PROPOSED SETTLEMENT AGREEMENT
BY AND BETWEEN
THE BAY AREA AIR QUALITY MANAGMENT DISTRICT
AND
CHEVRON PRODUCTS COMPANY
(Notice of Violation 56287)

I. **Background: Parties and Allegations**

1. The Bay Area Air Quality Management District ("Air District") is the regional governmental agency charged with the primary responsibility for maintaining healthy air quality in the San Francisco Bay Area. (Health & Saf. Code, §§ 39002, 40000 & 40200.)

2. The Air District alleges that, at all relevant times, Chevron Products Company, a division of Chevron U.S.A. Inc., ("Chevron") owned and operated a petroleum refinery located at 841 Chevron Way, Richmond, California, 94801 ("Facility"), and was subject to and violated Air District Regulations, as described in Notice of Violation ("NOV") 56287, which is, by this reference, incorporated into this Settlement Agreement.

II. **Terms and Conditions**

3. In consideration of the foregoing, and of the promises set forth herein, the Air District and Chevron (collectively, the "Parties," and individually, "Party") desire to settle and resolve all claims, disputes, and violations arising from the same facts and circumstances alleged in NOV No. 56287 and voluntarily agree to resolve this matter by means of this Settlement Agreement. Therefore, in order to resolve NOV No. 56287, Chevron has taken, or agrees to take, the actions enumerated in this Settlement Agreement, the Air District agrees to accept this Settlement Agreement in termination and full settlement of this matter, and not to file a legal action against Chevron and its beneficiaries, predecessors, successors, assigns, partners, partnerships, parent companies, subsidiaries, affiliates and related entities, officers, directors, principals, agents, servants, employees, and representatives, and the Parties agree to the terms in this Settlement Agreement. Chevron's entry into this Agreement is not and shall not be construed as an admission of any liability, or wrongdoing or responsibility, with respect to violation of any rule, law, statute, policy or regulation.

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4. Civil Penalty. Chevron shall pay the Air District a civil penalty in the amount of one hundred thousand dollars ($100,000) no later than 30 calendar days after the full execution of this Settlement Agreement. Chevron shall pay the civil penalty by wire, in accordance with wiring instructions provided by the Air District, with "NOV No. 56287" in the memo. Upon wiring the payment, Chevron shall notify the Air District via email. If the Air District does not receive the payment, the Air District shall notify Chevron via email, and Chevron shall, within 3 business days of the date such notice is sent, re-send the payment according to this Paragraph 4, and this process shall be repeated as needed until the Air District receives the payment. Chevron shall be responsible for all payment processing, check cancellation, and other fees or costs associated with carrying out this Paragraph 4.

5. Approvable Fenceline Air Monitoring Plan and Hydrogen Sulfide Monitoring Compliance Measures.

a) The Air Monitoring Plan (AMP), Quality Assurance Project Plan (QAPP), and Standard Operating Procedures (SOP) (collectively, the Fenceline Air Monitoring Plan, or FAMP) attached hereto as Attachment A is hereby approved as Chevron's Plan for purposes of compliance with Air District Regulation 12-15-403.

b) With respect to hydrogen sulfide air monitoring at the Facility, Chevron shall utilize point monitors in lieu of open path monitors for purposes of compliance with Rule 12-15, in accordance with the following provisions:

i) Chevron shall operate a minimum of four point monitors at or near the fenceline of the Facility. Each point monitor operated pursuant to this provision shall meet a minimum detection limit of less than or equal to 5 ppb and shall have a measurement error no greater than 20% at a concentration of 50 ppb. Chevron may meet this requirement by doing one of the following:

1) Incorporating the Ground Level Monitors (GLMs) it currently operates pursuant to Rule 9-2 into its fenceline monitoring program, in which case those GLMs shall be counted toward meeting the minimum of four monitoring locations specified in Paragraph 5.b.i, and installing a fourth point monitor in the area of the Facility property between

the Castro and Golden Gate GLMs, and in close proximity to measurement path E (see Figure 3.4 on page 16 of the AMP); or

2) Purchasing, installing, and operating four new point monitors at or near the fenceline of the Facility. One of those monitors shall be located in the area of the Facility property between the Castro and Golden Gate GLMs, and in close proximity to measurement path E (see Figure 3.4 on page 16 of the AMP). The other three monitors shall be placed at locations approved by the Air District pursuant to Paragraph 5.b.ii and demonstrated by Chevron to maximize the likelihood of detecting hydrogen sulfide plumes that may cross the Facility fenceline into the surrounding communities.

ii) In complying with Paragraph 5.b, Chevron shall comply with the following timelines:

1) No later than 7 calendar days after the full execution of this Settlement Agreement, Chevron shall notify the Air District, in writing, which option it selects from Paragraph 5.b.i.

2) No later than 30 days after the full execution of this Settlement Agreement, and before purchasing new monitoring equipment under Paragraph 5.b.i, Chevron shall submit to the Air District for approval a written description of the proposed equipment and proposed precise monitoring locations. If Chevron elects to satisfy the minimum monitoring requirement according to the provisions of Paragraph 5.b.i.2, this written submittal shall also include a demonstration that the proposed monitoring locations maximize the likelihood of detecting hydrogen sulfide plumes that may cross the Facility fenceline into the surrounding communities.

3) No later than 240 days after receiving the Air District's approval of the proposed monitoring equipment and locations under Paragraph 5.b.ii.2, Chevron shall install and begin operating the point monitors at the monitoring locations as approved by the Air District.

4) No later than 90 days after the full execution of this Settlement Agreement, Chevron shall submit a revised FAMP to the Air District, in writing, for

review and approval that makes all updates needed to include the monitors required under Paragraph 5.b. in Chevron's FAMP. Chevron may, at the same time and in the same document, propose any minor or nonsubstantive and approvable modifications to the FAMP that may be needed to make the FAMP consistent with this Settlement Agreement. Chevron shall also include in the revised FAMP any information the Air District determines is needed within 30 days of receiving notice of a required change from the Air District. The Air District shall approve or disapprove these FAMP changes by issuing a written approval or disapproval under this Settlement Agreement instead of under the process set out in Air District Regulation 12-15-404.

6. Injunctive Measures. Chevron agrees to fully implement all of the measures in this Paragraph 6 for the Facility by the dates specified below.

a) Data Public Access Improvements. Chevron shall provide the public, via www.richmondairmonitoring.org ("Website"), open access to all of the data in Paragraph 6.a.i, both by manual download and through an application programming interface (API). With respect to data from all monitors that are operating as of the date of execution of this Settlement Agreement, Chevron shall provide open access by no later than four months after the full execution of this Settlement Agreement. With respect to data from any new point monitors being installed pursuant to Paragraph 5.b, Chevron shall provide open access by no later than 30 days after the date such point monitors begin operation.

i) Data to be provided in accordance with Paragraph 6.a:

1) Preliminary 5-minute average concentration data and final quality-assured historical 5-minute average concentration data from the fenceline monitoring systems subject to Rule 12-15, including all of the point monitors installed and operated pursuant to Paragraph 5.b of this Settlement Agreement, for all pollutants covered by the FAMP approved under Paragraph 5 of this Settlement Agreement ("Fenceline Monitoring Data");

2) Preliminary and final quality-assured 5-minute average concentration data collected by Chevron's Community Monitoring Stations owned or operated by Chevron at any time this Settlement Agreement is in effect (Community Air Monitoring

Data), and by Chevron's ground level monitors (GLMs) for purposes of compliance with Air District Rules 9-1 and 9-2 (GLM Data); and

3) Geospatial data representing:

a. The Facility property boundary,

b. The locations of all analyzers, reflectors, meteorological stations, and other monitors covered by the FAMP approved under Paragraph 5 of this Settlement Agreement,

c. The location of all GLMs installed and operated pursuant to Air District Rules 9-1 and 9-2, and

d. The Community Monitoring Stations owned or operated by Chevron at any time this Settlement Agreement is in effect.

ii) The data required under Paragraph 6.a.i, above, shall be provided as described below, as applicable:

1) For all Fenceline Monitoring Data, GLM data, Community Monitoring Station Data, and geospatial data, Chevron shall provide:

a. A data dictionary that identifies and describes each field and its data type, and also identifies the API field name (if different than the display name or label), and

b. API documentation that explains how to use the API and its services.

2) For preliminary and final 5-minute average concentration data:

a. Preliminary 5-minute average concentration data shall be made available in near real time, consistent with the procedures in the FAMP approved pursuant to Paragraph 5 of this Settlement Agreement, and shall be updated at least every five minutes,

b. Final quality-assured data for each calendar quarter shall be made available no later than 90 days following the end of each respective quarter,

c. The preliminary and final quality-assured Fenceline Monitoring Data shall be provided together in a single data set such that once the final quality assured data are available for a given calendar quarter, the final quality assured data will replace the corresponding preliminary data records, and

d. Notwithstanding the replacement of preliminary data with final quality assured data as described in Paragraph 6.a.ii.2.c, all Fenceline Monitoring Data, Community Monitoring Station Data, and GLM Data made publicly available on the Website shall remain available for no less than five years.

e. Manually downloaded concentration data must be made available in at least comma separated value (CSV) and extensible markup language (XML) formats, and

f. Concentration data accessed through an API endpoint must be made available in at least CSV and JavaScript Object Notation (JSON) formats.

3) For Geospatial data:

a. Geospatial data shall be updated as necessary to maintain consistency with all installed equipment,

b. Manually downloaded geospatial data must be made available in at least CSV, shapefile, and GeoJSON formats, and

c. Geospatial data accessed through an API must be made available in at least CSV, JSON, and GeoJSON formats.

iii) For each type of data required, Chevron shall provide the information outlined below, as applicable:

1) For Fenceline Monitoring Data, Chevron shall provide the following information for each instrument/parameter combination:

a. facility_name – the name of the facility where the equipment is located,

b. instrument_id – a unique identification number assigned to a given instrument,

c. instrument – a short descriptive name for the instrument associated with the specified instrument identification number,

d. parameter – the name of the pollutant being measured and reported,

e. date – the date of measurement, reported in Pacific Standard Time and formatted as "yyyy-mm-dd",

f. time – the hour of the day and the beginning of the five-minute period over which measurements were collected and averaged, reported in Pacific Standard Time (without any adjustments for daylight savings time) and formatted as "hh:mm" using 24-hour notation,

g. mean concentration – the arithmetic mean pollutant concentration measured over the corresponding averaging period; for measurements below the minimum detection limit, the mean concentration must be reported as a numeric value based on the actual values returned by the instrument during the corresponding averaging period,

h. units_of_measure – the units of measure corresponding to reported mean concentration,

i. averaging_period – the averaging period (in minutes) for the reported mean pollutant concentration,

j. observation_count – the number of values that comprise the reported mean concentration,

k. validity_indicator – an indicator ("Y" or "N") representing whether the reported mean concentration represents a valid air measurement,

l. QC_code – the QC code (as described in the QAPP) assigned to the corresponding measurement,

m. OP_code – the OP code (as described in the QAPP) assigned to the corresponding measurement,

n. max_value – the maximum individual concentration measured during the corresponding averaging period, reported in the same units of measure as the mean concentration,

o. mdl – the real-time minimum detection limit (for the TDLAS open-path data only),

p. signal – the average measured light signal for the corresponding averaging period,

q. signal_units – the units of measure for the corresponding light signal measurement,

r. final_data – an indicator ("Y" or "N") indicating wither the data record reflects final quality assured data, and

s. change_log – a text field describing any changes made to the corresponding data record and the dates of any such changes.

2) For GLM Data, Community Monitoring Station Data, and Fenceline Monitoring Data from point monitors, Chevron shall provide all of the information specified in Paragraph 6.a.iii.1. except for the "signal," and "signal_units" fields and, in the case of Community Monitoring Station Data, the "max_value" field.

3) For geospatial data representing fenceline monitoring, Community Monitoring Station, or GLM equipment, Chevron shall provide the following information:

a. facility_name – the name of the facility where the equipment is located,

b. instrument_id – a unique identification number assigned to a given instrument,

c. instrument – a short descriptive name for the instrument associated with the specified instrument identification number, including whether points represent an open path analyzer or reflector,

d. parameters – the name of the pollutants being measured and reported by the instrument,

e. latitude – (for point data) the latitude of the location in decimal degrees, and

f. longitude – (for point data) the longitude of the location in decimal degrees.

iv) Subject to Paragraph 6.a.iii, above, for records in the Fenceline Monitoring Data, Community Monitoring Station Data, and GLM Data with missing pollutant concentrations, Chevron shall populate the following fields with their respective values and all remaining fields shall be populated with a value of "NA":

a. facility_name,

b. instrument_id,

c. instrument,

d. parameter,
e. date,
f. time,
g. QC_code, and
h. OP_code.

b) Public Reports. Chevron shall post quarterly summary reports on its Website within 60 days of the end of each calendar quarter, beginning with the second quarter of 2025, that include a narrative description of the observed concentration data in comparison to historical observations and health-based thresholds, the results of any QA/QC activities or checks, and summaries of all instrument downtime and other periods without valid concentration data. Chevron shall post on the Website the quarterly summary reports for download; provided, however, that, if a member of the public or the Air District should request a report greater than five years after it is initially posted, it may not be available to them and no liability or stipulated penalty shall be due from Chevron under Paragraph 8 of this Settlement Agreement. The first quarterly report, to be posted by August 29, 2025, shall reflect data from the second quarter of 2025 only for the monitors that are operating as of the date of execution of this Settlement Agreement. Beginning with the report submitted 60 days after the end of the quarter in which any new point monitors begin operation pursuant to Paragraph 5.b, quarterly reports shall also reflect data from the new point monitors.

c) Public Meeting. Chevron shall hold a public meeting to solicit feedback on improvements to data access and visualization from fenceline air monitoring systems, GLMs, and Community Monitoring Stations owned or operated by Chevron at any time this Settlement Agreement is in effect. The public meeting shall be held in a hybrid format that allows members of the public to participate in person or virtually by video conference or a telephone call-in number. This public meeting shall be held before the end of calendar year 2025 at a location in Richmond, California and be scheduled for a weekday (Monday through Friday) from 6 to 8 pm Pacific time. Chevron shall provide notice of this meeting to the public in at least English and Spanish at least 30 days prior to the date of the meeting via one or more local newspapers, on social media, via email to interested parties known to Chevron, and via radio advertisements.

Chevron shall provide a copy of the notice of this meeting to the Air District for distribution at least 35 days prior to the date of the meeting. The meeting notice shall include, or reference a website location that includes at the top of the webpage, at a minimum, the following: the meeting date, time, location; a statement that the purpose of the meeting is to solicit feedback on improvements to data access and visualization from the fenceline air monitoring systems and GLMs; ways of participating in the meeting (e.g., in person, by video conference; telephone); how comments can be submitted (e.g., at the meeting or in writing afterward by email); the deadline for written comments to be submitted after the meeting; contact information for questions and comments; how to request translation or accessibility services in advance of the meeting; and a statement that this meeting is being held because of a settlement with the Air District.

At the meeting, Chevron shall provide a presentation on its current monitoring program and related requirements, and any actions Chevron has taken or plans to improve monitoring, and answer questions. Chevron shall offer the community an opportunity to provide both verbal and written public comment, at the meeting and for at least 30 days after the meeting.

After the meeting, Chevron shall prepare and publish on the Website a written summary of the public comments provided by community members, Chevron's responses, and of the meeting. No later than 90 days after the meeting, Chevron shall consider the comments provided by members of the community and produce and publish on the Website a report that summarizes the comments and Chevron's responses thereto, including any improvements that will be made in response to such comments and a schedule for implementation of any such improvements.

7. <u>Stipulated Penalties</u>. Chevron shall pay the Air District stipulated penalties, as applicable, as laid out in this Paragraph 8. Stipulated penalties shall be paid by wire, in accordance with wiring instructions provided by the Air District, with "NOV No. 56287" in the memo. Upon wiring the payment, Chevron shall notify the Air District via email. If the Air District does not receive the payment, the Air District shall notify Chevron via email, and Chevron shall, within 3 business days of the date such notice is sent, re-send the payment according to this Paragraph 8, and this process shall be repeated as needed until the Air District

receives the payment. Chevron shall be responsible for all payment processing, check cancellation, and other fees or costs associated with carrying out this Paragraph 8. Each stipulated penalty is cumulative and in addition to any other applicable stipulated penalty or any other payment required by this Settlement Agreement.

a) If Chevron fails to pay the civil penalty in accordance with Paragraph 4, Chevron shall pay the Air District $2,000 for each day on which it fails to pay the civil penalty in accordance with Paragraph 4.

b) If Chevron fails to submit to the Air District information as required in Paragraphs 5.b.ii.1 or 5.b.ii.2, such as if Chevron fails to submit on time or submits materially unapprovable submissions, Chevron shall pay the Air District $2,500 for each day on which Chevron fails to submit information as required by Paragraphs 5.b.ii.1 or 5.b.ii.2. If Chevron fails to operate one or more of the monitors in accordance with Paragraph 5.b.ii.3 and the FAMP, Chevron shall pay the Air District $5,000 for each day on which it fails to operate one or more of the point monitors in accordance with Paragraph 5.b and the FAMP, provided, however, that no such stipulated penalty shall be due in the event that the inability to operate one or more of the point monitors in accordance with Paragraph 5.b is due to an act of God or other unforeseeable event outside of Chevron's control. If Chevron fails to submit a revised FAMP as required under 5.b.ii.4, Chevron shall pay the Air District $2,500 for each day on which it fails to submit a revised FAMP in accordance with Paragraph 5.b.ii.4.

c) In the event the Air District determines that Chevron's implementation of the measures described in Paragraph 6.a. of this Settlement Agreement do not meet the requirements of this Settlement Agreement and the Air District wishes to seek stipulated penalties, the Air District may provide notice to Chevron of the nature of the deficiency and the particular provision of this Settlement Agreement that the Air District alleges Chevron did not meet, and an opportunity for Chevron to cure any such deficiency, which period shall not exceed thirty (30) days, except upon advance Air District written approval and for good cause. If Chevron does not know how to cure the identified deficiency, Chevron may seek guidance from the Air District. If Chevron fails to deliver to the Air District, via email, proof that it has cured any such deficiency by 11:59 pm pacific time on the thirtieth day of the 30-day cure period, or by 11:59 pm pacific time on the last day of the alternative period approved by the Air District in advance in writing, Chevron shall pay the Air District stipulated penalties of $5,000 for each day on which Chevron failed to comply with Paragraph 6.a., as determined by the Air District, including any time of deficiency during the cure period.

In the alternative, Chevron may dispute the assertion of any deficiency in Chevron's implementation of the measures described in Paragraph 6.a. of this Settlement Agreement by delivering written notice to the Air District identifying the specific deficiency it disputes. The Air District and Chevron shall meet and confer within fourteen (14) days of Chevron's delivery of such notice to discuss: (i) the nature of the alleged deficiency, and (ii) the bases for both Parties' assertions as to why it is or is not a deficiency. After meeting and conferring, the Air District shall consider, in good faith, Chevron's notice and information provided, and shall determine, in its sole discretion, if a deficiency did in fact occur, in which case Chevron shall pay the Air District $5,000 for each day on which it failed to comply with Paragraph 6.a. of this Settlement Agreement, as determined by the Air District, including any time of deficiency during the dispute period.

Chevron may withdraw its dispute at any time until the Air District has made a final determination, but, in that case, shall pay the Air District $5,000 for each day on which it failed to comply with Paragraph 6.a., including any time of deficiency during the dispute period. If Chevron pursues a spurious dispute, or continues a dispute after, or in spite of, realizing a deficiency exists or after curing the deficiency, Chevron shall pay the Air District $10,000 for each day on which it failed to comply with Paragraph 6.a., including the dispute period, even if the deficiency was cured.

d) If Chevron fails to establish and maintain the Website required under Paragraph 6.a, Chevron shall pay the Air District $1,000 for each day on which it fails to establish and maintain the Website required under Paragraph 6.a., provided, however, that no such stipulated penalty shall be due in the event that the inability to establish or maintain the Website is due to an act of God or other, similar unforeseeable event outside of Chevron's control, including technical difficulties associated with the server or domain that is hosting the Website, the cloud host for the data management system (DMS), the DMS itself and any associated web application (WebApp) that presents data on the website, and/or unavailability of internet connectivity.

e) If Chevron fails to post quarterly summary reports as required under Paragraph 6.b, Chevron shall pay the Air District $1,000 for each day on which it fails to post quarterly summary reports as required under Paragraph 6.b.

f) If data and quarterly summary reports are not reported on the Website for at least 5 years from the date they were first posted, or the data and reports are not capable of manual download or access through an open API, Chevron shall pay $500 for each day on which data and quarterly summary reports are not posted on the Website for at least 5 years from the date they were first published, or the data and reports are not capable of manual download or access through an open API; provided, however, that no such stipulated penalty shall be due in the event that the inability to post such reports on the Website or to download or access a report via an API is due to an act of God or other, similar unforeseeable event outside of Chevron's control, including technical difficulties associated with the availability of information through any server on which such information is maintained, the domain that is hosting the Website, the cloud host for the DMS, the DMS itself and any associated WebApp that presents data on the website, and/or the unavailability of internet connectivity to such server or the end-user seeking to download such information.

g) If Chevron fails to notice or hold a public meeting as required by Paragraph 6.c, Chevron shall pay the Air District $500 for each day on which it fails to notice or hold a public meeting as required by Paragraph 6.c., and Chevron shall conduct a public meeting again no later than 30 days after the first one and in accordance with the requirements of Paragraph 6.c.

h) If Chevron fails to offer the community an opportunity to comment in accordance with the requirements of Paragraph 6.c, fails to prepare and publish on the Website a written summary or report, as required by Paragraph 6.c, Chevron shall pay $5,000 for each day on which it fails to offer the community an opportunity to comment in accordance with the requirements of Paragraph 6.c, or fails to prepare and publish on the Website a written summary or report, as required by Paragraph 6.c.

8. Chevron's failure to perform any of the terms or conditions of this Settlement Agreement will render Chevron in violation of the terms and conditions of this Settlement Agreement, and the Air District may, at its sole discretion, void this agreement, with written notice to Chevron, or take any other legal action allowed to it by law or equity. The failure to enforce any provision of this Settlement Agreement shall not be construed as a waiver of any such provision, nor prevent such Party thereafter from enforcing such provision or any other provision of this Settlement Agreement. The rights and remedies granted all Parties herein are cumulative and the election of one right or remedy by a Party shall not constitute a waiver of such Party's right to assert all other legal remedies available under this Settlement Agreement or otherwise provided by law.

9. Unless otherwise specified in this Settlement Agreement, whenever notice, submissions, or communications are required by or related to this Settlement Agreement, they shall be submitted in writing to the address or email below, as applicable:

As to the Air District:
Bay Area Air Quality Management District
Alexandra Kamel
Senior Assistant Counsel
375 Beale Street, Suite 600
San Francisco, CA 94105
akamel@baaqmd.gov

As to Chevron:
Brian J. Faulkner
Senior Counsel
Chevon Products Company
841 Chevron Way, Richmond, California, 94801
Brian.Faulkner@chevron.com

Each of the Parties may, by advance written notice to the other Party, change its designated notice recipient or notice address provided above. Notices submitted pursuant to this section shall be deemed submitted upon emailing or five days from mailing, as applicable.

10. In consideration of full payment of the civil penalty and the completion of all other requirements in this Settlement Agreement, the Air District hereby releases Chevron and its

principals, officers, receivers, trustees, successors and assignees, subsidiary and parent corporations, from any claims the Air District may have based on the allegations in Paragraph 3, above, except that the Air District reserves the right to:

a) Take action to enforce this Settlement Agreement;

b) Take future enforcement actions arising out of violations not explicitly covered by this Settlement Agreement;

c) Demand increased penalties in connection with any future alleged violations; and

d) Rely upon the alleged violations described in Paragraph 3 above, and offer proof thereof in connection with any other administrative or judicial proceeding not related to this proceeding for the purpose of showing a history of violation.

11. Chevron reserves the rights to challenge an increase in penalties in connection with any future alleged violations and to contest any offers of proof and present any evidence disputing the events or allegations described in Paragraph 3 above.

12. The Superior Court of California, located in the County of San Francisco, shall hear any dispute between the Parties arising from this Settlement Agreement.

13. This Settlement Agreement shall be interpreted and enforced in accordance with the laws of the State of California, without regard to California's choice-of-law rules.

14. Any rule of construction to the effect that ambiguities are to be resolved against the drafting party shall not be applied in interpreting this Settlement Agreement.

15. This Settlement Agreement is not a permit, or a modification of any permit, under any federal, State, or local laws or regulations. Chevron is responsible for achieving and maintaining compliance with all applicable federal, State, and local laws, regulations, and permits; and Chevron’s compliance with this Settlement Agreement shall not be a defense to any action commenced pursuant to any such laws, regulations, or permits. The Air District does not, by its execution of this Settlement Agreement, warrant or aver in any manner that Chevron’s compliance with any aspect of this Settlement Agreement will result in compliance with any provisions of federal, State, or local laws, regulations, or permits, except Air District Regulation

12-15-403.

16. The Parties agree that the penalties described in this Settlement Agreement are non-dischargeable under United States Code, title 11, section 523(a)(7), which provides an exception from discharge for any debt to the extent such debt is for a fine, penalty, or forfeiture payable to and for the benefit of a governmental unit.

17. The settlement of the allegations in Paragraph 3 without further litigation is fair, reasonable, and in the interests of the Parties and the public. The Parties have participated fully in the review and drafting of this Settlement Agreement; understand and accept all terms; enter into this Settlement Agreement freely and voluntarily; have had an opportunity to consult with legal counsel; are fully informed of the terms and effect of this Settlement Agreement; have agreed to this Settlement Agreement after independent investigation and agree it was not arrived at through fraud, duress, or undue influence; and knowingly and voluntarily intend to be legally bound by this Settlement Agreement.

18. Each provision of this Settlement Agreement is severable, and in the event that any provision, or part thereof, of this Settlement Agreement is held to be illegal, invalid or unenforceable in any jurisdiction, the remainder of this Settlement Agreement remains in full force and effect.

19. This Settlement Agreement constitutes the entire agreement and understanding between the Parties, and fully supersedes and replaces any and all prior negotiations and agreements of any kind or nature, whether written or oral, between the Parties, concerning the allegations in Paragraph 3 above.

20. No agreement to modify, amend, extend, supersede, terminate, or discharge this Settlement Agreement, or any portion thereof, shall be valid or enforceable unless it is in writing, signed by all the Parties, and dated after the date of the full execution of this Settlement Agreement.

21. This Settlement Agreement may be executed in counterparts. Electronic, facsimile, and photocopied signatures shall be considered as valid signatures.

22. Upon execution by both Parties, this Settlement Agreement shall become final and

binding upon Chevron and any of its principals, officers, receivers, trustees, successors and assignees, subsidiary and parent corporations, and upon the Air District and any successor agency that may have responsibility for and jurisdiction over the subject matter of this Settlement Agreement.

23. The pieces of this Settlement Agreement shall terminate as follows:

a) This Settlement Agreement, except for the FAMP approved under Paragraph 5.a. or 5.b.ii.4 of this Settlement Agreement, whichever is later, shall terminate upon the earlier of: (a) three years from the date of full execution of this Settlement Agreement, or (b) the date on which the Air District approves a revised AMP, QAPP, and SOPs submitted by Chevron in response to the Air District adopting a new or revised rule or Guidelines.

b) The FAMP approved under Paragraph 5.a or 5.b.ii.4 of this Settlement Agreement, whichever is later, shall remain in effect and Chevron shall continue operating the monitors required under Paragraph 5.b. and reporting the data in accordance with Paragraph 6.b. until the Air District approves a revised AMP, QAPP, and SOPs submitted by Chevron in response to the Air District adopting a new or revised rule or Guidelines, or until the Air District approves a revised AMP, QAPP, and SOPs submitted by Chevron as otherwise required by Air District Regulation 12-15 or the Guidelines adopted pursuant thereto, including prior to adoption of a new or revised rule or Guidelines.

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Each of the undersigned expressly represents that he or she is authorized to execute this Settlement Agreement on behalf of, and to bind, the Party for whom he or she signs below.

SO AGREED, STIPULATED AND EXECUTED:

BAY AREA AIR QUALITY
MANAGEMENT DISTRICT
375 Beale Street, Suite 600
San Francisco, California 94105

By: Signed by:
98506AF9981D4CC...
Philip M. Fine
EXECUTIVE OFFICER/APCO

Date: 6/9/2025

CHEVRON PRODUCTS COMPANY,
A DIVISION OF CHEVRON U.S.A. INC.
841 Chevron Way
Richmond, California, 94801

By: Signed by:
CCB463F27420406...
Scott M. Banks
Assistant Secretary

Date: 2025-Jun-09 | 2:20 PM PDT

APPROVED AS TO FORM BY:
BAY AREA AIR QUALITY
MANAGEMENT DISTRICT
375 Beale Street, Suite 600
San Francisco, California 94105

By: DocuSigned by:
Alexander Crockett
6DC7110552B5451...
ALEXANDER CROCKETT
GENERAL COUNSEL
ALEXANDRA KAMEL
SENIOR ASSISTANT COUNSEL

Date: 6/9/2025

ATTACHMENT A

Fenceline Air Monitoring Plan

For BAAQMD Rule 12-15

Chevron Richmond Refinery

Revision 6

May 30, 2025

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Document Control

Document	Rev. No.	Rev. Date	Effective Date	Distribution	Description
AMP	0	12/7/2018	12/7/2018	Program Manager, Project Manager, Data Manager, Field Technician Supervisor, Information Technology Manager, BAAQMD	Original submission.
AMP	1	6/1/2022		Program Manager, Project Manager, Data Manager, Field Technician Supervisor, Information Technology Manager, BAAQMD	Addressing BAAQMD comments, including addition of Tunable Diode Laser measurements of H_2S
AMP	2	2/16/2023		Program Manager, Project Manager, Data Manager, Field Technician Supervisor, Information Technology Manager, BAAQMD	Addressing BAAQMD comments on Revision 1; the original submission of Rev. 2 on 11/2/2022 was rescinded and modified
AMP	3	9/5/2023		Program Manager, Project Manager, Data Manager, Field Technician Supervisor, Information Technology Manager, BAAQMD	Revised in response to July 19, 2023, comments from BAAQMD
AMP	4	2/13/2024		Program Manager, Project Manager, Data Manager, Field Technician Supervisor, Information Technology Manager, BAAQMD	Revised in response to October 19, 2023, comments from BAAQMD
AMP	5	10/31/2024		Program Manager, Project Manager, Data Manager, Field Technician Supervisor, Information Technology Manager, BAAQMD	Revised in response to June 21, 2024, comments from BAAQMD
AMP	6	5/30/2025		Program Manager, Project Manager, Data Manager, Field Technician Supervisor, Information Technology Manager, BAAQMD	Revised in response to May 7, 2025, comments received from BAAQMD

List of Acronyms

BAAQMD – Bay Area Air Quality Management District

BTEX – Benzene, Toluene, Ethylbenzene, Xylenes

CFR – Code of Federal Regulations

CHS – Contra Costa County Health Services

COES – California Governor’s Office of Emergency Services

CWS – Contra Costa County Community Warning System

DMS – Data Management System

EBV – Emergency Block Valves

EPA – Environmental Protection Agency

FTIR – Fourier Transform Infrared

GC-PID – Gas Chromatograph followed by Photoionization Detector

GLM – Ground Level Monitor required by Rules 9-1 and 9-2

H_2S – Hydrogen Sulfide

IR – Infrared Light

LFL/LEL – Lower Flammability Limit/Lower Explosive Limit

OEHHA – California Office of Environmental Health Hazard Assessment

PMT - Photomultiplier Tube

ppb – Parts Per Billion

ppm – Parts Per Million

QA/QC – Quality Assurance / Quality Control

QAPP – Quality Assurance Project Plan

RCAMP – Richmond Community Air Monitoring Program

REL – Reference Exposure Level; RELs used are from OEHHA (http://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary)

RLOP – Richmond Lube Oil Project

SO_2 – Sulfur Dioxide

TDL – Tunable Diode Laser

TRI – Toxic Release Inventory

UV-DOAS – Ultraviolet Differential Optical Absorption Spectroscopy

UV – Ultraviolet

Section 1. Overview

On April 20, 2016, the Bay Area Air Quality Management District (BAAQMD) published guidelines containing criteria for an approvable Air Monitoring Plan, required by BAAQMD Rule 12-15 Section 403. On October 6, 2021, the BAAQMD provided updated requirements for refineries to conduct additional monitoring of hydrogen sulfide (H_2S) concentrations along refinery fenceline paths, and to implement this enhanced monitoring by January 1, 2023. On December 22, 2022, the BAAQMD revised the requirements for H_2S monitoring. The additional H_2S monitoring was operational on January 1, 2023. BAAQMD issued updated specifications on December 22, 2022, and Chevron's response to the updated specifications was submitted on February 17, 2023. This revision addresses feedback from BAAQMD received July 19, 2023, October 19, 2023, June 21, 2024, and May 7, 2025.

The Chevron Richmond Refinery (Chevron) has followed these guidelines to generate the Air Monitoring Plan (this document) in November of 2020, and has updated the Air Monitoring Plan and the Quality Assurance Project Plan (QAPP, located in Appendix B) to account for the H_2S requirements. As presented in "Air Monitoring Guidelines for Petroleum Refineries, AIR DISTRICT REGULATION 12, RULE 15: PETROLEUM REFINING EMISSIONS TRACKING," the key elements of the BAAQMD guidelines (Guidelines) are as follows (Bay Area Air Quality Management District, 2016):

Element #1 – Gases Requiring Monitoring

Refinery operators must measure benzene, toluene, ethylbenzene, and xylenes (BTEX) and H_2S concentrations at refinery fencelines with technology capable of measuring in the parts-per-billion (ppb) range.

Element #2 – Other Gases to Be Considered for Measurements

Measurement of sulfur dioxide (SO_2), alkanes, or other organic compound indicators, 1,3-butadiene, and ammonia concentrations are to be considered in the Air Monitoring Plan. Refinery operators must provide a rationale in the Air Monitoring Plan for not measuring all the above compounds. The rationale must address the following:

- Why these compounds are not contained in the compositional matrix of emissions
- Why these compounds are not at expected concentrations measured by available equipment
    - Address the technical or other considerations that make specific measurements inappropriate or unavailable.

Element #3 – Fenceline Coverage

For refineries that do not have open-path monitoring capabilities in place, measurements must cover populated areas within 1 mile of the refinery fenceline likely to be affected when the annual mean wind direction lies in an arc within 22.5 degrees of a direct line from source to receptors 10% of the time, or greater, based on the most representative meteorological measurements for sources likely to emit the compounds listed above at the refinery. In addition, the monitoring plan should take into consideration seasonal and short-term meteorological events. Refineries that already have open-path monitoring capabilities in place need only provide verification that current systems adequately address population requirements.

Element #4 – Sample Time Resolution and Data Completeness

Open-path fenceline measurements must be continuously measured with a time resolution of five minutes. If this is not the case, refinery operators must provide rationale in the Air Monitoring Plan for lesser time resolutions based on equipment or other operational limitations. Instruments are operated to meet a minimum of 75% completeness on an hourly basis, 90% of the time based on annual quarters. Atmospheric conditions beyond the control of the refinery that affect accurate measurements, such as dense fog, shall not be counted against data completeness calculations.

Element #5 – Data Presentation to the Public

Measurements must be provided to the public on a real-time basis, with appropriate Quality Assurance/Quality Control (QA/QC) measures taken to provide assurance of data accuracy.

Element #6 – Develop a Quality Assurance Project Plan

A QAPP that follows U.S. Environmental Protection Agency (EPA) guidelines must be developed that outlines QA/QC parameters.

Chevron’s policy is to comply with all local and federal environmental regulations, including the fenceline monitoring provisions of BAAQMD Rule 12-15. In accordance with Rule 12-15-403, Chevron’s goal is to provide the BAAQMD with an approvable Air Monitoring Plan (Plan) and QAPP, and then operate and install systems in accordance with the plans.

Section 2. Chevron’s Existing Fenceline and Community Monitoring

As of the establishment of Rule 12-15, the Richmond refinery was operating 3 open-path fenceline monitors and 3 community monitors as part of the Richmond Community Air Monitoring Program (RCAMP). The fenceline monitors have been in operation since 2013 and the community monitors have been in operation since 2014. Siting of the fenceline and community monitors and the compounds to be monitored were subject to City of Richmond approval. Site locations for the fenceline equipment were selected to strategically position the fenceline monitors using predominant and variable meteorological conditions and topographical terrain features within and near the refinery.

The fenceline and community monitoring sites were selected with the following considerations, consistent with guidance from EPA and CARB. Environmental requirements were considered when selecting the monitors’ placement with respect to on-site and off-site sources. The existing fenceline monitors do not have any large-scale sources between the monitor and the fenceline. Monitors were placed with consideration toward proximity to off-site emissions sources and sampling requirements were considered. Chevron aimed to make the horizontal distance from a point sampler to an obstacle, such as a building, at least twice the vertical distance that the obstacle protrudes above the sampler. Chevron aimed to make the horizontal distance from 90% of open-path to obstacles at least twice the vertical distance that the obstacles protrude above the path. For open-path monitors, a direct line of sight between light source and receiver must be available for the monitors to function. Logistical requirements were considered, such as proximity to power, capability to access the internet for real-time data reporting and on-line troubleshooting, and adequate security.

Chevron also met on multiple occasions between September 2011 and November 2012 with Shields-Reid, Point Richmond, and Atchison Village Neighborhood Councils for input on the locations of the air monitors. These are all the neighborhoods that border the refinery. The compounds to be monitored were selected with input from the City of Richmond, Chevron consultants, and community representatives. The compounds monitored by the fenceline system are considered to be common for refinery operations. The specific chemicals that require monitoring were evaluated for each source from emissions estimates based on available Toxic Release Inventory (TRI) reports. The compounds monitored by the community monitors represent a larger spectrum of compounds that can be attributed to many sources present in the Richmond community. The final siting locations and compounds to be monitored were approved by the City of Richmond in 2013. The fenceline and community monitoring data are made available to the public online at https://www.richmondairmonitoring.org/index.html. The following sections provide a summary of Chevron's Air Monitoring Plan in accordance with Rule 12-15 Section 403.

Section 3. Evaluation

Element #1 – Gases Requiring Measurements

In 2013, Chevron installed and began operating open-path air monitoring systems in cooperation with the City of Richmond. Chevron compared the BAAQMD Air Monitoring Guidelines with Chevron's existing monitoring system, which quantifies benzene, carbon disulfide, H_2S, ozone, SO_2, toluene, and xylene. Chevron has added capability to their open-path Ultraviolet Differential Optical Absorption Spectroscopy (UV-DOAS) system to measure ethylbenzene. Benzene, toluene, and xylene will continue to be detected and quantified by UV-DOAS. H_2S will temporarily be detected and quantified for informational purposes only using an open-path Tunable Diode Laser (TDL) air monitoring system pending deployment of more precise point monitors. The Castro Street ground level point monitor will be used for compliance with BAAQMD Rule 12-15, Rule 9-1 and Rule 9-2. Relevant equipment specifications are provided in Section 4 of this Plan.

Element #2 – Other Gases to Be Considered for Open-Path Measurements

Chevron considered the measurement of SO_2, alkanes, or other organic compound indicators, 1,3-butadiene, and ammonia for inclusion in this Air Monitoring Plan. Chevron continues to perform fenceline monitoring for SO_2, and has added fenceline monitoring of alkanes. Chevron does not plan to add fenceline monitors for 1,3-butadiene and ammonia.

SO_2

SO_2 will continue to be monitored by the existing UV-DOAS monitoring system and the Castro Street ground level monitor.

Alkanes or other organic compound indicators

Chevron has added monitoring for alkanes at BAAQMD's suggestion for measuring refinery fugitive leak emissions from process units that do not emit BTEX compounds detectable on the UV-DOAS monitors. Chevron does not expect refinery alkane emissions to be regularly detected, and rare detections will contain some ambient alkanes (Stephens and Burleson, 1969). The installed analyzers provide indication of emissions from process units that do not emit BTEX compounds, namely the Alkylation Unit, Liquid Petroleum Gas spheres and loading racks, and Hydrogen Plant.

The alkanes being monitored include methane, ethane, propane, butane, and pentane. Methane and alkane (C2 through C5) concentrations are reported on the website. C6 and greater are not measured because process streams, such as gasoline, naphtha, and crude containing C6 and greater also contain BTEX compounds, which are measured on the UV-DOAS monitors. Chevron has installed open-path Fourier Transform Infrared (FTIR) monitors for monitoring alkanes to accommodate the public's preference for open-path monitors. Chevron appreciates that open-path monitors span long distances around a refinery and are more likely than point monitors to capture a possible plume that may cross the fenceline. Chevron received a manufacturer's guarantee based on results of a study conducted in Atlanta, GA, in December 2017 that an open-path FTIR with a 500-meter path length will measure alkanes C2 through C4 at 200 ppb concentration with 75% accuracy at 2 vol% water vapor in ambient air. In the Atlanta study, at 800 meters path length and 1.1 vol% water in ambient air, water vapor did not cause interference in alkane measurements. Interpolation of data justifies the manufacturer's guarantee.

The FTIR monitoring technology has the ability to detect ambient methane and ppb detection limits for C2 through C5 alkanes. Relevant equipment specifications are provided in Section 4 of this plan.

Existing measures for monitoring alkane and organic compound leaks

The systems do not serve as a first alert to Chevron of an alkane leak because Chevron has numerous systems in place for detecting an alkane leak. On most days, seven contracted individuals are monitoring background hydrocarbon concentrations and components in the refinery using Method 21, which is described in 40 Code of Federal Regulations Subpart 60 Appendix A-7. In accordance with Rule 8-18, Chevron repairs any leak source causing background concentration higher than 50 parts per million by volume (ppmv). Chevron Method 21 monitors light liquid pumps monthly, valves and pressure relief devices quarterly, and connectors annually. Leaks are typically repaired within 24 hours of discovery. Tank floating roof seals are inspected on a quarterly, semiannual, or annual basis per the requirements of BAAQMD Regulation 8, Rule 5. The liquid petroleum gas sphere area has five lower flammability limit (LFL) analyzers that alarm operators inside and outside the console when 5% of the LFL is detected. Chevron employees also wear personal LFL monitors while inside the process units that alarm at 5% of the LFL. All contractors entering Chevron process units are required to wear personal LFL monitors that sound an alarm at 5% of the LFL.

1,3-Butadiene

1,3-Butadiene is not produced as an intermediate or end product and is only present in trace quantities at the refinery. Chevron reports about 100 lb. per year of 1,3 butadiene emissions to the EPA in its annual TRI Report. Chevron does not expect 1,3-butadiene to be present in measurable concentrations at the fenceline.

Ammonia

Chevron excludes ammonia from fenceline monitoring because it is not emitted in measurable amounts at the fenceline as anhydrous ammonia, which is BAAQMD's primary toxicity concern. Sources of ammonia leaks are not as prevalent as alkanes. Ammonia is produced at refinery plants 8 and 18;

however, it is otherwise isolated to three anhydrous ammonia vessels for storage/loading or use in small streams in process units, primarily for pollution control devices. Anhydrous ammonia is sold as a by-product. Anhydrous ammonia loading points are tightly sealed and closely monitored by operators as explained below. Chevron's aqueous ammonia emission rates are already monitored through direct measurement in source tests submitted to BAAQMD. Aqueous ammonia reduces nitrogen oxide emissions from furnace stacks and filterable particulate emissions from the fluidized catalytic cracking unit (FCCU). Ammonia slip emissions from the FCCU have dramatically decreased following Regulation 6-5 compliance implementation.

Additionally, Chevron already has numerous systems in place, developed in cooperation with the City of Richmond, for preventing, detecting, and mitigating an anhydrous ammonia leak. The bulk of the refinery's anhydrous ammonia is kept in storage vessels near the ammonia loading rack and rail cars. Anhydrous ammonia is produced at 8 and 18 plants and consumed at the cogeneration units, FCCU, hydrogen plant, and Richmond Lube Oil Project (RLOP). The ammonia storage vessels are elevated above normal vehicle height and surrounded by steel barricades to prevent a motor vehicle from puncturing a vessel. Chevron also documented in its Risk Management Plan that the ammonia storage vessels will not be filled more than 45% full. Redundant high-level alarms sound at 41% and emergency alarms sound at 43% to ensure operators do not fill the ammonia storage vessels past 45%. Ammonia pumps are protected from cavitation by ensuring the ammonia storage vessels are at least 10% filled. Redundant low-level alarms sound at 15% and emergency low level alarms sound at 10%. As shown in Appendix A, anhydrous ammonia storage is located away from the refinery perimeter to minimize the effect on the public in the event of a release.

The ammonia storage area is equipped with excess flow valves and emergency block valves (EBV) to prevent or limit the severity of a release. EBVs are installed at the train loading racks' liquid and vapor lines, suction lines on the ammonia storage vessels, and on the common header. EBVs close with emergency shutdown switches, hand activation, and fusible plugs. When an EBV closes, the associated pumps are interlocked to shut down as well. Operators routinely test the EBVs.

In the event of a fire, each storage vessel is equipped with a firewater deluge system to scrub vapor from the atmosphere and cool the vessel. The fusible plugs on the EBVs cause the EBVs to close in the event of a fire. The ammonia storage area is encircled by a firewater-monitor fog system. One large water fog spray can be remotely operated. In the case of a leak, operators wearing air-supplying respirators immediately begin mitigation by isolating the line where the leak is located, applying water spray, and/or shutting down the process unit.

Any significant release of ammonia would be detected by the refinery, and if off-site impacts are possible, this would be communicated by Chevron to the community via the Contra Costa County Community Warning System (CWS). Numerous ammonia sensors located throughout the refinery would alert operators if a leak were to occur. If more than 100 lb. of ammonia are released in a 24-hr period, Chevron would immediately notify the Contra Costa County Health Services (CHS) Department on-call pager via the CWS as Level 1 and would call BAAQMD, the National Response Center, and the California Governor's Office of Emergency Services (COES). In the case of possible off-site health impacts, CHS would alert the community with sirens.

Lastly, Chevron voluntarily measures ammonia with three community monitors. The monitors collect 5-min average concentration data similar to fenceline monitors and post the 5-min average concentrations to a website. Since measurement began in 2014, ammonia concentration data through December 31, 2016, has been consistently well below the California health standards at all three community locations. **Figure 3.1** compares the community monitor data with health standards and shows that the maximum 1-hr average concentration was less than 4% of the acute health standard. To determine the maximum 1-hr average concentrations for comparison with the acute health standard, 60-min averages were calculated for every 5 minutes of data from the community monitor's start of operation in 2014 through December 31, 2016. During periods when a chemical was not detected, 1 ppb was substituted for calculating the average concentration. The average concentration measured at each community monitoring station was less than 2% of the chronic health standard. The California Office of Environmental Health Hazard Assessment (OEHHA) publishes reference exposure levels (REL), which are health standards, at https://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary. Lastly, as described in Section 2, compounds expected to be commonly emitted by refinery operations were required to be monitored at existing fenceline monitors, of which ammonia was not selected.

Figure 3.1 – Comparison of Richmond Community Monitors 1-Hr Average Concentrations with Acute (1-Hr Average) OEHHA Health Standard

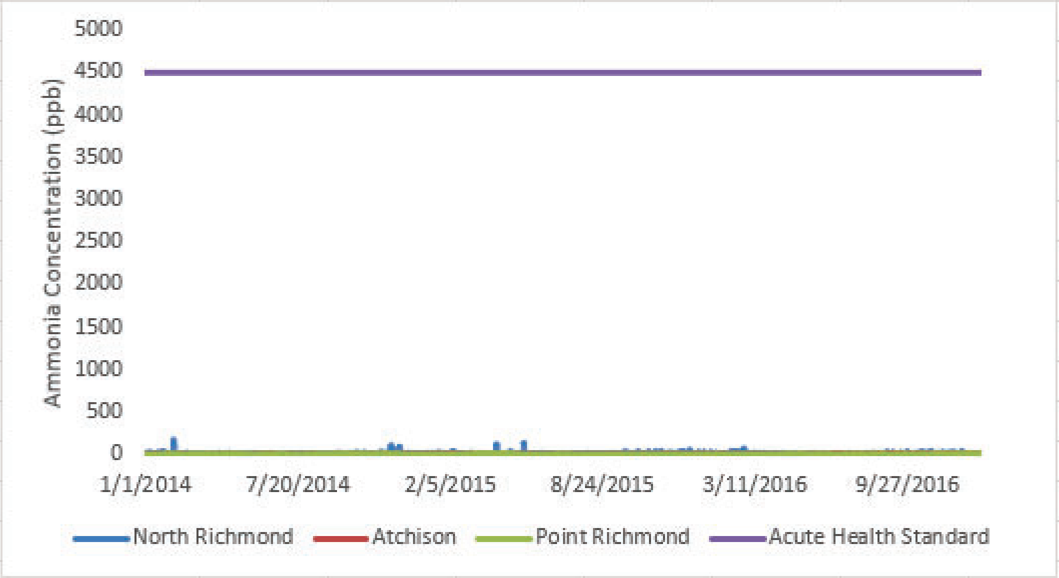


Table 3.1 summarizes the gases included in the Rule 12-15 fenceline AMP and the equipment to be used to detect them.

Table 3.1 – Gases Included in the Fenceline Air Monitoring Plan

Gas	Equipment
Alkanes (C2 through C5)	5 open-path FTIRs
Benzene	3 open-path UV-DOAS instruments North Richmond community monitor Sorbent tubes at sample stations 6 and 7*
Ethylbenzene	3 open-path UV-DOAS instruments North Richmond community monitor
Hydrogen Sulfide	3 open-path TDLs along 5 monitoring paths** Castro Street ground level monitor
Methane	5 Open-path FTIRs
Sulfur Dioxide	3 open-path UV-DOAS instruments Castro Street ground level monitor
Toluene	3 open-path UV-DOAS instruments North Richmond community monitor
Xylene	3 open-path UV-DOAS instruments North Richmond community monitor

*Sampled and analyzed in accordance with 40 CFR 63.658.

** H2S will temporarily be detected and quantified for informational purposes only using an open-path TDL air monitoring system pending deployment of more precise point monitors..

Element #3 – Fenceline Coverage

This section describes the process used to determine where fenceline air monitoring equipment are installed and/or made part of the Rule 12-15 fenceline monitoring compliance program. In accordance with the Guidelines, wind rose analyses were completed to determine monitor locations needed to cover populated areas within 1 mile of the refinery fenceline likely to be affected when the annual mean wind direction lies in an arc within 22.5 degrees of a direct line from source to receptors 10% of the time or greater, given site topography.

Meteorological data collected from January 1, 2012, through December 31, 2016, from the Gertrude Meteorological Station, associated with the Rules 9-1 and 9-2 ground level monitors, were used to generate the wind roses in **Figures 3.2 and 3.3** and the summary in **Table 3.2**. Figure 3.2 compares the 2016 wind rose with the 5-yr wind rose to show a consistent wind pattern with wind primarily blowing from the south. Wind occurred greater than 10% of the time from 0 degrees north and from 135 degrees to 225 degrees. Thus, the Guidelines suggest monitoring for Rule 12-15 in the arc from 292.5 degrees to 67.5 degrees and in the arc from 157.5 degrees to 202.5 degrees if there are receptors downwind of sources within 1 mile of the refinery fenceline, depending upon site topography.

Figure 3.2 – Wind Rose (1/1/12 – 12/31/16) Consistent Wind Pattern Primarily from South

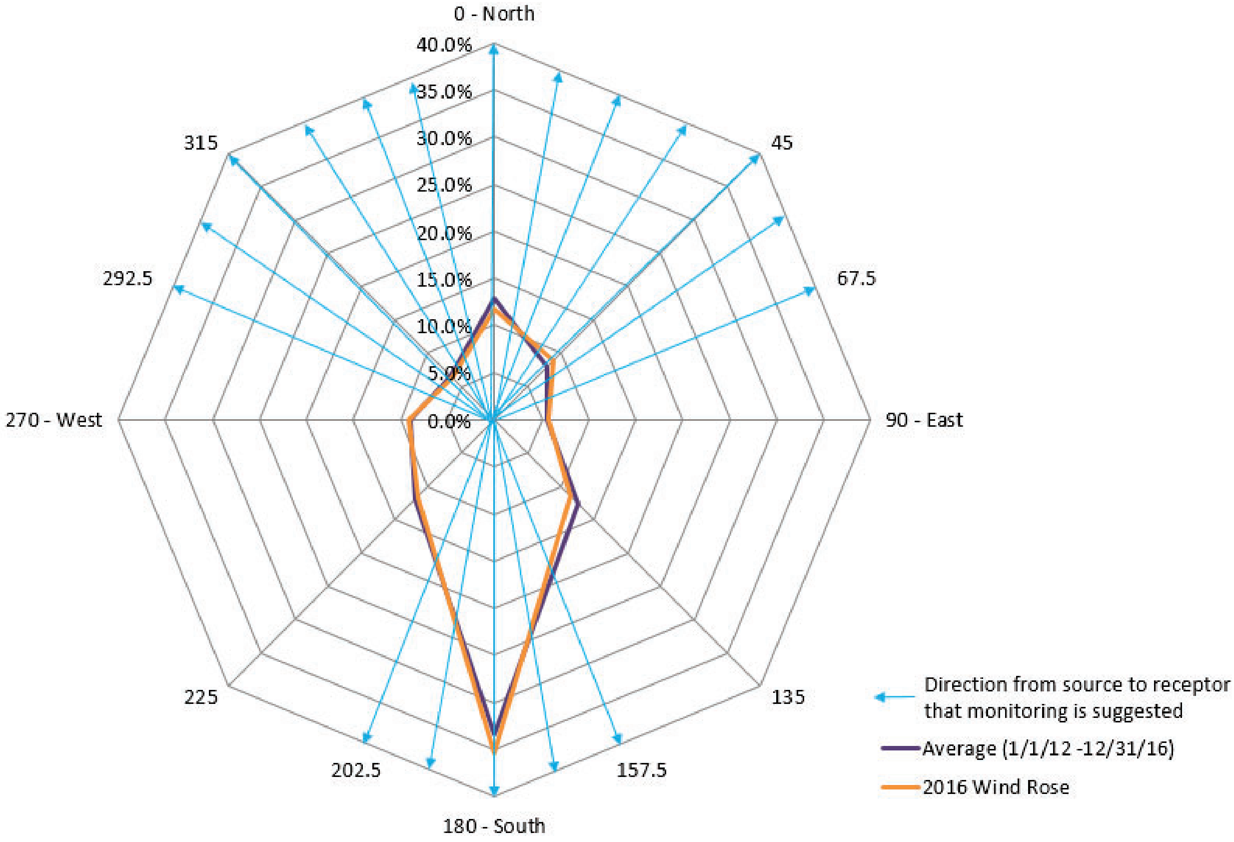
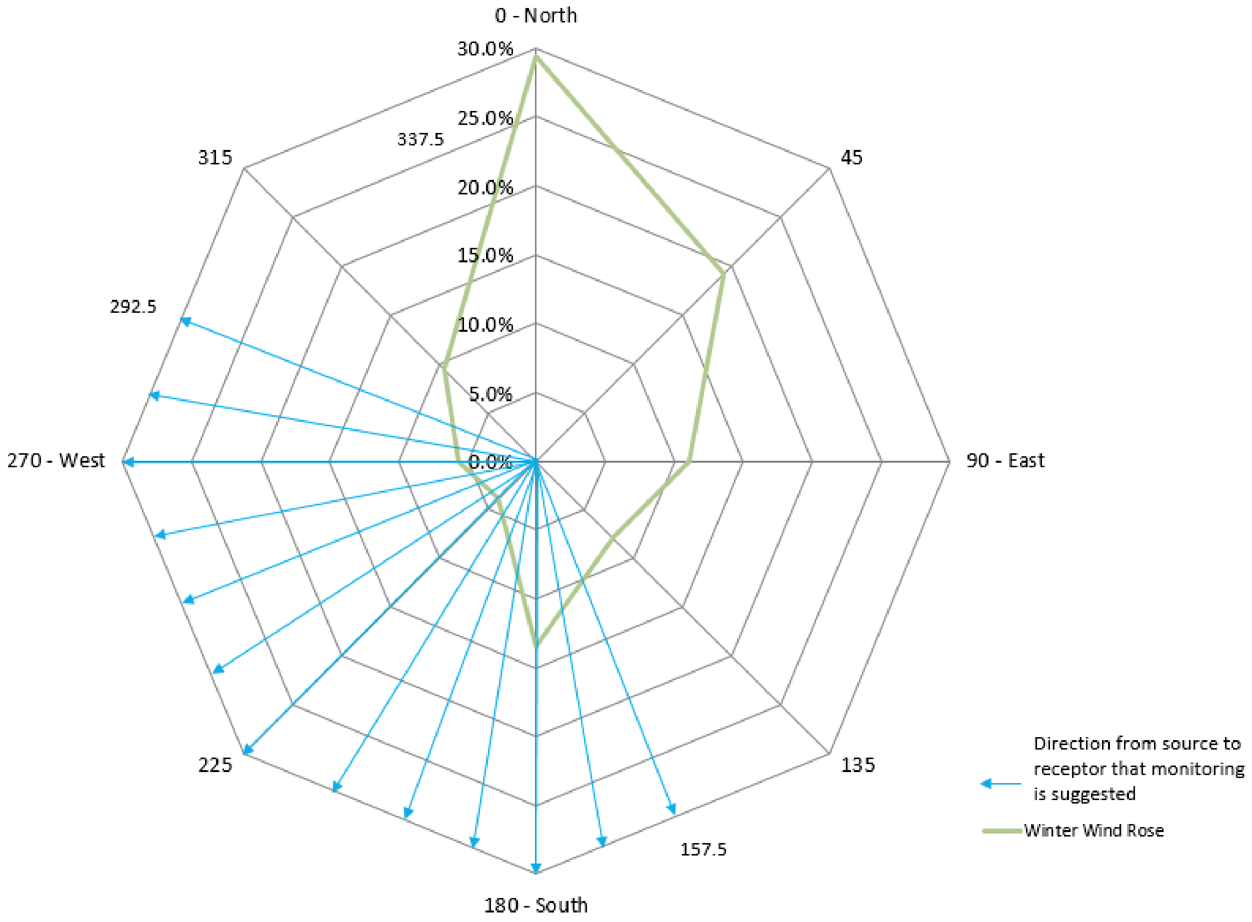


Figure 3.3 contains a wind rose of winter winds from November 1 through February 15 for the years 2012 through 2016. This figure shows winds blowing primarily from the north and northeast during winter months. The wind direction is from 0 degrees north through 90 degrees east more than 10% of the time during winter months. Per the guidelines, fenceline monitoring coverage should be considered in the arc between 157.5 and 292.5 degrees if there are receptors downwind from sources within one mile of a receptor, depending upon site topography.

Figure 3.3 – Winter Wind Rose (2012-2016): Wind Primarily from North/Northeast



Based on the wind rose analyses, the Guidelines suggest some additional fenceline monitor coverage beyond the pre-existing RCAMP fenceline monitors. As described in Section 2, the existing fenceline monitor open-path locations were already agreed upon with the City of Richmond and developed in cooperation with local neighborhood councils. In adhering to this agreement, Chevron aims to either keep the monitors in the same locations or expand the path to capture more sources. Table 3.2 shows the percentage of time that wind blew from each wind rose sector.

Table 3.2 – Additional Monitors Based on Wind Rose Analyses. Sectors where wind blows in that quadrant greater than 10% of the time are highlighted in blue.

Direction From	Range (Degrees)	Percent of Time	Coverage on Existing Public Website
North	337.5-22.5	12.61%	Partial coverage by Point Richmond open-path UV-DOAS, FTIR, and TDL monitors
Northeast	22.5-67.5	7.68%	Southwest refinery perimeter is not populated
East	67.5-112.5	5.49%	West refinery perimeter is not populated
Southeast	112.5-157.5	12.68%	Northwest refinery perimeter is not populated
South	157.5-202.5	33.74%	North refinery perimeter is not populated
Southwest	202.5-247.5	12.18%	• Atchison Village and North Richmond open-path UV-DOAS, FTIR, and TDL monitors • North Richmond community monitor • Benzene sorbent tube sample at stations 6 and 7 • Castro Street ground level monitor
West	247.5-292.5	9.04%	• Atchison Village and North Richmond open-path UV-DOAS, FTIR, and TDL monitors • North Richmond community monitor • Benzene sorbent tube sample at stations 6, 6D, and 7 • Castro Street ground level monitor
Northwest	292.5-337.5	6.59%	Atchison Village and Point Richmond open-path UV-DOAS, FTIR, and TDL monitors

Based on the 2012 through 2016 wind rose analysis, the monitors cover populated areas within 1 mile of the refinery fenceline likely to be affected when the annual mean wind direction lies in an arc within 22.5 degrees of a direct line from source to receptors 10% of the time or greater, given site topography. Refinery emission sources, and existing air monitoring equipment, are shown on a map of the refinery in Appendix A. The open-path monitors are located south, east, and northeast of refinery processes in between the processes and populated areas. The North Richmond open-path monitors are located northeast of the refinery. The Atchison Village open-path monitors are located east of the refinery. The Point Richmond open-path monitors are located south/southeast of the refinery. The map shows that the refinery is surrounded on the north, west, and southwest parts of the refinery by large bodies of water, which are not populated.

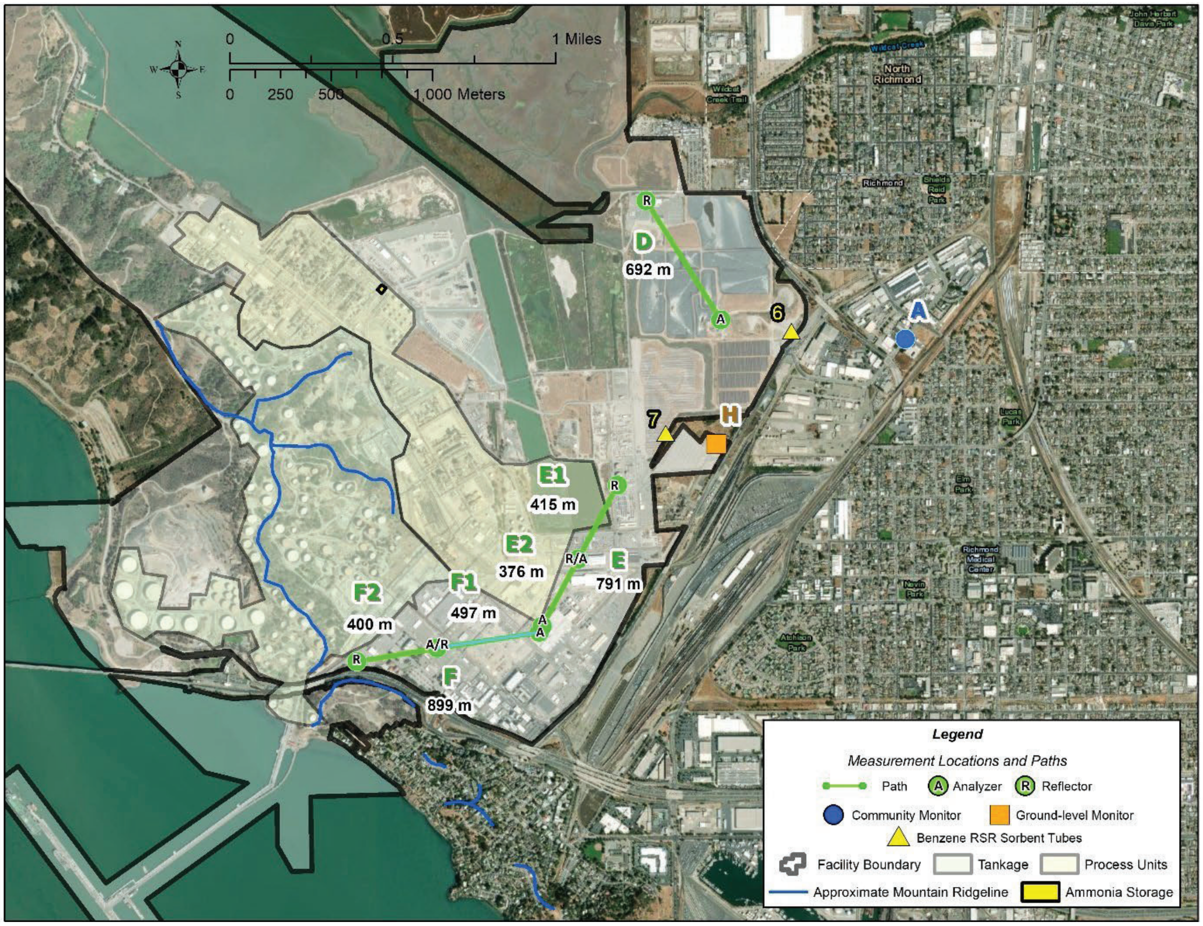
Chevron has installed open-path FTIR, UV-DOAS, and TDL analyzers and retroreflectors along the North Richmond, Point Richmond, and Atchison paths. The path lengths for the UV-DOAS, TDL, and FTIR open-path monitors are provided in **Table 3.3**. Because intermediate paths (e.g., F1 and F2) are close to but not exactly the same as the overall path (e.g., path F), the distances may not be exactly the same.

Table 3.3 – Fenceline Open-Path Lengths

Fenceline[1]	Path Designation	Open-Path Equipment	Approximate Path Length (meters)
North Richmond	D	UV-DOAS, TDL, FTIR	692
Atchison	E	UV-DOAS	791
Atchison (North)	E1	FTIR, TDL	415
Atchison (South)	E2	FTIR, TDL	376
Point Richmond	F	UV-DOAS	899
Point Richmond (East)	F1	FTIR, TDL	497
Point Richmond (West)	F2	FTIR, TDL	400

Chevron has included measurements from benzene sample stations 6 and 7, the Castro Street ground level monitors, and the North Richmond community monitor BTEX measurements in the Rule 12-15 program. **Figure 3.4** provides a visual summary of the monitoring locations that are part of Rule 12-15 compliance.

Figure 3.4 – Locations of Rule 12-15 Monitors



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[1] FTIR and TDL instruments cover paths E and F via subpaths E1, E2, F1, and F2.

The City of Richmond was interested in capturing emissions from as many refinery sources as possible, including elevated sources, such as flares and furnaces. At BAAQMD's suggestion, Chevron moved the Point Richmond open-path monitors to a lower elevation so that fugitive emissions are primarily measured. The manufacturers of the open-path analyzers (Cerex for the UV-DOAS and FTIR), who are experienced with operating and maintaining the monitors, indicated that the current minimum detection limits (MDLs) for BTEX and SO_2 should be achievable at the path lengths installed. Flare and furnace stack emissions are already measured continuously with sampling systems, flow meters, and stack analyzers. Most fugitive emissions are measured at each component periodically using Method 21, but site-wide fugitive emissions can only be measured continuously with fenceline monitors. Thus, BAAQMD is primarily interested in using the fenceline monitors to measure fugitive emissions, which occur near ground level.

During winter winds from the north, the Point Richmond and Atchison Village open-path monitors provide the suggested monitoring coverage when terrain is considered. Due to the mountainous terrain and presence of the Interstate 580 freeway, it is not practicable to install an open-path monitor west of the Point Richmond monitor. Appendix A shows a mountain ridge line southwest of the Point Richmond open-path monitor that is expected to direct wind from refinery tanks away from receptors. It is expected that for the tanks located northwest of the Point Richmond open-path monitor and to the west of the mountain ridge that runs north-south, the mountains would cause wind across the tanks to move westward away from the community. It is expected that for the tanks located northwest of the Point Richmond open-path monitor and to the east of the mountain ridge that runs north-south, the mountains would cause wind across the tanks to pass through the Point Richmond open-path fenceline monitor. Also, the tanks are compliant with Rule 8-5 storage-vessel requirements, which limit organic compound emissions. The seals are inspected at least semiannually to verify proper function of the emission control technology. It is expected that a potential seal leak from a tank located northwest of the Point Richmond open-path monitor would be detected on the Point Richmond open-path monitor because wind direction varies throughout the day.

Monitoring coverage is not needed for wind directions from the northeast, east, southeast, and south, because the downwind areas are not populated.

Monitoring coverage between the North Richmond and Atchison open-path monitors are fulfilled with point monitors. The following point monitors are part of the Rule 12-15 compliance program.

- Castro Street ground level monitor fulfills H_2S and SO_2 monitoring
- One sorbent tube at each sample station 6 and 7 fulfills suggested benzene monitoring
- North Richmond community monitor fulfills BTEX monitoring

The two sorbent tube samples will continue to be analyzed for benzene every two weeks as specified in 40 CFR 63 Subpart CC. In April 2019, the EPA began reporting benzene sorbent tube data over a public website on a quarterly basis. The EPA website link is: https://cfpub.epa.gov/webfire/reports/eSearchResults.cfm. To access the Chevron Richmond data, enter or select the following search criteria:

- Report Type: All, then click Submit
- Facility Name: Chevron
- Facility Location: California, Contra Costa County, Richmond

- Regulatory Part and Subpart:
    - CFR Part: 63-NESHAP
    - CFR Subpart: NESHAP-CC: Petroleum Refineries

Next, submit the search. Once the search results appear, select the row with the submission date of interest and download the file in the document column.

Five-min average Castro Street ground-level monitor (GLM) data and 5-min average North Richmond community monitor data are posted to the public website.

The only sources located within one mile upwind of a receptor greater than 10% of the time that are between the North Richmond and Atchison monitors are the bioreactor and two recovered oil storage tanks. We expect that the Atchison open-path monitor, which crosses the bioreactor, or the North Richmond open-path monitor, typically catch any possible plumes from these sources. However, in the rare instance when wind direction is between the North Richmond and Atchison open-path monitors, it is expected that the previously mentioned point monitors will measure possible emissions.

A review of 10 years of GLM reports showed that Chevron has not caused exceedance of the SO_2 ground level concentration limits in Rule 9-1-301, or the H_2S limits in Rule 9-2-301 at the Castro Street GLM. Additionally, the GLM has much lower detection limits than open-path monitors. The GLM's MDL for H_2S and SO_2 is about 0.5 ppb.

Analyses of sorbent tubes installed in preparation for compliance with 40 CFR 63.658 indicate that benzene concentrations at sample stations 6 and 7 along the fenceline between the North Richmond and Atchison open-path monitors are much lower than the OEHHA chronic health standard of 3 $\mu g/m^3$. Sorbent tubes were replaced and analyzed for benzene approximately every 14 days. Sorbent tube data available to date for sample points 5 through 8 located between and nearby the North Richmond and Atchison open-path monitors are provided in **Table 3.4**. The refinery map in Appendix A shows the sorbent tube locations. Sample point 5A located on refinery property near the heavy-traffic intersection of Gertrude Avenue, Castro Street, and Richmond Parkway had the highest readings of all the sample points in the refinery. The benzene concentrations decreased when the sample station was moved closer to the refinery processes around March 7, 2017. The current location is labeled as sample point 5. The elevated results at sample point 5A were attributed to off-site sources, likely traffic congestion at the Gertrude Avenue intersection or nearby off-site excavation of contaminated soil.

Table 3.4 – Benzene Sorbent Tube Results Are Within OEHHA Chronic Health Standard

Sample Start Date	Sample End Date	Sample Point / Benzene Concentration* (ug/m^3)				
		5A	5	6	7	8
7/27/2016	8/10/2016	0.19		Not Detectable	0.18	Not Detectable
8/10/2016	8/24/2016	0.18		0.24	0.25	0.20
8/24/2016	9/7/2016	0.36		0.38	0.29	0.40
9/7/2016	9/21/2016	0.52		0.34	0.38	0.29
9/21/2016	10/5/2016	0.69		0.52	0.51	0.52
10/5/2016	10/19/2016	0.68		0.44	0.46	0.41
10/19/2016	11/2/2016	0.97		0.57	0.60	0.55
11/2/2016	11/16/2016	2.41		0.96	0.75	0.77
11/16/2016	11/30/2016	1.34		0.67	0.79	0.76
11/30/2016	12/14/2016	1.44		0.65	0.64	0.71
12/14/2016	12/28/2016	0.94		0.63	0.63	0.58
12/28/2016	1/11/2017	1.03		0.85	0.48	0.50
1/11/2017	1/25/2017	1.09		0.62	0.64	0.60
1/25/2017	2/8/2017	1.07		0.65	0.58	0.59
2/8/2017	2/22/2017	0.86		0.49	0.44	0.55
2/22/2017	3/8/2017	1.04		0.51	0.49	0.55
3/8/2017	3/22/2017		0.44	0.46	0.40	0.41
3/22/2017	4/5/2017		0.38	0.34	0.31	0.44
4/5/2017	4/19/2017		0.34	0.33	0.30	0.38
4/19/2017	5/3/2017		0.26	0.28	0.28	0.29
5/3/2017	5/17/2017		0.21	0.20	0.21	0.23
5/17/2017	5/31/2017		0.17	0.21	0.18	0.22
5/31/2017	6/14/2017		0.20	0.18	0.19	0.25

* Values less than 0.37 are less than the analytical reporting limit, but greater than the method detection limit.

Lastly, Chevron continues to operate the existing North Richmond community monitor, located at Richmond Fire Station 62 on 7th Street, to deliver BTEX data to meet Rule 12-15 needs. The North Richmond community monitor is located downwind of the refinery when wind is from the west or southwest. The monitor also measures H_2S, ammonia, several alkanes, trimethylbenzenes, 3-methylpentane, 2,2,4-trimethylpentanes, $PM_{2.5}$, and black carbon. All data from the North Richmond community monitoring station is posted at https://www.richmondairmonitoring.org/index.html.

The North Richmond community monitor collects 5-min average concentration data and posts the 5-min averages to the website similar to fenceline monitors. To determine the maximum 1-hr average concentrations for comparison with the acute health standard, 60-min averages were calculated for every 5 minutes of data from January 1, 2014, through December 31, 2016. During periods when a chemical was not detected, one half the detection limit of 0.25 ppb was substituted for calculating the average concentration. The table shows that the maximum 1-hr average concentration was equal to 34% (2.75 ppb 1-hr average/8 ppb acute health standard) of a health standard.

Table 3.5 shows that BTEX concentrations measured at the North Richmond community monitor for any wind direction are far below OEHHA chronic health standards. To determine the average concentration for comparison with the chronic health standard, all 5-min average data was averaged from January 1, 2014, through December 31, 2016. During periods when a chemical was not detected, one half the detection limit of 0.25 ppb was substituted for calculating the average concentration. The table shows that for the worst-case chemical (benzene), the average concentration was about 25% (0.25 ppb average/1 ppb benzene of the chronic health standard) of a chronic health standard.

Given the data in Table 3.5, Chevron does not expect BTEX compounds to be regularly detectable by an open-path fenceline monitor between the North Richmond and Atchison open-path monitors and does not expect any exceedance of a health standard. The community monitor is more sensitive than open-path fenceline monitors, and only half a mile downwind (westerly wind) from the North Richmond fenceline.

Table 3.5 – North Richmond Community Monitor Data Are Within Health Standards (1/1/2014 – 12/31/2016)

Chemicals	Maximum 1-Hr Average Concentration (ppb)	Acute OEHHA REL (ppb)	Average Concentration (ppb)	Chronic OEHHA REL (ppb)
Benzene	2.75	8.6	0.25	1
Ethylbenzene	12	None published	0.25	400
Toluene	111	1,328	0.30	70
Xylenes	65	5,000	0.57	200

Element #4 – Sample Time Resolution and Data Completeness

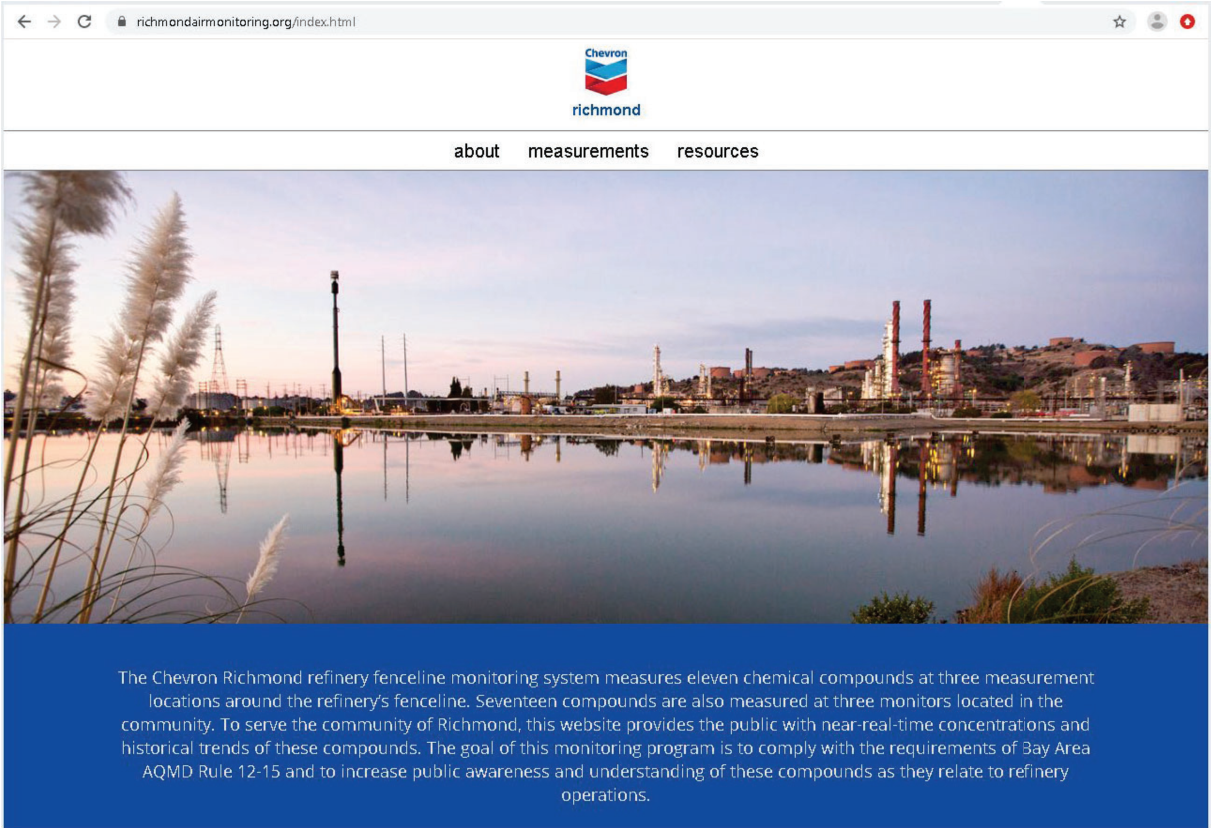
Continuous monitoring equipment specified for the Chevron fenceline system collects data on 5-min averages and reports the 5-min averages. Instruments are operated to meet a minimum of 75% completeness on an hourly basis, 90% of the time based on annual quarters. Atmospheric conditions beyond the control of the refinery that affect accurate measurements, such as dense fog, are not counted against data completeness requirements. In addition to rain and fog, other types of environmental conditions beyond the control of the refinery can occur. These environmental factors include, but are not limited to, strong winds, dust, and earthquakes, which can impact the ability of open-path instruments to provide accurate measurements.

Element #5 – Data Presentation to the Public

A Data Acquisition System (DAS) or data logger at each sampling site performs basic quality control (QC) and averages raw analyzer data to 5-min resolution. Data are then transmitted to Sonoma Technology's Data Management System (DMS), where a robust automated QC (AutoQC) logic assigns data flags in real time based on instrument diagnostics and local meteorological measurements. These preliminary data are displayed on the public website, usually within approximately 10–15 minutes of collection. Additional details regarding data flow and QC processes are described in Sections B.10 and D.2 of the QAPP, as well as the Standard Operating Procedure (SOP) for Data Verification and Validation (Attachment 7).

Preliminary data collected by the fenceline monitoring network are displayed on a public website in real time. Key components of the public website include visual display of real-time and historical data, contextual information to help the public understand the concentrations displayed, and a feedback mechanism. The public website includes time-series plots and map marker visualizations of preliminary 5-min and rolling hourly concentration values in real time. Data quality information is also included, and is described further in the SOP for Data Verification and Validation (Attachment 7). **Figure 3.5** shows the home page of the fenceline webpage, located at https://www.richmondairmonitoring.org/index.html.

Figure 3.5 – Sample Real-Time Fenceline and Community Air Monitoring Webpage



The Chevron Richmond refinery fenceline monitoring system measures eleven chemical compounds at three measurement locations around the refinery's fenceline. Seventeen compounds are also measured at three monitors located in the community. To serve the community of Richmond, this website provides the public with near-real-time concentrations and historical trends of these compounds. The goal of this monitoring program is to comply with the requirements of Bay Area AQMD Rule 12-15 and to increase public awareness and understanding of these compounds as they relate to refinery operations.

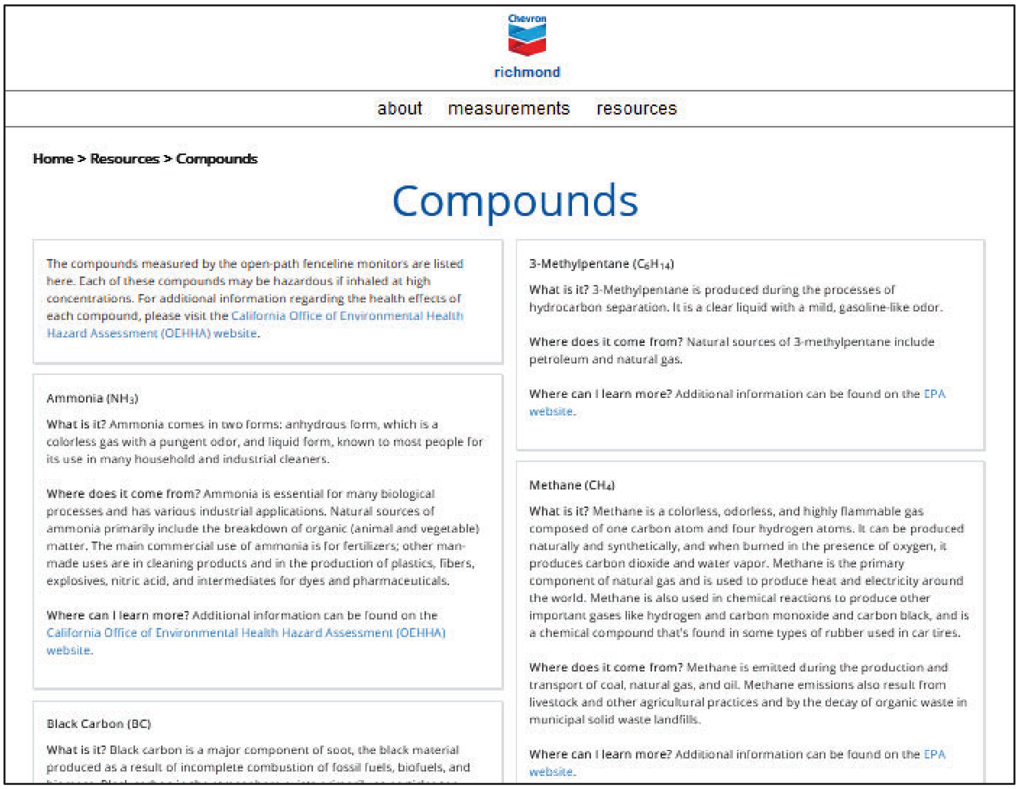
The data collected are high-time-resolution, spatially variable, and chemically complex. To provide context to this multifaceted data set for the public, the following information is included through a combination of links, graphics, and captions:

- Information about the species measured and the measurement techniques
- Discussion of levels of concern with links to third-party sources, such as the OEHHA website on the health effects of each species
- Discussion of non-refinery sources that could affect the measured concentrations
- Definitions for abbreviations
- Discussion of data below the MDL
- Definitions of data flags and their meanings
- Frequently asked questions (FAQs)

To facilitate public input, a feedback mechanism is provided on the web page to allow users to submit questions or comments about the website. An email is delivered to a Chevron contact and the website host, who are responsible for deciding how to respond to public comments. The emails received through the website are archived. Although not all comments have to be addressed, they can be made available to BAAQMD upon request.

Figure 3.6 shows an example page from the website that appears when a person clicks the Compounds page of the Resources section on the website. The web page describes the chemical's properties, common sources of the chemical, and links to the OEHHA health standards.

Figure 3.6 – Example Website Display of Compound Descriptions and Resources



Home > Resources > Compounds

Compounds

The compounds measured by the open-path fenceline monitors are listed here. Each of these compounds may be hazardous if inhaled at high concentrations. For additional information regarding the health effects of each compound, please visit the California Office of Environmental Health Hazard Assessment (OEHHA) website.

Ammonia (NH_3)

What is it? Ammonia comes in two forms: anhydrous form, which is a colorless gas with a pungent odor, and liquid form, known to most people for its use in many household and industrial cleaners.

Where does it come from? Ammonia is essential for many biological processes and has various industrial applications. Natural sources of ammonia primarily include the breakdown of organic (animal and vegetable) matter. The main commercial use of ammonia is for fertilizers; other man-made uses are in cleaning products and in the production of plastics, fibers, explosives, nitric acid, and intermediates for dyes and pharmaceuticals.

Where can I learn more? Additional information can be found on the California Office of Environmental Health Hazard Assessment (OEHHA) website.

Black Carbon (BC)

What is it? Black carbon is a major component of soot, the black material produced as a result of incomplete combustion of fossil fuels, biofuels, and

3-Methylpentane (C_6H_{14})

What is it? 3-Methylpentane is produced during the processes of hydrocarbon separation. It is a clear liquid with a mild, gasoline-like odor.

Where does it come from? Natural sources of 3-methylpentane include petroleum and natural gas.

Where can I learn more? Additional information can be found on the EPA website.

Methane (CH_4)

What is it? Methane is a colorless, odorless, and highly flammable gas composed of one carbon atom and four hydrogen atoms. It can be produced naturally and synthetically, and when burned in the presence of oxygen, it produces carbon dioxide and water vapor. Methane is the primary component of natural gas and is used to produce heat and electricity around the world. Methane is also used in chemical reactions to produce other important gases like hydrogen and carbon monoxide and carbon black, and is a chemical compound that's found in some types of rubber used in car tires.

Where does it come from? Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.

Where can I learn more? Additional information can be found on the EPA website.

Final data sets are compiled quarterly and will be provided to the BAAQMD no later than 60 days after the end of each calendar quarter. Data deliveries are consistent with BAAQMD guidance and additional details are provided in Section C.2 of the QAPP. The BAAQMD may make data available to the public through a BAAQMD website or through public records requests. The refinery will make data available to BAAQMD upon request prior to the report submittal. All data are retained by Chevron for a period of 5 years, consistent with Regulation 12-15-502.

Element #6 – Quality Assurance Project Plan

An updated QAPP is included with this monitoring plan as Appendix B.

Section 4. Monitoring Equipment Description

The fenceline monitoring program for Rule 12-15 integrates the equipment currently used as part of RCAMP along with additional equipment to monitor additional target gases, namely alkanes, and extend spatial coverage. This equipment used to meet the monitoring requirements for Rule 12-15 are described below.

Section 4.1 – Fundamentals of Operation

The following paragraphs describe how the equipment measures compound concentrations. Open-path monitors report average concentration over the path length. Point monitors measure the concentration at the point of each monitor's intake line.

Castro Street Sulfur Dioxide and Hydrogen Sulfide Pulsed Fluorescence GLMs

The SO_2 and H_2S GLMs comply with the BAAQMD Manual of Procedures Volume VI. The SO_2 GLM is a trace-level pulsed fluorescence SO_2 analyzer, which operates by measuring the emitted fluorescence of SO_2 produced by the absorption of ultraviolet (UV) light. Pulsating UV light is focused through a narrow band-pass filter mirror, allowing only light wavelengths of 190 to 230 nm to pass into the fluorescence chamber. SO_2 absorbs light in this region without any quenching by air or most other molecules found in ambient air. The SO_2 molecules are excited by UV light and emit fluorescent light at a longer wavelength (lower energy). A second filter allows only this fluorescent light to contact a photomultiplier tube (PMT), which converts the optical signal from the fluorescent light into a voltage that is recorded and turned into a concentration value.

The H_2S GLM operates using similar technology to the GLM SO_2 analyzer. Continuous H_2S monitoring is accomplished by conversion of H_2S in the sample to SO_2 and its subsequent detection by the SO_2 analyzer.

North Richmond Community Monitor Auto Gas Chromatograph

Automated Gas Chromatographs (Auto GC) use point sampling technology. The systems work by inserting a sample of ambient air into a narrow tube known as the column. A carrier gas flows through the column and carries the sample through the column; depending on the chemical composition, the various sample gases exit the column at different times. As the chemicals exit the end of the column, they are detected using a photoionization detector. The major advantage of the Auto GC air monitoring system is its sensitivity in that it can measure gases, such as BTEX compounds, at very low concentrations in the air.

Open-Path FTIR

Open-path FTIR air monitoring systems use a beam of infrared (IR) light to detect and measure alkanes in the air. A beam of light passes across ambient air to a reflector that sends the light beam back to the light detector. If a gas is present that absorbs IR light, it can be identified by the specific wavelengths of light that were absorbed. The concentration of a gas can be determined by measuring the amount of each specific wavelength of light that was absorbed. The primary interferents associated with FTIR air monitoring systems are water vapor and carbon dioxide (CO_2). The two gases absorb light in the same region as alkanes and can be mistaken for the target gas. Also, due to the similarity in chemical structure, the C1 through C5 alkanes absorb light in a similar region and may interfere with measurements of total alkanes. However, the presence of potentially interfering gases can be accounted for through the analytical software of the system.

Open-path FTIRs can theoretically achieve lower MDLs than extractive FTIRs because the beam path is much longer. The primary limitations for these systems are that the light signal cannot penetrate heavy fog or rain. Thus, they may not be effective during situations where dense fog or heavy rain are present.

Open-Path TDL

Open-path TDLs are similar to open-path FTIR air monitoring systems in that they use beams of infrared light to measure gases. The primary difference between the two systems is the TDL system uses a laser as its light source whereas the FTIR uses a broad-band beam of light as its source. TDL systems are designed to measure a limited number of gases, which, for this application, are H_2S, CO_2, and water vapor. The primary interferents for the H_2S measurement are water vapor and CO_2 because both absorb light in the same region as H_2S. The primary limitation for the system is that the light signal cannot penetrate heavy fog or rain.

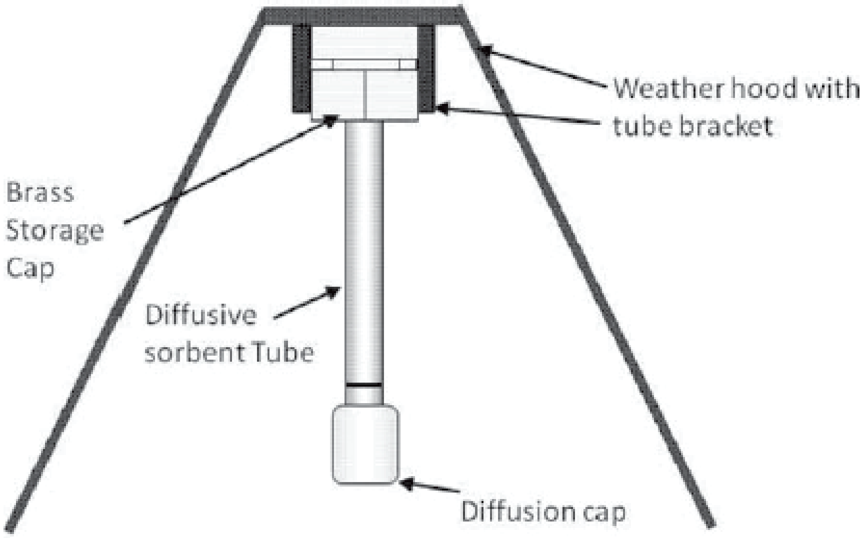
Open-Path UV-DOAS

The open-path UV-DOAS system differs from open-path FTIR and TDL systems in two major ways. First, the system has a light source at one end of the path that sends a beam directly to the light detector at the other end of the light beam. Second, the system uses UV light as a light source. The open-path UV-DOAS air monitoring system is used to detect BTEX and SO_2. The primary interferents associated with the UV-DOAS air monitoring systems are ozone and oxygen, because both absorb light in the same region as the target gases. However, the presence of these gases can be accounted for with the system's analytical software. The primary limitation for the systems is that the light signal cannot penetrate heavy fog or rain.

Sorbent Tubes

Sorbent tubes placed approximately six feet above ground level absorb benzene, if present, from the ambient air during the sampling period, which is about 14 days. The sorbent tubes are installed at locations along the refinery perimeter specified in 40 CFR 63 Appendix A Method 325A Section 8.2. The tubes are analyzed in a laboratory at the end of the sampling period in accordance with 40 CFR 63 Appendix A Method 325B. The sorbent tubes are placed in shelters similar to the one shown in **Figure 4.1** to protect them from rain. Thus, the tubes can provide average benzene concentrations in the ambient air during nearly all weather conditions, including fog, except for periods of extremely high winds with rain. The sorbent tube method also achieves benzene concentration measurements at concentrations lower than open-path monitor MDLs.

Figure 4.1 – Benzene Sorbent Tube and Shelter



Section 4.2 – Monitoring Equipment Capabilities

Table 4.1 summarizes monitoring equipment capabilities, interferences, limitations, and measurement errors.

Table 4.1 – Monitoring Technology Capabilities, Interferences, Limitations, Measurement Errors

Equipment	Capabilities	Interferences	Limitations	Measurement Errors
Sorbent tubes	Absorbs benzene from ambient air, if present, at a point over approximately 14-day periods; Lower MDLs than open-path monitors	Sorbent artifacts, water (rain)	Heavy rains with high winds; Continuous reporting not possible	Within 30% (Per 40 CFR 63 Appendix A Method 325B Section 9.7)
North Richmond Community Monitor Auto GC	Measures BTEX continuously at a point with lower MDLs than open-path monitors	--	Measures at point vs. open-path	Within 25%
Open-path FTIR	Continuously measures alkanes across an open path; Likely lower MDL than extractive FTIR	Water (humidity), CO_2, and C2-C5 alkanes may interfere with each other	Heavy fog and rain	Refer to Section A.7 of the QAPP.
Open-path UV-DOAS	Continuously measures BTEX and SO_2 across an open path	Ozone and oxygen	Heavy fog and rain	Refer to Section A.7 of the QAPP.
Open-path TDL	Continuously measures H_2S across an open path	H_2O and CO_2	Heavy fog and rain	Not applicable – temporary informational monitoring
Castro St. GLM H_2S and SO_2 Pulsed-Florescence Analyzers	Continuously measures H_2S and SO_2 at a point; Lower MDLs than open-path monitors	High concentrations of hydrocarbons; Mercaptans interfere with H_2S measurement	Measures at a point vs. open-path	Within 10% for SO_2, within 15% for H_2S (BAAQMD MOP Volume VI)

Section 4.3 – Detection Range

Table 6 in the QAPP summarizes the expected detection ranges of the open-path monitors. Alkane detection ranges are based on an initial study conducted in Atlanta, GA, in December 2017. The alkane detection ranges shown are accurate when multiple alkanes are present. The detection ranges are much wider if only an individual alkane is present. The FTIR should routinely report methane readings between 1,520 and 2,280 ppb (± 20% of a global average concentration of 1,900 ppb) due to the inherent presence of methane in ambient air.

Table 4.2 lists the messages displayed on the public website that outline the conditions and detection limits for the pollutants measured in this program.

Table 4.2 – Messages Displayed on the Website with Each Compound and Data Value (Hover Over the Data Point to View the Message)

Condition	Message
Valid	X ppb of Compound Y were measured at this location
Below detection	The concentration of the compound is so low that the instrument cannot accurately detect it.
Questionable	No additional information available. Pending further review.
Missing	A problem (such as power failure, calibration, etc.) prevented the instrument from collecting or reporting the data.
Invalid	No additional information available. Pending further review.
Not Measured	There is no instrumentation at the given site to measure this chemical.

The MDL of the sorbent tubes is dependent upon several analytical factors, including the presence of moisture. The MDL for benzene is typically 0.07 $^{\mu g/m3}$ (equivalent to 0.02 ppb), while the minimum reporting limit, which is the lowest end of the calibration range, is typically 0.37 ug/m^3 (equivalent to 0.12 ppb). The MDL of the Castro Street GLMs and North Richmond BTEX community monitor is 0.5 ppb for each compound.

Section 4.4 – Monitoring Equipment Locations

Table 4.3 lists the locations of the fenceline monitoring equipment.

Table 4.3 – Monitoring Equipment Locations

ID	Fenceline Name	Equipment	Approx. Elevation (ft agl)	Location
D	North Richmond	UV-DOAS analyzer; TDL & FTIR analyzers (D)	28.5	Next to Gertrude Ave. GLM
D	North Richmond	UV-DOAS source; TDL & FTIR reflectors (D)	23	Near maintenance building
6	North Richmond	Sorbent tube site 6	5	Reclamation yard gate to Castro St.
6D	North Richmond	Sorbent tube site 6D	5	Reclamation yard gate to Castro St.
A	North Richmond Community Monitor	Auto GC	13	Fire Station #62
7	Atchison Village	Sorbent tube site 7	5	Solar-panel field
H	Atchison Village - Castro GLM	Pulsed fluorescence analyzers	8	Gate 91
E	Atchison Village	UV-DOAS source (E)	38.5	Parking lot south of RARE Plant

ID	Fenceline Name	Equipment	Approx. Elevation (ft agl)	Location
E1	Atchison Village	FTIR & TDL reflectors (E1)	38.5	Parking lot south of RARE Plant
E1/E2	Atchison Village	FTIR & TDL analyzers (E1); FTIR & TDL reflectors (E2)	37	Next to warehouse 8
E2	Atchison Village	FTIR & TDL analyzers (E2)	64.5	Top level roof of Lube Plant
E	Atchison Village	UV-DOAS analyzer (E)	64.5	Top level roof of Lube Plant
F	Point Richmond	UV-DOAS analyzer (F)	31.5	Near SW corner of Lube Plant roof
F1	Point Richmond	FTIR & TDL analyzers (F1)	31.5	Near SW corner of Lube Plant roof
F1/F2	Point Richmond	FTIR & TDL reflectors (F1); FTIR & TDL analyzers (F2)	37.5	Next to permits office
F2	Point Richmond	FTIR & TDL reflectors (F2)	23.5	Hill SW of Chevron Fire Department
F	Point Richmond	UV-DOAS source (F)	23.5	Hill SW of Chevron Fire Department

Section 5. Timing

Chevron reports near real-time data over a website from open-path TDL, UV-DOAS, and FTIR monitors. The operation of these instruments will be conducted in accordance with this Plan pursuant to the timing requirements in Rule 12-15.

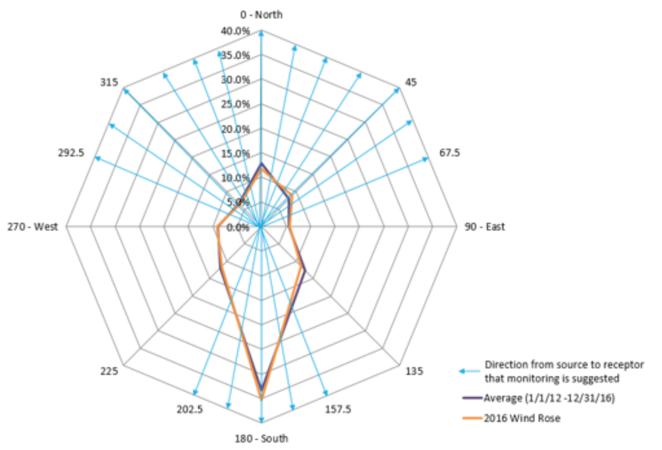
Section 6. References

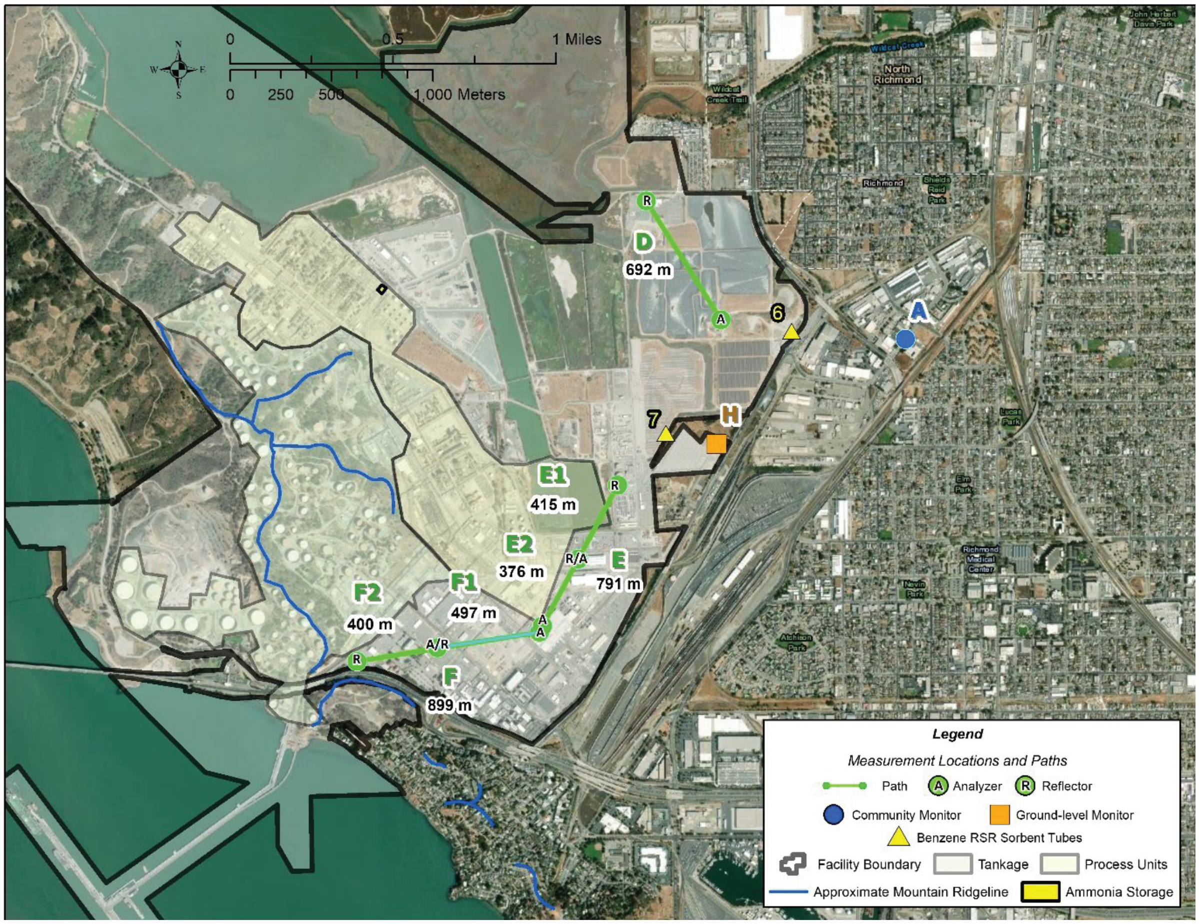
Bay Area Air Quality Management District (2016) Air monitoring guidelines for petroleum refineries: Air District Regulation 12, Rule 15: Petroleum Refining Emissions Tracking; April. Available at http://www.baaqmd.gov/~/media/files/planning-and-research/public-hearings/2016/9-14-and-12-15/042016-hearing/1215-amg-041416-pdf.pdf?la=en.

APPENDIX A

Wind Roses and Refinery Map of Fenceline Monitoring Equipment

Figure 3.2 – Wind Rose (1/1/12 – 12/31/16) Consistent Wind Pattern Primarily from South





APPENDIX B

Quality Assurance Project Plan for the Chevron Richmond Refinery Fenceline Air Monitoring Program

Quality Assurance Project Plan

Prepared by

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May 30, 2025
Revision 9

This document contains blank pages to accommodate double-sided printing.

A. Project Management

A.1 Title and Approval Page

Quality Assurance Project Plan
Fenceline Monitoring for the Chevron Products Company in Richmond, CA

Signature	Date
Name Chevron Products Company	Title
Signature	Date
Name Sonoma Technology, Inc.	Title

The attached Quality Assurance Project Plan (QAPP) is hereby recommended for approval and commits Chevron Products Company to follow the elements described within.

A.2 Table of Contents

Figures

Tables

Review and Revision History

Rev. No.	Date	Responsible Party	Description of Change
0	December 7, 2018	Chevron Richmond	Initial Submission to BAAQMD
1	August 23, 2019	Chevron Richmond	Submission to BAAQMD; Addressed comments on initial submission, including revised emergency maintenance procedures and description of key personnel.
2	January 8, 2020	Chevron Richmond	Submission to BAAQMD; addressed comments from BAAQMD on August 2019 submission including modifications to FTIR, data completeness, and other open-path-related items.
3	October 20, 2020	Chevron Richmond	Submission to BAAQMD; Modified descriptions of UV and FTIR systems. Added detail on visibility measurements. Added description of QC/OP Codes.
4	June 1, 2022	Chevron Richmond	Submission to BAAQMD; including addition of Tunable Diode Laser measurements of hydrogen sulfide.
5	February 15, 2023	Chevron Richmond	Submission to BAAQMD; addressed comments on June 1, 2022, submission
6	September 5, 2023	Chevron Richmond	Submission to BAAQMD; addressed comments from BAAQMD on February 15, 2023, submission
7	February 13, 2024	Chevron Richmond	Submission to BAAQMD; addressed comments from BAAQMD on September 5, 2023, submission
8	October 31, 2024	Chevron Richmond	Submission to BAAQMD; addressed comments from BAAQMD on February 13, 2024, submission
9	May 30, 2025	Chevron Richmond	Submission to BAAQMD; addressed comments from BAAQMD on October 31, 2024, submission

This Quality Assurance Project Plan (QAPP) is a living document, meaning it will undergo regular review to ensure that data quality assurance practices are robust and current. This QAPP will be reviewed at least annually and any proposed updates will be submitted for approval to Bay Area Air Quality Management District (BAAQMD). The official version of this QAPP is maintained by Chevron in Richmond, CA. This QAPP contains all critical documents for this program, including Standard Operating Procedures (SOPs) and blank data entry forms.

A.3 Distribution List

Name	Organization	Role
Luke Honnen	Chevron Richmond	Refinery Contact
Director, Meteorology & Measurement Division	BAAQMD	BAAQMD Contact
Director, Compliance & Enforcement Division	BAAQMD	BAAQMD Contact
Neil Fernandez	Sonoma Technology	Project Manager
Hilary Hafner	Sonoma Technology	Quality Assurance Manager
All Project Personnel	Sonoma Technology	Various

Personnel included in above list will be provided with revisions of all critical documentation.

A.4 Project Organization

This QAPP details the specifications for operating the monitoring network. It outlines the operation and maintenance of all instrumentation and equipment, data management and quality control (QC) procedures, and public reporting via a publicly accessible website.

Refinery staff work with a designated contractor to achieve the goals of the fenceline monitoring network. An organization chart (**Figure 1**) and various project roles are detailed below. Contact information for key personnel is provided in **Table 1**.

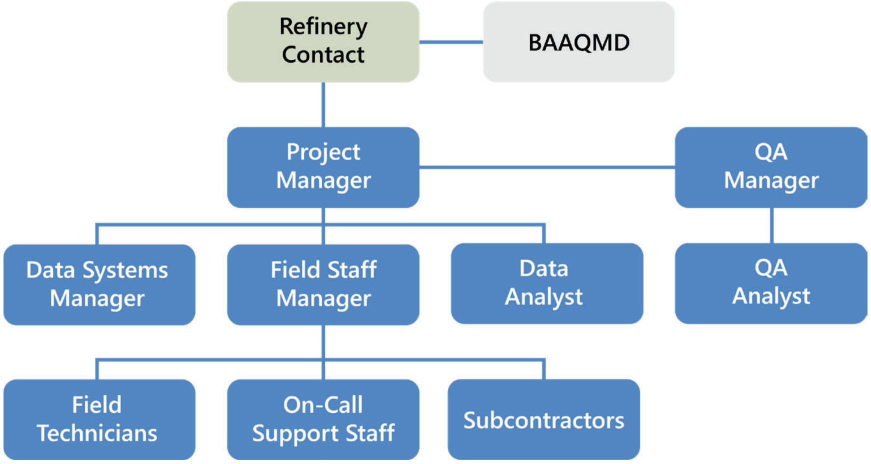

Figure 1. Organization chart for the refinery's fenceline monitoring project.

Refinery Contact. The Refinery Contact is responsible for project oversight and serves as the primary point of contact for the refinery. They facilitate communication between the refinery and BAAQMD.

Project Manager. The Project Manager is responsible for the successful execution of the fenceline monitoring project and serves as the primary point of contact for the contractor. The Project Manager oversees day-to-day monitoring operations, coordinates with all project personnel, and reports to the Refinery Contact. They also work closely with the Quality Assurance Manager to ensure that the QAPP and SOPs are followed, and oversee corrective action plans when needed.

Quality Assurance Manager. The Quality Assurance Manager (QA Manager) provides overall guidance for the evaluation of data. The QA Manager is responsible for evaluating data for adherence to project specifications and ensuring that QA activities remain independent from data collection. If deviations are discovered, the QA Manager coordinates with the Project Manager to determine and implement necessary corrective actions.

Field Staff Manager. The Field Staff Manager oversees the team responsible for operating and maintaining all instrumentation and equipment at the refinery fenceline monitoring sites. They work closely with Field Technicians and Subcontractors, coordinate staff coverage and additional science support as needed, and regularly provide updates to the Project Manager.

Field Technicians. Field Technicians are responsible for the successful operation of instrumentation and equipment, providing routine maintenance according to SOPs. They are qualified to work on refinery property and with all scientific instrumentation. They also perform required quality checks according to this QAPP and document work in site logs.

On-Call Support Staff. On-Call Support Staff are responsible for responding to automated system alerts outside of normal business hours, including remotely troubleshooting data flow outages and validating potential detection events. They are trained on the theory of operation for all field instrumentation and equipment, and conduct abbreviated data checks to identify operational issues requiring field support.

Subcontractors. Subcontractors may be used to provide additional technical support for instrumentation and equipment. They are overseen by the Field Staff Manager and adhere to all project requirements.

Quality Assurance Analyst. The Quality Assurance Analyst (QA Analyst) conducts independent reviews of data products to confirm that data analysis activities have been conducted according to the QAPP. The QA Analyst works closely with the QA Manager and Data Analysts.

Data Analysts. Data Analysts conduct routine daily data checks to ensure accuracy of real-time reporting on the public website, and relay issues to the Field Staff Manager as needed. They also conduct an extended analysis every calendar quarter to generate data products for regulatory reporting efforts, including the assembly of final data sets.

Data System Manager. The Data System Manager is responsible for continuous real-time data flow, routine operation of the automated alerting system, and proper data display on the public website. They work closely with Field Technicians, Data Analysts, and the Project Manager to ensure that the system is operational and real-time data is reported to the public.

Table 1. Contact information for key project personnel.

Name	Organization	Role	Contact Information
Luke Honnen	Chevron Richmond	Refinery Contact	luke.honnen@chevron.com 510-242-5271
Neil Fernandez	Sonoma Technology	Project Manager	nfernandez@sonomatech.com 707-665-9900
Hilary Hafner	Sonoma Technology	QA Manager	hilary@sonomatech.com 707-665-9900

A.5 Problem Definition and Background

The Chevron Products Company (Chevron Richmond) conducts air quality monitoring at its refinery in Richmond, CA, in response to BAAQMD Regulation 12, Rule 15 (Rule 12-15).[1] Measurements are collected according to an Air Monitoring Plan (AMP) consistent with BAAQMD Air Monitoring

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[1] Petroleum Refining Emission Tracking (Rule 12-15; approved by the BAAQMD on April 20, 2016).

Guidelines for Petroleum Refineries,[2] and data are reported in real time on a publicly accessible website.

Rule 12-15 Guidelines from BAAQMD require fenceline monitoring with "open path technology capable of measuring in the parts per billion range regardless of path length," or an alternative measurement technology.[2] The required compounds to be measured include benzene, toluene, ethylbenzene, xylenes (BTEX), and hydrogen sulfide (H_2S). As described in the facility's AMP, sulfur dioxide (SO_2), methane, and C2 through C5 alkanes (ethane, propane, butane, and pentane) were also included in the list of compounds to be measured. Detailed information regarding monitoring methods is provided in Section B of this document.

The California Environmental Protection Agency (EPA) Office of Environmental Health Hazard Assessment's (OEHHA) acute 1-hr reference exposure limits (RELs) are used as references for fenceline monitoring because they represent the concentration threshold above which compounds are considered hazardous to human health. Table 2 lists the RELs for the compounds included in this fenceline monitoring program, for which sampling methods capable of measuring below these values were selected. For clarity, the California Ambient Air Quality Standards (CAAQS; California EPA) and National Ambient Air Quality Standards (NAAQS; U.S. EPA) are also included. Detailed information regarding monitoring methods is provided in Section B of this document.

Table 2. Reference thresholds for fenceline monitoring.

Compound	1-Hr REL (ppb)	1-Hr CAAQS (ppb)	1-Hr NAAQS (ppb)
Benzene	8.5	--	--
Ethylbenzene	--	--	--
Hydrogen Sulfide	30	30	--
Sulfur Dioxide	252	250	75
Toluene	1,327	--	--
Xylenes	5,066	--	--

Sorbent tube analysis for benzene is discussed in Section B of this document and is subject to quality assurance/quality control (QA/QC) requirements in 40 CFR 63 Appendix A Methods 325A[3] and 325B.[4] Ground Level Monitors (GLMs) are subject to QA/QC requirements in BAAQMD Manual of Procedures Volume VI.[5]

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[2] Bay Area Air Quality Management BAAQMD (2016) Air monitoring guidelines for petroleum refineries. April. Available at baaqmd.gov/~/media/files/planning-and-research/public-hearings/2016/9-14-and-12-15/042016-hearing/1215-amg-041416-pdf.pdf?la=en.

[3] https://www.epa.gov/sites/default/files/2019-08/documents/method_325a.pdf

[4] https://www.epa.gov/sites/default/files/2016-07/documents/m-325b.pdf

[5] https://www.baaqmd.gov/~/media/files/records/mop/vol-6/vol6.pdf

A.6 Project Description

Chevron Richmond currently conducts open-path monitoring of BTEX, H_2S, SO_2, methane, and alkanes along five fenceline paths in accordance with BAAQMD Rule 12-15 and the facility's AMP. Sampling sites were selected in consideration of dominant wind patterns, sources of potential air emissions on the property, nearby local receptors, and logistical feasibility. Details regarding fenceline monitoring sites are provided in Table 3.

Preliminary data from fenceline monitors is quality controlled and reported in real time to a publicly accessible website, and final quarterly data sets are provided to BAAQMD. Additional details are provided in the AMP and Section B of this document.

Table 3. Fenceline monitor geographical locations and coverage paths. Because intermediate paths (e.g. F1 and F2) are close to but not exactly the same as the overall path (e.g. path F), the distances may not be exactly the same.

Endpoint	Coordinate (Decimal Degrees)	UV-DOAS	FTIR and TDLAS
North end of North Richmond fenceline monitor	37.953652, -122.379626	Path D, 692 m	Path D, 692 m
South end of North Richmond fenceline monitor	37.948302, -122.375505		
North end of Atchison fenceline monitor	37.940985, -122.381348	Path E, 791 m	Path E1, 415 m
Intermediate point of Atchison Fenceline Monitor	37.937706, -122.383615		Path E2, 376 m
South end of Atchison fenceline monitor	37.934659, -122.385536		
North end of Point Richmond fenceline monitor	37.934345, -122.385961	Path F, 899 m	Path F1, 497 m
Intermediate point of Point Richmond fenceline Monitor	37.933810, -122.391573		Path F2, 400 m
South end of Point Richmond fenceline monitor	37.933217, -122.396070		

A.7 Quality Objectives and Criteria

Data Quality Objectives

Data quality objectives (DQOs) outline the major question(s) to be answered by a monitoring project and ensure that collected data are of sufficient quality to support project goals. The U.S. EPA provides a seven-step process to establish DQOs:

1. **Problem Statement**: The goal of this monitoring program is to meet the requirements of BAAQMD Rule 12-15, which was established to provide the public with information regarding concentrations of target compounds at the fenceline of refining facilities.
2. **Decision**: The refinery provides information to the public regarding concentrations of target compounds consistent with BAAQMD Rule 12-15 and the facility's AMP.
3. **Information Inputs**: Concentration data from open-path monitors are provided as 5-min and 1-hr rolling average concentrations. Data are reviewed with respect to representativeness and comparability, and measurements from other available sources in similar geographic locations serve as a basis of comparison.
4. **Study Boundaries**: Concentration measurements are collected along the refinery fenceline, in accordance with BAAQMD Rule 12-15 and the facility's AMP.
5. **Decision Rule**: Measurements are collected and reported in real time, in accordance with BAAQMD Rule 12-15 and the facility's AMP.
6. **Acceptance Criteria**: Data will be considered acceptable for reporting, provided they meet the defined performance criteria for the project.
7. **Data Collection**: Raw data are collected at various frequencies (depending on the instrumentation and equipment), 24 hours a day, 7 days a week, and aggregated into 5-min averages. Automated quality control logic (AutoQC) and DMS-level screening checks are performed in real time before data are posted to a publicly accessible website.

Data Quality Indicators

Data quality indicators (DQIs) are the quantitative statistics and qualitative descriptors used to interpret the degree of data's acceptability or utility in consideration of the project's DQOs. The DQIs for the BAAQMD Rule 12-15 fenceline monitoring project are defined below. Accuracy and precision are quantitative metrics, representativeness and comparability are qualitative metrics, and completeness combines quantitative and qualitative metrics.

Accuracy is the metric of agreement between an observed value and an accepted reference value. Accuracy is calculated using some derivation of error or recovery from data sets collected during bump tests and calibration checks. Additional details are provided in Section B.7 of this document.

Precision is the metric of mutual agreement among individual measurements of the same parameter, otherwise known as the random component of error. Precision is calculated using some derivation of the standard deviation data sets collected during bump tests and calibration checks. Additional details are provided in Section B.7 of this document.

Representativeness refers to the degree to which data collected by the monitoring project broadly represent ambient conditions, variations between sampling sites, and potential detection events. Representativeness is primarily controlled by the sampling locations, which are detailed in the facility's AMP.

Concentrations of target compounds will be reported in parts per billion (ppb), consistent with the requirements of the Rule 12-15 Guidelines from BAAQMD. Routine bump tests and calibration checks with NIST-traceable reference gases ensure that concentrations reported by open-path analyzers are comparable to other available measurements.

Completeness is a measure of the amount of usable data obtained by the monitoring project compared to the potential amount expected to be obtained under normal operating conditions. The goal of the monitoring project is to maximize system uptime through robust analyzer maintenance, routine data review and short response times for addressing system issues. Quantitative metrics for calculating completeness are detailed further within this section, consistent with BAAQMD guidance.

Measurement Quality Objectives

Measurement quality objectives (MQOs) are individual performance or acceptance goals that directly translate each DQI into discrete analytical performance criteria. The MQOs for this fenceline monitoring project are detailed below.

Accuracy and Precision

Accuracy and precision are assessed for the Ultraviolet-Differential Optical Absorption Spectroscopy (UV-DOAS) and Fourier Transform Infrared (FTIR) open-path systems through routine bump tests with NIST-traceable reference gases. The acceptance criteria shown in **Table 4** are used for periodic testing (i.e., monthly, quarterly, annually), as well as for continuous, AutoQC of real-time data. Test gases were identified based on which compounds are required for monitoring by Rule 12-15, and concentrations were selected to be representative of potential detection events and near or below health thresholds of concern. Regarding accuracy and precision of open-path bump tests, warning levels are defined as 5% less than the acceptance criteria and are further discussed in the individual instrument SOPs (see Attachments 1-6). Bump tests and calibration checks are performed for information purposes only with the Tunable Diode Laser Absorption Spectroscopy (TDLAS) open-path system.

An appropriate manufacturer-specific calibration kit is used to assess accuracy of the visibility sensor and generally consists of a blocking plate (sensor zero) and scatter plate (span). The calibration fixture is assigned a factory-traceable extinction coefficient, which is compared to the value reported by the sensor.

Additional details regarding instrument calibration and frequency are shown in Section B.7, and step-by-step procedures are provided in the relevant instrument SOPs (Attachments 1–6).

Table 4. Acceptance criteria for instrumentation and equipment.

QA/QC Checks	Frequency	Gas/Concentration	Acceptance Criteria
UV-DOAS			
Bump test (accuracy and precision)	Monthly (and after major service)	Benzene 1–20 ppb	±20%
Spectral match (r^2)	Continuous	--	0.8–1.0
Integration time	Continuous	--	≤250 ms
Signal intensity	Continuous	--	≥70% (if integration time >250 ms)
TDLAS			
Bump test (informational purposes)	Monthly (and after major service)	Not applicable – temporary informational monitoring	
3-point calibration (informational purposes)	Quarterly	Not applicable – temporary informational monitoring	
H_2S spectral match (r)	Continuous	--	0.72–1.0
Signal power	Continuous	--	≥0.1 mW (corresponds to <1% transmission)
H_2O spectral match (r)	Continuous	--	0.95–1.0
CO_2 spectral match (r) (in the presence of dry air masses)	Continuous	--	0.95–1.0
FTIR			
Bump test (accuracy and precision)	Monthly (and after major service)	Propane 50–200 ppb	±20%
Spectral match (r^2)	Continuous	--	0.7–1.0
Signal intensity	Continuous	--	≥2%

QA/QC Checks	Frequency	Gas/Concentration	Acceptance Criteria
AutoGC			
Zero	Monthly	--	<2 ppb
Span test (accuracy and precision)	Monthly	Benzene (10–20 ppb) and n-Hexane (10–20 ppb)	±15%
Multi-point calibration (linearity)	Quarterly (and after major service)	Benzene 10–20 ppb	±15% (each point) R^2 >0.96 y-intercept ±2 ppb
H_2S Point Monitor			
Zero/span verification (accuracy and precision)	Monthly	Zero air and H_2S (450 ppb) [a]	<3 ppb (zero) ±15% (span)
Zero/span calibration	Quarterly (and after failed Zero/Span Verification)	Zero air and H_2S (450 ppb) [a]	--
Multi-point verification (linearity)	After Zero/Span Calibration	H_2S 75 ppb, 200 ppb, 325 ppb	±15% (each point) R^2 >0.96 y-intercept ±3 ppb
Visibility Sensor			
Extinction coefficient (accuracy)	Annually	--	±25%

[a] This concentration, if detected during one 5-min period, would result in an hourly ambient concentration close to the OEHHA REL and CAAQS for H_2S (30 ppb).

Completeness

Data completeness is assessed after reviewing the data flags assigned for each 5-min average data point (see Section B.5). BAAQMD guidance for open-path measurement data recovery is that instrumentation must meet a minimum of 75% completeness on an hourly basis, 90% of the time based on annual quarters. Completeness is therefore calculated as follows:

$$Quarterly\ \%\ Completeness = \left(\frac{Count\ of\ hours\ in\ the\ calendar\ quarter\ where\ hourly\ completeness > 75\%}{Count\ of\ all\ hours\ in\ the\ calendar\ quarter}\right) x\ 100$$

Additional data completeness definitions are included below.

- **Possible**. Maximum number of 5-min average concentrations that can be measured in a given hour and logged in the data management system (DMS)
- **Captured.** Actual number of 5-min average concentrations that were measured in a given hour and logged in the DMS
- **Missing.** Number of 5-min average concentrations not measured or logged in the DMS in a given hour

  Missing = Possible – Captured
- **% Missing.** Percentage of missing 5-min average concentrations in a given hour relative to the possible number 5-min average concentrations

  % Missing = (Missing / Possible) x 100
- **Invalid Total.** Number of invalid 5-min average concentrations measured and logged in the DMS in a given hour
- **% Invalid Total**. Percentage of invalid 5-min average concentrations in a given hour relative to the possible number of 5-min average concentrations

  % Invalid Total = (Invalid Total / Possible) x 100
- **Invalid Environmental.** Number of invalid 5-min average concentrations in a given hour due to adverse atmospheric or environmental conditions
- **Invalid Other.** Number of invalid 5-min average concentrations in a given hour due to anything other than adverse atmospheric or environmental conditions
- **% Invalid Other.** Percentage of invalid 5-min average concentrations in a given hour due to anything other than adverse atmospheric or environmental conditions relative to the possible number of 5-min average concentrations

  % Invalid Other = (Invalid Other / Possible) x 100
- **Expected.** Number of possible 5-min average concentrations in a given hour, adjusted for periods of low visibility during adverse atmospheric or environmental conditions

  Expected = Possible – Invalid Environmental

- **Valid.** Number of valid 5-min average concentrations in a given hour
- **% Valid.** Percentage of valid 5-min average concentrations in a given hour relative to the possible number of 5-min average concentrations

  % Valid = (Valid / Possible) x 100
- **% Hourly Completeness.** Percentage of valid 5-min average concentrations in a given hour relative to the expected number of 5-min average concentrations

  % Hourly Completeness = (Valid / Expected) x 100

A.8 Special Training and Certifications

All project personnel are provided with necessary training and oversight, including:

1. Safety courses administered through the Occupational Safety Councils of America (OSCA)
2. Instrument-specific training from vendors
3. Data validation training from experienced analysts
4. Routine operations and maintenance training from experienced field technicians

Training is conducted by senior staff with at least one year of experience operating refinery fenceline monitoring systems, and analyzer manufacturers. Project personnel are provided copies of the QAPP and SOPs, and receive updated versions when available. Initial training is provided prior to personnel performing work on the system, and refresher trainings are conducted on an annual basis. The QA Manager will identify specific training requirements for all project personnel and will determine when trainees are qualified to work independently. Training records will be maintained by the Field Staff Manager. Additional details regarding training and certification are provided in the individual SOPs included as attachments (Attachments 1-6).

A.9 Documents and Records

Quality System documentation, including the AMP, QAPP, and SOPs, are frequently revised to reflect current best practices, improvements to available technology and data control practices, and fenceline monitoring program changes. Revisions (and new SOPs) are undertaken at the direction of the QA Manager. In addition to Quality System documentation, quarterly reports are produced that provide a summary of system performance over each calendar quarter, which may include data summaries, statistical analyses, and the results of QC tests. These reports are generated by relevant project staff, overseen by the QA Manager, and delivered to BAAQMD along with quarterly data deliveries.

The fenceline contractor (Sonoma Technology) achieves work product quality through a series of internal review-and-correction cycles and an external review by the client. Documents undergo at least two internal reviews – the first by a senior technical staff member who is knowledgeable about the subject matter but is not the primary author of the work, and the second by a technical editor who is skilled in English mechanics and writing style. Before any document (draft or final) is delivered to the refinery, the lead author or Project Manager conducts a final quality review and approves it for delivery. Final approved versions in PDF format are distributed to the refinery and/or appropriate project personnel via email. Final approved versions in PDF format are distributed to the refinery and/or appropriate project personnel via email. The refinery reviews the report for accuracy and any changes are jointly discussed between the refinery and the fenceline contractor prior to finalization and submission.

Sonoma Technology employs a robust, systematic approach to version tracking and file maintenance. Each document is stored by project number on a shared fileserver. Only the most recent version is stored in the top-level folder, and each draft version is tracked by a timestamp as well as all reviewers' initials in a subfolder. A unique Master File Number is assigned to each document and all versions of that document retain that number.

Sonoma Technology's proprietary Deliverables Organizer and Tracking System (DOTS) is used to track progress and facilitate management of all quality documentation and work products. The web-based system retains information on document versions, including the dates and names of employees who edited, reviewed, and revised each document. DOTS also contains standard reports for tracking deliverables through the QA/QC and delivery process, and ensures that document information can be easily retrieved. A lead author or Project Manager creates a DOTS entry for each upcoming deliverable; the project Technical Editor maintains the DOTS record as each deliverable progresses through the update, review, delivery, and disposition process. Microsoft Word and PDF versions of all final approved documents are preserved on Sonoma Technology's fileserver in a secured Master File Library.

All staff involved in fenceline monitoring have been provided with electronic copies of all SOPs. Revised versions of the QAPP and SOPs will be distributed to both refinery and contractor staff via email, and will also be stored on a shared drive. Additionally, hard copies of the SOPs and analyzer user manuals are kept in the analyzer shelters and replaced when revisions are completed. By updating digital and hard copies of the QAPP, SOPs, and other QC documents, we ensure that staff only use the most recent version to meet measurement and data quality objectives.

The analyzer shelters also contain logbooks where all onsite activities related to the fenceline monitoring system are recorded. This includes planned maintenance activities and emergency site visits. The field logbooks are scanned monthly to generate electronic copies.

Any corrections that are made to hard-copy documents will be indicated by (1) a cross out of the previous entry, (2) the addition of a new entry, (3) the date of correction, and (4) the initials or name of the individual making the correction. Electronic documents (reports and data) are stored on a password-protected server at Sonoma Technology, with current and previous versions stored by project and document (**Table 5**). The document retention policy for the fenceline monitoring network is shown in **Table 5**.

Table 5. Document management procedures for the Chevron Richmond Refinery fenceline monitoring project.

Document	Retention Policy
AMP	Fenceline Project Manager to retain all versions for project duration
QAPP	Fenceline Project Manager to retain all versions for the duration of the air monitoring program
Maintenance Forms	QA Manager to retain all documents for 5 years
Audit Forms	QA Manager to retain all documents for 5 years
Corrective Action Report	QA Manager to retain all documents for 5 years
Calibration Standard Certifications	QA Manager to retain all documents for 5 years
Daily Data Check Logs	QA Manager to retain all documents for 5 years
Logbooks	Field Staff Manager to retain all versions for 5 years at Chevron Richmond (or electronically)
Training Documents	QA Manager to retain all documents for 5 years

B. Data Generation and Acquisition

B.1 Sampling Process Design

Open-path analyzers were selected after consideration of all Rule 12-15 requirements, including (1) spatial coverage necessary to monitor hundreds of meters of refinery fencelines, (2) 5-min resolution for real-time data, and (3) required detection limits, accuracy, and precision of target compounds. Additional details about open-path analyzers are provided in Section B.2.

Heavy fog, rain, or smoke may block the signal from an open-path instrument and prevent data collection, but even light fog can partially absorb the signal and interfere with measurements. Visibility measurements are made at one representative location to confirm when low-visibility conditions result in invalid data from open-path instruments. Three sampling paths, composed of five segments in total, are shown in Figure 2.

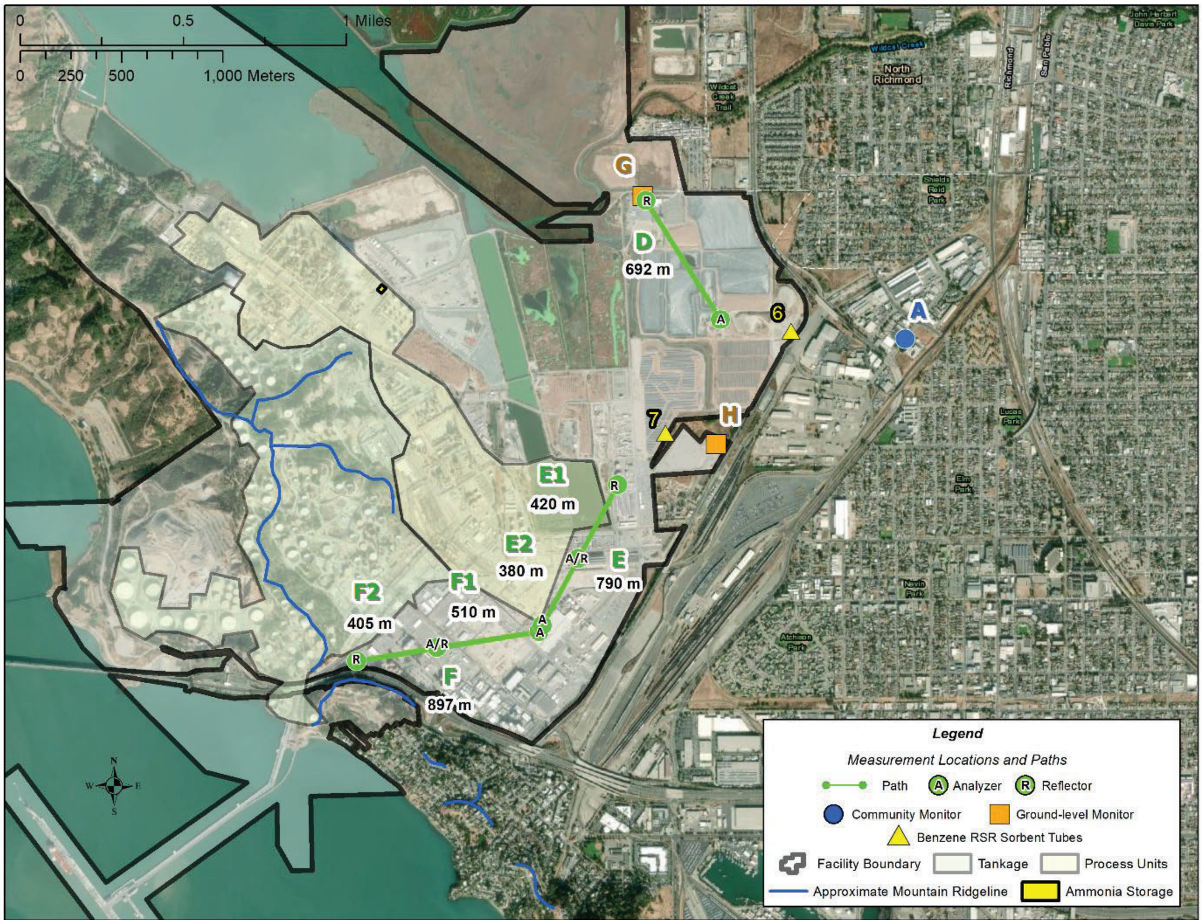

Figure 2. Location of sensors and measurement paths. Bistatic UV-DOAS instruments are used at paths D, E, and F. Monostatic FTIR and TDLAS instruments are used at paths D, E1, E2, F1, and F2.

Separate community monitors near the open-path monitoring sites include UV-fluorescence analyzers to measure H_2S, cavity ring-down spectroscopy analyzer for ammonia (NH_3), aethalometers for black carbon (BC), beta attenuation monitors (BAMs) for particulate matter ($PM_{2.5}$), and automated gas chromatography analyzers (AutoGCs) for volatile organic compounds (VOCs). GLMs provide additional measurements of H_2S and SO_2, and passive sorbent-tube samplers provide additional measurements of benzene. Real-time data from these additional community monitors are shown on the public website.

Meteorological stations contain visibility sensors and provide measurements of wind speed, wind direction, temperature, and relative humidity.

B.2 Sampling Methods

BTEX and SO_2 are measured by bistatic UV-DOAS (source and detector on opposite ends of the sampling path) with a xenon light source. The xenon light source is required to achieve sufficient detection limits for target compounds over the approximately 800-m sampling paths. Each target ultraviolet- (UV) absorbing compound has a unique absorbance spectrum, meaning they absorb different amounts of light at discrete wavelengths. This is measured by the analyzer, which then compares regions of a sample absorbance spectra to the same regions of a reference absorbance spectra.

Methane and alkanes are measured by monostatic (source and detector collocated, with a retroreflector on the opposite end of the path) FTIR, which operates similarly to the UV-DOAS. A combination of industry standard and proprietary methods are used to mitigate interference from water vapor and interference gases.

For both UV-DOAS and FTIR, a classic least squares regression analysis provides a spectral match parameter (r^2) which is used to identify potential interferences present in the sample path. The primary means of avoiding absorbance due to interfering gases is to select regions of the absorbance spectrum that are specific to the target compounds and free of absorbance due to other gases. Spectral subtraction is used in cases with overlapping absorbance features, and the subtraction technique is proprietary to the instrument manufacturer. Spectral matching is used to identify the target compounds and Beer's Law is used to report the concentration. This approach is comparable to U.S. EPA's TO-16 Methodology,[6] though TO-16 was not written specifically for UV-DOAS applications.

H_2S will temporarily be measured for informational purposes only by monostatic TDLAS pending deployment of more precise point monitors. A tunable diode laser emits light at a very small range of wavelengths, which allows spectral measurement of an H_2S absorption peak. The Unisearch TDLAS

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[6] U.S. Environmental Protection Agency (1999) Compendium of methods for the determination of toxic organic compounds in ambient air: compendium method TO-16. Second edition, prepared by the U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, OH, EPA/625/R-96/010b, January. Available at https://www3.epa.gov/ttnamti1/files/ambient/airtox/tocomp99.pdf.

operates in a wavelength range that also contains an absorbance feature for water vapor and carbon dioxide (CO_2), both of which are present in Earth's atmosphere, so the spectral match of those gases can be used as additional performance metrics. If the water vapor spectral match drops below a threshold value, the CO_2 spectral match is examined. If that also drops below a threshold value, data are flagged as invalid. The signal strength of the light transmitted through the atmosphere is recorded using a photodiode detector and recorded in the data file. Together with an independent visibility measurement, the signal strength can be used to evaluate the impact of atmospheric conditions or misalignment on data quality. The TDLAS detection limit for H_2S is variable and also depends on atmospheric conditions.

The North Richmond community monitor uses an AutoGC with a photoionization detector (PID) to measure BTEX in ambient air. Sample gas flows through the gas chromatograph column and separates at different rates depending on the various chemical and physical properties. The photoionization detector causes ionization of the sample using UV light. The ionization chamber exposed to the light source contains a pair of electrodes. When a positive potential is applied to one electrode, an electro-magnetic field is created in the chamber. Ions formed by the adsorption of photons are driven to a collector electrode. The current produced correlates with concentration.

The North Richmond community monitor and Castro Street GLM use UV pulse analyzers to measure H_2S and SO_2 in ambient air. The H_2S analyzer draws sample gas through an H_2S-to-SO_2 converter coupled to a pulsed-fluorescence SO_2 analyzer. Continuous H_2S monitoring is accomplished by conversion of H_2S in the sample to SO_2 and its subsequent detection by the SO_2 analyzer. The SO_2 fluorescence analyzer has a similar principle of measurement as the H_2S analyzer: sample flows into the fluorescence chamber, where pulsating UV light excites the SO_2 molecules. The condensing lens focuses the pulsating UV light into the mirror assembly, which contains four selective mirrors that reflect only the wavelengths that excite SO_2 molecules. As the excited SO_2 molecules decay to lower energy states, they emit UV light that is proportional to the SO_2 concentration.

Table 6 summarizes the estimated MDLs and upper detection limits (UDLs), which are the lowest and highest concentrations of each species that can be measured by each instrument and sampling path, as reported by instrument manufacturers. Values are presented as the average concentration along the sampling path, meaning a higher concentration is needed for detection when a narrow plume covers only a portion of the path. The MDL may be higher than those listed in Table 6 if there is poor atmospheric visibility (e.g., fog, rain, smoke, or dust), misalignment of the light source with the retroreflectors, hardware problems, or interfering gases. MDLs at the lower end of the specified range are expected under the opposite conditions.

Additional information regarding instrument operations and maintenance, emergency site visits, and corrective actions are detailed in Section B.6.

Table 6. Open-path instruments and approximate detection limits by pollutant and path. Actual detection limits will differ and depend on ambient conditions. H_2S MDLs will be evaluated in real-time and used for informational purposes only.

Path	Compound	Path Integrated Values		North Richmond (D)		Atchison (E)		Atchison (E1)		Atchison (E2)		Point Richmond (F)		Point Richmond (F1)		Point Richmond (F2)	
Distance (m)		N/A		692 m		791 m		415 m		376 m		899 m		497 m		400 m	
Technology		MDL (ppb)	UDL (ppb)	MDL (ppb)	UDL (ppb)	MDL (ppb)	UDL (ppb)	MDL (ppb)	UDL (ppb)	MDL (ppb)	UDL (ppb)	MDL (ppb)	UDL (ppb)	MDL (ppb)	UDL (ppb)	MDL (ppb)	UDL (ppb)
UV-DOAS	Benzene	0.27	16,000	0.19	23,000	0.17	20,000	-	-	-	-	0.15	18,000	-	-	-	-
	Toluene	0.84	22,000	0.61	32,000	0.53	28,000	-	-	-	-	0.47	25,000	-	-	-	-
	Ethylbenzene	0.3	11,000	0.22	16,000	0.19	14,000	-	-	-	-	0.17	12,000	-	-	-	-
	o-xylene	3.8	2,100	2.7	3,100	2.4	2,700	-	-	-	-	2.1	2,400	-	-	-	-
	m-xylene	0.35	920	0.25	1,300	0.22	1,200	-	-	-	-	0.2	1,000	-	-	-	-
	p-xylene	0.24	360	0.17	510	0.15	450	-	-	-	-	0.13	400	-	-	-	-
	Sulfur Dioxide	0.68	21,000	0.49	30,000	0.43	26,000	-	-	-	-	0.38	23,000	-	-	-	-
TDLAS	H_2S	N/A[a]	7,500	N/A[a]	5,400	-	-	N/A[a]	8,900	N/A[a]	9,900	-	-	N/A[a]	7,500	N/A[a]	9,300
FTIR	Methane	7	4,200	5.1	3,000	-	-	8.4	5,000	9.2	5,500	-	-	7.1	4,200	8.8	5,200
	Ethane	3.2	1,100	2.3	810	-	-	3.8	1,300	4.2	1,500	-	-	3.2	1,100	4	1,400
	Propane	3.8	1,100	2.7	810	-	-	4.5	1,300	5	1,500	-	-	3.8	1,100	4.7	1,400
	Butane	4.2	1,100	3	810	-	-	5	1,300	5.5	1,500	-	-	4.2	1,100	5.2	1,400
	Pentane	1.6	1,100	1.2	810	-	-	1.9	1,300	2.1	1,500	-	-	1.6	1,100	2	1,400

[a] The TDLAS detection limit for H_2S is variable and also depends on atmospheric conditions. H_2S will temporarily be detected and quantified for informational purposes only using an open-path TDL air monitoring system pending deployment of more precise point monitors.

B.3 Sample Handling and Custody

Analyzers are located in secured sites to prohibit tampering or handling by anyone other than authorized personnel. Technicians keep sampling shelters clean and routinely check analyzers for any debris or residue during site visits. Real-time data are transmitted to the DMS by cellular modem and can only be accessed by authorized personnel. All changes to data within the DMS are tracked through chain-of-custody logs.

As discussed in the AMP, benzene concentrations are measured at select sites through the use of an absorbent tube deployed inside a sampling shelter. Sampling and analysis are performed following EPA 325 A/B methodology. Sample tubes are conditioned, blank checked, assigned to sample sites, and recorded in an electronic chain-of-custody file in the lab. A colored loom band is placed on each conditioned tube prior to deployment in the field, which differentiates deployed tubes from retrieved tubes. Tubes are deployed and retrieved every 14 days using separate “retrieval” and “deployment” carriers, and chain-of-custody logs are updated at each deployment and retrieval.

B.4 Analytical Methods

Refer to Section B.2 for information regarding real-time sampling methods.

Sampling and analysis for the benzene sorbent tubes are performed following EPA 325 A/B methodology. Sorbent tube samples received in the laboratory for analysis are thermally desorbed and analyzed by gas chromatography/mass spectrometry (GC/MS) for trace-level benzene. Critical steps included in the process of thermal desorption are described below and performed automatically by the thermal desorption system.

- Leak testing under stop flow
- Recording ambient conditions
- Internal standard addition
- Tube purging
- Thermal desorption of the sample tube
- Refocusing on a cold trap
- Secondary desorption of the cold trap with transfer/injection of the sample to the capillary GC column for analysis of the analytes of interest

B.5 Quality Control Requirements

Real-time data from open-path analyzers and point monitors undergo several rounds of QC, including a review by AutoQC logic, which flags data before they are posted on the public website. Additional details on analysis and quality control of real-time and final data are described in Section D.2.

Field blanks for the benzene sorbent tubes are deployed in the same manner as samples, except that the long-term storage caps remain on both ends of the tube and are placed in the sample shelter alongside the field sample. One field blank is required per sampling event and is chosen randomly in different quadrants. Two co-located duplicates are collected for every sampling event following the normal deployment procedure.

B.6 Instrument/Equipment Testing, Inspection, and Maintenance

Routine Maintenance

The UV-DOAS, TDLAS, and FTIR open-path analyzers are designed to require only modest service and maintenance. **Tables 7 through 9** summarize the routine maintenance activities for open-path analyzers as recommended by instrument manufacturers, and additional details are provided in the instrument SOPs (Attachments 1–3). Preventive maintenance frequency depends on the operating environment and may need to be adjusted depending on field conditions. Any potential changes will be reflected in an updated version of this QAPP, which will be sent to BAAQMD for approval.

Table 7. Schedule of routine maintenance activities for UV-DOAS open-path analyzers.

Activity	Monthly	Quarterly	Annually
Visually inspect the system	✓		
Inspect detector and retroreflector optics; clean if necessary	✓		
Inspect and clean system filters	✓		
Inspect all electrical cables for wear; replace as needed	✓		
Confirm the alignment of the light source and detector	✓		
Ensure that there are no obstructions between the light source and detector (e.g., refinery equipment, vegetation, or vehicles)	✓		
Document signal levels to establish a baseline for light source replacement frequency	✓		
Archive historical data and remove from analyzer computer	✓		
Perform bump test	✓		
Replace light source if diagnostics are outside the acceptable range		✓	
Replace ventilation exit and intake filters		✓	
Clean detector optics		✓	
Confirm the alignment of the light source and detector		✓	
Verify system settings			✓

Table 8. Schedule of routine maintenance activities for TDLAS open-path analyzers.

Activity	Monthly	Quarterly	Annually
Visually inspect the system	✓		
Inspect detector and retroreflector optics; clean if necessary	✓		
Inspect all electrical cables for wear; replace as needed	✓		
Confirm the alignment of the light source/detector and retroreflector	✓		
Ensure that there are no obstructions between the light source/detector and retroreflector (e.g. refinery equipment, vegetation, or vehicles)	✓		
Archive historical data and remove from analyzer computer	✓		
Perform bump test	✓		
Document signal levels*		✓	
Perform 3-point calibration check		✓	
Verify system settings as described in the SOP			✓

* Although signal strength is recorded in real time, long-term trends are necessary to evaluate the status of optical components, effects of cleaning optical components, and the noise characteristics of the spectral data.

Table 9. Schedule of routine maintenance activities for FTIR open-path analyzers.

Activity	Monthly	Quarterly	Annually	Biannually	5 Years
Visually inspect the system	✓				
Inspect detector and retroreflector optics; clean if necessary	✓				
Confirm the alignment of the light source/detector and retroreflector	✓				
Ensure that there are no obstructions between the light source/detector and retroreflector (e.g., refinery equipment, vegetation, or vehicles)	✓				
Archive historical data and remove from analyzer computer	✓				
Perform bump test	✓				
Inspect and clean exterior heat sink for AC system		✓			
Test and document signal levels to establish a baseline for light source and retroreflector replacement frequency			✓		
Replace cryocooler or swap detector module assembly				✓	
Replace the light source					✓

Routine quarterly maintenance of the visibility sensors includes inspecting for dirt, spider webs, birds' nests, and other obstructions (Table 10). Obstructions are removed and the glass windows are cleaned if the sensor is dirty. There are no serviceable components in the sensor. Calibration is performed annually per the manufacturer's recommendation. Additional information regarding routine maintenance of the visibility sensor is provided in Attachment 4.

Table 10. Schedule of routine maintenance activities for visibility sensors.

Activity	Quarterly	Annually
Visually inspect the system, including all cables	✓	
Inspect detector optics; clean if necessary	✓	
Perform calibration (extinction coefficient)		✓

Routine maintenance activities for the AutoGC are summarized in Table 11, and additional details are provided in Attachment 5.

Table 11. Schedule of routine maintenance activities for the community site AutoGC.

Activity	Quarterly	Annually	Biannually
Replace micro dust filter for sample	✓		
Remove dust from ventilator	✓		
Clean the lamp		✓	
Clean the PID		✓	
Change the carrier gas filters		✓	
Clean the diaphragm		✓	
Renew external sample tubing		✓	
Replace preconcentration Tenax tube		✓	
Replace cooled preconcentration trap		✓	
Optimize hard disk		✓	
Clean internal gas tubing			✓
Clean lamp housing			✓

Routine maintenance activities for the H_2S point monitors are summarized in Table 12, and additional details are provided in Attachment 6. The North Richmond community H_2S monitor and Castro Street GLM are maintained following analogous practices. In addition, maintenance checks will be performed if data quality checks fail or data availability targets are not met.

Table 12. Schedule of routine maintenance activities for the community site H_2S analyzer.

Activity	Monthly	Quarterly	Annually
Perform Zero and Span (Z/S) check	✓		
Review and verify test functions	✓		
Inspect sample lines	✓		
Change inlet particulate filter	✓		
Perform flow check		✓	
Perform multi-point check		✓	
Replace SO_2 scrubber material and sintered filters			✓
Check for H_2S->SO_2 converter efficiency (CE), replace or service the converter if CE < 96%			✓
Replace the critical flow orifice assembly			✓
Perform a pump check and rebuild if needed			✓
Perform leak check			✓
Perform UV lamp adjustment			✓
Perform PMT sensor hardware calibration			✓
Calibrate offset and slope			✓

Emergency Maintenance and Corrective Actions

Emergency maintenance occurs when problems are identified with the fenceline monitoring network. Two teams of after-hours (on-call) support personnel remotely monitor the status of the instrumentation and the data pipeline (acquisition, DMS, public website) 24 hours a day, 7 days a week. Automated alerts are sent if potential issues are identified, such as:

1. Missing data
2. Reported concentrations are outside of an specified range
3. Instrument diagnostics indicate a potential malfunction

The Sonoma Technology field operations team (Field Ops) is led by the Field Staff Manager, and the data pipeline team, or information systems team (IS Ops), is led by the Data Systems Manager. The nature of the potential issue determines which team receives the automated alert. On-call personnel are required to acknowledge alerts within 30 minutes of receipt and attempt to resolve potential issues remotely. This approach ensures that issues are identified and addressed in a timely manner, which maximizes the uptime of the fenceline monitoring network.

The Field Ops team addresses most issues pertaining to instrumentation and equipment. In the case of missing data, the refinery is notified if the alert cannot be resolved remotely and a maintenance message is posted on the public website at the direction of the refinery, and BAAQMD is notified of monitoring downtime with a duration over 24 hours according to Regulation 1-530.[7] Spare instrumentation or equipment may be installed if an extended outage is anticipated. In the case of elevated concentrations, data are reviewed and the refinery is notified whether the detection is legitimate or due to a potential instrument malfunction. Data flags are updated on the public website during daily data checks to ensure accuracy, including for potential after-hours events. Any required field site visits occur on the next business day, and all corrective actions performed are documented in on-site logbooks.

The IS Ops team addresses most issues pertaining to data flow and the public website. **Table 13** outlines examples of automated screening, which the IS Ops team may review to troubleshoot potential issues.

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[7] Area Monitoring Downtime (BAAQMD Rule 1-530), available at **http://www.baaqmd.gov/~/media/dotgov/files/rules/reg-1-general-provisions--definitions/documents/rg0100.pdf?la=en**.

Table 13. Examples of automated screening pertaining to the data pipeline and public website.

Target	Test	Frequency	Threshold
Website Availability	HTTP test of the public and internal websites	300 sec	Pass/Fail
DMS	CPU utilization	300 sec	>60%
	Memory use		>75%
	Disk space used		>75%
Data Flow	Time since last datum received	30 min	Pass/Fail
Data Processing Errors	Process scheduler	300 sec	Pass/Fail

B.7 Instrument Calibration and Frequency

As discussed in Section A.7, DQIs for open-path and point analyzers are assessed through completion of bump tests, span tests, and calibrations. These are part of the routine operations and maintenance of the system, which are further detailed in Section B.6 and in the instrument SOPs (Attachments 1–6).

Bump and span testing verifies analyzer detection capability, accuracy, and precision. Concentrations are selected such that they are well above the level of quantitation, but near or below levels of concern for target compounds, and are shown in Table 4. Bump tests are performed when the atmospheric influence on sample variability is assumed to be minimal, so tests are not conducted in rain, fog, or when ambient concentrations of target compounds or interfering gases (e.g., ozone) are changing rapidly. Temperature control is accomplished by systems within the instrument enclosure itself, so instrument shelters are ventilated but not temperature controlled. Retroreflector housings include a heater/fan system designed to mitigate the effects of condensation and particulates on the retroreflector surface.

Bump and span tests are performed by introducing NIST-traceable reference gases into the open-sampling path using a test cell. During open-path bump tests, light from the analyzer source passes through the test cell and entire atmospheric path length to the retroreflector. Light is reflected back through the sampling path, test cell, and detector. Because the light travels through the ambient atmosphere, which includes other gases and particles as it would during a normal measurement, this test is a representative assessment of the instrument's capabilities under the influence of environmental conditions. During bump tests, a number (N) of replicated, raw time resolution measurements (x_i) of a standard reference material of known magnitude (x_{std}) are measured. An acceptable number of trials is defined as 7≤N≤15, and a subset of test data which meet the acceptance criteria (see Section A.7) are used for subsequent calculations. The average value of these measurements is calculated as:

$$\bar{x} = \frac{\sum_i x_i}{N}$$

The standard deviation (σ) as:

$$\sigma = \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{N-1}}.$$

From these definitions, accuracy (as % error) is defined as:

$$\%\ error = \left|\frac{\bar{x} - x_{std}}{x_{std}}\right| \times 100\%$$

Precision (as the % coefficient of variation, CV) is defined as:

$$Precision \equiv \%\ CV = \frac{\sigma}{\bar{x}} \times 100\%$$

The same calculations are used for span testing of point monitors.

B.8 Inspection/Acceptance of Supplies and Consumables

The Field Staff Manager is responsible for inspection and acceptance of all supplies and consumables for the monitoring project. A certification of reference gases used for routine bump tests will be requested from the gas supplier, and standards will not be used past their expiration date.

B.9 Non-Direct Measurements

Part of the data validation methods includes comparison of fenceline monitoring data to remote background and average urban concentrations with the goal of determining overall data reasonableness. This comparison includes a combination of qualitative and quantitative assessments of general spatial or temporal trends in target compound concentrations, such that measurements from this monitoring program may be compared against other external data sources. Though no direct quantitative data product is generated from this comparison effort, comparisons to external data sources generally increase the confidence in data products and, by extension, the overall value of the monitoring project.

External sources of data used for comparison may include the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the BAAQMD, and the U.S. EPA. Common target compounds may include smoke or ozone, depending on available data sets. Data used for comparison will include quality-controlled final data where available, though preliminary data may be considered for qualitative assessments.

Importantly, because these data sets are external and were not collected, verified, or validated by this project's personnel, they will not serve as an independent benchmark for data validation or invalidation. They will only be used as secondary references to gauge overall reasonableness of data once all QC has been completed. Additional information regarding data verification and validation methods is provided in Section D.2 and Attachment 7.

B.10 Data Management

Raw data collected at each monitoring site are stored on the analyzer computer and only reviewed if data validation efforts identify potential issues that require additional investigation. A Data Acquisition System (DAS), or data logger, performs basic QC, averages to 5-min resolution, and aggregates data into a desired file format. This data containing 5-min concentration data, diagnostic parameters, and quality control and operational (QC/OP) codes assigned by the DAS are then transmitted from each sampling site to a cloud-based file storage service via cellular modems, where they are stored and available for retrieval as needed. Data from the cloud are ingested into Sonoma Technology's Insight© DMS where a robust AutoQC assigns data flags in real time based on instrument diagnostics and local meteorological measurements. Subsequent, automated DMS-level screening checks are performed according to Section D.2. From this point forward, data are persisted within the DMS and any changes to data are recorded via chain-of-custody logs.

These preliminary data are displayed on the public website within 10 minutes of collection. Data are reviewed daily by air quality data analysts to assess system operations, confirm the automated data flagging is correct, and ensure any corrections to data flagging are propagated to the public website immediately. Extended analyses are performed every calendar quarter and reviewed by the project QA Manager. Figure 3 illustrates the general data flow and QC schematic. Additional details regarding data verification and validation are provided in Section D.2 and Attachment 7.

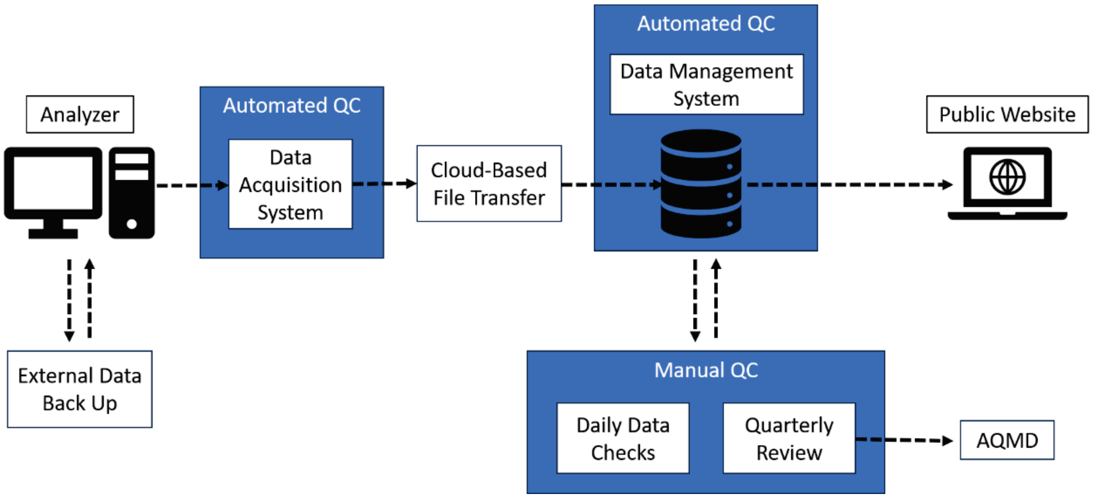

Figure 3. Data flow and QC schematic.

As described in Section B.6, data archival and management on the analyzer computers is part of routine operations and maintenance. Data are copied to external hard drives either manually or via an automated copy script and deleted from analyzer computers after confirmation that copy efforts were successful. Old files are deleted from the analyzer computer to allow continued data collection.

All ingested data are retained in the DMS. During quarterly analysis, data are downloaded from the database, analyzed, validated, and then backfilled into the DMS as final data sets. Redundancy of DMS data is maintained on a cloud-based system, and will be stored for 5 years after sampling.

In addition to the AutoQC and DMS-level screening checks, individual absorbance spectra from open-path measurements are available for additional review when automated processes identify either an anomaly or a detection event. This manual validation process relies on analytic software packages provided by the instrument manufacturers. Reference libraries and runtime settings are copied from analyzers in the field onto the auxiliary system where analysis is performed. This process is typically performed when detection events are observed, and doing so ensures accuracy of spectral information and allows qualified analysts to view individual absorbance spectra and associated fits. The ability to retain absorbance spectra and independently validate spectral matches and reported concentrations is a key part of the data validation process for open-path analyzers. Raw spectral data is manually backed up to external hard drives and retained for 5 years, and will be made available to BAAQMD upon request.

C. Assessment and Oversight

C.1 Assessments and Response Actions

On an annual basis, the refinery will work with the fenceline monitoring contractor to assess the performance of the network through:

1. Review of data completeness by monitoring path/site, instrument, and compound
2. Comparison of bump test results via control charting
3. Analysis of reported concentrations in the context of refinery operations
4. Analysis of reported concentrations with respect to meteorological conditions
5. Review of QC/OP codes that led to invalid data, including potential repeating combinations
6. Determination of whether any measures could be taken to reduce future occurrences of repeating invalid QC/OP code combinations, and implementation of those measures as necessary and appropriate
7. Verification that data are realistically achievable and not beyond the limits of what can be measured by the instrument

Using analyses similar to those used to support the network design, the contractor will further evaluate the overall performance of the network to ensure it is meeting project objectives. The contractor will also prepare an internal technical memorandum summarizing findings for the refinery, which will be submitted to BAAQMD along with the next quarterly report submission following completion of the memorandum. Following the assessment of the monitoring network, any necessary changes will be reflected as an update to the AMP, QAPP, or SOPs, which will be submitted to BAAQMD for approval prior to implementing any changes.

C.2 Reports to Management

Public Website

Posting data to a public website constitutes the most immediate and frequent reporting effort. Preliminary data collected by the fenceline monitoring network are displayed on a public website (usually within ~10–15 minutes of acquisition) with time series plots and map marker visualizations of 5-min and rolling hourly concentration values. Data are quality controlled in real time with AutoQC logic, and the resulting data flags (QC OP codes) assigned to each data point determine how they appear on the website. Additional information regarding website data display on the public website is provided in Section D.2.

The website is operated and maintained by the refinery's fenceline monitoring contractor (Sonoma Technology), and the general public is the intended user of the preliminary data. Accordingly, the public website contains supplemental information written at a public-friendly level about the monitoring network, target compounds, how to interpret data visualizations, and frequently asked questions (FAQs).

Quarterly Data Delivery to BAAQMD

Final data sets are compiled quarterly and will be provided to the BAAQMD no later than 60 days after the end of each calendar quarter. Outside of the normal quarterly delivery, data will be made available to BAAQMD within 30 days of a request. Consistent with BAAQMD guidance, quarterly data deliveries will include:

- Data for all instrument and parameter combinations in the comma separated value (.csv). Data will contain:
    - The name of the facility where the equipment is located
    - A unique identification number assigned to each instrument or system
    - A short descriptive name for the instrument associated with the reported unique ID (e.g., TDLAS, UV-DOAS)
    - The name of the compound being measured
    - The date of measurement, formatted as "yyyy-mm-dd"
    - The hour of the day and the beginning of the 5-min period over which measurements were collected and averaged, reported in Pacific Standard Time (PST) and formatted as "hh:mm" using 24-hr notation
    - The mean 5-min concentration, reported as numeric values for detection events above and below the LOQ
    - The unit of measure corresponding to the reported mean concentration
    - The averaging period duration (in minutes) for the reported mean concentration
    - The number of values that comprise the reported mean concentration
    - An indicator representing whether the reported mean concentration represents a legitimate air measurement ("Y") or one that has been affected ("N") by an instrument malfunction, adverse environmental conditions, maintenance events, etc.
    - Error codes explaining the reason for invalid or missing data, with multiple codes separated by a semicolon without spaces and the field left blank for valid data
    - The maximum concentration measured during the averaging period, reported in the same units of measure as the mean concentration
    - The required LOQ for the corresponding instrument, reported in the same units of measure as the mean concentration
    - The real-time LOQ for the averaging period, reported in the same units of measure as the mean concentration
    - The average measured light signal for the corresponding averaging period
    - The unit of measure for the corresponding light signal

- A record for each 5-min period of the quarter for all instrument and parameter combinations. Records corresponding to missing data will include the facility name, instrument ID, instrument descriptor, parameter, date, time, and error codes with their respective values, and remaining fields will be populated with a value of “NA.”
- An assessment of data completeness, as described in Section A.7.
- A summary of bump tests and calibration checks performed according to the QAPP, including the instrument or system, the type of test or check, the start and end date and time of the test or check, and the date and time that the instrument or system resumed normal operations. Potential failed bump tests or calibration checks will be included.
- The results of bump tests and calibration checks performed according to the QAPP, including accuracy and precision. Root cause analysis and a narrative description of maintenance or repairs performed to return the system to proper operations will be included for potential bump tests or calibration checks with accuracy and precision results that are not within the acceptance criteria.
- Data corrections accounting for the operational setup of bump tests and calibration checks, when they differ from ambient conditions.
- Meteorological data and a narrative explanation sufficient to justify where data have been excluded due to adverse atmospheric or environmental conditions.
- A summary of each instance of data invalidated for a reason other than failed acceptance criteria, including a brief statement of the cause.

D. Data Validation

D.1 Data Review, Verification, and Validation

Data verification is a process of comparing how the data were gathered to the procedures established by the project QAPP and SOPs. It is a data review technique that evaluates the conformance of data collection practices to established methods, procedures, or specifications. Data verification usually consists of checking that SOPs were followed and QC activities were performed.[8]

Data validation is a process of confirming that reported values meet the DQOs of the project. It is a data review technique that examines whether the particular requirements for a specific, intended use are fulfilled. Data validation examines whether acceptance criteria outlined in the QAPP were achieved.[7]

To produce defensible, quality environmental information for its intended use, Chevron shall:

- Meet regulatory requirements
    - Monitor in accordance with the AMP
    - Achieve the acceptance criteria outlined in the QAPP
    - Follow the procedures outlined in the relevant SOPs
- Maintain scientific robustness
    - Use validated methods and accepted practices for scientific quality
    - Use standard materials traceable to an authoritative source (NIST or equivalent)
    - Verify that the electronic output signals from instrumentation are representative of atmospheric conditions and real concentrations (vs. instrument noise)
- Ensure defensibility
    - Document all data collection steps and retain associated raw data
    - Maintain data integrity and reliability through chain-of-custody logging
    - Ensure ethical practices in achieving all project objectives

D.2 Verification and Validation

Data collected at each monitoring site receives five rounds of QC between the point of collection and final data set submission to the regulatory agency. A detailed process flow diagram of the data pipeline is provided in Section B.10, and additional details are provided in the Data Validation SOP (Attachment 7).

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[8] EPA Quality Assurance Handbook Vol II.

Tiered Data Quality Control

Data proceed through a tiered order at each point of the data flow and QC schematic, described below.

Level 0. Raw data collected on analyzer computers are referred to as Level 0 data. They do not receive any QC, but are retained for future review as needed.

Level 0.5. These data have been logged by the DAS and received only the most basic AutoQC. This stage of QC includes checking basic instrument diagnostic thresholds and whether a sufficient number of raw analyzer data points were collected to generate a 5-min average, which results in the data preliminarily being flagged as valid or invalid. Maintenance and calibration periods are commonly flagged at this stage, which do not receive additional QC because they are not representative of ambient monitoring data. Level 0.5 data are retained at least through the completion of quarterly analysis and generation of final data sets.

Level 1. Upon ingest to the DMS, the AutoQC further assesses data quality and subsequent DMS-level screening checks are performed, resulting in revised QC/OP codes for each individual data point in real time. The QC codes categorize data as valid, suspect/questionable, or invalid, and the OP codes provide additional context relevant to the assigned data flag. Unique AutoQC logic trees are developed for each piece of instrumentation and equipment by air quality scientists with input from instrument manufacturers where needed. Level 1 data are displayed on the public website within 10 minutes of collection by the analyzer.

Level 2. Daily review by Data Analysts allows system operations assessment and ensures that automated data flagging is correct. Data Analysts may adjust the QC/OP codes to reflect recent operational issues and have the ability to adjust data values if an independent validation of the raw data requires this action. Any and all changes to QC/OP codes or data values are made according to processes outlined in the SOPs and QAPP, recorded by the DMS via the chain-of-custody logs, and immediately reflected on the public website.

Level 3. Extended analyses are performed by Data Analysts every calendar quarter to verify and validate data as described in Attachment 7. As with Level 1 data, any and all changes to QC/OP codes or data values are recorded by the DMS via the chain-of-custody logs and are made according to processes outlined in the SOPs and QAPP.

Level 4. The final stage of QC is an independent review of data by the QA Analyst to confirm that analysis activities have been conducted according to the QAPP. Final data sets are prepared for submission to the regulatory agency and in support of quarterly reporting activities.

QC/OP Codes

Data flags within the Insight DMS are composed of QC/OP codes.

Table 14. QC/OP codes assigned in the Sonoma Technology Insight DMS.

QC/OP Codes	
QC Codes	
0	Valid
5	Suspect/Questionable
7	Insufficient Data
8	Missing
9	Invalid
OP Codes	
0	Valid
5	Suspect
7	Insufficient Data
9	Invalid
17	Below MDL
28	Planned Instrument Maintenance
29	Unplanned Instrument Maintenance
70	Instrument Malfunction
72	Marginal Operating Conditions (Good Spectral Match)
73	Low-Visibility Conditions
74	Poor Spectral Match
76	Marginal Operating Conditions (Poor Spectral Match)
100	Manual Data Review
101	Range Check
102	Rate-of-Change Check
103	Sticking Check
108	Real-Time MDL Outside of Required Range

QC codes are defined as follows:

- **Valid (QC=0).** Data that meet all defined thresholds for acceptance are considered valid and flagged with this QC code.

- **Suspect/Questionable (QC=5).** Data which meet the defined thresholds for acceptance but indicate marginal operating conditions based on secondary review criteria are flagged with this QC code. For example, elevated integration time reported by the UV-DOAS analyzer that coincides with elevated signal strength may indicate that the data require additional review but are likely accurate. Other causes of suspect/questionable data include concentrations out of a specified range, concentrations exceeding a defined rate-of-change, or stuck data values.
- **Insufficient Data (QC=7).** If insufficient data to generate an hourly average are received by the DMS, rolling hourly data is flagged with this QC code.
- **Missing (QC=8).** The DMS does not contain records for missing data that was not received by the DAS, but null records are created manually during the quarterly reporting process and included in final data sets.
- **Invalid (QC=9).** Data that do not meet defined thresholds for acceptance are flagged with this QC code in the DMS. Causes of invalid data include low visibility conditions, maintenance and calibration, open-path analyzer misalignment, and instrument malfunction. Data are only invalidated if acceptance criteria are not met or if a clear cause is identified that warrants invalidation. If data are anomalous but no clear cause is identified, data are flagged as suspect/questionable.

OP codes are defined as follows:

- **Valid (OP=0).** Data that meet all defined thresholds for acceptance are considered valid and flagged with this OP code.
- **Suspect/Questionable (OP=5).** This OP code is used as a fallback condition for aggregated hourly data to indicate data which meet the defined thresholds for acceptance but indicate marginal operating conditions based on secondary review criteria.
- **Insufficient Data (OP=7).** If insufficient data to generate an hourly average are received by the DMS, rolling hourly data is flagged with this OP code.
- **Missing (OP=8).** The DMS does not contain records for missing data that was not received by the DAS, but null records are created manually during the quarterly reporting process and included in final data sets.
- **Invalid (OP=9).** This OP code is used as a fallback condition for aggregated hourly data to indicate data that do not meet defined thresholds for acceptance.
- **Below MDL (OP=17).** Data that meet the spectral match criteria but are associated with concentrations below the defined MDL are flagged with this OP code. Concentration values with this OP code are shown as reported and included in statistical analysis.
- **Planned Instrument Maintenance (OP=28).** Data that are not representative of ambient conditions because planned maintenance is being performed on the system are flagged with this OP code.

- **Unplanned Instrument Maintenance (OP=29).** Data that are not representative of ambient conditions because unplanned maintenance is being performed on the system are flagged with this OP code.
- **Instrument Malfunction (OP=70).** Invalid data that are not coincident with low-visibility conditions are flagged with this OP code.
- **Marginal Operating Conditions; Good Spectral Match (OP=72).** This OP code is assigned to data that meet the spectral match criteria but have been flagged with a QC code of 5. Concentration values with this OP code are shown as reported and are included in statistical analysis.
- **Low-Visibility Conditions (OP=73).** Invalid data that are coincident with low-visibility conditions are flagged with this OP code.
- **Poor Spectral Match (OP=74).** This OP code is assigned to valid data that do not meet the spectral match criteria. These data are considered non-detections because the concentration of the target compound was so low that the analyzer does not determine it was present. In this scenario, the numerical output of the analyzer usually represents instrument noise but can occasionally range in magnitude depending on the result of the analytical fitting routine to the reference spectra. To reflect the status as a non-detection, data with poor spectral matches are adjusted to 0 ppb and are subsequently shown on the public website.
- **Marginal Operating Conditions; Poor Spectral Match (OP=76).** This OP code is assigned to data flagged with a QC code of 5 that also do not meet the spectral match criteria. These data are considered non-detections because the concentration of the target compound was so low that the analyzer did not determine it was present. In this scenario, the numerical output of the analyzer usually represents instrument noise but can occasionally range in magnitude depending on the result of the analytical fitting routine to the reference spectra. To reflect the status as a non-detection, data with poor spectral matches are adjusted to 0 ppb.
- **Manual Data Review (OP=100).** This OP code is used as a fallback condition to indicate data that have undergone additional manual review and are not readily categorized by the AutoQC logic. If this OP code is used, an accompanying explanation is provided in the quarterly report explaining why.
- **Range Check (OP=101).** This OP code is assigned when data are flagged by the associated DMS-level screening check for additional review.
- **Rate-of-Change Check (OP=102).** This OP code is assigned when data are flagged by the associated DMS-level screening check for additional review.
- **Sticking Check (OP=103).** This OP code is assigned when data are flagged by the associated DMS-level screening check for additional review.
- **Real-Time MDL Outside of Required Range (OP=108).** TDLAS data with real-time MDL values outside of the required range are flagged with this OP code.

Automated DMS-Level Screening Checks

For open-path analyzers, the DAS determines if each raw data point should be included in the 5-min average based on whether real-time instrument diagnostics are above the defined thresholds shown in Table 4 (Section A.7), which include signal return and spectral fit metrics. For analyzers with raw data resolutions on the order of 2–4 minutes (e.g., FTIR), the DAS requires that one measurement with diagnostic parameters above the defined thresholds must be collected for the 5-min average data point to be generated. For open-path analyzers with raw data resolutions on the order of 30 seconds (e.g., UV-DOAS), the DAS requires that six measurements with diagnostic parameters above the defined thresholds be collected for the 5-min average data point to be generated. TDLAS analyzers with raw data resolutions on the order of 8 seconds do not have a completeness requirement for the 5-min average data point to be generated. The number of data points used to calculate the 5-min average data point are reported in the final quarterly data sets.

In addition to the AutoQC logic conducted upon ingest to the DMS, **Table 15** summarizes DMS-level data screening checks, which help focus data review efforts on potentially anomalous data or where confirmation is otherwise needed that data values correctly reflect ambient conditions. These checks are based on expected instrument performance, and expected concentrations of target compounds relative to ambient background. The DMS auto-screening checks include:

- **Range**: This check flags data outside of a specified range when 5-min concentration values are greater than the defined threshold. With the exception of negative outliers, which are invalidated, this check does not alter the QC code and results in an OP code of 101.
- **Rate-of-Change**: Rapid changes between individual 5-min values are flagged for additional review as they may be anomalous. This check does not alter the QC code and results in an OP code of 102.
- **Sticking**: Stuck values are flagged for additional review as they may be indicative of an issue with the instrument and may not represent ambient data. Sticking checks are not applied to data that are below the instrument detection limit (i.e., concentration values of 0). This check does not alter the QC code and results in an OP code of 103.

QC/OP codes are assigned through a combination of AutoQC and DMS-level screening checks, and result in Level 1 data.

Table 15. DMS-level screening checks for 5-min data.

Compound	Range (ppb)	Rate-of-Change (ppb)	Sticking
Benzene	5	3	Four or more stuck values
Toluene	70	35	
Ethylbenzene	320	160	

Compound	Range (ppb)	Rate-of-Change (ppb)	Sticking
Xylenes	200	100	
SO_2	50	25	
H_2S	25	15	
Methane	1,520[a]	500	
Alkanes	1,000	5,000	

[a] Methane data is flagged when below this threshold because it is considered out of range of the expected global background.

Daily Data Checks

Following AutoQC and DMS-level screening checks, Data Analysts review the Level 1 data from the fenceline monitoring network on an at least a daily basis to identify operational issues and maximize system uptime, typically with a one- to two-day running time series plot of select parameters on an internal field operations website. The Data Analyst assesses the current operational status of the monitoring network and whether concentration patterns are reasonable with respect to the time of day, season, current meteorological conditions, facility operations, and concentration levels measured at other sites. Data are also reviewed on the public website to confirm that data flow and visualizations are current, and to additionally identify any anomalous behavior. Findings are documented after each check and made available to the Project Management, Field Staff, Data Analysts performing quarterly analysis, and the QA Manager.

Examples of observations requiring additional review include low signal strength or high integration time; spikes or dips in diagnostic parameters or reported concentrations; stuck or missing data; negative concentrations; and concentrations that are outside of a specified range based on nearby measurements or known atmospheric chemistry. Data are only invalidated if they do not meet defined acceptance criteria (see Section A.7) or a clear and verifiable cause has been identified and documented. This documentation is part of the daily data check logs and will be retained for a period of 5 years in accordance with Section 502 of Rule 12-15. Common reasons for invalidation include instrument malfunction, power failure, and bump test data that were incorrectly flagged.

Data flagged as suspect or invalid by AutoQC and DMS-level screening checks may also be validated during daily data checks if appropriate, meaning that temporary data flags are typically resolved within one to two business days. Following the daily data check, data are considered Level 2.

Unusual Observations

If unusual data are observed during daily data checks, the Data Analyst investigates whether an instrument malfunction occurred or if the anomalous data are explainable and therefore correct. Any need for corrective action is communicated to the Project Manager and Field Staff for further coordination. Technical staff may remotely access analyzers in the field to perform basic troubleshooting, and site visits are conducted as required.

When elevated concentrations (i.e., concentrations greater than routine background observations) are reported by open-path analyzers, a visual review of individual absorption spectra is performed using data processing software provided by the instrument manufacturer. Additional information regarding spectral validation of open-path data is provided in the SOPs attached to this document (Attachments 1–3). If this additional review proves data to be invalid, they are flagged accordingly and may be removed from the public display. The rationale for data invalidation is maintained in the chain-of-custody logs, and corrective action is overseen by the Field Staff Manager usually within one to two business days. If extended instrument downtime is necessary to address a data quality issue, BAAQMD personnel will be notified in accordance with Regulation 1-530.

On-Call Response

Similar review processes are completed outside of business hours by after-hours support staff in the event of missing data alerts or an exceedance of defined concentration thresholds. This helps to maximize system uptime and ensure the accuracy of data reported to the public website in real time.

Quarterly Review and Reporting

Data undergo an extended analysis every 90 days in alignment with quarterly reporting requirements, after which they are considered Level 3. Where possible, quarterly analysis is conducted by the same analysts who have been completing daily data checks to ensure consistency and familiarity with the monitoring network. Any and all changes to QC/OP codes or data values are recorded by the DMS via the chain-of-custody logs, and are made according to processes outlined in the SOPs and QAPP.

Analysts verify that SOPs were followed and QC activities were performed according to the QAPP. Examples of quarterly data verification may include:

- Review of daily data check documentation and routine instrument maintenance records to ensure consistency
- Confirmation that routine maintenance, calibrations, and bump and span tests were conducted according to schedule
- Review of instrument logbooks to assess whether data flagged as invalid or suspect/questionable are explainable based on recorded observations
- Review of site operator logbooks to assess whether observations by Field Technicians require additional examination of data

- Review of changes to data QC/OP codes or data values, and confirmation that they were appropriately recorded

Data Validation

Analysts validate data by exporting quarterly data sets from the DMS and analyzing them with a robust QC analysis code. Analysis code is maintained through an internal code repository, reviewed regularly, updated as requirements evolve, and shared with all analysts. The primary goal of quarterly data validation is to ensure reported values meet the quality objectives of the project and the acceptance criteria outlined in the QAPP were achieved. Quarterly data validation typically includes:

- Generation of monthly and quarterly summaries of data statistics (including concentration minimums, maximums, averages, and standard deviations)
- Identification and review of statistical outliers; negative outliers are defined as concentration values below –3 * MDL, and positive outliers are usually identified with DMS-level screening checks (range)
- Inspection of measurements before and after unusual data, missing data, instrument bump tests, and maintenance activities
- Review of data flagged as suspect/questionable, and flag adjustment to valid or invalid status, as appropriate
- Confirmation bump and span test results are within acceptance criteria detailed in the QAPP
- Comparison of data to remote background concentrations and average urban concentrations, including assessment of data consistency over longer time periods; as described in Section B.9, this comparison will not serve as an independent benchmark for data validation or invalidation and will only be used as secondary references to gauge overall reasonableness of data
- Verification that data are realistically achievable and not beyond the limits of what can be measured by the instrument
- Review of data completeness as detailed in Section A.7

Independent Review

An independent review of post-QC quarterly data sets ensures that data are reasonable and analysis activities were conducted according to the QAPP. This independent review is conducted on a representative sub-set of data using similar methods to those described for quarterly analysis by the QA Manager or another data analyst. Daily data check documentation and routine instrument maintenance records are also reviewed to ensure that the appropriate QC checks were applied. After this review, data are considered Level 4 (final).

Final data sets are prepared as a part of quarterly data review and reporting and are submitted to BAAQMD as discussed in Section C.2.

Public Website Display

Invalid Data (QC=9) are not representative of ambient conditions and are therefore omitted from the public website display. As noted above, causes of invalid data include low visibility conditions, maintenance and calibration, open-path analyzer misalignment, and instrument malfunction. On the time series plot and associated “tooltip” detail pane, no concentration value is shown and data are labeled “Invalid.” The map marker behavior is similar, but provides an extended message with additional information, such as the identification of maintenance periods, instrument malfunctions, or low-visibility conditions. Concentration values and diagnostic information for invalid data are retained within the DMS and included in final data deliveries to the regulatory agency.

Missing Data (QC=8) are not displayed on the website. Tooltip detail panes on the time series and map markers indicate where data are missing for each 5-min record. Null record indicators are created for these periods as a part of quarterly analysis, and are included in final data deliveries to the regulatory agency.

Insufficient Data (QC=7) only applies to the rolling hourly average concentrations, and the public website display behavior is the same as described for missing data.

Suspect/Questionable Data (QC=5) and **Valid Data (QC=0)** are displayed on the time series and map marker visualizations. Because suspect/questionable data do not coincide with failed acceptance criteria and merely indicate marginal operating conditions or the need for further manual review, concentration values are included in completeness calculations and statistical analyses. The suspect/questionable QC/OP code(s) may rarely remain following quarterly validation if they are unresolvable, but these data are considered valid despite unresolved questions. As such, they are also displayed on the public website.

Open-path data with a poor spectral match are considered **non-detections** because the concentration of the target compound is so low that the analyzer does not determine it was present. In this scenario, the numerical output of the analyzer usually represents instrument noise, but can occasionally range in magnitude depending on the result of the analytical fitting routine to the reference spectra. To reflect the status as a non-detection, data with poor spectral matches are adjusted to “0 ppb” and subsequently shown on the public website. Tooltip detail panes on the time series and map markers show “<MDL” or “BD” (below detection) for non-detections. Unadjusted concentration values for these non-detections are retained by the DMS.

Open-path data with a spectral match greater than the acceptance criteria (Table 4 in Section A.7) are considered **detections**, and the concentrations are displayed on the public website time series plots as recorded. If the recorded concentration is less than the defined instrument MDL, the tooltip detail panes on the time series and map markers show “<MDL” or “BD.” If the recorded concentrations are

greater than the defined instrument MDL, the tooltip detail panes on the time series and map markers show the recorded concentration.

Concentration data are always reported on the public website as recorded, unless the spectral match criteria are not met or the data are invalid or missing. A summary of public website display behavior according to QC/OP codes is shown in Table 16. Additional information regarding data display on the public website is included in the SOP for Data Verification and Validation (Attachment 7).

Table 16. Summary of public website display behavior according to QC/OP codes.

QC Code	OP Code	Concentration	Flag
0	74	0	Below Detection (BD or <MDL)
	17	As Recorded	Below Detection (BD or <MDL)
	0, 100, 101, 102, 108	As Recorded	Valid
5	76	0	Below Detection (BD or <MDL)
	17	As Recorded	Below Detection (BD or <MDL)
	0, 5, 72, 100, 101, 102, 103, 108	As Recorded	Suspect (Questionable)
7	7	None	Missing
8	8	None	Missing
9	28, 29, 70, 73	None	Invalid

D.3 Reconciliation with User Requirements

As discussed in Section C.2, the public website constitutes the primary, real-time reporting effort of preliminary data to the general public. Changes to data concentrations or data flags affect how data are displayed on the website, and are immediately propagated to the public website. In this manner, the refinery routinely provides the public with information regarding concentrations of target compounds at the fenceline of refining facilities, consistent with Rule 12-15 requirements.

Key components of the public website intended to meet user requirements of BAAQMD Rule 12-15 include visual display of data in real time, context for the public to better understand the concentrations displayed, and a mechanism for feedback. The website also includes a functionality to notify the public with custom messaging about instrument maintenance activities, potential issues with the monitoring network, or any other relevant information affecting the use of data.

E. Standard Operating Procedures

Instrument-specific SOPs for the systems listed below and an SOP for Data Verification and Validation are provided as attachments to this document.

- **Attachment 1**: Standard Operating Procedures for UV-DOAS
- **Attachment 2**: Standard Operating Procedures for TDLAS
- **Attachment 3**: Standard Operating Procedures for FTIR
- **Attachment 4**: Standard Operating Procedures for Visibility Sensor
- **Attachment 5**: Standard Operating Procedures for AutoGC
- **Attachment 6**: Standard Operating Procedures for H_2S Point Monitors
- **Attachment 7**: Standard Operating Procedure for Data Verification and Validation

Standard Operating Procedures for the CEREX UV Sentry UV-DOAS

October 31, 2024

STI-7024

APPROVED:

Sonoma Technology date

Fenceline Monitoring Refinery Representative date

Contents

1. Scope and Application

This SOP covers the use of the CEREX UV Sentry UV-DOAS analyzer in a fenceline monitoring application. This document addresses routine maintenance activities including visual inspections, instrument checks, data management, bump testing, and data validation. The maintenance forms are provided in Section 9.

2. Introduction and Overview

The CEREX UV Sentry ultraviolet differential absorption spectrometer (UV-DOAS, shown in **Figure 1**) is an instrument that is used to detect BTEX, SO_2, NO_2, and a number of other gases in the ultraviolet (UV) region of the electromagnetic spectrum. The instrument consists of a Xenon light source and several optical elements, including a spectrometer. UV-DOAS instruments may be configured so that the spectrometer and source are in one location (monostatic) or at opposite ends of the path (bistatic). For a monostatic configuration, the light from the light source is collimated with the primary mirror and directed along a path length of about 500 m. At the other end of the path is an array of corner-cube reflectors called retroreflectors that direct the light directly back into the analyzer where the light is dispersed and measured using a spectrometer. The working range of the spectrometer is from about 200 to 400 nm. This document addresses the routine operations and maintenance procedures for the CEREX Monitoring Solutions UV Sentry units. The procedure is intended to guide the field technician in ensuring and verifying that the equipment is performing to expectations. As required, hard copies of this procedure and the associated test forms will be kept on site and a copy of the test form showing the results will be sent to the Refinery Project Manager upon completion of the test procedure.

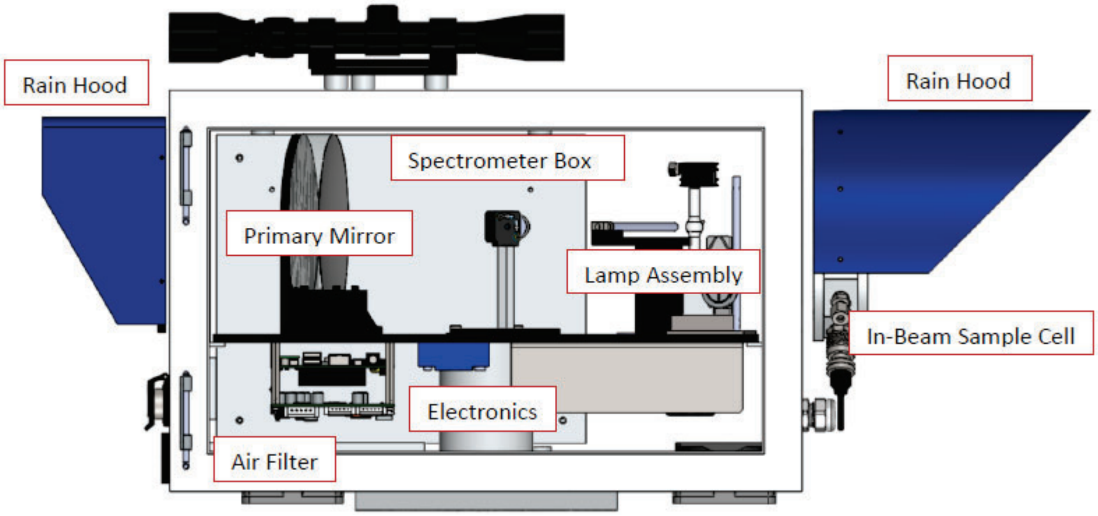


Figure 1. Schematic of the monostatic UV Sentry UV-DOAS analyzer.

The purpose of field maintenance is to ensure that the instrument is operated within specification and for field verification of the factory calibration of the UV Sentry. The QA Test process challenges the instrument using known concentrations of select BTEX reference gases and/or SO_2 to verify proper detection and quantification under field conditions.

3. Definitions

Table 1. Definitions of terms and acronyms used in this document.

Term/Acronym	Definition
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes (Xylenes are composed of ortho, meta and para isomers)
Bump Test	Test where gas of a known concentration is introduced to the analyzer to check for response accuracy and precision
CMS	Continuous Monitoring Software
Coefficent of Determination (R^2)	The square of the correlation coefficient. R^2 ranges from 0 (not correlated) to 1 (perfect correlation).
Correlation Coefficient (r)	A coefficient that measures the linear correlation between two sets of data. In the case of the UV-DOAS, it measures the correlation between the modeled and measured spectral data. It ranges from -1 (perfect anticorrelation) to 1 (perfect correlation).
Integration Time	The amount of time the spectrometer detector collects light for (typically 20 to 300 ms)
Intensity	A measure of how much light was collected
Percent Match	The coefficient of determination multiplied by 100. (R^2 x 100).
PPE	Personal Protective Equipment
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
SOP	Standard Operating Procedure
UV-DOAS	Ultraviolet Differential Absorption Spectroscopy

4. Safe Work, Hazard Identification, and Precautions

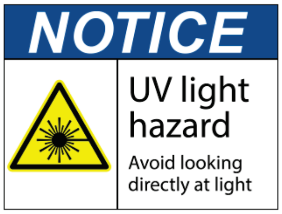
The following information is intended to provide guidance in ensuring a safe work environment.

Operator Qualifications

Installing, operating, and servicing CEREX UV Sentry analyzers should only be performed by personnel trained in the operation of the system components, familiar with the potential hazards associated with the deployment site, and familiar with the handling of gas delivery and testing equipment.

Work should conform to the manufacturer guidance and site health and safety practices.

The CEREX Monitoring Solutions UV Sentry Series Analyzers are not rated for safe operation in hazardous or explosive environments (not intrinsically safe). Any use in an area that may contain flammable mixtures or highly corrosive vapors requires special preparation to ensure operator safety and safe operation of the equipment.



WARNING – Eye hazard. Risk of eye injury. CEREX UV-DOAS Analyzers contain an ultra-violet light source that may cause eye injury after prolonged exposure. Always wear UVA/B/C eye protection when working on or near the operating equipment.

Procedure Warnings

The procedure contained within this document requires the handling of toxic substances including but not limited to benzene, aromatic hydrocarbons, and SO_2 gas, and it requires the operation of equipment designed for toxic gas containment and dispensation. Improper handling of materials or hardware may result in serious injury, destruction of property, or damage to the UV Sentry. Only qualified individuals should attempt or perform analyzer operation or testing activities.

Safe Operating Precautions

Ensure that a clear escape path is identified.

Standard site personal protective equipment (PPE) is appropriate. If gloves are required for work on optics, nitrile or latex should be used.

NOTICE

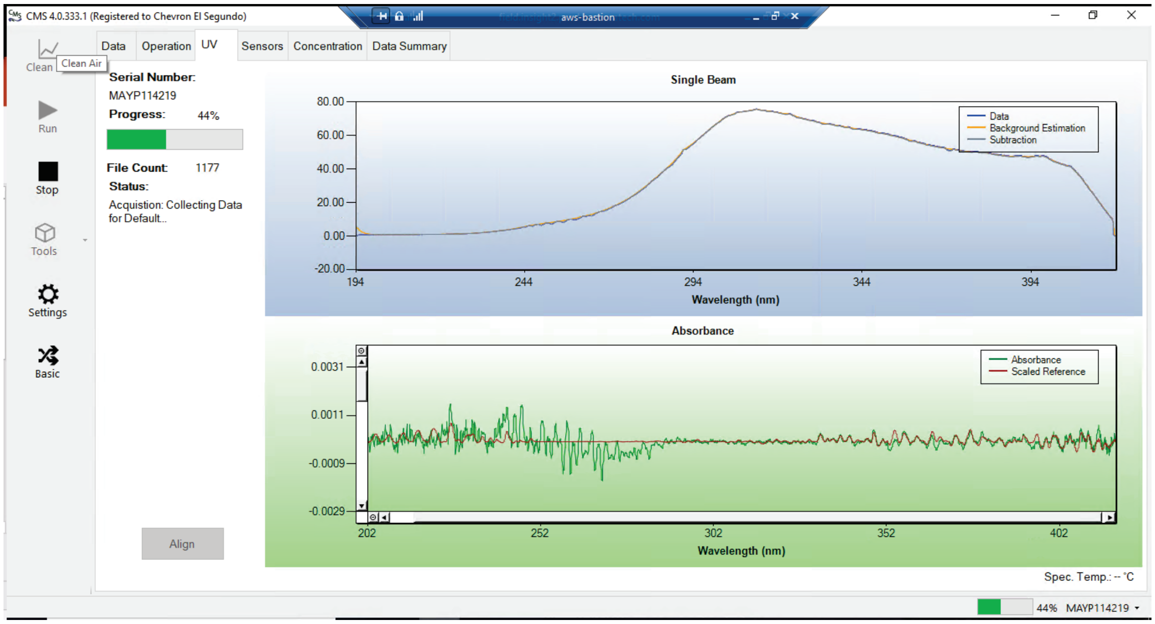
Please check off the following steps before conducting maintenance. Doing so reduces the chances of false notifications to the public and clients.

- ☐ Notify the client and project manager of maintenance tasks.
- ☐ Using the field tech tool at ftt.sonomatechmonitor.com, place the equipment into planned or unplanned maintenance mode.
- ☐ Confirm that the data is invalidated on the public website before proceeding with maintenance.
- ☐ When maintenance is complete check the public site <u>for at least 15 min</u> to ensure proper reporting (no missing data, no bump test data, etc.).
- ☐ Take out of maintenance mode
- ☐ Notify the project manager and client when maintenance is complete.

5. Routine Operations

To set the UV-DOAS instrument to acquire data for normal operations, the instrument CMS must be operating and the instrument must be aligned. These actions are detailed in the steps below.

1. Start the CMS software (if not already initiated). You should see a window similar to the one shown below in Figure 2.



Serial Number: MAYP114219
Progress: 44%
File Count: 1177
Status: Acquistion: Collecting Data for Default...

Figure 2. Screenshot showing the **UV** tab of the CMS software. Note that the **Align** button is grayed out because the instrument is in run mode (the **Run** button is also grayed out because the instrument is in run mode).

2. Under the **UV** tab, left-click on the **Align** button. This action brings up a new screen showing the instantaneous single beam plot (intensity vs wavelength). If the **Align** button is not active, you may need to press **Stop**. The **Align** mode is shown in Figure 3.

Integration Time: 38

Path Length: 2.000

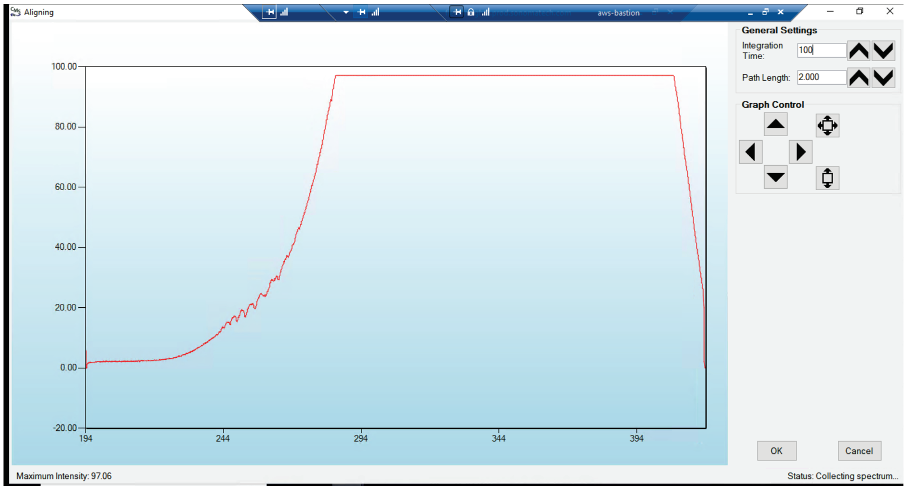
Maximum Intensity: 78.55

Status: Collecting spectrum...

Figure 3. Screenshot for **Align** mode. The integration time can be entered in the upper right of the screen. In this particular screenshot, the integration time is 38 ms.

3. Enter an integration time of 25 ms and optimize the signal intensity by adjusting the pan-tilt head of the UV-DOAS unit to adjust the position of the UV beam on the retroreflector.

   NOTE: Make sure not to saturate the peak of the spectrum when at 25 ms integration time. An example of a saturated spectrum is shown in Figure 4; note that the spectrum is flattened out starting at about 290 nm. Also, ensure there is sufficient intensity at 250 nm compared to the stray light intensity. If there is more than 10% stray light, advanced optical adjustment or bulb change may be necessary. To measure stray light, block the beam from exiting the analyzer with an opaque object (such as a black cloth) and measure the intensity at the wavelength of interest.



General Settings

Integration Time: 100

Path Length: 2.000

Maximum Intensity: 97.06

Status: Collecting spectrum...

Figure 4. An example of a saturated spectrum when in **Align** mode. Note the "flat top" profile of the spectrum. The spectrum flattens out because the detector has saturated at those wavelengths and cannot quantitatively measure additional light.

4. Once sufficient alignment is obtained, exit the align mode by pressing **Cancel**.
5. Verify settings by left-clicking **Settings**.

   Note: If you need to change any setting back to the original configuration, you must go to **File** and **Save** and **Save As Default.** If you change settings, record why they were changed and what they were changed to in the instrument logbook. If settings are changed, they are automatically saved under the directory: C:\Users\CMS-USER\Documents\Cerex\CMS.

- <u>RunTime</u>
  - General
    - Operator Name: **Default** (these will change based on the path and site you are working on)
    - Sitename: **Cerex** (these will change based on the path and site you are working on)
    - Auto Run: **ON**
    - Auto Run Delay (s): **15**
  - File
    - File Type: **.CSV**
    - Primary Data Logging File: **ON**
      - C:\Users\CMS-USER\Documents\Cerex\Data
    - Secondary Data File Logging: **ON**
      - \\OPT1-PC1\VLOData\OPT1_Path1\UVSentry_POC1
        - Note this path will change based on the different computer and path you are working on. This is just a basic file writing path to show you what it should look like.

        - Single Data Folder: **OFF**
        - Primary Summary File Logging: **ON**
            - C:\Users\CMS-USER\Documents\Cerex\Data
        - Secondary Summary File Logging: **ON**
            - \\OPT1-PC1\VLOData\OPT1_Path1\UVSentry_POC1
                - Note this path will change based on the different computer and path you are working on. This is just a basic file writing path to show you what it should look like
        - Single Summary File: **OFF**
    - Library
        - Library File: C:\Users\CMS-USER\Documents\Cerex\Library\
    - UI
        - Sort Column: Compound Name
        - Data Summary Chart: **OFF**
        - Concentration Chart: **OFF**
        - Password Protection Settings: **ON**
        - Pump Control: **OFF**
        - Status Control: **OFF**
        - Testing Control: **OFF**
- Analysis
    - General
        - Moving Average Interval: **12**
        - Display Units: **PPM**
    - Concentration
        - Zero Readings on Non-Detect: **OFF**
        - Zero Readings on Negative concentrations: **OFF**
        - Display BDL: **OFF**
        - Quick Analysis MDL Wave length Range: **276-280 (The range doesn't matter)**
        - Temperature/ Pressure Concentration: **OFF**
    - Filters
        - Absorbance Savitzhy-Golay: **ON**
        - Baseline Correction Savitzky-Golay: **OFF**

- Instruments
    - UV
        - Operation
            - UV: **ON**
            - Acquisition Time (s): **30 (this is the "averaging time" of the instrument)**

            - Integration Time (ms): **Always will change if Auto integration is turned on**. This is the amount of time that the instrument will collect light.
            - Path Length (m): **2 (2 for monostatic, 1 for bistatic)**
            - Trigger Mode: **Normal**
        - Auto Routine
            - Auto Integration: **ON** **(the software will determine the integration time)**
            - Intervals (s): **300**
            - Wavenumber Range: **300-310 (This is the range where the intensity will be measured for autointegration determination. This is different on all instruments due to Spectral Background and Intensity Range)**
            - Intensity Range **75-85 (This is the target intensity range for the autointegration routine)**
            - Maximum Integration: **300**
            - Auto Background: **ON**
            - Interval (Acquisitions): **5**
            - Wavenumber Range: **266-270**
        - Verification
            - Verification: **OFF** **(This inactivates all inputs)**
- <u>Controller</u>
    - General
        - Serial Port: **n/a**
        - Sensor Refresh Interval (s): **15**
    - Sensors
        - **Don’t Touch Anything**
    - Alarms
        - **Don’t Touch Anything**
- <u>Email</u>
    - General
        - Data Recipient: **Blank**
        - Email Sender: **Blank**
        - Email Periods (s): **60 (doesn’t matter the time, we don’t use this setting)**
        - Send Data: **OFF**
    - SMTP
        - Server: **smtp.gmail.com**
        - Port: **587**
        - Username: **Blank**
        - Password: **Blank**
        - Timeout (s): **100**
        - SSL Authentication: **ON**

- Auxiliary Coms
    - Modbus
        - Modbus: **ON**
        - System Type: **Ethernet**
        - TCP Port: **502**
        - Unit ID: **2**
        - 16-bit unsigned int to: **OFF**

6. After settings are verified and the instrument is aligned, you can place the instrument in run mode.

6. Equipment and Supplies

1. Field notebook
2. Tool kit, especially including: 7/64 hex driver, complete set of combination wrenches, adjustable wrenches, screwdrivers, etc.
3. Cleaning supplies designated to be safe for use on a CEREX UV-DOAS – especially lens paper
4. All relevant PPE, hardware, and procedural guidance per SOP, Safety Plan, and Safe Work Permit
5. Local or remote network link device (as required).
6. External laptop computer with network interface device to the Sentry unit (as required)
7. CEREX UV Sentry Unit equipped with CMS software
8. CEREX UV-DOAS 8″ x 8″ x 1″ pleated filter
9. Isopropyl alcohol (≥80%)
10. Distilled water
11. Pressurized sprayers
12. CEREX UV-DOAS UV source bulb
13. Nitrile gloves
14. Cell bump test apparatus (including panels, regulators, valves, meters, etc.)
15. Tubing as required: 1/4″ PTFE tubing for gas supply from the bottle to the QA cell
16. Tubing as required: 3/8″ PTFE tubing with inline flow indicator from the QA cell to the scrubber
17. Flow regulation system capable of delivering gas 0.1 to 5 L/min at a total system pressure of 3 psig or less
18. Gas scrubber appropriate for gas used. Activated carbon may be used for benzene.

19. Reference standard traceable zero compressed air purge gas
20. Reference standard traceable gas blend in nitrogen for detection at about 5X instrument theoretical detection limit or higher
21. CEREX UV Sentry Unit equipped with CMS software
22. Spare reflector for alignment

7. Maintenance Activities

The following sections outline the routine performance indicator checks and maintenance activities to be carried out for each analyzer and sensor, followed by maintenance forms (see Section 9) used to indicate when the checks are completed and document any corrective actions taken. These activities are also expected, based upon the project plan, to be logged in a site logbook either in hard copy or electronic form, and can reference this SOP and associated forms.

The following UV-DOAS maintenance activities and performance checks are recommended by the manufacturer:

- Visually inspect the system.
- Inspect optics on detector and retroreflector; clean if necessary.
- Inspect system filters on the optics and retroreflectors.
- Confirm the alignment to verify there has not been significant physical movement. Note: this is automatically monitored as well.
- Download data from detector hard drive and delete old files to free space, if needed. Ensure data are backed up on external drive.
- Ensure there are no obstructions between the detector and the retroreflector (such as equipment, vegetation, vehicles).
- Change out the UV source.
- Replace ventilation exit and intake filters.
- Clean optics on detector and retroreflector.
- Realign system after service.
- Perform bump test (simulates system-observed gas content at the required path average concentration) to verify the system can detect at or below a lower alarm limit.
- Review and test light and signal levels.
- Verify system software settings.
- Deliver previous years data to client and remove from brick and analyzer.

7.1 Visual Inspections

1. Ensure that the instrument is running and the data look reasonable.
2. Clean and correct any obvious problems with the system (cobwebs, rodent nests, broken optics, etc.).
3. Inspect all electrical cables for wear; replace as needed.
4. Indicate that these visual checks are complete on the form included at the end of this document.
5. Document any changes to the system in the course of these checks in the site logbook.

7.2 Filter Inspection and Replacement

Filters are present on both the instrument and the retroreflector fans. Some DOAS units may have two filters on the analyzer to mitigate salt intrusion and subsequent corrosion. Ensure all system filters are visually inspected and replaced if dirty.

Remove and inspect instrument filters following the procedure described here. Replace if necessary. Ensure fans are running (they should make an audible sound) when the system is turned back on.

NOTICE

The UV Sentry should be powered down prior to changing the filter. When powering down, adhere to the recommended shut-down procedure, which includes properly shutting down all applications, and then shut down the instrument PC.

When the PC has been successfully shut down, remove the power cord from the unit.

The UV Sentry contains a filter that must be changed on a periodic basis. Good airflow through the filter is directly related to the ability of the instrument to properly regulate internal temperature. If the filter is allowed to become clogged (through lack of maintenance), the system can overheat, and go into thermal shutdown. In extreme cases, damage may occur to the internal electronics.

The main filter is a custom size 8″ x 8″ x 1″ pleated filter, which is stocked at the CEREX factory. If a large number of replacement filters are ordered, the lead time could be several weeks.

7.2.1 Filter Installation Procedure

1. Power down the instrument—you cannot replace the filter with the instrument running. First,

close the software and shut down the onboard PC. Next, disconnect the power.

2. The filter is accessible by removing the black plate located beneath the instrument touchscreen. The plate has the words “Filter Access” imprinted on it (**Figure 5**).
3. Use a 7/64 hex driver to remove the six socket-head cap screws that retain the filter access panel.

Figure 5. Location of filter access plate.

4. Once the access plate is removed, the filter can be accessed for removal and replacement. Old filters should be discarded and not re-used. Insert the new filter with the “Airflow” arrow pointing in the “UP” direction (**Figures 6 and 7**).
5. When inserting the new filter, do not force the filter into the slot. If you encounter any unusual resistance, open the side door, and ensure no wires have fallen into the filter slot.
6. When fully inserted, the filter should be flush with the instrument case.

Figure 6. Filter access plate removed and filter partially removed.

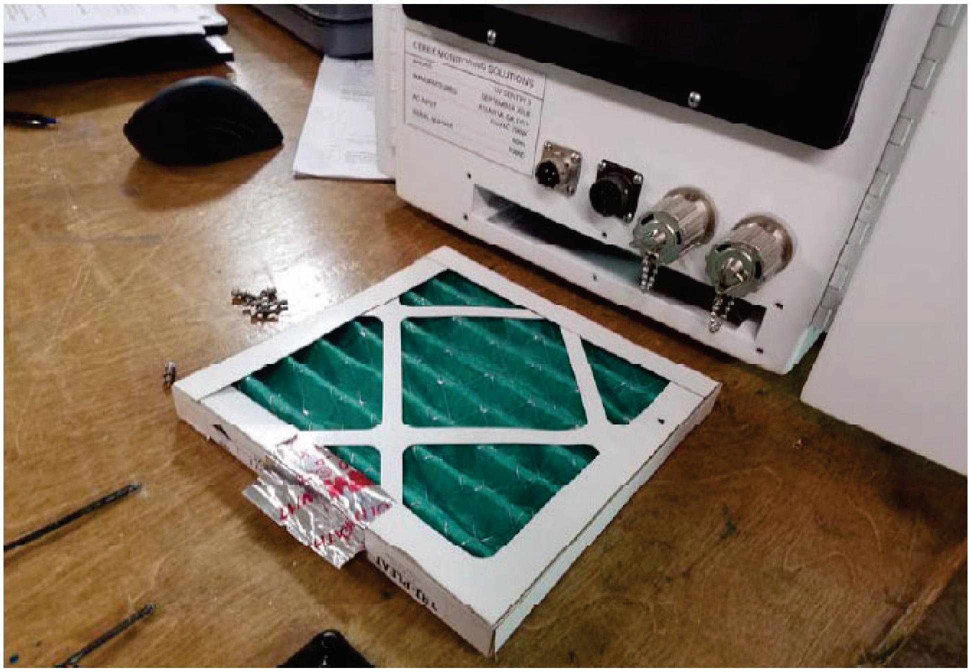


Figure 7. Filter completely removed.

7. Re-attach the black filter access panel using the same driver and six screws.
8. Power up the instrument, make sure CMS software has started, and realign the instrument.

7.3 Light Level Check

For good visibility conditions, signal strength is normally >90% and integration time is normally <50 ms. If it is determined that these values are out of range, re-alignment may be needed.

Check and record signal strength at 250 nm. With an integration time of less than 125 ms, minimum signal intensity at 250 nm should be greater than 5%.

7.3.1 Check for Stray Light

Ensure there is sufficient intensity at 250 nm compared to the stray light intensity. If there is more than 10-20% stray light, advanced optical cleaning, replacement, alignment, or a bulb change may be necessary. To measure stray light, block the beam from exiting the analyzer with an opaque object (such as a black cloth) and measure the intensity at the wavelength of interest. Calculate stray light by dividing the intensity of the beam while blocked by the intensity of the unblocked beam and multiplying by 100:

$$\%stray\ light = \frac{Intensity\ of\ blocked\ beam\ (\%)}{Intensity\ of\ unblocked\ beam(\%)} \times 100\%$$

Note the result of this stray light calculation in the form at the end of this document.

7.4 System Settings

Check the system settings and compare them to those documented in Section 5 (Routine Operations); if any settings do not match those listed in Section 5, provide any explanation for the changes. If you change any settings, document how the settings were changed in the instrument logbook present at the site. Note that all instrument settings are saved by the analyzer on a daily basis.

7.5 Data Management

7.5.1 Archiving and Deleting Older Data

Note: Data older than twelve months should be deleted from the instrument each month to prevent the instrument from filling its 125 GB internal hard drive.

Raw instrument data are stored on the analyzer computer, the site PC, and the hard drive attached to the site PC. Data consists of spectral data containing two columns: one for wavelength, and the other for intensity. There are also two types of “summary” files that contain data resulting from the classical least squares analysis of the spectral data as a function of time. These file formats are described in the CMS Software User Manual.[1] Spectral data and summary files are automatically written to the site PC and moved to the external hard drive after a regular interval. Deliver the external hard drive to the client with the frequency indicated in the QAPP.

As noted above, data on the instrument must be deleted at monthly intervals. Details on the proper procedure for deleting data files from the instrument are as follows.

1. Confirm that the data files have been successfully written to site PC and the external hard drive attached to the site PC.
2. Make a note of the amount of available space on the instrument's internal drive on the maintenance form.
3. Locate files older than 12 months on the instrument file directory here: C:\Users\CMS-USER\Documents\Cerex\Data\.

Note: This procedure excludes the Bump Test folder, which should always remain on the instrument computer.

4. Log into the brick PC located in the instrument shelter and locate the data files written from the instrument onto the external hard drive.
5. Confirm all Complete Data Summary files and Simple Data Summary files for the desired month have been transferred over completely to the external hard drive attached to the brick PC.
6. Once you have confirmed that those files have transferred over to the external hard drive, delete those exact Complete Data Summary and Simple Data Summary files from the instrument data folders.
7. For each individual day of single beam folders, ensure that the amount of single beam files are the same on both the external hard drive located on the brick pc and the internal hard of the instrument.
8. If both folder locations match and you have ensured proper file download, you may permanently delete the Single Beam folders from the instrument computer.
9. After all data older than 12 months have been deleted, note how much free space is now available on the instrument's internal drive. If removal of the files does not result in enough free disk space, the disk drive may need to be reindexed (see Section 7.4.2).

7.5.2 Rebuilding the Instruments Indexing Preferences

If deleting data from the instrument does not seem to increase free instrument disk space, you may need to re-index the files. To rebuild the index preferences, follow these steps.

1. Under the **Control Panel Menu**, use the search function in the lower left-hand corner of the

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[1] CMS Software User Manual Rev 4. CMS Version 4.0.298.1, CEREX Monitoring Solutions, December 5, 2017.

task bar to search for "Indexing Options."

2. Click on the **Advanced** tab with the shield logo.
3. Click **Rebuild**.
   Note: Once "Rebuild" has been selected, a message will appear saying that it might slow user activity. This will not affect the instruments' ability to perform data collection. On the original indexing option screen, the magnifying glass in the upper right-hand corner will move and the number of items indexed will slowly increase. Take note of the available space on the instrument's internal drive once the indexing has been completed.

7.6 Clean Optics on Detector and Retroreflector

Cleaning the retroreflector is an important part of the maintenance plan. Over time, the retroreflector will collect debris that can alter the performance of the instrument. Caution should be taken as there are electrical fan heaters that are used to keep moisture and particulates from collecting on the retroreflectors.

Optic Cleaning

If light levels are low or visual inspection reveals soiled optics, cleaning optical surfaces with lens paper and solvent can improve light throughput. This applies to the primary mirror, secondary mirror, and quartz windows. In general, if the optic is not dirty, don't clean it, as excessive cleaning of optics can result in scratches and wear over time. If the optic is obviously soiled and is affecting performance, take the following steps. Mirrors with metallic coatings should be treated with extra care because these surfaces are easily damaged on contact.

1. Wear powder-free gloves to avoid transferring skin oils onto the optics.
2. Use compressed air/canned air to remove particles from the surface of the optic. If the optic is sufficiently clean after this step, stop here.
3. Use a solvent (isopropyl alcohol or methanol/acetone in a 60/40 ratio) and lens tissue to wipe the optic clean. If using acetone, make sure to use acetone-impenetrable gloves. Wipe slowly from the edges first with a solvent-soaked lens tissue. One technique is to drop solvent on the unfolded lens tissue and drag from one end to the other.

7.6.1 Retroreflector Cleaning

1. Power down any equipment to prevent electrical shock or damage to the system.
2. Use a gentle stream of distilled water, usually from a weed sprayer or other type of gentle delivery method, to remove any salt or dust built up on the retroreflector.
3. Use a gentle stream of 80% isopropyl alcohol, usually from a weed sprayer or other type of gentle delivery method, to remove any remaining salt or dust built up on the retroreflector.

4. Once the retroreflector has been cleaned and is dry, repower any electrical equipment you powered down and clean any spills you created while cleaning.

7.7 Inspect and Change Out UV Source If Intensity Spectrum Has Dropped Below Acceptable Range

NOTICE

Never power the UV Sentry without a properly installed Xenon UV Source obtained from CEREX.

Powering the system without a UV source may cause an electrical short, which will permanently damage the instrument.

Always remove the Xenon UV Source and secure the analyzer heat sink anode prior to transporting or shipping the UV Sentry.

Failure to remove the Xenon Source and secure the Heat Sink anode prior to transporting or shipping the UV Sentry may cause destruction of the source as well as the anode.

Always check the polarity of the Xenon UV Source for proper installation prior to powering the analyzer.

Installing the UV source with reverse polarity will permanently damage the UV Source and cause immediate failure. The Xenon UV Source is shipped from CEREX with Heat Shrink and labeling over the Anode (+) end of the Source. The UV Source must be installed so the Anode (+) end of the bulb mounts to the Anode Heat Sink. The UV Source will be oriented with the (+) end at the top.

7.7.1 Xenon UV Source Handling

The UV Sentry Xenon Source is shipped from CEREX in a protective plastic enclosure (see **Figure 8**). The (+) Anode end of the UV Source is labeled “UP.” The UV Source must be installed with the (+) side UP. Always wear clean powder-free nitrile gloves when handling the UV Source. Oils from hands deposited on the UV Source glass bulb will cause damage in operation. Remove the “UP +” label from the UV Source prior to installation. If the glass bulb is touched with bare hands, clean the glass bulb with isopropyl alcohol or acetone prior to installation.

Figure 8. The ANODE end of the UV Source is marked (+). The CATHODE end of the UV Source is marked (-).

7.7.2 UV Sentry Xenon Source Removal

Prior to shipping or transporting the UV Sentry, remove the Xenon UV Source and secure the anode heat sink assembly.

1. Power off the analyzer and disconnect from power. Allow the analyzer to cool completely.
2. Use the provided key to remove the Source Access Panel (see **Figure 9**).

Figure 9. Opening the source access panel.

3. Wearing clean nitrile gloves, loosen the retaining thumbscrew on the Anode Heatsink at the top of the UV Source (see **Figure 10**).

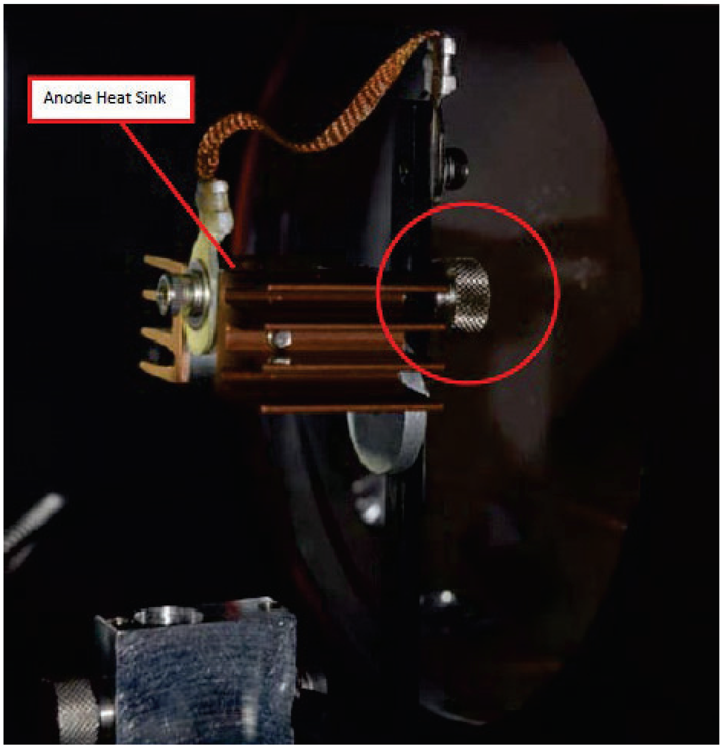

Figure 10. Anode heatsink at the top of the UV source.

4. Lift the Anode Heat Sink off the top of the UV Source. It is connected to the post by a cable. Gently let the heat sink dangle.
5. Loosen the retaining thumbscrew on the Cathode block at the bottom of the source (**Figure 11**).

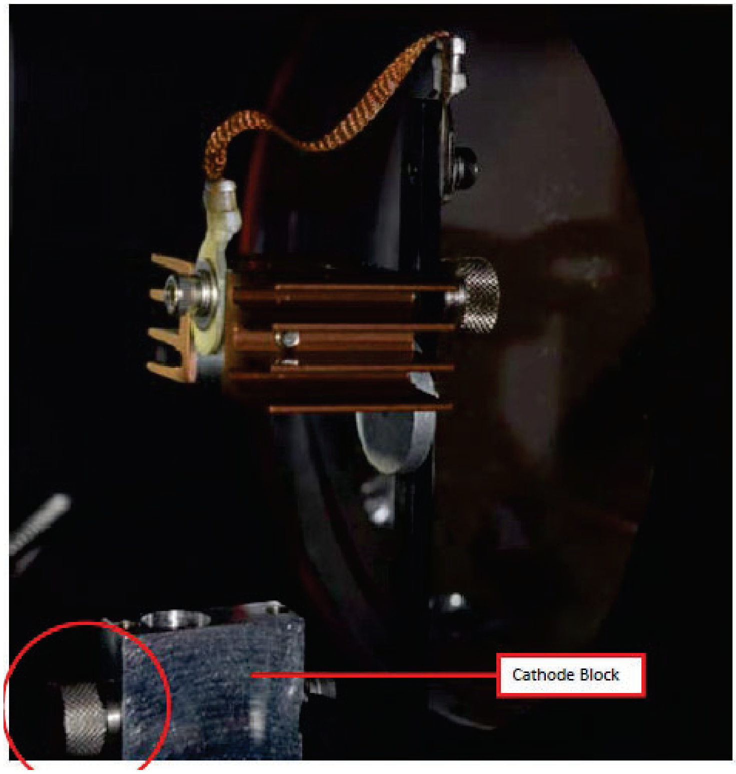

Figure 11. Loosen the thumbscrew on the Cathode block at the bottom of the UV source.

6. Lift the source lamp straight up and out of the mount.

7.7.3 UV Sentry Xenon UV Source Installation

1. Insert the Cathode (-) end of the Xenon UV Source into the Cathode Block (see **Figure 12**). The Cathode end of the UV Source is marked with (-).

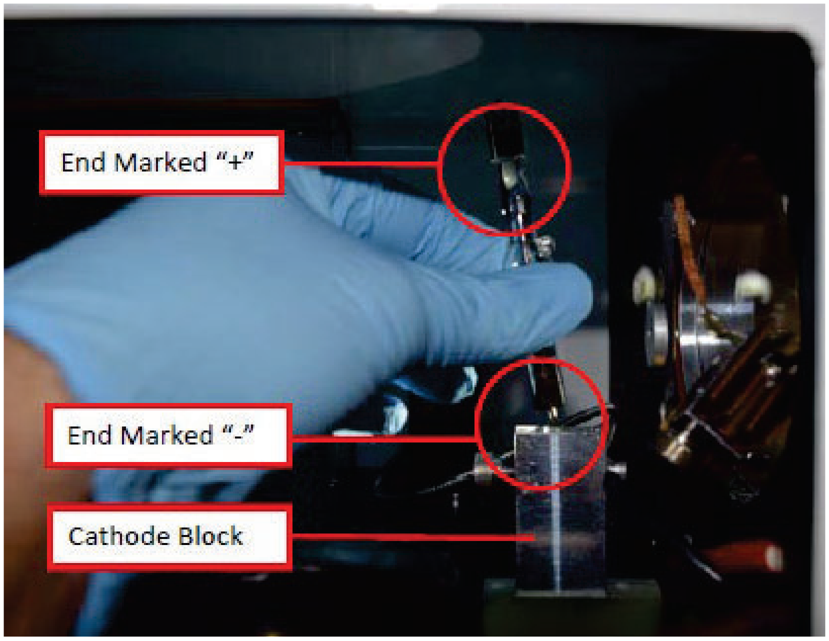

Figure 12. Inserting the Xenon UV Source into the Cathode block.

2. Rotate the UV Source so the nipple on the glass envelope faces the aluminum disc on the mounting post.
3. Tighten the Cathode block thumbscrew gently. Gently pull up on the Xenon UV Source to verify the thumbscrew has made contact with the nipple on the UV Source cathode.
4. Slide the Anode Heat Sink (+) over the top of the UV Source Anode. The Anode end of the UV Source is marked (+). Gently tighten the Anode Heat Sink thumbscrew to secure. Gently pull up on the heat sink to ensure the thumbscrew has made contact with the nipple on the UV Source anode.
5. Reinstall the Source Access Panel prior to powering on the analyzer.
6. Confirm signal strength through the remote desktop connection before leaving path.

7.7.4 Secondary Optic Alignment

If there is lower intensity than what was previously observed after the UV Source been replaced, an internal alignment of the secondary optic might be required. This should only be performed by a technician who has been properly trained to perform internal alignments.

Note: Proper PPE must be worn (glasses, sunblock) while performing a secondary alignment to prevent over-exposure to high intensity UV light from the UV Source within the instrument. Also, use an opaque object (such as cardboard or paper) to block as much of the light from the bulb as possible while still maintaining a view of the secondary mirror and fiber (if required).

1. Stop CMS and navigate to the **Alignment** menu.
2. Properly align the instrument at 20 to 25 ms integration time, as shown in **Figure 3**. Make a note of the intensity at 254 nm and the overall shape of the UV signal return.
3. Open the side of the instrument to gain access to the secondary optic.
4. Ensure alignment achieves maximum signal return and is fully aligned to the retroreflector. This is achieved by maximizing signal intensity in align mode at an 8 ms integration time. If signal cannot be confirmed in align mode, this can be done visually by maximizing the visual return brightness on the retroreflector either by looking through the telescope or by placing your head next to the instrument and observing the returned reflection from the retroreflector.
5. If the entire spectrum is visible in the alignment menu, take note of the deep UV intensity at 254 nm. If the instrument is over saturation, as seen in **Figure 4**, take note of the wavelength at which the oversaturation starts.
6. Once the instrument is aligned, take care not to bump the instrument.
7. Adjust the first secondary mirror mount thumb screw to maximize the overall intensity.
8. Move on to the second mirror mount thumb screw and repeat the same process of adjustment to maximize the signal return.
9. In an iterative process, continue to adjust the optical mount screws to maximize intensity, one at a time, until no further gain in signal intensity is achieved.

Note: Only adjust the two thumb screws of the secondary optic.

10. Set the integration time back to 20-25 ms and make sure the instrument is able to achieve a proper UV spectrum, as shown in Figure 3. If you are not able to achieve the proper UV spectrum, repeat steps 6-8.
11. Take note of the overall shape of the UV intensity and adjust secondary mirror to maximize intensity at 254 nm.
12. Close the access door of the instrument enclosure. Observe if having the access door closed has changed the internal alignment.
13. Return the instrument to its normal operation and observe the first few scans to ensure the UV spectra are acquired.

7.8 Perform Bump Test

7.8.1 Apparatus Setup

Bump tests of open-path analyzers require high concentration (~100 ppm) calibration gases. Standard refinery personal protective equipment (PPE) should be worn at all times, including safety glasses. This procedure requires the use of pressurized gas cylinders; training on proper handling of pressurized systems is required. The operator-supplied SOP, approved by the End User and in compliance with End User's Health and Safety Plan, is also required.

Verify the system is set up (minus the instrument connections) as depicted in Figure 13.

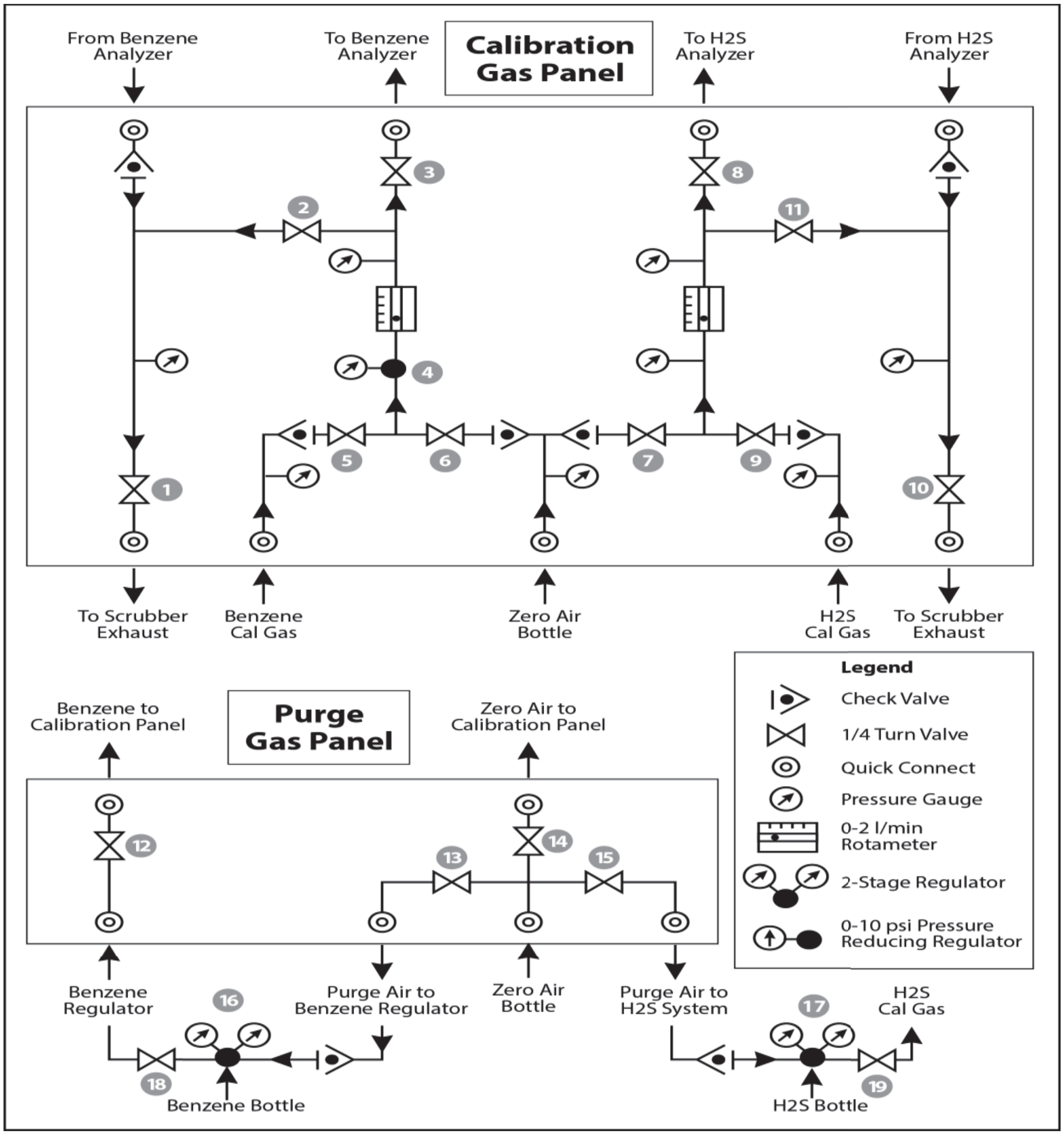

Figure 13. Diagram of the calibration gas panel (top) and purge gas panel (bottom) used for gas delivery.

7.8.2 Prepare CMS for Gas Testing

Note: There is a summary of system settings in Section 5 that can help you when you are changing any setting in the CEREX UV-DOAS instrument.

7.8.3 Configure CMS for Test (This may be concurrent with Gas Purge System setup)

1. The analyzer should be powered and running for **at least 30 minutes**.
2. Stop CMS data collection by pressing the **STOP** button.

7.8.4 Configure Test Files

1. Click **Advanced** on the left side of the CMS software window; the password can be provided by the Field Staff Manager.
2. Under **Advanced** -> **Settings** -> **Runtime -> File**, note the current file path so that it can be restored at the end of the test.
3. Under **Advanced** -> **Settings** -> **Runtime -> File**, turn off **Secondary Logging**.
4. Change the primary file logging paths (both of them) to: C:\Users\CMS-USER\Documents\Cerex\Data\bumptest. Then select **File** and select **Save**.

7.8.5 Leak Check

1. Ensure all the tubing from the purging panel is connected to the calibration panel. Ensure gas cylinders are connected to the purge panel as depicted in Figure 13. Then attach the calibration panel to the analyzer connection in the analyzer shelter.
2. Connect the PTFE tubing containing the activated carbon scrubber to the analyzer exhaust.
3. Close all valves on the calibration and purging panel.
4. Verify that the regulators on the zero air and benzene cylinders are completely closed (all the way to the left) to prevent any pressure buildup at the regulator.
5. Open high-pressure valves on both the benzene and zero air bottles.
6. Open valve (14) and slowly open the regulator on the zero air cylinder to a pressure of 5-10 psi, observed on the calibration panel zero gas pressure gauge. Do this by making small adjustments at the cylinder regulator and watching the pressure on the calibration panel.
7. Open valve (12) and slowly open the regulator on the benzene cylinder to a pressure of 5-10 psi on the pressure gauge on the benzene calibration gas channel of the panel. Do this by making small adjustments at the cylinder regulator and watching the pressure on the calibration panel.
8. Open the bypass valve (2).
9. Open zero air valve (6) and slowly open the regulator to a final pressure of about 2 psi (as

read on cell and exhaust pressure gauges). **DO NOT pressurize above 3 psi**.

10. Now pressurize cell: slowly open the valve going to the cell (valve 3) and close the bypass valve (2) while carefully watching the cell pressure gauge after the regulator (4). If you note any sudden pressure increases, just open the bypass valve (2) to relieve the pressure on the cell. Wait until the same pressure is reached on the pressure gauge of the exhaust side of the calibration panel.
11. Close the zero air valve (6) going to the benzene regulator on the panel so the system is now fully closed off to external pressure.
12. Watch the system for a minimum of 5 minutes to ensure there is no pressure drop and the system is leak free.
13. Open the leak check valve (1) to release the pressure from the system, and then close all the valves on both panels.
14. Record leak check.
15. Click the **ALIGN** button at the bottom left of the plot display.
16. Adjust the alignment until the signal intensity is optimized.
    a. **Target intensity is 70 – 90%.**
    b. **Target integration time is between 20 ms and 25 ms.**
17. **Record** the intensity and integration time.

7.8.6 Bump Test

This procedure was written assuming that the benzene and zero (purge) air side of the calibration panel has been pressurized according to the procedure above. At this point it is prudent to set up the instrument to start taking test measurements according to the UV-DOAS test procedure.

Background Measurement Using Zero (Purge) Gas

1. Close the secondary pressure regulator (4) on the panel by turning all the way to the left.
2. Open the leak check (1) and bypass valve (2).
3. Open Zero Air Valve (6).
4. Adjust the flow of purge air going through the bypass until the desired flow rate (1 lpm) and pressure are achieved by slowly increasing the pressure on the secondary pressure regulator (4). The backpressure on the scrubber (measured between valves [1] and [2]) is typically less than 1 psi.
5. Open the valve going to the cell (3) and close the valve on the bypass (2) while carefully watching the cell pressure gauge after the regulator (4). If you note any sudden pressure increases, just open the bypass valve (2) to relieve the pressure on the cell. Wait until the

desired flow rate has stayed the same and the pressure on the entire system has not increased.

6. Press **RUN** to start background acquisitions.
7. Flow compressed zero air purge gas at total flow of 1 L/min for ten 30-second acquisitions.
8. Monitor until a stable zero reading is reached and then allow the analyzer to run until an acceptable background is reached.
9. Close the zero gas valve (6).
10. Close all valves.
11. Close the secondary pressure regulator (4) on the panel.

7.8.7 Span Test

1. Open the leak check (1) and bypass valve (2).
2. Open the benzene valve (5).
3. Adjust the flow of benzene going through the bypass and scrubber until the desired flow rate (1 lpm) and pressure are achieved by slowly increasing the pressure on the secondary pressure regulator (4). The backpressure on the scrubber (measured between valves (1) and (2)) is typically less than 1 psi.
4. Open the valve going to the cell (3) and close the valve on the bypass (2) while carefully watching the cell pressure gauge after the regulator (4). If you note any sudden pressure increases, just open the bypass valve (2) to relieve the pressure on the cell. Ensure the desired flow rate has stayed the same and adjust as needed.
5. Wait 5 minutes to fill and condition lines and cell.
6. After 5 minutes of Check Gas flow, press **Start** in CMS.
7. Collect Check Gas data.
    a. Observe the concentration reported on the **DATA** tab.
    b. After the concentration becomes stable, allow the analyzer **to run until 7-15 stable measurements are made.**
    c. **Verify that the values meet the QA criteria. If the test fails QA criteria, follow the corrective actions listed at the end of this section (see: Data Evaluation, Reporting, and Corrective Action).**

7.8.8 Completion of Test and Purge of Benzene Regulator

1. Close the benzene cylinder. You will see benzene pressure increase and/or fluctuate as the pressure on the bottle regulator drops. This is normal - be patient and wait for the benzene pressure to zero out.

2. When pressure on cylinder and panel read zero, open the benzene purge valve (13)
3. **Verify that the target gas(es) concentration has returned to 0 ppm** with non-detect percent match.

   NOTE If not, ambient background target gas concentration has changed during the procedure; testing may need to be repeated to verify results.
4. Once zero reading is indicated on the UV-DOAS, close all valves.
5. Close the zero air cylinder and allow for all the pressure to be released from the system.
6. Close all valves and ensure there is zero pressure on the system.
7. Disconnect tubing to the analyzer and activated carbon scrubber.

7.8.9 Restore Normal Operation

1. **Restore** Normal Operation.

   Note: When restoring normal operation, you will change the file writing path in the settings menu back to the normal file writing path (this is slightly different for each unit, so make a note when first setting up the instrument for the QA test). Once you restart the CMS, you will see the file number located on the UV main menu of CMS. If the file count restarts and starts at file 1, you have the incorrect file writing path because it is starting a new folder for the entire day. Also, once you restart CMS, look at the single beam graph also located on the CMS UV main menu to ensure a good alignment and intensity in the lower UV wavelengths.
2. **STOP** CMS.
3. Click **Advanced** on the left side of the CMS software window; the password can be provided by the Field Staff Manager.
4. Under **Advanced** -> **Settings** -> **Runtime -> File**, turn On **Secondary Logging**. Change both of the primary file logging paths to: C:\Users\CMS-USER\Documents\Cerex\Data. Then select **File** and click **Save**.
5. Check the system alignment as previously described.
6. Press **RUN** to begin monitoring.

7.8.10 Test Suspension

In the event of a leak or plant alarm requiring the suspension of work, the process should be safely suspended.

1. If a plant or site alarm sounds during the validation, stop the test immediately as follows.
2. Close the reference gas bottle valve completely.
3. Allow the system to flow purge gas to the scrubber/vent.

7.8.11 Data Evaluation, Reporting and Corrective Action

During these tests, a number (N) of replicated, raw time resolution measurements (x_i) of a standard reference material of known magnitude (x_{std}) will be measured. Here, an acceptable number of trials will be defined as 7≤N≤15. The average value of these measurements is calculated as

$$\bar{x} = \frac{\sum_i x_i}{N} \qquad (1)$$

and the sample standard deviation (σ) as:

$$\sigma = \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{N-1}}. \qquad (2)$$

From these definitions, % error is defined as:

$$\%\ error = \left|\frac{\bar{x} - x_{std}}{x_{std}}\right| \times 100\% \qquad (3)$$

and precision as the coefficient of variation expressed as a percentage (% CV):

$$Precision \equiv \%\ CV = \frac{\sigma}{\bar{x}} \times 100\% \qquad (4)$$

1. Concentration
    a. Average the concentration of 15 consecutive stable measurements.
    b. Report the % error between the average and the certified value. The acceptable % error is listed in the QAPP.

        Note: To calculate the certified value that will be seen on the CEREX UV-DOAS from the actual certified instrument calibration gas concentration, you multiply the certified gas concentration by the calibration cell length (0.047 meters) and divide that answer by the path length set in the instrument software. For most CEREX instruments in operation by Sonoma Technology, the path length is set to 2 meters for monostatic instruments and 1 meter for bistatic instruments.
2. Calculate the Limits of Detection and Quantitation.
    a. Calculate the mean (average), sample standard deviation, and % error (sometimes also referred to as % difference) of the selected results.
    b. Report the Detection Limit as three times the standard deviation.
    c. Report the Quantitation Limit as five times the standard deviation.
3. Compile all configuration files, spectra files, and log files into a single folder.
    a. The folder should be named “CUS LOC QATest UV# YearMonDy” where CUS is a three-letter designator for the customer and LOC is a three-letter designator for the facility location.

The QAPP contains the acceptance criteria and warning levels to be used for the test.

Note:

- **If the test produces an error or precision greater than the warning level**: the test is considered passing if below the acceptance criteria, but corrective action should be taken so that the precision and error are below the warning levels.

- **If the test produces an error or precision greater than the acceptance criteria**: the test is not considered passing and corrective action should be taken so that the precision and error are below the warning levels. Equipment will not be placed into service (taken out of ”maintenance mode”) until it meets all measurement criteria.

If the measurements do not meet the data quality objectives listed in the QAPP, repeat the procedure without adjustment. If the instrument still fails to meet the QA criteria, retest the following day with no adjustment. If these repeated tests continue to fail, initiate corrective actions such as:

- Realign the system and perform the test again.
- Reviewing data for potential interferants, including a detailed check of absorbance spectra in the analysis regions configured for the analyte, noting any excessive noise or unexpected absorbance features.
- Consulting with the project technical lead to identify abnormal changes to the background
- Check wavelength calibration
- Checking for large changes in stray light since the last test and adjusting calibration factors as necessary
- Reviewing gas testing apparatus for leaks or other similar problems
- Review and confirm specifications of standard calibration equipment and gases (expiration dates, concentrations, etc.)

In the event of a failed test after following all steps outlined above, inform the Sonoma Technology Project Manager and Quality Assurance Manager, who will review the instrument performance parameters in the list above.

If all parameters indicate that the instrument was performing properly since the last test, data since the last test will be flagged as suspect. If an issue with the instrument is identified, data since the date and time of the instrument issue will be flagged as invalid. All data flagging will be performed by Data Analysts in consultation with the Quality Assurance Manager.

8. Data Validation and Quality Control

Data for the fenceline monitoring network appears on both public and internal sites. The internal website allows for detailed quality control and flagging of the data. Data are checked daily and finalized quarterly as outlined in the QAPP. This section outlines how to perform daily and quarterly data validation.

8.1 Daily Checks

Both the public website and the admin website need to be checked twice daily (for example, before 10 a.m. and 10 p.m.).

1. Ensure that the site is operating properly by pointing your browser to the public website.
2. View the data display on the public website. Take note of any outages by selecting **All Compounds**" from the pollutant dropdown menu.
3. View the time series graphs for each compound by selecting each compound in the pollutant dropdown menu. Verify that pollutant concentrations are reasonable by using the guidance in Table 2. Notify the field operations team if anything seems erroneous.

Table 2. Parameters measured with the UV-DOAS and typical observations.

Parameter	Observational Notes
Visibility	~30 miles is the maximum measured by the sensor. Values are typically less than 30 miles due to smog and fog.
Integration Time	Should generally be <250 ms. Report values stuck at 300 ms to PM and fieldopsalerts. Should be anticorrelated with visibility for fog events.
Winds	Typically there is a sea breeze during the day, land breeze at night. Winds are stronger near the coast at met west.
Benzene	Typically below MDL (~1 ppb) – note any high values above REL or immediately visible on the public website (this is a toxic compound
Toluene	Typically below MDL (~1 ppb) – note any high values above REL.
Ethylbenzene	Typically below MDL (~1 ppb) – note any high values above REL.
o-xylene	Typically below MDL (~1 ppb)– note any high values above REL.
m-xylene	Typically below MDL (~1 ppb) – note any high values above REL.
p-xylene	Typically below MDL (~1 ppb) – note any high values above REL.
SO_2	0 to 100 ppb, usually zero. Refineries are a local source – note any high values above REL.
NO_2	Typically 0 to 200 ppb. Values typically peak at night; sunlight destroys it, traffic and combustion produce it. Some instruments may not detect NO_2 if they are saturated.

8.2 Quarterly Validation

Quarterly validation activities involve looking at the data over a longer time period (3 months) than the daily checks (typically a time range of a few days). To validate the data:

1. Plot time series and look for statistical anomalies. If problems are found they may be flagged using the DMS.
2. Review any instrument bump test results.
3. Verify that daily instrument checks were acceptable.
4. Review manual changes to operations/data, and verify that the changes were logged and appropriately flagged; ensure that logged information is complete and understandable.
5. Ensure that instrument checks have the appropriate (Quality Control) QC codes applied.
6. Assign invalid data a Null Code, providing a reason for data being invalid.
7. If a record is not created for a particular site/date/time/parameter combination, create a null record for data completeness.
8. Inspect data consistency.
9. Review collected data ranges for consistency – ranges should remain within expected values over months of monitoring.
10. Check bump test values for completeness; ensure they meet acceptance criteria.
11. Review quarterly data completeness.

9. Maintenance Forms

Path:_______________________________

Technician:_________________________

Date:_______________________________

Instructions: complete checks described below and enter data or initial next to each one once complete. Make note of any corrective action.

- ☐ Notify the client and project manager of maintenance tasks.
- ☐ Using the field tech tool at ftt.sonomatechmonitor.com, place the equipment into planned or unplanned maintenance mode.
- ☐ Confirm that the data is invalidated on the public website before proceeding with maintenance.
- ☐ When maintenance is complete check the public site for at least 15 min to ensure proper reporting (no missing data, no high values, etc.).
- ☐ Take out of maintenance mode
- ☐ Notify the project manager and client when maintenance is complete.

Upon completion sign and date:________________________________

Table 3. Maintenance activities and performance indicator checks for the UV-DOAS.

Activity / Check	Completed (Y/N)
Visually inspect the system.	
Inspect optics on detector and retroreflector; clean if necessary.	
Inspect system filters on the optics and retroreflectors.	
Confirm the alignment to verify there has not been significant physical movement. Note: this is automatically monitored as well.	
Download data from detector hard drive and delete old files to free space, if needed. Ensure data are backed up on external drive.	
Ensure there are no obstructions between the detector and the retroreflector (such as equipment, vegetation, vehicles).	
Change out the UV source.[a]	
Replace ventilation exit and intake filters.	
Clean optics on detector and retroreflector.	
Realign system after service.	
Perform bump test (simulates system-observed gas content at the required path average concentration) to verify the system can detect at or below a lower alarm limit.	
Review and test light and signal levels. Check average light intensity to establish baseline for bulb change frequency.	
Verify system software settings.	
Deliver previous years data to client and remove from brick and analyzer	

[a] UV bulbs will be changed depending on deep UV performance.

Corrective Actions for UV-DOAS:

UV Sentry Fenceline Detection System

DATE: ___________________ Location: ____________________________________

Test Technician 1:________________________________ 2:________________________________

Physical one-way path length_______________ m Instrument Configuration (mono/bistatic)_______________

Sentry Alignment and Light Levels

Integration time	_____________________________	Target 20-24 ms
300 nm Intensity	_____________________________	Target 80-120%
254 nm Intensity	_____________________________	Target >5%
Blocked Beam Intensity at 254 nm	___________________	
% Stray Light	_____________________________	

Gas Purge System

Flow purge gas Start Time _______________________

Prepare CMS

Path length in the CMS Configuration (typically 1 m for monostatic and 2 m for bistatic)_______________________ m

Configure Test Files

Site File (i.e., Bump Test UV# YearMoDy) ____

Baseline Check _______________________ init

Reference Gas

Concentration _______________________ ppm

Source ____

Date _______________________

Cylinder Pressure _______________________

NOTES:

QA Audit Record - UV Sentry Detection System - Page 2

Purge Flow Conditions

Start Time ______________________

Purge Gas flow ______________________ L/min

NOTES: Around 1 LPM

Check Gas Test

Initial Gas flow ______________________ L/min

Around 1 LPM

Start Time ______________________

Collect Check Gas Data Start Time ______________________

Data Record:

TIME	PPM	R2

Verify Client ______________________ Init

Stop Time ______________________ Init

Open the **PURGE** gas Time ______________________

Reference Concentration __________ ppm

Average Concentration __________ ppm

% error __________ %

Std Deviation __________ ppm

% CV __________ ppm

Restore Normal Operation

Restore running data file ________________________ Init

Press **RUN** to begin monitoring. ________________________ Init

Unisearch LasIR Tunable Diode Laser System (TDLAS) Maintenance and Test Procedure

May 30, 2025

STI-7801

APPROVED:

Sonoma Technology date

Fenceline Monitoring Refinery Representative date

Contents

Definitions

Term/Acronym	Definition
Bump Test	Test where gas of a known concentration is introduced to the analyzer to check for response accuracy and precision.
Calibration	Procedure by which a series of standards are used to perform an instrument calibration.
Correlation coefficient	A statistical measure of the strength of the relationship between two variables (e.g., measured vs. theory).
FRC	Fire-retardant clothing
IDLH	Immediately dangerous to life or health
laser	A device that emits Light Amplified by Stimulated Emission of Radiation. The resultant light is often very bright, coherent, and monochromatic.
OAP	Off Axis Parabolic reflector. For the TDLAS, the OAP serves as the collection optic for the return beam after it has traversed the atmosphere. The OAP directs and focuses the return light onto the detector.
OEHHA	Office of Environmental Health Hazard Assessment
NIOSH	National Institute for Occupational Safety & Health
Power	A measure of the energy delivered by the laser beam per unit time. The units of power are typically expressed in watts, milliwatts (mW), or microwatts (μW).
PPE	Personal protective equipment
QA	Quality assurance
QC	Quality control
QAPP	Quality Assurance Project Plan
REL	Reference Exposure Level
Retroreflector	An array of reflective corner-cube optics that reflect light back in the direction of the light source.
SOP	Standard Operating Procedure
TAS	Terra Applied Systems
TDLAS	Tunable Diode Laser Absorption Spectroscopy
Transmission (%)	The ratio of return beam strength to the source beam strength, expressed as a percentage.

1. Applicability/Scope

This SOP includes procedures for the routine maintenance, and gas testing for Unisearch Tunable Diode Laser System (TDLAS) open-path analyzers. This document provides procedures that enable technicians to verify that equipment is performing to expectations and detection and communication links are functioning correctly. This SOP has the steps to conduct routine maintenance and quality control checks and calibrations, while the QAPP or other specific SOPs should be referenced for other related quality assurance (QA) system requirements, including the required frequency of these QA activities (**Section B.6** of the QAPP), criteria that must be met (**Section A.7** of the QAPP), management of the data (**Section B.10** of the QAPP), or corrective actions needed, depending on the outcome of the maintenance activities or QC checks.

***NOTE ***

This procedure should only be used by personnel with experience in the safe use of the analyzer and test equipment.

A number of these maintenance procedures closely follow the manuals provided by Unisearch.[1] Field staff should obtain access to and read these manuals. The QA Audit procedure ensures field verification and calibration of the TDLAS by challenging the instrument with a known concentration of hydrogen sulfide (H_2S) and verifying proper detection and quantification under field conditions.

2. Summary

The Unisearch LasIR H_2S monitoring system (**Figure 1**) is a monostatic open-path remote sensor that uses direct absorption technique. The LasIR sensor consists of an analyzer, transmitter/receiver, and retro-reflector array. The tunable infrared (IR) laser for the LasIR system is housed in the analyzer box and scanned over a small range of wavelengths at high frequency. A fiber optic cable guides the laser light to the transmitter/receiver telescope where it is collimated and sent across the atmospheric path. The retroreflector array at the other end of the path returns the signal to an off-axis parabolic mirror that focuses the light onto a photodiode detector. The electrical signal from the photodiode detector is amplified and returned to the analyzer box, where the absorption spectrum is analyzed to produce concentration data.

Classical least squares fitting of the absorption spectrum allows elucidation of low-H_2S concentrations by simultaneously accounting for overlapping water (H_2O) and carbon dioxide (CO_2)

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[1] Unisearch Associates: A. Preinstallation Manual, B. Installation Manual, C. Networking Manual, D. Remote Sensing Optics Manual, E. Operations Manual, H. Troubleshooting Manual, I. Laser Safety Manual, J. Maintenance Manual, LasIRView 2015 Manual, 2018.

absorbance bands. As a result, concentration data for H_2S, H_2O, and CO_2 are provided with correlation coefficients that indicate the “goodness of fit.”

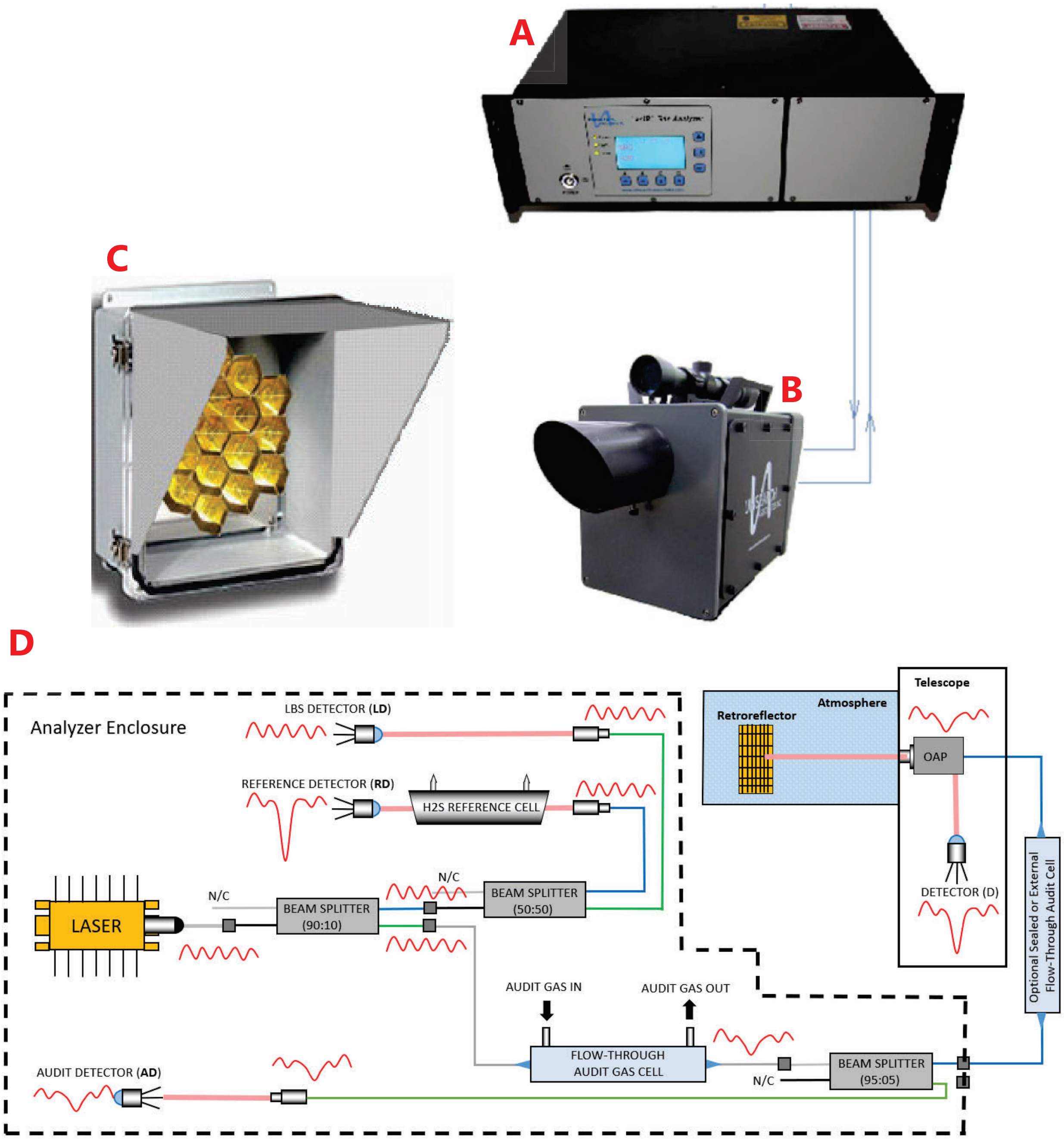
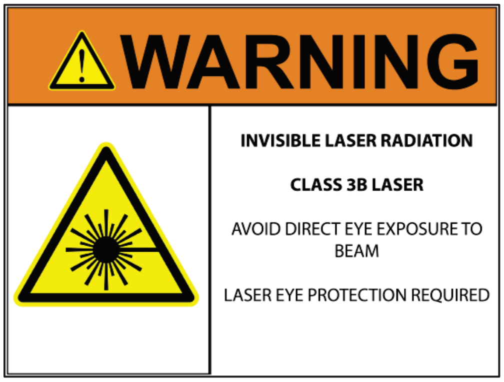


Figure 1. (A) Unisearch TDLAS Analyzer box, (B) telescope, (C) retroreflector, and (D) schematic diagram showing the optical fiber paths and detection points.

3. Health and Safety Warnings

The following information should be noted when preparing work plans and permits for safe work practices.

3.1 Laser Safety



The Unisearch TDLAS produces a class IIIB LASER EMISSION that is INVISIBLE. The laser can cause eye damage if the laser is viewed directly. Unisearch recommends the use of safety procedures consistent with Class II and IIIA lasers. **PROTECTIVE EYEWEAR SHOULD BE WORN WHEN WORKING WITH THE SYSTEM**. Always avoid looking directly into any part of the instrument that can produce laser light, including the transceiver head. Make sure to read the laser safety manual and all other manuals provided with the Unisearch TDLAS instrument.

3.2 Operator Qualifications

Installing, operating, and servicing Unisearch analyzers should only be performed by personnel who are trained in the operation of the system components and are familiar with handling gas delivery and testing equipment. These procedures should not be performed by personnel who do not understand the system, technology, or hazards of the materials involved.

3.3 Safe Work and Hazardous Environment Operation

Work should conform to manufacturer guidance and site health and safety practices. Standard refinery personal protective equipment (PPE) should be worn at all times, including laser safety glasses with side shields, a hard hat, goggles, steel-toed boots, hearing protection, fire-retardant clothing (FRC), an H_2S monitor, and appropriate gloves that are adequate for this procedure. For testing with the flow-through cell using H_2S concentrations in excess of 100 ppm, a second person should always be present as a safety monitor. H_2S levels should be monitored inside the enclosure. Two self-contained breathing apparatuses should be on standby.

The Unisearch TDLAS are not rated for safe operation in hazardous or explosive environments. Using the TDLAS in an area that may contain flammable mixtures or highly corrosive vapors requires special preparation to ensure human safety and safe operation of the equipment.

H_2S is a colorless gas that has an odor of rotten eggs. It is hazardous at low concentrations (the Immediately dangerous to life or health [IDLH] level is 100 ppm, the National Institute for Occupational Safety & Health [NIOSH] 10-min Reference Exposure Level [REL] is 10 ppm, and the California Office of Environmental Health Hazard Assessment [OEHHA] 1-hr REL is 30 ppb). Odor is not a reliable indicator of the presence of hazardous concentrations of H_2S because olfactory senses may be deadened by exposure to concentrations below safe exposure levels. A system for scrubbing H_2S gas from a test apparatus vent is used to prevent release and worker exposure.

This procedure has been written to limit exposure potential and mitigate the hazards of accidental release of the reference gas. Only personnel experienced with handling this material who are familiar with the test procedures and apparatus should perform these testing procedures.

WARNING – Toxic Gas and Eye Hazard. This procedure requires the use of H_2S concentrations as high as 3,000 ppm for the span check. This procedure must be conducted in a well-ventilated area and requires gas monitors, respirators, and the use of fume scrubbers. Make sure you and others fully understand the safety procedures and gas-handling systems required. Always wear proper eye protection having OD>4 above 900 nm. Improper handling of materials or hardware may result in death, serious injury, destruction of property, or damage to the TDLAS. Only qualified individuals should perform analyzer quality assurance audit activities.

4. Routine Maintenance

The TDLAS system is designed to require only modest service and maintenance. **Table 1** summarizes the TDLAS maintenance activities, as recommended by the manufacturer. The frequency of activities may vary from site to site, so always check the QAPP for facility-specific maintenance schedules and acceptance criteria.

Table 1. List of maintenance activities and performance indicator checks for the TDLAS.

Activity	SOP Section(s)
Visually inspect the system. Inspect electrical and optical cables for wear.	4.2
Inspect optics and clean if necessary	4.3, 4.4
Check the alignment to verify there has not been significant physical movement; note that this is automatically monitored as well	4.5
Download data from detector hard drive and delete old files to free space, if needed	4.6
Ensure there are no obstructions in the beam path	4.7
Review and test light and signal levels	4.7
Verify system settings	4.8
Perform bump test and take corrective action as needed	5 (flow-through) 6 (sealed cell)
3-point calibration check	5 (flow-through) 6 (sealed cell)

NOTICE

Perform the following steps before conducting maintenance. Doing so reduces the chances of false notifications to the public and/or clients.

1. Notify the client and project manager of maintenance tasks.
2. Using the field tech tool at ftt.sonomatechmonitor.com, place the equipment into planned or unplanned maintenance mode.
3. Confirm that the data is invalidated on the public website before proceeding with maintenance.
4. When maintenance is complete check the public site for at least 15 min to ensure proper reporting (no calibration data present; data is no longer invalid due to planned maintenance).
5. Take the equipment out of maintenance mode
6. Notify the project manager and client when maintenance is complete.

4.1 List of Equipment

1. Field notebook
2. Tool kit, especially including: hex drivers, complete set of combination wrenches, adjustable wrenches, screwdrivers, etc.
3. Cleaning supplies designated to be safe for use on a Unisearch TDLAS – especially lens paper
4. All relevant PPE, hardware, and procedural guidance per SOP, Safety Plan, and Safe Work Permit
5. Local or remote network link device (as required)
6. External laptop computer with network interface device to the Sentry unit (as required)
7. Unisearch TDLAS equipped with LasIRView software
8. Isopropyl alcohol (≥80%)
9. Distilled water
10. Pressurized sprayers
11. Nitrile gloves
12. Cell bump test apparatus (including panels, regulators, valves, meters, flow controllers etc.)
13. Tubing as required: 1/4” PTFE tubing for gas supply from the bottle to the QA cell
14. Tubing as required: 3/8” PTFE tubing with inline flow indicator from the QA cell to the scrubber
15. Flow regulation system capable of delivering gas 0.1 to 5 L/min at a total system pressure of 3 psig or less
16. Gas scrubber appropriate for gas used. Activated carbon may be used for benzene
17. Zero air supply
18. Reference standard traceable gas blend in nitrogen for detection at about 5X instrument theoretical detection limit or higher
19. Spare reflector for alignment

Related spare parts and equipment are available from Unisearch Associates and are detailed in the Unisearch manuals.

4.2 Visual Inspection

For each measurement site (includes both analyzer and any retroreflectors), complete the visual checks listed below on the form in **Section 10**. When maintenance is complete, file the forms from the "maintenance folder" in the main project folder on the company's shared drive. During visual inspection of the analyzer, complete the following checks.

1. Note and clean any excessive dust buildup on the equipment or analyzers. Use a damp rag to clean dust from surfaces.
2. Eliminate any pests from the sample site, including birds, spiders, rodents, etc., and remove cobwebs. Plug any holes that may serve as entry points for rodents. Work with the Project Manager and client to eliminate more extensive rodent issues.
3. Note the internal condition of the analyzer cabinet. Check for signs of condensation below the HVAC. Note other signs of water damage.
4. Inspect wiring and note and correct any corrosion or cracking insulation. Replace wires that have been chewed-through or show signs of imminent failure.
5. Check HVAC for proper operation by checking for cool air and reviewing cabinet temperature records, if available.
6. Check for corrosion. Common places to check are on top of the cabinet, various components of the instrument mount, nuts, and bolts. Mitigate corrosion by using oil or similar product designed to prevent corrosion.
7. Note and mitigate any condensation or water issues that may adversely affect equipment.
8. Check the door operation.
9. Note anything that may result in eventual degradation of the LasIR system.

For items that cannot be immediately corrected, notify the Project Manager to initiate corrective actions. If it is suspected that any issues that required corrective actions might have adversely affected data quality, note this in the form in **Section 10** and notify the Project Manager and QA analyst assigned to the project.

4.3 Cleaning the Transmitter/Receiver Optics

Only the front surface of the window on the telescope assembly may need to be cleaned on a monthly basis. Use a clean cloth to lightly wipe the front surface of the window. Normal lens cleaning solution can be used if necessary, but dust can usually be wiped away with a dry cloth. Be careful not to scratch the window surface by pressing too hard. The shroud protecting the window from the elements may be removed for cleaning. If necessary, loosen the locking screw on the bottom of the shroud and pull the shroud away from the window housing.

If the inside of the window gets dirty, it is best to remove the window from the housing and clean it rather than open the telescope side covers, as access from these points is limited. You may either remove the shroud and unscrew the locking ring that holds the window in place, or remove the entire front cover by loosening the four screws in the corners. In either case, be careful to keep the

O-ring seals properly seated. Improper seating may result in leaks if rain falls on the telescope, which could damage sensitive electronic components inside.

Document completion of this task using the Maintenance Task Checklist in **Section 8**.

4.4 Cleaning Retroreflector Array

Only the front surface of the acrylic protective window for the retro-reflector needs to be cleaned on a monthly basis. Use a clean cloth to lightly wipe the front surface of the window. A lens cleaner solution can be used if necessary, but dust can usually be wiped away with a dry cloth. Be careful not to scratch the window surface by pressing too hard. If, for some reason, the inside of the window gets dirty, this can be cleaned by opening the enclosure front cover.

Reflector elements may also be cleaned if necessary, but this should be done with extreme care to prevent damage to their gold-coated surfaces. To clean retroreflector cubes:

1. Power down any equipment to prevent electrical shock or damage to the system.
2. Use a gentle stream of distilled water, usually from a weed sprayer or other type of gentle delivery method, to remove any salt or dust build-up on the retroreflector.
3. Repeat step 2 with a gentle stream of 80% isopropyl alcohol.
4. Once the retroreflector has been cleaned and dried, repower any electrical equipment you powered down and clean any spills created while cleaning.

Document completion of this task using the Maintenance Task Checklist in **Section 8**.

4.5 Optical Alignment

Adjust the vertical and horizontal adjustment knobs to maximize signal return power as reported on the OPM-15 power meter. Lock the adjustment knobs (**Figure 2**) in place. Once signal return power is optimized, push on the telescope top and side. If the optical configuration is optimal, this action should not result in a fluctuation in return signal power as measured with the OPM-15; the laser beam size at the retro-reflector should be 2-3 times the diameter of the retro-reflector for this to be true. If a drop in signal return power is observed when pushing on the telescope, it may be necessary to adjust the collimator (see below) to obtain the best beam size and return power. If the beam is smaller than twice the retroreflector size, variation in the power will be observed, which may affect the alignment over time due to flexing of the mounting structure. When the vertical alignment is correct, tighten the locking thumbscrew. For the horizontal sweep, loosen the 5/8” locking nut located underneath the mount base and use the thumbscrew on the right hand side of the mount base (looking from the back) to adjust the horizontal position. When adjustment is complete, tighten the locking nut. Slight adjustment of the vertical alignment may be required after tightening the horizontal alignment-locking nut, as this tightens the rear end of the telescope to the mount, which affects the tilt.

Adjusting the collimator is an iterative process. The collimator affects the size of the beam that illuminates the retroreflector. If the beam size at the retroreflector is too small, the signal return power will be too large and can saturate the detector and result in alignment instability. Conversely, if the collimation results in a beam size that is too large, the beam power will be spread over too large of an area at the retroreflector and will not allow enough light to be reflected back to the detector for an acceptable measurement.

To adjust the collimation:

1. Rotate the collimator either clockwise or counterclockwise 1/16 of a turn and note the change in signal power on the OPM-15. There is wobble in the collimator lens assembly, so the alignment will need to be optimized after each turn.
2. After turning the collimator, optimize the horizontal and vertical alignment.
3. Check the alignment stability by pressing on the top and side of the telescope – if the collimation is adjusted correctly, this will not result in significant power fluctuations. Also check the signal return on the OPM-15 to ensure enough light is reaching the detector.
4. If necessary, repeat steps 1-3 until the signal return is sufficient.

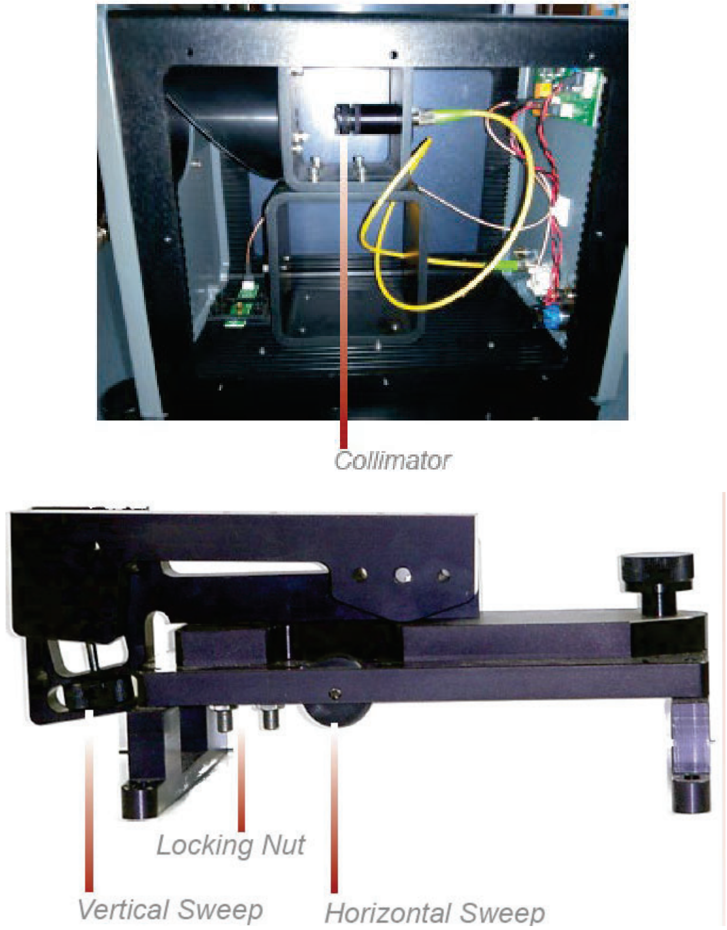


Figure 2. Location of adjustment knobs used for alignment of the Unisearch TDLAS.

Document completion of this task using the Maintenance Task Checklist in **Section 9**.

4.6 Data Management

Under normal operations, the LasIR system works together with a separate program called the TASDAcc to acquire and process raw TDLAS data, and reports 5-min data to the Sonoma Technology-operated data system. The TASDAcc software is developed and maintained by Terra Applied Systems (TAS), the integrator of the Unisearch TDLAS. As depicted in **Figure 3**, the LasIR, TASDAcc, and cellular modem are all connected through a network switch located in the same cabinet as the Unisearch analyzer box. The TASDAcc software handles four main data types: (1) raw data tables from the LasIR Analyzer (as .txt files for each species), (2) spectral data from the LasIR Analyzer (.spectrum), (3) 5-min data for ingestion to the Sonoma Technology data system and display on the public-facing website, and (4) configuration files that archive instrument settings (as either .xml or .cfg).

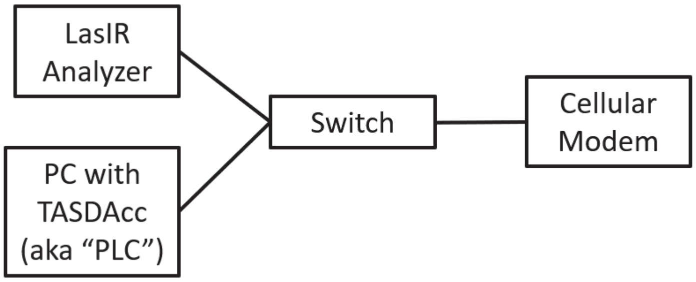


Figure 3. Diagram of local network configuration for the LasIR system.

On a routine basis, all TDLAS data from the PC running the TASDAcc software needs to be backed up on an external drive attached to the PC. To perform this task:

1. Transfer TDLAS files from the PC to the external hard drive (this may be accomplished on a continual basis using a .bat file).
2. Check to ensure all data have been backed up on the external drive for at least the previous quarter.

On an annual basis, the external storage device should be removed and transferred to the client. To perform this task:

1. Ensure the previous year's data has been transferred to the removable storage device.
2. Remove the storage device and replace it with new (empty) one.
3. Deliver the removable storage device with the previous year's data to the client for permanent redundant storage.
4. After data delivery to the client, confirm that all data from the previous year has undergone final QC and that the client has backed it up.
5. Remove the previous year's data from the PC by deleting it.
6. If enough free space cannot be created on the PC by transferring to the external drive, take corrective action with support from the IT department.

Document completion of this task using the Maintenance Task Checklist in **Section 8**.

4.7 Test Light Levels

Although the return light level is monitored continuously and reported with the 5-min data, it is important to verify and document observations of light levels during routine maintenance. Daily observations regarding light levels are documented by Sonoma Technology's analysts. Monitoring light levels over several days allows for the determination of root-cause for problems involving low signal return (e.g. thermal expansion). Field technicians are expected to review historical trends in light levels by utilizing the custom dashboards provided by the data management system. The effect of cleaning on light levels should be noted. Testing light levels at various points in the system can help troubleshoot damaged optical components, such as fibers.

To check light levels in the field, observe the power bar (S) in the scope display or the bar at the bottom of the "Main Running" display (**Figure 4**) on the analyzer. It should be green in the host trend display. The scope display will turn yellow if the power is low, and will turn purple if the power is very low and the instrument has stopped recording data. On the analyzer, the bar is normally between 25% and 75%. You may also check the percent (P) values on the analyzer display (Figure 4) by cycling to the "Species Information Screen." It should be greater than 5% for proper operation. Low power generally indicates a need for maintenance, such as cleaning the optics, or may also result from low visibility conditions (fog).

If light levels are not adequate, follow the procedure in **Section 4.5** (optical alignment) to correct the issue. If low signal return is still observed after optical alignment, test the power at various points in the system using the OPM-15 to identify bad optical fibers or connections. If the source of the low signal strength still cannot be traced, contact Unisearch for further guidance.

Document completion of this task using the Maintenance Task Checklist in **Section 8**, and document results of this test in the LasIR Response Test Form in **Section 9**.

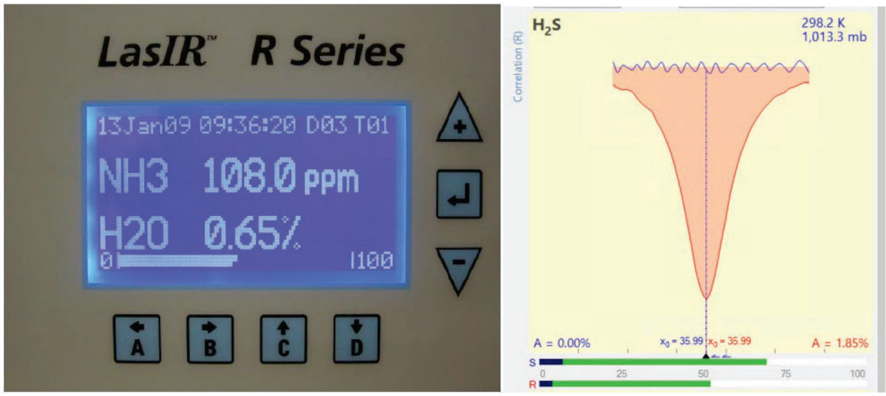


Figure 4. Main running window on instrument front panel (left) and scope display in LasIR View software (right).

4.7.1 Signal Strength Measurements

Light power measured at the detector can occur at several points in the system. There are two gains associated with these measurement points, as indicated in **Table 2**. The "signal gain" is the amplification placed on the signal itself through electronic hardware, and the "IO gain" is a multiplicative modification of the input-output data streams. Using this table together with the method-appropriate use case, the actual light power at the detector can be determined.

For example, if the signal gain is 2 (signal multiplier of 2), the IO gain stage is 3 (multiplier of 5), and the peak power at the detector is 0.12 mW, then the power displayed via RS232 data stream is:

RS232 **SignalPower** = Signal Multiplier x IO Multiplier x Peak Power = (2)(5)(0.12 mW) = 1.2

The ratio of MODBUS to RS232 signal powers is always 2.5, so in this case the **SignalPower** transmitted via MODBUS is: (1.2) (2.5) = 3

Following this example, by ratioing the power at the detector to the power of the laser (say, 18 mW for this example, can be obtained from instrument data sheets), a %transmission may be calculated:

%transmission = (0.12 mW / 18 mW) 100% = 0.67%

However, if the gains are set to “auto,” as they are during normal operations, it is impossible to know what gain settings are applied and, therefore, what the actual power at the detector is. Therefore, %transmission can only be assessed during routine maintenance.

Table 2. Multiplicative factors associated with gain stages and how they are translated to the Unisearch data files (SignalPower) and through the MODBUS data connection. Note that the ratio of MODBUS to RS232 is 2.5. The ratio of RMS power to peak power is 0.83.

Signal Gain	Signal Multiplier	IO Gain Stage	IO Multiplier	Power at Detector (mA or mW)	Peak Power at Detector (mA or mW)	MODBUS/ Display Power	RS232/TXT Signal Power
1	1	2	1	1	1.2	3	1.2
2	2	2	1	0.5	0.6	3	1.2
2	2	3	5	0.1	0.12	3	1.2
2	2	4	25	0.02	0.024	3	1.2
1	1	3	5	0.32	0.4	5	2
2	2	3	5	0.2	0.24	6	2.4
3	4	3	5	0.25	0.3	15 (or 1.0 if not in Fast gain with error)	6 (or 2.5 if not in Fast gain with error)
4	8	3	5	0.1	0.12	12 (or 1.0 if not in Fast gain with error)	4.8 (or 2.5 if not in Fast gain with error)
2	2	4	25	0.05	0.06	7.5 (or 1.0 if not in Fast gain with error)	3 (or 2.5 if not in Fast gain with error)
3	4	4	25	0.015	0.018	4.5	1.8

Using the OPM-15 Power Meter: When working with the laser power meter (OPM-15, provided with the analyzer, shown in Figure 5) plugged into the back of the telescope “coax out” port, the units the meter provides are in mA, which has a 1:1 conversion to laser power in mW. If a triangle appears on the screen, units will be in µA or µW. If the IO Gain is configured, the power reading will need to be adjusted by that amount, according to Table 2.

Figure 5. Measuring laser power with the OPM-15 meter provided.

Power reported in Unisearch files: The units for "Signal Power" reported in the raw data files downloaded from the LasIR analyzer are in units of mW. If the signal gain is configured to have a multiplier, the reading will need to be divided with that multiplier (Table 2) in order to get the signal power in mW.

Power reported in TASDAcc files: The power reported in the TASDAcc files are pulled from the MODBUS data stream provided by the instrument. Table 2 shows how this power is related to laser power elsewhere in the system.

4.8 System Settings

In the LasIR instrument software, select File > Configure Analyzer. Select "Expert" on the upper right corner of the Configure Analyzer window. View the settings for H_2S, CO_2, and H_2O, and compare these settings with historical settings and provide any explanation for change. For a complete description of the settings and their typical ranges, consult the LasIRView software manual[2]. If you change any settings, document how the settings were changed in the instrument logbook present at the site. Note that all instrument settings are saved on the analyzer on a daily basis.

5. Flow-Through Response Test

The purpose of this procedure is to check the system for expected H_2S response under the installed operating conditions. H_2S standard reference gas is introduced into the optical path by means of a flow-through cell, meaning the entire sample path is included at the time of testing.

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[2] Mackay, K., Chanda, A., Mackay, G. Software Manual: LasIRView2015, Application Software for LasIR Analyzers. Rev. 2015-10-01

The Unisearch analyzer enclosure comes equipped with a flow-through cell for use in response testing the LasIR units. This setup requires high-concentration compressed gases to flow through the analyzer in order to affect a response. An alternate way to response-test the analyzers is to use sealed cells as described in **Section 6**.

5.1 Supplies

1. Nitrogen gas
2. H_2S reference gas blend
   - Note that the H_2S reference gas tank and as many of the gas lines as possible should be outside the shelter in the open air. All gas lines should be tested for leaks while filled with nitrogen gas.
3. 1/8″ PTFE tubing for the reference and purge gas lines into the quality assurance (QA) cell
4. 1/8″ PTFE Swagelok tee union to couple the reference and purge gas feed lines into the QA cell
5. 1/4″ PTFE tubing for gas flow lines on the outlet of the QA cell
6. Unisearch external 0.167-m flow cell
7. Length of PTFE 1/4″ tubing with PTFE Swagelok nuts on both ends
8. Length of PTFE tubing to go from external flow cell to scrubbing system
9. A scrubbing system consisting of ½″ ID PTFE tubing, 6″ long, filled with GC Sulfursorb Plus activated carbon absorbent, or equivalent; this volume of absorbent has a minimum capacity of 38 grams of H_2S, which is approximately 1,000 times the amount of H_2S existing in 750 ppm H_2S gas flowing at 0.3 l/min for 100 minutes
10. A max 5 l/min rotameter attached at the exhaust line to view that flow is occurring

5.2 Test Preparation

Depending on the requirements in the QAPP, the path-average concentration will need to be determined using the flow-through cell length, the concentration of standard gas, and the length of the open path. Note that because this is a monostatic system, the total optical pathlength is twice the distance between the telescope and the retroreflector. For example, a 750-ppm blend of H_2S (in nitrogen or air) delivered to the optical path through the 0.167-m flow-through cell and a total path length of 1,000 m provide an approximate 125-ppb path average concentration of H_2S. An example calculation of this is as follows:

$$(H_2S \text{ concentration in cylinder})\ (\text{flow cell length}) = \text{Path Integrated Concentration ppm-m}$$

$$(750\ \text{ppm})\ (0.167\ \text{m}) = 125.25\ \text{ppm-m}$$

Path Integrated Concentration divided by the total optical path length = Path Average Concentration (ppm)

125.25 ppm-m / 1,000 m = **0.125 ppm or 125 ppb H_2S**

5.3 Gas Testing Procedure

1. Flow nitrogen gas and perform an internal zero test with nitrogen. Gas delivery should be about 5-10 psi from the regulator/cylinder, at a flow rate of 0.25 to 0.5 L/min.
2. Assemble test configuration with the Unisearch short flow-through cell (0.167 m) in the path.
3. Assemble the H_2S gas scrubbing system, with gas flow coming from the external flow cell into the column packed with appropriate scrubbing media for H_2S (e.g., Sulfursorb Plus).
4. Flow nitrogen to a stable baseline, typically about five volumes of the cell. The flow of nitrogen can be verified by viewing the rotameter at the exhaust.
5. Monitor readings until a stable zero reading is reached. Continue reading 7-15 measurement cycles.
6. Flow the H_2S reference gas. The H_2S should flow at 0.3 L/min.
7. Acquire replicated measurements, as described in Section 7.
8. Verify that the values are reasonable. If they are not, follow the corrective actions listed in Section 7.
9. Stop the H_2S flow and flow nitrogen to purge the H_2S gas to a stable baseline, typically about five volumes of the cell.
10. Disconnect H_2S and nitrogen gases and remove the external flow cell to return the TDLAS system to open-path monitoring of ambient air.

5.3.1 Clean-Up

1. Dispose of the waste PTFE tube filled with GC Sulfursorb Plus appropriately.
2. Download the .cfg and .spectrum files and save them along with the form at the end of this document.

6. Sealed-Cell Response Testing

The purpose of this procedure is to check the system for the expected H_2S response under the installed operating conditions. H_2S standard reference gas is introduced into the optical path by means of a sealed cell, meaning the entire sample path is included at the time of testing.

Sealed cells filled with a known concentration of H_2S are used for response testing the LasIR analyzers. These sealed cells are fiber coupled and may be connected into the light path as indicated in Figure 1.

6.1 Test Preparation

To meet the testing requirements, you must determine the path average concentrations using the certified cell concentration and the pathlength. An example calculation of expected path average concentration for a 250 ppm-m sealed cell together with a 500 m one-way path is as follows:

$$Path\ Average\ Concentration = \left(\frac{250\ ppm - m}{(2 * 500\ m)}\right)\left(\frac{1000\ ppb}{ppm}\right) = 250\ ppb$$

Prior to testing, you will need to ensure that the cells you have will satisfy the testing requirements.

6.2 Single-Point Bump Test

1. Disable alerts on Sonoma Technology Field Tech Tool (FTT) and put instrument into planned maintenance mode.
2. Disconnect the optical fiber from the instrument “Fiber In” port.
3. Connect the optical fiber from Step 2 to the sealed cell inlet.
4. Connect the optical fiber from the sealed cell outlet to the instrument “Fiber In” port.
5. Wait for response to stabilize before collecting data.
6. Acquire replicated measurements, as described in Section 7.
7. Calculate the average, %error, standard deviation, %CV, and average detection r. Record these values in the test form (Section 9).
8. Verify that the values are reasonable. If they are not, follow the corrective actions listed in Section 7.
9. Disconnect the sealed cell outlet optical fiber from the instrument and reconnect the optical fiber from Step 2 to the instrument “Fiber In” port.
10. Verify the instrument baseline and turn alerts back on in FTT. Take the instrument out of planned maintenance mode.
11. Download .cfg and .spectrum files and save along with the form in **Section 9**.

6.3 Three-Point Calibration

1. For the three-point calibration test, repeat the measurements described in Section 6.1 for the remaining concentrations using additional sealed cells.
2. Plot a curve of measured concentration vs. expected concentration. Then record the r^2, slope, and intercept.
3. Download .cfg and .spectrum files and save along with the form at the end of this document.

7. Data Evaluation, Reporting, and Corrective Action

During these tests, a number (N) of replicated (7 ≤ N ≤ 15), raw time resolution measurements (x_i) of a standard reference material of known magnitude (x_{std}) will be measured. For purposes of this SOP, a "trial" is considered one raw concentration value that is reported at the interval specified by the instrument. The average value of these measurements is calculated as:

$$\bar{x} = \frac{\sum_i x_i}{N} \tag{1}$$

and the sample standard deviation (σ) as:

$$\sigma = \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{N-1}}. \tag{2}$$

From these definitions, %error is defined as:

$$\%error = \left|\frac{\bar{x} - x_{std}}{x_{std}}\right| \times 100\% \tag{3}$$

and precision as the coefficient of variation expressed as a percentage (%CV):

$$Precision \equiv \%CV = \frac{\sigma}{\bar{x}} \times 100\% \tag{4}$$

Calculate the concentration.

- Average the concentration of "N" stable measurements.
- Report the %error between the average and the certified value.

  Note: To calculate the certified value that will be seen on the TDLAS from the actual certified instrument calibration gas concentration, you multiply the certified gas concentration by the calibration cell length (0.167 meters) and divide that answer by the path length set in the instrument software. For all TDLAS instruments in operation by Sonoma Technology, the path length is set to 2 meters.

Compile all configuration files, spectra files, and log files into a single folder in the maintenance folder for the project on Sonoma Technology's shared drive.

- The folder should be named "CUS LOC QATest TDL# YearMonDy", where CUS is a 3-letter designator for the customer and LOC is a three-letter designator for the facility location.

If the measurements collected during the test are not reasonable, repeat the procedure without adjustment. If the instrument still fails to meet the QA criteria, retest the following day with no adjustment. Confirm that atmospheric conditions were acceptable for bump testing. If these repeated tests continue to fail under acceptable atmospheric conditions, initiate corrective action to include the following:

- Realign the system and perform the test again.
- Review data for potential interferants, including a detailed check of absorbance spectra in the analysis regions configured for the analyte, noting any excessive noise or unexpected absorbance features
- Consult with the project technical lead to identify abnormal changes to the background
- Examine wavelength calibration
- Investigate any large changes in stray light since the last test and adjust calibration factors as necessary
- Review gas testing apparatus for leaks or other similar problems
- Review and confirm specifications of standard calibration equipment and gases (expiration dates, concentrations, etc.)

In the event of unreasonable results after following all steps outlined above, inform the Sonoma Technology Project Manager and Quality Assurance Manager, who will review the instrument performance parameters in the list above.

8. Maintenance Task Checklist

File this checklist, along with other maintenance documents, in the “maintenance” folder within the main project folder on Sonoma Technology’s shared drive.

Activity	SOP Section(s)	Complete?
Visually inspect the system. Inspect electrical and optical cables for wear.	4.2	
Inspect optics and clean if necessary	4.3, 4.4	
Check the alignment to verify there has not been significant physical movement; note that this is automatically monitored as well	4.5	
Download data from detector hard drive and delete old files to free space, if needed	4.6	
Ensure there are no obstructions in the beam path	4.7	
Review and test light and signal levels	4.7	
Verify system settings	4.8	
Perform bump test and take corrective action as needed	5 (flow-through) 6 (sealed cell)	
3-point calibration check	5 (flow-through) 6 (sealed cell)	

9. LasIR Response Test Form

Technician(s): ______________________________
Date: ____
Site Name: ________________________________
Pathlength: _______________________________________
Reference ID: ______________________________
Reference Cylinder Concentration (ppm):_____________
Test Cell Pathlength (m): ___________________
Path Average Concentration (ppb):__________________
Return Power (mW): _______________________
%Transmission: ___________________________________

Replicate	Time	Analyzer Concentration (ppm)	Concentration (ppb)	Correlation
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
Average				
Standard Deviation				

%Error: __________________ **%CV:** _______________________

Signature: ____

Notes:

10. Visual Inspection Checklist

☐ Note and clean any excessive dust buildup on the equipment or analyzers.

☐ Eliminate any pests from the sample site, including birds, spiders, rodents, etc.

☐ Note the condition of the analyzer cabinet internals.

☐ Inspect wiring and note and correct any corrosion or cracking insulation.

☐ Check HVAC for proper operation by checking for cool air and reviewing cabinet temperature records (if available).

☐ Check for corrosion, note anything that needs to be addressed.

☐ Note and mitigate any condensation or water issues that may adversely affect equipment.

☐ Check for door operation.

☐ Note anything that may result in eventual degradation of the LasIR system.

Notes:

Standard Operating Procedures for the CEREX AirSentry FTIR

October 31, 2024

STI-7036

APPROVED:

Sonoma Technology date

Fenceline Monitoring Refinery Representative date

Contents

1. Scope and Application

This Standard Operating Procedure (SOP) document covers the use of the CEREX AirSentry Fourier Transform Infrared Spectroscopy (FTIR) analyzer in a fenceline monitoring application. This document addresses routine maintenance activities, including visual inspections, instrument checks, data management, quality assurance (QA) bump testing, and data validation.

2. Introduction and Overview

The CEREX AirSentry FTIR monitoring system uses infrared (IR) light for gas detection. The system works by first generating IR radiation from an extremely hot Globar source. The light from the source is directed down the open path using a Cassegrain long-path telescope. When the light reaches the opposite end of the path, it is reflected using a retroreflector array back to the telescope, which then receives the light and sends it to the detector. The IR detection system is based on a Michelson Interferometer with a cooled Mercury Cadmium Telluride (MCT) or Deuterated TriGlycine Sulfate (DTGS) detector. A schematic of the CEREX AirSentry FTIR monitoring system is shown in **Figure 1.**

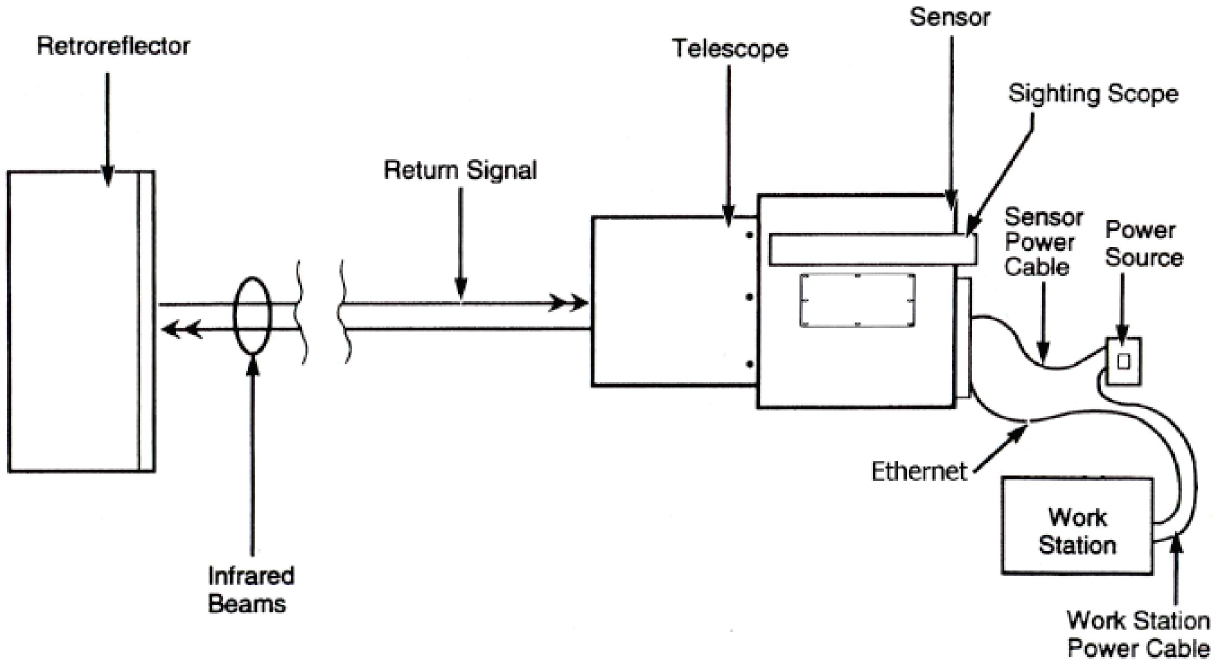


Figure 1. Schematic of the instrument.

The Michelson Interferometer includes the IR source and an optical assembly that includes both stationary and moving mirrors. While the light path defined by the stationary mirror is of fixed length, the light path defined by the moving mirror varies. The interferometer creates an interference pattern by combining the light from the stationary and moving mirror, thus cancelling different wavelengths of the IR spectrum at different times during each scan of the moving mirror. Once the IR beam returns from the sample volume defined by the path of the IR beam in the air, it is focused onto a cooled MCT or DTGS detector, which converts the incident IR wavelengths into electrical currents at high speed. The MCT detector synchronized with the interferometer continuously scans the full range of the IR spectrum. The IR spectrum, or single beam, is produced by measuring the electrical currents at each given scan and applying a Fourier Transform to produce a graph of signal intensity versus wavelength.

The raw data go through several transformations in the software. The final step occurs when the software compares the peaks produced in the field data against quantitative library references of the target gases being analyzed. This allows for identification and quantification of each specific gas. Since the calibration is inherent in the library references stored on the PC, there is no requirement for the AirSentry FTIR to undergo "calibration." There is no need to perform a recalibration on a periodic basis. However, as calibration verification is often a requirement in many applications, CEREX provides the (optional) provision to conduct a verification of the system.

3. Definitions

Table 1. List of definitions.

Term/Acronym	Definition
Beer's Law	A mathematical relationship that relates the attenuation of light to the concentration of a substance/material.
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes (Xylenes are composed of ortho, meta, and para isomers).
Bump Test	Test where gas of a known concentration is introduced to the analyzer to check for response accuracy (as % error) and precision.
CMS	Continuous Monitoring Software.
Coefficient of Determination (R^2)	The square of the correlation coefficient. R^2 ranges from 0 (not correlated) to 1 (perfect correlation).
Correlation Coefficient (r)	A coefficient that measures the linear correlation between two sets of data. In the case of the FTIR, it measures the correlation between the modeled and measured spectral data. It ranges from -1 (perfect anticorrelation) to 1 (perfect correlation).
Cryocooler	A device used to achieve cryogenic (very low) temperatures. A Stirling engine is commonly used to cool the FTIR detector.
FTIR	Fourier Transform Infrared Spectrometer/Spectroscopy.
Infrared (IR)	Light that has wavelengths of 700 nm to 1 mm, or 14,000 to 10 cm^{-1}.
Interferometer	Device that uses the interference of light to measure the light "spectrum."

Term/Acronym	Definition
Intensity	A measure of how much light was collected.
MCT detector	A semiconductor detector made of mercury, cadmium, and telluride.
PC	Personal Computer.
Percent Match	The coefficient of determination multiplied by 100 (i.e., R^2 x 100).
PPE	Personal Protective Equipment.
QA	Quality Assurance.
Retroreflector	A special array of "corner cube" mirrors that reflect light directly back to the source location. For FTIR, these are made using gold thin-film coatings.
Spectral Resolution	The ability of a measurement to resolve features in a spectrum. It is the smallest difference in wavelengths (or wavenumbers) that can be distinguished.
Spectroscopy	A technique that uses the absorption of light to detect and quantify the amount and properties of atoms and molecules.
Wavenumber	A common unit = 1/wavelength. It is the "spatial frequency" of the wave. This unit is commonly used in IR spectroscopy.
MDAs	Missing Data Alerts.

4. Safe Work and Hazard Identification

The following information should be noted when preparing work plans and permits for safe work practices.

Safe Operating Precautions

1. Ensure that a clear escape path is identified.
2. Standard site Personal Protective Equipment (PPE) is appropriate. If gloves are required, nitrile or latex should be used.

Operator Qualifications

Installing, operating, and servicing CEREX AirSentry FTIR analyzers should only be performed by personnel trained in the operation of the system components and familiar with the handling of gas delivery and testing equipment. This includes troubleshooting, cleaning, replacement of parts, IR light source installation, etc. The operator should be fully trained and experienced in the use of compressed gas cylinders, one- and two-stage regulators used in conjunction with the cylinders, flow controllers, and tubing connections. The operator should be experienced with the parameters of flow and pressure, and how these relate to compressed gas and its use with calibrating gas analysis equipment.

Safe Work and Hazardous Environment Operation

Work should conform with manufacturer guidance and site health and safety practices.

CEREX Monitoring Solutions AirSentry Series Analyzers are not rated for safe operation in hazardous or explosive environments. Any use in an area that may contain flammable mixtures or highly corrosive vapors requires special preparation to ensure operator safety and safe operation of the equipment.

CAUTION – Laser Radiation. Risk of eye injury with prolonged direct exposure. CEREX FTIR Analyzers contain Class 3B invisible laser radiation when the interferometer cover is removed. Do not remove the interferometer cover. Eye protection is recommended when working near the IR source.

Procedure Warnings

This QA Test procedure requires the handling of pressurized isobutylene. Improper handling of materials or hardware may result in serious injury, destruction of property, or damage to the AirSentry FTIR. Only qualified individuals should attempt or perform analyzer QA test activities. CEREX assumes no liability for the use or misuse of this guidance document, or for operator-performed QA Tests, Calibration, or Gas Handling activities. No claims are made by CEREX as to the compliance of this procedure with any regulations or engineering best practices. The operator is solely responsible for the safety of personnel and property.

NOTICE

Please check off the following steps before conducting maintenance. Doing so reduces the chance of false notifications to the public and clients.

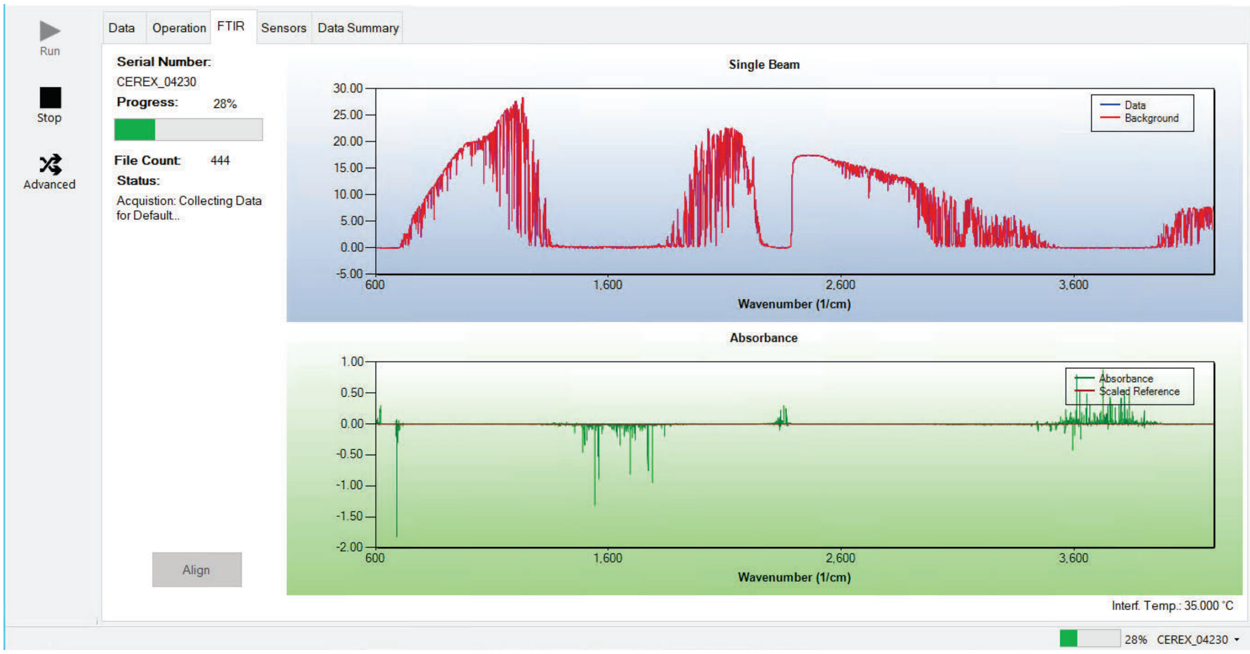
- ☐ Notify the client and project manager of maintenance tasks.
- ☐ Using the field tech tool at ftt.sonomatechmonitor.com, place the equipment into planned or unplanned maintenance mode.

☐ Confirm that the data are invalidated on the public website before proceeding with maintenance.
☐ When maintenance is complete, check the public site for at least 15 min to ensure proper reporting (no missing data, no high values, etc.).
☐ Take the equipment out of maintenance mode.
☐ Notify the project manager and client when maintenance is complete.

5. Routine Operations

To set the FTIR instrument to acquire data for normal operations, the instrument software (CMS) must be operating and the instrument must be aligned. These actions are detailed in the steps below.

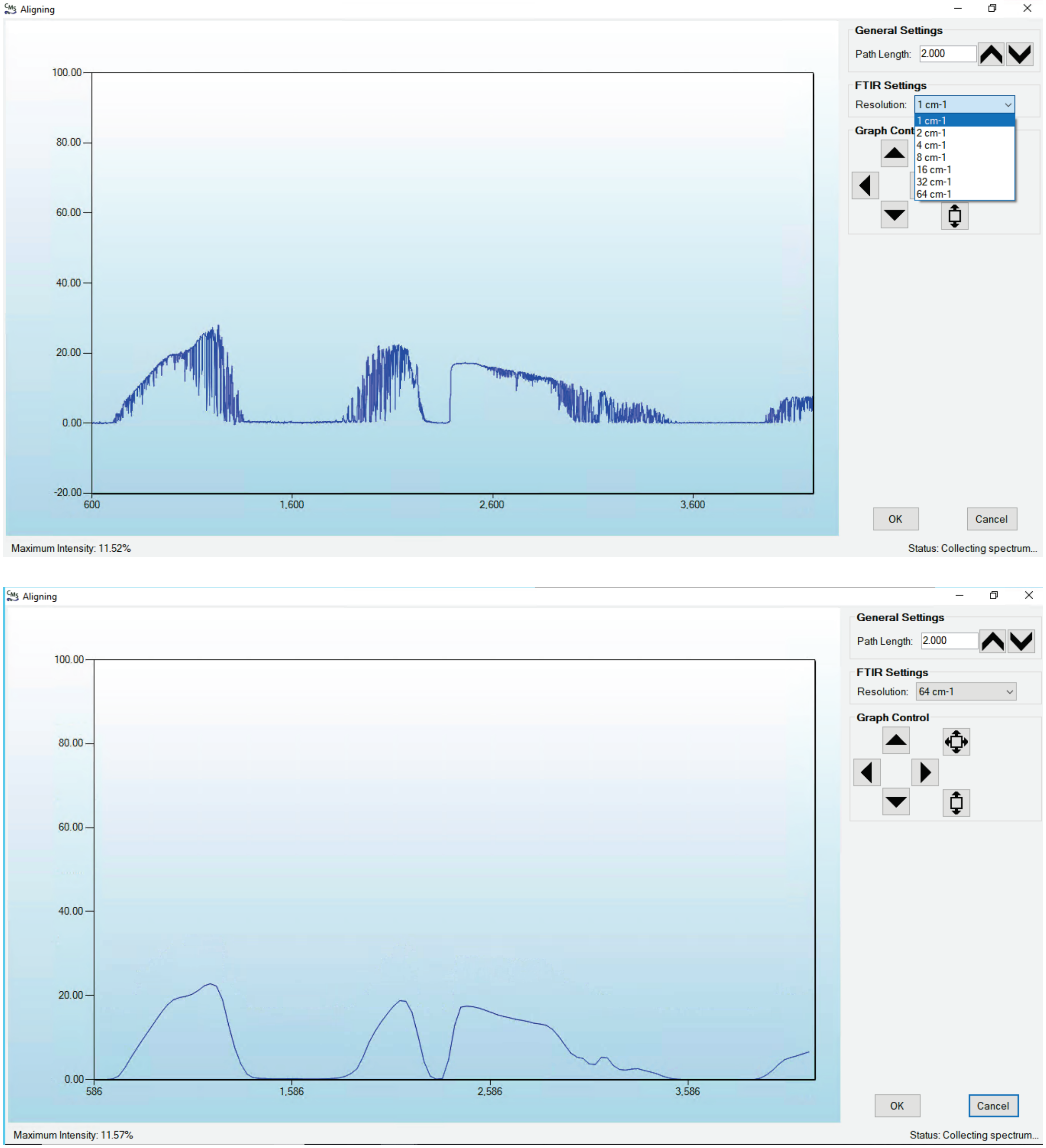
1. Start the CMS software (if not already initiated). You should see a window similar to the one shown in Figure 2.



Serial Number: CEREX_04230
Progress: 28%
File Count: 444
Status: Acquistion: Collecting Data for Default...

Figure 2. Screenshot showing the FTIR tab of the CMS software. Note that the Align and Run buttons are grayed out because the instrument is in run mode.

2. Under the **FTIR** tab, left-click on the **Align** button. This action brings up a new screen showing the instantaneous single-beam plot (intensity versus wavelength). If the **Align** button is not active, you may need to press **Stop**. The **Align** mode is shown in Figure 3.



Path Length: 2.000
Resolution: 1 cm-1
Maximum Intensity: 11.52%
Status: Collecting spectrum...

Path Length: 2.000
Resolution: 64 cm-1
Maximum Intensity: 11.57%
Status: Collecting spectrum...

Figure 3. Screenshots of Align mode. The spectral resolution can be selected from the dropdown menu. In these particular screenshots, resolutions of 1 cm^{-1} (top) and 64 cm^{-1} (bottom) are selected.

3. Select a spectral resolution of 64 cm^{-1} and optimize the signal intensity by adjusting the pan-tilt head of the FTIR unit to adjust the position of the IR beam on the retroreflector.

4. Once sufficient alignment is obtained, exit the **Align** mode by pressing **Cancel**.
5. Verify settings by left-clicking **Settings**.

Note: If you need to change any setting back to the original configuration, you must go to **File** and **Save**, then **Save As Default.** If you change settings, record why they were changed and what they were changed to in the instrument logbook. If settings are changed, they are automatically saved in this directory: C:\Users\CMS-USER\Documents\Cerex\CMS.

- RunTime
    - General
        - Operator Name: **Default** (these will change based on the path and site you are working on)
        - Sitename: **Cerex** (these will change based on the path and site you are working on)
        - Auto Run: **ON** (ON means the instrument will turn on automatically if the computer is running)
        - Auto Run Delay (s): **15** (time delay for CMS autostart)
    - File
        - File Type: **.CSV**
        - Primary Data Logging File: **ON**
            - C:\Users\CMS-USER\Documents\Cerex\Data (file path will vary by facility)
        - Secondary Data File Logging: **ON**
            - \\[SiteName]\STITempData\FTIR\OPT[Path#]
                - Note this path will change based on the computer and path you are working on. This is just a basic file-writing path to show you what it should look like.
        - Single Data Folder: **OFF**
        - Primary Summary File Logging: **ON**
            - C:\Users\CMS-USER\Documents\Cerex\Data
        - Secondary Summary File Logging: **ON**
            - \\OPT1-PC1\VLOData\OPT1_Path1\UVSentry_POC1
                - Note this path will change based on the computer and path you are working on. This is just a basic file-writing path to show you what it should look like.
        - Single Summary File: **OFF**
    - Library
        - Library File: C:\Users\CMS-USER\Documents\Cerex\Library\
    - UI
        - Sort Column: Compound Name
        - Data Summary Chart: **OFF**

    - Concentration Chart: **OFF**
    - Password Protection Settings: **ON**
    - Pump Control: **OFF**
    - Status Control: **OFF**
    - Testing Control: **OFF**
- Analysis
  - General
    - Moving Average Interval: **12**
    - Display Units: **PPM**
  - Concentration
    - Zero Readings on Non-Detect: **OFF** (zeros reading below threshold % match)
    - Zero Readings on Negative concentrations: **OFF** (zeros reading less than zero)
    - Display BDL: **OFF**
    - Quick Analysis MDL Wavelength Range: **276-280** (not typically used)
    - Temperature/ Pressure Concentration: **OFF**
  - Filters
    - Absorbance Savitzky-Golay: **OFF**
    - Baseline Correction Savitzky-Golay: **OFF**
  - Background
      - Auto Background: **ON** (typically ON for fenceline monitoring projects reporting concentration above background)
      - Interval (Acquisitions): **5** (How far back the routine will search for a background)
      - Depth: **4**

- Instruments
  - FTIR
    - Operational;
      - FTIR: **ON** (sets instrument type)
      - Averages/Co-adds: **28** (how many spectra will be averaged together)
      - Path Length (m): **2** (2 for monostatic units)
      - Resolution: **1 cm-1** (spectral resolution)
    - Verification
      - Verification: **OFF** **(This inactivates all inputs)**
- Controller
  - General
    - Serial Port: **n/a**
    - Sensor Refresh Interval (s): **10**
  - Sensors
    - **Don't Touch Anything**

  - Alarms
    - **Don't Touch Anything**
- Email
  - General
    - Data Recipient: **Blank**
    - Email Sender: **Blank**
    - Email Period (s): **60 (the time does not matter as this setting is not used)**
    - Send Data: **OFF**
  - SMTP
    - Server: **smtp.gmail.com**
    - Port: **587**
    - Username: **Blank**
    - Password: **Blank**
    - Timeout (s): **100**
    - SSL Authentication: **ON**
- Auxiliary Coms
  - Modbus (these settings are specific to the data-acquisition software used)
    - Modbus: **ON**
    - System Type: **Ethernet**
    - TCP Port: **502**
    - Unit ID: **2**
    - 16-bit unsigned int to: **ON** (does not greatly affect data)

6. After settings are verified and the instrument is aligned, you can place the instrument in run mode.

6. Equipment and Supplies

1. Field notebook
2. Tool kit, especially including: 7/64 hex driver, complete set of combination wrenches, adjustable wrenches, screwdrivers, etc.
3. Cleaning supplies designated to be safe for use on a CEREX FTIR
4. All relevant PPE, hardware, and procedural guidance per SOP, Safety Plan, and Safe Work Permit
5. Local or remote network link device (as required)
6. External laptop computer with network interface device to the Sentry unit (as required)
7. CEREX FTIR Sentry Unit equipped with CMS software
8. Isopropyl alcohol (≥80%)

9. Distilled water
10. Pressurized sprayers
11. Powder-free nitrile gloves
12. Cell bump test apparatus (including panels, regulators, valves, meters, etc.)
13. Tubing as required: 1/4” metal jacketed polytetrafluoroethane (PTFE) tubing for gas supply from the bottle to the QA cell
14. Tubing as required: 3/8” metal jacketed PTFE tubing with inline flow indicator from the QA cell to the scrubber
15. Flow regulation system capable of delivering gas at 0.1 to 5 L/min at a total system pressure of 3 psig or less
16. Gas scrubber appropriate for gas used. Activated carbon treated with phosphoric acid may be used for benzene
17. Reference standard traceable zero compressed air purge gas
18. Reference standard traceable gas blend in nitrogen for detection at about five times the instrument’s theoretical detection limit or higher

7. Maintenance Activities

The following sections outline the routine checks to be carried out for each analyzer and sensor, followed by maintenance forms (see Section 8) used to indicate when the checks are completed and document any corrective actions taken. These activities are also expected, based upon the project plan, to be logged in a site logbook either in hard or electronic form and can reference this SOP and associated forms.

The following FTIR maintenance activities and performance checks are recommended by the manufacturer:

- Visually inspect the system.
- Confirm the alignment to verify there has been no significant physical movement. Note: this is automatically monitored as well.
- Download data older than 6 months from detector hard drive and, if needed, delete old files to free up space.
- Ensure there are no obstructions between the detector and the retroreflector.
- Check and replace air conditioner fans when needed.
- Change out the IR source.
- Re-align system after service.

- Check system response (bump test). Take corrective action if % error exceeds the level specified in the quality assurance project plan (QAPP).
- Review and test light and signal levels.
- Verify system settings.
- Perform Cryocooler Check. Replace cooler or swap detector module assembly if necessary.

7.1 Monthly Visual Inspections

1. Ensure that the instrument is running and the data look reasonable.
2. Clean and correct any obvious problems with the system (cobwebs, rodent nests, broken optics, etc.).
3. Inspect all electrical cables for wear; replace as needed.
4. Indicate these visual checks are complete on the form included at the end of this document.
5. Document any changes to the system in the course of these checks in the site logbook.

7.2 Light Level Check

In good-visibility conditions, signal strength is normally >5%. If it is determined that these values are out of range, re-alignment may be needed. Check and record signal strength as reported by the instrument in align mode. If the value is <2%, corrective action should be taken. Common instrumental problems resulting in low signal strength include retroreflector fouling, poor internal alignment, suboptimal software and electronic gain, low source intensity, and a failing detector.

Check for Stray Light

Ensure there is sufficient intensity at 966 cm^{-1} compared to the stray light intensity. If the stray light is problematic, advanced optical cleaning, replacement, alignment, or a bulb change may be necessary. To measure stray light, put the instrument in align mode and block the beam from exiting the analyzer with an opaque object (such as a black cloth) and measure the intensity at the wavenumber range of interest (in this case 966 cm^{-1}). Calculate stray light as:

$$\%\, stray\ light = \frac{Intensity\ of\ blocked\ beam\ (\%)}{Intensity\ of\ unblocked\ beam\ (\%)} \times 100$$

Note the result of this stray light calculation in the form at the end of this document.

7.3 Data Management

7.3.1 Archiving and Deleting Older Data

Note: Data older than 12 months should be deleted from the instrument each month to prevent the instrument from filling its 125GB internal hard drive.

Raw instrument data are stored on the analyzer computer, the site PC, and the hard drive attached to the site PC. Data consist of spectral data containing two columns: one for wavelength and the other for intensity. There are also two types of "summary" files that contain data resulting from the classical least-squares analysis of the spectral data as a function of time. These file formats are described in the CMS Software User Manual.[1] Spectral data and summary files are automatically written to the site PC and moved to the external hard drive at regular intervals. Deliver the external hard drive to the client on an annual basis. Data on the instrument must be deleted at monthly intervals. Details on the proper procedure for deleting data files from the instrument are as follows.

1. Confirm that the data files have been successfully written to the site PC and the external hard drive attached to the site PC.
2. Make a note of the amount of available space on the instrument internal drive on the maintenance form.
3. Locate files older than 12 months on the instrument file directory here: C:\Users\CMS-USER\Documents\Cerex\Data\.

   Note: This procedure excludes the Bump Test folder, which should always remain on the instrument computer.
4. Log into the brick PC located in the instrument shelter and locate the data files written from the instrument onto the external hard drive.
5. Confirm all Complete Data Summary files and Simple Data Summary files for the desired month have transferred over completely to the external hard drive attached to the brick PC.
6. Once you have confirmed that those files have been transferred over to the external hard drive, delete those exact Complete Data Summary and Simple Data Summary files from the instrument data folders.
7. For each individual day of single-beam folders, ensure that the number of single-beam files is the same on both the external hard drive located on the brick PC and the internal hard drive of the instrument.
8. If both folder locations match and you have ensured proper file download, you may permanently delete the single-beam folders from the instrument computer.
9. After all data older than 12 months have been deleted, note how much free space is now available on the instrument's internal drive. If removal of the files does not result in enough

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[1] CMS Software User Manual Rev 4. CMS Version 4.0.298.1, CEREX Monitoring Solutions, December 5, 2017.

free disk space, the disk drive may need to be re-indexed (see Section 7.3.2).

7.3.2 Rebuilding the Instrument's Indexing Preferences

If deleting data from the instrument does not sufficiently increase available storage space on the instrument, you may need to also re-index files. To rebuild the index preferences, follow these steps.

1. Navigate to the **Control Panel Menu** by using the search function in the lower left-hand corner of the task bar.
2. Once in the control panel menu, click **Indexing Option.**
3. Click on the **Advanced** tab with the shield logo.
4. Click **Rebuild**.

Note: Once rebuild has been selected, a message saying that it might slow user activity will appear. This will not affect the instrument's ability to perform data collection. On the original indexing option screen, the magnifying glass in the upper right-hand corner will move and the number of items indexed will slowly increase. Take note of the available space on the instrument's internal drive once the indexing has been completed.

7.4 Clean Optics on Detector and Retroreflector

Cleaning the retroreflector is an important part of the maintenance plan. Over time, the retroreflector will collect debris that can alter the performance of the instrument. Caution should be taken, as there are electrical fan heaters that are used to keep moisture and particulates from collecting on the retroreflectors.

7.4.1 Retroreflector Cleaning

1. Power down any equipment to prevent electrical shock or damage to the system.
2. Use a gentle stream of distilled water, usually from a weed sprayer or other type of gentle delivery method, to remove any salt or dust buildup on the retroreflector.
3. Use a gentle stream of 80% isopropyl alcohol, usually from a weed sprayer or other type of gentle delivery method, to remove any salt or dust buildup on the retroreflector.
4. Once the retroreflector has been cleaned and dried, repower any electrical equipment you have powered down and clean up any spills you have created while cleaning.

7.4.2 Window and Scope Cleaning

If light levels are low or visual inspection reveals soiled optics, cleaning optical surfaces can improve light throughput. On the FTIR, the window and scope are the most likely surfaces to need cleaning. In general, if the optics are not dirty, do not clean them. Excessive cleaning of optics can result in scratches and wear over time. If the optics are obviously soiled and the soil is affecting their performance, take the following steps. Mirrors with metallic coatings should be treated with extra care because these surfaces are easily damaged on contact.

Window Cleaning

1. Place the instrument in maintenance mode.
2. Remove the scope from the instrument by loosening the two Allen screws on the side.
3. Slide the scope straight up, keeping it level to prevent it from jamming. Place the scope on stable ground, being mindful of any objects that could potentially fall inside the scope and damage it.
4. Once the scope is removed, you will be able to inspect the small round window.
5. Use compressed air to remove particles from the surface of the optics.
6. Use lens paper to lightly clean the surface of the window.

Scope Cleaning

1. Place the instrument in maintenance mode.
2. Remove the scope from the instrument by loosening the two Allen screws on the side.
3. Slide the scope straight up, keeping it level to prevent it from jamming.
4. Place the scope on the ground at a slight angle to allow the cleaning solution to drain out.
5. Use a pressurized sprayer with distilled water to lightly rinse any heavy dust or dirt off the primary and secondary mirrors of the scope.
6. Use a pressurized sprayer with 80% or higher isopropyl alcohol to lightly rinse any remaining contaminants from the primary and secondary mirrors of the scope.
7. Let the scope dry for about 20-30 min before placing it back on the instrument.

7.4.3 Replace AC Fans

Two AC fans are necessary to control the temperature inside the FTIR. The preventative maintenance procedure of replacing the AC fans every 2-3 years is needed to ensure proper operations and prevent critical components from being damaged due to high heat.

1. Turn off MDAs and place unit into Planned Maintenance mode.
2. Close CMS and shut down the operating system.
3. Unplug the power to the unit.
4. Open FTIR lid.
    a. Note: Place a barrier to prevent screws from falling into the FTIR assembly.

5. Remove shroud fan cover on the underside of the FTIR lid.
6. Make a note of each fan’s orientation (i.e., front facing) before removing it.
   a. Unplug each fan, then remove the four screws holding each fan for removal.
7. Install new fans with screws, then plug the fans into a power source.
8. Close the FTIR lid.
9. Plug in the FTIR power source and begin operations.
10. Start the CMS and align the FTIR if needed.

7.5 Perform Bump Test

This section addresses the commissioning and performance test procedure for CEREX Monitoring Solutions AirSentry units. The procedure is intended to verify that the equipment is performing to expectations and that the detection and communication links are functioning correctly.

***NOTE ***

This procedure should only be used by personnel with experience in the safe use of the analyzer and test equipment.

The purpose of the QA Test procedure is field verification of the factory calibration of the AirSentry. The QA Test process challenges the instrument using known concentrations of reference gas to verify proper detection and quantification under field conditions.

7.5.1 Apparatus Setup

This procedure is to be carried out when using the Internal AirSentry FTIR QA Cell.

Verify system is set up (minus the instrument connections) as shown in **Figure 4**.

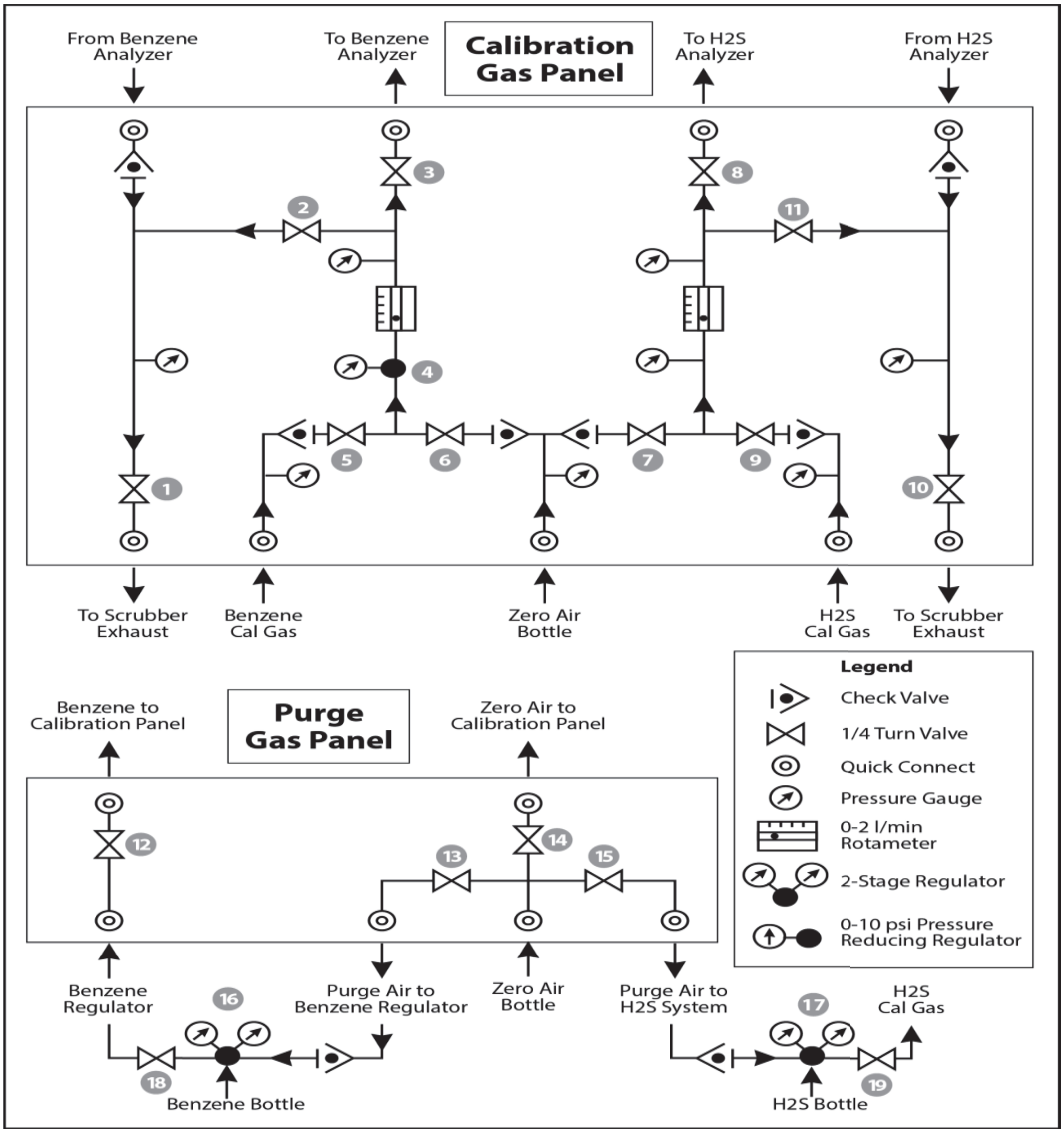


Figure 4. Diagram of the calibration gas panel (top) and purge gas panel (bottom) used for gas delivery. Note that the gas used will change depending on the instrument.

Materials Required

1. Operator-supplied SOP approved by the end user and in compliance with the end sser's Health and Safety Plan.
2. Cell bump test purge apparatus, including:
    a. Tubing as required: 1/4" PTFE tubing for gas supply from the calibration gas panel to the QA cell.

   b. Tubing as required: 3/8" PTFE tubing for gas supply from the QA cell to the calibration gas panel.
   c. All necessary tubing for supplying calibration and zero reference gas to the calibration gas panel.
   d. Flow regulation system capable of delivering gas at 0.1 to 5 L/min at a total system pressure of 3 psig or less.
3. Purge gas, typically zero air.
4. Reference standard traceable gas blend in nitrogen for detection at about five times the instrument's theoretical detection limit or higher.
5. All relevant PPE, hardware and procedural guidance per SOP, Safety Plan, and Safe Work Permit.
6. Local or remote network link device (as required).
7. External laptop computer with network interface device to the AirSentry FTIR unit (as required).

7.5.2 Configure CMS for Test (This may be done concurrently with Gas Purge System setup)

1. The analyzer should be powered on and running for <u>at least 30 minutes prior to testing</u>.
2. Stop CMS data collection by pressing the **STOP** button.

7.5.3 Gas Test System Setup

1. Connect the 1/4" reference cell line coming from the calibration panel to the 1/4" reference cell connection on the CEREX MS Air Sentry FTIR.
2. Connect the 3/8" reference cell line coming from the calibration panel to the 3/8" reference cell connection on the CEREX MS Air Sentry FTIR located just below the 1/4" refence cell inlet.
3. Ensure all valves on the calibration gas panel are in the closed position.
4. Make all necessary connections from zero air and calibration gas standard cylinders to the Gas Calibration Panel.

7.5.4 Verify Proper AirSentry Alignment

1. Open the CMS window.
2. Click on the **FTIR** tab.
3. If **Run** is active, press **STOP**.
4. Click the **ALIGN** button at the bottom left of the plot display.
5. Select 32 cm^{-1} and wait for the spectral resolution to change.

6. Aim the AirSentry FTIR at the retroreflector and adjust the alignment until the signal intensity is optimized.
   a. **The target intensity should be the highest achievable intensity, which varies based on instrument, but should be above 2%. Once a stable signal is obtained, select the desired operating resolution (1 cm^{-1} is required unless otherwise directed by CEREX).**
7. Record the signal intensity.
   a. **Optional – at this point you may wish to record the current field path length and create a backup of the existing configuration file.**
8. Press **OK** and **SAVE** or **ACCEPT** (when prompted) to exit the CMS Alignment window.

7.5.5 Leak Check

1. Ensure that all tubing from the purging panel is connected to the calibration panel in the mobile van. Ensure gas cylinders are connected to the purge panel as shown in Figure 4. Then attach the calibration panel to the analyzer connection in the analyzer shelter.
2. Connect the PTFE tubing containing the activated carbon scrubber to the analyzer exhaust.
3. Close all valves on the calibration and purging panel.
4. Verify that the regulators on the zero air and benzene cylinders are completely closed (**all the way to the left!**) to prevent any pressure buildup at the regulator.
5. Open the high-pressure valves on both the calibration gas and zero air bottles.
6. Open valve (14) and slowly open the regulator on the zero air cylinder to a pressure of 5-10 psi, as seen on the calibration panel zero gas pressure gauge. Do this by making small adjustments at the cylinder regulator and watching the pressure on the calibration panel.
7. Open valve (12) and slowly open the regulator on the calibration gas cylinder to a pressure of 5-10 psi on the pressure gauge on the benzene calibration gas channel of the panel. Do this by making small adjustments at the cylinder regulator and watching the pressure on the calibration panel.
8. Open the bypass valve (2).
9. Open the zero air valve (6) and slowly open the regulator (4) to a final pressure of about 2 psi (as read on cell and exhaust pressure gauges). **DO NOT pressurize above 3 psi**.
10. Now pressurize the cell. Slowly open the valve going to the cell (valve 3). Close the bypass valve (2) while carefully watching the cell pressure gauge (4). If you note any sudden pressure increase, open the bypass valve (2) to relieve pressure on the cell. Wait until the same pressure is reached on the exhaust-side calibration panel pressure gauge.
11. Close the zero air valve (6) going to the benzene regulator on the panel so the system is now fully closed off to external pressure.

12. Watch the system for a minimum of 5 min to ensure there is no drop in pressure and that the system is leak free.
13. Open the leak check valve (1) to release the pressure from the system, and then close all the valves on both panels.
14. Record leak check.

7.5.6 Configure Test Files

1. Click **Advanced** on the left side of the CMS software window. The password can be provided by the Field Staff Manager.
2. Under **Advanced** > **Settings** > **Runtime** > **File**, turn off **Secondary Logging**. Note current file logging paths.
3. Change both of the primary file logging paths to: C:\Users\CMS-USER\Documents\Cerex\Data\bumptest. Then select **File** and **Save**.

7.5.7 Gas System Purge

1. Close the secondary pressure regulator (4) on the panel by turning it all the way to the left.
2. Open the leak check (1) and bypass valve (2).
3. Open the zero air valve (6).
4. Adjust the flow of purge air going through the bypass until the desired flow rate (1 L/min) and pressure are achieved by slowly increasing the pressure on the secondary pressure regulator (4). The backpressure on the scrubber (measured between valves [1] and [2]) is typically less than 1 psi.
5. Open the valve going to the cell (3) and close the valve on the bypass (2) while carefully watching the cell pressure gauge after the regulator (4). If you note any sudden pressure increase, open the bypass valve (2) to relieve the pressure on the cell. Wait until the desired flow rate has stayed the same and the pressure on the entire system has not increased.
6. Press **RUN** to start background acquisitions.
7. Allow the analyzer to complete **three** or more acquisitions.
    a. If after two acquisitions the absorbance graph shows negative features greater than 3 times the peak-to-peak baseline noise level, take another clean air background.
8. Repeat this process until the sequential absorbance acquisition seen in the absorbance graph remains near zero (straight baseline with only normal noise peaks).
9. Once the instrument has performed ten or more acquisitions, close the zero-gas valve (6).
10. Close all valves.
11. Close the secondary pressure regulator (4) on the panel.

7.5.8 Gas Span and QA Test

1. Open the leak check (1) and the bypass valve (2).
2. Open the calibration gas valve (5).
3. Adjust the flow of calibration gas going through the bypass and scrubber until the desired flow rate (1 L/min) and pressure are achieved by slowly increasing the pressure on the secondary pressure regulator (4). The backpressure on the scrubber (measured between valves [1] and [2]) is typically less than 1 psi.
4. Open the valve going to the cell (3) and close the valve on the bypass (2) while carefully watching the cell pressure gauge (4). If you note any sudden pressure increase, open the bypass valve (2) to relieve the pressure on the cell. Ensure the desired flow rate has stayed the same and adjust as needed.
5. Wait 10 min to fill and condition the lines and cell.
6. After 10 min of calibration span gas flow, press **Start** in the CMS.
7. Collect span gas data.
    a. Observe the concentration reported on the **DATA** tab.
    b. After the concentration becomes stable, allow the analyzer **to run until at least seven stable measurements are made.**
    c. **Verify that the values meet the QA criteria. If the test fails QA criteria, follow the corrective actions listed at the end of this section (see Data Evaluation, Reporting, and Corrective Action).**
    d. **Verify the client system** is receiving and displaying instrument information correctly.
    e. After seven stable measurements are observed, **close the reference gas cylinder valve (6)**. Allow the pressure to fall to zero and the flow to stop.

7.5.9 Completion of Test and Purge of Instrument Calibration Cell

1. Close the calibration gas cylinder. You will see the calibration gas pressure increase and/or fluctuate as the pressure on the bottle regulator drops. This is normal—be patient and wait for the benzene pressure to zero out.
2. Close all valves on the calibration and purging panel.
3. Open the zero air valve (6).
4. Adjust the flow of purge air going through the bypass until the desired flow rate (1 L/min) and pressure are achieved by slowly increasing the pressure on the secondary pressure regulator (4). The backpressure on the scrubber (measured between valves [1] and [2]) is typically less than 1 psi.
5. Open the valve going to the cell (3) and close the valve on the bypass (2) while carefully

watching the cell pressure gauge (4). If you note any sudden pressure increase, open the bypass valve (2) to relieve the pressure on the cell. Wait until the desired flow rate has stayed the same and the pressure on the entire system has not increased.

6. **Verify that the target gas(es) concentration has returned to 0 ppm** with a nondetectable R^2.

   NOTE If the concentration has not returned to 0 ppm, this means the ambient background target gas concentration has changed during the procedure and testing may need to be repeated to verify results.

7. Once a zero reading is indicated on the FTIR, close all valves.
8. Close the zero air cylinder and allow all the pressure to be released from the system.
9. Close all valves and ensure there is zero pressure on the system.
10. Disconnect the tubing to the analyzer and the activated carbon scrubber.
11. Remove the hoses and cap the connectors.

7.5.10 Restore Normal Operation

1. **Restore** Normal Operation.

   Note: When restoring normal operation, you will change the file storage path in the settings menu back to the normal file path (this is slightly different for each unit, so make a note when first setting up the instrument for the QA Test). Once you restart the CMS, you will see the file number located on the FTIR main menu of the CMS. If the file count starts at file 1, you have the incorrect file writing path because it is starting a new folder for the entire day. If this happens:

   a. **STOP the** CMS.
   b. Click **Advanced** on the left side of the CMS software window; the password can be provided by the Field Staff Manager.
   c. Under **Advanced** > **Settings** > **Runtime** > **File**, turn On **Secondary Logging**. Change the primary file logging paths (both of them) to: C:\Users\CMS-USER\Documents\Cerex\Data. Then select **File** and select **Save**.

2. **Check the system alignment** as previously described.
3. Press **RUN** to begin monitoring.

Test Suspension

In the event of a leak or plant alarm requiring suspension of work, the process should be safely suspended. If a plant or site alarm sounds during the validation, stop the test immediately as follows.

1. Close the reference gas bottle valve completely.

2. Allow the system to flow purge gas to the scrubber/vent.

7.5.11 Data Evaluation, Reporting, and Corrective Action

During these tests, a number (N) of replicated, raw time-resolution measurements (x_i) of a standard reference material of known magnitude (x_{std}) will be measured. Here, an acceptable number of trials will be defined as 7≤N≤15. The average value of these measurements is calculated as:

$$\bar{x} = \frac{\sum_i x_i}{N} \tag{1}$$

and the sample standard deviation (σ) as:

$$\sigma = \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{N-1}}. \tag{2}$$

From these definitions, % error (accuracy) is defined as:

$$\%\ error = \left|\frac{\bar{x} - x_{std}}{x_{std}}\right| \times 100\% \tag{3}$$

and precision as the coefficient of variation expressed as a percentage (% CV):

$$Precision \equiv \%\ CV = \frac{\sigma}{\bar{x}} \times 100\% \tag{4}$$

1. Concentration
    a. Average the concentration of 7-15 consecutive stable measurements.
    b. Report the % error between the average and the certified value. The acceptable % error is listed in the QAPP.

    Note: To calculate the certified value that will be seen on the CEREX instrument from the actual certified instrument calibration gas concentration, multiply the certified gas concentration by the calibration cell length (0.047 meters), and divide that answer by the path length set in the instrument software. For most CEREX instruments in operation by Sonoma Technology, the path length is set to 2 meters for monostatic instruments and 1 meter for bistatic instruments.

2. Calculate the Limits of Detection and Quantitation
    a. Calculate the mean (average), sample standard deviation, and % error (sometimes also referred to as % difference) of the selected results.
    b. Report the Detection Limit as three times the standard deviation.
    c. Report the Quantitation Limit as five times the standard deviation.

3. Compile all configuration files, spectra files, and log files into a single folder.
    a. The folder should be named "CUS LOC QATest IR# YearMoDy," where CUS is a three-letter designator for the customer, and LOC is a three-letter designator for the facility location.

The QAPP contains the acceptance criteria and warning levels to be used for the test.

Note:

- **If the test produces an error or precision greater than the warning level:** the test is considered passing if below the acceptance criteria, but corrective action should be taken so that the precision and error are below the warning levels.

- **If the test produces an error or precision greater than the acceptance criteria:** the test is not considered passing and corrective action should be taken so that the precision and error are below the warning levels. Equipment will not be placed into service until it meets all measurement criteria.

If the measurements do not meet the data quality objectives listed in the QAPP, repeat the procedure without adjustment. If the instrument still fails to meet the QA criteria, retest the following day with no adjustment. If these repeated tests continue to fail, initiate corrective actions, such as:

- Re-aligning the system and performing the test again.
- Reviewing the data for potential interferants, including a detailed check of absorbance spectra in the analysis regions configured for the analyte, and noting any excessive noise or unexpected absorbance features.
- Consulting with the project technical lead to identify abnormal changes to the background.
- Checking the wavelength calibration.
- Checking for large changes in stray light since the last test and adjusting calibration factors as necessary.
- Reviewing the gas testing apparatus for leaks or other similar problems.
- Reviewing and confirming specifications of standard calibration equipment and gases (expiration dates, concentrations, etc.).

In the event of a failed test after following all steps outlined above, inform the Sonoma Technology Project Manager and Quality Assurance Manager, who will review the instrument performance parameters in the list above.

If all parameters indicate that the instrument was performing properly since the last test, data since the last test will be flagged as suspect. If an issue with the instrument is identified, data since the date and time of the instrument issue will be flagged as invalid. All data flagging will be performed by Data Analysts in consultation with the Quality Assurance Manager.

7.6 Cryocooler Replacement and Calibration

1. Remove cryocooler
    a. Turn off the power to the instrument. Please follow the proper shutdown procedure.
    b. Unplug the power connector (two-pin Molex with gray cable) from the cryocooler engine (**Figure 5**).

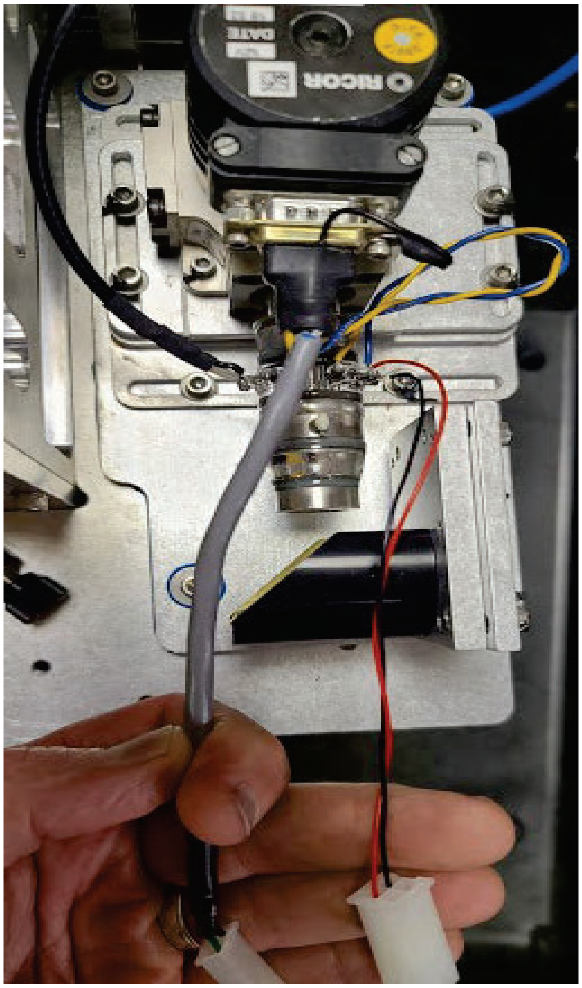


Figure 5. Detector assembly showing RICOR cryocooler, glass detector, DB9 connector, two white Molex connectors, and mirror.

    c. Unplug the black and red cable Molex connector coming from the glass detector assembly.
    d. In some installations, there is a ground cable coming from the connector and going to the chassis. Remove the ground cable by unscrewing it from the chassis.
    e. Take out the three #8 screws that hold the detector assembly to the baseplate—

these will have blue grommets in the holes (see **Figure 6**). Only remove three screws to release the entire assembly.

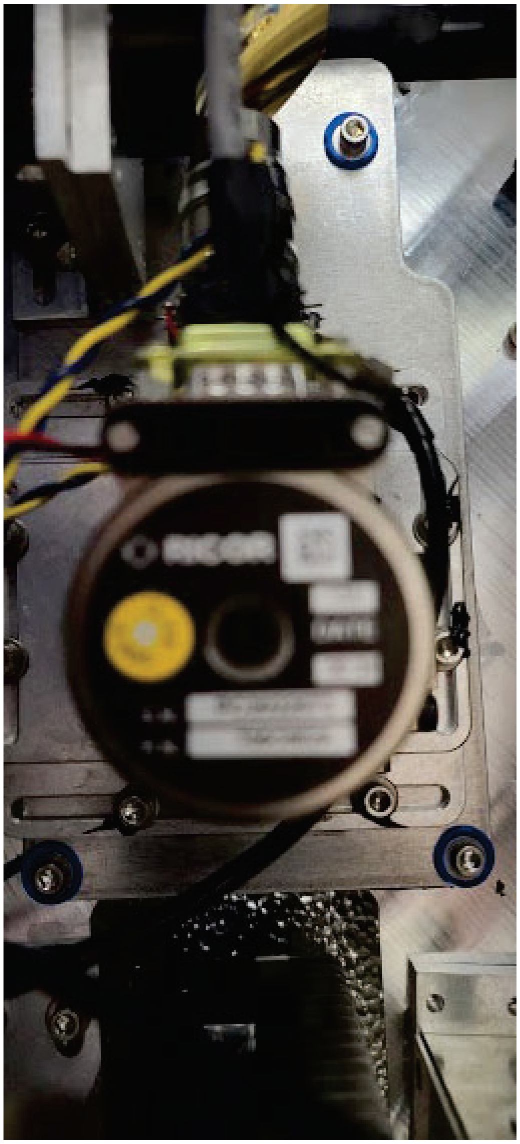


Figure 6. Image showing baseplate and screws with rubber grommets.

f. Follow the black coax connector to the small "Preamp" box - silver in color. This is held to the baseplate with 2 screws (**Figure 7**).

Figure 7. Preamp assembly (with orange, black, and purple wires) between the heatsink (left) and interferometer (right).

g. Disconnect power to the preamp—this is a four-pin Molex connector that can be pulled apart. The connector has purple, orange, and black wires.

h. Follow the second black coax cable from the preamp over the 4" x 6" heatsink assembly. Remove the BNC connection to this heatsink by hand twisting 1/4" turn counterclockwise and pulling it off.

i. The detector assembly and the preamp will come out together as they are attached to each other with a coax cable.

j. Pack the detector assembly and the preamp in the same box. But wrap both items separately so they can not touch. Immobilize all items in the box. Use a protective case to transport the entire assembly securely.

2. Re-install the cryocooler
    a. The installation process is the reverse of the removal process.
    b. Make sure all screws and connectors are secured and tightened.
3. Optics calibration
    a. After replacing or installing a new detector and optics, optimization using a small test retroreflector array is required.
        i. Place the test retroreflector array about 2 feet from the front of the FTIR scope. Alternatively, use a small "bike reflector" in the outgoing beam path, just before the light enters the bump test cell.
        ii. With the instrument powered on and using the Align window, set the resolution to 64 ms and align the scope to obtain the maximum signal strength possible.
        iii. Open the instrument and carefully use the beam splitter adjustment screws to maximize signal strength. This means making small adjustments to each screw until you reach the maximum signal strength (**Figure 8**).

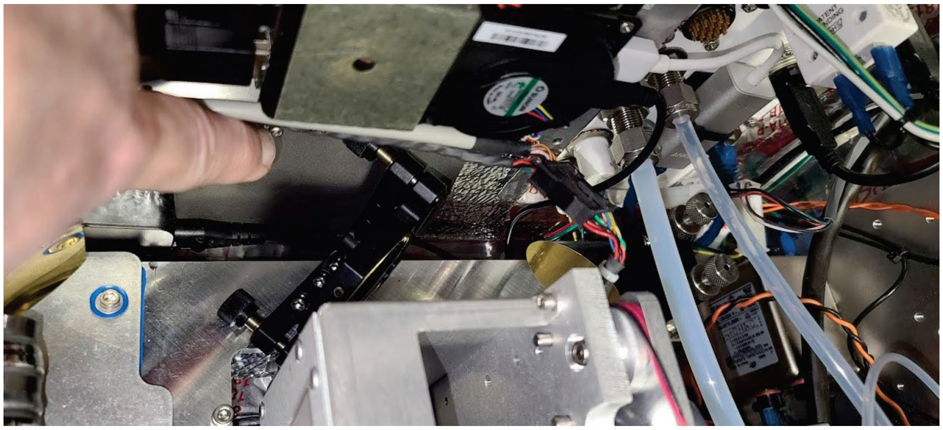


Figure 8. Beamsplitter (black object at 45-degree angle) with adjustment screws.

Repeat the same steps with the beam steering mirror. Keep in mind that the secondary mirror has two lower thumb screw nuts that lock the adjustment in place. You will have to unscrew those nuts before making any adjustments. Tighten the nuts once you have reached the desired adjustment. The beam splitter and the beam steering mirror work in tandem, so you may have to go back and forth between the two to optimize the signal strength (**Figure 9**).

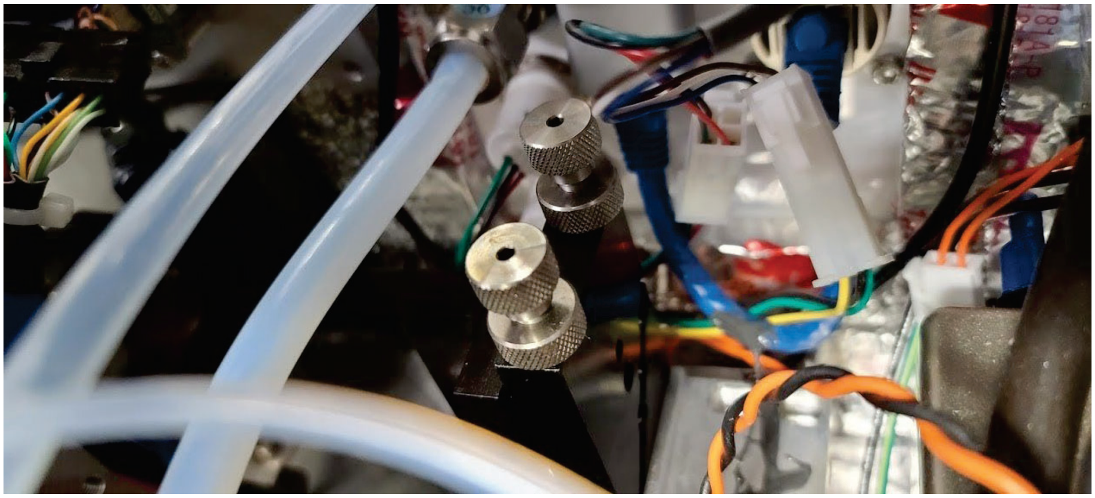


Figure 9. Beam steering mirror with sliver adjustment screws.

8. Monthly Maintenance Forms

Path:____

Technician:____

Date:____

Instructions: complete checks described below and enter data or initial next to each one once complete. Make note of any corrective action.

Please check off the following steps before conducting maintenance. Doing so reduces the chances of false notifications to the public and clients.

- ☐ Notify the client and project manager of maintenance tasks.
- ☐ Using the field tech tool at ftt.sonomatechmonitor.com, place the equipment into planned or unplanned maintenance mode.
- ☐ Confirm that the data are invalidated on the public website before proceeding with maintenance.
- ☐ When maintenance is complete, check the public site for at least 15 min to ensure proper reporting (no missing data, no high values, etc.).
- ☐ Take the equipment out of maintenance mode.
- ☐ Notify the project manager and client when maintenance is complete.

Upon completion, sign and date:______________________________

Table 2. Maintenance activities and performance indicator checks for the FTIR.

Activity	Completed (Y/N)
Visually inspect the system.	
Current source service hours.	
Check light levels.	
Confirm the alignment to verify there has not been significant physical movement. This is also automatically monitored.	
Ensure there are no obstructions between the detector and the retroreflector (such as equipment, vegetation, or vehicles).	
Move data older than 1 week into an archive folder and note location.	
Ensure data are backed up on external drive. Delete files older than 12 months from the instrument computer.	
Re-align instrument.	
Perform bump test.	
Check system performance indicators.	
Inspect and clean optics on detector.	
Verify system settings.	
Inspect air conditioner heat sinks and clean, if necessary.	
Inspect and clean AC system interior heat sink.	
Review and test light and signal levels.	
Check average light intensity to establish baseline for IR source.	
Change frequency and retroreflector wear.	
Replace cryocooler.	
Change out the IR source.	

Corrective Actions for FTIR:

CEREX FTIR Air Sentry Gas Test Summary

DATE: ________________________ Location: __________________________________

Test Technician 1:______________________________ 2:______________________________

Sentry Alignment

Signal Intensity (average) ___________________________

Signal Intensity at 966 cm^{-1} ___________________________

Blocked Beam Intensity at 966 cm^{-1} _________________________

% Stray Light ___________________________

Gas Purge System

Flow purge Start Time __________________________

Prepare CMS

Path length in the CMS Configuration _________________________ m

Configure Test Files

Site File (i.e., QA Bump Test UV# YearMoDy)____

Baseline Check _______________________ init

Reference Gas

Concentration ______________________ ppm

Source ____

Date ____

NOTES:

Gas Test Summary – CEREX FTIR - Page 2

Purge Flow Conditions

Start Time ______________________

NOTES:

Check Gas Test

Initial Gas Flow ______________________ L/min

Start Time ______________________

Collect Check Gas Data Start Time ______________________

Data Record:

TIME	PPM	R^2

Verify Client ______________________ Init

Stop Time ______________________ Init

Open the PURGE Gas Time ______________________

Reference Concentration __________ ppm

Average Concentration __________ ppm

% Error __________ %

% Spectral Match __________ %

Standard Deviation __________ ppm

Estimated MDL (3 × Standard Dev) __________
ppm

Restore Normal Operation

Restore running data file ______________________ Init

Press **RUN** to begin monitoring ______________________ Init

Standard Operating Procedure for Campbell Visibility Sensor (CS 120A)

October 31, 2024

STI-7504

APPROVED:

Sonoma Technology date

Fenceline Monitoring Refinery Representative date

Contents

1. Scope and Applicability

This standard operating procedure (SOP) provides instructions for servicing the Campbell visibility sensors used in fenceline monitoring applications. The procedures here cover routine maintenance and calibration of the Campbell CS120A visibility sensor.

2. Routine Service and Maintenance

Routine service tasks are designed to maintain the visibility sensor in good working condition. This is intended to lower the frequency of non-routine maintenance. The routine service tasks are described below. The site should be serviced once every four weeks. If no problems are encountered, the site visit will take less than one hour.

When maintenance is complete, the maintenance forms in Section 6 should be saved in the maintenance folder for the project located on Sonoma Technology's shared drive. Data will be flagged in a manner consistent with the QAPP if there are issues that cannot be immediately corrected. In the case of extended down time, the sensor should be replaced with a working sensor.

2.1 Maintenance Checklist

Table 1 depicts the maintenance activities that must be performed during each site visit to ensure all instruments are performing correctly.

Table 1. Routine quarterly maintenance checklist.

Action
Visually inspect the system, including all cables. Ensure they are not fraying.
Inspect optics on detector and clean if necessary.
Check calibration. An acceptable % error is less than 25%

[a] Lowering the meteorological tower is not necessary for routine site maintenance visits. Do not attempt to lower the tower with fewer than two people.

After physically inspecting the meteorological sensors, the technician should take note of the current visibility reading from the instrument and confirm that it matches current atmospheric conditions. Visibility data from the National Weather Service can be used to aid in this task.

2.2 Securing the Shelter

Turn off the computer's display monitor, and record your completion time in the Site Log form. Turn off the shelter lights and lock the shelter.

3. Calibration and Standard Operating Procedures for Meteorological Sensors

Annual audits will be conducted on meteorological instrumentation. The meteorological instrumentation calibrations will be conducted with reference to the recommendations in the EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems (QA Handbook), Volumes I, II, and IV* (U.S. Environmental Protection Agency, 2017, 1994, 2008) and in accordance with the *Technical Assistance Document for the National Air Toxics Trends Stations Program, Revision 3* (U.S. Environmental Protection Agency, 2016) and the *Technical Assistance Document for Sampling and Analysis of Ozone Precursors for the Photochemical Assessment Monitoring Stations Program*, Revision 2 (Battelle, 2018).

As part of the calibration process, each instrument will first be tested to determine whether it is operating within the prescribed operational limits and whether non-routine maintenance or adjustments are required. Based on an instrument's response to the initial performance test with respect to the minimum acceptable performance criteria (see data quality objectives in the QAPP), the instrument will then be repaired, calibrated, or in rare cases, replaced. A standard form will be used to document the performance of each sensor before and after any adjustments. A digital copy of this document is to be kept on the Sonoma Technology servers. Notes on what was performed are also to be recorded in the station logbook. The performance criteria for the visibility sensor is that the measured extinction coefficient must be within 25% of the reference value.

3.1 Visibility Sensor Testing and Calibration

3.1.1 Materials Needed

- Microfiber cloth
- Calibration bungs
- Calibration disk
- Micro-USB to USB-A cable

3.1.2 Startup Checklist

Verify that the following actions are completed when starting up the Campbell Visibility Sensor:

_____ Verify that serial connections (transmit [TX] and receive [RX]) to the datalogger are correct (sensor TX to logger RX, sensor RX to logger TX, and sensor ground to any ground terminal on the logger).

_____ Check datalogger to see if data are coming from the sensor.

_____ Check the data to make sure they make sense (visibility value is a reasonable number and the correct values are being recorded to the right parameters).

_____ Make sure the lenses are clean and clear of obstructions (spider webs, etc.).

_____ Use a microfiber cloth (you can use a blower first). Do not use abrasive cleaners; use isopropyl alcohol only if needed.

3.1.3 System Verification Procedure

The following tests will be performed as a verification of analyzer operation.

Testing and Calibration Prep

The sensor can be checked and adjusted using the optional sensor high-grade calibration kit Part Number 28678 from Campbell Scientific. The calibration must be performed using the onboard menu system. To access this menu via LoggerNet’s terminal emulation program, see the procedure in Section 4.

The test should ideally be performed under the following conditions:

- Ambient temperature between 0ºC and 50ºC.
- The local visibility is approximately 10,000 meters or more.

To perform the verification test, follow these steps:

1. Select Menu Item 4 on the main terminal screen. Once you have selected Menu Item 4, the following is an example of what should appear on the screen.

```
CS120A INFORMATION - MENU 4
 ID 0
 S/N 1234
 OS version: 007646v12
                                   Alarm   Value
- Last visibility reading:          -       65m
- Overall system status:            0       No faults
- Emitter dirty window alarm:       0       0%
- Emitter internal temperature:     0       27.4
- Detector dirty window alarm:      0       -4%
- Detector internal temperature:    0       23.2
- Detector DC light saturation:     0       -
- Hood heater temperature:          0       16.9
- CS120A Calibrator Serial No:       -       1192
- CS120A Calibrator EXCO:            -       48.4
- Calibration value factory offset: -       0.025
- Calibration value factory scale:  -       0.02630
- Calibration value cal offset:     -       0.090
- Calibration value cal scale:      -       0.02814
- Signature fault:                  0       -
- Flash write errors:               0       0
- Flash read errors:                0       0
- Supply voltage:                   <7.0V  12.0V
- Aux supply voltages:              +5V=4.9 -5V=--5.1 +6V=6.0
(8) Get debug
(9) Refresh
(0) Return to main menu
```

2. Make note of the extinction coefficient on the sensor calibrator. Once suitable local visibility conditions have been verified, install the sensor calibrator by fastening it to the central mounting point.

3. Allow 5-10 minutes for the measurements to stabilize.

4. Record the As Found system parameters, which can be found in Menu 4.

5. Enter 9 as needed to continue to refresh the data to see the last visibility reading.

6. Once the last visibility reading is consistent, take note of the new reading.

7. The conversion of the visibility reading to the extinction coefficient for comparison is 3,000 divided by the last reading.

8. Calculate the percent error between this new value and the extinction coefficient. The percent error should be equal to or less than the %Error specified in the QAPP.

9. If the precent error is greater than specified in the QAPP, attempt cleaning the lenses. If the percent error is still greater than the value specified in the QAPP, proceed with calibration.

3.1.4 System Calibration Procedure

1. To perform the calibration, select Menu Item 3 on the main terminal screen. Once you have selected Menu Item 3, the following screen should appear.

```
CS125 CALIBRATION - MENU 3
ID 0
S/N 1006
(1) Perform calibration
(2) Restore the factory calibration
(3) Perform dirty windows zero offset calibration
(4) Restore dirty windows factory calibration

(9) Refresh
(0) Return to main menu
```

2. Select Option 1 to start the calibration.

3. Confirm that a calibration is to be performed. Please note that once “Yes” is entered, exiting the program is not possible until the test is complete. However, power cycling the unit at this point will have no adverse effect on the sensor.

4. Once the test has started, the program will ask for the sensor calibrator serial number and coefficient, with a confirmation at each step giving the opportunity to correct typing mistakes.

```
Starting calibration.
Input the sensor calibrator serial number ->E2002
Is E2002 correct? (Y/N)?
Input the sensor calibrator constant ->28.8
Is 28.8 correct? (Y/N)?
```

5. Start the dark level calibration by placing one calibration bung into each hood, and then pressing any key.

   Once calibrator information has been entered, the sensor will hold until the foam bungs are placed into the sensor hoods. The bungs are designed to block all light from the outside from reaching inside the head. Place one bung into each hood. If either of the bungs are damaged or appear to have any gaps around the edges, contact Campbell Scientific.

```
Starting dark level calibration.
This test will take approximately two minutes
```

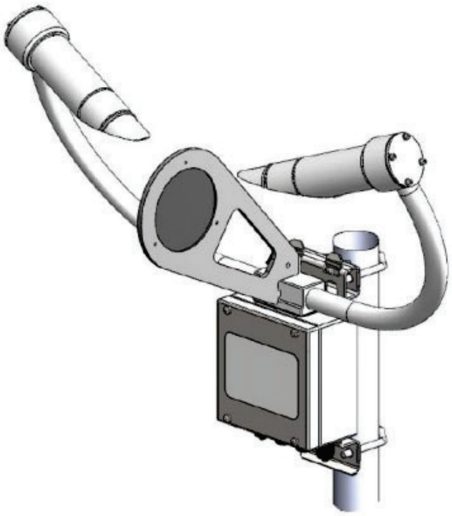
This part of the test will take approximately two minutes. Every ten seconds, a dot should appear indicating that the test is progressing as normal.

```
Dark level test complete. Please remove the bungs.
Now place the sensor calibrator into the sampling
volume.
Press any key once this is done.
```

6. Remove the bungs once the sensor instructs for this to be done.

Light Level Calibration

7. Place the sensor calibrator into the volume by fastening it to the central mounting point. Press any key.



```
Starting light level calibration.
This test will take approximately two minutes.
```

This part of the test will take approximately two minutes. Every ten seconds, a dot should appear indicating that the test is progressing as normal.

```
Calibration is now complete.
Saving user settings
Press any key to exit.
```

Once the second stage of the test has been completed, the new calibration constants will be saved automatically. Exit the menu by pressing any key. All calibration constants, including both the user and the factory settings, can be viewed from Menu Item 4 from the main menu once the test is completed.

8. Document the new user calibration constant and the factory setting each time a calibration is done.

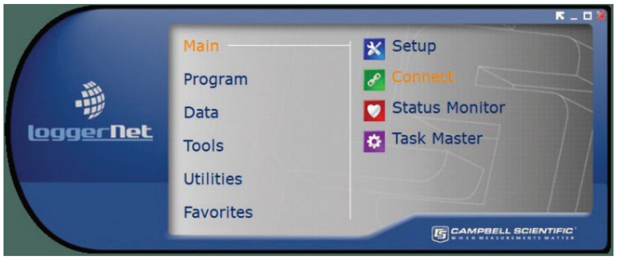
9. REMEMBER to remove the calibration disk once finished.

4. Campbell Terminal Emulator Connection Procedure

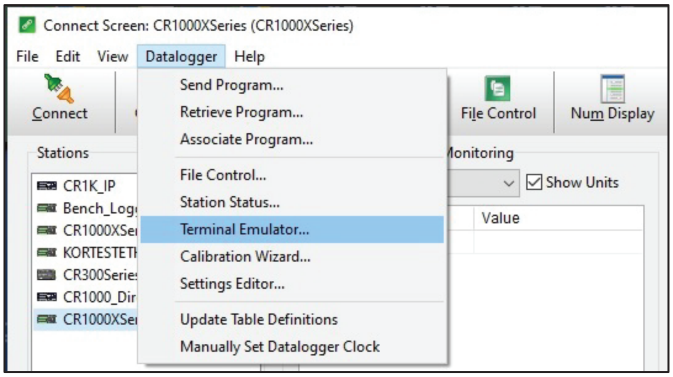
The following is a procedure to access the real-time visibility sensor data using a Campbell Scientific Data Logger through a LoggerNet Terminal Emulator.

1. Connect a laptop to the Campbell Scientific Data Logger with a USB cable, RS232 cable, or via ethernet cable and IP address.

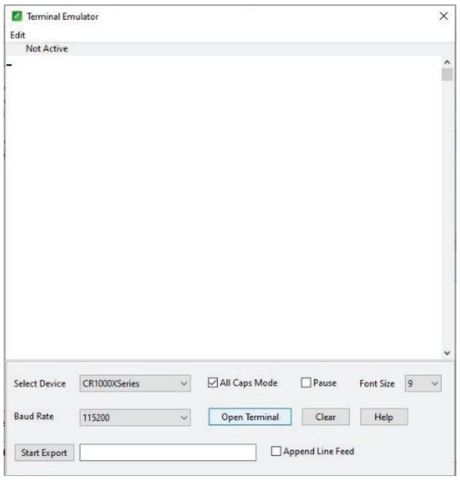
2. From the LoggerNet application, open the “Connect Screen” through “Main” and “Connect” options.



3. Select the “Datalogger” tab at the top right of the “Connect Screen.” Then select “Terminal Emulator…” from the drop down menu.

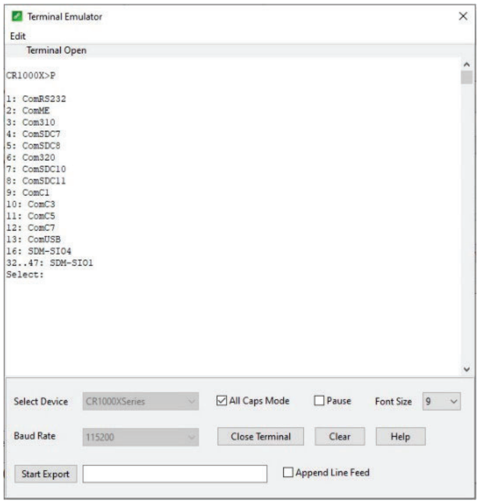


4. A blank window will display, but the terminal emulator is not open yet. To open the connection to the terminal emulator, select "Open Terminal" at the bottom of the Terminal Emulator window.



5. When the terminal is open, the button that previously said "Open Terminal" will change to "Close Terminal." Press enter until "CR1000X>_" appears in the terminal.

6. Type the capital letter "P" to display the comport options.



```
CR1000X>P

1: ComRS232
2: ComME
3: Com310
4: ComSDC7
5: ComSDC8
6: Com320
7: ComSDC10
8: ComSDC11
9: ComC1
10: ComC3
11: ComC5
12: ComC7
13: ComUSB
16: SDM-SIO4
32..47: SDM-SIO1
Select:
```

7. Look at the lowest terminal bar on the data logger and identify which terminal port has a blue wire to the left of a white wire. The terminal port that the blue wire is connected to corresponds to the comport that needs to be selected. For example, the "C1" terminal port corresponds to the option "9: comC1." Type the list number after "Select:_" that corresponds to the correct comport and press enter.

8. If the correct comport is selected, "opening [comport number]; press ESC ESC ESC ESC to close" will display and will sometimes be followed by an array of numbers. Now type "open

0” and press enter. Note that oftentimes the curser or the text will not be visible during this step. Also, frequently, the first attempt will not work. Allow time for the command to process. Typically, additional rows of array numbers will display after failed attempts are finished processing. Continue to enter “open 0” until the following setup menu displays.

```
WELCOME TO THE CAMPBELL SCIENTIFIC LTD CS120A SETUP MENU
 ID 0
 S/N 1234
 (1) Message output menu
 (2) User alarm menu
 (3) Calibrate CS120A
 (4) System information
 (5) Communications setup
 (6) System Configuration
 (9) Exit and save
 (0) Exit and don't save
  ->
```

9. Enter “4” for “System information” and the real-time data from the visibility sensor will display.

10. Enter “9” as needed to continue to display the most current data.

11. To exit the terminal emulator session, enter 0 to exit the information menu and return to the main menu.

12. Enter 0 again to exit and not save.

13. Press Esc four times to close.

14. Select “Close Terminal” to close the terminal

15. Close the terminal emulator window.

16. LoggerNet can be closed and the laptop can be disconnected from the logger.

17. Note: opening the terminal emulator will halt data transfer from the data logger. To re-establish data transfer, reset the data logger by disconnecting the power source, wait 10 seconds, and plug the power source back into the data logger.

18. Confirm data flow has been re-established.

5. References

Battelle (2018) Technical assistance document for sampling and analysis of ozone precursors for the Photochemical Assessment Monitoring Stations program, Revision 2. Revised draft prepared for the U.S. Environmental Protection Agency, Research Triangle Park, NC, by Battelle, Columbus, OH, March.

U.S. Environmental Protection Agency (1994) Quality assurance handbook for air pollution measurement systems, Volume I: a field guide to environmental quality assurance. Report prepared by the U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA/600/R-94/038a. Available at **https://www3.epa.gov/ttn/amtic/qalist.html**.

U.S. Environmental Protection Agency (2008) Quality assurance handbook for air pollution measurement systems, Volume IV: meteorological measurements version 2.0 (final). Prepared by the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Air Quality Assessment Division, Research Triangle Park, NC, EPA-454/B-08-002, March. Available at **https://www3.epa.gov/ttn/amtic/qalist.html**.

U.S. Environmental Protection Agency (2016) Technical assistance document for the National Air Toxics Trends Stations Program, Revision 3. Prepared for the Office of Air Quality Planning and Standards, Research Triangle Park, NC, by Battelle, Columbus, OH, October. Available at **https://www3.epa.gov/ttnamti1/files/ambient/airtox/NATTS%20TAD%20Revision%203_FINAL%20October%202016.pdf**.

U.S. Environmental Protection Agency (2017) Quality assurance handbook for air pollution measurement systems, Volume II: ambient air quality monitoring program. Prepared by the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Air Quality Assessment Division, Research Triangle Park, NC, EPA-454/B-17-001, January. Available at **https://www3.epa.gov/ttnamti1/qalist.html**.

6. Campbell Visibility Sensor Audit Record Example

Visibility
As Found

Site Name:	Field Site Name	**Date:**	January 1, 2024
Site Latitude:	12.345678 N	**Technician:**	Tech Name
Site Longitude:	-123.456789 W	**Reference Make:**	Campbell Scientific
Sensor Make:	Campbell Scientific	**Reference Model:**	CS125
Sensor Model:	CS120A	**Reference Serial No:**	E21192
Sensor Serial No:	E1234	**Reference Cal Date:**	N/A

	Reference	**Site Sensor**	**Error (%)**	**PASS/FAIL**
Extinction Coefficient (km^{-1})	48.4	50.0	3.3	PASS
Visibility (m)		60.0000		

Overall system status:	No faults	Calibration value factory offset:	-0.041
Emitter dirty window alarm:	-1%	Calibration value factory scale:	0.02619
Emitter internal temperature:	30.8	Calibration value cal offset:	0.064
Detector dirty window alarm:	0%	Calibration value cal scale:	0.029
Detector internal temperature:	25.7		
Hood heater temperature:	20.9		

Notes:

Sensor found to be within specification.
Will clean sensor lenses with alcohol wipes, lint-less lens tissue, and a blast of compressed air.

Visibility
As Left

	Reference	Site Sensor	Error (%)	PASS/FAIL
Extinction Coefficient (km^{-1})	48.4	52.6	8.7	PASS
Visibility (mi)		57.0000		

Overall system status:	No faults
Emitter dirty window alarm:	-1%
Emitter internal temperature:	31.2
Detector dirty window alarm:	-1%
Detector internal temperature:	26.1
Hood heater temperature:	21.2

Calibration value factory offset:	-0.041
Calibration value factory scale:	0.02619
Calibration value cal offset:	0.064
Calibration value cal scale:	0.029

Notes:

Sensor left within specification

STi Sonoma Technology

Standard Operating Procedure for Synspec GC955 Hydrocarbon Analyzer

October 31, 2024

STI-7984

APPROVED:

Sonoma Technology date

Fenceline Monitoring Refinery Representative date

Contents

1. Scope and Application

This appendix refers to the use of the Synspec GC955 analyzer for the continuous measurement of volatile organic compounds (VOCs) at community air monitoring stations. It includes procedures on the operation, quality checking, and calibration of the unit. Maintenance forms can be found in Section 9.

2. Summary of Method

An automatic gas chromatograph (AutoGC) collects air samples via vacuum pump (ambient) or pressurized source (span/calibration) and separates compounds according to their retention time in an internal separation column. Following separation, compounds are measured with a photoionization detector (PID). This combination of separation and detection allows for identification and quantification of a range of VOCs. **Figure 1** from the GC955 manual shows the unit configuration.

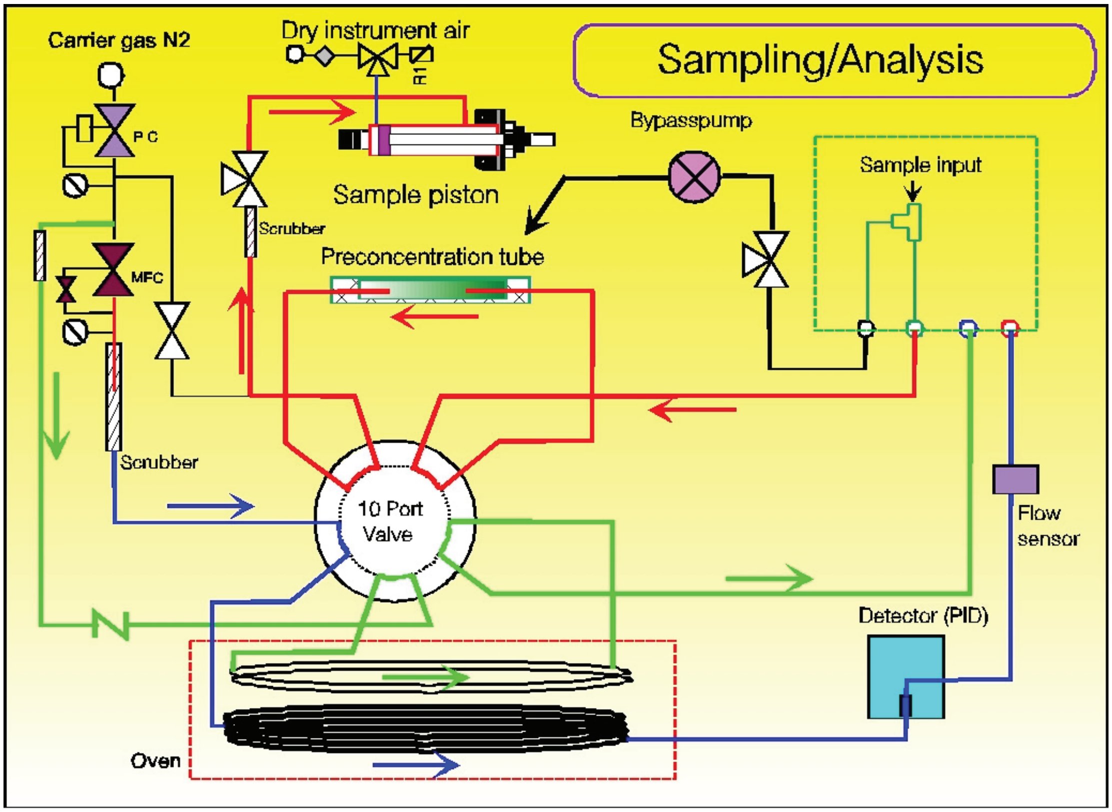


Figure 1. Instrument configuration in analyzing/sampling mode from the GC955 manual.

The major processes in getting from a sample to a concentration value are described in Section 3 of the GC955 manual. They include:

- **Sampling**: collecting a sample of ambient air.
- **Pre-concentration**: accumulating enough samples for analysis.
- **Desorption and Stripping**: moving sample from the pre-concentrator into the separation column.
- **Separation**: separating compounds based on their interaction with the separation column.
- **Detection**: measuring separated compounds with a PID to allow identification and quantification.

3. Definitions

Abbreviation	Meaning
AC	Alternating current
BAM	Beta attenuation monitor
BC	Black carbon
C14	Carbon 14
CFR	Code of Federal Regulations
CO_2	Carbon dioxide
CPU	Central processing unit
CV	Coefficient of variance
DAS	Data acquisition system
DOT	Department of Transportation
DQO	Data quality objective
DRV	Documented reference value
EC	Elemental carbon
FEM	Federal equivalent method
GC	Gas chromatograph
H_2O	Water
H_2S	Hydrogen sulfide
IO	Input/output
IR	Infrared

Abbreviation	Meaning
IZS	Internal zero/span device
kV	Kilo volts
LPM	Liters per minute
MFC	Mass flow control/controller
MSDS	Material safety datasheet
N/A	Not applicable
NH_3	Ammonia
NH_3_CE_FACTOR1	The ammonia converter efficiency factor
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_2_CE_FACTOR1	Nitrogen oxide efficiency factor
NO_x	Oxides of nitrogen
O_2	Oxygen
PC	Personal computer
PID	Photoionization detector
PM	Particulate matter
PM_{10}	Particulate matter with aerodynamic diameter less than 10 um
$PM_{2.5}$	Particulate matter with aerodynamic diameter less than 2.5 um
ppb	Part per billion
ppm	Parts per million
psi	Pounds per square inch
QA	Quality assurance
QC	Quality control
QS	Quality standard
RH	Relative humidity
RS-232	Analyzer digital communication port
SO_2	Sulfur dioxide
SOP	Standard operating procedure

Abbreviation	Meaning
TM	Trademark
TNX	The sum of the ammonia and the oxides of nitrogen concentrations
UPS	Uninterrupted power supply
U.S. EPA	United States Environmental Protection Agency
UV	Ultraviolet
VAC	Volts alternating current
VSCC	Very sharp cut cyclone
Z/S	Zero/span

4. Health and Safety Warnings

The following is a summary of risks and qualifications relevant to analyzer operations. See the GC955 manual for additional information.

- Compressed gas at pressures from 0.5 to 5 bar will be connected to the analyzer. Personnel must be qualified to work safely with pressurized systems.
- The analyzer contains a high-voltage power supply in a protective housing. Personnel must be qualified to work safely with high-voltage power supplies.
- The pre-concentrator operates at temperatures of 100°C to 260°C. Personnel must be qualified to work safely with heated systems.

5. Interferences

Individual analyses can be affected by the peaks from other compounds in the gas mixture. These can be mitigated by the following actions.

- Ensuring peak breadth is as expected, following the recommendations of the instrument manufacturer.
- Performing monthly zero and span checks with a known concentration of reference gas (Section 7.5).
- Performing quarterly checks for analyzer linearity and precision (Section 7.5).

6. Equipment and Supplies

Monitoring Apparatus: GC955 with PID detector.

Instrument Shelter: A shelter is required to (1) protect the analyzer from precipitation and adverse weather conditions, (2) maintain operating temperature within analyzer specifications, (3) provide sufficient and consistent electrical power, and (4) securely operate the analyzer.

Spare Parts and Incidental Supplies: See Section 6 in the GC955 manual for a list of recommended spare parts.

Calibration System: A system that generates known concentrations of high-quality reference gas is required for monthly and quarterly services (Section 7.5).

DAS: A data acquisition system (DAS) is required for collection, telemetry, and storage of data from the GC955.

7. Sampling Procedures

7.1 Sample Collection

Sample collection for hydrocarbons is performed by drawing ambient air through a sample manifold into the analyzer using a vacuum pump. The inlet is constructed of Teflon^{TM} and borosilicate glass. The siting of the community monitoring station containing the GC955 was completed according to the U.S. EPA Quality Assurance Handbook Volume II.

7.2 Sample Handling and Preservation

The sample is pre-concentrated in the analyzer before being desorbed, delivered into the separation column, and sent to the PID. Nitrogen is used as a carrier gas.

7.3 Sample Preparation and Analysis

This section does not apply to the Synspec GC955 analyzer.

7.4 Instrument Startup/Shutdown, Operation and Maintenance

This section describes the operation and maintenance of the GC955. The operator of the instrument should be familiar with the GC955 manual before attempting to operate the unit.

7.4.1 Sample Collection

The following are excerpts from Sections 2 and 4 of the GC955 manual. See the GC955 manual for additional information.

1. The instrument can be switched on once the gases are connected and the filter is in place. The AutoGC must be connected to a mouse and a keyboard, the oven cover must be closed, and the L-shaped cover must be put on.

2. After starting the GC, the Windows system starts and the GC955 graphical user interface (GUI) appears. A self-test is performed on electronics and the PID lamp, and the oven is heated to the base temperature of the default application program. The PID lamp is subsequently turned on.

3. Carrier gas flows through the capillary and packed columns at programed flow rates maintained by mass flow controller(s). Checking for leaks or obstructions is advised after long transports or after working without adequate filters.

4. A pressure sensor monitors the switching of the internal diaphragm valve.

5. The program contains seven different functions: actual run, data file, program edit, calibration, graphs, auto-linearization, and IO-state diaphragm. See Section 3 of the GC955 manual for additional information.

6. The default mode is actual run. After an automatic check of the settings, the program is on standby to run. The oven must reach the desired starting temperature before the first cycle can be started by clicking **Start run**. Once the background zero adjust signal is set, the program begins. The detector needs to stabilize, which can cause the first reset to take longer. In automatic mode, the analyzer will either start immediately or once synchronization is reached. The measured values can be seen on the chromatogram. You can find clock time, cycle time, measured value for the detectors, ambient temperature, and oven temperature in the status lines below the chromatogram. Additional diagnostics include pressure of valve switching air and flow of carrier gas. Note that the ambient temperature is measured on the underside of the instrument. The baseline is normally set about 10 mm above the edge of the chromatogram window, but can be changed under **Actual run\Options\Adjust detector Y-offset** as needed.

7.4.2 Shutdown

There are three ways to shut down the analyzer.

1. The preferred method is to click **Stop Run**, which stops the program at the end of the present run.

2. If the program must be stopped between runs, click **Abort Run**. The program will stop immediately and the analyzer can be powered off. The next run of the GC may be contaminated by the aborted run.

3. Although not recommended, in the case of an emergency, the analyzer can be powered off without stopping the instrument software. The last run will not be saved and the analyzer has no way of saving open files.

7.4.3 Diagnostic Checks/Manual Checks

Field operators will perform diagnostic checks to ensure analyzer operation. **Table 1** is an excerpt of checks from the GC955 manual.

Table 1. An excerpt of checks from the GC955 manual.

No.	Action	Dialog to Use	Optional
1	Switch on power.	--	--
2	Complete first run by clicking **Start Run.**	ViewMode \ actual run	Check temperatures, PID lamp functioning, attenuation.
3	Check peak windows.	ViewMode \ data file \ edit screen elements and edit peak windows	Wait for second run after start to get actual chromatogram.
4	Stop program.	ViewMode \ actual run – stop run	Click **Abort run** in emergencies. Close the GC955 program by clicking the left top pulldown menu.

7.4.4 Preventative Maintenance

Table 2 below summarizes the maintenance tasks for the unit.

Table 2. A schedule of maintenance tasks required for this instrument.

Activity	Quarterly	Annually	Two Years
Replace micro dust filter for sample	✓		
Remove dust from ventilator	✓	✓	
Clean the lamp		✓	
Clean the PID		✓	
Change the carrier gas filters		✓	
Clean the diaphragm		✓	

Activity	Quarterly	Annually	Two Years
Renew external sample tubing		✓	
Replace pre-concentration tenax tube		✓	
Replace cooled pre-concentration trap		✓	
Optimize hard disk		✓	
Clean internal gas tubing			✓
Clean lamp housing			✓

7.4.5 Troubleshooting

See Section 6.02 of the GC955 manual for the troubleshooting scheme.

7.5 Calibration and Standardization

Acceptance criteria for the GC955 are defined in Section A.7 of the QAPP.

If the measurements do not meet the data quality objectives listed in the QAPP, repeat the procedure without adjustment. If the repeated test also fails, initiate corrective action to include the following:

- Review data for potential interferants, including a detailed check of chromatograms and retention times, noting any unexpected features
- Review gas testing apparatus for leaks or other similar problems
- Review and confirm specifications of standard calibration equipment and gases (expiration dates, concentrations, etc.)

In the event of a failed test after following all steps outlined above, inform the Sonoma Technology Project Manager and Quality Assurance Manager, who will review the instrument performance parameters in the list above.

If all parameters indicate that the instrument was performing properly since the last test, data collected since the last test will be flagged as suspect. If an issue with the instrument is identified, data collected since the date and time of the instrument issue will be flagged as invalid. All data flagging will be performed by Data Analysts in consultation with the Quality Assurance Manager.

7.5.1 Adjustment to Zero Air

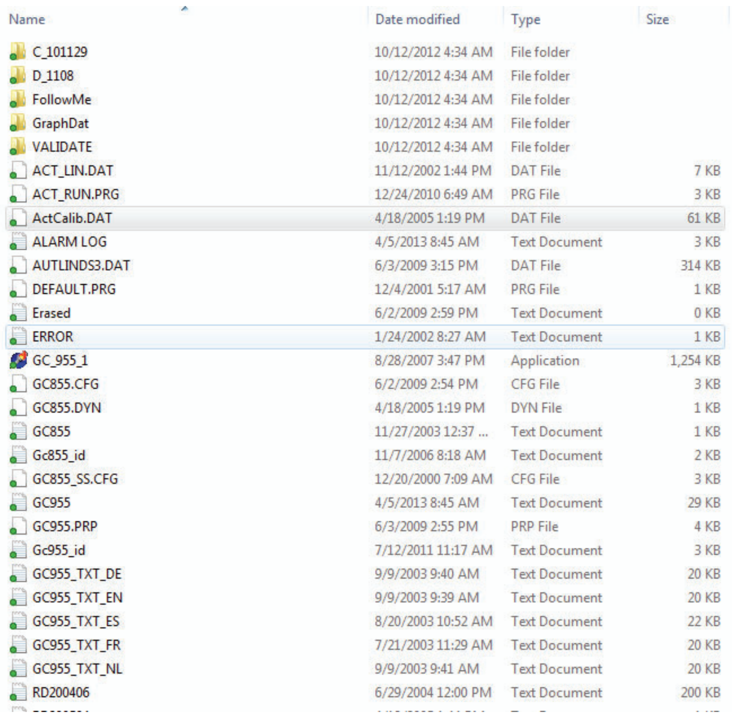
See Section 4 of the GC955 manual for additional information.

7.5.2 Adjustment to Calibration Gas

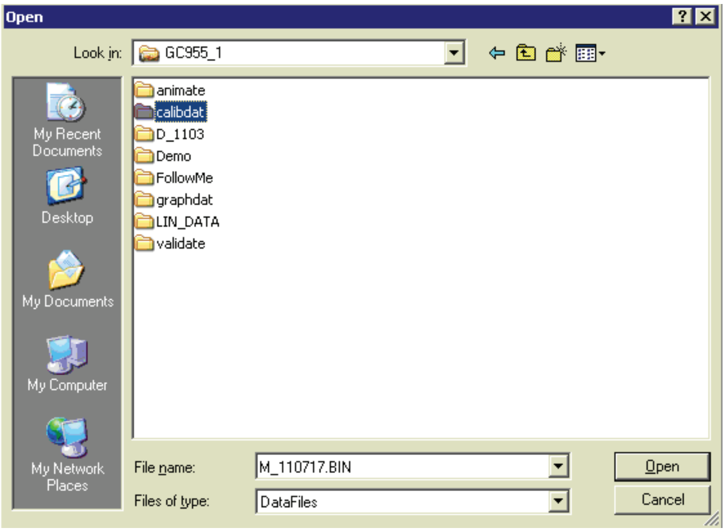
An overview of the calibration process is shown below. See Section 4.3 of the GC955 manual for additional information.

1. Go to the DAS and put it into Cal mode from the View screen.

2. Use explorer and copy actcalib.dat from the GC955 root directory into the last valid calibration file folder as shown below.



Name	Date modified	Type	Size
C_101129	10/12/2012 4:34 AM	File folder	
D_1108	10/12/2012 4:34 AM	File folder	
FollowMe	10/12/2012 4:34 AM	File folder	
GraphDat	10/12/2012 4:34 AM	File folder	
VALIDATE	10/12/2012 4:34 AM	File folder	
ACT_LIN.DAT	11/12/2002 1:44 PM	DAT File	7 KB
ACT_RUN.PRG	12/24/2010 6:49 AM	PRG File	3 KB
ActCalib.DAT	4/18/2005 1:19 PM	DAT File	61 KB
ALARM LOG	4/5/2013 8:45 AM	Text Document	3 KB
AUTLINDS3.DAT	6/3/2009 3:15 PM	DAT File	314 KB
DEFAULT.PRG	12/4/2001 5:17 AM	PRG File	1 KB
Erased	6/2/2009 2:59 PM	Text Document	0 KB
ERROR	1/24/2002 8:27 AM	Text Document	1 KB
GC_955_1	8/28/2007 3:47 PM	Application	1,254 KB
GC855.CFG	6/2/2009 2:54 PM	CFG File	3 KB
GC855.DYN	4/18/2005 1:19 PM	DYN File	1 KB
GC855	11/27/2003 12:37 ...	Text Document	1 KB
Gc855_id	11/7/2006 8:18 AM	Text Document	2 KB
GC855_SS.CFG	12/20/2000 7:09 AM	CFG File	3 KB
GC955	4/5/2013 8:45 AM	Text Document	29 KB
GC955.PRP	6/3/2009 2:55 PM	PRP File	4 KB
Gc955_id	7/12/2011 11:17 AM	Text Document	3 KB
GC955_TXT_DE	9/9/2003 9:40 AM	Text Document	20 KB
GC955_TXT_EN	9/9/2003 9:39 AM	Text Document	20 KB
GC955_TXT_ES	8/20/2003 10:52 AM	Text Document	22 KB
GC955_TXT_FR	7/21/2003 11:29 AM	Text Document	20 KB
GC955_TXT_NL	9/9/2003 9:41 AM	Text Document	20 KB
RD200406	6/29/2004 12:00 PM	Text Document	200 KB



Open

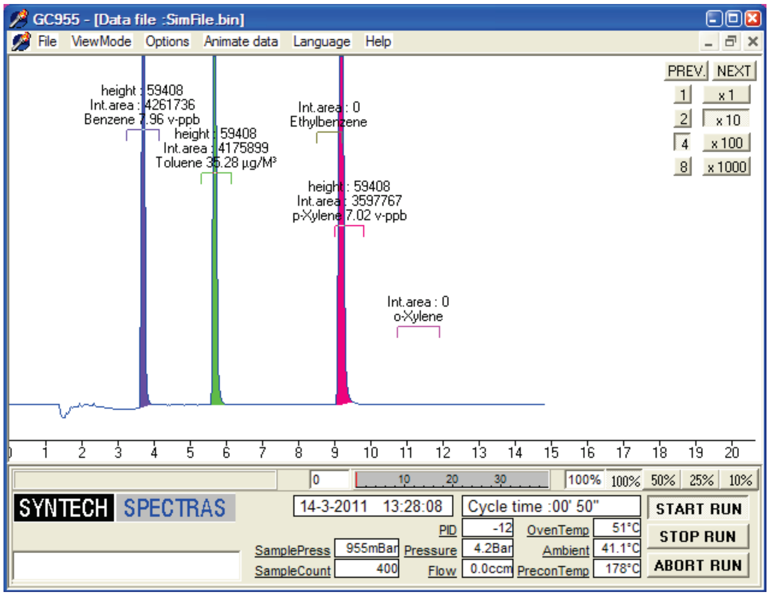
Look in: GC955_1

animate
calibdat
D_1103
Demo
FollowMe
graphdat
LIN_DATA
validate

File name: M_110717.BIN

Files of type: DataFiles

3. On the GC955, go to **ViewMode** and select **Act Run PID**.



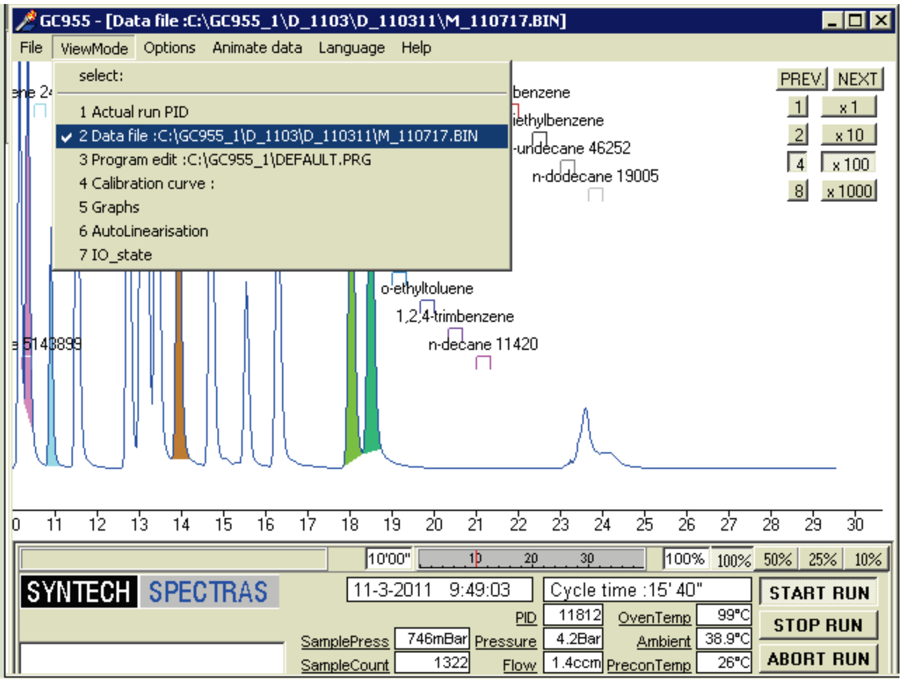
14-3-2011 13:28:08
Cycle time :00' 50"
PID -12
OvenTemp 51°C
SamplePress 955mBar
Pressure 4.2Bar
Ambient 41.1°C
SampleCount 400
Flow 0.0ccm
PreconTemp 178°C

4. Connect the span gas to the span port on switchbox. Purge gas at the analyzer inlet so that calibration gas is available for measurement.

5. Under **Options**, click on **Open validation gas valve**.

6. Let the unit run for four to five samples and observe peaks.

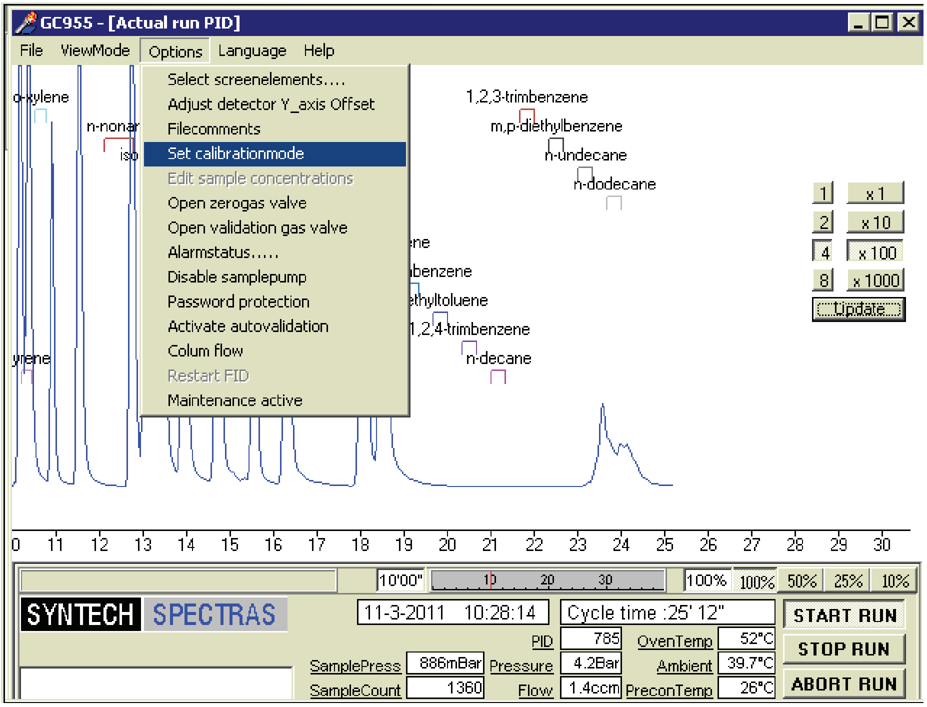
7. Go to the ViewMode data file and open recent files. Adjust the peak windows if necessary.



11-3-2011 9:49:03
Cycle time :15' 40"
PID 11812
OvenTemp 99°C
SamplePress 746mBar
Pressure 4.2Bar
Ambient 38.9°C
SampleCount 1322
Flow 1.4ccm
PreconTemp 26°C

8. Go to **ViewMode act run PID** and put the unit into calibration mode – have gas flowing to the span valve inlet on the switch box.

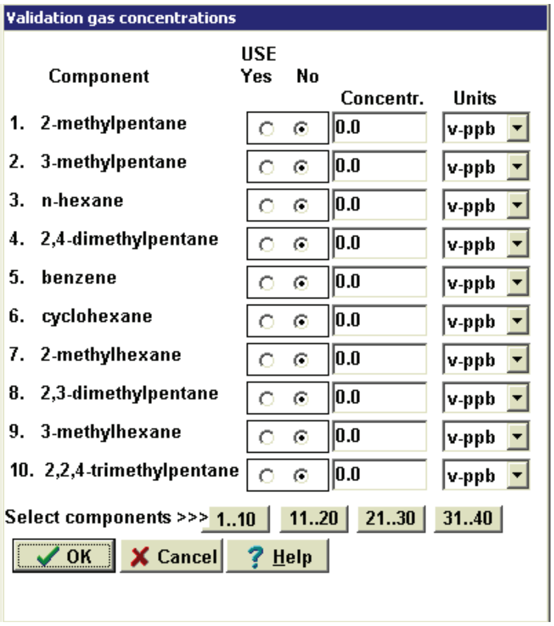
9. Select **Start New Calibration**.



11-3-2011 10:28:14
Cycle time :25' 12"
PID 785
OvenTemp 52°C
SamplePress 886mBar
Pressure 4.2Bar
Ambient 39.7°C
SampleCount 1360
Flow 1.4ccm
PreconTemp 26°C

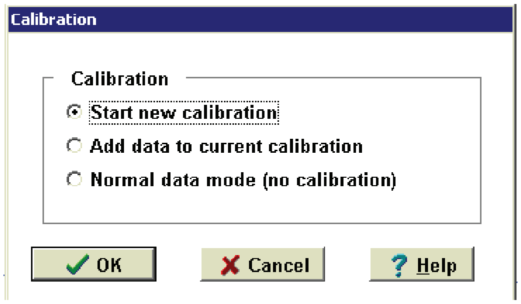
10. Enter in known reference concentration values.
    a. Recall that m- and p-xylene co-elute, so those two values should be added together.

11. Click the **USE – Yes** radio buttons as appropriate.



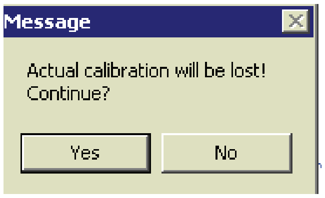
Validation gas concentrations

Component	USE Yes	USE No	Concentr.	Units
1. 2-methylpentane	○	●	0.0	v-ppb
2. 3-methylpentane	○	●	0.0	v-ppb
3. n-hexane	○	●	0.0	v-ppb
4. 2,4-dimethylpentane	○	●	0.0	v-ppb
5. benzene	○	●	0.0	v-ppb
6. cyclohexane	○	●	0.0	v-ppb
7. 2-methylhexane	○	●	0.0	v-ppb
8. 2,3-dimethylpentane	○	●	0.0	v-ppb
9. 3-methylhexane	○	●	0.0	v-ppb
10. 2,2,4-trimethylpentane	○	●	0.0	v-ppb



Calibration

Calibration
● Start new calibration
○ Add data to current calibration
○ Normal data mode (no calibration)



Message

Actual calibration will be lost!
Continue?

Make sure you have the ACTCALIB.DAT backed up per instructions above.

12. Let the system run until it has generated two files or until data is stable.

13. Go to **ViewMode calibration mode**.

14. Go to **Data selection calibration files**.

15. Choose the component to calibrate.

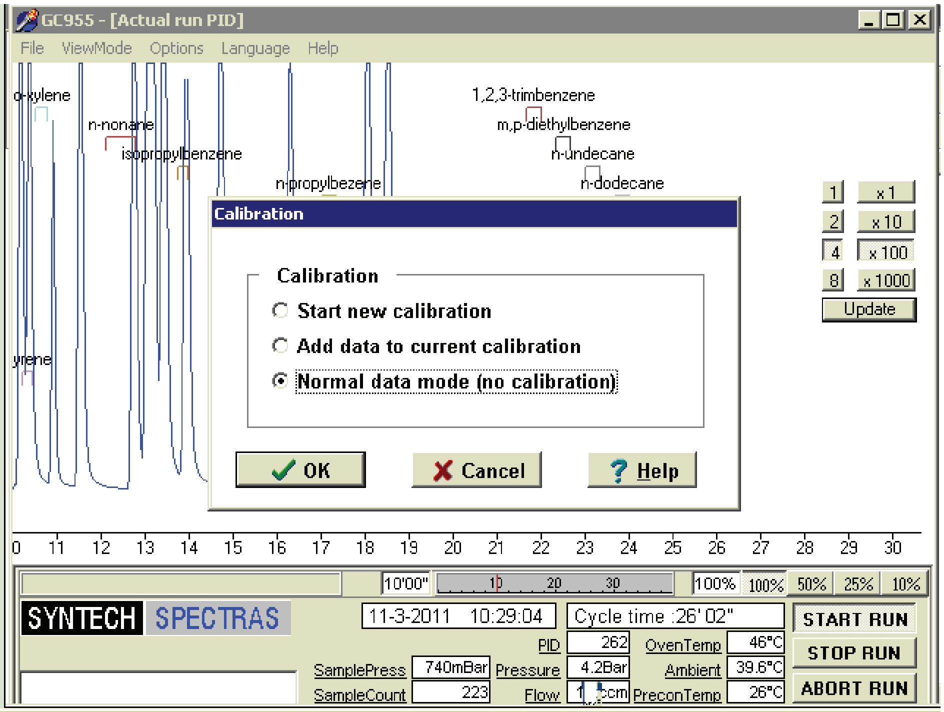
16. Select data files from the calibdat folder (YR/month/day) of data files collected – add to the display.

17. Select **Calculate calibration line** – select linear regression with fixed basepoint.

18. Calculate the calibration line.

19. Repeat for all parameters.

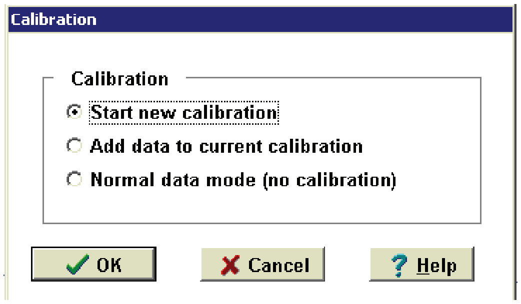
20. Let the DAS stay in calibration flag mode for 30 mins after the system finishes collecting calibration data so that the data are flagged in DAS.



Calibration

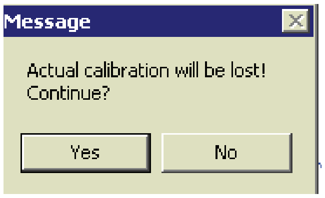
Calibration
○ Start new calibration
○ Add data to current calibration
● Normal data mode (no calibration)

10'00"
100%
11-3-2011 10:29:04
Cycle time :26' 02"
PID 262
OvenTemp 46°C
SamplePress 740mBar
Pressure 4.2Bar
Ambient 39.6°C
SampleCount 223
Flow 1[illegible]ccm
PreconTemp 26°C



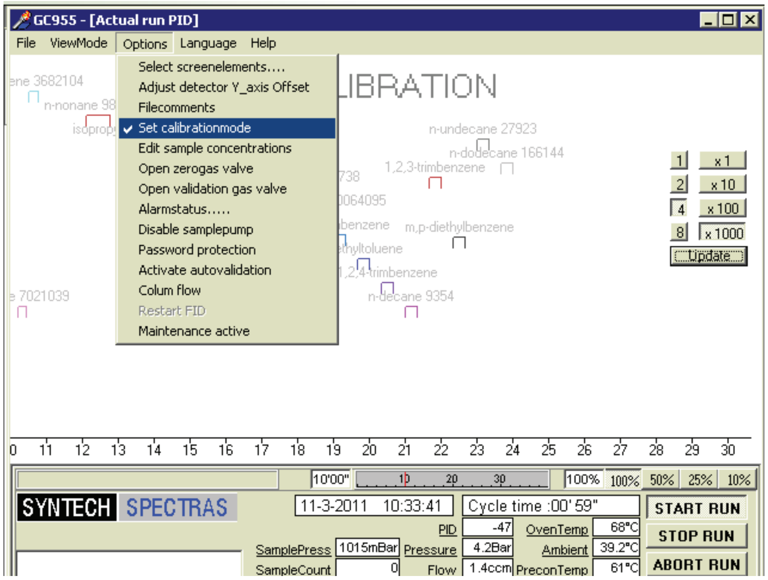
Calibration

Calibration
● Start new calibration
○ Add data to current calibration
○ Normal data mode (no calibration)



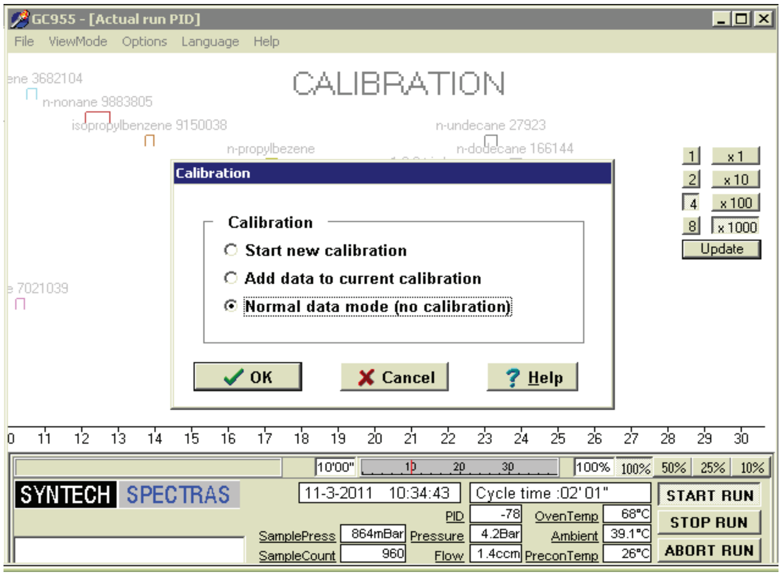
Message

Actual calibration will be lost!
Continue?



GC955 - [Actual run PID]

11-3-2011 10:33:41
Cycle time :00' 59"
PID -47
OvenTemp 68°C
SamplePress 1015mBar
Pressure 4.2Bar
Ambient 39.2°C
SampleCount 0
Flow 1.4ccm
PreconTemp 61°C



GC955 - [Actual run PID]

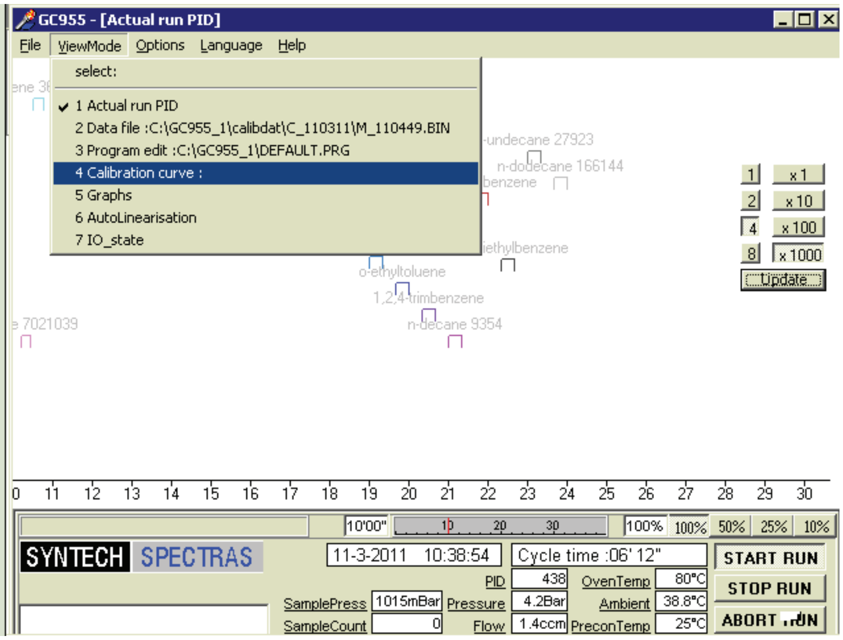
Calibration

Calibration
○ Start new calibration
○ Add data to current calibration
● Normal data mode (no calibration)

11-3-2011 10:34:43
Cycle time :02' 01"
PID -78
OvenTemp 68°C
SamplePress 864mBar
Pressure 4.2Bar
Ambient 39.1°C
SampleCount 960
Flow 1.4ccm
PreconTemp 26°C

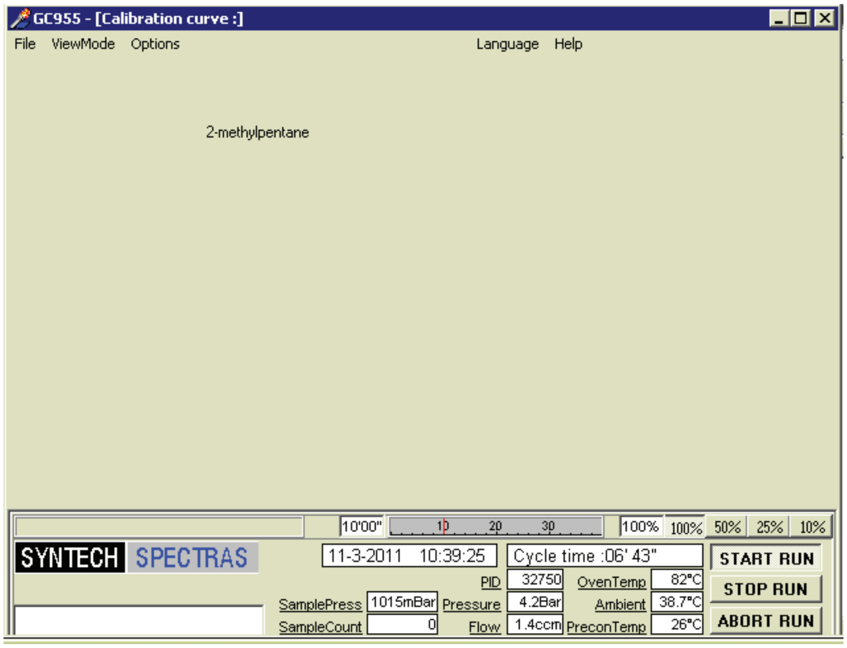
To construct a calibration curve:

1. Select **ViewMode** and then **Calibration curve**.



10'00"
11-3-2011 10:38:54
Cycle time :06' 12"
PID 438
OvenTemp 80°C
SamplePress 1015mBar
Pressure 4.2Bar
Ambient 38.8°C
SampleCount 0
Flow 1.4ccm
PreconTemp 25°C

2. You will see:

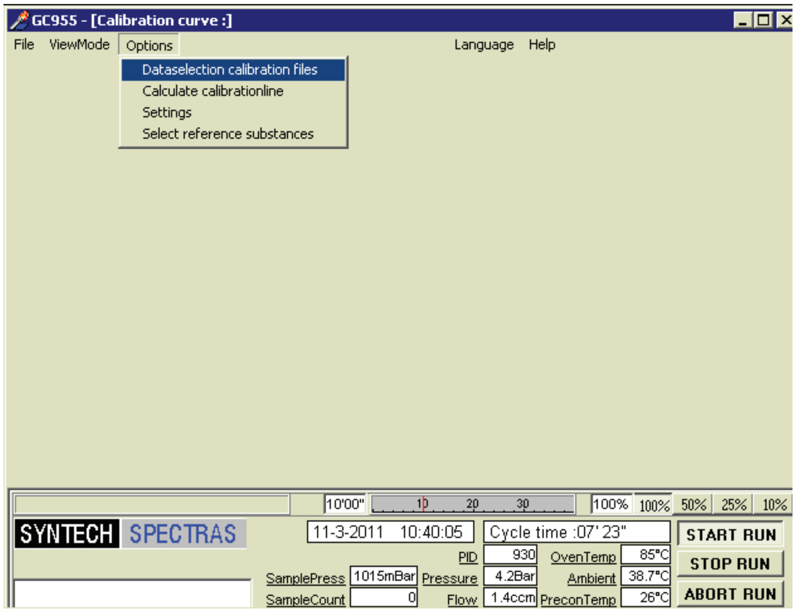


10'00"
11-3-2011 10:39:25
Cycle time :06' 43"
PID 32750
OvenTemp 82°C
SamplePress 1015mBar
Pressure 4.2Bar
Ambient 38.7°C
SampleCount 0
Flow 1.4ccm
PreconTemp 26°C

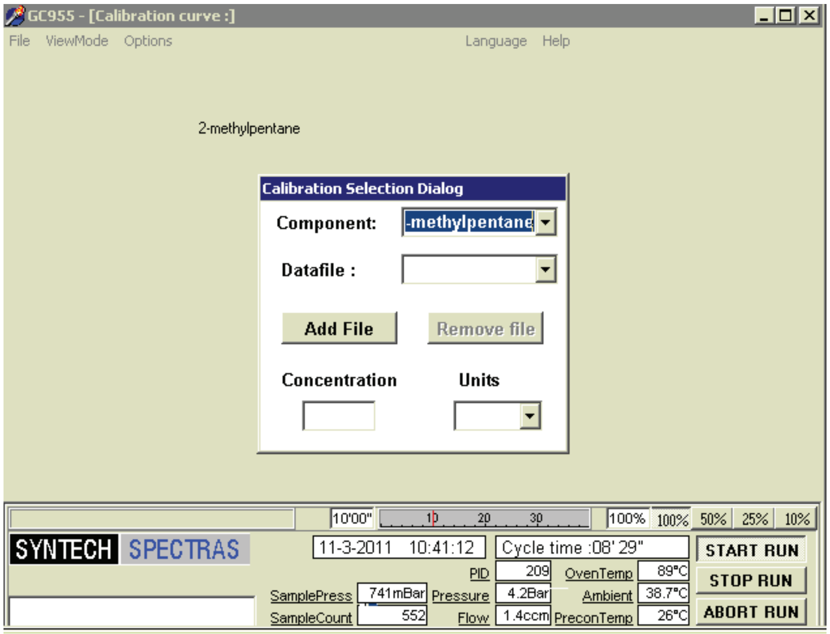
Click on:

- **Options**
- **Data selection calibration file**

3. You will see:



4. You will see:

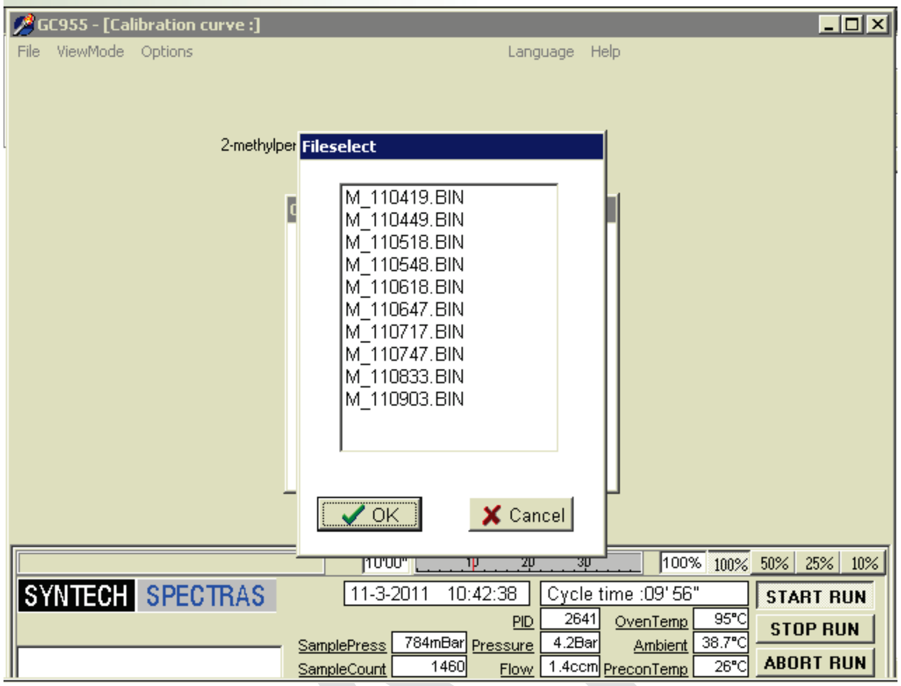


Component: -methylpentane
Datafile :
Concentration
Units

Click on:

- **Add File**

5. You will see:

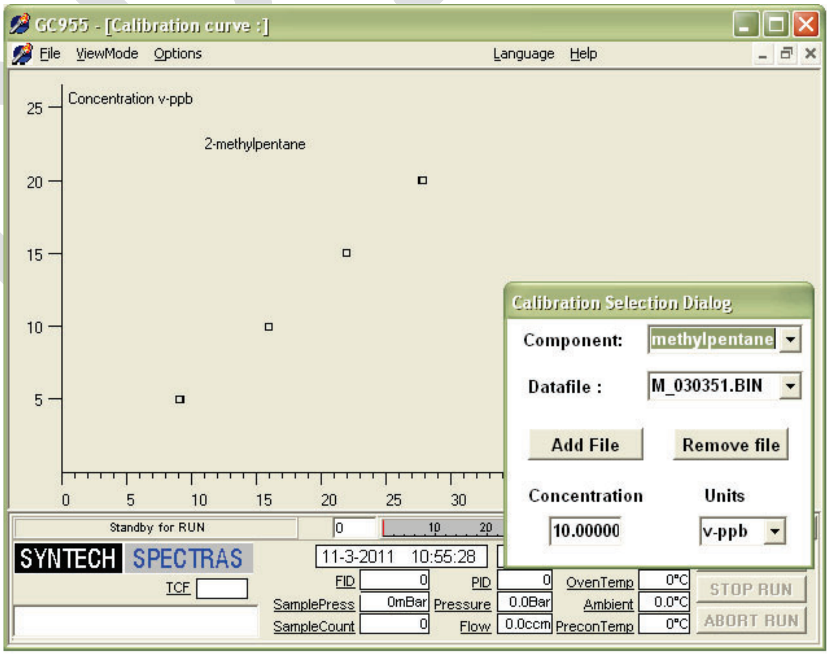


M_110419.BIN
M_110449.BIN
M_110518.BIN
M_110548.BIN
M_110618.BIN
M_110647.BIN
M_110717.BIN
M_110747.BIN
M_110833.BIN
M_110903.BIN

11-3-2011 10:42:38
Cycle time :09' 56"
PID 2641
OvenTemp 95°C
SamplePress 784mBar
Pressure 4.2Bar
Ambient 38.7°C
SampleCount 1460
Flow 1.4ccm
PreconTemp 26°C

6. You should select:

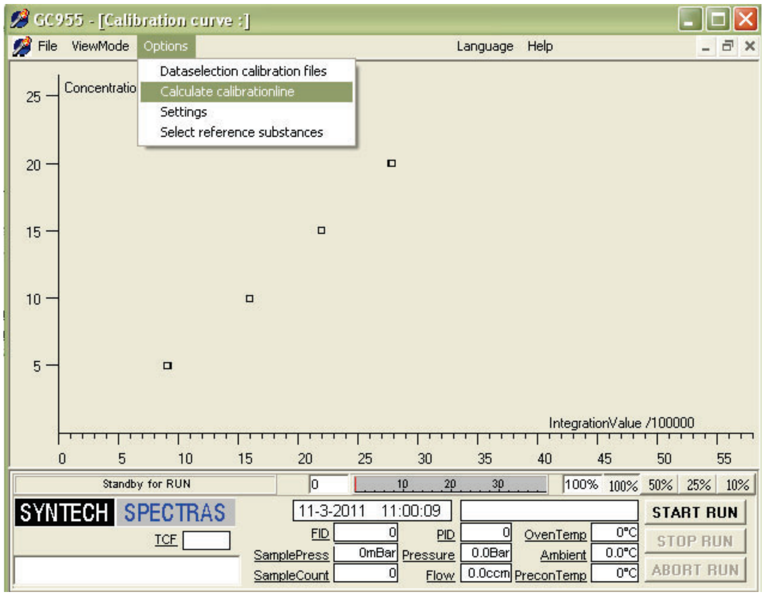
- **All Files**, in this case M_110419 to M_110903
- **OK**



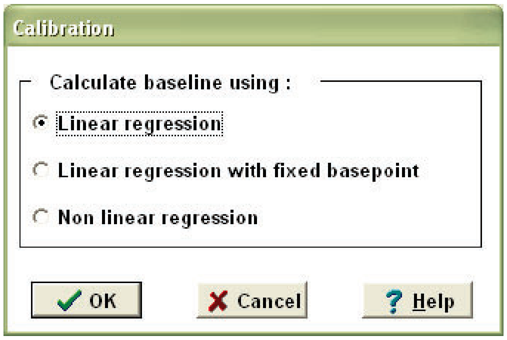
Component: methylpentane
Datafile : M_030351.BIN
Concentration 10.00000
Units v-ppb

11-3-2011 10:55:28
TCF
FID 0
PID 0
OvenTemp 0°C
SamplePress 0mBar
Pressure 0.0Bar
Ambient 0.0°C
SampleCount 0
Flow 0.0ccm
PreconTemp 0°C

7. You will see that there is no calibration curve but only points, so you have to make a calibration curve. Click on:
   - **Options**
   - **Calculate calibration line**



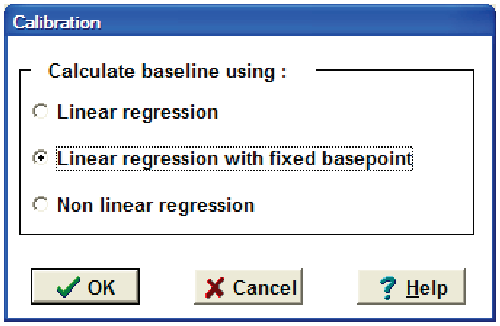
8. You will see:



Calculate baseline using :

● Linear regression
○ Linear regression with fixed basepoint
○ Non linear regression

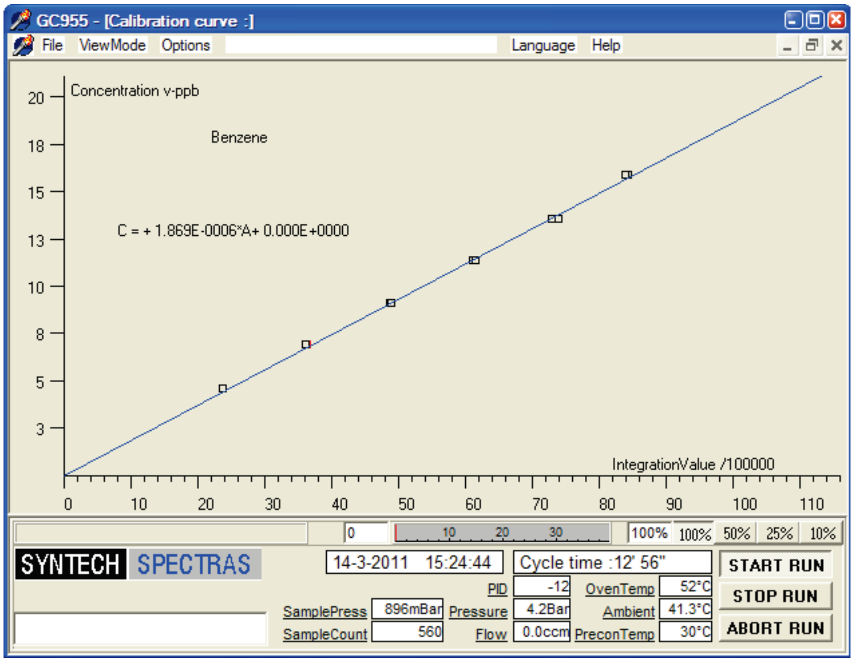
9. Click on:
   - **Linear regression with fixed basepoint**
   - **Ok**



Calculate baseline using :

○ Linear regression
● Linear regression with fixed basepoint
○ Non linear regression

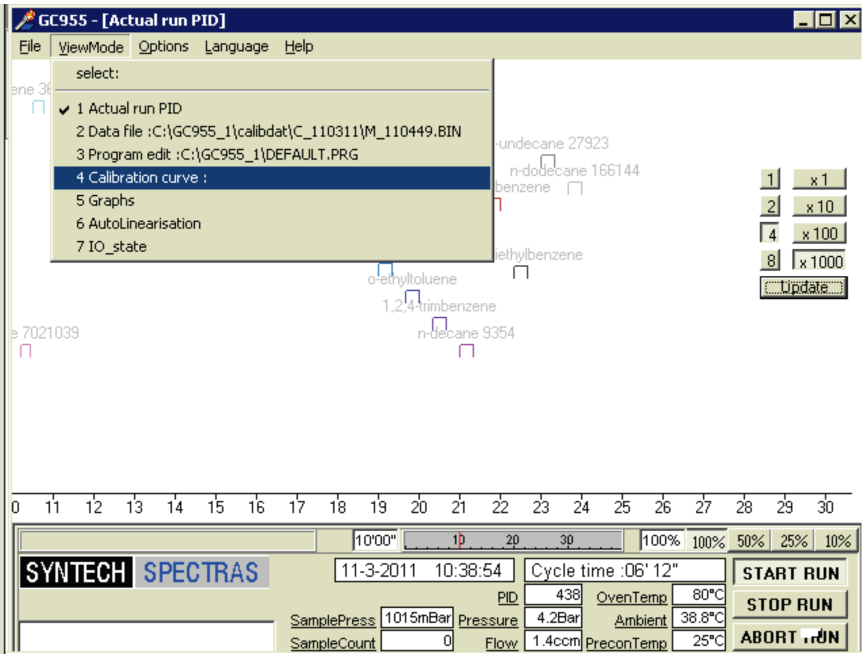
A calibration line like example below should now appear.



C = + 1.869E-0006*A+ 0.000E+0000

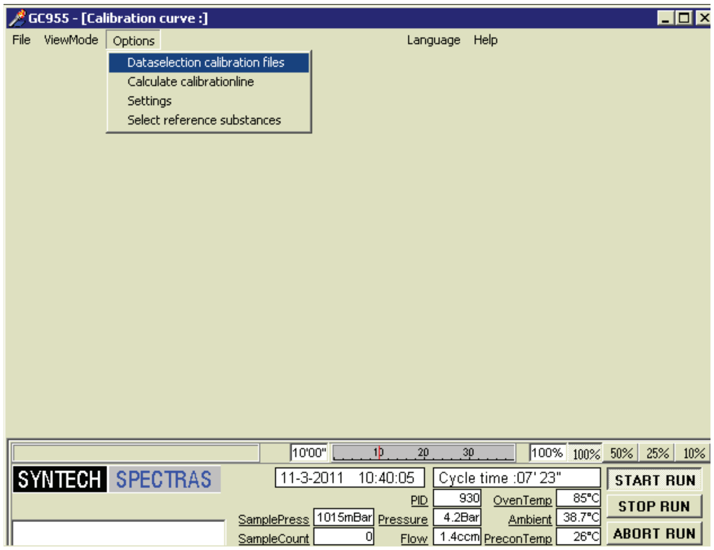
14-3-2011 15:24:44
Cycle time :12' 56"
PID -12
OvenTemp 52°C
SamplePress 896mBar
Pressure 4.2Bar
Ambient 41.3°C
SampleCount 560
Flow 0.0ccm
PreconTemp 30°C

This may be repeated for additional compounds, if applicable. To do this, click **ViewMode** and then **Calibration curve.**



10'00"
11-3-2011 10:38:54
Cycle time :06' 12"
PID 438
OvenTemp 80°C
SamplePress 1015mBar
Pressure 4.2Bar
Ambient 38.8°C
SampleCount 0
Flow 1.4ccm
PreconTemp 25°C

10. You will see:

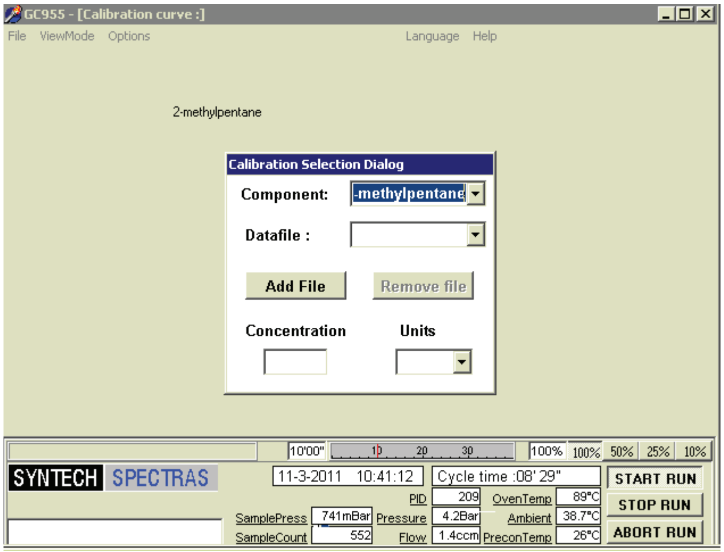


11-3-2011 10:40:05
Cycle time :07' 23"
PID 930
OvenTemp 85°C
SamplePress 1015mBar
Pressure 4.2Bar
Ambient 38.7°C
SampleCount 0
Flow 1.4ccm
PreconTemp 26°C

Click on:

- **Options**
- **Data selection calibration files**

11. You will see:



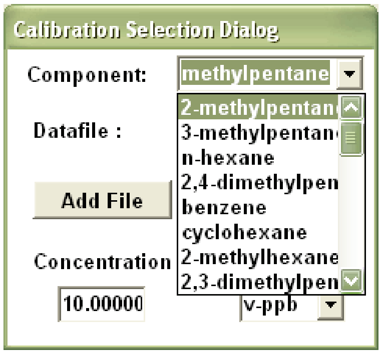
2-methylpentane

Component: -methylpentane
Datafile :
Concentration
Units

11-3-2011 10:41:12
Cycle time :08' 29"
PID 209
OvenTemp 89°C
SamplePress 741mBar
Pressure 4.2Bar
Ambient 38.7°C
SampleCount 552
Flow 1.4ccm
PreconTemp 26°C

Select a component by clicking the arrow in the component drop down box.

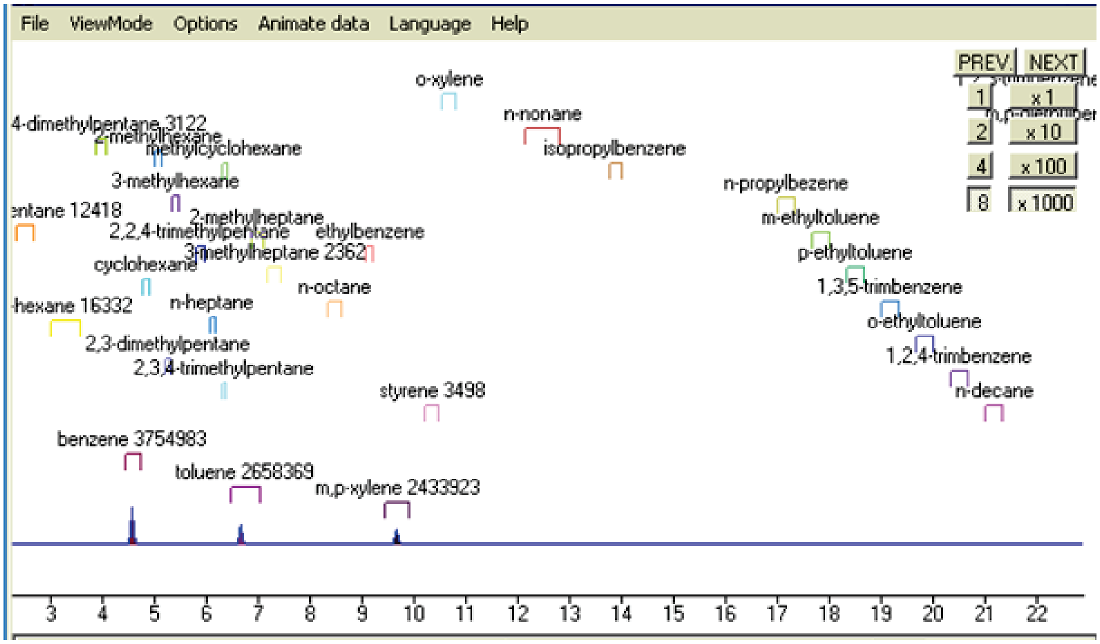
You will see:



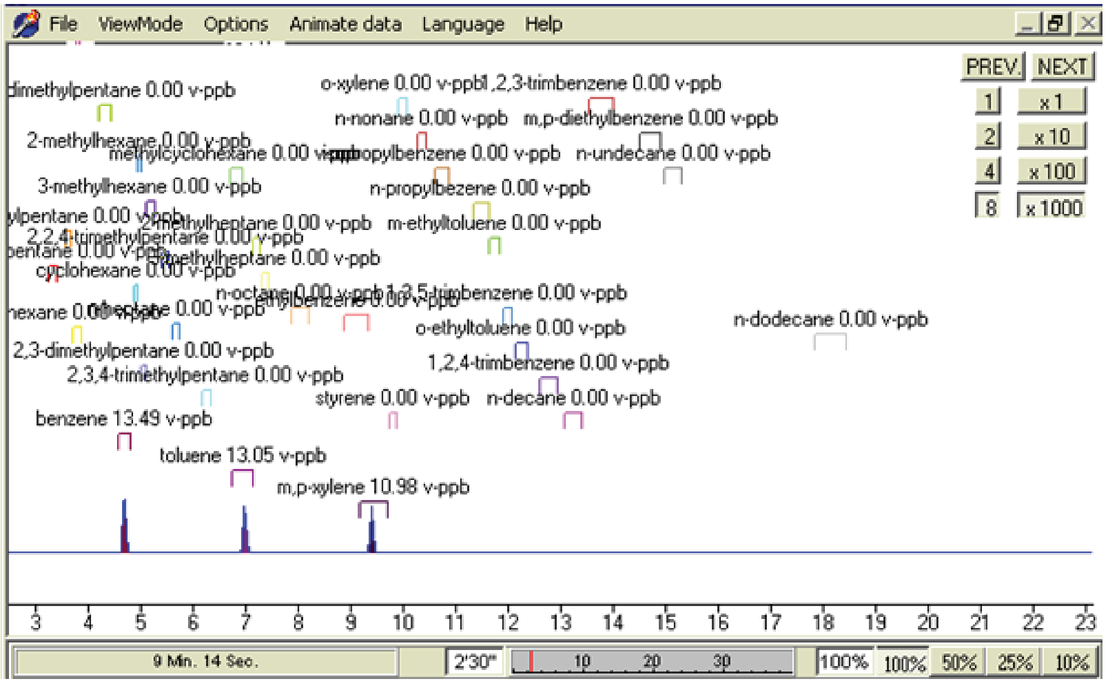
Component: methylpentane
Datafile :
Concentration 10.00000 v-ppb

12. Click on **Next compound** and start again with **Add File** and so on.

    Chromatograms with the concentrations, but not areas, are now visible in calibdat.

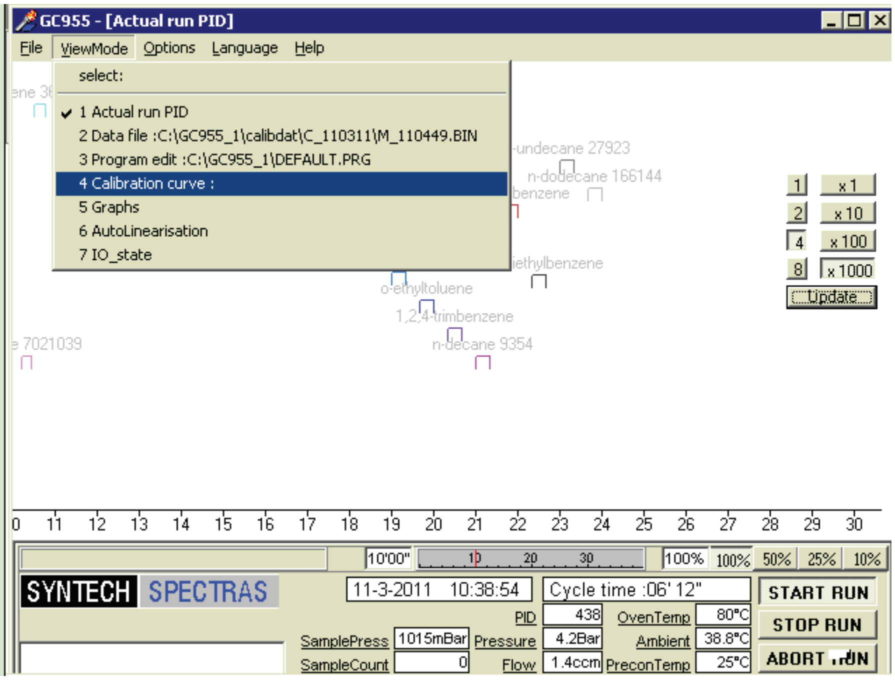


After calibration, the concentrations are visible in ppb:

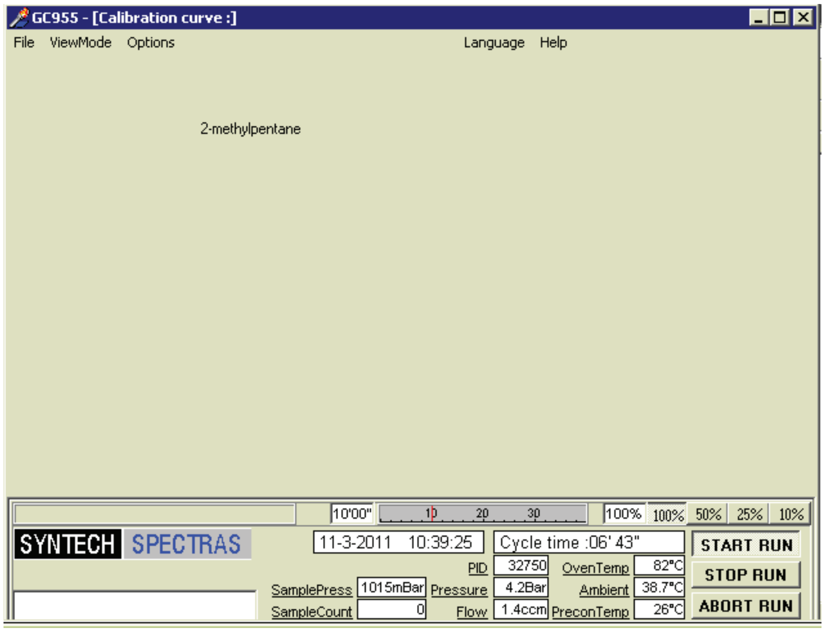


Using the calibration setting

1. Click in the **ViewMode** on **Calibration curve**:

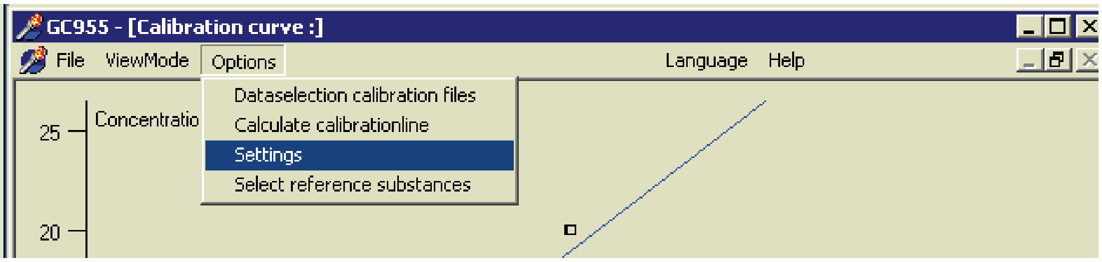


2. You will see:

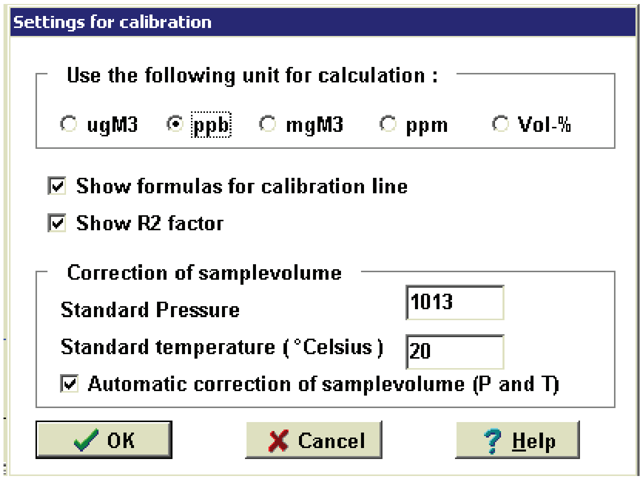


Click:

- **Options**
- **Settings**



3. You will see:



Use the following unit for calculation :

○ ugM3 ● ppb ○ mgM3 ○ ppm ○ Vol-%

☑ Show formulas for calibration line

☑ Show R2 factor

Correction of samplevolume

Standard Pressure 1013

Standard temperature (°Celsius) 20

☑ Automatic correction of samplevolume (P and T)

You can choose the unit for calculation.

8. References

Manual for the Syntech Spectras GC955-series Version 4, Synspec b.v, March 2009.

Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II, U.S. EPA Ambient Air Quality Monitoring Program, December 2008.

9. Analyzer Checklist

Criteria	Value	Notes
SN		
Power on functional		
Column flow		
Pressure		
Ambient temp.		
Oven start temp.		
Pre-concentrator start temp.		
Syringe sample strokes		
Peak windows		
Zero check (if applicable)		
Span check (if applicable)		

Standard Operating Procedure for H_2S Point Monitors

October 31, 2024

STI-8094

APPROVED:

____

Sonoma Technology date

____

Fenceline Monitoring Refinery Representative date

Contents

Tables

Figures

1. Scope and Application

This document is the standard operating procedure (SOP) for the maintenance and calibration of the Teledyne T101 analyzer, which measures concentrations of ambient hydrogen sulfide (H_2S). The calibration system described herein presumes the use of a Teledyne T700 gas dilution calibrator, an external zero air generator, and a National Institute of Standards and Technology (NIST)-traceable H_2S gas cylinder. However, other suitable calibration equipment may be used for the purpose of performing maintenance and verification on the T101 analyzer.

2. Safety

This procedure requires the handling of hazardous compounds (H_2S and SO_2) in the forms of compressed gas cylinders, permeation tubes, and exhaust gas from the analyzer. H_2S and SO_2 must be discharged outdoors and away from all personnel after passing through a scrubber or filtration system. Improper handling may result in acute, long-term health impacts. Personnel must be properly trained and qualified prior to performing any procedure in this SOP.

3. Method Overview

The Teledyne T101 determines the concentration of H_2S by converting it to sulfur dioxide (SO_2), which is then measured by ultraviolet (UV)-induced fluorescence. Ambient air is drawn by an internal pump through a sample particulate filter to remove particles, a hydrocarbon scrubber to remove hydrocarbons, and finally an SO_2 scrubber to remove ambient SO_2 prior to the converter. The sampling flow rate is 700 standard cubic centimeters per minute (sccm). H_2S in the ambient air is converted to SO_2 through high-temperature catalytic oxidation, and the converter is most efficient at 315°C. The resulting SO_2 is exposed to UV light with a wavelength of 214 nm to create an excited-state molecule (SO_2*). The SO_2* molecule quickly returns to a lower energy ground state by releasing excess energy in the form a photon (at 330 nm). The amount of emitted light at 330 nm is directly related to the SO_2 concentration, which is used to quantify H_2S concentration. The system can also measure the SO_2 concentration present in the ambient air by bypassing the sampling flow from the SO_2 scrubber and the catalytic converter, if desired.

4. Equipment and Supplies

Before beginning the quality control (QC) check and maintenance, ensure you have the following:

- NIST-certified H_2S gas cylinder with regulator or H_2S permeation tube
- NIST-certified SO_2 gas cylinder with regulator or SO_2 permeation tube (for converter efficiency (CE) check)
- Gas calibrator

- Zero air generator
- Certified, NIST-traceable flow meter
- Technician's tool bag, including screwdrivers, pliers, wrenches, etc.
- Inlet filter opening wrenches
- Replacement particulate filters
- Replacement converter catalyst
- Pump rebuild kit

5. Maintenance Schedule

A list of regular maintenance activities, and the corresponding sections of the T101 user manual where they are described in detail, is listed in Table 1. Additional information regarding frequency of service is presented in the facility's Quality Assurance Project Plan (QAPP).

Table 1. QC and maintenance schedule for the T101 series H_2S analyzer.

Activity	SOP Section	User Manual Reference
Perform zero and span check	6.1	5.2
Review and verify test functions	6.2	6.72
Review and verify test functions	6.2	6.7.2
Inspect sample lines	6.3	--
Change inlet particulate filter	6.4	6.6.1
Perform flow check	6.5	6.6.9.3
Perform multipoint check	6.1	--
Replace SO_2 scrubber material and sintered filters	6.6	6.6.3
Check for H_2S -> SO_2 converter efficiency (CE), replace or service the converter if CE < 96%	6.7-6.8	6.6.5.2
Service the critical flow orifice assembly; replace as needed	6.9	6.6.7
Perform pump check and rebuild pump diaphragm as needed	6.10	6.6.9.1
Perform leak check	6.10	6.6.9.1
Adjust UV lamp	6.11	6.7.10.3
PMT sensor hardware calibration	6.12	6.7.10.4
Calibrate offset and slope	6.13	5.2

6. Field Operation and Maintenance

Common maintenance and QC activities are described below. Additional information about maintenance activities, troubleshooting, and fault codes can be found in the T101 user manual.[1]

For regulatory projects, the analyzer should never be taken offline or put into Maintenance Mode if ambient H_2S concentrations are elevated (>10 ppb), especially if they are approaching a public notification level. Report any observations of concern to the Project Manager immediately before performing maintenance.

6.1. Perform Zero/Span or Multipoint Check

A Z/S check evaluates analyzer performance without altering the response curve (slope and offset values) and is a recommended regular maintenance item. A multipoint check similarly evaluates performance across the analyzer's measurement range and shall be conducted only after the analyzer is calibrated. The multipoint check can be used to confirm the linearity of the analyzer's response.

6.1.1. Manual Verification

1. Verify that the ambient conditions are acceptable to take the system down for QC checks (i.e., ambient H_2S concentration is <10 ppb), prior to proceeding with gas verification. Put the H_2S channel into Maintenance Mode from the Field Tech Tool.
2. Connect the sources of zero and span (Z/S) gas as shown in **Figure 1**, depending on the instrument configuration. The zero air generator can be replaced by a zero air cylinder. If using the T700 dilution calibrator, make sure the calibrator contains the accurate gas standard concentration in the Cylinder Setup menu.
3. Generate the instrument zero using the zero air source.
4. When using NumaView software with the T101 analyzer, view the concentration and stability responses by clicking the Home Tab and the blue H_2S icon. Verify the T101 mode remains in SAMPLE in the lower-right corner of the display. This ensures the verification is conducted through the inlet probe.
5. Wait at least 15 min until the analyzer stability (STAB) is below 0.5 ppb (wait longer than 15 min if more time is needed for STAB to be < 0.5 ppb). Record the reading. If the stability threshold cannot be achieved, contact the Project Manager and proceed to additional troubleshooting steps.

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[1] https://www.teledyne-api.com/prod/Downloads/083730101B%20-%20MANUAL,%20USER,%20NVS,%20T101-T102.pdf

6. From the dilution calibrator, set the target H_2S span gas concentration(s) as defined in Section A.7 of the QAPP for both span and multipoint checks.
    a. Wait at least 45 min until STAB is below 0.5 ppb for each concentration level (wait longer than 45 min if more time is needed for STAB to be < 0.5 ppb at each level). Record the readings. If the stability threshold cannot be achieved, contact the Project Manager and proceed to additional troubleshooting steps.
7. Refer to the facility's QAPP for the test acceptance criteria.
8. Purge the sampling line and the analyzer by generating a high flow of zero air for at least 5 min. This step helps the analyzer return to sampling ambient conditions.
9. At the conclusion of the check, put the calibrator into STANDBY mode.

    IMPORTANT: Failing to change the calibrator to STANDBY mode means the analyzer will continue to detect zero air or span gas fed to the inlet, resulting in INVALID ambient data.
10. Verify that the SAMPLE mode status of the T101 is reflected in the lower-right corner of the display.
11. Observe and make sure the H_2S reading has returned to ambient concentrations **before** putting the channel back to Normal Operations from the Field Tech Tool.

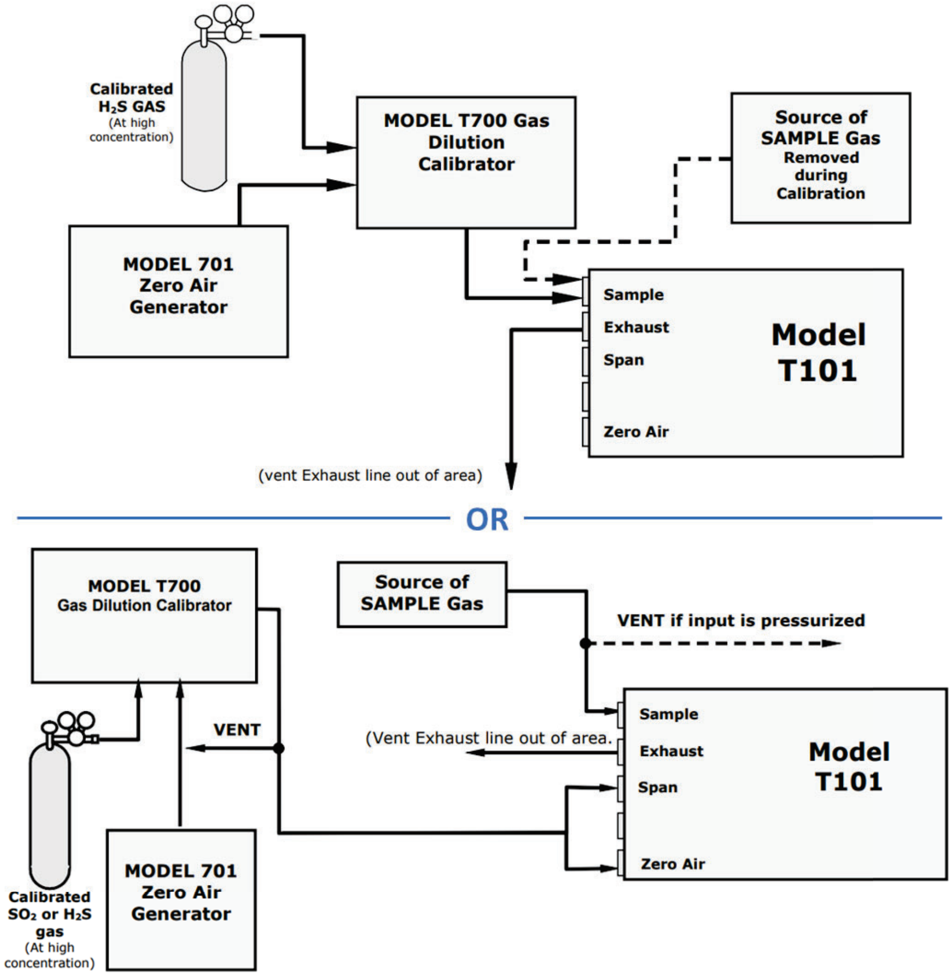


Figure 1. Connection setup for verification and calibration with basic configuration (top) or Z/S valves option (bottom).

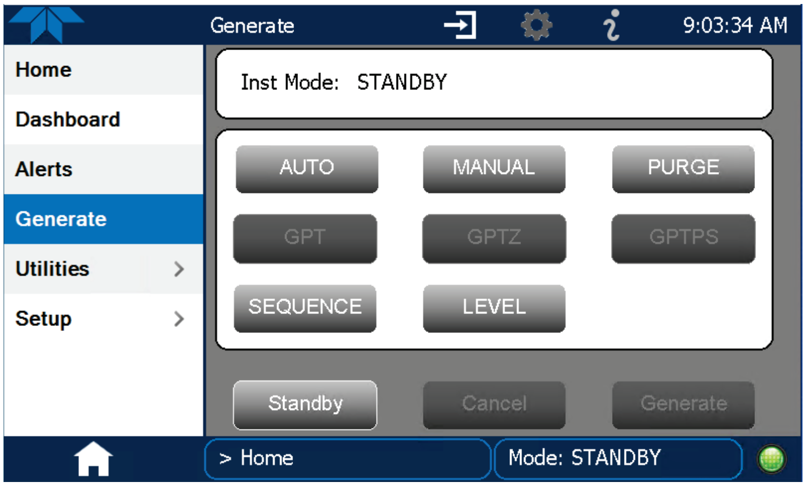
6.1.2. Automated Verification

For some monitoring sites, automated verification may be configured and initiated manually. Note the following procedure is only applicable when the Teledyne T101 analyzer and T700 dilution calibrator are used together.

The preset sequences are set up such that an abundance of time (at least 15 min for a zero and 45 min for any non-zero concentration level) is built in to achieve stabilized readings from a properly functioning, calibrated analyzer.

1. Verify the ambient conditions are acceptable (H_2S < 10 ppb) to proceed with gas verification. Put the H_2S channel into Maintenance Mode from the Field Tech Tool.

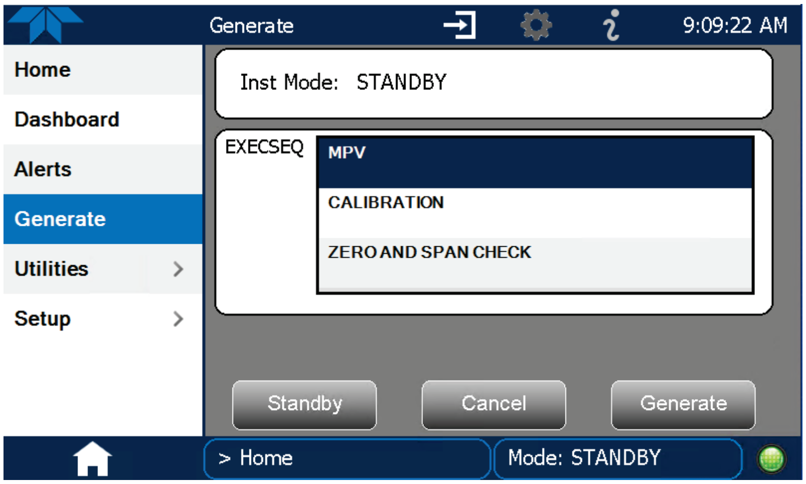
2. Connect the Z/S gas sources as shown in Figure 1, depending on instrument configuration. The zero air generator can be replaced by a zero air cylinder. Make sure the T700 dilution calibrator contains the accurate gas standard concentration in the Cylinder Setup menu.
3. If the verification is to be initiated remotely via the NumaView Remote Software, open the software and launch the analyzer and calibrator of interest.
4. From the T700 dilution calibrator, go to **Generate** > **Sequence** to view a selection of preset sequences, as shown in Figures 2 and 3.
5. Select the sequence to be initiated and select Generate.
6. Verify that the calibrator is beginning the steps by observing the Instant Mode in the Generate menu or Mode in the lower-right corner of the display.



Inst Mode: STANDBY

Mode: STANDBY

Figure 2. Screenshot of the Generate menu on the T700 calibrator.



Inst Mode: STANDBY

Mode: STANDBY

Figure 3. Screenshot of preset automated sequences on the T700 calibrator.

7. When using NumaView software with the T101 analyzer, view the concentration and stability responses by clicking the Home Tab and the blue H_2S icon. Verify the analyzer remains in SAMPLE mode during the Z/S check and multipoint check by looking in the lower-right corner of the display. This ensures the verification is conducted through the inlet probe.
8. Review the **entire** check results to confirm the completion of a Z/S check or multipoint check using Sonoma Technology's Insight data management system.
9. When the check is finished, verify the calibrator has been switched back to STANDBY mode and the analyzer has been switched back to SAMPLE mode.

   IMPORTANT: Failing to change the calibrator to STANDBY mode means the analyzer will continue to detect zero air or span gas that is fed to the inlet, resulting in INVALID ambient data.
10. Observe and make sure the H_2S value has returned to ambient concentrations **before** putting the channel back to Normal Operations from the Field Tech Tool.

6.2. Review and Verify Test Functions

Test functions on the Dashboard should be carefully reviewed and verified during each scheduled site visit. Minimally, operators should check and verify that major test functions remain within the nominal range listed in Table 2 (also included on the maintenance checklist). Operators should also review active warning alerts to determine if troubleshooting or corrective actions are required.

Table 2. Major diagnostics for the Teledyne API T101 H_2S analyzer.

Diagnostic	Acceptable Value Range
H_2S Slope	1.0±0.3
H_2S Offset (mV)	< 250
Converter Temp (°C)	315±1
Sample Flow (sccm)	585-715 (650±10%)
Pressure (inHg)	~ 5 < ambient pressure
UV Lamp Signal (mV)	2,000-4,000
UV Lamp Ratio (%)	30-120

Refer to the T101 user manual for a detailed list of test functions, nominal values, and possible causes for out-of-range values. Additionally, the acceptable ranges for these functions of a specific analyzer can be found in the *Final Test and Validation Data Sheet* shipped with the instrument.

6.3. Inspect Sample Lines

Contaminated or kinked sample line can adversely impact sampling data over time. Check for any sample line flow restrictions or visible dirt or condensation accumulation along the sampling path between the sample inlet and the analyzer sampling port, as well as the calibration lines. Replace the sample and calibration lines as needed.

6.4. Change Sample Particulate Filter

The sample particulate filter inside this instrument needs to be changed monthly, even without obvious signs of dirt; filters with pore sizes of 1 and 5 µm can clog even when they look clean. A schematic of the particulate filter is shown in **Figure 4**.

1. Turn OFF the analyzer to prevent drawing debris into the sample line.
2. Open the T101’s hinged front panel and unscrew the knurled retaining ring of the filter assembly.
3. Carefully remove the retaining ring, glass window, PTFE O-ring, and filter element.
4. Use a tweezer to carefully replace the filter element, centering it at the bottom of the holder. Alternatively, wear latex gloves if handling the filter to avoid contamination.
5. Re-install the PTFE O-ring with the notches facing up, replace the glass cover, screw on the hold-down ring, and hand tighten the assembly. **Inspect the (visible) seal between the edge of the glass window and the O-ring to ensure proper gas tightness.** This is critical for ensuring that the sample flow rate does not drop.
6. Restart the analyzer and perform a leak check.

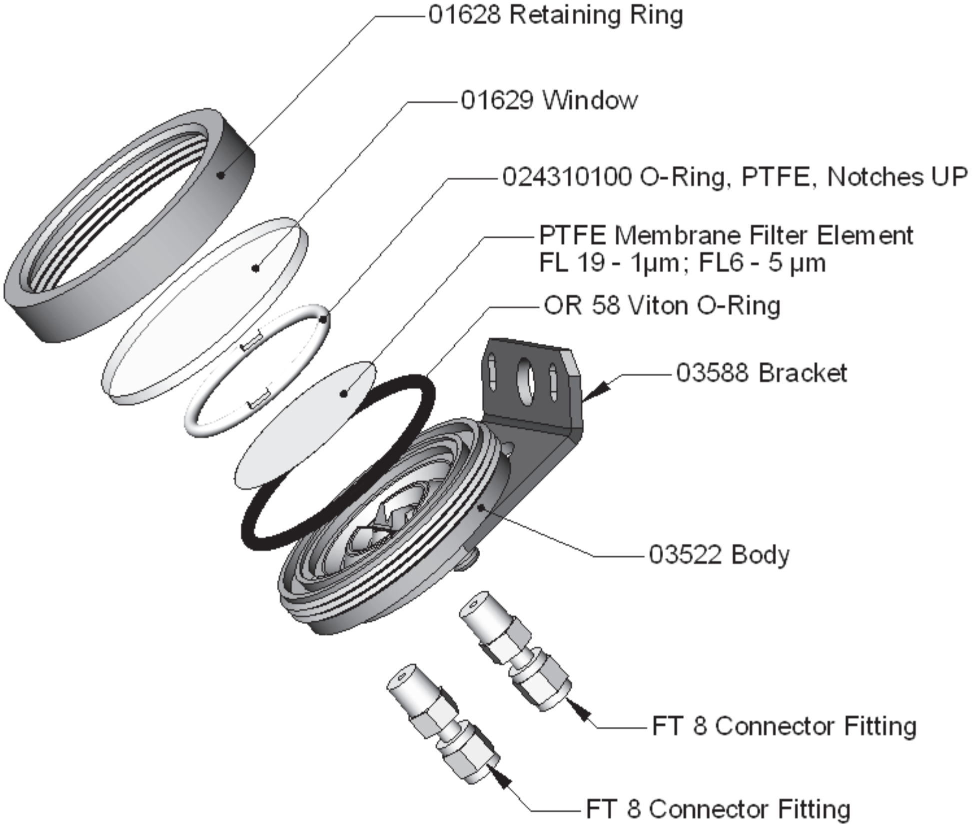


Figure 4. Particulate filter assembly.

6.5. Perform Flow Check

Use an external, calibrated NIST-traceable flow meter capable of measuring the instrument's flow specifications for this check. Do not use the built-in flow measurement viewable in the Dashboard as this value is only calculated, not measured. A decreasing sample flow may point to slowly clogging pneumatic paths, most likely critical flow orifices or sintered filters.

1. Disconnect the sample inlet tubing from the rear panel SAMPLE port.
2. Attach the outlet port of a suitable flow meter to the rear panel SAMPLE port.
3. The sample flow measured with the external flow meter should be within 585-715 sccm.
12. Record the sample flow reading from the external flow meter. If the flow is beyond the specified range, contact the Project Manager and proceed to additional troubleshooting steps. A passing flow check is required for normal instrument operations.

6.6. Change the SO_2 Scrubber (Activated Charcoal)

1. Input zero air for 5 min.

2. Turn off the analyzer.
3. Remove the instrument cover.
4. Locate the SO_2 scrubber cartridge in the front of the analyzer (it looks like a big white cylinder).
5. Undo the two 1/8″ fittings on the top of the scrubber.
6. Remove the two screws holding the scrubber to the instrument chassis, and remove the scrubber.
7. Take the two Teflon™ fittings off the instrument.
8. Empty the SO_2 scrubbing material and discard the sintered filters into a hazmat bin.
9. If any SO_2 scrubber residual is visible in the line, disconnect the line and clear the line of powder with compressed air.
10. Fill each side of the scrubber with new SO_2 scrubber material until it is ½″ from the bottom of the thread lines (about ½″ from the top of the scrubber); do not fill it too high or the fitting will crush the material.
11. Install a new set of sintered filters. The filters should be leveled at the bottom of the fittings.
12. Remove the Teflon tape from both of the removed fittings, and retape them with new Teflon tape.
13. Install both fittings back onto the scrubber.
14. Put the scrubber back into the analyzer and replace the two screws on the bottom.
15. Screw the two 1/8″ fittings back onto the top of the scrubber.
16. Return the analyzer to normal operation.

6.7. Check for H_2S -> SO_2 Converter Efficiency

1. Set the analyzer to SO_2 measurement mode.
2. Supply a gas with a known concentration of SO_2 to the sample gas inlet of the analyzer.
3. Wait until the analyzer's SO_2 concentration measurement stabilizes. This can be determined by setting the analyzer's display to show the SO_2 STAB test function. SO_2 STAB should be 0.5 ppb or lower before proceeding.
4. Record the stable SO_2 concentration.
5. Set the analyzer to H_2S measurement mode.
6. Supply a gas with a known concentration of H_2S, equal to that of the SO_2 gas used in steps 2-4 above, to the sample gas inlet of the analyzer.
7. Wait until the analyzer's H_2S concentration measurement stabilizes. This can be determined by setting the analyzer's display to show the H_2S STAB test function. H_2S STAB should be

0.5 ppb or lower before proceeding.

8. Record the stable H_2S concentration.
9. Divide the H_2S concentration by the SO_2 concentration.
   EXAMPLE: If the SO_2 and H_2S reference concentration of the two test gases used is 500 ppb:

   Measured SO_2 Concentration = 499.1 ppb
   Measured H_2S Concentration = 490.3 ppb
   CE = 490.3 ÷ 499.1
   CE = 0.982 (98.2%)
10. It is recommended that the H_2S -> SO_2 converter catalyst material be replaced if the CE falls below 96%. Proceed to the next section to change the converter catalyst material.

6.8. Change H_2S -> SO_2 Converter Catalyst Material

The H_2S -> SO_2 converter is located at the center of the instrument. The converter is designed for replacement of the cartridge only; the heater with built-in thermocouple can be reused. A schematic of the H_2S-to-SO_2 converter assembly is shown in **Figure 5**.

1. Turn off the analyzer power, remove the cover, and allow the converter to cool down.
2. Remove the top lid of the converter and the top layers of insulation until the converter cartridge is visible.
3. Remove the tube fittings from the converter.
4. Disconnect the power and the thermocouple of the converter. Unscrew the grounding clamp of the power leads with a Phillips-head screwdriver.
5. Remove the converter assembly (cartridge and band heater) from the can. Make a note of the orientation of the tubes relative to the heater cartridge.
6. Unscrew the band heater and loosen it. Take out the old converter cartridge.
7. Wrap the band heater around the new replacement cartridge and tighten the screws using a high-temperature, anti-seize agent such as copper paste. Make sure to properly align the heater with respect to the converter tubes.
8. Replace the converter assembly, route the cables through the holes in the housing, and reconnect them properly. Reconnect the grounding clamp around the heater leads for safe operation.
9. Re-attach the tube fittings to the converter and replace the insulation.
10. Replace the instrument cover and power up the analyzer.

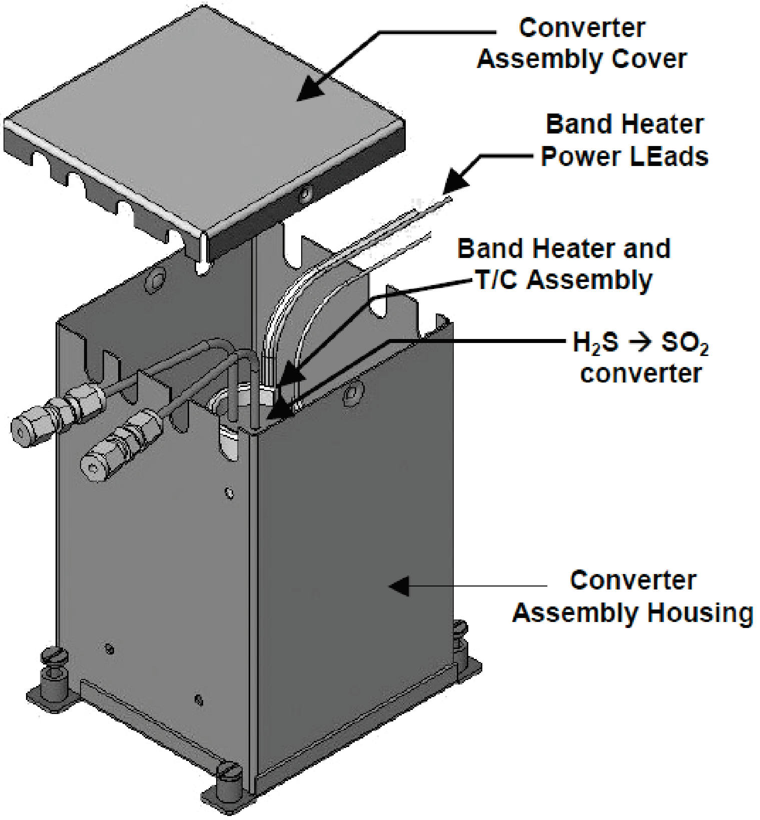


Figure 5. H_2S -> SO_2 converter assembly.

6.9. Service the Critical Flow Orifice Assembly

The critical flow orifice assembly shown in **Figure 6** can clog despite being protected by sintered stainless steel filters, particularly if the instrument operates without a sample filter or in an environment with very fine, submicron-sized dust.

1. Turn off power to the instrument and vacuum pump.
2. Locate the critical flow orifice on the pressure sensor assembly.
3. Disconnect the pneumatic line.
4. Unscrew the NPT fitting.
5. Remove the assembly components: one spring, one sintered filter, two O-rings, and one critical flow orifice. You may need to use a scribe or pressure from the vacuum port to remove parts from the manifold.
6. Discard the sintered filter. Inspect the two O-rings and replace as needed.
7. Inspect the critical flow orifice. Replace as needed.
8. Re-assemble the parts using a new filter and O-rings.

9. Reinstall the NPT fitting and connect all tubing.
10. Power up the analyzer and allow it to warm up for 60 min.
11. Perform a leak check.

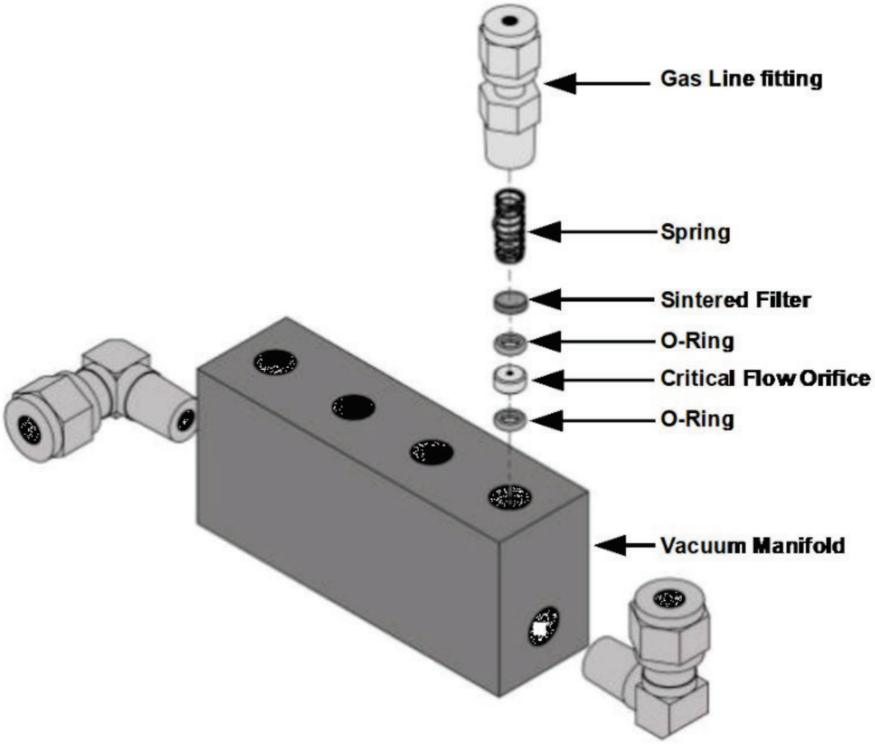


Figure 6. Critical flow orifice assembly.

6.10. Perform Leak Check/Pump Check

Leaks are the most common cause of analyzer malfunction. **A leak check should be carried out whenever the pneumatic flow path is disrupted.** Examples of such disruptions can include, but are not limited to, changing the sample inlet filter, changing the SO_2 scrubber materials, or opening the critical flow orifice assembly. The method described here is easy, fast, and detects (but does not locate) most leaks. It also verifies the sample pump condition, thereby acting as a pump check. An in-depth pressure leak check may also be performed with additional tools, and the protocol for that process can be found in the T101 user manual.

1. Turn the analyzer on if it is not already running and allow at least 30 min for flows to stabilize.
2. Cap the sample inlet port (cap must be wrench-tight).
3. After several minutes of stable pressures, go to the Dashboard to view the readings.

  - If the Sample Flow is less than 10 sccm, the instrument is free of large leaks. If not, the leak point should be identified and rectified.
  - If the Sample Pressure is less than 10 inHg, the pump is in good condition. If not, the pump diaphragm needs to be replaced.
4. When finished, switch off the pump and SLOWLY open the cap to the sample inlet port to minimize in-rush flow.

6.11. UV Lamp Adjustment and Calibration

The UV lamp output can be affected by a change in line voltage, an aging lamp, or lamp position. Two metrics need to be considered when assessing lamp life: UV lamp intensity and the lamp ratio. The lamp intensity should be 2,000-4,000 mV, and the lamp ratio should be 30-120%. These values will decrease over time. To optimize signal intensity, perform the following steps.

IMPORTANT: DO NOT grasp the UV lamp by the cap when changing the lamp's position—always grasp the main body of the lamp. Inattention to this detail could twist and potentially disconnect the lamp's power supply wires, which COULD DAMAGE THE INSTRUMENT AND VOID THE WARRANTY.

1. Let the instrument run for one hour to stabilize the UV lamp.
2. Set the Dashboard to show the UV LAMP function.
3. Slightly loosen the large brass thumbscrew located on the shutter housing so that the lamp can be moved.
4. While watching the UV LAMP reading, slowly rotate the lamp clockwise and counter-clockwise, and move the lamp up and down vertically until the UV LAMP reading is at its maximum.
5. Finger-tighten the thumbscrew.
6. Assess whether the lamp signal is within optimal intensity (i.e., 3,500±200 mV).
7. If the signal intensity is too high or too low, locate the UV reference detector adjustment potentiometer screw and turn the screw clockwise to increase the signal or counter-clockwise to decrease the signal until the signal intensity is optimal.

IMPORTANT: Increasing the UV reference detector adjustment potentiometer to its maximum introduces measurement noise, which renders the results unstable. If the potentiometer has to be maxed out to achieve an optimal signal, the lamp should be replaced.

A video of the lamp-adjustment process performed by the manufacturer can be found at: https://www.youtube.com/watch?v=PF6MGK1FftQ.

Now the optimal lamp signal is achieved, the lamp must be calibrated to reset the lamp ratio. Based on the lamp ratio, the T101 compensates for variations in the intensity of the available UV light by adjusting the H_2S concentration calculation. The lamp ratio is calculated by dividing the current UV lamp intensity by a value stored in the CPU’s memory from the last lamp calibration. Once the lamp ratio is less than 30% or greater than 120%, the CPU can no longer compensate for the difference in the current signal from the last saved signal. Calibrate the lamp by doing the following:

1. From the Home page, navigate to **Utilities** > **Diagnostics** > **Lamp Cal**.
2. Press Calibrate, and the CPU will save the current lamp signal intensity automatically.
3. Confirm the lamp calibration is complete by checking if the lamp ratio is close to 100% (plus or minus the average fluctuation of the lamp intensity).
4. If the lamp ratio is not close to 100%, power the T101 off and then on again. The lamp ratio should be close to 100% and the lamp calibration is complete. If not, repeat the lamp calibration steps.

6.12. PMT Sensor Hardware Calibration

At times when the instrument’s slope and offset values exceed the acceptable range (see Table 2 in Section 6.2) and all other more obvious causes for this problem have been eliminated, the PMT sensor may be calibrated to reset the PMT output.

1. Set the instrument reporting range to SINGLE.
2. Perform a zero calibration using zero air.
3. Run a UV lamp calibration (Section 6.11). This protocol is required to ensure proper scaling of the NORM PMT value.
4. Locate the pre-amplifier board installed on top of the PMT assembly.
5. Locate the following components on the pre-amplifier board (**Figure 7**):
    a. High-voltage power supply (HVPS) coarse adjustment switch (range 0-9, then A-F)
    b. HVPS fine adjustment switch (range 0-9, then A-F)
    c. Gain adjustment potentiometer (full scale is 10 turns)

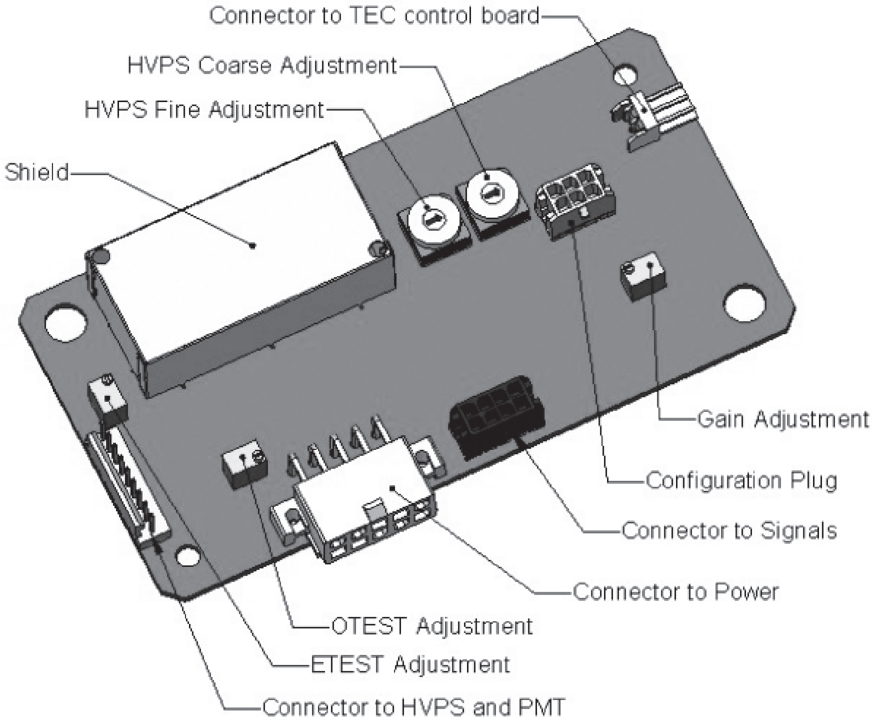


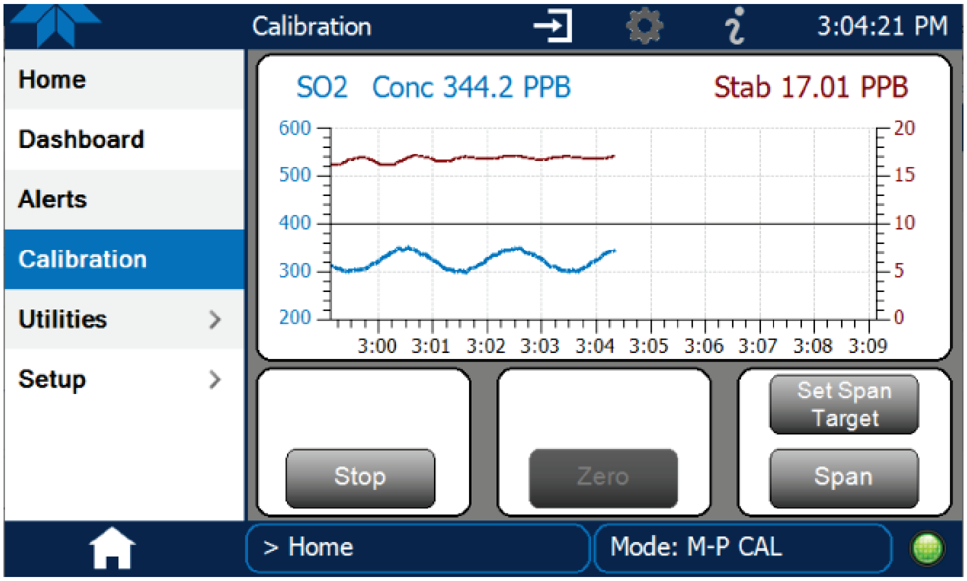
Figure 7. Pre-amplifier board layout.

6. Turn the gain adjustment potentiometer 12 times <u>counter-clockwise</u> to its minimum setting and then four turns <u>clockwise</u> to have some voltage to work with.
7. While feeding at least 80% of measurement range value to the analyzer and waiting until the STAB value is below 0.5 ppb, calculate the target concentration by multiplying the span concentration by the analyzer slope. For example, target concentration = 400 ppb H_2S × 1.25 = 500 ppb H_2S.
8. Note the position of the two HVPS adjustment switches. Carefully use a flathead or Phillips-head screwdriver to adjust the HVPS coarse and fine adjustments until the instrument concentration reads close to the target concentration calculated in the previous step.
9. **IMPORTANT:** DO NOT overload the PMT by accidentally setting both adjustment switches to their maximum setting (i.e., mark F). Start at the lowest setting and increase slowly.
10. Perform a span calibration. The slope should now be close to 1.0 and the concentration should be close to the span gas concentration.
11. Use the Dashboard or Home page to review the NORM PMT value. This value should be double the span gas concentration (in ppb), such that 400 ppb H_2S corresponds to a NORM PMT value of 800 mV on a properly calibrated analyzer.
12. Review and record the new slope and offset as part of the calibration procedure.

6.13. Calibrate Offset and Slope

Generally, a calibration is required when Z/S or multipoint check results fail or are marginal, and after major part repairs. Care should be taken to troubleshoot and eliminate all other more obvious causes for the check failures before proceeding with calibration.

Navigate to the Calibration menu as shown in Figure 8 to perform a calibration. On units with a Z/S valve option installed, select the calibration gas source (Zero or Span) accordingly. Detailed screenshots can be found in the T101 user manual.



SO2 Conc 344.2 PPB Stab 17.01 PPB

Mode: M-P CAL

Figure 8. Calibration page.

6.13.1. Manual Calibration

IMPORTANT: Before any calibration, record the as-found slope and offset on the maintenance form. You will NOT be able to retrieve these values once the analyzer is calibrated.

NOTE: If the ZERO or SPAN buttons are not displayed during the Z/S calibration, the measured concentration value is too different from the expected value and the analyzer does not allow for zeroing or spanning the instrument.

Zero calibration:

1. From the calibrator, generate the zero air.
2. From the analyzer, select **Calibration > Start**.
3. Wait until the analyzer stability (STAB) is below 0.5 ppb.
4. Click Zero to calibrate.

5. Click Stop and verify the reading.

Span calibration:

6. From the calibrator, generate the desired span gas concentration.
7. From the analyzer, select **Calibration > Start**.
8. Wait until the analyzer stability (STAB) is below 0.5 ppb.
9. Click Set Span Target and enter the actual reading from the calibrator and then click Done. Use the target concentration if the actual reading is not available.
10. To perform calibration (i.e., adjust the slope and offset), click Span.
11. Click Stop and verify the reading.
12. At the conclusion of the Z/S calibration, verify that the new slope and offset are within the acceptable range listed in Table 2. If the values are beyond the acceptable range, some parts may be causing the slope and offset to overcompensate, and corrective action is needed.
13. Record the new slope and offset on the maintenance form.
14. Proceed to Section 6.1 to perform a post-calibration multipoint check.

    IMPORTANT: On units with a Z/S valve option installed, DO NOT rely on the Sample dropdown option in the Calibration page to return to the sampling mode. Instead, navigate to the Home page to ensure the analyzer is back in SAMPLE mode.

6.13.2. Automated Calibration

For some monitoring sites, automated calibration may be configured and initiated manually. Note the following procedure is only applicable when the Teledyne T101 analyzer and T700 dilution calibrator are used together.

The preset calibration sequence is set up such that an abundance of time (at least 15 min for a zero and 45 min for any non-zero concentration) is built in to achieve stabilized readings before the analyzer is automatically calibrated.

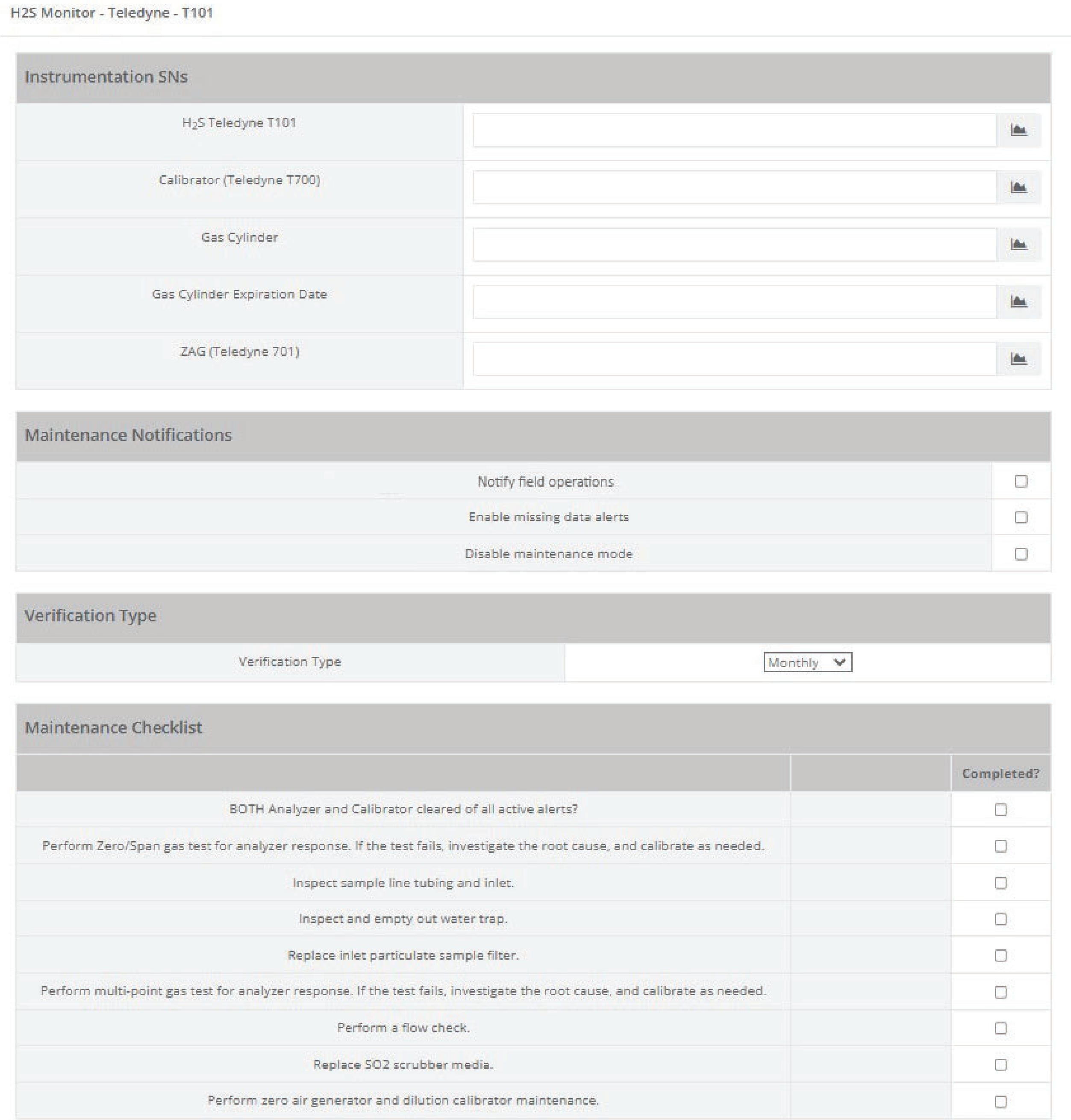
Due to the similarity between the automated verification and automated calibration feature, this section describes only the major steps involved in initiating an automated calibration sequence. Read this section thoroughly before proceeding to Section 6.1.2 to perform an automated calibration.

- Before any calibration, record the as-found slope and offset on the maintenance form. <u>You will NOT be able to retrieve these values once the analyzer is calibrated.</u>
- Make sure the T700 dilution calibrator contains the accurate gas standard concentration information in the cylinder setup menu.
- Once the calibration sequence is initiated, verify the calibrator begins the steps by observing the Instant Mode in the Generate Menu or Mode at the lower right corner of the display.

- At the conclusion of the Z/S calibration, verify the new slope and offset are within the acceptable range listed in Table 2. If not, some parts may be causing the slope and offset to overcompensate, and corrective action is needed.
- Record the new slope and offset on the maintenance form.
- Proceed to Section 6.1 to perform a postcalibration multipoint check.

7. Maintenance Form Template

Examples of the maintenance checklist and response summary are shown in **Figures 9 and 10**. These documents may be used as templates to be customized to meet specific monitoring project goals.



H2S Monitor - Teledyne - T101

Instrumentation SNs

H_2S Teledyne T101	
Calibrator (Teledyne T700)	
Gas Cylinder	
Gas Cylinder Expiration Date	
ZAG (Teledyne 701)	

Maintenance Notifications

Notify field operations	☐
Enable missing data alerts	☐
Disable maintenance mode	☐

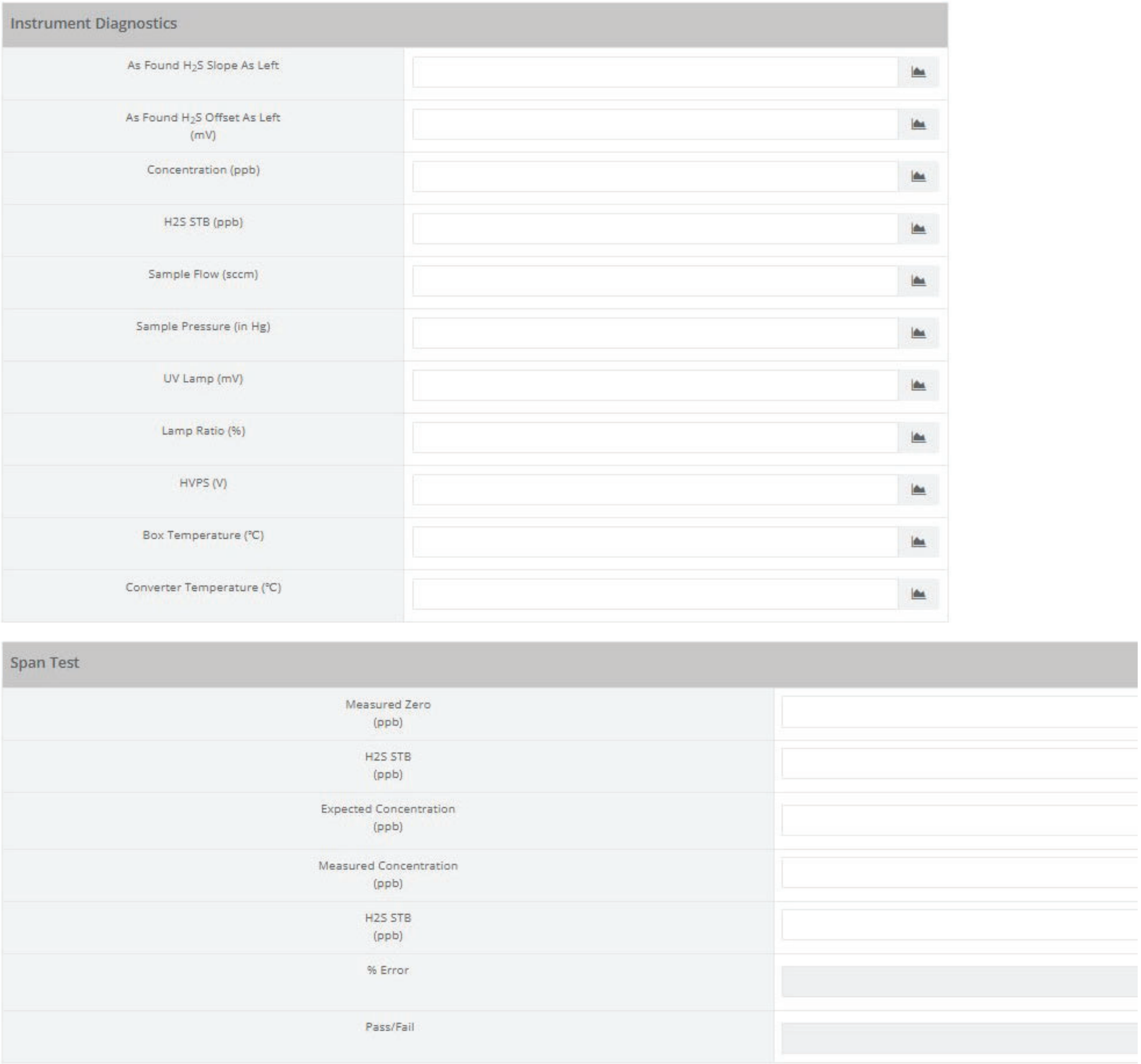
Verification Type

Verification Type	Monthly

Maintenance Checklist

		Completed?
BOTH Analyzer and Calibrator cleared of all active alerts?		☐
Perform Zero/Span gas test for analyzer response. If the test fails, investigate the root cause, and calibrate as needed.		☐
Inspect sample line tubing and inlet.		☐
Inspect and empty out water trap.		☐
Replace inlet particulate sample filter.		☐
Perform multi-point gas test for analyzer response. If the test fails, investigate the root cause, and calibrate as needed.		☐
Perform a flow check.		☐
Replace SO2 scrubber media.		☐
Perform zero air generator and dilution calibrator maintenance.		☐

Figure 9. Example T101 H_2S analyzer checklist.



Instrument Diagnostics

As Found H_2S Slope As Left	
As Found H_2S Offset As Left (mV)	
Concentration (ppb)	
H2S STB (ppb)	
Sample Flow (sccm)	
Sample Pressure (in Hg)	
UV Lamp (mV)	
Lamp Ratio (%)	
HVPS (V)	
Box Temperature (°C)	
Converter Temperature (°C)	

Span Test

Measured Zero (ppb)	
H2S STB (ppb)	
Expected Concentration (ppb)	
Measured Concentration (ppb)	
H2S STB (ppb)	
% Error	
Pass/Fail	

Figure 10. Example T101 H_2S diagnostics and span test summary.

Standard Operating Procedure for Data Verification and Validation

October 31, 2024

STI-8078

APPROVED:

Sonoma Technology date

Fenceline Monitoring Refinery Representative date

Contents

1. Scope and Application

This standard operating procedure (SOP) describes the verification and validation of fenceline monitoring data, including daily checks and quarterly analyses. Additional information is provided in the corresponding air monitoring plan (AMP) and Section D.2 of the quality assurance project plan (QAPP).

2. Introduction and Overview

At all fenceline monitoring sites, a Data Acquisition System (DAS), or data logger, performs basic quality control (QC), averages data to 5-min resolution, and aggregates data into a desired file format. Data are then transmitted from each sampling site to a cloud-based file storage service via cellular modem, where they are stored and available for retrieval as needed. Data from the cloud are ingested into Sonoma Technology's Insight© data management system (DMS), where a robust automated QC (AutoQC) logic and subsequent DMS-level screening checks assign data flags in real time based on instrument diagnostics, local meteorological measurements, and concentrations of target compounds. Data are stored within the DMS and any changes to data are recorded via chain-of-custody logs. These preliminary data are displayed on the public website within 10–15 minutes of raw data collection.

Data are reviewed daily by air quality data analysts to assess system operations, confirm the automated data flagging is correct, and ensure any corrections to data flagging are propagated to the public website immediately. Extended analyses are performed every calendar quarter and reviewed by the project Quality Assurance (QA) Manager. **Figure 1** illustrates the general data flow and QC schematic.

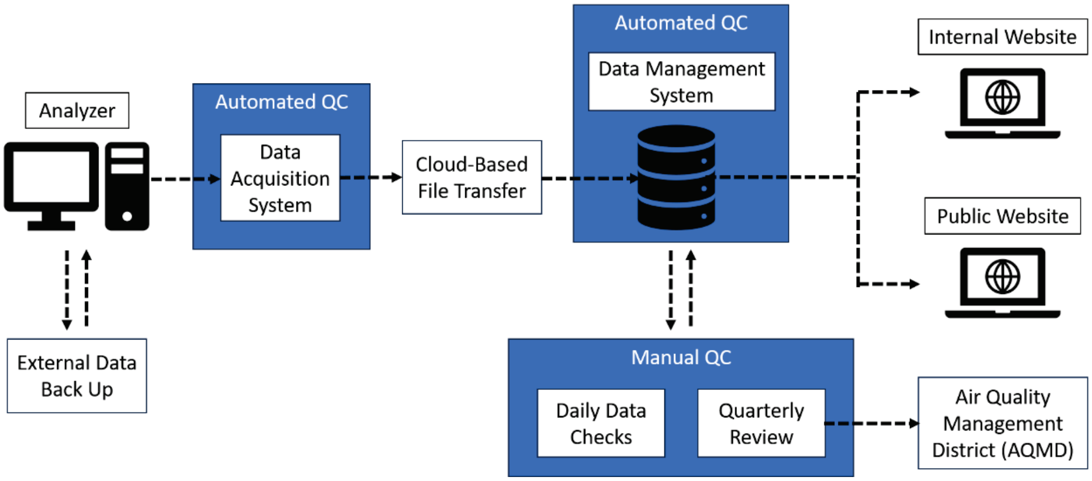


Figure 1. Data flow and QC schematic.

3. Definitions

Data verification is a process of comparing how the data were gathered to the procedures established by the project QAPP and SOPs. It is a data review technique that evaluates the conformance of data collection practices to established methods, procedures, or specifications. Data verification consists of checking that SOPs were followed and QC activities were performed.[1]

Data validation is a process of confirming that reported values meet the quality objectives of the project. It is a data review technique that examines whether the particular requirements for a specific, intended use are fulfilled. Data validation examines whether acceptance criteria outlined in the QAPP were achieved.[1]

Acceptance criteria are the defined performance criteria for the project that data must meet to be considered acceptable for reporting. Additional information regarding acceptance criteria is provided in Section A.7 of the QAPP.

Data flags are assigned to each data point based on instrument diagnostics and local meteorological measurements. Within the Sonoma Technology Insight DMS, data flags are composed of QC and operational (OP) codes. Additional information regarding data flags is provided in Section D.2 of the QAPP.

The **minimum detection limit (MDL)** is the lowest concentration of each parameter that can be measured by each analyzer at each sampling path. Additional information regarding MDLs is provided in Section B.2 of the QAPP.

Spectral data refers to the individual absorbance spectra collected at each open-path monitoring site. The analytic software evaluates raw spectral data in real time to report concentration data, and can be reviewed if data validation efforts identify potential issues that require investigation. Additional information regarding spectral data is provided in Section B.10 of the QAPP.

A **spectral match parameter** is used to identify parameters of interest and potential interferences present with open-path sampling. Spectral subtraction is used in cases with overlapping absorbance features, and the subtraction technique is proprietary to the instrument manufacturer. Additional information regarding spectral match parameters is provided in Section B.2 of the QAPP.

4. Safe Work, Hazard Identification, and Training for Data Review

Data verification and validation is performed remotely in an office environment away from field sampling sites. Common office hazards include slips and trips, sprains and strains, poor workstation ergonomics, indoor air-quality problems, insufficient or excessive lighting, noise, and electrical

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[1] EPA Quality Assurance Handbook Vol II, https://www.epa.gov/sites/default/files/2020-10/documents/final_handbook_document_1_17.pdf.

hazards. These hazards are identified and mitigated through safety walkthroughs, formal reporting of unsafe conditions, and regular training sessions on correcting safety hazards.

Training for data review is conducted by senior staff with at least one year of experience with refinery fenceline monitoring systems, as well as analyzer manufacturers. Project personnel are provided copies of the QAPP and SOPs, and receive updated versions when available. Initial training is provided prior to personnel performing work, and refresher trainings are conducted on an annual basis. The QA Manager will identify specific training requirements for all project personnel and will determine when trainees are qualified to work independently. Training records will be maintained by the Field Staff Manager.

5. Data Review and Quality Control

Data for the fenceline monitoring network appears on both public and internal websites (see Figure 1 in Section 2). The internal website allows for detailed QC and flagging of the data, which are checked daily and finalized quarterly as outlined in Section D.2 of the QAPP. The following text describes how to perform daily and quarterly data verification and validation.

5.1 Daily Checks

Data are manually reviewed on a daily basis by qualified analysts. An internal, non-public field operations website (Sonoma Technology's Insight DMS) is used for customized data queries and visualizations, and the public-facing website is reviewed to ensure the real-time display is current and accurate. Instrument performance issues or data gaps are escalated to the field operations team, and the Project Manager determines the appropriate actions to resolve issues in a timely manner.

Data analysts are qualified to perform daily checks after a training period of at least two weeks. Training includes education on monitoring rules and requirements, instrumentation, automated QC processing, expected concentration ranges, diagnostic thresholds, and internal procedures to escalate a data issue. Trainees shadow an experienced data analyst during daily checks for a week, and are then overseen by an experienced analyst while they perform their first week of data checks.

This daily data review allows the analyst to visualize fenceline concentrations and instrument diagnostics, thereby identifying potential instrument performance issues and confirming the current operational status of the network. Instances of missing or invalid data, instrument signal strength below defined thresholds, repeated (stuck) data values, rapid changes (spikes or dips) in data values, or negative concentrations are recorded in a spreadsheet that tracks observations across a calendar quarter. This form provides a template for data analysts to check relevant parameters against acceptance criteria and commonly expected values for routine reference. Daily data check spreadsheets from past quarters are maintained in an archive with other project documentation.

The following procedure details the daily data check for an individual monitoring network:

1. Log in to the Sonoma Technology Insight DMS with the facility-specific credentials for the check being performed. Credentials are stored in a secure password management software.
2. Navigate to the Dashboard, which contains configurable widgets showing time series plots of relevant parameters.
3. Record any periods of **missing data** and verify that (1) missing data alerts were sent, and (2) resolution is being pursued by the field operations team. If this cannot be verified, escalate the finding to the Project Manager.
4. Review any **detection events** and confirm the validity determination made by the after-hours on-call team through review of instrument diagnostic parameters and spectral validation (see Section 5.3 of this SOP).
5. Review recent **visibility measurements** and note any periods with visibility <2.5 miles on the spreadsheet.
    a. Periods with visibility <2.5 miles may impact the performance of open-path analyzers and often correlate with observations of invalid data at multiple sampling paths.
6. Check that the **meteorological instrumentation** is functional and that measured values are within reason (e.g. directional measurements are between 0–360 degrees, speeds generally match local weather conditions). Record any instances of missing or abnormal meteorological measurements in the daily observation spreadsheet and escalate to the field operations team.
7. Compare the current **open-path analyzer diagnostic parameters** to the acceptance criteria (see Section A.7 of the QAPP) to assess the operational status of the monitoring network.
    a. Periods with diagnostic parameters (e.g. signal strength, integration time) outside of acceptance criteria will result in invalid data and may result from open-path analyzer misalignment. Record these periods in the spreadsheet and escalate to the field operations team for necessary site visits.
8. Because data flagging for each compound is determined by the analyzer diagnostic parameters, review one **representative compound concentration time series** for each analyzer at each sampling site, and note the following information:
    a. Any periods of missing or invalid data.
    b. Any periods of data flagged for additional review (i.e. automated checks for range, rate-of-change, and sticking).
    c. For periods where data were flagged as invalid due to environmental conditions, confirm that (1) analyzer diagnostic parameters are outside of acceptance criteria, and (2) visibility is <2.5 miles.
    d. Any QC and OP codes that are inconsistent with the expected values, based on analyzer diagnostic parameters.

   e. Instances of apparent baseline drift.

   f. Reported concentrations (valid data) not within the specified range for each compound.

      i. Verify that concentration patterns are reasonable with respect to the time of day, season, and current meteorological conditions, and whether they correlate across multiple sampling sites. This check is for information purposes only and should not itself result in invalidation of data.

      ii. Verify that concentrations are within the limits of what can be measured by the instrument.

9. Perform any edits to QC and OP codes to reflect the findings of the daily data check. Additional information regarding propagation of these changes to the public website is provided in Section D.3 of the QAPP.

   a. Changes to **concentration values** are extremely infrequent and should only be made if a problem with the analytical concentration determination or the averaging scheme is discovered. Changes to QC and OP codes are often sufficient to correctly reflect data quality.

   b. Changes to **QC and OP codes** are infrequent, and are only made if a clear reason to do so is discovered.

      i. For example, invalidate data if there is a violation of the acceptance criteria that was not captured by AutoQC logic.

      ii. Similarly, validate data that was flagged for additional review if it meets acceptance criteria.

   c. All edits to data and data quality flags are captured by chain-of-custody logs within the DMS.

10. Verify detection events with elevated concentrations (>5–10 times the minimum detection limit) by performing spectral validation according to Section 5.3 of this SOP.

11. Navigate to the public website for the facility, review the 5-min time series plot for each individual compound, and verify that:

    a. Data displayed on the public site matches the data viewed in the non-public data review website (Sonoma Technology’s Insight DMS). Note any discrepancies in the spreadsheet and escalate to the Project Manager.

    b. Periods of missing or invalid data are correctly reflected on the public website.

    c. Detection events are correctly reflected on the public website, where suspect/questionable data flags are not shown for legitimate detection events.

12. Report any observed anomalies to the field operations team and Project Manager, and update the daily data check spreadsheet in the project documentation archive. Additional information regarding project documentation is provided in Section A.9 of the QAPP.

Typical observations for select diagnostic parameters and compounds monitored under BAAQMD Rule 12-15 are shown in Table 1. The full list of measured compounds is provided in Section A.5 of the QAPP.

Table 1. Typical observations for select compounds monitored under BAAQMD Rule 12-15.

Parameter	Observational Notes
Visibility	The maximum value measured by the sensor is 30 miles. Values <10 miles may affect instrument performance, and values <2.5 miles may result in invalid data due to environmental conditions if analyzer diagnostics are also not within acceptance criteria.
Integration Time (UV-DOAS)	This parameter is commonly between 20–250 ms for most sampling sites. Values stuck at 300 ms should be recorded and escalated to the field operations team. A pattern of elevated integration time and low signal strength can indicate poor instrument alignment. This parameter should be anticorrelated with visibility during fog events.
Signal Strength (UV-DOAS)	This parameter is commonly >70%. A pattern of elevated integration time and low signal strength can indicate poor instrument alignment.
Signal Power (TDLAS)	This parameter is commonly >0.1mW. A pattern of low signal power can indicate poor instrument alignment.
Signal Strength (FTIR)	This parameter is commonly >2%. A pattern of low signal strength can indicate poor instrument alignment.
Winds	Wind speeds are typically 1-20 mph, and wind direction should generally follow expected patterns due to local terrain (e.g., sea and land breezes along the coast).
Benzene	This parameter is typically below the detection limit of the instrument.
Toluene	This parameter is typically below the detection limit of the instrument.
Ethylbenzene	This parameter is typically below the detection limit of the instrument.
o-xylene	This parameter is typically below the detection limit of the instrument.
m-xylene	This parameter is typically below the detection limit of the instrument.
p-xylene	This parameter is typically below the detection limit of the instrument.

Parameter	Observational Notes
SO_2	This parameter is typically below the detection limit of the instrument, but ambient background concentration are detected occasionally.
H_2S	This parameter is typically below the detection limit of the instrument.

5.2 Quarterly Validation

Quarterly validation is performed after each calendar quarter to ensure quality and in accordance with BAAQMD Rule 12-15 requirements. The 5-min resolution data for all relevant parameters are exported from the Sonoma Technology Insight DMS and imported into an R analysis workbook. Here, analysts perform additional analyses, visualizations, and assessments to verify AutoQC, confirm determinations made during daily data checks, and perform completeness calculations (see Section A.7 of the QAPP).

Data analysts are qualified to perform quarterly analysis after a training period of at least three months. Training includes the daily data check steps outlined in Section 5.1, experience conducting daily data checks for a period of three months, and shadowing an experienced data analyst during at least one complete quarterly analysis process. The trainee’s work is reviewed by the experienced analyst while they perform their first round of quarterly analysis, and they are released for independent work during their second round.

The following procedure details the quarterly analysis process for an individual monitoring network:

1. Log in to the Sonoma Technology Insight DMS with the facility-specific credentials for the check being performed. Credentials are stored in a secure password management software.
2. Navigate to the Data Export page, where configurable export queries can be programmed and executed. Export all relevant parameters collected during the quarter as “.csv” files.
3. Import these exported data files into an R workspace using the most recent quarterly analysis script(s), maintained in the Sonoma Technology Bitbucket code repository.
4. Execute the quarterly analysis script(s), which performs the following tasks:
    a. Assign data flags using the same AutoQC logic as real-time data flagging (see Sections B.10 and D.2 of the QAPP).
    b. Flag negative outliers as invalid, using “–3 x MDL” as the threshold for comparison.
    c. Generate a series of output tables, figures, and “.csv” files for additional review.
5. Review the quarterly data set in detail. Note that findings pertaining to missing or invalid data are usually identified and corrected during the quarter, meaning the quarterly analysis process is commonly a redundant check on previously identified issues and resolutions. Any

new findings identified during quarterly analysis must be escalated to the Project Manager for investigation, and proposed resolutions must be approved by the QA Manager.

a. If >5% of diagnostic parameters (signal strength, integration time, spectral match) are missing, escalate the finding to the Project Manager for additional investigation.

b. If >25% of missing or invalid data are associated with one analyzer or sampling site, escalate the finding to the Project Manager for additional investigation.

c. If concentration data were collected but coincident diagnostic information was missing or outside of the specified range, AutoQC determinations are manually inspected to ensure accurate data flagging.

    i. If visibility data are missing during a period of invalid concentration data, manual data review confirms that concentration data **<u>are not</u>** flagged as "invalid due to environmental conditions." In the absence of visibility data to confirm low-visibility conditions, data count against completeness (see Section A.7 of the QAPP).

    ii. If instrument diagnostic parameters are missing but concentration data are reported, a malfunction of the analyzer software (which reports both fields simultaneously) has occurred and data are flagged as invalid.

    iii. If spectral match parameters are reported outside of the expected range (e.g. <0 or >100 for percent match), a malfunction of the data acquisition script has occurred and data are flagged as invalid.

d. Review periods where visibility data is <2.5 miles, ensuring that **<u>only</u>** concentration data with diagnostic parameters outside of acceptance criteria are flagged as "invalid due to environmental conditions" and are not counted against completeness.

e. Review periods of invalid or missing data lasting longer than two hours and escalate findings to the Project Manager. Create null records in the place of missing data according to Section C.2 of the QAPP.

f. Review periods of planned and unplanned maintenance and compare them to field logbooks and maintenance records. Ensure that routine maintenance was performed as scheduled, logs reflect a sufficient level of detail, and all bump tests results are within acceptance criteria.

    i. Any failed bump tests should have been followed by additional maintenance and retesting as outlined in the individual instrument SOPs.

    ii. Maintenance logs may explain data anomalies and justify adjustments to QC and OP Codes, following discussion with the Project Manager.

g. If applicable, review any suspect/questionable data for which investigation was not performed and QC and OP codes were not adjusted during the daily data checks.

Adjust QC and OP codes according to Section D.2 of the QAPP and escalate the finding(s) to the Project Manager.

   h. Review any and all changes to QC and OP codes, including their justification, with the Project Manager.

6. Assess the data reasonableness through statistical analyses, review of exceptional conditions off-refinery, and comparisons to outside data.
   a. For all sampling sites and parameters, calculate the monthly and quarterly 5-min concentration mean, standard deviation, and minimum and maximum values. Non-detections are assigned a value of “0 ppb” for statistical analysis.
      i. Compare observations to previous quarters and typical observations (Table 1) and escalate any anomalies to the Project Manager.
      ii. Confirm that known detection events observed during the quarter are correctly reflected in the calculated monthly and quarterly maxima.
      iii. Verify that the calculated monthly and quarterly minima are > “–3 x MDL,” and escalate the finding of any negative outliers to the Project Manager.
   b. In the event of anomalous data, review exceptional conditions off-refinery in conjunction with meteorological data to assess potential impacts to fenceline measurements. Data should not be invalidated based on the potential emission source being identified as off refinery property.
   c. In the event of anomalous data, retrieve available outside data sources for comparison according to Section B.9 of the QAPP.
7. Review any detection events and periods where reported concentrations are >5–10 times the minimum detection limit, according to Section 5.3 of this SOP.
8. For all sites and compounds, calculate data completeness according to Section A.7 of the QAPP.
   a. Review the resulting completeness tables and compare against logbooks and maintenance logs.
   b. Escalate findings of data completeness <95% to the Project Manager for additional investigation.
9. For all sites and compounds, manually calculate the rolling hourly average data from quality-controlled 5-min data, following the same logic used in real-time by the public website.
   a. Investigate the cause of any discrepancies between hourly values reported on the website and hourly values calculated during quarterly analysis, and escalate findings to the Project Manager.

5.3 Spectral Validation

Measurements made in real time by open-path analyzers can be replicated with manufacturer-provided data processing software. This enables analysts to visualize and confirm each real-time analytic determination made by the analyzer during daily and quarterly analysis, to ensure data accuracy and quality.

The following procedure details the spectral validation process:

1. Retrieve the relevant (raw) data files from the analyzer of interest, which correspond to the event requiring spectral validation.
    a. This consists of:
        i. The daily data summary file corresponding to the day of interest.
        ii. Individual absorbance spectra (including applicable background spectra) corresponding to the time period of interest.
        iii. Instrument libraries from the analyzer of interest.
        iv. The analytic software configuration file from the analyzer of interest.
2. Open the manufacturer-provided data processing software and adjust the analysis parameters to match the configuration file retrieved from the analyzer of interest.
3. Where applicable, load the instrument libraries and verify that the available compounds match the expected values for the monitoring network.
4. Since this is a differential measurement, concentrations are reported by comparing observations in detection to observations of clean air. Examine the daily data summary file from the date and time period of interest to determine which individual absorbance spectra are of interest, and (where applicable) which dynamic background was loaded for each absorbance spectrum.
5. Load the applicable background and absorbance spectra. The software will automatically duplicate the analysis, according to the configuration parameters (see Step 2 above), and generate a differential absorbance spectrum overlaid with the applicable instrument library.
6. Select the compound of interest and visually inspect the plot, confirming the curve fitting to the library reference spectrum, and associated spectral match determination relative to the programmed analysis regions.
7. Report any discrepancies or incorrect peak fits to the Project Manager for additional investigation.

5.4 Quality Assurance Management

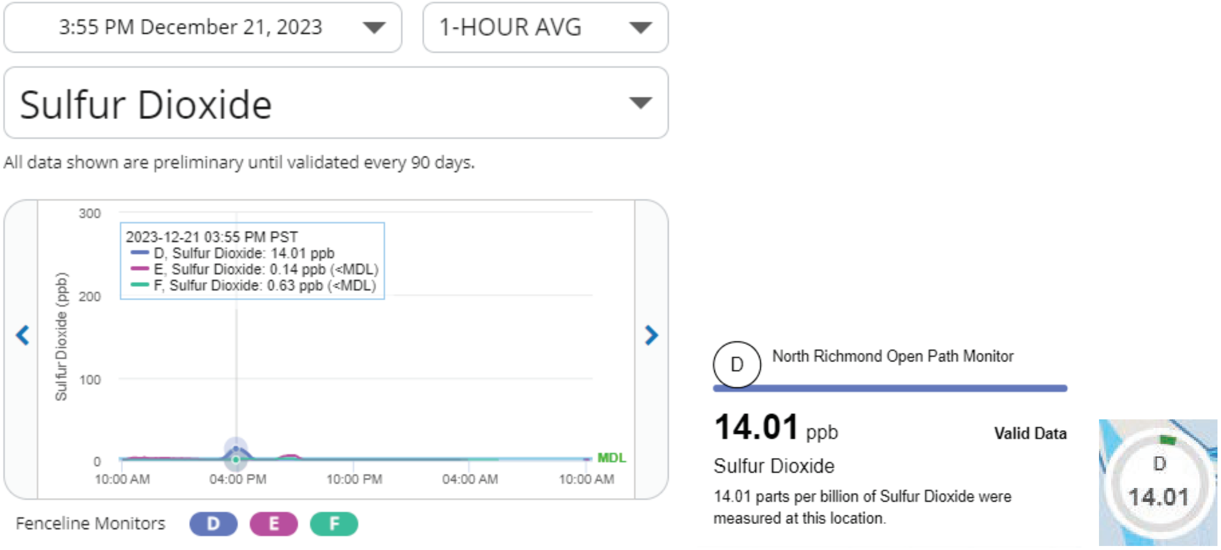
Following the completion of quarterly analysis, an independent review of post-QC quarterly data sets is completed by the QA Analyst. This independent review is conducted on a representative sub-set of data using similar methods to those described in Section 5.2 of this SOP. Data are reviewed without input from the data analyst who prepared the post-QC quarterly data set.

Findings of the independent review are compared to those of the quarterly analysis in a joint meeting between the Data Analyst, QA Analyst, and QA Manager. The QA Manager conducts an informal interview process to ensure that quarterly analysis was conducted according to the QAPP, and that field documentation reflects the procedures outlined by the QAPP. New findings or deviations are reported to the Project Manager by the QA Manager for additional investigation, and any necessary resolutions must be approved by the QA Manager before quarterly data are submitted (see Section C.2 of the QAPP).

6. Public Website Display

Data is displayed on the public website according to the data flags (QC and OP codes) for each record. Data flags are assigned by the AutoQC logic and further evaluated according to Section D.2 of the QAPP. Display behavior is the same for both 5-min data and rolling hourly average data.

Valid detections (e.g. QC=0, OP=0) are shown on the website (**Figure 2**). Concentrations are reported as recorded by the analyzer, with numeric values shown in the time series detail panel (left), the map detail panel (middle), and the map marker (right). For valid detections with concentrations below the MDL (e.g. QC=0, OP=17), numeric values are shown but data are flagged as "<MDL." For hourly data only, the outer ring of the map marker visualizes the concentration relative to an hourly threshold, with green indicating values below the threshold and orange indicating values above the threshold.



3:55 PM December 21, 2023

1-HOUR AVG

Sulfur Dioxide

All data shown are preliminary until validated every 90 days.

2023-12-21 03:55 PM PST
D, Sulfur Dioxide: 14.01 ppb
E, Sulfur Dioxide: 0.14 ppb (<MDL)
F, Sulfur Dioxide: 0.63 ppb (<MDL)

North Richmond Open Path Monitor

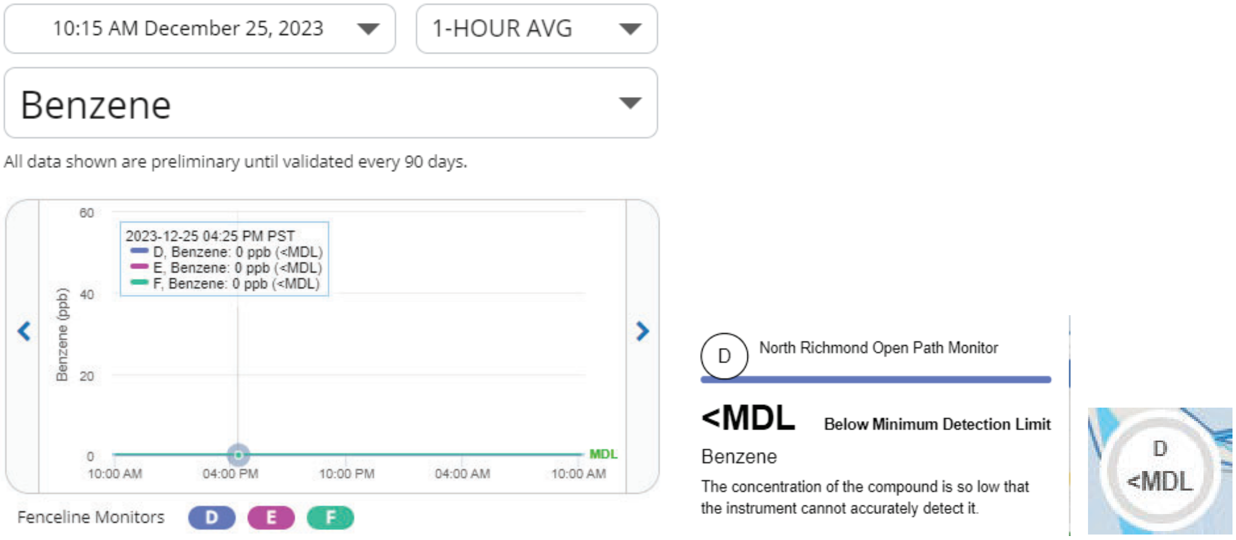
14.01 ppb **Valid Data**

Sulfur Dioxide

14.01 parts per billion of Sulfur Dioxide were measured at this location.

Figure 2: Example of valid detections as displayed on the public website.

Valid non-detections (e.g. QC=0, OP=74) are shown on the website (**Figure 3**). Concentrations are reported as "0 ppb" on the time series detail panel (left) according to Section D.2 of the QAPP. On the map detail panel (middle) and map marker (right), valid non-detections are flagged as "<MDL."



10:15 AM December 25, 2023

1-HOUR AVG

Benzene

All data shown are preliminary until validated every 90 days.

2023-12-25 04:25 PM PST
D, Benzene: 0 ppb (<MDL)
E, Benzene: 0 ppb (<MDL)
F, Benzene: 0 ppb (<MDL)

North Richmond Open Path Monitor

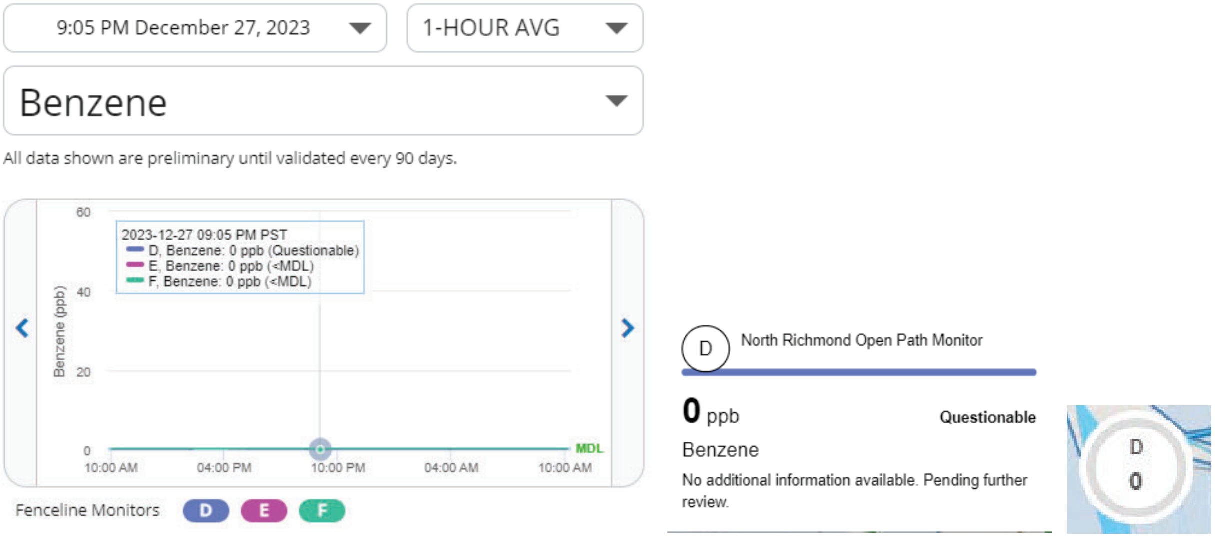
<MDL **Below Minimum Detection Limit**

Benzene

The concentration of the compound is so low that the instrument cannot accurately detect it.

Figure 3: Example of valid non-detections as displayed on the public website.

Suspect/Questionable data (e.g. QC=5) are shown on the website (**Figure 4**). Concentration values are reported on the time series detail panel (left), either as recorded (e.g. OP=72) or as "0 ppb" (e.g. OP=76), depending on whether or not they correspond to detection events. The map detail panel (middle) and map marker (right) do not display these values and indicate that further review is needed. This additional review is completed according to Section D.2 of the QAPP.



9:05 PM December 27, 2023

1-HOUR AVG

Benzene

All data shown are preliminary until validated every 90 days.

2023-12-27 09:05 PM PST
D, Benzene: 0 ppb (Questionable)
E, Benzene: 0 ppb (<MDL)
F, Benzene: 0 ppb (<MDL)

North Richmond Open Path Monitor

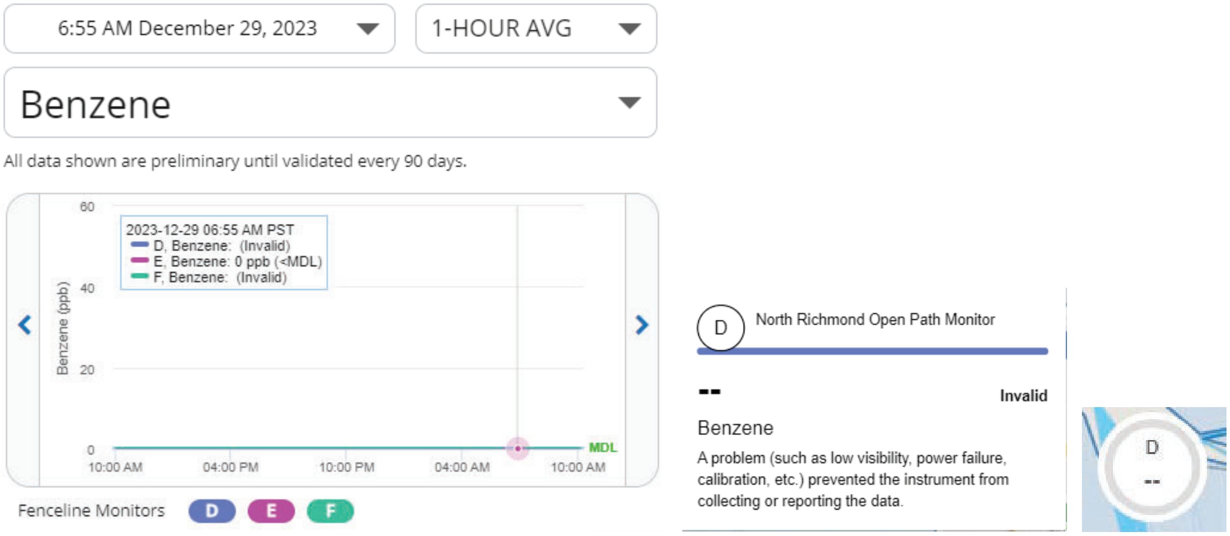
0 ppb — Questionable

Benzene

No additional information available. Pending further review.

Figure 4: Example of questionable data as displayed on the public website.

Invalid data (e.g. QC=9) are not shown on the website (Figure 5). Concentration values are not reported on the time series detail panel (left), the map detail panel (middle), or the map marker (right), because the data do not meet acceptance criteria.



6:55 AM December 29, 2023

1-HOUR AVG

Benzene

All data shown are preliminary until validated every 90 days.

2023-12-29 06:55 AM PST
D, Benzene: (Invalid)
E, Benzene: 0 ppb (<MDL)
F, Benzene: (Invalid)

North Richmond Open Path Monitor

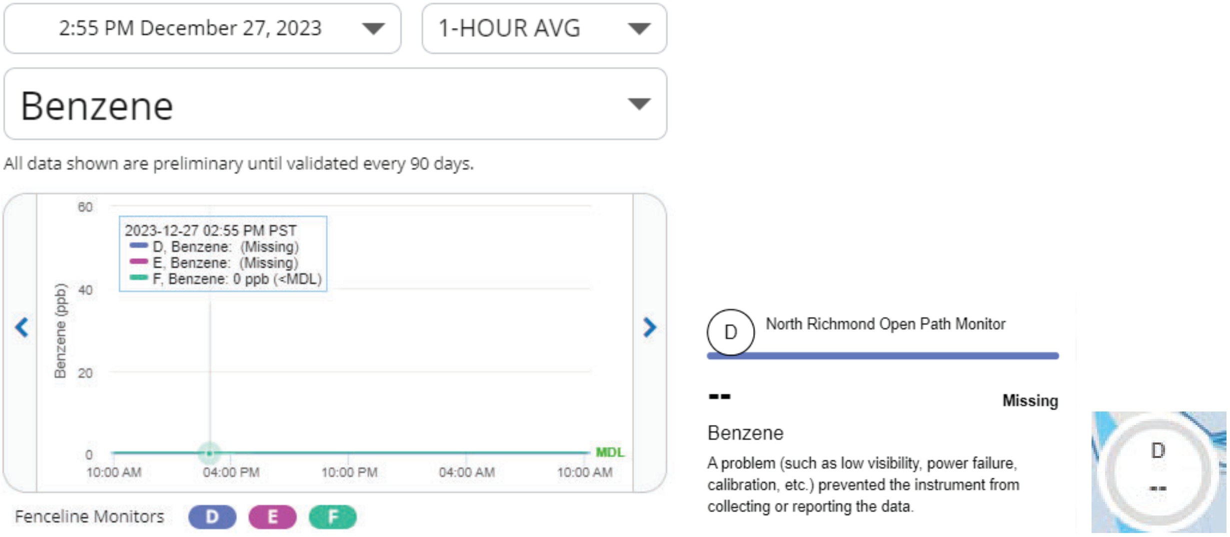
-- — Invalid

Benzene

A problem (such as low visibility, power failure, calibration, etc.) prevented the instrument from collecting or reporting the data.

Figure 5: Example of invalid data as displayed on the public website.

Missing data (e.g. QC=8) are not shown on the website (Figure 6). Concentration values are not reported on the time series detail panel (left), the map detail panel (middle), or the map marker (right), because data were not collected. Missing data results in internal alerts to the project team (see Section B.6 of the QAPP).



2:55 PM December 27, 2023

1-HOUR AVG

Benzene

All data shown are preliminary until validated every 90 days.

2023-12-27 02:55 PM PST
D, Benzene: (Missing)
E, Benzene: (Missing)
F, Benzene: 0 ppb (<MDL)

D North Richmond Open Path Monitor

-- Missing

Benzene

A problem (such as low visibility, power failure, calibration, etc.) prevented the instrument from collecting or reporting the data.

Figure 6: Example of missing data as displayed on the public website.

7. Daily Data Check Spreadsheet

Complete the checks described below and record observations in the space provided. Note any corrective action or issues that were escalated to the field operations team or Project Manager. Additional information regarding acceptance criteria is provided in Section A.7 of the QAPP.

Data Analyst: ________________________ Date and Time: ____________________________

Parameter	Reference	Observations
Internal Website Review (5-min data)		
UV-DOAS		
Signal Intensity	Confirm that values ≥70%	
Integration Time	Confirm that values ≤250 ms	
Representative Parameter (e.g., benzene)	Record any instances of invalid data	
	Record any instances of missing data	
	Record maximum concentration	
TDLAS		
Signal Power	Confirm that values ≥0.1 mW	
H_2O Spectral Match	Confirm that values **>**0.95	
Real-Time MDL (rtMDL)	Record any instances of rtMDL >25 ppb	
Representative Parameter (e.g., H_2S)	Record any instances of invalid data	
	Record any instances of missing data	
	Record maximum concentration	
FTIR		
Signal Intensity	Confirm that values ≥70%	
Representative Parameter (e.g., methane)	Record any instances of invalid data	
	Record any instances of missing data	
	Record maximum concentration	
Met		
Visibility	Confirm that values >2.5 mi	
Wind Direction	Confirm that values are reasonable (0-360 degrees)	
Wind Speed	Confirm that values are within typical values for this site	
Public Website Review (5-min data)		
UV-DOAS	Record any instances of invalid data	
	Record any instances of missing data	
	Record any benzene detection events	
	Record any toluene detection events	
	Record any ethylbenzene detection events	
	Record any m-xylene detection events	
	Record any o-xylene detection events	
	Record any p-xylene detection events	
	Record any SO_2 detection events	
TDLAS	Record any instances of invalid data	
	Record any instances of missing data	
	Record any H_2S detection events	

Parameter	Reference	Observations
FTIR	Record any instances of invalid data	
	Record any instances of missing data	
	Record any methane detection events	
	Record any ethane detection events	
	Record any propane detection events	
	Record any butane detection events	
	Record any pentane detection events	
All Compounds	Record any instances of missing data	