Appendix A
Detailed Statistical Analysis Results

A.1 Response Time

The ANOVA analyses of response time are contained in the following sections (see Chapter 5 for more details on the ANOVA procedure used). It should be noted that, in all cases, the log response time was modeled. The geometric mean of each result from the ANOVA model was then used to put the findings back into the original scale (as opposed to the log scale).

A.1.1 Effect of Temperature on TIC Response Time

The HAZMATCAD Plus response time for each TIC was tested at low, medium, and high temperature. Test IDs included in this analysis are contained in Table A-1. Over the range of temperature settings, average response time varied from a low of about 8 seconds with the AC runs to a high of about 12 seconds with the CG runs.

Table A-1. IDs of Tests Included in the Test of Effect of Temperature on TIC Response Time

AC-01-A	CG-01-A	Cl_2-01-A	SA-01-A
AC-01-B	CG-01-B	Cl_2-01-B	SA-01-B
AC-05-A	CG-05-A	Cl_2-05-A	SA-05-A
AC-05-B	CG-05-B	Cl_2-05-B	SA-05-B
AC-07-A	CG-07-A	Cl_2-07-A	SA-07-A
AC-07-B	CG-07-B	Cl_2-07-B	SA-07-B

P-values for tests of the effects of temperature are contained in Table A-2. For each test, the p-value is greater than 0.05. Thus, there is no evidence that temperature has an effect on HAZMATCAD Plus response time.

Table A-2. Tests for Effects of Temperature on Response Time by TIC

TIC	P-value
AC	0.18
CG	0.78
Cl_2	0.16
SA	0.93

A.1.2 Effect of Humidity on TIC Response Time

The HAZMATCAD Plus response time for each TIC also was tested at low, medium, and high humidity. Test IDs for this analysis are contained in Table A-3. P-values for tests of these effects are contained in Table A-4.

Table A-3. IDs of Tests Included in the Test of Effect of Humidity on TIC Response Time

AC-01-A	CG-01-A	Cl_2-01-A	SA-01-A
AC-01-B	CG-01-B	Cl_2-01-B	SA-01-B
AC-03-A	CG-03-A	Cl_2-03-A	SA-03-A
AC-03-B	CG-03-B	Cl_2-03-B	SA-03-B
AC-04-A	CG-04-A	Cl_2-04-A	SA-04-A
AC-04-B	CG-04-B	Cl_2-04-B	SA-04-B

Table A-4. Tests for Effects of Humidity on Response Time by TIC

TIC	P-value
AC	0.56
CG	0.03
Cl_2	0.27
SA	0.64

As evidenced by Table A-4, humidity only has a significant effect on the response time for CG. For each TIC, Figure A-1 provides the modeled geometric means of response time based on the appropriate ANOVA model.

From Figure A-1, the longest response time for CG is for the highest level of humidity. It should be noted that while there is a *statistically* significant difference among the response times for the different levels of humidity for CG, the difference does not seem practically significant.

A.1.3 Effect of Start State on TIC Response Time

The HAZMATCAD Plus response time for AC was recorded under medium temperature and humidity with three start states:

1. Cold soak/cold start
2. Hot soak/cold start
3. Room temperature/cold start

The average response time varied from a low of about 7 seconds with cold soak/cold start runs to a high of about 8 seconds with the room temperature/cold start runs. Start-state results were combined with the responses from the medium humidity and medium temperature AC results from the previous tests for the sake of comparison. The test IDs for this analysis are contained in Table A-5. The p-value for the significance of start state is 0.63, so there is no evidence that start state has a significant effect on HAZMATCAD Plus response time.

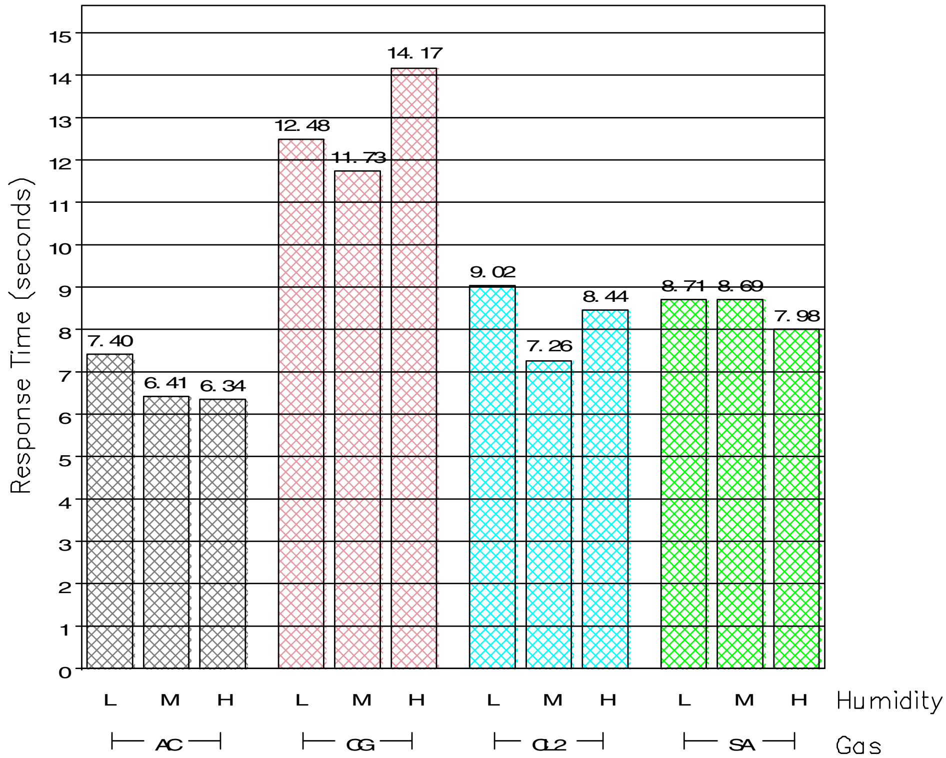

Figure A-1. Modeled geometric mean of the response time by TIC and level of humidity.

Table A-5. IDs of Tests Included in the Test of Effect of Start State on TIC Response Time

AC-01-A
AC-01-B
AC-20-A
AC-20-B
AC-21-A
AC-21-B
AC-22-A
AC-22-B

A.1.4 Effect of Temperature on CW Agent Response Time

The tests used to assess the effect of temperature on response time are identified in Table A-6. For GB, there were 5 runs at each temperature level. For HD there were 10 runs at each of two temperature levels: medium and high. It was not possible to include HD data at low temperature at the targeted HD concentration because the test was run at a lower concentration.

Table A-6. IDs of Tests included in the Agent Testing of the Effect of Temperature on Response Time

GB-01-BA1	HD-1A-1
GB-5-1	HD-1B-1
GB-7-1	HD-7A-1
	HD-7B-1

With both GB and HD, there was no evidence that temperature has an effect on HAZMATCAD Plus response time (p-values of 0.79 and 0.92, respectively).

A.1.5 Effect of Humidity on CW Agent Response Time

The tests used to assess the effect of humidity on response time are identified in Table A-7. For HD there were 10 runs at each humidity level. For GB there were 5 runs at each humidity level. One of the GB high humidity runs had no response and thus no associated response time. The remaining high humidity runs were associated with a response, but the response was not stable. For those runs, an initial response time was captured and that time is used in the analysis.

Table A-7. IDs of Tests included in the Agent Testing of the Effect of Humidity on Response Time

GB-01-BA1	HD-1A-1
GB-03-B	HD-1B-1
GB-04-B	HD-3A-1
	HD-3B-1
	HD-4AA-1
	HD-4BA-1

With both GB and HD, there was no evidence that humidity has an effect on HAZMATCAD Plus response time (p-values of 0.18 and 0.06, respectively).

A.1.6 Summary of Response Time Analysis

Variations in temperature, humidity, and start state appear to have little effect on HAZMATCAD Plus response time. Over all testing, the only significant finding was for CG with variation in humidity, but the effect did not appear to be of practical significance.

A.2 Recovery Time

The humidity and temperature recovery time data were analyzed with a standard ANOVA model. None of the recovery times in those tests exceeded the maximum allowable time of 600 seconds.

For the analysis of start state, some of the TIC recovery time data were "censored," i.e., truncated at 600 seconds, even though HAZMATCAD Plus response had not yet returned to baseline after that length of time. A survival model as described in Chapter 5 was used.

It should be noted that, in all cases, the log recovery time was modeled. The geometric mean of each result from the appropriate model was then used to put the findings back into the original scale (as opposed to the log scale).

A.2.1 Effect of Temperature on TIC Recovery Time

The HAZMATCAD Plus recovery time for each TIC was tested at low, medium, and high temperature. P-values for tests of these effects are contained in Table A-8. (Test IDs included in this analysis can be found in Table A-1 in Section A.1.1)

Table A-8. Tests for Effects of Temperature on Recovery Time

TIC	P-value
AC	<0.01
CG	<0.01
Cl_2	<0.01
SA	0.49

As evidenced by Table A-8, temperature has a significant effect on recovery time for every TIC except SA. Figure A-2 contains the geometric mean recovery time for each TIC by level of temperature based on the ANOVA model for each TIC.

While differences among the levels of temperature are evident for each of the first three TICs, the greatest differences are apparent for AC. In this case, recovery time increases as temperature decreases. The mean recovery time for AC under low temperature is more than twice as long as that for AC at higher temperatures, as well as that for any other TIC under any temperature level.

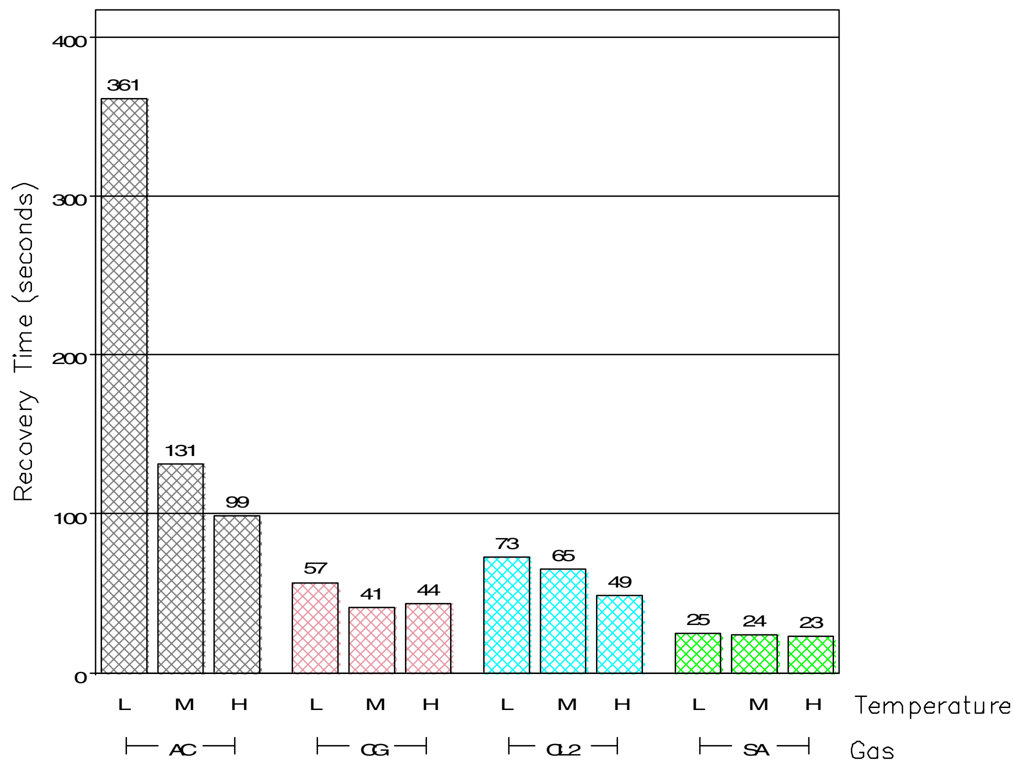

Figure A-2. Modeled geometric mean of recovery time by TIC and level of temperature.

A.2.2 Effect of Humidity on TIC Recovery Time

The HAZMATCAD Plus recovery time for each TIC also was tested at low, medium, and high humidity. P-values for tests of these effects are contained in Table A-9. (Test IDs included in this analysis can be found in Table A-3 in Section A.1.2.)

As evidenced by Table A-9, humidity has a significant effect on the recovery time for AC, CG and Cl_2. Figure A-3 contains the geometric mean for recovery time based on the ANOVA models by TIC and level of humidity.

Once again, the largest differences among recovery times for the different levels of humidity occur for AC. The recovery time for AC is longest for medium humidity.

Table A-9. Tests for Effects of Humidity on Recovery Time

TIC	P-value
AC	<0.01
CG	<0.01
Cl_2	0.02
SA	0.84

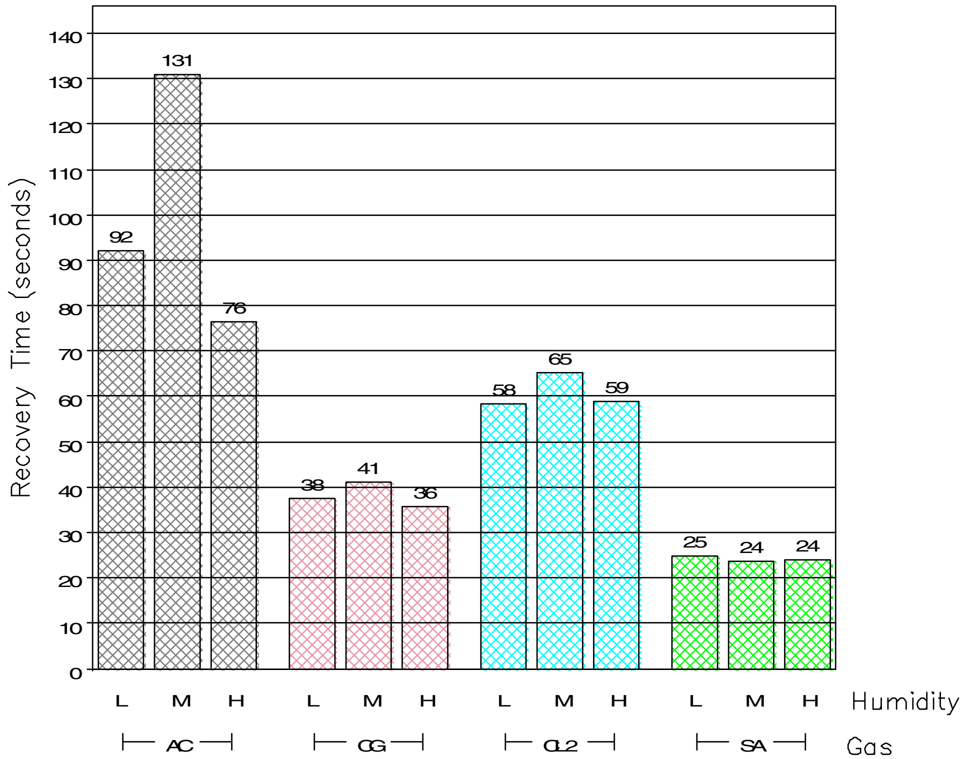

Figure A-3. Modeled geometric mean of recovery time by TIC and level of humidity.

A.2.3 Effect of Start State on TIC Recovery Time

The HAZMATCAD Plus recovery time for AC was recorded under medium temperature and humidity with three start states:

1. Cold soak/cold start
2. Hot soak/cold start
3. Room temperature/cold start

These results were combined with the responses from the medium humidity and medium temperature AC results from the previous tests for the sake of comparison. The p-value for the significance of start state is <0.01, indicating that start state does have a significant effect on HAZMATCAD Plus recovery time. (See Table A-5 in Section A.1.3 for a list of test IDs included in this analysis.) The p-values comparing the recovery times for each of the three start states with the control start state are contained in Table A-10.

Table A-10. Effect of Each Start State on Recovery Time Compared with the Control Start State

Comparison	P-value
Cold Soak/Cold Start vs. Control	0.06
Hot Soak/Cold Start vs. Control	0.02
Room Temperature Cold Start vs. Control	<0.01

As evidenced by Table A-10, both the Hot Soak and Room Temperature start states have recovery times that differ significantly from the recovery time for the control start state. Figure A-4 contains the modeled geometric mean recovery times by start state.

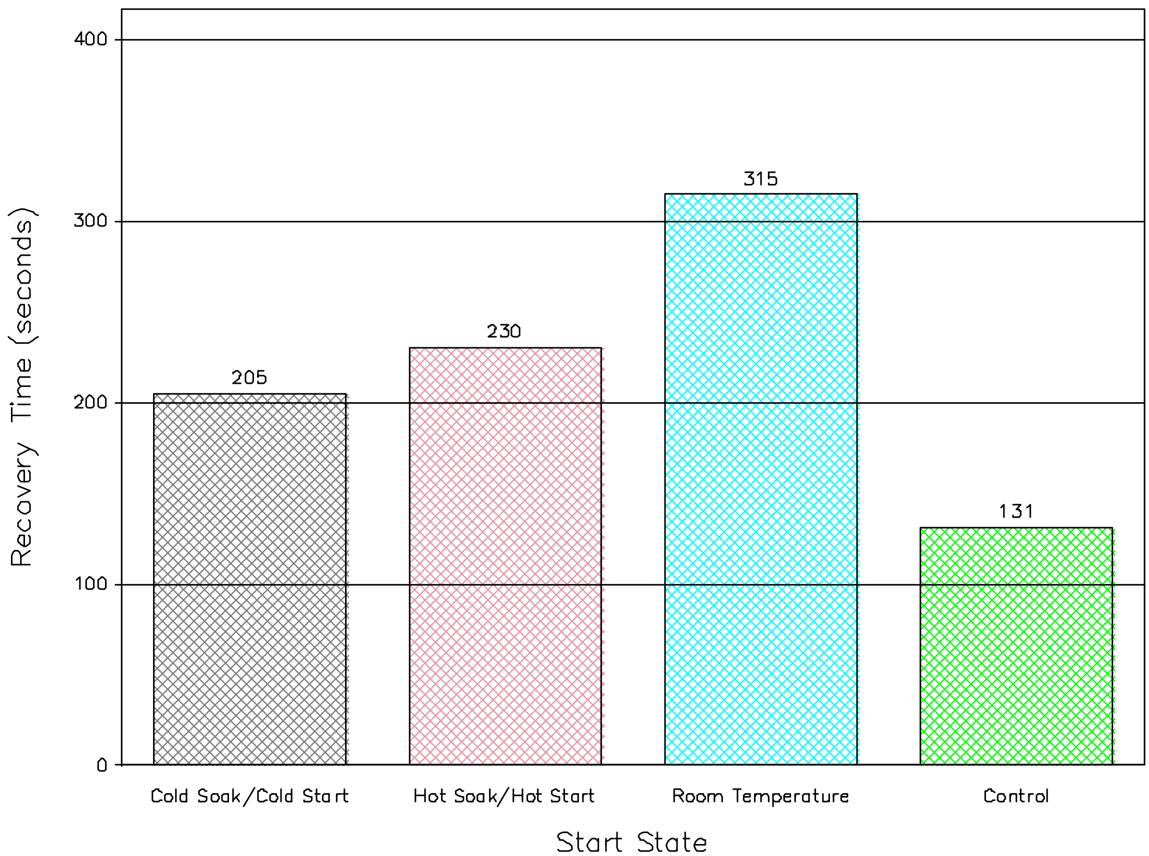

Figure A-4. Modeled geometric mean of recovery time by start state.

As the figure suggests, the recovery times for Hot Soak/Hot Start and Room Temperature are greater than the recovery time for the control tests.

A.2.4 Effect of Temperature on CW Agent Recovery Time

Data available for the agent analysis of the effect of temperature on recovery time came from the tests identified in Table A-6. For both agents, there was evidence that temperature had an effect on HAZMATCAD Plus recovery time (p-value <0.01 for both agents). Figure A-5 summarizes the modeled geometric mean of recovery time for each agent by temperature level. Recovery time appears to be greater for lower temperatures.

A.2.5 Effect of Humidity on CW Agent Recovery Time

Data available for the agent analysis of the effect of humidity on recovery time came from the tests identified in Table A-7. For GB, the high humidity runs at room temperature had either no

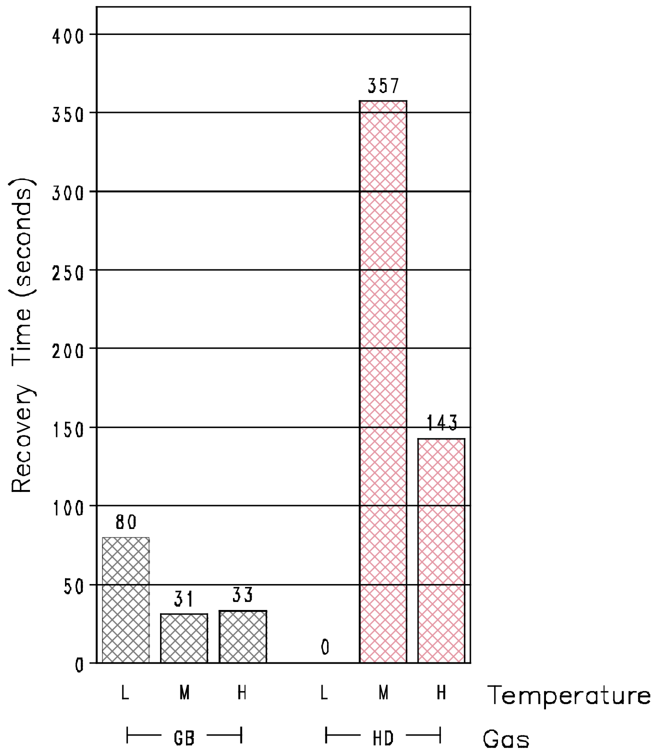

Figure A-5. Modeled geometric mean of recovery time by agent and temperature level.

response or an unstable response. For all five high humidity runs, no recovery time could be captured. These runs were not included in the analysis.

For both agents, there was evidence that humidity had an effect on HAZMATCAD Plus recovery time (p-value <0.01 for both agents). Figure A-6 summarizes the modeled geometric mean of recovery time for each agent by humidity level. The trends were not consistent. Recovery time was longer for higher humidity in the case of GB, but longer for lower humidity in the case of HD.

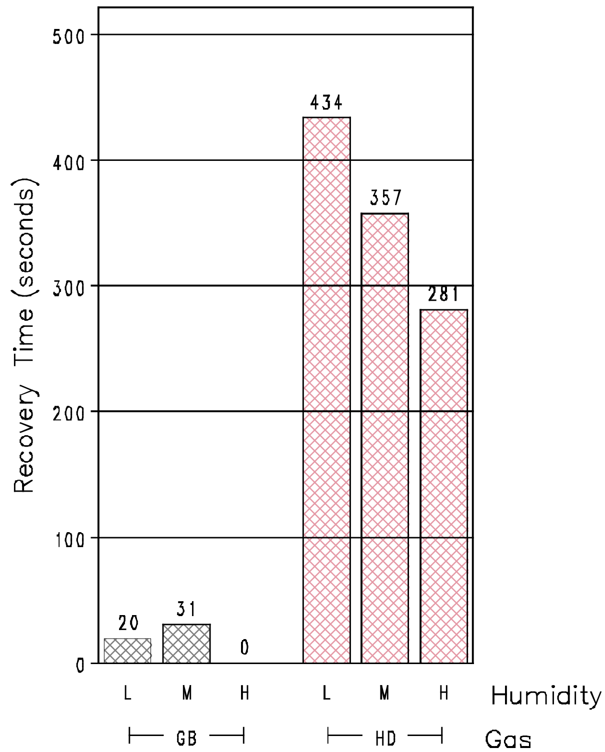

Figure A-6. Modeled geometric mean of recovery time by agent and humidity level.

A.2.6 Summary of Recovery Time Analysis

In contrast to response time, variation in temperature, humidity, and start state appear to have an effect on HAZMATCAD Plus recovery time. Over all the testing, only SA was not associated with a statistically significant finding.

A.3 Accuracy

The following sections present the results of analyses of the accuracy of HAZMATCAD Plus response. The HAZMATCAD Plus was considered to be "accurate" under a given set of conditions if the HAZMATCAD Plus:

1. Alarmed in the presence of a TIC or CW agent challenge
2. Correctly identified the TIC or CW agent

A.3.1 Effects of Temperature and Humidity on TIC Accuracy

The correct identification for each TIC was as follows:

1. AC: blood or choke (BLOD or CHOK)
2. CG: choke (CHOK)
3. Cl_2: halogen (HALO)
4. SA: hydride (HYDR)

The HAZMATCAD Plus performed with perfect accuracy (by the criteria above) with the TICs under all levels of temperature and humidity. The test IDs for TIC accuracy are contained in Table A-11.

Table A-11. IDs of Tests for Determining TIC Accuracy

AC-01-A	CG-01-A	Cl_2-01-A	SA-01-A
AC-01-B	CG-01-B	Cl_2-01-B	SA-01-B
AC-03-A	CG-03-A	Cl_2-03-A	SA-03-A
AC-03-B	CG-03-B	Cl_2-03-B	SA-03-B
AC-04-A	CG-04-A	Cl_2-04-A	SA-04-A
AC-04-B	CG-04-B	Cl_2-04-B	SA-04-B
AC-05-A	CG-05-A	Cl_2-05-A	SA-05-A
AC-05-B	CG-05-B	Cl_2-05-B	SA-05-B
AC-07-A	CG-07-A	Cl_2-07-A	SA-07-A
AC-07-B	CG-07-B	Cl_2-07-B	SA-07-B

A.3.2 Effects of Temperature and Humidity on CW Agent Accuracy

Data available for the agent analysis of the effect of temperature on accuracy came from the tests identified in Table A-6. The HAZMATCAD Plus performed with perfect accuracy under all levels of temperature for both agents. Given 35 out of 35 accurate responses, a lower bound on the chance of an accurate response with medium humidity under varying temperature conditions is 92%.

Data available for the agent analysis of the effect of humidity on accuracy came from the tests identified in Table A-7. For HD, the HAZMATCAD Plus performed with perfect accuracy under all humidity conditions. For GB, one of the HAZMATCAD Plus units did not respond. The other HAZMATCAD Plus unit performed with perfect accuracy under low and medium humidity. However, all of the 5 high humidity runs were inaccurate due to the lack of a stable response.

It would seem that the HAZMATCAD Plus has little chance of accurate performance in the presence of GB at high humidity. However, only 5 runs were made. Hence an estimate of the true chance of inaccuracy at high humidity has a large error. Given 5 out of 5 inaccurate responses, a lower bound on the chance of inaccuracy with high humidity is only 55%.

A.3.3 Summary of Accuracy Analysis

Variation in temperature and humidity do not appear to affect the accuracy of the HAZMATCAD Plus response to TICs; and variation in temperature does not appear to affect the accuracy of the HAZMATCAD Plus response to agents. The HAZMATCAD Plus responded with perfect accuracy throughout this testing.

The humidity testing of agents, however, did not follow the same pattern. While the HAZMATCAD Plus responded with perfect accuracy to HD under all humidity conditions, for all the high humidity runs, response to GB was unstable.

A.4 Repeatability

The following sections contain the statistical analyses of the repeatability of HAZMATCAD Plus response, response time, and recovery time. For TICs, see Table A-1 in section A.1.1 for the test IDs used to determine the effects of temperature on repeatability; and Table A-3 in section A.1.2 contains the test IDs used to determine the effects of humidity on repeatability.

A.4.1 Repeatability of TIC Response

For testing repeatability of response, the mode (the most common response) of all responses observed under a given condition was computed. Then the number of observed responses that equal that value was determined. The proportion of responses equaling the most common response was the measure for HAZMATCAD Plus response repeatability. The effects of temperature and humidity were tested using a logit model (see Chapter 5 for more details).

For all TICs except Cl_2, repeatability was perfect under all levels of temperature and humidity (a high response was recorded consistently for AC, CG, and SA). Chlorine was associated with more variability in response. Typically the HAZMATCAD Plus registered a medium response with Cl_2. For one of the 10 runs at high temperature, it responded with a low; and for 8 of the 10 runs at high humidity it responded with low. However, neither of the deviations was statistically significant. The p-values for temperature and humidity for Cl_2 were 0.32 and 0.10, respectively. Given the mix of concentrations and TICs used in the repeatability analysis, there appears to be no evidence for a temperature or humidity effect on HAZMATCAD Plus response repeatability.

A.4.2 Repeatability of TIC Response Time

A Brown-Forsythe test of equal variances was used to test the effect of temperature and humidity on repeatability of response and recovery time. When there is a difference between the variability in time for the different levels of temperature or humidity, there is evidence that temperature or humidity has an effect on the repeatability of the response or recovery time.

For the TICS, there were no significant differences in variability of response time for the different levels of temperature or the different levels of humidity.

A.4.3 Repeatability of TIC Recovery Time

Table A-12 contains the p-values for the effects of temperature on the repeatability of recovery time.

Table A-12. Effects of Temperature on the Repeatability of TIC Recovery Time

TIC	P-value
AC	0.13
CG	0.34
Cl_2	0.01
SA	0.37

The effect of temperature on the repeatability of recovery time is significant for Cl_2. Figure A-7 illustrates the spread in observed recovery times with Cl_2 through box plots. The figure indicates that recovery time is most repeatable under medium temperature.

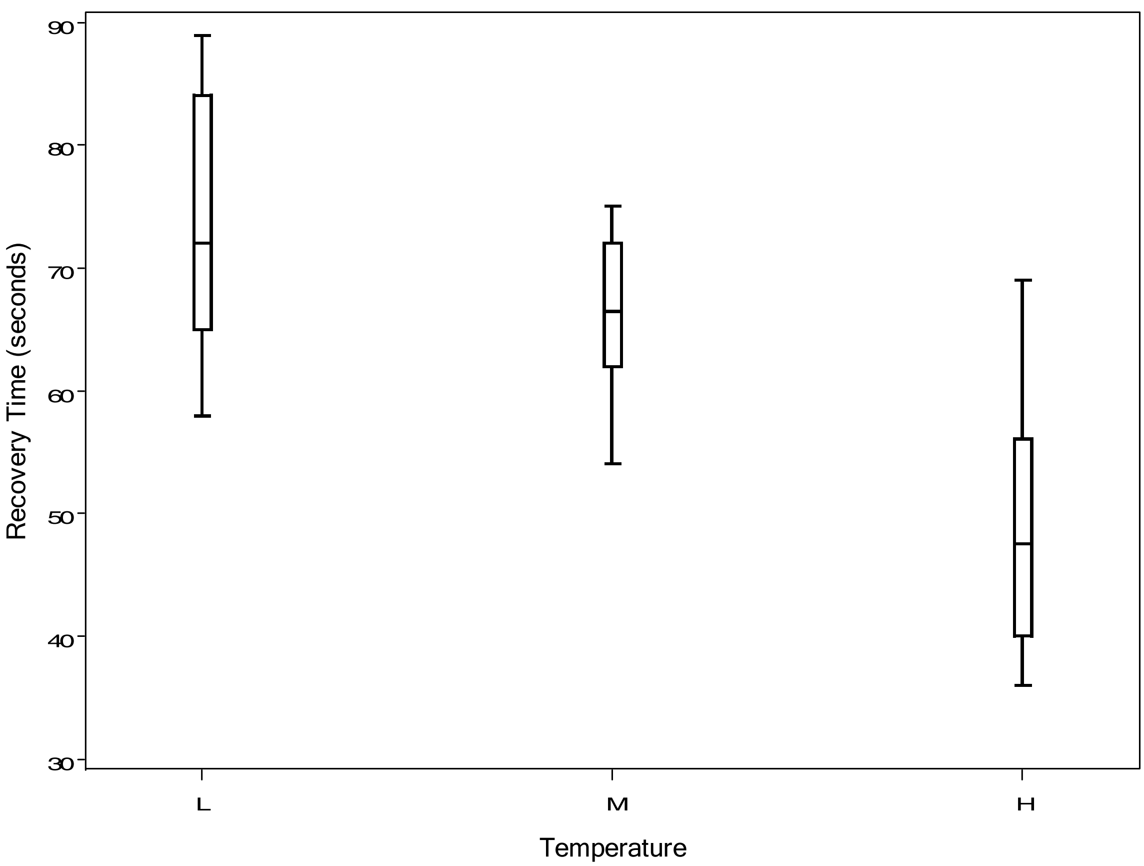

Figure A-7. Box plots for recovery time by temperature for Cl_2.

Table A-13 contains the p-values for the effects of humidity on the repeatability of recovery time. This table indicates that humidity is only significant for AC.

Table A-13. Effects of Humidity on the Repeatability of TIC Recovery Time

TIC	P-value
AC	<0.01
CG	0.46
Cl_2	0.19
SA	0.94

Figure A-8 contains box plots for the observed times at different levels of humidity for AC. Clearly the greatest variability in recovery time occurs under medium humidity.

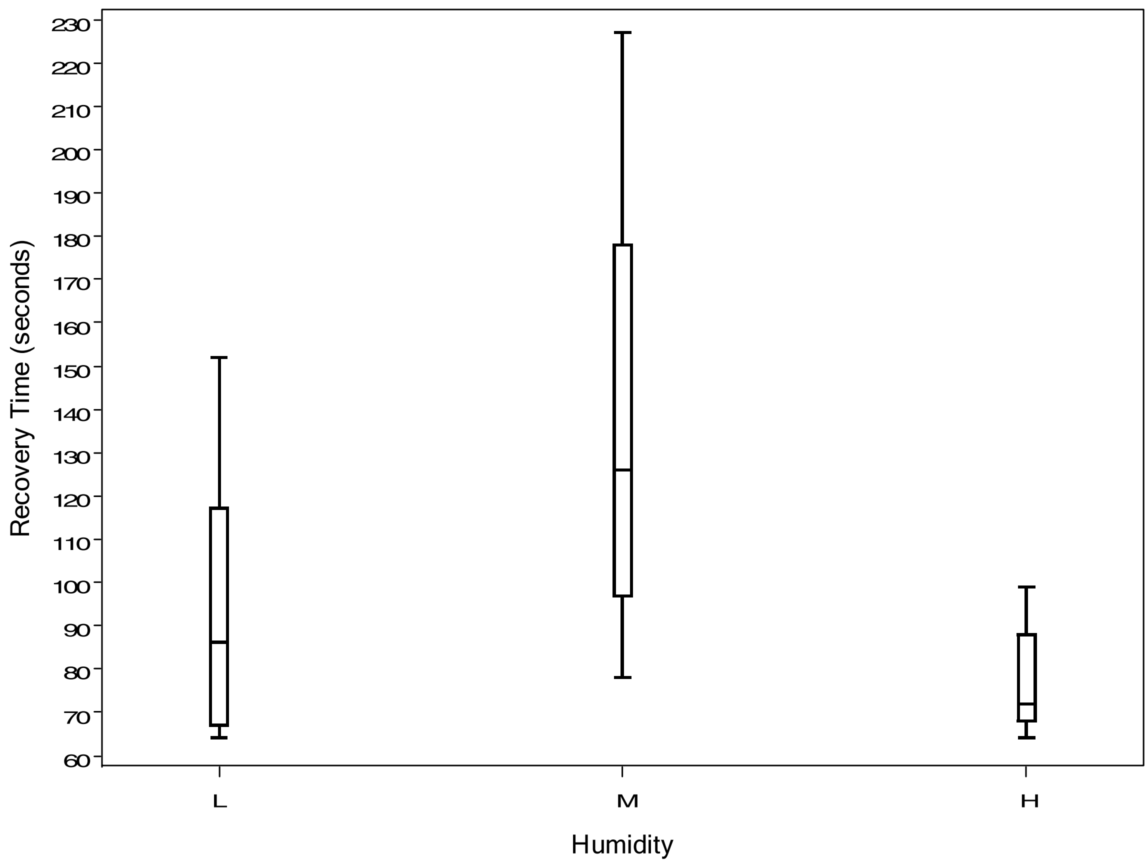

Figure A-8. Box plots for recovery time by humidity for AC.

A.4.4 Repeatability of CW Agent Response

Data available for the agent analysis of the effect of temperature on the repeatability of response came from the tests identified in Table A-6. For each agent, there was no evidence that temperature affects repeatability of response. At each temperature level, the response was perfectly consistent.

Data available for the agent analysis of the effect of humidity on the repeatability of response came from the tests identified in Table A-7. At each humidity level, the response of the HAZMATCAD Plus to HD was perfectly consistent. For GB at high humidity there was either no response or the response was not stable, while at both medium and high temperature, the response was perfectly consistent. In summary, the data from the agents provides no evidence that humidity affects repeatability of response, with the caveat that at high humidity the HAZMATCAD Plus appears to consistently have problems responding to GB.

A.4.5 Repeatability of CW Agent Response Time

Data available for the agent analysis of the effect of temperature on the repeatability of response time came from the tests identified in Table A-6. With both GB and HD, there was no evidence that temperature has an effect on repeatability of response time (p-values of 0.94 and 0.19, respectively).

Data available for the agent analysis of the effect of humidity on the repeatability of response time came from the tests identified in Table A-7. The runs used for the analysis were those used for the analysis of the effect of humidity on response time. With both GB and HD, there was no evidence that humidity affects repeatability of response time (p-values of 0.27 and 0.45, respectively).

A.4.6 Repeatability of CW Agent Recovery Time

Data available for the agent analysis of the effect of temperature on the repeatability of recovery time came from the tests identified in Table A-6. With both GB and HD, there was no evidence that temperature has an effect on repeatability of recovery time (p-values of 0.91 and 0.07, respectively).

Data available for the agent analysis of the effect of humidity on the repeatability of recovery time came from the tests identified in Table A-7. The runs used for the analysis were those used for the analysis of the effect of humidity on recovery time. With both GB and HD, there was no evidence that humidity has an effect on repeatability of recovery time (p-values of 0.71 and 0.79, respectively).

A.4.7 Summary of Repeatability Analysis

Variation in temperature and humidity appear to have little affect on the repeatability of HAZMATCAD Plus performance. Over all the repeatability testing, only two TICs were associated with statistically significant findings, both in the testing of the repeatability of recovery time. Temperature appeared to have an effect on the repeatability of recovery from Cl_2 and humidity on the repeatability of recovery from AC.

A.5. Effects of Temperature, Humidity, and Start State on Response

A.5.1 Effect of Temperature on TIC Response

The HAZMATCAD Plus response to each TIC was tested under medium humidity at low, medium, and high temperature. The test IDs used in the following statistical analysis are included in Table A-1 in Section A.1.1. A high response was recorded for all tests under all temperatures for every TIC except Cl_2. Typically the HAZMATCAD Plus registered a medium response with Cl_2. For one of the 10 runs at high temperature, it responded with a low. A Jonckheere-Terpstra test was used to test the effect of temperature on HAZMATCAD Plus response to Cl_2 (see Chapter 5 for more details). The p-value for this test was 0.67, indicating that there is no evidence that temperature has a significant effect on the HAZMATCAD Plus response.

A.5.2 Effect of Humidity on TIC Response

The HAZMATCAD Plus response to each TIC also was tested under medium temperature at low, medium, and high humidity. The test IDs used in the following statistical analysis are included in Table A-3 in Section A.1.2. As in the temperature tests, a high response was recorded for all tests under all temperatures for every TIC except Cl_2. A Jonckheere-Terpstra test was used to test the effect of humidity on HAZMATCAD Plus response to Cl_2 (see Chapter 5 for more details). The p-value for this test was <0.01, indicating that humidity has a significant effect on HAZMATCAD Plus response. Figure A-9 contains the counts for each response by level of humidity for Cl_2.

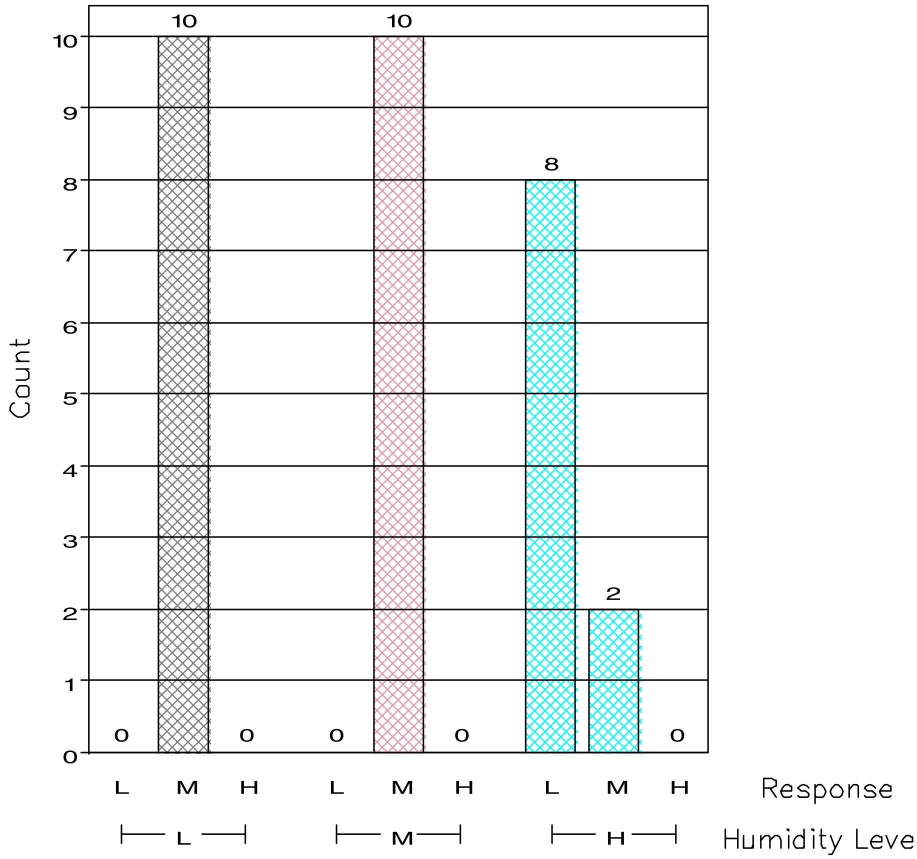

Figure A-9. Response to Cl_2 as a function of humidity.

Figure A-9 indicates that the typical HAZMATCAD Plus response is lower for the highest level of humidity.

A.5.3 Effect of Start State on TIC Response

The HAZMATCAD Plus response to AC was recorded under medium temperature and humidity with three start states:

1. Cold soak/cold start
2. Hot soak/cold start
3. Room temperature/cold start

These results were combined with the responses from the medium humidity and medium temperature AC results for the sake of comparison. The highest response was recorded for all start states and for the control. No effect of start state could be detected for AC run at 1 IDLH. (See Table A-5 in Section A.1.3 for a list of test IDs included in this analysis.)

A.5.4 Effect of Temperature on CW Agent Response

Data available for the agent analysis of the effect of temperature on HAZMATCAD Plus response came from the tests identified in Table A-6. For HD, response was a consistent high for all runs within each temperature level. Thus for HD there was no evidence of an effect of temperature on HAZMATCAD Plus response. For GB, at low temperature the response was consistently high, while at medium and high temperature the response was consistently at the medium level. These data provided sufficient statistical evidence to conclude that temperature has an effect on HAZMATCAD Plus response to GB (p-value <0.01).

A.5.5 Effect of Humidity on CW Agent Response

Data available for the agent analysis of the effect of humidity on HAZMATCAD Plus response came from the tests identified in Table A-7. For HD, response was a consistent high for all runs within each humidity level. Thus for HD there was no evidence of an effect of humidity on HAZMATCAD Plus response. At high humidity there was either no response to GB or the response was not stable for the HAZMATCAD Plus unit that typically responded to the presence of GB. At low and medium humidity the response was consistently at the medium level. These data provide sufficient statistical evidence to conclude that humidity has an effect on HAZMATCAD Plus response to GB (p-value <0.01).

A.5.6 Summary of Response Analysis

Variation in temperature, humidity, and start state appear to have little affect on HAZMATCAD Plus response to TICs. Over all TIC testing, the only significant finding was for Cl_2 with variation in humidity.

For the agent testing, variation in temperature and humidity appeared to have little affect on HAZMATCAD Plus response to HD. However, both temperature and humidity appeared to affect response to GB.

A.6 Interference Effects

The HAZMATCAD Plus response, response time, and recovery time were tested under medium temperature and humidity with each of the following interferents, both in the absence of any TIC or CW agent and in the presence of each TIC and CW agent.

1. Latex paint fumes
2. Floor cleaner vapors
3. Air freshener vapors
4. Gasoline engine exhaust
5. DEAE

Results for each TIC and CW agent without interferent present served as the control data for the interferent results. The following sections summarize the statistical analyses of the effect of interferents on HAZMATCAD Plus response, response time, and recovery time. The test IDs included in the analysis for TICs are contained in Table A-14 below; the corresponding test IDs for the CW agents are shown in Table A-17.

Table A-14. IDs of Tests included in the Analysis of Interferents with TICs

AC-01-A	CG-01-A	Cl_2-01-A	SA-01-A
AC-01-B	CG-01-B	Cl_2-01-B	SA-01-B
AC-09-A	CG-09-A	Cl_2-09-A	SA-09-A
AC-09-B	CG-09-B	Cl_2-09-B	SA-09-B
AC-10-A	CG-10-A	Cl_2-10-A	SA-10-A
AC-10-B	CG-10-B	Cl_2-10-B	SA-10-B
AC-11-A	CG-11-A	Cl_2-11-A	SA-11-A
AC-11-B	CG-11-B	Cl_2-11-B	SA-11-B
AC-12-A	CG-12-A	Cl_2-12-A	SA-12-A
AC-12-B	CG-12-B	Cl_2-12-B	SA-12-B
AC-13-A	CG-13-A	Cl_2-13-A	SA-13-A
AC-13-B	CG-13-B	Cl_2-13-B	SA-13-B

A.6.1 Effect of Interferent on TIC Response

As described in Chapter 5, the effects of interferent on HAZMATCAD Plus response were tested using a Kruskal-Wallis test. The highest response was recorded for all interferents for all TICs except Cl_2. Thus, no effect of interferent could be determined for AC, CG, and SA. For Cl_2, a p-value of < 0.01 indicates that interferent had a significant effect on HAZMATCAD Plus response. Figure A-10 contains the response by interferent counts for Cl_2. It is apparent from the figure that air freshener may reduce the level of response to Cl_2, while floor cleaner appears to increase the response level. It should be noted that according to Dunn's multiple comparison procedure (see Chapter 5), neither of the response levels for these two interferents is significantly different from the control. Thus, while there is an overall effect of interferent, there is insufficient power to detect differences between the interferents and the control.

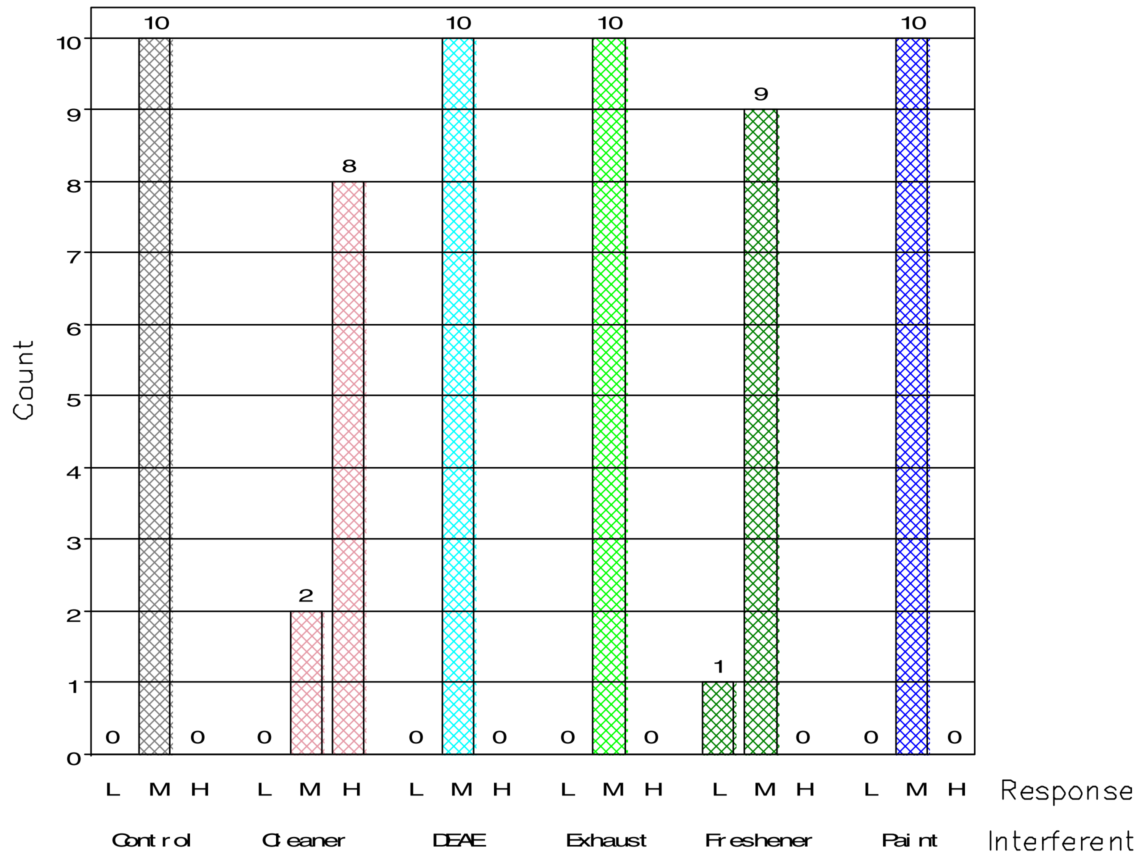

Figure A-10. Response to Cl_2 by interferent.

A.6.2 Effect of Interferent on TIC Response Time

An ANOVA model was used to analyze the effect of interferent on response time. Table A-15 contains the p-values for these effects.

Table A-15. Effects of Interferent on TIC Response Time

TIC	P-value
AC	0.77
CG	0.46
Cl_2	<0.01
SA	0.07

As evidenced by Table A-15, interferent has a significant effect on the response time for Cl_2. Figure A-11 contains the modeled geometric means of the Cl_2 response times. Floor cleaner appeared to increase response time to Cl_2, while the other interferents had little effect on response time.

A.6.3 Effect of Interferent on TIC Recovery Time

An ANOVA model was used to analyze the effect of interferent on recovery time for each TIC.

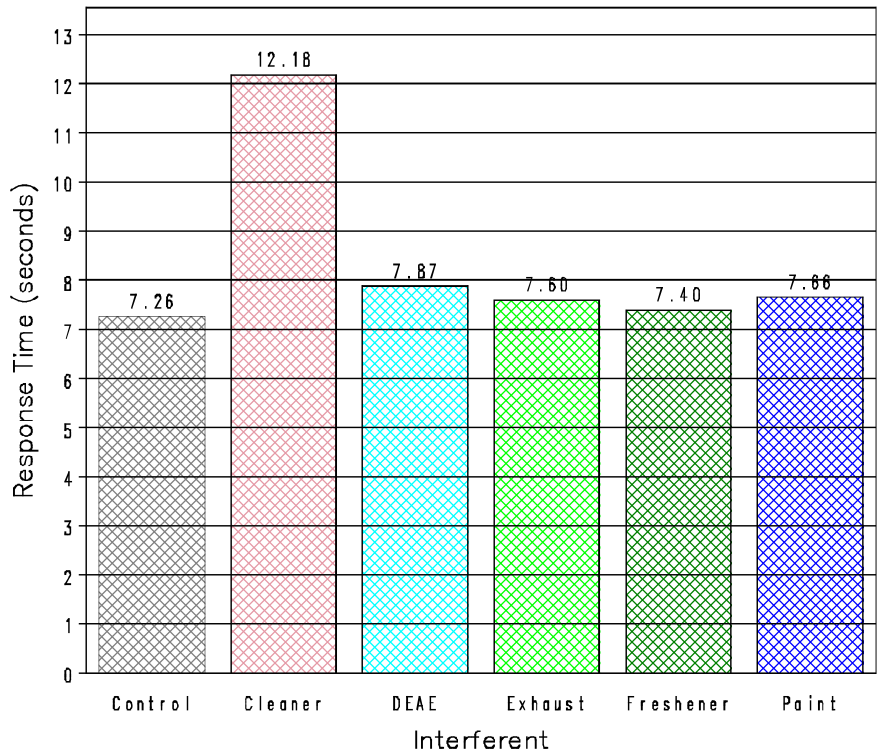

Figure A-11. Modeled geometric means of response time by interferent for Cl_2.

Table A-16 presents the p-values for these effects.

Table A-16. Tests for Effects of Interferent on Recovery Time

TIC	P-value
AC	<0.01
CG	<0.01
Cl_2	0.02
SA	0.19

As evidenced by Table A-16, interferent has an effect on the recovery time for AC, CG, and Cl_2 Figures A-12, A-13, and A-14 contain the geometric mean recovery times by interferent for AC, CG, and Cl_2, respectively. For all of these TICs, interferents either had little effect on or tended to increase recovery time.

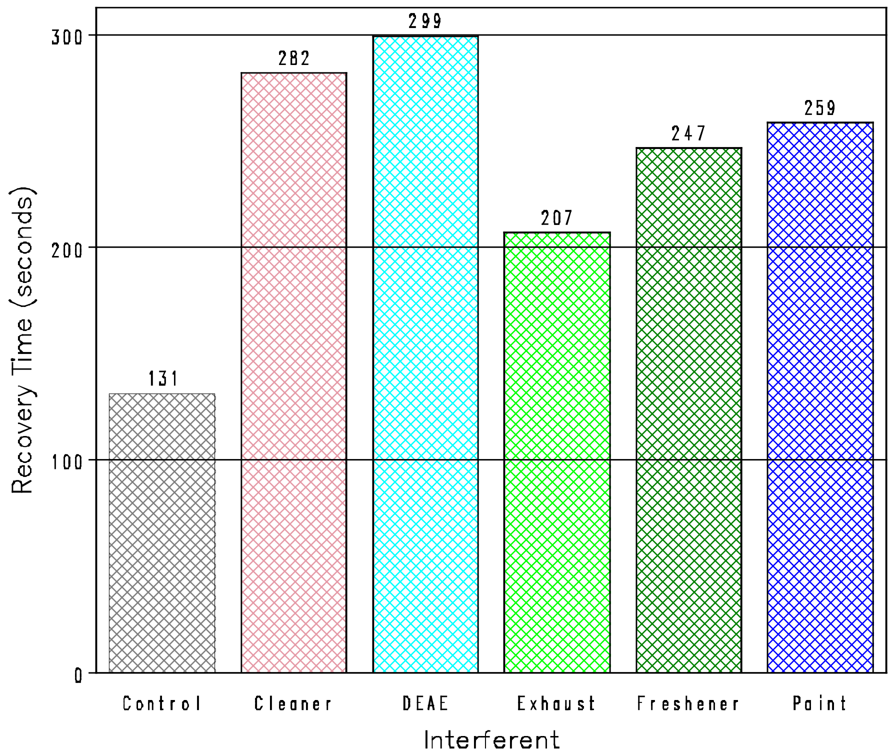

Figure A-12. Modeled geometric means of recovery time by interferent for AC.

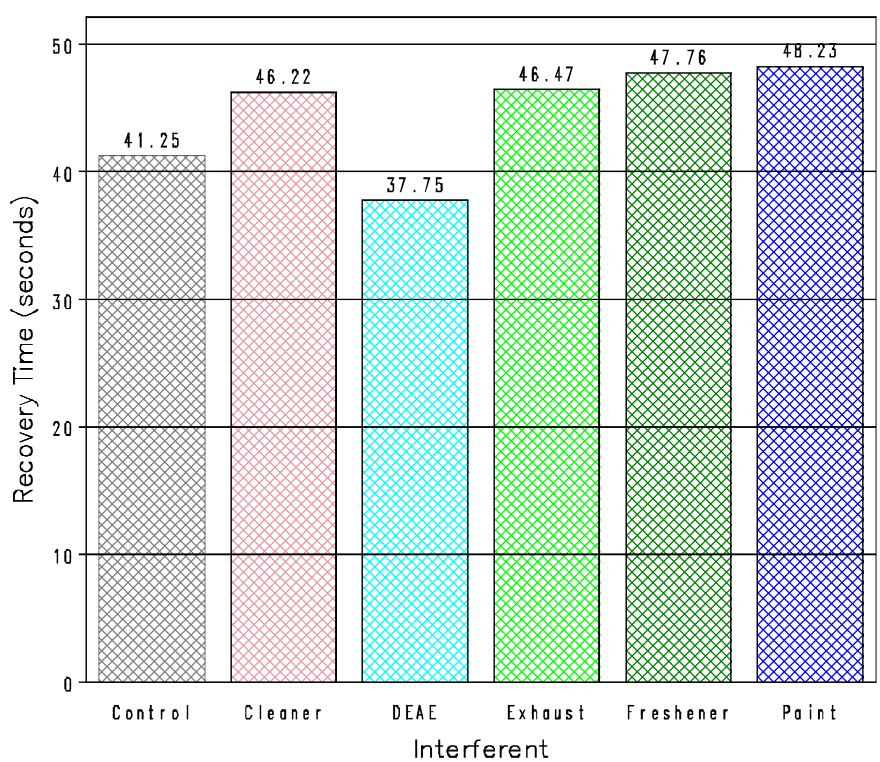

Figure A-13. Modeled geometric mean of recovery time by interferent for CG.

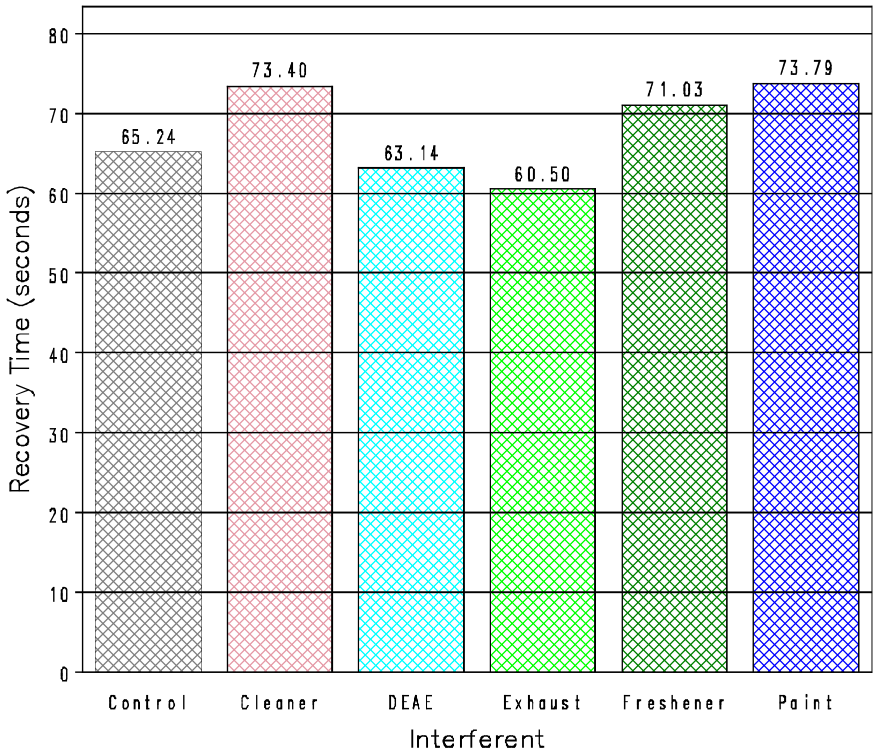

Figure A-14. Modeled geometric mean of recovery time by interferent for Cl_2.

Upon review of the interferent recovery times, a trend was apparent for AC. Figure A-15 presents AC recovery time by test sequence number for each interferent. It is evident that recovery times tended to increase with each successive challenge. One of the assumptions of the ANOVA model is that the successive tests are independent. The figure suggests that this assumption was violated for AC testing. The p-value associated with AC in Table A-16 should be interpreted with caution.

A.6.4 Effect of Interferent on CW Agent Response

The tests used to assess the effect of interferents on HAZMATCAD Plus performance are identified in Table A-17. For GB there were 5 runs for each of the five interferents. For HD there were 10 runs for four of the interferents and 12 for the fifth (paint).

For both GB and HD, interferents appear to have a significant effect on the response of the HAZMATCAD plus (p-value <0.01 for both agents). The HAZMATCAD plus did not respond to GB in the presence of air freshener and paint; and in two of the exhaust runs, response was not stable. The HAZMATCAD plus did not respond to HD in the presence of ammonia cleaner and paint.

For those interferents that were associated with a machine response, there was no statistically significant difference between the response of HAZMATCAD with or without the interferent.

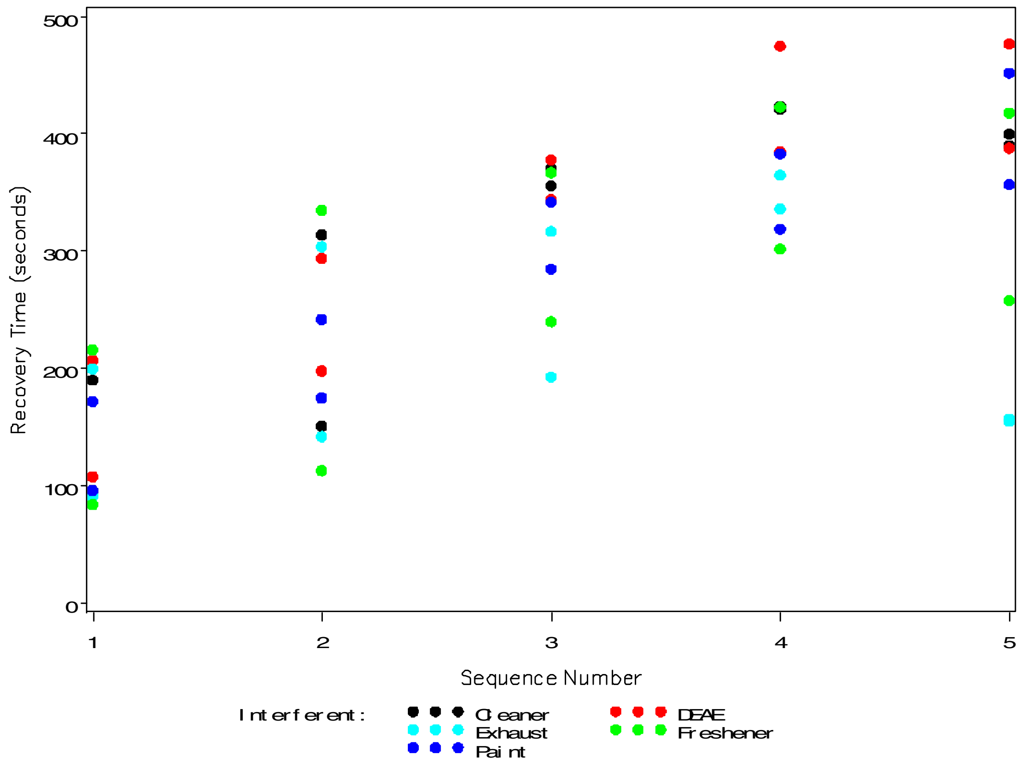

Figure A-15. AC recovery time by test sequence number.

Table A-17. IDs of Tests included in the Agent Testing of the Effect of Interferents on Performance

GB-01-BA1	HD-10A-1
GB-10-1	HD-10B-1
GB-11-B	HD-11A-1
GB-12-1	HD-11B-1
GB-13-1	HD-12A-1
GB-9-1	HD-12B-1
	HD-13A-1
	HD-13B-1
	HD-1A-1
	HD-1B-1
	HD-9A-1
	HD-9B-1

A.6.5 Effect of Interferent on CW Agent Response Time

Because the HAZMATCAD plus did not respond in the presence of some interferents, response times were collected for only a subset of the interferents. For GB, analysis of the effect of interferent on response time was limited to the runs for ammonia cleaner, DEAE, and exhaust; for HD, analysis of the effect of interferent on response time was limited to the runs for air freshener, DEAE, and exhaust.

The data for GB provided no evidence of interferent effect on the HAZMATCAD response time (p-value=0.18). However the data for HD did (p-value <0.01). Figure A-16 contains the modeled geometric means of the response time to HD in the presence of air freshener, DEAE, and exhaust. DEAE and exhaust decreased response time, while air freshener increased response time.

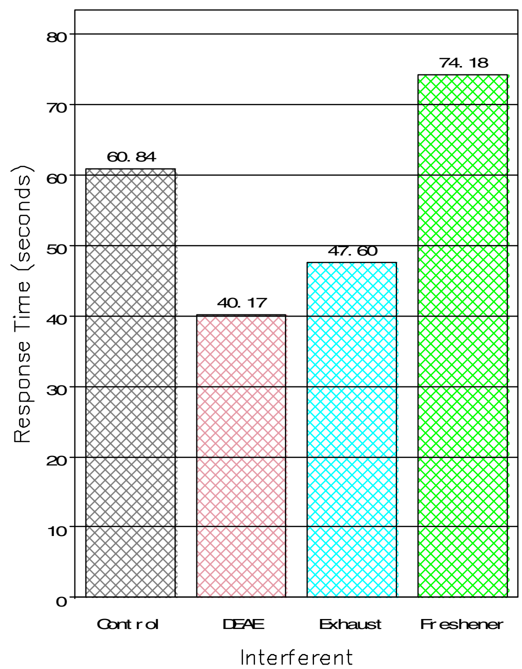

Figure A-16. Modeled geometric mean of response time to HD by interferent.

A.6.6 Effect of Interferent on CW Agent Recovery Time

As with response times, recovery times were collected for only a subset of the interferents. For GB, analysis of the effect of interferent on recovery time was limited to runs for ammonia cleaner, DEAE, and exhaust. Two of the five exhaust runs were met with unstable response and no associated recovery time. For HD, analysis of the effect of interferent on recovery time was limited to the runs for air freshener, DEAE, and exhaust.

The data for HD provided no evidence of interferent effect on the HAZMATCAD recovery time (p-value=0.95). However the data for GB did (p-value <0.01). Figure A-17 contains the modeled geometric means of the recovery time to GB in the presence of ammonia cleaner, DEAE, and exhaust. Recovery in the presence of exhaust was shorter than that required from GB without the interferent.

A.6.7 Summary of Interferent Analysis

Presence of interferents appears to have an effect on HAZMATCAD Plus performance. The effect of interferents was most pronounced for agents, where there was no response to GB in the presence of air freshener and paint, and no response to HD in the presence of ammonia cleaner and paint.

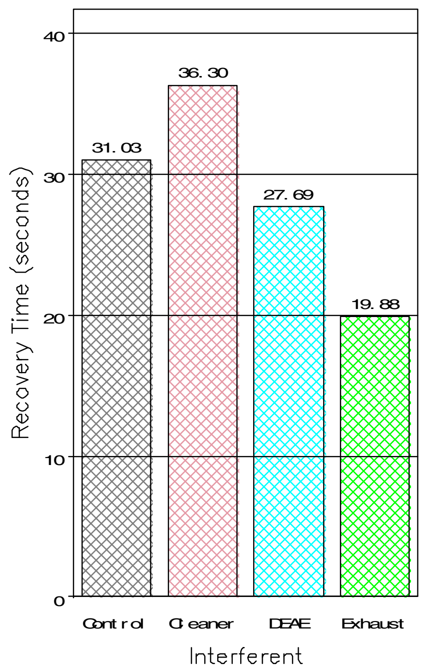

Figure A-17. Modeled geometric mean of recovery time from GB by interferent.

A.7 Analysis of False Positives

The machine response was tested under medium temperature and humidity without TICs in the presence of each of the following interferents:

1. Latex paint fumes
2. Floor cleaner vapors
3. Air freshener vapors
4. Gasoline engine exhaust
5. DEAE

A false-positive was defined as any machine response. The number of false positive readings was recorded, and Clopper-Pearson 95% confidence intervals were constructed for the proportion of false positives for each interferent. Table A-18 contains the test IDs included in this analysis.

Table A-18. IDs of Tests included in the False Positive Analysis

AC-14-A
AC-14-B
AC-15-A
AC-15-B
AC-16-A
AC-16-B
AC-17-A
AC-17-B
AC-18-A
AC-18-B

The HAZMATCAD Plus performed perfectly during the false positive testing. Over the range of interferents, there was never any machine response. Thus an estimate of the chance of false positive is 0%. Six tests were performed for each interferent. For a given interferent, the Clopper-Pearson upper bound on the chance of a false positive is about 46%.

A.8 Effect of Oscillation on Response

Twelve cycles were conducted in which the HAZMATCAD Plus alternated sampling from high and low challenge plenums. For the TICs, the high challenge was IDLH, and the low challenge was as follows: AC at 0.1 IDLH, CG at 0.2 IDLH, Cl_2 at 0.1 IDLH, and SA at 0.2 IDLH. In six of the 12 cycles, the high plenum was sampled first, then the low plenum; in the other six, the order was reversed. Clean air was sampled before the first cycle and again after every high/low or low/high cycle. This test with alternating concentrations was conducted only at the medium temperature and humidity levels. Test IDs included in this analysis are contained in Table A-19.

Table A-19. IDs of Tests included in the Oscillation Analysis

AC-01-A	CG-01-A	Cl_2-01-A	SA-01-A
AC-01-B	CG-01-B	Cl_2-01-B	SA-01-B
AC-06-A	CG-06-A	Cl_2-06-A	SA-06-A
AC-06-B	CG-06-B	Cl_2-06-B	SA-06-B

A.8.1 Effect of Order of Challenge Levels on TIC Response

One of the purposes of this testing was to assess whether HAZMATCAD Plus response to a given concentration was affected by initial exposure to an alternate concentration. The effect of an initial alternate concentration was investigated using a Cochran-Mantel-Hansel statistic (see Chapter 5 for more details). Table A-20 contains the p-values for these tests.

Table A-20. Effects of Order of Challenge Levels on TIC Response

TIC	P-value
AC	0.29
CG	0.95
Cl_2	0.34
SA	0.95

According to Table A-20, there is no evidence that machine response to a given concentration is affected by preceding alternate concentrations.

A.8.2 Difference in Response to the Challenge Levels

When challenged by a high concentration after being challenged by a low concentration, the HAZMATCAD Plus response might be expected to increase. Similarly, when challenged by low concentration after being challenged by a high concentration, the response might be expected to decrease. The proportion of tests exhibiting this behavior for each TIC was recorded. In the case of AC, CG, and SA, all tests performed as expected (12 per gas). However, in the case of Cl_2, only one of the 12 tests performed as expected.

For AC, CG, and SA, a Clopper-Pearson lower bound was placed on the probability that the machine response would perform as expected. The lower bound is about 74%. For Cl_2 it appears likely that the expected response will not be observed. The chance that expectations will not be met with Cl_2 has a lower bound of about 62%.

A.8.3 Effect of Oscillation on CW agents

The tests used to assess the effect of fluctuating concentration on HAZMATCAD Plus performance are identified in Table A-21. For GB, 6 cycles of alternating concentration were conducted; for HD, 12 were conducted. The high concentration challenge for GB was 11 IDLH; the low was 4 IDLH. The high concentration challenge for HD was 7 AEGL-2 ; the low was 2 AEGL-2.

Table 21. IDs of Tests included in the Agent Testing of Fluctuating Concentration

GB-01-BA1	HD-1A-1
GB-6-1	HD-1B-1
	HD-6A-1
	HD-6B-1

There was no evidence that the HAZMATCAD Plus response to a given concentration of GB was affected by an initial alternate concentration. However, there was evidence that the HAZMATCAD Plus response to a given concentration of HD was affected by an initial alternate concentration ($p\text{-value}<0.01$). The response to HD at high concentration was consistently high. But the response to HD at low concentration tended to be higher when preceded by the alternate concentration.

When challenged by a high concentration after being challenged by a low concentration or visa versa, the HAZMATCAD Plus response to both agents was as expected: the response was consistently higher for the former condition and consistently lower for the latter condition. A Clopper-Pearson lower bound was placed on the probability that the machine response would perform as expected to each of the gases. For GB with 6 observations the lower bound is 61%. For HD with 12 observations the lower bound is 74%.

A.8.4 Summary of the Oscillation Analysis

HAZMATCAD Plus response appears to be little affected by a preceding challenge of different concentration. An exception was found during the HD testing, where response to low concentration was elevated when preceded with a higher concentration.

It appears that, with fluctuating concentrations, the HAZMATCAD Plus does what you might expect: when challenged by a high concentration after being challenged by a low concentration, the response seems to increase. Similarly, when challenged by low concentration after being challenged by a high concentration, the response seems to decrease.