Chapter 13

The Technology Demonstration of the Third Generation JPL Electronic Nose on the International Space Station

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ABSTRACT

This chapter describes the development, operation, and experimental results of the Third Generation JPL Electronic Nose (ENose), which operated on board the International Space Station (ISS) as a technology demonstration for seven months from 2008-2009. The JPL ENose is an array of chemiresistive sensors designed to monitor the environment for the sudden release of targeted chemical species, such as leaks or spills. The Third Generation JPL ENose was designed to detect, identify, and quantify eleven chemical species, three inorganic, ammonia, mercury, and sulfur dioxide, and eight organic compounds, which represent common classes of organic compounds such as alcohols, aromatics, and halocarbons. Chemical species were quantified at or below their 24 hour Spacecraft Maximum Allowable Concentrations.

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**INTRODUCTION**

The JPL Electronic Nose (Ryan, 1997, 1998, 2000, 2001, 2004a, 2004b) is an event monitor designed and built for near real time air quality monitoring in crew habitat aboard the space shuttle/space station. This is an array–based sensing system which is designed to run continuously and to monitor for the presence of selected chemical species in the air at parts-per-million (ppm) to parts-per-billion (ppb) concentration ranges. The Jet Propulsion Laboratory (JPL) is a federally funded research and development facility managed by the California Institute of Technology for the National Aeronautics and Space Administration (NASA) (http://www.jpl.nasa.gov/). Its mission is to enable space exploration for the benefit of humankind by developing robotic spacecraft and instruments.

There have been three phases of development of the JPL Electronic Nose. In the first phase, arrays of sensors were investigated and a device capable of detecting, analyzing, and quantifying ten analytes at the 1-hour Spacecraft Maximum Allowable Concentration (SMAC) (Toxicology Group, 1999) was developed. This device was tested successfully for six days on Space Shuttle flight STS-95 in 1998 (Ryan, 2004a). In the second phase, the ENose was miniaturized and the capabilities were significantly expanded to include 21 analytes and detection at varying humidity and temperature. This device, the Second Generation ENose, was tested extensively on the ground, and was demonstrated to be able to detect, identify, and quantify the 21 analytes at or below their 24-hour SMACs. The third phase of development was designed to monitor spacecraft cabin air quality in near real-time. A technology demonstration of the Third Generation JPL ENose aboard the International Space Station (ISS) was performed in 2008-09. Analytes included ammonia, mercury and sulfur dioxide, and eight organic compounds, which represent common classes of organic compounds. Analytes and targeted detection concentrations are shown in Table 1.

Development of the Third Generation JPL ENose required two major areas of development. One area is the design and fabrication of an interface unit which allowed the ENose to be operated through the EXPRESS Rack (EXPedite The PRocessing Of Experiments To Space Station) on the ISS; installation on this rack allows experimental devices to be tested in a realistic space environment. In the other area, the capabilities of the sensing platform, the Second Generation ENose, including sensing materials, sensor substrate, and data analysis routines were expanded.

Table 1. Target analytes for the third generation JPL ENose technology demonstration aboard the international space station. SMAC refers to the Spacecraft Maximum Allowable Concentration.

<table>
<thead>
<tr>
<th>ANALYTE</th>
<th>QUANTITATIVE TARGET (ppm)</th>
<th>24-HOUR SMAC (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ammonia</td>
<td>5.0</td>
<td>20</td>
</tr>
<tr>
<td>2. Mercury</td>
<td>0.010</td>
<td>.0020</td>
</tr>
<tr>
<td>3. Sulfur Dioxide</td>
<td>1.0</td>
<td>NA</td>
</tr>
<tr>
<td>4. Acetone</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>5. Dichloromethane</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>6. Ethanol</td>
<td>500</td>
<td>2000</td>
</tr>
<tr>
<td>7. Freon 218</td>
<td>20</td>
<td>11,000</td>
</tr>
<tr>
<td>8. Methanol</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>9. 2-Propanol</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>10. Toluene</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>11. Formaldehyde</td>
<td>0.10</td>
<td>0.10</td>
</tr>
</tbody>
</table>
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