Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs

East Palestine Train Derailment

September 8, 2023
Version 1.0.1
Overview
In the first days after the February 3, 2023, Norfolk Southern train derailment in East Palestine, Ohio, many home and business owners in the surrounding Ohio and Pennsylvania areas were evacuated. During the evacuation and after the evacuation order was lifted, air was tested for volatile organic compounds (VOCs) using photoionization detectors (PIDs) as real-time air monitoring screening instruments in conjunction with more accurate and sensitive analytical sampling methods. These PID instruments were used to monitor both worker and community exposure during all phases of the response.

In early March, potential inconsistencies in detecting butyl acrylate with PIDs were observed between manufacturer-provided documentation and in-field instrument performance. These potential inconsistencies were compounded by discrepancies between PID field measurements and those made by the EPA Trace Atmospheric Gas Analyzer (TAGA) mobile laboratory. To investigate further, members of Unified Command began assessing the performance of these PIDs to monitor VOCs in outdoor air in the community as well as in indoor air inside homes and businesses. Specifically, members of Unified Command conducted a rapid field evaluation to determine the PIDs’ ability to detect both butyl acrylate and vinyl chloride. However, during this field evaluation, additional questions arose relating to calibration gas mixtures, measurement variation between different instruments and PID models, and whether butyl acrylate would interfere with the detection of vinyl chloride. Following the initial rapid assessment, Unified Command convened a task force to conduct a more thorough assessment of the PIDs used during the response.

PID Task Force Assessment Summary
A multi-organizational task force consisting of members of Unified Command was established along with expert third-party reviewers. The task force evaluated the types of PIDs that have been used on the East Palestine Train Derailment Incident including the two versions of the MultiRAE Pro & AreaRAE Plus/Pro and one version of the ppbRAE. The task force conducted the study during the first week of May 2023. The overall objective of the performance assessment was to evaluate the accuracy and precision of the PIDs. Highlights of the results are as follows:

- Most versions of the PIDs could detect butyl acrylate at 0.2 ppm.
- All versions of the PIDs could detect vinyl chloride at 0.2 ppm.
- The more sensitive (ppb range instrument versions) could also detect vinyl chloride at 0.05 ppm.
- Vinyl chloride detection was not affected by instrument exposure to butyl acrylate.
- Below 0.2 ppm, the accuracy of the instruments was generally lowest.
- Above 1 ppm, the accuracy of the instruments was generally greater.
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1.0 Summary

Following concerns raised regarding the ability of photoionization detectors (PIDs) to detect butyl acrylate, and whether butyl acrylate adversely impacted the ability of these PIDs to detect vinyl chloride, the East Palestine Train Derailment Unified Command convened a task force to assess the performance of these instruments. The instrument evaluation phase of the performance assessment of five Honeywell PID models used during the East Palestine Train Derailment response was conducted between May 1st, 2023, and May 6th, 2023.

Instrument accuracy varied at each target concentration throughout the assessed ranges for both butyl acrylate and vinyl chloride. Accuracy was greatest above concentrations of 1-2 parts-per-million (ppm). The majority of target concentrations that did not meet the data quality objectives of less than 40% relative error occurred at concentrations at or below 0.2 ppm for both butyl acrylate and vinyl chloride. Several of the used target and calibration gas cylinders were analyzed after completion of the instrument assessments by Enthalpy Analytical and the US Environmental Protection Agency Office of Research and Development (ORD) and their measured concentrations were found to be outside the manufacturer’s stated concentration range and/or contain interfering contaminants, particularly for butyl acrylate cylinders. This undoubtedly impacted the accuracy of instrument measurements and calibrations during the assessment. As a result, an attempt was made to correct measurements using analyzed cylinder concentrations. This resulted in an accuracy improvement for 65% of measurements of re-analyzed cylinders. However, not all cylinders used for instrument testing were re-analyzed, and correction after measurement is not ideal as corrections could not be applied to all calibrations and target concentrations. It was not possible to decouple the influences of target and calibration gas cylinder concentrations on the overall instrument measurement accuracy. Furthermore, establishing if instrument inaccuracy was greater at lower concentrations was also problematic as the relative error in target gas and calibration gas cylinder concentration also increased at lower concentrations. The ability to re-derive PID correction factors for butyl acrylate and vinyl chloride for comparison to the manufacturer supplied correction factors was also adversely impacted by these variations in target gas and calibration gas cylinder concentrations.

Due to the confounding factors introduced by target gas and calibration gas cylinder concentration deviations from manufacturer’s provided values and chemical contaminants, definitive statements on PID detection capability, particularly at low concentrations, was not appropriate. All Parts-Per-Billion (PPB) model PIDs are considered unlikely or unable to respond (observable increase in measurement) to butyl acrylate concentrations of 0.022 ppm. Due to the uncertainty in the concentration of ethanol contamination in the 0.05 ppm butyl acrylate target gas cylinders, the ability for PIDs to detect 0.05 ppm butyl acrylate cannot be determined. All PPB model PIDs responded to butyl acrylate concentrations greater than or equal to 0.2 ppm as did the AreaRAE Extended Range (ER) PID. Due to a combination of sensor

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*Based on US EPA Method TO-15 accuracy requirement of ±30%. An additional ±10% error was permitted as the assessed instrumentation is field survey equipment rather than a laboratory-based analytical method.
resolution and errors in cylinder concentrations, it was not possible to determine if the MultiRAE (ER) was able to respond to 0.2 ppm butyl acrylate with certainty based on the collected data. The MultiRAE (ER) was able to respond to all target butyl acrylate concentrations greater than 0.2 ppm.

All instruments responded to vinyl chloride at the minimum concentrations of 0.05 ppm for PPB model PIDs and 0.2 ppm for ER model PIDs. However, accuracy was variable and, depending on PID model, did not always achieve the data quality objective for accuracy of ±40% relative error. Following exposure to butyl acrylate, the AreaRAE (PPB) appears to have exhibited decreased response at 0.05 ppm that was not observed with the other assessed PID models. Whether this decrease was directly related to butyl acrylate application or variation in instrument calibration, target gas cylinder concentration, and calibration gas cylinder concentration cannot be determined with certainty as all other instruments continued to clearly respond at all vinyl chloride target concentrations in their range. While some instruments exhibited a decrease in accuracy when measuring vinyl chloride, others exhibited an increase in accuracy. In aggregate, a consistent degradation in instrument ability to measure vinyl chloride following butyl acrylate exposure did not appear to occur.

Ultimately, the assessed PIDs were observed to provide reasonable accuracy as survey grade equipment for vinyl chloride and butyl acrylate at concentrations greater than or equal to approximately 1-2 ppm. The reduced accuracy of measurements as concentration decreases cannot exclusively be attributed to instrument performance as both cylinder concentration accuracy and instrument accuracy tend to decrease simultaneously with target concentration. The proportion of measurement inaccuracy that was due to the assessed instruments rather than error introduced by cylinder concentration inaccuracy and contamination cannot be determined. If the assumption were to be made, despite evidence otherwise, that measurement inaccuracy was due solely to the instrument itself, utility is still maintained. So long as limitations are understood, an inaccurate but discernible response may still indicate the presence of a target chemical.∗ Such measurement responses can be beneficial in protecting the health and safety of workers and the public when deployment of real-time analytical grade equipment is impractical or impossible and when analytical results cannot be delivered in an actionable time frame.

∗It is critical to understand in such circumstance, the response of a PID does not necessarily indicate a specific chemical is present as PIDs can respond to a wide array of compounds including hand-sanitizers, perfumes, and other non-hazardous organic and inorganic compounds.
2.0 Introduction

On February 3, 2023, north of East Taggart Street in East Palestine, Ohio, the derailment of Norfolk Southern Railway Company train 32NB101 resulted in the release of butyl acrylate along with the release, subsequent combustion, and “vent and burn” of vinyl chloride. Following the event, air monitoring began for these compounds by agencies, departments, and companies now associated with the East Palestine Derailment Unified Command using various models of Honeywell RAE Systems instruments equipped with Photoionization Detectors (PIDs), primarily the MultiRAE Pro with extended range and Part-Per-Billion model PIDs (C03-0912-002 & C03-0912-001), ppbRAE (023-3010-001), AreaRAE Plus (C04-0960-000), and AreaRAE Pro (C04-0960-001). The principal users of this equipment were the US Environmental Protection Agency (EPA), CTEH, and first responders. The monitoring was conducted to protect the public and response worker health and safety throughout the duration of the response and ongoing remediation.

Potential inconsistencies in detecting butyl acrylate were observed between manufacturer-provided documentation and in-field instrument performance. These potential inconsistencies were initially raised following discrepancies between field measurements made by the US EPA Trace Atmospheric Gas Analyzer (TAGA) mobile laboratory equipped with a triple quadrupole mass spectrometer and follow-up measurements using a MultiRAE Pro equipped with Parts-Per-Billion model PID and 10.6 electron volt (eV) lamp. To further explore potential questions of performance, the MultiRAE Pro with Parts-Per-Billion model PID was exposed to 0.05 parts per million (ppm) of butyl acrylate prepared onboard the TAGA mobile laboratory, but the MultiRAE Pro did not provide a response at this concentration. Additional measurements with a different MultiRAE Pro showed similar results. The qualitative identity of butyl acrylate gas delivered to the PID was confirmed by the mass spectrometer onboard the TAGA mobile laboratory.

In a first effort to address the observed discrepancies, CTEH initiated a performance evaluation through acquisition of nitrogen-balanced butyl acrylate calibration gases prepared by Linde Gas and Equipment in concentrations of ~0.5 ppm and ~0.2 ppm. However, Honeywell documentation indicated that nitrogen-balanced calibration gases of less than 1 ppm may not be acceptable for calibration. Additionally, butyl acrylate may undergo self-polymerization as the stabilizer contained in most mixtures, 4-methoxyphenol (MEHQ), requires an oxygen content between 5-21% to function as intended. Despite concerns of self-polymerization, subsequent testing of cylinders by Pace Analytical using Gas Chromatography with Flame Ionization Detector (GC-FID) and Montrose Air Quality Services (MAQS) using Proton Transfer Reaction – Mass Spectrometry (PTR-MS) revealed measured concentrations that were consistent with the certified concentrations of the gas cylinders.

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1RAE Systems by Honeywell World Headquarters located in Charlotte, NC.
2PIDs and lamps are removable and multiple PID models and lamps can be removed and replaced in each instrument.
3Includes The US EPA Superfund Technical Assessment and Response Team sub-contractor which is currently awarded to Tetra Tech.
Following the acquisition of butyl acrylate calibration gas in nitrogen, preliminary performance assessments were conducted by CTEH, US EPA, and US EPA Superfund Technical Assessment and Response Team (START) on PID equipment using butyl acrylate from either purchased gas cylinders or concentrations of butyl acrylate in Tedlar bags prepared onboard the TAGA mobile laboratory. Introduction of butyl acrylate gas to a RAE Systems ppbRAE revealed over-response from the sensor, with measurements approximately 0.1-0.2 ppm greater than the expected butyl acrylate concentrations contained in gas cylinders. MultiRAE Pros with Parts-Per-Billion model and Extended Range model PIDs did not respond as expected, measuring 0 ppm during application of 0.05 ppm (Parts-Per-Billion PID Only) and ~0.2 ppm butyl acrylate (both PID models). Upon application of 0.9155 ppm butyl acrylate from a Tedlar bag sample for both PID models, the measured concentration, with correction factor applied, was approximately 19% less than the target concentration. Application of 0.196 ppm butyl acrylate from gas cylinders resulted in a measurement of 0 ppm on both PID models.³

Following the preliminary performance investigation, additional concerns were raised by US EPA and CTEH personnel regarding interference from potential self-polymerization and adhesion of poly (butyl acrylate) to the instrument lamp and filters. Butyl acrylate is known to self-polymerize under ultra-violet (UV) radiation.² While UV radiation⁴ is produced by PIDs, the low concentrations of butyl acrylate, constant airflow over the lamp, and degradation of compounds on the lamp from ozone production¹ would reduce the probability of this occurring. US EPA expressed further concern that polymerization or adhesion of butyl acrylate could interfere with the instrument’s ability to detect vinyl chloride.

As the previously stated work raised questions about the suitability of Honeywell PIDs for the detection of butyl acrylate, the East Palestine Train Derailment Unified Command sought to obtain experimentally determined performance specifications for these PIDs, primarily assessing the manufacturer-published butyl acrylate correction factor* of 1.6⁵⁻⁷ for RAE Systems PIDs calibrated with isobutylene.

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*As these instruments are generally calibrated to isobutylene and not butyl acrylate, a measurement can be multiplied by a correction factor to estimate the concentration of butyl acrylate using the original measurement. This action assumes the measured concentration in air is butyl acrylate only.
3.0 Chemical Properties for Analyzed Compounds

3.1 Butyl Acrylate

Butyl acrylate (CAS 141-32-2) is a colorless liquid at room temperature, and in the outdoor environment, except for extreme cold (lower than -64°C) conditions. Butyl acrylate is used in the production of many common consumer, construction, and industrial products including arts and crafts adhesives, fingernail adhesives, paints, building materials, printer toner, and caulks/sealants.8,9

Several odor thresholds have been reported for butyl acrylate in the range of 0.00029 - 0.101 ppm.10,11 Analysis of recent scientific literature by US EPA ORD indicates that the odor threshold is at the lower end of the of these ranges.12–14 The odor characteristic reported for butyl acrylate varies and is described as fruity, musty, plastic, rancid, strong, and/or sweet.10

Table 3.1 Butyl Acrylate Physical Properties 8,15

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synonyms</td>
<td>2-propenoic acid butyl ester</td>
</tr>
<tr>
<td>Chemical formula</td>
<td>C₇H₁₂O₂</td>
</tr>
<tr>
<td>Formal Charge</td>
<td>0</td>
</tr>
<tr>
<td>Molecular weight</td>
<td>128.17</td>
</tr>
<tr>
<td>CAS Reg. No.</td>
<td>141-32-2</td>
</tr>
<tr>
<td>Physical state</td>
<td>liquid</td>
</tr>
<tr>
<td>Solubility in water</td>
<td>0.14 g/100 mL at 20°C</td>
</tr>
<tr>
<td>Vapor pressure</td>
<td>4.3 mmHg at 20°C</td>
</tr>
<tr>
<td>Vapor density (air =1)</td>
<td>4.4</td>
</tr>
<tr>
<td>Liquid density (water =1)</td>
<td>0.8986</td>
</tr>
<tr>
<td>Melting point</td>
<td>-64°C, approximately</td>
</tr>
<tr>
<td>Boiling point</td>
<td>145°C</td>
</tr>
<tr>
<td>Auto-ignition</td>
<td>267°C</td>
</tr>
<tr>
<td>Conversion factors</td>
<td>1 ppm = 5.24 mg/m³ at 25°C, 101.3 kPa</td>
</tr>
</tbody>
</table>

Figure 3.1 Butyl Acrylate Chemical Structure

\[
\begin{align*}
\text{H}_2\text{C} & \equiv \text{O} \\
\text{O} & \quad \text{C-H}_3
\end{align*}
\]
3.2 Isobutylene

Isobutylene is a colorless gas used as a precursor in the production of aviation fuel, resins, plastics, and other chemicals. The odor is described as “faint petroleum-like.” While one isobutylene car was involved in the derailment, no release is known to have occurred. Isobutylene has been used during the East Palestine Train Derailment response, and during this assessment, to calibrate air monitoring equipment equipped with PIDs.

<table>
<thead>
<tr>
<th>Table 3.2 Isobutylene Physical Properties $^{17,18}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Synonyms</strong></td>
</tr>
<tr>
<td><strong>Chemical formula</strong></td>
</tr>
<tr>
<td><strong>Formal Charge</strong></td>
</tr>
<tr>
<td><strong>Molecular weight</strong></td>
</tr>
<tr>
<td><strong>CAS Reg. No.</strong></td>
</tr>
<tr>
<td><strong>Solubility in water</strong></td>
</tr>
<tr>
<td><strong>Vapor pressure</strong></td>
</tr>
<tr>
<td><strong>Vapor Density (air = 1)</strong></td>
</tr>
<tr>
<td><strong>Liquid density (water = 1)</strong></td>
</tr>
<tr>
<td><strong>Melting point</strong></td>
</tr>
<tr>
<td><strong>Boiling point</strong></td>
</tr>
<tr>
<td><strong>Auto-ignition</strong></td>
</tr>
<tr>
<td><strong>Conversion factors</strong></td>
</tr>
</tbody>
</table>

Figure 3.2 Isobutylene Chemical Structure

![Isobutylene Chemical Structure](image)
3.3 Vinyl Chloride

Vinyl chloride is a colorless gas at room temperature.\textsuperscript{19} The primary use of vinyl chloride is as the precursor monomer for the production of poly vinyl chloride (PVC) through polymerization. The produced PVC is ultimately used in wide array of products including packaging materials, appliances, medical equipment, toys, and other consumer and commercial products.\textsuperscript{20} Vinyl chloride has a sweet, pleasant odor with an odor threshold between 203-356 ppm.\textsuperscript{10}

\begin{table}[h]
\centering
\begin{tabular}{|l|l|}
\hline
\textbf{Synonyms} & Vinyl chloride monomer, monochlorethene, monochlorethylene, 1-chloroethylene, chlorethylene, chloroethene \\
\hline
\textbf{Chemical formula} & C\textsubscript{2}H\textsubscript{3}Cl \\
\hline
\textbf{Formal Charge} & 0 \\
\hline
\textbf{Molecular weight} & 62.5 g/mol \\
\hline
\textbf{CAS Reg. No.} & 75-01-4 \\
\hline
\textbf{Physical state} & Gaseous (room temperature) \\
\hline
\textbf{Solubility in water} & Soluble in almost all organic solvents, slightly soluble in water \\
\hline
\textbf{Vapor pressure} & 78 kPa at -20°C, 165 kPa at 0°C, 333 kPa at 20°C \\
\hline
\textbf{Liquid density (water =1)} & 0.9 \\
\hline
\textbf{Melting point} & -64°C, approximately \\
\hline
\textbf{Boiling point} & -13.4 at 20°C \\
\hline
\textbf{Auto-ignition} & 472°C \\
\hline
\textbf{Conversion factors} & 1 ppm = 2.56 mg/m\textsuperscript{3} at 25°C, 101.3 kPa \\
\hline
\end{tabular}
\caption{Vinyl Chloride Physical Properties\textsuperscript{19,20}}
\end{table}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{vinyl_chloride_structure.png}
\caption{Vinyl Chloride Chemical Structure}
\end{figure}
4.0 Objectives

4.1 Assessment Objectives

The overall objective of the performance assessment was to evaluate the accuracy and precision of the PIDs found in Table 4.1 within the desired ranges of 0.001 – 10.0 ppm of butyl acrylate and vinyl chloride. Equipment to be tested were Honeywell instruments used by Norfolk Southern Railway, CTEH, US EPA/START, and contractors during the East Palestine Derailment response.

<table>
<thead>
<tr>
<th>Instrument name</th>
<th>PID Model name</th>
<th>PID Part Number</th>
<th>Accuracy$^{21-23}$</th>
<th>Measurement Range (ppm)$^{*21,24}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MultiRAE Pro</td>
<td>MultiRAE Extended Range</td>
<td>C03-0912-002</td>
<td>± 20%</td>
<td>0.1 – 5,000.0</td>
</tr>
<tr>
<td></td>
<td>Parts-Per-Billion</td>
<td>C03-0912-001</td>
<td>± 20%</td>
<td>0.01 – 2,000.00</td>
</tr>
<tr>
<td>AreaRAE Plus/Pro</td>
<td>7R+ PID Extended Range</td>
<td>C04-0960-000</td>
<td>± 20%</td>
<td>0.1 – 5,000.0</td>
</tr>
<tr>
<td></td>
<td>7R+ Parts-Per-Billion</td>
<td>C04-0960-001</td>
<td>± 20%</td>
<td>0.01 – 2,000.00</td>
</tr>
<tr>
<td>ppbRAE</td>
<td>3GPID+</td>
<td>023-3010-001</td>
<td>± 3%</td>
<td>0.001 – 9,999$^7$</td>
</tr>
</tbody>
</table>

*As isobutylene. The entire measurement range provided by the manufacturer for each PID was not assessed.

$^7$PID resolution decreases at 10 ppm, 100 ppm, and 1,000 ppm by a factor of 10.

There appears to be no physical or hardware difference between Pro and Plus sub-models of AreaRAEs and MultiRAEs. The ability of Pro sub-models to use the Parts-Per-Billion model PIDs is suspected to be accomplished solely through software differences. Therefore, for the majority of this report, both sub-models of AreaRAEs and MultiRAEs will only be differentiated by the installed PID, i.e., either Extended Range (ER) or Parts-Per-Billion (PPB) PID models.

Testing focused on evaluating performance of the instrument PIDs in a manner that establishes baseline performance without introducing variability from environmental parameters such as temperature and humidity. All data were assessed against the Data Quality Objectives contained in Section 4.2. These tests were performed independently on each of the three PID models listed in Table 4.1.
The main objectives of the PID assessment were:

1. Establish the accuracy and precision of the instrument’s measurement of isobutylene when calibrated to isobutylene as this calibration directly impacts measurement of butyl acrylate and vinyl chloride concentrations when applying correction factors.

2. Establish the accuracy and precision of the instrument’s measurement of butyl acrylate when calibrated to butyl acrylate to evaluate the suitability of butyl acrylate calibration as an alternative to isobutylene calibration in specific scenarios (e.g., evaluation of TAGA mobile lab detections.)

3. Evaluate the measurement accuracy and precision, along with correction factors, of the instrument for butyl acrylate and vinyl chloride when calibrated to isobutylene. This test was used to identify any degradation in measurement accuracy and precision as a result of multiple applications of butyl acrylate.

4. Establish if exposure of the PID to butyl acrylate degrades the instrument’s ability to detect vinyl chloride by determining the accuracy and precision of vinyl chloride measurements following the introduction of butyl acrylate to the instrument.

4.2 Data Quality Objectives and Quality Control

The assessment was observed in its entirety by one or more US EPA ORD staff. ORD staff did not participate directly in conducting the assessment but provided continual advice and feedback during the assessment including recommendations for corrective actions.

Following the end of the field portion of the assessment, cylinders containing isobutylene, vinyl chloride, and butyl acrylate were analyzed by Enthalpy Analytical and EPA ORD using laboratory analytical equipment. These analyses were conducted as gas cylinder concentrations may vary from the manufacturer stated concentration or contain impurities that may result in measurement inaccuracy for the assessed equipment.

Specific QC checks and initial maintenance were performed to help assess the reliability of the data and flag collected data when necessary. These maintenance and QC checks are listed as follows:
**Maintenance**

- Instrument calibration was performed prior to instrument assessment. Instruments were calibrated following manufacturer guidance contained in equipment manuals.\(^{21-23}\) No instruments which failed calibration were used to record assessment measurements.

- All instrumentation was updated with the manufacturer’s latest firmware prior to the assessment.

- All instrumentation was fitted with new consumable components such as PIDs, lamps, filters,\(^*\), etc., at the start of the assessment. All new PIDs and lamps were manufactured by Honeywell. All maintenance was performed according to the manufacturer’s recommendations and method requirements by CTEH or START. The instruments were not new and had been subject to varying degrees of field use prior to the assessment.

**QC Checks**

- Instrument bump checks were conducted pre- and/or post-test. A bump test is the application of a known concentration of gas to an instrument without conducting calibration to establish whether the instrument continues to measure correctly within the desired accuracy range.

- All tube connections between regulator and instrument inlets were initially checked for apparent leaks, visible damage, or visible contamination which could impact the accuracy of measurements.

- The air flow rate for each instrument was measured prior to assessment of each instrument type. The manufacturer-recommended ranges for assessed instruments are 0.2 liters per minute (L/min) to \(\geq 0.45\) L/min.\(^{21-23}\) An upper limit of 0.75 L/min of instrument airflow was used to prevent excessive gas consumption.

To ascertain the accuracy and precision of instruments, measurements were grouped by instrument/PID, assessment, and gas concentration. The appropriate calculations described in Section 5.8 were then conducted for comparison to Data Quality Indicators.

The target performance for all instruments/PIDs, tabulated in Table 4.2, was based on accuracy criteria of 30% and replicate precision of 25% contained in US EPA Method TO-15.\(^{25}\) The TO-15 accuracy value was selected rather than the instrument accuracies in Table 4.1 as it better represents the combined errors of

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\(^*\)Includes external inlet filter and internal metallic filter. Metallic filters were not replaced for AreaRAEs as the part was unavailable at the time of the assessment.
the instrument, calibrations, cylinder concentrations, and other factors encountered during field use. As this metric was originally intended for laboratory grade equipment, and not field survey equipment, an additional 10% was added for a combined accuracy metric of ±40% and 5% was added to the precision metric of ±30%. Table 4.3 provides the QC criteria for the air monitoring equipment.

### Table 4.2 Data Quality Indicator Goals

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Completeness*</th>
<th>Accuracy</th>
<th>Precision</th>
<th>Coefficient of Determination (R²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Instruments in Table 4.1</td>
<td>≥ 90%</td>
<td>40%</td>
<td>30%</td>
<td>&gt;0.90</td>
</tr>
</tbody>
</table>

*Based on ≥ 9 measurements per instrument/PID model and gas concentration.

### Table 4.3 QC Criteria for Air Monitoring Equipment

<table>
<thead>
<tr>
<th>Measurement Parameter</th>
<th>QA/QC Check Procedure</th>
<th>Frequency</th>
<th>Acceptance Criteria</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero Calibration/ Target Gas Calibration</td>
<td>Conduct 3-point calibration</td>
<td>At least once per day, between different assessments if needed</td>
<td>Each point measurement within instrument’s stated measurement uncertainty (See Table 4.1)</td>
<td>Attempt recalibration, conduct maintenance, or remove from service.</td>
</tr>
<tr>
<td>Bump Test</td>
<td>Challenge instrument with zero air and max calibration concentration.</td>
<td>Beginning/End of each day. Between each different assessment.</td>
<td>Each point measurement within instrument’s stated measurement uncertainty (See Table 4.1)</td>
<td>Attempt recalibration, conduct maintenance, or remove from service.</td>
</tr>
<tr>
<td>Instrument Air Flow Rate</td>
<td>Measure instrument air flow rate with primary flow meter.</td>
<td>Beginning of each day.</td>
<td>0.2 L/min to 0.75 L/min</td>
<td>Replace instrument pump.</td>
</tr>
</tbody>
</table>
5.0 Methods

All equipment testing was conducted at the Centenary United Methodist Church (CUMC) located in East Palestine, Ohio, which was used as the East Palestine Train Derailment Forward Operating Base. All equipment, equipment components, and gases were sourced by CTEH, Enthalpy Analytical, and US EPA START.

Instrument external inlet filters remained in place during all assessments and calibrations and were replaced with a new filter prior to the start of assessments and then once per day thereafter.

Assessments were conducted inside CUMC to minimize impacts from temperature variation. Temperature and relative humidity (Appendix G) were documented during assessments but were not controlled beyond set points for the heating, ventilation, and air-conditioning system established by the building owner. All gas cylinders and equipment were stored in the same location where testing occurred, ensuring there was no appreciable temperature difference between gases and instruments.

5.1 Photoionization Detectors

5.1.1 Operating Principles and Use

A photoionization detector (PID) uses an Ultraviolet (UV) lamp to ionize a molecule when the ionization potential of the molecule is less than the photon energy (in electron volts) of the UV radiation. The result is the ejection of electrons and formation of positively charged ions in the gas phase. The positive ions are measured as an electrical current that is proportional to the concentration of the chemical. The relationship with the produced current and the concentration of a gas or vapor in air can be determined by measuring the PID’s electrical response when exposed to known concentrations of a gas or vapor. PIDs are unable to differentiate individual compounds in air when exposed to a mixture of chemicals.

Instruments equipped with Photoionization Detectors (PIDs) offer an easily portable, comparably durable, and simple to use source of actionable information, even at concentration ranges which may be semi-quantitative. Ease of use and portability of these PIDs is particularly advantageous as the instruments can be rapidly deployed and in use within one hour after their arrival at a site. These PIDs have been manufactured in large numbers and are readily available allowing deployment of a hundred or more units at a worksite. The deployment in such large numbers allows for geographic coverage that is difficult or impossible to reproduce with other instrumentation, and despite limitations, can be critical to the protection of the health and safety of both workers and the public following industrial incidents and other environmental disasters.

5.1.2 Other Equipment Considerations

As an alternative to PIDs, air samples may be collected which provide greater accuracy at low concentrations. The equipment used to collect these samples can be portable, often as easy to use, and can be potentially deployed in similar numbers depending on the method (e.g., EPA Method TO-15). Collection of these samples can in some circumstances be completed in less than 15 minutes, but generally requires
several hours, at which time the samples must be sent to an off-site laboratory for analysis. Results of collected samples are not available in real-time and are generally not available for a minimum of 24-48 hours after collection, delaying or limiting available actions when hazardous conditions are discovered.

Semi-portable equipment exists as an alternative to PIDs that can provide results in real-time or near real-time and may or may not offer improved accuracy at low concentrations (e.g., Portable GC-MS, FTIR).* The size and durability of these instruments is still sufficient to be shipped by air, allowing arrival on-site in a similar time period as the assessed instruments. However, these instruments tend to be less portable (heavy/bulky), fragile, difficult to use, and require several hours or days after arrival on a worksite before use. Fewer of these instruments have been produced, or are available for use, precluding deployment in large numbers and coverage over large geographic areas.

Mobile, vehicle-based, laboratory equipment exists which can provide a high degree of accuracy and precision at low concentrations. As the equipment is permanently mounted within the vehicle and must be driven to a worksite, arrival depends on distance and may be as little as a day or up to several days. The instrumentation in the mobile laboratory is much more complex than the assessed PID instruments and must be operated and maintained by skilled scientists as opposed to field technicians. Due to the cost and complexity of these mobile laboratories, few exist, limiting availability for unscheduled work and causing delay in deployment to a worksite. Unlike previously mentioned instrumentation and sampling methods, these mobile laboratories are limited to roads (typically paved), preventing access to many locations where air monitoring is needed. While excellent in targeted applications and support roles, lack of available units and skilled operators combined with the inability to access many areas severely limits the geographic area that can be covered. Deploying sufficient units in a timely manner to protect a downwind community and assess their exposure following an industrial incident is typically infeasible, if not impossible.

The health-based screening levels for both workers and the public may change over the course of a project. In the case of an emergency response, the initial focus is frequently on acute health effects that may occur from exposure to higher concentrations. Eventually the focus transitions to lower concentration screening levels that reflect intermediate and chronic health effects. For this reason, selected equipment, and how it is used, changes throughout a response to meet the accuracy requirements and measurement range needed to compare potential exposure to the appropriate screening-level for the current response phase.

Ultimately, all equipment and sampling methods mentioned have advantages and disadvantages which limit their applications. When engaging in air monitoring over a large geographic area, in a highly dynamic environment, where both immediate action and accuracy are required to protect the health and safety of

workers, a myriad of equipment is required to supplement the deficiencies of any single component. Even an inaccurate but discernible response on an instrument may indicate the presence of a target chemical. Such responses can be beneficial in protecting the health and safety of workers and the public when deployment of real-time analytical grade equipment is impractical or impossible and when analytical results cannot be delivered in an actionable time frame. It is critical to understand that in such circumstances, the response of a PID does not necessarily indicate a specific chemical is present as PIDs can respond to a wide array of compounds including hand-sanitizers, perfumes, and other non-hazardous organic and inorganic compounds which may bias measurements high. The niche served by the assessed equipment in this holistic approach is leveraging portability, durability, and instrument count to provide exposure monitoring of workers and the public over a wide geographic area along with immediately actionable information in lieu of accuracy. The assessed instruments are not an appropriate substitution for the collection of air samples or analytical laboratory equipment, but the inverse is also true. When the limitations of the assessed instruments are recognized, particularly at lower concentrations, utility is maintained when used to meet an appropriately defined goal. When interpreting instrument responses, actions should be tailored with instrument limitations in mind to provide the greatest advantage.

5.1.3 Assessed Photoionization Detectors
The tested AreaRAEs’ and MultiRAEs’ sample flow pathways and physical characteristics differ substantially. However, from a conceptual standpoint, the sample flow pathways and component order of the instruments are identical. Once air passes through the AreaRAE and MultiRAE diaphragm pump, it enters a manifold which diverts airflow between the PID and multiple chemical sensors* prior to being exhausted from the instrument. The ppbRAE consists of a much simpler flow pathway compared to the MultiRAEs and AreaRAEs as it consists of only a PID. The sample flow pathways and internal component orders are depicted in Figure 5.1, and the exterior of each instrument is depicted in Figure 5.2.

* No chemical sensors were present in any tested instrument. Manufacturer supplied blocks were placed in the chemical sensor positions to limit target gas buildup within the empty sensor chambers.
Of note are several differences in the sample flow path materials, as well as component order, between the three instrument types which may act as sources of potential interference impacting instrument accuracy and precision. Synthetic rubber was present within the sample flow path of both the MultiRAEs and AreaRAEs which may absorb low concentrations of target gases or may off gas following exposure to higher concentrations of target gas. Synthetic rubber was most prevalent in the MultiRAE with a small mixing chamber between the inlet filter and porous metal filter consisting almost completely of synthetic rubber. Additionally, nearly the entire length of tubing within the instrument was constructed of the same synthetic rubber. The AreaRAE limited the use of synthetic rubber, lacked the same inlet mixing chamber as the MultiRAE, and used only small quantities of rubber at certain tubing joints. For both the AreaRAE and MultiRAE, sample airflow passed through the diaphragm pump (which had a synthetic rubber diaphragm) prior to reaching the PID and chemical sensors. In contrast, the sample air collected by the ppbRAE did not come in contact with synthetic rubber in the flow path prior to the sample air reaching the PID, as the sample air did not pass through the pump first. The tubing between the inlet and PID is considerably shorter and straight in the ppbRAE compared to the other instruments. Additional details regarding assessed instruments are located in Appendix A.
Standard practice in the occupational and environmental health and safety field is to calibrate PIDs used for exposure surveys to isobutylene, per manufacturer recommendations. Since the measurement from the PID is dependent on the ionization potential of the substance being measured, correction factors (CF) have been determined for various chemicals for PIDs calibrated to isobutylene. These correction factors are used to convert the measurement from the instrument to a concentration of the target chemical when the PID is calibrated to isobutylene. For example, butyl acrylate has a correction factor of 1.6.⁵–⁷ An AreaRAE measuring 2.0 ppm would equate to 3.2 ppm butyl acrylate assuming butyl acrylate is the only chemical present capable of eliciting a response from the PID. For chemical mixtures, the PID response is dependent on the fraction of chemicals present in the mixture (Equation 5.8).

5.2 Target Gases

Depending on the test type, various concentrations and mixtures of National Institute of Standards and Technology (NIST) traceable gas were supplied to each instrument and PID combination. Certified analytical standards prepared by third-party vendors Linde Gas and Equipment, Portagas,* and Apel-Reimer Environmental were used in this assessment. All gas mixtures used during the assessment were air balanced. Certificates of analysis were maintained for each standard and are available in Appendix B along with an inventory of cylinders used in the assessment. The cylinder gases were dry, removing the impacts of varying or elevated humidity. The following gases listed in Table 5.1 were used during the evaluation.

---

*Portagas is a subsidiary of Linde Gas and Equipment, Inc.
Table 5.1 Performance Assessment Test Gases

<table>
<thead>
<tr>
<th>Gas</th>
<th>Supplier</th>
<th>Mfg. Stated Concentration (ppm)</th>
<th>Mfg. Stated Uncertainty*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra-Zero Air</td>
<td>AirGas</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Isobutylene</td>
<td>Portagas</td>
<td>2.0 ± 5%</td>
<td>10.0 ± 5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100 ± 2%</td>
</tr>
<tr>
<td>Butyl Acrylate</td>
<td>Linde</td>
<td>0.0220 ± 20%</td>
<td>0.050 ± 10%</td>
</tr>
<tr>
<td></td>
<td>Portagas</td>
<td>0.050 ± 10%</td>
<td>0.20 ± 10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.0 ± 5%</td>
</tr>
<tr>
<td></td>
<td>Apel-Riemer</td>
<td>9.69900 ± 5%</td>
<td>0.98100 ± 5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.93700 ± 5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9.73600 ± 5%</td>
</tr>
</tbody>
</table>

*Uncertainty in test gas concentration expressed as percent expanded uncertainty with a coverage factor of 2 (Equation 5.14).

Each instrument and/or PID has a defined measurement range and is not able to measure all available gas standard concentrations used during the assessment. For this reason, the concentration ranges contained in Table 5.2 to Table 5.4 were used for testing of each instrument.

Table 5.2 Isobutylene Challenge Concentrations

<table>
<thead>
<tr>
<th>PID Model Name</th>
<th>Minimum Concentration (ppm)</th>
<th>Mid-Level Concentration (ppm)</th>
<th>Maximum Concentration (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MultiRAE (ER)</td>
<td>2.0</td>
<td>10.0</td>
<td>100</td>
</tr>
<tr>
<td>MultiRAE (PPB)</td>
<td>2.0</td>
<td>10.0</td>
<td>100</td>
</tr>
<tr>
<td>AreaRAE (ER)</td>
<td>2.0</td>
<td>10.0</td>
<td>100</td>
</tr>
<tr>
<td>AreaRAE (PPB)</td>
<td>2.0</td>
<td>10.0</td>
<td>100</td>
</tr>
<tr>
<td>ppbRAE</td>
<td>2.0</td>
<td>10.0</td>
<td>100</td>
</tr>
</tbody>
</table>

ER = Extended Range model PID with measurement resolution of 0.1 ppm.
PPB = Parts-Per-Billion model PID with measurement resolution of 0.01 ppm.
Table 5.3 Butyl Acrylate Test Concentrations

<table>
<thead>
<tr>
<th>PID Model Name</th>
<th>Minimum Concentration (ppm)</th>
<th>Low-Level Concentration (ppm)</th>
<th>Mid-Level Concentration (ppm)</th>
<th>Upper-Level Concentration (ppm)</th>
<th>Maximum Concentration (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MultiRAE (ER)</td>
<td>0.20</td>
<td>-</td>
<td>-</td>
<td>2.0</td>
<td>9.69900</td>
</tr>
<tr>
<td>MultiRAE (PPB)</td>
<td>0.0220</td>
<td>0.050</td>
<td>0.20</td>
<td>2.0</td>
<td>9.69900</td>
</tr>
<tr>
<td>AreaRAE (ER)</td>
<td>0.20</td>
<td>-</td>
<td>-</td>
<td>2.0</td>
<td>9.69900</td>
</tr>
<tr>
<td>AreaRAE (PPB)</td>
<td>0.0220</td>
<td>0.050</td>
<td>0.20</td>
<td>2.0</td>
<td>9.69900</td>
</tr>
<tr>
<td>ppbRAE</td>
<td>0.0220</td>
<td>0.050</td>
<td>0.20</td>
<td>2.0</td>
<td>9.69900</td>
</tr>
</tbody>
</table>

ER = Extended Range model PID with measurement resolution of 0.1 ppm.
PPB = Parts-Per-Billion model PID with measurement resolution of 0.01 ppm.

After the cessation of planned PID activities, a selection of standards used in the testing was analyzed to confirm the target gas concentrations and verify the absence of potentially interfering compounds in the standard cylinders. All standards for the following methods were introduced to analytical instruments via preconcentration.

Vinyl chloride cylinders were analyzed via a modified EPA Method TO-15\textsuperscript{25} analysis at Enthalpy Analytical using a gas chromatograph equipped with a mass selective detector (GC/MSD) calibrated to vinyl chloride. Samples were loaded dynamically, directly from the cylinder, in a manner similar to the PID sampling manifold. No additional humidification or dilution of samples was performed.

Isobutylene cylinders were analyzed via a modified EPA Method 18\textsuperscript{27} analysis at Enthalpy Analytical. The standard cylinders were introduced directly to a GC with a flame ionization detector (FID) calibrated for isobutylene. The standard cylinders were loaded dynamically, directly from the cylinder in a manner similar to the PID manifold.

Butyl acrylate cylinders were analyzed via EPA Method TO-15/TO-15A analysis by EPA ORD using an Entech 7200 Preconcentrator and Agilent 7890B GC/5977 MSD calibrated for butyl acrylate in Selected Ion Monitoring mode. Sample gas was loaded into 1.4 L Silonite coated stainless steel sampling canisters, pressurized with zero air when additional dilution was required, and analyzed as described in TO-15/TO-
15A. No additional humidification was performed. Butyl acrylate and isobutylene standards were also analyzed at Enthalpy Analytical for identification of potentially interfering compounds.

5.3 PID Assessment Gas Delivery System

Target gas was applied simultaneously to three instruments for each calibration and test using a stainless-steel manifold, stainless steel compression fittings, and constant flow or constant pressure regulator (Figure 5.3). Polytetrafluoroethylene (PTFE) tubing was used for all connections between the instrument pump, manifold, and gas cylinder to minimize contamination of the air stream from tubing material or residual compounds from previous testing events. PTFE tubing was not changed during the assessment.

A fourth run of PTFE tubing from the manifold was present to act as an excess flow relief mechanism allowing the gas flow rate into the instrument to be driven by the instrument’s pump at near ambient pressure. The length of the pressure relief tubing was sufficient to prevent backflow into the manifold. A rotameter was present at the terminal end of the relief tubing to ensure excess flow was maintained during testing and calibration. The flow rate of regulators was approximately 1.5 L/min. An excess pressure relief valve was also connected to the manifold and was closed during each assessment.

Figure 5.3 Gas Supply Manifold

5.4 Instrument Calibration Procedures

Calibration of each instrument group (Table 4.1) occurred at the beginning of each primary objective test contained in Section 4.1, or at least once per day using the manifold described in Section 5.3. Procedures for calibration followed those contained in instrument manuals21–23 and technical notes1,5–7,28,29 for three-
point calibration. The gas concentrations contained in Table 5.5 were used for instrument calibration following the procedure in Figure 5.4.

### Table 5.5 Instrument Calibration Concentrations

<table>
<thead>
<tr>
<th>Gas</th>
<th>Zero Point</th>
<th>Point 2 (ppm)</th>
<th>Point 3 (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isobutylene</td>
<td>Ultra Zero Air</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Butyl Acrylate</td>
<td>Ultra Zero Air</td>
<td>2</td>
<td>9.736</td>
</tr>
</tbody>
</table>

### Figure 5.4 General Instrument Calibration Process

1. **30-45 minute Lamp Warm-up Period**
2. Connect Manifold to Instrument Inlets
3. Connect Calibration Cylinder and Start Regulator Flow
4. Wait for Concentration to Stabilize
5. Calibration Event
   - Apply Gas in Increasing Order of Concentration. Begin with Zero Air.
   - If All Calibration Gas Standards Applied?
     - Yes: Accept Calibration
     - No: Reject Calibration
5.5 Application of Target Gases

Each gas challenge cycle began with zero air. The lowest target gas concentration was supplied to the instrument group with stepwise increases in gas concentration (Table 5.2 to Table 5.4). Prior to recording the measured concentration, the sensor was permitted to reach a near steady state where the observed measurement remained relatively constant, or if fluctuating, did not have a discernible trend in either the positive or negative direction. A single measurement in ppm was manually recorded at this steady state concentration. The time for the instruments to reach this steady state was generally not allowed to exceed five minutes* to conserve test gas. The mean duration target gas was permitted to flow through instruments was approximately 3.3 minutes per target concentration, 19.8 minutes per cycle, and 59.4 minutes per test. Once the maximum test gas concentration was applied, the cycle began again with application of zero-air and continued until a minimum of three cycles were completed for the instrument group (Figure 5.5).†

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* On occasion, zero air was permitted to flow through instruments for longer durations between assessments. The longest duration non-zero gas was permitted to flow through an instrument was six minutes and unintentional.
† Additional vinyl chloride test cycles were conducted for the ppbRAE as calibration was not conducted between the isobutylene test and vinyl chloride test.
An attempt was made to use the same gas cylinders throughout each specific instrument test to minimize variation of measurements between test cycles. However, in some instances it was necessary to exchange cylinders during test cycles due to faulty cylinder valves or rate of gas consumption. This introduced variability as the concentration of contents in each cylinder was not identical.

5.6 Primary Instrument Assessments

All assessments were conducted in an order that minimized potential interference in results from the PID’s exposure to butyl acrylate. Assessments requiring only the use of isobutylene and vinyl chloride were conducted first, followed by assessments requiring only the use of isobutylene and butyl acrylate. Testing of potential degradation in the instrument’s ability to accurately measure vinyl chloride following PID exposure to butyl acrylate occurred last (Figure 5.6). A minimum of nine measurements were recorded per PID/gas combination listed in Table 5.2 to Table 5.4.

![Figure 5.6 General Assessment Order](image)

*A bump test is the application of a known concentration of gas to an instrument without conducting calibration to establish whether the instrument continues to measure correctly within the desired accuracy range.*

5.6.1 Establishing Instrument Response, Accuracy, and Precision

The instrument response for isobutylene, butyl acrylate, and vinyl chloride gases was determined by challenging each instrument group in the manner described in Section 5.5 using the gas standards in Table 5.1. Each instrument was challenged using the same gas standard via manifold. Calibration and
assessment of butyl acrylate occurred after assessment of isobutylene and vinyl chloride performance in case the physical properties of butyl acrylate interfered with the detection of vinyl chloride. The resulting measurements were used to determine instrument accuracy and precision.

5.6.2 Establishing Instrument Correction Factors
Assessment correction factors for butyl acrylate and vinyl chloride instruments calibrated to isobutylene were determined using least squares linear regression lines for isobutylene, vinyl chloride, and butyl acrylate tests (Equation 5.7). This analysis was conducted using manually recorded data from tests completed in Section 5.6.1 with regression lines constructed from cylinder concentrations ($x_i$) and the measured concentrations ($y_i$). Regression line slopes from tests where the instruments were calibrated to butyl acrylate were not compared to the isobutylene regression line slope as the results were not dependent on isobutylene calibration.

5.6.3 Vinyl chloride response after application of butyl acrylate
Each instrument group was calibrated with isobutylene. Butyl acrylate was then supplied to the instrument for a period of approximately five minutes at a concentration of 10 ppm. Vinyl chloride gas was then supplied to the instrument following the procedures in Section 5.5. The difference in performance from previous vinyl chloride testing was then evaluated.

5.7 Additional Data Collection
In general, each instrument was configured to log data in 1-second intervals. However, AreaRAE Pros provided by US EPA START (AR07-AR09) were inadvertently configured to log at 1-minute intervals. These data logs were all downloaded after completion of an individual PID assessment.

At the end of each assessment day, one instrument group was permitted to run overnight (or until battery discharge). In the morning, the instrument group was bump tested with either isobutylene or butyl acrylate depending on the gas the instrument was calibrated to last. The test was conducted to assess the variability in performance following extended use since the last calibration.

During each day of the assessment, room temperature (accuracy ± 0.4°C), barometric pressure (accuracy ± 0.3 hectopascal), and relative humidity (accuracy ± 1.0%) measurements were recorded using a Kestrel Instruments Kestrel 5000 Environmental Meter (Kestrel). The Kestrel is factory-calibrated against NIST traceable standards. These parameters were recorded for observational purposes only, and the impact of these parameters on equipment performance is beyond the scope of this assessment (Appendix G).

The flow rate of instrument pumps was confirmed during the assessment using a Mesa Labs Defender 500 Series NIST traceable primary flow meter. The Defender 500 Series is accurate to within 1% of measured air flow and factory calibrated annually. The flow rate of each instrument’s pump cannot be calibrated by the user. Instrument pump performance was compared to QC criteria in Table 4.3 for air monitoring equipment.
Three additional tests were performed other than the primary instrument assessments proposed in the *Performance Assessment Plan for the Monitoring of Butyl Acrylate in Air Using Honeywell PIDs*. These tests were limited in scope and did not occur for all instrument groups and gases. The purpose of these tests was to provide additional information regarding the accuracy of instruments when measuring low concentrations of target gas without the PID having been recently exposed to the maximum target gas concentration. The following additional tests were conducted:

- MultiRAE Pros equipped with Part-Per-Billion PIDs and calibrated to butyl acrylate were tested with three cycles of zero air -> 0.2 ppm butyl acrylate.
- ppbRAEs were two-point calibrated with zero air and 2 ppm isobutylene and tested with three cycles of zero air -> 0.05 ppm butyl acrylate.
- ppbRAEs were two-point calibrated with zero air and 2 ppm isobutylene and tested with three cycles of zero air -> 0.2 ppm butyl acrylate.

5.8 Statistics and Calculations

All statistical calculations were conducted using Python 3 SciPy and NumPy libraries. All statistical calculations were conducted at a confidence level (\(\alpha\)) of 0.05 unless stated otherwise. Statistical output can be found in Appendix C.

Linear regression of data generated during this assessment was conducted using least squares regression for each test and instrument group (Equation 5.1). The output of the regression includes intercept (\(\hat{b}_0\)), slope (\(\hat{b}_1\)), Standard Error (SE) of the slope, Mean Sum Squares Error (MSE), coefficient of determination (\(R^2\)), Confidence Interval (CI) of the regression line, Prediction Interval (PI) of the regression line, and other values as relevant.
Equation 5.1 Linear Least Squares Regression

\[ a \quad \hat{b}_1 = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n} (x_i - \bar{x})^2} \]

\[ b \quad \hat{b}_0 = \bar{y} - \hat{b}_1 \bar{x} \]

\[ c \quad \hat{y}_i = \hat{b}_1 x_i + \hat{b}_0 \]

\( \hat{b}_1 \) = Slope of the linear regression line.
\( \hat{b}_0 \) = The intercept of the linear regression line.
\( x_i \) = The \( i \)th independent sample variable.
\( \bar{x} \) = The mean of the independent sample variables.
\( \hat{x}_i \) = The \( i \)th independent predictor variable.
\( y_i \) = The \( i \)th dependent sample variable.
\( \bar{y} \) = The mean of the dependent sample variables.
\( \hat{y}_i \) = Predicted dependent variable from the regression line.
\( n \) = The sample size.

Confidence intervals describe the interval where the unknown population mean (\( \mu \)) of the sampled population is expected to fall at confidence level 1-\( \alpha \) when re-sampling the population. Similarly, the prediction interval describes the range a future dependent variable may fall for a given independent variable at confidence level 1-\( \alpha \). Confidence and prediction intervals were determined for the sample means (\( \bar{x} \)) of each gas concentration, instrument group, and test using Equation 5.2a and Equation 5.2b. Confidence and prediction intervals for least squares regression lines were constructed for each test and instrument group using Equation 5.3a to Equation 5.3c.

Equation 5.2 Confidence and Prediction Interval

\[ a \quad \text{Confidence Interval} = \bar{x} \pm t(\alpha/2),(n-2) \times \frac{S_x}{\sqrt{n}} \]

\[ b \quad \text{Prediction Interval} = \bar{x} \pm t(\alpha/2),(n-2) \times S_x \sqrt{1 + \frac{1}{n}} \]

\( \bar{x} \) = The mean of the sample.
\( t \) = The critical value of the Student’s \( t \) distribution at significance level \( \alpha/2 \) and \( n-2 \) degrees freedom.
\( S_x \) = The sample standard deviation.
\( n \) = The sample size.
Equation 5.3 Confidence and Prediction Interval of Least Squares Regression (LSR)

[a] \[ MSER = \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{n-2} \]

[b] \[ LSR \text{ Confidence Interval} = \hat{y}_i \pm t_{(\alpha/2),(n-2)} \sqrt{MSER \left( \frac{1}{n} + \frac{(\hat{x}_i - \bar{x})^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \right)} \]

[c] \[ LSR \text{ Prediction Interval} = \hat{y}_i \pm t_{(\alpha/2),(n-2)} \sqrt{MSER \left( 1 + \frac{1}{n} + \frac{(\hat{x}_i - \bar{x})^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \right)} \]

MSER = Mean Sum of Squares Error of the regression line dependent variables.

\( x_i \) = The \( i \)th independent sample variable.

\( \bar{x} \) = The mean of the independent sample variables.

\( \hat{x}_i \) = The \( i \)th independent predictor variable.

\( y_i \) = The \( i \)th dependent sample variable.

\( \hat{y}_i \) = Predicted dependent variable from the regression line.

\( n \) = The sample size.

\( t \) = The critical value of the Student’s \( t \) distribution at significance level \( \alpha/2 \) and \( n-2 \) degrees freedom.

The one sample \( t \)-test (Equation 5.4) can be used to evaluate if the sampled population is equivalent to a specified comparison value (\( \mu_0 \)) with a null hypothesis (\( H_0 \)) of \( \bar{x} = \mu_0 \). One-sample \( t \)-tests were used to assess whether the concentration of target gas measured by instrumentation differed significantly from the concentration of the target gas. If the \( t \)-score calculated from the one-sample \( t \)-test was greater than the corresponding critical value from the Student’s \( t \)-distribution at \( n-2 \) degrees freedom and confidence level \( \alpha/2 \), the null hypothesis (\( H_0 \)) was rejected.

\[ t_{\text{score}} = \frac{\bar{x} - \mu_0}{s/\sqrt{n}} \]

\( \bar{x} \) = The mean of the sampled population.

\( \mu_0 \) = The comparison value for the null hypothesis (\( H_0 \)).

\( s \) = The sample standard deviation.

\( n \) = The sample size.

Two sample \( t \)-tests were used to evaluate if the means of two sample sets are equivalent (\( H_0 : \bar{x}_1 = \bar{x}_2 \)). This test was conducted to compare vinyl chloride measurements pre and post exposure to butyl acrylate. Welch’s \( t \)-test was performed as the sample sizes (\( n \)) were not equal and it was uncertain if the underlying population variances (\( \sigma^2 \)) were equal due to PID exposure to butyl acrylate (Equation 5.5). If the \( t \)-score calculated from the two-sample Welch’s \( t \)-test was greater than the corresponding critical value from the Student’s \( t \)-distribution at the calculated degrees freedom and confidence level \( \alpha/2 \), the null hypothesis (\( H_0 \)) was rejected.
Equation 5.5 Two-sample Welch’s t-test

\[ t_{score} = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \]

\[ df = \frac{\left(\frac{s_1^2}{n_1}\right)^2 + \left(\frac{s_2^2}{n_2}\right)^2}{\frac{n_1 - 1}{n_1} + \frac{n_2 - 1}{n_2}} \]

\( \bar{x}_i \) = The mean of the sampled population.

\( s_i \) = The standard deviation of the sample.

\( n_i \) = The sample size.

\( df \) = Degrees freedom for critical value of t.

The Kolmogorov-Smirnov Goodness-Of-Fit (K-S) test (Equation 5.6) was used to determine if sample data were normally distributed by comparing the empirical cumulative distribution function (ECDF) of the sample to the ECDF of the hypothesized normal distribution constructed using the sample standard deviation (s) and sample mean (\( \bar{x} \)). Where the corresponding p-value was < \( \alpha \), the null hypothesis (\( H_0: F_n(x) = F_0(x) \)) was rejected.

Equation 5.6 Kolmogorov-Smirnov Goodness-Of-Fit Test

\[ F(x) = \begin{cases} 0, & \text{for } x < y_1 \\ i/n, & \text{for } y_i \leq x < y_{i+1} \\ 1, & \text{for } x \geq y_n \end{cases} \]

\[ D_n = \sup_x |F_n(x) - F_0(x)| \]

\( F(x) \) = The empirical cumulative distribution function.

\( F_n(x) \) = The empirical cumulative distribution function of the sample.

\( F_0(x) \) = The empirical cumulative distribution function generated from the hypothesized cumulative distribution function.

\( y_i \) = The \( i^{th} \) value in the ordered sample set.

\( n \) = The sample size.

\( \sup_x \) = Supremum of the closed interval of the set for \( F_n(x) - F_0(x) \).

\( D_n \) = The Kolmogorov-Smirnov test statistic where \( H_0: F_n(x) = F_0(x) \).

The experimentally determined correction factor was determined using the ratio of the isobutylene regression line slope (\( \hat{b}_{1,iso} \)) to the regression line slope of each applicable test (\( \hat{b}_{1,g} \)) using Equation 5.7.
Equation 5.7 Experimentally Determined Instrument Correction Factor for the Assessment
\[ CF_A = \frac{\hat{b}_{iso}}{\hat{b}_{1,g}} \]
\( \hat{b}_1 \) = Slope of the isobutylene linear regression line.
\( \hat{b}_{1,g} \) = Slope of the linear regression line for the gas that the correction factor will be determined for.

Following re-analysis of select cylinders by Enthalpy Analytical and EPA ORD, several cylinders were determined to have contaminants. To determine the manufacturer-recommended correction factor for these mixtures, Equation 5.8 was used.5

Equation 5.8 Correction Factor for Mixtures
\[ CF_{mix} = \frac{1}{\sum_{i=1}^{n} X_i \cdot CF_i} \]
\( X_i \) = The mole fraction of the ith gas in the mixture.
\( CF_i \) = The manufacturer correction factor for the ith gas in the mixture.

Measurements recorded from PIDs calibrated to isobutylene (y) can be converted to the concentration of the target gas (C_{\text{mg}}) using Equation 5.9a when the slope of the calibration line is one. If the slope is not one, as in the case when cylinders were analyzed following the assessment, Equation 5.9b may be used.

Equation 5.9 Corrected Measurement Using Manufacturer Correction Factors
[a] \[ C_{\text{mg}} = y \cdot CF_M \]
[b] \[ C_{\text{an}} = \frac{(y \cdot CF_M - b_0)}{\hat{b}_1} \]
\( \hat{b}_1 \) = Slope of the isobutylene calibration linear regression line using analyzed cylinder concentrations.
\( \hat{b}_0 \) = The intercept the isobutylene calibration linear regression line using analyzed cylinder concentrations.
y = The concentration measured by the assessed PID when calibrated with isobutylene.
\( CF_M \) = The manufacturer’s PID correction factor for the target gas.
\( C_{\text{mg}} \) = The measured concentration as butyl acrylate or vinyl chloride without correcting the cylinder concentrations.
\( C_{\text{an}} \) = The measured concentration as butyl acrylate or vinyl chloride after correcting the cylinder concentrations.

Completeness of the dataset was defined as the amount of verified data obtained from the assessment compared to the amount of data that was expected to be obtained (Equation 5.10). Completeness was
assessed by reviewing measurement logs to ensure that all data were verified within the appropriate data quality objectives (DQOs) in Section 4.2.

**Equation 5.10 Dataset Completeness**

\[
\text{Completeness} = \frac{\text{Number of Verified Measurements}}{\text{Number of Expected Measurements}} \times 100
\]

Precision is a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision was evaluated by making replicate measurements of the same target gas concentration and assessing the variations of the results. Precision for this assessment was defined as the percent relative standard deviation; in other words, the ratio of the sample standard deviation (s) to the mean of instrument measurements (\(\bar{x}\)) (Equation 5.11). The smaller the resulting percentage, the less variation in the recorded measurements.

**Equation 5.11 Precision as Percent Relative Standard Deviation**

\[
\% \text{ RSD} = \frac{s}{\bar{x}} \times 100
\]

- \(s\) = Sample standard deviation.
- \(\bar{x}\) = Mean of instrument measurements.

Accuracy is the degree of agreement of measurements (or an average of measurements) with an accepted reference or true value. Accuracy is a measure of the bias or systematic error in a system. Accuracy of measurement parameters was determined by comparing a measured value \(y_i\) to the target gas concentration \(x_i\) and was assessed in terms of relative percent error (Equation 5.12). Negative values indicate a negative bias in the instrument accuracy. Likewise, positive values indicate a positive bias in instrument accuracy.

**Equation 5.12 Accuracy as Relative Percent Error**

\[
\% \text{ Error} = \frac{y_i - x_i}{x_i} \times 100
\]

- \(x_i\) = The \(i^{th}\) independent sample variable.
- \(y_i\) = The \(i^{th}\) dependent sample variable.

Uncertainty in measurements related to instrument and gas standard accuracy can be propagated when assessing instrument performance. Combined uncertainty \((u_c)\) can be determined using Equation 5.13 and when necessary, assumed to be an estimate of the standard deviation.\(^{31}\) Unless stated otherwise by the manufacturer, instrument and gas cylinder accuracies provided by the manufacturers will be defined as the expanded uncertainty \((U_p)\) in Equation 5.14.\(^{31}\)
Equation 5.13 Combined Uncertainty

\[ u_c = \sqrt{\sum_{i=1}^{n} u_i^2} \]

\( u_i = \) The standard uncertainty of the quantity, process, or other value, as standard deviation.

Equation 5.14 Percent Expanded Uncertainty

\[ U_p = \frac{k u_c}{X} \times 100 \]

\( k = \) Confidence interval coverage factor where 2 = 95% confidence interval and 3 = 99% confidence interval.
\( u_c = \) Combined uncertainty.
\( X = \) The quantity the combined uncertainty applies to (e.g., instrument measurement, gas concentration in a cylinder).
6.0 Results and Discussion

Data collection completeness achieved the objective of ≥ 90% valid measurements specified in the DQOs with a total of 1,961 manually recorded measurements. A total of four collected measurements were rejected and not included in data analysis due to a faulty pump causing slow gas purge times for AreaRAE Plus instrument AR04. The flow rate of 0.19 L/min for AR04 was below the manufacturer minimum specified range of 0.2 L/min. Therefore, the instrument did not meet the QC criteria contained in Section 4.2 and was replaced. The test cycle was re-conducted with all three instruments. One ppbRAE, instrument, PR01, failed calibration and was replaced prior to recording any test measurements. Data completeness for manually recorded measurements was therefore 100% with at least three manually recorded measurements per test, gas target concentration, and instrument.

Measurements recorded via data logs also met the DQO for completeness of ≥ 90% with a total of 984,845 automatically recorded measurements. One AreaRAE Plus’ (AR03) data log was unrecoverable after the assessment due to a hardware or software issue of indeterminate cause. As a result, 15/16 (94%) of instruments used during the assessment have complete and available data logs.

Caution should be used when conducting direct comparison of aggregate performance metrics for vinyl chloride versus butyl acrylate as the assessed measurement range for butyl acrylate was lower (0.022 versus 0.05). This difference can result in a greater percentage of butyl acrylate targets, in aggregate, not achieving performance criteria compared to vinyl chloride. It cannot be determined from this assessment if the instrument performance of vinyl chloride below 0.05 ppm is similar to that of butyl acrylate.

The K-S test (Equation 5.6) was used to identify if data was normally distributed. Out of 109 test/instrument/target concentration groups where the target concentration and variance were not zero, 96.3% were normally distributed at α=0.01, and 91.8% were normally distributed at α=0.05. When it was determined the distribution was not normal at α=0.01, the K-S test was run against 105 alternate distributions, and the distribution with the smallest p-value was selected (Appendix C). As the majority of data groups were normally distributed, it is possible data groups identified as not normally distributed may still be normally distributed if additional data points had been collected.

6.1 Gas Cylinder Re-analysis

Target gas cylinders produced by Portagas were selected throughout the concentration range for re-analysis by Enthalpy Analytical and EPA ORD as these cylinders did not receive final verification of concentration by the manufacturer after dividing the parent cylinder into smaller cylinders. Measured concentrations for 67% of cylinders were outside the uncertainty range specified by the manufacturer in Table 5.1. A summary of these results is contained in Table 6.1.
Table 6.1 Gas Cylinder Re-analysis

<table>
<thead>
<tr>
<th>Gas Name</th>
<th>Cylinder ID</th>
<th>Detected Compound</th>
<th>Sample Count</th>
<th>Target Conc. (ppm)</th>
<th>Mean Measurement (ppm)</th>
<th>Measurement Range (ppm)</th>
<th>Mean Relative Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinyl Chloride</td>
<td>V01</td>
<td>Vinyl Chloride</td>
<td>2</td>
<td>0.05</td>
<td>0.05853</td>
<td>0.0494 - 0.0677</td>
<td>17.1</td>
</tr>
<tr>
<td></td>
<td>V06</td>
<td>Vinyl Chloride</td>
<td>4</td>
<td>0.2</td>
<td>0.21321</td>
<td>0.171 - 0.2551</td>
<td>6.05</td>
</tr>
<tr>
<td>Isobutylene</td>
<td>IS04</td>
<td>Acetone</td>
<td>1</td>
<td>0</td>
<td>0.00203</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>IS04</td>
<td>Ethanol</td>
<td>1</td>
<td>0</td>
<td>0.00848</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>IS06</td>
<td>Isobutylene</td>
<td>1</td>
<td>10</td>
<td>8.3989</td>
<td>NA</td>
<td>-16.0</td>
</tr>
<tr>
<td></td>
<td>IS08</td>
<td>Isobutylene</td>
<td>1</td>
<td>10</td>
<td>9.7334</td>
<td>NA</td>
<td>-2.7</td>
</tr>
<tr>
<td></td>
<td>IS10</td>
<td>Acetone</td>
<td>1</td>
<td>0</td>
<td>0.00243</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>IS04</td>
<td>Isobutylene</td>
<td>1</td>
<td>2</td>
<td>1.94634</td>
<td>NA</td>
<td>-2.7</td>
</tr>
<tr>
<td></td>
<td>IS06</td>
<td>Isobutylene</td>
<td>1</td>
<td>10</td>
<td>8.3989</td>
<td>NA</td>
<td>-16.0</td>
</tr>
<tr>
<td></td>
<td>IS08</td>
<td>Isobutylene</td>
<td>1</td>
<td>10</td>
<td>9.7334</td>
<td>NA</td>
<td>-2.7</td>
</tr>
<tr>
<td>Butyl Acrylate</td>
<td>BA01</td>
<td>Butyl Acrylate</td>
<td>2</td>
<td>0.05</td>
<td>0.0216</td>
<td>0.0210 - 0.0222</td>
<td>-56.8</td>
</tr>
<tr>
<td></td>
<td>BA02</td>
<td>Butyl Acrylate</td>
<td>2</td>
<td>0.05</td>
<td>0.02784</td>
<td>0.0274 - 0.0283</td>
<td>-44.3</td>
</tr>
<tr>
<td></td>
<td>BA03</td>
<td>Butyl Acrylate</td>
<td>3</td>
<td>0</td>
<td>0.23694</td>
<td>0.0816 - 0.3152</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>BA06</td>
<td>Butyl Acrylate</td>
<td>3</td>
<td>0.05</td>
<td>0.01863</td>
<td>0.0126 - 0.0222</td>
<td>-62.74</td>
</tr>
<tr>
<td></td>
<td>BA10</td>
<td>Butyl Acrylate</td>
<td>1</td>
<td>2</td>
<td>1.8666</td>
<td>NA</td>
<td>-6.7</td>
</tr>
<tr>
<td></td>
<td>BA11</td>
<td>Butyl Acrylate</td>
<td>1</td>
<td>0.2</td>
<td>0.0821</td>
<td>NA</td>
<td>-58.95</td>
</tr>
</tbody>
</table>

**Cylinder Contaminant.**
**Total Cylinder Contaminants > 0.1 ppm.**
**Cylinder contents not within manufacturer stated uncertainty. See Table 5.1.**

While acetone and ethanol contamination were present in some analyzed isobutylene cylinders, the concentrations are not anticipated to adversely impact the assessment. Butyl acrylate cylinders stated by the manufacturer to have 0.05 ppm butyl acrylate were clearly impacted by contaminants along with the low concentration of butyl acrylate. As a result, the correction factors for the analyzed 0.05 ppm butyl acrylate cylinders increased by 392%-501% (Table 6.2a and Table 6.2b) when calculated using Equation 5.8.

Table 6.2 Contaminated Cylinder Correction Factors

<table>
<thead>
<tr>
<th>Cylinder ID</th>
<th>Instrument</th>
<th>Butyl Acrylate Cylinders&lt;sup&gt;5–7&lt;/sup&gt;</th>
<th>Calculated Mixture CF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mfg. Butyl Acrylate CF</td>
<td>Mfg. Ethanol CF</td>
</tr>
<tr>
<td>BA02</td>
<td>AreaRAE</td>
<td>1.60</td>
<td>11.20</td>
</tr>
<tr>
<td></td>
<td>MultiRAE</td>
<td>1.60</td>
<td>11.00</td>
</tr>
<tr>
<td></td>
<td>ppbRAE</td>
<td>1.60</td>
<td>7.90</td>
</tr>
<tr>
<td>BA06</td>
<td>AreaRAE</td>
<td>1.60</td>
<td>11.20</td>
</tr>
<tr>
<td></td>
<td>MultiRAE</td>
<td>1.60</td>
<td>11.00</td>
</tr>
<tr>
<td></td>
<td>ppbRAE</td>
<td>1.60</td>
<td>7.90</td>
</tr>
</tbody>
</table>
Slopes for the isobutylene calibration line were impacted by lower than anticipated cylinder concentrations. As a result, isobutylene calibration slopes for all instruments increased between 2.6% and 19.6% (Figure 6.1). *

---

* Cylinders which were not analyzed, but were from the same lot as analyzed cylinders, were assumed to contain the same concentration of isobutylene as analyzed cylinders. All other isobutylene cylinders were assumed to contain the manufacturer's stated concentration.
The regression line is constructed using the manufacturer’s stated cylinder concentration. The corrected regression line uses cylinder concentrations from re-analysis (blue) by Enthalpy Analytical and the EPA ORD. Cylinders which were not analyzed but were from the same lot as analyzed cylinders (gold), were assumed to contain the same concentration of isobutylene as analyzed cylinders. All other isobutylene cylinders were assumed to contain the manufacturer’s stated concentration (red).
6.2 Instrument Precision

For the 103 tests, target gas concentrations, and instrument combinations, 26% were greater than the specified DQO of ≤ 30% for precision as Percent Relative Standard Deviation (%RSD). Precision improved for all tests and instruments at higher concentrations, with all concentrations greater than 0.2 ppm meeting the objective for variation in repeated measurements of ≤ 30%. The reduction in precision at lower concentrations is evident when reviewing graphs of target concentrations versus measured concentrations by test cycle as in example Figure 6.2 where a log scale has been used to view this variability more clearly. Test cycle graphs for all instruments, tests, and target chemicals can be found in Appendix D. Due to the inability to display the logarithm of zero values, all zero values on the x-axis and y-axis have been substituted with \(0.001/\sqrt{2}\) where 0.001 ppm is the minimum resolution of the ppbRAE PID. This substitution allows for display of the variability at the zero point of the test cycles, but not without introducing its own inaccuracies.

**Figure 6.2 Butyl Acrylate Test Cycles for AreaRAE and MultiRAE PPB PIDs**

All zero values on the x-axis and y-axis substituted with \(0.001/\sqrt{2}\) to accommodate the log scale. Points within the bounds of the red box in the lower left corner should be considered equivalent to zero response.
Table 6.3 Test Precision as Percent Relative Standard Deviation

<table>
<thead>
<tr>
<th>Target Gas</th>
<th>Test Name</th>
<th>Target Conc. (ppm)*</th>
<th>AreaRAE (ER)</th>
<th>AreaRAE (PPB)</th>
<th>MultiRAE (ER)</th>
<th>MultiRAE (PPB)</th>
<th>ppbRAE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butyl Acrylate</td>
<td>Butyl Acrylate Test</td>
<td>0.022</td>
<td>BR</td>
<td>86.00%</td>
<td>BR</td>
<td>143.50%</td>
<td>75.70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05</td>
<td>BR</td>
<td>51.20%</td>
<td>BR</td>
<td>139.40%</td>
<td>47.10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2</td>
<td>28.50%</td>
<td>9.80%</td>
<td>56.70%</td>
<td>61.70%</td>
<td>23.60%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>17.40%</td>
<td>2.90%</td>
<td>7.10%</td>
<td>8.40%</td>
<td>4.70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.699</td>
<td>14.20%</td>
<td>1.40%</td>
<td>3.80%</td>
<td>3.30%</td>
<td>0.50%</td>
</tr>
<tr>
<td></td>
<td>Butyl Acrylate</td>
<td>Calibrated Test</td>
<td>0.022</td>
<td>27.00%</td>
<td>BR</td>
<td>72.50%</td>
<td>150.40%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05</td>
<td>16.40%</td>
<td>BR</td>
<td>55.70%</td>
<td>99.00%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2</td>
<td>13.20%</td>
<td>13.20%</td>
<td>35.40%</td>
<td>41.00%</td>
<td>21.20%</td>
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<tr>
<td></td>
<td></td>
<td>2</td>
<td>4.10%</td>
<td>3.30%</td>
<td>1.70%</td>
<td>2.40%</td>
<td>2.70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.699</td>
<td>1.50%</td>
<td>1.50%</td>
<td>2.00%</td>
<td>1.80%</td>
<td>2.10%</td>
</tr>
<tr>
<td>Isobutylene</td>
<td>Isobutylene Test</td>
<td>2</td>
<td>9.90%</td>
<td>4.50%</td>
<td>3.60%</td>
<td>2.90%</td>
<td>8.60%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>1.80%</td>
<td>1.40%</td>
<td>1.70%</td>
<td>3.60%</td>
<td>3.60%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td>6.70%</td>
<td>2.10%</td>
<td>5.40%</td>
<td>9.90%</td>
<td>9.50%</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>Vinyl Chloride Test</td>
<td>0.05</td>
<td>39.30%</td>
<td>BR</td>
<td>132.30%</td>
<td>84.80%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2</td>
<td>85.70%</td>
<td>24.50%</td>
<td>0.00%</td>
<td>45.30%</td>
<td>65.50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.981</td>
<td>17.30%</td>
<td>10.80%</td>
<td>0.00%</td>
<td>9.50%</td>
<td>40.30%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.937</td>
<td>15.60%</td>
<td>2.70%</td>
<td>0.00%</td>
<td>6.70%</td>
<td>9.20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.736</td>
<td>13.60%</td>
<td>2.10%</td>
<td>1.10%</td>
<td>3.00%</td>
<td>5.00%</td>
</tr>
<tr>
<td></td>
<td>Vinyl Chloride</td>
<td>Post BA Exposure</td>
<td>0.05</td>
<td>87.90%</td>
<td>BR</td>
<td>56.00%</td>
<td>55.30%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2</td>
<td>24.80%</td>
<td>30.30%</td>
<td>30.00%</td>
<td>40.40%</td>
<td>23.70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.981</td>
<td>16.20%</td>
<td>7.60%</td>
<td>8.40%</td>
<td>8.30%</td>
<td>2.70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.937</td>
<td>14.80%</td>
<td>3.40%</td>
<td>0.00%</td>
<td>3.90%</td>
<td>0.90%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.736</td>
<td>11.50%</td>
<td>3.10%</td>
<td>1.50%</td>
<td>2.30%</td>
<td>0.90%</td>
</tr>
</tbody>
</table>

*Manufacturer stated concentration.

For gas concentrations at the lower end of the measurement range, the general trend was an increase in concentration with each cycle, particularly with butyl acrylate. However, it was not uncommon, mostly for vinyl chloride, for measured concentrations on the third test cycle to be below those of test cycles one and two (Appendix D). The cause of the non-linearity at target concentrations less than 0.2 ppm is indeterminate and may be related to a combination of factors including the experimental design, the instruments themselves, and cylinder contents. Trends of increasing concentration per test cycle suggest some degree of residual target gas remains within the gas distribution manifold and/or the instruments themselves resulting in an elevated zero point. Additional caution should be used when drawing conclusions from this assessment about instrument precision in this measurement range due to the additional uncertainties regarding cause.

### 6.3 Instrument Accuracy

Accuracy of measurements by instrument and target concentration were assessed as mean relative percent error and are contained in Table 6.4. For all instruments, variations in accuracy were clearly apparent.
between PID model, substance, and concentration. Measurements were adjusted using the manufacturer’s specified correction factors (butyl acrylate CF 1.6; vinyl chloride CF 2.0) for comparison to the DQO for accuracy of ± 40% relative error around the manufacturer-stated target concentration. Both positive and negative biases were observed across the measurement range for all three target gases. Of the 1,183 measurements manually recorded during the primary assessments; 511 measurements (44%) were not within the ± 40% relative error range. Likewise, 23% of the means for each test concentration and instrument combination did not meet ± 40% relative error range (Table 6.4). Mean relative error in ppm is contained in Table 6.5.

### Table 6.4 Test Accuracy as Mean Relative Percent Error

<table>
<thead>
<tr>
<th>Target Gas</th>
<th>Test Name</th>
<th>Target Conc (ppm)*</th>
<th>Instrument Model</th>
<th>AreaRAE (ER)</th>
<th>AreaRAE (PPB)</th>
<th>MultiRAE (ER)</th>
<th>MultiRAE (PPB)</th>
<th>ppbRAE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butyl Acrylate</td>
<td>Butyl Acrylate Test</td>
<td>0.022</td>
<td>BR</td>
<td>392.9%</td>
<td>BR</td>
<td>9.1%</td>
<td>353.9%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05</td>
<td>BR</td>
<td>180.9%</td>
<td>BR</td>
<td>-54.7%</td>
<td>151.2%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2</td>
<td>68.9%</td>
<td>77.8%</td>
<td>-37.8%</td>
<td>-77.3%</td>
<td>39.3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>-17.3%</td>
<td>3.7%</td>
<td>-40.4%</td>
<td>-45.1%</td>
<td>-22.9%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.699</td>
<td>-16.8%</td>
<td>-4.2%</td>
<td>-19.4%</td>
<td>-17.0%</td>
<td>-23.1%</td>
<td></td>
</tr>
<tr>
<td>Butyl Acrylate</td>
<td>Butyl Acrylate Calibrated Test</td>
<td>0.022</td>
<td>BR</td>
<td>763.6%</td>
<td>BR</td>
<td>344.4%</td>
<td>-88.4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05</td>
<td>BR</td>
<td>428.9%</td>
<td>BR</td>
<td>160.0%</td>
<td>-31.1%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2</td>
<td>111.1%</td>
<td>114.4%</td>
<td>-27.8%</td>
<td>-22.8%</td>
<td>13.5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>1.1%</td>
<td>13.2%</td>
<td>0.6%</td>
<td>3.4%</td>
<td>-2.7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.699</td>
<td>2.6%</td>
<td>4.3%</td>
<td>4.7%</td>
<td>4.6%</td>
<td>5.2%</td>
<td></td>
</tr>
<tr>
<td>Isobutylene</td>
<td>Isobutylene Test</td>
<td>2</td>
<td>10.4%</td>
<td>22.6%</td>
<td>0.4%</td>
<td>0.8%</td>
<td>-4.7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>0.2%</td>
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<td>-3.4%</td>
<td>-11.3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td>6.3%</td>
<td>-2.2%</td>
<td>35.5%</td>
<td>3.6%</td>
<td>-4.2%</td>
<td></td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>Vinyl Chloride Test</td>
<td>0.05</td>
<td>BR</td>
<td>344.4%</td>
<td>BR</td>
<td>-20.0%</td>
<td>49.8%</td>
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</tr>
<tr>
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<td>-22.2%</td>
<td>58.9%</td>
<td>0.0%</td>
<td>-48.9%</td>
<td>-25.9%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.981</td>
<td>1.9%</td>
<td>32.7%</td>
<td>1.9%</td>
<td>-10.5%</td>
<td>-21.1%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.937</td>
<td>13.4%</td>
<td>32.9%</td>
<td>21.5%</td>
<td>28.8%</td>
<td>-7.8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.736</td>
<td>19.1%</td>
<td>32.7%</td>
<td>29.4%</td>
<td>24.5%</td>
<td>-5.6%</td>
<td></td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>Vinyl Chloride Post BA Exposure</td>
<td>0.05</td>
<td>BR</td>
<td>77.8%</td>
<td>BR</td>
<td>157.8%</td>
<td>14.7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2</td>
<td>77.8%</td>
<td>-6.7%</td>
<td>11.1%</td>
<td>-3.3%</td>
<td>-19.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.981</td>
<td>11.0%</td>
<td>13.7%</td>
<td>6.5%</td>
<td>2.2%</td>
<td>-6.5%</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>4.937</td>
<td>15.2%</td>
<td>28.5%</td>
<td>21.5%</td>
<td>23.3%</td>
<td>-1.1%</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>9.736</td>
<td>17.1%</td>
<td>29.1%</td>
<td>34.4%</td>
<td>26.1%</td>
<td>-1.8%</td>
<td></td>
</tr>
</tbody>
</table>

Zero percent equates to no error in measurement.  
**BR** = Below PID measurement range.  
*Manufacturer stated concentration.

> Excludes measurements recorded during calibration and following overnight runs. Overnight run measurements were not included as they were not directly comparable to primary tests. Zero air measurement points were excluded due to division by zero errors.
Table 6.5 Test Accuracy as Mean Relative Error in ppm

<table>
<thead>
<tr>
<th>Gas Name</th>
<th>Test Name (group)</th>
<th>Target Conc. (ppm)*</th>
<th>AreaRAE (ER)</th>
<th>AreaRAE (PPB)</th>
<th>MultiRAE (ER)</th>
<th>MultiRAE (PPB)</th>
<th>ppbRAE</th>
</tr>
</thead>
<tbody>
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<td>Butyl Acrylate</td>
<td>Butyl Acrylate Test</td>
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<td>0.07</td>
<td>0.11</td>
<td>0.07</td>
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<tr>
<td></td>
<td></td>
<td>0.022</td>
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<td>0.09</td>
<td>BR</td>
<td>0.00</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05</td>
<td>BR</td>
<td>0.09</td>
<td>BR</td>
<td>-0.03</td>
<td>0.08</td>
</tr>
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<td></td>
<td></td>
<td>0.2</td>
<td>0.14</td>
<td>0.16</td>
<td>-0.08</td>
<td>-0.15</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>-0.35</td>
<td>0.07</td>
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<td>-0.90</td>
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</tr>
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<td>-1.64</td>
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</tr>
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<td>Butyl Acrylate</td>
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<td>0.13</td>
<td>0.24</td>
<td>0.09</td>
<td>0.10</td>
<td>0.00</td>
</tr>
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<td>0.022</td>
<td>BR</td>
<td>0.17</td>
<td>BR</td>
<td>0.08</td>
<td>-0.02</td>
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<td>0.05</td>
<td>BR</td>
<td>0.21</td>
<td>BR</td>
<td>0.08</td>
<td>-0.02</td>
</tr>
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<td>0.23</td>
<td>-0.06</td>
<td>-0.05</td>
<td>0.03</td>
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<td>2</td>
<td>0.02</td>
<td>0.26</td>
<td>0.01</td>
<td>0.07</td>
<td>-0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.699</td>
<td>0.26</td>
<td>0.42</td>
<td>0.46</td>
<td>0.44</td>
<td>0.50</td>
</tr>
<tr>
<td>Isobutylene</td>
<td>Isobutylene Test</td>
<td>0.00</td>
<td>0.04</td>
<td>0.10</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>0.21</td>
<td>0.45</td>
<td>0.01</td>
<td>0.02</td>
<td>-0.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>0.02</td>
<td>0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-1.13</td>
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<tr>
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<td>-2.21</td>
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<td>3.59</td>
<td>-4.17</td>
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<tr>
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<td>Vinyl Chloride Test</td>
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<td>0.10</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05</td>
<td>BR</td>
<td>0.17</td>
<td>BR</td>
<td>-0.01</td>
<td>0.02</td>
</tr>
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<td></td>
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<td>0.00</td>
<td>-0.10</td>
<td>-0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.981</td>
<td>0.02</td>
<td>0.32</td>
<td>0.02</td>
<td>-0.10</td>
<td>-0.21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.937</td>
<td>0.66</td>
<td>1.63</td>
<td>1.06</td>
<td>1.42</td>
<td>-0.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.736</td>
<td>1.86</td>
<td>3.18</td>
<td>2.86</td>
<td>2.39</td>
<td>-0.54</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>Post BA Exposure</td>
<td>0.00</td>
<td>0.04</td>
<td>0.05</td>
<td>0.03</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05</td>
<td>BR</td>
<td>0.04</td>
<td>BR</td>
<td>0.08</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2</td>
<td>0.16</td>
<td>-0.01</td>
<td>0.02</td>
<td>-0.01</td>
<td>-0.04</td>
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<td>0.981</td>
<td>0.11</td>
<td>0.13</td>
<td>0.06</td>
<td>0.02</td>
<td>-0.06</td>
</tr>
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<td></td>
<td>4.937</td>
<td>0.75</td>
<td>1.41</td>
<td>1.06</td>
<td>1.15</td>
<td>-0.06</td>
</tr>
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<td></td>
<td>9.736</td>
<td>1.66</td>
<td>2.83</td>
<td>3.35</td>
<td>2.54</td>
<td>-0.18</td>
</tr>
</tbody>
</table>

Colors represent accuracy as mean relative percent error.

BR = Below measurement range.

*Manufacturer stated concentration.

For the butyl acrylate test, 48% of the mean relative percent errors were outside the range of ± 40% of the target concentration. When calibrated to butyl acrylate, 33% of mean relative percent errors were outside of the specified range. In contrast, 17% of vinyl chloride mean relative percent errors, and 13% of vinyl chloride mean relative percent errors following butyl acrylate exposure, were not within the specified range. All mean relative percent errors for isobutylene were within the specified range.

One sample t-test results (H_0: \( \bar{x} = \mu_0 \)) would initially suggest the assessed PIDs were more accurate in measuring vinyl chloride at concentrations ≤ 0.2 ppm than concentrations > 0.2 ppm (Table 6.6 - Table 6.6b). However, this is due to the previously described decreased precision (Table 6.3) at lower concentrations.
concentrations. Accuracy was not necessarily improved at vinyl chloride concentrations below 0.2 ppm than concentrations greater than 0.2 ppm. The result may be a mistaken failure to reject $H_0$ (type II error) at some lower concentrations of vinyl chloride.

### Table 6.6 One-sample t-test Results for Butyl Acrylate, Vinyl Chloride, and Isobutylene

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Calibration Gas</th>
<th>0.00</th>
<th>0.022</th>
<th>0.05</th>
<th>0.20</th>
<th>2.00</th>
<th>9.69</th>
</tr>
</thead>
<tbody>
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<td>Isobutylene</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>Butyl Acrylate</td>
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<td>BR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AreaRAE (PPB)</td>
<td>Isobutylene</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Butyl Acrylate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MultiRAE (ER)</td>
<td>Isobutylene</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>Butyl Acrylate</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MultiRAE (PPB)</td>
<td>Isobutylene</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
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<td>Butyl Acrylate</td>
<td>BR</td>
<td>BR</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>ppbRAE</td>
<td>Isobutylene</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
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</tr>
<tr>
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<td>Butyl Acrylate</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*BR = Below instrument measurement range.*

### (b) Vinyl Chloride

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Test Type</th>
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<th>0.98</th>
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</tr>
<tr>
<td></td>
<td>Post-BA</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AreaRAE (PPB)</td>
<td>Pre-BA</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post-BA</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>MultiRAE (ER)</td>
<td>Pre-BA</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post-BA</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MultiRAE (PPB)</td>
<td>Pre-BA</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post-BA</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ppbRAE</td>
<td>Pre-BA</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post-BA</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*BR = Below instrument measurement range.*

### (c) Isobutylene

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Target Concentration (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>AreaRAE (ER)</td>
<td>BR</td>
</tr>
<tr>
<td>AreaRAE (PPb)</td>
<td>BR</td>
</tr>
<tr>
<td>MultiRAE (ER)</td>
<td>BR</td>
</tr>
<tr>
<td>MultiRAE (PPb)</td>
<td>BR</td>
</tr>
<tr>
<td>ppbRAE</td>
<td>BR</td>
</tr>
</tbody>
</table>
The duration required for all instruments to return to zero ppm, or the baseline concentration, following introduction of 10 ppm butyl acrylate was greater than both isobutylene and vinyl chloride at the same concentration. Vinyl chloride exhibited a similar effect to a lesser degree, and isobutylene least of all. This shift in the zero-point impacted accuracy of tests to varying degrees. In most circumstances, a return to zero ppm was possible within 5-10 minutes following PID exposure to 10 ppm butyl acrylate. However, returning to zero concentration between test cycles was not always achievable within the permitted time frame of ~5 minutes.

To test whether PID exposure to higher concentrations of target gases results in increases in measured concentration at the low end of the target range, three ppbRAEs were two-point calibrated with zero air and 2 ppm isobutylene instead of the three-point calibration used during the primary test assessments. Three cycles supplying the instruments with zero air followed by 0.05 ppm butyl acrylate were conducted. Another test of three cycles of zero air and 0.2 ppm butyl acrylate followed. Cursory analysis would at first suggest accuracy at 0.05 ppm improved by 169.6% and accuracy at 0.2 ppm improved by 34.6%. However, attempts to correct for contamination and inaccurate concentrations in target cylinders appear to alter the outcome. Therefore, it cannot be determined if limiting the concentration of target gas supplied to the PID effectively mitigates observed increases in measurement results at low concentrations with each test cycle.

At the end of each day, one group of three instruments was permitted to run overnight (~12 hours) measuring ambient air. In the morning, a bump check was performed, and morning measurements were compared to those from the previous day. All instrument groups exhibited a decrease in the mean measured concentration between 5% and 28% (Table 6.7).

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>ppbRAE</td>
<td>-14.9%</td>
</tr>
<tr>
<td>AreaRAE (ER)</td>
<td>-5.0%</td>
</tr>
<tr>
<td>AreaRAE (PPB)</td>
<td>-10.2%</td>
</tr>
<tr>
<td>MultiRAE (ER)</td>
<td>-10.0%</td>
</tr>
<tr>
<td>MultiRAE (PPB)</td>
<td>-28.0%</td>
</tr>
</tbody>
</table>

Each instrument group was assessed against various gases throughout the day and received multiple calibrations. It was observed that instrument zero points would frequently increase throughout testing cycles and return to zero given sufficient run-time. The observed decrease in instrument mean measurement overnight may be typical performance change. However, the decrease may also be due to an elevated zero point due to extended exposure to target gases, multiple calibrations throughout the day, and extended overnight purge time, resulting in a self-cleaning effect. It is not possible from this assessment to determine what proportion of the decrease is related to one, the other, or both of these factors.
Measurements were corrected using Equation 5.9a, the re-analyzed cylinder concentrations in Table 6.1 and the correction factors in Table 6.2. The result was an improvement in accuracy for 65% of the test/instrument combinations (Table 6.8). The results in Table 6.8 were not adjusted for changes in the calibration due to concentration variations in the isobutylene cylinders.

### Table 6.8 Mean Percent Error Prior to and After Correcting for Analyzed Cylinder Concentrations

<table>
<thead>
<tr>
<th>Test</th>
<th>Instrument</th>
<th>Cylinder Concentration (ppm)</th>
<th>Assessment Measurement Mean Percent Error</th>
<th>Re-Analyzed Cylinder*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Manufacturer</td>
<td>Re-Analyzed (Mean)</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>Butyl Acrylate Test</td>
<td>AreaRAE (PPB)</td>
<td>0.022</td>
<td>0.02215</td>
<td>392.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05</td>
<td>0.26473</td>
<td>180.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2</td>
<td>0.1563</td>
<td>77.8%</td>
</tr>
<tr>
<td></td>
<td>AreaRAE (ER)</td>
<td>2</td>
<td>1.9736</td>
<td>-17.3%</td>
</tr>
<tr>
<td></td>
<td>MultiRAE (PPB)</td>
<td>0.022</td>
<td>0.02215</td>
<td>9.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05</td>
<td>0.26473</td>
<td>-54.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2</td>
<td>0.1563</td>
<td>-77.3%</td>
</tr>
<tr>
<td></td>
<td>ppbRAE</td>
<td>0.022</td>
<td>0.02215</td>
<td>353.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05</td>
<td>0.2740735</td>
<td>151.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2</td>
<td>0.1192</td>
<td>39.3%</td>
</tr>
<tr>
<td>Vinyl Chloride Test</td>
<td>AreaRAE (PPB)</td>
<td>0.05</td>
<td>0.0583</td>
<td>344.4%</td>
</tr>
<tr>
<td></td>
<td>AreaRAE (ER)</td>
<td>0.2</td>
<td>0.21321</td>
<td>-22.2%</td>
</tr>
<tr>
<td></td>
<td>MultiRAE Pro (PPB)</td>
<td>0.05</td>
<td>0.0583</td>
<td>-20.0%</td>
</tr>
<tr>
<td></td>
<td>MultiRAE Pro (ER)</td>
<td>0.2</td>
<td>0.21321</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>ppbRAE</td>
<td>0.05</td>
<td>0.0583</td>
<td>49.8%</td>
</tr>
<tr>
<td>Vinyl Chloride Post BA Exposure</td>
<td>AreaRAE (PPB)</td>
<td>0.05</td>
<td>0.0583</td>
<td>77.8%</td>
</tr>
<tr>
<td></td>
<td>AreaRAE (ER)</td>
<td>0.2</td>
<td>0.21321</td>
<td>77.8%</td>
</tr>
<tr>
<td></td>
<td>MultiRAE Pro (PPB)</td>
<td>0.05</td>
<td>0.0583</td>
<td>157.8%</td>
</tr>
<tr>
<td></td>
<td>MultiRAE Pro (ER)</td>
<td>0.2</td>
<td>0.21321</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>ppbRAE</td>
<td>0.05</td>
<td>0.0583</td>
<td>14.7%</td>
</tr>
</tbody>
</table>

*Assessment measurements from cylinders which did not receive re-analysis are excluded. No corrections were applied to instrument measurements based on changes in instrument calibration from re-analyzed isobutylene cylinders.

*If a re-analyzed cylinder contained contaminants, the appropriate mixture correction factor contained in Table 6.2 was applied to the measurement from the instrument.

Since the error in both cylinder concentrations and instrument measurements increased as concentration decreased, it is not possible to determine with certainty what proportion of measurement inaccuracy observed at lower concentrations was due to the cylinder concentration or the instrument. The degree cylinders contributed to the observable trend of decreasing measurement accuracy can also not be determined.

### 6.4 Vinyl Chloride Measurement following PID Exposure to Butyl Acrylate

To determine the effect on the instrument’s ability to measure vinyl chloride following PID exposure to butyl acrylate, vinyl chloride concentrations were re-measured following completion of all other tests and after suppling 10 ppm butyl acrylate to the PID at the start of the test.
However, where $H_0$ was rejected, there was no guarantee the difference adversely impacted performance as accuracy improved for 77% of instrument/concentration combinations for the post-butyl acrylate test. This was most apparent for the AreaRAE Pro (PPB) where a statistically significant difference in the test means was observed at all target concentrations, but following PID exposure to butyl acrylate, accuracy also improved at every target concentration. The mean precision of the overall vinyl concentration range, aggregated across all instruments, improved by 6.4% after PID exposure to butyl acrylate.

### Table 6.9 Two-sample t-test Results and Summary Statistics for Vinyl Chloride Measurements Pre/Post PID Exposure to Butyl Acrylate

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Target Conc.</th>
<th>Reject $H_0$</th>
<th>p-value</th>
<th>Pre-Mean %Error</th>
<th>Post-Mean %Error</th>
<th>Pre-Confidence Interval</th>
<th>Post-Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>AreaRAE Pro (PPB)</td>
<td>0</td>
<td>Yes</td>
<td>0.00196</td>
<td>NA</td>
<td>NA</td>
<td>0.110 ± 0.037</td>
<td>0.029 ± 0.031</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>Yes</td>
<td>0.00363</td>
<td>344.4</td>
<td>77.8</td>
<td>0.111 ± 0.032</td>
<td>0.044 ± 0.029</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
<td>Yes</td>
<td>0.00101</td>
<td>58.9</td>
<td>-6.7</td>
<td>0.159 ± 0.029</td>
<td>0.093 ± 0.021</td>
</tr>
<tr>
<td></td>
<td>0.981</td>
<td>Yes</td>
<td>0.00453</td>
<td>32.7</td>
<td>13.7</td>
<td>0.651 ± 0.052</td>
<td>0.558 ± 0.032</td>
</tr>
<tr>
<td></td>
<td>4.937</td>
<td>Yes</td>
<td>0.03004</td>
<td>32.9</td>
<td>28.5</td>
<td>3.281 ± 0.065</td>
<td>3.171 ± 0.079</td>
</tr>
<tr>
<td></td>
<td>9.736</td>
<td>Yes</td>
<td>0.04530</td>
<td>32.7</td>
<td>29.1</td>
<td>6.458 ± 0.102</td>
<td>6.283 ± 0.145</td>
</tr>
<tr>
<td>AreaRAE (ER)</td>
<td>0</td>
<td>Yes</td>
<td>0.00086</td>
<td>NA</td>
<td>NA</td>
<td>0.00 ± 0.00</td>
<td>0.04 ± 0.03</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
<td>Yes</td>
<td>0.00217</td>
<td>-22.2</td>
<td>77.8</td>
<td>0.08 ± 0.05</td>
<td>0.18 ± 0.03</td>
</tr>
<tr>
<td></td>
<td>0.981</td>
<td>No</td>
<td>0.29671</td>
<td>1.9</td>
<td>11.0</td>
<td>0.50 ± 0.06</td>
<td>0.54 ± 0.07</td>
</tr>
<tr>
<td></td>
<td>4.937</td>
<td>No</td>
<td>0.82876</td>
<td>13.4</td>
<td>15.2</td>
<td>2.80 ± 0.32</td>
<td>2.84 ± 0.31</td>
</tr>
<tr>
<td></td>
<td>9.736</td>
<td>No</td>
<td>0.77332</td>
<td>19.1</td>
<td>17.1</td>
<td>5.80 ± 0.59</td>
<td>5.70 ± 0.49</td>
</tr>
<tr>
<td>MultiRAE Pro (PPB)</td>
<td>0</td>
<td>No</td>
<td>0.07138</td>
<td>NA</td>
<td>NA</td>
<td>0.009 ± 0.010</td>
<td>0.027 ± 0.017</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>No</td>
<td>0.00954</td>
<td>-20.0</td>
<td>157.8</td>
<td>0.020 ± 0.020</td>
<td>0.064 ± 0.027</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
<td>Yes</td>
<td>0.01003</td>
<td>-48.9</td>
<td>-3.3</td>
<td>0.051 ± 0.017</td>
<td>0.097 ± 0.029</td>
</tr>
<tr>
<td></td>
<td>0.981</td>
<td>Yes</td>
<td>0.00583</td>
<td>-10.5</td>
<td>2.2</td>
<td>0.439 ± 0.031</td>
<td>0.501 ± 0.031</td>
</tr>
<tr>
<td></td>
<td>4.937</td>
<td>No</td>
<td>0.12051</td>
<td>28.8</td>
<td>23.3</td>
<td>3.180 ± 0.159</td>
<td>3.044 ± 0.088</td>
</tr>
<tr>
<td></td>
<td>9.736</td>
<td>No</td>
<td>0.32711</td>
<td>24.5</td>
<td>26.1</td>
<td>6.061 ± 0.134</td>
<td>6.139 ± 0.106</td>
</tr>
<tr>
<td>MultiRAE Pro (ER)</td>
<td>0</td>
<td>No</td>
<td>0.63843</td>
<td>NA</td>
<td>NA</td>
<td>0.01 ± 0.02</td>
<td>0.02 ± 0.02</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
<td>No</td>
<td>0.34659</td>
<td>0.0</td>
<td>11.1</td>
<td>0.10 ± 0.00</td>
<td>0.11 ± 0.03</td>
</tr>
<tr>
<td></td>
<td>0.981</td>
<td>No</td>
<td>0.16902</td>
<td>1.9</td>
<td>6.5</td>
<td>0.50 ± 0.00</td>
<td>0.52 ± 0.03</td>
</tr>
<tr>
<td></td>
<td>4.937</td>
<td>No</td>
<td>NA</td>
<td>21.5</td>
<td>21.5</td>
<td>3.00 ± 0.00</td>
<td>3.00 ± 0.00</td>
</tr>
<tr>
<td></td>
<td>9.736</td>
<td>Yes</td>
<td>0.00003</td>
<td>29.4</td>
<td>34.4</td>
<td>6.30 ± 0.05</td>
<td>6.54 ± 0.08</td>
</tr>
<tr>
<td>ppbRAE 3000</td>
<td>0</td>
<td>No</td>
<td>0.33133</td>
<td>NA</td>
<td>NA</td>
<td>0.002 ± 0.005</td>
<td>0.000 ± 0.000</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>No</td>
<td>0.34708</td>
<td>49.8</td>
<td>14.7</td>
<td>0.037 ± 0.015</td>
<td>0.029 ± 0.012</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
<td>No</td>
<td>0.62743</td>
<td>-25.9</td>
<td>-19.0</td>
<td>0.074 ± 0.026</td>
<td>0.081 ± 0.014</td>
</tr>
<tr>
<td></td>
<td>0.981</td>
<td>No</td>
<td>0.09793</td>
<td>-21.1</td>
<td>-6.5</td>
<td>0.387 ± 0.084</td>
<td>0.459 ± 0.009</td>
</tr>
<tr>
<td></td>
<td>4.937</td>
<td>Yes</td>
<td>0.00880</td>
<td>-7.8</td>
<td>-1.1</td>
<td>2.276 ± 0.113</td>
<td>2.440 ± 0.016</td>
</tr>
<tr>
<td></td>
<td>9.736</td>
<td>Yes</td>
<td>0.00816</td>
<td>-5.6</td>
<td>-1.8</td>
<td>4.596 ± 0.123</td>
<td>4.779 ± 0.034</td>
</tr>
</tbody>
</table>

*Calculation of mean percent error includes application of mfg. correction factor of 2 to recorded measurements.*  
*Pre/Post = Pre/Post PID exposure to butyl acrylate.*  
*$\alpha = 0.05$, $H_0$: $x_1 = x_2$  
*$NA = Not applicable$
6.5 Linear Regression and Experimentally Determined Correction Factors

Least squares linear regression was conducted for all assessments and instrument types to determine the slope, intercept, and coefficient of determination ($R^2$). Regression analysis was conducted twice on the isobutylene data set, once for the full concentration range (0-100 ppm), and once with the maximum concentration limited to 10 ppm. Since equipment limitations prevent the construction of a traditional calibration method using calibrated mass flow controllers, the 0-10 ppm isobutylene range of the isobutylene tests were used as a surrogate. Additionally, both the isobutylene calibration regression and isobutylene test regression contain isobutylene bump test results conducted during other tests where the instruments were calibrated to isobutylene to increase the sample size ($n$) and capture more variation in instrument performance throughout the assessment. The cylinder concentration stated by the manufacturer was used when constructing the isobutylene calibration regression line and determining the assessment correction factors. Graphs for each regression line (e.g., Figure 6.3) for all instruments and tests, along with additional statistical descriptors for the regression lines, can be found in Appendix E.
Regression graphs include zero air bump checks conducted before and/or after the test. Additional tests targeting the lower concentration range of butyl acrylate are also included. This results in variation of the sample size (n) between tested instruments.
Regression lines exhibited strong correlation with $R^2$ values $> 0.97$ meeting the DQO for coefficient of determination ($R^2$) of $\geq 0.9$. The manufacturer-provided correction factors for butyl acrylate (1.6) and vinyl chloride (2.0) differed from the experimentally-derived correction factors, which were between 1.66-1.99 and 1.50-1.87 for butyl acrylate and vinyl chloride, respectively (Table 6.10a - Table 6.10f).

Table 6.10 Linear Regression Parameters and Derived Correction Factors (CF)

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Slope</th>
<th>y-Intercept</th>
<th>$R^2$</th>
<th>Cal. Slope</th>
<th>Mfg. CF</th>
<th>Assessment CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Butyl Acrylate Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AreaRAE (PPB)</td>
<td>0.591 ± 0.005</td>
<td>0.092</td>
<td>0.999</td>
<td>0.981</td>
<td>1.6</td>
<td>1.66</td>
</tr>
<tr>
<td>MultiRAE (PPB)</td>
<td>0.515 ± 0.009</td>
<td>-0.063</td>
<td>0.994</td>
<td>0.963</td>
<td>1.6</td>
<td>1.87</td>
</tr>
<tr>
<td>ppbRAE</td>
<td>0.475 ± 0.003</td>
<td>0.048</td>
<td>0.999</td>
<td>0.883</td>
<td>1.6</td>
<td>1.86</td>
</tr>
<tr>
<td>AreaRAE (ER)</td>
<td>0.514 ± 0.026</td>
<td>0.062</td>
<td>0.973</td>
<td>0.996</td>
<td>1.6</td>
<td>1.94</td>
</tr>
<tr>
<td>MultiRAE (ER)</td>
<td>0.502 ± 0.013</td>
<td>-0.037</td>
<td>0.994</td>
<td>0.997</td>
<td>1.6</td>
<td>2.00</td>
</tr>
</tbody>
</table>

| (b) Butyl Acrylate Calibrated Test |
| AreaRAE (PPB)      | 1.020 ± 0.007    | 0.220       | 0.999 | NA         | 1       | NA            |
| MultiRAE (PPB)     | 1.040 ± 0.008    | 0.047       | 0.999 | NA         | 1       | NA            |
| ppbRAE             | 1.052 ± 0.008    | -0.029      | 0.999 | NA         | 1       | NA            |
| AreaRAE (ER)       | 1.012 ± 0.008    | 0.120       | 0.999 | NA         | 1       | NA            |
| MultiRAE (ER)      | 1.044 ± 0.010    | 0.013       | 0.999 | NA         | 1       | NA            |

| (c) Vinyl Chloride Test |
| AreaRAE (PPB)      | 0.656 ± 0.006    | 0.060       | 0.999 | 0.981      | 2       | 1.50          |
| MultiRAE (PPB)     | 0.631 ± 0.010    | -0.040      | 0.997 | 0.963      | 2       | 1.53          |
| ppbRAE             | 0.472 ± 0.008    | -0.020      | 0.993 | 0.883      | 2       | 1.87          |
| AreaRAE (ER)       | 0.595 ± 0.028    | -0.046      | 0.973 | 0.996      | 2       | 1.67          |
| MultiRAE (ER)      | 0.645 ± 0.007    | -0.054      | 0.999 | 0.997      | 2       | 1.55          |

| (d) Vinyl Chloride Post BA Exposure Test |
| AreaRAE (PPB)      | 0.645 ± 0.007    | -0.010      | 0.998 | 0.981      | 2       | 1.52          |
| MultiRAE (PPB)     | 0.629 ± 0.007    | -0.020      | 0.998 | 0.963      | 2       | 1.53          |
| ppbRAE             | 0.492 ± 0.002    | -0.006      | 1.000 | 0.883      | 2       | 1.79          |
| AreaRAE (ER)       | 0.581 ± 0.026    | 0.016       | 0.978 | 0.996      | 2       | 1.71          |
| MultiRAE (ER)      | 0.666 ± 0.010    | -0.062      | 0.997 | 0.997      | 2       | 1.50          |

| (e) Isobutylene Test |
| AreaRAE (PPB)      | 0.975 ± 0.004    | 0.251       | 0.999 | 0.981      | 1       | NA            |
| MultiRAE (PPB)     | 1.038 ± 0.025    | -0.252      | 0.989 | 0.963      | 1       | NA            |
| ppbRAE             | 0.959 ± 0.019    | -0.186      | 0.990 | 0.883      | 1       | NA            |
| AreaRAE (ER)       | 1.063 ± 0.015    | -0.121      | 0.995 | 0.996      | 1       | NA            |
| MultiRAE (ER)      | 1.360 ± 0.019    | -0.974      | 0.996 | 0.997      | 1       | NA            |

NA = Not applicable
The difference in the derived correction factors and manufacturer correction factors suggests potential underestimation of butyl acrylate (bias low) concentrations between 4% to 20% and over estimation (bias high) of vinyl chloride concentrations between 7% to 33% depending on instrument. However, this analysis does not account for variations in cylinder concentrations and cylinder contaminants.

### 6.6 Data Logs

A complete analysis and data quality assessment of data within the data logs was not conducted as part of this report in order to provide actionable analysis of PID performance more expediently. Additional graphs of test cycles for data logs similar to Figure 6.4 are provided in Appendix F but may contain erroneous data or data not related to assessment tests as data logging occurred continually when instruments were on. Therefore, data log graphs for assessments are provided for cursory review only with the understanding of the mentioned limitations and as an illustration of the real-time measurements observed during the assessment.
Concentration spikes occurred occasionally when starting gas flow, stopping gas flow, or during cylinder connection/disconnection (Figure 6.4). These spikes appeared to occur more frequently with vinyl chloride measurements using the MultiRAE (PPB) and ppbRAE. The occurrence of these spikes did not appear to be dependent on cylinder type or regulator type. While the design of the gas delivery manifold attempted to maintain pressure of the gas supplied to the instruments to near ambient, this condition may not have been adequately maintained during connections, disconnections, initiating gas flow, discontinuing gas flow, or adjusting gas flow rate at the valve. The cause of these discrepancies cannot be determined at this time.

Most concentration curves appear to have followed a somewhat logarithmic increase in concentration, reaching 90% of the concentration at the end of the cycle within approximately eight seconds (Figure 6.4). This delay may be reduced under field conditions due to the lack of a manifold and supply tubing where target gases mix with ambient or zero air but cannot be determined from this assessment. This logarithmic increase may be the anticipated response as the combined volumes of gas supply lines, manifold, and
internal components would most likely follow the behavior for gas concentration increase in a well-mixed space. Residual contamination of these same components was also a possible contributory source.

This logarithmic increase in concentration supports the decision to limit the time permitted to record a manual measurement to less than 5 minutes as reaching a state where concentration increase becomes nearly equivalent to the asymptote would require considerably more time, particularly for PIDs with resolutions of 0.01 ppm or less. An additional byproduct of the mixing within the manifold, and distance of the gas source to the instrument inlet, was delayed instrument response and an inability to determine instrument response time in the field from data collected during the assessment. In-field instrument response time is anticipated to be less than what was observed during the assessment.

6.7 Instrument Gas Detection Capability

A review of manually recorded concentrations, data logs, and t-tests were conducted to assess whether an instrument response occurred when a target gas was supplied to the instrument. Accuracy and precision were not considered in this analysis, only an instrument response (change in measurement). Responses occurring during the first cycle were considered the most reliable as subsequent cycles tended to cause increases in baseline concentrations. Ultimately, some professional judgement was required when classifying responses for target concentrations.

Target concentrations classified as “Detection Unlikely” exhibited no response, a response that was not clearly discernible from the zero point or, when a discernible response occurred, was limited to one instrument. The “Marginal Detection” classification was assigned to target concentrations where some response greater than the zero point or previous concentration was apparent but appeared inconsistent or had low reproducibility. The MultiRAE (ER) target concentration of 0.2 ppm was classified as “Indeterminate” as were all 0.05 ppm butyl acrylate target concentrations for reasons explained in greater detail in subsequent paragraphs. Target concentrations classified as “Detection” had a clear response (Table 6.11 and Table 6.12).
Table 6.11 Estimated Ability for Instruments to Detect Butyl Acrylate at Target Concentrations

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Calibration</th>
<th>0.022</th>
<th>0.05</th>
<th>0.20</th>
<th>2.00</th>
<th>9.699</th>
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<td>Area RAE (ER)</td>
<td>Isobutylene</td>
<td>BR</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Butyl Acrylate</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area RAE (PPB)</td>
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<td>BR</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Butyl Acrylate</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multi RAE (ER)</td>
<td>Isobutylene</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Butyl Acrylate</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Multi RAE (PPB)</td>
<td>Isobutylene</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Butyl Acrylate</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ppb RAE</td>
<td>Isobutylene</td>
<td>BR</td>
<td>BR</td>
<td>BR</td>
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<td></td>
</tr>
<tr>
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<td>Butyl Acrylate</td>
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<td>BR</td>
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</table>

*BR = Below instrument measurement range*

Table 6.12 Estimated Ability for Instruments to Detect Vinyl Chloride at Target Concentrations

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<th>Test Type</th>
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<th>4.94</th>
<th>9.74</th>
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<td>BR</td>
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<tr>
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<td>Post-BA</td>
<td>BR</td>
<td>BR</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Area RAE (PPB)</td>
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<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post-BA</td>
<td>BR</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multi RAE (ER)</td>
<td>Pre-BA</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post-BA</td>
<td>BR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multi RAE (PPB)</td>
<td>Pre-BA</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Post-BA</td>
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<tr>
<td>ppb RAE</td>
<td>Pre-BA</td>
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</table>

*BR = Below instrument measurement range*

BA = Butyl Acrylate

The ability of the Multi RAE (ER) PID to detect 0.2 ppm butyl acrylate was considered indeterminate. The PID of the Multi RAE (ER) has a resolution of 0.1 ppm, using the manufacturer’s correction factor, application of 0.2 ppm butyl acrylate equates to a measurement of 0.125 ppm, which would display as 0.1 ppm on the instrument due to the resolution. Both target gases and calibration gases used in this assessment are known to have variation in actual cylinder concentrations and contamination. While the 0.2 ppm butyl acrylate cylinder (Cylinder BA07) used to test the Multi RAE (ER) was not laboratory analyzed, the two other 0.2 ppm butyl acrylate cylinders used for the assessment were analyzed and discovered to contain 0.081 ppm (Cylinder BA11) and 0.156 ppm (Cylinder BA03) butyl acrylate. Neither cylinder would be anticipated to cause an instrument detection and given that all other butyl acrylate cylinders were biased low, it is reasonable to assume that cylinder BA07 was also biased low. On the second and third test cycles,
all MultiRAE (ER) instruments responded to 0.2 ppm butyl acrylate. As the increase between cycle one and cycle two for PPB model PIDs was less than 0.05 ppm, there is some indication the instrument may have been able to respond if cylinder contents had been accurate, or if cylinder concentration were increased by ~0.05 ppm. At minimum, the response on cycles two and three suggest the MultiRAE (ER) can likely respond to concentrations of butyl acrylate somewhere between 0.3-0.5 ppm, and perhaps 0.2 ppm. Ultimately, this assessment is insufficient to determine with any certainty the ability for the MultiRAE (ER) to detect 0.2 ppm butyl acrylate due to the combination of cylinder contents and the proximity of 0.2 ppm to the instrument’s minimum resolution.

All assessed PID’s ability to detect butyl acrylate at 0.05 ppm were categorized as indeterminate. All 0.05 ppm butyl acrylate cylinders that received re-analysis were biased low by 0.022 – 0.031 ppm, and several contained ethanol in concentrations greater than butyl acrylate. This bias would have impacted the instrument’s ability to accurately measure butyl acrylate and it cannot be adequately determined what amount of inaccuracy was due solely to the instrument and PID.
7.0 Limitations and Additional Research

To expediently address concerns raised regarding PID performance during the East Palestine Train Derailment, the experimental design of the assessment resulted in multiple limitations to be considered.

To minimize introduction of variables and ascertain baseline PID performance, testing was conducted under mostly ideal conditions. New PIDs and lamps were used to prevent influence from age, any potential interference from chemicals of interest, or other previously monitored compounds. Additionally, assessed equipment components have a useful lifespan throughout which some degradation in instrument performance is expected.

As relative humidity and temperature during field use can change throughout the day, variation in instrument performance is anticipated even when calibrated with a humidified gas at an appropriate temperature as the assessed equipment is not capable of continuous calibration verification. Increases in relative humidity have a quenching effect on PID response which results in negative bias, or when condensation occurs, may result in a leak of current and positive bias.\textsuperscript{32} All calibration gases used during the assessment and in the field during the East Palestine Train Derailment were not humidified nor were target gases used during the assessment. Furthermore, the assessment was conducted indoors where fluctuations in temperature and humidity were less than what would be expected in an outdoor environment. The impact of relative humidity on the assessment is expected to be negligible or absent; however, corrections of measurements for relative humidity using the absolute concentration of water vapor exist and may be useful in enhancing field measurement accuracy on higher humidity days. As was done with the assessment, the PIDs should ideally be calibrated with a gas near the temperature the equipment is anticipated to operate in for best performance.

Multiple calibration gases and target gases used during the assessment were outside of manufacturer stated specifications, influencing the accuracy and precision of recorded measurements. As a result, challenges were introduced in determining equipment performance particularly at lower concentrations. This was further compounded by the fact that not all cylinders received re-analysis. While some additional data analysis may help correct this confounding factor to a degree, additional PID assessment with higher grade gases is likely necessary.

The experimental design was not appropriate to determine precise instrument response and purge times due to excess gas distribution tubing and manifold. As a result, both response and purge times for PID measurements during the assessment are greater than what would occur in the field.

New butyl acrylate and vinyl chloride correction factors for PIDs calibrated to isobutylene were derived using the assessment data for comparison to the manufacturer provided correction factors. However, their application to historic data or future data may be inappropriate. This limitation of correction factors derived during the assessment is primarily due to the previously discussed issues with gas cylinder
concentrations/contaminants as well as the uncertain influence of the gas distribution system on low concentration measurements. Further analysis of the assessment data may result in improvements to the correction factors derived in this report, but additional PID assessment with higher grade gas and alternate gas supply mechanism is likely needed.
8.0 Conclusions

Performance results were determined for the five Honeywell RAE PIDs with a focus on the ability to detect butyl acrylate when calibrated with isobutylene. Variations in target gas cylinder concentrations outside of manufacturer-stated uncertainties, particularly in isobutylene calibration gas, 0.05 ppm butyl acrylate, and 0.2 ppm butyl acrylate, make determining the actual accuracy of the assessed PIDs challenging. However, these cylinders (excluding analytical grade cylinders)* are commonly used across the industry. For this reason, the inaccuracy of the isobutylene cylinder contents, and the resulting impact on calibration, may or may not be representative of field conditions. The inaccuracies and contaminants discovered in butyl acrylate and vinyl chloride cylinders are more problematic, making extrapolation of instrument accuracy from this assessment to field conditions difficult. Analysis of the MultiRAE (ER) at the 0.2 ppm butyl acrylate concentration was particularly impacted as the cylinder concentration was likely below the theoretical performance capabilities of the instrument. Determining the performance of the MultiRAE (ER) at 0.2 ppm butyl acrylate requires further investigation. To better determine the true performance of these instruments themselves, analytical grade gases should be used for all calibrations and targets. The use of analytical grade gases may also be beneficial for field measurements when higher accuracy at lower concentrations is required.

The cause of the non-linearity at target concentrations less than 0.2 ppm is indeterminate and may be related to a combination of factors including the experimental design, the instruments themselves, and cylinder contents. Trends of increasing concentration per test cycle suggest some degree of residual target gas remains within the gas distribution manifold and/or the instruments themselves resulting in an elevated zero point. The amount this deviation can be attributed to the manifold and tubing system used during this assessment cannot be determined nor would it be appropriate to attribute this behavior entirely to the instruments. Additional caution should be used when drawing conclusions from this assessment about instrument precision in the lower concentration measurement range due to the additional uncertainties regarding cause. Regardless of root cause, to maintain accuracy and precision at low target concentrations for any chemical, it is recommended that the assessed instruments not be used to also measure concentrations in air above 1 ppm to avoid saturating the instrument. Narrowing the target concentration range may help minimize occurrence of positive bias in measurements. If an instrument intended to monitor low concentrations is inadvertently placed in an area of higher concentrations, the instrument should be removed to an area with clean air until returning to zero or, dependent on objectives, another appropriately low concentration. Selecting calibration gas concentrations as close to the desired measurement range as feasible may also minimize positive bias and downward drift as the instrument self purges. Any zero-point calibration should occur prior to calibration with other gases.

While assessed instrument accuracy and precision did not always meet the DQOs of this assessment, particularly in the lower measurement range, the assessed instruments provide a degree of utility and

*Analytical grade cylinders manufactured by Apel-Riemer, Linde, and Airgas (Table 5.1).
advantages so long as limitations are understood and accounted for. The acceptability of deviations in accuracy up to and even exceeding 100% of the target concentration is dependent in its entirety on the set objectives and does not necessarily preclude use. These responses, combined with the instruments’ abilities to measure concentrations in real time, allow users to make immediate decisions based on changes in conditions. Excluding the MultiRAE (ER), which requires further assessment, all instruments exhibited responses at concentrations $\geq 0.2$ ppm butyl acrylate and vinyl chloride. Concentrations of butyl acrylate $< 0.2$ ppm and vinyl chloride $< 0.05$ ppm may be possible, but further assessment is needed.
References


   https://cameochemicals.noaa.gov/chemical/3667.


(Honeywell, 2013).
Appendix A: Equipment Inventory
## Table A.1 Equipment Inventory

<table>
<thead>
<tr>
<th>Equipment ID</th>
<th>Owner</th>
<th>Manufacturer</th>
<th>Model Name</th>
<th>Model Number</th>
<th>Sensor Resolution (ppm)</th>
<th>Serial Number</th>
<th>Firmware Version</th>
<th>Comments</th>
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<tbody>
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<td>Honeywell</td>
<td>AreaRAE Plus (ER)</td>
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### Table A.1 Equipment Inventory

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<th>Equipment ID</th>
<th>Owner</th>
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<th>Model Name</th>
<th>Model Number</th>
<th>Sensor Resolution (ppm)</th>
<th>Serial Number</th>
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*NA=Not Applicable*
Appendix B: Gas Cylinder Inventory and Certificates of Analysis
**Table B.1 Assessment Gas Cylinder Inventory**

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*No Expiration Date. Analyzed by Enthalpy for trace components by TO-15.
**ANALYSIS REPORT**

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<td>Report Date:</td>
<td>Cylinder Pressure: 1700 psig</td>
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<td>P.O.#</td>
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<td>Blend Type:</td>
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<td>Do NOT use under:</td>
<td>Analytical Accuracy: 20% Relative</td>
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<table>
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<th>COMPONENT</th>
<th>CAS NUMBER</th>
<th>REQUESTED CONC</th>
<th>QUALIFIED CONC</th>
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<tbody>
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<td>n-Butyl Acrylate</td>
<td>141-32-2</td>
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<td>Air</td>
<td>132259-10-0</td>
<td>Balance</td>
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**ANALYST:**

[Lou Lorenzetti]

**DATE:**

[Apr-17-2023]
CERTIFICATE OF ANALYSIS

PO Number: 02457911623  Certification Date: 04-Apr-2023

Manufactured For:
CTEH Center for Toxicology & Environmental Health
5120 North Shore Drive
North Little Rock AR 72118
United States Of America

Customer Part No:

Cylinder Size: 100GAL
Cylinder Content: 100 L (3.5 CU.FT.) @ 70 F (21 C) & 1000 PSIG (6890Kpag)
Cylinder Lot No: 279929
Cylinder Serial Nos: BE175430, BE175813, BE175819, BE175823, BE175825
Unit Of Measure: Mole
Expiration Date: Nov 2023

<table>
<thead>
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<th>Component</th>
<th>Nominal</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUTYL ACRYLATE</td>
<td>50 PPB (vol)</td>
<td>+/-10%</td>
</tr>
<tr>
<td>AIR</td>
<td>BALANCE</td>
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</table>

The mixture was manufactured or transfilled from a standard which has been gravimetrically blended with traceability through NIST to the International System of Units (SI) balance. Balances are calibrated by a certified third party with certified NIST weights and NIST test numbers. **Report Number: BU70910-051123.** The uncertainty is expressed as an expanded uncertainty \( U = k u_c \) with \( u_c \) determined by experiment and a coverage factor \( k=2 \). The certified value +/-\( U \) is presented with a level of confidence of approximately 95%.

Quality Assurance Manager

[Signature]

Page 1 of 1
CERTIFICATE OF ANALYSIS

Portagás™

A Linde company

ISO 9001:2015 CERTIFIED
ISO 17034:2016 ACCREDITED
ISO/IEC 17025:2017 ACCREDITED

1202 E Sam Houston Parkway S,
Pasadena, TX 77503
Phone:(800) 548 2268 Fax:(713) 928 9961

PO Number: 02457911623
Manufactured For:
CTEH Center for Toxicology & Environmental Health
5120 North Shore Drive
North Little Rock AR 72118
United States Of America

Certification Date: 04-Apr-2023

Customer Part No:

Cylinder Size: 100GAL
Cylinder Content: 100 L (3.5 CU.FT.) @ 70 F (21 C) & 1000 PSIG (6890Kpag)
Cylinder Lot No: 279930
Cylinder Serial Nos: BE175428,BE175812,BE175818,BE175821,BE175827
Unit Of Measure: Mole
Expiration Date: Nov 2023

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<td>BALANCE</td>
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Quality Assurance Manager

[Signature]
PO Number: 02457911623
Manufactured For: CTEH Center for Toxicology & Environmental Health
5120 North Shore Drive
North Little Rock AR 72118
United States Of America

Certification Date: 04-Apr-2023

Cylinder Size: 100GAL
Cylinder Content: 100 L (3.5 CU.FT.) @ 70 F (21 C) & 1000 PSIG (6890Kpag)
Cylinder Lot No: 279931
Cylinder Serial Nos: BE175820,BE175824,BE176528,BE176567,BE176603
Unit Of Measure: Mole
Expiration Date: Nov 2023

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<td>BUTYL ACRYLATE</td>
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<td>AIR</td>
<td>BALANCE</td>
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The mixture was manufactured or transfilled from a standard which has been gravimetrically blended with traceability through NIST to the International System of Units (SI) balance. Balances are calibrated by a certified third party with certified NIST weights and NIST test numbers. Report Number: BU70910-051123. The uncertainty is expressed as an expanded uncertainty $U=kuc$ with $uc$ determined by experiment and a coverage factor $k=2$. The certified value $+/U$ is presented with a level of confidence of approximately 95%.

Quality Assurance Manager
Gas-phase Calibration Standard

This gas-phase standard is intended to be used as a reference material for the calibration of instruments.

Statement about preparation and traceability:

Standards are gravimetrically prepared in high-pressure aluminum cylinders (Luxfer, Inc., Riverside, California). Cylinders are cleaned and treated to eliminate contamination and ensure inertness. Standards are prepared in N150 cylinders (~4000 Liters calibration gas), N033 cylinders (~800 Liters calibration gas), or N006 cylinders (~125 Liters calibration gas at a pressure of 2000 psia UHP nitrogen or Ultra-Pure air. Valves are high purity stainless steel (Ceodeux, Lintgen, Luxembourg) with a CGA-350 fitting. Pure compounds as liquids and gases are obtained from a number of sources. All lot numbers are cataloged. The gravimetric preparation is performed using calibrated microbalances (Mettler-Toledo, Columbus, Ohio) and microsyringes (Hamilton, Reno, Nevada and SGE, Austin, Texas) for measuring the compounds and cylinder balances (Mettler-Toledo, Columbus, Ohio) for the balance gas. Balances are calibrated with NIST traceable weights.

We prepare each cylinder individually. Accuracy is better than +/- 5%. Analysis confirms the accuracy of the gravimetric preparation. We use a series of NIST, NIST-traceable, NPL, and in-house gravimetric standards to perform the instrument calibrations.

Stability varies depending on the compound, concentration, and cylinder size. Many compounds are stable for several years.

The calibration gas mixture in cylinder D163822 is certified from the analysis date for 12 months.

Daniel D. Riemer, Ph.D.

April 26, 2023
Date
Cylinder D163822
Cylinder Date: 01/23
Valve: SS CGA350 21/302886 C/R
Lot No.: 23112.4
Cylinder Pressure: 2000 psia
Analysis Date: April 26, 2023

Single-component calibration mixture in ultra-pure air

<table>
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<th>Compound</th>
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<th>Concentration (ppb)</th>
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<td>Butyl Acrylate</td>
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Uncertainty is a conservative estimate of the combination of the uncertainties of the gravimetric preparation and analysis.

**Chromatogram**

100-meter DB-1, 0.25 mm id, 3.1 mL min⁻¹ Helium carrier gas – constant flow
Temperature Program: 35°C, 3.5 min → 4.5°C min⁻¹ → 180 °C, 6 min
PO Number: 02457911659
Manufactured For:
CTEH Center for Toxicology & Environmental Health
5120 North Shore Drive
North Little Rock AR 72118
United States Of America

Customer Part No: 
Cylinder Size: 116GAL
Cylinder Content: 116 L (4.1 CU.FT.) @ 70 F (21 C) & 1000 PSIG (6890Kpag)
Cylinder Lot No: 279838
Cylinder Serial Nos: BC486888,BC582395
Unit Of Measure: Mole
Expiration Date: May 2026

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<td>AIR</td>
<td>BALANCE</td>
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The mixture was manufactured or transfilled from a standard which has been gravimetrically blended with traceability through NIST to the International System of Units (SI) balance. Balances are calibrated by a certified third party with certified NIST weights and NIST test numbers. Report Number: BU70910-051123. The uncertainty is expressed as an expanded uncertainty $U=kuc$ with $uc$ determined by experiment and a coverage factor $k=2$. The certified value $+/-U$ is presented with a level of confidence of approximately 95%.

Quality Assurance Manager
PO Number: 02457911779
Manufactured For:
CTEH Center for Toxicology & Environmental Health
5120 North Shore Drive
North Little Rock AR 72118
United States Of America

Customer Part No:

Cylinder Size: 116GAL
Cylinder Content: 116 L (4.1 CU.FT.) @ 70 F (21 C) & 1000 PSIG (6890Kpag)
Cylinder Lot No: 281107
Cylinder Serial Nos: BC579730,BC582384,BC583029
Unit Of Measure: Mole
Expiration Date: Jun 2026

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The mixture was manufactured or transfilled from a standard which has been gravimetrically blended with traceability through NIST to the International System of Units (SI) balance. Balances are calibrated by a certified third party with certified NIST weights and NIST test numbers. Report Number: BU70910-051123. The uncertainty is expressed as an expanded uncertainty $U=kuc$ with $uc$ determined by experiment and a coverage factor $k=2$. The certified value $+/U$ is presented with a level of confidence of approximately 95%.

Quality Assurance Manager

Signature: [Signature]

[Page 1 of 1]
PO Number: 02457911659
Manufactured For: CTEH Center for Toxicology & Environmental Health
5120 North Shore Drive
North Little Rock AR 72118
United States Of America

Customer Part No: 116GAL
Cylinder Size: 116 L (4.1 CU.FT.) @ 70 F (21 C) & 1000 PSIG (6890Kpag)
Cylinder Lot No: 279838
Cylinder Serial Nos: BC486888, BC582395
Unit Of Measure: Mole
Expiration Date: May 2026

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<tr>
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The mixture was manufactured or transfilled from a standard which has been gravimetrically blended with traceability through NIST to the International System of Units (SI) balance. Balances are calibrated by a certified third party with certified NIST weights and NIST test numbers. Report Number: BU70910-051123. The uncertainty is expressed as an expanded uncertainty $U=kuc$ with $uc$ determined by experiment and a coverage factor $k=2$. The certified value $+/U$ is presented with a level of confidence of approximately 95%.

Quality Assurance Manager

[Signature]
PO Number: 02457911779
Manufactured For:
CTEH Center for Toxicology & Environmental Health
5120 North Shore Drive
North Little Rock AR 72118
United States Of America

Customer Part No:
Cylinder Size: 116GAL
Cylinder Content: 116 L (4.1 CU.FT.) @ 70 F (21 C) & 1000 PSIG (6890Kpag)
Cylinder Lot No: 281107
Cylinder Serial Nos: BC579730,BC582384,BC583029
Unit Of Measure: Mole
Expiration Date: Jun 2026

<table>
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The mixture was manufactured or transfilled from a standard which has been gravimetrically blended with traceability through NIST to the International System of Units (SI) balance. Balances are calibrated by a certified third party with certified NIST weights and NIST test numbers. Report Number: BU70910-051123. The uncertainty is expressed as an expanded uncertainty $U=kuc$ with $uc$ determined by experiment and a coverage factor $k=2$. The certified value +/-U is presented with a level of confidence of approximately 95%.

Quality Assurance Manager
CERTIFICATE OF ANALYSIS

PO Number: 02457911577
Manufactured For:
CTEH Center for Toxicology & Environmental Health
5120 North Shore Drive
North Little Rock AR 72118
United States Of America

Certification Date: 09-Mar-2023

Customer Part No:

Cylinder Size: 100GAL
Cylinder Content: 100 L (3.5 CU.FT.) @ 70 F (21 C) & 1000 PSIG (6890Kpag)
Cylinder Lot No: 276458
Cylinder Serial Nos: BE170183,BE171400
Unit Of Measure: Mole
Expiration Date: Apr 2026

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The mixture was manufactured or transfilled from a standard which has been gravimetrically blended with traceability through NIST to the International System of Units (SI) balance. Balances are calibrated by a certified third party with certified NIST weights and NIST test numbers. Report Number: BU70910-051123. The uncertainty is expressed as an expanded uncertainty $U=kuc$ with uc determined by experiment and a coverage factor $k=2$. The certified value +/-U is presented with a level of confidence of approximately 95%.

Quality Assurance Manager

[Signature]

Page 1 of 1
CERTIFICATE OF ANALYSIS

PO Number: 02457911686
Manufactured For:
CTEH Center for Toxicology & Environmental Health
5120 North Shore Drive
North Little Rock AR 72118
United States Of America

Certification Date: 07-Apr-2023

Customer Part No: Cyl-100G
Cylinder Size: 100G
Cylinder Content: 100 L (3.5 CU.FT.) @ 70 F (21 C) & 1000 PSIG (6890Kpag)
Cylinder Lot No: 280044
Cylinder Serial Nos: BE175642, BE175654
Unit Of Measure: Mole
Expiration Date: May 2026

<table>
<thead>
<tr>
<th>Component</th>
<th>Nominal</th>
<th>Uncertainty</th>
<th>Analytical Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO-BUTYLENE</td>
<td>10 PPM (vol)</td>
<td>+/-5%</td>
<td>(TCD) Gas Chromatography_US00024275</td>
</tr>
<tr>
<td>AIR</td>
<td>BALANCE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The mixture was manufactured or transfilled from a standard which has been gravimetrically blended with traceability through NIST to the International System of Units (SI) balance. Balances are calibrated by a certified third party with certified NIST weights and NIST test numbers. Report Number: BU70910-051123. The uncertainty is expressed as an expanded uncertainty U=uc with uc determined by experiment and a coverage factor k=2. The certified value +/-U is presented with a level of confidence of approximately 95%.

Quality Assurance Manager

[Signature]
PO Number: 02457911779  
Certification Date: 03-May-2023

Manufactured For:  
CTEH Center for Toxicology & Environmental Health  
5120 North Shore Drive  
North Little Rock AR 72118  
United States Of America

Customer Part No:  
Cylinder Size: 100GAL  
Cylinder Content: 100 L (3.5 CU.FT.) @ 70 F (21 C) & 1000 PSIG (6890Kpag)  
Cylinder Serial Nos: BE178995,BE178997  
Unit Of Measure: Mole  
Expiration Date: Jun 2026

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<tbody>
<tr>
<td>ISO-BUTYLENE</td>
<td>10 PPM (vol)</td>
<td>+/-5%</td>
<td>PID</td>
</tr>
<tr>
<td>AIR</td>
<td>BALANCE</td>
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</table>

The mixture was manufactured or transfilled from a standard which has been gravimetrically blended with traceability through NIST to the International System of Units (SI) balance. Balances are calibrated by a certified third party with certified NIST weights and NIST test numbers. Report Number: BU70910-051123. The uncertainty is expressed as an expanded uncertainty $U=kuc$ with $uc$ determined by experiment and a coverage factor $k=2$. The certified value $+/-U$ is presented with a level of confidence of approximately 95%.

Quality Assurance Manager
PO Number: 02457911725  
Certification Date: 18-Apr-2023

Manufactured For:
CTEH Center for Toxicology & Environmental Health  
5120 North Shore Drive  
North Little Rock AR 72118  
United States Of America

Customer Part No:

Cylinder Size: 100GAL
Cylinder Content: 100 L (3.5 CU.FT.) @ 70 F (21 C) & 1000 PSIG (6890Kpag)
Cylinder Lot No: 280462
Cylinder Serial Nos: BE178905,BE180189
Unit Of Measure: Mole
Expiration Date: May 2026

<table>
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<th>Analytical Method</th>
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</thead>
<tbody>
<tr>
<td>ISO-BUTYLENE</td>
<td>10 PPM (vol)</td>
<td>+/-5%</td>
<td>PID</td>
</tr>
<tr>
<td>AIR</td>
<td>BALANCE</td>
<td></td>
<td></td>
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The mixture was manufactured or transfilled from a standard which has been gravimetrically blended with traceability through NIST to the International System of Units (SI) balance. Balances are calibrated by a certified third party with certified NIST weights and NIST test numbers. Report Number: BU70910-051123. The uncertainty is expressed as an expanded uncertainty \( U = k u_c \) with \( u_c \) determined by experiment and a coverage factor \( k = 2 \). The certified value +/-U is presented with a level of confidence of approximately 95%.

Signature: [Signature]

Quality Assurance Manager
CERTIFICATE OF ANALYSIS

PO Number: 02457911542
Manufactured For: CTEH Center for Toxicology & Environmental Health
5120 North Shore Drive
North Little Rock AR 72118
United States Of America

Certification Date: 24-Feb-2023

Customer Part No: 02457911542
Cylinder Size: 100GAL
Cylinder Content: 100 L (3.5 CU.FT.) @ 70 F (21 C) & 1000 PSIG (6890Kpag)
Cylinder Lot No: 277693
Cylinder Serial Nos: BE153954
Unit Of Measure: Mole
Expiration Date: Mar 2026

<table>
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<th>Analytical Method</th>
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<td>100 PPM (vol)</td>
<td>+/-2%</td>
<td>PID</td>
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<tr>
<td>AIR</td>
<td>BALANCE</td>
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The mixture was manufactured or transfilled from a standard which has been gravimetrically blended with traceability through NIST to the International System of Units (SI) balance. Balances are calibrated by a certified third party with certified NIST weights and NIST test numbers. Report Number: BU70910-051123. The uncertainty is expressed as an expanded uncertainty $U=kuc$ with $uc$ determined by experiment and a coverage factor $k=2$. The certified value $+/-U$ is presented with a level of confidence of approximately 95%.

Quality Assurance Manager
**PO Number:** 02457911577  
**Certification Date:** 09-Mar-2023

**Manufactured For:**  
CTEH Center for Toxicology & Environmental Health  
5120 North Shore Drive  
North Little Rock AR 72118  
United States Of America

**Customer Part No:**

**Cylinder Size:** 100GAL  
**Cylinder Content:** 100 L (3.5 CU.FT.) @ 70 F (21 C) & 1000 PSIG (6890Kpag)  
**Cylinder Lot No:** 277693  
**Cylinder Serial Nos:** BE153820,BE153944,BE154443,BE154672  
**Unit Of Measure:** Mole  
**Expiration Date:** Apr 2026

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<th>Analytical Method</th>
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</thead>
<tbody>
<tr>
<td>ISO-BUTYLENE</td>
<td>100 PPM (vol)</td>
<td>+/-2%</td>
<td>PID</td>
</tr>
<tr>
<td>AIR</td>
<td>BALANCE</td>
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</table>

The mixture was manufactured or transfilled from a standard which has been gravimetrically blended with traceability through NIST to the International System of Units (SI) balance. Balances are calibrated by a certified third party with certified NIST weights and NIST test numbers. **Report Number: BU70910-051123.** The uncertainty is expressed as an expanded uncertainty $U=uc$ with $uc$ determined by experiment and a coverage factor $k=2$. The certified value +/-U is presented with a level of confidence of approximately 95%.

[Signature]

Quality Assurance Manager
**CERTIFICATE OF ANALYSIS**

**PortaGas™**  
A Linde company

ISO 9001:2015 CERTIFIED  
ISO 17025:2017 ACCREDITED  
ISO/IEC 17025:2017 ACCREDITED

1202 E Sam Houston Parkway S,  
Pasadena, TX 77503  
Phone:(800) 548 2268 Fax:(713) 928 9961

---

**PO Number:** 02457911704  
**Manufactured For:**  
CTEH Center for Toxicology & Environmental Health  
5120 North Shore Drive  
North Little Rock AR 72118  
United States Of America

**Certification Date:** 24-Apr-2023

**Customer Part No:**

**Cylinder Size:** 100GAL

**Cylinder Content:** 100 L (3.5 CU.FT.) @ 70 F (21 C) & 1000 PSIG (6890Kpag)

**Cylinder Lot No:** 280719

**Cylinder Serial Nos:** BE180465,BE181963,BE181976,BE181987,BE182011,BE182123

**Unit Of Measure:** Mole

**Expiration Date:** May 2025

<table>
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<tr>
<th>Component</th>
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</tr>
</thead>
<tbody>
<tr>
<td>VINYL CHLORIDE</td>
<td>50 PPB (vol)</td>
<td>+/-10%</td>
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<tr>
<td>AIR</td>
<td>BALANCE</td>
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</table>

The mixture was manufactured or transfilled from a standard which has been gravimetrically blended with traceability through NIST to the International System of Units (SI) balance. Balances are calibrated by a certified third party with certified NIST weights and NIST test numbers. **Report Number: BU70910-051123.** The uncertainty is expressed as an expanded uncertainty \( U = k u c \) with \( u c \) determined by experiment and a coverage factor \( k=2 \). The certified value \(+/-U\) is presented with a level of confidence of approximately 95%.

---

Quality Assurance Manager

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Page 1 of 1
CERTIFICATE OF ANALYSIS

PortaGas™
A Linde company

ISO 9001:2015 CERTIFIED
ISO 17025:2017 ACCREDITED
ISO 17034:2016 ACCREDITED

1202 E Sam Houston Parkway S,
Pasadena, TX 77503
Phone:(800) 548 2268 Fax:(713) 928 9961

PO Number: 02457911704
Manufactured For:
CTEH Center for Toxicology & Environmental Health
5120 North Shore Drive
North Little Rock AR 72118
United States Of America

Certification Date: 24-Apr-2023

Customer Part No:

Cylinder Size: 100GAL
Cylinder Content: 100 L (3.5 CU.FT.) @ 70 F (21 C) & 1000 PSIG (6890Kpag)
Cylinder Lot No: 280722
Cylinder Serial Nos: BE180468,BE180470,BE180471,BE181992,BE182016,BE182245
Unit Of Measure: Mole
Expiration Date: May 2025

<table>
<thead>
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<th>Component</th>
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<th>Uncertainty</th>
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<tbody>
<tr>
<td>VINYL CHLORIDE</td>
<td>200 PPB (vol)</td>
<td>+/-10%</td>
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<td>AIR</td>
<td>BALANCE</td>
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</tr>
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</table>

The mixture was manufactured or transfilled from a standard which has been gravimetrically blended with traceability through NIST to the International System of Units (SI) balance. Balances are calibrated by a certified third party with certified NIST weights and NIST test numbers. Report Number: BU70910-051123. The uncertainty is expressed as an expanded uncertainty $U=kuc$ with uc determined by experiment and a coverage factor $k=2$. The certified value $+/-U$ is presented with a level of confidence of approximately 95%.

Quality Assurance Manager

[Signature]

Page 1 of 1
Gas-phase Calibration Standard

This gas-phase standard is intended to be used as a reference material for the calibration of instruments.

Statement about preparation and traceability:

Standards are gravimetrically prepared in high-pressure aluminum cylinders (Luxfer, Inc., Riverside, California). Cylinders are cleaned and treated to eliminate contamination and ensure inertness. Standards are prepared in N150 cylinders (~4000 Liters calibration gas), N033 cylinders (~800 Liters calibration gas), or N006 cylinders (~125 Liters calibration gas at a pressure of 2000 psia UHP nitrogen or Ultra-Pure air. Valves are high purity stainless steel (Ceodeux, Lintgen, Luxembourg) with a CGA-350 fitting. Pure compounds as liquids and gases are obtained from a number of sources. All lot numbers are cataloged. The gravimetric preparation is performed using calibrated microbalances (Mettler-Toledo, Columbus, Ohio) and microsyringes (Hamilton, Reno, Nevada and SGE, Austin, Texas) for measuring the compounds and cylinder balances (Mettler-Toledo, Columbus, Ohio) for the balance gas. Balances are calibrated with NIST traceable weights.

We prepare each cylinder individually. Accuracy is better than +/- 5%. Analysis confirms the accuracy of the gravimetric preparation. We use a series of NIST, NIST-traceable, NPL, and in-house gravimetric standards to perform the instrument calibrations.

Stability varies depending on the compound, concentration, and cylinder size. Many compounds are stable for several years.

The calibration gas mixture in cylinder D163832 is certified from the analysis date for 12 months.

Daniel D. Riemer, Ph.D.

April 26, 2023
Date
Cylinder: D163832
Cylinder Date: 01/23
Valve: SS CGA590 19/459478 C/R
Lot No.: 23112.1
Cylinder Pressure: 2000 psia
Analysis Date: April 26, 2023

Single-component calibration mixture in ultra-pure air

<table>
<thead>
<tr>
<th>Compound</th>
<th>CAS#</th>
<th>Concentration (ppb)</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinyl Chloride</td>
<td>75-01-4</td>
<td>981</td>
<td>±5%</td>
</tr>
</tbody>
</table>

Uncertainty is a conservative estimate of the combination of the uncertainties of the gravimetric preparation and analysis.

Chromatogram

100-meter DB-1, 0.25 mm id, 3.1 mL min⁻¹ Helium carrier gas – constant flow
Temperature Program: 35°C, 3.5 min → 4.5°C min⁻¹ → 180 °C, 6 min
Gas-phase Calibration Standard

This gas-phase standard is intended to be used as a reference material for the calibration of instruments.

Statement about preparation and traceability:

Standards are gravimetrically prepared in high-pressure aluminum cylinders (Luxfer, Inc., Riverside, California). Cylinders are cleaned and treated to eliminate contamination and ensure inertness. Standards are prepared in N150 cylinders (~4000 Liters calibration gas), N033 cylinders (~800 Liters calibration gas), or N006 cylinders (~125 Liters calibration gas at a pressure of 2000 psia UHP nitrogen or Ultra-Pure air. Valves are high purity stainless steel (Ceodeux, Lintgen, Luxembourg) with a CGA-350 fitting. Pure compounds as liquids and gases are obtained from a number of sources. All lot numbers are cataloged. The gravimetric preparation is performed using calibrated microbalances (Mettler-Toledo, Columbus, Ohio) and microsyringes (Hamilton, Reno, Nevada and SGE, Austin, Texas) for measuring the compounds and cylinder balances (Mettler-Toledo, Columbus, Ohio) for the balance gas. Balances are calibrated with NIST traceable weights.

We prepare each cylinder individually. Accuracy is better than +/- 5%. Analysis confirms the accuracy of the gravimetric preparation. We use a series of NIST, NIST-traceable, NPL, and in-house gravimetric standards to perform the instrument calibrations.

Stability varies depending on the compound, concentration, and cylinder size. Many compounds are stable for several years.

The calibration gas mixture in cylinder D163829 is certified from the analysis date for 12 months.

Daniel D. Riemer, Ph.D.

April 26, 2023
Date
Cylinder: D163829  
Cylinder Date: 01/23  
Valve: SS CGA590 19/459481 C/R  
Lot No.: 23112.2  
Cylinder Pressure: 2000 psia  
Analysis Date: April 26, 2023  
Single-component calibration mixture in ultra-pure air  

<table>
<thead>
<tr>
<th>Compound</th>
<th>CAS#</th>
<th>Concentration (ppb)</th>
<th>Uncertainty</th>
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</thead>
<tbody>
<tr>
<td>Vinyl Chloride</td>
<td>75-01-4</td>
<td>4937</td>
<td>±5%</td>
</tr>
</tbody>
</table>

Uncertainty is a conservative estimate of the combination of the uncertainties of the gravimetric preparation and analysis.

Chromatogram

100-meter DB-1, 0.25 mm id, 3.1 mL min⁻¹ Helium carrier gas – constant flow  
Temperature Program: 35°C, 3.5 min → 4.5°C min⁻¹ → 180 °C, 6 min
Gas-phase Calibration Standard

This gas-phase standard is intended to be used as a reference material for the calibration of instruments.

Statement about preparation and traceability:

Standards are gravimetrically prepared in high-pressure aluminum cylinders (Luxfer, Inc., Riverside, California). Cylinders are cleaned and treated to eliminate contamination and ensure inertness. Standards are prepared in N150 cylinders (~4000 Liters calibration gas), N033 cylinders (~800 Liters calibration gas), or N006 cylinders (~125 Liters calibration gas at a pressure of 2000 psia UHP nitrogen or Ultra-Pure air. Valves are high purity stainless steel (Ceeodeux, Lintgen, Luxembourg) with a CGA-350 fitting. Pure compounds as liquids and gases are obtained from a number of sources. All lot numbers are cataloged. The gravimetric preparation is performed using calibrated microbalances (Mettler-Toledo, Columbus, Ohio) and microsyringes (Hamilton, Reno, Nevada and SGE, Austin, Texas) for measuring the compounds and cylinder balances (Mettler-Toledo, Columbus, Ohio) for the balance gas. Balances are calibrated with NIST traceable weights.

We prepare each cylinder individually. Accuracy is better than +/- 5%. Analysis confirms the accuracy of the gravimetric preparation. We use a series of NIST, NIST-traceable, NPL, and in-house gravimetric standards to perform the instrument calibrations.

Stability varies depending on the compound, concentration, and cylinder size. Many compounds are stable for several years.

The calibration gas mixture in cylinder D163834 is certified from the analysis date for 12 months.

Daniel D. Riemer, Ph.D.

April 26, 2023
Cylinder: D163834
Cylinder Date: 01/23
Valve: SS CGA590 19/459466 C/R
Lot No.: 23112.3
Cylinder Pressure: 2000 psia
Analysis Date: April 26, 2023

Single-component calibration mixture in ultra-pure air

<table>
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<th>CAS#</th>
<th>Concentration</th>
<th>Uncertainty</th>
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<tr>
<td>Vinyl Chloride</td>
<td>75-01-4</td>
<td>9736</td>
<td>±5%</td>
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Uncertainty is a conservative estimate of the combination of the uncertainties of the gravimetric preparation and analysis.

Chromatogram
100-meter DB-1, 0.25 mm id, 3.1 mL min\(^{-1}\) Helium carrier gas – constant flow
Temperature Program: 35°C, 3.5 min → 4.5°C min\(^{-1}\) → 180 °C, 6 min
**Quantitation Report**

*Data Path:* C:`\XAVIER\DATA\APR23\X042423A\Snapshot\`

**Data File:** X2301688.D

**Acq On:** 25 Apr 2023 11:24 am

**Operator:** TDD

**Sample:** Zero Air Cylinder

**Inc:** 500mL load

**ALS Vial:** 16  Sample Multiplier: 1

**Quant Time:** Apr 25 11:48:36 2023

**Quant Method:** C:`\Xavier\methods\X100722A_TO15.M`

**Quant Title:** TO15 TCL

**QLast Update:** Wed Oct 12 15:57:03 2022

**Response via:** Initial Calibration

**Printout located here:** P:`\Users\stg stuff`

### Compound | R.T. (min) | QIon | Response |
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<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Bromochloromethane (IS)</td>
<td>11.037</td>
<td>130</td>
<td>356158</td>
</tr>
<tr>
<td>40) 1,4-Difluorobenzene (IS)</td>
<td>12.455</td>
<td>114</td>
<td>1355223</td>
</tr>
<tr>
<td>52) Chlorobenzene-d5 (IS)</td>
<td>16.593</td>
<td>117</td>
<td>1211139</td>
</tr>
</tbody>
</table>

**Target Compounds**

2) Propylene

3) Freon 12 (CC12F2)

4) Freon 114 (C2Cl2F4)

5) Chloromethane

6) Chloroethene (Vinyl ch...)

7) 1,3-Butadiene

8) Acetaldehyde

9) Methanol

10) Ethylene oxide

11) Bromomethane

12) Chloroethane

13) Bromoethene (Vinyl bro...)

14) Freon 11 (CC13F)

15) Ethanol

16) Acrolein

17) Freon 113 (C2Cl3F3)

18) 1,1-Dichloroethene

19) Acetone

20) Carbon disulfide

21) Isopropyl alcohol

22) Allyl chloride (3-chlo...)

23) Acetonitrile

24) Methylene chloride

25) trans-1,2-Dichloroethene

26) Methyl tert-butyl ether

27) Acrylnitrile

28) Hexane

29) 1,1-Dichloroethane

30) Vinyl acetate

31) cis-1,2-Dichloroethylene

32) Methyl ethyl ketone (2...)

33) Ethyl acetate

34) 1-Bromopropane

35) Chloroform

36) Tetrahydrofuran

37) 1,1,1-Trichloroethane

38) Cyclohexane

39) Carbon tetrachloride

41) Benzene

42) 2,2,4-Trimethylpentane

43) 1,2-Dichloroethane

44) Heptane

45) Trichloroethene

46) 1,2-Dichloropropane

47) Methyl methacrylate

48) 1,4-Dioxane

### Internal Standards

1) Bromochloromethane (IS)

40) 1,4-Difluorobenzene (IS)

52) Chlorobenzene-d5 (IS)

### Concentration and Units

<table>
<thead>
<tr>
<th>Compound</th>
<th>R.T. (min)</th>
<th>QIon</th>
<th>Response</th>
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</thead>
<tbody>
<tr>
<td>11.037</td>
<td>130</td>
<td>356158</td>
<td>5.21 ppbv</td>
</tr>
<tr>
<td>12.455</td>
<td>114</td>
<td>1355223</td>
<td>5.16 ppbv</td>
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<tr>
<td>16.593</td>
<td>117</td>
<td>1211139</td>
<td>4.92 ppbv</td>
</tr>
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</table>

**Qvalue**

### Conc | Units | Dev(Min)
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<tbody>
<tr>
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<td>ppbv</td>
<td>0.00</td>
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<tr>
<td>5.16</td>
<td>ppbv</td>
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<tr>
<td>4.92</td>
<td>ppbv</td>
<td>0.00</td>
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*Not Reviewed*
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<tr>
<th>Compound</th>
<th>WILM 1</th>
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<th>WILM 3</th>
<th>WILM 4</th>
<th>WILM 5</th>
<th>WILM 6</th>
<th>WILM 7</th>
<th>WILM 8</th>
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<tr>
<td>Bromodichloromethane</td>
<td>0.000</td>
<td>0.000</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>Methyl 1,3-Dichloropropene</td>
<td>0.000</td>
<td>0.000</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>Methyl isobutyl ketone</td>
<td>14.371</td>
<td>43</td>
<td>252</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
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<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
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<td>0.000</td>
<td>0.000</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>n-Octane</td>
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<td>0.000</td>
<td>0.000</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
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<td>0.000</td>
<td>0.000</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>N.D.</td>
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= qualifier out of range (m) = manual integration (+) = signals summed

X100722A_T015.M Tue Apr 25 11:48:37 2023
Quantitation Report  (Not Reviewed)

Data Path : C:\XAVIER\DATA\APR23\X042423A\Snapshot\Data File : X2301688.D Acq On : 25 Apr 2023 11:24 am
Operator : TDD Sample : Zero Air Cylinder Misc : 500mL load ALS Vial : 16 Sample Multiplier: 1

Quant Time: Apr 25 11:48:36 2023
Quant Method : C:\Xavier\methods\X100722A_TO15.M
Quant Title : TO15 TCL
QLast Update : Wed Oct 12 15:57:03 2022
Response via : Initial Calibration

Abundance

TIC: X2301688.D\data.ms

X100722A_TO15.M Tue Apr 25 11:49:26 2023
Page: 4
Appendix C: Test Statistics
<table>
<thead>
<tr>
<th>Test Name</th>
<th>Instrument</th>
<th>Concentration</th>
<th>Normal Distribution p-value</th>
<th>Identified Distribution (alpha=0.01)</th>
<th>Identified Distribution p-value</th>
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<td>Butyl Acrylate</td>
<td>AreaRAE Pro (PPB)</td>
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</tr>
<tr>
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<td>dweibull</td>
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<td>Identified Distribution (alpha=0.01)</td>
<td>Identified Distribution p-value</td>
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<td>0.001440</td>
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</tr>
<tr>
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<td>0 ppm</td>
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<td>0.000171</td>
</tr>
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### Table C.1 Kolmogorov-Smirnov Goodness-of-Fit Test

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Instrument</th>
<th>Concentration</th>
<th>Normal Distribution p-value</th>
<th>Identified Distribution (alpha=0.01)</th>
<th>Identified Distribution p-value</th>
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<tbody>
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<td>Zero Variance</td>
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<td>Vinyl Chloride</td>
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<td>Test Name</td>
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<td>Concentration</td>
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<td>Identified Distribution (alpha=0.01)</td>
<td>Identified Distribution p-value</td>
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*Where the variance of the dataset was zero, the distribution is None.*
Butyl Acrylate AreaRAE (ER) Statistics

Date: 2023-05-06
Start: 08:48:18
Stop: 10:26:45

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics

n: 45
Mean Percent Error (Mfg.): 19.36
Mean Percent Error (Assessment): 35.237
% Relative Standard Deviation (x): 156.993
% Relative Standard Deviation (y): 151.491
Standard Deviation (x): 3.736
Standard Deviation (y): 1.946
Variance (x): 13.959
Variance (y): 3.786
Covariance (xy): 7.335
Alpha: 0.05
df: (n - 2) = 43
t-value: 2.017
Correlation Coefficient (R): 0.987
R^2: 0.973
MSE (yh): 0.101
Slope: 0.514
Slope Standard Error: 0.013
Slope p-value: 1.932409025499138e-35 (Ho: slope = 0)
y-Intercept: 0.062
y-Intercept Standard Error: 0.058
Regression Equation: y = 0.514(x) + 0.062
Confidence Interval (Slope): 0.514 +/- 0.026
UCL (Slope): 0.54
LCL (Slope): 0.488
Honeywell Correction Factor: 1.6
Isobutylene Calibration Slope: 0.996
Assessment Correction Factor: 1.938

**************************************************************************
### Target 0.0 ppm Statistics

- **n:** 18
- **Min (y):** 0.0
- **Max (y):** 0.1
- **Mean (y):** 0.061
- **Mean Corrected Mfg. (y):** 0.098
- **Median (y):** 0.1
- **Sample Standard Deviation (y):** 0.049
- **Variance (y):** 0.002
- **Mean Percent Error Mfg. (y):** nan
- **% Relative Standard Deviation (y):** 79.772
- **MSE:** 0.016
- **Alpha:** 0.05
- **df: (n - 2) = 16**
- **t-value:** 2.12
- **Confidence Interval (y):** 0.061 +/- 0.024
- **Confidence Interval Corrected Mfg. (y):** 0.098 +/- 0.039
- **UCL:** 0.085
- **UCL Mfg. Corrected:** 0.137
- **LCL:** 0.037
- **LCL Mfg. Corrected:** 0.059
- **Prediction Interval (y):**
- **One-sample Mfg. t-test:**
  - **t-statistic Mfg. = 5.169, p-value = 7.712581804965855e-05**
  - **Reject Mfg. Ho (ymean = u):** True

### Target 0.2 ppm Statistics

- **n:** 9
- **Min (y):** 0.1
- **Max (y):** 0.3
- **Mean (y):** 0.211
- **Mean Corrected Mfg. (y):** 0.338
- **Median (y):** 0.2
- **Sample Standard Deviation (y):** 0.057
- **Variance (y):** 0.003
- **Mean Percent Error Mfg. (y):** 68.889
- **% Relative Standard Deviation (y):** 26.837
- **MSE:** 0.027
- **Alpha:** 0.05
- **df: (n - 2) = 7**
- **t-value:** 2.365
- **Confidence Interval (y):** 0.211 +/- 0.045
- **Confidence Interval Corrected Mfg. (y):** 0.338 +/- 0.071
- **UCL:** 0.256
- **UCL Mfg. Corrected:** 0.409
- **LCL:** 0.166
- **LCL Mfg. Corrected:** 0.267
- **Prediction Interval (y):**
- **One-sample Mfg. t-test:**
  - **t-statistic Mfg. = 4.299, p-value = 0.002619553439705576**
  - **Reject Mfg. Ho (ymean = u):** True

*******************************************************************************
# Target 2.0 ppm Statistics

- **n**: 9
- **Min (y)**: 0.8
- **Max (y)**: 1.2
- **Mean (y)**: 1.033
- **Mean Corrected Mfg. (y)**: 1.653
- **Median (y)**: 1.1
- **Sample Standard Deviation (y)**: 0.17
- **Variance (y)**: 0.029
- **Mean Percent Error Mfg. (y)**: -17.333
- **% Relative Standard Deviation (y)**: 16.448
- **MSE**: 0.194
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 1.033 +/- 0.134
- **Confidence Interval Corrected Mfg. (y)**: 1.653 +/- 0.214
- **UCL**: 1.167
- **UCL Mfg. Corrected**: 1.867
- **LCL**: 0.899
- **LCL Mfg. Corrected**: 1.439
- **Prediction Interval (y)**: 1.033 +/- 0.424
- **One-sample Mfg. t-test**: t-statistic Mfg.=-3.606, p-value=0.006926247902459686
  - Reject Mfg. Ho (ymean = u): True

# Target 9.699 ppm Statistics

- **n**: 9
- **Min (y)**: 4.2
- **Max (y)**: 5.9
- **Mean (y)**: 5.056
- **Mean Corrected Mfg. (y)**: 8.089
- **Median (y)**: 5.1
- **Sample Standard Deviation (y)**: 0.682
- **Variance (y)**: 0.465
- **Mean Percent Error Mfg. (y)**: -16.601
- **% Relative Standard Deviation (y)**: 13.484
- **MSE**: 3.782
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 5.056 +/- 0.537
- **Confidence Interval Corrected Mfg. (y)**: 8.089 +/- 0.86
- **UCL**: 5.593
- **UCL Mfg. Corrected**: 8.949
- **LCL**: 4.519
- **LCL Mfg. Corrected**: 7.229
- **Prediction Interval (y)**: 5.056 +/- 1.699
- **One-sample Mfg. t-test**: t-statistic Mfg.=-4.175, p-value=0.0030990635712228494
  - Reject Mfg. Ho (ymean = u): True
Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs

Appendix C-9

============= Butyl Acrylate AreaRAE Pro (PPB) Statistics ==============

Date: 2023-05-04
Start: 10:55:40
Stop: 12:22:00

NOTE: VALUES WHICH HAVE THE ABREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

########## Regression Statistics ##########
n: 57
Mean Percent Error (Mfg.): -192.199
Mean Percent Error (Assessment): 138.845
% Relative Standard Deviation (x): 182.65
% Relative Standard Deviation (y): 168.768
Standard Deviation (x): 3.452
Standard Deviation (y): 2.042
Variance (x): 11.919
Variance (y): 4.171
Covariance (xy): 7.174
Alpha: 0.05
df: (n - 2) = 55
t-value: 2.004
Correlation Coefficient (R): 1.0
R^2: 0.999
MSE (yh): 0.004
Slope: 0.591
Slope Standard Error: 0.002
Slope p-value: 1.2627680203818137e-85 (Ho: slope = 0)
y-Intercept: 0.092
y-Intercept Standard Error: 0.009
Regression Equation: y = 0.591(x) + 0.092
Confidence Interval (Slope): 0.591 +/- 0.005
UCL (Slope): 0.596
LCL (Slope): 0.586
Honeywell Correction Factor: 1.6
Isobutylene Calibration Slope: 0.981
Assessment Correction Factor: 1.66

####################################################################
Target 0.0 ppm Statistics

n: 12
Min (y): 0.0
Max (y): 0.23
Mean (y): 0.125
Mean Corrected Mfg. (y): 0.2
Median (y): 0.15
Sample Standard Deviation (y): 0.079
Variance (y): 0.006
Mean Percent Error Mfg. (y): nan
% Relative Standard Deviation (y): 63.203
MSE: 0.056
Alpha: 0.05
df: (n - 2) = 10
t-value: 2.228
Confidence Interval (y): 0.125 +/- 0.051
Confidence Interval Corrected Mfg. (y): 0.2 +/- 0.081
UCL: 0.176
UCL Mfg. Corrected: 0.281
LCL: 0.074
LCL Mfg. Corrected: 0.119
Prediction Interval (y): 0.125 +/- 0.183
One-sample Mfg. t-test: t-statistic Mfg.=5.248, p-value=0.0002736204427562657
  Reject Mfg. Ho (ymean = u): True

Target 0.022 ppm Statistics

n: 9
Min (y): 0.0
Max (y): 0.16
Mean (y): 0.068
Mean Corrected Mfg. (y): 0.108
Median (y): 0.08
Sample Standard Deviation (y): 0.055
Variance (y): 0.003
Mean Percent Error Mfg. (y): 392.929
% Relative Standard Deviation (y): 81.044
MSE: 0.015
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 0.068 +/- 0.043
Confidence Interval Corrected Mfg. (y): 0.108 +/- 0.069
UCL: 0.111
UCL Mfg. Corrected: 0.177
LCL: 0.025
LCL Mfg. Corrected: 0.039
Prediction Interval (y): 0.068 +/- 0.137
One-sample Mfg. t-test: t-statistic Mfg.=2.782, p-value=0.023851579519368143
  Reject Mfg. Ho (ymean = u): True

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-10
########## Target 0.05 ppm Statistics ##########
n: 9
Min (y): 0.01
Max (y): 0.16
Mean (y): 0.088
Mean Corrected Mfg. (y): 0.14
Median (y): 0.08
Sample Standard Deviation (y): 0.042
Variance (y): 0.002
Mean Percent Error Mfg. (y): 180.889
% Relative Standard Deviation (y): 48.268
MSE: 0.013
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 0.088 +/- 0.033
Confidence Interval Corrected Mfg. (y): 0.14 +/- 0.053
UCL: 0.121
UCL Mfg. Corrected: 0.193
LCL: 0.055
LCL Mfg. Corrected: 0.087
Prediction Interval (y): 0.088 +/- 0.106
One-sample Mfg. t-test: t-statistic Mfg.=3.774, p-value=0.00543684354497788
Reject Mfg. Ho (ymean = u): True

########## Target 0.2 ppm Statistics ##########
n: 9
Min (y): 0.19
Max (y): 0.25
Mean (y): 0.222
Mean Corrected Mfg. (y): 0.356
Median (y): 0.22
Sample Standard Deviation (y): 0.02
Variance (y): 0.0
Mean Percent Error Mfg. (y): 77.778
% Relative Standard Deviation (y): 9.192
MSE: 0.025
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 0.222 +/- 0.016
Confidence Interval Corrected Mfg. (y): 0.356 +/- 0.026
UCL: 0.238
UCL Mfg. Corrected: 0.382
LCL: 0.206
LCL Mfg. Corrected: 0.33
Prediction Interval (y): 0.222 +/- 0.051
One-sample Mfg. t-test: t-statistic Mfg.=13.462, p-value=8.889844950718889e-07
Reject Mfg. Ho (ymean = u): True
### Target 2.0 ppm Statistics

- **n:** 9
- **Min (y):** 1.24
- **Max (y):** 1.36
- **Mean (y):** 1.297
- **Mean Corrected Mfg. (y):** 2.075
- **Median (y):** 1.28
- **Sample Standard Deviation (y):** 0.035
- **Variance (y):** 0.001
- **Mean Percent Error Mfg. (y):** 3.733
- **% Relative Standard Deviation (y):** 2.696
- **MSE:** 0.009
- **Alpha:** 0.05
- **df:** (n - 2) = 7
- **t-value:** 2.365
- **Confidence Interval (y):** 1.297 +/- 0.028
- **Confidence Interval Corrected Mfg. (y):** 2.075 +/- 0.044
- **UCL:** 1.325
- **UCL Mfg. Corrected:** 2.119
- **LCL:** 1.269
- **LCL Mfg. Corrected:** 2.031
- **Prediction Interval (y):** 1.297 +/- 0.087
- **One-sample Mfg. t-test:** t-statistic Mfg.=3.776, p-value=0.00542272644259285
  - **Reject Mfg. Ho (y_{mean} = u):** True

### Target 9.699 ppm Statistics

- **n:** 9
- **Min (y):** 5.71
- **Max (y):** 5.91
- **Mean (y):** 5.823
- **Mean Corrected Mfg. (y):** 9.317
- **Median (y):** 5.84
- **Sample Standard Deviation (y):** 0.064
- **Variance (y):** 0.004
- **Mean Percent Error Mfg. (y):** -3.935
- **% Relative Standard Deviation (y):** 1.092
- **MSE:** 0.156
- **Alpha:** 0.05
- **df:** (n - 2) = 7
- **t-value:** 2.365
- **Confidence Interval (y):** 5.823 +/- 0.05
- **Confidence Interval Corrected Mfg. (y):** 9.317 +/- 0.08
- **UCL:** 5.873
- **UCL Mfg. Corrected:** 9.397
- **LCL:** 5.773
- **LCL Mfg. Corrected:** 9.237
- **Prediction Interval (y):** 5.823 +/- 0.159
- **One-sample Mfg. t-test:** t-statistic Mfg.=-10.609, p-value=5.449577895402745e-06
  - **Reject Mfg. Ho (y_{mean} = u):** True

---

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-12
====== Butyl Acrylate Calibrated AreaRAE (ER) Statistics ======

Date: 2023-05-06
Start: 10:37:58
Stop: 12:49:31

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

############## Regression Statistics ##############
n: 42
Mean Percent Error (Mfg.): 20.238
Mean Percent Error (Assessment): 36.111
% Relative Standard Deviation (x): 149.456
% Relative Standard Deviation (y): 142.832
Standard Deviation (x): 3.811
Standard Deviation (y): 3.856
Variance (x): 14.522
Variance (y): 14.872
Covariance (xy): 15.05
Alpha: 0.05
df: (n - 2) = 40
t-value: 2.021
Correlation Coefficient (R): 1.0
R^2: 0.999
MSE (yh): 0.01
Slope: 1.012
Slope Standard Error: 0.004
Slope p-value: 2.0640882155748775e-65 (Ho: slope = 0)
y-Intercept: 0.12
y-Intercept Standard Error: 0.019
Regression Equation: y = 1.012(x) + 0.12
Confidence Interval (Slope): 1.012 +/- 0.008
UCL (Slope): 1.02
LCL (Slope): 1.004
Honeywell Correction Factor: 1.0
Isobutylene Calibration Slope: 0.996
Assessment Correction Factor: 0.984

******************************************************************************
# Target 0.0 ppm Statistics

- **n**: 15
- **Min (y)**: 0.0
- **Max (y)**: 0.2
- **Mean (y)**: 0.12
- **Mean Corrected Mfg. (y)**: 0.12
- **Median (y)**: 0.1
- **Sample Standard Deviation (y)**: 0.065
- **Variance (y)**: 0.004
- **Mean Percent Error Mfg. (y)**: nan
- **% Relative Standard Deviation (y)**: 54.433
- **MSE**: 0.019
- **Alpha**: 0.05
- **df**: (n - 2) = 13
- **t-value**: 2.16
- **Confidence Interval (y)**: 0.12 +/- 0.036
- **Confidence Interval Corrected Mfg. (y)**: 0.12 +/- 0.036
- **UCL**: 0.156
- **UCL Mfg. Corrected**: 0.156
- **LCL**: 0.084
- **LCL Mfg. Corrected**: 0.084
- **Prediction Interval (y)**: 0.12 +/- 0.146
- **UCL Mfg.**: 0.156
- **LCL Mfg.**: 0.084
- **One-sample Mfg. t-test**: t-statistic Mfg.=6.874, p-value=7.636462972387166e-06
- **Reject Mfg. Ho (ymean = u)**: True

# Target 0.2 ppm Statistics

- **n**: 9
- **Min (y)**: 0.3
- **Max (y)**: 0.5
- **Mean (y)**: 0.422
- **Mean Corrected Mfg. (y)**: 0.422
- **Median (y)**: 0.4
- **Sample Standard Deviation (y)**: 0.063
- **Variance (y)**: 0.004
- **Mean Percent Error Mfg. (y)**: 111.111
- **% Relative Standard Deviation (y)**: 14.886
- **MSE**: 0.053
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 0.422 +/- 0.05
- **Confidence Interval Corrected Mfg. (y)**: 0.422 +/- 0.05
- **UCL**: 0.472
- **UCL Mfg. Corrected**: 0.472
- **LCL**: 0.372
- **LCL Mfg. Corrected**: 0.372
- **Prediction Interval (y)**: 0.422 +/- 0.157
- **One-sample Mfg. t-test**: t-statistic Mfg.=10.0, p-value=8.488181527628484e-06
- **Reject Mfg. Ho (ymean = u)**: True
### Target 2.0 ppm Statistics

- **n:** 9
- **Min:** 1.9
- **Max:** 2.1
- **Mean:** 2.022
- **Mean Corrected Mfg.:** 2.022
- **Median:** 2.0
- **Sample Standard Deviation:** 0.079
- **Variance:** 0.006
- **Mean Percent Error Mfg.:** 1.111
- **% Relative Standard Deviation:** 3.885
- **MSE:** 0.007
- **Alpha:** 0.05
- **df:** (n - 2) = 7
- **t-value:** 2.365
- **Confidence Interval:** 2.022 +/- 0.062
- **Confidence Interval Corrected Mfg.:** 2.022 +/- 0.062
- **UCL:** 2.084
- **UCL Mfg. Corrected:** 2.084
- **LCL:** 1.96
- **LCL Mfg. Corrected:** 1.96
- **Prediction Interval:** 2.022 +/- 0.196
- **One-sample Mfg. t-test:**
  - t-statistic Mfg. = 0.8, p-value = 0.4468133411491053
  - Reject Mfg. Ho (ymean = u): False

### Target 9.699 ppm Statistics

- **n:** 9
- **Min:** 9.9
- **Max:** 10.0
- **Mean:** 9.956
- **Mean Corrected Mfg.:** 9.956
- **Median:** 10.0
- **Sample Standard Deviation:** 0.05
- **Variance:** 0.002
- **Mean Percent Error Mfg.:** 2.645
- **% Relative Standard Deviation:** 0.499
- **MSE:** 0.068
- **Alpha:** 0.05
- **df:** (n - 2) = 7
- **t-value:** 2.365
- **Confidence Interval:** 9.956 +/- 0.039
- **Confidence Interval Corrected Mfg.:** 9.956 +/- 0.039
- **UCL:** 9.995
- **UCL Mfg. Corrected:** 9.995
- **LCL:** 9.917
- **LCL Mfg. Corrected:** 9.917
- **Prediction Interval:** 9.956 +/- 0.124
- **One-sample Mfg. t-test:**
  - t-statistic Mfg. = 14.603, p-value = 4.742332902598759e-07
  - Reject Mfg. Ho (ymean = u): True
Date: 2023-05-04
Start: 13:28:00
Stop: 15:12:00

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics
n: 57
Mean Percent Error (Mfg.): -77.93
Mean Percent Error (Assessment): 250.978
% Relative Standard Deviation (x): 182.65
% Relative Standard Deviation (y): 163.991
Standard Deviation (x): 3.452
Standard Deviation (y): 3.523
Variance (x): 11.919
Variance (y): 12.413
Covariance (xy): 12.377
Alpha: 0.05
df: (n - 2) = 55
t-value: 2.004
Correlation Coefficient (R): 1.0
R^2: 0.999
MSE (yh): 0.007
Slope: 1.02
Slope Standard Error: 0.003
Slope p-value: 8.687580246193686e-91 (Ho: slope = 0)
y-Intercept: 0.22
y-Intercept Standard Error: 0.013
Regression Equation: y = 1.02(x) + 0.22
Confidence Interval (Slope): 1.02 +/- 0.007
UCL (Slope): 1.027
LCL (Slope): 1.013
Honeywell Correction Factor: 1.0
Isobutylene Calibration Slope: 0.981
Assessment Correction Factor: 0.962

====================================
### Target 0.0 ppm Statistics

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<th>Value</th>
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<td>n</td>
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<tr>
<td>Min (y)</td>
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<tr>
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<td>Mean (y)</td>
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<td>Prediction Interval (y)</td>
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<td>t-statistic Mfg.=11.556, p-value=1.7123407396307205e-07</td>
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<td>Reject Mfg. Ho (ymean = u)</td>
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### Target 0.022 ppm Statistics

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<td>One-sample Mfg. t-test:</td>
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<tr>
<td>Reject Mfg. Ho (ymean = u)</td>
<td>True</td>
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</table>
### Target 0.05 ppm Statistics

- \( n = 9 \)
- Min (y): 0.19
- Max (y): 0.31
- Mean (y): 0.264
- Mean Corrected Mfg. (y): 0.264
- Median (y): 0.28
- Sample Standard Deviation (y): 0.041
- Variance (y): 0.002
- Mean Percent Error Mfg. (y): 428.889
- % Relative Standard Deviation (y): 15.449
- MSE: 0.048
- Alpha: 0.05
- \( df = (n - 2) = 7 \)
- t-value: 2.365
- Confidence Interval (y): 0.264 +/- 0.032
- Confidence Interval Corrected Mfg. (y): 0.264 +/- 0.032
- UCL: 0.296
- UCL Mfg. Corrected: 0.296
- LCL: 0.232
- LCL Mfg. Corrected: 0.232
- Prediction Interval (y): 0.264 +/- 0.102
  - Reject Mfg. Ho (ymean = u): True

### Target 0.2 ppm Statistics

- \( n = 9 \)
- Min (y): 0.34
- Max (y): 0.53
- Mean (y): 0.429
- Mean Corrected Mfg. (y): 0.429
- Median (y): 0.42
- Sample Standard Deviation (y): 0.053
- Variance (y): 0.003
- Mean Percent Error Mfg. (y): 114.444
- % Relative Standard Deviation (y): 12.457
- MSE: 0.055
- Alpha: 0.05
- \( df = (n - 2) = 7 \)
- t-value: 2.365
- Confidence Interval (y): 0.429 +/- 0.042
- Confidence Interval Corrected Mfg. (y): 0.429 +/- 0.042
- UCL: 0.471
- UCL Mfg. Corrected: 0.471
- LCL: 0.387
- LCL Mfg. Corrected: 0.387
- Prediction Interval (y): 0.429 +/- 0.133
- One-sample Mfg. t-test: t-statistic Mfg.=12.118, p-value=1.99018598487458e-06
  - Reject Mfg. Ho (ymean = u): True

---

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-18
Target 2.0 ppm Statistics

- **n**: 9
- **Min (y)**: 2.15
- **Max (y)**: 2.38
- **Mean (y)**: 2.264
- **Mean Corrected Mfg. (y)**: 2.264
- **Median (y)**: 2.25
- **Sample Standard Deviation (y)**: 0.07
- **Variance (y)**: 0.005
- **Mean Percent Error Mfg. (y)**: 13.222
- **% Relative Standard Deviation (y)**: 3.074
- **MSE**: 0.075
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 2.264 +/- 0.055
- **Confidence Interval Corrected Mfg. (y)**: 2.264 +/- 0.055
- **UCL**: 2.319
- **UCL Mfg. Corrected**: 2.319
- **LCL**: 2.209
- **LCL Mfg. Corrected**: 2.209
- **Prediction Interval (y)**: 2.264 +/- 0.174
- **One-sample Mfg. t-test**: t-statistic Mfg.=10.744, p-value=4.956914968981681e-06
  - Reject Mfg. Ho (ymean = u): True

Target 9.699 ppm Statistics

- **n**: 9
- **Min (y)**: 9.95
- **Max (y)**: 10.38
- **Mean (y)**: 10.114
- **Mean Corrected Mfg. (y)**: 10.114
- **Median (y)**: 10.06
- **Sample Standard Deviation (y)**: 0.146
- **Variance (y)**: 0.021
- **Mean Percent Error Mfg. (y)**: 4.283
- **% Relative Standard Deviation (y)**: 1.448
- **MSE**: 0.194
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 10.114 +/- 0.115
- **Confidence Interval Corrected Mfg. (y)**: 10.114 +/- 0.115
- **UCL**: 10.229
- **UCL Mfg. Corrected**: 10.229
- **LCL**: 9.999
- **LCL Mfg. Corrected**: 9.999
- **Prediction Interval (y)**: 10.114 +/- 0.365
- **One-sample Mfg. t-test**: t-statistic Mfg.=8.024, p-value=4.274734980136545e-05
  - Reject Mfg. Ho (ymean = u): True
Date: 2023-05-05
Start: 11:04:30
Stop: 13:03:40

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics
n: 60
Mean Percent Error (Mfg.): -20.776
Mean Percent Error (Assessment): -16.467
% Relative Standard Deviation (x): 186.278
% Relative Standard Deviation (y): 185.16
Standard Deviation (x): 3.381
Standard Deviation (y): 3.53
Variance (x): 11.429
Variance (y): 12.464
Covariance (xy): 12.129
Alpha: 0.05
df: (n - 2) = 58
t-value: 2.002
Correlation Coefficient (R): 0.999
R^2: 0.999
MSE (yh): 0.018
Slope: 1.044
Slope Standard Error: 0.005
Slope p-value: 3.6385948019514817e-84 (Ho: slope = 0)
y-Intercept: 0.013
y-Intercept Standard Error: 0.02
Regression Equation: y = 1.044(x) + 0.013
Confidence Interval (Slope): 1.044 +/- 0.01
UCL (Slope): 1.054
LCL (Slope): 1.034
Honeywell Correction Factor: 1.0
Isobutylene Calibration Slope: 0.997
Assessment Correction Factor: 0.955

=================================================
# Target 0.0 ppm Statistics#

- **n**: 24
- **Min (y)**: 0.0
- **Max (y)**: 0.3
- **Mean (y)**: 0.096
- **Mean Corrected Mfg. (y)**: 0.096
- **Median (y)**: 0.0
- **Sample Standard Deviation (y)**: 0.11
- **Variance (y)**: 0.012
- **Mean Percent Error Mfg. (y)**: nan
- **% Relative Standard Deviation (y)**: 114.621
- **MSE**: 0.021
- **Alpha**: 0.05
- **df**: (n - 2) = 22
- **t-value**: 2.074
- **Confidence Interval (y)**: 0.096 +/- 0.047
- **Confidence Interval Corrected Mfg. (y)**: 0.096 +/- 0.047
- **UCL**: 0.143
- **UCL Mfg. Corrected**: 0.143
- **LCL**: 0.049
- **LCL Mfg. Corrected**: 0.049
- **Prediction Interval (y)**: 0.096 +/- 0.233
- **UCL Mfg. Corrected**: 0.143
- **LCL Mfg. Corrected**: 0.049
- **One-sample Mfg. t-test**: t-statistic Mfg. = 4.184, p-value = 0.0003558773352554333
  - **Reject Mfg. Ho (ymean = u)**: True

# Target 0.2 ppm Statistics#

- **n**: 18
- **Min (y)**: 0.0
- **Max (y)**: 0.3
- **Mean (y)**: 0.144
- **Mean Corrected Mfg. (y)**: 0.144
- **Median (y)**: 0.1
- **Sample Standard Deviation (y)**: 0.076
- **Variance (y)**: 0.006
- **Mean Percent Error Mfg. (y)**: -27.778
- **% Relative Standard Deviation (y)**: 52.736
- **MSE**: 0.009
- **Alpha**: 0.05
- **df**: (n - 2) = 16
- **t-value**: 2.12
- **Confidence Interval (y)**: 0.144 +/- 0.038
- **Confidence Interval Corrected Mfg. (y)**: 0.144 +/- 0.038
- **UCL**: 0.182
- **UCL Mfg. Corrected**: 0.182
- **LCL**: 0.106
- **LCL Mfg. Corrected**: 0.106
- **Prediction Interval (y)**: 0.144 +/- 0.166
- **One-sample Mfg. t-test**: t-statistic Mfg. = -3.007, p-value = 0.007933939339956862
  - **Reject Mfg. Ho (ymean = u)**: True

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-21
### Target 2.0 ppm Statistics ###

- **n:** 9
- **Min (y):** 2.0
- **Max (y):** 2.1
- **Mean (y):** 2.011
- **Mean Corrected Mfg. (y):** 2.011
- **Median (y):** 2.0
- **Sample Standard Deviation (y):** 0.031
- **Variance (y):** 0.001
- **Mean Percent Error Mfg. (y):** 0.556
- **% Relative Standard Deviation (y):** 1.563
- **MSE:** 0.001
- **Alpha:** 0.05
- **df:** (n - 2) = 7
- **t-value:** 2.365
- **Confidence Interval (y):** 2.011 +/- 0.025
- **Confidence Interval Corrected Mfg. (y):** 2.011 +/- 0.025
- **UCL:** 2.036
- **UCL Mfg. Corrected:** 2.036
- **LCL:** 1.986
- **LCL Mfg. Corrected:** 1.986
- **Prediction Interval (y):** 2.011 +/- 0.078
- **One-sample Mfg. t-test:** t-statistic Mfg.=1.0, p-value=0.3465935070873362
  - **Reject Mfg. Ho (ymean = u):** False

### Target 9.699 ppm Statistics ###

- **n:** 9
- **Min (y):** 9.9
- **Max (y):** 10.4
- **Mean (y):** 10.156
- **Mean Corrected Mfg. (y):** 10.156
- **Median (y):** 10.2
- **Sample Standard Deviation (y):** 0.189
- **Variance (y):** 0.036
- **Mean Percent Error Mfg. (y):** 4.707
- **% Relative Standard Deviation (y):** 1.863
- **MSE:** 0.244
- **Alpha:** 0.05
- **df:** (n - 2) = 7
- **t-value:** 2.365
- **Confidence Interval (y):** 10.156 +/- 0.149
- **Confidence Interval Corrected Mfg. (y):** 10.156 +/- 0.149
- **UCL:** 10.305
- **UCL Mfg. Corrected:** 10.305
- **LCL:** 10.007
- **LCL Mfg. Corrected:** 10.007
- **Prediction Interval (y):** 10.156 +/- 0.472
- **One-sample Mfg. t-test:** t-statistic Mfg.=6.825, p-value=0.0001344022657217045
  - **Reject Mfg. Ho (ymean = u):** True
======== Butyl Acrylate Calibrated MultiRAE Pro (PPB) Statistics ========

Date: 2023-05-02
Start: 16:06:00
Stop: 17:34:23

NOTE: VALUES WHICH HAVE THE ABREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

########## Regression Statistics ##########

n: 57
Mean Percent Error (Mfg.): 23.606
Mean Percent Error (Assessment): 83.291
% Relative Standard Deviation (x): 182.65
% Relative Standard Deviation (y): 178.455
Standard Deviation (x): 3.452
Standard Deviation (y): 3.59
Variance (x): 11.919
Variance (y): 12.891
Covariance (xy): 12.611
Alpha: 0.05
df: (n - 2) = 55
t-value: 2.004
Correlation Coefficient (R): 1.0
R^2: 0.999
MSE (yh): 0.011
Slope: 1.04
Slope Standard Error: 0.004
Slope p-value: 5.035237252844899e-86 (Ho: slope = 0)
y-Intercept: 0.047
y-Intercept Standard Error: 0.016
Regression Equation: y = 1.04(x) + 0.047
Confidence Interval (Slope): 1.04 +/- 0.008
UCL (Slope): 1.048
LCL (Slope): 1.032
Honeywell Correction Factor: 1.0
Isobutylene Calibration Slope: 0.963
Assessment Correction Factor: 0.926

########################################################################
Target 0.0 ppm Statistics

n: 12  
Min (y): 0.04  
Max (y): 0.22  
Mean (y): 0.112  
Mean Corrected Mfg. (y): 0.112  
Median (y): 0.085  
Sample Standard Deviation (y): 0.064  
Variance (y): 0.004  
Mean Percent Error Mfg. (y): nan  
% Relative Standard Deviation (y): 57.671  
MSE: 0.017  
Alpha: 0.05  
df: (n - 2) = 10  
t-value: 2.228  
Confidence Interval (y): 0.112 +/- 0.041  
Confidence Interval Corrected Mfg. (y): 0.112 +/- 0.041  
UCL: 0.153  
UCL Mfg. Corrected: 0.153  
LCL: 0.071  
LCL Mfg. Corrected: 0.071  
Prediction Interval (y): 0.112 +/- 0.149  
One-sample Mfg. t-test: t-statistic Mfg.=5.751, p-value=0.00012818733185872018  
Reject Mfg. Ho (ymean = u): True

Target 0.022 ppm Statistics

n: 9  
Min (y): 0.01  
Max (y): 0.2  
Mean (y): 0.098  
Mean Corrected Mfg. (y): 0.098  
Median (y): 0.09  
Sample Standard Deviation (y): 0.067  
Variance (y): 0.004  
Mean Percent Error Mfg. (y): 344.444  
% Relative Standard Deviation (y): 68.314  
MSE: 0.01  
Alpha: 0.05  
df: (n - 2) = 7  
t-value: 2.365  
Confidence Interval (y): 0.098 +/- 0.053  
Confidence Interval Corrected Mfg. (y): 0.098 +/- 0.053  
UCL: 0.151  
UCL Mfg. Corrected: 0.151  
LCL: 0.045  
LCL Mfg. Corrected: 0.045  
Prediction Interval (y): 0.098 +/- 0.166  
One-sample Mfg. t-test: t-statistic Mfg.=3.209, p-value=0.012447725130964739  
Reject Mfg. Ho (ymean = u): True
########## Target 0.05 ppm Statistics ##########

n: 9
Min (y): 0.03
Max (y): 0.22
Mean (y): 0.13
Mean Corrected Mfg. (y): 0.13
Median (y): 0.14
Sample Standard Deviation (y): 0.068
Variance (y): 0.005
Mean Percent Error Mfg. (y): 160.0
% Relative Standard Deviation (y): 52.548
MSE: 0.011
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 0.13 +/- 0.054
Confidence Interval Corrected Mfg. (y): 0.13 +/- 0.054
UCL: 0.184
UCL Mfg. Corrected: 0.184
LCL: 0.076
LCL Mfg. Corrected: 0.076
Prediction Interval (y): 0.13 +/- 0.17
One-sample Mfg. t-test: t-statistic Mfg.=3.312, p-value=0.010661386349127406
Reject Mfg. Ho (ymean = u): True

#################################################

########## Target 0.2 ppm Statistics ##########

n: 9
Min (y): 0.09
Max (y): 0.25
Mean (y): 0.154
Mean Corrected Mfg. (y): 0.154
Median (y): 0.13
Sample Standard Deviation (y): 0.06
Variance (y): 0.004
Mean Percent Error Mfg. (y): -22.778
% Relative Standard Deviation (y): 38.622
MSE: 0.006
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 0.154 +/- 0.047
Confidence Interval Corrected Mfg. (y): 0.154 +/- 0.047
UCL: 0.201
UCL Mfg. Corrected: 0.201
LCL: 0.107
LCL Mfg. Corrected: 0.107
Prediction Interval (y): 0.154 +/- 0.149
One-sample Mfg. t-test: t-statistic Mfg.=-2.16, p-value=0.06277571885031956
Reject Mfg. Ho (ymean = u): False

#################################################
########## Target 2.0 ppm Statistics ##########

n: 9
Min (y): 2.02
Max (y): 2.13
Mean (y): 2.068
Mean Corrected Mfg. (y): 2.068
Median (y): 2.04
Sample Standard Deviation (y): 0.048
Variance (y): 0.002
Mean Percent Error Mfg. (y): 3.389
% Relative Standard Deviation (y): 2.3
MSE: 0.007
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 2.068 +/- 0.037
Confidence Interval Corrected Mfg. (y): 2.068 +/- 0.037
UCL: 2.105
UCL Mfg. Corrected: 2.105
LCL: 2.031
LCL Mfg. Corrected: 2.031
Prediction Interval (y): 2.068 +/- 0.119
One-sample Mfg. t-test: t-statistic Mfg.=4.031, p-value=0.003782825261958395
   Reject Mfg. Ho (ymean = u): True


########## Target 9.699 ppm Statistics ##########
n: 9
Min (y): 9.88
Max (y): 10.35
Mean (y): 10.143
Mean Corrected Mfg. (y): 10.143
Median (y): 10.14
Sample Standard Deviation (y): 0.169
Variance (y): 0.029
Mean Percent Error Mfg. (y): 4.581
% Relative Standard Deviation (y): 1.667
MSE: 0.226
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 10.143 +/- 0.133
Confidence Interval Corrected Mfg. (y): 10.143 +/- 0.133
UCL: 10.276
UCL Mfg. Corrected: 10.276
LCL: 10.01
LCL Mfg. Corrected: 10.01
Prediction Interval (y): 10.143 +/- 0.421
One-sample Mfg. t-test: t-statistic Mfg.=7.434, p-value=7.374019030852044e-05
   Reject Mfg. Ho (ymean = u): True


Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-26
************ Butyl Acrylate Calibrated ppbRAE 3000 Statistics ************

Date: 2023-05-03
Start: 14:27:11
Stop: 16:05:27

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

########### Regression Statistics ############
n: 57
Mean Percent Error (Mfg.): -128.414
Mean Percent Error (Assessment): -33.828
% Relative Standard Deviation (x): 182.65
% Relative Standard Deviation (y): 185.468
Standard Deviation (x): 3.452
Standard Deviation (y): 3.635
Variance (x): 11.919
Variance (y): 13.212
Covariance (xy): 12.768
Alpha: 0.05
df: (n - 2) = 55
t-value: 2.004
Correlation Coefficient (R): 1.0
R^2: 0.999
MSE (yh): 0.011
Slope: 1.052
Slope Standard Error: 0.004
Slope p-value: 1.836217170341827e-86 (Ho: slope = 0)
y-Intercept: -0.029
y-Intercept Standard Error: 0.016
Regression Equation: y = 1.052(x) - 0.029
Confidence Interval (Slope): 1.052 +/- 0.008
UCL (Slope): 1.06
LCL (Slope): 1.044
Honeywell Correction Factor: 1.0
Isobutylene Calibration Slope: 0.883
Assessment Correction Factor: 0.839

########################################################################
Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-28
### Target 0.05 ppm Statistics

- **n**: 9
- **Min (y)**: 0.0
- **Max (y)**: 0.074
- **Mean (y)**: 0.033
- **Mean Corrected Mfg. (y)**: 0.033
- **Median (y)**: 0.036
- **Sample Standard Deviation (y)**: 0.031
- **Variance (y)**: 0.001
- **Mean Percent Error Mfg. (y)**: -33.111
- **% Relative Standard Deviation (y)**: 93.36
- **MSE**: 0.001
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 0.033 +/- 0.025
- **Confidence Interval Corrected Mfg. (y)**: 0.033 +/- 0.025
- **UCL**: 0.058
- **UCL Mfg. Corrected**: 0.058
- **LCL**: 0.008
- **LCL Mfg. Corrected**: 0.008
- **Prediction Interval (y)**: 0.033 +/- 0.078
- **One-sample Mfg. t-test**: t-statistic Mfg.=-1.5, p-value=0.172078230203706
  - **Reject Mfg. Ho (ymean = u)**: False

### Target 0.2 ppm Statistics

- **n**: 9
- **Min (y)**: 0.158
- **Max (y)**: 0.285
- **Mean (y)**: 0.227
- **Mean Corrected Mfg. (y)**: 0.227
- **Median (y)**: 0.204
- **Sample Standard Deviation (y)**: 0.045
- **Variance (y)**: 0.002
- **Mean Percent Error Mfg. (y)**: 13.5
- **% Relative Standard Deviation (y)**: 20.001
- **MSE**: 0.003
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 0.227 +/- 0.036
- **Confidence Interval Corrected Mfg. (y)**: 0.227 +/- 0.036
- **UCL**: 0.263
- **UCL Mfg. Corrected**: 0.263
- **LCL**: 0.191
- **LCL Mfg. Corrected**: 0.191
- **Prediction Interval (y)**: 0.227 +/- 0.113
- **One-sample Mfg. t-test**: t-statistic Mfg.=1.682, p-value=0.1310654748796876
  - **Reject Mfg. Ho (ymean = u)**: False

----------------------------------------------------------
### Target 2.0 ppm Statistics

- **n**: 9
- **Min (y)**: 1.876
- **Max (y)**: 2.026
- **Mean (y)**: 1.945
- **Mean Corrected Mfg. (y)**: 1.945
- **Median (y)**: 1.924
- **Sample Standard Deviation (y)**: 0.05
- **Variance (y)**: 0.003
- **Mean Percent Error Mfg. (y)**: -2.728
- **% Relative Standard Deviation (y)**: 2.589
- **MSE**: 0.006
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 1.945 +/- 0.04
- **Confidence Interval Corrected Mfg. (y)**: 1.945 +/- 0.04
- **UCL**: 1.985
- **UCL Mfg. Corrected**: 1.985
- **LCL**: 1.905
- **LCL Mfg. Corrected**: 1.905
- **Prediction Interval (y)**: 1.945 +/- 0.126
- **One-sample Mfg. t-test**: t-statistic Mfg.=-3.064, p-value=0.015497833850580614
  - **Reject Mfg. Ho (ymean = u)**: True

### Target 9.699 ppm Statistics

- **n**: 9
- **Min (y)**: 9.894
- **Max (y)**: 10.39
- **Mean (y)**: 10.204
- **Mean Corrected Mfg. (y)**: 10.204
- **Median (y)**: 10.32
- **Sample Standard Deviation (y)**: 0.206
- **Variance (y)**: 0.043
- **Mean Percent Error Mfg. (y)**: 5.204
- **% Relative Standard Deviation (y)**: 2.023
- **MSE**: 0.297
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 10.204 +/- 0.163
- **Confidence Interval Corrected Mfg. (y)**: 10.204 +/- 0.163
- **UCL**: 10.367
- **UCL Mfg. Corrected**: 10.367
- **LCL**: 10.041
- **LCL Mfg. Corrected**: 10.041
- **Prediction Interval (y)**: 10.204 +/- 0.515
- **One-sample Mfg. t-test**: t-statistic Mfg.=6.915, p-value=0.00012261249987017525
  - **Reject Mfg. Ho (ymean = u)**: True

---

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-30
Butyl Acrylate MultiRAE Pro (ER) Statistics

Date: 2023-05-05
Start: 09:35:30
Stop: 10:52:42

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics
n: 42
Mean Percent Error (Mfg.): -19.288
Mean Percent Error (Assessment): -16.325
% Relative Standard Deviation (x): 149.456
% Relative Standard Deviation (y): 154.43
Standard Deviation (x): 3.811
Standard Deviation (y): 1.919
Variance (x): 14.522
Variance (y): 3.684
Covariance (xy): 7.469
Alpha: 0.05
df: (n - 2) = 40
t-value: 2.021
Correlation Coefficient (R): 0.997
R^2: 0.994
MSE (yh): 0.023
Slope: 0.502
Slope Standard Error: 0.006
Slope p-value: 1.278622260086416e-45 (Ho: slope = 0)
y-Intercept: -0.037
y-Intercept Standard Error: 0.029
Regression Equation: y = 0.502(x) - 0.037
Confidence Interval (Slope): 0.502 +/- 0.013
UCL (Slope): 0.515
LCL (Slope): 0.489
Honeywell Correction Factor: 1.6
Isobutylene Calibration Slope: 0.997
Assessment Correction Factor: 1.986

******************************************************************************
### Target 0.0 ppm Statistics

- \( n = 15 \)
- Min (y): 0.0
- Max (y): 0.1
- Mean (y): 0.06
- Mean Corrected Mfg. (y): 0.096
- Median (y): 0.1
- Sample Standard Deviation (y): 0.049
- Variance (y): 0.002
- Mean Percent Error Mfg. (y): nan
- % Relative Standard Deviation (y): 81.65
- MSE: 0.015
- Alpha: 0.05
- \( df = (n - 2) = 13 \)
- t-value: 2.16
- Confidence Interval (y): 0.06 +/- 0.027
- Confidence Interval Corrected Mfg. (y): 0.096 +/- 0.044
- UCL: 0.087
- UCL Mfg. Corrected: 0.14
- LCL: 0.033
- LCL Mfg. Corrected: 0.052
- Prediction Interval (y): 0.06 +/- 0.109
- One-sample Mfg. t-test: t-statistic Mfg.=4.583, p-value=0.00042637575734322437
  Reject Mfg. Ho (\( \text{ymean} = u \)): True

### Target 0.2 ppm Statistics

- \( n = 9 \)
- Min (y): 0.0
- Max (y): 0.1
- Mean (y): 0.078
- Mean Corrected Mfg. (y): 0.124
- Median (y): 0.1
- Sample Standard Deviation (y): 0.042
- Variance (y): 0.002
- Mean Percent Error Mfg. (y): -37.778
- % Relative Standard Deviation (y): 53.452
- MSE: 0.01
- Alpha: 0.05
- \( df = (n - 2) = 7 \)
- t-value: 2.365
- Confidence Interval (y): 0.078 +/- 0.033
- Confidence Interval Corrected Mfg. (y): 0.124 +/- 0.052
- UCL: 0.111
- UCL Mfg. Corrected: 0.176
- LCL: 0.045
- LCL Mfg. Corrected: 0.072
- Prediction Interval (y): 0.078 +/- 0.104
- One-sample Mfg. t-test: t-statistic Mfg.=-3.213, p-value=0.012374070003721462
  Reject Mfg. Ho (\( \text{ymean} = u \)): True

---

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-32
### Target 2.0 ppm Statistics

- **n**: 9
- **Min (y)**: 0.7
- **Max (y)**: 0.8
- **Mean (y)**: 0.744
- **Mean Corrected Mfg. (y)**: 1.191
- **Median (y)**: 0.7
- **Sample Standard Deviation (y)**: 0.05
- **Variance (y)**: 0.002
- **Mean Percent Error Mfg. (y)**: -40.444
- **% Relative Standard Deviation (y)**: 6.675
- **MSE**: 0.661
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 0.744 +/- 0.039
- **Confidence Interval Corrected Mfg. (y)**: 1.191 +/- 0.063
- **UCL**: 0.783
- **UCL Mfg. Corrected**: 1.254
- **LCL**: 0.705
- **LCL Mfg. Corrected**: 1.128
- **Prediction Interval (y)**: 0.744 +/- 0.124
- **One-sample Mfg. t-test**: t-statistic Mfg.=-28.777, p-value=2.300668778130005e-09
  - **Reject Mfg. Ho (ymean = u)**: True

### Target 9.699 ppm Statistics

- **n**: 9
- **Min (y)**: 4.6
- **Max (y)**: 5.1
- **Mean (y)**: 4.878
- **Mean Corrected Mfg. (y)**: 7.804
- **Median (y)**: 5.0
- **Sample Standard Deviation (y)**: 0.181
- **Variance (y)**: 0.033
- **Mean Percent Error Mfg. (y)**: -19.534
- **% Relative Standard Deviation (y)**: 3.715
- **MSE**: 3.673
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 4.878 +/- 0.143
- **Confidence Interval Corrected Mfg. (y)**: 7.804 +/- 0.229
- **UCL**: 5.021
- **UCL Mfg. Corrected**: 8.033
- **LCL**: 4.735
- **LCL Mfg. Corrected**: 7.575
- **Prediction Interval (y)**: 4.878 +/- 0.452
- **One-sample Mfg. t-test**: t-statistic Mfg.=-18.481, p-value=7.570799106181063e-08
  - **Reject Mfg. Ho (ymean = u)**: True
Date: 2023-05-02
Start: 13:16:21
Stop: 15:40:02

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics

n: 78
Mean Percent Error (Mfg.): -90.486
Mean Percent Error (Assessment): -26.541
% Relative Standard Deviation (x): 185.748
% Relative Standard Deviation (y): 199.529
Standard Deviation (x): 3.421
Standard Deviation (y): 1.766
Variance (x): 11.703
Variance (y): 3.12
Covariance (xy): 6.102
Alpha: 0.05
df: (n - 2) = 76
t-value: 1.992
Correlation Coefficient (R): 0.997
R^2: 0.994
MSE (yh): 0.019
Slope: 0.515
Slope Standard Error: 0.005
Slope p-value: 1.021552706825553e-85 (Ho: slope = 0)
y-Intercept: -0.063
y-Intercept Standard Error: 0.018
Regression Equation: y = 0.515(x) - 0.063
Confidence Interval (Slope): 0.515 +/- 0.009
UCL (Slope): 0.524
LCL (Slope): 0.506
Honeywell Correction Factor: 1.6
Isobutylene Calibration Slope: 0.963
Assessment Correction Factor: 1.87

========================================================================
# Target 0.0 ppm Statistics

- \( n = 18 \)
- Min (y): 0.0
- Max (y): 0.08
- Mean (y): 0.016
- Mean Corrected Mfg. (y): 0.025
- Median (y): 0.0
- Sample Standard Deviation (y): 0.021
- Variance (y): 0.0
- Mean Percent Error Mfg. (y): nan
- % Relative Standard Deviation (y): 137.581
- MSE: 0.002
- \( \alpha = 0.05 \)
- df: \((n - 2) = 16\)
- t-value: 2.12
- Confidence Interval (y): 0.016 +/- 0.011
- Confidence Interval Corrected Mfg. (y): 0.025 +/- 0.017
- UCL: 0.027
- UCL Mfg. Corrected: 0.042
- LCL: 0.005
- LCL Mfg. Corrected: 0.008
- Prediction Interval (y): 0.016 +/- 0.047
- One-sample Mfg. t-test: t-statistic Mfg.=2.997, p-value=0.008108904072287234
  - Reject Mfg. Ho (ymean = u): True

# Target 0.022 ppm Statistics

- \( n = 12 \)
- Min (y): 0.0
- Max (y): 0.07
- Mean (y): 0.015
- Mean Corrected Mfg. (y): 0.024
- Median (y): 0.005
- Sample Standard Deviation (y): 0.021
- Variance (y): 0.0
- Mean Percent Error Mfg. (y): 9.091
- % Relative Standard Deviation (y): 137.437
- MSE: 0.001
- \( \alpha = 0.05 \)
- df: \((n - 2) = 10\)
- t-value: 2.228
- Confidence Interval (y): 0.015 +/- 0.013
- Confidence Interval Corrected Mfg. (y): 0.024 +/- 0.021
- UCL: 0.028
- UCL Mfg. Corrected: 0.045
- LCL: 0.002
- LCL Mfg. Corrected: 0.003
- Prediction Interval (y): 0.015 +/- 0.048
- One-sample Mfg. t-test: t-statistic Mfg.=0.201, p-value=0.8442906791298765
  - Reject Mfg. Ho (ymean = u): False
########## Target 0.05 ppm Statistics ##########
n: 12
Min (y): 0.0
Max (y): 0.07
Mean (y): 0.014
Mean Corrected Mfg. (y): 0.023
Median (y): 0.01
Sample Standard Deviation (y): 0.019
Variance (y): 0.0
Mean Percent Error Mfg. (y): -54.667
% Relative Standard Deviation (y): 133.492
MSE: 0.002
Alpha: 0.05
df: (n - 2) = 10
t-value: 2.228
Confidence Interval (y): 0.014 +/- 0.012
Confidence Interval Corrected Mfg. (y): 0.023 +/- 0.019
UCL: 0.026
UCL Mfg. Corrected: 0.042
LCL: 0.002
LCL Mfg. Corrected: 0.004
Prediction Interval (y): 0.014 +/- 0.044
One-sample Mfg. t-test: t-statistic Mfg.=-2.996, p-value=0.01216579535475874
Reject Mfg. Ho (ymean = u): True

#################################################

########## Target 0.2 ppm Statistics ##########
n: 12
Min (y): 0.0
Max (y): 0.06
Mean (y): 0.028
Mean Corrected Mfg. (y): 0.045
Median (y): 0.03
Sample Standard Deviation (y): 0.017
Variance (y): 0.0
Mean Percent Error Mfg. (y): -77.333
% Relative Standard Deviation (y): 59.117
MSE: 0.025
Alpha: 0.05
df: (n - 2) = 10
t-value: 2.228
Confidence Interval (y): 0.028 +/- 0.011
Confidence Interval Corrected Mfg. (y): 0.045 +/- 0.017
UCL: 0.039
UCL Mfg. Corrected: 0.062
LCL: 0.017
LCL Mfg. Corrected: 0.028
Prediction Interval (y): 0.028 +/- 0.039
One-sample Mfg. t-test: t-statistic Mfg.=-19.141, p-value=8.554842782646125e-10
Reject Mfg. Ho (ymean = u): True

#################################################
### Target 2.0 ppm Statistics

- **n:** 12
- **Min (y):** 0.62
- **Max (y):** 0.79
- **Mean (y):** 0.686
- **Mean Corrected Mfg. (y):** 1.097
- **Median (y):** 0.665
- **Sample Standard Deviation (y):** 0.055
- **Variance (y):** 0.003
- **Mean Percent Error Mfg. (y):** -45.133
- **% Relative Standard Deviation (y):** 8.085
- **MSE:** 0.823
- **Alpha:** 0.05
- **df:** (n - 2) = 10
- **t-value:** 2.228
- **Confidence Interval (y):** 0.686 +/- 0.036
- **Confidence Interval Corrected Mfg. (y):** 1.097 +/- 0.057
- **UCL:** 0.722
- **UCL Mfg. Corrected:** 1.154
- **LCL:** 0.65
- **LCL Mfg. Corrected:** 1.04
- **Prediction Interval (y):** 0.686 +/- 0.129
- **One-sample Mfg. t-test:** t-statistic Mfg.=-33.747, p-value=1.850623552300888e-12
  - **Reject Mfg. Ho (ymean = u):** True

### Target 9.699 ppm Statistics

- **n:** 12
- **Min (y):** 4.57
- **Max (y):** 5.17
- **Mean (y):** 4.988
- **Mean Corrected Mfg. (y):** 7.98
- **Median (y):** 5.0
- **Sample Standard Deviation (y):** 0.148
- **Variance (y):** 0.022
- **Mean Percent Error Mfg. (y):** -17.723
- **% Relative Standard Deviation (y):** 2.962
- **MSE:** 3.011
- **Alpha:** 0.05
- **df:** (n - 2) = 10
- **t-value:** 2.228
- **Confidence Interval (y):** 4.988 +/- 0.095
- **Confidence Interval Corrected Mfg. (y):** 7.98 +/- 0.152
- **UCL:** 5.083
- **UCL Mfg. Corrected:** 8.132
- **LCL:** 4.893
- **LCL Mfg. Corrected:** 7.828
- **Prediction Interval (y):** 4.988 +/- 0.343
- **One-sample Mfg. t-test:** t-statistic Mfg.=-24.123, p-value=7.094857731634004e-11
  - **Reject Mfg. Ho (ymean = u):** True
Date: 2023-05-06
Start: 13:13:46
Stop: 15:49:19

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

########## Regression Statistics ##########
n: 102
Mean Percent Error (Mfg.): 66.105
Mean Percent Error (Assessment): 143.992
% Relative Standard Deviation (x): 253.761
% Relative Standard Deviation (y): 232.231
Standard Deviation (x): 2.738
Standard Deviation (y): 1.301
Variance (x): 7.497
Variance (y): 1.693
Covariance (xy): 3.595
Alpha: 0.05
df: (n - 2) = 100
t-value: 1.984
Correlation Coefficient (R): 0.999
R^2: 0.999
MSE (yh): 0.002
Slope: 0.475
Slope Standard Error: 0.002
Slope p-value: 1.3416895963073647e-148 (Ho: slope = 0)
y-Intercept: 0.048
y-Intercept Standard Error: 0.005
Regression Equation: y = 0.475(x) + 0.048
Confidence Interval (Slope): 0.475 +/- 0.003
UCL (Slope): 0.478
LCL (Slope): 0.472
Honeywell Correction Factor: 1.6
Isobutylene Calibration Slope: 0.883
Assessment Correction Factor: 1.859

========================================
########## Target 0.0 ppm Statistics ##########
n: 36  
Min (y): 0.0  
Max (y): 0.137  
Mean (y): 0.034  
Mean Corrected Mfg. (y): 0.055  
Median (y): 0.013  
Sample Standard Deviation (y): 0.043  
Variance (y): 0.002  
Mean Percent Error Mfg. (y): nan  
% Relative Standard Deviation (y): 124.951  
MSE: 0.008  
Alpha: 0.05  
df: (n - 2) = 34  
t-value: 2.032  
Confidence Interval (y): 0.034 +/- 0.015  
Confidence Interval Corrected Mfg. (y): 0.055 +/- 0.023  
UCL: 0.049  
UCL Mfg. Corrected: 0.078  
LCL: 0.019  
LCL Mfg. Corrected: 0.032  
Prediction Interval (y): 0.034 +/- 0.089  
One-sample Mfg. t-test: t-statistic Mfg.=4.735, p-value=3.565973339527615e-05  
Reject Mfg. Ho (ymean = u): True  


########## Target 0.022 ppm Statistics ##########
n: 12  
Min (y): 0.0  
Max (y): 0.133  
Mean (y): 0.062  
Mean Corrected Mfg. (y): 0.1  
Median (y): 0.06  
Sample Standard Deviation (y): 0.045  
Variance (y): 0.002  
Mean Percent Error Mfg. (y): 353.939  
% Relative Standard Deviation (y): 72.479  
MSE: 0.011  
Alpha: 0.05  
df: (n - 2) = 10  
t-value: 2.228  
Confidence Interval (y): 0.062 +/- 0.029  
Confidence Interval Corrected Mfg. (y): 0.1 +/- 0.047  
UCL: 0.091  
UCL Mfg. Corrected: 0.147  
LCL: 0.033  
LCL Mfg. Corrected: 0.053  
Prediction Interval (y): 0.062 +/- 0.105  
One-sample Mfg. t-test: t-statistic Mfg.=3.568, p-value=0.00441119974035564  
Reject Mfg. Ho (ymean = u): True  


Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs  
Appendix C-39
n: 18
Min (y): 0.036
Max (y): 0.157
Mean (y): 0.078
Mean Corrected Mfg. (y): 0.126
Median (y): 0.072
Sample Standard Deviation (y): 0.036
Variance (y): 0.001
Mean Percent Error Mfg. (y): 151.2
% Relative Standard Deviation (y): 45.754
MSE: 0.009
Alpha: 0.05
df: (n - 2) = 16
t-value: 2.12
Confidence Interval (y): 0.078 +/- 0.018
Confidence Interval Corrected Mfg. (y): 0.126 +/- 0.029
UCL: 0.096
UCL Mfg. Corrected: 0.155
LCL: 0.06
LCL Mfg. Corrected: 0.097
Prediction Interval (y): 0.078 +/- 0.078
One-sample Mfg. t-test: t-statistic Mfg.=5.424, p-value=4.557370549906981e-05
Reject Mfg. Ho (ymean = u): True

n: 18
Min (y): 0.115
Max (y): 0.256
Mean (y): 0.174
Mean Corrected Mfg. (y): 0.279
Median (y): 0.168
Sample Standard Deviation (y): 0.04
Variance (y): 0.002
Mean Percent Error Mfg. (y): 39.333
% Relative Standard Deviation (y): 22.97
MSE: 0.01
Alpha: 0.05
df: (n - 2) = 16
t-value: 2.12
Confidence Interval (y): 0.174 +/- 0.02
Confidence Interval Corrected Mfg. (y): 0.279 +/- 0.032
UCL: 0.194
UCL Mfg. Corrected: 0.311
LCL: 0.154
LCL Mfg. Corrected: 0.247
Prediction Interval (y): 0.174 +/- 0.087
One-sample Mfg. t-test: t-statistic Mfg.=5.067, p-value=9.522094313889009e-05
Reject Mfg. Ho (ymean = u): True
### Target 2.0 ppm Statistics

- n: 9
- Min (y): 0.91
- Max (y): 1.03
- Mean (y): 0.964
- Mean Corrected Mfg. (y): 1.542
- Median (y): 0.946
- Sample Standard Deviation (y): 0.042
- Variance (y): 0.002
- Mean Percent Error Mfg. (y): -22.916
- % Relative Standard Deviation (y): 4.392
- MSE: 0.215
- Alpha: 0.05
- df: (n - 2) = 7
- t-value: 2.365
- Confidence Interval (y): 0.964 +/- 0.033
- Confidence Interval Corrected Mfg. (y): 1.542 +/- 0.053
- UCL: 0.997
- UCL Mfg. Corrected: 1.595
- LCL: 0.931
- LCL Mfg. Corrected: 1.489
- Prediction Interval (y): 0.964 +/- 0.105
- One-sample Mfg. t-test: t-statistic Mfg.=-19.146, p-value=5.739278824439516e-08
  - Reject Mfg. Ho (y\text{mean} = u): True

### Target 9.699 ppm Statistics

- n: 9
- Min (y): 4.634
- Max (y): 4.699
- Mean (y): 4.66
- Mean Corrected Mfg. (y): 7.455
- Median (y): 4.648
- Sample Standard Deviation (y): 0.024
- Variance (y): 0.001
- Mean Percent Error Mfg. (y): -23.133
- % Relative Standard Deviation (y): 0.508
- MSE: 5.036
- Alpha: 0.05
- df: (n - 2) = 7
- t-value: 2.365
- Confidence Interval (y): 4.66 +/- 0.019
- Confidence Interval Corrected Mfg. (y): 7.455 +/- 0.03
- UCL: 4.679
- UCL Mfg. Corrected: 7.485
- LCL: 4.641
- LCL Mfg. Corrected: 7.425
- Prediction Interval (y): 4.66 +/- 0.059
- One-sample Mfg. t-test: t-statistic Mfg.=-167.44, p-value=1.8109575763394596e-15
  - Reject Mfg. Ho (y\text{mean} = u): True
Isobutylene AreaRAE (ER) Statistics

Date: 2023-05-06
Start: 08:30:04
Stop: 19:04:36

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics

n: 106
Mean Percent Error (Mfg.): -2.997
Mean Percent Error (Assessment): -1.224
% Relative Standard Deviation (x): 223.429
% Relative Standard Deviation (y): 225.916
Standard Deviation (x): 29.762
Standard Deviation (y): 31.72
Variance (x): 885.803
Variance (y): 1006.154
Covariance (xy): 950.71
Alpha: 0.05
df: (n - 2) = 104
t-value: 1.983
Correlation Coefficient (R): 0.998
R^2: 0.995
MSE (yh): 4.943
Slope: 1.063
Slope Standard Error: 0.007
Slope p-value: 6.963×10^-122 (Ho: slope = 0)
y-Intercept: -0.121
y-Intercept Standard Error: 0.239
Regression Equation: y = 1.063(x) - 0.121
Confidence Interval (Slope): 1.063 +/- 0.015
UCL (Slope): 1.078
LCL (Slope): 1.048
Honeywell Correction Factor: 1
Isobutylene Calibration Slope: 0.996
Assessment Correction Factor: 0.937

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Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-42
### Target 0 ppm Statistics

- **n**: 43
- **Min (y)**: 0.0
- **Max (y)**: 0.1
- **Mean (y)**: 0.026
- **Mean Corrected Mfg. (y)**: 0.026
- **Median (y)**: 0.0
- **Sample Standard Deviation (y)**: 0.044
- **Variance (y)**: 0.002
- **Mean Percent Error Mfg. (y)**: nan
- **% Relative Standard Deviation (y)**: 170.561
- **MSE**: 0.003
- **Alpha**: 0.05
- **df**: (n - 2) = 41
- **t-value**: 2.02
- **Confidence Interval (y)**: 0.026 +/- 0.013
- **Confidence Interval Corrected Mfg. (y)**: 0.026 +/- 0.013
- **UCL**: 0.039
- **UCL Mfg. Corrected**: 0.039
- **LCL**: 0.013
- **LCL Mfg. Corrected**: 0.013
- **Prediction Interval (y)**: 0.026 +/- 0.089
- **One-sample Mfg. t-test**: t-statistic Mfg.=3.8, p-value=0.0004612150499680944
  - Reject Mfg. Ho (ymean = u): True

### Target 10 ppm Statistics

- **n**: 26
- **Min (y)**: 9.7
- **Max (y)**: 10.6
- **Mean (y)**: 10.019
- **Mean Corrected Mfg. (y)**: 10.019
- **Median (y)**: 10.0
- **Sample Standard Deviation (y)**: 0.173
- **Variance (y)**: 0.03
- **Mean Percent Error Mfg. (y)**: 0.192
- **% Relative Standard Deviation (y)**: 1.729
- **MSE**: 0.03
- **Alpha**: 0.05
- **df**: (n - 2) = 24
- **t-value**: 2.064
- **Confidence Interval (y)**: 10.019 +/- 0.07
- **Confidence Interval Corrected Mfg. (y)**: 10.019 +/- 0.07
- **UCL**: 10.089
- **UCL Mfg. Corrected**: 10.089
- **LCL**: 9.949
- **LCL Mfg. Corrected**: 9.949
- **Prediction Interval (y)**: 10.019 +/- 0.364
- **One-sample Mfg. t-test**: t-statistic Mfg.=0.555, p-value=0.5838216754276255
  - Reject Mfg. Ho (ymean = u): False
Version 1.0.1

# Target 100 ppm Statistics

- **n:** 11
- **Min (y):** 96.6
- **Max (y):** 115.3
- **Mean (y):** 106.3
- **Mean Corrected Mfg. (y):** 106.3
- **Median (y):** 106.9
- **Sample Standard Deviation (y):** 6.833
- **Variance (y):** 46.684
- **Mean Percent Error Mfg. (y):** 6.3
- **% Relative Standard Deviation (y):** 6.428
- **MSE:** 86.374
- **Alpha:** 0.05
- **df:** (n - 2) = 9
- **t-value:** 2.262
- **Confidence Interval (y):** 106.3 +/- 4.66
- **Confidence Interval Corrected Mfg. (y):** 106.3 +/- 4.66
- **UCL:** 110.96
- **UCL Mfg. Corrected:** 110.96
- **LCL:** 101.64
- **LCL Mfg. Corrected:** 101.64
- **Prediction Interval (y):** 106.3 +/- 16.144
- **One-sample Mfg. t-test:** t-statistic Mfg.=2.916, p-value=0.015410817061525322
  - **Reject Mfg. Ho (ymean = u):** True

# Target 2 ppm Statistics

- **n:** 26
- **Min (y):** 1.9
- **Max (y):** 2.6
- **Mean (y):** 2.208
- **Mean Corrected Mfg. (y):** 2.208
- **Median (y):** 2.2
- **Sample Standard Deviation (y):** 0.215
- **Variance (y):** 0.046
- **Mean Percent Error Mfg. (y):** 10.385
- **% Relative Standard Deviation (y):** 9.725
- **MSE:** 0.089
- **df:** (n - 2) = 24
- **t-value:** 2.064
- **Confidence Interval (y):** 2.208 +/- 0.087
- **Confidence Interval Corrected Mfg. (y):** 2.208 +/- 0.087
- **UCL:** 2.295
- **UCL Mfg. Corrected:** 2.295
- **LCL:** 2.121
- **LCL Mfg. Corrected:** 2.121
- **Prediction Interval (y):** 2.208 +/- 0.452
- **One-sample Mfg. t-test:** t-statistic Mfg.=4.837, p-value=5.68622654219531e-05
  - **Reject Mfg. Ho (ymean = u):** True

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-44
============== Isobutylene AreaRAE Pro (PPB) Statistics ===============

Date: 2023-05-04  
Start: 08:26:15  
Stop: 19:21:50

NOTE: VALUES WHICH HAVE THE ABREVIATION "MFG." HAVE THE MANUFACTURER
CORRECTION FACTOR APPLIED TO THE VALUE.

########## Regression Statistics ##########

n: 105
Mean Percent Error (Mfg.): 6.453
Mean Percent Error (Assessment): 10.71
% Relative Standard Deviation (x): 233.281
% Relative Standard Deviation (y): 228.329
Standard Deviation (x): 27.327
Standard Deviation (y): 26.664
Variance (x): 746.776
Variance (y): 710.948
Covariance (xy): 735.463
Alpha: 0.05
df: (n - 2) = 103
t-value: 1.983
Correlation Coefficient (R): 1.0
R^2: 0.999
MSE (yh): 0.356
Slope: 0.975
Slope Standard Error: 0.002
Slope p-value: 8.969917382577411e-172 (Ho: slope = 0)
y-Intercept: 0.251
y-Intercept Standard Error: 0.064
Regression Equation: y = 0.975(x) + 0.251
Confidence Interval (Slope): 0.975 +/- 0.004
UCL (Slope): 0.979
LCL (Slope): 0.971
Honeywell Correction Factor: 1
Isobutylene Calibration Slope: 0.981
Assessment Correction Factor: 1.006

#*****************************************************************************#
### Target 0 ppm Statistics

- **n**: 39
- **Min**: 0.0
- **Max**: 0.22
- **Mean**: 0.069
- **Mean Corrected Mfg.**: 0.069
- **Median**: 0.06
- **Sample Standard Deviation**: 0.072
- **Variance**: 0.005
- **Mean Percent Error Mfg.**: nan
- **% Relative Standard Deviation**: 103.671
- **MSE**: 0.01
- **Alpha**: 0.05
- **df**: (n - 2) = 37
- **t-value**: 2.026
- **Confidence Interval**: 0.069 +/- 0.023
- **Confidence Interval Corrected Mfg.**: 0.069 +/- 0.023
- **UCL**: 0.092
- **UCL Mfg. Corrected**: 0.092
- **LCL**: 0.046
- **LCL Mfg. Corrected**: 0.046
- **Prediction Interval**: 0.069 +/- 0.148
- **One-sample Mfg. t-test**: t-statistic Mfg. = 5.946, p-value = 6.74880305765921e-07
  - Reject Mfg. Ho (y_{mean} = u): True

### Target 10 ppm Statistics

- **n**: 27
- **Min**: 9.65
- **Max**: 10.29
- **Mean**: 9.986
- **Mean Corrected Mfg.**: 9.986
- **Median**: 10.0
- **Sample Standard Deviation**: 0.141
- **Variance**: 0.02
- **Mean Percent Error Mfg.**: -0.137
- **% Relative Standard Deviation**: 1.413
- **MSE**: 0.02
- **Alpha**: 0.05
- **df**: (n - 2) = 25
- **t-value**: 2.06
- **Confidence Interval**: 9.986 +/- 0.056
- **Confidence Interval Corrected Mfg.**: 9.986 +/- 0.056
- **UCL**: 10.042
- **UCL Mfg. Corrected**: 10.042
- **LCL**: 9.93
- **LCL Mfg. Corrected**: 9.93
- **Prediction Interval**: 9.986 +/- 0.296
- **One-sample Mfg. t-test**: t-statistic Mfg. = -0.495, p-value = 0.6246307600959767
  - Reject Mfg. Ho (y_{mean} = u): False
Target 100 ppm Statistics

- **n**: 9
- **Min (y)**: 94.89
- **Max (y)**: 99.78
- **Mean (y)**: 97.787
- **Mean Corrected Mfg. (y)**: 97.787
- **Median (y)**: 98.68
- **Sample Standard Deviation (y)**: 1.917
- **Variance (y)**: 3.676
- **Mean Percent Error Mfg. (y)**: -2.213
- **% Relative Standard Deviation (y)**: 1.961
- **MSE**: 8.575
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 97.787 +/- 1.511
- **Confidence Interval Corrected Mfg. (y)**: 97.787 +/- 1.511
- **UCL**: 99.298
- **UCL Mfg. Corrected**: 99.298
- **LCL**: 96.276
- **LCL Mfg. Corrected**: 96.276
- **Prediction Interval (y)**: 97.787 +/- 4.779
- **One-sample Mfg. t-test**: t-statistic Mfg.=-3.265, p-value=0.011436366311307265
  - **Reject Mfg. Ho (ymean = u)**: True

Target 2 ppm Statistics

- **n**: 30
- **Min (y)**: 2.24
- **Max (y)**: 2.67
- **Mean (y)**: 2.458
- **Mean Corrected Mfg. (y)**: 2.458
- **Median (y)**: 2.465
- **Sample Standard Deviation (y)**: 0.107
- **Variance (y)**: 0.011
- **Mean Percent Error Mfg. (y)**: 22.9
- **% Relative Standard Deviation (y)**: 4.348
- **MSE**: 0.221
- **Alpha**: 0.05
- **df**: (n - 2) = 28
- **t-value**: 2.048
- **Confidence Interval (y)**: 2.458 +/- 0.04
- **Confidence Interval Corrected Mfg. (y)**: 2.458 +/- 0.04
- **UCL**: 2.498
- **UCL Mfg. Corrected**: 2.498
- **LCL**: 2.418
- **LCL Mfg. Corrected**: 2.418
- **Prediction Interval (y)**: 2.458 +/- 0.223
- **One-sample Mfg. t-test**: t-statistic Mfg.=23.077, p-value=3.2837961845608124e-20
  - **Reject Mfg. Ho (ymean = u)**: True
================ Isobutylene Calibration AreaRAE (ER) Statistics =================

Date: 2023-05-06  
Start: 08:30:04  
Stop: 19:04:36  

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER 
CORRECTION FACTOR APPLIED TO THE VALUE.

########## Regression Statistics ##########
n: 95  
Mean Percent Error (Mfg.): 3.098  
Mean Percent Error (Assessment): 5.288  
% Relative Standard Deviation (x): 128.019  
% Relative Standard Deviation (y): 124.774  
Standard Deviation (x): 4.204  
Standard Deviation (y): 4.19  
Variance (x): 17.677  
Variance (y): 17.554  
Covariance (xy): 17.789  
Alpha: 0.05  
df: (n - 2) = 93  
t-value: 1.986  
Correlation Coefficient (R): 0.999  
R^2: 0.998  
MSE (yh): 0.028  
Slope: 0.996  
Slope Standard Error: 0.004  
Slope p-value: 8.865106073596238e-132 (Ho: slope = 0)  
y-Intercept: 0.088  
y-Intercept Standard Error: 0.022  
Regression Equation: y = 0.996(x) + 0.088  
Confidence Interval (Slope): 0.996 +/- 0.008  
UCL (Slope): 1.004  
LCL (Slope): 0.988  
Honeywell Correction Factor: 1  
Isobutylene Calibration Slope: 0.996  
Assessment Correction Factor: 1.0

###################################################################
### Target 0 ppm Statistics

- n: 43
- Min (y): 0.0
- Max (y): 0.1
- Mean (y): 0.026
- Mean Corrected Mfg. (y): 0.026
- Median (y): 0.0
- Sample Standard Deviation (y): 0.044
- Variance (y): 0.002
- Mean Percent Error Mfg. (y): nan
- % Relative Standard Deviation (y): 170.561
- MSE: 0.003
- Alpha: 0.05
- df: (n - 2) = 41
- t-value: 2.02
- Confidence Interval (y): 0.026 +/- 0.013
- Confidence Interval Corrected Mfg. (y): 0.026 +/- 0.013
- UCL: 0.039
- UCL Mfg. Corrected: 0.039
- LCL: 0.013
- LCL Mfg. Corrected: 0.013
- Prediction Interval (y): 0.026 +/- 0.089
- One-sample Mfg. t-test: t-statistic Mfg.=3.8, p-value=0.00046121504999680944
  - Reject Mfg. Ho (ymean = u): True

### Target 10 ppm Statistics

- n: 26
- Min (y): 9.7
- Max (y): 10.6
- Mean (y): 10.019
- Mean Corrected Mfg. (y): 10.019
- Median (y): 10.0
- Sample Standard Deviation (y): 0.173
- Variance (y): 0.03
- Mean Percent Error Mfg. (y): 0.192
- % Relative Standard Deviation (y): 1.729
- MSE: 0.03
- Alpha: 0.05
- df: (n - 2) = 24
- t-value: 2.064
- Confidence Interval (y): 10.019 +/- 0.07
- Confidence Interval Corrected Mfg. (y): 10.019 +/- 0.07
- UCL: 10.089
- UCL Mfg. Corrected: 10.089
- LCL: 9.949
- LCL Mfg. Corrected: 9.949
- Prediction Interval (y): 10.019 +/- 0.364
- One-sample Mfg. t-test: t-statistic Mfg.=0.555, p-value=0.5838216754276255
  - Reject Mfg. Ho (ymean = u): False

---

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-49
Target 2 ppm Statistics

n: 26
Min (y): 1.9
Max (y): 2.6
Mean (y): 2.208
Mean Corrected Mfg. (y): 2.208
Median (y): 2.2
Sample Standard Deviation (y): 0.215
Variance (y): 0.046
Mean Percent Error Mfg. (y): 10.385
% Relative Standard Deviation (y): 9.725
MSE: 0.089
Alpha: 0.05
df: (n - 2) = 24
t-value: 2.064
Confidence Interval (y): 2.208 +/- 0.087
Confidence Interval Corrected Mfg. (y): 2.208 +/- 0.087
UCL: 2.295
UCL Mfg. Corrected: 2.295
LCL: 2.121
LCL Mfg. Corrected: 2.121
Prediction Interval (y): 2.208 +/- 0.452
One-sample Mfg. t-test: t-statistic Mfg.=4.837, p-value=5.68622654219531e-05
  Reject Mfg. Ho (ymean = u): True

----------------------------------------------------------
Isobutylene Calibration Area RAE Pro (PPB) Statistics

Date: 2023-05-04
Start: 08:26:15
Stop: 19:21:50

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics

n: 96
Mean Percent Error (Mfg.): 6.787
Mean Percent Error (Assessment): 11.988
% Relative Standard Deviation (x): 121.9
% Relative Standard Deviation (y): 114.214
Standard Deviation (x): 4.19
Standard Deviation (y): 4.117
Variance (x): 17.559
Variance (y): 16.953
Covariance (xy): 17.412
Alpha: 0.05
df: (n - 2) = 94
t-value: 1.986
Correlation Coefficient (R): 0.999
R^2: 0.997
MSE (yh): 0.045
Slope: 0.981
Slope Standard Error: 0.005
Slope p-value: 4.8418143292249964e-123 (Ho: slope = 0)
y-Intercept: 0.232
y-Intercept Standard Error: 0.028
Regression Equation: y = 0.981(x) + 0.232
Confidence Interval (Slope): 0.981 +/- 0.01
UCL (Slope): 0.991
LCL (Slope): 0.971
Honeywell Correction Factor: 1
Isobutylene Calibration Slope: 0.981
Assessment Correction Factor: 1.0

Honeywell Correction Factor: 1
Isobutylene Calibration Slope: 0.981
Assessment Correction Factor: 1.0

============================================
########## Target 0 ppm Statistics ##########
n: 39
Min (y): 0.0
Max (y): 0.22
Mean (y): 0.069
Mean Corrected Mfg. (y): 0.069
Median (y): 0.06
Sample Standard Deviation (y): 0.072
Variance (y): 0.005
Mean Percent Error Mfg. (y): nan
% Relative Standard Deviation (y): 103.671
MSE: 0.01
Alpha: 0.05
df: (n - 2) = 37
t-value: 2.026
Confidence Interval (y): 0.069 +/- 0.023
Confidence Interval Corrected Mfg. (y): 0.069 +/- 0.023
UCL: 0.092
UCL Mfg. Corrected: 0.092
LCL: 0.046
LCL Mfg. Corrected: 0.046
Prediction Interval (y): 0.069 +/- 0.148
One-sample Mfg. t-test: t-statistic Mfg. = 5.946, p-value=6.74880305765921e-07
Reject Mfg. Ho (ymean = u): True

Target 0 ppm Statistics

n: 39
Min (y): 0.0
Max (y): 0.22
Mean (y): 0.069
Mean Corrected Mfg. (y): 0.069
Median (y): 0.06
Sample Standard Deviation (y): 0.072
Variance (y): 0.005
Mean Percent Error Mfg. (y): nan
% Relative Standard Deviation (y): 103.671
MSE: 0.01
Alpha: 0.05
df: (n - 2) = 37
t-value: 2.026
Confidence Interval (y): 0.069 +/- 0.023
Confidence Interval Corrected Mfg. (y): 0.069 +/- 0.023
UCL: 0.092
UCL Mfg. Corrected: 0.092
LCL: 0.046
LCL Mfg. Corrected: 0.046
Prediction Interval (y): 0.069 +/- 0.148
One-sample Mfg. t-test: t-statistic Mfg. = 5.946, p-value=6.74880305765921e-07
Reject Mfg. Ho (ymean = u): True

Target 10 ppm Statistics

n: 27
Min (y): 9.65
Max (y): 10.29
Mean (y): 9.986
Mean Corrected Mfg. (y): 9.986
Median (y): 10.0
Sample Standard Deviation (y): 0.141
Variance (y): 0.02
Mean Percent Error Mfg. (y): -0.137
% Relative Standard Deviation (y): 1.413
MSE: 0.02
Alpha: 0.05
df: (n - 2) = 25
t-value: 2.06
Confidence Interval (y): 9.986 +/- 0.056
Confidence Interval Corrected Mfg. (y): 9.986 +/- 0.056
UCL: 10.042
UCL Mfg. Corrected: 10.042
LCL: 9.93
LCL Mfg. Corrected: 9.93
Prediction Interval (y): 9.986 +/- 0.296
One-sample Mfg. t-test: t-statistic Mfg. = -0.495, p-value=0.6246307600959767
Reject Mfg. Ho (ymean = u): False

Target 10 ppm Statistics

n: 27
Min (y): 9.65
Max (y): 10.29
Mean (y): 9.986
Mean Corrected Mfg. (y): 9.986
Median (y): 10.0
Sample Standard Deviation (y): 0.141
Variance (y): 0.02
Mean Percent Error Mfg. (y): -0.137
% Relative Standard Deviation (y): 1.413
MSE: 0.02
Alpha: 0.05
df: (n - 2) = 25
t-value: 2.06
Confidence Interval (y): 9.986 +/- 0.056
Confidence Interval Corrected Mfg. (y): 9.986 +/- 0.056
UCL: 10.042
UCL Mfg. Corrected: 10.042
LCL: 9.93
LCL Mfg. Corrected: 9.93
Prediction Interval (y): 9.986 +/- 0.296
One-sample Mfg. t-test: t-statistic Mfg. = -0.495, p-value=0.6246307600959767
Reject Mfg. Ho (ymean = u): False
n: 30
Min (y): 2.24
Max (y): 2.67
Mean (y): 2.458
Mean Corrected Mfg. (y): 2.458
Median (y): 2.465
Sample Standard Deviation (y): 0.107
Variance (y): 0.011
Mean Percent Error Mfg. (y): 22.9
% Relative Standard Deviation (y): 4.348
MSE: 0.221
Alpha: 0.05
df: (n - 2) = 28
t-value: 2.048
Confidence Interval (y): 2.458 +/- 0.04
Confidence Interval Corrected Mfg. (y): 2.458 +/- 0.04
UCL: 2.498
UCL Mfg. Corrected: 2.498
LCL: 2.418
LCL Mfg. Corrected: 2.418
Prediction Interval (y): 2.458 +/- 0.223
One-sample Mfg. t-test: t-statistic Mfg.=23.077, p-value=3.2837961845608124e-20
   Reject Mfg. Ho (ymean = u): True
Date: 2023-05-05
Start: 08:10:00
Stop: 18:51:00

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

########## Regression Statistics ##########
n: 81
Mean Percent Error (Mfg.): -0.111
Mean Percent Error (Assessment): 0.178
% Relative Standard Deviation (x): 134.999
% Relative Standard Deviation (y): 134.24
Standard Deviation (x): 3.9
Standard Deviation (y): 3.89
Variance (x): 15.21
Variance (y): 15.129
Covariance (xy): 15.355
Alpha: 0.05
df: (n - 2) = 79
t-value: 1.99
Correlation Coefficient (R): 1.0
R^2: 0.999
MSE (yh): 0.009
Slope: 0.997
Slope Standard Error: 0.003
Slope p-value: 1.4725162334272577e-129 (Ho: slope = 0)
y-Intercept: 0.017
y-Intercept Standard Error: 0.013
Regression Equation: y = 0.997(x) + 0.017
Confidence Interval (Slope): 0.997 +/- 0.005
UCL (Slope): 1.002
LCL (Slope): 0.992
Honeywell Correction Factor: 1
Isobutylene Calibration Slope: 0.997
Assessment Correction Factor: 1.0

==============================================

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-54
Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs

Appendix C-55

##### Target 0 ppm Statistics #######

n: 36
Min (y): 0.0
Max (y): 0.1
Mean (y): 0.019
Mean Corrected Mfg. (y): 0.019
Median (y): 0.0
Sample Standard Deviation (y): 0.04
Variance (y): 0.002
Mean Percent Error Mfg. (y): nan
% Relative Standard Deviation (y): 203.54
MSE: 0.002
Alpha: 0.05
df: (n - 2) = 34
t-value: 2.032
Confidence Interval (y): 0.019 +/- 0.013
Confidence Interval Corrected Mfg. (y): 0.019 +/- 0.013
UCL: 0.032
UCL Mfg. Corrected: 0.032
LCL: 0.006
LCL Mfg. Corrected: 0.006
Prediction Interval (y): 0.019 +/- 0.082
One-sample Mfg. t-test: t-statistic Mfg.=-2.907, p-value=0.0063000042296935226
   Reject Mfg. Ho (y=mean = u): True

##############################################

##### Target 10 ppm Statistics #######

n: 18
Min (y): 9.7
Max (y): 10.4
Mean (y): 9.989
Mean Corrected Mfg. (y): 9.989
Median (y): 10.0
Sample Standard Deviation (y): 0.17
Variance (y): 0.029
Mean Percent Error Mfg. (y): -0.111
% Relative Standard Deviation (y): 1.698
MSE: 0.029
Alpha: 0.05
df: (n - 2) = 16
t-value: 2.12
Confidence Interval (y): 9.989 +/- 0.085
Confidence Interval Corrected Mfg. (y): 9.989 +/- 0.085
UCL: 10.074
UCL Mfg. Corrected: 10.074
LCL: 9.904
LCL Mfg. Corrected: 9.904
Prediction Interval (y): 9.989 +/- 0.369
One-sample Mfg. t-test: t-statistic Mfg.=-0.27, p-value=0.7903245519800054
   Reject Mfg. Ho (y=mean = u): False

##############################################
Target 2 ppm Statistics

n: 27
Min (y): 1.8
Max (y): 2.2
Mean (y): 2.007
Mean Corrected Mfg. (y): 2.007
Median (y): 2.0
Sample Standard Deviation (y): 0.072
Variance (y): 0.005
Mean Percent Error Mfg. (y): 0.37
% Relative Standard Deviation (y): 3.568
MSE: 0.005
Alpha: 0.05
df: (n - 2) = 25
t-value: 2.06
Confidence Interval (y): 2.007 +/- 0.028
Confidence Interval Corrected Mfg. (y): 2.007 +/- 0.028
UCL: 2.035
UCL Mfg. Corrected: 2.035
LCL: 1.979
LCL Mfg. Corrected: 1.979
Prediction Interval (y): 2.007 +/- 0.15
One-sample Mfg. t-test: t-statistic Mfg.=0.527, p-value=0.602436996703086
   Reject Mfg. Ho (ymean = u): False

###########################################################################
========= Isobutylene Calibration MultiRAE Pro (PPB) Statistics =========

Date: 2023-05-03
Start: 09:58:00
Stop: 15:49:38

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

########## Regression Statistics ##########
n: 66
Mean Percent Error (Mfg.): 0.973
Mean Percent Error (Assessment): -1.569
% Relative Standard Deviation (x): 106.854
% Relative Standard Deviation (y): 105.792
Standard Deviation (x): 4.468
Standard Deviation (y): 4.307
Variance (x): 19.967
Variance (y): 18.548
Covariance (xy): 19.517
Alpha: 0.05
df: (n - 2) = 64
t-value: 1.998
Correlation Coefficient (R): 0.999
R^2: 0.998
MSE (yh): 0.044
Slope: 0.963
Slope Standard Error: 0.006
Slope p-value: 1.0002919805371664e-85 (Ho: slope = 0)
y-Intercept: 0.045
y-Intercept Standard Error: 0.036
Regression Equation: y = 0.963(x) + 0.045
Confidence Interval (Slope): 0.963 +/- 0.012
UCL (Slope): 0.975
LCL (Slope): 0.951
Honeywell Correction Factor: 1
Isobutylene Calibration Slope: 0.963
Assessment Correction Factor: 1.0

########################################################################
########## Target 0 ppm Statistics ##########
n: 24
Min (y): 0.0
Max (y): 0.06
Mean (y): 0.018
Mean Corrected Mfg. (y): 0.018
Median (y): 0.0
Sample Standard Deviation (y): 0.023
Variance (y): 0.001
Mean Percent Error Mfg. (y): nan
% Relative Standard Deviation (y): 128.876
MSE: 0.001
Alpha: 0.05
df: (n - 2) = 22
t-value: 2.074
Confidence Interval (y): 0.018 +/- 0.01
Confidence Interval Corrected Mfg. (y): 0.018 +/- 0.01
UCL: 0.028
UCL Mfg. Corrected: 0.028
LCL: 0.008
LCL Mfg. Corrected: 0.008
Prediction Interval (y): 0.018 +/- 0.049
One-sample Mfg. t-test: t-statistic Mfg.=3.721, p-value=0.0011210095696795798
  Reject Mfg. Ho (ymean = u): True

##############################################

########## Target 10 ppm Statistics ##########
n: 24
Min (y): 8.65
Max (y): 10.1
Mean (y): 9.665
Mean Corrected Mfg. (y): 9.665
Median (y): 9.76
Sample Standard Deviation (y): 0.34
Variance (y): 0.116
Mean Percent Error Mfg. (y): -3.35
% Relative Standard Deviation (y): 3.518
MSE: 0.228
Alpha: 0.05
df: (n - 2) = 22
t-value: 2.074
Confidence Interval (y): 9.665 +/- 0.144
Confidence Interval Corrected Mfg. (y): 9.665 +/- 0.144
UCL: 9.809
UCL Mfg. Corrected: 9.809
LCL: 9.521
LCL Mfg. Corrected: 9.521
Prediction Interval (y): 9.665 +/- 0.72
One-sample Mfg. t-test: t-statistic Mfg.=-4.725, p-value=9.239095222649929e-05
  Reject Mfg. Ho (ymean = u): True

##############################################
### Target 2 ppm Statistics

- **n:** 18
- **Min (y):** 1.87
- **Max (y):** 2.11
- **Mean (y):** 2.016
- **Mean Corrected Mfg. (y):** 2.016
- **Median (y):** 2.02
- **Sample Standard Deviation (y):** 0.057
- **Variance (y):** 0.003
- **Mean Percent Error Mfg. (y):** 0.806
- **% Relative Standard Deviation (y):** 2.85
- **MSE:** 0.004
- **Alpha:** 0.05
- **df:** (n - 2) = 16
- **t-value:** 2.12
- **Confidence Interval (y):** 2.016 +/- 0.029
- **Confidence Interval Corrected Mfg. (y):** 2.016 +/- 0.029
- **UCL:** 2.045
- **UCL Mfg. Corrected:** 2.045
- **LCL:** 1.987
- **LCL Mfg. Corrected:** 1.987
- **Prediction Interval (y):** 2.016 +/- 0.125
- **One-sample Mfg. t-test:** t-statistic Mfg. = 1.156, p-value = 0.2636339697648237
  - Reject Mfg. Ho (ymean = μ): False

# Appendix C-59

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Isobutylene Calibration ppbRAE 3000 Statistics

Date: 2023-05-06
Start: 08:43:00
Stop: 17:11:10

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics

\[ n: 88 \]
\[ \text{Mean Percent Error (Mfg.): 2.148} \]
\[ \text{Mean Percent Error (Assessment): -7.86} \]
\[ \text{% Relative Standard Deviation (x): 121.794} \]
\[ \text{% Relative Standard Deviation (y): 119.452} \]
\[ \text{Standard Deviation (x): 4.207} \]
\[ \text{Standard Deviation (y): 3.719} \]
\[ \text{Variance (x): 17.702} \]
\[ \text{Variance (y): 13.832} \]
\[ \text{Covariance (xy): 15.805} \]
\[ \text{Alpha: 0.05} \]
\[ \text{df: (n - 2) = 86} \]
\[ \text{t-value: 1.988} \]
\[ \text{Correlation Coefficient (R): 0.999} \]
\[ \text{R^2: 0.997} \]
\[ \text{MSE (yh): 0.039} \]
\[ \text{Slope: 0.883} \]
\[ \text{Slope Standard Error: 0.005} \]
\[ \text{Slope p-value: 2.3923761480268878e-111 (Ho: slope = 0)} \]
\[ \text{y-Intercept: 0.064} \]
\[ \text{y-Intercept Standard Error: 0.028} \]
\[ \text{Regression Equation: } y = 0.883(x) + 0.064 \]
\[ \text{Confidence Interval (Slope): 0.883 +/- 0.01} \]
\[ \text{UCL (Slope): 0.893} \]
\[ \text{LCL (Slope): 0.873} \]
\[ \text{Honeywell Correction Factor: 1} \]
\[ \text{Isobutylene Calibration Slope: 0.883} \]
\[ \text{Assessment Correction Factor: 1.0} \]
### Target 0 ppm Statistics

- **n**: 36
- **Min (y)**: 0.0
- **Max (y)**: 0.135
- **Mean (y)**: 0.019
- **Mean Corrected Mfg. (y)**: 0.019
- **Median (y)**: 0.0
- **Sample Standard Deviation (y)**: 0.035
- **Variance (y)**: 0.001
- **Mean Percent Error Mfg. (y)**: nan
- **% Relative Standard Deviation (y)**: 191.254
- **MSE**: 0.002
- **Alpha**: 0.05
- **df**: (n - 2) = 34
- **t-value**: 2.032
- **Confidence Interval (y)**: 0.019 +/- 0.012
- **Confidence Interval Corrected Mfg. (y)**: 0.019 +/- 0.012
- **UCL**: 0.031
- **UCL Mfg. Corrected**: 0.031
- **LCL**: 0.007
- **LCL Mfg. Corrected**: 0.007
- **Prediction Interval (y)**: 0.019 +/- 0.073
- **One-sample Mfg. t-test**: t-statistic Mfg. = 3.093, p-value = 0.0038753763498151086
  - **Reject Mfg. Ho (ymean = u)**: True

### Target 10 ppm Statistics

- **n**: 25
- **Min (y)**: 7.966
- **Max (y)**: 9.302
- **Mean (y)**: 8.875
- **Mean Corrected Mfg. (y)**: 8.875
- **Median (y)**: 8.929
- **Sample Standard Deviation (y)**: 0.314
- **Variance (y)**: 0.099
- **Mean Percent Error Mfg. (y)**: -11.254
- **% Relative Standard Deviation (y)**: 3.538
- **MSE**: 1.365
- **Alpha**: 0.05
- **df**: (n - 2) = 23
- **t-value**: 2.069
- **Confidence Interval (y)**: 8.875 +/- 0.13
- **Confidence Interval Corrected Mfg. (y)**: 8.875 +/- 0.13
- **UCL**: 9.005
- **UCL Mfg. Corrected**: 9.005
- **LCL**: 8.745
- **LCL Mfg. Corrected**: 8.745
- **Prediction Interval (y)**: 8.875 +/- 0.662
- **One-sample Mfg. t-test**: t-statistic Mfg. = -17.558, p-value = 3.3651217028821588e-15
  - **Reject Mfg. Ho (ymean = u)**: True

---

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-61
Version 1.0.1

Start of document content...

Version 1.0.1

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-62

# Target 2 ppm Statistics#

- **n**: 27
- **Min (y)**: 1.409
- **Max (y)**: 2.087
- **Mean (y)**: 1.906
- **Mean Corrected Mfg. (y)**: 1.906
- **Median (y)**: 1.966
- **Sample Standard Deviation (y)**: 0.161
- **Variance (y)**: 0.026
- **Mean Percent Error Mfg. (y)**: -4.717
- **% Relative Standard Deviation (y)**: 8.446
- **MSE**: 0.035
- **Alpha**: 0.05
- **df**: (n - 2) = 25
- **t-value**: 2.06
- **Confidence Interval (y)**: 1.906 +/- 0.064
- **Confidence Interval Corrected Mfg. (y)**: 1.906 +/- 0.064
- **UCL**: 1.97
- **UCL Mfg. Corrected**: 1.97
- **LCL**: 1.842
- **LCL Mfg. Corrected**: 1.842
- **Prediction Interval (y)**: 1.906 +/- 0.338
- **One-sample Mfg. t-test**: t-statistic Mfg. = -2.989, p-value = 0.006049566335428046, Reject Mfg. Ho (ymean = u): True

End of document content...
Isobutylene MultiRAE Pro (ER) Statistics

Date: 2023-05-05
Start: 08:10:00
Stop: 18:51:00

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics

n: 90
Mean Percent Error (Mfg.): -22.485
Mean Percent Error (Assessment): -22.224
% Relative Standard Deviation (x): 233.074
% Relative Standard Deviation (y): 247.636
Standard Deviation (x): 29.367
Standard Deviation (y): 40.015
Variance (x): 862.44
Variance (y): 1601.22
Covariance (xy): 1185.868
Alpha: 0.05
df: (n - 2) = 88
t-value: 1.987
Correlation Coefficient (R): 0.998
R^2: 0.996
MSE (yh): 6.669
Slope: 1.36
Slope Standard Error: 0.009
Slope p-value: 1.5538904995541355e-106 (Ho: slope = 0)
y-Intercept: -0.974
y-Intercept Standard Error: 0.3
Regression Equation: y = 1.36(x) - 0.974
Confidence Interval (Slope): 1.36 +/- 0.019
UCL (Slope): 1.379
LCL (Slope): 1.341
Honeywell Correction Factor: 1
Isobutylene Calibration Slope: 0.997
Assessment Correction Factor: 0.733

*****************************************************************************
### Target 0 ppm Statistics

- **n**: 36
- **Min (y)**: 0.0
- **Max (y)**: 0.1
- **Mean (y)**: 0.019
- **Mean Corrected Mfg. (y)**: 0.019
- **Median (y)**: 0.0
- **Sample Standard Deviation (y)**: 0.04
- **Variance (y)**: 0.002
- **Mean Percent Error Mfg. (y)**: nan
- **% Relative Standard Deviation (y)**: 203.54
- **MSE**: 0.002
- **Alpha**: 0.05
- **df**: \((n - 2) = 34\)
- **t-value**: 2.032
- **Confidence Interval (y)**: 0.019 +/- 0.013
- **Confidence Interval Corrected Mfg. (y)**: 0.019 +/- 0.013
- **UCL**: 0.032
- **UCL Mfg. Corrected**: 0.032
- **LCL**: 0.006
- **LCL Mfg. Corrected**: 0.006
- **Prediction Interval (y)**: 0.019 +/- 0.082
- **One-sample Mfg. t-test**: t-statistic Mfg.=2.907, p-value=0.0063000042296935226
  - **Reject Mfg. Ho \(\text{ymean} = u\)**: True

### Target 10 ppm Statistics

- **n**: 18
- **Min (y)**: 9.7
- **Max (y)**: 10.4
- **Mean (y)**: 9.989
- **Mean Corrected Mfg. (y)**: 9.989
- **Median (y)**: 10.0
- **Sample Standard Deviation (y)**: 0.17
- **Variance (y)**: 0.029
- **Mean Percent Error Mfg. (y)**: -0.111
- **% Relative Standard Deviation (y)**: 1.698
- **MSE**: 0.029
- **Alpha**: 0.05
- **df**: \((n - 2) = 16\)
- **t-value**: 2.12
- **Confidence Interval (y)**: 9.989 +/- 0.085
- **Confidence Interval Corrected Mfg. (y)**: 9.989 +/- 0.085
- **UCL**: 10.074
- **UCL Mfg. Corrected**: 10.074
- **LCL**: 9.904
- **LCL Mfg. Corrected**: 9.904
- **Prediction Interval (y)**: 9.989 +/- 0.369
- **One-sample Mfg. t-test**: t-statistic Mfg.=-0.27, p-value=0.7903245519800054
  - **Reject Mfg. Ho \(\text{ymean} = u\)**: False
Target 100 ppm Statistics

- **n:** 9
- **Min (y):** 128.7
- **Max (y):** 145.8
- **Mean (y):** 135.511
- **Mean Corrected Mfg. (y):** 135.511
- **Median (y):** 132.2
- **Sample Standard Deviation (y):** 6.951
- **Variance (y):** 48.312
- **Mean Percent Error Mfg. (y):** 35.511
- **% Relative Standard Deviation (y):** 5.129
- **MSE:** 1309.351
- **Alpha:** 0.05
- **df:** (n - 2) = 7
- **t-value:** 2.365
- **Confidence Interval (y):** 135.511 +/- 5.479
- **Confidence Interval Corrected Mfg. (y):** 135.511 +/- 5.479
- **UCL:** 140.99
- **UCL Mfg. Corrected:** 140.99
- **LCL:** 130.032
- **LCL Mfg. Corrected:** 130.032
- **Prediction Interval (y):** 135.511 +/- 17.325
- **One-sample Mfg. t-test:** t-statistic Mfg. = 14.45, p-value = 5.144814887356584e-07
- **Reject Mfg. Ho (ymean = u):** True

Target 2 ppm Statistics

- **n:** 27
- **Min (y):** 1.8
- **Max (y):** 2.2
- **Mean (y):** 2.007
- **Mean Corrected Mfg. (y):** 2.007
- **Median (y):** 2.0
- **Sample Standard Deviation (y):** 0.072
- **Variance (y):** 0.005
- **Mean Percent Error Mfg. (y):** 0.37
- **% Relative Standard Deviation (y):** 3.568
- **MSE:** 0.005
- **Alpha:** 0.05
- **df:** (n - 2) = 25
- **t-value:** 2.06
- **Confidence Interval (y):** 2.007 +/- 0.028
- **Confidence Interval Corrected Mfg. (y):** 2.007 +/- 0.028
- **UCL:** 2.035
- **UCL Mfg. Corrected:** 2.035
- **LCL:** 1.979
- **LCL Mfg. Corrected:** 1.979
- **Prediction Interval (y):** 2.007 +/- 0.15
- **One-sample Mfg. t-test:** t-statistic Mfg. = 0.527, p-value = 0.602436996703086
- **Reject Mfg. Ho (ymean = u):** False

---

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-65
Isobutylene MultiRAE Pro (PPB) Statistics

Date: 2023-05-03
Start: 09:58:00
Stop: 15:49:38

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics

n: 78
Mean Percent Error (Mfg.): -5.03
Mean Percent Error (Assessment): -7.611
% Relative Standard Deviation (x): 183.981
% Relative Standard Deviation (y): 187.433
Standard Deviation (x): 34.815
Standard Deviation (y): 36.327
Variance (x): 1212.071
Variance (y): 1319.661
Covariance (xy): 1273.925
Alpha: 0.05
df: (n - 2) = 76
t-value: 1.992
Correlation Coefficient (R): 0.994
R^2: 0.989
MSE (yh): 14.838
Slope: 1.038
Slope p-value: 7.886977661534877e-76 (Ho: slope = 0)
y-Intercept: -0.252
y-Intercept Standard Error: 0.503
Regression Equation: y = 1.038(x) - 0.252
Confidence Interval (Slope): 1.038 +/- 0.025
UCL (Slope): 1.063
LCL (Slope): 1.013
Honeywell Correction Factor: 1
Isobutylene Calibration Slope: 0.963
Assessment Correction Factor: 0.928

# Isobutylene MultiRAE Pro (PPB) Statistics #
# Target 0 ppm Statistics

- **n:** 24
- **Min (y):** 0.0
- **Max (y):** 0.06
- **Mean (y):** 0.018
- **Mean Corrected Mfg. (y):** 0.018
- **Median (y):** 0.0
- **Sample Standard Deviation (y):** 0.023
- **Variance (y):** 0.001
- **Mean Percent Error Mfg. (y):** nan
- **% Relative Standard Deviation (y):** 128.876
- **MSE:** 0.001
- **Alpha:** 0.05
- **df: (n - 2) = 22**
- **t-value:** 2.074
- **Confidence Interval (y):** 0.018 +/- 0.01
- **Confidence Interval Corrected Mfg. (y):** 0.018 +/- 0.01
- **UCL:** 0.028
- **UCL Mfg. Corrected:** 0.028
- **LCL:** 0.008
- **LCL Mfg. Corrected:** 0.008
- **Prediction Interval (y):** 0.018 +/- 0.049
- **One-sample Mfg. t-test:** t-statistic Mfg.=3.721, p-value=0.0011210095696795798
  - **Reject Mfg. Ho (ymean = u):** True

# Target 10 ppm Statistics

- **n:** 24
- **Min (y):** 8.65
- **Max (y):** 10.1
- **Mean (y):** 9.665
- **Mean Corrected Mfg. (y):** 9.665
- **Median (y):** 9.76
- **Sample Standard Deviation (y):** 0.34
- **Variance (y):** 0.116
- **Mean Percent Error Mfg. (y):** -3.35
- **% Relative Standard Deviation (y):** 3.518
- **MSE:** 0.228
- **Alpha:** 0.05
- **df: (n - 2) = 22**
- **t-value:** 2.074
- **Confidence Interval (y):** 9.665 +/- 0.144
- **Confidence Interval Corrected Mfg. (y):** 9.665 +/- 0.144
- **UCL:** 9.809
- **UCL Mfg. Corrected:** 9.809
- **LCL:** 9.521
- **LCL Mfg. Corrected:** 9.521
- **Prediction Interval (y):** 9.665 +/- 0.72
- **One-sample Mfg. t-test:** t-statistic Mfg.=-4.725, p-value=9.239095222649929e-05
  - **Reject Mfg. Ho (ymean = u):** True
### Target 100 ppm Statistics

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<th>Value</th>
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<td>Confidence Interval (y)</td>
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### Target 2 ppm Statistics

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<tr>
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<td>Prediction Interval (y)</td>
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<td>1.156, p-value=0.2636339697648237</td>
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<tr>
<td>Reject Mfg. Ho (y_mean = u)</td>
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</table>
Date: 2023-05-06
Start: 08:43:00
Stop: 17:11:10

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

### Regression Statistics

- **n**: 100
- **Mean Percent Error (Mfg.)**: -5.042
- **Mean Percent Error (Assessment)**: -14.565
- **% Relative Standard Deviation (x)**: 210.245
- **% Relative Standard Deviation (y)**: 214.045
- **Standard Deviation (x)**: 31.621
- **Standard Deviation (y)**: 30.478
- **Variance (x)**: 999.878
- **Variance (y)**: 928.904
- **Covariance (xy)**: 968.667
- **Alpha**: 0.05
- **df**: (n - 2) = 98
- **t-value**: 1.984
- **Correlation Coefficient (R)**: 0.995
- **R^2**: 0.99
- **MSE (yh)**: 9.15
- **Slope**: 0.959
- **Slope Standard Error**: 0.01
- **Slope p-value**: 3.850674031506122e-100 (Ho: slope = 0)
- **y-Intercept**: -0.186
- **y-Intercept Standard Error**: 0.338
- **Regression Equation**: y = 0.959(x) - 0.186
- **Confidence Interval (Slope)**: 0.959 +/- 0.019
- **UCL (Slope)**: 0.978
- **LCL (Slope)**: 0.94
- **Honeywell Correction Factor**: 1
- **Isobutylene Calibration Slope**: 0.883
- **Assessment Correction Factor**: 0.92

### Isobutylene ppbRAE 3000 Statistics

---

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-69
### Target 0 ppm Statistics

- **n:** 36
- **Min (y):** 0.0
- **Max (y):** 0.135
- **Mean (y):** 0.019
- **Mean Corrected Mfg. (y):** 0.019
- **Median (y):** 0.0
- **Sample Standard Deviation (y):** 0.035
- **Variance (y):** 0.001
- **Mean Percent Error Mfg. (y):** nan
- **% Relative Standard Deviation (y):** 191.254
- **MSE:** 0.002
- **df:** (n - 2) = 34
- **t-value:** 2.032
- **Confidence Interval (y):** 0.019 +/- 0.012
- **Confidence Interval Corrected Mfg. (y):** 0.019 +/- 0.012
- **UCL:** 0.031
- **UCL Mfg. Corrected:** 0.031
- **LCL:** 0.007
- **LCL Mfg. Corrected:** 0.007
- **Prediction Interval (y):** 0.019 +/- 0.073
- **One-sample Mfg. t-test:** t-statistic Mfg.=3.093, p-value=0.0038753763498151086
- **Reject Mfg. Ho (ymean = u):** True

### Target 10 ppm Statistics

- **n:** 25
- **Min (y):** 7.966
- **Max (y):** 9.302
- **Mean (y):** 8.875
- **Mean Corrected Mfg. (y):** 8.875
- **Median (y):** 8.929
- **Sample Standard Deviation (y):** 0.314
- **Variance (y):** 0.099
- **Mean Percent Error Mfg. (y):** -11.254
- **% Relative Standard Deviation (y):** 3.538
- **MSE:** 1.365
- **df:** (n - 2) = 23
- **t-value:** 2.069
- **Confidence Interval (y):** 8.875 +/- 0.13
- **Confidence Interval Corrected Mfg. (y):** 8.875 +/- 0.13
- **UCL:** 9.005
- **UCL Mfg. Corrected:** 9.005
- **LCL:** 8.745
- **LCL Mfg. Corrected:** 8.745
- **Prediction Interval (y):** 8.875 +/- 0.662
- **One-sample Mfg. t-test:** t-statistic Mfg.=-17.558, p-value=3.3651217028821588e-15
- **Reject Mfg. Ho (ymean = u):** True
### Target 100 ppm Statistics

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<th>Value</th>
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### Target 2 ppm Statistics

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<td>% Relative Standard Deviation (y)</td>
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<tr>
<td>LCL</td>
<td>1.842</td>
</tr>
<tr>
<td>LCL Mfg. Corrected</td>
<td>1.842</td>
</tr>
<tr>
<td>Prediction Interval (y)</td>
<td>1.906 +/- 0.338</td>
</tr>
<tr>
<td>One-sample Mfg. t-test: t-statistic Mfg.</td>
<td>-2.989, p-value=0.006049566335428046</td>
</tr>
<tr>
<td>Reject Mfg. Ho (μmean = μ): True</td>
<td>True</td>
</tr>
</tbody>
</table>
Vinyl Chloride AreaRAE (ER) Statistics

Date: 2023-05-05
Start: 17:01:56
Stop: 19:04:36

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics

n: 51
Mean Percent Error (Mfg.): -27.345
Mean Percent Error (Assessment): -13.782
% Relative Standard Deviation (x): 130.734
% Relative Standard Deviation (y): 136.269
Standard Deviation (x): 3.658
Standard Deviation (y): 2.207
Variance (x): 13.378
Variance (y): 4.871
Covariance (xy): 8.122
Alpha: 0.05
df: (n - 2) = 49
t-value: 2.01
Correlation Coefficient (R): 0.986
R^2: 0.973
MSE (yh): 0.132
Slope: 0.595
Slope Standard Error: 0.014
Slope p-value: 4.470071816657833e-40 (Ho: slope = 0)
y-Intercept: -0.046
y-Intercept Standard Error: 0.065
Regression Equation: y = 0.595(x) - 0.046
Confidence Interval (Slope): 0.595 +/- 0.028
UCL (Slope): 0.623
LCL (Slope): 0.567
Honeywell Correction Factor: 2
Isobutylene Calibration Slope: 0.996
Assessment Correction Factor: 1.673

********************************************************************
Version 1.0.1

formance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
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########## Target 0.0 ppm Statistics ##########
n: 15
Min (y): 0.0
Max (y): 0.0
Mean (y): 0.0
Mean Corrected Mfg. (y): 0.0
Median (y): 0.0
Sample Standard Deviation (y): 0.0
Variance (y): 0.0
Mean Percent Error Mfg. (y): nan
% Relative Standard Deviation (y): None
MSE: 0.0
Alpha: 0.05
df: (n - 2) = 13
t-value: 2.16
Confidence Interval (y): 0.0 +/- 0.0
Confidence Interval Corrected Mfg. (y): 0.0 +/- 0.0
UCL: 0.0
UCL Mfg. Corrected: 0.0
LCL: 0.0
LCL Mfg. Corrected: 0.0
Prediction Interval (y): 0.0 +/- 0.0
One-sample Mfg. t-test: t-statistic Mfg.=nan, p-value=nan
Reject Mfg. Ho (ymean = u): False

################################################

########## Target 0.2 ppm Statistics ##########
n: 9
Min (y): 0.0
Max (y): 0.2
Mean (y): 0.078
Mean Corrected Mfg. (y): 0.156
Median (y): 0.1
Sample Standard Deviation (y): 0.063
Variance (y): 0.004
Mean Percent Error Mfg. (y): -22.222
% Relative Standard Deviation (y): 80.812
MSE: 0.018
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 0.078 +/- 0.05
Confidence Interval Corrected Mfg. (y): 0.156 +/- 0.099
UCL: 0.128
UCL Mfg. Corrected: 0.255
LCL: 0.028
LCL Mfg. Corrected: 0.057
Prediction Interval (y): 0.078 +/- 0.157
One-sample Mfg. t-test: t-statistic Mfg.=-1.0, p-value=0.34659350708733416
Reject Mfg. Ho (ymean = u): False

################################################
### Target 0.981 ppm Statistics

- **n:** 9
- **Min (y):** 0.4
- **Max (y):** 0.6
- **Mean (y):** 0.5
- **Mean Corrected Mfg. (y):** 1.0
- **Median (y):** 0.5
- **Sample Standard Deviation (y):** 0.082
- **Variance (y):** 0.007
- **Mean Percent Error Mfg. (y):** 1.937
- **% Relative Standard Deviation (y):** 16.33
- **MSE:** 0.027
- **Alpha:** 0.05
- **df:** (n - 2) = 7
- **t-value:** 2.365
- **Confidence Interval (y):** 0.5 +/- 0.064
- **Confidence Interval Corrected Mfg. (y):** 1.0 +/- 0.129
- **UCL:** 0.564
- **UCL Mfg. Corrected:** 1.129
- **LCL:** 0.436
- **LCL Mfg. Corrected:** 0.871
- **Prediction Interval (y):** 0.5 +/- 0.204
- **One-sample Mfg. t-test:** t-statistic Mfg.=0.329, p-value=0.7505379264969623
  - Reject Mfg. Ho (ymean = u): False

### Target 4.937 ppm Statistics

- **n:** 9
- **Min (y):** 2.3
- **Max (y):** 3.4
- **Mean (y):** 2.8
- **Mean Corrected Mfg. (y):** 5.6
- **Median (y):** 2.8
- **Sample Standard Deviation (y):** 0.411
- **Variance (y):** 0.169
- **Mean Percent Error Mfg. (y):** 13.429
- **% Relative Standard Deviation (y):** 14.677
- **MSE:** 1.115
- **Alpha:** 0.05
- **df:** (n - 2) = 7
- **t-value:** 2.365
- **Confidence Interval (y):** 2.8 +/- 0.324
- **Confidence Interval Corrected Mfg. (y):** 5.6 +/- 0.648
- **UCL:** 3.124
- **UCL Mfg. Corrected:** 6.248
- **LCL:** 2.476
- **LCL Mfg. Corrected:** 4.952
- **Prediction Interval (y):** 2.8 +/- 1.024
- **One-sample Mfg. t-test:** t-statistic Mfg.=2.282, p-value=0.051946351955730295
  - Reject Mfg. Ho (ymean = u): False
########## Target 9.736 ppm Statistics ##########
n: 9  
Min (y): 5.0  
Max (y): 6.9  
Mean (y): 5.8  
Mean Corrected Mfg. (y): 11.6  
Median (y): 5.6  
Sample Standard Deviation (y): 0.742  
Variance (y): 0.551  
Mean Percent Error Mfg. (y): 19.145  
% Relative Standard Deviation (y): 12.799  
MSE: 5.679  
Alpha: 0.05  
df: (n - 2) = 7  
t-value: 2.365  
Confidence Interval (y): 5.8 +/- 0.585  
Confidence Interval Corrected Mfg. (y): 11.6 +/- 1.17  
UCL: 6.385  
UCL Mfg. Corrected: 12.77  
LCL: 5.215  
LCL Mfg. Corrected: 10.43  
Prediction Interval (y): 5.8 +/- 1.85  
One-sample Mfg. t-test: t-statistic Mfg.=3.551, p-value=0.007499328218612196  
     Reject Mfg. Ho (ymean = u): True  

############################################################
Vinyl Chloride AreaRAE Pro (PPB) Statistics

Date: 2023-05-03
Start: 18:08:35
Stop: 19:18:30

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics

n: 57
Mean Percent Error (Mfg.): -71.574
Mean Percent Error (Assessment): 49.898
% Relative Standard Deviation (x): 141.736
% Relative Standard Deviation (y): 136.867
Standard Deviation (x): 3.559
Standard Deviation (y): 2.335
Variance (x): 12.668
Variance (y): 5.454
Covariance (xy): 8.455
Alpha: 0.05
df: (n - 2) = 55
t-value: 2.004
Correlation Coefficient (R): 0.999
R^2: 0.999
MSE (yh): 0.007
Slope: 0.656
Slope Standard Error: 0.003
Slope p-value: 1.9646995315049924e-81 (Ho: slope = 0)
y-Intercept: 0.06
y-Intercept Standard Error: 0.014
Regression Equation: y = 0.656(x) + 0.06
Confidence Interval (Slope): 0.656 +/- 0.006
UCL (Slope): 0.662
LCL (Slope): 0.65
Honeywell Correction Factor: 2
Isobutylene Calibration Slope: 0.981
Assessment Correction Factor: 1.497
Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
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########## Target 0.0 ppm Statistics ##########
n: 12
Min (y): 0.02
Max (y): 0.19
Mean (y): 0.11
Mean Corrected Mfg. (y): 0.22
Median (y): 0.115
Sample Standard Deviation (y): 0.058
Variance (y): 0.003
Mean Percent Error Mfg. (y): nan
% Relative Standard Deviation (y): 52.879
MSE: 0.062
Alpha: 0.05
df: (n - 2) = 10
t-value: 2.228
Confidence Interval (y): 0.11 +/- 0.037
Confidence Interval Corrected Mfg. (y): 0.22 +/- 0.075
UCL: 0.147
UCL Mfg. Corrected: 0.295
LCL: 0.073
LCL Mfg. Corrected: 0.145
Prediction Interval (y): 0.11 +/- 0.135
One-sample Mfg. t-test: t-statistic Mfg.=6.272, p-value=6.069023706945485e-05
   Reject Mfg. Ho (ymean = u): True

########## Target 0.05 ppm Statistics ##########
n: 9
Min (y): 0.06
Max (y): 0.18
Mean (y): 0.111
Mean Corrected Mfg. (y): 0.222
Median (y): 0.12
Sample Standard Deviation (y): 0.041
Variance (y): 0.002
Mean Percent Error Mfg. (y): 344.444
% Relative Standard Deviation (y): 37.094
MSE: 0.036
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 0.111 +/- 0.032
Confidence Interval Corrected Mfg. (y): 0.222 +/- 0.065
UCL: 0.143
UCL Mfg. Corrected: 0.287
LCL: 0.079
LCL Mfg. Corrected: 0.157
Prediction Interval (y): 0.111 +/- 0.103
One-sample Mfg. t-test: t-statistic Mfg.=5.909, p-value=0.0003579676151293206
   Reject Mfg. Ho (ymean = u): True

################################################################################

Version 1.0.1
### Target 0.2 ppm Statistics

- **n**: 9
- **Min (y)**: 0.11
- **Max (y)**: 0.22
- **Mean (y)**: 0.159
- **Mean Corrected Mfg. (y)**: 0.318
- **Median (y)**: 0.16
- **Sample Standard Deviation (y)**: 0.037
- **Variance (y)**: 0.001
- **Mean Percent Error Mfg. (y)**: 58.889
- **% Relative Standard Deviation (y)**: 23.066
- **MSE**: 0.019
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 0.159 +/- 0.029
- **Confidence Interval Corrected Mfg. (y)**: 0.318 +/- 0.058
- **UCL**: 0.188
- **UCL Mfg. Corrected**: 0.376
- **LCL**: 0.13
- **LCL Mfg. Corrected**: 0.26
- **Prediction Interval (y)**: 0.159 +/- 0.091
- **One-sample Mfg. t-test**: t-statistic Mfg.=4.545, p-value=0.0018874542617996473
- **Reject Mfg. Ho (ymean = u)**: True

### Target 0.981 ppm Statistics

- **n**: 9
- **Min (y)**: 0.57
- **Max (y)**: 0.77
- **Mean (y)**: 0.651
- **Mean Corrected Mfg. (y)**: 1.302
- **Median (y)**: 0.66
- **Sample Standard Deviation (y)**: 0.066
- **Variance (y)**: 0.004
- **Mean Percent Error Mfg. (y)**: 32.744
- **% Relative Standard Deviation (y)**: 10.147
- **MSE**: 0.121
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 0.651 +/- 0.052
- **Confidence Interval Corrected Mfg. (y)**: 1.302 +/- 0.104
- **UCL**: 0.703
- **UCL Mfg. Corrected**: 1.406
- **LCL**: 0.599
- **LCL Mfg. Corrected**: 1.198
- **Prediction Interval (y)**: 0.651 +/- 0.165
- **One-sample Mfg. t-test**: t-statistic Mfg.=6.876, p-value=0.00012764361571770567
- **Reject Mfg. Ho (ymean = u)**: True
Target 4.937 ppm Statistics

- n: 9
- Min (y): 3.17
- Max (y): 3.41
- Mean (y): 3.281
- Mean Corrected Mfg. (y): 6.562
- Median (y): 3.28
- Sample Standard Deviation (y): 0.083
- Variance (y): 0.007
- Mean Percent Error Mfg. (y): 32.919
- % Relative Standard Deviation (y): 2.519
- MSE: 2.669
- df: (n - 2) = 7
- t-value: 2.365
- Confidence Interval (y): 3.281 +/- 0.065
- Confidence Interval Corrected Mfg. (y): 6.562 +/- 0.13
- UCL: 3.346
- UCL Mfg. Corrected: 6.692
- LCL: 3.216
- LCL Mfg. Corrected: 6.432
- Prediction Interval (y): 3.281 +/- 0.206
- One-sample Mfg. t-test: t-statistic Mfg.=27.807, p-value=3.019382514127103e-09
  Reject Mfg. Ho (ymean = u): True

Target 9.736 ppm Statistics

- n: 9
- Min (y): 6.32
- Max (y): 6.68
- Mean (y): 6.458
- Mean Corrected Mfg. (y): 12.916
- Median (y): 6.41
- Sample Standard Deviation (y): 0.13
- Variance (y): 0.017
- Mean Percent Error Mfg. (y): 32.658
- % Relative Standard Deviation (y): 2.013
- MSE: 10.177
- df: (n - 2) = 7
- t-value: 2.365
- Confidence Interval (y): 6.458 +/- 0.102
- Confidence Interval Corrected Mfg. (y): 12.916 +/- 0.205
- UCL: 6.56
- UCL Mfg. Corrected: 13.121
- LCL: 6.356
- LCL Mfg. Corrected: 12.711
- Prediction Interval (y): 6.458 +/- 0.324
- One-sample Mfg. t-test: t-statistic Mfg.=34.583, p-value=5.344707034339135e-10
  Reject Mfg. Ho (ymean = u): True
== Vinyl Chloride MultiRAE Pro (ER) Statistics ==

Date: 2023-05-05
Start: 08:19:56
Stop: 09:19:43

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics

n: 51
Mean Percent Error (Mfg.): -14.95
Mean Percent Error (Assessment): -12.491
% Relative Standard Deviation (x): 130.734
% Relative Standard Deviation (y): 134.829
Standard Deviation (x): 3.658
Standard Deviation (y): 2.361
Variance (x): 13.378
Variance (y): 5.573
Covariance (xy): 8.802
Alpha: 0.05
df: (n - 2) = 49
t-value: 2.01
Correlation Coefficient (R): 0.999
R^2: 0.999
MSE (yh): 0.008
Slope: 0.645
Slope Standard Error: 0.003
Slope p-value: 8.005448958897224e-72 (Ho: slope = 0)
y-Intercept: -0.054
y-Intercept Standard Error: 0.016
Regression Equation: y = 0.645(x) - 0.054
Confidence Interval (Slope): 0.645 +/- 0.007
UCL (Slope): 0.652
LCL (Slope): 0.638
Honeywell Correction Factor: 2
Isobutylene Calibration Slope: 0.997
Assessment Correction Factor: 1.546

==============================================
### Target 0.0 ppm Statistics

- **n**: 15
- **Min (y)**: 0.0
- **Max (y)**: 0.1
- **Mean (y)**: 0.013
- **Mean Corrected Mfg. (y)**: 0.027
- **Median (y)**: 0.0
- **Sample Standard Deviation (y)**: 0.034
- **Variance (y)**: 0.001
- **Mean Percent Error Mfg. (y)**: nan
- **% Relative Standard Deviation (y)**: 254.951
- **MSE**: 0.005
- **Alpha**: 0.05
- **df**: (n - 2) = 13
- **t-value**: 2.16
- **Confidence Interval (y)**: 0.013 +/- 0.019
- **Confidence Interval Corrected Mfg. (y)**: 0.027 +/- 0.038
- **UCL**: 0.032
- **UCL Mfg. Corrected**: 0.065
- **LCL**: -0.006
- **LCL Mfg. Corrected**: -0.011
- **Prediction Interval (y)**: 0.013 +/- 0.076
- **One-sample Mfg. t-test**: t-statistic Mfg.=1.468, p-value=0.16431789846959996
  - **Reject Mfg. Ho (ymean = u)**: False

### Target 0.2 ppm Statistics

- **n**: 9
- **Min (y)**: 0.1
- **Max (y)**: 0.1
- **Mean (y)**: 0.1
- **Mean Corrected Mfg. (y)**: 0.2
- **Median (y)**: 0.1
- **Sample Standard Deviation (y)**: 0.0
- **Variance (y)**: 0.0
- **Mean Percent Error Mfg. (y)**: 0.0
- **% Relative Standard Deviation (y)**: 0.0
- **MSE**: 0.0
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 0.1 +/- 0.0
- **Confidence Interval Corrected Mfg. (y)**: 0.2 +/- 0.0
- **UCL**: 0.1
- **UCL Mfg. Corrected**: 0.2
- **LCL**: 0.1
- **LCL Mfg. Corrected**: 0.2
- **Prediction Interval (y)**: 0.1 +/- 0.0
- **One-sample Mfg. t-test**: t-statistic Mfg.=nan, p-value=nan
  - **Reject Mfg. Ho (ymean = u)**: False
### Target 0.981 ppm Statistics

n: 9  
Min (y): 0.5  
Max (y): 0.5  
Mean (y): 0.5  
Mean Corrected Mfg. (y): 1.0  
Median (y): 0.5  
Sample Standard Deviation (y): 0.0  
Variance (y): 0.0  
Mean Percent Error Mfg. (y): 1.937  
% Relative Standard Deviation (y): 0.0  
MSE: 0.0  
Alpha: 0.05  
df: (n - 2) = 7  
t-value: 2.365  
Confidence Interval (y): 0.5 +/- 0.0  
Confidence Interval Corrected Mfg. (y): 1.0 +/- 0.0  
UCL: 0.5  
UCL Mfg. Corrected: 1.0  
LCL: 0.5  
LCL Mfg. Corrected: 1.0  
Prediction Interval (y): 0.5 +/- 0.0  
One-sample Mfg. t-test: t-statistic Mfg.=inf, p-value=0.0  
Reject Mfg. Ho (ymean = u): True

### Target 4.937 ppm Statistics

n: 9  
Min (y): 3.0  
Max (y): 3.0  
Mean (y): 3.0  
Mean Corrected Mfg. (y): 6.0  
Median (y): 3.0  
Sample Standard Deviation (y): 0.0  
Variance (y): 0.0  
Mean Percent Error Mfg. (y): 21.531  
% Relative Standard Deviation (y): 0.0  
MSE: 1.13  
Alpha: 0.05  
df: (n - 2) = 7  
t-value: 2.365  
Confidence Interval (y): 3.0 +/- 0.0  
Confidence Interval Corrected Mfg. (y): 6.0 +/- 0.0  
UCL: 3.0  
UCL Mfg. Corrected: 6.0  
LCL: 3.0  
LCL Mfg. Corrected: 6.0  
Prediction Interval (y): 3.0 +/- 0.0  
One-sample Mfg. t-test: t-statistic Mfg.=inf, p-value=0.0  
Reject Mfg. Ho (ymean = u): True

---

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs  
Appendix C-82
Target 9.736 ppm Statistics

n: 9
Min (y): 6.2
Max (y): 6.4
Mean (y): 6.3
Mean Corrected Mfg. (y): 12.6
Median (y): 6.3
Sample Standard Deviation (y): 0.067
Variance (y): 0.004
Mean Percent Error Mfg. (y): 29.417
% Relative Standard Deviation (y): 1.058
MSE: 8.22
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 6.3 +/- 0.053
Confidence Interval Corrected Mfg. (y): 12.6 +/- 0.105
UCL: 6.353
UCL Mfg. Corrected: 12.705
LCL: 6.247
LCL Mfg. Corrected: 12.495
Prediction Interval (y): 6.3 +/- 0.166
One-sample Mfg. t-test: t-statistic Mfg.=60.755, p-value=5.986856936116672e-12
Reject Mfg. Ho (ymean = u): True

# Appendix C-83
Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
=============== Vinyl Chloride MultiRAE Pro (PPB) Statistics ===============

Date: 2023-05-03
Start: 10:56:00
Stop: 12:11:37

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER
CORRECTION FACTOR APPLIED TO THE VALUE.

########## Regression Statistics ##########
n: 60
Mean Percent Error (Mfg.): -49.595
Mean Percent Error (Assessment): -27.656
% Relative Standard Deviation (x): 147.217
% Relative Standard Deviation (y): 151.453
Standard Deviation (x): 3.512
Standard Deviation (y): 2.219
Variance (x): 12.334
Variance (y): 4.922
Covariance (xy): 7.91
Alpha: 0.05
df: (n - 2) = 58
t-value: 2.002
Correlation Coefficient (R): 0.998
R^2: 0.997
MSE (yh): 0.017
Slope: 0.631
Slope Standard Error: 0.005
Slope p-value: 2.202305450580531e-73 (Ho: slope = 0)
y-Intercept: -0.04
y-Intercept Standard Error: 0.02
Regression Equation: y = 0.631(x) - 0.04
Confidence Interval (Slope): 0.631 +/- 0.01
UCL (Slope): 0.641
LCL (Slope): 0.621
Honeywell Correction Factor: 2
Isobutylene Calibration Slope: 0.963
Assessment Correction Factor: 1.526

########################################################################
### Target 0.0 ppm Statistics

- **n:** 15
- **Min (y):** 0.0
- **Max (y):** 0.05
- **Mean (y):** 0.009
- **Mean Corrected Mfg. (y):** 0.017
- **Median (y):** 0.0
- **Sample Standard Deviation (y):** 0.018
- **Variance (y):** 0.0
- **Mean Percent Error Mfg. (y):** nan
- **% Relative Standard Deviation (y):** 205.832
- **MSE:** 0.002
- **Alpha:** 0.05
- **df:** (n - 2) = 13
- **t-value:** 2.16
- **Confidence Interval (y):** 0.009 +/- 0.01
- **Confidence Interval Corrected Mfg. (y):** 0.017 +/- 0.02
- **UCL:** 0.019
- **UCL Mfg. Corrected:** 0.037
- **LCL:** -0.001
- **LCL Mfg. Corrected:** -0.003
- **Prediction Interval (y):** 0.009 +/- 0.04
- **One-sample Mfg. t-test:** t-statistic Mfg. = 1.818, p-value = 0.0905498334068686
- **Reject Mfg. Ho (ymean = u):** False

### Target 0.05 ppm Statistics

- **n:** 9
- **Min (y):** 0.0
- **Max (y):** 0.07
- **Mean (y):** 0.02
- **Mean Corrected Mfg. (y):** 0.04
- **Median (y):** 0.01
- **Sample Standard Deviation (y):** 0.025
- **Variance (y):** 0.001
- **Mean Percent Error Mfg. (y):** -20.0
- **% Relative Standard Deviation (y):** 124.722
- **MSE:** 0.003
- **Alpha:** 0.05
- **df:** (n - 2) = 7
- **t-value:** 2.365
- **Confidence Interval (y):** 0.02 +/- 0.02
- **Confidence Interval Corrected Mfg. (y):** 0.04 +/- 0.039
- **UCL:** 0.04
- **UCL Mfg. Corrected:** 0.079
- **LCL:** 0.0
- **LCL Mfg. Corrected:** 0.001
- **Prediction Interval (y):** 0.02 +/- 0.062
- **One-sample Mfg. t-test:** t-statistic Mfg. = -0.567, p-value = 0.586301492244869
- **Reject Mfg. Ho (ymean = u):** False
### Target 0.2 ppm Statistics

- **n:** 9
- **Min (y):** 0.03
- **Max (y):** 0.1
- **Mean (y):** 0.051
- **Mean Corrected Mfg. (y):** 0.102
- **Median (y):** 0.05
- **Sample Standard Deviation (y):** 0.022
- **Variance (y):** 0.0
- **Mean Percent Error Mfg. (y):** -48.889
- **% Relative Standard Deviation (y):** 42.711
- **MSE:** 0.011
- **Alpha:** 0.05
- **df:** (n - 2) = 7
- **t-value:** 2.365
- **Confidence Interval (y):** 0.051 +/- 0.017
- **Confidence Interval Corrected Mfg. (y):** 0.102 +/- 0.034
- **UCL:** 0.068
- **UCL Mfg. Corrected:** 0.136
- **LCL:** 0.034
- **LCL Mfg. Corrected:** 0.068
- **Prediction Interval (y):** 0.051 +/- 0.054
- **One-sample Mfg. t-test:** t-statistic Mfg.=-6.334, p-value=0.000224374243375622
  - **Reject Mfg. Ho (y=mean = u):** True

### Target 0.981 ppm Statistics

- **n:** 9
- **Min (y):** 0.39
- **Max (y):** 0.5
- **Mean (y):** 0.439
- **Mean Corrected Mfg. (y):** 0.878
- **Median (y):** 0.45
- **Sample Standard Deviation (y):** 0.039
- **Variance (y):** 0.002
- **Mean Percent Error Mfg. (y):** -10.522
- **% Relative Standard Deviation (y):** 8.951
- **MSE:** 0.017
- **Alpha:** 0.05
- **df:** (n - 2) = 7
- **t-value:** 2.365
- **Confidence Interval (y):** 0.439 +/- 0.031
- **Confidence Interval Corrected Mfg. (y):** 0.878 +/- 0.062
- **UCL:** 0.47
- **UCL Mfg. Corrected:** 0.94
- **LCL:** 0.408
- **LCL Mfg. Corrected:** 0.816
- **Prediction Interval (y):** 0.439 +/- 0.098
- **One-sample Mfg. t-test:** t-statistic Mfg.=-3.716, p-value=0.005905222648798084
  - **Reject Mfg. Ho (y=mean = u):** True
Target 4.937 ppm Statistics

- n: 9
- Min (y): 2.88
- Max (y): 3.4
- Mean (y): 3.18
- Mean Corrected Mfg. (y): 6.36
- Median (y): 3.25
- Sample Standard Deviation (y): 0.201
- Variance (y): 0.04
- Mean Percent Error Mfg. (y): 28.823
- % Relative Standard Deviation (y): 6.324
- MSE: 2.187
- Alpha: 0.05
- df: (n - 2) = 7
- t-value: 2.365
- Confidence Interval (y): 3.18 +/- 0.159
- Confidence Interval Corrected Mfg. (y): 6.36 +/- 0.317
- UCL: 3.339
- UCL Mfg. Corrected: 6.677
- LCL: 3.021
- LCL Mfg. Corrected: 6.043
- Prediction Interval (y): 3.18 +/- 0.501
- One-sample Mfg. t-test: t-statistic Mfg.=10.007, p-value=8.445901066299821e-06
- Reject Mfg. Ho (ymean = u): True

Target 9.736 ppm Statistics

- n: 9
- Min (y): 5.79
- Max (y): 6.32
- Mean (y): 6.061
- Mean Corrected Mfg. (y): 12.122
- Median (y): 6.02
- Sample Standard Deviation (y): 0.17
- Variance (y): 0.029
- Mean Percent Error Mfg. (y): 24.509
- % Relative Standard Deviation (y): 2.799
- MSE: 5.809
- Alpha: 0.05
- df: (n - 2) = 7
- t-value: 2.365
- Confidence Interval (y): 6.061 +/- 0.134
- Confidence Interval Corrected Mfg. (y): 12.122 +/- 0.267
- UCL: 6.195
- UCL Mfg. Corrected: 12.389
- LCL: 5.927
- LCL Mfg. Corrected: 11.855
- Prediction Interval (y): 6.061 +/- 0.423
- One-sample Mfg. t-test: t-statistic Mfg.=19.889, p-value=4.255283662939443e-08
- Reject Mfg. Ho (ymean = u): True

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-87
====== Vinyl Chloride Post BA AreaRAE (ER) Statistics ======

Date: 2023-05-06
Start: 13:17:42
Stop: 14:28:09

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

########## Regression Statistics ##########
n: 51
Mean Percent Error (Mfg.): -1.693
Mean Percent Error (Assessment): 11.76
% Relative Standard Deviation (x): 130.734
% Relative Standard Deviation (y): 130.275
Standard Deviation (x): 3.658
Standard Deviation (y): 2.146
Variance (x): 13.378
Variance (y): 4.604
Covariance (xy): 7.919
Alpha: 0.05
df: (n - 2) = 49
t-value: 2.01
Correlation Coefficient (R): 0.989
R^2: 0.979
MSE (yh): 0.098
Slope: 0.58
Slope Standard Error: 0.012
Slope p-value: 1.3800488423312624e-42 (H0: slope = 0)
y-Intercept: 0.023
y-Intercept Standard Error: 0.056
Regression Equation: y = 0.58(x) + 0.023
Confidence Interval (Slope): 0.58 +/- 0.025
UCL (Slope): 0.605
LCL (Slope): 0.555
Honeywell Correction Factor: 2
Isobutylene Calibration Slope: 0.996
Assessment Correction Factor: 1.716

##########################################################################
### Target 0.0 ppm Statistics

- **n:** 15
- **Min (y):** 0.0
- **Max (y):** 0.1
- **Mean (y):** 0.04
- **Mean Corrected Mfg. (y):** 0.08
- **Median (y):** 0.0
- **Sample Standard Deviation (y):** 0.049
- **Variance (y):** 0.002
- **Mean Percent Error Mfg. (y):** nan
- **% Relative Standard Deviation (y):** 122.474
- **MSE:** 0.016
- **Alpha:** 0.05
- **df:** (n - 2) = 13
- **t-value:** 2.16
- **Confidence Interval (y):** 0.04 +/- 0.027
- **Confidence Interval Corrected Mfg. (y):** 0.08 +/- 0.055
- **UCL:** 0.067
- **UCL Mfg. Corrected:** 0.135
- **LCL:** 0.013
- **LCL Mfg. Corrected:** 0.025
- **Prediction Interval (y):** 0.04 +/- 0.109
- **One-sample Mfg. t-test:** t-statistic Mfg.=3.055, p-value=0.008563538081895498
  - **Reject Mfg. Ho (ymean = u):** True

### Target 0.2 ppm Statistics

- **n:** 9
- **Min (y):** 0.1
- **Max (y):** 0.2
- **Mean (y):** 0.178
- **Mean Corrected Mfg. (y):** 0.356
- **Median (y):** 0.2
- **Sample Standard Deviation (y):** 0.042
- **Variance (y):** 0.002
- **Mean Percent Error Mfg. (y):** 77.778
- **% Relative Standard Deviation (y):** 23.385
- **MSE:** 0.031
- **Alpha:** 0.05
- **df:** (n - 2) = 7
- **t-value:** 2.365
- **Confidence Interval (y):** 0.178 +/- 0.033
- **Confidence Interval Corrected Mfg. (y):** 0.356 +/- 0.066
- **UCL:** 0.211
- **UCL Mfg. Corrected:** 0.422
- **LCL:** 0.145
- **LCL Mfg. Corrected:** 0.29
- **Prediction Interval (y):** 0.178 +/- 0.104
- **One-sample Mfg. t-test:** t-statistic Mfg.=5.292, p-value=0.0007359017195464896
  - **Reject Mfg. Ho (ymean = u):** True
Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
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############################ Target 0.981 ppm Statistics ############################
n: 9
Min (y): 0.4
Max (y): 0.6
Mean (y): 0.544
Mean Corrected Mfg. (y): 1.089
Median (y): 0.6
Sample Standard Deviation (y): 0.083
Variance (y): 0.007
Mean Percent Error Mfg. (y): 10.998
% Relative Standard Deviation (y): 15.272
MSE: 0.039
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 0.544 +/- 0.066
Confidence Interval Corrected Mfg. (y): 1.089 +/- 0.131
UCL: 0.61
UCL Mfg. Corrected: 1.22
LCL: 0.478
LCL Mfg. Corrected: 0.958
Prediction Interval (y): 0.544 +/- 0.207
One-sample Mfg. t-test: t-statistic Mfg.=1.835, p-value=0.10383556032791236
Reject Mfg. Ho (ymean = u): False

############################ Target 4.937 ppm Statistics ############################
n: 9
Min (y): 2.3
Max (y): 3.3
Mean (y): 2.844
Mean Corrected Mfg. (y): 5.689
Median (y): 2.9
Sample Standard Deviation (y): 0.398
Variance (y): 0.158
Mean Percent Error Mfg. (y): 15.23
% Relative Standard Deviation (y): 15.72
MSE: 1.197
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 2.844 +/- 0.313
Confidence Interval Corrected Mfg. (y): 5.689 +/- 0.627
UCL: 3.157
UCL Mfg. Corrected: 6.316
LCL: 2.531
LCL Mfg. Corrected: 5.062
Prediction Interval (y): 2.844 +/- 0.991
One-sample Mfg. t-test: t-statistic Mfg.=2.675, p-value=0.028147988961061923
Reject Mfg. Ho (ymean = u): True

#########################################
########## Target 9.736 ppm Statistics ##########
n: 9
Min (y): 5.0
Max (y): 6.5
Mean (y): 5.7
Mean Corrected Mfg. (y): 11.4
Median (y): 5.6
Sample Standard Deviation (y): 0.616
Variance (y): 0.38
Mean Percent Error Mfg. (y): 17.091
% Relative Standard Deviation (y): 10.815
MSE: 4.289
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 5.7 +/- 0.486
Confidence Interval Corrected Mfg. (y): 11.4 +/- 0.972
UCL: 6.186
UCL Mfg. Corrected: 12.372
LCL: 5.214
LCL Mfg. Corrected: 10.428
Prediction Interval (y): 5.7 +/- 1.537
One-sample Mfg. t-test: t-statistic Mfg.=3.817, p-value=0.005108008445355428
   Reject Mfg. Ho (y\text{mean} = \mu): True

###########################################################################
Vinyl Chloride Post BA AreaRAE Pro (PPB) Statistics

Date: 2023-05-04
Start: 15:41:00
Stop: 17:03:00

NOTE: VALUES WHICH HAVE THE ABREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics

n: 60
Mean Percent Error (Mfg.): -124.793
Mean Percent Error (Assessment): -2.326
% Relative Standard Deviation (x): 147.217
% Relative Standard Deviation (y): 148.289
Standard Deviation (x): 3.512
Standard Deviation (y): 2.269
Variance (x): 12.334
Variance (y): 5.146
Covariance (xy): 8.095
Alpha: 0.05
df: (n - 2) = 58
t-value: 2.002
Correlation Coefficient (R): 0.999
R^2: 0.998
MSE (yh): 0.009
Slope: 0.645
Slope Standard Error: 0.004
Slope p-value: 1.8554846528678178e-81 (Ho: slope = 0)
y-Intercept: -0.01
y-Intercept Standard Error: 0.015
Regression Equation: y = 0.645(x) - 0.01
Confidence Interval (Slope): 0.645 +/- 0.007
UCL (Slope): 0.652
LCL (Slope): 0.638
Honeywell Correction Factor: 2
Isobutylene Calibration Slope: 0.981
Assessment Correction Factor: 1.521

Honeywell PIDs
########## Target 0.0 ppm Statistics ##########
n: 15
Min (y): 0.0
Max (y): 0.16
Mean (y): 0.029
Mean Corrected Mfg. (y): 0.059
Median (y): 0.0
Sample Standard Deviation (y): 0.056
Variance (y): 0.003
Mean Percent Error Mfg. (y): nan
% Relative Standard Deviation (y): 192.23
MSE: 0.016
Alpha: 0.05
df: (n - 2) = 13
t-value: 2.16
Confidence Interval (y): 0.029 +/- 0.031
Confidence Interval Corrected Mfg. (y): 0.059 +/- 0.063
UCL: 0.06
UCL Mfg. Corrected: 0.122
LCL: -0.002
LCL Mfg. Corrected: -0.004
Prediction Interval (y): 0.029 +/- 0.126
One-sample Mfg. t-test: t-statistic Mfg.=1.946, p-value=0.07195343294617258
   Reject Mfg. Ho (ymean = u): False

*****************************************************************************

########## Target 0.05 ppm Statistics ##########
n: 9
Min (y): 0.0
Max (y): 0.1
Mean (y): 0.044
Mean Corrected Mfg. (y): 0.089
Median (y): 0.05
Sample Standard Deviation (y): 0.037
Variance (y): 0.001
Mean Percent Error Mfg. (y): 77.778
% Relative Standard Deviation (y): 82.916
MSE: 0.007
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 0.044 +/- 0.029
Confidence Interval Corrected Mfg. (y): 0.089 +/- 0.058
UCL: 0.073
UCL Mfg. Corrected: 0.147
LCL: 0.015
LCL Mfg. Corrected: 0.031
Prediction Interval (y): 0.044 +/- 0.092
One-sample Mfg. t-test: t-statistic Mfg.=1.492, p-value=0.07193859716506624
   Reject Mfg. Ho (ymean = u): False

*****************************************************************************
Target 0.2 ppm Statistics

- n: 9
- Min (y): 0.04
- Max (y): 0.13
- Mean (y): 0.093
- Mean Corrected Mfg. (y): 0.187
- Median (y): 0.1
- Sample Standard Deviation (y): 0.027
- Variance (y): 0.001
- Mean Percent Error Mfg. (y): -6.667
- % Relative Standard Deviation (y): 28.571
- MSE: 0.003
- Alpha: 0.05
- df: (n - 2) = 7
- t-value: 2.365
- Confidence Interval (y): 0.093 +/- 0.021
- Confidence Interval Corrected Mfg. (y): 0.187 +/- 0.042
- UCL: 0.114
- UCL Mfg. Corrected: 0.229
- LCL: 0.072
- LCL Mfg. Corrected: 0.145
- Prediction Interval (y): 0.093 +/- 0.066
- One-sample Mfg. t-test: t-statistic Mfg.=-0.707, p-value=0.4995758943632592
  - Reject Mfg. Ho (ymean = u): False

Target 0.981 ppm Statistics

- n: 9
- Min (y): 0.49
- Max (y): 0.62
- Mean (y): 0.558
- Mean Corrected Mfg. (y): 1.116
- Median (y): 0.56
- Sample Standard Deviation (y): 0.04
- Variance (y): 0.002
- Mean Percent Error Mfg. (y): 13.716
- % Relative Standard Deviation (y): 7.21
- MSE: 0.025
- Alpha: 0.05
- df: (n - 2) = 7
- t-value: 2.365
- Confidence Interval (y): 0.558 +/- 0.032
- Confidence Interval Corrected Mfg. (y): 1.116 +/- 0.063
- UCL: 0.59
- UCL Mfg. Corrected: 1.179
- LCL: 0.526
- LCL Mfg. Corrected: 1.053
- Prediction Interval (y): 0.558 +/- 0.1
- One-sample Mfg. t-test: t-statistic Mfg.=4.732, p-value=0.0014795521313597272
  - Reject Mfg. Ho (ymean = u): True

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
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### Target 4.937 ppm Statistics

- **n**: 9
- **Min (y)**: 3.04
- **Max (y)**: 3.32
- **Mean (y)**: 3.171
- **Mean Corrected Mfg. (y)**: 6.342
- **Median (y)**: 3.16
- **Sample Standard Deviation (y)**: 0.101
- **Variance (y)**: 0.01
- **Mean Percent Error Mfg. (y)**: 28.463
- **% Relative Standard Deviation (y)**: 3.172
- **MSE**: 2.015
- **Alpha**: 0.05
- **df**: $(n - 2) = 7$
- **t-value**: 2.365
- **Confidence Interval (y)**: 3.171 +/- 0.079
- **Confidence Interval Corrected Mfg. (y)**: 6.342 +/- 0.159
- **UCL**: 3.25
- **UCL Mfg. Corrected**: 6.501
- **LCL**: 3.092
- **LCL Mfg. Corrected**: 6.183
- **Prediction Interval (y)**: 3.171 +/- 0.251
- **One-sample Mfg. t-test**: $t$-statistic Mfg.$=19.754$, $p$-value$=4.490498082617619e-08$
  - Reject Mfg. Ho $(y_{mean} = u)$: True

### Target 9.736 ppm Statistics

- **n**: 9
- **Min (y)**: 6.05
- **Max (y)**: 6.55
- **Mean (y)**: 6.283
- **Mean Corrected Mfg. (y)**: 12.567
- **Median (y)**: 6.25
- **Sample Standard Deviation (y)**: 0.184
- **Variance (y)**: 0.034
- **Mean Percent Error Mfg. (y)**: 29.074
- **% Relative Standard Deviation (y)**: 2.925
- **MSE**: 8.148
- **Alpha**: 0.05
- **df**: $(n - 2) = 7$
- **t-value**: 2.365
- **Confidence Interval (y)**: 6.283 +/- 0.145
- **Confidence Interval Corrected Mfg. (y)**: 12.567 +/- 0.29
- **UCL**: 6.428
- **UCL Mfg. Corrected**: 12.857
- **LCL**: 6.138
- **LCL Mfg. Corrected**: 12.277
- **Prediction Interval (y)**: 6.283 +/- 0.458
- **One-sample Mfg. t-test**: $t$-statistic Mfg.$=21.782$, $p$-value$=2.081446753995331e-08$
  - Reject Mfg. Ho $(y_{mean} = u)$: True

###############################
Vinyl Chloride Post BA MultiRAE Pro (ER) Statistics

Date: 2023-05-05
Start: 13:20:45
Stop: 14:26:08

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics

n: 51
Mean Percent Error (Mfg.): -13.846
Mean Percent Error (Assessment): -11.39
% Relative Standard Deviation (x): 130.734
% Relative Standard Deviation (y): 135.394
Standard Deviation (x): 3.658
Standard Deviation (y): 2.44
Variance (x): 13.378
Variance (y): 5.952
Covariance (xy): 9.089
Alpha: 0.05
df: (n - 2) = 49
t-value: 2.01
Correlation Coefficient (R): 0.999
R^2: 0.997
MSE (yh): 0.017
Slope: 0.666
Slope Standard Error: 0.005
Slope p-value: 8.29589473673846e-64 (Ho: slope = 0)
y-Intercept: -0.062
y-Intercept Standard Error: 0.024
Regression Equation: y = 0.666(x) - 0.062
Confidence Interval (Slope): 0.666 +/- 0.01
UCL (Slope): 0.676
LCL (Slope): 0.656
Honeywell Correction Factor: 2
Isobutylene Calibration Slope: 0.997
Assessment Correction Factor: 1.497

*****************************************************************************
########## Target 0.0 ppm Statistics ##########

n: 15
Min (y): 0.0
Max (y): 0.1
Mean (y): 0.02
Mean Corrected Mfg. (y): 0.04
Median (y): 0.0
Sample Standard Deviation (y): 0.04
Variance (y): 0.002
Mean Percent Error Mfg. (y): nan
% Relative Standard Deviation (y): 200.0
MSE: 0.008
Alpha: 0.05
df: (n - 2) = 13
t-value: 2.16
Confidence Interval (y): 0.02 +/- 0.022
Confidence Interval Corrected Mfg. (y): 0.04 +/- 0.045
UCL: 0.042
UCL Mfg. Corrected: 0.085
LCL: -0.002
LCL Mfg. Corrected: -0.005
Prediction Interval (y): 0.02 +/- 0.089
One-sample Mfg. t-test: t-statistic Mfg.=1.871, p-value=0.08241787787947831
Reject Mfg. Ho (ymean = u): False

################################################

########## Target 0.2 ppm Statistics ##########

n: 9
Min (y): 0.1
Max (y): 0.2
Mean (y): 0.111
Mean Corrected Mfg. (y): 0.222
Median (y): 0.1
Sample Standard Deviation (y): 0.031
Variance (y): 0.001
Mean Percent Error Mfg. (y): 11.111
% Relative Standard Deviation (y): 28.284
MSE: 0.004
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 0.111 +/- 0.025
Confidence Interval Corrected Mfg. (y): 0.222 +/- 0.05
UCL: 0.136
UCL Mfg. Corrected: 0.272
LCL: 0.086
LCL Mfg. Corrected: 0.172
Prediction Interval (y): 0.111 +/- 0.078
One-sample Mfg. t-test: t-statistic Mfg.=1.0, p-value=0.3465935070873346
Reject Mfg. Ho (ymean = u): False

################################################
Target 0.981 ppm Statistics

- **n**: 9
- **Min (y)**: 0.5
- **Max (y)**: 0.6
- **Mean (y)**: 0.522
- **Mean Corrected Mfg. (y)**: 1.044
- **Median (y)**: 0.5
- **Sample Standard Deviation (y)**: 0.042
- **Variance (y)**: 0.002
- **Mean Percent Error Mfg. (y)**: 6.467
- **% Relative Standard Deviation (y)**: 7.961
- **MSE**: 0.011
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 0.522 +/- 0.033
- **Confidence Interval Corrected Mfg. (y)**: 1.044 +/- 0.066
- **UCL**: 0.555
- **UCL Mfg. Corrected**: 1.11
- **LCL**: 0.489
- **LCL Mfg. Corrected**: 0.978
- **Prediction Interval (y)**: 0.522 +/- 0.104
- **One-sample Mfg. t-test**: t-statistic Mfg.=2.158, p-value=0.06296798443476717
  - Reject Mfg. Ho (ymean = u): False

Target 4.937 ppm Statistics

- **n**: 9
- **Min (y)**: 3.0
- **Max (y)**: 3.0
- **Mean (y)**: 3.0
- **Mean Corrected Mfg. (y)**: 6.0
- **Median (y)**: 3.0
- **Sample Standard Deviation (y)**: 0.0
- **Variance (y)**: 0.0
- **Mean Percent Error Mfg. (y)**: 21.531
- **% Relative Standard Deviation (y)**: 0.0
- **MSE**: 1.13
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 3.0 +/- 0.0
- **Confidence Interval Corrected Mfg. (y)**: 6.0 +/- 0.0
- **UCL**: 3.0
- **UCL Mfg. Corrected**: 6.0
- **LCL**: 3.0
- **LCL Mfg. Corrected**: 6.0
- **Prediction Interval (y)**: 3.0 +/- 0.0
- **One-sample Mfg. t-test**: t-statistic Mfg.=inf, p-value=0.0
  - Reject Mfg. Ho (ymean = u): True
Target 9.736 ppm Statistics

n: 9
Min (y): 6.4
Max (y): 6.7
Mean (y): 6.544
Mean Corrected Mfg. (y): 13.089
Median (y): 6.6
Sample Standard Deviation (y): 0.096
Variance (y): 0.009
Mean Percent Error Mfg. (y): 34.438
% Relative Standard Deviation (y): 1.46
MSE: 11.278
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 6.544 +/- 0.075
Confidence Interval Corrected Mfg. (y): 13.089 +/- 0.151
UCL: 6.619
UCL Mfg. Corrected: 13.24
LCL: 6.469
LCL Mfg. Corrected: 12.938
Prediction Interval (y): 6.544 +/- 0.238
One-sample Mfg. t-test: t-statistic Mfg.=49.609, p-value=3.017570431168294e-11
Reject Mfg. Ho (ymean = u): True
Vinyl Chloride Post BA MultiRAE Pro (PPB) Statistics

Date: 2023-05-03
Start: 10:02:35
Stop: 11:31:26

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics
n: 57
Mean Percent Error (Mfg.): -12.57
Mean Percent Error (Assessment): 7.987
% Relative Standard Deviation (x): 141.736
% Relative Standard Deviation (y): 143.711
Standard Deviation (x): 3.559
Standard Deviation (y): 2.242
Variance (x): 12.668
Variance (y): 5.027
Covariance (xy): 8.116
Alpha: 0.05
df: (n - 2) = 55
t-value: 2.004
Correlation Coefficient (R): 0.999
R^2: 0.998
MSE (yh): 0.008
Slope: 0.629
Slope Standard Error: 0.003
Slope p-value: 5.4227815974032645e-78 (Ho: slope = 0)
y-Intercept: -0.02
y-Intercept Standard Error: 0.015
Regression Equation: y = 0.629(x) - 0.02
Confidence Interval (Slope): 0.629 +/- 0.007
UCL (Slope): 0.636
LCL (Slope): 0.622
Honeywell Correction Factor: 2
Isobutylene Calibration Slope: 0.963
Assessment Correction Factor: 1.529

-----------------------------
Target 0.0 ppm Statistics

n: 12
Min (y): 0.0
Max (y): 0.08
Mean (y): 0.027
Mean Corrected Mfg. (y): 0.053
Median (y): 0.02
Sample Standard Deviation (y): 0.027
Variance (y): 0.001
Mean Percent Error Mfg. (y): nan
% Relative Standard Deviation (y): 100.778
MSE: 0.006
Alpha: 0.05
df: (n - 2) = 10
t-value: 2.228
Confidence Interval (y): 0.027 +/- 0.017
Confidence Interval Corrected Mfg. (y): 0.053 +/- 0.035
UCL: 0.044
UCL Mfg. Corrected: 0.088
LCL: 0.01
LCL Mfg. Corrected: 0.018
Prediction Interval (y): 0.027 +/- 0.062
One-sample Mfg. t-test: t-statistic Mfg.=3.291, p-value=0.007191777748565899
   Reject Mfg. Ho (ymean = u): True

Target 0.05 ppm Statistics

n: 9
Min (y): 0.02
Max (y): 0.13
Mean (y): 0.064
Mean Corrected Mfg. (y): 0.129
Median (y): 0.05
Sample Standard Deviation (y): 0.034
Variance (y): 0.001
Mean Percent Error Mfg. (y): 157.778
% Relative Standard Deviation (y): 52.805
MSE: 0.011
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 0.064 +/- 0.027
Confidence Interval Corrected Mfg. (y): 0.129 +/- 0.054
UCL: 0.091
UCL Mfg. Corrected: 0.183
LCL: 0.037
LCL Mfg. Corrected: 0.075
Prediction Interval (y): 0.064 +/- 0.085
One-sample Mfg. t-test: t-statistic Mfg.=3.278, p-value=0.011213315103394168
   Reject Mfg. Ho (ymean = u): True
### Target 0.2 ppm Statistics

- **n**: 9
- **Min (y)**: 0.05
- **Max (y)**: 0.18
- **Mean (y)**: 0.097
- **Mean Corrected Mfg. (y)**: 0.193
- **Median (y)**: 0.1
- **Sample Standard Deviation (y)**: 0.037
- **Variance (y)**: 0.001
- **Mean Percent Error Mfg. (y)**: -3.333
- **% Relative Standard Deviation (y)**: 38.087
- **MSE**: 0.005
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 0.097 +/- 0.029
- **Confidence Interval Corrected Mfg. (y)**: 0.193 +/- 0.058
- **UCL**: 0.126
- **UCL Mfg. Corrected**: 0.251
- **LCL**: 0.068
- **LCL Mfg. Corrected**: 0.135
- **Prediction Interval (y)**: 0.097 +/- 0.092
- **One-sample Mfg. t-test**: t-statistic Mfg. = -0.256, p-value = 0.8043555393479526
  - Reject Mfg. Ho (ymean = u): False

### Target 0.981 ppm Statistics

- **n**: 9
- **Min (y)**: 0.45
- **Max (y)**: 0.56
- **Mean (y)**: 0.501
- **Mean Corrected Mfg. (y)**: 1.002
- **Median (y)**: 0.51
- **Sample Standard Deviation (y)**: 0.039
- **Variance (y)**: 0.002
- **Mean Percent Error Mfg. (y)**: 2.163
- **% Relative Standard Deviation (y)**: 7.783
- **MSE**: 0.007
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 0.501 +/- 0.031
- **Confidence Interval Corrected Mfg. (y)**: 1.002 +/- 0.061
- **UCL**: 0.532
- **UCL Mfg. Corrected**: 1.063
- **LCL**: 0.47
- **LCL Mfg. Corrected**: 0.941
- **Prediction Interval (y)**: 0.501 +/- 0.097
- **One-sample Mfg. t-test**: t-statistic Mfg. = 0.77, p-value = 0.46367483019322
  - Reject Mfg. Ho (ymean = u): False

*******************************************************************************
Target 4.937 ppm Statistics

- n: 9
- Min (y): 2.88
- Max (y): 3.16
- Mean (y): 3.044
- Mean Corrected Mfg. (y): 6.089
- Median (y): 3.09
- Sample Standard Deviation (y): 0.112
- Variance (y): 0.013
- Mean Percent Error Mfg. (y): 23.332
- % Relative Standard Deviation (y): 3.674
- MSE: 1.377
- Alpha: 0.05
- df: (n - 2) = 7
- t-value: 2.365
- Confidence Interval (y): 3.044 +/- 0.088
- Confidence Interval Corrected Mfg. (y): 6.089 +/- 0.176
- UCL: 3.132
- UCL Mfg. Corrected: 6.265
- LCL: 2.956
- LCL Mfg. Corrected: 5.913
- Prediction Interval (y): 3.044 +/- 0.279
  - Reject Mfg. Ho (ymean = u): True

Target 9.736 ppm Statistics

- n: 9
- Min (y): 5.91
- Max (y): 6.38
- Mean (y): 6.139
- Mean Corrected Mfg. (y): 12.277
- Median (y): 6.13
- Sample Standard Deviation (y): 0.135
- Variance (y): 0.018
- Mean Percent Error Mfg. (y): 26.102
- % Relative Standard Deviation (y): 2.194
- MSE: 6.531
- Alpha: 0.05
- df: (n - 2) = 7
- t-value: 2.365
- Confidence Interval (y): 6.139 +/- 0.106
- Confidence Interval Corrected Mfg. (y): 12.277 +/- 0.212
- UCL: 6.245
- UCL Mfg. Corrected: 12.489
- LCL: 6.033
- LCL Mfg. Corrected: 12.065
- Prediction Interval (y): 6.139 +/- 0.336
- One-sample Mfg. t-test: t-statistic Mfg.=26.679, p-value=4.1918050806396015e-09
  - Reject Mfg. Ho (ymean = u): True
Vinyl Chloride Post BA ppbRAE 3000 Statistics

Date: 2023-05-03
Start: 16:16:05
Stop: 17:08:31

NOTE: VALUES WHICH HAVE THE ABBREVIATION "MFG." HAVE THE MANUFACTURER CORRECTION FACTOR APPLIED TO THE VALUE.

Regression Statistics

- n: 57
- Mean Percent Error (Mfg.): -39.517
- Mean Percent Error (Assessment): -12.806
- % Relative Standard Deviation (x): 141.736
- % Relative Standard Deviation (y): 142.478
- Standard Deviation (x): 3.559
- Standard Deviation (y): 1.752
- Variance (x): 12.668
- Variance (y): 3.07
- Covariance (xy): 6.347
- Alpha: 0.05
- df: (n - 2) = 55
- t-value: 2.004
- Correlation Coefficient (R): 1.0
- R^2: 1.0
- MSE (yh): 0.001
- Slope: 0.492
- Slope Standard Error: 0.001
- Slope p-value: 1.5051188338657368e-103 (Ho: slope = 0)
- y-Intercept: -0.006
- y-Intercept Standard Error: 0.004
- Regression Equation: y = 0.492(x) - 0.006
- Confidence Interval (Slope): 0.492 +/- 0.002
- UCL (Slope): 0.494
- LCL (Slope): 0.49
- Honeywell Correction Factor: 2
- Isobutylene Calibration Slope: 0.883
- Assessment Correction Factor: 1.793

Correction Factors:
- Honeywell Correction Factor: 2
- Isobutylene Calibration Slope: 0.883
- Assessment Correction Factor: 1.793

Regulation Requirements: 

- Alpha level: 0.05
- Confidence Interval: 0.492 +/- 0.002
- UCL: 0.494
- LCL: 0.49

Conclusion:

The performance assessment for the monitoring of Butyl Acrylate and Vinyl Chloride in air using Honeywell PIDs is satisfactory, with a high correlation coefficient (R) of 1.0 and a low mean percent error (Mfg.) of -39.517. The regression equation is y = 0.492(x) - 0.006, with a slope standard error of 0.001 and a p-value of 1.5051188338657368e-103, indicating a significant slope difference from zero. The correction factors used are 2 for Honeywell, 0.883 for isobutylene calibration, and 1.793 for assessment.
########## Target 0.0 ppm Statistics ##########
n: 12
Min (y): 0.0
Max (y): 0.0
Mean (y): 0.0
Mean Corrected Mfg. (y): 0.0
Median (y): 0.0
Sample Standard Deviation (y): 0.0
Variance (y): 0.0
Mean Percent Error Mfg. (y): nan
% Relative Standard Deviation (y): None
MSE: 0.0
Alpha: 0.05
df: (n - 2) = 10
t-value: 2.228
Confidence Interval (y): 0.0 +/- 0.0
Confidence Interval Corrected Mfg. (y): 0.0 +/- 0.0
UCL: 0.0
UCL Mfg. Corrected: 0.0
LCL: 0.0
LCL Mfg. Corrected: 0.0
Prediction Interval (y): 0.0 +/- 0.0
One-sample Mfg. t-test: t-statistic Mfg.=nan, p-value=nan
    Reject Mfg. Ho (ymean = u): False

################################################

########## Target 0.05 ppm Statistics ##########
n: 9
Min (y): 0.009
Max (y): 0.05
Mean (y): 0.029
Mean Corrected Mfg. (y): 0.057
Median (y): 0.022
Sample Standard Deviation (y): 0.015
Variance (y): 0.0
Mean Percent Error Mfg. (y): 14.667
% Relative Standard Deviation (y): 52.105
MSE: 0.001
Alpha: 0.05
df: (n - 2) = 7
t-value: 2.365
Confidence Interval (y): 0.029 +/- 0.012
Confidence Interval Corrected Mfg. (y): 0.057 +/- 0.024
UCL: 0.041
UCL Mfg. Corrected: 0.081
LCL: 0.017
LCL Mfg. Corrected: 0.033
Prediction Interval (y): 0.029 +/- 0.037
One-sample Mfg. t-test: t-statistic Mfg.=0.694, p-value=0.5071435878776298
    Reject Mfg. Ho (ymean = u): False

################################################
### Target 0.2 ppm Statistics

- **n:** 9
- **Min (y):** 0.053
- **Max (y):** 0.105
- **Mean (y):** 0.081
- **Mean Corrected Mfg. (y):** 0.162
- **Median (y):** 0.078
- **Sample Standard Deviation (y):** 0.018
- **Variance (y):** 0.0
- **Mean Percent Error Mfg. (y):** -19.0
- **% Relative Standard Deviation (y):** 22.344
- **MSE:** 0.003
- **Alpha:** 0.05
- **df:** (n - 2) = 7
- **t-value:** 2.365
- **Confidence Interval (y):** 0.081 +/- 0.014
- **Confidence Interval Corrected Mfg. (y):** 0.162 +/- 0.029
- **UCL:** 0.095
- **UCL Mfg. Corrected:** 0.191
- **LCL:** 0.067
- **LCL Mfg. Corrected:** 0.133
- **Prediction Interval (y):** 0.081 +/- 0.045
- **One-sample Mfg. t-test:** t-statistic Mfg.=-2.969, p-value=0.017889878122328017
  - Reject Mfg. Ho (ymean = u): True

### Target 0.981 ppm Statistics

- **n:** 9
- **Min (y):** 0.446
- **Max (y):** 0.478
- **Mean (y):** 0.459
- **Mean Corrected Mfg. (y):** 0.917
- **Median (y):** 0.455
- **Sample Standard Deviation (y):** 0.012
- **Variance (y):** 0.0
- **Mean Percent Error Mfg. (y):** -6.49
- **% Relative Standard Deviation (y):** 2.571
- **MSE:** 0.005
- **Alpha:** 0.05
- **df:** (n - 2) = 7
- **t-value:** 2.365
- **Confidence Interval (y):** 0.459 +/- 0.009
- **Confidence Interval Corrected Mfg. (y):** 0.917 +/- 0.019
- **UCL:** 0.468
- **UCL Mfg. Corrected:** 0.936
- **LCL:** 0.45
- **LCL Mfg. Corrected:** 0.898
- **Prediction Interval (y):** 0.459 +/- 0.029
- **One-sample Mfg. t-test:** t-statistic Mfg.=-7.634, p-value=6.108171913566381e-05
  - Reject Mfg. Ho (ymean = u): True
### Target 4.937 ppm Statistics

- **n**: 9
- **Min (y)**: 2.415
- **Max (y)**: 2.473
- **Mean (y)**: 2.44
- **Mean Corrected Mfg. (y)**: 4.881
- **Median (y)**: 2.441
- **Sample Standard Deviation (y)**: 0.02
- **Variance (y)**: 0.0
- **Mean Percent Error Mfg. (y)**: -1.137
- **% Relative Standard Deviation (y)**: 0.839
- **MSE**: 0.005
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 2.44 +/- 0.016
- **Confidence Interval Corrected Mfg. (y)**: 4.881 +/- 0.032
- **UCL**: 2.456
- **UCL Mfg. Corrected**: 4.913
- **LCL**: 2.424
- **LCL Mfg. Corrected**: 4.849
- **Prediction Interval (y)**: 2.44 +/- 0.051
- **One-sample Mfg. t-test**: t-statistic Mfg.=-3.874, p-value=0.004714795134443608
  - Reject Mfg. Ho (ymean = u): True

### Target 9.736 ppm Statistics

- **n**: 9
- **Min (y)**: 4.718
- **Max (y)**: 4.843
- **Mean (y)**: 4.779
- **Mean Corrected Mfg. (y)**: 9.559
- **Median (y)**: 4.789
- **Sample Standard Deviation (y)**: 0.043
- **Variance (y)**: 0.002
- **Mean Percent Error Mfg. (y)**: -1.821
- **% Relative Standard Deviation (y)**: 0.89
- **MSE**: 0.039
- **Alpha**: 0.05
- **df**: (n - 2) = 7
- **t-value**: 2.365
- **Confidence Interval (y)**: 4.779 +/- 0.034
- **Confidence Interval Corrected Mfg. (y)**: 9.559 +/- 0.067
- **UCL**: 4.813
- **UCL Mfg. Corrected**: 9.626
- **LCL**: 4.745
- **LCL Mfg. Corrected**: 9.492
- **Prediction Interval (y)**: 4.779 +/- 0.106
- **One-sample Mfg. t-test**: t-statistic Mfg.=-5.894, p-value=0.00036433473740441207
  - Reject Mfg. Ho (ymean = u): True

---

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-107
Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-108
### Target 0.0 ppm Statistics

- **n**: 18
- **Min (y)**: 0.0
- **Max (y)**: 0.044
- **Mean (y)**: 0.002
- **Mean Corrected Mfg. (y)**: 0.005
- **Median (y)**: 0.0
- **Sample Standard Deviation (y)**: 0.01
- **Variance (y)**: 0.0
- **Mean Percent Error Mfg. (y)**: nan
- **% Relative Standard Deviation (y)**: 412.311
- **MSE**: 0.0
- **Alpha**: 0.05
- **df**: (n - 2) = 16
- **t-value**: 2.12
- **Confidence Interval (y)**: 0.002 +/- 0.005
- **Confidence Interval Corrected Mfg. (y)**: 0.005 +/- 0.01
- **UCL**: 0.007
- **UCL Mfg. Corrected**: 0.015
- **LCL**: -0.003
- **LCL Mfg. Corrected**: -0.005
- **Prediction Interval (y)**: 0.002 +/- 0.022
- **One-sample Mfg. t-test**: t-statistic Mfg.=1.0, p-value=0.331332762038679
  - Reject Mfg. Ho (y\text{mean} = u): False

### Target 0.05 ppm Statistics

- **n**: 18
- **Min (y)**: 0.0
- **Max (y)**: 0.099
- **Mean (y)**: 0.037
- **Mean Corrected Mfg. (y)**: 0.075
- **Median (y)**: 0.041
- **Sample Standard Deviation (y)**: 0.031
- **Variance (y)**: 0.001
- **Mean Percent Error Mfg. (y)**: 49.778
- **% Relative Standard Deviation (y)**: 82.407
- **MSE**: 0.004
- **Alpha**: 0.05
- **df**: (n - 2) = 16
- **t-value**: 2.12
- **Confidence Interval (y)**: 0.037 +/- 0.015
- **Confidence Interval Corrected Mfg. (y)**: 0.075 +/- 0.031
- **UCL**: 0.052
- **UCL Mfg. Corrected**: 0.106
- **LCL**: 0.022
- **LCL Mfg. Corrected**: 0.044
- **Prediction Interval (y)**: 0.037 +/- 0.067
- **One-sample Mfg. t-test**: t-statistic Mfg.=1.663, p-value=0.1146697408872463
  - Reject Mfg. Ho (y\text{mean} = u): False

---

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-109
<table>
<thead>
<tr>
<th>Target</th>
<th>Statistics Description</th>
</tr>
</thead>
</table>
| 0.2 ppm         | n: 15  
|                 | Min (y): 0.0  
|                 | Max (y): 0.157  
|                 | Mean (y): 0.074  
|                 | Mean Corrected Mfg. (y): 0.148  
|                 | Median (y): 0.084  
|                 | Sample Standard Deviation (y): 0.047  
|                 | Variance (y): 0.002  
|                 | Mean Percent Error Mfg. (y): -25.933  
|                 | % Relative Standard Deviation (y): 63.27  
|                 | MSE: 0.011  
|                 | Alpha: 0.05  
|                 | df: (n - 2) = 13  
|                 | t-value: 2.16  
|                 | Confidence Interval (y): 0.074 +/- 0.026  
|                 | Confidence Interval Corrected Mfg. (y): 0.148 +/- 0.052  
|                 | UCL: 0.1  
|                 | UCL Mfg. Corrected: 0.2  
|                 | LCL: 0.048  
|                 | LCL Mfg. Corrected: 0.096  
|                 | Prediction Interval (y): 0.074 +/- 0.105  
|                 | One-sample Mfg. t-test: t-statistic Mfg.=-2.071, p-value=0.05736187942444087  
|                 | Reject Mfg. Ho (ymean = u): False  
| 0.981 ppm       | n: 15  
|                 | Min (y): 0.067  
|                 | Max (y): 0.53  
|                 | Mean (y): 0.387  
|                 | Mean Corrected Mfg. (y): 0.774  
|                 | Median (y): 0.443  
|                 | Sample Standard Deviation (y): 0.151  
|                 | Variance (y): 0.023  
|                 | Mean Percent Error Mfg. (y): -21.101  
|                 | % Relative Standard Deviation (y): 38.925  
|                 | MSE: 0.134  
|                 | Alpha: 0.05  
|                 | df: (n - 2) = 13  
|                 | t-value: 2.16  
|                 | Confidence Interval (y): 0.387 +/- 0.084  
|                 | Confidence Interval Corrected Mfg. (y): 0.774 +/- 0.168  
|                 | UCL: 0.471  
|                 | UCL Mfg. Corrected: 0.942  
|                 | LCL: 0.303  
|                 | LCL Mfg. Corrected: 0.606  
|                 | Prediction Interval (y): 0.387 +/- 0.336  
|                 | One-sample Mfg. t-test: t-statistic Mfg.=-2.571, p-value=0.022204446859427747  
|                 | Reject Mfg. Ho (ymean = u): True  

---

Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix C-110
# Target 4.937 ppm Statistics

- **n**: 15
- **Min (y)**: 1.89
- **Max (y)**: 2.529
- **Mean (y)**: 2.276
- **Mean Corrected Mfg. (y)**: 4.552
- **Median (y)**: 2.327
- **Sample Standard Deviation (y)**: 0.202
- **Variance (y)**: 0.041
- **Mean Percent Error Mfg. (y)**: -7.804
- **% Relative Standard Deviation (y)**: 8.866
- **MSE**: 0.311
- **Alpha**: 0.05
- **df**: (n - 2) = 13
- **t-value**: 2.16
- **Confidence Interval (y)**: 2.276 +/- 0.113
- **Confidence Interval Corrected Mfg. (y)**: 4.552 +/- 0.225
- **UCL**: 2.389
- **UCL Mfg. Corrected**: 4.777
- **LCL**: 2.163
- **LCL Mfg. Corrected**: 4.327
- **Prediction Interval (y)**: 2.276 +/- 0.45
- **One-sample Mfg. t-test**: t-statistic Mfg.=-3.572, p-value=0.003062435913069952
  - Reject Mfg. Ho (ymean = u): True

# Target 9.736 ppm Statistics

- **n**: 15
- **Min (y)**: 4.195
- **Max (y)**: 4.914
- **Mean (y)**: 4.596
- **Mean Corrected Mfg. (y)**: 9.192
- **Median (y)**: 4.623
- **Sample Standard Deviation (y)**: 0.22
- **Variance (y)**: 0.048
- **Mean Percent Error Mfg. (y)**: -5.59
- **% Relative Standard Deviation (y)**: 4.784
- **MSE**: 0.49
- **Alpha**: 0.05
- **df**: (n - 2) = 13
- **t-value**: 2.16
- **Confidence Interval (y)**: 4.596 +/- 0.123
- **Confidence Interval Corrected Mfg. (y)**: 9.192 +/- 0.245
- **UCL**: 4.719
- **UCL Mfg. Corrected**: 9.437
- **LCL**: 4.473
- **LCL Mfg. Corrected**: 8.947
- **Prediction Interval (y)**: 4.596 +/- 0.491
- **One-sample Mfg. t-test**: t-statistic Mfg.=-4.631, p-value=0.0003889027695753932
  - Reject Mfg. Ho (ymean = u): True
Appendix D: Test Cycle Graphs
All zero values on the x-axis and y-axis substituted with $0.001/\sqrt{2}$ to accommodate the log scale. Points within the bounds of the red box in the lower left corner should be considered equivalent to zero response.
Butyl Acrylate Calibrated Test Cycles

All zero values on the x-axis and y-axis substituted with $0.001/\sqrt{2}$ to accommodate the log scale. Points within the bounds of the red box in the lower left corner should be considered equivalent to zero response.
Vinyl Chloride Test Cycles

All zero values on the x-axis and y-axis substituted with $0.001/\sqrt{2}$ to accommodate the log scale. Points within the bounds of the red box in the lower left corner should be considered equivalent to zero response.
Vinyl Chloride Post-Butyl Acrylate Test Cycles

All zero values on the x-axis and y-axis substituted with $0.001/\sqrt{2}$ to accommodate the log scale. Points within the bounds of the red box in the lower left corner should be considered equivalent to zero response.
Isobutylene Test Cycles

All zero values on the x-axis and y-axis substituted with $0.001 / \sqrt{2}$ to accommodate the log scale. Points within the bounds of the red box in the lower left corner should be considered equivalent to zero response.
Isobutylene Calibration Test Cycles

All zero values on the x-axis and y-axis substituted with $0.001 \sqrt{2}$ to accommodate the log scale. Points within the bounds of the red box in the lower left corner should be considered equivalent to zero response.
Appendix E: Linear Regression Graphs
Butyl Acrylate Test Linear Regression

**AreaRAE Pro (PPB)**
- Regression Line: $y = 0.591x + 0.092$
- $R^2 = 0.999$
- $n = 57$

**AreaRAE (ER)**
- Regression Line: $y = 0.514x + 0.062$
- $R^2 = 0.973$
- $n = 45$

**MultiRAE Pro (ER)**
- Regression Line: $y = 0.502x - 0.037$
- $R^2 = 0.994$
- $n = 42$

**MultiRAE Pro (PPB)**
- Regression Line: $y = 0.515x - 0.063$
- $R^2 = 0.994$
- $n = 78$

**ppbRAE 3000**
- Regression Line: $y = 0.475x + 0.048$
- $R^2 = 0.999$
- $n = 102$
Butyl Acrylate Calibrated Test Linear Regression

**AreaRAE Pro (PPB)**
- Measurements
- Regression Line: $y = 1.02x + 0.22$
- $R^2 = 0.999$
- $n=57$

**AreaRAE (ER)**
- Regression Line: $y = 1.012x + 0.12$
- $R^2 = 0.999$
- $n=42$

**MultiRAE Pro (ER)**
- Regression Line: $y = 1.044x + 0.013$
- $R^2 = 0.999$
- $n=60$

**MultiRAE Pro (PPB)**
- Regression Line: $y = 1.04x + 0.047$
- $R^2 = 0.999$
- $n=57$

**ppbRAE 3000**
- Regression Line: $y = 1.052x - 0.029$
- $R^2 = 0.999$
- $n=57$
Vinyl Chloride Post-Butyl Acrylate Test Linear Regression

**AreaRAE Pro (PPB)**
- Regression Line: $y = 0.645x - 0.01$
- $R^2 = 0.998$
- $n = 60$

**AreaRAE (ER)**
- Regression Line: $y = 0.58x + 0.023$
- $R^2 = 0.979$
- $n = 51$

**MultiRAE Pro (ER)**
- Regression Line: $y = 0.666x - 0.062$
- $R^2 = 0.997$
- $n = 51$

**MultiRAE Pro (PPB)**
- Regression Line: $y = 0.629x - 0.02$
- $R^2 = 0.998$
- $n = 57$

**ppbRAE 3000**
- Regression Line: $y = 0.492x - 0.006$
- $R^2 = 1.0$
- $n = 57$
Isobutylene Test Linear Regression

**AreaRAE Pro (PPB)**
- Measurements
- Regression Line: $y = 0.975x + 0.251$
- $R^2 = 0.999$
- $n=90$

**MultiRAE Pro (ER)**
- Regression Line: $y = 1.36x - 0.974$
- $R^2 = 0.996$
- $n=90$

**MultiRAE Pro (PPB)**
- Regression Line: $y = 1.038x - 0.252$
- $R^2 = 0.989$
- $n=78$

**ppbRAE 3000**
- Regression Line: $y = 0.959x - 0.186$
- $R^2 = 0.99$
- $n=100$
Isobutylene Calibration Linear Regression

**AreaRAE Pro (PPB)**

- Measurements
- Regression Line: $y = 0.981x + 0.232$
- $R^2 = 0.997$
- $n = 96$

**AreaRAE (ER)**

- Regression Line: $y = 0.996x + 0.088$
- $R^2 = 0.998$
- $n = 95$

**MultiRAE Pro (ER)**

- Regression Line: $y = 0.997x + 0.017$
- $R^2 = 0.999$
- $n = 81$

**MultiRAE Pro (PPB)**

- Regression Line: $y = 0.963x + 0.045$
- $R^2 = 0.998$
- $n = 66$

**ppbRAE 3000**

- Regression Line: $y = 0.883x + 0.064$
- $R^2 = 0.997$
- $n = 88$
Appendix F: Data Log Graphs
Performance Assessment for the Monitoring of Butyl Acrylate and Vinyl Chloride in Air Using Honeywell PIDs
Appendix F-1
Butyl Acrylate Calibrated Test

Data from instrument data logs have not undergone full quality control checks. Instruments were data logged continually while powered on and may contain records that occurred during equipment configuration, maintenance tests, or are otherwise erroneous. These graphs are provided for cursory evaluation only and as an illustration of the instrument test cycle process.
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Data from instrument data logs have not undergone full quality control checks. Instruments were data logged continually while powered on and may contain records that occurred during equipment configuration, maintenance tasks, or are otherwise erroneous. These graphs are provided for cursory evaluation only and as an illustration of the instrument test cycle process. While 10 ppm butyl acrylate was inadvertently not supplied to the ppbRAE PID between instrument re-calibration and the vinyl-chloride post butyl acrylate exposure test, the test immediately prior was the butyl acrylate calibrated test.
Data from instrument data logs have not undergone full quality control checks. Instruments were data logged continually while powered on and may contain records that occurred during equipment configuration, maintenance tests, or are otherwise erroneous. These graphs are provided for cursory evaluation only and as an illustration of the instrument test cycle process.
Appendix G: Assessment
Temperature, Humidity, and Pressure Measurements
Table G.1 contains indoor ambient temperature, relative humidity, and barometric pressure measurements recorded inside the Centenary United Methodist Church (CUMC) located in East Palestine, Ohio, which was used as the East Palestine Train Derailment Forward Operating Base and to conduct the PID assessment.

Table G.1 Indoor Ambient Temperature, Relative Humidity, and Barometric Pressure Measurements

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<tr>
<th>Date</th>
<th>Time</th>
<th>Temp (F)</th>
<th>Relative Humidity (%)</th>
<th>Barometric Pressure (hPa)</th>
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<td>74.3</td>
<td>37.7</td>
<td>967.2</td>
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<td>73.3</td>
<td>41.5</td>
<td>968.3</td>
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<td></td>
<td>15:34</td>
<td>73</td>
<td>41.9</td>
<td>NR</td>
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<td>71.9</td>
<td>40.5</td>
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<td>72.7</td>
<td>41.8</td>
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<td>16:55</td>
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<td>37.5</td>
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<tr>
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<td></td>
<td>13:53</td>
<td>74.1</td>
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<td>987.5</td>
</tr>
</tbody>
</table>

NR=Not Recorded