Maintaining IMS particulate radioactivity measurement capabilities – integration of a next generation automated air sampler – Cinderella G2

Aleksandr Tarasov, Bernd Wernsperger, Richard Britton, Nikolaus Helmut Hermanspahn

P3.1-299
The verification regime of the CTBT includes radionuclide monitoring technology which comprises 80 stations distributed around the globe. Basic components of a radionuclide station include a **high-volume air sampler**, a gamma ray detection system, and a communication link. Around 36% of installed IMS radionuclide stations are equipped with automated air sampling systems. 5 stations (7% of installed base) are built based on the automated air sampler **CINDERELLA** by Senya Ltd., Finland.

**Air sampler “Cinderella” G.2 - Introduction**
## Air sampler “Cinderella” G.2 - Technical specifications

The relevant technical specs of the industrial prototype meet Minimum Requirements for Particulate Monitoring System Specifications.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Requirements</th>
<th>CINDERELLA sampler parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Manual or automated</td>
<td>Manual or automated</td>
<td>automated</td>
</tr>
<tr>
<td>Airflow</td>
<td>≥ 500 m³/h</td>
<td>&gt; 550 m³/h in STP with clean filter</td>
</tr>
<tr>
<td>Collection time</td>
<td>24 h</td>
<td>fulfilled</td>
</tr>
<tr>
<td>Collection efficiency for filter</td>
<td>≥ 80% at Ø = 0.2 µm</td>
<td>&gt; 80% for particles of 0.2um diameter</td>
</tr>
<tr>
<td>Collection efficiency Global</td>
<td>≥ 60% at Ø = 10 µm</td>
<td>&gt;60% for particles of 10um diameter</td>
</tr>
<tr>
<td>Decay time</td>
<td>≤ 24 h</td>
<td>fulfilled</td>
</tr>
<tr>
<td>Time before reporting</td>
<td>≤ 72 h</td>
<td>fulfilled</td>
</tr>
<tr>
<td>Measurement time</td>
<td>≥ 20 h</td>
<td>fulfilled</td>
</tr>
<tr>
<td>Measurement mode</td>
<td>HPGe high resolution gamma spectrometry</td>
<td>HPGe detectors are supposed to be in use as a pat of the system</td>
</tr>
<tr>
<td>Auxiliary data</td>
<td>Meteorological data, Flow rate, SoH data</td>
<td>— Connection for the WXT536 weather station. — Air flow calculation in real-time in m³/h at STP (273.15K, 101.325 Pa) — Air flow measurement accuracy equal or better than + 5%</td>
</tr>
</tbody>
</table>
Air sampler “Cinderella” G.2 - Other technical specifications

- 30 cassettes (automated cycles) as standard, option for 60;
- Traceable 3rd body calibration available;
- Filter size: 460 x 285mm, active area 15 x Ø77mm;
- Laboratory quality background shielding, 10 cm wall thickness, 1mm Cu and 2.0 mm Sn lining inside;
- Split type lead shield cover, mounted permanently into the body of the sampler;
- Shielding has a form of cylinder, made of casted lead, OD Ø450 x ID Ø250mm, IH 250mm.;
- Hidden beakers, only the decay beaker is still in the robot compartment;
- New and used beakers handled through beaker compartment;
- LED lightning in the robot compartment.

The dimensions are:
- Length ~2300 mm
- Width ~ 1400 mm
- Hight ~ 2000 mm

Total weight (shielding is included) ~ 1500 kg

Power:
- Main pump, 2BH1900-7AH07, 9kW, 3-phase,400V/50Hz, N, PE;
- Electronics powered throw the UPS that connected to the single-phase power supply source;
- Omron frequency converter with PID flow control and motor PTC.

The pump is a separated part/unit. The dimensions are:
- Length ~1200 mm
- Width ~ 800 mm
- Hight ~ 1000 mm

Total weight ~ 300 kg
The CINDERELLA sampler provides manual and automated modes to manipulate samples. In daily routine the sampler is run in automated mode with sampling time, decay time and measurement time adjusted for Minimum Requirements for Particulate Monitoring System Specifications. The sampler is operated in manual mode for maintenance and calibration purposes.

**Air sampler “Cinderella” G.2 - Process**

- **MANUAL**
  - Filter/beaker refilling
  - Start sampling
  - Stop sampling
  - Run filter change
  - Calibration measurement

- **AUTOMATED**
  - Load new:
    - filters
    - beakers
  - Select mode
  - Select regime
  - Special measurements (Blank, background)
  - Routine measurements
  - Every 30 samplings:
    - Prepare new 30 cassettes
    - Removed stored samples

**Diagram:**

1. New filter cassettes in New Cassette Storage
2. Used Cassette Storage empty
3. Empty beaker in lead shield
4. Empty beaker in decay position
5. New beakers in New Beaker Storage
6. Used Beaker Storage, only bottom plate

**Initial position before starting**

**Disclaimer:** The views expressed on this poster are those of the author and do not necessarily reflect the view of the CTBTO.
Air sampler “Cinderella” G.2 – Process.
Sequence of manipulations in automated mode

1. Pump stops.
2. Cassette is changed.
   When cassette change is done the pump starts.
3. Filter is cut and put to a new beaker E.
4. Cut cassette is moved to Storage B.
5. Lead shield is opened.
6. Beaker from Lead Shield is moved to Used Beaker Storage F.
7. Decayed beaker is moved to Lead Shield.
   Now when robot arm is in the Lead Shield,
   there is 15 min pause for QC measurements.
8. Lead Shield is closed.
9. Today cut filter beaker is moved to Decay D.
10. Robot returns to parking position.
Data outputs interface:

- Ethernet/RJ45, all measured data are retrieved through Ethernet

Cinderella PC is identified by its IP address, and provides via Ethernet all relevant data in data string to RSSI:

- Cinderella operational status,
- sampling data,
- weather data,
- bar code reading.

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle ID</td>
<td>[0]</td>
</tr>
<tr>
<td>Changing ordinal [6:0f]</td>
<td></td>
</tr>
<tr>
<td>Start time of sampling [dd.mm.yyyy hh:mm:ss]</td>
<td></td>
</tr>
<tr>
<td>Update time [dd.mm.yyyy hh:mm:ss]</td>
<td></td>
</tr>
<tr>
<td>Sampling duration [hh:mm:ss]</td>
<td></td>
</tr>
<tr>
<td>Air flow [m3/h]</td>
<td>[6:1f]</td>
</tr>
<tr>
<td>Total Volume (m3)</td>
<td>[9:1f]</td>
</tr>
<tr>
<td>Pressure difference over orifice, [6:1f]</td>
<td></td>
</tr>
<tr>
<td>Static pressure at orifice, [6:1f]</td>
<td></td>
</tr>
<tr>
<td>Temperature at orifice, [6:1f]</td>
<td></td>
</tr>
<tr>
<td>Air temperature, [6:1f]</td>
<td></td>
</tr>
<tr>
<td>Rain information, [7:1f]</td>
<td></td>
</tr>
<tr>
<td>Rain duration, [4:1f]</td>
<td></td>
</tr>
<tr>
<td>Sampler ON/OFF, [1d]</td>
<td></td>
</tr>
<tr>
<td>Wind speed, [3:0f]</td>
<td></td>
</tr>
<tr>
<td>Wind direction [4:1f]</td>
<td></td>
</tr>
<tr>
<td>Wind speed, 10 min avg, [3:0f]</td>
<td></td>
</tr>
<tr>
<td>Wind direction, 10 min avg, [4:1f]</td>
<td></td>
</tr>
<tr>
<td>Relative humidity, [5:1f]</td>
<td></td>
</tr>
<tr>
<td>Tapper status 0 (0): [1d]</td>
<td></td>
</tr>
<tr>
<td>Carbon air flow, only in systems with carbon cartridges, [6:1f]</td>
<td></td>
</tr>
<tr>
<td>Carbon pressure difference, only with carbon systems, [6:1f]</td>
<td></td>
</tr>
<tr>
<td>Carbon total volume, only with carbon systems, [3:1f]</td>
<td></td>
</tr>
<tr>
<td>Calculation code, 1=short Semlin, 2=STP, [1d]</td>
<td></td>
</tr>
<tr>
<td>End of text (ASCII Code 003)</td>
<td></td>
</tr>
</tbody>
</table>

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Air sampler “Cinderella” G.2 – 2 Integration into the standard IMS configuration

The entire In-house project for the integration of Cinderella 2 into IMS framework, including new SW with full control of the development from the PTS.

Manual RN station hardware configuration

“Cinderella” G.2 based on the RN station hardware configuration

The main principles of the integration:

• Keep (as much as possible) commonalities with manual station configuration
• Use of the same ancillary equipment:
  o weather transmitter
  o environmental and tamper sensors
  o UPS as for manual station
  o Authentication
• Use of the same detectors, with flexibility in detector choice
• Use of the same software and computer hardware

Several daily manual tasks: Filter change, Sample preparation, measurements, etc. Each step with the possibility of human errors.

One monthly manual task, minimal possibility of human errors.
Air sampler “Cinderella” G.2 – 2 Integration into the standard IMS configuration

The entire In-house project for the integration of Cinderella 2 into IMS framework, including new Software with full control of the development from the PTS.

- All aspects controlled via new RSSI browser interface
- Cinderella specific module (Automated SO) continually updates status via poll
- Automatically performs routine tasks that currently require manual operator (measurement, etc.)

Radionuclide Station Software Interface

- Authentication fully integrated via a web API
- Supports multiple tokens for flexibility
- Based on Python & OpenSC, maintainable
- Easy to set up
Steps for integration Air sampler “Cinderella” G.2 into the standard configuration

- Cinderella Hardware testing and combining with other equipment:
  - Test of routine and special automated and manual operation modes
  - Assess lead shielding design change to accommodate multiple detector types
  - Integration with a detector system, DAS, ancillaries and an uninterrupted power supply
- Software: new RSSI upgrade to interface CINDERELLA G2 outputs
- Hardware upgrades:
  - Integration a QC source into CINDERELLA G2 (as for G1)
  - Integration with authentication tokens
- 6 months testing with full configuration
- Developing Standard Operation Procedures (SOP)
- System acceptance

START in Q3 2019

<table>
<thead>
<tr>
<th>Item</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware</td>
<td>80%</td>
</tr>
<tr>
<td>Software</td>
<td>70%</td>
</tr>
<tr>
<td>SOP</td>
<td>30%</td>
</tr>
<tr>
<td>Testing</td>
<td>20%</td>
</tr>
</tbody>
</table>

EXPECTED FINISH in Q4 2021
Air sampler “Cinderella” G.2 – Roll-out plan

As the old Cinderella systems have reached obsolescence and frequent problems are encountered, it is planned to roll out installation of Cinderella G2 systems without delay (after the new station configuration has been accepted). The test system has been assigned to RN63 and will be transferred and installed at RN63 once testing is complete. All five stations are planned to be upgraded within a 2-3 year time frame.

<table>
<thead>
<tr>
<th>Station</th>
<th>Upgrade</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISP34 (Reykjavik)</td>
<td>Q1 2023</td>
</tr>
<tr>
<td>MXP44 (Mexico)</td>
<td>Q1 2023</td>
</tr>
<tr>
<td>NOP49 (Spitsbergen)</td>
<td>Q2 2022</td>
</tr>
<tr>
<td>PTP53 (Ponta Delgada)</td>
<td>Q1 2023</td>
</tr>
<tr>
<td>SEP63 (Stockholm)</td>
<td>Q1 2022</td>
</tr>
</tbody>
</table>