**Requirement Specification**

**FT-IR instrument for gas phase analysis**

1. **Requirements**

**1.1. Description of the requirement**

DALO wish to acquire a Fourier Transform Spectrophotometer for gas analysis. The instrument must be a high resolution instrument that can fit on a standard laboratory benchtop. The instrument must be capable of analyzing impurities in Aviator’s Breathing oxygen and breathing gases for scuba divers. The quality requirements are outlined in Appendix 1.

The delivery must include software and computer hardware enabling identification and quantification of the analytes. The expected (but not required) solution is either two or more fixed length gas cells or one variable length gas cell.

Desired wavelengths: MID-IR, 400 – 4000 cm-1

**1.2. Description and definitions**

The requirement specification, cf. section 1.4, describes all the requirements for the acquisition and consists of six columns with the following information:

|  |  |
| --- | --- |
| "#" | ID number |
| "Requirement" | Requirement description |
| "Classification" | The classification of the requirement as further described in section 1.3 |
| "DALO remarks" | Further information regarding the requirement |
| "Requirement compliance" | The tenderer's indication of compliance (YES or NO) |
| "Tender description" | Requirements regarding the tenderer's compliance description |

**1.3. Classification**

All requirements are mandatory requirements (SHALL) and shall be fulfilled by the tenderer. If just one of the mandatory requirements is not fulfilled, the tenderer's tender will not be taken into further consideration.

**1.4. Requirement and response sheet**

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| --- | --- | --- | --- | --- | --- | --- |
| **#** | **Requirement** | **Classification** | **DALO remarks** | **To be filled out be the tenderer** | | |
| **Requirement compliance**  **(tick a box)** | | **Tenderer's description** |
| **YES** | **NO** |
| **1** | **Technology**  The instrument shall use Fourier transform infrared (FTIR) spectroscopy technology to perform the analysis | SHALL |  |  |  |  |
| **2** | **Gas cell(s)**  The gas cell(s) shall be compatible with 99.5% oxygen | SHALL |  |  |  |  |
| **3** | **Sample composition**  The instrument shall be able to analyze gas samples with the compositions specified in Appendix 1. | SHALL | Appendix 1 specifies the quality requirements for the gas samples |  |  |  |
| **4** | **Sample composition**  The instrument shall be able to detect the compounds listed in Appendix 1. | SHALL | The relevant compounds are listed under “Determined by FT-IR” |  |  |  |
| **5** | **Quantification limits**  It shall be possible to quantify the compounds listed in Appendix 1 at the specified concentrations. | SHALL | The relevant compounds are listed under “Determined by FT-IR”.  A signal-to-noise ratio of 10 after data treatment is necessary for quantification. |  |  |  |
| **6** | **Electricity requirements**  The instrument shall run on a 230 V standard European power supply. | SHALL |  |  |  |  |
| **7** | **Size**  The instrument shall fit on a standard laboratory bench with the following available space: 82 cm X 160 cm. | SHALL |  |  |  |  |
| **8** | **Sample introduction**  It shall be possible to interface the gas cell with an external sampling and pressure reduction system. | SHALL | Samples are typically contained in pressure vessels with pressure between 10 and 150 barg |  |  |  |
| **9** | **Detector(s)**  The instrument shall be equipped with one or two detectors for detection of the compounds listed in Appendix 1. | SHALL |  |  |  |  |
| **10** | **Detector(s)**  If two detectors are used, these shall be mounted in the instrument simultaneously and it shall be possible to use the software to switch between measurements on the detectors. | SHALL |  |  |  |  |
| **11** | **Detector(s)**  The detector(s) shall function without the need for external cooling nor by supplying cryogenic gasses. | SHALL | If cooling of a detector is necessary, this shall be an integral part of the instrument that can be controlled by the software |  |  |  |
| **12** | **Window material**  The window material shall be compatible with the sample types listed in Appendix 1 | SHALL |  |  |  |  |
| **13** | **Wavelengths**  The instrument shall measure in the MID IR spectrum. The minimum required wavenumber interval is 400-4000 cm-1. | SHALL |  |  |  |  |
| **14** | **Software**  Software for instrument control, analysis and data handling shall be included in the tender | SHALL |  |  |  |  |
| **15** | **Library**  The software shall include one or more libraries of gases and common impurities | SHALL |  |  |  |  |
| **16** | **Library**  It shall be possible to evaluate a measured spectrum against the library to obtain a list of matching compounds | SHALL |  |  |  |  |
| **17** | **Data analysis**  The software shall be able to perform quantification using both Beer-Lambert law and multivariate quantification (including Partial Least Square regression) | SHALL |  |  |  |  |
| **18** | **Reference materials**  Quantification shall be based on one or more calibration gases. | SHALL |  |  |  |  |
| **19** | **Calibration gases**  The calibration gases shall be provided by the instrument supplier. | SHALL |  |  |  |  |
| **20** | **Quantification**  The quantification methods shall be provided and implemented by the instrument supplier or a subcontractor of the instrument supplier as part of the installation. | SHALL |  |  |  |  |
| **21** | **Quantification**  Quantification shall be made using actual measurements and extrapolations of these where necessary. | SHALL | Quantification of a compound requires a signal-to-noise ratio of at least 10 after data treatment. |  |  |  |
| **22** | **Computer**  A PC running on the newest Windows version including one monitor of at least 17 inches shall be included. | SHALL |  |  |  |  |
| **23** | **Delivery**  The instrument shall be delivered to the Danish Defence Laboratory, Perimetervejen 71, DK-3500 Værløse, Denmark. | SHALL |  |  |  |  |
| **24** | **Installation**  The instrument shall be installed at the Danish Defence Laboratory, Perimetervejen 71, DK-3500 Værløse, Denmark. | SHALL |  |  |  |  |
| **25** | **Installation**  The instrument’s ability to perform the required measurements, based on measurements performed on the calibration gases, shall be demonstrated on site as part of the installation. | SHALL |  |  |  |  |
| **26** | **Service**  A service contract shall be included in the tender.  The service contract shall include annual preventive maintenance (PM) according to the instrument manufacturer’s specification for 5 consecutive years starting in the calendar year after installation (ie. 2024, 2025, 2026, 2027, and 2028). | SHALL |  |  |  |  |
| **27** | **Service**  The service contract shall include software patches and upgrades | SHALL |  |  |  |  |
| **28** | **Service**  The service contract shall include all expences related to PM, including labor, transport and accomodation | SHALL | Spare parts and consumables shall not be included |  |  |  |

**Appendix 1. Quality requirements for various breathing gases**