Third and Fourth Channels Voltage Measurement

### Calculation of Voltages

The third and fourth channels are for voltage measurement.

As the following block diagram of the measurement circuit presents, the first amplifier will scale the signal to be suitable for the AD converter:

The measuring range is nominal $0 .. 2V_{ref}$ which is about $0 .. 8.2V$.

The contacts where the measured voltage must be connected are illustrated in Appendix A on page 89. The voltage measurement is a single pole measurement. It refers the voltage to the ground level. The voltage between the following contacts is measured:

```markdown
+ positive input
Ground
```

All the resistors in the above drawing are nominal 10 kΩ.
The Analog to Digital converter behind the preamplifier converts the voltage signal to a 16bit word (a number between 0 and 65535) as described in the above chapter:

$$ADC_{out} = \left(\frac{V_{in} \cdot 2^{16}}{V_{ref ch}}\right)$$

This gives value for $V_{in}$ on both channels 3 and 4:

$$V_{inch} = ADC_{OUT} \cdot \left(\frac{V_{ref ch}}{2^{16}}\right)$$

**Calibration of Channels 3 and 4**

The preamplifier for the third and fourth channels and their reference voltage non-idealities will be taken into account, if the calibrated value of $V_{ref}$ from interface calibration coefficients is used. The nominal value of $(V_{ref, ch})$ calibration coefficient for the third and fourth channels are 8.2V +- 5%.

The calibrated value of $V_{ref, ch}$ is given as printed on the interface board label. See Figure 37 on page 57.

**Input Resistance**

Remark that the input resistance for the voltage measurement is 20 kΩ as seen from the drawing. This means that the measured voltage must have a low in-built source resistance. E.g. 20 Ω in-built resistance decrease the ADC reading with 0.1%. Recommended maximum in-built resistance is 4 Ω (0.02% ADC-reading decrease). If the in-built resistance is known the error can be corrected.

Input resistance correction to measured voltage ($V_{inch}$) is included to formulation:

$$V_{in corrected} = V_{inch} \ast (1 + \frac{R_{source}}{20k \ \Omega})$$

where

- $R_{source}$ is the measured voltage in-built source resistance
- $V_{inch}$ is the measured voltage with OIF92 in channel 3 or 4
- $V_{in corrected}$ is the corrected result for OIF92
The above equation should be used to correct the reading if serial resistors are used. Serial resistor operates similar than an in-built source resistance. If the measured voltage has a remarkable additional in-built source resistance, this should be added to $R_{\text{serial}}$ in the above equation.

The voltage measurement is a single pole measurement. It refers the voltage to the ground level, which is also used to power the electronics of the interface OIF92. Equal to the ozone current measurement there is also a minimum voltage for the amplifier able to operate. This is maximum 20 mV ($=V_{\text{min}}$). If smaller voltages are applied the amplifier cannot handle them. In this case the interface OIF92 shows a value more or less random value between 0 to 20 mV.

**For Double Pole Measurements**

As written above the voltage measurement is a single pole measurement. It refers the voltage to the ground level. If a voltage difference, where the reference in not at ground level, should be measured, a $10k\Omega$ resistor should be connected between the reference (-pole) and the -negative input- contact, which is drawn in the in Appendix A on page 89. The block diagram of the measurement (for double pole) is now:
Generation of Brewer-Mast Cell Potential Voltage

If the OIF92 is used to measure the Mast Dev. Corp. Brewer-Mast ozone sensor, the fourth channel is used to create the backward cell potential. In this case the adjustable potentiometer must be installed to OIF92 and this channel is not available for any other purpose. The fourth channel reading indicates the cell driving potential.

\[
V_{cellpotential} = \frac{ADC_{outch4} \cdot V_{ref}}{2^{16}} - V_{offset}
\]

where

- \( V_{offset} \) is 33.3 mV (this offset is needed to enable current measurement near 0 value.
- \( V_{ref} \) Electronic offset voltage 4.096 V
- \( ADC_{out \ ch4} \) reading value for the 4th channel.
This page intentionally left blank.
This chapter covers ozone calculation in detail.

The ozone data is combined with meteorological sonde data: pressure (P), temperature (T) and relative humidity (U) in the ground equipment. The measuring sample interval (measures once each sensor) of the RS92 Radiosonde is 0.5 s (for RS92-SGP it is 1s). The interface OIF92 is scanned in phase with the sonde PTU-measuring sequence. Therefore all the measured data is synchronized.

Averaging and Eliminating Irrelevant Measuring Results

Filtering eliminates obvious false data. Errors originate from various different phenomena e.g. from electrical spikes.

The filtering is made by calculating the Median of a given amount of consecutive samples. The Median is the middlemost sample in order of magnitude. This algorithm cuts all remarkable higher and lower measurement results compared to other measurement results near the measurement (in a given time window). The filtering window (the amount of consecutive samples, where the median is made) is given to the ground equipment during ozone sounding preparation.

The Median calculation algorithm is well defined only for odd number of filtering window length (1, 3, 5, 7...) (amount of measurement samples in the window). Therefore the filtering window is defined in the ground equipment as the window radius; from middle to last sample or equally from the middle to the first sample. In other word the window radius indicates how many samples before and after the corresponded sample will be taken with in the filtering window. The amount of samples where the Median is calculated is as follows:
Filter Window Length = 2* Window Radius + 1

The sample radius is the value given for the ground equipment. Now if the Windows Radius is defined as an Integer, the filter window is always an odd integer and the Median algorithm is well defined.

The ozone sensor response time is typical about 40 s. The median filtering window length should be clearly shorter than the response time of the sensor to avoid cutting real ozone values of measurement results. Please remark that the length is defined as the amount of samples. Therefore there should be used different values for sondes with different sample rates. Typical value for the window radius is 10 for RS92-SGP (filtering window = 21 seconds) and 20 for RS92 types where the measuring interval is 0.5 s (filtering window = 20.5 seconds).

The Median filtering algorithm is disabled by setting the Window Radius = 0.

The ozone box temperature (-5 °C < T < +60 °C) and sensor current (>0.1µA) are done first.

Ozone Partial Pressure Calculation

The ozone sensor operating principles are explained detailed in the sensor manufacturer manuals. To clarify the ozone calculation the operation of the SPC ozone sensor ECC6A is here shortly explained.

Ozone Sensor Operating Principle

The ozone sensor used within the ozonesonde is an iodine-iodide redox electrochemical concentration cell made of two bright platinum electrodes immersed in potassium iodide solutions of different concentrations contained in separate cathode and anode chambers that are fabricated from polytetrafluoroethylene (Teflon TFE resin). The chambers are linked together with an ion bridge that serves as an ion pathway and retards mixing of the cathode and anode electrolytes, thereby preserving their concentrations. Driving emf for the cell is derived from a difference of potassium iodide concentrations present in the two half cells. See Figure 38 on page 71.
A chemical reaction starts as soon as ozone (in air) flows into the cathode solution. The reaction is an iodide-iodine redox reaction. The current can be measured when the switch S is closed. R is the load resistance of the circuit.

**Ozone Sensor reactions**

The cell system is shown in Figure 38 above. Platinum electrodes are chemically inert and they do not take part in chemical reactions. Electrochemical reactions take place in the boundary layers of the electrodes. As soon as air that contains O₃ molecules is bubbled through the cathode solution the following total reaction occurs:

\[ 2 \text{KI} + 0₃ + \text{H}_2\text{O} \rightarrow 2 \text{KOH} + \text{I}_₂ + \text{O}_2 \]  

Iodine, I₂, is formed and the I₂ concentration of the solution starts to increase. If the external circuit is closed (switch S, in Figure 38 above), reaction 1 is followed by reactions 2 and 3:

In the cathode chamber

\[ 3 \Gamma^- \rightarrow \text{I}_3^- + 2 e^- \]  

---

**Figure 38  Electrochemical Cell Construction**

[Diagram of electrochemical cell construction showing air inlet, cathode electrolyte solution, Pt-cathode, cathode chamber, ANODE, R, Pt-anode, anode electrolyte solution, ion bridge, S, and switch connections.]
In the anode chamber
\[ I_2 + 2 \text{e}^- \rightarrow 2 I^- \]  \hspace{1cm} (3)

These chemical reactions result to the following statement:

**ONE O\textsubscript{3} MOLECULE CAUSES A CURRENT OF TWO ELECTRONS**

The current is measured with the OIF92 interface.

**NOTE**

1. The reaction occurs with all oxidants (e.g. O\textsubscript{2}).
2. The chemical reaction in sensor chambers is affected by the sensor dimensions, air bubbling rate, the total liquid volume of the sensor, and the temperature of the sensor solution. These factors introduce some basic error and variance.

### Calculation of Local Ozone Values

The partial pressure of ozone is a measure for local ozone concentration. Sometimes ppm\textsubscript{v} values are used. Basic principles for this step of calculations are given in the sensor manufacturer's manuals. See Related Manuals on page 8 for details. As each molecule of ozone creates a current of two electrons, ozone concentration.

\[
C = \frac{I \cdot t}{F \cdot 2 \cdot 00ml} \]

where:

- \(C\) = ozone concentration in mmol l\(^{-1}\)
- \(F\) = \(9.6485 \cdot 10^4 \text{ C (mol)}^{-1}\) (Faraday constant)
- \(I\) = measured current in \(\mu\text{A}\)
- \(t\) = pumping time for 100 ml of air, in seconds

The partial pressure of ozone (\(P_3\)) is:

\[
P_3 = C \cdot R \cdot T_{air} = \frac{R}{F \cdot 2 \cdot 100ml} \cdot I \cdot T_{air} \cdot t \]

\hspace{1cm} (5)
R = 8.31451 K·mol⁻¹ (Molar gas constant)

Finally we get:

$$P_3 = 4.3087 \times 10^{-4} (I - I_{BG}) \cdot T_p \cdot t \cdot C_{ef} \cdot C_{ref}$$

(6)

where

- $P_3$ = partial pressure of ozone in mPa
- $I$ = measured ozone current in $\mu$A
- $I_{BG}$ = current caused by oxidants other than ozone (mainly O₂) in $\mu$A.
- $T_p$ = measured airflow temperature in K from pump base.
- $t$ = pumping time for 100 ml of air in seconds
- $C_{ef}$ = correction due to reduced ambient pressure for pump
- $C_{ref}$ = additional correction factor

**NOTE**

Each ozone sensor manufacturer has their own recommendations for calculating $I_{BG}$, $T_p$, and $C_{ef}$. For details see Related Manuals on page 8.

**Background current correction ($I_{BG}$)**

Background current correction ($I_{BG}$) is caused by oxidants other than ozone (mainly O₂). Because the concentration of ozone without any additional oxidants is wanted to be measured, the background current needs to be deducted away from the measurement current.

The amount of oxidants (mainly oxygen) will decrease during sounding when ambient pressure decreases. The Background current $I_{BG}$ is counted from the following equation recommended for the SPC ECC-6A sensor.

$$I_{BG} = \frac{(A_0 + A_1 \times P + A_2 \times P^2)}{(A_0 + A_1 \times P_0 + A_2 \times P_0^2)} \times I_0$$

(7)
\[ I_0 = \text{Background current } I_0 \text{ is measured using ozone destruction filter through, which air is pumped during the sounding preparation activities, just before release} \]

\[ P = \text{ambient pressure in hPa} \]

\[ P_0 = \text{ambient pressure when } I_0 \text{ is measured in hPa - ground pressure;} \]

\[ A0 = 0.00122504 \]

\[ A1 = 0.0001241115 \]

\[ A2 = -2.687066 \cdot 10^{-8} \]

The EN-SCI Model Z ECC-sensor recommended correction is constant:

\[ I_{BG} = I_0 \]

when \( I_0 \) is measured is measured, just before release during sounding setup configuration.

With Mast Dev. Corp. model 730-10 it is not recommended to use \( I_{BG} \).

By setting the Background current \( I_0 = 0 \), the Background current correction is disabled.

**Pumping Time for 100 ml of Air (t)**

The pumping time is measured during sounding preparations. The value is told to the ground equipment during sounding preparations.

**Measured Airflow Temperature (T_P)**

All sensors use measured values in Vaisala application. However, original Mast Dev. Corp. Model 730-10 use listed temperature values. Refer to manufacturer's documentation for details.

**Pump Efficiency Correction (Cef)**

The efficiency of the SPC Model 6A OzoneSonde air sampling pump decreases with altitude. Calculated ozone partial pressures must, therefore, be corrected for the efficiency loss. Correcting factors for Model 6A pumps, with ECC sensor cathodes filled with 2.5 cm\(^3\) sensing solution and 3.0 cm\(^3\) sensing solution, are shown in Table 2,
respectively. At pressure level (P) value of $C_{ef}$ is calculated by using linear interpolation as a function of pressure.

**Table 10 Ozone Partial Pressure Correction Factors**

<table>
<thead>
<tr>
<th>Atmospheric pressure hPa</th>
<th>Sensor cathode solution volume 2.5 cm$^3$</th>
<th>Sensor cathode solution volume 3.0 cm$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>1.160</td>
<td>1.171</td>
</tr>
<tr>
<td>3.0</td>
<td>1.124</td>
<td>1.131</td>
</tr>
<tr>
<td>5.0</td>
<td>1.087</td>
<td>1.092</td>
</tr>
<tr>
<td>10.0</td>
<td>1.054</td>
<td>1.055</td>
</tr>
<tr>
<td>20.0</td>
<td>1.033</td>
<td>1.032</td>
</tr>
<tr>
<td>30.0</td>
<td>1.024</td>
<td>1.022</td>
</tr>
<tr>
<td>50.0</td>
<td>1.015</td>
<td>1.015</td>
</tr>
<tr>
<td>100.0</td>
<td>1.010</td>
<td>1.011</td>
</tr>
<tr>
<td>200.0</td>
<td>1.007</td>
<td>1.008</td>
</tr>
<tr>
<td>300.0</td>
<td>1.005</td>
<td>1.006</td>
</tr>
<tr>
<td>500.0</td>
<td>1.002</td>
<td>1.004</td>
</tr>
<tr>
<td>1000.0</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

For other sensor manufacturer the pump correction is very similar to SPC ozone sensor only the table values differ.

For Mast Dev. Corp. ozone sensor (730-10), the following pump correction table should be used:

<table>
<thead>
<tr>
<th>P/hPa</th>
<th>$C_{ef}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;= 3</td>
<td>1.177</td>
</tr>
<tr>
<td>5</td>
<td>1.133</td>
</tr>
<tr>
<td>10</td>
<td>1.088</td>
</tr>
<tr>
<td>20</td>
<td>1.053</td>
</tr>
<tr>
<td>30</td>
<td>1.037</td>
</tr>
<tr>
<td>50</td>
<td>1.020</td>
</tr>
<tr>
<td>100</td>
<td>1.004</td>
</tr>
<tr>
<td>&gt;=200</td>
<td>1</td>
</tr>
</tbody>
</table>

For EN-SCI Model Z, the following table should be used:

<table>
<thead>
<tr>
<th>P/hPa</th>
<th>$C_{ef}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;= 3</td>
<td>1.24</td>
</tr>
<tr>
<td>5</td>
<td>1.124</td>
</tr>
<tr>
<td>7</td>
<td>1.087</td>
</tr>
<tr>
<td>10</td>
<td>1.066</td>
</tr>
<tr>
<td>15</td>
<td>1.048</td>
</tr>
<tr>
<td>20</td>
<td>1.041</td>
</tr>
<tr>
<td>30</td>
<td>1.029</td>
</tr>
<tr>
<td>50</td>
<td>1.018</td>
</tr>
<tr>
<td>70</td>
<td>1.013</td>
</tr>
</tbody>
</table>
Additional correction factor \((C_{\text{ref}})\)

There might be a reason to scale the ozone measurement values with an addition correction factor. For instance, if another (e.g., light absorption) method is usable for measuring total ozone concentration, partial pressure values can be corrected to fit the inferred total ozone value with the total ozone measurement in question.

This can be done in the ground equipment software by modifying one of the scaling calibration coefficients of the sensor. Most preferable, the pumping time for 100 ml of air should be used for this correction.

\[ t_{\text{corrected}} = t \times C_{\text{ref}} \]

**Total Ozone Calculation**

Total ozone is the integrated ozone in a column, extending from the bottom to the top of the atmosphere. Thus, it is the sum of measured total ozone from the sounding and the estimated residual ozone (for example, total ozone after burst).

\[
TOTAL \ OZONE = \Delta \Omega_S + \Delta \Omega_R \tag{8}
\]

where

\[ \Delta \Omega_S = \text{Total ozone from the sounding} \]
\[ \Delta \Omega_R = \text{Residual total ozone} \]

For further information on total ozone calculation, see Chapter 6, section Performance Review Literature, on page 82.

In the software used in Vaisala equipment, the results of total ozone calculation are in Dobson Units (DU).

**Total Ozone from Sounding**

The total ozone from the sounding is calculated by summing up the amounts of ozone in the layers between two measurement points as
expressed in Equation 9. When using the units indicated in the list below, the equation gives total ozone in units of grams per square meter (g/m²).

\[
\Delta \Omega_s = \frac{\varepsilon_3}{g} \int \frac{p_3 d\ln p_i}{p_i} + \sum_j \frac{\varepsilon_3}{g} \left( \frac{p_{3i} + p_{3i+1}}{2} \right) \ln \left( \frac{p_{3i}}{p_{3i+1}} \right)
\]  

(9)

where

\[\varepsilon_3 = 1.6571, \text{ ratio of molecular masses of ozone and air}\]
\[g = 9.80665 \text{ m/s}^2, \text{ acceleration of gravity}\]
\[p_{i...i+n} = \text{Ambient pressure, [hPa]}\]
\[i = \text{Index for a measurement point}\]
\[p_{3i...3i+n} = \text{Ozone partial pressure [mPa]}\]
\[M_3 = 48.00 \text{ g/mol, molar mass of ozone}\]

When the constants are inserted into the equation, it reduces to:

\[
\Delta \Omega_s = \sum_j 0.0845 \left( p_{3i} + p_{3i+1} \right) \ln \left( \frac{p_{3i}}{p_{3i+1}} \right)
\]  

(10)

**NOTE**
The equation above gives the ozone in grams per square meter (g/m²).

The commonly used unit for total ozone is Dobson Unit (DU = 2.687 \times 10^{20} \text{ molecules/m}²). To get the result in DUs, ozone grams must first be divided by molar mass of ozone 48.00 g/mol and then multiplied by Avogadro's number 6.02217 \times 10^{23} \text{ molecules/mol}. The result is ozone in molecules/m². The unit relation above is used to convert this to DUs.

The final equation (11) gives the result in DUs when the partial pressures are given in mPa and ambient pressures in hPa.

\[
\Delta \Omega_s = \sum_j 3.9449 \left( p_{3i} + p_{3i+1} \right) \ln \left( \frac{p_{3i}}{p_{3i+1}} \right)
\]  

(11)
Residual Ozone (Total Ozone after Balloon Burst)

After the balloon burst level ozone is estimated by using Equation 11 with a constant mixing ratio \( p_{3i} = p_{3i+1} = p_{3\text{END}} \) up to ambient pressure 0 hPa. The equation changes to:

\[
\Delta \Omega_R = \varepsilon_3 \times p_{3\text{END}} \approx 7,8899 \times p_{3\text{END}}
\]  

(12)

When the pressure is given in hPa, equation 12 gives the residual total ozone in DUs.

The total ozone can now be calculated from Equation 8.

Ozone in \( \mu g/m^3 \)

Ozone density \( \varsigma_3 \) is by definition

\[
\varsigma_3 = \frac{m_3}{V_3} ,
\]  

(13)

where \( m_3 \) = mass of ozone in volume \( V_3 \).

The ideal gas law

\[
p_3 \times V_3 = n_3 \times R \times T
\]  

(14)

where

- \( p_3 \) = Partial pressure of ozone in mPa
- \( n_3 \) = Mole number of ozone
- \( R \) = Ideal gas constant
- \( T \) = Temperature in K

gives

\[
V_3 = \frac{n_3 \times R \times T}{p_3}
\]  

(15)

and combining (13) with (15) gives
\[ \zeta_3 = \frac{m_3}{n_3 \times R} \times \frac{P_3}{T} = \frac{M_3}{R} \times \frac{P_3}{T} \]

\[ \approx \frac{48.00 \times 10^2}{8.314510} \times \frac{P_3}{T} \, \text{\(\mu g\)} \, \text{m}^{-3} \]

where

\( M_3 \) = Molar mass of ozone = 48.00 g/mol
\( P_3 \) = Ozone partial pressure in mPa
\( T \) = Temperature in K

This means that for ozone

\[ 1 \text{ mPa} \approx \frac{10 \times 48.00 \times 10^2}{8.314510} \times \frac{1}{T} \, \text{\(\mu g\)} \, \text{m}^{-3} = 5773.04 \times \frac{1}{T} \, \text{\(\mu g\)} \, \text{m}^{-3} \]
This page intentionally left blank.
CHAPTER 6
TECHNICAL DATA

This chapter provides the technical specifications for the RS92 ECC Ozoneonde, the Ozone Interface Card (OIF92), and ozone measurements.

Accuracy of the Ozoneonde Measurement

Certain sources of inaccuracy must be kept in mind when considering errors in ozone measurements. Errors can originate from the ozone sensor cell, the interface (converter), temperature and flow rate measurement, telemetry, or they can be random errors. The measurement procedure affects the accuracy. For example, if you measure only ozone partial pressure, you can do measurements in a way, which is slightly different from the method you use when calculating total ozone in the end. It is also possible to improve measurement accuracy by developing the measurement methods in the sensing system.

Basic sources for errors and differences between measurement systems (the ECC system, the Brewer sonde, light absorption measurement) are quite well known, although not completely. Relevant literature is also available, see Performance Review Literature on page 82.

NOTE
The latest detailed technical data for the RS92 Radiosonde and OIF92 can be found on the Vaisala website, www.vaisala.com

NOTE
Detailed specifications for the ozone sensors are available directly from the manufacturers or from Vaisala.
### Performance Review Literature

Below is a list of available performance review literature.

<table>
<thead>
<tr>
<th>Item</th>
<th>Name</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>D.B.B. Powell and E.L. Simmons</td>
<td>Some Laboratory and Field Investigations of the Accuracy of Brewer-Mast Ozone Sensors.</td>
</tr>
<tr>
<td>14</td>
<td>F.J. Schmidlin, B.A. Hoegger &amp; all</td>
<td>Sondex96: A Field Experiment Conducted by NASA and SMI at Payerne, Switzerland. WMO Instruments and Observing Methods Report No 70, WMO Technical Conference on</td>
</tr>
<tr>
<td>Item</td>
<td>Name</td>
<td>Details</td>
</tr>
<tr>
<td>------</td>
<td>------</td>
<td>---------</td>
</tr>
</tbody>
</table>
This page intentionally left blank.
CHAPTER 7

VAISALA HELPDESK

Getting Help

For technical questions or assistance, contact Vaisala technical support:

E-mail helpdesk@vaisala.com
Telephone +358 9 8949 2789
Fax +358 9 8949 2790

Return Instructions

If the product needs repair, please follow the instructions below to speed up the process and avoid extra costs.

1. Read the warranty information.
2. Write a Problem Report with the name and contact information of a technically competent person who can provide further information on the problem.
3. On the Problem Report, please explain:
   - What failed (what worked / did not work)?
   - Where did it fail (location and environment)?
   - When did it fail (date, immediately / after a while / periodically / randomly)?
   - How many failed (only one defect / other same or similar defects / several failures in one unit)?
   - What was connected to the product and to which connectors?
- Input power source type, voltage and list of other items (lighting, heaters, motors etc.) that were connected to the same power output.
- What was done when the failure was noticed?

4. Include a detailed return address with your preferred shipping method on the Problem Report.

5. Also include the Flight Preparations Checklist with your written comments and remarks.

6. Pack the faulty product using an ESD protection bag of good quality with proper cushioning material in a strong box of adequate size. Please include the Problem Report and Flight Preparations Checklist in the same box.

7. Send the box to:
Vaisala Oyj
Helpdesk
Vanha Nurmijärventie 21
FIN-01670 Vantaa
Finland
Radiosonde Warranty

Storage and transport of radiosondes

a) Storage
   The radiosondes must be stored and used properly and in accordance with applicable instructions, the User’s Manual, and specifications issued by Vaisala.
   Proper storage conditions must fulfill the following requirements: Radiosondes are to be kept in their original packaging (unopened vacuum envelopes) in a dry, ventilated indoor storage space, and within the following key environmental limits (ref. IEC 721-3-3 class 3K3):
   - Constant temperature, within the range of +5 °C to +40 °C
   - Constant humidity below 85 % RH

b) Transport
   Vaisala radiosondes must be transported in their original shipping packings. These packings are designed and built to survive and protect their contents in the environmental conditions described herein with the terminology and definitions per standard: IEC 60721-3-2, Transportation of radiosondes requires climatic conditions 2K2 and mechanical conditions class 2M1 of this standard:
   - Transportation in weather protected conditions.
   - Using conventional means (car, truck, and/or aircraft), with free fall not exceeding 0,25 m in any circumstance.
   - Additional markings on packing must be followed.

Warranty

Vaisala guarantees to repair or, at its discretion, replace any Vaisala radiosondes that are proven (with reasonable satisfaction) to have failed in the 13 months following the radiosonde's calibration date by reason of faulty materials or workmanship with the following conditions c)-e) providing that the storage and transport of radiosondes are done according to sections a)-b) of this document:

c) If the failure rate is in excess of 2 percent of the total delivery quantity, then each failed radiosonde type, exceeding the 2 percent limit, will be grounds for investigation and compensation of failed radiosondes.

d) The Customer shall fill in the Radiosonde Failure Report (failure report) separately for each failed radiosonde. The failure report includes information on discovered defects stating the radiosonde serial numbers, flight date and individual failure description. The Customer shall send the completed failure report(s) to Vaisala together with the radiosonde or data at the end of the calendar year. The Customer, upon request, will promptly return the failed radiosondes, complete with calibration tape and a copy of the failure report, shipment prepaid, unless Vaisala agrees to inspect and/or repair them on site.

Upon expiration of the warranty period, the total defective quantities are assessed, based on the Customers initiative, in December of the current year. If the Customer is entitled to compensation, said compensation will be delivered together with the next radiosonde delivery order. To determine any compensation, Vaisala must be able to inspect the radiosondes as they were when the failure occurred. Therefore, the returned radiosondes must be packed accordingly.

e) Criteria for Defective Radiosondes are:

   1. General:
      1.1 Radiosondes must be used in accordance with the instructions of the relevant Radiosonde User’s Manual and other instructions issued by Vaisala. The battery life time is at least 135 minutes from activation. Maximal sounding slant range is 250 kilometers.
      1.2 The ground equipment printouts and status reports or EDT-data files must be included with the individual Radiosonde Failure Reports. Raw data from failed soundings must, upon Vaisala’s request, be delivered with the individual failure reports to Vaisala for the determination of causes for failure. Early termination caused by balloon burst or external disturbance e.g. another nearby radiosonde, or other external causes, does not entitle compensation.

   2. Pre-flight failures:
      2.1 Radiosonde ground check correction values are larger than defined by the DigiCORA software.
      2.2 Radiosonde transmitter does not work, e.g. receiving equipment reports "No signal"

   3. In-flight failures between 200 meters and 100 hPa
      3.1 The radiosonde stops to transmit one or more parameters
      3.2 The radiosonde transmits obviously erroneous data
      3.3 A continuous EDT data loss exceeding the below values resulting in the need for an additional sounding:
         P > 5 min; T > 5 min; U > 5 min; W > 5 min
Radiosonde Failure Report

To be sent with the failed radiosonde, contact information below.

<table>
<thead>
<tr>
<th>Filled by</th>
<th>Station</th>
<th>Date</th>
</tr>
</thead>
</table>

**Sounding Equipment**

<table>
<thead>
<tr>
<th>Ground Equipment</th>
<th>Status Report printout attached</th>
<th>pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Processor</td>
<td>Raw Data disks included</td>
<td>pcs</td>
</tr>
<tr>
<td>Antenna</td>
<td>METGRAPH/EDT data included</td>
<td>pcs</td>
</tr>
<tr>
<td>Receiver</td>
<td>Config List printout attached</td>
<td>pages</td>
</tr>
<tr>
<td>PTU Processor</td>
<td>Additional printouts/material</td>
<td></td>
</tr>
<tr>
<td>Sounding Program Revision Number (from printout):</td>
<td>Sonde returned</td>
<td></td>
</tr>
</tbody>
</table>

**Weather at Launch**

<table>
<thead>
<tr>
<th>Present Weather</th>
<th>No precipitation</th>
<th>Fog</th>
<th>Drizzle</th>
<th>Rain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clounds group</td>
<td>Clear sky</td>
<td>Low clouds</td>
<td>High clouds</td>
<td></td>
</tr>
<tr>
<td>Temperature °C</td>
<td>Relative Humidity %</td>
<td>Wind Speed m/s</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sounding**

<table>
<thead>
<tr>
<th>Radiosonde Type</th>
<th>Serial Number</th>
<th>Parachute</th>
<th>Radar Reflector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground check</td>
<td>P Correction hPa; T Correction °C U Correction % RH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sounding preparations</td>
<td>Approximative time from battery activation to balloon launch min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balloon Type</td>
<td>Size g Nozzle lift g</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Failure Description**

<table>
<thead>
<tr>
<th>Reason</th>
<th>Material</th>
<th>GC failure</th>
<th>Failure during sounding</th>
<th>Other reason (describe below)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sounding data at failure</td>
<td>Time from start min; P hPa; T °C; U % RH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground equipment display error code</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loudspeaker sound</td>
<td>Silence</td>
<td>Noise</td>
<td>Noisy signal</td>
<td>Clear signal</td>
</tr>
<tr>
<td>Field strength</td>
<td>1 (weak)</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

**Detailed Failure Description**

| Continues on additional paper |

**Customer Contact Information**

<table>
<thead>
<tr>
<th>Customer</th>
<th>Contact Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postal Address</td>
<td>Phone</td>
</tr>
<tr>
<td>Fax</td>
<td>E-mail</td>
</tr>
</tbody>
</table>

**Complaint Sent to Vaisala HelpDesk By**

<table>
<thead>
<tr>
<th>E-mail</th>
<th><a href="mailto:Helpdesk@Vaisala.com">Helpdesk@Vaisala.com</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>Telefax</td>
<td>+358-9-8949 2790</td>
</tr>
<tr>
<td>Post</td>
<td>Vaisala Oyj HelpDesk, P.O. Box 26, FIN-00421 Helsinki, Finland</td>
</tr>
</tbody>
</table>

**Filled in By Vaisala HelpDesk**
APPENDIX A

OIF92 INTERFACE SENSOR CONNECTORS (AND ADJUSTMENT TRIMMER)

In Figure 39 below, the OIF92 interface sensor connectors (and adjustment trimmer) are shown in detail.
This page intentionally left blank.
APPENDIX B

DIGICORA III DATA FORMAT
ARCHIVED OZONE SOUNDING

From DigiCORA III archived soundings several measurement data files can be exported to be viewed with other programs as instructed in the DigiCORA III manuals. For further information see Related Manuals on page 8.

The ozone-related data can be exported in following files, calc_ozone.tsv and specsens.tsv. See the following paragraphs for details.

CALC_OZONE.tsv

The calculated and corrected values are presented in this file.

An example of the file is shown on the following page.
These are the calculated and corrected ozone measurement values during sounding starting (time = 0) from the sonde launching or manual start in DigiCORA III. In the headers of the file all the columns are defined. This file can be modified with DigiCORA III scripts so it may vary.

The ozone related parameters are self-explaining. A few words of the last 2 parameters might be advisable.

The 6th column in this case is the 4th channel Analog to Digital convert value (0 .. $2^{16}$ = 65535) of the OIF92 interface. e.g. the value 10766 respect a measured voltage of:

$$10766 / 2^{16} \times 8.192 \text{V} = 1.346 \text{V}$$
In this file the last column is the 3rd channel Analog to Digital convert value (0 .. $2^{16}$ (= 65535)) of the OIF92 interface. E.g. the value 55118 respect a measured voltage of:

$$55118 / 2^{16} \times 8.192 \text{V} = 6.809 \text{V}$$

The scale 8.192 V is the nominal scale for the interface OIF92. To get a higher accuracy instead of the nominal scale (8.192V) the calibration coefficient printed on the paper taped on the rear side of the interface OIF92 should be used.

**SPECSENSORS.tsv**

In this file all the data sent from the ozone interface is presented as sent by the ozonesonde.

Please see an example of the file on the following page.
Information about map: SPECSENSORS

Map name (internal) : EXPORTTMP000
Sounding set (internal) : 0
RS-Number : Y4827002100
Data record length : 45 bytes
Number of data records : 16728
Max filemap size : 16728 bytes
Data header size : 12504 bytes
Free space in map : -704536 bytes (95428061 records)
Status flag (not used) : 1

Record name:  Unit:  Data type:  Divisor:  Offset

<table>
<thead>
<tr>
<th>time</th>
<th>sec</th>
<th>float (4)</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>0.63</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1.63</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2.63</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3.63</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4.63</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5.63</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>6.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>6.63</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>7.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>7.63</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>8.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>8.63</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>9.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>9.63</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>10.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>10.63</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>11.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>11.63</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>12.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>12.63</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>13.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>13.63</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>14.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>14.63</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>15.13</td>
<td>10</td>
<td>00000640</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
These are the ozone interface-data that the sonde send to the DigiCORA III as they are without any processing.

The first column is the time the sonde sent the data. Starting from the moment DigiCORA III gets the first data from the sonde. The third column is the data string sent by the sonde.

With OIF92 the string is as following (as an example):

0000 6502 7b53 a4a9 082a 0000 0000 0000 0000 0000 0...

First word is 0000 (as Hexadecimal number) telling that OIF92 is connected; for a different sensor/interface there will be a different code.

With OIF92 the words 2..5 are the Analog to Digital convert channel data in hexadecimal numbers, written in order LSB (least significant byte) first and MSB (most significant byte) as second.

The string can be interpreted as following:

The first channel is the ozone current channel:

65 02 => 02 65 (LSB and MSB switched)

so the ADC reading of the first channel was 0265 as a hexadecimal number.

0265 as hexadecimal => 613 as a normal integer number.

This 613 is be used to calculate the ozone current as described in this manual. This value corresponds an ozone current of about 24 nA. Exact value depends on the calibration coefficients.

The second channel is the thermistor channel:

7b 53 => 53 7b (LSB and MSB switched)

537b as hexadecimal => 21371 as a normal integer number.

According to the mathematics of thermistor channel (as described in this manual) this corresponds a temperature measurement of about 25 ºC.

The third channel is for voltage measurement.

a4 a9 => a 9a4 (LSB and MSB switched)

a9a4 as hexadecimal => 43428 as a normal integer number.
And as a voltage 5.428 V

The fourth channel is also for voltage measurement.

08 2a => 2a 08 (LSB and MSB switched)

2a08 as hexadecimal => 10760 as a normal integer number.

And as a voltage 1.345 V
APPENDIX C

FLIGHT PREPARATIONS CHECKLIST
FOR SPC ECC-6A OZONE SENSOR
WITH DIGITAL OIF92 INTERFACE

For your convenience, the checklist for flight preparations begins on
the following page. The limit values mentioned in this document are
valid only for SPC ECC-6A ozone sensor. Photocopy the checklist for
easy handling. Use the list to record advance preparations,
preparations on the day of release, 0 to 2 hours prior to release, and
post launch data.

For other ozone sensors, a modified checklist should be created and
used.
Advance Preparations 3 to 7 Days prior to Release

1. Date____ ________Station__________ Operator_________
   
   **Note:** Record information below or place removable label here.
   
   Ozonesensor number: __________________
   Manufacturer: __________________
   Date of manufacture: __________________
   Pump pressure: __________________ in Hg
   Pump voltage: __________________ V DC
   Pump current: __________________ mA
   Flow rate: __________________ s/100 ml

2. Connect ECC sonde to ozonizer/test unit (motor, output, sensor leads).

3. Condition pump and dry sensor with HI O₃ for 30 min.
   After 10 minutes of HI O₃:
   
   **Measured** | **Limit Values**
   Pump voltage: ________ V | 12 ... 13 V
   Pump current: ________ mA | <115 mA
   Head pressure: ________ Pa | $\geq 670 \text{ hPa} \approx 20 \text{ in Hg}$
   Vacuum: ________ Pa | $\geq 670 \text{ hPa} \approx 20 \text{ in Hg}$
   
   (Normal head pressure and vacuum values are 700 ... 900 hPa)

4. Shut of HI O₃, run NO O₃ for some minutes.

5. Charge sensor **cathode** with solution: 2.5 cm³ 3.0 cm³
   Charge sensor **anode** with solution: 1.5 cm³

6. Sensor background current after 5 min on NO O₃: ________ µA

7. Sensor response to LO O₃ (5 µA): ________

8. Run on NO O₃ for 10 min and store sonde in dark clean-air environment at a temperature of 20 ... 25 °C until use. ________
Preparations on the Day of Release

Date ___________ Station __________ Operator ________
Ozonesensor number: ________________
Manufacturer: _______________________
Date of manufacture: _________________

9. Run sonde motor for 5 minutes on NO O3. _____

10. Pump performance check:

<table>
<thead>
<tr>
<th>Measured</th>
<th>Limit Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump voltage:</td>
<td>______ V</td>
</tr>
<tr>
<td></td>
<td>12 ... 13 V</td>
</tr>
<tr>
<td>Pump current:</td>
<td>______ mA</td>
</tr>
<tr>
<td></td>
<td>&lt;115 mA</td>
</tr>
<tr>
<td>Head pressure:</td>
<td>______ Pa</td>
</tr>
<tr>
<td></td>
<td>≥670 hPa ≈ 20 in Hg</td>
</tr>
<tr>
<td>Vacuum:</td>
<td>______ Pa</td>
</tr>
<tr>
<td></td>
<td>≥670 hPa ≈ 20 in Hg</td>
</tr>
</tbody>
</table>

11. Condition pump **only** with HI O3 for 10 to 20 min. _____

12. Change cathode solution in SONDE (S) and CAL (calibrator, C) sensors:

S: ________ ml

C: ________ ml

13. SONDE (S) and CAL (C) conditioned with NO O3 for 10 min. _____

14. Sensors background currents (<0.2 µA):

ibc= ________ µA

ibs= ________ µA

15.-16. Condition SONDE and CAL sensors with 5±0.2 µA O3 for 10 min.

Measure:

SONDE sensor air flow rate: \( t_s = \) ____, ____ , ____ s

CAL sensor air flow rate: \( t_c = \) ____ , ____ s

\( T_{room} = \) ______ °C; \( P_{room} = \) ______ hPa; \( RH_{room} = \) _____%

17. After 10 min of conditioning with about 5 µA O3:

\( i_s = \mu A \) ______  \( i_b = \mu A \) _____

Sensor response test:

\( i_1c = \) ______ µA  \( i_1s = \mu A \) _____ 1 minute

\( i_2c = \) ______ µA  \( i_2s = \mu A \) _____ 2 minutes

\( i_3c = \) ______ µA  \( i_3s = \mu A \) _____ 3 minutes
i_{10c}: \mu A \quad i_{10s}: \mu A \quad 10 \text{ minutes}

Computed for calibration acceptance check out:

\( (i_c-i_{bc}) t_c = \ldots \) \quad \( (i_s-i_{bs}) t_s = \ldots \) (agree to within 5 %)

\( i_{1c} = \ldots <0.20 \) \quad \( (i_c-i_{bc}) = \ldots \)

\( i_{1s} = \ldots <0.20 \) \quad \( (i_s-i_{bs}) = \ldots \)

Preparations Just Before (0-2 h) Release

Date ____________ Station__________ Operator_________

Ozonesonde number: __________________
Manufacturer: __________________
Date of manufacture: __________________

18. Radiosonde serial number: __________
19. Ozonesonde interface OIF92 serial number: __________

tape (or copy) the interface calibration sheet in the space below:

20. Connect the OIF92 interface cable to the RS92 sonde ___
21. Connect the radiosonde holder to the styrofoam box. ___
22. Connect the Interface OIF92 to the ozone sensor
   Insert thermistor into the pump base. ___
23. Attach ozone destruction filter to pump inlet tube. ___
24. Put ground equipment (e.g. DigiCORA III and GC25) for
   radiosonde on and make sounding preparations for them.
   - Feed in basic values for sounding program
   selecting the correct interface (ozone OIF92) in
   the ground equipment initialization. ___
Appendix C  Flight Preparations Checklist for SPC ECC-6A Ozone Sensor with Digital OIF92 Interface

- Check radiosonde and system operation (data coming through).
- Make the ground check for the sonde RS92

25. Construct the ozone sonde
   - Place the ozone sonde into it's flight case
   - Assemble the flight case cover and seal with tape. Note also hangers.

26. Connect the ozone sensor pump to its power supply and turn the ozone pump on.

27. Check that ozone data is coming through, showing reasonable ozone current and ozone box temperatures.

28. Run ozonesonde for 10 min (with ozone destruction filter on for sensor background values):
   Background sensor current: ______________ µA (≤0.2 µA)

29. Enter the measured background value into PC program.

30. Turn ozonesonde pump off first.

31. Remove the radiosonde from the GC25.

32. Remove the ozone destruction filter.

33. Prepare the rigging for sounding
   - Construct the rigging. Note that different installations are used depending on the components of the sounding.
   - Always use the RSU921 Unwinder and RSU Detainer,
   - If either a radar reflector or parachute is used, connect the RSU Stabilizer.

34. Activate radiosonde battery (not more than 20 min prior to release).

35. Pack ozonesonde and radiosonde ready for flight. Do not connect ozonesonde battery wires, leave connections outside.
   Activate ozonesonde battery (20 minutes prior to release) and pack battery into sonde (do not connect ozonesonde motor wires), check telemetry.

36. Take ozonesonde outside and connect pump motor battery wires.

37. Launch the sounding.
Post-Launch Data

38. Enter surface data as instructed in ground equipment manual:

Launch time:

\[ P_{surf} = \quad \text{hPa} \]
\[ T_{surf} = \quad \text{°C} \]
\[ U_{surf} = \quad \% \text{RH} \]

Surface wind speed: \quad \text{m/s} \quad \text{Wind direction:}

\[ \quad \]

Sky condition:

Sounding storage file:

Other information:
APPENDIX D

CHECKLIST FOR EQUIPMENT AND SUPPLIES FOR FLIGHT PREPARATIONS

For detailed information on equipment, see section Equipment and Materials Needed for Sounding Preparations on page 15.

1. Ozone sensor, with polystyrene flight box, and motor battery
2. Vaisala RS92 series radiosonde.
3. Vaisala OIF92 ozone Interface card,
4. Balloon (plastic or rubber)
5. 5 meters of string (strength about 300 to 500 N) and possibly unwinder and detainer
6. Optional: Parachute, 200-inch (500 cm) circumference
7. Short circuit cable for the ozone sensor (optional)
8. Ozonesonde interface-radiosonde extender test cable
9. Bottle, for sensor cathode solution prepared according to instructions
10. Bottle, for sensor anode solution prepared according to instructions
11. Bottle, for distilled H₂O
12. Syringe, 3 ml volume (equipped with Teflon tube), for use with sensor cathode solution
13. Syringe, 3 ml volume, for use with sensor anode solution
14. Roll of firm tape, 2 inches (5 cm) wide
15. Apparatus for measuring ozone sensor air flow rate
16. Ozonesonde power supply for pump motor rated at 12 to 13 VDC, 300 mA
17. Radiosonde power supply rated at 9 VDC, 300 mA, with adapter cable for radiosonde plug (not delivered by Vaisala, see Power Supply on page 26. In normal operation, the Vaisala RS92 Radiosonde is powered by the GC25 or FSD25 ground check unit.

18. SPC Ozonizer / Test Unit Model TSC-1 with adapter cables
19. Ozone destruction filter
20. Thermometer graduated in degrees centigrade
21. Hand-held pressure / vacuum gauge for pump tests
22. Small strips of No. 600A sandpaper for grasping Teflon tubing
23. Plastic squirt bottle filled with research-grade methanol
24. Methanol and acetone for cleaning
25. Pair of lint-free gloves for laboratory work (made of artificial fabric or plastic, disposable)