No. 07-

IN THE

Supreme Court of the United States

JANE H. CHUN, *et al.*,

Petitioners,

v.

STATE OF NEW JERSEY,

Respondent.

ON PETITION FOR A WRIT OF CERTIORARI TO THE NEW JERSEY SUPREME COURT

PETITION FOR A WRIT OF CERTIORARI

MATTHEW W. REISIG
One Broad Street
First Floor
Freehold, NJ 07728

SAMUEL L. SACHS
P.O. Box 968
East Windsor, NJ 08520

JONATHAN A. KESSOUS
GARCES & GRABLER
235 Livingston Avenue
New Brunswick, NJ 08901

EVAN M. LEVOW
Counsel of Record
LEVOW & ASSOCIATES, P.A.
1415 Route 70 East
Suite 200
Cherry Hill, NJ 08034
(856) 428-5055

JOHN MENZEL
2911 Route 88
Suite 12
Point Pleasant, NJ 08742

Attorneys for Petitioners

216114

COUNSEL PRESS
(800) 274-3321 • (800) 359-6859

QUESTION PRESENTED

Is an individual's Sixth Amendment right to confront witnesses against him violated where the State is permitted to rely on documents created for the sole purpose of supporting computer-generated evidence used to convict the individual, without requiring the proponent of the document to testify?

LIST OF PARTIES

Petitioners:

JANE H. CHUN; JAMES R. HAUSLER; JEFFREY R. WOOD; ANTHONY ANZANO; RAJ DESAI; PETER LIEBERWIRTH; JEFFREY LING; HUSSAIN NAWAZ; FREDERICK OGBUTOR; PETER PIASECKI; LARA SLATER; CHRISTOPHER SALKOWITZ; ELINA TIRADO; DAVID WALKER; DAVID WHITMAN; JAIRO J. YATACO

Respondent:

STATE OF NEW JERSEY

Intervenor:

DRAEGER SAFETY DIAGNOSTICS, INC.

TABLE OF CONTENTS

Contents

TABLE OF APPENDICES

TABLE OF CITED AUTHORITIES

Page

Cases:

Petitioners respectfully petition for a Writ of Certiorari to the Supreme Court of New Jersey in *State v. Chun*, 194 N.J. 54 (2008).

OPINIONS BELOW

The opinion of the New Jersey Supreme Court is reported at *State v. Chun*, 194 N.J. 54 (2008). *See* Appendices A-B. The opinion adopts, as modified, the unpublished Reports of the Special Master. *See* Appendices C-D.

STATEMENT OF JURISDICTION

This Court's jurisdiction is invoked under 28 U.S.C. § 1257(a).

The New Jersey Supreme Court's decision in this matter, entered on March 17, 2008, is final as to the scientific reliability and the foundational prerequisites to establish operability of a newly adopted breath testing machine, the Draeger Alcotest® 7110 MKIII-C. While each individual matter was remanded to the lower courts for separate disposition based on the determinations set forth in the challenged opinion, the question at issue were decided to conclusion by the highest court of the State of New Jersey. This decision by the New Jersey Supreme Court is repugnant to the United States Constitution, and affects thousands of pending cases similarly situated to the named defendants herein, and is worthy of review by this Court.

CONSTITUTIONAL PROVISION INVOLVED

Sixth Amendment to the United States Constitution:

> In all criminal prosecutions, the accused shall enjoy the right . . . to be confronted with the witnesses against him. . . .

STATEMENT OF THE CASE

1. Procedural History

Defendants in this case and similarly situated defendants across the State of New Jersey[1], were and are charged with driving with a prohibited blood alcohol content after being breath tested on the Draeger Alcotest® 7110 MKIII-C, a machine never previously held to be reliable by another court. The parties in this matter are sixteen individuals who were arrested in various municipalities in one county in New Jersey. At the State's request, a lower court consolidated these particular defendants to consider the scientific reliability of the Alcotest. All other cases involving Alcotest results proceeded, pending the result of the reliability hearing. The New Jersey Supreme Court, sua sponte, certified the matter, and remanded the case to a Special Master, who submitted findings and conclusions on two separate occasions. *See* Appendices C and D.

Prior to its opinion and order of March 17, 2008, the New Jersey Supreme Court requested briefs from the parties regarding the application of *Crawford v. Washington*, 541 U.S. 36 (2004) to the foundational documents required to prove a defendant's breath alcohol content.

---

1. According to the State, there are approximately 36,000 DWI arrests in New Jersey each year.

2. The New Jersey Supreme Court's Determinations

The New Jersey Supreme Court's decision in *State v. Chun*, 194 N.J. 54 (2008), undermines and is repugnant to the United States Constitution — specifically, the Confrontation Clause of the Sixth Amendment — by admitting into evidence critical information generated by police and the manufacturer for the sole purpose of prosecution, without challenges to reliability in the crucible of cross examination.

The New Jersey Supreme Court's analysis of the general scientific reliability of the Alcotest is grounded, in part, on an expectation that there will be proof that the particular machine that has generated an Alcohol Influence Report being offered into evidence was in good working order, and that the operator of the machine was appropriately qualified to administer the test. This requires that the test results be supported by foundational proofs for admissibility. *See* Appendix A, 105a.

These "foundational documents" that are to be produced during discovery are:

> (1) Calibrating Unit, New Standard Solution Report, most recent change, and the operator's credentials of the officer who performed that change;
>
> (2) Certificate of Analysis 0.10 Percent Solution used in New Solution Report;

(3) Draeger Safety Certificate of Accuracy Alcotest CU34 Simulator;

(4) Draeger Safety Certificate of Accuracy Alcotest 7110 Temperature Probe;

(5) Draeger Safety Certificate of Accuracy Alcotest 7110 Instrument (unless more relevant NJ Calibration Records (including both Parts I and II are offered));

(6) Calibration Check (including both control tests and linearity tests and the credentials of the operator/coordinator who performed the tests);

(7) Certificate of Analysis 0.10 Percent Solution (used in Calibration-Control);

(8) Certificate of Analysis 0.04, 0.08, and 0.16 Percent Solution (used in Calibration-Linearity);

(9) Calibrating Unit, New Standard Solution Report, following Calibration;

(10) Draeger Safety Certificate of Accuracy Alcotest CU34 Simulator for the three simulators used in the 0.04, 0.08, and 0.16 percent solutions when conducting the Calibration-Linearity tests;

(11) Draeger Safety Certificate of Accuracy Alcotest 7110 Temperature Probe used in the Calibration tests; and

> (12) Draeger Safety, Ertco-Hart Digital Temperature Measuring System Report of Calibration, NIST traceability.

See Appendix A, 106-07a.

The Court, citing to *Crawford v. Washington*, 541 U.S. at 56, categorized these foundational documents into three classes:

> (1) those pertaining to the qualifications of the operator;
>
> (2) documents seeking to demonstrate that the machine was in working order at the time of the test, subdividing this category into
>
>> (i) documents directly evidencing the good working order of the machine as of the time of the test, including: the most recent calibration record, the most recent new standard solution report, and the certificate of analysis of the 0.10 simulator solution used in the control tests; and
>>
>> (ii) documents evidencing the accuracy of the devices used and chemical composition of the solutions used to routinely test and calibrate the machine, including the analysis of all of the solutions used to test linearity, the documents attesting to the accuracy of the devices used in the simulator, and the certificates of accuracy of the simulator and temperature probes; and

> (3) the AIR being offered into evidence to demonstrate the results of the breath testing.

See Appendix A, 113a.

The Court's second classification of documents — documents demonstrating the working order of the machine — as business records admissible as hearsay without the protections of the Confrontation Clause is error. This classification disregards that (a) many of these documents are generated from functions performed by the police, (b) these documents are created solely for the purpose of prosecution, and (c) these documents are integral in ensuring that the machine is in good working order. *See* Appendix A, 119a.

The Court acknowledged that some of these documents are prepared by the police and the manufacturer, but, citing *Davis v. Washington*, 547 U.S. 813, 821-24 (2006), justified its classification of the documents as non-testimonial by stating that none of them relates to or reports a past fact, and none of them is generated or prepared in order to establish any fact that is an element of the offense.

Further, the Court dismissed the importance of these documents as "too attenuated to require that they be admitted as part of the evidence." *See* Appendix A, 120a. These documents include those relating to the working order of the simulator, the reports of the solutions used during simulation and calibration, the certificate of accuracy of the simulator used to calibrate the device, and the temperature probe documents. The Court's suggestion that any defendant perceiving an irregularity in any of these documents that might affect the proper operation of the device in question may timely issue a subpoena, disregards the proper placement of the burden of proof for conviction, and disregards the right of citizens to confront evidence against them.

As a result, the foundational documents the Court required to be entered into evidence without witness testimony are: (1) the most recent calibration report prior to a defendant's test, with part I-control tests, part II-linearity tests, and the credentials of the coordinator who performed the calibration; (2) the most recent new standard solution report prior to a defendant's test; and (3) the certificate of analysis of the 0.10 simulator solution used in a defendant's control tests. The calibration and new standard solution reports are included in that class of foundational documents discussed above. That is, they are generated by police for the sole purpose of prosecution and are integral to establishing the existence of an element of the offense.

As to the Alcohol Influence Report itself, the Court concluded that it is also a non-testimonial document that should be admitted without witness testimony, although the operator of the machine will be available to testify as to his general role in the operation of the machine. In a contested matter, the operator must testify as to whether the defendant was observed for twenty minutes prior to the breath testing, that the subject has neither swallowed nor regurgitated any substances during that time that would influence the test results; inputting and verifying the accuracy of the identifying information needed to start the sequence; changing the control solution if the machine alerts him to do so; attaching a new mouthpiece; reading the instructions about how to blow into the machine; observing the LED screen and following its prompts; and observing the subject to ensure that he or she actually provides a sample. *See* Appendix A, 114a.

Under this rubric, critical Alcohol Influence Report information — like the identification of equipment used, times samples are taken, and the test result itself — is admissible, notwithstanding the operator's testimony. The Court envisioned that, "It may well be that, as the use of the device becomes more routine, some, or even most, defendants will eventually forgo cross-examination of the operator in light of the limited information that can be achieved in that effort." *See* Appendix A, 115a n.44. Thus, the New Jersey Supreme Court expresses the view that confrontation would be unnecessary and should be disregarded for citizens charged with having a prohibited blood alcohol content while operating a motor vehicle.

REASONS FOR GRANTING THE PETITION

I. REVIEW IS WARRANTED TO CORRECT THE MISAPPLICATION OF THE SIXTH AMENDMENT AND HEARSAY EXCEPTIONS BY THE NEW JERSEY SUPREME COURT, ALLOWING ADMISSION OF DOCUMENTS WITHOUT SUPPORTING TESTIMONY TO CONVICT DEFENDANTS

All of the foundational documents were created by the State Police and by Draeger for the sole purpose of litigation. The documents address facts of elemental concern in per se prosecutions, and, as such, are testimonial in nature, rendering the documents, alone, inadmissible without testimony from the declarant of each document. It is axiomatic that defendants must have the ability to cross examine the humans whose written declarations will be used to prove the machine's operability and to obtain convictions in these cases. "[C]ross-examination is the principal means by which the . . . truth [is] tested," *Davis v. Alaska*, 415 U.S. 308, 316 (1974), and "is fundamental and essential to a fair trial in a criminal prosecution." *Pointer v. Texas*, 380 U.S. 400, 403-04 (1965).

A defendant in a DWI prosecution is entitled to vigorously cross examine all aspects of the breath machine. *California v. Trombetta*, 467 U.S. 479, 490 (1984). "[A]s to operator error, the defendant retains the right to cross-examine the law enforcement officer who administered the Intoxilyzer test, and to attempt to raise doubts in the mind of the fact-finder whether the test was properly administered." *Id.*

"Under the Due Process Clause of the Fourteenth Amendment, criminal prosecutions must comport with prevailing notions of fundamental fairness." *Id.* at 485. "Whether rooted directly in the Due Process Clause of the Fourteenth Amendment, or in the Compulsory Process or Confrontation clauses of the Sixth Amendment, the Constitution guarantees criminal defendants 'a meaningful opportunity to present a complete defense.'" *Crane v. Kentucky*, 476 U.S. 683, 690 (1986) (citations omitted) (quoting *Trombetta*, 467 U.S. at 485).

Crawford holds that out-of-court statements by witnesses that are testimonial in nature are barred, under the Confrontation Clause, unless witnesses are unavailable and defendants had prior opportunity to cross-examine witnesses, regardless of whether such statements are deemed generally reliable by the court, abrogating *Ohio v. Roberts*, 448 U.S. 56 (1980). "[T]his bedrock procedural guarantee applies to both federal and state prosecutions." *Crawford*, 541 U.S. at 42, citing *Pointer*, *supra*.

The term "witness" refers to all those who "bear testimony." *Id.* at 51. "'Testimony,' in turn, is typically '[a] solemn declaration or affirmation made for the purpose of establishing or proving some fact.'" *Id.* (citations omitted). It applies both to "in-court testimony" and "out-of-court statements introduced at trial." *Id.* at 50-51. "The constitutional text . . . reflects an especially acute concern with a specific type of out-of-court statement." *Id.* at 51. "[T]his core class of 'testimonial' statements" includes:

> ex parte in-court testimony or its functional equivalent—that is, material such as affidavits, custodial examinations, prior testimony that

> the defendant was unable to cross-examine, or similar pretrial statements that declarants would reasonably expect to be used prosecutorially . . . extrajudicial statements . . . contained in formalized testimonial materials, such as affidavits, depositions, prior testimony, or confessions . . . statements that were made under circumstances which would lead an objective witness reasonably to believe that the statement would be available for use at a later trial. . . .

Id. at 51-52.

"To be testimonial, [a] communication must itself, explicitly or implicitly, relate a factual assertion or disclose information." *Hiibel v. Sixth Judicial Dist. Court of Nevada*, *Humboldt County*, 542 U.S. 177, 189 (2004) (quoting *Doe v. United States*, 487 U.S. 201, 210 (1988)).

Davis v. Washington, 547 U.S. at 822, defined testimonial statements:

> Statements are nontestimonial when made in the course of police interrogation under circumstances objectively indicating that the primary purpose of the interrogation is to enable police assistance to meet an ongoing emergency. They are testimonial when the circumstances objectively indicate that there is no such ongoing emergency, and that the primary purpose of the interrogation is to

> establish or prove past events potentially relevant to later criminal prosecution.

The final test is whether the "evidentiary products" of the communication are of the same character as their "courtroom analogues" so that they "substitute for live testimony." *Id.* at 2277-78. When out of court statements "do precisely what a witness does on direct examination . . . they are inherently testimonial." *Id.* at 2278.

Each of these out-of-court "testimonial statements" are subject to the accused's right to confrontation. *Crawford*, 541 U.S. at 68-69. This requires that they be subject to "testing in the crucible of cross-examination." *Id.* at 61. Accordingly, the Sixth Amendment places an absolute prohibition against the introduction of out-of-court "testimonial statements" made by any witness unless: (1) the witness is unavailable; and (2) the defendant had a prior opportunity to cross-examine the witness. *Id.* at 68. Further, "a witness is not 'unavailable' . . . unless the prosecutorial authorities have made a good-faith effort to obtain his presence at trial." *Barber v. Page*, 390 U.S. 719 (1968).

The foundational documents described by the New Jersey Supreme Court are certifications or statements prepared solely for the purpose of litigation to prove the truth of the matters asserted in the documents. They are not business records. They have no purpose other than to support the Alcotest and the proposition that it was properly operating on the date of the defendant's breath test.

While Alcotest maintenance has been characterized as a "regular business function . . ." that business has one purpose: to convict persons charged with DWI. The particular machine is not used generally in society except for that one purpose. Draeger never sells the machine to anyone but law enforcement, cloaking the machine in secrecy. This is a policy that distinguishes breath testing equipment from virtually all other scientific instruments, like the gas chromatograph or mass spectroscope, which are sold to whomever wishes to purchase one and are used throughout the forensic, academic, and medical communities. Inspection and maintenance procedures are conducted in secret and under the complete direction and supervision of the State. The creator of the document is the proponent of the document. Defendants have no window into the process other than through cross examination.

A laboratory certificate certifying simulator solution ultimately certifies operability of the Alcotest. The State and Draeger rely heavily on the before and after control tests, claiming this to be the bedrock of the Alcotest's reliability. This reliability of the control tests is predicated on the assay of the simulator solution being accurate. To preclude confrontation on this certifying document would prevent examination of one of the most fundamental documents in an Alcotest prosecution.

The State contends that their Alcotest generated calibrations and linearity checks equal proper operation of the machine, and seeks to admit these self-created documents without right of confrontation.

As for documents generated by the machine itself — i.e., the New Standard Solution Reports, Calibration Reports (including control and linearity tests), and the Alcohol Influence Reports, without testimony and cross-examination of the person who tested and calibrated the machine, the certificate becomes the sole proof of the machine's accuracy. It will be accepted as the full proof required for conviction. Trial by this machine without proof of its accuracy holds no place in our system of jurisprudence.

Likewise, Draeger offers various certificates of accuracy for the CU34 simulator, temperature probes, the machine itself, and the Ertco-Hart temperature measuring system to demonstrate that the machine and its many parts (simulator, temperature probe, etc.) are accurate.

These records, made in anticipation of prosecution, are not business records. Business records were defined by *Palmer v. Hoffman*, 318 U.S. 109 (1943), as commercial records with entries made systematically or as a matter of routine to record events or occurrences to reflect transactions with others or to provide internal controls. Business records are records that reflect day to day operation of the business, and are not testimonial since they are not prepared with litigation in mind. In *Palmer*, an accident report was held not to be a business record, because it was prepared in anticipation of litigation.

Crawford intends that business records are still admissible when the primary reason for their creation is not prosecution-oriented — e.g., bank records are created for banking purposes. Their use at trial is secondary to their primary use, and are likely acceptable under *Crawford*.

The statements made in the "foundational documents" are clearly intended to be used in a quasi-criminal prosecution to prove that the machine is calibrated and in proper working order.

The Confrontation Clause is directed at those who make solemn declarations or affirmations of facts to government officers for the purpose of establishing or proving facts in issue in the case being prosecuted. These documents contain statements only useful prosecutorially, and are made under circumstances which would lead an objective witness to reasonably believe the statements would be available for trial.

These documents are prepared solely for admission at trial. They are crucial to the State's case against an individual, because the admissibility of the breath testing results depends on the machine being in proper working order. There is no other way for the State to prove whether the machine was maintained and in proper working order, but to have these documents admitted at the time of trial or to have a witness testify to the substance of the documents. This requires confrontation of the proponent.

The documents at issue are solemn declarations or affirmations of fact for the purpose of establishing or proving a fact in issue in this quasi-criminal prosecution. The fact in issue is operation of the machine: whether it was set up and configured properly. Each document certifies to the operability of the machine and testing in some way, thus seeking to remove doubt as to the accuracy of the final result used to convict. The documents thus constitute testimonial evidence.

This is the precise scenario that this Court used to exemplify a Confrontation Clause violation, discussing Sir Walter Raleigh's trial for treason, wherein an alleged co-conspirator's affidavit was read in court as evidence against Raleigh. Raleigh contested the allegations and demanded an opportunity to confront the attestor, face-to-face.

"Leaving the regulation of out-of-court statements to the law of evidence would render the Confrontation Clause powerless to prevent even the most flagrant inquisitorial practices." *Crawford*, 541 U.S. at 51. Allowing the foundational documents into evidence without confrontation, subverts the most basic of constitutional rights and would astound the framers.

These foundational documents were (a) created by the prosecuting authority or the manufacturer, (b) for the sole purpose of establishing operability of the machine, (c) to prove facts leading to a conviction of a per se offense of DWI. When used in an official proceeding to prove, support, establish or evidence some proposition, these documents are proffered to be the equivalent of affidavits, even though unsworn. The documents testify to (1) the accuracy of the evidence, establishing the breath alcohol level, which constitutes an element of the per se offense, and (2) the qualifications of the individual making that determination. In this context, they also testify to their own credibility, both in the methods used to create them and their substantive contents.

Subjecting these facts to the fundamental principles enunciated in *Crawford*, the foundational documents are clearly testimonial in nature. These documents are neither affidavits nor certifications. They are assertions of fact without support. They were "produced with an eye toward trial . . . under circumstances which would lead an objective witness reasonably to believe that the statement would be available for use at trial." *Id.* at 51-52. They are submitted as a "solemn declaration or affirmation made for the purpose of establishing or proving some fact," i.e. the machine was in proper working order on the date in question and that the individual's breath test result was accurate (and hence over the legal limit).

In every way, the documents offered by the State satisfy *Crawford's* definition of "testimonial statements."

Further, these documents are written assertions made out of court and offered at trial to prove the truth of the matter asserted. This characterization is firmly in line with the definition of testimony utilized by the *Crawford* court as an "affirmation made for the purpose of establishing or proving some fact." *Id.* at 51. As such, before it can be admitted, the State is required to establish that the witness who created the document was both unavailable and that the defendant had a prior opportunity to cross-examine the author of the document. If the State fails to meet these requirements, the documents are inadmissible under the Sixth Amendment.

The rule enunciated by the Court in *Crawford* is clear, strict and unambiguous. "Where testimonial statements are at issue, the only indicia of reliability sufficient to satisfy constitutional demands is the one the Constitution actually prescribes: confrontation." *Id.* at 68-69. Where out-of-court testimonial "evidence is at issue the Sixth Amendment demands unavailability and a prior opportunity for cross-examination" before it may be introduced. *Id.* at 68-69. The conditions are "necessary" and "dispositive" in determining admissibility of "testimonial statements." *Id.* at 55-56. As neither condition is satisfied, the foundational documents cannot, alone, be admitted.

As the Alcohol Influence Report is admissible without the operator's testimony, the machine will never be confronted.

The New Jersey Supreme Court acknowledged that the ability to cross-examine the operator of the Alcotest will provide little means to challenge the veracity of the Alcohol Influence Report. *See* Appendix A, 126a. The Court stated that because it gave the opportunity to cross-examine the witnesses most familiar with the machine, and because the Court caused Draeger to divulge its source code, confrontation rights have been satisfied for all pending and future cases.

This is especially problematic, as the Court allowed for an outrageous shortcoming in the machine, an algorithm that corrects for drifting of one of the measuring devices on the machine, the fuel cell. Drifting is aging of the fuel cell, which reacts more slowly and with less intensity to the same amount of alcohol than when the fuel cell is new. As a result, Draeger added a compensating algorithm into the software that attempts to compensate for the lack of complete data arising from the fuel cell measurement. In the event that fuel cell drift is detected during the control test, the algorithm mathematically increases the EC reading that is reported by up to twenty-five percent of the difference between the IR and EC readings from the tests of the subsequent breath samples. *See* Appendix A, 88-89a. Even with this manufacturing of a reported breath test result from the machine, the Court alarmingly stated, "We are confident, based on this far-reaching and searching inquiry, that the device is sufficiently reliable so that the rights of all defendants have been protected." *See* Appendix A, 126a.

The New Jersey Supreme Court paradoxically states, "We perceive both in the Constitution itself and in *Crawford*, ample room for admissibility of these foundational documents consistent with protecting defendants' rights." *See* Appendix A, 119-20a. Without the ability to confront the humans, whose written statements attest to how they have set up the machine, the breath test reading printed out by the machine will be accepted with no ability to challenge the process undertaken to achieve the result, i.e. true trial by machine.

II. THIS PETITION SHOULD BE GRANTED BECAUSE THE DECISION FROM NEW JERSEY'S HIGHEST COURT IS FINAL AS TO THE NAMED DEFENDANTS AND THOUSANDS OF AFFECTED PARTIES WHOSE CASES REMAIN PENDING TRIAL

While the Petitioner's individual cases have not yet been finalized based on their remand to the lower courts, the holding of the New Jersey Supreme Court is final as to the issues raised in this Petition. The Order that accompanies the Opinion states:

> the previously imposed stay is vacated and prosecutions, appeals, and imposition of sentences in all matters arising pursuant to N.J.S.A. 39:4-50, shall proceed in accordance with the following directives:
>
> A. For all pending prosecutions, including all prosecutions in which imposition of sentence has been stayed by our January 10, 2006 Order, and in all future prosecutions based on tests conducted prior to the implementation of our directives through creation of and implementation of revised firmware, Alcotest 7110 MKIII-C with New Jersey Firmware version 3.11 is sufficiently scientifically reliable, and the Alcohol Influence Report (AIR) which sets forth the results of breath tests is admissible as evidence of blood alcohol content (BAC) . . .

Thus, the New Jersey Supreme Court has undermined the protection of the United States Constitution, not only to the Petitioners herein, but to thousands of pending cases in New Jersey and countless future cases. Whether Petitioners' individual matters are not finalized should be of no moment to the consideration of the Constitutional violations set forth by the New Jersey Supreme Court's ruling inasmuch as the decision on the confrontation question is not only repugnant to the Constitution but also final in application.

CONCLUSION

For all the foregoing reasons, petitioners respectfully request that the Supreme Court grant review of this matter.

Respectfully submitted,

Evan M. Levow
Counsel of Record
Levow & Associates, P.A.
1415 Route 70 East
Suite 200
Cherry Hill, NJ 08034
(856) 428-5055

Matthew W. Reisig
One Broad Street
First Floor
Freehold, NJ 07728

Samuel L. Sachs
P.O. Box 968
East Windsor, NJ 08520

Jonathan A. Kessous
Garces & Grabler
235 Livingston Avenue
New Brunswick, NJ 08901

John Menzel
2911 Route 88
Suite 12
Point Pleasant, NJ 08742

Attorneys for Petitioners

APPENDIX

APPENDIX

APPENDIX A — OPINION OF THE SUPREME COURT OF NEW JERSEY FILED MARCH 17, 2008

SUPREME COURT OF NEW JERSEY
A-96 September Term 2006

STATE OF NEW JERSEY,

Plaintiff-Appellant,

v.

JANE H. CHUN, DARIA L. DE CICCO, JAMES R. HAUSLER, ANGEL MIRALDA, JEFFREY R. WOOD, ANTHONY ANZANO, RAJ DESAI, PETER LIEBERWIRTH, JEFFREY LING, HUSSAIN NAWAZ, FREDERICK OGBUTOR, PETER PIASECKI, LARA SLATER, CHRISTOPHER SALKOWITZ, ELINA TIRADO, DAVID WALKER, DAVID WHITMAN and JAIRO J. YATACO,

Defendants-Respondents,

and

MEHMET DEMIRELLI and
JEFFREY LOCASTRO,

Defendant,

and

DRAEGER SAFETY DIAGNOSTICS, INC.,

Intervenor.

Appendix A

Argued April 5, 2007 — Remanded April 30, 2007
Master's Report filed — November 8, 2007
Re-argued January 7, 2008 — Decided March 17, 2008

On certification to the Superior Court, Law Division, Middlesex County.

JUSTICE HOENS delivered the opinion of the Court.

INTRODUCTION

For decades, this Court has recognized that certain breath testing devices, commonly known as breathalyzers, are scientifically reliable and accurate instruments for determining blood alcohol concentration (BAC)[1] and that drivers whose breathalyzer test results demonstrate the requisite statutorily-imposed BAC are

1. Although the statute fixes limits in terms of BAC, violations of the statute have been proven routinely through analysis of breath and a conversion of breath alcohol concentration (BrAC) into a BAC reading. *See* Sections III.A. and VIII.A., *infra.*

guilty per se of driving while intoxicated (DWI). Although the Legislature has from time to time reduced the permissible BAC limits and has altered the penalties for this offense, and although we have required foundational proofs relating to the operation of the breathalyzer device as a precondition for admission of the breathalyzer test results into evidence, the accuracy and reliability of the breathalyzer itself has remained essentially unquestioned since our decision in *Romano v. Kimmelman,* 96 N.J. 66, 474 A.2d 1 (1984).

Nevertheless, in the intervening years, the devices have become technologically outdated, with the result that replacement parts are no longer available and the machines themselves, when they fail, cannot be repaired or replaced with like equipment. Faced with an increasingly difficult situation, the Attorney General's office began to consider alternate devices to use for breath-testing purposes. That process led to the decision by the Attorney General to select the Alcotest 7110 MKIII-C (the Alcotest).[2] Following its introduction into service in a pilot program in Pennsauken, the use of the Alcotest has been expanded to all but four of our counties. Its use and its capabilities, as a means to analyze breath samples with sufficient accuracy so that

2. Throughout this opinion, we will refer to the Alcotest without specifying further the model number and we will generally refer to the firmware without designating the version utilized except in instances where the designation is important for clarity. We intend to make no comments about other models of the device or about the software used to operate any other Alcotest model.

the results will be admissible into evidence to support a conviction, withstood an initial challenge arising from the Pennsauken program. Thereafter, the continued expansion of use of the Alcotest around the state resulted in a further challenge to its scientific reliability, which has been the essential focus of our inquiry here.

In our effort to analyze the reliability of the Alcotest, we have not only considered the questions concerning the scientific challenges to the machine, but we have also considered the underlying constitutional questions about the permissibility of its use in the context of a per se violation of the statute based solely on the results it reports, together with such safeguards and foundational requirements that will allow its admissibility in a DWI prosecution. We have been aided enormously in this task by the efforts of the Special Master for his analysis of the voluminous record created during the extended proceedings on remand.

In summary, we conclude that the Alcotest, utilizing New Jersey Firmware version 3.11, is generally scientifically reliable, but that certain modifications are required in order to permit its results to be admissible or to allow it to be utilized to prove a per se violation of the statute. Some of these conditions upon admissibility we impose as a matter of constitutional imperative, others as a matter of addressing certain of the device's mechanical and technical shortcomings that were revealed during the proceedings on remand. Within the framework for admissibility that we here establish, pending prosecutions should be able to proceed in an orderly and uniform fashion.

I. *Facts and Procedural History*

The matters that we have been called upon to consider are both many and varied; even among those issues on which the parties agree, we are required to create mechanisms for addressing the uses of Alcotest results generated in prosecutions undertaken prior to this analysis.

The Alcotest is a breath-testing device,[3] manufactured and marketed by Draeger Safety Diagnostics Inc. (Draeger), which was first utilized in New Jersey as part of a pilot project in Pennsauken. The admissibility of the results derived from breath testing by this device was first challenged in 2003. *See State v. Foley,* 370 N.J. Super. 341, 851 A.2d 123 (Law Div.2003). In a published decision addressing that challenge, the Law Division judge concluded that the device was generally scientifically reliable and that the BAC readings it generates are therefore admissible as proof of a per se violation of the drunk driving statute. *Id.* at 345, 851 A.2d 123.

Following the decision in *Foley,* the State expanded the use of the device to other municipalities, including county-wide utilization in Middlesex County. At the same time, in cooperation with State Police personnel charged with overseeing the device's implementation, *see*

3. To the extent that the technical manner in which the device operates is germane to our analysis, we set it forth in Section III.B., *infra.*

N.J.A.C. 13:51-3.2, the manufacturer created revised software for use in the device.[4]

A. *Certification to this Court*

Defendants are twenty individuals who were arrested in various municipalities in Middlesex County and were charged with driving while intoxicated, *see N.J.S.A.* 39:4-50. Each of these defendants challenged the admissibility of results from the Alcotest in their respective proceedings. The Law Division consolidated all of these matters for consideration of the challenge to the Alcotest. In response, the State filed a motion seeking to have the court recognize the *Foley* opinion as binding authority and apply its findings about the scientific reliability of the device to all pending prosecutions. The Law Division denied that motion and stayed all DWI-related cases involving the Alcotest that were then pending in Middlesex County.

The Appellate Division granted the State's motion for leave to appeal and remanded the matter to the Law Division for a hearing regarding the admissibility of Alcotest results. Before that hearing could proceed, this Court certified the pending appeal pursuant to *Rule* 2:12-1, vacated the remand to the trial court, and instead remanded the case to a Special Master, retired Appellate Division Presiding Judge Michael Patrick King. The Court ordered the Special Master to:

---

4. The technical alterations in the software, referred to as firmware, some of which are significant to our evaluation of the device, are explained in Section VIII.D.1, *infra*.

1. Conduct a plenary hearing on the reliability of Alcotest breath test instruments, including consideration of the pertinent portions of the record in *State v. Foley,* 370 N.J.Super. 341 [851 A.2d 123] (Law Div.2003), and the within matters in the Superior Court, Law Division, Middlesex County, together with such additional expert testimony and arguments as may be presented by the parties;

2. Determine whether the testimony presented by the parties should be supplemented by that of independent experts selected by the Special Master;

3. Grant, in the Special Master's discretion, motions by appropriate entities seeking to participate as *amici curiae,* said motions to be filed with the Special Master within ten days of the filing date of this Order;

4. Invite, in the Special Master's discretion, the participation of entities or persons as *amici curiae* or, to the extent necessary in the interests of justice, as intervenors to assist the Special Master in the resolution of the issues before him; and

5. Within thirty days of the completion of the plenary hearing, file findings and conclusions with the Clerk of the Court and contemporaneously serve a copy on the

> parties and *amici curiae*, which service may be effectuated by the posting of the report on the Judiciary's website.

Although we also vacated the Law Division's stay of all drunk driving cases then pending in Middlesex County, we subsequently created a distinction among pending prosecutions based upon the proofs and the status of the charged individuals. Our January 10, 2006 Order therefore directed that all drunk driving prosecutions, *see N.J.S.A.* 39:4-50, that did not involve an Alcotest, and all cases of repeat offenders, should proceed normally. As to repeat offenders who were thereafter found guilty, we directed that the sentences to be imposed on those defendants would be stayed only if the conviction were based on the Alcotest results alone. We ordered that first-offender cases involving the Alcotest be tried "based on clinical evidence when available, including but not limited to objective observational evidence, as well as the relevant Alcotest readings." We further ordered that if a court found that a first offender was guilty, it was required to articulate, if possible, the alternate bases for the finding. We stayed the execution of all first offenders' sentences pending resolution of this matter, except where public interest required otherwise, and stayed all further requests for Alcotest reliability hearings. Finally, we reiterated our earlier Order authorizing conditional guilty pleas, *see R.* 7:6-2(c), with a reservation of the right to appeal in the event that we concluded that the Alcotest is not reliable.

The Association of Criminal Defense Lawyers of New Jersey (ACDL) and the New Jersey State Bar Association (NJSBA) were subsequently permitted to participate as amici curiae in all of the remand and appellate proceedings.

B. *Remand Hearings*

Shortly after being appointed to serve, the Special Master issued a discovery order directing the State to provide defendants with certain technical information concerning the operation of the Alcotest device, followed by an order directing the State to make several Alcotest machines available to defendants and the NJSBA. In large part, the ensuing dispute about the disclosure of the software used to operate the device, called firmware, and the source codes needed for an analysis of that software, caused significant disruption in the orderly completion of the proceedings and eventually led to our further remand for additional proceedings.

In short, however, the Special Master was advised that Draeger considered the software and the source code to be proprietary information and would not disclose it. He proposed that counsel enter into a standard protective order and invited Draeger, which was not then a party, to intervene in the proceedings. Draeger declined the Special Master's invitation to intervene. At the same time, Draeger refused to permit the parties to review the software except under extremely limited conditions and refused to disclose the source code under any circumstances. As a result of this impasse, the Special Master concluded that he could utilize an adverse inference as to the reliability of the device, but he proceeded with the hearings in the absence of any participation by Draeger. Near the end of the initial hearings, defendants and Draeger entered into a letter agreement, which would have permitted defendants to evaluate future changes to the software in the event that the Alcotest was found to be scientifically reliable.[5]

Following hearings that spanned four months, the Special Master issued his findings and conclusions, embodied in a report to this Court dated February 13, 2007. In that report, the details of which we address in Section IV.A., *infra,* the Special Master concluded that the Alcotest is generally scientifically reliable, but he recommended that several changes be incorporated both prospectively and with respect to pending matters. Thereafter, but prior to the time when we received briefs on the merits and entertained oral argument, Draeger moved for leave to intervene before this Court, which motion we granted.

After the initial oral arguments on April 5, 2007, including those offered by Draeger, we remanded the matter to the Special Master again to allow defendants an opportunity to conduct the analysis of the source

---

5. In some respects, the parties disagree about the continued need for and viability of the agreement, which they referred to as Addendum A. We address future testing of software revisions further below, *see* Section X, *infra.*

code that they had contended was essential to an accurate determination of the reliability of the device. *State v. Chun,* 191 N.J. 308, 309, 923 A.2d 226 (2007). In doing so, we directed that the review be undertaken by an independent softwarehouse, to be agreed upon by Draeger and defendants, in order to preserve Draeger's proprietary interests. *Id.* at 309-10, 923 A.2d 226.

The parties, however, were unable to agree on an independent software house that would conduct the source code analysis. Although our order authorized the Special Master in that event to make the selection, he believed he was not well equipped to choose and he so advised us. Therefore, this Court issued a supplemental order allowing each of the parties, at its own expense, to designate an independent software house to review the source code. The supplemental order also provided that the Special Master, at his discretion, could conduct further hearings following his receipt and review of the expert reports.

Draeger and defendants each designated a software house to analyze the source code and report on its reliability. Because the reports reached different conclusions, the Special Master scheduled further hearings. After ten additional days of testimony and two days devoted to summations, the hearings were completed on October 24, 2007. The Special Master submitted his Supplemental Findings and Conclusions to this Court on November 8, 2007. He concluded, in summary, that the source code analysis did not alter his original opinion that the Alcotest is scientifically reliable, as to both its hardware and software elements. However, he conditioned this conclusion on additional recommendations, which supplemented those contained in the initial report.

II. *Legislative Framework*

Our analysis of the issues surrounding the scientific reliability of the Alcotest device and our consideration of the Special Master's recommendations must begin with an understanding of the legislative framework that bears upon drunk driving prosecutions. We turn, then, to an explanation of the statutes governing the offenses that we generally refer to as drunk driving, together with an analysis of the relevant legislative history that bears on the issues before us.

The Legislature has established that an individual is guilty of driving while intoxicated if he or she "operates a motor vehicle with a blood alcohol concentration of [0].08 [percent] or more by weight of alcohol in [his or her] blood." *N.J.S.A.* 39:4-50(a). For first offenders who have a BAC that is 0.10 percent or greater, harsher penalties and higher fines apply. *See N.J.S.A.* 39:4-50(a)(1). Subsequent offenses, as measured by the 0.08 percent standard, are treated with increasingly harsh penalties, including not only longer periods of license suspension, but incarceration as well. *See N.J.S.A.* 39:4-50(a)(2), -50(a)(3).

As we have previously found, the primary purpose behind our drunk driving laws is to remove intoxicated drivers from our roadways and thereby "to curb the senseless havoc and destruction" caused by them. *State v. Tischio,* 107 N.J. 504, 512, 527 A.2d 388 (1987). We have consistently construed these laws both broadly and pragmatically to ensure that the Legislature's intent is effectuated. *See id.* at 513, 527 A.2d 388; *State v. Mulcahy,* 107 N.J. 467, 479, 527 A.2d 368 (1987) (concluding that turning on ignition is not required for finding that person behind the wheel was in control of and intended to operate vehicle); *State v. Wright,* 107 N.J. 488, 497, 527 A.2d 379 (1987) (concluding that predicate of actual operation of vehicle is not required for request that individual undergo breathalyzer testing).

As part of the effort to rid our roads of drunk drivers, the Legislature has sought over time to streamline the process by which those charged with DWI offenses are efficiently and successfully prosecuted. *See Tischio, supra,* 107 N.J. at 514, 527 A.2d 388. Our current laws, as a result, can only be interpreted correctly if they are viewed in the context of this continuing evolution.

Our analysis begins in 1951, when, in order to address growing difficulties and confusion surrounding the evidentiary burden for establishing operation of a vehicle "under the influence," the Legislature enacted *N.J.S.A.* 39:4-50.1. *Tischio, supra,* 107 N.J. at 514-15, 527 A.2d 388; *see also State v. Protokowicz,* 55 N.J.Super.

598, 603, 151 A.2d 396 (App.Div.1959). This statute provided that a 0.15 percent blood-alcohol level gave rise to a presumption of intoxication for purposes of a driving under the influence prosecution. *Tischio, supra,* 107 N.J. at 515, 527 A.2d 388. A blood-alcohol level below 0.05 percent gave rise to a presumption of non-intoxication, and a level between the two gave rise to no presumption. *Id.* at 515 n. 3, 527 A.2d 388. These legislative presumptions were targeted at reducing the evidence, specifically expert and other testimony, which was otherwise needed to prove intoxication and convict a drunk driver. *Id.* at 515, 527 A.2d 388.

At that time, New Jersey's 0.15 percent standard was the most permissive in the country, *see id.* at 515-16, 527 A.2d 388 (citing Motor Vehicle Study Commission, Report to the Senate and the General Assembly of 1975 (hereinafter "Report"), at 135), although the penalties imposed were "among the most stringent." *Id.* at 515, 515 n. 4, 527 A.2d 388. Nevertheless, studies revealed that most drivers were impaired at BAC levels significantly lower than the statutory presumption employed in the 1951 statute. *Id.* at 516, 527 A.2d 388 (citing Report, *supra,* at 141-42). As a result, the Legislature amended *N.J.S.A.* 39:4-50.1, in 1977, *see L.* 1977, *c.* 29, to lower the presumptive BAC for intoxication purposes from 0.15 to 0.10 percent. *Tischio, supra,* 107 N.J. at 516, 527 A.2d 388.

In 1983, the Legislature again amended the drunk driving statutes to take into account "mounting scientific findings," to the effect that almost all drivers suffered reduced driving ability at a BAC of 0.10 percent. *Ibid.* At the same time, the amended statute brought the state into compliance with minimum federal grant standards. *L.* 1983, *c.* 129; Assembly Judiciary, Law, Public Safety & Defense Committee, *Statement to Assembly Committee Substitute for Senate Bill No. 1833* (Feb. 14, 1983). Significantly, the amended version of *N.J.S.A.* 39:4-50 provided that a 0.10 percent BAC level constituted a per se offense, instead of simply giving rise to a presumption.[6]

In 1990, the New Jersey Commercial Driver License Act was enacted. *L.* 1990, *c.* 103. It created an even more stringent standard to be applied to drivers of commercial vehicles. It provides a penalty, in addition to any other applicable penalties, of a one to three-year commercial license suspension for commercial drivers caught driving with a BAC level of 0.04 percent or greater. *N.J.S.A.* 39:3-10.13, -10.20(a)(1). The 0.04 percent BAC standard for commercial drivers was enacted both to comply with the federal standard in the Commercial Motor Vehicle Safety Act of 1986, Pub.L. No. 99-570, 100 Stat. 3207 (1986) (codified at 49 *U.S.C.A.* § 31310), and in recognition of the fact that significant impairment occurred well below the otherwise applicable 0.10 percent BAC levels. *See L.* 1990, *c.* 103; Assembly Appropriations Committee, *Statement to Assembly Bill No. 3258,* at 23 (Oct. 1, 1990).

---

6. This change essentially engulfed the rule provided in *N.J.S.A.* 39:4-50.1, which nonetheless remained in the statutes until 1990, when it was repealed by *L.* 1990, *c.* 103, § 38.

In 1992, the Legislature enacted an additional drunk driving prohibition by creating a new per se offense, which applies to drivers who are under the legal drinking age. *L.* 1992, *c.* 189. This most recently-added tier provides that any person under the age of twenty-one who is caught driving with a BAC level above 0.01 percent faces a thirty to ninety-day license suspension, in addition to community service requirements. *See N.J.S.A.* 39:4-50.14. The statement attached to the legislation explained that the bill was intended to establish penalties for any driver under the age of twenty-one who is "found to have consumed an alcoholic beverage." *L.* 1992, *c.* 189; Assembly Judiciary, Law & Public Safety Committee, *Statement to Assembly Committee Substitute for Assembly Nos. 1447 & 1426* (June 1, 1992). The purpose of the enactment was two-fold: "to deter younger drivers from drinking and driving, and to establish an early detection and treatment program for young people. . . ." Anthony Impreveduto, et al., *Statement to Assembly No. 1426* (May 14, 1992).

In 2003, the per se violation set forth in the statute was further reduced. In order to comply with federal highway funding requirements, the statutory standard of 0.10 percent BAC was reduced to 0.08 percent BAC. *L.* 2003, *c.* 314. At the same time, the amendment created two separate, graduated penalties relevant to prosecution for a first offense. As a result of this legislative enactment, first time offenders with a BAC level between 0.08 percent and 0.10 percent are subject to a three-month license suspension, but first time offenders with a BAC level of 0.10 percent or greater are subject to a seven to twelve-month license suspension. *Ibid.*

In addition, throughout this time, penalties for second and third offenders have become increasingly harsh. *See, e.g., L.* 1995, *c.* 286 (registration revocation); *L.* 1999, *c.* 417 (ignition interlock device installation); *L.* 2003, *c.* 315 (Michael's Law; imposing mandatory jail time or inpatient rehabilitation program time for a third or subsequent violation); *L.* 2004, *c.* 8 (increasing penalties for refusal to submit to breath test).

Although when considered together, these statutory enactments make plain the Legislature's view that drunk driving is not to be tolerated, the relationship between this increasingly restrictive legislative scheme and the new technology of the Alcotest, as compared to the breathalyzer, requires us to re-examine much of our earlier jurisprudence as part of our consideration of the issues raised in this appeal.

In virtually all of these statutes, the Legislature has utilized blood alcohol concentration, not breath alcohol concentration, as its standard measure.[7] Both the breathalyzer and the Alcotest, however, test breath samples and convert that analysis by mathematical

---

7. Although the commercial driving statute defines "alcohol concentration" in terms of both blood and breath, *see N.J.S.A.* 39:3-10.11, our focus here will be on the more commonly applied articulation of blood alcohol.

calculations to an expression of the subject's presumed blood alcohol concentration. The principle question, then, is whether the Alcotest does so with sufficient accuracy and reliability to permit the results to be admitted in evidence in a DWI prosecution, or used as the basis for a per se violation of the statute and, therefore, a conviction.

III. *How the Alcotest Works*

The State seeks in this proceeding to establish that the Alcotest is scientifically reliable to measure defendants' blood alcohol levels. We turn, then, to a discussion of the physiological effects of alcohol on the body, how the Alcotest measures the concentration of alcohol in the breath and converts it to a measure of blood alcohol levels, and the State's proposed procedures to ensure that the Alcotest functions properly.

A. *Scientific and Physiological Framework*

Much of the scientific evidence in the record before the Court is undisputed. In fact, the basic physiological mechanisms on which all breath testing devices rely are not themselves controversial. We set these scientific propositions forth here, however, to provide the basis for our analysis of the scientific matters that are in dispute.

1. *Alcohol and Blood*[8]

Alcohol is ordinarily ingested orally and enters the stomach where it is absorbed through the stomach's walls and intestines and is thereafter carried by the blood through the liver to the heart. The heart pumps the blood and, along with it, the alcohol, through the body, including carrying it to the brain and the lungs. Alcohol exerts its effects on an individual when the blood containing the alcohol reaches the brain.

Absorption begins immediately once a person starts drinking. The rate of absorption varies greatly from one person to the next and can even vary in the same person at different times. It depends on a wide variety of factors including general health, recent food consumption, physical makeup, amount of alcohol consumed, weight, and gender.

Elimination of alcohol also starts as soon as a person begins to drink. Alcohol is eliminated through excretion and metabolization, which occur when alcohol passes through the liver and is broken down by enzymes and dehydrogenates. When a person's body is absorbing alcohol faster than he or she is eliminating it, the concentration of alcohol in the blood will continue to rise.

---

8. We draw these scientific descriptions from the testimony in the record offered by Barry Logan, a board-certified forensic toxicologist, and Patrick Harding, a biochemist who has also previously testified in proceedings involving breath testing devices. *See State v. Downie,* 117 N.J. 450, 454, 569 A.2d 242 (1990).

This period of time is ordinarily referred to as the absorptive phase. The concentration will reach its peak, and it will achieve a plateau, at the time when elimination and absorption are occurring at about the same rate.

When the person stops ingesting alcohol, or slows down ingestion to the point where the body is eliminating alcohol more quickly than absorbing it, the body enters what has generally been referred to as the post-absorptive phase. During this period of time, the concentration of alcohol in the blood decreases.

2. *Alcohol and Breath*

The reported concentration of alcohol in any particular person varies depending upon the source of the test sample. An understanding of the relationship of these potential test sample sources to BAC is important to our analysis. Alcohol passes into the lungs, through the walls of the air sacs, called alveoli. As it does so, it mixes with the air that the person has inhaled. When the person exhales, alcohol passes out of the body as part of the breath.

An individual's breathing pattern can influence the amount of alcohol that appears in any particular breath. In addition, the amount of alcohol in the breath sample represented by a single act of exhalation will vary from the beginning to the end. This is because the breath actually comes from different parts of the body, from the mouth to the deepest part of the lungs. Except for the possible interference that would occur if the test subject had ingested alcohol so recently that residual mouth alcohol were captured, the first part of the breath comes from the mouth and throat where there is little contact with the alcohol passing through the alveoli. However, as the person continues to exhale, the expelled air comes from deeper in the respiratory system, where it contains alcohol that more closely represents the amount passing through the lungs from the circulating blood.

3. *Differences Between Blood and Breath Tests*

Our statute establishes the violation in terms of blood, and not breath alcohol concentration. Although testing an individual's blood would presumably provide more direct evidence of that person's BAC, there are obvious practical and logistical problems associated with attempting to collect blood samples from suspected drunk drivers routinely.

As a result, although because of our statute New Jersey is considered to be a "blood state," we have long permitted BAC to be established through breath testing, in which breath samples are tested and converted to determine blood alcohol levels. Breath testing therefore uses an indirect measure of BAC by calculating the alcohol concentration in the breath (breath alcohol concentration, or BrAC) and extrapolating to derive the BAC using a blood/breath ratio. Breath testing has become the preferred method for field testing because it can be performed easily, is highly automated, does not require scientific skill, and produces an immediate result.

B. *Operation of the Alcotest*

In light of the fact that breath testing always relies on the extrapolation of BAC through testing of breath, the precision with which any device evaluates BAC through this method is critical to our consideration of the admissibility of the device's results. We turn then to a description of the manner in which the Alcotest operates.

The Alcotest, which is currently in use in seventeen of our twenty-one counties,[9] as well as in other states, including Alabama and parts of New York, is a device that purports to accurately measure the concentration of alcohol from a human subject through breath testing. The Alcotest is an embedded system, meaning that it is a device with a specific purpose, and it relies on pre-loaded software that the manufacturer refers to as firmware.

The Alcotest uses both infrared (IR) technology and electric chemical (EC) oxidation in a fuel cell to measure breath alcohol concentration. The device therefore produces two test results for each breath sample, one derived from an IR reading and the other, by and large, from an EC reading.

Although the precise mechanism by which these tests are accomplished is not relevant to the issues

---

9. Only Bergen, Essex, Monmouth, and Hudson counties do not currently use it.

before us, the IR chamber, also called a cuvette, captures the breath sample and uses infrared energy to calculate absorption of the energy by the alcohol concentrated in the chamber. IR technology has been available since the 1970's or early 1980's and scientists have concluded that it is reliable. *See, e.g., Foley, supra,* 370 N.J.Super. at 350, 851 A.2d 123.

The EC, or fuel cell technology, uses a catalyst to absorb alcohol and provide a second measurement[10] of breath alcohol concentration from a small sample captured from the cuvette. In the EC chamber, voltage is applied to cause the catalytic reaction, which causes any alcohol that is present to oxidize. As that occurs, the oxidation process creates electricity, which is then measured to determine the amount of alcohol interacting with the fuel cell.

C. *Test Administration and the Alcohol Influence Report*

The Alcotest reports the IR and EC readings on a printout from the machine, referred to as the Alcohol Influence Report (AIR).[11] One of the claimed advantages

---

10. Draeger has consistently represented that the IR and EC tests are "completely independent" as a basis for its claim that the device is reliable. As our discussion of the fuel cell drift algorithm, *see* Section IX.A., *infra,* explains, however, the reported results of the two tests are not always independent.

11. To the extent relevant to our analysis, we describe the specific details of the information reported on each AIR further, *see infra.*

of the Alcotest, as compared to the breathalyzer, is that it is not operator-dependent, but performs its analysis in accordance with a sequence through a computerized program that gives visual prompts to the operator. We turn, then, to a description of the manner in which the device operates in practice in performing these functions.

The actual administration of the test is performed by one of the more than 5000 certified Alcotest operators in New Jersey. When a person has been arrested, based on probable cause that the person has been driving while intoxicated, he or she is transported to the police station to provide a sample for the Alcotest. The Alcotest, consisting of a keyboard, an external printer, and the testing device itself, is positioned on a table near where the test subject is seated.

Operators must wait twenty minutes before collecting a sample to avoid overestimated readings due to residual effects of mouth alcohol. The software is programmed to prohibit operation of the device before the passage of twenty minutes from the time entered as the time of the arrest. Moreover, the operator must observe the test subject for the required twenty-minute period of time to ensure that no alcohol has entered the person's mouth while he or she is awaiting the start of the testing sequence. In addition, if the arrestee swallows anything or regurgitates, or if the operator notices chewing gum or tobacco in the person's mouth, the operator is required to begin counting the twenty-minute period anew.

The Alcotest that is the focus of this matter utilizes software developed in collaboration with the New Jersey State Police and known as New Jersey Firmware version 3.11.[12] This software prompts the operator through a specific testing sequence on each arrestee. Essentially, the process begins when the operator has typed identifying information into the machine through a series of questions and prompts. The device then starts and automatically samples the room air to determine if there are chemical interferents in the room. This is known as a blank air test. Assuming that there are none, the machine then uses its attached wet bath simulator to heat a solution and produce a vapor sample from a control test solution[13] with a known alcohol concentration of 0.10, which is then measured using IR and EC technology. In order to be valid, the control test, in accordance with currently-programmed firmware, must produce results between 0.095 and 0.105. If the results do not identify the known sample within the defined parameters, the device is programmed so that

---

12. The Alcotest that was the subject of the Law Division's findings and conclusions in *Foley, supra,* utilized an earlier version of the software known as New Jersey Firmware version 3.8. A number of changes made to the software following the court's decision in *Foley* have become important to our analysis as we will detail.

13. The record reflects that the control solution must be changed after approximately twenty-five test sequences or thirty days. The device prompts the operator when the solution needs to be changed and generates a separate report evidencing the results of control testing after each change in the solution.

the test cannot proceed. If the machine is working properly as demonstrated by the control test, then the instrument performs a second blank air test, again using room air to purge the test sample out of the chamber.

Assuming that the results of the control test are within the established parameters, the instrument prompts the operator through a message on the LED screen to collect a breath sample. The operator then attaches a new, disposable mouthpiece and removes cell phones and portable electronic devices from the testing area. The operator is required to read the following instruction to the test subject: "I want you to take a deep breath and blow into the mouthpiece with one long, continuous breath. Continue to blow until I tell you to stop. Do you understand these instructions?" The arrestee then provides the first breath sample, which is measured in the IR and EC chambers.

Lights on the LED screen and an audible sound alert the operator when a breath sample which meets the minimum fixed standards, comprised of four criteria, has been provided. The operator then tells the subject to stop and the instrument performs a third blank test to purge the first breath sample. After a two-minute lock-out period during which the device will not permit another test, the instrument prompts the operator to read the instruction again to the arrestee and collect the second breath sample. The second sample is also measured using the IR and EC technology. The second sample is purged from the machine and the device performs a fourth blank test using room air.

If the measurements for the first breath test are out of the accepted range of tolerance with the measurements for the second breath test, the machine prompts the operator to conduct a third breath test. Depending on the relationship among the three tests, the results are reported. The instrument then performs a second control test with the known solution from the simulator. Finally, the air is purged again and a final blank test is performed.

The device gives the operator three minutes to collect each sample. If that time expires without a sample, the device will present the operator with three options. The options are to terminate the test, report that the person refused the test, or continue with the test. If the officer opts to continue the test, the device will purge itself and then prompt the operator to collect another sample. The operator has a maximum of eleven attempts to collect two breath samples. After the eleventh failed test, the only two options permitted by the device are to terminate testing or report refusal.[14]

---

14. Even if the officer types in the code for a refusal, he is not required to issue a summons for refusal. Instead, the officer may opt to start the test again and give the arrestee eleven more attempts. Alternatively, the officer may decide to terminate testing, without charging the test subject with refusal. An operator will generally select this option if he or she concludes that the subject has in fact attempted to comply but is not capable of providing a sample that meets the minimum test criteria.

As currently configured by New Jersey Firmware version 3.11, the software now being utilized, the device will accept a sample only if it meets certain minimum criteria that have been devised by the State.[15] Once the subject has provided an acceptable breath sample, the machine prompts the operator, through a system of lights on the LED screen and an audible beep, to tell the subject that he or she may stop. If any of these minimum test criteria has not been met, the machine will generate an error message and a report of how much air was submitted. The machine then offers the operator the option of giving the person another attempt or asserting refusal.

The results of the test sequence are printed out from the device in a sequentially numbered document referred to as an AIR. The AIR contains the test subject's identifying information, date, time, and test results for each stage of the procedure. Each AIR includes a variety of other information relevant to the test, including the serial number of the device used in the test, dates of and file numbers for calibration and linearity checks, and solution control lot and bottle numbers. The operator must retain a copy of the AIR and give a copy to the arrestee.

In the event that the administration of the test resulted in errors because of, for example, insufficient

---

15. The legitimacy of some of these criteria are in issue in this dispute. We need not explain them in detail here but will do so in the context of our analysis of those criteria that have given rise to a debate. *See infra,* Section VIII.B.

breath volume or duration, the AIR will report those errors and will not attempt to calculate the BAC from an inadequate sample. Similarly, if the results of the control test do not fall within the acceptable tolerance, the device will produce an AIR that reports that the test could not be accomplished because of an invalid control test.

If the results are within the acceptable tolerance, the AIR shows the BAC values for each IR and EC reading for each of the tests to three decimal places. The AIR then reports the final BAC test result, which will be the lowest of the four acceptable readings, that is, readings within acceptable tolerance, which the device is programmed to truncate to two decimal places. Truncating, as opposed to rounding, involves simply reporting the first and second decimal places and dropping the third. For example, by truncating, a reading of 0.079 percent BAC would be reported as 0.07 and a reading of 0.089 percent BAC would be reported as 0.08. The effect of truncating, as opposed to rounding, is to under-report the concentration, to the benefit of the arrestee.

By statute, the Legislature has designated the Attorney General to create and implement a breath testing program. *See N.J.S.A.* 39:4-50.3. The Attorney General, in turn, has vested responsibility for carrying out this command in the State Police. *See N.J.A.C.* 13:51-3.2. The Alcotest program was designed and is overseen by the Office of Forensic Sciences, a Division of the New Jersey State Police. The director of the forensic laboratory, Dr. Thomas Brettell, together with other forensic scientists in the Office assigned to the alcohol/drug testing unit, conducted tests on a variety of breath testing devices in an effort to select a successor to the breathalyzer.

After the Alcotest was chosen, Brettell assisted in the creation of the test criteria and provided other input into the original programming and the updates to the software that now is utilized in operating the device. His office has collaborated with municipalities to train Alcotest operators and to oversee certain aspects of the program. State Police Sergeant Kevin Flanagan is the field supervisor for five State Police coordinators, each of whom monitors a geographic area. The coordinators receive factory and classroom training from Draeger and they, in turn, train the operators. Coordinators do not perform any repairs, but they perform "black key" functions, such as calibration and software uploads, which are not done by other police personnel.

Calibration of the machines involves attaching the machine to an external simulator which uses a variety of solutions of known alcohol concentrations to create vapors that approximate human breath. By exposing the IR and EC mechanisms to these differing concentrations, and by analyzing the device's ability to identify accurately each of those samples within the acceptable range of tolerance, referred to as a linearity test, the coordinator is able to ensure that the machine is correctly calibrated. When coordinators undertake to perform this calibration, currently on an annual basis, and other routine inspections, they also download the device's test information onto two compact discs.[16] In accordance with current State Police protocol, one of these discs is kept in the local police department's evidence file and the other is held by the coordinator.[17]

IV. *Findings of the Special Master*

Following hearings that spanned four months and included testimony from eleven fact and expert witnesses called by the State and two experts offered by defendants, the Special Master issued his first report on February 13, 2007. Although there are some aspects of that report and certain of the Special Master's recommendations that are not disputed by any of the parties, much of the report and many of the recommendations are challenged in this proceeding. As a result, we briefly summarize the report and its findings and recommendations before turning to our analysis of the matters in dispute.

A. *Initial Report*

In short, the Special Master concluded that the Alcotest in general is scientifically reliable, that it is

---

16. The record reflects that each device is capable of storing the data from 1000 test results. Current State Police protocol, however, requires the coordinators to download data from each device before it exceeds 500 tests.

17. *See* Part IV, *infra* (Special Master's Finding 7, recommending creation of centralized database).

superior to the breathalyzer because it relies less on operator influence, and that the AIR it generates, therefore, meets the test for admissibility in drunk driving prosecutions in general. Notwithstanding that conclusion, however, the Special Master offered a large number of suggestions for modifications both as to the future operation of the device and as to the use of the extant AIRs as evidence in pending prosecutions.

In his first report, the Special Master offered all of the following specific findings and recommendations.[18] He found that the use of the 2100 to 1 blood/breath ratio is scientifically reliable (Special Master's Finding 1(b)); he recommended that the AIR, solution change report and calibration documents be amended to include a listing of the temperature probe serial number and value (Special Master's Finding 2(a)); he recommended that the State be required to publish future firmware revisions (Special Master's Finding 2(b)); he recommended that the State continue to lock the firmware so that only Draeger and the coordinators would be able to make changes to that software (Special Master's Finding 2(c)); he found that the AIR, which reports all of the breath test results, rather than only the final reported lowest result, should be admissible in evidence (Special Master's Finding 2(d)); he recommended that the AIR be revised to identify the reason that a particular defendant did not achieve a

18. We have elected to adopt, only for the sake of simplicity and clarity, the numbering of the recommendations utilized by the Special Master rather than to proceed with a sequential enumeration.

reportable result (Special Master's Finding 2(e)); he found that Firmware version 3.11 is itself scientifically reliable and that future changes would not undermine its current reliability (Special Master's Finding 2(f)); he concluded that the Alcotest is not operator dependent, (Special Master's Finding 2(g)), and that it is therefore superior to the breathalyzer (Special Master's Finding 8); he recommended that all defendants have access to centrally collected data on their matters as well as to redacted versions of information relating to breath tests performed on other arrestees (Special Master's Finding 2(h)); he recommended that the calibration, certification and linearity reports be amended to include the serial number of the digital temperature measuring system utilized (Special Master's Finding 2(i)); he found that the State should be required to provide training for defense counsel and their experts similar to that provided to the certified operators (Special Master's Finding 2(j)); he found that the agreement between Draeger and defendants regarding future testing of firmware revisions should be enforced (Special Master's Finding 3); he concluded that the Alcotest is well shielded against radio frequency interference (RFI) (Special Master's Finding 4); he recommended that operators be required to testify about their qualifications and the testing procedures utilized in any proceeding relying on Alcotest results (Special Master's Finding 5(a)); he identified twelve foundational documents that the State must provide in discovery, which may be admitted into evidence without further formal proofs, and reasoned that they must be admitted into evidence in cases in which the defendant is not represented by counsel (Special Master's Finding 5(b)); he concluded that the technical criteria for a minimum breath sample utilized by the Alcotest are appropriate, with the exception of the minimum breath volume as it relates to women over sixty years of age (Special Master's Finding 6); he recommended that the State create and maintain a centralized database of the digitally recorded data (Special Master's Finding 7); he concluded that the State must commence use of the Draeger breath temperature sensor and apply a mathematical formula to account for the effect of temperature to pending reported results (Special Master's Finding 9); and he recommended that the State must reduce the acceptable tolerance for breath results to a total range of ten percent in place of the currently utilized calculation of a range of plus or minus ten percent for future use of the device (Special Master's Finding 10).

B. *Draeger's Role in the Proceedings*

During the first oral argument before this Court following the Special Master's release of his report and recommendations, defendants argued that the entire proceedings were tainted by the manner in which defendants were required to proceed. They argued that because Draeger had refused to make its source code available for their inspection and for analysis by their experts, the Court could have no confidence in the reliability or accuracy of the device from a scientific perspective. In short, they argued that the manufacturer's intransigence forced the Special Master and, by extension, this Court, to rely on "black box" testing,[19] when only a complete and thorough analysis of the source code used to operate the device would suffice for constitutional purposes.

Indeed, the refusal of Draeger to intervene precluded the Special Master from permitting any testing of the manner in which the device operates, and required him to rely on tests that at best could only demonstrate that the machine reliably appeared to be able to identify correctly, or at least acceptably within the established parameters, the alcohol concentration of a known test sample. There is some logic to that method of proceeding. If a breath testing device can, reliably and consistently over time, correctly analyze a sample of known alcohol concentration, one might argue that it matters little how the device is able to do so. Notwithstanding the rather considerable force of that logic, we were persuaded that, in light of the constitutional dimension of the issues before us, Draeger's eventual election to intervene in this matter afforded us the opportunity to permit defendants to engage in the technical analysis of the source code that they had asserted was so necessary to the adequate protection of their rights.

---

19. "Black box" testing refers in this context to a method of evaluating the reliability of the device by using known concentrations to test whether the device accurately detects those concentrations. It refers to testing that does not also consider whether the mechanism by which the result is achieved might be flawed.

C. *Source Code Remand*

Following our order remanding the matter for further analysis of the issues by means of the source code evaluation by the two independent testing entities, *see Chun, supra,* 191 N.J. at 309-10, 923 A.2d 226, the Special Master entertained further testimony on the issues. His supplemental report, dated November 8, 2007, included several additional recommendations, but continued to adhere to his initial conclusion that the device is scientifically reliable for use in pending and, with modifications, future proceedings.

In summary, the Special Master found that a mathematical algorithm that corrects for fuel cell drift did not undermine the reliability of the results, but he recommended that the machines be recalibrated every six months rather than annually to afford more regular opportunities to replace aging fuel cells; he found that a specific buffer overflow error should be corrected in future versions of the software and recommended that in all pending matters in which a third test was performed, that the AIR be excluded or recalculated according to a corrective formula, described in the record as the Shaffer formula; he recommended that catastrophic error detection be re-enabled to stop and restart the machine in the event that such an error occurs; he recommended that the AIR should be inadmissible in any case in which there is data missing from it; he revised his initial finding 5(b) to recommend that the twelve foundational documents be produced in discovery and be admissible in all cases, without regard to whether a particular defendant is represented by counsel or not; he suggested that notice of any and all proposed software revisions be provided to the NJSBA; he recommended generally that defendants' expert's suggestions for reorganizing and simplifying the source code be considered for implementation, but declined to mandate adherence to any specific design standard for future software revisions; he concluded that a weighted averaging algorithm in the code was an accurate methodology that fairly aids in the measurement of breath samples in a test subject; and he accepted the testing method employed by the State's expert and rejected the hypothetical probability analysis raised by defendants as being unnecessarily speculative.

V. *Uncontested Issues*

We begin our analysis with the observation that some of the Special Master's findings and recommendations have not been contested by any of the parties. We will therefore limit our review of those findings and recommendations to a consideration of whether they are supported by sufficient credible evidence in the record, *see State v. Locurto*, 157 N.J. 463, 472, 724 A.2d 234 (1999); *State v. Johnson,* 42 N.J. 146, 158-59, 199 A.2d 809 (1964), and, by extension, whether we will adopt them as our own. With this standard to guide us, we need only briefly address each of them. We do not, however, by the relative brevity of the attention we here accord to these findings and recommendations, intend to suggest that any of them is unimportant to our overall evaluation of the support in the record for the ultimate determination of the scientific reliability of the device.

Certainly, there is adequate support in the record for the Special Master's finding that the Alcotest is not as operator-dependent as was the breathalyzer. (Special Master's Findings 2(g), 8). Indeed, the testing sequence we have described is almost entirely controlled and prompted by the device and, with only a very few exceptions, the operator is not able to influence the manner in which the test is administered. Similarly, there is ample support for the finding that the Alcotest is well-shielded from the impact of any potential RFI that might otherwise affect the reported results or limit our confidence in the accuracy of the test results. (Special Master's Finding 4).

The parties agree, as well, about certain of the Special Master's recommendations for future revisions in the firmware that will provide additional information on the reported results that the device generates. For example, the parties agree that the firmware should be rewritten so that the AIR, solution change report, and calibration documents include the temperature probe serial number and probe value (Special Master's Finding 2(a)); that if the particular test subject has not received a reportable result, the AIR must include a statement identifying why that occurred (Special Master's Finding 2(e)); and that future calibration, certification and linearity reports should include the serial number of the Ertco-Hart digital temperature measuring system utilized in performing those testing and maintenance operations (Special Master's Finding 2(i)).

As to each of these recommendations, there is sufficient evidence in the record to support the conclusion that the addition of this information for future firmware revisions might be of some assistance to future defendants. Notwithstanding our agreement that these proposed alterations, to which the State has acceded, might be beneficial, we discern no basis in the record that suggests that any previously-generated report that lacks these additional details is therefore insufficient as a matter of proof of a per se violation. Rather, we agree with the Special Master that updating the firmware to provide this information in addition to that which it already provides would merely be beneficial.

Similarly, the Special Master recommended, and the parties by and large agree, that the State should create and maintain a centralized database of information regularly uploaded through modem (Special Master's Finding 7), and that defendants should have access to centrally collected and maintained data on their own cases, as well as to the compiled scientific data on matters involving others that has been redacted to shield the personal information related to those other individuals as appropriate (Special Master's Finding 2(h)).[20] Our review of the record satisfies us that there

20. The amicus NJSBA suggests that defendants should have access to previously downloaded, centrally collected data. We do not perceive this to be different from the Special Master's recommendation in this regard and the extent of the access to be afforded to any litigant does not appear to be a matter in dispute. In the absence of any suggestion in the record that there is a genuine difference of agreement among the parties on this matter, we see no need to address it further.

is substantial, credible evidence that supports the Special Master's recommendation concerning the creation and maintenance of a regularly-updated database, as well as his recommendation relating to providing access to that data to defendants.

VI. *Standards of Review*

We turn, then, to the matters as to which the parties are deeply divided. In part, our task is made more complicated by the fact that some of the shortcomings in the operation of the device can only be corrected with respect to future uses of the machine, leaving, potentially, doubt as to the validity of the previously-generated AIRs which form the basis for prosecutions stayed pending the outcome of these proceedings. Moreover, our task has become further complicated by the questions raised by the United States Supreme Court's recent Confrontation Clause[21] cases, *see Crawford v. Washington,* 541 U.S. 36, 124 S.Ct. 1354, 158 L.Ed.2d 177 (2004); *Davis v. Washington,* 547 U.S. 813, 126 S.Ct. 2266, 165 L.Ed.2d 224 (2006); *cf. Whorton v. Bockting,* __ U.S. __, 127 S.Ct. 1173, 167 L.Ed.2d 1 (2007), as to which we must proceed with great care when the only "witness" confronting a defendant is a machine.

---

21. Because the *Crawford* implications were not thoroughly briefed in connection with our consideration of the Special Master's Initial or Supplemental Reports, we invited the parties to submit additional briefs directed to these issues, which we have considered.

We begin, as we must, with a brief review of the applicable principles of law governing admissibility of novel scientific evidence. Admissibility of scientific test results in a criminal trial is permitted only when those tests are shown to be generally accepted, within the relevant scientific community, to be reliable. *See State v. Harvey,* 151 N.J. 117, 169-70, 699 A.2d 596 (1997) (citing *Frye v. United States,* 293 F. 1013, 1014 (D.C.Cir.1923)); *Romano, supra, 9*6 N.J. at 80, 474 A.2d 1; *Johnson, supra*, 42 N.J. at 170-71, 199 A.2d 809. That is to say, the test must have a "sufficient scientific basis to produce uniform and reasonably reliable results and will contribute materially to the ascertainment of the truth." *State v. Hurd,* 86 N.J. 525, 536, 432 A.2d 86 (1981) (quoting *State v. Cary,* 49 N.J. 343, 352, 230 A.2d 384 (1967)). As we have previously commented, however, proof of general acceptance is often "elusive." *Harvey, supra,* 151 N.J. at 171, 699 A.2d 596.

Proof of general acceptance does not mean that there must be complete agreement in the scientific community about the techniques, methodology, or procedures that underlie the scientific evidence. *See Romano, supra,* 96 N.J. at 80, 474 A.2d 1. Even "the possibility of error" does not mean that a particular scientific device falls short of the required showing of general acceptance. *Ibid.* As we long ago recognized, "[p]ractically every new scientific discovery has its detractors and unbelievers, but neither unanimity of opinion nor universal infallibility is required for judicial acceptance of generally recognized matters." *Johnson, supra,* 42 N.J. at 171, 199 A.2d 809. Neither "complete agreement over the accuracy of the test [nor] the exclusion of the possibility of error" is required. *Harvey, supra,* 151 N.J. at 171, 699 A.2d 596.

Nevertheless, before we can conclude that scientific test results are admissible in evidence, the proponent of the scientific device must bear its burden to "clearly establish" that the device or the test meets the standard of general acceptance as we have defined it. *Id.* at 170, 699 A.2d 596*; see State v. Kelly,* 97 N.J. 178, 209-11, 478 A.2d 364 (1984); *State v. Cavallo,* 88 N.J. 508, 521, 443 A.2d 1020 (1982).

VII. *Defendants' Challenges to Scientific Reliability*

Defendants raise three distinct sets of challenges to the basic scientific reliability of the Alcotest. First, they attack it on numerous traditional grounds relating to scientific acceptance, not unlike the challenges raised in *Romano* with regard to two breathalyzer models, by contesting many of the Special Master's findings and recommendations. Second, defendants separately attack the source code utilized to operate the device as being so inherently flawed as to be independently lacking in scientific reliability. Third, following the United States Supreme Court's lead in *Crawford,* defendants attack the admissibility of documents generated by or in connection with the device, which the Special Master suggested be routinely admitted into evidence, as violating their constitutional rights under the Confrontation Clause.

In addition, the State, although urging us to adopt the Special Master's conclusion about the general scientific reliability of the device, argues that many of his recommendations are unnecessary and that none of them undermines the accuracy of any of the previously-reported BAC results for any defendant. The State therefore contends that the majority of the Special Master's recommendations are merely precatory, that is, suggestions that the State may or may not elect to adopt. Finally, the NJSBA, although in large part agreeing with the Special Master's findings and conclusions, suggested a refinement to his recommendation relating to minimum breath sample criteria.

In reviewing the findings and conclusions set forth by the Special Master in his report, we employ our ordinary standards of review, considering them in the same manner as we would the findings and conclusions of a judge sitting as a finder of fact. We therefore accept the fact findings to the extent that they are supported by substantial credible evidence in the record, *see Locurto, supra,* 157 N.J. at 472, 724 A.2d 234, but we owe no particular deference to the legal conclusions of the Special Master, *see Manalapan Realty, L.P. v. Twp. Comm. of Manalapan,* 140 N.J. 366, 378, 658 A.2d 1230 (1995). With these standards in mind, we turn to our analysis of the issues in dispute.

VIII. *Disputed Findings and Recommendations*

We begin our discussion by more specifically identifying the three categories of disputed findings and recommendations. First, there are a number of disputes about the criteria employed by the Alcotest to identify an acceptable breath sample and convert the measurement data into a reported result. This category includes the Special Master's recommendations on each of the following matters: (a) the utilization of the 2100 to 1 blood/breath ratio (Special Master's Finding 1(b)); (b) the minimum breath sample criteria (Special Master's Finding 6); (c) the requirement for the addition of a breath temperature sensor (Special Master's Finding 9); and (d) the acceptable tolerance among test results (Special Master's Finding 10).

Second, there are a number of disputes arising from the supplemental remand that relate to the firmware and source code analysis. This category includes the Special Master's recommendations about each of the following matters: (a) the fuel cell drift algorithm; (b) the weighted averaging sequence; and (c) the adequacy of the overall software design. In addition, although the parties agree on the need to revise the firmware to address two shortcomings identified through the source code analysis, namely, the buffer overflow error and the disabling of the catastrophic error detector, to the extent that these conceded errors may have an impact on the reliability of AIR results pending modification of the firmware, we are compelled to address them as well.

Finally, there are a number of issues that arise as a result of the Special Master's findings and recommendations concerning foundational evidence (Special Master's Findings 5(a), 5(b)). This category includes all of the following recommendations: (a) the requirement for disclosure of foundational documents as a prerequisite for admissibility of any Alcotest results; (b) the required foundational documentary proofs at trial; (c) the admissibility or uses of incomplete reports; and (d) the constitutionally-required testimonial proofs.

We begin, then, with the disputed findings and recommendations as they relate to the criteria employed by the Alcotest for the collection of an adequate breath sample and the creation of an acceptable and reportable result.

A. *Blood/Breath Ratio*

As we have previously noted, the drunk driving statutes in New Jersey define the offense in terms of BAC. In the majority of cases involving individuals charged with these offenses, however, the particular defendant has not undergone a blood test but instead has submitted to a breath test. Modern breath testing devices include an internal mechanism that collects an acceptable breath sample and converts the alcohol detected in the breath (BrAC) into a measure of the person's BAC.

Historically, breath testing devices convert from BrAC to BAC by using a mathematical calculation based upon a scientifically accepted, judicially established blood/breath ratio. The Alcotest utilizes a blood/breath ratio of 2100 to 1, a ratio that this Court has previously considered as a part of a challenge to the breathalyzer. *See Downie, supra,* 117 N.J. at 460-63, 569 A.2d 242.

The Special Master concluded that the 2100 to 1 blood/breath ratio adopted by this Court in *Downie* and utilized by the Alcotest remains a valid measuring mechanism. He based this conclusion on the opinions of three of the State's experts and on a number of published studies here and abroad relating to the average, or mean, blood/breath ratio that he found to be authoritative.[22] At the same time, the Special Master rejected the opinions offered by two of the experts who testified on behalf of the defendants. He found that the analysis of one of these experts was filled with so many errors that it could not be reliable, and he rejected as flawed the assertion of the other defense expert that the Alcotest actually does not test alveolar air. Defendants nonetheless assert that the continued use

---

22. *See, e.g.,* Allan R. Gainsford, et al., *A Large-Scale Study of the Relationship Between Blood and Breath Alcohol Concentrations in New Zealand Drinking Drivers,* 51 *J. Forensic Sci.* 173 (2006); Alan Wayne Jones & Lars Andersson, *Variability of the Blood/Breath Alcohol Ratio in Drinking Drivers,* 41 *J. Forensic Sci.* 916 (1996). These studies appeared in the *Journal of Forensic Sciences,* which our Appellate Division has noted is an authoritative publication in the field of forensic science. *See State v. Miller,* 64 N.J.Super. 262, 268-69, 165 A.2d 829 (App.Div.1960) (citing *Journal of Forensic Sciences* to support reliability of breath test).

of the 2100 to 1 ratio is not scientifically supported and they urge us to reject any use of the Alcotest on this basis.

The true focus of our analysis on this issue must be on whether there has been any development in the scientific community in the time since we decided *Downie* that undermines our continued confidence in the accuracy and validity of the conclusion we drew there about the 2100 to 1 blood/breath ratio. Simply put, there is not. Our review of the record demonstrates that the arguments that we considered and rejected in *Downie* have been raised anew, but there is no basis on which to conclude that the continued utilization of this ratio is in any way in error.

We reach this result for reasons similar to those that we relied upon in *Downie.* First, we defer to the findings of the Special Master concerning the credibility of the expert witnesses who testified. *See Locurto, supra,* 157 N.J. at 471, 724 A.2d 234. In part, his credibility analysis reflects the fact that one of defendants' experts candidly conceded that the use of this ratio generally tends to underestimate blood alcohol, to the benefit of the test subject.

Second, although there is some evidence that there is a percentage of the population for whom the 2100 to 1 blood/breath ratio may actually overstate the presence of blood alcohol, this evidence is not significantly different from the record considered in *Downie, supra,* 117 N.J. at 460, 569 A.2d 242. Scientific studies comparing actual blood alcohol content to breath-tested alcohol content found only a minute number of individuals for whom this ratio would have incorrectly reported a result over the established legal limit for driving while intoxicated. The percentage of individuals for whom there may be an overestimation by use of this ratio remains "extraordinarily small." *Id.* at 469, 569 A.2d 242.

Finally, defendants' experts on this issue did not produce any evidence to the effect that the ratio is regarded by authorities in the field with even the slightest suspicion or is otherwise subject to any significant scientific challenge. Indeed, the overwhelming evidence demonstrates that use of this ratio tends to underestimate the actual BAC in the vast majority of persons whose breath is tested. Although, as in *Downie,* there may be a small number of individuals who are disadvantaged by a device that uses the 2100 to 1 blood/breath ratio, there is sound scientific support for its continued utilization.

We are confident, based on our review of the record and our evaluation of the Special Master's findings, that there is sufficient credible evidence to support his findings as to the continued validity of the 2100 to 1 blood/breath ratio. We therefore reject defendants' challenge to its use and we adopt the Special Master's recommendation that it continue to be utilized in the Alcotest.

B. *Minimum Test Sample Criteria*

As we have explained, the Alcotest is programmed to require that a test subject produce a breath sample that meets four minimum criteria before the sample is considered to be sufficient for purposes of deriving an accurate test result. The Special Master recommended approval, in general, of four minimum criteria for a breath sample, which are: (1) minimum volume of 1.5 liters; (2) minimum blowing time of 4.5 seconds; (3) minimum flow rate of 2.5 liters per minute; and (4) that the IR measurement reading achieves a plateau (i.e., the breath alcohol does not differ by more than one percent in 0.25 seconds). However, the Special Master also found that there was credible evidence to support lowering the minimum breath volume from 1.5 to 1.2 liters for women over the age of sixty. He recommended that the State reprogram the device to reflect that finding, but found no need to lower the minimum volume for the general population.

Although both defendants and the State agreed with these recommendations, the amicus NJSBA suggested that the minimum breath volume be reduced to 1.2 liters for all persons, so as to avoid a potential equal protection challenge to the tests. Because no party has raised a challenge to any of these criteria other than the minimum required volume and because the Special Master's findings as to the other minimum criteria are based on substantial credible evidence, we consider only the minimum breath volume issue.

Appendix A

1. *Scientific Data Concerning Breath Volume*

Breath alcohol concentration increases, in general, as exhalation continues and deep alveolar air is expelled. The rate of increase in alcohol concentration declines as a person exhales, but the breath alcohol concentration itself continues to increase until exhalation ends. The record reflects that the minimum breath volume for the Alcotest in New Jersey was fixed at 1.5 liters because the State's experts believe that this volume will exceed the point after which most of the relatively rapid rise in concentration has occurred and the average person is in a fairly level part of the exhalation curve. In addition, the State's experts contend that 1.5 liters is the minimum volume necessary for an accurate BAC calculation because samples of lesser volume, in general, do not include deep lung air.

At present, the most commonly used minimum breath sample among the states is 1.5 liters. That requirement, however, is not universal. For example, Alabama, where the Alcotest is currently in use, has adopted a minimum sample requirement of 1.3 liters for all test subjects. Moreover, although the experts generally agreed that 1.5 liters is the optimal minimum, some people may be incapable of providing that sample.

In particular, the record demonstrates that as women age, they have an increasingly difficult time producing a 1.5 liter breath sample. Data from Alabama introduced during the proceedings shows that women aged sixty to sixty-nine have more difficulty producing the 1.5 liter minimum requirement than their younger counterparts. One of the State's experts cited a study from Germany[23] that demonstrated that women from age sixty- to sixty-nine have an average breath volume of 1.4 liters, women seventy and over have an average of 1.3 liters, and women eighty and over have an average volume of 1.2 liters. The German study included data that demonstrates that men, regardless of age, were capable of producing a sample of 1.5 liters. Indeed, Brettell also conceded that his own study data confirmed the accuracy of the assertion that older women were the only ones unable to produce a sample of 1.5 liters.

Based on this data and the expert opinions offered during the hearing, the Special Master recommended that the minimum breath sample be fixed at 1.5 liters for all test subjects except for women over the age of sixty. He suggested that the device be reprogrammed to require women over the age of sixty to provide a 1.2 liter minimum sample for a valid test result. Although defendants and the State agreed with these recommendations, the NJSBA suggests that this Court should instead require that the minimum required sample volume for all subjects be reduced from 1.5 to 1.2 liters in order to avoid a future potential equal protection challenge.

---

23. Although it is not entirely clear, it appears that the study, a copy of which was marked in evidence, is only available as an unpublished manuscript. *See* G. Schoknecht & B. Stock, The Technical Concept for Evidential Breath Testing in Germany 1 (1995)(unpublished manuscript, Institute of Biophysics).

There is substantial credible evidence in the record to support the Special Master's findings and recommendations concerning the required minimum breath sample volume. The assertion by the NJSBA that adopting a different standard for women over the age of sixty than we apply to all other test subjects might give rise to an equal protection challenge, however, requires our careful consideration.

The minimum breath volume is significant, in and of itself, because the Alcotest is programmed to determine whether the four minimum criteria have been met in a precise order, the first of which is the volume analysis. A sample that falls short of the currently required 1.5 liter volume measurement will be found to be unacceptable. In that event, the Alcotest will report the amount of air delivered and will display an error message which reads: "minimum volume not achieved." The Alcotest permits up to eleven attempts to collect two breath samples, after which, the only options that the device offers are "terminate" or "refusal." If the operator chooses terminate, the Alcotest will reset and the subject can then be given the opportunity for eleven more attempts. If the operator chooses "refusal," the test sequence ends, but the operator is not required to issue a summons for refusal. *N.J.S.A.* 39:4-50.4a. Charging an arrestee with refusal remains largely within the officer's discretion. *See generally State v. Widmaier*, 157 N.J. 475, 724 A.2d 241 (1999).

Although an Alcotest operator has several options if the device reports that the test sample is inadequate, the fact remains that one of them, refusal, carries with it the possibility of severe sanctions. *See N.J.S.A.* 39:4-50.4a. In the face of abundant evidence in the record that there is an identifiable group in the test population who may be physiologically incapable of complying, the risk of permitting the device to reject samples from members of that group and, by extension, authorizing the issuance of a summons for refusal, is unjust.

By the same token, however, if the machine were reprogrammed to accept the lowered volume from a woman of the appropriate age, even if she could produce the ordinarily required higher volume but attempted to limit her breath output to avoid producing the deep lung air needed for the most accurate analysis, the machine would reject the sample because it would not achieve the plateau. It is therefore clear that lowering the volume for this identifiable group of test subjects will not, in reality, afford them any advantage over others. The constitutional question raised by the NJSBA, however, also requires us to consider whether it will disadvantage the other individuals required to take the test.

2. *Equal Protection and Lowered Breath Volume Requirement*

Lowering the minimum breath volume for women over sixty implicates both age and gender classifications and requires us to consider a potential challenge brought pursuant to both the federal and state constitutions. Because these standards are different and because the decision-making paradigm is different in the federal and state courts, we address them in turn.

The Equal Protection Clause of the United States Constitution mandates that no state shall "deny to any person within its jurisdiction the equal protection of the laws." *U.S. Const.* amend. XIV, § 1. The Equal Protection Clause "is essentially a direction that all persons similarly situated should be treated alike." *City of Cleburne v. Cleburne Living Ctr., Inc.,* 473 U.S. 432, 439, 105 S.Ct. 3249, 3254, 87 L.Ed.2d 313, 320 (1985). The federal equal protection analysis looks to the characteristics of the impacted protected class or the nature of the right being affected by the government action.

The federal test used to evaluate an age-based challenge is concerned with whether "the age classification in question is rationally related to a legitimate state interest. The rationality commanded by the Equal Protection Clause does not require States to match age distinctions and the legitimate interests they serve with razorlike precision." *Kimel v. Fla. Bd. of Regents,* 528 U.S. 62, 83, 120 S.Ct. 631, 646, 145 L.Ed.2d 522, 542 (2000). On the other hand, if the government distinguishes between males and females, the classification is subject to a heightened scrutiny. *Nev. Dep't of Human Res. v. Hibbs,* 538 U.S. 721, 728, 123 S.Ct. 1972, 1978, 155 L.Ed.2d 953, 963 (2003). For a gender classification to survive this scrutiny, the government "must show 'at least that the [challenged] classification serves 'important governmental objectives and that the discriminatory means employed' are 'substantially related to the achievement of those objectives.''" *United States v. Virginia,* 518 U.S. 515, 533, 116 S.Ct. 2264, 2275, 135 L.Ed.2d 735, 751 (1996) (alteration in original) (quoting *Miss. Univ. for Women v. Hogan,* 458 U.S. 718, 724, 102 S.Ct. 3331, 3336, 73 L.Ed.2d 1090, 1098 (1982) (quoting *Wengler v. Druggists Mut. Ins. Co.,* 446 U.S. 142, 150, 100 S.Ct. 1540, 1545, 64 L.Ed.2d 107, 114 (1980))).

Unlike its federal counterpart, the New Jersey Constitution does not contain an equal protection clause. Instead, we have found that "[a] concept of equal protection is implicit in Art. I, par. 1 of the 1947 New Jersey Constitution. . . ." *McKenney v. Byrne,* 82 N.J. 304, 316, 412 A.2d 1041 (1980). Therefore, even though Article I, paragraph 1 of our Constitution does not include the phrase "equal protection," "it is well settled law that the expansive language of that provision is the source for [this] fundamental constitutional guarantee [ ]." *Sojourner A. v. N.J. Dep't of Human Servs.,* 177 N.J. 318, 332, 828 A.2d 306 (2003).

"Although conceptually similar, the right under the State Constitution can in some situations be broader than the right conferred by the Equal Protection Clause." *Doe v. Poritz,* 142 N.J. 1, 94, 662 A.2d 367 (1995). Indeed, we have held that our Constitution provides "analogous or superior protections to our citizens" in the context of equal protection. *Peper v. Princeton Univ. Bd. of Trs.,* 77 N.J. 55, 79, 389 A.2d 465 (1978).

> [W]here an important personal right is affected by governmental action, this Court often requires the public authority to demonstrate a greater "public need" than is traditionally required in construing the federal constitution. Specifically, it must be shown that there is an "appropriate governmental interest suitably furthered by the differential treatment."
>
> [*Taxpayers Ass'n of Weymouth Twp. v. Weymouth Twp.,* 80 N.J. 6, 43, 364 A.2d 1016 (1976) (citing *Collingswood v. Ringgold,* 66 N.J. 350, 370, 331 A.2d 262 (1975)).]

In considering equal protection-based challenges, we have not followed the traditional equal protection paradigm of the federal courts, which focuses rigidly on the status of a particular protected class or the fundamental nature of the implicated right. Instead, when analyzing equal protection challenges under New Jersey's Constitution, we have applied a balancing test that weighs the "nature of the affected right, the extent to which the governmental restriction intrudes upon it, and the public need for the restriction." *Caviglia v. Royal Tours of Am.,* 178 N.J. 460, 473, 842 A.2d 125 (2004) (quoting *Greenberg v. Kimmelman,* 99 N.J. 552, 567, 494 A.2d 294 (1985)).

Finally, in addressing equal protection challenges raised in the context of the exercise of police power, we have held that "[t]he constitutional principles of due process and equal protection demand that the exercise of the power be devoid of unreason and arbitrariness, and the means selected for the fulfillment of the policy bear a real and substantial relation to that end." *Katobimar Realty Co. v. Webster*, 20 N.J. 114, 123, 118 A.2d 824 (1955).

There are, in theory, two potential equal protection challenges to the adoption of a different minimum volume standard for women over the age of sixty. First, one could argue that the lowered volume allows testing of a smaller sample of shallower depth and therefore results in a lower BAC reading. As to this challenge, it is undisputed that the device will not accept a sample that has not reached a plateau. An older woman who is capable of producing a greater volume of air but does not do so can be identified by her failure to meet the plateau. Therefore, we can be certain that all test subjects, regardless of age or gender, will only achieve a valid sample when the deeper lung air is included.

Second, one could argue that the differentiation permits older women who produce a sample with a volume between 1.2 and 1.5 liters to avoid being charged with refusal but exposes both younger women and all men who provide samples of the same volume to be prosecuted with that offense. The record on which the differentiation between the test groups is based, however, demonstrates that the older women, and only the older women, may be physically incapable of producing the larger sample.

The right to equal protection does not require us to scrutinize gender distinctions that are based on real physiological differences to the same extent we would scrutinize those distinctions when they are based on archaic, invidious stereotypes about men and women. *See State v. Vogt,* 341 N.J.Super. 407, 418, 775 A.2d 551 (App.Div.2001) (recognizing that "[t]he Equal Protection Clause . . . does not demand that things that are different in fact be treated the same in law, nor that a state pretend that there are no physiological differences between men and women"). Similarly, the federal courts have recognized that not all sex-based differentiations are actionable. For example, in the employment context some "standards that appropriately differentiate between the genders are not facially discriminatory." *Jespersen v. Harrah's Operating Co.,* 444 F.3d 1104, 1109-10 (9th Cir.2006); *see Healey v. Southwood Psychiatric Hosp.,* 78 F.3d 128, 132 (3d Cir.1996) (recognizing that gender may, in certain defined circumstances, be a bona fide occupational qualification for employment).

Applying the principles we have derived from both the federal and state constitutional analyses, we discern no meritorious ground for an equal protection challenge to the proposed two-tiered approach for minimum breath sample volume, regardless of which level of scrutiny we apply. Viewed against our flexible approach to equal protection challenges as derived from Article I, paragraph 1 of our Constitution, the system survives the constitutional challenge. The governmental policy of achieving accurate breath samples as part of law enforcement's role in ridding our roads of drunk drivers is appropriately coupled with the authority to prosecute for refusal. The proposed two-tiered system for minimum breath volume, however, is neither unreasonable nor arbitrary for it advances these goals without holding the identified class, older women, to a standard that they cannot meet. In this manner, the policy goals are fulfilled through "means . . . [that] bear a real and substantial relation to that end." *Katobimar, supra,* 20 N.J. at 123, 118 A.2d 824.

Similarly, under either the rational relationship test applicable to age-based classifications, or the heightened level of scrutiny applied to gender-based classifications under the federal constitution, the lowered requirement for women over sixty passes constitutional muster. The policy goals we have identified for our state constitutional analysis are, in federal parlance, "important governmental objectives," *see Hibbs, supra,* 538 U.S. at 728-29, 123 S.Ct. at 1978, 155 L.Ed.2d at 963. The selection of the two tiers for this aspect of the test requirements is both rationally related to those goals and "substantially related" to their achievement. *Ibid.*

Notwithstanding the concern voiced by the NJSBA, there is no scientific or other ground in the record to direct that the minimum volume be lowered for all test subjects. On the contrary, there is ample support for the Special Master's two-tiered approach and we discern no equal protection violation in lowering the required breath volume to 1.2 liters for women over the age of sixty.

3. *Application to Pending Prosecutions*

Our conclusion that the firmware must be revised to accept a minimum breath volume sample of 1.2 liters from women over the age of sixty requires us to consider the impact of this directive for pending prosecutions. We presume that there may be women who meet this criteria and whose prosecutions have been stayed pending our decision on these issues. For the sake of completeness of our analysis, we address briefly the possible factual scenarios relevant to these defendants. First, there may be defendants who attempted but failed to achieve a sufficient volume for an acceptable sample. These individuals will be readily identified by an AIR with a breath volume error message. Obviously, proof of the charge of drunk driving for these women can only be based on observational proofs because there will be no reportable BAC results in an AIR.

The significance of the lowered breath sample volume, however, rests less in the evidence utilized to support a charge of drunk driving and more in its relationship to a charge of refusal. In light of the scientific evidence that we have found to be persuasive, in the absence of some other evidence that supports the conclusion that any such individual was capable of providing an appropriate sample, by volume, we must assume that she was unable to do so. For these individuals, then, an AIR demonstrating insufficient breath volume may not be used as proof on a charge of refusal. On the other hand, if the AIR demonstrates that a woman over the age of sixty was able to provide at least one sample that was deemed to be sufficient for purposes of the 1.5 liter volume requirement, but she failed to do so on a subsequent attempt, the AIR demonstrating those facts may be utilized as evidence, albeit not conclusive proof, in support of a refusal charge.

C. *Breath Temperature Sensor*

The Special Master also recommended that in the future the State acquire and utilize a breath temperature sensor device separately marketed by Draeger,[24] and that, in the interim, all previously reported results be reduced by 6.58 percent to account for breath variations in individuals tested. (Special Master's Finding 9). This recommendation was based on the Special Master's factual findings about breath temperature.

We are compelled to reject this recommendation because there is insufficient support in the record for the factual findings on which it is based. In particular, the Special Master found that "[m]ost breath analyzers

---

24. There are several temperature devices related to the Alcotest. One, which is an integral part of each device, and the report of which is included on the AIR, heats the simulator solution in the control test both in the device and, by extension, in the calibration process. Another heats the breath tube, but not the subject's actual breath sample, to prevent condensation. The device that is the focus of this recommendation, is an optional device that tests the temperature of the actual breath sample and reports it.

used in the United States operate on the assumption that the temperature of an expired breath sample is 34 degrees C[elsius]," but that "[r]ecent scientific research supports the proposition that the temperature of an expired breath sample is actually almost 35 degrees C[elsius]." He then found that BrAC increases by 6.58 percent for each degree above thirty-four degrees Celsius, and reasoned that all BAC results should be reduced by 6.58 percent to ensure their accuracy and that the optional breath temperature sensor should be used in the future. He noted, in support of his recommendation, that the State of Alabama requires reduction of all breath results from the Alcotest by this percentage.

Although defendants and the NJSBA urge this Court to adopt this finding and recommendation, in part based on the assertion that the most relevant scientific community is Alabama, the State argues that Alabama's program is an aberration and that this recommendation is both unsupported and unsound.

We are persuaded to agree with the State for both evidentiary and practical reasons.[25] First, the record

---

25. We reject, however, the State's suggestion that a measuring device that might more accurately determine BAC and serve as a basis for a per se prosecution is an "option" that falls within the sole discretion of the State in performing its prosecutorial function. Rather, to the extent that the State seeks to utilize a device, like the Alcotest, to prove a per se violation of the statute, we think it abundantly plain that the decision as to the accuracy of any innovation for proof purposes, consistent with our Constitution, is ours to make.

reflects that the generally accepted average temperature for human breath is 34 degrees Celsius. Only one study, performed in Alabama and therefore relevant for that jurisdiction's purposes, concluded that the average breath temperature is closer to 35 degrees Celsius. At best, then, there is a debate about average breath temperature. In fact, however, there is no support in the record for the Special Master's assumption that a rise in breath temperature increases BrAC.

Notwithstanding that, some of the experts conceded that a one-degree Celsius increase in breath temperature could theoretically produce a 5.5 to 6.8 percent increase in BrAC, assuming that all other variables remained constant. Accordingly, a one-degree Fahrenheit increase in breath temperature could theoretically cause the BrAC to rise by 3.8 percent. There is, however, no evidence in the record that this theoretical increase translates into an inaccurately elevated BAC result.

Moreover, all of the experts agreed that even a theoretical possibility of a link would not alter the reported BAC readings in practice. That is, if a person with a normal temperature submitted a breath sample with a 0.07 percent BAC, that person's breath test would be read as being over 0.08 percent BAC only if he had a 2.5 degree-Celsius or 4.5 degree-Fahrenheit increase in body temperature. There is no evidence in the record from which we can conclude that there is any risk that any individuals with such an elevated temperature are even being tested. There is also no evidence in the record to support the finding that the average breath temperature exceeds 34 Celsius or that an elevation of the breath temperature, in and of itself, results in an elevated BAC reading.

Second, to the extent that there might be a relationship between the breath temperature of the subject submitting the sample and BAC, there is significant evidence in the record to support the finding that an independent device to measure that temperature or to reduce the results to account for it[26] would be redundant. The device as currently configured incorporates two methods that account for any possible overestimation of the BAC reading that an elevated breath temperature might theoretically cause, and they operate to the benefit of the person being tested. Both the truncation of results and the use of the 2100 to 1 blood/breath ratio, a ratio that in part takes temperature into account, effectively underestimate the calculation to the advantage of the test subject.

The debate about the effect of temperature is not new. It was presented specifically in *Foley, supra,* and in part in *Downie, supra.* The trial court in *Foley, supra,*

---

26. The record reflects that the Alcotest with the added breath temperature device does not actually recalculate BAC to account for elevations in breath temperature. Instead, in Alabama, the sensor reports breath temperature and if it is shown to be elevated above 34 degrees Celsius, the court reduces the reported BAC results by a factor of 6.58 percent for every degree.

analyzing virtually the same factual assertions as are included in this record, concluded that, apart from a test subject suffering from a very high fever, the natural variation of temperature was subsumed within the variability of the blood/breath ratio. 370 N.J.Super. at 355, 851 A.2d 123. As that court recognized:

> The factor of 2100 to 1 was developed by doing studies on persons in the field including both arrested subjects and research subjects. The breath temperature of all these subjects varied. Therefore, the 2100 to 1 ratio already subsumes within it the variation in breath temperature of the general population.

[*Ibid.*]

We, too, have previously considered the relationship, in general, between temperature and the blood/breath ratio, *see Downie, supra*, 117 N.J. at 462-63, 569 A.2d 242. We there concluded that the utilization of the 2100 to 1 ratio adequately accounts for any small impact that a particular subject's elevated temperature might potentially have on the result.

Our review of the record convinces us that the Alcotest BAC reading would not be made more accurate by the addition of the breath temperature sensor or by the across-the-board reduction of all values by 6.58 percent to account for the theoretical temperature factor as suggested by the Special Master. More to the point, perhaps, we reach our conclusion for practical reasons as well. The unrebutted evidence in the record convincingly demonstrates that requiring the addition of the breath temperature sensors would result in an unreasonable maintenance burden to the program. In fact, the record includes detailed descriptions of the added steps, equipment, time and personnel that are necessary simply to maintain and calibrate the temperature sensors.[27] That added practical and logistical burden on the State and the municipalities in New Jersey, while perhaps not prohibitive, is unreasonable in light of the scant basis in the record that might support requiring the sensor.

Our evaluation of the evidence therefore leads us to reject the Special Master's recommendation concerning utilization of a breath temperature sensor or reduction in BAC results by a 6.58 percent factor as unsupported by the factual record and unnecessary. Rather, we are persuaded that the effect of breath temperature on BAC is theoretical at best, and that the effect, if any, is ameliorated because the Alcotest uses both truncation and the 2100 to 1 blood/breath ratio to calculate BAC. Because both of these safeguards effectively underestimate BAC, any additional subtraction to account for temperature is redundant and unnecessary.

---

27. Because of the equipment needed to do so, the temperature sensors cannot be maintained or calibrated on-site. Instead, the equipment must be taken out of service and moved to a central location for these purposes, resulting in the need for arrestees to be transported to an adjoining municipality for testing while the equipment is undergoing routine maintenance.

We therefore reject the Special Master's finding and recommendations concerning the breath sensor and a 6.58 percent compensating reduction.

D. *Acceptable Tolerance Analysis*

The Special Master recommended that the firmware be revised to correct the acceptable tolerance among the reported results so as to permit results to be accepted if they are within plus or minus 0.005 percent BAC or plus or minus five percent of the mean for the four readings, whichever is greater. (Special Master's Finding 10). Although the State does not dispute the need to correct future firmware versions, both the recommendation of the Special Master as to the acceptable tolerance range and the effect of this determination upon pending cases require our analysis.

The acceptable tolerance question raises a variety of concerns, including its implications for the validity of any particular test result, our confidence in the accuracy and reliability of a specific Alcotest unit, the need for performance of a third test on any particular test subject, and the appropriate method by which to assess tolerance in light of changes to the quantification of the per se violation in recent years. We address each of these difficult issues in turn.

Appendix A

1. *Doubled Tolerance Range in Firmware version 3.11*

Tolerance is the range of any set of measurements that is accepted as being representative of a true reading. Precision and accuracy can be ensured by requiring the application of a narrow range for tolerance. Conversely, the wider the acceptable tolerance between reported results, the lower our confidence in the accuracy of any of the reported results. Therefore, for purposes of permitting any device to be utilized for proof of a per se violation of the statute, the acceptable tolerance is of fundamental importance.

As a matter of historical perspective, we first considered the question of acceptable tolerance ranges in *Romano, supra.* There, as a part of our evaluation of whether the test results obtained from two breathalyzer models which might have been affected by radio frequency interference (RFI) could be admissible, we accepted the 0.01 percent BAC standard as a scientifically reliable tolerance range, based on the opinions of two experts who so opined, *see Romano, supra,* 96 N.J. at 86, 474 A.2d 1. At the time, the statute created a per se offense for any person whose BAC was 0.10 percent or greater, *see id.* at 78, 474 A.2d 1. As we articulated the tolerance analysis in *Romano,* "admissibility is satisfactorily established . . . [i]f the breathalyzer results consist of two tests or readings within a tolerance of 0.01 percent of each other. . . ." *Id.* at 87-88, 474 A.2d 1. The point, of course, was that if a breathalyzer that might be influenced by RFI could nevertheless read two separate breath samples with results within this range, we would presume those results were unaffected by external influences and, therefore, valid.

After our decision in *Romano,* the 0.01 percent BAC tolerance range became the benchmark against which all breathalyzer results, not just those from RFI-susceptible models, were tested for general reliability and accuracy. In *Downie,* we again referred to the 0.01 percent BAC tolerance range as a benchmark for reporting accurate results. *See Downie, supra,* 117 N.J. at 455, 569 A.2d 242. Although we did not independently evaluate the continuing validity of that tolerance range, we adhered to it as a part of our evaluation of the overall scientific accuracy and reliability of the breathalyzer. Indeed, we have never departed from that standard and have not previously been called upon to consider any different articulation of that accepted range of tolerance.

Prior to the trial court's decision in *Foley,* the tolerance range for the Alcotest was fixed by the software to be 0.01 percent BAC or a range of ten percent for all samples. That range was determined by Brettell when the Alcotest program was first devised. The range, however, was tested by reference to the arithmetic mean, the effect of which halves the expression of the range. In addressing the challenge to the tolerance as being inconsistent with *Romano,* the court in *Foley* described the tolerance as fixed in the Alcotest in somewhat different terms. The *Foley* court explained that our long-accepted standard of a required tolerance of 0.01 percent BAC between two breath samples was the "strictest standard in the United States," and concluded that, as applied to the four results derived by Alcotest, "the additional parameter of ±10 [percent] is within the tolerance considered acceptable for reliable results by the scientific community." *Foley, supra,* 370 N.J.Super. at 357, 851 A.2d 123.

In so articulating the tolerance range, however, the court did not simply re-articulate a long-accepted tolerance, expressing it as a percentage rather than an absolute. Nor did it accurately express the tolerance used by the device, an earlier version of software known as Firmware version 3.8, in which the tolerance was expressed in alternate terms. Rather, the court, inadvertently, we think, endorsed a tolerance range that effectively doubled that which we have allowed.

There are several considerations arising from this expanded tolerance that are now before us. First, the use of a percentage tolerance range tends to permit readings at higher levels that are wide of the previously accepted 0.01 percent BAC standard. This might lead to results that are, in and of themselves suspicious in terms of their intrinsic reliability. That is to say, although for purposes of guilt, it might not matter whether we accepted two test results that were within ten percent but beyond 0.01 percent BAC of each other, those results might raise a concern about the overall reliability of the particular machine. Second, however, use of an absolute rather than a percentage might arguably disadvantage subjects whose test results are at the lower end of the range by accepting test results that are, by percentage, more widely separated and that would be rejected as out of tolerance were a percentage analysis applied.

Third, in some measure the amendments to the statute and the creation of new per se offenses, not extant when we considered the acceptable tolerance in *Romano* and *Downie,* makes our evaluation of this issue more complex. In the abstract, tested against a statute that only utilized one per se test for drunkenness, namely, 0.10 percent BAC, our acceptance of the single test for acceptable tolerance was well supported in the scientific record. The question, in light of the lowered per se limits now in force, is what we should demand in terms of precision to demonstrate accuracy and support admissibility.

Taking into account these considerations, we turn to an evaluation of the evidence in the record concerning tolerance and its significance. At present, assuming the subject has provided an otherwise acceptable sample, the Alcotest reports the EC and IR results of the first sample. The device is programmed to accept the EC and IR test results from a second sample only if those results are within its programmed tolerance of the EC and IR results from the first breath sample. If the second-sample results are not within the tolerance, the Alcotest will record the results, but require a third sample.

For Firmware version 3.8, used in the Alcotest program at issue in *Foley,* Brettell testified that he set the tolerance in accordance with the breathalyzer tolerance expressed in *Downie.* He interpreted the *Downie* standard to mean that two breath tests had to be within 0.01 percent BAC of each other when the mean BAC measured below 0.10 percent BAC, which was the per se level when *Downie* was decided. Brettell testified that, notwithstanding the fact that the Court never varied from the 0.01 percent BAC standard, he assumed we intended a tolerance of ten percent for BAC values above 0.10 percent BAC. Therefore, Firmware version 3.8 was programmed to accept the second breath test if there was no more than 0.01 percent BAC or ten percent between the highest and lowest readings.

Notwithstanding Brettell's acknowledgment that he knew that the *Foley* statement about tolerance was mathematically incorrect, he concedes that following the decision in *Foley,* the State directed Draeger to reprogram the device so as to take advantage of that far wider, effectively doubled, range for tolerance. He explained that he did so to make the test conform with programs in other states and to address criticism of the relative frequency with which the device in *Foley* rejected results for being out of tolerance and required the administration of a third test. Brettell believed that taking advantage of the court-sanctioned wider tolerance would alleviate a similar challenge in the future. The State concedes that Firmware version 3.11

did precisely that, creating a range of either plus ten percent or minus ten percent of the mean, for a doubled tolerance.[28]

2. ***Expert Testimony***

Although New Jersey, prior to the introduction of Firmware version 3.11, in compliance with our decision in *Romano* and *Downie,* adhered to the 0.01 percent BAC tolerance standard, there is no general agreement among the states as to what standard is acceptable. Many states other than New Jersey utilize the 0.01 percent BAC tolerance standard as well, but the National Safety Council, for example, recommends a tolerance of no more than 0.02 between the highest and lowest readings.

One of the State's witnesses, Rod Gullberg, testified about his previously published conclusions on tolerance measurement. He opined, therefore, that the Firmware version 3.11 tolerance is too broad. *See* R.G. Gullberg, *Determining an Appropriate Standard for Duplicate*

---

28. There is, in addition, a further distinction that is a subtle one. Using a range, whether expressed in absolute or percentage-based terms, when comparing two numbers as in *Romano,* is not the same as expressing the same range for tolerance among four numbers as evaluated against their arithmetic mean. Technically, Firmware version 3.11 is a good deal more sophisticated in its measure for tolerance. In fact the device tests tolerance as the greater of plus or minus ten percent of the mean of all four results *or* plus or minus 0.01 percent BAC of that mean.

Breath Test Agreement, 39 *Can. Soc'y Forensic Sci. J.* 15, 23 (2006). Instead, he recommended using plus or minus five percent of the mean of the four tests. He estimated that if the firmware were changed to utilize this tolerance, the number of people who would have to submit additional samples would increase by approximately five percent. That estimate is mirrored by a comparison of the data from Pennsauken, in which Firmware version 3.8 was used, with the data from Middlesex County, in which Firmware version 3.11, with its doubled tolerance, was used.

Another of the State's witnesses, Hansueli Ryser, explained that if New Jersey used a tolerance of plus or minus 0.005 percent BAC, or plus or minus five percent, of the mean, whichever is greater, then for mean measurements below 0.10 percent BAC, the acceptable tolerance would be plus or minus 0.005 percent BAC. As an example, if a person had a mean alcohol concentration of 0.08 percent BAC, the tests would be in tolerance if they fell between 0.075 and 0.085 percent BAC.[29] For mean concentrations above 0.10 percent BAC, the relevant tolerance would be plus or minus five percent.

---

29. The significance of tolerance, as this example demonstrates, is related to the truncation procedure. A test subject with results ranging from 0.075 to 0.085 would not be guilty of the per se violation because the machine must report the lowest truncated value, here 0.07 percent BAC. By the same token, however, the machine could not reject these results and subject the individual to a third test, with a potentially higher BAC.

Brettell testified that he planned to "revisit" the tolerance because it had caused "so much litigation." He testified that the 0.02 percent BAC National Safety Council recommendation might be the easiest to adopt, but he preferred the use of a combination of a set value and a percentage because the percentage would account for scientifically defensible wider tolerance at very high values. Overall he favored[30] plus or minus 0.005 percent BAC from the mean or plus or minus five percent of the mean, whichever was greater.

3. *Future Firmware Revisions*

Although we have never considered the use of a tolerance other than the absolute 0.01 authorized in *Romano,* intervening legislative enactments require us to address the continuing validity of that standard. At the time that we decided the question of acceptable tolerance in *Romano,* there was but one per se standard for drunk driving prosecutions, namely, the 0.10 percent BAC. Since that time, however, the Legislature has reduced that per se limit to 0.08 percent BAC, while maintaining the 0.10 percent BAC standard for enhanced punishment.[31] The issue is what measure of

---

30. We are constrained to observe that, for purposes of assessing scientific accuracy and therefore admissibility in evidence as proof of a per se violation, "ease" and "simplicity" are irrelevant. Similarly, a test based on whatever the current director of the program "favors" is unlikely to withstand scrutiny.

31. In addition, the separately-adopted per se limits that apply to commercial drivers (0.04 percent BAC) and individuals (Cont'd)

tolerance comports with scientifically reliable, and therefore admissible, results.

Expressing the tolerance in terms of the greater of the absolute or a percentage of deviation from the mean authorizes, in effect, a wider range of tolerance at the higher readings. There is, in this record, evidence that demonstrates to our satisfaction that at the higher readings, all measures of BAC are somewhat less precise than they are at the lower ranges. As a result, the wider tolerance expressed by a percentage deviation from the mean applied to the upper ranges of possible readings does not suggest that the device is not working properly. At the lower readings, in contrast, a deviation outside of the tolerance limit we have traditionally required most assuredly will raise a question about the functioning of the particular device.

Our evaluation of the record compels us to conclude that, even in light of the lowered overall per se limit adopted since *Romano*, the continued use of the absolute 0.01 percent BAC standard, coupled with the use of a like range of tolerance expressed as a percentage deviation from the mean, is both scientifically appropriate and consistent with our understanding of the intention of the Legislature in adopting these per se limits.

(Cont'd)

under the legal drinking age (0.01 percent BAC) are entirely new. Although the effect of the absolute measure of tolerance might have less validity when applied to these separate offenses, it is not challenged here and we do not address it.

To the extent that Firmware version 3.11 took advantage of an explanation of the tolerance range in *Foley* that inadvertently doubled the permissible range, however, it cannot be sustained. We therefore direct that for future firmware revisions, the device be programmed to fix the tolerance range to be plus or minus 0.005 percent BAC from the mean or plus or minus five percent of the mean, whichever is greater, in order to ensure scientifically accurate, admissible test results.

4. *Application to Pending Prosecutions*

Our inquiry, however, cannot end there. There is stark evidence in the record, based on a comparison of the data from the Pennsauken program, in which the device with Firmware version 3.8 and the appropriate tolerance was utilized, with the data collected in Middlesex County, using Firmware version 3.11 and its doubled range, that the intervening expansion of the tolerance range resulted in tests being deemed acceptable by the device that cannot meet the tolerance range we have required. In fact, the data demonstrates that precisely the effect that Brettell desired, namely, reducing the frequency of out of tolerance readings that required third samples, was achieved to the point of apparent elimination. The Special Master, while recommending that the software be revised for future uses to reflect his analysis of acceptable tolerance ranges, did not regard the State's adoption of a different and widely expanded tolerance to be problematical for pending prosecutions. The State urges us to adopt this finding that the doubled tolerance had no effect on any defendant's substantive rights. We disagree.

The simple fact is that the tolerance range is a critical component in our conclusion that this or any other device correctly and accurately measures breath alcohol and converts that data into a scientifically reliable, accurate BAC analysis. Our acceptance of those results for purposes of supporting, without more, a criminal conviction, must be based on our conclusion that the results are reliable and accurate. The use of a doubled tolerance, however, deprived some percentage of test subjects of a third, and perhaps dispositive, test. At the same time, it undermines our confidence in the accuracy of the reports of those tests that fall outside of the range that we have demanded be utilized as a prerequisite for scientific accuracy and that undergirds admissibility in a criminal proceeding.

It is easy enough to identify those individuals for whom a third test should have been given. To be sure, if we had the third test data for those defendants, some of them would achieve a result within the authorized tolerance and thus be shown to have violated the per se limits. But just as surely, there may be others for whom a third test would have yielded a result still further out of range so as to, perhaps, call the accuracy of the particular machine into question. And it is even possible that there might be a defendant for whom a third test would result in a reading that would meet the test for tolerance but would exonerate that individual.

The suggestion that we permit those test results that are outside of the range for tolerance to be utilized for purposes of a per se conviction unfortunately is, simply put, unacceptable. Zealousness in ridding our roads of drunk drivers cannot overcome our ordinary notions of fairness to those accused of these offenses. Therefore, we are constrained to direct not only that future firmware updates utilize the tolerance computation that we have concluded is acceptable, but that all pending prosecutions include an evaluation of whether the two reported test results exceeded this acceptable tolerance.

Any AIR that reports results from tests of only two breath samples, therefore, must be analyzed to determine whether its results are within our accepted tolerance by use of a mathematical calculation. The appropriate calculation for this purpose will consist of applying the following formula: (a) add the IR and EC results given for the first breath sample to the IR and EC results for the second breath sample; (b) divide the sum calculated in (a) by 4 to derive the arithmetic mean; (c) compute the upper limit of tolerance by taking the larger value of the mean multiplied by 1.05 or the mean plus 0.005 percent BAC; (d) compute the lower limit of tolerance by taking the smaller of the value of the mean multiplied by 0.95 or the mean minus 0.005 percent BAC; (e) if all of the IR and EC results of the two samples fall within the upper and lower limits of the tolerance range, the AIR is valid, but if any of the results fall outside of the tolerance range, the AIR is not valid.

Although we have prepared a worksheet that is attached to the order that accompanies this opinion for use in all prosecutions pending reprogramming of the device, two examples will, we think, illustrate the way in which the formula should be utilized in practice to differentiate between an AIR that reports results within tolerance and one that does not. If, for example, a defendant's first breath test sample yielded an IR result of 0.100 percent BAC and an EC result of 0.101 percent BAC, and the second sample yielded an IR result of 0.104 percent BAC and an EC result of 0.103 percent BAC, the calculations would be performed as follows:

> (a) first all four of the results (two IR and two EC) would be added, in this example, 0.100 + 0.101 + 0.104 + 0.103 = 0.408;
>
> (b) next, the arithmetic mean would be derived by dividing that sum by four, 0.408 / 4 = 0.102;
>
> (c) then the upper limit of acceptable tolerance must be determined by comparing the two methods for computing the range, namely, the use of the absolute or the percentage. This is done by computing each separately and selecting the greater of the two. In this example, the computation would yield the following options: (0.102 x 1.05 = 0.1071) OR (0.102 + 0.005 = 0.1070). Because the greater of these is 0.1071, that will be the correct upper tolerance limit;
>
> (d) next, the lower limit of acceptable tolerance must be derived by comparing the

> two methods for computing the range, again, by using the absolute and the percentage calculations. This is done by computing each separately and selecting the lesser of the two. In this example, the computation would yield the following options: (0.102 x 0.95 = 0.0969) OR (0.102-0.005 = 0.0970). Because the lesser of these is 0.0969, that will be the correct lower tolerance limit; and
>
> (e) finally, by comparing all four of the reported test sample results (0.100, 0.101, 0.104, 0.103) against this accepted tolerance range of 0.0969 to 0.1071, it becomes plain that, in this example, the *AIR is valid* because all four test results fall within the accepted tolerance range.

Because the Firmware version 3.11 utilized a doubled tolerance range, there will be AIRs that will not meet the test for tolerance that we have deemed to be permissible. We therefore provide a further example to illustrate the calculations relating to an AIR that would be out of tolerance under this standard and, therefore, inadmissible in a prosecution. If, for example, a defendant's first breath test sample yielded an IR result of 0.089 percent BAC and an EC result of 0.080 percent BAC, and the second sample yielded an IR result of 0.091 percent BAC and an EC result of 0.084 percent BAC, the calculations, which would be performed in the same manner, would yield a different outcome, as follows:

(a) first, all four of the results (two IR and two EC) would be added, in this example, 0.089 + 0.080 + 0.091 + 0.084 = 0.344;

(b) next, the arithmetic mean would be derived by dividing that sum by four, 0.344 / 4 = 0.086;

(c) then the upper limit of acceptable tolerance must be determined by comparing the two methods for computing the range, namely, the use of the absolute or the percentage. This is done by computing each separately and selecting the greater of the two. In this example, the computation would yield the following options: (0.086 x 1.05 = 0.0903) OR (0.086 + 0.005 = 0.0910). Because the greater of these is 0.0910, that will be the correct upper tolerance limit;

(d) next, the lower limit of acceptable tolerance must be derived by comparing the two methods for computing the range, again, by using the absolute and the percentage calculations. This is done by computing each separately and selecting the lesser of the two. In this example, the computation would yield the following options: (0.086 x 0.95 = 0.0817) OR (0.086-0.005 = 0.0810). Because the lesser

> of these is 0.0810, that will be the correct lower tolerance limit; and
>
> (e) finally, by comparing all four of the reported test sample results (0.089, 0.080, 0.091, 0.084) against this accepted tolerance range of 0.0810 to 0.0910, it becomes plain that, in this example, the *AIR is invalid* because the first breath sample's EC result (0.080) does not fall within the accepted tolerance range.

The use in Firmware version 3.11 of the doubled tolerance range, which we have rejected, requires that all AIRs that report results of only two breath samples be tested for validity against the tolerance range we have accepted. Therefore, in all prosecutions stayed by our January 10, 2006 Order, the State shall review the BAC results as reported in the AIR and shall calculate whether those results fall within tolerance, and the court shall review those calculations and make them a part of the record. In those cases in which this review reveals that the results fall outside of the acceptable tolerance, the AIR cannot be deemed to be sufficiently scientifically reliable to be admissible and it shall not be admitted into evidence as proof of a per se violation.

IX. *Source Code Remand*

We turn, then, to a series of issues that arose following the supplemental remand for evaluation of the source code. Not all of the firmware issues we must address are disputed, but our review of the record has identified issues that bear on the extent and manner in which existing AIR results may be utilized in pending prosecutions. We begin with the software-based questions that are in dispute.

A. *EC Readings and Fuel Cell Drift Algorithm*

One of the most controversial findings that came out of the second remand proceedings, during which the parties were afforded the opportunity to undertake an analysis of the source code that is the heart of the operation of the Alcotest device, related to the EC readings. During the proceedings, the Special Master summoned Brian Shaffer, a Draeger employee responsible for the code and for implementing changes to the New Jersey Firmware since the *Foley* decision, to testify. Near the end of his testimony, Shaffer revealed that Firmware version 3.11 utilizes a compensating algorithm to account, in part, for a phenomenon known as fuel cell drift.

As Shaffer explained it, the EC reading is obtained by passing an electrical current through a small sample of the breath that has otherwise been captured for IR testing in the cuvette. The fuel cell that creates the electrical charge reacts in the presence of alcohol. The reaction of the fuel cell can be represented graphically as a curve and the percentage of alcohol in the breath is measured by calculating the area under the curve mathematically. As fuel cells age, the area under the curve that expresses the same breath alcohol content is unchanged, but the shape of the curve itself changes from a high sharp peak to a longer, flatter one. As a matter of mathematical computation, the area being measured is the same even though the curves, were they plotted graphically, would appear to be different when observed visually.

According to Shaffer, the flattening of the curve is caused by the aging of the fuel cell, which reacts more slowly and with less intensity to the same amount of alcohol than when the fuel cell is new. This phenomenon, known as fuel cell drift, does not actually alter the accuracy of the EC measurement. However, because the fuel cell begins to react more slowly to the presence of alcohol as it ages, a portion of the area under the curve that is the basis for the alcohol measurement is not captured during the time when the Alcotest EC data is collected. Instead, a portion of the end of the curve is, in essence, cut off, resulting in a lower than accurate measurement.

Because fuel cell drift is a known scientific phenomenon that would otherwise result in an inaccurate underreporting of the percentage of alcohol in the test subject's breath, Draeger added a compensating algorithm into the firmware. The EC fuel cell drift algorithm, therefore, is intended to capture a portion of the missing data and, in theory, create a more accurate result as the reported EC reading. The algorithm, however, does not attempt to quantify the missing area under the curve per se, but instead attempts to compensate in part for the lack of complete data arising from the EC measurement. In the event that fuel cell drift is detected during the control test, the algorithm mathematically increases the EC reading that is reported by up to twenty-five percent of the difference between the IR and EC readings from the tests of the subsequent breath samples.

The compensating algorithm is not routinely applied, but only functions if the appropriate preconditions are met. The device, in performing the control test, compares the EC and the IR readings and accurately reports those results. Because the control test utilizes a known test solution to ensure that the device is functioning properly and that it accurately reads a solution of a known percentage of alcohol, fuel cell drift can be detected from the control test's results. If the device detects drift, the algorithm will adjust the EC measurement standard, which, in turn, will slightly increase the reported EC results for the test subject's breath sample to account for the fuel cell drift.

The discovery of the EC fuel cell drift algorithm in the source code prompted the Special Master to conclude that more frequent re-calibration of the devices with replacement of fuel cells that had become "depleted" would reduce reliance on the EC fuel cell drift algorithm and, therefore, increase the accuracy of the readings. The State objects to this proposal as unnecessary and burdensome, arguing that its current program of annual calibration is sufficient.

Defendants, on the other hand, raise several challenges to this EC algorithm, both in theory and in practice. First, they argue that it demonstrates that Draeger's claim that the device uses two completely independent measurements for breath alcohol is false. Second, they argue that it demonstrates that the device is simply not accurate in any sense. Third, they argue that the algorithm, which they attack as having been hidden from them throughout the initial remand proceedings, is evidence that the software may be utilizing other hidden mechanisms that might inflate readings so that the accuracy of the results can never be reliable.

We do not share either the State's or defendants' concerns. The record reflects that a semi-annual inspection and recalibration program recommended by the Special Master is consistent with the manufacturer's recommendations. At the same time, it provides a useful safeguard by affording a more regular opportunity to evaluate and replace aging fuel cells. We discern no reason to permit the State to continue to adhere to its program of annual recalibration, particularly in light of the concerns raised as to the utilization of a compensating algorithm in the interim.

However, we do not find merit in defendants' concerns about the EC algorithm or its use. There is sound scientific evidence that supports the conclusion that fuel cells begin to age as soon as they are put into service and that fuel cell drift is inevitable. But there is equally ample support for the proposition that even as the intensity of the peak demonstrated by the EC evaluation of the sample diminishes over time, the reactive effect overall (that is, the area under the curve being calculated) does not. Instead, the time within which the test is performed simply truncates the EC reading before all of the otherwise appropriate data can be generated. Theoretically, one could, perhaps, program the machine to calculate the missing area based on a presumed regularly-shaped curve. Although that might even be a more accurate method of supplying the missing data, it would not, in the end, be as advantageous to defendants as is the minor upward adjustment that the algorithm effects. Indeed, because the device will not generate a result that can be utilized if the readings are out of tolerance, the algorithm alters the EC result in an amount that, we are confident, cannot fairly be seen as convicting the innocent.

Nor do we consider the fact that the algorithm was unknown until Shaffer revealed it or the fact that neither of the independent experts who evaluated the source code recognized its existence to be indicative of any broader shortcoming in the firmware. Two reasons support this result. First, in "black box" testing, the machine performed accurately by demonstrating the ability to identify the percentage of alcohol in known solutions within the applicable tolerance parameters. Were there a fundamental defect in the source code, one would expect that the machine would not be able to perform in this fashion. Second, the evidence in the record demonstrates that the EC reading is not always less than the IR reading either during control tests or in actual testing. If, as defendants fear, the EC is always being artificially inflated to approximate, if not absolutely match, the IR, one would expect to find only results in which the IR was the higher reading. That, however, is simply not the case, as there are numerous examples of readings from both actual and control tests in which the EC reading is higher than the IR. We cannot therefore conclude that the source code includes hidden commands to artificially inflate the EC to raise it to the level of the IR.

Finally, however, defendants argue that the existence of the EC algorithm calls into question all of the testimony received during the original remand proceedings. They point out that several witnesses referred to the fact that the Alcotest uses two independent testing methods as proof of its superiority and as support for their opinions that the device is scientifically reliable and accurate. They further point to Draeger's representations to the State that this technology made the device superior to others which was essentially accepted by the Special Master. Although the use of this algorithm certainly undercuts the accuracy of the marketing claims made by Draeger, it does not, in and of itself, alter the support in the record for the conclusion by the Special Master about the general scientific reliability of the device.

B. *Weighted Averaging Algorithm*

During the supplemental remand proceedings, source code analysis revealed the use of a calculation referred to as the weighted averaging algorithm. In short, this algorithm relates to the manner in which the

IR result is calculated. This technology measures the effect of breath alcohol on an infrared signal. In order to calculate the result, the device is programmed to calculate a reading every quarter of a second, based on measurements taken every 8.192 milliseconds. The reported IR result is then computed by means of the algorithm, which places proportionately greater weight on the later measurements than on the earlier ones. In operation, the algorithm directs that the first two readings are averaged, and that value is averaged further with each successive reading. The effect is that the measurement is calculated to place greater and greater weight on the readings taken as the sample of breath continues.

Defendants attack the use of this methodology as scientifically unsound. They point out, correctly, that it is neither an average nor technically even a weighted average. They further assert, however, that the use of this algorithm is evidence of a scientifically unsound device operated by inherently flawed software. We do not find merit in these arguments. To be sure, the calculation is not an average in accordance with the strict mathematical definition. It is, however, in a more general sense, a calculation designed to accord greater weight to that part of the breath sample that enters the cuvette at the end. In doing so, it gives greater weight to the breath that, inevitably, includes the deepest air drawn from the lung. It therefore focuses the analysis on the portion of the breath sample that most accurately represents the subject's BAC. In this manner, the weighted averaging algorithm seeks to achieve a more accurate result. We discern nothing in defendants' attacks on this weighted averaging algorithm that persuades us that it is inherently flawed or that it leads to an inaccurate measurement of BAC.

C. *Buffer Overflow Error*

During the proceedings on remand, Draeger's expert, Bruce Geller, identified a significant flaw in the program's source code that, in limited circumstances, can lead to an inaccurate reported BAC test result. Following Geller's testimony, Draeger's programmer, Shaffer, disputed many of the conclusions proffered by defendants' experts, but he acknowledged and explained the buffer overflow defect, admitting that he was responsible for the inclusion of this error in the code.

The buffer overflow error is only relevant when a test subject, based on the IR and EC results of the first two breath samples that fall outside of the accepted tolerance, is given a third test.[32] Whenever that occurs, there are six results (an IR and EC value for each test) that must be evaluated. According to Shaffer, an array of temporary variables is declared in order to calculate

---

32. Although the frequency with which this error occurs has not been quantified with precision, the experience in Pennsauken suggests that, absent the State's adoption of an expanded tolerance level between the two initial sets of results in NJ Firmware version 3.11, and its resultant diminution of third test results in Middlesex, one might estimate that as many as five percent of all test subjects would ordinarily have results that would require a third breath sample.

the blood alcohol level from the six readings. The available Alcotest array, as currently programmed, however, is only large enough for four readings, and therefore does not hold the second and third EC values. For purposes of this calculation, the third EC value is stored, accurately, in a previous memory location, but the second EC value is altered because of the buffer overflow error. In a situation in which there are six readings, if the second EC result is the lowest value, the device will effectively overlook it and the calculated BAC level will be incorrectly reported instead as the next lowest of the six readings.

Shaffer testified that although the buffer overflow error must be corrected,[33] the previously recorded AIRs correctly display the values for each of the six readings. According to Shaffer, the only error on the AIR will be its report of the BAC. Whether the buffer overflow error affected the reported result, however, is not immediately obvious from looking at the AIR. Instead, a set of calculations, referred to by all of the parties as the Shaffer formula, must be employed to determine whether the buffer overflow error occurred, and, if so, what the proper BAC should have been.

The Special Master, finding Shaffer's candor to be impressive and his testimony "completely reliable," concluded that the buffer overflow error is a "real" one that must be corrected. Pending any corrective action,

---

33. He explained that he has not done so because of the pendency of this litigation.

he recommended that the use of all AIRs that report three breath samples either be prohibited as a basis for prosecution or, in the alternative, that Shaffer's corrective formula be applied.

Defendants argue that the Special Master's solution is inadequate because of the effect of the widened tolerance which led to fewer third tests, but they do not otherwise suggest that either of his proposed alternatives is inappropriate for AIRs reporting third test results. The State, although conceding that the error is one that must be corrected, argues that there is no basis on which to discard previously reported results in light of the ability of the courts to apply the corrective formula to the reported results.

There is no doubt in the record that the Firmware version 3.11 source code includes an error, which may cause the BAC to be incorrectly reported in cases when a third breath sample has been taken.[34] The record, however, makes clear that the error does not in any way alter the accuracy of the reported results for each test

34. We recognize, of course, the force of defendants' argument that the severity of the impact of this error has been masked by the State's unilateral decision to double the tolerance and therefore to reduce the circumstances in which a third test would be permitted. Our decision to address the extant third test result cases does not in any way, in our view, alter the separate manner in which we have elected to deal with the problem presented to us by the increased tolerance range. We instead have addressed that aspect of the record separately, *see* Section VIII.D., *supra*.

of each breath sample, but instead lies in the manner in which the device reads and evaluates that data to calculate the lowest BAC, which then may be both inaccurately calculated and reported.

Were we without confidence in the accuracy of the individually reported results, we would be constrained to agree with the Special Master's suggestion that we reject all of the tests in which a third sample was taken. However, in light of the fact that there is no evidence in the record on which to conclude that the six readings will themselves be inaccurate, we find no ground on which to order a resolution so drastic.

Instead, we conclude that each AIR that includes three breath tests will be admissible as evidence of an accurate BAC reading only after application of the Shaffer formula[35] to ensure the correct calculation of the lowest possible result and reading. We do so, however, with two added cautions heretofore unspoken. First, a third sample is taken only when the four readings from the first two samples are outside of the accepted range of tolerance. As a result, where there are three breath samples, the device does not simply identify and report the lowest of the six reported readings. Instead, it must

35. Although referred to as the Shaffer formula, the mechanism for the correct determination of whether a buffer overflow error has occurred and, if so, the calculation of the correct BAC is embodied in a worksheet that we have revised to apply the correct tolerance range and have appended as Worksheet B to the Order that accompanies this opinion for use in all proceedings pending revision of Firmware version 3.11.

first evaluate the six readings to determine which of the samples fall within the accepted tolerance and then determine, through truncation, which is the lowest acceptable reported result. Calculating the correct result in the face of the buffer overflow error is therefore not a matter of visually inspecting the reported results and selecting the lowest of them. Rather, the use of the formula is required to ensure that the apparently lowest result is also the lowest acceptable one in accordance with the tolerance range.[36] Second, we note that in devising the formula, Shaffer continued to utilize the tolerance calculation reflecting the doubled range. Because we have rejected that range as unacceptable, we have revised the formula, in the form of a worksheet, and have appended it to the Order that accompanies this opinion in its corrected format.

The use of this methodology, however, will require that, pending appropriate correction to the firmware, each AIR with three test sample results must be separately reviewed and that calculations must be performed and verified for accuracy in accordance with

---

36. As an example, if the results on test one were IR = 0.030 and EC = 0.031 and the results on test two were IR = 0.085 and EC = 0.088, and the results on the third test were IR = 0.091 and EC = 0.092, the latter tests are within tolerance of one another, but neither of the latter tests is in tolerance with the first. The correct BAC result, therefore, would be 0.08 even though the results of the first test were far lower. We use this example by way of explanation and only to highlight the need for applying the formula.

Shaffer's formula.[37] We therefore direct that the State undertake to review all such AIRs, perform the calculations to identify the correct BAC in accordance with the Shaffer formula as we have adopted it, and provide that data to the court in which each matter is pending. We further direct that the calculations be made a part of the evidence in any prosecution, pending correction of the firmware, to facilitate appellate review.

D. *Catastrophic Error Detection*

Following the remand for source code analysis, the Special Master also recommended that the machine's catastrophic error detection device be re-enabled. He based his recommendation on his findings that the Alcotest's ability to detect catastrophic errors, which was included in the original source code, had been disabled from use in Firmware version 3.11 and that, if utilized, it would ensure that the device would shut down if it encountered such an error. Although defendants agree with the recommendation that this device be enabled in future software updates, they argue that the implications of the unilateral decision of the manufacturer to disable this feature and the use of the Alcotest without this error detection capability must undermine any confidence in any of the results reported. The State, although disagreeing with both the significance of the decision to disable this detection

---

37. The calculations based on the formula, which is set forth in a table, appended to the Order that accompanies this opinion, should be included as part of the record to facilitate further review.

device and with the impact it might have had on any readings by the machine, agrees that the firmware will be revised to re-enable catastrophic error detection.

Our review of the record demonstrates that there is ample support for the findings and recommendations of the Special Master concerning this aspect of the source code. The witnesses were in general agreement that the absence of an operational catastrophic error detection device is not optimal, and they candidly conceded that in the interim, and based on these proceedings, the feature has been re-enabled for use in other jurisdictions. Notwithstanding that general agreement, the experts disagreed about how the machine would respond if it encountered a catastrophic error.

Defendants' expert suggested that the machine might under those circumstances create an inaccurate AIR, although he could not explain, even theoretically, how it would do so. Apart from that rather speculative opinion, the experts agreed that the machine would most likely enter an endless loop of non-productive analysis and become unresponsive. Because there is no credible evidence in this record that an Alcotest machine that encounters a catastrophic error would create, in reaction thereto, an incorrect AIR, we discern no basis on which to conclude that any of the previously-generated AIRs might represent a test in which the machine encountered an error of this magnitude and reacted by recording an inaccurate series of test results.

Rather, we direct that the State arrange to have the software corrected to re-enable the catastrophic error detection feature.

E. *Overall Firmware Reliability*

As part of the analysis during the supplemental remand proceedings, defendants' expert opined that his evaluation of the source code revealed thousands of programming errors. He criticized the source code on multiple levels, arguing that the style utilized is outdated, that the reliance on global variables leaves too much room for executional errors, and that the program lacks adherence to any recognizable design criteria. In short, he opined that there are so many, and so great a variety of shortcomings in the source code and the programming methodology that we should conclude it is too flawed to be relied upon to generate accurate test results.

The State and Draeger disagree. They assert that most of the programming flaws that defendants' expert identified are simply stylistic programming preferences and that they do not, in fact, represent errors in theory or in reality. They urge us not to be misled into concluding that the source code is inadequate for purposes of scientific reliability.

Our consideration of this matter need not be extended. In actuality, few aspects of the firmware required our analysis and fewer still require our intervention. Of the four major issues—the EC fuel cell drift algorithm, the buffer overflow error, the disabled catastrophic error detention device, and the weighted averaging algorithm — only the buffer overflow error is capable of producing an erroneous AIR. Two of the challenged features, the EC fuel cell drift algorithm and weighted averaging algorithm, we have concluded, contrary to defendants' assertions, are scientifically sound. The last of these, the catastrophic error detection device, we have concluded should not have been disabled but its absence was incapable of producing an inaccurate AIR.

Our evaluation of the exhaustive record relating to the source code leaves us confident that its errors have been revealed. Based on that record, we do not share defendants' larger concerns that it is likely to generate inaccurate results simply because, from a source code writer's viewpoint, it is complex or prolix. There being no evidence in the record that these asserted shortcomings are anything more than stylistic, theoretical challenges, we decline defendants' invitation to require that the firmware comply with any specific programming standards as unnecessary at this time.

X. *Additional Firmware Recommendations*

We next turn to a variety of issues arising from the Special Master's recommendations that require our attention. Some of these matters are not in significant dispute, but our consideration of each of them is essential to ensuring that the Alcotest remains in compliance with our directives. Most of these matters relate to the recommendations of the Special Master concerning the future revisions to the firmware, but some we independently deem to be necessary based on our review and analysis of this record. None, however, requires significant analysis or detail.

The Special Master included a recommendation (Special Master's Finding 2(c)) that the firmware be locked so that only the manufacturer or the coordinators would be able to make changes to the firmware. Although defendants and the State agreed with this recommendation, the NJSBA argued that it would be more appropriate if only the manufacturer had the ability to make changes to the firmware. In light of defendants' continued criticism of the programming style and lack of rigorous programming standards used in the source code, we are firmly convinced that the pool of individuals who are able to make alterations to the firmware should be reduced rather than expanded. Our concern for uniformity in the firmware compels us to direct that the firmware be locked so that only the manufacturer will be able to make changes to it, which changes may then be downloaded by the coordinators.

Further, considering the numerous changes that we have directed be incorporated into the Alcotest in order to ensure that the device is scientifically reliable and as a prerequisite for admissibility of its BAC readings in the future, we anticipate that our courts will encounter AIRs from devices that utilize different versions of the firmware. We therefore direct, for ease of analysis, that the device be programmed so that on all future AIR printouts, the firmware version then being utilized by the device is reported.

The Special Master also recommended that the State should be required to publish future firmware revisions and that notice of all such future revisions should be given to the public in general and to the amicus NJSBA in particular. Our analysis of this record demonstrates, however, that this recommendation may be insufficient. In our view, merely requiring that the parties or the NJSBA receive notice of future revisions will not be sufficient to ensure that the device is not reprogrammed in a manner inconsistent with producing accurate and reliable results that will be admissible in DWI prosecutions. We therefore have concluded that this required notice, to the parties, the public and the amicus NJSBA, of the future firmware revisions must be sufficiently specific to identify the proposed changes in a manner that affords notice in compliance with due process. A generic notice to the effect that the firmware has been revised, in light of some of the previous alterations that we today correct, will not suffice.[38]

The Special Master also recommended that the State provide Alcotest training for defense attorneys and their experts similar to that provided for operators

38. We note that the parties asked this Court to appoint an independent software house to be responsible for any future reviews of the Alcotest source code. We decline to do so at this time, and will determine that issue should there be a challenge in the future to the scientific reliability of the Alcotest based on future firmware revisions.

and coordinators. The State, understandably, objected to this recommendation and urges us to reject it. Although we reject it in part, defense attorneys should not be left without any means of learning about the device or its operation. Rather, we deem it to be in the interests of justice that some form of training be made available to defense attorneys to enable them to better prepare to represent their clients. However, we agree that the State should not be burdened with this responsibility. We therefore direct that Draeger make Alcotest training, substantially similar to that provided to Alcotest operators and coordinators, available to licensed New Jersey attorneys and their designated experts. The training shall be offered at regular intervals and at locations within the State of New Jersey, at a reasonable cost to those who attend.

XI. *Requirements Prior to the Admissibility of Alcotest Evidence*

Our analysis of the general scientific reliability of the Alcotest is grounded, in part, on our expectation that there will be proof that the particular device that has generated an AIR being offered into evidence was in good working order and that the operator of the device was appropriately qualified to administer the test. This requirement that the test results be supported by foundational proofs for admissibility has been part of our jurisprudence since we decided *Romano*. There we demanded that, as a precondition for admissibility of the results of a breathalyzer, the State was required to establish that: (1) the device was in working order and had been inspected according to procedure; (2) the operator was certified; and (3) the test was administered according to official procedure. *Romano, supra,* 96 N.J. at 81, 474 A.2d 1.

In matters relating to the Alcotest, the same general considerations that gave rise to these requirements must, of course, apply. In an effort to address these concerns, the Special Master recommended that certain documents, which he referred to as the "foundational documents," be produced during discovery and that they be admitted into evidence as part of the State's case-in-chief.[39] The documents in question can be described as follows: (1) Calibrating Unit, New Standard Solution Report, most recent change, and the operator's credentials of the officer who performed that change; (2) Certificate of Analysis 0.10 Percent Solution used in New Solution Report; (3) Draeger Safety Certificate of Accuracy Alcotest CU34 Simulator; (4) Draeger Safety Certificate of Accuracy Alcotest 7110 Temperature Probe; (5) Draeger Safety Certificate of Accuracy Alcotest 7110 Instrument (unless more relevant NJ Calibration Records (including both Parts I and II are offered)); (6) Calibration Check (including both control

---

39. Technically, in his initial report, the Special Master only suggested that these documents be admitted into evidence in cases in which the defendant was not represented by counsel. He amended that recommendation in his supplemental report to extend it to all prosecutions, without regard to whether the particular defendant was represented by counsel or not. Regardless of that, the arguments raised by the State as to this requirement have not been altered.

tests and linearity tests and the credentials of the operator/coordinator who performed the tests); (7) Certificate of Analysis 0.10 Percent Solution (used in Calibration-Control); (8) Certificate of Analysis 0.04, 0.08, and 0.16 Percent Solution (used in Calibration-Linearity); (9) Calibrating Unit, New Standard Solution Report, following Calibration; (10) Draeger Safety Certificate of Accuracy Alcotest CU34 Simulator for the three simulators used in the 0.04, 0.08, and 0.16 percent solutions when conducting the Calibration-Linearity tests; (11) Draeger Safety Certificate of Accuracy Alcotest 7110 Temperature Probe used in the Calibration tests; and (12) Draeger Safety, Ertco-Hart Digital Temperature Measuring System Report of Calibration, NIST traceability.

Defendants, although not conceding the scientific reliability of the Alcotest device, generally or otherwise, and the NJSBA, agreed with the Special Master that the State should be required to produce all of these documents as part of routine discovery. In addition, in their initial briefs, they also agreed that admitting these documents into evidence in all prosecutions based on Alcotest results is essential. In response to our request for further briefs directed to the admissibility of these documents, defendants have altered their position, contending that the documents can only be admitted into evidence if accompanied by testimony from a witness who may be cross-examined about the statements included within them.

The amicus NJSBA has argued that testimony from the operator, the officer who performed the control solution change, and the coordinator who calibrated the machine, should be routinely required. The amicus ACDL charted a middle course. They suggested that testimony from the coordinator should be required. Nevertheless, they conceded that if the Court concludes that the device is generally scientifically reliable, it would serve no purpose to require a witness to testify about the reports, generated by the device itself, that evidence its good working order.

The State disagreed in part with the Special Master's recommendations in its initial and supplemental briefs. Although representing that all of these documents are and will continue to be routinely produced in discovery, the State asserts that only four documents should be required to be admitted into evidence in support of the use of the device: the AIR itself, which should be deemed admissible, and the required foundational documents, which should be limited to the New Standard Solution Report that immediately preceded the administration of the test in question and is referred to in the AIR, the Calibration Check Report documents, which are also referred to in the AIR, and the documents demonstrating that the operator was certified as an Alcotest Breath Test Operator.[40] Those alone are required, in the view of the

40. Although the State refers to this as being four documents, in fact the State's list includes parts of multiple categories from the Special Master's list and others not included in his foundational list.

State, because all of the other documents included on the Special Master's list are, in essence, tests of tests or relate to testing standards that are not now, and should not be in the future, required for prosecution.

A. *Confrontation Clause Implications*

We begin by noting that this argument is complicated by our consideration of the way in which the standards set forth by the United States Supreme Court in *Crawford, supra,* impact on admissibility of these proofs. We turn, then, to an analysis of the implications of the constitutional protections identified by *Crawford* and its progeny.

The Sixth Amendment of the United States Constitution guarantees defendants in criminal[41] cases "the right . . . to be confronted with the witnesses against" them. *U.S. Const.* amend. VI. Our own Constitution includes identical language. *N.J. Const.* art. I, ¶ 10. As we have previously recognized, defendants exercise their right to confrontation through cross-examination. *See State v. Branch,* 182 N.J. 338, 348, 865

41. We recognize, and our Appellate Division has recently observed, that we have not specifically held that the Confrontation Clause applies to quasi-criminal proceedings or that it applies generally to DWI matters. *See State v. Kent,* 391 N.J.Super. 352, 387-88, 918 A.2d 626 (App.Div.2007) (Stern, P.J.A.D., concurring). In light of the manner in which we have addressed the potential impact of *Crawford* on the evidence we here consider, we need not directly consider this constitutional question.

A.2d 673 (2005); *see also Crawford, supra,* 541 U.S. at 61, 124 S.Ct. at 1370, 158 L.Ed.2d. at 199 ("reliability [of witnesses must be] assessed by testing in . . . the crucible of cross-examination"). Although we commented in *Branch* that "[a]n established and recognized exception to the hearsay rule will not necessarily run afoul of the Confrontation Clause," *Branch, supra,* 182 N.J. at 349, 865 A.2d 673, the United States Supreme Court in *Crawford* explained that for certain categories of evidence, falling within a recognized hearsay exception is not enough. *Crawford, supra,* 541 U.S. at 51-52, 124 S.Ct. at 1364, 158 L.Ed.2d. at 192-93.

Rather, the Court held that the Confrontation Clause derives from the concern of the Framers that certain categories of evidence are the equivalent of testimony and thus only appropriately tested through cross-examination. *Ibid.* For evidence in these categories, namely, "testimonial" evidence, only confrontation through cross-examination will suffice. As a result, merely testing such evidence against the standards for reliability represented by the exceptions to the hearsay rules is insufficient to comport with the protections afforded by the Confrontation Clause. *See Crawford, supra,* 541 U.S. at 60-61, 124 S.Ct. at 1369-70, 158 L.Ed.2d at 198-99.

Although the Court "le[ft] for another day," *id.* at 68, 124 S.Ct. at 1374, 158 L.Ed.2d. at 203, the precise delineation of what it meant by "testimonial" as opposed to "nontestimonial" evidence, the Court identified that the "core class of 'testimonial' statements" includes:

> "*ex parte* in-court testimony or its functional equivalent—that is, material such as affidavits, custodial examinations, prior testimony that the defendant was unable to cross-examine, or similar pretrial statements that declarants would reasonably expect to be used prosecutorially," "extrajudicial statements ... contained in formalized testimonial materials, such as affidavits, depositions, prior testimony, or confessions," [and] "statements that were made under circumstances which would lead an objective witness reasonably to believe that the statement would be available for use at a later trial[.]"

[*Id.* at 51-52, 124 S.Ct. at 1364, 158 L.Ed.2d. at 193 (citations omitted).]

The Court further explained that this definition of testimonial includes " *ex parte* testimony at a preliminary hearing [and s]tatements taken by police officers in the course of interrogations. . . ." *Id.* at 52, 124 S.Ct. at 1364, 158 L.Ed.2d. at 193. More recently, the Court has explained the distinction between "testimonial and nontestimonial" as follows:

> Statements are nontestimonial when made in the course of police interrogation under circumstances objectively indicating that the

> primary purpose of the interrogation is to enable police assistance to meet an ongoing emergency. They are testimonial when the circumstances objectively indicate that there is no such ongoing emergency, and that the primary purpose of the interrogation is to establish or prove past events potentially relevant to later criminal prosecution.

[*Davis, supra* 547 U.S. at 822, 126 S.Ct. at 2273-74, 165 L.Ed.2d at 237.]

The *Crawford* paradigm, therefore, begins with an analysis of whether any particular piece of evidence is admissible as a matter of complying with the rules of evidence. Typically, the issue arises in the context of hearsay and the exceptions thereto. The model adopted in *Crawford* then considers whether the particular evidence is "testimonial" within the meaning of the Confrontation Clause, for if it is, then the fact of admissibility for purposes of the exceptions to the hearsay rules is insufficient. *See Crawford, supra,* 541 U.S. at 60-61, 124 S.Ct. at 1369-70, 158 L.Ed.2d at 198-99. That is to say, if the evidence is testimonial, reliability as defined by the exceptions to the hearsay rules does not equate with, and cannot substitute for, confrontation through cross-examination.

In order to correctly apply the *Crawford* analysis, then, we must consider first whether the particular evidence is admissible under the ordinary rules of evidence and then whether it is testimonial, thus requiring the declarant to be made available for cross-examination. Significantly, for purposes of our analysis, the Court in *Crawford* noted that business records are considered "by their nature" to be nontestimonial, *see id.* at 56, 124 S.Ct. at 1367, 158 L.Ed.2d. at 195, and therefore their admission into evidence would not implicate the Confrontation Clause's guarantees. Although we recognize that the broadest reading of that observation would permit us to end the analysis here, we do not regard the Court's apparent exclusion of all business records from the Constitution's protective scope to be dispositive of the issues before us.

B. *Application of Crawford v. Washington*

For purposes of our analysis of the *Crawford* issue, the foundational documents identified by the Special Master are only part of the matters we must consider. Overall, we perceive of three categories of documents[42] relevant to our discussion: (1) the documents evidencing the qualifications of the operator; (2) the documents evidencing that the machine was in working order at the time of the test; and (3) the AIR being offered into evidence to demonstrate[43] the results of the breath

---

42. The NJSBA, in its supplemental letter brief addressing the *Crawford* question, suggested dividing these documents into categories based upon which entity could be identified as having prepared it. We believe that our functional analysis provides the more useful analytical framework.

43. Two issues generally relating to the AIR require comment. First, the amicus ACDL urges us to conclude that (Cont'd)

testing. Very different levels of analysis pertain to each of these categories.

1. *Operator's Qualifications*

For *Crawford* purposes, we begin by noting that the parties agree that, unlike the breathalyzer, the Alcotest is not "operator-dependent," meaning that the device is not subject to influences from the operator. Instead, the record demonstrates that the operator will play a relatively lesser role here than has been the case in the past. His role now consists of observing the subject to ensure that twenty minutes has passed and to be certain that the subject has neither swallowed nor regurgitated any substances during that time that would influence the test results; inputting and verifying the accuracy of the identifying information needed to start the sequence; changing the control solution if the machine alerts him to do so; attaching a new mouthpiece; reading the instructions about how to blow into the machine; observing the LED screen and following its prompts;

(Cont'd)

the Alcotest is sufficiently new that the AIR should merely be evidence of BAC. In light of the thorough record about the general scientific reliability of the device, we reject that suggestion. Second, the Special Master recommended that incomplete AIRs should be inadmissible. An AIR that is incomplete in its report of breath test results cannot be admissible as proof of a per se DWI violation. On the other hand, an AIR that is "incomplete" in that it does not include added data we here order for the future is not necessarily inadmissible.

and observing the subject to ensure that he or she actually provides a sample. There are no meters to read, no dials to turn, and if the machine detects an error, the error is reported and no test results are derived. The operators are not able to alter or affect the software that governs the performance of the device and cannot fix the machine should a repair be needed.

Even so, the Special Master recommended, and the State concedes, that the operator should be available to testify in a contested matter. Notwithstanding this reduced role to be played by the operator as relates to the ultimate BAC results reported, requiring that he or she be made available for cross-examination is an important constitutional safeguard. We therefore, consistent with our longstanding practice, *see Romano, supra,* 96 N.J. at 90-91, 474 A.2d 1, can ensure that each defendant has the opportunity to confront the witness who has potentially relevant testimony.[44]

It is in this context, however, that we consider the Special Master's requirement that the operator produce evidence of his qualifications through a certificate or a current operator card.[45] We perceive of no potential

---

44. It may well be that, as the use of the device becomes more routine, some, or even most, defendants will eventually forgo cross-examination of the operator in light of the limited information that can be achieved in that effort.

45. Technically, the Special Master included this as part of his description of the required operator's testimony rather than listing it among the foundational documents. None of the parties has voiced any objection to this requirement.

violation of the right to confrontation that might arise from the admission into evidence of these documents. Apart from the fact that these documents fall squarely within the traditional business records exception[46] to the hearsay rule, *N.J.R.E.* 803(c)(6); *see State v. Matulewicz,* 101 N.J. 27, 28, 499 A.2d 1363 (1985) (defining scope of business record exception), and thus are presumably exempted from the *Crawford* analysis entirely, *see* 541 U.S. at 56, 124 S.Ct. at 1367, 158 L.Ed.2d at 195, they are not testimonial within the contemplation of *Crawford.* On the contrary, these supporting documents are not testimonial because they neither establish an element of the offense charged nor demonstrate the truth of any fact in issue. Even were we concerned that there is some constitutional infirmity in permitting these documents to be offered into evidence, in light of the fact that the operator will ordinarily be called to testify, all defendants will be able to exercise their right to cross-examine the individual to whom these documents actually pertain.

2. *Foundational Documents*

In addition to the requirement relating to the operator's credentials, however, we next consider the

46. Although in *Crawford* the Court used business records as an example of nontestimonial evidence, other courts have suggested that the distinction is not so clear. *See, e.g., Thomas v. United States,* 914 A.2d 1, 13 (D.C.2006) (contrasting historically limited definition of business records with current interpretation; questioning validity for Confrontation Clause analysis).

Crawford-based challenge to the twelve foundational documents, relating to the good working order of the device, that the Special Master has recommended be produced and admitted into evidence. These documents fall into two categories: (1) documents directly evidencing the good working order of the machine as of the time of the test, including: the most recent calibration record, the most recent new standard solution report, and the certificate of analysis of the 0.10 simulator solution used in the control tests; and (2) documents evidencing the accuracy of the devices used and chemical composition of the solutions used to routinely test and calibrate the machine, including the analysis of all of the solutions used to test linearity, the documents attesting to the accuracy of the devices used in the simulator, and the certificates of accuracy of the simulator and temperature probes.

As a threshold matter, we perceive no shortcoming, from a constitutional perspective, with respect to any of this large group of foundational documents that the Special Master identified as prerequisites to a finding of guilt. All of the twelve documents that the Special Master identified qualify as business records in the traditional sense. For purposes of the hearsay exception, we can describe all of these documents as being records of tests of the device, or of the simulator unit that is used to calibrate the device, or of the chemical composition of the solutions used to either perform the control tests or calibrate the machine. Although these are part and parcel of ensuring that the machine is in good working order, from the perspective of the hearsay analysis, we do not regard them as being anything other than business records that are ordinarily reliable. We reach this conclusion notwithstanding the arguments raised by defendants to the effect that any document prepared by either the State Police or Draeger, in connection with the Alcotest, should be viewed with suspicion. In part, defendants' concerns pre-suppose that these documents are similar to affidavits or include statements by their preparers. There is, however, nothing in this record that suggests that any of these foundational documents is subject to manipulation by the preparer.

Nor do we reach a different conclusion on the question of whether they fall within the ambit of that which *Crawford* teaches us is testimonial and therefore requires an opportunity for cross-examination. In this, we find accord with the great majority of the jurisdictions that have considered this, or similar, questions relating to foundation documents for scientific testing devices. *See Bohsancurt v. Eisenberg,* 212 Ariz. 182, 129 P.3d 471, 476-77 (App.2006) (holding that maintenance and calibration records for breath testing machine are routine business records that are not testimonial); *Rackoff v. State,* 281 Ga. 306, 637 S.E.2d 706, 707, 709 (2006) (holding that inspection certifications are business records and are not testimonial); *People v. Kim,* 368 Ill.App.3d 717, 307 Ill.Dec. 92, 859 N.E.2d 92, 93-94 (2006), *appeal denied,* 224 Ill.2d 589, 312 Ill.Dec. 660, 871 N.E.2d 60 (2007) (holding that affidavit certifying that device was tested is non-testimonial); *Jarrell v. State,* 852 N.E.2d 1022, 1026

(Ind.Ct.App.2006) (holding that a breath test device certification is not testimonial); *Napier v. State,* 820 N.E.2d 144, 149 (Ind.Ct.App.2005) (holding that inspection and operator certifications are not testimonial); *Commonwealth v. Walther,* 189 S.W.3d 570, 575 (Ky.2006) (holding that notations regarding maintenance and testing of device are not testimonial); *State v. Fischer,* 272 Neb. 963, 726 N.W.2d 176, 181-83 (2007) (holding that a simulator solution certificate is not testimonial); *People v. Lebrecht,* 13 Misc.3d 45, 823 N.Y.S.2d 824, 826-27 (Sup.2006) (holding that calibration/maintenance report and simulator solution certification are not testimonial); *State v. Norman,* 203 Or.App. 1, 125 P.3d 15, 18-20 (2005), *review denied,* 340 Or. 308, 132 P.3d 28 (2006) (holding that certificates of accuracy are not testimonial). *But see Shiver v. State,* 900 So.2d 615, 618 (Fla.Dist.Ct.App.2005) (holding that breath test affidavit, including portion used to show that device had required maintenance, is testimonial).

To be sure, some of these documents and certificates are prepared by the police, but none of them relates to or reports a past fact and none of them is generated or prepared in order to establish any fact that is an element of the offense. *See Davis, supra,* 547 U.S. at 821-24, 126 S.Ct. at 2273-74, 165 L.Ed.2d at 237. The fact that they may be used to demonstrate that a device, which was used to conduct the breath tests for a particular defendant, was in good working order does not transform them into evidence of an element of the offense nor make them testimonial in the constitutional sense. We perceive both in the Constitution itself and in

Crawford, ample room for admissibility of these foundational documents consistent with protecting defendants' rights.

Although we therefore conclude that they would all be admissible within the confines of the Constitution, we will not adopt the Special Master's recommendation and require that they all be offered into evidence routinely. Indeed, as the State has correctly pointed out, many of the documents on the Special Master's list of foundational proofs are tests of tests and, therefore, are too attenuated to require that they be admitted as part of the evidence. We include in that category all of the documents relating to the working order of the simulator, the reports of the solutions used during simulation and calibration, the certificate of accuracy of the simulator used to calibrate the device, and the temperature probe documents. Although, as all parties agree, these documents should continue to be produced in discovery,[47] they are not fundamentally a part of

---

47. We note that there is already, according to the State, a routine disclosure of all of the documents on the Special Master's list. We presume that, in the event that any defendant perceives of an irregularity in any of these documents that might affect the proper operation of the device in question, timely issuance of a subpoena will suffice for purposes of protecting that defendant's rights. Were the use of the subpoena power to become routine, we would commend to the parties, with the assistance of our municipal courts, the use of pretrial *de bene esse* depositions or video conferencing technology to reduce the burden on the State or any independent testing laboratories.

demonstrating that the particular device was in good working order.[48]

The foundational documents that we conclude need to be entered into evidence therefore are few. They are: (1) the most recent calibration report prior to a defendant's test, with part I-control tests, part II — linearity tests, and the credentials of the coordinator who performed the calibration; (2) the most recent new standard solution report prior to a defendant's test; and (3) the certificate of analysis of the 0.10 simulator solution used in a defendant's control tests. Absent a pre-trial challenge to the admissibility of the AIR based on one of the other foundational documents produced in discovery, we perceive of no reason to require that they be made a part of the record routinely.

3. *Alcohol Influence Report Admissibility*

The final aspect of our *Crawford* analysis must be focused on the AIR itself. In the time since *Crawford*

---

48. The record includes scant evidence relating to repair history of any of these devices. Presumably the devices that were part of the evidence in the prosecutions for the named defendants were so newly put into service that no repairs have been needed. At the same time, there is evidence suggesting that from time to time one or more of the devices has been adjusted by a coordinator or returned to Draeger for repair. The record reflects that in either event, a document is generated by the coordinators that evidences those repairs. We commend to the State the establishment of a protocol for maintaining repair logs to the extent that these become more frequent and, therefore, potentially relevant.

was decided, courts around the country have struggled to analyze its import in matters relating to scientific or forensic testing generally. A few have directly confronted documents that are similar to the AIR and have attempted to apply *Crawford's* constitutional commands in that context.

The AIR, unlike the foundational documents evidencing the good working order of the machine, reports the results of a test which, in and of itself under our statute, suffices to support a conviction. It is proof of BAC, over a specified threshold, that forms the basis for a per se violation. Were we to step back and consider it in *Crawford* terms, we might well conclude that it is the modern day, functional equivalent of testimony. It comes, however, not from the mouth of a living witness, but from a machine. Surely the Founding Fathers did not envision the day when a device that cannot itself be cross-examined would be the equivalent of a witness.

We have previously addressed the constitutional question of the right to confront a written document that is itself evidence of a crime. In *State v. Simbara,* 175 N.J. 37, 811 A.2d 448 (2002), we identified the essence of the constitutional quandary in considering the admissibility of a laboratory certificate analyzing suspected controlled dangerous substances. We reasoned:

> A laboratory certificate in a drug case is not of the same ilk as other business records, such

> as an ordinary account ledger or office memorandum in a corporate-fraud case. Those latter documents have not been prepared specifically for the government's use in a potential criminal prosecution. In contrast, the analyst prepares the laboratory certificate at a prosecuting agency's request for the sole purpose of investigating an accused. Because the certificate is singularly important in determining whether the accused will be imprisoned or set free, we must be sensitive to Sixth Amendment interests whenever a defendant preserves those interests for trial.

[*Id.* at 49, 811 A.2d 448.]

In *Simbara,* we acknowledged that a defendant could seek to cross-examine the laboratory technician who performed the test on the sample as a means to protect his or her Confrontation Clause rights. *Ibid.* The AIR presents us with a somewhat more complex constitutional question.

Although no court has considered the Alcotest and its AIR, other courts have suggested a variety of analytical frameworks to be utilized in determining whether test results are testimonial. Some have concluded that because a test result or report is generated by a machine, rather than a human, it cannot qualify as a statement in the sense *Crawford* intended. *See United States v. Washington,* 498 F.3d 225, 230-32

(4th Cir.2007) (finding that "[t]he raw data generated by the diagnostic machines are the 'statements' *of the machines* themselves, not their operators"); *United States v. Khorozian,* 333 F.3d 498, 506 (3d Cir.2003) explaining that "a statement is something uttered by 'a person,' so nothing 'said' by a machine . . . is hearsay").

Other courts have focused on the fact that the machine has no discretion as to whether it will produce a particular result and cannot be manipulated to produce a result to secure a conviction of a particular defendant in the way that interrogating a person could. *See People v. Geier,* 41 Cal.4th 555, 61 Cal.Rptr.3d 580, 161 P.3d 104, 140 (2007) (holding that lab reports are not testimonial because they are made of part of a routine and non-adversarial process); *Commonwealth v. Verde,* 444 Mass. 279, 827 N.E.2d 701, 705 (2005) (holding that lab reports are not testimonial because they are neither discretionary nor based on opinion); *State v. Forte,* 360 N.C. 427, 629 S.E.2d 137, 143 (2006) (holding that a serology report is nontestimonial because it is neutral and has the possibility to exonerate or convict).

Neither of these analytical frameworks is entirely sufficient in our view. Instead, we return to the fundamentals of the definition of testimonial as the Court explained in both *Crawford, supra,* and *Davis, supra.* Viewed against that standard, the essential elements of testimonial evidence are a report of a past event, given in response to police interrogation, with the purpose of establishing evidence that a defendant committed an offense. Judged against this standard, the AIR falls outside of the definition of testimonial on two, and arguably all three, grounds. First, the AIR reports a present, and not a past, piece of information or data. Second, although given in the presence of a police officer who operates the device, nothing that the operator does can influence the machine's evaluation of the information or its report of the data. Third, although the officer may have a purpose of establishing evidence of a BAC in excess of the permissible limit, the machine has no such intent and may as likely generate a result that exonerates the test subject as convicts him or her. Seen through this prism, we conclude that the AIR is not testimonial in the sense that was intended by the Framers of the Confrontation Clause.

Although we have concluded that the AIR is not testimonial, we have nevertheless concluded that defendants are entitled to certain safeguards that we have required be implemented in prosecutions based on the Alcotest. We have directed that an opportunity for cross-examination similar to that described in *Simbara* and *Romano* be provided to these defendants through our requirement that the operator of the device be made available to testify. Likewise, we have required the routine production in discovery of all of the foundational documents that might reveal some possible flaw in the operation of the particular device and we have demanded that the core foundational documents that establish the good working order of the device be admitted into evidence.

But more than implementing these safeguards, because the ability to cross-examine the operator of the Alcotest will provide little means to challenge the veracity of the AIR, we appointed a Special Master, who we commend and thank for his extraordinary assistance. Through him, we have engaged in a lengthy process of receiving testimony and evidence, both initially and in the supplemental proceedings to ensure the scientific reliability of the Alcotest. In our effort to judge the scientific reliability of the device, we have made available the opportunity for cross-examination of the witnesses who are most familiar with the device and we have directed that the manufacturer divulge its source code and make available the personnel who can explain it.

We are confident, based on this far-reaching and searching inquiry, that the device is sufficiently reliable so that the rights of all defendants have been protected. We are satisfied that, with the directions we here adopt for pending and future matters, the confrontation rights of all defendants have been, and will continue to be, protected. We have no doubt that the device, with the safeguards we have required, is sufficiently scientifically reliable that its reports may be admitted in evidence. And we are confident that, in so concluding, all of defendants' rights have been advanced and considered.

XII. *Conclusion*

The Report and Recommendations and the Supplemental Report and Recommendations of the Special Master are adopted as modified. The stay effected by our January 10, 2006 Order shall be lifted in accordance with the Order that accompanies this decision and that sets forth the precise manner in which our directives shall be applied. The matters involved in these consolidated proceedings are remanded to the Law Division for further proceedings consistent with this opinion and the accompanying Order.

JUSTICES LONG, LaVECCHIA, ALBIN, WALLACE, and RIVERA-SOTO join in JUSTICE HOEN'S opinion. CHIEF JUSTICE RABNER did not participate.

APPENDIX B — ORDER OF THE SUPREME COURT OF NEW JERSEY DATED MARCH 17, 2008

SUPREME COURT OF NEW JERSEY
A-96 September Term 2006
58,879

STATE OF NEW JERSEY,

Plaintiff-Appellant,

v.

JANE H. CHUN, DARIA L. DE CICCO, JAMES R. HAUSLER, ANGEL MIRALDA, JEFFREY R. WOOD, ANTHONY ANZANO, RAJ DESAI, PETER LIEBERWIRTH, JEFFREY LING, HUSSAIN NAWAZ, FREDERICK OGBUTOR, PETER PIASECKI, LARA SLATER, CHRISTOPHER SALKOWITZ, ELINA TIRADO, DAVID WALKER, DAVID WHITMAN and JAIRO J. YATACO,

Defendants-Respondents,

and

MEHMET DEMIRELLI and
JEFFREY LOCASTRO,

Defendant,

and

DRAEGER SAFETY DIAGNOSTICS, INC.,

Intervenor.

Appendix B

ORDER

The Court having previously certified the within matter directly pursuant to *Rule* 2:12-1, and having contemporaneously appointed retired Appellate Division Presiding Judge Michael Patrick King to serve as the Court's Special Master,

And the Court having remanded the matter to the Special Master to develop a record, conduct hearings, and report his findings and conclusions regarding the scientific reliability of the Alcotest 7110 MKIII-C (the Alcotest),

And the Court having received the Special Master's Report dated February 13, 2007, and Supplemental Report dated November 8, 2007,

And the Court having considered the briefs and arguments of counsel for the parties, the intervenor, Draeger Safety Diagnostics, Inc. (Draeger) and the amici curiae, New Jersey State Bar Association and Association of Criminal Defense Lawyers,

And the Court having on January 10, 2006, issued an Order governing prosecution, appeals, and imposition of sentences pursuant to *N.J.S.A.* 39:4-50 pending the decision in this matter,

And the Court having issued this day its decision in the matter,

And good cause appearing,

Appendix B

1. IT IS ORDERED that the previously imposed stay is vacated and prosecutions, appeals, and imposition of sentences in all matters arising pursuant to *N.J.S.A.* 39:4-50, shall proceed in accordance with the following directives:

A. For all pending prosecutions, including all prosecutions in which imposition of sentence has been stayed by our January 10, 2006 Order, and in all future prosecutions based on tests conducted prior to the implementation of our directives through creation of and implementation of revised firmware, Alcotest 7110 MKIII-C with New Jersey Firmware version 3.11 is sufficiently scientifically reliable, and the Alcohol Influence Report (AIR) which sets forth the results of breath tests is admissible as evidence of blood alcohol content (BAC), *except* that:

(1) in each prosecution in which an AIR is offered as evidence and in which there are only two reported test samples:

(a) the State shall prepare and produce a calculation, in a form consistent with Worksheet A attached hereto, that ensures that the two samples meet the acceptable range of tolerance as follows:

(i) add the sum of the IR and EC results given for the first breath sample to the sum of the IR and EC results for the second breath sample;

(ii) divide the sum calculated in (a) by 4 to derive the arithmetic mean;

(iii) compute the upper limit of the tolerance range by taking the higher of the mean multiplied by 1.05 or the mean plus 0.005;

(iv) compute the lower limit of the tolerance range by taking the lower of the mean multiplied by 0.95 or the mean minus 0.005;

(v) if *all* of the IR and EC results of the two samples fall within the upper and lower limits of the tolerance range, the two tests are in tolerance and the AIR is valid; if any of the results fall outside of the tolerance range, the AIR is not valid;

(b) the court shall verify the accuracy of the State's calculation and, in any event, shall make the calculation a part of the record to facilitate further review;

(c) if the two samples meet the test for tolerance as we have defined it, the AIR shall be deemed admissible (unless challenged on an alternate ground as set forth herein) into evidence in the prosecution of the matter;

(d) if the two samples do not meet the test for acceptable tolerance as we have defined it, the AIR shall not be admissible into evidence;

(2) in each prosecution in which an AIR is offered as evidence and in which there are three reported test samples,

(a) the State shall prepare and produce a calculation, in a form consistent with Worksheet B attached hereto, that, in accordance with the formula on the attached worksheet, analyzes the reported results to determine which, if any, meet the test for tolerance as we have defined it, and

(i) if, after completing the worksheet there are at least two breath samples for which IR and EC results are within the acceptable range of tolerance, the AIR will be admissible and the BAC shall be the lowest of those results; but

(ii) if, after completing the worksheet, there are no two test samples that meet the test for tolerance as we have defined it, then the AIR shall not be admissible into evidence;

(b) the court shall verify the accuracy of the State's calculations and shall ensure that there has been no buffer overflow error or that the calculation of the BAC, accounting for a buffer overflow error, has been corrected;

(c) the calculations relating to the possibility of a buffer overflow error and its correction, if appropriate, shall be made a part of the record to facilitate further review;

(3) in each prosecution involving any woman who, at the time of the alleged offense, was over the age of sixty and for whom an AIR was generated with an error message evidencing a breath sample of inadequate volume, the AIR shall not be admissible as evidence in a prosecution for refusal, *see N.J.S.A.* 39:4-50.4a, unless the woman also provided another breath sample of at least 1.5 liters; and it is further

2. ORDERED that the State shall arrange forthwith with Draeger for revisions to the New Jersey Firmware utilized in Alcotest 7110 MKIII-C, as needed to accomplish the directives set forth in the Court's opinion regarding the admissibility into evidence of results of Alcotest breath testing, currently New Jersey Firmware version 3.11, as follows:

A. The firmware shall be locked so that only the manufacturer of the device is able to change the firmware, with changes to be downloaded by State Police Coordinators as needed;

B. The firmware shall utilize minimum breath sample criteria as follows: (1) minimum volume of 1.5 liters for all test subjects except for women over sixty years of age, for whom the minimum volume shall be fixed at 1.2 liters; (2) for all subjects, regardless of age or gender, the minimum criteria shall also include (a) a minimum 4.5 second blowing time; (b) a minimum flow rate of 2.5 liters per minute; and (c) a plateau as established by the infrared (IR) measure which does not differ by more than one percent in 0.25 seconds;

C. The firmware shall be corrected to set the acceptable tolerance range for breath sample readings at the greater of plus or minus five percent of the mean, or plus or minus 0.005 percent BAC from the mean;

D. The firmware shall be corrected to eliminate the buffer overflow programming error;

E. The firmware shall be corrected to re-enable catastrophic error detection;

F. The firmware shall be corrected so that the AIR will report control test results for IR and EC readings prior to the application of the fuel cell drift algorithm;

G. The firmware shall be programmed to include the serial number of the Ertco-Hart digital temperature measuring system utilized as a part of each calibration, certification and linearity report;

H. The firmware shall be corrected to identify, on any AIR which reveals that the test subject has no reportable results, why there has been no reportable result derived or generated;

I. The firmware shall be reprogrammed to include, on all future AIR printouts, solution change reports, calibration documents, and a listing of the temperature probe serial number and value; and

J. The firmware shall be reprogrammed to include, on all future AIR printouts, a designation of the firmware version utilized by the device reporting breath results; and it is further

3. ORDERED that the State shall forthwith:

A. Commence inspection and recalibration of all Alcotest devices every six months in place of the current annual inspection and recalibration program;

B. Create and maintain a centralized statewide database, comprised of downloaded Alcotest results, and shall make the data, following appropriate redactions of personal identification as needed, available to defendants and counsel; and

C. Produce in discovery the twelve foundation documents identified by the Special Master as follows:

(1) New Standard Solution Report of the most recent control test solution change, and the

credentials of the operator who performed that change;

(2) Certificate of Analysis for the 0.10 percent solution used in that New Solution Report;

(3) Draeger Safety Certificate of Accuracy for the Alcotest CU34 Simulator;

(4) Draeger Safety Certificate of Accuracy for the Alcotest 7110 Temperature Probe;

(5) Draeger Safety Certificate of Accuracy for the Alcotest 7110 Instrument;

(6) Calibration Records, including control tests, linearity tests, and the credentials of the coordinator who performed the calibration;

(7) Certificate of Analysis for the 0.10 percent solution used in the calibration control test;

(8) Certificate of Analysis for the 0.04, 0.08, and 0.16 percent solutions used in the calibration linearity test;

(9) New Standard Solution Report, following the most recent calibration;

(10) Draeger Safety Certificates of Accuracy for the Simulators used in calibration;

(11) Draeger Safety Certificate of Accuracy for the Alcotest 7110 Temperature Probe used in calibration; and

(12) Draeger Safety Ertco-Hart Calibration Report; and it is further

4. ORDERED that the State shall provide notice, both to the parties and by means calculated to be generally accessible to the public and shall specifically provide notice to the New Jersey State Bar Association, of any and all proposed future revisions to the Alcotest New Jersey Firmware, which notice shall not be generic, but shall be sufficiently specific to identify the proposed software changes so as to afford notice in compliance with due process; and it is further

5. ORDERED that Draeger shall make training on the Alcotest device, substantially similar to that provided to Alcotest operators and coordinators, available to licensed New Jersey attorneys and their designated experts, at regular intervals and at locations within the State of New Jersey, at a reasonable cost to those who attend; and it is further

6. ORDERED that in all pending prosecutions based on or including Alcotest New Jersey Firmware version 3.11 and all future firmware versions, and consistent with past practices in prosecutions based on breathalyzer analysis,

Appendix B

A. The operator who conducted the tests shall be made available to testify and shall produce the documents evidencing his or her training, and

B. The following foundational documents shall be offered into evidence to demonstrate the proper working order of the device:

(1) the most recent Calibration Report prior to a defendant's test, including control tests, linearity tests, and the credentials of the coordinator who performed the calibration;

(2) the most recent New Standard Solution Report prior to a defendant's test; and

(3) the Certificate of Analysis of the 0.10 Simulator Solution used in a defendant's control tests.

WITNESS, the Honorable Virginia Long, Associate Justice, at Trenton, this 17th day of March, 2008.

/s/ Stephen W. Townsend
Clerk of the Supreme Court

JUSTICES LONG, LaVECCHIA, ALBIN, WALLACE, RIVERA-SOTO, and HOENS join in the Court's Order. CHIEF JUSTICE RABNER did not participate.

Appendix B

[FOLDOUT — WORKSHEET A]

[FOLDOUT — WORKSHEET B]

APPENDIX C — SUPPLEMENTAL FINDINGS AND CONCLUSIONS OF REMAND COURT DATED NOVEMBER 8, 2007

SUPREME COURT OF NEW JERSEY
September Term 2005
Docket No. 58,879

STATE OF NEW JERSEY,

Plaintiff-Appellant,

v.

JANE H. CHUN, DARIA L. DE CICCO, JAMES R. HAUSLER, ANGEL MIRALDA, JEFFREY R. WOOD, ANTHONY ANZANO, RAJ DESAI, PETER LIEBERWIRTH, JEFFREY LING, HUSSAIN NAWAZ, FREDERICK OGBUTOR, PETER PIASECKI, LARA SLATER, CHRISTOPHER SALKOWITZ, ELINA TIRADO, DAVID WALKER, DAVID WHITMAN and JAIRO J. YATACO,

Defendants-Respondents,

and

MEHMET DEMIRELLI and
JEFFREY LOCASTRO,

Defendants,

and

DRAEGER SAFETY DIAGNOSTICS, INC.,

Intervenor-Respondent.

Appendix C

SUPPLEMENTAL FINDINGS AND CONCLUSIONS OF REMAND COURT

On remand from the Supreme Court of New Jersey: December 14, 2005

Findings and Conclusions Submitted to Supreme Court: February 13, 2007

On limited remand from the Supreme Court of New Jersey: April 30, 2007

Supplemental Findings and Conclusions Submitted to Supreme Court: November 8, 2007

KING, P.J.A.D., SPECIAL MASTER

TABLE OF CONTENTS

SUPPLEMENTAL FINDINGS AND CONCLUSIONS OF REMAND COURT

I. PROCEDURAL HISTORY

We filed our initial findings and conclusions on February 13, 2007. The Supreme Court heard argument on April 5, 2007. Consequent upon argument, the Court issued an order on April 30, 2007 (Order) temporarily remanding the matter to the Special Master for the limited purpose of providing defendants the opportunity to conduct at their expense an analysis of the software used in the Alcotest 7110 MKIII-C, NJ 3.11 (Alcotest). The remand was limited to determining whether firmware version NJ 3.11 reliably analyzed, recorded and reported alcohol breath test results. The Court's order further provided the outline of the protocol for independent source code testing, now that Draeger Safety Diagnostics, Inc. (Draeger) was a party and finally had agreed to cooperate in a scientific inquiry concerning the reliability of its product.

When defendants and Draeger could not agree on an independent software house for source code testing, the Court issued a supplemental order on May 22, 2007 (Supplemental Order) requiring the affected parties to designate their own experts. Elaborate discussions ensued which resulted in examination of the Alcotest source code under non-disclosure agreements by two allegedly independent software houses: (1) SysTest Labs, Inc. (SysTest) designated by Draeger and (2) Base One Technologies (Base One) designated by defendants. The Special Master received the reports of the two experts in due course. They disagreed. The Special Master then scheduled and conducted a testimonial hearing on the experts' reports, pursuant to the Court's supplemental order.

We now advise the Supreme Court that the remand hearing conducted at the Camden County Courthouse for ten days between September 17, 2007 and October 11, 2007, with summations on October 23 and 24, 2007, did not change the Special Master's opinion expressed in the initial findings and conclusions contained in his February 13, 2007 report. We conclude that the Alcotest, the subject of scrutiny in this proceeding, is scientifically reliable as an evidentiary breath testing instrument, as to both the hardware and software elements, subject to the conditions set forth in the Special Master's initial report and this supplemental report.

Our review of the testimony of the witnesses now follows, along with our more elaborate conclusions.

II. SUPPLEMENTAL ON BURDEN OF PROOF

All agree the burden of proof in this proceeding is on the proponents of the evidence, the State and Draeger, by clear and convincing evidence. The parties also agree that there is no extant New Jersey case which quantifies this burden. All agree that it rests somewhere between the customary civil burden of reasonable probability (51%) and beyond a reasonable doubt (perhaps 98+% or 99+%). One well-recognized authority, Judge Jack Weinstein of the Eastern District of New York, has expressed this view in a criminal law context: "Quantified, the probabilities might be in the order of above 70% under a clear and convincing evidence burden." *United States v. Fatico*, 458 *F. Supp.* 388, 404 (E.D.N.Y. 1978), *aff'd*, 603 *F.*2d 1053 (2d Cir. 1979), *cert. denied*, 444 *U.S.* 1073, 100 *S. Ct.* 1018, 62 *L. Ed.* 2d 755 (1980). *See United States v. Copeland*, 369 *F. Supp.* 2d 275, 286 (E.D.N.Y 2005), *aff'd*, 232 *Fed. App'x.* 72 (2d Cir. 2007) (Judge Weinstein cites *Fatico* with approval of a 70% burden in "clear and convincing standard" cases).

The Oregon Supreme Court has referred favorably to research disclosing a purported national consensus on the "clear and convincing" burden of proof as a 75% likelihood. *Willbanks v. Goodwin*, 709 *P.*2d 213, 218 n.9 (Or. 1985). Personally, we might be inclined to put the burden as high as 85% to 90%. However, we conclude that the State and Draeger have met the clear and convincing burden in this proceeding.

III. EXPERT TESTIMONY

1. *Overview*

The parties called four expert witnesses: Bruce Geller on behalf of Intervener Draeger; Norman Dee on behalf of the State; and John Wisniewski and Thomas Workman on behalf of the defense. Geller and Wisniewski examined the Alcotest's source code for obvious issues and consistency with the algorithms pursuant to the Court's supplemental order dated May 22, 2007. Dee and Workman drew conclusions on the code's scientific reliability based on their analyses of the static code reviews performed by the other experts. Neither Dee nor Workman saw the actual code, although Dee scanned portions of it shortly before this remand hearing. All four witnesses submitted reports. This court found each of them qualified in their areas of expertise.

This court called Brian Shaffer, an employee of Draeger who wrote the customized portions of the source code for New Jersey, as a witness. Shaffer testified as both a fact and an expert witness but did not prepare a written report.

Because of the need to analyze many pages of testimony to fully understand each expert's opinion on any particular issue, we provide detailed summaries of their findings and conclusions with comments, where appropriate, on the weight this court placed on their testimony. The order of these summaries corresponds to the appearance of the witnesses on the stand, except for Shaffer who also appeared as a State rebuttal witness. To assist the Court in its understanding of this highly technical evidence, we present the following overview of the testimony.

Geller was a software quality engineer who worked for SysTest of Denver, Colorado, a nationally recognized company which specializes in software testing. Geller and another employee reviewed the Alcotest's source code under the supervision of a senior project director. Although their report was a collaborative effort, Geller fully agreed with its findings.

Geller testified that the source code was written by more than one programmer and evolved over numerous transitions. Although the code did not adhere to usual software design "best practices," he did not find any defects intentionally written to produce inaccurate test results. Geller's review identified three issues with the code: complexity; use of global variables; and the presence of a buffer overflow.

Relying on a software metric known as cyclomatic complexity, Geller measured the number of paths through the code and determined that it was highly complex. He explained that the code's complexity made it more difficult to understand and maintain, which placed an added burden on the programmers. A highly complex code also increased the inherent risks of defects. In Geller's opinion, however, the source code's complexity did not affect the Alcotest's accuracy or cause failures in the interface between software and hardware.

SysTest's review also discovered that the code used a number of global variables. Unlike locally declared variables, global variables were accessible from any function within an application and could be used throughout its duration. Because global variables could be intentionally or unintentionally modified by any function in the application, Geller believed their presence increased the risk of program error and their use should be limited. Nonetheless, he maintained that the use of global variables did not negatively impact on his opinion that the Alcotest's software was reliable.

Geller, however, did find one serious error in the source code which he identified as a buffer overflow. By attempting to store more bytes or units of information into an allocated variable than space available, the buffer overflow invalidated the reported breath test result on the alcohol influence report (AIR) under well-defined conditions. The error occurred only in very limited circumstances where the first two breath tests were out of tolerance, the subject provided a third breath sample which was within tolerance of each of the other two samples, and the lowest of the six recorded test results was the second breath sample's electrochemical (EC) test result. In these cases, the AIR would not report the lowest breath test result even though it retained and reported the measured alcohol concentration values for the six tests. According to Geller, the buffer overflow error could be easily corrected with one keystroke by replacing the number "four" with a "six" at a particular place in the code.

Wisniewski's review was far more critical of the Alcotest's source code. Base One Technologies (Base One) retained his firm, Winc Research, to determine if the code was scientifically reliable. Because Wisniewski believed that it was time-prohibitive to test complex software, he relied on industry standards or development methodologies to assess a source code's reliability. In his opinion, the use of these methodologies produced the most error-free and reliable software. Wisniewski found that the Alcotest's source code did not follow any system-wide development methodology. The lack of use of any standards prevented the testing of all the critical paths in the software.

Relying on a program called Lint, Wisniewski identified approximately 19,500 defects in the Alcotest's source code. To insure the code's reliability, he recommended the removal of every defect. While many of the defects reflected poor coding practices or simply bad housekeeping in his opinion, Wisniewski warned that they could cause unintended consequences in other parts of the program. He then identified nine major defects which he claimed could ultimately effect the breath alcohol reading. Wisniewski, however, was unable to say with any reasonable certainty that any of these defects produced a real problem that could influence the test result on an AIR.

Dee testified as a witness for the State at the initial hearing in October 2006, when this court found that he was qualified as an expert in data management business systems and fully credited his testimony. Dee described SysTest as a well-established company in the computer industry. He was impressed with SysTest's ability to reverse engineer the pseudo source code, and especially with Geller's ability to find the buffer overflow error. Dee did not believe that the source code's complexity affected the instrument's performance and said it simply reflected a tradeoff between performance and ease of maintenance. He concluded that SysTest performed an in-depth review and accepted its finding that there was no evidence of any attempt to maliciously alter the Alcotest's source code.

Dee was not impressed with Base One's analysis. He did not accept Wisniewski's criticism of the code's lack of standards or his use of Lint to quantify errors without considering their quality. Dee continued to maintain, as he did at the initial hearing, that black-box testing was the most appropriate method to determine the Alcotest's reliability. If black-box testing disclosed a problem, then he would examine the source code to see if its logic or a hardware-related error was the cause.

Workman was a licensed engineer before he attended law school. He currently operates a computer forensic business and works as a court-appointed criminal defense attorney in misdemeanor court in Massachusetts, representing clients charged with operating-under-the-influence and other misdemeanors. Like Wisniewski, Workman believed that the source code's complexity and design made it impossible to test and, therefore, it was not reliable. He agreed with Wisniewski that the source code's reliability would significantly increase if Draeger applied standards to its software development. Workman also criticized Draeger for the lack of any quality assurance organization to test the source code and support Shaffer's programming efforts.

Workman supported Wisniewski's selection of Lint to find source code modules with particular problems. After reviewing the Lint warnings, he concluded that their sheer numbers increased the likelihood of producing a totally wrong result such as an incorrect reporting of a breath test as too high or low, or a sample as insufficient. In his view, the most significant problem identified by Lint involved the Alcotest's use of an unscientific formula in its so-called averaging routine. He understood the routine or algorithm averaged the last breath measurement with the sum of the three previous measurements, minimizing the earlier values. He further supported Wisniewski's finding that the EC and IR sensors did not operate independently despite Draeger's assertions to the contrary.

Workman generally accepted Wisniewski's testimony and concluded that Base One delved more deeply into the source code than SysTest. In his opinion, the Alcotest's source code was not capable of measuring and accurately reporting the concentration of alcohol in human breath.

Finally, Shaffer testified at the court's request about the technical aspects of writing this source code. He explained that several persons wrote the Alcotest's code, which he also described as complex. Contrary to the defense witnesses, however, he did not believe that a more highly organized and consistently structured code would be more understandable. Shaffer further explained that the instrument's core routines were written in Draeger's offices in Luebeck, Germany, while he was responsible for its customization in the United States including the changes made to the Alcotest after *State v. Foley*, 370 *N.J. Super.* 341 (Law Div. 2003). Although the code did not delineate or "wall-off" the core routines, Shaffer was aware of their locations and avoided making any changes to them.

Shaffer performed his own static code review. While acknowledging that there was no dedicated quality assurance in-house designee with respect to software, he stated that Draeger subjected the code to black-box testing by its technical writer, service department, and ultimately the consumer. He disagreed with Base One's assertion that Draeger's lack of use of any standards prevented the testing of critical paths in the software.

Shaffer agreed with several findings by Base One and SysTest. For example, he agreed with Base One's finding that the source code failed to detect catastrophic errors or illegal opcode traps and recommended resetting the microprocessor whenever such a situation arose to restart the test anew. In fact, Shaffer testified that Draeger already had begun implementing this reset feature with its customers in the United States. He also agreed that the source code relied on global variables, but believed their benefits outweighed any potential risks. He further agreed that the code relied on a weighted average routine, but said it was absolutely necessary to assign the greatest weight to the most recent value in order to get an accurate breath test measurement.

Shaffer readily admitted that in error he created the buffer overflow, that it existed only in New Jersey, and that it should be corrected. For pending cases, he prepared a series of instructions to compensate for the overflow and ascertain the true breath test result. He also readily admitted that the fuel cell slowly depleted over time, but he adamantly disagreed that the code's aging compensation routine affected the analysis of a subject's breath. The formula for the depletion of the fuel cell used in the control tests was in part derived from the constant infrared (IR) value but did not corrupt the breath test results in any way. For this reason, Shaffer insisted that the Alcotest used two independent technologies to analyze breath samples.

The Court will find a review of the summations of counsel very helpful. All summations were carefully prepared and well delivered, and will help greatly in understanding the testimony.

2. *Summary of Testimony of Draeger's Expert, Bruce Geller*: September 17, 18 and 19, 2007

Draeger presented the testimony of Bruce Geller, a senior software quality engineer with SysTest Labs in Denver, Colorado (1RT18).[1] Geller graduated in 1978 with a degree in biology from the University of Colorado (1RT28-1RT29). After working as an accountant, he went back to school and, in 1992, earned a Bachelor of Science degree in computer science from Metropolitan State College in Denver (1RT29;1RT40). For the past four years, Geller has worked at SysTest (2RT135).

SysTest performs commercial software testing along with independent verification and validation services for private and public entities (1RT20). It also is one of three laboratories in the country which reviews and tests voting system software to verify that it conforms to the Election Assistance Commission's software standards (1RT19;1RT27;2RT162). SysTest has approximately 100 employees, including ten source code reviewers, and maintains strategic partnerships with hardware-specific testing laboratories (1RT20-1RT21;2RT138-2RT139).

---

1. For designation of transcripts, *see* Appendix A.

Geller and another employee, Dan McNamee, reviewed the Alcotest's source code, version NJ 3.11, under the direction of Geoffrey Pollich, a senior products manager (1RT30-1RT31;1RT67). SysTest also hired a professional translator to assist in the translation of the German-language component of the code (1RT31). Although the report was a collaborative effort, Geller approved the final version before it was released (3RT4-3RT5).

During his career in the software industry, Geller has reviewed more than two million lines of source code (1RT27). Prior to this hearing, however, he had never testified in court about a source code review or any other topic nor did he have any experience with breath testing instruments (1RT35;1RT45). We qualified Geller as an expert, noting that as the trier of fact, we would decide the weight of his testimony (1RT45-1RT46).

Draeger retained SysTest to inspect the Alcotest's source code for the consistency of the application of its algorithms — whether the same inputs produced the same results — and any other observable issues (1RT54;2RT149;3RT6). Draeger did not charge SysTest with testing the hardware nor did it give SysTest an instrument on which to "run" the code (1RT107;2RT53; 2RT150-2RT151).

Geller described source code as the human readable version of a program (1RT47). This consists of statements created by a programmer with a text editor or a visual programming tool which are then saved in a file (SysTest report at 6).[2] As in English, source code is written from top to bottom and reads from left to right (1RT47). There is no requirement regarding a source code's organization; instead, this is an issue of style (2RT6). A compiler translates the source code into machine-readable code (2RT57;2RT194).[3]

Source code is segregated into separate functions within certain files (2RT194). A function is a named block of code that contains the instructions to retrieve a specified text screen in a single file (2RT56-2RT57). A call is made to that function providing the index number of the string within the file and the string is retrieved (2RT57). The Alcotest source code contained 504 or 505 functions (2RT103). Some of the functions were left inactive because certain operational aspects were unused under New Jersey's requirements (2RT92-2RT93).

Using an analogy to a player piano, Geller explained that the piano (or Alcotest) will not work unless a person (or compiler) transcribes the sheet music (or source code) onto a roll with holes (or a binary file composed of bits or non-human readable series of zeros and ones) (1RT47-1RT51). However, unlike a piano roll with multiple holes making concurrent sounds, the Alcotest's microprocessor is single-threaded (1RT49-RT50;2RT79;

---

2. *See Assessment Report for Draeger Safety Diagnostics, Inc. Alcotest 7110 MKIII-C. New Jersey Firmware Version NJ 3.11* by SysTest Labs, Inc., August 28, 2007 (I-20).

3. For a detailed explanation of how to write source code, *see* 3RT9-3RT17.

2RT170-2RT171). Because everything must pass through the central processing unit (CPU), which can only process one course of logical instructions at a time, the current state of the running application is placed on hold in a stack frame for later retrieval (1RT110-1RT111).

SysTest performed a static code review of New Jersey firmware version 3.11 (2RT9;2RT39). Unlike a dynamic analysis, static code analysis examines computer software without actually executing programs built from that software (2RT11). The purpose of the review was not to translate all 45,000 lines of code, but to examine things of interest (1RT152;2RT17). A component of the static review included reverse engineering of the code by SysTest (2RT12).

To begin the source code review, Geller used Module Finder, an in-house software program developed by SysTest about a year-and-a-half earlier (1RT55-1RT56;2RT155). SysTest created the program to determine the number and length of the individual functions, the extent of the comments embedded in the functions, and the number of source code lines (1RT55). Geller described Module Finder as a work-in-progress and noted that it did not adhere to any development standards, which made its software more difficult to maintain (2RT155).

Next, Geller processed the code through a software program called Understand for C++ (1RT60). That program produced illustrations of the invocation tree, which showed the order and sequence in which functions might be executed (1RT62;3RT46). Geller analogized the invocation tree to a street map, where rectangles were given function names and lines showed the logical paths from one function to the next (2RT184).The invocation tree served as a guide for reviewing the code (1RT69-1RT70). SysTest also created control flow diagrams, which illustrated the logical paths through each function's execution (2RT184-2RT185).

Geller also ran the code through two additional software programs: (1) C-Doc, which is a C-language-specific source code review tool; and (2) Fortify SCA (1RT68). C-Doc prints out measurements, function lengths and names, the extent of the comments and lines of code, and some information on complexity (1RT68). Because it reports a lot of the same information, he used C-Doc mostly to verify the metric results from Understand for C++ (1RT68). Unlike those programs, Fortify SCA is a security-oriented application which looks for vulnerabilities in the code (1RT68-1RT69).

There are a multitude of available software programs, and Geller admitted that he was not familiar with many of them (2RT32). He never heard of the Lint program until he read Base One's report (1RT70-1RT71;1RT73;2RT35). From his on-line research, Geller found a January 1979 paper written by S.C. Johnson which explained that "Bell Labs" created Lint at a time when programming was done on large mainframe computers in shared environments (1RT71;2RT41). By enforcing strict syntax rules, Lint warned programmers of possible mistakes in their code (1RT73). Because some of the "mistakes" were not necessarily errors in the software, Lint was known for verbosity (1RT73-1RT75;1RT82-1RT83;1RT85). Geller believed that (1) Lint was created as a development tool, not a review tool; (2) it was outdated after the development of personal computers; and (3) it produced output not particularly informative to programmers (2RT38;3RT63;3RT69). Thus, he believed that the Lint document, contained in Appendix C of SysTest's report, was irrelevant (3RT71).

Geller's review of the source code revealed that it was written by more than one programmer and evolved over numerous transitions (1RT187-1RT188). It contained comments written in German and English, which he explained served to jog the memory of the programmer who wrote them and to advise future programmers (1RT188;3RT13-3RT14;3RT24;3RT133). Geller used the comments to find his way through the code (1RT190).

The review by SysTest led to the identification of three issues with the Alcotest's software: (1) its complexity; (2) its use of global variables; and (3) a buffer overflow (1RT102;1RT108;1RT114). Regarding complexity, Geller explained that some functions had a fairly large number of comparison operations which resulted in "branching" of the code (1RT102). To measure the number of independent paths through the application's code, he used a software measurement developed by Thomas McCabe called "cyclomatic complexity" (2RT98-2RT99).

Because high complexity increases the risk of inherent defects, coding guidelines recommend keeping the cyclomatic complexity of functions under ten, and or even seven (2RT100-2RT101;SysTest report at 23). SysTest identified more than eighty-one modules whose cyclomatic complexity of functions was in excess of ten and three in excess of a hundred (3RT7;SysTest report at 23-35). While restructuring the code could reduce its complexity, Geller said that the presence of modules with high complexity indices did not effect the instrument's accuracy (2RT102;3RT7-3RT8). He also said that excessive complexity did not cause failures in interfaces between software and hardware (3RT22). Because complexity related to the ease of understanding and maintenance, its presence did place an increased burden on the programmers who work with the software (3RT21).

Geller also addressed the source code's use of global variables to store all test and result data (3RT117). Unlike locally declared variables designed for specific purposes within small subsets of the code, global variables are accessible from any function within an application (1RT108-1RT109;SysTest report at 10). Also unlike local variables which pass from existence after a single use, global variables can be used throughout the duration of the program (3RT110). Thus, global variables make information available without need for the resources required to pass a value from one function to another (2RT85;3RT116).

However, data contained in global variables are not protected and can be changed intentionally or unintentionally at any time by any function in the application (2RT83). Because they can be potentially modified from anywhere, global variables should not be used to store critical data (2RT83). Given the increased risk of program error, their use should be extremely limited (2RT83;2RT85-2RT88). Nonetheless, Geller said there was nothing inherently wrong with global variables and their presence did not impact negatively on his conclusion that the Alcotest's software was reliable (1RT114). In fact, he said that some computer languages — such as COBOL and assembly — only use global variables (1RT114;2RT90;3RT107-3RT108). Moreover, the preponderance of the code's variables were locally declared (2RT90).

Geller testified that Fortify SCA found a "real error" in the source code which he referred to as a "buffer overflow" (1RT114;1RT116;1RT163). Buffer overflow occurs when a program attempts to store more bytes or units of information into an allocated variable not large enough to hold them (1RT114). Geller used the analogy of trying to park a full-sized Cadillac in a compact-car parking space (1RT114;2RT119). After the computer program warned of a potential overflow, Geller opened the code to the particular file and function, and saw a situation in the source code where six bytes were being parked into a space allocated to hold four (1RT115;1RT118). The two overhanging values were used by the next two declared variables and thus were overridden (1RT116;1RT126-1RT127).

Geller explained that the buffer overflow affected only one aspect of the AIR, and not the way in which measurements were read (1RT118). Specifically, it arose only in very limited circumstances where: (1) the results of the first two breath tests were out of tolerance; (2) a third breath test was taken; (3) the result of the third breath test fell between the values of the first two and was centered enough to be within tolerance of both; and (4) the ER result from the second breath test was the lowest measured value (1RT119-1RT120).[4] In these cases, the AIR would not report the actual lowest breath test result because the sorting routine would read a ".32" in place of the ER result from the second breath test (1RT121-1RT126;2RT124). The overflow problem, however, could easily be corrected with one keystroke by replacing the number "four" with a "six" at the proper place in the code (1RT129-1RT130;2RT124-2RT125). Base One's report did not identify the buffer overflow problem (1RT117).

Geller acknowledged that the code was not written in a manner consistent with usual software design "best practices" (3RT135-3RT137). While such practices are set out in various publications, programmers often have to adapt them to fit the available resources (3RT141). In cases where a code deviated from best practices, it still was safe to use but this placed an added burden on programmers to understand it (3RT140-3RT141). Geller

4. As represented by State's counsel at the remand hearing, the record from the initial hearing established there were no instances where tolerances required a third test in the Middlesex County data (1RT145-1RT146).

did not find anything in the code that was intentionally written to skew the results (1RT133-1RT134).

Finally, Geller addressed the key findings in Base One's report (1RT135-1RT163). Among other things, he did not know if there were any "industry standards" that governed source code review (1RT136;1RT140;2RT24; 2RT51). In Geller's opinion, quality software could be developed without governing standards and conversely, software could meet standards but still be of questionable quality (1RT137;1RT140-1RT141). He was not personally familiar with any of the standards cited in Base One's report nor did he know if any of those standards applied to the Alcotest (2RT50-2RT51).

Overall, he found there was nothing particularly unusual about the Alcotest software in terms of its style and organization (1RT137;3RT76-3RT77). He was unconcerned that the software did not contain confidentiality or copyright notices, or that some sections of the code were not "walled off" (1RT138). Geller explained that programmers had to exercise caution, but that he never had any classification restrict his access to all or part of a code (1RT138-1RT139).

He also did not agree with Base One's finding that there was proof of incomplete software testing (1RT143-1RT144). Instead, Geller noted that some branches of the source code would never be executed — such as requirements of other jurisdictions — and did not require any testing (1RT144-1RT145). Moreover, he disagreed with Base One's finding that the instrument produced unreliable results because its catastrophic error detection was disabled (1RT147-1RT148). Geller expected that the instrument would go into an endless wait cycle, meaning it would basically cease to function, and not produce a final result in the event of a catastrophic error (1RT148-1RT149). He also objected to Base One's other findings, noting that some of its criticisms were invalid, undocumented, unimportant, not peculiar to the Alcotest, or normal in software (1RT150-1RT163).

Geller fully agreed with all of the findings and conclusions in SysTest's report (3RT5-3RT6;3RT116). Based on his review and the review by SysTest, Geller concluded that the Alcotest software was reliable and consistent when used in accordance with the instructions in the State Police user manual (1RT164;2RT188;3RT6-3RT7). Geller saw no indication of any inconsistencies with the algorithms as documented in the software, and considered buffer overflow as the only real error (1RT163;3RT5).

We found Geller an honest and technically impressive witness, without bias. We fully credit his testimony.

3. *Summary of Testimony of State's Expert, Norman Dee:* September 19 and 20, 2007

Norman Dee testified as a State witness at the initial Alcotest remand hearing in October 2006. At that time, we qualified him as an expert in data management business systems (30T60-30T61).[5] We incorporate by reference his testimony on that occasion.

At the State's request, Dee analyzed the expert reports by SysTest and Base One and prepared a report addressing their static code reviews (4RT5;4RT9). He also examined the experts' work materials and unpublished appendices and scanned the code, but only after he wrote his report, when the code finally first became available to him, two weeks before this remand hearing (3RT157;4RT17-4RT18).

Dee had performed static code reviews of embedded systems in the late 1970s and early 1980s (4RT13; 4RT137). Although he never wrote embedded code, he reviewed and performed problem determinations of embedded code for large IBM mainframes and mid-range computers (4RT137; 4RT239). He defined his "world" today as one of larger, multi-user systems (4RT187).

Dee described SysTest as a well-known, established company in the computer industry with a reputation for thorough and independent testing of source code (3RT157). Dee was particularly impressed by SysTest's reverse engineering of the pseudo source code, a descriptive English narrative of the algorithms without language-specific syntax (3RT159;4RT15;4RT19; 4RT169). In other words, SysTest reviewers read the source code, which is not very human-friendly, and

---

5. *See* transcript of October 18, 2006 (morning).

turned it into fairly human-friendly statements by looking at the modules ("the logic itself, the post-compiled code") and typing out the flow (4RT170-4RT171;4RT176). By reverse engineering the pseudo code, which usually was written before the actual code, SysTest was able to identify the main core program and recreate the design of the product (3RT159-3RT160; 4RT20;4RT175). Dee also was very impressed with SysTest's ability to find the buffer overflow error; this discovery clearly demonstrated the level of SysTest's competence and the independent nature its review (3RT160;3RT175).

Regarding SysTest's key findings, Dee did not believe that cyclomatic complexity affected the instrument's performance (3RT173). To the contrary, he believed that the presence of large numbers of "decision trees" in one module was better than breaking them into additional modules in terms of system performance (3RT173). He defined decision trees as boxes containing expressions of code from which branched other boxes, with a "calling program" or "main module" deciding which box to proceed to depending on what the code ordered (4RT181-4RT182). Thus, Dee considered cyclomatic complexity as a stylistic issue which implicated a tradeoff between performance and ease of maintenance (4RT189-4RT190;Dee report at 27).[6]

---

6. *See Comments on the Source Code Reviews by SysTest Labs, Inc. and Base One Technologies, Inc.*, by Norman Dee, The CMX Group, September 4, 2007 (SR-4).

While Dee recognized the potential significance of buffer overflow, he believed this was a limited vulnerability (3RT175). He described the problem here as a situation where six values must be put into four boxes (4RT193;4RT212). Because of the closed nature of the application in this embedded system, Dee explained that the situation in which this "three tests" error occurred was quite uncommon (3RT175;Dee report at 27).[7] For that reason, he surmised that the problem never arose in field testing and that it took a program tool specialized in exposing vulnerabilities to raise it as an issue (4RT134-4RT135). That program tool, Fortify SCA, checked the source code for approximately 150 different kinds of exposure and code issues (4RT236). Dee said, as did Geller, this flaw could easily be fixed (3RT175). He recommended correction in a future release (Dee report at 27).

Dee acknowledged that SysTest's report identified numerous unused or uncalled modules, which consumed memory and space in the source code (3RT187;4RT74-4RT75). While their presence could be due to the carelessness of programmers, he believed they were more typical of software development projects where code was developed and used for multiple customers, was decommissioned, or was developed for future releases (3RT187;4RT74-4RT75;Dee report at 29). Dee explained that it was more convenient to leave these unused functions in the code, than to remove them

7. Dee defined an embedded system as "the combination of hardware and software to perform a specific function" (4RT6).

(3RT187-3RT188;4RT74). In any event, Dee thought their presence was a matter of style and did not effect the reliability or results of the executed program (3RT188).

Dee accepted SysTest's conclusion that its static code review (or "desk checking") did not find anything in the source code that would cause irrational or unreliable results (3RT176). Because static review works with the real code and hypothetical values, it is considered "white-box" testing (3RT167). Dee, however, reiterated his prior testimony that "black-box" testing was the most appropriate method to determine the Alcotest's reliability and accuracy (3RT197-3RT198; 4RT151). If black-box testing disclosed a problem, Dee would want to look into the source code to see if a logic-related or hardware-related error was the cause (4RT43). He assumed that black-box testing did not identify the buffer overflow issue because the underlying circumstances never actually arose in the field (4RT134-4RT135;4RT151-4RT152).

Dee, however, seriously questions many of the findings in Base One's report. For example, he did not think it was impossible to fully test the source code given the singular function of this application (3RT177). He also said it was standard operating procedure in mature systems to disable the capabilities of the processor which detect catastrophic errors (3RT178-3RT179). Dee explained that these aborts were disabled and replaced with software which "captured" the errors so that a determination could be made as to whether the error was recoverable or not, or whether a more meaningful message should be written (3RT179;4RT56).

Dee also disagreed with Base One's statement that the source code ignored or suppressed error messages unless they occurred a large number of consecutive times (3RT179-3RT181). In his opinion, this was normal in embedded systems in order to wait for the coordination of the application with the operating system or hardware (3RT181;Dee report at 7-8). Thus, the purported error did not mean something was wrong but rather something simply was not ready (3RT181). For example, there might be slight timing differences between internal components which needed adjustment (3RT180-3RT181;Dee report at 8).

Dee also addressed SysTest's and Base One's criticism of the source code's extensive use of global variables (3RT182-3RT184). He agreed that a programmer must be careful to avoid overwriting a global variable (3RT183;4RT204). If an error occurred, a global variable would remain until the system was reset, re-initialized or re-powered whereas a local variable remained only for the specific calculation and then vanished (4RT233-4RT234). On the other hand, the use of global variables conserved memory (as the only place in memory where that variable was found) and increased efficiency by reducing performance time (eliminating the need for multiple copies) (3RT183; 4RT70). Also, it is more expensive to change over to all local variables (4RT70). In this event, the presence of global variables did not concern Dee because the source code made extensive use of local variables and only retained those common to all modules at the global level (3RT183-3RT184).

Moreover, Dee disagreed with Base One's criticism that the routines were written in C language rather than assembly language (3RT186-3RT187). He believed the use of C language would not cause problematic delays or effect the results in any way (3RT187). Also, despite Base One's assertion to the contrary, he found a copyright notice in the first module which he opened (4RT153).

Dee also did not agree with Base One's criticism of the Alcotest's lack of standards (3RT192-3RT193). In his opinion, such standards usually referred to the design and documentation of the code; they rarely addressed the tasks the code actually performed (3RT193;4RT217-4RT218). Moreover, he objected to Base One's reference to standards without citing specific instances in the code where standards were violated (4RT93-4RT94;4RT96).

Finally, Dee was "outraged" when he reviewed Appendix C in Base One's report which purported to find "errors" in 19,000 of the 45,000 lines of code (3RT188-3RT189). Wisniewski found these errors using a pre-compiling syntax checking program called Lint (3RT190). In Dee's view, Lint was a product of the 1970s and was not a commonly-used program today (4RT24;4RT206). He believed that interactive development environments (IDEs) replaced the need for Lint by keeping a programmer within the parameters of the proper syntax during the coding process (3RT190;4RT205-4RT206).

Dee objected to Base One's attempt to quantify the errors (3RT189). For example, Lint generated approximately 7657 lines of warnings based on its misunderstanding that the "U_Byte" variable was undeclared or used incorrectly (3RT189). Dee later explained these lines might have values which truncated the lower digits and retained the higher values (4RT167-4RT168). Also, Lint ignored the quality of the errors, and improperly flagged "comments within comments" (3RT189-3RT190). Based on these alleged errors, Dee believed that Lint did not understand some of the specific code needed for embedded systems (4RT24). He would not have used Lint to review the Alcotest's source code (4RT48).

Dee understood that the source code was written between 1993 and 1997 (4RT78). Although he only scanned the code, he saw about three or four different writing styles (4RT97-4RT98). He did not know if Draeger gave its programmers requirements documents with instructions on how to code (4RT99;4RT180).

Based on his review of the reports, the testimony, and his own experience, Dee was of the opinion that SysTest performed an in-depth review of the source code and produced a professional report (3RT194-3RT195). He found that SysTest was able to reverse engineer, conduct a "fairly good accounting" of the system, and expose the "overflow" error not previously found through actual field usage of the instrument (3RT195). He also supported SysTest's finding that there was no evidence of any attempt to maliciously alter the code (4RT177). Dee, in the overall, was completely unimpressed with Base One's analysis (3RT195).

We find Dee an impressive witness, as we did at the initial hearing. We give considerable weight to his opinion and find that he was fair and even-handed in all respects.

4. *Summary of Testimony of Defendants' Expert*, *John Wisniewski*: September 25, 26, October 9 and 10, 2007

John Wisniewski has a Bachelor of Arts degree in computer science from the State University of New York at Potsdam (6RT197-6RT198). For the past thirty-one years, he has worked as a computer professional primarily in the areas of programming and software development (6RT177;6RT183;6RT202-6RT203; Wisniewski report at 47).[8] In June 1991, he became a free-lance, independent contractor and established Winc Research which he currently operates from his home in Lakeview Terrace, California (6RT188;6RT222;7RT21; 7RT37).

---

8. *See Report: Alcotest 7110 MK IIIC*, by John J. Wisniewski, Base One Technologies, undated (DR-30).

Base One Technologies (Base One) retained Winc Research to review the Alcotest's source code for obvious defects and inconsistencies (7RT20;7RT34; 7RT44). Base One is a "virtual" consulting company with its main office in New Rochelle, New York (6RT187;6RT190-6RT191;7RT37). Most of its personnel work from their homes in different cities throughout the country (6RT188). After writing his report with the assistance of a translator in Germany, Wisniewski sent his draft to Base One's technical writer in Colorado for formatting and editing (7RT37;7RT39-7RT40;8RT215).

The defense offered Wisniewski as an expert in software and hardware development, specifically C language, programming, source code reviews, software troubleshooting, computer interfacing, and embedded systems (7RT19). Based on Wisniewski's education and experience, the court found he was qualified to testify (7RT35).

Wisniewksi maintained that it was time-prohibitive to thoroughly test a complex computer program (7RT190). For that reason, he relied on industry standards to test the reliability of software (7RT190-7RT191). Various standards initially governed how programmers wrote each individual line or segment of code, but Wisniewski described "current standards" as more akin to software development methodologies which applied to the whole system (7RT100-7RT101;8RT216-8RT217). In his opinion, these methodologies produced the most error-free and reliable software (7RT101). They also made software easier to maintain, produced more robust overall systems, and allowed for testing of all the critical paths (6RT196;7RT98;Wisniewski report at 3-4).

Wisniewski recognized that private industry was slow to adopt the new methods of producing software because they took time to develop (7RT102-7RT103). He claimed, however, that "standards" saved money in the long run (7RT102). For that reason, he said the United States military, some federal agencies, and the European community had developed their own methodologies (7RT103).

Wisniewski identified five widely used software development methodologies: (1) IEC 6158 Functional Safety International Standard, regarding safety of electrical devices and software; (2) ISO 9001 international standard for requirements, regarding the software life cycle; (3) IEC 62304, regarding Federal Drug Administration (FDA) standards for software in medical devices; (4) DOD-178B, regarding Federal Aviation Administration (FAA) devices used on commercial and private aircraft; and (5) DOD-STD-2167 and MIL-STD-498 regarding software used by the military and some government law enforcement agencies (7RT99;7RT191-7RT196;Wisniewski report at 34). Wisniewski recommended that the State of New Jersey refuse to accept any device unless the manufacturer followed one of these five methodologies or developed one of its own (8RT131-8RT132;8RT217; 9RT86;9RT125).

According to Wisniewski, the Alcotest's source code did not adhere to any software development methodology (7RT104-7RT105). On cross-examination, he conceded that the code followed a known, function-oriented methodology, but claimed that methodology applied only to software, not the "whole system" (8RT218;8RT224-8RT225). He was unaware of the national breath testing standards promulgated by NHTSA, but understood they did not apply to software (8RT218-8RT219).

Wisniewski described early software development as "bottom-up programming" which focused on details rather than the overall picture (7RT181). Eventually, the industry adopted "structured programming" or the "top-down" approach which started at the highest level and then added more complicated and lower-level functions (7RT180-7RT181). In Wisniewski's view, the Alcotest used a "little bit" of structured programming with a lot of low-level detail (7RT181;Wisniewski report at 33). However, because Draeger did not employ any software development methodology, it was Wisniewski's opinion that the Alcotest's source code was not reliable (7RT193;7RT201).

Wisniewski described source code as human-readable statements which were written in programming language such as assembly or C (7RT63-7RT64;7RT80; DR-15). In C language, a single line of English-looking code could have multiple instructions (7RT79). In assembly language, however, each instruction was assigned a word called an operation code or opcode which generated one instruction for every line (7RT79). According to Wisniewski, the Alcotest's source code was written in C and assembly languages (7RT159;9RT79-9RT80).

The purpose of source code was to correctly implement the algorithms or mathematical formulas (7RT67). A compiler translated the source code into object code, which consisted of a binary set of machine-readable instructions consisting of ones and zeros (7RT64;DR-15). The microprocessor executed the instructions (7RT79).

When Wisniewski examined the Alcotest's source code, he was unable to distinguish between its core and customized sections (8RT17-8RT18). He believed that programmers should be able to touch the core software in order to learn more about it (8RT17-8RT19;9RT44;9RT46). If Draeger wanted to protect the core, however, he recommended taking the core routines out of the regular code and converting them into libraries of object modules (8RT176-8RT177). The programmers would then get a reference with the library routines, and they would be protected from change (8RT177).

Wisniewski determined that at least three programmers worked on the source code based on stylistic variations (7RT178-7RT179;8RT103-8RT105). Although the code was created between 1993 and 1997, Wisniewski said it was written in a style reminiscent of the 1970s and 1980s (7RT56;7RT179). He did not view that style observation as a criticism, and acknowledged that Draeger had done a "great job" of adhering to an older style methodology (7RT56-7RT57;7RT193). He further acknowledged that it was not necessary to always adopt the newest technology, and that many people preferred to stay with the familiar (7RT180).

Wisniewski used a variety of tools to review and analyze the Alcotest's source code (7RT158-7RT161). For example, he used the "Understand C Code Analyzer" to find fifty-one uncalled functions, which were either empty pending future release, temporarily disabled, or full but forgotten (7RT161-7RT162;8RT30;8RT167). In Wisniewski's view, these uncalled functions were confusing and untidy (7RT163). Given the possibility that they could confuse future programmers or be executed accidentally, Wisniewski said they should be purged from the executable code (7RT163-7RT165;7RT167). He also observed that there were 475 active functions in ninety-five source files with 26.5% in seven files (8RT175; 8RT178). He preferred one function per file (8RT175).

Wisniewski selected Lint to analyze the source code's C language syntax, data initialization, and data management (7RT158;8RT19). Specifically, he used a cost-free program tool derived from Lint called Splint, version 3.1.2, which raised warnings or flags (8RT235; 9RT6-9RT7;9RT41). Wisniewski called these warnings "defects" because they required action whether they were serious or simply flaws (8RT26;8RT235). Splint allowed Wisniewski to customize the warning messages by selecting which ones to show (9RT7). He selected the option which displayed all of them (8RT8-8RT9).

Wisniewski used Lint to check the source code because it looked across the boundaries of several modules whereas IDEs looked for errors one module at a time (7RT154-7RT155;9RT126).

Wisniewski recognized that Lint was quite verbose because it tended to produce a number of defects including repetitive examples of the same coding style (8RT19-8RT21;9RT39). Despite its "voluminous" output, he maintained that disciplined coders would want to know about the defects and remove them to avoid confusion or any chance the code might not work correctly (8RT19-8RT21). Although the presence of these defects did not prove the software program would fail to execute, they indicated a disregard for use of industry coding standards (Wisniewski report at 37).

Lint found approximately 19,500 defects in the Alcotest's source code, which Wisniewski described as consisting of 35,000 lines after eliminating "comments and other things like that" and 3200 decision paths (8RT29;8RT180;8RT211). To insure the source code's reliability, Wisniewski said every defect should be removed (8RT23-8RT24). He would undertake an aggressive, ongoing campaign to find and dispose of them as part of what he called the software life cycle (8RT27;8RT127-8RT128;9RT123-9RT124). Wisniewski estimated that it would take about one year to fix all the "defects" in the Alcotest's source code (8RT126).

Wisniewski estimated there were defects in three out of every five lines of the code, ranging from substantive problems to variations in programmer style and organization (8RT180). Some of the defects appeared numerous times, like print interrupts which were flagged about 2000 times (8RT64). The Lint program did not categorize the warnings or flags, nor did it quantify any of them (9RT16;9RT19). Wisniewski did not attempt to fix any of the defects identified in the source code nor did he check to see if they applied to functions actually used in New Jersey (9RT29-9RT30;9RT70).

Some defects simply reflected poor coding practices, in his opinion, such as using a variable as a character in one place and a number in another (8RT31-8RT32). Another example involved mismatched function argument types where the code expected to see a variable with a plus or minus value, but received only a positive variable (8RT43-8RT44).[9] While not as serious as other defects, Wisniewski said their presence could cause unintended consequences in other parts of the program (8RT32-8RT33;8RT44-8RT45).

Other defects flagged by Lint included the use of a local variable as a global and vice versa, and the assignment of the same name to local and global variables (8RT48-8RT49). Wisniewski described these cases as confusing and inconsistent, and expressed concern that they might influence some other operation in the program such as calibration (8RT49-8RT50). He

9. Wisniewski defined an argument as "something passed to a function to allow it to take different paths or make different decisions" (8RT64).

acknowledged, however, that identically named local and global variables would not confuse the compiler because the local would take precedence over the global declaration (9RT37-9RT38).

Wisniewski also found such defects as: mismatched types (where the computer assigned integers to floating-point variables); memory leaks (where unused memory was taken from the system and not returned); variables assigned different types depending on conditions (where the types of values assigned were inconsistent); and arrays initialized with too many variables (where there were too many variables to fit into the declared space) (8RT50-8RT59).[10] Wisniewski believed these defects could ultimately effect some calculation which, in turn, could effect the breath alcohol reading (8RT58-8RT59). However, he was unable to determine, by desk checking alone, if these defects had corrupted any critical values (8RT74). He would need an Alcotest instrument and an emulator to "run" the code to see how it performs (8RT74-8RT75). In any event, he said many of the defects were simply bad housekeeping and extraneous, and should be removed (8RT73-8RT74).

Wisniewski also testified about inconsistencies between the code and corresponding comments (8RT118). For example, he found a comment in the code stating that a conversion to "%BAC" needed to be performed, but this was not done (8RT116-8RT117;

---

10. For a discussion of errors detected by Lint, *see* 8RT43-8RT98;Wisniewski report at 37-43.

Wisniewski report at 17). He also found comments which said values should be averaged when, in fact, he claimed the source code performed weighted averages or successive averaging routines (8RT118). Wisniewski said such comments could affect the breath test result if they were unintentionally executed; otherwise, they reflected a sloppy coding style (9RT18). He agreed, however, that comments were not compiled, never reached the object code, and did not effect the performance of the Alcotest (9RT18). Therefore, they would not affect the Alcotest's performance if placed correctly within the source code (9RT18).

Of the many defects identified by Lint, Wisniewski selected nine with the greatest impact on the Alcotest's test results: (1) the software would not pass industry standards for development and testing; (2) the lack of use of industry coding standards prevented the testing of all critical paths in the software; (3) the catastrophic error detection was disabled, making it difficult to detect if the software was executing indefinite branching or invalid code; (4) the implemented design lacked positive feedback; (5) the diagnostic routines were performed during data measurement cycles, allowing the substitution of arbitrary data values when a routine failed; (6) the air flow readings were adjusted at the beginning of the measurement, causing defective measurements when the baseline value was corrupted; (7) the error detection logic failed to flag an error unless it occurred thirty-two times; (8) the heavy use of global variables failed to insulate software modules; and (9) the software instructions were out-of-phase with the continuously operating timer interrupt routine, which went off every 8.192 milliseconds (8RT110-8RT116; 8RT120-8RT125;8RT134-8RT141;8RT152-8RT166;Wisniewski report at 3-6).

At this remand hearing, however, Wisniewski was unable to find an illustration of diagnostics adjust/substitute data readings (8RT137;9RT66-9RT67). He also admitted on cross-examination that the use of global variables was a tradeoff, stating that fewer globals would result in more functions with arguments passed but more variables protected (9RT76-9RT78). He further admitted that time constraints prevented him from determining if a global variable was misused and could actually change the result on an AIR (9RT78). Indeed, he was unable to identify anything in the code that posed a real problem that would effect a result on the AIR (9RT86-9RT87).

Wisniewski also raised an issue regarding the independence of the IR and EC measurements (8RT182-8RT198). He found a section in the code where the IR reading mathematically modified the EC reading (8RT183-8RT184;8RT191). That section could be called or activated from seven different paths in the code (8RT190). Thus, under certain conditions, the code would take the results of the calculations under the EC curve and divide them by the IR average (8RT187;8RT191). In Wisniewski's opinion, the Alcotest's source code should not be accepted as scientifically reliable in his field (8RT199).

We were not particularly impressed with Wisniewski's testimony. He was very negative and deconstructive. He said many things were wrong but did not convince us that these negatives made the Alcotest unreliable. We doubt that he was as experienced as he portrayed.

5. *Summary of Testimony of Defendants' Expert, Thomas E. Workman, Jr.*: October 10 and 11, 2007

Thomas E. Workman, Jr. has Bachelor and Master of Science degrees in electrical engineering from the University of Texas at Austin (1970 and 1974), and a JD degree with a high technology law concentration from Suffolk University Law School in Boston, Massachusetts (1997) (9RT151;9RT176). He is a licensed patent attorney and admitted to practice before the U.S. Patent Office (9RT151).

Workman was an engineer for over twenty years with various technology-based companies including Thinking Machines Corporation, Digital Equipment, Hewlett-Packard, Xerox Corporation, Austron Corporation, and Texas Instruments (9RT152-9RT155). He also worked as an independent consultant on projects which developed embedded systems primarily for law enforcement and communication customs software for remote job emulators (9RT155). Workman has experience in software engineering, quality assurance, systems verification, and standards (9RT163-9RT164;9RT168-9RT172).

For example, at Hewlett-Packard, Workman was co-chair of a working group for the Institute of Electrical and Electronic Engineers (IEEE) which promulgated a standard for measuring software reliability (9RT170;DR-15). That standard, IEEE 982.1, was voluntary and recommended a classification scheme for severity and class of defect (10RT199). At a presentation to one of the IEEE standards boards, Workman observed that unless some step was taken to improve the reliability of software, the number of problems would double every two years as a result of the computer operating twice as fast (9RT174-9RT175). His observation became codified within the IEEE as Workman's law of software reliability (9RT175).

Workman currently practices law, provides expert testimony, and operates a computer forensic business (9RT183;10RT206). He primarily works as a court-appointed criminal defense attorney in misdemeanor court in Massachusetts for clients charged with operating-under-the-influence (OUI), assault and batteries, and other misdemeanors (9RT183). In his "spare time," he performs as a classical singer at such venues as Carnegie Hall (9RT185;10RT206).

Workman has qualified as an expert in multiple subject areas in fifteen to twenty cases, two on behalf of the prosecution (10RT201-10RT202). He has testified as an expert on source code for breath testing instruments in Arizona and Georgia, and prepared for a case in New Hampshire (9RT180-9RT181). He is scheduled to testify in Tennessee, South Carolina, Georgia, Arizona and California (9RT181). Except for here in New Jersey, most of his other testimony involved issues relating to the production of source code for discovery (10RT214). In Arizona and Florida, he worked on cases where the court ordered CMI, Inc. to produce the source code for Intoxilyzers 5000 and 8000 (9RT204).

The defense here offered Workman as an expert in source code review and the application of standards (9RT186). The court found him qualified to offer testimony in engineering by education and in the other areas by work experience (9RT186-9RT187).

Based on his education, background, experience and understanding of the Alcotest from exhibits introduced at the remand hearing, Workman offered the opinion that the Alcotest was not a reliable instrument on human subjects (9RT187). He believed the source code's complexity and design made it impossible to test (9RT195-9RT196). However, because he would not enter into a non-disclosure agreement with Draeger, Workman never saw the source code except for several snippets introduced in evidence at this remand hearing (10RT59;10RT183;10RT198).

Both SysTest and Base One identified the software's complexity as a major issue (9RT195). Whereas Base One concluded that the software was too complex to test, SysTest relied on the cyclomatic complexity metric developed by Thomas McCabe in 1976 to measure the number of potential paths through the code (9RT195-9RT196;9RT199-9RT200;9RT211). While acknowledging that McCabe wrote in 1976 that a cyclomatic complexity of ten was not a magical upper limit, Workman maintained that modules with excessive McCabe metric scores were overly complex (9RT196-9RT197;9RT199-9RT201;10RT187;Workman supplemental report at 4).[11]

Workman also described another software metric called the Halstead Metric, which measured a routine's data complexity (9RT200). This metric measured the number of operands (things that are operated on) and operators (how the operands or data are manipulated) to provide a single number (9RT200;DR-15).

In Workman's view, the Alcotest's software was "far too complex" to test (9RT200-9RT201). Therefore, its reliability could only be determined retrospectively based on the occurrences of failures (9RT201). He said the problem could be corrected by re-partitioning the routines so there was a more manageable number of paths through particular functions (9RT211).

Workman acknowledged that it was impossible to write perfect source code (9RT201;10RT215). First, human beings, by nature, were fallible (9RT201). Second, specifications changed over time in response to new regulations and legislation (9RT201). Third, codes — like the Alcotest's — contained trillions of paths which made it impossible to find and fix all the errors (10RT33). Indeed, Workman estimated it would require all of

11. *See Supplemental Report* by Thomas E. Workman, Jr., October 4, 2007 (DR-31).

mankind for the rest of time to test all the paths in the Alcotest's source code (10RT33). Nonetheless, Workman thought it was possible to achieve 99.98% reliability by applying standards to software development (9RT202-9RT203;10RT33-10RT34). He did not know if any breath testing instruments on the market had achieved that level of reliability (9RT204).

To make the Alcotest reliable, Draeger would need to develop standards that would dictate the complexity of the modules and discourage the use of global variables (10RT33-10RT34). Such standards also would establish testing processes and procedures, which Workman believed would have detected the buffer overflow problem (10RT34).

Programmers make mistakes all the time (10RT34). For that reason, companies relied on their quality assurance organizations to test source codes and determine if they adhered to standards (10RT34-10RT35). While he considered Shaffer a good programmer, Workman saw no evidence that Shaffer had the support of such an organization within Draeger to review and test the code (10RT34).

Workman defined source code review as an inspection method for identifying and documenting problems (9RT209-9RT211). Unlike desk checking, source code review was a more rigorous process typically performed by someone other than the author (9RT210). To review code, Workman would: (1) use a static tool, like Lint, to find source code modules with particular problems that needed to be investigated; (2) evaluate the build process to determine how the code was assembled and identify what source code went into the modules; and (3) methodically test the sections of code which were most likely to have problems and yield useful results (9RT213;9RT218;10RT38-10RT39). For example, Wisniewski looked at the interrupt handlers, timing routines, and the algorithms purporting to average the samples, and found significant problems (10RT39). Workman described this type of review as "static code analysis" because it did not involve the execution of the code (9RT218).

Workman described Lint as a generic term for a class of tools that performed static code analysis (9RT220-9RT221). Lint is designed to find problems in source code; IDEs facilitated the writing and testing of code for a particular environment by providing tools such as a programming editor, a compiler, a link editor, and often a debugger (9RT223). Most Lint programs were shareware, meaning they were cost-free, while others had fairly modest fees (9RT222). Splint was a variant of Lint that focused primarily on security issues relating to coding errors (9RT222). Lint and Splint functioned on C language source code (9RT222).

Workman explained that people committed errors in writing code by acts of commission or omission (9RT229). Errors resulted in defects which existed in the lines of source code (9RT229). When the microprocessor executed a defect in the code, a fault occurred (9RT230-9RT231). A fault meant that the computer was doing something unintended or wrong, which could result in a failure to perform the desired specification (9RT231;9RT235-9RT236). Because the software development process was imperfect, there were always some defects and failures (10RT7).

Workman reviewed the warnings or errors flagged by Lint on the Alcotest's source code (9RT224-9RT225). Among other things, Lint found prolific "u_byte" errors, which meant that a byte variable was being loaded with a number too large to fit within eight bits (10RT59-10RT60). For example, in base two, the number of values that could fit into a byte was 255 or 2 to the eighth minus one which accommodated for zero (10RT60-10RT61). When too much data was assigned to a byte, Lint raised a warning because of the risk of losing data and causing a wrong reading (10RT63-10RT65).

Lint also found errors involving mismatched functions against type, meaning a function was expecting a variable of one type and was passed a variable of a different type (10RT66). In Workman's opinion, such errors might produce totally wrong results (10RT67-10RT68). He also agreed with Base One's finding that the source code had timing problems, explaining the difficulties arose from the use of two different clocks within the instrument plus a realtime clock which kept track of date and time (10RT88). As an example, Workman mentioned that Draeger did not add a new daylight savings variable in its code to anticipate the recent legislative change (10RT88-10RT91).

He further agreed with Base One's finding that the lack of positive feedback in the hardware did not give the source code the proper tools to do its job successfully, citing the inability to confirm that the pump worked properly (10RT98-10RT99). In Workman's view, the absence of positive feedback made it impossible to demonstrate the Alcotest's reliability (10RT99-10RT100). He also considered the notion of ignoring thirty-one consecutive errors before reporting an error message as "junk science" (10RT130).

Workman recognized that there was an error re-insertion rate in the industry between twenty to seventy percent, but estimated it was on the high end for the Alcotest because of its lack of use of standards (10RT96). There also was a greater probability of creating new problems given the complexity of the source code (10RT97-10RT98). He cited the case where Draeger added a new capability to find the minimum value of six breath samples and inadvertently created the buffer overflow problem (10RT95;DR-4).

Workman believed the most significant problem uncovered by Lint was the Alcotest's averaging routine (10RT69-10RT70). Instead of computing a simple average by adding together a set of numbers and dividing by the number in the distribution, a weighted average took into account the number of times each value was present (10RT74;10RT80;DR-15). While Draeger claimed to average the data points from the continuum of IR measurements of the alcohol content in human breath, it actually averaged the last measurement along the continuum with the sum of the three earlier measurements (10RT71-10RT74). By minimizing the earlier values (1/6 each) and giving half the weight to the final value, Workman said the formula was scientifically unreliable as an average or weighted average (10RT77;10RT83;10RT85-10RT87;10RT121-10RT122;10RT173).

While acknowledging that the final point was a valid reading, Workman maintained it should have no more weight than the earlier values (10RT177). He recognized, however, other instances where later values were given greater weight because they were more important, referring to the Bayesian formula used to predict the future based on past events (10RT159-10RT160).

Workman also agreed with Base One's finding that the EC and IR sensors did not operate independently as represented by Draeger (10RT129). He explained that fuel cells were very common devices which deteriorated over time until at some point they ceased to function (10RT142;10RT144). He described this process as a function of time and the fuel cell's use (10RT145). As fuel cells drifted, they did not give the same output, just as a battery flashlight becomes weaker with time (10RT142).

When the Alcotest's fuel cell drifted out of tolerance, the instrument used an IR value to compute an electrochemical result (10RT132-10RT133;10RT136;DR-

14). Workman believed that this adjustment was made in the first and last control tests based on Wisniewski's finding that it was called from seven different places within the code (10RT141). Even if the adjustment was made only in the first control test, it would affect everything that followed it because the adjusted EC was used in the ambient air blanks and succeeding breath tests (10RT149). Workman could not find any warning about fuel cell drift in Draeger's operator manual (10RT144;10RT154). He would "fix" the problem by stopping the test, shutting the machine down, and putting out a message that the fuel cell had drifted out of tolerance and required replacement (10RT144-10RT145).

Although the probability that any one problem would result in a failed AIR was small, the large number of warnings identified by Lint increased the likelihood of such an outcome (9RT224-9RT225). Workman raised the probability that an error could incorrectly report a breath test as too high or low, or a sample as insufficient (9RT225). It also could incorrectly find a third test was not necessary or result in global variables being overwritten so that AIRs were printed without such information as the expiration date or solution control lot as in the Longport example (9RT225-9RT226; 10RT102;AB-2). Moreover, an AIR could appear valid on its face, when it really was invalid (10RT152).

For example, Workman testified about a series of AIRs from the East Brunswick, Milltown, and South

River Police Departments (10RT9-10RT11;D-129).[12] All three tests were administered by the same officer on May 15, 2006, on three different instruments (10RT14;10RT17-10RT18). The East Brunswick and Milltown readings were taken at 4:03 a.m. and 4:36 a.m., and both results were zero (10RT13-10RT14). The third test was given in South River, at 5:14 a.m., with a reading of .14 BAC (10RT14-10RT15). Workman believed a software defect caused the underreporting on the two AIRs (10RT15). While the problem could be hardware-related, he believed the coincidence had to be very high for hardware to fail in exactly the same way in two different instruments (10RT42-10RT43). While he acknowledged the problem also could be caused by operator error, Workman posited that even if there was a sucking-back problem, the software should have detected it and produced an error message (10RT44).[13]

Instead of Lint, Workman observed that SysTest relied on a different tool called Fortify to look for security defects (10RT39-10RT40). Fortify was designed to look for malware or viruses that might exist in the software (10RT40). Workman thought this was an inappropriate tool because the user did not touch the interface to the

---

12. Exhibits with a "D" designation refer to exhibits marked into evidence by the defense at the initial hearing before the Special Master in this matter.

13. State's counsel represented that at the initial hearing, Sergeant Kevin Flanagan said the underreporting was caused by the subject who was sucking air into the instrument (10RT29-10RT30).

software (10RT40). Both SysTest and Base One used another tool called Understand C++, which provided information about the complexity of routines such as the number of global variables and uncalled modules (10RT40). Workman thought this tool was appropriate (10RT40).

Unlike other computer-dependent industries, Workman expressed concern that there was no easy access to Draeger when problems occurred in the field (10RT20-10RT21). There was no button on the Alcotest which could be pressed to alert the manufacturer of a problem and no evidence of data logs (10RT21). He acknowledged on cross-examination, however, that he did not review the actual code and seemed unaware of the data log functions in the instrument, as related by Shaffer (10RT183-10RT184).

Moreover, New Jersey did not maintain a centralized data base in contrast to Alabama, which logged over 200,000 breath tests, or Massachusetts (10RT27-10RT28). Workman observed that the forensic breath testing field did not encourage the reporting of problems, that state organizations had limited skills in software and computer science, and that police officers often had even fewer skills (10RT23-10RT25). He also was highly critical of New Jersey's operation (10RT24-10RT25).

Workman found nothing really wrong with Wisniewski's testimony, although he might have done things a "little bit" differently (10RT200). He said that

Wisniewski delved significantly deeper into the code than Geller (10RT224-10RT225). While both experts identified the code's use of global variables and its excessive complexity, he thought Wisniewski was the only one who properly testified about their consequences (10RT225). Because Wisniewski concluded that the Alcotest was not scientifically reliable, he could not contemplate any method to distinguish between correct and incorrect test results in the pending cases (10RT147).

The court heard Workman's testimony under *R.* 1:7-3, which provides in relevant part that in actions tried without a jury, a court shall permit the evidence to be taken down by a court reporter in full unless it was not admissible on any ground, a valid claim of privilege was asserted or the interest of justice required otherwise. This court found that Workman was qualified to voice his opinion on technical, computer and legal matters. The weight was for the court.

We did not find Workman's testimony persuasive on the point of Alcotest's unsuitability. He did not convince us that its hardware or software was inappropriate. His suggestion that the EC cell should be replaced on an indication of depletion may have some merit and could be considered by the Court as a correction of the current practice and program.

6. *Summary of Testimony of Court's Witness, Brian Shaffer:* September 24 and 25, 2007, and October 11, 2007

Brian Shaffer received a Bachelor of Science degree in electrical engineering in 1992 from the University of Pittsburgh (5RT5). After working nine years in the semiconductor industry as a product test engineer, he spent one year as a design engineer for an electronics company which served the hobby industry (5RT5). In July 2003 Shaffer joined Draeger in Durango, Colorado as a software engineer (5RT5;5RT56;5RT38). He currently works with evidential table-top instruments, primarily the Alcotest 7110 and 9510 (5RT38;5RT124).

Shaffer has written source code for Alcotest instruments used in California, Massachusetts, Alabama, and New Jersey (6RT32-6RT33). In New Jersey, he wrote the post-*Foley* changes into the code which appeared in version NJ 3.11 (5RT5-5RT6). Norbert Schwarz is his primary Draeger colleague in Luebeck, Germany (5RT19). Shaffer prepared no written report, as he was called by the court as a witness (5RT4;5RT6). Although he was a fact witness, the court also found him qualified as an expert on source code writing (5RT53).

The Alcotest's source code consists of core routines and customized tasks designed around them (5RT10-5RT11;5RT175-5RT176). A compiler translates the source code into instructions which the microprocessor follows to complete the sequence and print a result

(5RT8).[14] The software, however, cannot function without the critical hardware (5RT11).

The core routines in the Alcotest relate directly to the measurement of alcohol (5RT178-5RT179). Because these analytical algorithms were tested many times in different applications around the world, Shaffer avoided altering them (5RT18-5RT19;5RT93). The instrument also was tested by the National Highway Traffic Safety Administration (NHTSA), which would require re-testing if any changes were made to the core routines (5RT18-5RT19;5RT93-5RT95). While the code did not delineate or "wall-off" these sections of code, Shaffer was alerted to their presence by comments from previous developers, and discussions with Ryser and Shaffer's own engineering supervisor (5RT93-5RT94). Shaffer acknowledged it would be easier to find the core routines if they were documented in the code, but did not believe this was necessary (6RT28-6RT29).

These routines were the same in instruments used in New Jersey, Alabama, Massachusetts, and California (6RT41).

Shaffer described the Alcotest's source code as complex with various styles of syntax (5RT148;6RT28). While a highly organized and consistently structured presentation would make the source code more

---

14. The Alcotest uses three microprocessor chips: Motorola; Toshiba; and a low-voltage version of the Motorola device (6RT136-6RT137).

readable, Shaffer did not believe this would make the code more understandable (6RT28-6RT30).

The source code was written in assembly and C program languages (5RT36). The core algorithms were written in Germany, and the customized ones here in the States (5RT93;5RT98). Shaffer customized various tasks for New Jersey including display prompts, external printouts, removal of internal printout functions, modifications of tolerance agreements, test sequence changes, and data memory (5RT179-5RT180).

In Shaffer's opinion, there was nothing proprietary about a very common algorithm (5RT13). However, software developers and scientists worked very hard and invested a lot of time and money to develop routines to create breath test measurements (5RT13-5RT14). If the Alcotest's source code was openly available, competitors could use Draeger's hardware and software to create "knock-offs" (5RT14). They also could use Draeger's technology to create their own products (5RT14). For example, anyone who marketed products with fuel cells might be interested in the way that Draeger captured data from the Alcotest's electrochemical sensor (6RT133). Shaffer was unaware of any companies that openly published their source codes or of any instance where he personally shared code that he wrote (5RT14-5RT15).

After writing source code, Shaffer performed his own static code review or "desk checking" (5RT192). He also conducted "black-box testing with white-box knowledge" by exercising certain logical paths through the code to confirm that these paths worked as he intended (5RT192-5RT193). A technical writer then conducted black-box testing to find out how the test sequence performed and if it met the customer's requirements, and documented the procedures (5RT193-5RT194; 5RT197). The service department next performed black-box testing to determine if the code supported its service capabilities (5RT194;5RT197). Finally, the customer performed user acceptance verification testing (5RT197).

Draeger did not have a dedicated quality assurance person or anyone who functioned in that role with respect to software (6RT38). Shaffer admitted that he would have a higher degree of certainty about the source code if another person participated in the code review process (5RT195-5RT196).

Shaffer was unaware of any single industry standard for software development (5RT15-5RT16). Instead, he referred to "industry standards" as collections of techniques and common-sense wisdom which had proved effective over time (5RT16). During his career, Shaffer collected his own set of development standards, albeit unwritten (5RT16;5RT144-5RT145). He was not familiar with the ISO 9000 standards for software (6RT38).

Shaffer did not agree with Base One's assertion that the failure to use industry coding standards prevented the testing of critical paths in the Alcotest's software including 3200 lines of code designed to make decisions

(5RT17-5RT20). Because the Alcotest in the United States was highly configured to meet the requirements of specific applications, all of the 3200 lines of decision code — as calculated by Base One — were not relevant (5RT18;6RT152-6RT153). Shaffer also said there were by design many unused or uncalled modules or sections of code (5RT17).

Shaffer, however, agreed with Base One's finding that the source code failed to detect catastrophic errors (5RT20-5RT23). He explained that when the microprocessor encountered a command or a memory location that it did not recognize, such as when an instruction in the stack or temporary memory area became corrupted, the microprocessor would lose its place in the script and jump to another section of code (5RT20;5RT150;5RT216;6RT44-6RT45). When the microprocessor attempted to execute the code at the new location, it would become confused and fail to respond appropriately (5RT22;5RT216-5RT217).

Shaffer used the term "illegal opcode trap" to describe this scenario and considered it highly likely that the hardware would "lock up" or freeze so that it would be impossible to finish a breath testing sequence (5RT21-5RT22;5RT217-5RT218;6RT37). Because the operator would immediately become aware of the situation, there would be no risk to the subject of a false reading (5RT22-5RT23). Nonetheless, Shaffer recommended resetting the microprocessor whenever the instrument detected an illegal opcode trap by clearing the memory and starting anew as if the instrument had been turned off (5RT20-5RT21;5RT215; 6RT36-6RT37;6RT98). Based on Shaffer's discussions with his engineering colleagues in Germany, Draeger already has begun to implement this reset feature with its customers in the United States (6RT36;6RT40).

Shaffer disputed Base One's finding that the implemented design lacked positive feedback (5RT23). He explained that there was a direct or indirect way of monitoring the functioning of every circuit, sensor or electrochemical device in the Alcotest (5RT23-5RT24). For example, a problem with the IR detector on either end of the cuvette would be directly observable because during the operational cycle every 8.192 milliseconds, the measurements would immediately drop below the minimum threshold and the instrument would flag a hardware error (5RT24). Likewise, if the pump or the solenoids were not in the proper position, the problem would be indirectly observable because air would not flow past the sensor at the appropriate times (5RT25).

Shaffer was uncertain about Base One's findings on diagnostic adjustments and substitute data readings (5RT26-5RT27). He explained that the Alcotest performed diagnostic checks every 8.192 milliseconds or 122 times a second, including when a subject was blowing and results were analyzed (5RT26;5RT82-5RT83;5RT141). Unlike other customers, New Jersey did not ask Draeger to take "diagnostic snapshots" and store them in the instrument's memory as part of the data log (5RT26). Nonetheless, if a diagnostic routine failed in New Jersey's firmware version, the instrument would generate a hardware error which would halt its operation and make further tests impossible (5RT27). Contrary to Base One's assertion, Shaffer never saw an instance where a diagnostic routine failed and the Alcotest substituted "canned" or arbitrary data values (5RT27).

Shaffer also disagreed with Base One's criticism about flow measurement (5RT27-5RT29). At the beginning of the power-on cycle which started a breath test measurement, the Alcotest assumed that the airflow was zero without conducting a "reasonableness check" (5RT27-5RT28). This "zeroing" of the instrument, however, was offset by many real-time checks which made certain that the instrument was working within its prescribed ranges (5RT28-5RT29).

Shaffer said it was common practice in electrical engineering to ignore error messages unless they occurred a large number of consecutive times (5RT30-5RT31). Indeed, he mentioned several advantages of the Alcotest's requirement that measurement errors had to occur thirty-two consecutive times before they were reported (5RT30-5RT31). Shaffer explained that all sensors had a natural range of values and that it would be surprising for them to rely on only one decision point (5RT31). The use of thirty-two events also allowed Draeger to set tighter tolerance ranges to avoid falsely triggering errors (5RT31-5RT32). For example, this meant that if a subject blew into a breath hose before the operator pressed the button to start the test, the instrument would not flag "blowing not allowed" if the subject blew for less than one-quarter of a second (thirty-two times 8.192 milliseconds), but would display the error message if the subject blew one-quarter second or longer (5RT30-5RT31).

Shaffer estimated that the Alcotest's source code contained approximately 200 global variables and 1500 local variables, which he described as a lot of variables in general (5RT32). He described the use of global variables as a tradeoff (5RT33). On the downside, they placed an additional burden on programmers to exercise caution when adjusting the code to avoid unintended consequences such as overriding local variables or assigning to a new module a name already used by a global variable (5RT33;6RT14). On the upside, global variables were easily accessible in all modules of the program, and contained information for the use of such things as calibration which Shaffer wanted the instrument to remember after it was powered off (5RT33-5RT34). Their use also resulted in far less complexity and overhead, and made the code easier to design (5RT117).

Shaffer believed the advantages of global variables outweighed the risks (5RT33). Moreover, to reduce their number, he would have to add more code and functions which, in turn, would create higher complexity (6RT135). He also would have to touch more portions of the code than otherwise necessary (6RT135). Shaffer emphasized that the decision to use global variables was made in the design process and that he did not consider their presence as a liability for the product (5RT34).

Shaffer also took exception with Base One's identification of timing problems (5RT34-5RT36). Because the Alcotest had a separate real-time chip on the motherboard that could be accessed for any evidential time stamp, he considered the clock free-running and independent of the microprocessor (5RT34). He also explained that the clock was used for administrative functions, and was not absolute (5RT34-5RT35). He specifically objected to the characterization of the external interrupt routines as very lengthy, stating they handled many functions by design, and to the representation that they were written exclusively in C language when, in fact, portions were written in assembly language (5RT36).

Shaffer agreed that headers could be used to identify the last time a section of code was modified and the name of the programmer who made the change (5RT119). However, he did not consider them a priority because he usually worked alone or as part of a very small engineering team (5RT120). If he needed to determine when a module was changed, he simply would compare previous versions of the code using other tools (5RT120;5RT190). For example, he used "diff programs" which highlighted the lines of code that were changed and the way they were changed, allowing him to interpolate file creation dates (6RT22). If he worked with a larger engineering team, Shaffer acknowledged that the header comments would have far more value (5RT120).

Shaffer defended the Alcotest's use of weighted averages, stating it was absolutely appropriate to assign the greatest weight to the most recent value (taken from the sample with the deepest lung air) for the purpose of making a very accurate breath test measurement (5RT136-5RT138;6RT144-6RT147;10RT229). He explained that individual samples of breath from the IR measurement were taken every 8.192 milliseconds but that the weighted average routine only considered the points derived from them every .25 seconds (10RT228). By relying on samples taken at .25-second intervals, the weighted average was actually less than the value of the last reading (10RT227-10RT230).

Likewise, Shaffer took issue with Base One's finding that results were limited to small discrete values (5RT139-5RT140). Specifically, Base One found that there were only eight values possible for the IR detector and sixteen for the EC sensor (5RT140). Shaffer, however, said the range of possible values was significantly higher, with the IR about 12,000 and the EC as low as 100 and as high as the thousands (6RT139-6RT140). By multiplying 4096 — all possible values that can be observed from the IR system — by a sine wave, the IR value could be as high as 22,000, which gave tremendous precision (5RT139).

Shaffer defined "a defect" as anything which does not work in accordance with the specifications (5RT126;6RT30). He expected to see defects in the development process, and estimated an average of one defect in each version of the source code sent to customers (6RT31-6RT32). By his definition, defects might include typographical errors, misunderstandings about specifications, or anything else which caused some undesired result (6RT32-6RT35).

Shaffer was the creator of the buffer overflow defect (5RT39-5RT40;5RT154). He was quite surprised and impressed that SysTest found this problem which had remained undetected despite significant white-box and black-box testing (5RT49-5RT50). Shaffer inadvertently introduced the buffer overflow when he implemented the post-*Foley* third-test changes requested by New Jersey (6RT19-6RT20). Specifically, he added a section of code without changing the initialization of the variable to allow it to accommodate six instead of four values (6RT19;6RT94). Thus, the code allocated four spaces for data when it needed six (6RT95). The sorting routine that created the buffer overflow occurred only in New Jersey, not in other jurisdictions (10RT231-10RT232;10RT246).

Buffer overflows can have far-reaching effects (5RT50). After studying the specifics of this particular overflow, Shaffer concluded that it occurred only in limited situations where (1) breath tests one and two were not in tolerance with each other, (2) a third test was required, and (3) the EC result of the second breath test was the lowest of the six values (5RT46-5RT48). In these cases, the code only allowed the instrument to allocate to its "temporary scratch pad" four of the six values within the locally declared variable (5RT40-

5RT42). By overwriting the true lowest value as a .32, the instrument was unable to recognize that EC second test value as the lowest when the software went through the sorting routine (5RT43-5RT46). Consequently, the instrument reported the second-lowest value for the breath test result (5RT46). The overflow error did not affect the six alcohol breath test results printed on the AIR, which came from global variables (5RT42). To correct this buffer overflow, Shaffer simply would change the number four to six at the appropriate place in the code and then recompile the code (5RT49).

Shaffer did not think it necessary to exclude the use of the AIR in all pending third-test cases (6RT120-6RT121). Instead, he crafted a series of instructions to determine if the buffer overflow had an effect and to find the true reported breath test result (6RT121-6RT122;10RT234-10RT235;CR-3). The instructions consisted of twelve discrete mathematical operations shown in green on exhibit CR-3 involving addition, subtraction, multiplication and division, and some other steps involving basic comparisons or copying from other lines (10RT235). Shaffer explained that these calculations were necessary to determine if breath test three was within tolerance of breath tests one and two, and that it would be incorrect to select the lowest of the six unaffected test results on the AIR (10RT237-10RT238).

Shaffer understood there were no cases in Middlesex County in 2005 which required a third breath test due to lack of tolerance (5RT46-5RT47;5RT155-

5RT156). He further understood that some third tests would be generated when New Jersey tightened its tolerance requirement (5RT156). Shaffer, therefore, recommended that New Jersey include the buffer overflow correction on its change request list (5RT184). According to Shaffer, the only other defect pending in New Jersey occurred in very specific circumstances where an instrument did not wait quite the full two-minute period between subject samples (5RT132-5RT133). He also recommended correcting this defect (6RT116).

In contrast to Workman's testimony, Shaffer stated that data logs were part of the Alcotest's source code and were enabled in version 3.11 (10RT230). These logs stored data within the instrument's memory such as the time stamp of each event which occurred within the breath testing sequence, the individual IR and EC results, and the aborted tests (10RT230-10RT231). This data could be retrieved from the memory of each instrument (10RT231). New Jersey also could retrieve this data on a statewide basis, but it has chosen not to do so up to the present (10RT231).

Shaffer also testified that the fuel cell changes or depletes throughout its life (6RT104). Because older fuel cells tended to underreport the ethanol level, engineers in Germany inserted into the source code an algorithm or aging compensation routine to address this drift over time (5RT222-5RT223;6RT105). Because IR detection remains unaffected by age, the algorithm performed a fine-tune adjustment in the EC value (6RT108-6RT109).

Depending on the IR result, there could be an adjustment, but only up to 25% of the difference between the IR and EC results (6RT108-6RT109;6RT126; 10RT243). In other words, if during the first control test, the EC reading was out-of-target with the IR reading, the EC could be corrected up to 25% of the EC-IR difference (6RT126). This algorithm compensated for the inevitable aging which took place during the twelve-month calibration cycle (10RT233).

The aging compensation routine occurred several times in the source code (10RT233-10RT234). Except in two cases, the routine was "commented out" and in one of the remaining cases it was disabled (10RT234). Thus, the routine occurred or was "called" only once in the code, which represented two instances, both of which involved control tests (10RT234).

Shaffer stressed that the aging compensation routine occurs only during a control test under certain special circumstances, and not during the analysis of a subject's breath (10RT232). Thus, he believed the Alcotest used two independent technologies to analyze breath samples (10RT232-10RT233).

In response to the court's questions, Shaffer explained the process this way:

> THE COURT: This discussion, I read your earlier testimony about the circumstance where the EC may be borrowed by the IR

under certain conditions and influence the IR reading. You heard Mr. Workman describe that.

Do you have any comment on that further than what I've read? You remember what you said —

THE WITNESS [Mr. Shaffer]: I do.
Not to the word, but certainly the concept.

I heard prior testimony from other witnesses that misstated the circumstances in which this occurs. The truth is that this occurs only during a control test, and even at that time it only occurs under certain circumstances. It never occurs during the analysis of a subject's breath sample. There are two independent technologies analyzing that sample at any time that we're collecting a breath sample where the instrument says please blow.

THE COURT: What is the point of this borrowing from the IR — I mean EC value?

THE WITNESS: The main thing that I want to clarify is that this is an aging compensation routine. The — some electronics or some radios even have a macro or a big tuning adjust knob and there's a fine adjust knob. Think of it in terms of this. The macro, the

> big adjustment, is being performed by the fact that we are integrating that area underneath the EC curve. That takes care of the aging compensation almost in its entirety. There is this algorithm in place to account for the fine tuning, the adjustment, that is required to compensate for the aging that does occur in between the 12-month calibration cycle.
>
> [10RT232-9 to 10RT233-15.]

When asked to explain anomalistic discrepancies between an AIR and a new solution report from Longport, Shaffer refused to speculate on the cause without more information such as the data log from the instrument (6RT117-6RT118;AB-1;AB-2). In that case, the solution control lot was left blank on the AIR but not on the solution report; the expiration data also was left blank and the reported bottle number was zero (6RT118). Shaffer said the problem could be related to the software or hardware (6RT119). In any event, this court specifically finds that such incomplete AIRs should *never* be used for evidentiary purposes.

Finally, Shaffer testified that a subject should not be able to suck air into his lungs from the breath hose if the hardware worked as intended and the flapper valve was sealed properly (10RT245-10RT246). But even in this unlikely scenario — sucking air out through the instrument — the reading would be a nonincriminating .000 in this event, as in D-129 (the three AIRs from Middlesex towns — Milltown, South River, and East Brunswick).

Shaffer recommended that New Jersey's next firmware version consider: (1) updating for current daylight savings time; (2) allowing a full 120-second delay between the collection of two subject breath samples; (3) forcing the instrument to reset upon encountering an illegal opcode trap; (4) correcting the buffer overflow defect; and (5) tightening the tolerance between breath tests by half (6RT116-6RT117;6RT123-6RT124).

This court was most impressed by Shaffer's candor, cooperation, careful explanations, and dignified demeanor. We found his testimony completely reliable and forthright.

IV. FINDINGS AND CONCLUSIONS OF LAW

1. *The Beginning Of The End*

Our charge in this limited remand was to determine whether software in the Alcotest "reliably analyzes, records and reports alcohol breath test results" (Order at 2). That order requested us to advise the Court of the "effect, if any" of the expert opinion rendered on the "findings and conclusions contained" in our original February 13, 2007 report (Order at 4).

We now conclude that the proofs presented at the original hearing and at the remand hearing combine to satisfy this court that the Alcotest is scientifically reliable, both as to software and hardware, in reporting alcohol breath testing results for evidentiary purposes. We make this finding by the clear and convincing evidence burden of proof placed on the State.

The proofs at the limited remand hearing on the software and the source code aspect did not change our opinion on reliability and trustworthiness of the instrument but reinforced our initial view. We are also so convinced based on the assumption that the recommendations we made in our original report and in this report are followed in the future to ensure the continuing and possibly improved accuracy of breath test results *(see* Initial Findings and Conclusions).

We are firmly convinced that the Alcotest is much more reliable than the prior state-of-the-art breath testing instrument, the breathalyzer, which has been used in the past in New Jersey, and is still used in four counties. The Alcotest essentially functions independently of operator influence, unlike the breathalyzer, which is very dependent on the operator and produces no objective and permanent record of test results. The Alcotest is also much more precise.

Based on the testimony with respect to the source code which we heard at this twelve-day remand hearing we make these further findings and recommendations, supplementing our original thoughts. Quite obviously, developing source code in this context is a dynamic, evolutionary process, not a static undertaking. The process should be re-examined and re-evaluated periodically and neither the legal nor the forensic community should fear improvement of the accepted wisdom when necessary. We should fear stagnation; we should not create an idolatry of the status quo. And simply because a procedure can be improved, does not necessarily mean the older model was illicit or worthless.

2. *The Critical Issues*

We now summarize the critical issues raised at this second hearing and provide our recommendations.

A. *Fuel Cell Drift*

Wisniewski: He found a section in the code where he said the IR reading mathematically modified the EC reading. He said that section could be called or activated from seven different paths in the code. Thus, under certain conditions, the code would take the results of the calculations under the EC curve and divide them by the IR average.

Workman: He agreed with Wisniewski's finding that the EC and IR sensors did not operate independently as represented by Draeger. He explained that fuel cells were very common devices which depleted over time until at some point they ceased to function. He described the depletion as a function of time and the fuel cell's use. As fuel cells drift, they did not give the same output — just as a battery flashlight becomes weaker with time.

When the Alcotest's fuel cell drifted out of tolerance, the instrument used an IR value to compute an electrochemical result. Workman thought that the adjusted EC value then was used in the ambient air blanks and succeeding breath tests. Workman believed that adjustment was made in the first and last control tests based on Wisniewski's finding that it was called from seven different places within the code. Even if the adjustment was made only in the first control test, it still would affect everything that followed it. Workman could not find any warning about fuel cell drift in Draeger's operator manual. He would fix the problem by stopping the test, shutting the machine down, and putting out a message that the fuel cell had drifted out of tolerance and required replacement.

Shaffer: Fuel cells changed overtime. Because older fuel cells tended to underreport the ethanol level, the engineers in Germany inserted into the source code an algorithm or aging compensation routine to address the drift over time. Because the IR detection remained stable and unaffected by age, the algorithm performed a fine-tune adjustment in the EC value. Depending on the IR result, there could be up to a 25% adjustment of the difference between the IR and EC results. In other words, if during the first control test, the EC reading was out of target with the IR reading, the EC could be corrected up to 25% to bring it into tolerance with the IR. This EC depletion algorithm compensated for the aging which occurred during the twelve-month calibration cycle.

The aging compensation routine occurred several times in the source code. Except in two cases, the routine was "commented out" and in one of the remaining cases it was disabled. Thus, the routine occurred only once in the code, which represented two instances both of which involved control tests. Because the adjustment never occurred during the analysis of a subject's breath, Shaffer maintained that the Alcotest employed two independent technologies to analyze breath samples.

Recommendation: We accept Shaffer's testimony and explanation. He clearly explained this issue, which we have quoted at 77-78 *supra* and we fully credit his testimony in this regard. This explanation may reflect on Draeger's marketing claim that it uses two completely independent technologies. We conclude that this depletion explanation does not undermine the scientific reliability of the breath measurement. The standard of measurement is adjusted for fuel cell depletion, not for any alcohol content. We recommend that the Alcotest should be calibrated every six months rather than every twelve months and the fuel cell replaced at that time, if necessary.

B. *The Buffer Overflow*

Geller: The buffer overflow occurs when a program attempts to store more bytes or units of information in an allocated variable which is not large enough. Geller used the analogy of trying to park a full-sized Cadillac in a compact-car parking space. After Fortify SCA warned of a potential overflow, Geller opened the code to the particular file and function, and saw a situation in the source code where six bytes were stored into a space allocated to hold only four. The two overhanging values then were used by the next two declared variables and thus were overwritten.

Geller explained that the buffer overflow affected one small part of the AIR, and not the way in which the Alcotest 7110 made any of its breath test calculations. Specifically, it arose only in these limited circumstance: (1) the results of the first two breath tests were out of tolerance; (2) a third breath test was taken; (3) the result of the third breath test fell between the values of the first two and was centered enough to be within tolerance of both of them; and (4) the ER result from the second breath test was the lowest measured value. In such cases, the AIR would not report the lowest breath test result. The overflow problem easily could be corrected with one keystroke by replacing the number "four" with a "six" at this array in the code. Geller also correctly testified that Base One's report did not discover and describe the buffer overflow problem.

Dee: While Dee recognized the potential significance of a buffer overflow, he believed it was a limited vulnerability. He described the problem as a situation where six values must be put into four boxes. Given the closed nature of the application, Dee explained that the situation in which the error occurred — three tests with similar values — was uncommon. For that reason, he surmised that the problem never actually arose in field testing and that it took a program tool specialized in exposing vulnerabilities to raise it as an issue. That program tool, Fortify SCA, checked the source code for approximately 150 different kinds of exposure and code issues. Dee said the error could be easily fixed and recommended that it be corrected in a future release.

Shaffer: He inadvertently introduced the buffer overflow when he implemented the post-*Foley* changes requested by New Jersey. Specifically, he added a section of code without changing the initialization of the variable to allow it to accommodate six instead of four values. Thus, the code allocated four spaces for data when it really needed six. The sorting routine that created the buffer overflow occurred only in New Jersey, not in other jurisdictions.

The buffer overflow occurred only in limited situations where (1) breath tests one and two were not in tolerance with each other, (2) a third test was required, and (3) the EC result of the second breath test was the lowest of the six values. In these cases, the code only allowed the instrument to copy four values within the local variable causing the other two values to be overridden. By overwriting a .32 for the EC value from the second test, the instrument was unable to recognize that EC value as the lowest as it went through the sorting routine and instead, reported the second-lowest value for the breath test result. The error did not affect the six alcohol results from the three breath tests printed on the AIR, which were never overwritten.

To correct the buffer overflow, Shaffer simply would change the number four to six at the appropriate place in the code and then run the code through the compiler. For pending cases, he did not think it was necessary to prohibit the use of the AIR in all third-test cases. Instead, Shaffer crafted a series of instructions to determine if the buffer overflow had an effect and to find the true reported breath test result. The instructions included twelve discrete mathematical operations involving addition, subtraction, multiplication and division, and several other steps. Shaffer explained that these calculations were necessary to determine if breath test three was within tolerance of breath tests one and two, and that it would be incorrect to just select the lowest of the six unaffected test results on the AIR. Shaffer recommended that New Jersey correct the buffer overflow defect.

Recommendation: As to pending cases, either prohibit the use of the BAC evidence in all third test cases or use Shaffer's formula, which the State agrees is appropriate to correct the overflow error. Because the buffer overflow is a *real error* in the source code, this must be corrected.

C. *Weighted Averages*

Workman: He believed the most significant problem uncovered by Lint was the Alcotest's averaging routine. Instead of computing a simple arithmetic average by adding a set of numbers and dividing by the total number in the distribution, he said a weighted average takes into account the number of times each value is present. Draeger claimed to use a weighted average when the Alcotest processed the IR measurements of the alcohol content in human breath. It actually averaged the final measurement on the continuum with the sum of the three previous measurements. By minimizing the earlier values and giving half the weight to the final value, Workman said the formula was scientifically unreliable as an "average."

While acknowledging the final point was a valid reading, Workman maintained it should have no more weight than the three previous values. He recognized, however, other instances where later values were given greater weight because they were more important, referring to the Bayesian probability formula used to predict the future based on past events.

Shaffer: He defended the use of weighted averages, stating it was absolutely appropriate to assign the greatest weight to the most recent value for the purpose of making a very accurate breath test measurement. He explained that individual samples of breath from the IR measurement were taken every 8.192 milliseconds but that the weighted average routine only considered the points derived from them every .25 seconds. By relying on samples taken at .25-second intervals, the weighted average was really *less* than the value of the last reading.

Recommendation: None. We accept Shafer's testimony and use of the weighted average which accurately and fairly measures blood alcohol content in the subject.

D. *Lack of Standards*

Wisniewski: Wisniewski said that standards or development methodologies produce the most error-free and reliable software. They also made software easier to maintain and produce more robust overall systems. They saved money in the long run. He recommended that Draeger adopt one of five he listed in his report or develop its own. However, he conceded on cross that the present code followed a known, function-oriented methodology which he said applied to the software only.

Workman: It is possible to achieve 99.98% reliability by applying standards to software development. He did not know if any breath testing instruments on the market had achieved that level of reliability. Use of standards would dictate the complexity of the modules, discourage the use of global variables, and establish testing processes and procedures.

Geller: He did not know if there were any industry standards which governed source code review. In Geller's opinion, quality software could be developed without standards and conversely, software could meet standards but still be of questionable quality. He was not personally familiar with any of the standards cited in Base One's report nor did he know if Draeger applied any standards to the Alcotest source code.

Dee: He did not agree with Base One's criticism of the Alcotest's lack of standards. In his opinion, such standards usually referred to the design and documentation of the code, and rarely addressed the code's performance. He was unaware of any standard against which the United States evaluated software. Moreover, he objected to Base One's reference to standards without stating which specific provisions were violated. He said it was possible to fully test the source code given the singular or specialized function of this application.

Shaffer: He was unaware of any single industry standard for software development. He referred to "industry standards" as collections of techniques and common-sense wisdom which had proven effective over time. Shaffer did not agree with Base One's assertion that the failure to use industry coding standards prevented the testing of critical paths in the Alcotest's software including 3200 lines of code designed to make decisions. Because the Alcotest in the United States was highly configured to meet the requirements of specific applications, all of the 3200 lines of decision code — as calculated by Base One — were not relevant. Shaffer also said there were many unused or uncalled modules or sections of code by design. Shaffer did say standard style would be helpful but was not necessary.

Recommendation: None. The testimony of Geller, Dee and Shaffer discussed this topic persuasively and we see no need to recommend any particular style or standard.

E. *Cyclomatic Complexity*

Geller: He relied on the cyclomatic complexity metric developed by Thomas McCabe in 1976 to measure the number of potential paths through the code. Because high complexity increases the risk of inherent defects, coding guidelines recommend keeping the cyclomatic complexity of functions under ten, and or even seven. The SysTest report identified more than eighty-one modules in excess of ten and three in excess of a hundred. While the report recommended restructuring the code to make it less complex, Geller said the complexity indices did not influence the instrument's accuracy. Nor did excessive complexity cause failures in the interfaces between software and hardware. However, the higher complexity made the code more difficult to understand and maintain, placing an increased burden on the programmers who worked with the software.

Dee: He did not believe that cyclomatic complexity affected the instrument's performance. To the contrary, he believed that the presence of large numbers of "decision trees" in one module was better than breaking them up into additional modules in terms of system performance. He defined decision trees as boxes containing expressions of code out of which branched other boxes, with a calling program or "main module" directing which box to go to depending on what the code said to do. Thus, Dee considered cyclomatic complexity as a stylistic issue which implicated a tradeoff between performance and ease of maintenance.

Workman: He said the code was too complex and could not be demonstrated as reliable.

Recommendation: None, because this goes to style and not the accuracy of the Alcotest. We accept Geller's and Dee's testimony as persuasive that the Alcotest performs accurately at this level of complexity.

F. *Design and Style*

1. *Older Style*

Wisniewski: Although the code was created between 1993 and 1997, it was written in a style reminiscent of the 1970s and 1980s. Wisniewski did not consider that a criticism, and acknowledged that Draeger had done a "great job" of adhering to the older style. He further said that it was not necessary to always adopt the newest technology, and that many people preferred to stay with the familiar.

Geller: The source code was written by more than one programmer and evolved over numerous transitions. It contained comments written in German and English, which comments he explained served as memory joggers for the programmer who wrote them and as advice to future programmers. Geller used the comments to find his way through the code.

Geller acknowledged the code was not written in a manner consistent with usual software design "best practices." While such practices are described in various publications, programmers often have to adapt them to fit the available resources. In cases where a code deviated from best practices, it still is safe to use but this places an added burden on programmers to understand it. Geller did not find anything in the code that looked intentionally written to skew the results. Overall, he found there was nothing particularly unusual about the Alcotest software in terms of its style and organization.

Dee: He understood that the source code was written between 1993 and 1997. Although he only scanned the code, he saw about three or four different writing styles. He did not know if Draeger gave its programmers requirements documents with instructions on how to code.

Workman: Workman believed it was impossible to write perfect source code because (1) human beings, by nature, were fallible, (2) specifications changed over time, and (3) codes — like the Alcotest's — contained trillions of paths which made it impossible to find and fix all the errors.

2. *Global Variables*

Geller: The code uses global variables to store test and result data. Unlike locally declared variables designed for specific purposes within small subsets of the code, global variables are accessible from any function within the application. Also unlike local variables which pass out of existence after their use, global variables can be used throughout the duration of the program. Thus, they make information available without the resources required to pass a value from one function to another.

However, data contained in global variables is not protected and can be changed intentionally or unintentionally at any time by any function. Because they can be potentially modified from anywhere, global variables should not be used to store critical data. Given the increased risk of program error, their use should be extremely limited. Nonetheless, Geller said there was nothing inherently wrong with global variables and their presence did not impact negatively on his conclusion that the Alcotest's software was reliable. In fact, he said that some computer languages — such as COBOL and assembly — use only global variables.

Wisniewski: He said Lint flagged defects including the use of a local variable as a global and vice versa, and the assignment of the same name to local and global variables. He described these as confusing and inconsistent, and expressed concern that they might affect some other operation in the program such as calibration. However, he acknowledged that identically named local and global variables would not confuse the compiler because the local would take precedence over the global declaration. He also admitted that there were legitimate reasons to use global variables. Time constraints prevented him from determining if a global variable actually was misused and changed the result on an AIR. Indeed, he was unable to identify anything in the code that posed a real problem that would affect a result on the AIR.

Dee: He addressed SysTest's and Base One's issue of the source code's extensive use of global variables. He agreed that a programmer must be careful to avoid overwriting a global variable written by someone else. If an error occurred, a global variable would remain until the system was reset, re-initialized or re-powered whereas a local variable remained only for the particular calculation and then was gone. On the other hand, the use of global variables conserved memory and increased efficiency by reducing performance time. It also would be expensive to change everything to local variables. In any event, the presence of global variables did not concern Dee because the source code made extensive use of local variables and only kept what was common to all modules at the global level.

Shaffer: There are approximately 200 global variables in the Alcotest's source code and 1500 local variables. The use of globals is a tradeoff. On the downside, they placed an additional burden on programmers to exercise caution when adjusting the code to avoid unintended consequences such as overriding local variables or assigning to a new module a name already used by a global variable. On the upside, global variables were easily accessible in all modules of the program, and contained information for the use of such things as calibration which Shaffer wanted the instrument to remember after it was turned off. Their use also resulted in far less complexity and overhead, and made the code easier to design.

Moreover, to reduce their number, Shaffer would have to add more code and functions which, in turn, would create higher complexity. He also would have to touch more portions of the code than otherwise necessary. Shaffer emphasized that the decision to use global variables was made in the design process and that he did not consider their presence as a deficiency in the product.

3. *Headers*

Wisniewski: He was unable to determine when sections of the code were modified because there were no headers to track that information. The lack of headers made the code unreliable.

Shaffer: Headers can identify the last time a section of code was modified and the name of the programmer who made the change. He did not consider them a priority because he usually worked alone or as part of a very small engineering team. If he worked with a larger engineering team, Shaffer acknowledged that the header comments would have far more value. To determine when a module was changed, Shaffer compared previous versions of the code using other tools. For example, he used "diff programs" which highlighted the lines of code that were changed and the way they were changed, allowing him to interpolate file creation dates.

4. *Core Routines*

Geller: He was not concerned that the software did not contain confidentiality or copyright notices, or that core sections or routines were not "walled off." Geller explained that programmers must exercise caution, but he never had an arbitrary classification which restricted access to any part of a code.

Wisniewski: The code did not distinguish between core and customized sections. He believed that programmers should be able to touch the core software in order to learn more about it. If Draeger wanted to protect the core, however, he recommended taking the core routines out of the regular code and filing them in accessible "libraries" of object modules. The programmers would then get a reference with the library routines, and the core algorithms would be protected from change.

Shaffer: The core routines related directly to the measurement of alcohol. Because these algorithms were time-tested, field-tested, and NHTSA-tested, Shaffer avoided them. While there was no black-and-white designation of these "walled-off" sections of code, he was alerted to their presence by comments from previous developers, and discussions with Ryser and Draeger's engineering supervisor. Shaffer acknowledged it would be easier to find the core routines if they were documented in the code, but did not believe it was necessary.

5. *Comments*

Wisniewski: He found several inconsistencies in the code's comments, which must be fixed. For example, he found a comment in the code stating that a conversion to "%BAC" needed to be done, but it was not done. He also found comments which said values should be averaged, but found that the source code instead performed weighted averages or successive averaging routines. Wisniewski said such comments could affect the breath test result if they were unintentionally executed; otherwise, they merely reflected a sloppy coding style. He acknowledged, however, that comments were not compiled and never reached the object code.

6. *Uncalled Functions*

Wisniewski: He identified fifty-one functions in the source code which were not used. Wisniewski said these uncalled functions were confusing, untidy, and unnecessary, and should be purged from the executable code.

Dee: Dee acknowledged that SysTest's report identified numerous unused or uncalled modules, which took up memory and space in the source code. While their presence could be due to the sloppiness of programmers, he believed they were typical of software development projects where code was being used by multiple customers, decommissioned, or developed for future releases. Dee explained that it was more convenient to leave these unused functions in the code than to remove them. In any event, Dee said their presence was a question of style, and did not effect the reliability or results of the executed code.

Shaffer: There were many unused or uncalled modules or sections of code by design.

Recommendation: These design and stylistic issues are not within the scope of our recommendations. They are matters of the creator's preference and do not relate to the efficacy of breath testing in our view.

G. *Catastrophic Error Detection or Illegal Opcode Trap*

Wisniewski: Draeger disabled an interrupt that otherwise would detect when the microprocessor was trying to execute an illegal instruction or indefinite branching. By turning off this safeguard, the Alcotest possibly could produce unpredictable results.

Geller: He disagreed with Wisniewski's finding that the instrument could produce unreliable results because its catastrophic error detection was disabled. When this situation occurred Geller expected that the instrument would go into an endless wait cycle, meaning it would basically cease to function, and not produce a result.

Dee: It was standard operating procedure in mature systems to disable the capabilities of the processor that detect catastrophic errors. Dee explained that these aborts were disabled and replaced with software which "captured" the errors so that a determination could be made as to whether the error was recoverable or not, or whether a more meaningful message must be written.

Shaffer: He said that when the microprocessor encountered a command or a memory location that it did not recognize — such as when an instruction in the stack or temporary memory area became corrupted — the microprocessor could lose its place in the script and jump to another section of code. When the microprocessor attempted to execute the code at the new location, it could become confused and fail to respond appropriately.

Shaffer said it was highly likely that the hardware would "lock up" or freeze so that it would be impossible to complete a breath testing sequence in these cases. Because the operator would immediately become aware of the situation, there would be no risk to the subject of a false reading.

Recommendation: We recommend that Draeger reset the microprocessor so that whenever the instrument detects an illegal opcode trap the memory will clear and start anew, as if the instrument was turned off. Based on Shaffer's discussions with his engineering colleagues in Germany, Draeger already has begun to implement this reset feature with its other customers in the United States. He did not want to touch New Jersey's program until this case is concluded.

H. *Error Detection Logic*

Wisniewski: He claimed the software design detects measurement errors but does not report an error message unless the errors occur thirty-two times. In the court's view, that means the instrument will report the 32nd error. Wisniewski maintained this meant an error could occur thirty-one times, but remain unreported.

Dee: He disagreed with Wisniewski's statement that the source code "ignored or suppressed" error messages unless they occurred a large number of consecutive times. In his opinion, it was normal in embedded systems to wait for the coordination of the application with the operating system or hardware. Thus, the purported error did not mean that something was wrong but rather that something was not ready. For example, there might be slight timing differences between internal components that need adjustment.

Shaffer: Measurement errors in the Alcotest must occur thirty-two consecutive times before they are reported. He said the common practice in electrical engineering was to ignore error messages unless they occurred a large number of consecutive times. This technique has several advantages: (1) all sensors have a natural range of values and it would be surprising for them to rely on only one decision point; (2) the use of thirty-two events also allows Draeger to set tighter tolerance ranges to avoid falsely triggering errors.

Recommendation: We accept the Dee and Shaffer view that an error message is communicated effectively when stabilized, accurate and reliable. We see no need for a change.

I. *Software Program Tool - Lint*

Wisniewski: Wisniewski selected Lint to find defects in the source code's C language syntax, data initialization, and data management. He used a cost-free program tool derived from Lint called Splint, version 3.1.2, which raised warnings or flags, which Wisniewski called "defects" because they required action whether they were serious or harmless flaws. Wisniewski customized Splint to display all the warning or defect messages, and found about 19,500.

Lint was wordy or verbose because it tended to produce a number of defects, including repetitive examples of the same coding style. Despite its "voluminous" output, he maintained that disciplined coders would want to know about these defects and remove them to avoid any possible confusion or chance the code might not work correctly. Although the presence of these defects did not prove the software program would fail to execute, they indicated the lack of use of industry coding standards.

To insure the source code's reliability, Wisniewski said every defect should be removed. He would undertake an aggressive, ongoing campaign to find and dispose of them as part of what he called the software life cycle. Wisniewski estimated that it would take about one year to fix all the defects in the Alcotest's source code.

Defects ranged from substantive problems to variations in programmer style and organization. Some of the defects appeared numerous times, like print interrupts which were flagged about 2000 times. The Lint program did not categorize the warnings or flags, nor did it quantify any of the messages. Wisniewski did not propose corrections to any of the defects he identified in the source code nor did he check to see if they applied to functions used in New Jersey.

Geller: Lint was created as a development tool, not a review tool. It was outdated after the development of personal computers and it produced output not particularly informative to programmers.

Dee: Lint was a product of the 1970s and was not commonly used today. He believed that IDEs replaced the need for Lint by keeping a programmer within the parameters of the proper syntax during the coding process.

He was "outraged" when he reviewed Appendix C in Base One's report which purported to find "errors" in 19,000 of the 45,000 lines of code. Dee objected to Base One's attempt to quantify the errors. For example, Lint generated approximately 7657 lines of warnings based on its misunderstanding that the "U_-byte" variable was undeclared or used incorrectly. Dee later explained these lines might have values which truncated the lower digits and retained the higher values. Also, Lint ignored the quality of the errors, and improperly flagged "comments within comments." Based on the alleged errors, Dee believed that Lint did not understand some of the specific code needed for embedded system. He would not have used Lint to review the Alcotest's source code.

Recommendation: Notably, Lint did not disclose the buffer overflow error but Fortify SCA, used by Geller, did disclose this error. The alleged hypothetical probability of irregularities raised by Lint are much too speculative and unreliable to recommend abandonment of the Alcotest on these grounds. *See State v. Harvey*, 151 *N.J.* 117, 171 (1997) (holding general acceptance of scientific evidence "does not require complete agreement over the accuracy of the test or the exclusion of the possibility of error").

We accept the testimony of Geller, Dee and Shaffer that the source code in these respects is reliable and reject Wisniewski and Workman's claims as too speculative.

J. *Source Code Writing and Review*

Although perhaps not critical, Shaffer's following recommendations should be considered as helpful in improving the product: (1) it is easier to find core routines if they are documented in the source code, but not necessary; (2) a more highly organized and consistently structured presentation would make the source code more readable and easier to sort, but would not make the code more understandable; and (3) a dedicated quality assurance person or outside expert who functioned in that role with respect to the source code review process would give Shaffer and Draeger a higher degree of certainty about the code.

V. FURTHER CONCLUSION

If *any* of the categories of data fields in the AIR are incomplete in any respect, e.g., missing calibration data, no part of the AIR can be used by the State for purposes of finding guilt. A BAC finding of .08 or above in such circumstance may not be admitted into evidence.

Foundational materials should be provided in all contested cases, not just in pro se or unrepresented cases as per our initial opinion. With reference to Addendum A in our initial opinion, and in the public interest, the State Bar, through its counsel Jeffrey E. Gold of Cherry Hill, is entitled to written notice of any proposed software revisions.

*****

We again express our gratitude for the very valuable work in this matter by our Appellate Division Staff Attorney Olga Chesler, Esquire, and for her excellent contribution to completing this difficult task both throughout the twelve-day hearing and the supplemental opinion preparation process. Many thanks, Ms. Chesler.

APPENDIX A — TRANSCRIPTS

1RT — transcript of September 17, 2007

2RT — transcript of September 18, 2007

3RT — transcript of September 19, 2007

4RT — transcript of September 20, 2007

5RT — transcript of September 24, 2007

6RT — transcript of September 25, 2007

7RT — transcript of September 26, 2007

8RT — transcript of October 9, 2007

9RT — transcript of October 10, 2007

10RT — transcript of October 11, 2007

11RT — transcript of October 23, 2007

12RT — transcript of October 24, 2007

APPENDIX D — FINDINGS AND CONCLUSIONS OF REMAND COURT DATED FEBRUARY 13, 2007

SUPREME COURT OF NEW JERSEY
September Term 2005
Docket No. 58,879

STATE OF NEW JERSEY,

Plaintiff,

v.

JANE H. CHUN, DARIA L. DE CICCO, JAMES R. HAUSLER, ANGEL MIRALDA, JEFFREY R. WOOD, ANTHONY ANZANO, MEHMET DEMIRELLI, RAJ DESIA, JEFFREY LOCASTRO, PETER LIEBERWIRTH, JEFFREY LING, HUSSAIN NAWAZ, FREDERICK OGBUTOR, PETER PIASECKI, LARA SLATER, CHRISTOPHER SALKOWITZ, ELINA TIRADO, DAVID WALKER, DAVID WHITMAN and JAIRO J. YATACO,

Defendants.

FINDINGS AND CONCLUSIONS OF REMAND COURT

On remand from the Supreme Court of New Jersey: December 14, 2005

Findings and Conclusions Submitted to Supreme Court: February 13, 2007

KING, P.J.A.D., SPECIAL MASTER

Appendix D

TABLE OF CONTENTS

I. PROCEDURAL HISTORY

The case arises from quasi-criminal actions involving twenty defendants who were arrested in Middlesex County for driving while under the influence of alcohol in violation of *N.J.S.A.* 39:4-50. Defendants challenged the admissibility and reliability of breath test results obtained from the Alcotest 7110 MKIII-C, firmware version NJ 3.11 (Alcotest 7110).

On October 14, 2005 the Law Division granted the State's motion to consolidate the cases pending as of May 23, 2005 in several Middlesex County municipal courts. Among other things, Judge Cantor denied the State's motion to take judicial notice of the opinion in *State v. Foley*, 370 *N.J. Super.* 341, 359 (Law Div. 2003), which ruled that the Alcotest 7110 MKIII-C was scientifically accurate and reliable and that its reported readings would be admitted into evidence without the need for expert testimony. At the time of *Foley*, New Jersey was using firmware version 3.8.

In her written statement of November 10, 2005 Judge Cantor explained that the Alcotest 7110 MKIII-C was a new instrument adopted throughout New Jersey on a county-by-county basis on a sequential timetable. She emphasized that only the Camden County, Law Division in *Foley* had found it scientifically reliable and that Judge Orlando, in dictum, had concluded that New Jersey should make certain changes in the instrument's firmware and the instructions given to its users. *Ibid.* Because the Alcotest 7110 MKIII-C was a novel scientific instrument which had never been vetted by an appellate court or our Supreme Court, Judge Cantor concluded that its scientific reliability remained a justiciable issue.

On December 1, 2005 the Appellate Division granted the State's motion for leave to appeal and denied its motion for a summary reversal. The Appellate Division remanded the matter to the trial court for an accelerated hearing on the validity of breath tests for alcohol, obtained through the use of Alcotest instruments.

On December 14, 2005 our Supreme Court certified the appeal pending in the Appellate Division on its own motion pursuant to *R.* 2:12-1. The Court vacated the remand to the Law Division and remanded the matter to retired Appellate Division Judge Michael Patrick King, to preside as a Special Master. The Court ordered the Special Master to conduct a hearing and report his findings and conclusions on an accelerated basis.

The Court ordered the Special Master to:

> 1. Conduct a plenary hearing on the reliability of Alcotest breath test instruments, including consideration of the pertinent portions of the record in *State v. Foley*, 370 *N.J. Super.* 341 (Law Div. 2003), and the within matters in the Superior Court, Law Division, Middlesex County, together with such additional expert testimony and arguments as may be presented by the parties;
>
> 2. Determine whether the testimony presented by the parties should be supplemented by that of independent experts selected by the Special Master;
>
> 3. Grant, in the Special Master's discretion, motions by appropriate entities seeking to participate as amici curiae, said motions to be filed with the Special Master within ten days of the filing date of this Order;
>
> 4. Invite, in the Special Master's discretion, the participation of entities or persons as amici curiae or, to the extent necessary in the

> interests of justice, as intervenors to assist the Special Master in the resolution of the issues before him; and
>
> 5. Within thirty days of the completion of the plenary hearing, file findings and conclusions with the Clerk of the Court and contemporaneously serve a copy on the parties and amici curiae, which service may be effectuated by the posting of the report on the Judiciary's website . . . .

The Court also ordered the parties, and permitted all amici curiae who participated in the plenary hearing, to serve and file initial briefs within fourteen days of the filing of the Special Master's report as well as responses, if any, within ten days. It further ordered the Clerk to set the matter for oral argument on the first available date after completion of briefing by the parties. Finally, the Court ordered the stay of *N.J.S.A.* 39:4-50 proceedings pending in Middlesex County, and directed all Superior and Municipal Court judges before whom such proceedings were pending, to ensure strict enforcement of the Court's Guidelines for Operation of Plea Agreements in the Municipal Courts of New Jersey.

On January 9, 2006 the Special Master granted to the Association of Criminal Defense Lawyers of New Jersey (ACDL) leave to appear as amicus curiae. On January 23, 2006 the Special Master also admitted the New Jersey State Bar Association (NJSBA) as amicus curiae, under *R.* 1:13-9, in view of the matter's public importance.

On January 10, 2006 the Court sua sponte issued an order addressing issues that affected the prosecution of *N.J.S.A.* 39:4-50 offenses statewide. The Court ordered all prosecutions and appeals which did not involve the Alcotest 7110 to proceed in the normal course. The Court, however, ordered the stay of prosecutions and appeals involving repeat offenders and the execution of their sentences where the convictions were based solely on Alcotest readings. The Court also ordered that first-offender prosecutions proceed to trial based on clinical evidence when available and on Alcotest readings. It ordered, however, that the execution of sentences for all first offenders be stayed pending disposition of the Court's final decision on the Alcotest 7110's reliability, unless public interest required their immediate implementation.

As explained by the Administrative Director, Judge Carchman, in a clarifying memorandum to municipal court judges dated January 17, 2006, a court could admit evidence of an Alcotest reading, over the objection of defense counsel, without first holding a hearing on the instrument's scientific reliability. He further explained that under *N.J.S.A.* 39:4-50(a)(2) and (3), the penalty for repeat offenders was the same whether the finding of guilt was based on observation or blood alcohol levels. However, for first offenders, the penalty could vary, making the Alcotest reliability hearing of fundamental importance.

On March 15, 2006 the Court entered an order directing the Special Master to designate an independent expert or experts. Upon deliberation and consultation with the parties and amici curiae, the Special Master determined that a court-appointed expert was not necessary for proof purposes, especially because of the quasi-criminal nature of the proceedings.

Meanwhile, discovery proceeded. On February 3, 2006 the Special Master entered an order directing the State to give defendants certain information, documents and materials pertaining to the Alcotest 7110's firmware, software, algorithms, electronic schematics, and source codes. Among other things, the discovery order recognized that the exchange of firmware and software might require a protective order to be submitted by the State or manufacturer for court approval. On February 17, 2006 the Special Master entered a supplemental discovery order directing the State to lend three Alcotest 7110s to defense counsel and one to counsel for the amicus NJSBA. Among other things, the supplemental discovery order also allowed the manufacturer Draeger Safety Diagnostics, Inc. (Draeger) to apply to intervene in this matter, especially because of the issue of "trade secrets."

Draeger objected to the discovery orders claiming that they permitted the release of trade secrets and proprietary information. On February 23, 2006 Draeger's intellectual property counsel prepared a proposed protective order and sent it to the State for submission to the court. Draeger's proposal included a request for indemnification from defense counsel. In response to defendants' objections to Draeger's initial draft — especially to the request for indemnity — and a revised proposal by the State, the Special Master requested defense counsel to submit a proposed protective order.

Draeger then offered to make copies of the Alcotest 7110's source codes available to the Special Master and explain them to him during an *in camera* session provided there would be no testimonial record and the data would be returned after his inspection and decision. Again, defense counsel objected, explaining that the purpose of requesting the source codes and algorithms was to allow their expert to review and test them.

On April 19, 2006 defendants submitted their proposed protective order. In anticipation of a court-issued protective order, the State provided to defense counsel and the amicus the four Alcotest 7110 instruments for their inspection.

On April 26, 2006 the Special Master entered a protective order which required all discovery information in which Draeger asserted an intellectual property right so marked. With regard to the marked discovery, the protective order required: (1) that the information could not be disclosed by parties or amici curiae, or by consultants and experts given access to it; and (2) that the information must be returned to Draeger following the conclusion of all litigation. The protective order also extended its terms and restrictions for three years from the termination of litigation or until such time as the marked discovery information entered the public domain, whichever came first, and stated that the violation or breach of any condition would be grounds for court contempt action, civil damages or other appropriate sanctions after a hearing where the accused would be afforded due process under *R.* 1:10. Additionally, if Draeger did not cooperate with discovery, the protective order allowed the Special Master to draw any appropriate negative inferences in his decision on the Alcotest 7110's reliability. The protective order did not include an indemnification provision.

Shortly after, on April 28, 2006, the State submitted comments on its revised proposed protective order. In part, the State explained that the indemnification provision would require those defendants who received the instruments to indemnify and hold harmless the State from any damage that might result from the firmware's use or installation.

On May 15, 2006 Draeger wrote to the State with its objections noting that it would not cooperate with discovery unless the court entered a "satisfactory" protective order. On May 22, 2006, after consideration of Draeger's expressed objections, the Special Master amended the protective order by: further limiting access to the information disclosed; extending the term and restrictions from three years to as long as the marked discovery information remained a trade secret or until it entered the public domain; and providing that other sanctions might be appropriate in cases where Draeger demonstrated at a hearing that it would suffer irreparable harm and there was no adequate remedy at law.

On June 15, 2006 Draeger wrote again to the State indicating that the amended protective order was an "improvement" but still did not provide adequate protection. Draeger continued to insist that the Special Master adopt an order substantially similar to its initial proposal. For example, Draeger contended: it should be provided with the identity of experts who would be given the marked information in discovery; it should not have to appear before the Special Master at a hearing to demonstrate irreparable harm; it should be allowed to demonstrate its intellectual property rights or prove its need for injunctive relief in a forum other than before Judge King; and it should not be forced to comply with an order essentially based upon a proposal by defendants who did not have any trade secrets or proprietary information to be protected.

Draeger also advised the Special Master and the State that it "recently" had adopted a "new policy" regarding confidential disclosure of the Alcotest 7110's source codes and other trade secrets to those individuals ¾ including parties involved in the *Chun* litigation — who accepted the following conditions: (1) individuals who agreed to sign appropriate non-disclosure and confidentiality agreements prepared by Draeger; (2) individuals who agreed to review the information in a room at Draeger's offices in Durango, Colorado; (3) individuals who agreed to allow a Draeger representative to be present in the room when they reviewed the information; and (4) individuals who agreed not to take photographs, make copies by writing or other means, or make any recordings of the information. To maintain its "non-party status," Draeger again declined the Special Master's offer to meet with him or participate in any conferences. Incidentally, Draeger has no United States or foreign patent protection on the Alcotest 7110.

Neither the State nor defendants expressed any interest in complying with Draeger's fastidious conditions on the source codes' disclosure. The Special Master also declined to further amend the protective order. Consequently, discovery and the exchange of documents and expert reports proceeded without Draeger's participation. This created an anomalous situation: the manufacturer was not a party to the defense of its product. The State had to defend the Alcotest 7110 derivately.

Pursuant to *N.J.R.E.* 104, the Special Master held forty-one full days of evidentiary hearings which commenced on September 18, 2006 and concluded on January 10, 2007. The parties and amicus NJSBA submitted proposed findings of fact and conclusions of law regarding the scientific reliability of the Alcotest 7110. As further ordered by the Court, the Special Master has issued his findings and conclusions in this matter within thirty days of the completion of the hearings.

II. STANDARD OF PROOF

The key issue is whether the Alcotest 7110 is a scientifically reliable instrument for determining the alcohol content of the breath and blood. The resolution of this question will assist the Supreme Court in determining whether the results of Alcotest 7110 readings generally may be admitted in evidence and support convictions under *N.J.S.A.* 39:4-50 and cognate statutes.

Under New Jersey's statutory scheme, a driver of a motor vehicle is guilty of a so-called "per se" violation of *N.J.S.A.* 39:4-50(a) at a "blood alcohol concentration of 0.08% or more by weight of alcohol in the defendant's blood." Thus, New Jersey is a "blood" alcohol jurisdiction as opposed to a "breath" alcohol jurisdiction. *See State v. Downie*, 117 *N.J.* 450, 469-71 (1990) (Stein, J., dissenting). A person "under the legal age [twenty-one] to purchase alcoholic beverages" while operating a motor vehicle "with a blood alcohol concentration of 0.01% or more" is subject to special penalties imposed by *N.J.S.A.* 39:4-50.14 (the so-called "kiddie drunk" law). Operation of a commercial vehicle "with an alcohol concentration of 0.04% or more" is separately prohibited by *N.J.S.A.* 39:3-10.13. Interestingly, this latter statute defines alcohol concentration either by "blood" or "breath," not by "blood" alone, as does *N.J.S.A.* 39:4-50. *See N.J.S.A.* 39:3-10.11. All agree that this "commercial vehicle" section is rarely, if ever, invoked by the police.

The .08% blood alcohol level must be enforced by the several states under pain of withholding of federal highway-aid funds. *See* 23 *U.S.C.A.* §§ 163 and 410; 23 *C.F.R.* § 1225. We understand that New Jersey is in compliance with the federal mandate as of 2004.

See L. 2004, *c.* 8 § 2 (amending *N.J.S.A.* 39:4-50(a), eff. April 26, 2004); *State v. Chambers*, 377 *N.J. Super.* 365, 371 (App. Div. 2005).

To allow the admission of scientific evidence in criminal cases, there must be general acceptance by the relevant scientific community. *State v. Harvey*, 151 *N.J.* 117, 169-70 (1997) (citing *Frye v. United States*, 293 *F.* 1013, 1014 (D.C. Cir. 1923); *Romano v. Kimmelman*, 96 *N.J.* 66, 80 (1984); *State v. Johnson*, 42 *N.J.* 146, 170-71 (1964); *Foley*, 370 *N.J. Super.* at 349. To establish general acceptance, test results must have "'sufficient scientific basis to produce uniform and reasonably reliable results [which] will contribute materially to the ascertainment of the truth.'" *Romano*, 96 *N.J.* at 80 (quoting *State v. Hurd*, 86 *N.J.* 525, 536 (1981)). "Proving general acceptance 'entails the strict application of the scientific method, which requires the extraordinarily high level of proof based on prolonged, controlled, consistent, and validated experience.'" *Harvey*, 151 *N.J.* at 171 (quoting *Rubanick v. Witco Chem. Corp.*, 125 *N.J.* 421, 436 (1991)).

Given the rapidly changing nature of modern science, courts recognize that continuing research may affect the scientific community's acceptance of a novel technology. *Id.* at 167-68. Thus, newly-devised scientific technology essentially achieves general acceptance only after it passes from an experimental to a demonstrable technique. *Id.* at 171.

General acceptance, however, does not require unanimous agreement about the accuracy of the scientific test or the infallibility of its methodology, techniques or procedures. *Ibid.* Nor does it require the exclusion of the possibility of error. *Ibid.*; *Romano*, 96 *N.J.* at 80. Indeed, our courts recognize that "[e]very scientific theory has its detractors." *Harvey*, 151 *N.J.* at 171.

In a criminal case where defendants challenge the prosecution's attempt to introduce a novel type of scientific evidence, a court may conduct a hearing under *N.J.R.E.* 104 to determine whether the scientific evidence is generally accepted. *Id.* at 167. Proof of its general acceptance can be obtained through expert testimony, publications or judicial opinions. *Id.* at 172-76; *Foley*, 370 *N.J. Super.* at 350. The party offering the evidence has the burden to "clearly establish" each of these methods. *Harvey*, 151 *N.J.* at 170; *Foley*, 370 *N.J. Super.* at 349 ("To establish general acceptance within the scientific community the proponent must meet the clear and convincing standard of proof.").

At a *N.J.R.E.* 104 hearing, however, proofs need not comply with the other rules of evidence, except that *N.J.R.E.* 403 may be invoked and valid rules of privilege are recognized. Biunno, *Current N.J. Rules of Evidence*, comment 4 on *N.J.R.E.* 104(a) (2006). Thus, hearsay evidence is admissible. *Ibid.* When a showing of general acceptability has been made, courts will take judicial notice of the scientific instrument's reliability. *Romano*, 96 *N.J.* at 80-82 (holding that the breathalyzer's general acceptance within the scientific community demonstrated its scientific reliability and that such reliability was the subject of judicial notice in all cases under *N.J.S.A.* 39:4-50).

The State must prove by clear and convincing evidence that the Alcotest 7110 is generally accepted in the relevant scientific community — even if such acceptance is not unanimous — for the purpose of determining the concentration of alcohol in the blood. If the Alcotest 7110 is a scientifically reliable instrument for measuring blood alcohol, the test results are admissible in evidence only in those cases where the State clearly establishes that: (1) the instrument was in proper working order; (2) the operator was qualified to administer the instrument; and (3) the test was administered in accordance with official instructions and New Jersey State Police protocol for the instrument's use. *See Romano*, 96 *N.J.* at 81.

III. THE FACTS

1. *Chemistry and Physiology*

Scientists have long known the presence of alcohol (ethanol) in the brain causes cerebral dysfunction leading to automobile accidents. The medium through which alcohol reaches the brain is the blood. If we could directly sample blood from the brain, the amount of alcohol it contains could be easily and accurately known. But we can not.

Alcohol comes into the human body through the stomach and passes to the small intestines. It is absorbed into the blood partly in the stomach but principally from the small intestines. Absorption can take place quite quickly or more slowly, depending on the contents of the stomach and the strength and quantity of the alcohol ingested. The alcohol-laden blood then passes to the liver and circulates through all parts of the body. It is found in all water in the body. Freshly formed urine, saliva or other body fluids receive alcohol in proportion to their water content. Blood from many parts of the body, taken after time allowed for absorption, will reflect the alcohol present throughout the body. Urine specimens and saliva samples are not particularly accurate and are difficult to obtain, especially on a repeat basis over a short period of time. They are unsatisfactory for field work.

The taking of blood samples poses some inconveniences but not of great magnitude. With blood the first issue is from what part of the body is the sample taken. The amount of alcohol present in the blood will vary between venous blood from the cubital or elbow vein in the arm, from fingertip capillary blood, or from arterial blood. Even arterial blood will provide different readings on the amount of alcohol present depending on the site where the blood sample is taken.

Arterial blood passes through the lungs into the heart and from there goes to the brain through the carotid arteries. On leaving the brain it travels through the venous system, goes back through the liver, and continues through the heart where it is again pumped into the arterial system and lungs.

Appendix D

Returning to the problem of determining how much alcohol is in the brain, the immediate source of blood supply to the brain is through the carotid arteries. If we could simply and safely draw a blood sample from one of those arteries this would be an excellent measure of alcohol in the brain. Such a procedure is neither simple nor safe.

Blood can be taken from other sites, commonly the finger tips or the cubital vein. Both sites are much more remote from the brain and do not give a precise indication of what is present in the brain at the time. The alcohol content of blood constantly changes as it circulates through the body. It is eliminated through various parts of the circulatory system but gains more alcohol from the small intestines so long as alcohol remains in the stomach.

For multiple tests, upon which the accuracy of blood readings depends, the fingertip blood or capillary blood is not satisfactory. The size of the sample is quite small and there is immediate danger of exposure to the air and evaporation of some of the alcohol, because alcohol is a very volatile substance. Venous blood is satisfactory as to quantity. However, it does not always give an accurate reflection of the alcohol in the brain, especially during the period during which alcohol is still being absorbed through the stomach and small intestines into the blood. All of this has been known to scientists for a long time.

Appendix D

Scientists also have long known that as the blood passes along the alveolar or honey-comb-like cells in the lungs, some of the volatile alcohol in the blood will escape into the breath chambers on the other side of the thin membrane which makes up those cells. This transfer of alcohol from blood to breath in the lungs proceeds, in general, at a fairly predictable rate for most, but probably in no two people is that rate precisely the same. This is because of biological variation.

Since arterial blood passing through the lungs is the most accessible practical spot for testing prior to going through the carotid arteries to the brain, it became apparent that if an accurate form of detecting the amount of alcohol in the breath could be developed and if the breath-alcohol level could be related to an assumed amount of alcohol in the arterial blood which produced it, a prediction could be made as to how much alcohol must be present in the blood flowing through the brain. Thus emerged the Breathalyzer and its progeny: all other breath-alcohol analyzing instruments.

In our view, there is really no problem at all with the technology for measuring the amount of alcohol present in a given sample of breath or vapor. The breathalyzer has been one of a number of scientifically-proven instruments. With proper working order and a trained operator, it can read alcohol in breath quite well and with satisfactorily scientific acceptability. Most all experts agree on this. The problem is converting that breath-alcohol reading or concentration (BrAC) into a blood alcohol concentration (BAC). This outcome depends on the process in the subject's lungs.

2. *History*

Evidential breath testers (EBTs) have been in use since Robert F. Borkenstein invented the breathalyzer in 1954. In 1984, National Draeger, Inc., the American subsidiary of Draegerwerk Aktiengesellschaft (Draeger AG), acquired Smith and Wesson, the breathalyzer's manufacturer, partially to gain access to the United State's market. Draeger AG was founded in 1887 in Luebeck, Germany.

Also in 1984, the National Highway Traffic Safety Administration (NHTSA), United States Department of Transportation (USDOT), issued a notice converting the mandatory standards for EBTs to model specifications and publishing a conforming products list (CPL) of such instruments to assist states in their purchasing decisions. 49 *Fed. Reg.* 48854 (Dec. 14, 1984). The model specifications also added an alternative laboratory method to test breath sampling capability, eliminating the need to test with human subjects. *Ibid.* NHTSA defined EBT's as "instruments that measure the alcohol content of deep lung breath samples with sufficient accuracy for evidential purposes." *Ibid.*

In 1993, NHTSA published the amended Model Specifications for Devices to Measure Breath Alcohol and an updated CPL to accommodate transportation workplace alcohol testing programs, to meet new zero tolerance laws for underage offenders, and to add testing for acetone interference. 58 *Fed. Reg.* 48705 (Sept. 17, 1993). The updated CPL listed the "Alcotest 7110." *Ibid.*

Appendix D

The USDOT Volpe National Transportation Systems Center (Volpe) in Cambridge, Massachusetts performs EBT testing for NHTSA on instruments submitted by manufacturers to determine their accuracy and precision. *Ibid.* NHTSA, through Volpe, also does special testing for end-users upon request. As Edward Conde explained, Volpe performs an “initial type approval” consisting of eight steps: accuracy and precision testing; acetone interference testing; blank testing; breath alcohol sample simulator (BASS) testing; power variation or voltage testing; temperature testing; post-vibration testing; and electrical safety inspection.

In 1994 Hanseuli Ryser, a key State’s witness in this proceeding and Draeger’s United States’ principal, established the Breathalyzer Division in the United States. Eight years later, the Breathalyzer Division merged with Draeger Interlock, Inc., and the name changed from National Draeger to Draeger Safety Diagnostics, Inc. (Draeger). As vice president of Draeger’s operations in Durango, Colorado, Ryser supervises the production, servicing and engineering of evidential breath-testing instruments.

In 1995 Draeger introduced to the United States market the Alcotest 7110 MKIII, which used a dual sensor measuring system consisting of infrared spectroscopy (IR) and electrochemical or fuel cell technology (EC), to analyze breath alcohol results. From November 1995 through February 1996, personnel from the Alcohol Drug Testing Unit (ADTU) of the New Jersey State Police along with then chief forensic scientist, Charles Tindall, Ph.D., and assistant chief forensic scientist, Thomas A. Brettell, Ph.D., performed various tests on four EBTs including the Alcotest 7110 MKIII. They conducted the tests for the purpose of selecting a new breath-testing instrument to replace the Breathalyzer Models 900 and 900A. As Brettell explained, breathalyzers produced "very good, reliable, precise, accurate" results when operated and maintained properly, but they were fast becoming dinosaurs since Draeger acquired the manufacturer and eventually stopped making spare parts, ampules and new instruments.

In addition to the Alcotest 7110 MKIII, the forensic scientists and ADTU members evaluated three other instruments: BAC Datamaster; Intoxilyzer 5000; and Intoximeter EC/IR. They performed validation studies including side-by-side testing for accuracy, precision, linearity, and specificity. They also qualitatively evaluated the instruments for such things as ease of operation, operator dependence, transportability, and printout information. Brettell testified that the results showed the Alcotest 7110 MKIII was capable of providing accurate and precise results. Brettell further testified that he recommended the State select the Alcotest 7110 with the wet bath simulator (Draeger CU34) and a laser-jet external printer, but without the detector for radio frequency interference (RFI) or the breath temperature sensor option.

In January 1996 Volpe successfully tested the Alcotest 7110 MKIII for accuracy and precision, among other things, and listed the instrument on the CPL. 61 *Fed. Reg.* 3078 (Jan. 30, 1996). Independent laboratories in the Netherlands (1994) and Paris, France and the German government (1998) also successfully tested the Alcotest 7110 MKIII for compliance with the more rigorous standards adopted by the Organisation Internationale de Metrologie Legale (OIML), an international treaty organization established in 1955 to address issues relating to the application of common legal measurements by its 113 members.

Draeger subsequently developed the Alcotest 7110 MKIII-C, which added an internal computer communications capability or modem as a standard feature. NHTSA did not re-test the instrument, concluding that the communication enhancement did not affect the instrument's accuracy or precision. In 1998 NHTSA amended the CPL to include, among others, the Alcotest 7110 MKIII-C. 63 *Fed. Reg.* 10066 (Feb. 27, 1998).

In 1998 the New Jersey Attorney General (AG) proposed the readoption, with amendments, of the Chemical Breath Testing Regulations, *N.J.A.C.* 13:51, which were scheduled to expire on September 16, 2001. 30 *N.J.R.* 4321(a) (Dec. 21, 1998). The proposed amendments addressed the introduction of new chemical breath testing methods and technology including the Alcotest 7110 MKIII as an improved instrument for testing a person's breath by chemical analysis. *Ibid.* After receiving no public comments, the AG approved the Alcotest 7110 MKIII for evidential breath testing in New Jersey. *N.J.A.C.* 13:51-3.5(a)(2); *N.J.A.C.* 13:51-3.5(a)(2)(i); *N.J.A.C.* 13:51-3.6(c). The regulations state in relevant part:

> 2. Infrared analysis and electrochemical analysis, when utilized in a single approved instrument as a dual system of chemical breath testing, is approved as a method of chemical breath testing.
>
>> i. The Alcotest 7110 MKIII, is a chemical breath test instrument which employs both infrared analysis and electrochemical analysis as a dual system of chemical breath testing and is an approved instrument for use in the testing of a person's breath by chemical analysis.

[*N.J.A.C.* 13:51-3.5(a)(2)(i).]

The State subsequently commissioned Draeger to develop a version of the Alcotest 7110's firmware to meet its particular needs. In 1998 Draeger delivered the first instruments with firmware version 3.8 to the New Jersey State Police.

On September 6, 2002 Draeger, the licensor, and the State of New Jersey, Department of Treasury, Division of Purchase and Property, on behalf of the State Police, the licensee, entered into a Firmware/Software License Agreement. The license agreement recognized that

Draeger owned the firmware and software, and that the State Police had a non-exclusive license to use the Alcotest 7110 MKIII-C under certain terms and conditions. One of the conditions required the licensee to agree not to "reverse engineer, decompile or disassemble the Firmware/Software or otherwise attempt to derive source codes from the Firmware/Software, not shall Licensee allow any other entity to do so."

Meanwhile, New Jersey reviewed and evaluated the operation of the Alcotest 7110, NJ 3.8 in the Pennsauken Township pilot program (pilot program) which took place from December 2000 through December 2001. Sergeant Kevin Flanagan, New Jersey State Police, testified that he loaned two instruments to the Pennsauken Township Police Department which then performed breath tests on 372 subjects suspected of operating a motor vehicle under the influence of alcohol. After the pilot program ended, the Camden County Prosecutor applied to the court for a consolidated proof hearing on the instrument's scientific reliability. *Foley*, 370 *N.J. Super.* at 345. The request related to cases pending before the Pennsauken Township Municipal Court which involved prosecutions for violation of *N.J.S.A.* 39:4-50, *N.J.S.A.* 39:3-10.13 or *N.J.S.A.* 12:7-46 (reckless boating). *Ibid.* The court granted the application and held an evidentiary hearing from September 8, 2003 to October 14, 2003. *Id.* at 345-46.

In 2003 New Jersey also requested Volpe to perform special testing of the Alcotest 7110, NJ 3.8, including informal RFI testing. Conde performed the tests and found that the instrument conformed to NHTSA's model specifications.

The *Foley* court also found that the Alcotest 7110 was a scientifically reliable evidential breath-testing instrument. *Id.* at 351. It found that the test readings produced by the Alcotest 7110 were accurate and admissible in evidence in a prosecution for violation of *N.J.S.A.* 39:4-50, *N.J.S.A.* 39:3-10.13 or *N.J.S.A.* 12:7-46 without the need for expert testimony. *Id.* at 359.

During the *Foley* hearings, however, it became apparent there were several functions or features of firmware version NJ 3.8 which required revision. For example, the judge expressed concern about the unusually high number of subjects in the pilot program who were unable to provide the minimum breath sample and were charged with refusal to submit to a breath test. *Id.* at 345. In response to the 28% refusal rate, the court directed the State to modify the firmware and change the instructions given to individuals who were about to use the instrument. *Ibid.* The court also ordered that no person who delivered a breath sample of at least 0.5 liters of air during a test on the Alcotest 7110 could be charged with refusal. *Ibid.*

After *Foley*, the State asked Draeger to make certain scientific and administrative changes to the firmware. From July through September 2004 Brettell and his laboratory staff performed validation testing on two beta or experimental versions of NJ 3.10. Brettell confirmed that Draeger made the requested changes to the instrument which included: giving operators the option simply to terminate the test rather than record it as a refusal; displaying "error" messages on the LED screen so operators could take them into consideration; automatically truncating the final blood alcohol result to two decimal places; instituting a two-minute lockout between breath tests; and allowing operators to observe the protocol for the twenty-minute observation period instead of locking the instrument preventing use during that period. Draeger also revised the alcohol influence report (AIR) to present all information on one page, including error messages, and New Jersey revised its blowing instructions to ask subjects for deep breaths.

Shortly thereafter, Flanagan and the ADTU operators discovered that four data fields could not be reviewed including the subject's drivers license number, the issuing state, the agency case number, and the summons number. Draeger made these changes, which Flanagan verified, and the State then received current firmware version NJ 3.11. Brettell did not perform additional testing and validation because he believed these changes did not affect the analytical operation.

New Jersey asked Volpe to perform special testing to determine if the Alcotest 7110, NJ 3.11 complied with NHTSA's model specifications. From December 2005 to February 2006, Conde performed tests on the Alcotest 7110, NJ 3.11, retaining only those AIRs which contained data needed for type approval or disapproval. Conde again concluded that the NJ 3.11 met the model specifications and was suitable for use in an evidential environment.

In January 2005 police departments in Middlesex County began to use the Alcotest 7110, NJ 3.11. By December 2005 thirteen of New Jersey's twenty-one counties were using the Alcotest 7110 in place of the breathalyzer for evidential breath testing. In April and June 2006, at the recommendation of the Division of Criminal Justice and the State Police, the roll-out of the Alcotest 7110 continued in several more counties including Atlantic, Cape May, Passaic and Sussex. The State Police had scheduled roll-outs in October 2006 for the remaining four counties — Bergen, Hudson, Monmouth and Essex — but ceased pending decision in this case. To date, New Jersey and its municipalities have bought about 480 instruments with extended four-year warranties for approximately $11,800 each.

At the time of the hearing, at least three other states (Alabama, New York and Massachusetts) and several countries including Germany, Finland, Austria, Italy, Spain, South Africa, Taiwan, Hong Kong, Bulgaria, Guam and the Northern Marianas were using the Alcotest 7110 for evidential breath testing.

3. *The Instrument*

The Alcotest 7110 is a breath alcohol analyzer used for evidential breath alcohol measurements. It weighs approximately 16.5 pounds and resembles a tool kit. The entire system includes the breath analyzer, a special organizer stand with a drawer, a standard keyboard, an external laser printer, a wet bath simulator, and a temperature probe.

The instrument fits in a metal case with a cover that is removed when in use. On its rear side, there are various interfaces including an exhaust port, an outlet port to deliver air to the simulator, and an inlet port to the IR absorption chamber (or cuvette). There also are power and start buttons, and a tag with the instrument's serial number. The top surface contains a flexible breath hose which is forty-six inches long and heated with two temperature sensors to 43 plus or minus 0.3 degrees Celsius to prevent condensation and overheating of the hose material. A disposable mouthpiece fits onto the breath hose to ensure a better seal, make it easier to exhale, and aid hygiene. The mouthpiece is changed after each breath sample.

The top of the instrument contains a forty-character light-emitting diode (LED) display screen which prompts the operator to take certain actions, describes the operation being performed, conveys error messages, and displays BAC results. The instrument operates in AC or DC modes. It contains an internal printer which uses paper 2 1/4 inches in width and approximately 22 inches in length, but is disabled in New Jersey in favor of an external printer.

While the Alcotest 7110 shares some of the same features as a computer, we find it best described as an embedded system with a very specific, dedicated purpose. The instrument has fairly limited interface sensors and operates by using a very reduced logic code which is sufficient to support its function. Like a computer, however, the Alcotest 7110 contains both hardware and software components.

Hardware components include the IR absorption chamber, EC sampling system, sensors (flow and pressure), a signal processing system, and a microprocessor. Software components include firmware for the microprocessor and software to handle data communications, data retrieval, and operator input.

The Alcotest 7110 is the only evidential breath-testing instrument which uses a dual system of IR absorption analysis and EC fuel cell technology to independently measure alcohol concentration in the same breath sample. Ryser explained that Draeger does not hold a patent for the dual technology because, among other things, it wants to avoid the disclosure of company "trade secrets." Draeger, however, does hold a trademark for the name "Alcotest."

The *Foley* court accurately described the IR and EC methods this way:

> IR Analysis
>
> Within the instrument a source emits an infrared light which is sensed by a detector. The infrared light from the source to the detector is established in the absence of

> alcohol as the baseline condition. When a breath containing alcohol is introduced into the chamber some of the infrared light is absorbed by the alcohol molecules and therefore does not reach the detector. The comparison between the presample IR and the sample IR transmission results in a lesser amount of infrared light with the sample present. The quantitative difference in the amount of infrared light reaching the detector is converted by the circuitry into a printed result which equates to the alcohol concentration of the person's breath.
>
> EC Analysis
>
> The instrument also contains a fuel cell which produces an electrical current. In the absence of alcohol the current is flat. When alcohol is introduced the electrons which flow between the anode and cathode on the fuel cell increase. This increase in the flow of electricity is interpreted by the [Alcotest] 7110 as the effect of alcohol in the breath.

[*Foley*, 370 *N.J. Super.* at 346.]

While we adopt as fact the descriptions of these two methods as set forth in *Foley*, we find these additional facts about the Alcotest 7110 in connection with our decision.

Appendix D

IR technology has been available since 1974. In the Alcotest 7110, IR analysis observes a subject's breath from the beginning to the end of its presentation. The solid brass cuvette chamber holds approximately seventy milliliters which is small enough to avoid mixing old and new breath but large enough to absorb energy when alcohol is present. The chamber is heated to prevent condensation on its walls and internal parabolic mirrors. The mirrors are gold-plated to optimize energy reflection and placed at either end of the cuvette, where they deflect the emitted IR light a specific number of times until a detector receives it. Unlike the majority of breath-testing instruments which operate at the 3.4 or 3.5 micron range, the Alcotest 7110 detects alcohol in the 9.5 micron range of the IR spectrum. By only allowing energy at the higher wavelength to pass through the IR filter, the instrument is less susceptible to endogenous interfering substances such as acetone, acetaldehyde and ketones.

EC technology also has been available for many years, at least since the mid-1960s, but has not been used for evidential purposes until the mid-to-late 1980s when the introduction of microprocessors provided the necessary speed. Unlike IR absorption, however, EC analysis waits until the end of a subject's exhalation to take a breath sample out of the IR chamber for analysis.

The fuel cell consists of plastic housing with a vapor inlet port and an exhaust port, and its interior consists of a porous matrix of plastic materials filled with sulfuric acid. Platinum plates on both sides attach to two electrodes or wires which lead to the outside of the fuel cell housing. A small piston assembly draws in a sample approximately one cubic centimeter in volume from the same breath sample in the cuvette.

For a single breath sample to be acceptable, Draeger programmed the Alcotest 7110 with a preset tolerance which requires the IR and EC results to agree within .008 blood alcohol concentration (BAC) or 10% of the IR reading, whichever is greater. Draeger set that particular tolerance so the instrument would be compatible with OIML specifications.

To detect interfering substances, the Alcotest compares the IR and EC readings. Where only alcohol is present on the breath, the readings will be similar but where interferents — endogenous and exogenous — are present, the readings will diverge.

Another standard feature includes RFI shielding, which protects the instrument from outside interference which can affect its components. The RFI shielding consists of metal coating underneath the top lid and a metal bottom, both of which prevent electromagnetic waves from entering the instrument. The instrument's five-layer printed circuit board (or motherboard) also suppresses RFI influence. Because of the shielding and special design, Ryser did not recommend that New Jersey purchase the optional RFI detector offered by Draeger. He expressed concern that the RFI detector permitted undesirable penetration of the shield through a small hole. The Alcotest 7110 also successfully underwent informal RFI testing by NHTSA, by laboratories using OIML standards, and Brettell's staff at the State's forensic laboratory. Nonetheless, the ADTU instructs operators to keep portable radios and cell phones out of the room during breath testing.

The State also did not purchase the breath temperature sensor option. The sensor consists of a thermistor placed into the breath hose to measure a subject's breath temperature. For calibration, the temperature sensor requires substantial equipment including two large heated tanks which cost about $15,000 each and two automatic calibration devices which cost about $36,000 each. Draeger is the only manufacturer which offers the sensor. Alabama uses the optional sensor to make downward corrections in the software of 6.58% for each degree that the breath temperature exceeds the standard 34 degrees C; Germany uses it to make both upward and downward corrections.

Draeger designed the Alcotest 7110 to measure samples of alveolar or deep lung air. To provide a valid breath sample in New Jersey, a subject must meet five criteria: (1) minimum breath volume of 1.5 liters; (2) minimum blow duration of 4.5 seconds; (3) minimum flow rate of 2.5 liters per minute; (4) the breath sample must reach a plateau (equilibrium), meaning that the IR reading must not change by more than 1% per 0.25 second; and (5) no detection of mouth alcohol or interfering substances. When a subject fails to meet any of the criteria, the display screen will report an "error" message.

With regard to mouth alcohol, operators in New Jersey must continuously observe a subject for a full twenty minutes, without interruption, before they can begin the breath test. During that time, the subjects cannot have any substances in their mouths nor can they regurgitate or burp. If there are any interruptions, the twenty minutes must start over again. New Jersey also intended for the Alcotest 7110 to institute a two-minute lockout between breath samples to prevent mouth alcohol inside the cuvette from contaminating the second sample. However, Flanagan and Brettell recently became aware that the instrument was not uniformly adhering to the two-minute lockout by about a second or two, and have contacted Draeger about the problem. The instrument's slope detector also provides an additional safeguard against mouth alcohol.

After receiving two valid breath samples, the Alcotest 7110 compares the results of the four readings: two taken by the IR and two by the EC technologies. The two breath samples must be within a specific tolerance of each other for the tests to be considered reliable. If the two samples are not within the tolerance range, a third test is forced.

This court recognizes Brettell's testimony that firmware version NJ 3.11 requires the test results to be within plus or minus .01 or plus or minus 10% of the mean of the four readings (two EC and two IR), whichever is greater. The NJ 3.11 version allows the operator a maximum of eleven attempts to collect two valid breath samples. After the eleventh try, the operator may terminate the test and restart the sequence, terminate the test and report it as a refusal, or terminate the test and give an opinion that the subject was not capable of providing a proper sample. For example, both Flanagan and Brettell stated that women over age seventy would have trouble providing 1.5 liters of breath and should not be charged with refusal. In those cases, the officers may chose to take the women to a hospital for blood tests or issue a summons based solely on observations.

Draeger ships the instruments directly to the police departments which purchased them. Prior to shipping, Draeger calibrates the instruments, simulators, and temperature probes, and certifies their accuracy. Upon their arrival and before the instruments are placed into service, an ADTU coordinator from the State Police verifies the firmware version, calibrates them, sets the tolerances, conducts control and linearity tests, and performs a solution change.

Calibration of the Alcotest 7110 involves a wet bath simulator, the Draeger CU34, and one bottle of 0.10 ethanol alcohol solution. The ethanol alcohol solution is poured into the simulator jar where it is heated to 34 plus or minus 0.2 degrees C. A NIST-traceable temperature probe monitors the temperature of the simulator solution. NIST refers to the National Institute of Standards and Technology, which is responsible for establishing, maintaining and publishing basic standards of measurement consistent with their international counterparts. Each temperature probe has a probe value, which can be changed only by a coordinator using the "black-key" function. When the instrument determines that the simulator has reached the correct temperature, the coordinator hooks up the simulator to the back of the instrument through the rear port of the cuvette. The coordinator then hits the escape key, the function appears on the display screen, the coordinator types in calibrate, and follows the instrument's prompts.

The coordinator then performs a control test to verify that the instrument is properly calibrated to the .10 simulator solution. The linearity test then uses three different simulator solutions of .04, .08 and .16. The instrument performs two tests on each solution. Afterwards, the coordinator uses a bottle of solution from the local police department and generates a solution change report. At that point, the calibration test sequence is complete and the instrument prints a calibration record.

Draeger ships the simulator solutions in lots of 1000, but only after Brettell's laboratory has tested six bottles from each lot to make sure they are within tolerance. For the .10 solution change, Brettell set the tolerance at .005 or 5%. Draeger's default tolerance at .010 or 10%. Brettell's laboratory issues certificates of analysis stating that each simulator solution was within specifications of the target value for the particular concentration. New Jersey protocol requires bottles to be changed after thirty days or twenty-five subject tests, or sooner if the instrument gives an error message that the solution is depleted.

After the initial calibration, an ADTU coordinator will recalibrate the instrument every twelve months, after an instrument is returned for service after repairs, or whenever a coordinator considers it necessary. *See N.J.A.C.* 13:51-4.3(b). Draeger also annually recalibrates the simulators and temperature probes.

The Alcotest 7110 employs multiple steps in testing an individual's breath alcohol concentration. While the court accurately described the sequence in *Foley*, 370 *N.J. Super.* at 347-48, a brief review of the salient facts is presented here.

After the operator explains the process to the individual, the operator removes a new mouthpiece from a sealed plastic bag and inserts it onto the breath hose. The operator then starts the instrument and inputs basic identifying information such as the test subject's name, weight, age, and identifying documentation and license number. The instrument automatically inputs the time and date.

The breath test sequence adopted for New Jersey consists of the following steps: ambient air blank check; control test; ambient air check; breath test one; ambient air check; breath test two; ambient air check; control test; and ambient air check. The purpose of the ambient air checks is to ensure that the air in the instrument's chamber (or cuvette) is free of any interfering substances and registers an alcohol level of 0.00%.

For the breath test, the operator instructs the individual to take a deep breath and blow into the instrument. When ten asterisks appear on the LED screen, the subject has reached the minimum volume requirement of 1.5 liters. However, the ADTU trains operators to encourage subjects to blow up to 3.0 liters (or until twenty asterisks appear on the screen) in order to ensure that the subject has reached deep lung air. After registering at least the minimum volume of air required for testing, the operator instructs the individual to stop blowing.

Upon completion of the test sequence, the Alcotest 7110 prints an AIR on an 8.5 X 11 sheet of paper which contains the individual's identification, date, time, and test results for each stage of the procedure. If the results are within the acceptable tolerance, the AIR shows the successful BAC values to three decimal places. The AIR then shows the final BAC test results as the lowest of the four readings which the instrument truncates to two decimal places. The AIRs are sequentially numbered. The ADTU instructs operators to give one copy to the local police department, retain one copy, and give a copy to the subject.

The Alcotest 7110 has a modem capable of communicating with a central server. Such communication would allow for data to be uploaded daily or weekly from each instrument in the field to a central location for the purpose of data collection. The digital data would be maintained there for a period of time which this court believes should not be less than ten years. Draeger is willing to provide the State with a Microsoft Access database program at no cost.

New Jersey, however, does not use the standard modem. Brettell discussed the issue of centralized data management with the Porter Lee Corporation, the software company which created New Jersey's laboratory information management (LIM) system. In September 2005 Porter Lee gave Brettell an estimate of $9760 for the transfer of the Alcotest data to the LIM database. The State, however, never proceeded with the project.

As of the time of this hearing, ADTU coordinators download the electronic data in the field onto their laptops. Although the Alcotest 7110 has the option to store 1000 test results, New Jersey protocol requires coordinators to download data at or before 500 tests.

Finally, the Alcotest 7110 relies upon source codes which consist of its own language with syntax, specially named routines, and formatting conventions. An examination of the source codes presumably would reveal if the firmware was properly implementing the intended algorithms and computations, and if the data communication, retrieval and input software was subject to malicious manipulation.

We already have discussed Draeger's grudging attitude and non-cooperation about revealing the source codes during discovery. From the onset of this matter, the parties could not agree about terms for inspection of the source codes. We cannot fault the refusal of defense counsel to permit the Draeger interests to propagandize the court in an *ex parte* proceeding. *See R.* 1:2-2. Nor can we fault the defense's rejection of Draeger's proffer of an inspection in Durango, Colorado under very restrictive and sanitized conditions.

But we draw no negative inference against Draeger for its recalcitrant and less than forthright cooperation in discovery in this litigation, which centered upon the integrity of its Alcotest 7110 product. Indeed, Ryser's response to the subpoena served upon him and the Draeger interests during his cross-examination in this case on October 12, 2006, and at this court's suggestion, was substantial and very helpful to this court and the parties. We do not think that this dispute about the source codes has any substantial relevance to our ultimate conclusion, that the Alcotest 7110 instrument is very good at measuring breath alcohol. Further, we conclude that the under-resourced defendants and amici had no way of examining or testing the elaborate source codes at this late point in the litigation. Source code issues arise when the instrument fails to perform properly or its various components fail to interface with each other. We have seen no hint of source code problems or failure throughout this litigation.

IV. EXPERT TESTIMONY

1. *Summary of Testimony of State's Expert and Draeger's Principal, Hansueli Ryser*

Hansueli Ryser was born and raised in Zurich, Switzerland where he received an electrical engineering degree in 1973 from the Federal College of Technology (19T13).[1] After working several years as an engineer for Seeholzer AG in Zurich, Ryser joined CMI, Incorporated, the manufacturer of the Intoxilyzer (19T16-19T17;19T51). At CMI, he designed electronic circuitries for the Intoxilyzer series (1978-1979), established a quality assurance department (1979-1980), served as director of manufacturing (1980-1982), and ultimately became president when it came under new ownership (1982-1986) (19T16-19T18;19T25-19T26). He then accepted the position of Director and CEO at EyeMetrics Corporation in Switzerland, a firm which specialized in optics and electronic imaging analysis (19T16;19T18;19T27).

In early 1991, Ryser became President of Draeger Switzerland AG, a subsidiary of Draeger Safety AG (19T14-19T16;49T58). In mid-1994, Ryser established the Breathalyzer Division of National Draeger, Inc. in the United States (19T15;49T30-49T31). In 2002, the Breathalyzer Division merged with Draeger Interlock, Inc. (a separate company which sold breath analyzers for installation in cars) and the name changed from

1. For designation of transcripts, *see* Appendix A.

National Draeger to Draeger Safety Diagnostics, Inc. (Draeger) (19T14;49T30-49T31;49T104). Draeger has offices in Durango, Colorado (production, servicing and engineering) and in Dallas, Texas (sales and marketing, and the interlock business) (49T104). Ryser is vice president in charge of the Durango operations, where he supervises a staff of thirteen (19T15;49T143;50T9). He holds dual citizenship: Swiss and American (19T60).

Ryser ranked these Draeger entities in their hierarchy: (1) Draeger; (2) Draeger Safety, Inc. (DSI); (3) Draeger Safety AG (Draeger AG) in Luebeck; and (4) the holding company, Draegerwerk Aktiengesellschaft (Draegerwerk AG) in Luebeck (23T4;49T59;49T140;49T142;50T14). According to Ryser, Draeger remained under the "very tight control" of Draeger AG (19T59).

Ryser is a member of several professional organizations including the International Association of Chemical Testers (IACT), the National Safety Council's Committee on Alcohol and Other Drugs, and the National Commission for Alcohol and other Drugs (19T19). He previously testified in Florida on the scientific reliability of the Intoxilyzer 5000, in Colorado on the source code issue relating to the Alcotest 7410 handheld instrument, and in *Foley* (19T19-19T20;19T24-19T25). The State moved to qualify Ryser as an expert in electrical engineering and breath-testing devices (19T20). He testified over the course of seven days.[2]

2. Ryser testified at the hearings on October 5, 10, 11, and 12, on November 14 and 15, and by telephone on December 12, 2006.

In 1984 the Draeger organization acquired Smith and Wesson, the manufacturer of the breathalyzer, partially to gain access to the United State's market (20T49-20T50;20T54). Ryser believed that the breathalyzer's once state-of-the-art technology still was "very proper and correct" (20T51;20T56-20T57). He explained, however, that the breathalyzer differed from the Alcotest 7110 in several major respects: (1) the breathalyzer was more susceptible to an operator's influence; (2) every thirty days, a trooper had to check the breathalyzer in the field; and (3) the breathalyzer recorded data by the operator's hand on a "little paper" (20T51-20T56;51T88).

In 1995 Draeger introduced to the United State's market the first Alcotest 7110 MKIII which was "built" in Durango (49T116). The instrument was tested successfully by NHTSA and by independent laboratories against OIML standards including the MNI Laboratory in the Netherlands (OIML draft three) (1994) and NLA (or NLE) the national laboratory in Paris (OIML draft four) (20T41-20T42). In 1998 the German government also tested the instrument against the OIML specifications, which provided the basis for Germany's switch from blood analysis to breath (20T43).

The Alcotest 7110, however, is not included on the OIML certification list (51T101). In fact, the list contained only one breath-testing device which was the Seres instrument made in France by a company that subsequently went bankrupt (51T102). Because of the cost of OIML testing, in excess of $45,000, and the fact that its requirements have been continuously diluted over time, Draeger has not submitted the Alcotest 7110, NJ 3.11 for OIML testing (51T102).

The Alcotest 7110 instrument costs approximately $7300 for the basic instrument or $10,000 for the entire system, excluding extended warranties or other services (19T62-19T63). At the time of the hearing, the Alcotest 7110 was used exclusively by the State Police in New York, New Jersey (except for four counties which are awaiting the changeover), Alabama, Massachusetts, and the Ramah Navaho Indian Reservation in New Mexico, and nonexclusively in California, Rhode Island, New Mexico, Oregon and Illinois (20T43-20T45;20T47;21T11;50T45-50T51).[3] It also is used exclusively in Guam, the Northern Marianas, Finland, Germany, Austria, Italy, Spain, South Africa, Taiwan, Hong Kong, and Bulgaria, and non-exclusively in various former Russian or Soviet countries, the Middle East, Australia, and Denmark (20T45-20T47;20T60). New Zealand also used an infrared table-top type instrument, although it was unclear from the testimony if Ryser was referring to the Alcotest 7110 (20T48).

In 1998 Draeger delivered the first instruments to the New Jersey State Police (22T72). In September 2002

---

3. Draeger sold about 240 instruments to Alabama (a "blood" state) and 430 instruments to Massachusetts (a "breath" state) (20T29;25T33-25T34). Draeger also sold the Alcotest 7110 to individual police departments in California along with its hand-held device, which it sold statewide (25T34).

Draeger and the State entered into a software licensing agreement (22T74). To date, New Jersey has bought 480 of the instruments with extended four-year warranties for approximately $11,800 each (19T63;21T12;26T34).

Ryser fully described the Alcotest 7110, NJ 3.11, including its various components (19T79-19T148). For a detailed discussion and visual demonstration, we refer the reader to the videotape produced during the hearing (S-26).[4] A brief overview follows.

The Alcotest 7110 analyzes alcohol vapor in the human breath according to an evidential protocol (19T80). The entire system includes a special organizer stand with a drawer, a breath analyzer, a standard keyboard, an external laser printer, a wet bath simulator used to introduce a known alcohol concentration for accuracy verification purposes, and a temperature probe (19T62-19T63;19T79-19T82).

The instrument's external features include: various interfaces on the back side including an exhaust port, an outlet port delivering air to the simulator, and an inlet port to the cuvette; a power button; a start button which engages a test or wakes up the instrument from standby mode; a forty-character backlit fluorescent display screen; a serial tag; a flexible breath hose which

4. At the State's request, the videographer also made copies onto DVDs which were distributed to this court, defense counsel, and *amici* (19T149;S-26A).

is forty-six inches long (so the subject does not have to bend forward to take the test) and heated with two temperature sensors to 43 degrees C plus or minus 3 degrees C to prevent condensation and overheating of the rubber hose; a mouthpiece for the breath hose which ensures a better seal, makes it easier to exhale, and aids hygiene; and an AC power cord (19T83-19T91; 19T120;19T122;21T53-21T57).

The internal features include: an infrared (IR) absorption chamber or cuvette; an electrochemical sampling system (EC) which consists of a fuel cell, pump, and motor; a power supply for direct current (DC) low power voltage to the entire system; a DC pump which purges the air inside the cuvette after a test is completed and provides air to the simulator for control check purposes; a solenoid which sends air to either the cuvette or the simulator; a large printed circuit (PC) board or motherboard which contains all the electronic components including the microprocessor[5] and the electronically erasable programmable read only memory (EEPROM) which stores the firmware; an interface board which contains all the outside connections; an internal printer which prints data on register-type tape as opposed to the easier-to-read letter-size paper used

---

5. "All incoming signals from the sensors are passed to the microprocessor via a multiplexer and 12 bit A/D converters for further analysis. The microprocessor continuously checks all supply voltages and important components to ensure proper operation. It also has an RS 232 interface to communicate with a computer allowing all stored data to be uploaded with optional communication software" (S-49 at 18).

by the external printer; electrical chokes; an AC compartment; a pressure sensor which provides information on breath volume; and a flow sensor which detects and measures the flow rate of a subject's breath (19T82-19T83;19T91-19T93;19T98-19T99; 19T101;19T112-19T113). Ryser explained that the Bundesamt, the German governmental entity for legal metrology, required redundant sensors (19T99-19T100).[6]

The Alcotest 7110 is the only breath-testing instrument using dual technology to quantify alcohol concentration in the same breath sample (19T175-19T176;20T21). Draeger does not hold a patent for the dual technology, but holds several patents for certain processes within the system (19T38;20T21-20T22). Ryser believed that Draeger did not aggressively pursue patents, desiring to avoid disclosure of company "trade secrets" (20T22;22T67). The name "Alcotest," however, is protected as a trademark (19T40).

IR technology has been available since 1974 (19T174). In the Alcotest 7110, IR technology acts as the "real time analyzer" because it observes breath from the beginning to the end of its presentation (19T174). The solid brass IR chamber is heated to prevent condensation on its walls and internal parabolic mirrors (19T94-19T95). The mirrors cover the front and back of

---

6. To open the Alcotest 7110, Ryser released the four safety screws using a security screwdriver made in England (19T122).

the chamber, and are gold-coated to optimize IR energy reflection (19T95).[7] The mirrors deflect the IR energy within the chamber a specific number of times before the energy hits the IR detector (19T95).[8] The IR filter (which sits on top of the detector) allows only those parts of energy to pass through the filter that relate to 9.5 microns[9] on the IR spectrum (19T132;21T60). Unlike the majority of breath-testing instruments operating at the 3.4 or 3.5 micron range, the higher wavelength is less susceptible to endogenous interfering substances such as acetone, acetaldehyde and ketones (19T155-19T158;21T60-21T61). The chamber's inner volume is small enough at 70 ml. to avoid mixing old with new breath but large enough to absorb energy when alcohol vapor is present (19T93;19T153).

EC technology or fuel cells have been used since the mid-1960s for alcohol measurement (19T162). In the mid-to-late 1980s, the introduction of microprocessors provided the speed necessary to allow fuel cells to perform calculations for evidential purposes (19T162-

---

7. IR energy refers to "[t]he part of the invisible spectrum, contiguous to the red end of the visible spectrum of electromagnetic radiation, which travels through space in waves. Behavior of such waves is similar to that of visible light waves" (S-49 at 8).

8. "The IR detector converts IR energy to electrical energy" (D-7 at 10).

9. One micron equals one millionth of a meter (D-7 at 8).

19T163). Unlike IR technology, the fuel cell in the Alcotest 7110 waits until the end of exhalation to take a breath sample out of the IR chamber for analysis (19T175). The fuel cell consists of plastic housing about an inch in diameter with a vapor inlet port and an exhaust port leading to the pump (19T97-19T98;S-28). Its interior contains a porous matrix of plastic material filled with sulfuric acid (19T97). There are platinum plates on both sides which are attached to two electrodes or wires leading to the outside of the fuel cell housing (19T97). A small piston pump assembly draws in a sample approximately one cubic centimeter in volume from the same breath sample, which is already in the cuvette (19T134;19T161).[10]

Another standard feature includes shielding for RFI, which can affect the instrument's components (19T104). RFI refers to interference which enters the instrument from the outside whereas electromagnetic interference (EMI) refers to interference which the instrument generates (23T39;61T19-61T20). Both RFI and EMI are subsets of electromagnetic compatibility (EMC) (23T39). The Alcotest 7110's shielding consists of metal coating underneath the top lid along with a metal bottom, which simulates a faraday chamber by preventing any electromagnetic waves from entering the

---

10. According to Draeger's Instructor Training Manual, "[o]nce ethanol reaches the [EC] sensor, a chemical reaction is triggered. The resulting current is used to determine the amount of alcohol in the sample" (D-7 at 5).

instrument (19T106;19T129).[11] Ryser also explained that the instrument's five-layer PC board is designed specifically to suppress the influence of RFI (19T107-19T108;23T38-23T39).

Because of the shielding and special design, Ryser did not recommend that New Jersey purchase the optional RFI detector offered by Draeger (19T109;61T43-61T44). To the contrary, he expressed concern that the detector required a small hole in the faraday chamber to bring the signal into the processor (19T109).[12]

Instead, Ryser recommended RFI testing in a special laboratory where the Alcotest 7110 would be exposed to different frequencies (19T109). For example, the National Laboratory for Metrology in Holland and the national laboratory in Paris performed RFI testing on the Alcotest 7110 in accordance with OIML standards (19T110;61T57-61T58). The tests were done in a special radiation chamber with an antenna source which allowed for the transmission of various frequencies and modulations (61T58). The tests exposed the instrument

---

11. A faraday chamber or cage is "a grounded metallic screen completely surrounding a space to protect it from external electrostatic influence." *Webster's Third New International Dictionary* 823 (3d ed. 1971).

12. Germany does not use the RFI detector, but New York does (61T56-61T57). Ryser could not recall if Massachusetts or Alabama used it (61T57).

to radiation as strong as ten volts per meter and over a frequency span up to one gigahertz (61T58).

To detect interfering substances, the Alcotest 7110 compares the IR and EC readings (19T169). If only alcohol (ethanol) is present, the readings are similar (19T173). If another substance is present, however, the readings diverge (19T173). There is a preset tolerance that requires the results of both readings to be within .008% BAC or 10% of the IR reading, whichever is greater; if the two results exceed the tolerance, the instrument displays an interference message and aborts the test (19T168-19T169;19T173-19T174). Draeger set the tolerance to make the system compatible with OIML standards (19T169).

Ryser testified that the two samples or four tests (two IR and two EC) must agree within plus or minus .01 BAC of the average of the four measurements or plus or minus 10% of the average of the four measurements, whichever is greater (19T170). If the first two breath samples are not within acceptable tolerance agreement, the Alcotest 7110 requires collection of a third, valid breath sample (D-15 at 13). Recognizing that there had been confusion over the correct tolerance, Ryser explained there was no change between versions 3.8 and 3.11 — the only two versions used in New Jersey — but that the language in Draeger's operator's manual for version 3.8 was not correct (22T36-22T38;49T53). This language has been corrected for current use.

Draeger calibrated its evidential breath analyzers based upon the customer's request (19T73). Draeger calibrated the Alcotest 7110 in New Jersey to interpret a certain concentration of alcohol with reference to a blood/breath ratio of 2100:1 (21T70). Ryser understood the ratio in the population was higher and believed that the 2100 figure favored an average defendant (21T70;22T20-22T21). While he could not recall the exact percentage, he seemed to agree that the ratio favored at least 84% of the population (21T71-21T72). He also understood that the ratio differed between individuals and for the same individual from time-to-time based upon changing physiological conditions (21T70-21T71). Draeger recommended that the instrument be recalibrated every twelve months (50T21-50T23).

Ryser also reviewed New Jersey's testing protocol. New Jersey's control test verifies accuracy every time a breath test is done (50T26;50T30). Ryser considered this the most rigorous possible quality control regime.

First, an ambient air blank verifies that the air inside the chamber is free of any absorbing alcohol vapor (19T178-19T179). Essentially, the air blanks force ambient or room air through the chamber to produce a result of .000% alcohol levels (19T178-19T179).

Next, a control test verifies the instrument's accuracy by using a simulator with a known standard of water-ethanol solution (19T179). With a probe to monitor the solution's temperature, the simulator is heated to 34 degrees C to produce a reading equivalent to the targeted value labeled on the bottle (19T181-19T182). The testing protocol requires a bottle of known standard solution of .10, which must be changed every thirty calendar days or twenty-five subject tests (50T85). Periodic calibration inspections use standard solutions of .04, .08, .10, and .16 (50T84). Draeger produces the simulator and temperature probe, both of which are returned to Draeger for recertification and calibration every twelve months (19T67;19T183;19T185;19T189).

Draeger purchases the simulator solution from an independent laboratory called Plus Four Engineering in Colorado and then, sells it to New Jersey in batches of 1000 bottles (19T190-19T191;50T99;50T100-50T101). However, it first ships six bottles — the first two from the lot, the middle two, and the last two — to the State Laboratory where Brettell or his associates perform quality control testing (50T102). Each bottle has a "shelf life" of two years (50T103).

Ryser also testified about the margin of error determined by using freshly certified standard solution and a NHTSA-approved simulator (61T65). He explained that the margin of error was the same as the one employed by New Jersey for control testing, and recommended by the NHTSA and OIML specifications (61T65). For the Alcotest 7110, it was plus or minus .005 BAC (absolute tolerance) or plus or minus 5% (relative tolerance), whichever was greater (50T17-50T18;51T64;61T71-61T72).[13] The absolute tolerance

---

13. We assume that Ryser was referring to the breath result as BAC.

applied to concentrations below .10 whereas the relative tolerance applied at or above .10 (50T18-50T19). Therefore, a subject who presented a reading of .08 would have a relative tolerance window from .076 to .084 (61T72).[14] However, that same subject would have an absolute tolerance window from .075 to .085 (61T72). Because the absolute tolerance window was greater, all readings would have to be within .075 and .085 (61T73). Ryser was unaware of any state program that automatically reduced an alcohol reading by the instrument's margin of error, although he noted that Alabama apparently recognized it by refusing to prosecute anyone unless they had result of at least .084 (50T19).

Regarding the actual tests, Draeger designed the Alcotest 7110 to measure samples of alveolar or deep lung air (19T191). To accomplish that task, Draeger proposed, and New Jersey accepted, four sampling criteria: (1) a minimum flow rate of 2.5 liters of breath per minute; (2) a minimum blow duration of at least 4.5 seconds; (3) a minimum breath volume of 1.5 liters; and (4) the use of a slope detector to ensure that the instrument waited until the IR absorption plateau is reached (19T191-19T192;20T77-20T79;D-7 at 21). If the sample did not meet all of the minimum criteria, the screen displayed an error message (20T5).

Draeger also designed the Alcotest 7110 to detect potential residual alcohol in the mouth cavity produced

14. 5% of .08 = .004.

by regurgitation, burping, belching, or hiccups (20T5;21T99). Alcohol also can be retained in the mouth in cavities, under dentures or in certain absorbent materials such as chewing tobacco or food (21T99). Absent any direction from NHTSA or the states regarding the conditions under which mouth alcohol detection must occur, Draeger relied upon the OIML specifications to develop its safeguard routine (20T6).[15]

The Alcotest 7110 is manufactured by the parent company in Luebeck (20T9). Draeger in Colorado customizes the instrument to the specific applications requested by each state (20T9). For example, the instrument by default is manufactured to accept a wet bath simulator that can attach to the back but can be modified if a state prefers to use a dry gas standard (20T9). Draeger follows a lengthy checklist to verify that the instrument is calibrated within the specified tolerance and that it is built with the correct firmware

---

15. The New Jersey User Manual-Technical described mouth alcohol detection as follows:

> Mouth alcohol is characterized by a sharp increase of the alcohol concentration at the beginning of the subject's sample followed by a decrease until the end of the sample. While a breath sample is delivered, the breath's alcohol concentration is continuously monitored. If mouth alcohol is detected, a reference message is displayed and the test is aborted.

[S-49 at 18.]

according to the customer's specifications (20T10). Draeger also verifies the serial number, performs temperature verifications for the breath hose and cuvette, checks the printer, and cleans the instruments (20T14-20T15). After it completes all the quality control and quality assurance steps, Draeger issues a twelve-month certificate of accuracy before it ships each instrument to the customer (20T10).

Draeger offers a standard twelve-month warranty (20T11). It also offers an extended four-year warranty which New Jersey chose to purchase (20T11). Draeger performs all warranty work at no charge for parts and labor (20T12). In 2005 New Jersey returned for repairs three instruments to Draeger from Middlesex County (20T12). The East Brunswick Police Department returned one instrument for replacement of the motherboard, which is manufactured by another company in Germany and delivered complete to Draeger (20T13-20T14;21T29-21T30;S-33). Because the motherboard basically held the "entire electronics real estate," Ryser acknowledged that anything stored on the random access memory (RAM) chip, mounted on the motherboard's surface, could be lost (20T15; 50T42;50T59-50T61). He noted that the motherboard had been sent to Luebeck where it probably was undergoing repairs in the service department (50T63;50T80).

The East Brunswick police also returned an instrument for replacement of the printer cable, which essentially required a new connecting wire between the motherboard and the receptacle for the external printer (20T16;S-34). New Brunswick also returned an instrument which showed an error — its memory was exceeding capacity (20T17-20T18;S-35). In the last case, Draeger cleared the memory and performed the requisite tests to confirm that the instrument was functioning properly (20T18).

The Alcotest 7110 consists of "core" software that has never been changed since the first units were built in Durango in 1995 (49T116;61T66). The core software contains the essential routines relating to how the instrument measures and analyzes alcohol vapor (23T58;24T55;24T58). These routines or critical functions include the IR and EC systems, the temperature sensors on the breath hose and cuvette, pressure sensor, flow sensor, AC/DC analysis, and general processor controls (24T58;24T60-24T65;D-99). Despite vague earlier testimony, Ryser insisted that the Alcotest 7110's core software was the same everywhere (49T119-49T120). Among other things, Ryser modified his earlier statements that the core software in Alabama's instrument had been changed for breath temperature sensing and fuel cell fatigue, claiming they were customized features which did not affect the way the unit read alcohol (25T17-25T18;49T119;61T66-61T68). We think this was no more than a dispute bout nomenclature.

The Alcotest 7110 also consists of customized software or firmware (20T18-20T19;24T55). Firmware consists of the binary code of the "compiled source code," and contains all the instructions or routines necessary for the instrument to operate according to precise guidelines and specifications (20T19). Ryser noted that firmware constantly changes (20T33). Such revisions can by initiated by the customer or the manufacturer (if laws or regulations change, or tolerances change) (20T33;49T81-49T82). For example, since 1998 Draeger has made approximately twenty-seven revisions to the Alcotest 7110's firmware in Alabama's program which Ryser described as very complex (25T12;25T15;25T29-25T30;D-100). As an aside, Ryser indicated that Draeger will have to update the firmware in 2007 to make its instruments compliant with the new daylight savings time structure (20T33;25T41-25T42). Draeger, however, will not make firmware changes that affect the measurement of alcohol (20T31-20T32). Draeger also will not make changes which may affect an instrument's compliance with the NHTSA specifications without first advising the customer (20T32).

Each time the firmware changes, Draeger assigns a new firmware number which initially is accompanied by a letter designation (20T33). After the engineering department performs a quality assurance test, the instrument is given to the technical writing department which runs control tests and writes a new manual (20T34). The instrument then goes to the service department where the instrument is checked again for quality control and assurance (20T34). Draeger then instructs its customers to perform all the necessary tests to assure that it has successfully embedded the requested changes (20T35). Only after the completion of successful testing by the customer will Draeger remove the letter designation (20T35). The new firmware version then is installed and recorded in the instrument's EEPROM (20T35).

Unlike Alabama and Germany, New Jersey did not purchase the optional breath temperature sensor (20T72;22T20). While Germany uses the sensor to make both upward and downward corrections, Alabama uses it to make downward corrections in the software of 6.58% for each degree that the subject's breath temperature exceeds the standard 34 degrees C programmed into the instrument (20T72;61T58). This rise in breath temperature causes the BAC reading to increase to this extent.

The sensor costs about $1300 if ordered at the time of manufacture or $1600 if retrofitted to the top of an instrument (19T64). For calibration, the temperature sensor requires substantial equipment including two large heated tanks which cost about $15,000 each and two automatic calibration devices which cost about $36,000 each (61T62).

While Draeger offered the sensor in its literature and Ryser admitted that it makes the Alcotest 7110 a better instrument, he does not "loudly" market it for several reasons: (1) Draeger is the only manufacturer that offers the feature and if he pushed it too strongly, it might reflect on the reliability of other breath-testing instruments; and (2) the 2100:1 ratio already "took into account" this variability in breath temperature (22T23-22T28;61T40;61T58).

The Alcotest 7110 stores approximately 1000 tests (20T37). After the memory is full, the data can be removed by an upload procedure to a computer (20T37-20T38). If the tests are not removed, they will be erased on a first-in, first-out basis (20T38). New Jersey's instrument also has hardware capable of communicating with a remote computer — similar to the Alcotest 7110 system used in Alabama — but Ryser said the State claimed it did not have the financial resources to install dedicated telephone lines to allow frequent data uploads (20T38-20T39;49T87). If New Jersey did download data via computer or modem to a central computer, Draeger could provide a program that used Microsoft Access to "grab" the information relevant to New Jersey's breath-testing program in a readable format (20T40-20T41). The program would be limited to 255 fields, instead of the current 310 fields in New Jersey's current software (61T55-61T56).

The source codes for the Alcotest 7110 consist of 53,744 lines or approximately 896 pages (20T106; 22T22;D42). Software engineers in Luebeck wrote the code in C+ or C++ computer language which is humanly viewable but only meaningful to a programmer (20T106-20T107;22T117;23T68). The codes, however, cannot be understood without access to the Alcotest 7110's algorithms and hardware (20T109). Because Draeger puts a "tremendous amount of effort" into the development of its breath-testing instruments, it views source codes as highly proprietary (20T20;22T113). Specifically, Draeger believes that release of its source codes would give its competitors a chance to duplicate its "state-of-the-art" technology (20T24). Ryser explained that Draeger was the technology leader in the breath-testing field as, for example, it was the first company to operate a breath-testing instrument at 9.5 microns in the IR spectrum and the only company to use a dual IR and EC system to quantify breath samples (20T20-20T21). Draeger keeps the source codes for New Jersey's Alcotest 7110 in its engineer's locked computer in Durango (49T135-49T136).

In April 2006 Ryser attended an IACT conference in Anaheim, California where he presented Draeger's new instrument, the Alcotest 9510 (20T113).[16] At the conference, he approached representatives of several competitors about their source code policies including CMI (which would not discuss the issue due to ongoing litigation), Intoximeter (which refused to release it), and National Patent (which invited attorneys to its factory in Ohio to examine the code) (20T27;20T112).

At Ryser's suggestion, Draeger changed its policy to adopt the approach taken by National Patent (20T28). Since then, it received one inquiry from attorneys in Massachusetts (20T28-20T29). To date, Draeger has not released source codes to any of its customers (20T30). Nor has Draeger apparently released the actual

---

16. The Alcotest 9510 measures alcohol the same as the Alcotest 7110, but communicates through an intranet computer network (23T33). Ryser described the Alcotest 9510 as a "computer" with endless memory, easy accessibility to communication tools, USB connections, and nicer housing (23T34).

algorithms although it has provided customers with explanations of how the Alcotest 7110 determines mouth alcohol (20T20).

During the hearing, Draeger and defense counsel by negotiation reached a tentative agreement in principle relating to the source code issue and techniques to insure the Alcotest 7110's scientific reliability (61T5-61T6). Defense counsel agreed to forego further cross-examination of Ryser and to limit its direct case to concerns about hardware issues (61T7). In return, Draeger agreed to: (1) submit the source codes and algorithms for the Alcotest 7110, NJ 3.11 to a jointly acceptable independent software house for examination; (2) program the software to include a self-reporting tamper feature to prevent any modifications except for intentional ones which Draeger would report; (3) allow a laboratory in the United States to verify that the next revised firmware version of the Alcotest 7110 (possibly NJ 3.12) satisfied OIML specifications; and (4) sell the instrument to defense attorneys and experts on the same terms that they sell them to the State of New Jersey (61T8-61T11;61T14;D-232). Ryser understood that these terms would be included in the Special Master's recommendations and findings of fact (61T7;61T17). Of course, he recognized that Draeger's license agreement with the State required the latter's approval before the instrument could be used by someone other than a state representative (61T18).

Ryser also testified at length about the documents produced in response to a subpoena issued to him in court on October 12, 2006 addressed to Draeger and Draegerwerk AG (49T23;49T139-49T140;D-175;D-220). Draeger produced 578 pages of documents which referred to New Jersey's software (49T132). Draeger AG, the German "parent" company, did not respond to the subpoena, claiming that it did not have any offices or employees in New Jersey, and did not do any business or sell any products in the State (50T15). Ryser's testimony about these documents is incorporated where appropriate throughout this summary.

Finally, Ryser briefly addressed the "sucking" issue, i.e., where a subject sucks air back into the instrument (61T36;61T63). He was unaware of similar complaints from other users and was unable to duplicate the problem when Durango tested three instruments (61T38;61T64). Because the subjects in New Jersey apparently sucked the air into the instrument through the port by the breath hose, Ryser thought the problem could be a hardware issue (61T64). In the event, the "sucking" issue could not result in a wrongful conviction because the BAC reading is .000.

Based upon his training and experience, Ryser was 100% convinced that the Alcotest 7110 accurately read alcohol in human breath within the specified tolerances and was scientifically reliable (20T49).

This court finds that Ryser was a candid, forthright, and most cooperative witness. He seemed understandably uncomfortable at his company's secrecy and reluctance to disclose information. He was a very credible and thoughtful witness and the court could detect no evasive or deceptive quality in his testimony.

2. *Summary of Testimony of State's Expert, Thomas A. Brettell*

Thomas A. Brettell holds a Ph.D. in analytical chemistry from Villanova University (33T7). He is certified as a forensic laboratory director and a public manager by the State of New Jersey, and as a laboratory inspector by the American Society of Crime Laboratory Directors (33T8-33T9). He also is a certified Diplomate for the American Board of Criminalistics, which encompasses the collection, preservation and analysis of trace evidence (33T17). Brettell has certificates for breathalyzer and Alcotest 7110 training (33T9).

In March 1976 Brettell began working for the Office of Forensic Sciences, Division of the New Jersey State Police, as a forensic chemist and, in August 2001, became forensic laboratory director (33T9-33T10;33T13). At the time of the Alcotest hearing, Brettell supervised 250 personnel and had administrative and technical responsibilities for the State laboratory system, including: three regional laboratories for drug, toxicology and fire debris analysis; the criminalistics laboratory for drug and toxicology analysis; the full service laboratory for nuclear and mitochondrial DNA; and the equine testing laboratory (33T9-33T10;33T13). He planned to retire on December 31, 2006 (33T19;34T30).

Brettell is a member of the American Chemical Society, the International Association of Chemical Testing, and various forensic science associations, and has published numerous articles on basic chemistry, toxicology and drug analysis (33T15). He has testified as an expert more than seventy-five times in administrative, municipal and Superior courts in New Jersey on such subjects as drug analysis, forensic toxicology, and forensic chemistry, and testified on the scientific reliability of an evidential breath tester (EBT) in *Foley* (33T16-33T17). The State offered him as an expert in forensic chemistry and breath testing; the defense agreed that he was eminently qualified (33T17;33T35).

Over the years, Brettell worked closely with the Alcohol Drug Testing Unit (ADTU), which administers and manages the State's breath-testing program (33T13-33T14;33T36;34T109;41T43). While Brettell performed the scientific studies and validation of the instruments, the ADTU staff supervised the testing protocols, trained the operators, set up the instruments in the field, performed periodic testing including calibration and linearity checks, and gave testimony in court when needed (33T36;34T109). The ADTU, however, did not perform any actual maintenance on the Alcotest 7110 instruments, which were returned to Draeger for repairs (36T77;48T44).

From November 1995 through February 1996, Brettell assisted Dr. Charles Tindall (then chief forensic scientist) and members of the ADTU in the selection of an EBT to replace the breathalyzer in New Jersey (33T31;33T35-33T36;D-185). Brettell believed that the breathalyzer produced "very good, reliable, precise, accurate" results when operated and maintained properly, but explained that it was no longer produced and parts were increasingly difficult to find (34T23). The breathalyzer also depended upon operators to follow a checklist, perceive the movement of the pointer on the galvanometer, take a visual reading from the scale, and record the reading by pressing down the marker on carbon paper to make an imprint (34T23-34T24;39T20-39T21). We gather that this imprint was rarely used and produced in court. The visual reading usually was simply recorded by the operator.

The group selected four instruments which were considered "state-of-the-art" at the time, and had been successfully tested by NHTSA and placed on the conforming products list (CPL) (33T37). The instruments were the Alcotest 7110 MKIII, BAC Datamaster, Intoxilyzer 5000, and Intoximeter (33T36-33T37;D-185). They tested the instruments to determine which would fit best into New Jersey's program (33T38).

For each instrument, Brettell and Tindall performed validation studies including side-by-side testing for accuracy (how close the measurements were to the true value), precision (how close the measurements were to each other), linearity (how close the plotting of test results from solutions of increasing concentrations were to a straight line), and specificity (how the measurement of ethanol compared to other organic compounds)

(33T38;33T41-33T42;33T49;34T35-34T37). The group also qualitatively evaluated the instruments for ease of operation, operator dependence, transportability, ticket printout information, computer compatibility, and integrity (D-185).

For accuracy, Brettell and Tindall took six known standards of simulator solutions ranging from .016 to .320 ethanol and ran twenty tests on the instruments (33T41;33T50). Using the same solutions, they also tested for precision by determining the standard deviations of the measurements, and for linearity by measuring the instruments' responses (33T41-33T42).

For specificity, they checked for interferents including acetone (a metabolite which appears on the breath of diabetics), isopropanol (rubbing alcohol), methanol (wood alcohol), and methyl tertiary butyl ether (MTBE) (an antioxidant found in oxygenated fuels and gasoline) (33T42-33T43;39T54-39T55). They checked for interferents by relying upon the instrument's use of dual technologies, EC or IR, to measure the same breath sample (33T45;42T14-42T15). If the two technologies deviated by more than .008 or the EC reading deviated 10% or more from the IR reading, the instrument signaled an interferent error (33T45;37T145).

For example, Brettell explained that the fuel cell did not respond to acetone, but that the IR spectrophotometer would detect acetone if the concentrations were high enough (33T46;39T52). By designing the Alcotest 7110 to detect IR absorption at the 9.5 micron range, Draeger eliminated the potential for acetone to interfere with the ethanol reading (39T52;39T57-39T58). Brettell said that his laboratory detected acetone at a frequency of maybe 10%, very infrequently detected isopropanol, and never detected methanol or MTBE (33T43-33T44).

Brettell found the Alcotest 7110 MKIII was reliable for breath testing, performed accurately with precision and specificity, and gave a good linear response up to .320 ethanol (33T48). He liked the dual detectors which produced two readings and the built-in safeguards against RFI and mouth alcohol, and the minimum blowing criteria (34T25-34T26). The evaluation group and the ADTU coordinators in particular found the instrument easy to operate, portable, essentially operator independent, computer compatible, and tamper-proof (33T48;D-185). The group also found it complied with the standards in OIML Draft III (47T54-47T55;D-185;D-186). Deputy Attorney General Hoffman represented to the court that the OIML historically had approved only one breath-testing instrument, which was made in France by the now-defunct Seres Company (47T57-47T58).

New Jersey selected the Alcotest 7110 with the wet bath simulator (33T52-33T53). The simulator contained the solution and vapor, was separately maintained, and was attached to the breath hose (41T126;45T73). The State also chose to use a laser-jet external printer so the AIRs would contain all the information customized to the State's program (33T53). Brettell explained that

New Jersey did not select the RFI detector because the instrument already was shielded and had successfully been informally tested by NHTSA and OIML-approved labs (33T53-33T54). His lab also did some informal testing with walkie-talkies, radios and "things like that," and found no variation from the expected outputs using known concentrations (33T54). Brettell was convinced there was no interference from radio frequencies (33T54).

Brettell decided that New Jersey did not need to purchase the breath temperature sensor option (33T55-33T56;35T72-35T73;35T119). The sensor consisted of a thermistor placed into the breath hose to measure the temperature of breath as the subject blew into the tube (33T56). In Brettell's opinion, the temperature sensor was not generally accepted in the breath-testing community based upon the lack of peer-reviewed scientific publications and the absence of its use in programs throughout the country, except in Alabama (33T56;35T73-35T74;35T120;35T122;44T70). Most vendors did not offer a similar option nor did they recommend setting the simulator temperature to anything other than 34 degrees C (33T56-33T57). He mentioned that the purchase of sensors would impose additional costs on municipalities, but maintained that cost was not a factor in his decision (35T72-35T73).

Brettell was aware of research showing that changes in body temperature influenced the breath alcohol reading (37T186-37T187;51T55). As temperature increased, more ethanol molecules entered the breath, changing the partition coefficient (37T187-37T188;51T55-51T56). It was generally accepted that for every degree centigrade above normal body temperature, the alcohol reading in breath could vary by about 6.8% upwards, requiring an adjustment (33T60-33T61;51T55-51T56). Alabama used the sensor to make only downward corrections; Germany corrected both upwards and downwards (35T102;37T184). In Brettell's opinion, however, there was no need to correct for breath temperature (33T63). He explained that the important temperature was in the deep lungs, not the bronchial tubes (33T61).

Brettell further explained that the Alcotest 7110 took into account such temperature variation by using a blood-breath ratio of 2100:1, which was lower than the actual ratio of 2300 or 2400:1 reported recently by A.W. Jones (33T62;39T85).[17] By doing so, the instrument underestimated alcohol in the blood by 9 to 10% (33T62). The 2100:1 ratio was not programmed into the software but was based upon the fact that when the simulator solution turned from a liquid to a gas it would be in the ratio of one gram per 210 liters (34T106-34T107). If the State wanted to reduce the ratio to 2000:1 to benefit more defendants, Draeger would only need to change the solution (34T107-34T108).

---

17. We assume that Brettell was referring to A.W. Jones and Lars Andersson, *Variability of the Blood/Breath Alcohol Ratio in Drinking Drivers*, 41 *J. Forensic Sci.* 916 (1996) (D-19). Although he made repeated references to the "partition" ratio, Brettell later said that he actually meant blood-breath ratio (37T183).

Draeger subsequently developed the Alcotest 7110 MKIII-C, which added a communication port (33T51-33T52). The communication consisted of a modem, which allowed the instrument to obtain data over the telephone (44T44-44T45). New Jersey purchased the instruments and customized the firmware (33T64). Prior to its use in the field, the Alcotest 7110, NJ 3.8, was tested successfully by Brettell and Lt. Tom Cambria, now retired, and by NHTSA for accuracy and precision (33T88-33T89). Brettell did not recall working with firmware version 3.6 (39T9-39T10).

New Jersey then engaged in the Pennsauken pilot program which began in December 2000 and continued for one calendar year; this tested 372 subjects in the field (33T64;33T89;34T31;34T39-34T40). Brettell reviewed and analyzed the data, and testified about the results in *Foley* which raised several issues, including: the instrument was not reporting the lowest breath alcohol concentration when it went to a third test; the minimum volume of 1.5 liters possibly was too high and should be lowered; the operator did not have the opportunity to terminate the test without charging refusal, resulting in a high "automatic" refusal rate of 28%; the blowing instructions were "a concern" and should be changed; and an operator had to use the "black key" to set the instrument to truncate the final BAC result to two decimals (33T90-33T92;34T83).

There is a probe value on the black key which matches a particular temperature probe (35T47). The coordinator enters the probe value into the instrument

(35T46-35T47). The probe values differ and are used to ensure that the simulator reads at the proper temperature (35T48;35T56;47T44-47T45). The probes are periodically returned to Draeger for recertification (36T70;36T72). Brettell was aware that Draeger also had a yellow key which apparently inhibited incrementing the sequential file numbers and setting the calibration file number, date of calibration, and storing of the calibration record (46T74-46T75; D-175 at DS168).

After the *Foley* decision, the State asked Draeger to make certain firmware changes to include more information on the AIR and add error messages, among other things (33T64;33T93). Draeger subsequently produced firmware version 3.9, which New Jersey never saw (33T65;47T79). Instead, in June 2004, Draeger gave the State a beta version 3.10Y for testing and validation (33T65;33T79;33T104;43T82;D-175 at DS174).[18] All requests for software changes — scientific and administrative — required Brettell's approval (43T88-43T89). And Brettell, not the ADTU, tested the firmware (43T117).

Among other things, NJ 3.10Y incorporated the following changes: (1) operators had the option to terminate the test, rather than record it as a refusal; (2) the instrument automatically truncated the final blood alcohol result to two decimal points; (3) the instrument added the safeguard of a two-minute lockout

18. For dates, we are relying upon Draeger's internal memorandum outlining the New Jersey Alcotest 7110 firmware timeline (D-175 at DS174).

between breath tests; and (4) the instrument allowed the operator to follow protocol for the twenty-minute observation period, no longer automatically locking the instrument (33T96-33T99;33T102;42T71-42T72). With regard to the latter, if a subject regurgitated, burped or belched or was not continuously observed for twenty minutes, Brettell explained that the change allowed an operator to test another subject in the interim and restart the process again for the initial subject after a full twenty-minute observation period had elapsed (33T99;37T25;40T11). He further explained that local police departments had discretion to determine when the observation period began, either on arrest or on arrival at the station house (36T47;46T23-46T24).

At Brettell's request, the revised firmware also addressed the high refusal rate in *Foley* by displaying error messages on the screen so that operators could take them into consideration (33T96). The State also changed its training protocol to teach operators to instruct subjects to blow deep breaths (33T96). The new instruction stemmed from the assumption that breath at the end of a deep exhalation accurately reflected alveolar or deep-lung air (39T66). Additionally, Brettell requested changes in the AIR including the presentation of all information on one page, whenever possible, and the inclusion of error messages (33T103;34T71).

From July 22, 2004 through September 17, 2004, Brettell's laboratory performed validation testing on four instruments with firmware version NJ 3.10Y

(33T104;40T52;47T79). During that time, Draeger made additional changes to the firmware at Brettell's request and, in September 2004, upgraded beta version NJ 3.10ZH remotely onto the units in the Hamilton Township laboratory (44T12;46T80;47T79;47T104-47T105;D-175 at DS174, DS187).

In his report dated December 2004, Brettell confirmed that Draeger made the requested changes including, among other things: modifying the AIR to reflect the location where the instrument was installed; allowing the operator the option to hit terminate, refusal or continue when the error message "blowing not allowed" appeared; and reporting the final error message on the AIR and then reporting "test terminated" (40T54-40T55).[19]

In August 2004 forensic scientist Nirmal Sawhney and Flanagan informally tested the four instruments with beta version NJ 3.10Y for RFI (33T104;41T86;D-120). The following items were placed in the room at various times near the Alcotest 7110: RCA TV/VCR/DVD; State Police Motorola portable radio; Durabrand AM/FM cassette recorder; State Police Motorola pager, and Motorola cell phone (33T104-33T106;D-120). At all times, the Alcotest 7110 performed properly and gave the expected results without any suggestion of interference (33T107;47T114-47T115;D-120).

19. *See* "Validation of Firmware NJ 3.10[Y] Draeger Alcotest MKIII-C Evidentiary Breath Testing Instrument," a copy of which Brettell attached to his expert report (43T61-43T63;C-13).

New Jersey accepted firmware version 3.10 but subsequently, Flanagan noticed during training classes that operators could not review four data fields including the defendant's drivers license number, issuing state, case number, and summons number (33T79;33T107;D-175 at DS528). Draeger made these changes, and the State then received current firmware version NJ 3.11 (33T79). Flanagan verified the changes (33T109;40T53). Brettell did not conduct another validation procedure for NJ 3.11 (40T53-40T54). He believed the changes in the historical data fields were only administrative and did not pertain to the analytical operation of the instrument (40T55-40T57).

NHTSA, however, successfully tested the Alcotest 7110, NJ 3.11 for accuracy and precision (33T109-33T110). Brettell reviewed NHTSA's data and report, which related that the instrument and revised firmware were operating properly (33T110).

At Brettell's recommendation, NJ 3.11 kept Draeger's default criteria because they were reasonable and generally accepted throughout the scientific community (33T88). These criteria included: a minimum breath volume of 1.5 liters; a minimum blow time of 4.5 seconds; a minimum flow rate of 2.5 liters; and an IR absorption plateau with no change of more than 1% per 0.25 second (33T88;36T16;39T42).

NJ 3.11 followed the same testing sequence implemented in NJ 3.8: ambient air check; control test one; ambient air check; breath test one; ambient air check; breath test two; ambient air check; control test two; and ambient air check (33T80;39T14). In NJ 3.11, however, the firmware changed to allow the subject a maximum of eleven attempts to provide two valid breath tests (33T80). The revised firmware only allowed a maximum of three valid samples in the breath test sequence (42T93-42T95;D-175 at DS247, DS248, DS313, DS314). If the three valid breath tests were not within tolerances, the instrument would automatically abort the test and the operator would have to start over again rather than pursue a fourth test, as with the breathalyzer (42T96-42T97;D-175 at DS247, DS248, DS313 and DS314).

The purpose of the control test was to check the instrument for accuracy by using a known concentration of ethanol vapor (33T81). The Alcotest 7110 set the tolerance for the control test at plus or minus 5% (33T81;34T36). For example, if the control test ran with .10 ethanol solution, the acceptable tolerance range would be .095 to .105 (33T81;40T50-40T51). The purpose of two breath samples was to ensure a valid result by protecting the subject against potential interferents, RFI or mouth alcohol (33T81).

Regarding the acceptable tolerance between two breath tests or four readings (2 IR and 2 EC), Brettell set the tolerance in firmware version NJ 3.8 as .01 or 10% of the highest and lowest of the four readings, whichever is greater (33T82;33T94). He determined the tolerance based in part upon his understanding that *Downie* required two breath tests to agree within .01 of each other, which he believed actually meant that the tests had to be within 10% of the then per se level of .10 (51T61-51T62). He changed the *Downie* tolerance to include 10% of the highest and lowest readings, explaining that there was uncertainty in any measurement so it was best to select a tolerance that expanded as values increased (33T82-33T83). Brettell was not aware of any other state that used an absolute .01 as a tolerance (51T62). In *Foley*, 370 *N.J. Super.* at 355-57, the judge inadvertently doubled the overall range to 20% stating that the results had to be within .01% or plus or minus 10% of the average of the highest and lowest IR and EC values, whichever was greater (35T35-35T36;43T27-43T28).

Brettell further widened the tolerance in NJ 3.11. While there were certain inconsistencies throughout Brettell's testimony with respect to his expression of the standard, he actually set the acceptable tolerance as plus or minus .01 or plus or minus 10% of the mean of the four readings, whichever is greater (34T78; 36T26;37T145-37T148;37T214). He doubled the tolerance from NJ 3.8 to reduce the number of subjects who had to blow third tests, an issue raised in *Foley* (35T13-35T15;43T31;51T62-51T63). According to Brettell, the "plus or minus .01" — below the level of .10 BAC — was consistent with the National Safety Council's recommendation of .02 and what Alabama uses, and the "plus or minus 10%" was consistent with what the State of Washington uses (45T90-45T91;51T63). While no other state used the exact same tolerances as New Jersey, Brettell noted that Germany also used a hybrid standard which was .04 milligrams per liter or plus or minus 10%, whichever was greater (51T63).

Brettell explained that tolerances did not affect the accuracy of the Alcotest 7110's measurements, but affected its precision and uncertainty (51T61). Unlike the breathalyzer which took two breath tests and two readings, the Alcotest 7110 takes two breath tests and four readings; it also reports only the lowest reading, which it truncates to two decimal places, thereby accommodating, to some extent, the doubling of the tolerance (35T15-35T17;51T61).

Brettell extensively analyzed the breath-testing data collected in Middlesex County in 2005 (33T110;36T15). This was the "universe" selected by Judge King for the empirical data base in this *Chun* case. The data came from twenty-seven instruments and 1865 subjects (33T111;34T19). Of these twenty-seven instruments, evidential testing data came from twenty-five but electronic data came from all of them (34T119-34T120). The coordinators went to every police department in Middlesex County to download the electronic data onto the hard drives of their lap tops and then made copies which Brettell analyzed in excel format (3T111). Brettell reviewed all data including the hard copy AIRs and 300 plus fields of electronic data (33T111-33T112; 45T113;48T34).

Brettell compared the electronic data and AIRs from all instruments in Middlesex County except two, and found no discrepancies (33T116).[20] He concluded that NJ 3.11 worked properly except for six valid breath tests which did not allow the two-minute lockout (33T119;51T73). After speaking with a Draeger representative, Brettell learned that there was a problem with the firmware (33T119-33T120). The internal clock apparently did not start running at the end of the first breath test, actually taking less time by about a fraction of a second (33T120-33T121;47T89-47T92;51T73). Brettell wanted the full two-minute lockout to ensure that all the breath was expelled from a subject's mouth before the second breath test was taken, and intended to correct this problem on the next firmware change (33T122;35T125;47T93-47T94).

Brettell concluded that all of the other problems with the AIRs were due to human errors (37T17). For example, he mentioned two cases involving the Milltown Borough and Plainsboro police departments where the coordinator failed to set the control-test tolerance to 5% when he installed the instrument, causing it to revert to Draeger's default tolerance of 10% (33T123;51T71-51T72;S-47;S-48). In other cases, coordinators recalibrated instruments and failed to push the quick reset button, causing the test to abort and move to the next sequential file number without a printout (33T123;51T72-51T73;D-57;D-58). Other AIRs provided examples of operators who failed to reset the

20. The two exceptions came from Helmetta (where Brettell thought the instrument might have been recently installed) and East Brunswick (where certain electronic data was lost when the motherboard failed) (33T117-33T119).

instrument before inputting; made transcriptional errors such as entering the wrong date, year or time; incorrectly hit the "Y" key when reviewing data; or failed to follow the twenty-minute observation period (33T125;37T17-37T18;37T22-37T24;51T65-51T67;D-131;D-132;D-134;D-135). These "human errors" did not produce any misleading BAC readings which might cause a wrongful conviction.

Brettell also explained that two AIRs with 0.00 readings indicated the subjects were sucking instead of blowing through the breath tube (35T28;39T45-39T52;51T64;D-129;D-130). Brettell personally performed tests where he repeatedly sucked in air through the breath tube and replicated these results, as did Flanagan (36T85;48T42;51T64-51T65;51T78). In another case, Brettell concluded that the AIR showed subject refused and control test failure because the State Police operator selected the refusal option and the instrument ran a control test after the simulator solution had depleted (51T67-51T68;D-137).

Some of the alleged errors involved decimal place issues. For example, two AIRs properly reported control test failures even though the test results at three decimal places looked like they were within tolerance due to the fact that the instrument actually read to the fourth decimal place, at which the results were out of tolerance (51T68-51T69;D-138;D-139). On another AIR, the instrument correctly issued a simulator temperature error because the second decimal place read over 34.2 degrees C (51T69;D-60). Other errors implicated keyboard malfunctions or instances where the operator pushed subject refused but then continued the test (51T69-51T71;D-63;D-140;D-142). None of the AIRs showed any problems with the firmware itself (51T73). Again, these "errors" did not result in flawed BAC results capable of improper convictions.

With regard to the refusal issue, Brettell found that 405 of the 1865 subjects in Middlesex County were charged with refusals and tests terminated (33T126;33T135). Of those subjects, 396 actually were issued refusal tickets resulting in a 21.2% refusal rate (33T126;33T135). As Brettell pointed out, the Middlesex County rate was lower than the refusal rate of 28% from the Pennsauken data in *Foley*, or the 25% cited as the national average by NHTSA (33T127).

Brettell also looked at the issue of minimum breath volume to determine who would be affected if the State lowered the criteria to 1.0 liter (33T128). He found thirty-seven subjects who blew between 1.0 and 1.4 liters, and 302 subjects who blew all tests less than 1.0 liter of whom 256 did not blow anything (33T129;33T137;34T4;S-37). Of the thirty-seven subjects between 1.0 and 1.4 liters, he concluded that only eight or .4% of all 1865 subjects would not have been charged with refusal if the minimum volume had been reduced (33T129-33T130;33T132;34T6-34T7).

Under the wider tolerance adopted for NJ 3.11, Brettell observed that there was only one subject in the Middlesex County data who required a third breath sample (35T18). He also found that only twenty-six subjects or about 1.4% of the total subjects from Middlesex County had reported mouth alcohol error messages (34T12;37T29).

Brettell also conducted an independent breath volume study using 179 volunteers who went to his laboratory and blew into an Alcotest 7110 (34T7-34T8;S-39). The volunteers included 106 females and seventy-three males who ranged in age from fourteen to eighty (34T8). Each subject provided at least two breath samples (34T9;S-39). Breath volumes ranged from about .1 liters to 5.1 liters of air (33T9). For the first breath exhalation, two of the 179 volunteers blew less than 1.5 liters and both of them were females over the age of seventy (34T9). The second time, only one female over age seventy was unable to blow 1.5 liters (34T10;S-40). Brettell concluded that the cooperative subjects could meet the minimum volume requirement except that women over seventy might have difficulty (34T11).[21]

In Brettell's opinion, the Middlesex County data and his breath volume study indicated that the 1.5 liter minimum volume was sufficient (34T11). He believed that a reduction to 1.0 or even 1.4 liters would make it difficult for subjects to give a true deep lung air sample, thus requiring more blows into the instrument (34T11;36T16-36T17;36T22;39T42;45T71).

---

21. The last revision of the OIML recommendations (OIML R-126-1) specified that the exhaled volume should be greater than or equal to 1.2 liters (35T93;AB-46 at 8). Alabama has a minimum requirement of 1.3 liters (35T89;36T17).

Brettell did state, however, that there should be some consideration given to elderly women, but did not specify a minimum volume (34T11). Brettell thought that Draeger could easily change the software to lower the minimum breath volume — if only for individuals over a particular age — and that, in any event, the slope detector would still ensure that the subject gave deep alveolar air (35T100-35T101). Brettell generally agreed with the old adage that "the longer you blow, the higher you go," but said that a person who blew more than 1.5 liters would get a truer value of BAC, not an overestimate (36T23-36T24;37T97).[22] In other words, the old adage applied only where a subject's exhalation had not yet reached the plateau and the curve still was increasing (37T98). For his study, the average breath volume was 3.1 liters (37T97).

Although New Jersey did not use the instrument's modem for downloading or monitoring data, Brettell was working with a vendor to develop a program which would allow daily remote transfers of electronic data collected statewide by municipal police and state troopers to a central data base (3T113-3T114;35T105).[23] The vendor, Porter Lee Corporation, was the same software company which created New Jersey's laboratory information management (LIM) system and

22. Brettell never saw a volunteer blow more than 5.5 liters of air (37T97).

23. Alabama uses the modem to communicate with a central computer (44T56).

Brettell wanted the breath-testing data to interface with LIM (33T115;37T6-37T7;44T42;48T48-48T49). In September 2005, Porter Lee gave him an estimate of $9780 for the data collection project (48T47-48T48;D-214).

Brettell said there were logistical problems related to the running of dedicated telephone lines to the barrier islands and the processing of the data (33T114-33T115;44T46-44T50;48T50-48T51). Brettell was aware of a Draeger-based program, but said that he was looking for one that was more user-friendly and would allow him to do more (37T7;37T11-37T12;44T45;44T52-44T53). He did not know when New Jersey would be ready to move forward on the data collection project (35T108-35T109;44T54).

Coordinators from the ADTU inspect the Alcotest instruments when they are installed and then, annually or on an "as-needed" basis (34T13). Brettell relied upon these inspections to verify that the instruments worked properly (34T13). Unlike New York where the State Police bring the Alcotest 7110 instruments in for testing every six months, New Jersey conducts its annual inspections in the field (34T14). Because New Jersey uses control tests on each subject, Brettell made the decision that annual calibrations were sufficient (34T14;51T43).

The coordinator inspects or calibrates an instrument using standard solutions purchased in lots of 1000 from Draeger which, in turn, purchased them from Plus Four

Company which puts Draeger's labels on them (34T17;47T21;48T94;51T12). Although Draeger certifies the solutions, New Jersey performs its own tests and Draeger will not ship a lot until it receives the State's approval (34T18;47T50).

Specifically, New Jersey tests six bottles from each lot, including the first two bottles, middle two bottles, and last two bottles (which are numbered 1, 2, 499, 500, 999 and 1000), which Brettell claimed gave a confidence level of 96.5% (34T19;47T21;48T94). Brettell's laboratory tests each of the six bottles three times using head space gas chromatography (34T19;48T94;48T96). If there is depletion from freezing during shipping or otherwise, the calibration process and control tests will detect this because the results will be out-of-tolerance (34T19). In any event, depletion of the simulator solution would have no effect on the reading of the breath test (39T20). Under New Jersey protocol, each bottle should not be changed for thirty days or twenty-five subject tests, unless the instrument gives an error message that the solution is depleted (48T100;51T28-51T29;51T31).

Brettell's laboratory issues certificates of analysis stating that each simulator solution was within specifications of the target value for the particular concentration (34T20;S-41;S-42;S-43;S-44). Brettell does not look at simulators in the field (44T61).

For calibration, the coordinator uses a known standard of .10 ethanol solution (34T15). If the instrument detects that concentration, the coordinator will run three control tests to make sure that the readings fall within the tolerances of that simulator solution (34T15). Next, the coordinator will run concentrations of .04, .08, and .16 through the breath test hose and check the responses for accuracy, precision and linearity (34T16). Finally, the coordinator will take solution from the police department, make a solution change, set the instrument for operation, and do a run to make sure that the instrument gives a response within the tolerance which is plus or minus 5% (34T16). All tests produce reports which the coordinator keeps on record (34T16). The coordinator also issues certificates of accuracy after the instrument successfully completes the calibration and linearity checks (36T68).

Brettell noted that the Alcotest 7110 was programmed to accept 1000 tests and, at 1001, to replace the first test and so on (44T24). He did not recall any instrument that exceeded its memory capacity of 1000 tests (44T24). If an instrument exceeded the limit, however, it still would operate properly but would noticeably slow down (44T25). Brettell believed that the ADTU was downloading data after about 500 tests (48T52-48T54).

Although he was not an expert in physiology, Brettell had a working knowledge of the human body and understood that the Alcotest 7110 depended upon certain physiological assumptions (39T65-39T66). He agreed that respiration involves the passage of air through the nasal cavity, the nasal pharynx, the oral pharynx, epiglottis, glottis, and trachea into the bronchial tubes (39T67). The inhaled air, which is heated as it passes through the upper airways, then moves through different airways of the increasingly narrow bronchial tubes until they end in a very large number of thin-walled sacs called alveoli (39T67-39T68;39T73).

Gas exchange occurs in the alveoli at which time oxygen is exchanged with carbon dioxide from the pulmonary capillaries (39T67-39T68). Gas in the alveolar air is assumed in equilibrium with the pulmonary capillary blood (39T69). During exhalation, the alveolar air passes through the upper airways where heat is transferred from the exhaled air to the mucus lining of the airways and water vapor condenses on the way up to the mouth (39T74-39T75;39T79). Brettell was not aware of any discussion in the literature that the alcohol in breath samples comes primarily from the airways, rather than the alveoli (39T80).

Brettell further explained that the body absorbs alcohol very quickly at first but after a short time, begins to eliminate it (39T88). When absorption occurs faster than elimination, the alcohol concentration continues to rise until it reaches a “peak” where absorption and elimination occur close to the same rate (39T89). Generally, the average rate of “burn off” or elimination of alcohol is .015 in an hour (36T104-36T105).

The rate of absorption varies between individuals and in the same individual at different times (39T90). For example, a body absorbs alcohol more quickly on an empty stomach (39T95). During absorption, blood alcohol content tends to rise and, therefore, the blood-breath ratio will be lower than 2100:1 (39T93-39T94). Brettell was aware that Rod Gullberg's and Jones' studies suggested ratios during absorption as low as 1500:1 and 1700:1, respectively (39T103). Based upon the amount of time that generally elapsed between an arrest and a breath test, Brettell thought most subjects would be in the post-absorptive phase and, therefore, the assumed ratio of 2100:1 was justified (40T36-40T37).

Brettell never asked Draeger for the Alcotest 7110's source codes nor did he ever ask to see source codes for other complicated instruments which he had used in the laboratory during his thirty-year career (34T12). He asked Draeger once for the tolerance algorithms and got a description of them in response (47T63).

Brettell testified that he did not need the sources codes because he determined an instrument's reliability by testing it with known standards and evaluating the outputs for accuracy and precision (34T13;47T93-47T94;51T28). Although he recognized that there was analytical uncertainty in every measurement, Brettell stated that the Alcotest 7110 was "very close to being 100 percent accurate" (36T51;36T54;37T13). While he acknowledged that a forensic blood test was more accurate than a breath test for determining BAC, he stated that New Jersey had the "smallest uncertainty of many of the programs out there, including Alabama's" (36T51;36T55;44T75).

Based upon his training, experience, the scientific literature, the tests that he performed, and his experience with the instrument, to the best degree of scientific certainty, Brettell believed that the Alcotest 7110 was scientifically reliable to produce breath alcohol results in an evidentiary setting with excellent accuracy, precision and linearity (34T22).

However, Brettell recommended the following changes in New Jersey's program: (1) women over the age of seventy who legitimately tried to blow into the instrument and gave a reasonable breath volume "such as one liter" should not be charged with refusal; (2) there should be a full two-minute lockout between valid breath tests; (3) the firmware version should be written on the AIRs so that everyone would be aware of the requirements used to produce the reports; (4) the AIRs should include an error message "tolerance out of range" when a second breath test did not meet the tolerance; and (5) New Jersey should expeditiously create a data collection system to manage and review data in a more timely fashion (33T122;35T124-35T125;35T129;46T57-46T58;48T64-48T65;51T76-51T77). He did not recommend that New Jersey use the breath temperature sensor based upon its lack of general acceptance in the breath-testing field (51T76).

Brettell also recommended changes in the tolerances between breath tests, stating:

> Yes. After going through these proceedings I think I would recommend that the tolerances

> be tightened up and I would be in favor of using a hybrid such as .01 or plus or minus five percent, whichever is greater. It also may be even clearer and easier for everyone to understand what the tolerances are if we just went to simply the National Safety Council's recommendation of using two tests within .02 of each other all the way across the board.
>
> If the decision is to go to those tolerances, everyone has to understand that when we get to the higher alcohol readings, and I'm talking now out around .3, over .2, that the subject may have to — several subjects may have to give more than two valid breath tests to fall within those tolerances.

[51T75-15 to 51T76-3.]

Dr. Brettell testified over a ten-day period. He testified patiently and candidly admitted the problems that inhered in implementing the program. He assisted this court greatly in understanding the scientific problems. We fully accept his very credible opinion that the Alcotest 7110 is scientifically reliable in an evidentiary setting but that certain improvements could be made in the program to effect even greater confidence.

3. *Summary of Testimony of State's Expert, Sergeant Kevin Michael Flanagan*

After serving four years in the United States Navy, Sergeant Kevin Michael Flanagan graduated in 1984 from Glassboro State College (now Rowan University) with a Bachelor of Arts degree in law and justice (52T9). In September 1986 he joined the State Police (52T9). In January 1987, he became a road duty trooper after graduating from the State Police Academy (52T9). In February 1995 he was assigned to the Alcohol Drug Test Unit (ADTU) as a breath test coordinator and since January 2004 has been responsible for the Alcotest 7110 program (52T13;58T73).

Throughout his career, Flanagan has received extensive technical training in the area of alcohol breath testing. In February 1988 he became a certified breathalyzer operator after attending a five-day training course conducted by the State Police (52T9). He subsequently attended Draeger's repair and maintenance training course on the breathalyzer models 900 and 900A (July 1994), a State Police instructor training course (October 1994), a State Police breath test coordinator training program (February 1995), and the Borkenstein course at Indiana University (May 1995) (52T9-52T11).

Flanagan also received instruction from Draeger on the Alcotest 7110 including: (1) a three-day course in Ewing, New Jersey on basic operation (January 1998); (2) a one-day training course with defense counsel in

Foley (January 2003); and (3) a four-day training course for ADTU staff on operation and maintenance (October 2004) (52T10-52T11;52T29-52T30).

While serving as a breath test coordinator for Camden County, Flanagan became involved in the Pennsauken Township Pilot Program (52T12). After receiving additional training by Lt. Cambria, he loaned the Township two instruments and implemented the pilot program in December 2000, assuming responsibility for installation, calibration and solution changes for the project (52T12-52T13). When the pilot program ended in December 2001, Pennsauken Township resumed using the breathalyzer (52T13).

Flanagan has operated the Alcotest 7110 thousands of times and, since November 2004, has trained over 5000 operators (52T14-52T16). He has performed several hundred calibrations, demonstrated the instrument to chiefs of police in the seventeen counties which presently use it, and trained municipal prosecutors (52T16-52T17;54T115). He also has conducted seminars for the Institute of Continuing Legal Education (ICLE) and demonstrated the instrument to the Special Master and defense counsel in *Chun* in February 2006 (52T17;54T98).

During his career, Flanagan has testified numerous times as an expert on the breathalyzer in Municipal and Superior Courts, and as a fact witness in *Foley* (52T18-52T20). The State moved to qualify him here as an expert in breath testing in New Jersey (52T19;52T43-

52T44). This court recognized that he also would testify as a fact witness (52T19).

Under Flanagan's direction, the ADTU developed a training program for the Alcotest 7110 and coordinated its "rollout" (52T13). Between November 1, 2004 and December 22, 2004 the ADTU trained approximately 900 troopers and police officers in Middlesex County on the new instrument (52T35). On January 3, 2005 Middlesex County became the first county to use the Alcotest 7110, NJ 3.11 for evidential purposes (55T37).

Among his other duties, Flanagan worked closely with Brettell, the director of the forensic science laboratory (57T60-57T61;58T6-58T7). Flanagan assisted the forensic laboratory in performing breath volume and simulator solution studies (52T14). For example, he assisted in performing blind proficiency studies for Collaborative Testing Services, Inc. (CTS) where the ADTU introduced different solutions into a simulator, then introduced them into the Alcotest 7110 in vapor form, and sent the results to CTS for evaluation (52T14-52T15). Beginning in late 2004 or early 2005, Flanagan joined Brettell and others in a working group to discuss various issues relating to alcohol breath testing (58T69-58T70).[24]

---

24. The working group also included Flanagan's supervisor (Sgt. First Class Bernhardson) or the lieutenant of his unit at the time, Nirmal Sawhney, and Deputy Attorneys General Christine Hoffman, John Dell'Aquillo, and Stephen Monson (58T70).

Flanagan presently supervises five coordinators who handle inspections and implement the program throughout the State (52T13-52T14;52T24;52T110-52T111;58T49). The coordinators receive two days of factory training by Draeger after which they receive certificates as factory-trained technicians, observe ADTU training classes, and receive field supervision by Flanagan (52T111-52T112;S-73). Coordinators generally put two new instruments into service each day (52T112-52T113).

The coordinators report to Flanagan when problems arise in the field (52T14;52T114). For example, they received complaints about a number of control gas supply errors and upon investigation, discovered that operators were moving the instrument closer to themselves to read the message on the LED screen, inadvertently disconnecting the simulator and causing the error (52T14;52T102-52T103;53T62). Another time a coordinator discovered that an operator was using a solution jar with a cracked top which caused a control gas supply error (52T114). Recently, a police department reported that an instrument would not permit a solution change (52T115). After realizing that the instrument was still in the standby mode, Flanagan advised the operator to "wake up" the instrument, wait twelve minutes, and then change the solution (52T115).

Coordinators also may contact Draeger for assistance (52T116). Most contact is made orally and the ADTU does not keep a contact log (52T117-52T118). If a problem cannot be corrected, a coordinator downloads the electronic files onto a laptop and then transfers the data onto two non-writeable CDs: one for the local police department and another logged into evidence (52T119;54T34-54T36). The instrument then is taken out-of-service and returned to Durango for inspection and repair (52T117). Coordinators also download data when an instrument has performed 500 tests, a New Jersey policy adopted to avoid the instrument's tendency to slow down as it searches large numbers of files (54T34-54T35). After downloading, all information in the Alcotest 7110 is removed but the sequential file numbers continue (54T36). Flanagan later testified that East Brunswick was the only police department that might reach 500 DWI arrests in one year (54T112).

The Alcotest 7110 also has a modem for remote downloading to a central computer for data collection (55T34-55T35). Flanagan was aware that Brettell wanted the data collection system to be hooked up to the laboratory information management (LIM) system and that he had contacted a company named Porter Lee to look into it (55T34). He did not know the status of the project in light of Brettell's pending retirement (55T33-55T34). He also was aware that there was some concern about the cost of running dedicated telephone lines to the barrier islands for that purpose (58T71-58T72).

Coordinators neither repair the instruments nor open them (52T119). The State only has one special screwdriver to access the inside mechanism of the Alcotest 7110, which Flanagan keeps but has never used (52T119;55T63). Operators also do not perform maintenance other than cleaning the instrument and changing the simulator solutions (52T110). When a police department reports a hardware problem rendering an instrument inoperable, the ADTU instructs the operator to use an Alcotest 7110 in a nearby town and sends a coordinator to see if the problem can be resolved (60T10-60T11). If not, the local police department returns the instrument to Draeger for repair, and keeps all the repair records (52T120).

Draeger also annually recalibrates the simulators and temperature probes (55T73-55T74;58T16). The ADTU recommends that each police department purchase a back-up simulator and probe so that they can rotate them in and out of the factory (58T16).

As mandated by *N.J.A.C.* 13:51-1.6(b), the ADTU offers a one-day conversion training class taught by its coordinators to police officers who previously were certified as breathalyzer operators (52T44; 55T57;58T25;59T76-59T77).[25] To date, the ADTU has not trained any new officers on the Alcotest 7110 and

25. *N.J.A.C.* 13:51-1.6(b) provides in relevant part:

> Subject to the requirements of *N.J.A.C.* 13:51-1.4(c), certification of an operator, whose certification is valid, on an instrument approved by *N.J.A.C.* 13:51-3.5(a), other than the instrument upon which the operator was previously trained and certified, requires satisfactory completion of a minimum of one day of training as prescribed and conducted by the Division of State Police.

does not plan to offer the initial four-day training course until 2008 (52T44;55T95;57T28). Flanagan explained that the ADTU cannot begin training new officers on the Alcotest 7110 in 2007 due to its other obligations, including the need to bring the last four counties — Bergen, Hudson, Monmouth, and Essex — into the Alcotest program as well as a few towns in the seventeen counties which failed to purchase their instruments before the Attorney General stayed the program (54T122;54T124).[26] The ADTU also must recertify approximately 5000 operators who received training on the Alcotest 7110 in 2005, and hold thirty weeks of DWI classes required by the federal government to receive reimbursement for two training positions, including Flanagan's and another sergeant's (57T28-57T30).

The conversion training class first reviews the breathalyzer, which Flanagan believed was still very accurate (52T48;57T23). (This court suggests that the State produce a breathalyzer at argument for the Justices to view.) Like the Alcotest 7110, the breathalyzer measured a subject's end-expired breath, specifically the last 52.5 milliliters of air (54T17). He recognized, however, that it represented older photometric technology, that it was operator dependent, that it required "periodic" inspections (every thirty to sixty days), and that it had a tighter tolerance (57T23;54T31). Instead of a machine-printed AIR, the

26. These towns include Buena Borough in Atlantic County and Sea Isle City in Cape May County along with a few unnamed towns in North Jersey (54T116).

breathalyzer's operator manually recorded the test results by moving the blood alcohol pointer up the scale until the instrument became balanced and then pushing down on the plastic shield to transfer the ink from the pointer to an overlay of paper (57T24). The breathalyzer also did not reveal a subject's breath volume (57T50). Flanagan expressed concern that there were no spare parts for the breathalyzer, which no longer was being made (57T25). Particularly, the State is running out of ampules leaving police officers in the four counties with only the option of taking a subject to a hospital for a blood test (54T124;57T25). Of course, subjects always have the option of a blood test as well as the right to an independent breath test of their own choosing after the State completes its test (60T90-60T91). New Jersey does not offer the option of preserving a breath sample (60T92).

On the other hand, the Alcotest 7110 uses newer technology and is more transparent because it produces a printout (57T23-57T24). It also eliminates the chance of operator manipulation after the subject begins to blow and only requires annual inspections (57T23; 57T27). The Alcotest 7110 gives subjects the benefit of truncating to two decimals the lowest of the four test results (57T32-57T35). Since New Jersey's Alcotest 7110 program is relatively new in comparison with the breathalyzer which has been in use since 1966, Flanagan expected efficiency to increase over time (57T27).

New Jersey does not use portable breath testers in the field (57T27). The ADTU recommends using only the field sobriety test (57T27).

The conversion class relies upon a lesson plan and the User Manual-Operator (operator's manual) to review the "nuts and bolts" of the instrument such as the IR and fuel cell technologies, minimum criteria, acceptable tolerances, temperatures in the cuvette and breath hose, and AIRs, (52T48-52T50;54T17;D-15;D-224).[27] The class also addresses the function of the simulator including the introduction of solution heated to 34 degrees C and the need to change the solution a maximum of every thirty days or after twenty-five test sequences (which include the control tests performed before and after a subject blows) or if depletion occurs (52T50-52T51;53T35;53T46;54T104;60T20). Although Brettell determined the solution change requirements based on his laboratory depletion study, Flanagan testified that the alcohol level in the bottles was depleting before thirty days in the field (58T80-58T81). He also testified that if a coordinator entered the wrong number of days or tests during the calibration process, the instrument would go beyond the maximum limit but that the mistake would be transparent on the AIR (60T20-60T21). Although the ADTU trains everyone to change the solution, it recommends that police departments assign only two or three individuals to do so (52T52).

The conversion class also instructs operators on how to input data (52T53;D-29). Unlike the breathalyzer,

27. During cross-examination, Flanagan admitted that the lesson plan incorrectly stated that the minimum flow rate was 3.0 liters, instead of 2.5 (54T94-54T96;D-224). The operator's manual correctly stated the rate (54T96).

there is no checklist; instead, the operators push the orange button and follow the "prompts" (52T54-52T59). Among other things, operators enter a summons number for every arrest and if they later decide not to charge the subject with drunk driving or refusal, they will issue the summons based on the probable cause for the stop such as speeding, careless driving, reckless driving or broken taillight (52T57-52T58;52T93-52T94).[28] The operators, however, have the option of dashing out the required field for reporting the summons numbers, proceeding with the test sequence, and adding the number later by hand if they get a reading of .08 or above (56T8-56T9;60T28-60T29). This option may apply in cases where there was an inference of intent to operate a motor vehicle and no other probable cause (56T10).

After inputting the data, the last prompt reminds the operators to review the information for mistakes (52T60;52T62). Flanagan recalled one operator who reviewed the data and mistakenly hit the Y key for each field, inadvertently erasing all the information he previously had entered (52T64). He attributed the mistake to human error, noting it had no effect on the instrument's accuracy in breath testing (52T63).

All operators in the conversion class eventually are divided into teams and instructed to perform a minimum of four tests on the Alcotest 7110 including a full

---

28. State Police protocol considers the arrest time as the time of the stop (55T63).

sequence of data entry and breath testing (52T65). Each team also must induce errors into the instrument such as minimum volume or blowing time too short (52T53-52T54;52T65-52T66). All tests are done without alcohol (59T59).

Additionally, the ADTU instructs operators to change the mouthpiece after each breath sample and read specific blowing instructions to the subject (52T70;52T80). The class provides each officer with a sheet of the instructions, which also are included in the manual and posted on the wall near the instrument at each police department (52T75). The instructions read: "I want you to take a deep breath and blow into the mouthpiece with one long, continuous breath. Continue to blow until I tell you to stop. Do you understand these instructions?" (52T75). The *Foley* decision prompted the change in the instructions from "normal" to "deep" breath to make sure that a subject provided alveolar or deep lung air (52T76-52T77). Operators coach the subject through the blowing process (52T78). The State Police do not videotape subjects on the Alcotest 7110 (57T53).

The ADTU further instructs operators that the Alcotest 7110 has RFI shielding up to one gigahertz, but that portable radios and cell phones should be kept out of the room during breath testing (52T95; 54T102;58T62-58T63). According to Flanagan, the manufacturer did not recommend the use of an RFI detector because it would require the drilling of a hole through the shield (58T61-58T62).

With regard to the issue of "sucking," the ADTU now trains operators to be keenly aware of subjects who suck air from the room through the top port, normally used to draw in air for ambient air checks or purges (53T60-53T61;53T68;54T81). He did not believe that the air was drawn into the instrument through the one-way flapper valve at the back of the instrument (58T54-58T55). Flanagan found that the instrument reported a result of .000 because it could not distinguish room air from breath (53T61). When operators observe sucking, the ADTU instructs them to terminate the test and charge the subject with refusal (53T61;53T67;54T76-54T78).

At the end of their training, operators take a twenty-five question test based on the material covered during the day (52T97). Operators who miss eight or more questions fail the class and do not get certified on the Alcotest 7110 (52T97). They can take the class again on another date but must sit through another entire day of training (52T97-52T98). If they pass, the operators receive a certificate and get their breathalyzer pocket card updated and signed, which certifies them as trained operators on the Alcotest 7110 (60T11;60T14-60T15). The certification remains valid for the rest of the calendar year plus two more years (60T11-60T12;S-71).

To obtain breath samples, Draeger and the ADTU recommend that a subject remain seated during the test (52T67;54T97-54T98). Flanagan also recommended that subjects wear handcuffs (52T66-52T67). He explained that subjects still were under arrest and did not need the use of their hands to blow into the instrument (52T67). He further explained that it was easier to control a subject who was sitting and handcuffed, and such measures prevented situations where a subject could damage the instrument by ripping out the breath tube, requiring its return to Draeger for repairs (52T67;52T69). The sitting position also made it easier for subjects to give samples whereas if they stood, there was a greater chance of falling or staggering or bending which could restrict their diaphragms and airflow (52T69;54T99-54T100).

An operator may not begin the test on a subject prior to a twenty-minute observation period to ensure that there is no alcohol in the mouth cavity (52T70). In New Jersey, the twenty minutes may begin at the station or immediately after the arrest provided that an officer can testify that the observation was continuous and uninterrupted (52T71-52T72). For example, Flanagan said that State Police ride double and a trooper could sit in the back and properly observe the subject (52T71). However, if any substances enter the mouth or a subject regurgitates, the twenty minutes must start over again (52T72). The twenty-minute period also must restart if there were any interruptions in the officer's observation of the subject (60T10).

After the operator performs the initial data entry, the LED screen displays a message to "please blow/R" (52T72). The operator has three minutes to read the blowing instructions, insert the mouthpiece, and collect a breath sample or the instrument will display the error message “ready to blow expired” (52T73). If the error message appears, the operator must select one of three prompts: (1) terminate; (2) refused; or (3) continue (52T73). When an operator pushes button three, the instrument purges itself and again prompts “please blow/R” and the process repeats (52T73). If the operator pushes the refusal button and then decides to continue the test, he will get the same three choices and can hit the number three button and continue with the process (60T10).

The Alcotest 7110 allows the operator eleven attempts at collecting two valid breath samples (52T74). After the eleventh attempt, the instrument gives only two options: (1) terminate; and (2) refused (52T82). At that point, the operator does not necessarily have to charge refusal (52T90). For example, if a subject has made several unsuccessful attempts, the operator can choose to terminate the test and give an opinion that the subject was not capable of providing a proper sample (52T91-52T93). While Flanagan acknowledged that women over seventy have trouble providing the minimum 1.5 liters, he did not think it was necessary to reduce the breath volume criteria (52T93;58T40). In such cases, he said the police officer could take the subject to a hospital for a blood test or issue a summons based solely on observations (52T93).

If the operator wants to allow a subject more than eleven attempts, he can simply restart the process (52T81-52T82). As Flanagan explained, the ultimate goal is to get good breath samples (52T89).

When a subject blows into the instrument, a maximum of twenty asterisks can appear on the LED screen (52T79;54T105). If ten or more asterisks appear, the subject has reached the minimum volume requirement of 1.5 liters (52T79;54T105). Because a subject must expel all the air in the lungs in order to reach deep lung air, the ADTU trains operators to encourage subjects to blow 3.0 liters or until twenty asterisks appear on the screen (54T107; 54T110;57T39;57T41;57T43). A subject may observe the screen at the operator's discretion (57T93-57T95).

If no asterisks appear, the operator knows that a subject is not blowing into the instrument (52T79). The operator also will receive an error message indicating "minimum volume not achieved" with the amount of air actually delivered (52T79). The message remains on the screen for thirty seconds at which time the operator must decide how to proceed (52T79). Flanagan explained that if a subject was providing 1.2 to 1.4 liters, he would give that person numerous "seven, eight, nine" attempts to collect two good breath samples (52T80). But if a subject was providing .2 or .3 liters after three attempts, he would charge that person with refusal (52T80).

The instrument also is programmed to institute a two-minute lockout between breath samples (53T53). Flanagan understood that Brettell instituted the lockout after *Foley* for quality assurance and to prevent contamination from any mouth alcohol still inside the cuvette from the previous breath test (56T21; 60T27;60T68-60T69). NHTSA recommended two to ten minutes between breath test sequences (60T28). When Flanagan and Brettell recently became aware that the instrument was not adhering to the two-minute lockout all the time, Brettell contacted Draeger which explained that there was a problem with the amount of time the pump was taking to purge and that the instrument was performing a correctible, very slight rounding error (59T64).

If a testing sequence is terminated or aborted, the ADTU instructs the operators to retain the documents (52T96). Flanagan emphatically stated that "[e]verything is sequentially numbered. We don't destroy anything, whether it's good or bad. We save everything. They are not to destroy any documents" (52T96). Upon completion of a test, the ADTU recommends that the operator give a copy of the AIR to the subject (57T71-57T72).

The operator manual lists all of the possible error functions with their possible causes and remedies (52T99;D-15 at 24). Such messages include:

1. AMBIENT AIR CHECK FAILED [where instrument detects something in room air that may affect the breath test];

2. BLOWING NOT ALLOWED [where subject blows, stops, and blows again];

3. BLOWING TIME TOO SHORT [where subject blows for less than 4.5 seconds];

4. BLOWING TIME TOO LONG [which never appears as subject cannot blow too long];

5. CTRL GAS SUPPLY ERROR [e.g., where simulator is disconnected from the back];

6. CTRL TEST FAILED [where results do not fall within tolerance of plus or minus 5% of .10];

7. ERROR STORING DATA [which Flanagan never saw];

8. EXTERNAL PRINTER ERROR;

9. FUNCTION NOT POSSIBLE [where access requires black key held by coordinators];

10. INTERFERENCE [where instrument detects interfering substances];

11. KEYBOARD ERROR [where faulty keyboard requires replacement];

12. MEMORY FULL [which never appears because instrument holds 1000 tests and requires downloading at 500];

13. MEMORY NEARLY FULL [which never appears because of downloading at 500];

14. MINIMUM VOLUME NOT ACHIEVED;

15. MODEM ERROR [which never appears because New Jersey does not use the modem];

16. MOUTH ALCOHOL;

17. OUT OF MEASURING RANGE [where instrument measures BAC above .630 at which time operator must take subject to hospital due to possible alcohol poisoning];

18. PLATEAU NOT REACHED [where operator must collect another breath sample];

19. PURGING ERROR [where instrument draws in room air];

20. READY TO BLOW EXPIRED [where three-minute period to collect sample expires]

21. SIMULATOR TEMP. ERROR [where simulator is heated outside the range of 34 degrees C plus or minus .2];

22. SOLUTION CHANGE REQUIRED [where solution is not changed within thirty days or after twenty-five test sequences];

23. SOLUTION HAS EXPIRED [where solution was not changed within thirty-day window)];

24. TESTS NOT WITHIN +/- TOL. [if third test is out of tolerance, instrument automatically aborts]; and

25. WARNING LOW BATTERY [where lithium battery requires replacement].

[52T99-52T110;D-15 at 24-25.]

Flanagan also explained the procedure for putting a new Alcotest 7110 into service. Draeger ships the instrument directly to the police department that purchased it (53T4). Draeger also sends certificates of accuracy with the dates of the calibrations of the instrument, temperature probe, and simulator (53T6;59T9). After the police department receives the equipment, a coordinator assembles the tri-level stand and the instrument (53T5). The coordinator checks the firmware version, calibrates the new instrument, sets the tolerances, performs control and linearity tests, and performs a solution change (53T5;53T39;54T32;59T52).

If an instrument is not using firmware version NJ 3.11, the coordinator does a firmware update (52T10). Each coordinator has a laptop with a CD burner on which Flanagan installs the most recent firmware version (52T11). Because all of the laptops in the field are new, the only firmware burned into them is NJ 3.11 (53T11-53T12).

To calibrate a new instrument, the coordinator must use a black key temperature probe to gain access to the calibration function (53T7;57T74).[29] The coordinator introduces into the simulator a bottle of .10 solution which must be heated for at least one hour (53T10;59T8). To measure the temperature of the simulator solution, the coordinator uses an Ertco Hart digital NIST thermometer (53T8;55T66;S-70).[30] After checking that the simulator temperature is 34 degrees plus or minus .2 degrees C, the coordinator hooks-up the simulator to the back of the instrument through the rear port of the cuvette (54T21). The coordinator then hits the escape key, gets function on the LED screen, types in calibrate, and follows the prompts (54T21). After reviewing the entered data, the coordinator hits the "N" key and the instrument calibrates itself and generates a report (54T22;S-51).

---

29. Flanagan was aware that the manufacturer also had a yellow key temperature probe which it used to gain "deeper access" into the instrument (55T68;57T75-57T77).

30. NIST is the National Institute of Traceable Standards and Technology (57T5).

New Jersey purchases the .10 solution from Draeger, which purchases the bottles from a company called Plus Four in Colorado (53T8;56T34-56T35). Draeger ships the bottles to New Jersey year-round on an as-needed basis in lots of 1000 (56T47-56T48;56T55). Prior to full shipment, Draeger sends six bottles to Brettell's laboratory, which uses gas chromatographs to make certain the solutions are within tolerance (56T46).

The coordinator sets the absolute tolerance at .005 and the relative tolerance at 5% for the .10 solution change as established by Brettell (53T13-53T14;53T17). Draeger's default tolerances are wider at .010 or 10% (53T17). The AIR will show if an instrument inadvertently used the default setting (53T19;55T87). For example, in 2005, both the Milltown and Plainsboro Township police departments asked a coordinator to check the solution configuration of their instruments (53T19). In each case, the coordinator found that the absolute tolerance on the solution configuration was incorrectly set at .010 and corrected it to .005, then recalibrated the instrument and prepared a special report stating exactly what had happened (53T19;53T30-53T31;S-47;S-48).[31] In both cases, the readings fell outside of the tolerances and should have been flagged as control test failures (53T31). Despite

31. Coordinators prepare special reports only if they deem them necessary to explain in further detail what actions were taken in the field (55T5;55T30;55T59). The ADTU has no written protocol regarding such reports and to date, only four have been prepared (55T5;55T7;55T9).

the mistakes, the instrument performed correctly to the "default" tolerance (53T30).

The purpose of the control test is to verify that the instrument calibrated itself properly to the .10 simulator solution (54T23). The control test analyzes the vapor through the rear cuvette using a wet-bath simulator (57T65). The coordinator enters "CTRL-TEST," hits the enter key and follows the prompts (54T23). After reviewing the inputted data for mistakes, the coordinator hits the "N" key and the instrument starts running the test through the rear of the cuvette (54T54;58T59). The control test runs three separate testing sequences and generates a report (54T24-54T25;S-52).

Brettell designed the annual linearity test to use simulator solutions of .04, .08, and .16 (54T28-54T29). To conduct the linearity test, the coordinator disconnects the simulator from the rear of the instrument (54T25). The coordinator then removes the NIST-verified temperature probe from the simulator and inserts it into one of the solutions (54T25). Each temperature probe has an assigned value, which can be changed only by a coordinator using the black key function (60T23).

After hitting the escape key and typing in "LIN-TEST," the coordinator follows the prompts to enter his name, badge number, lot number, bottle number, percentage of the solution, bottle's expiration date, the wet bath calibration unit, the simulator model (CU34), and the serial number (54T25-54T26). After the coordinator reviews the information, the Alcotest 7110 performs two tests on the solution through the breath hose (54T27;54T59). The instrument repeats the same process for each of the solutions (54T27;S-53).

After the linearity test, the coordinator uses a bottle of solution from the local police department, performs a solution change, and generates a report (54T29-54T30;S-54). Upon completion of the solution change, the calibration test sequence is complete and the instrument automatically prints an Alcotest 7110 Calibration Record on the external printer (54T30;D-224). After the calibration, control and linearity tests, and solution changes, the instrument is assumed to operate correctly and will not be inspected again for one year unless a problem arises or the instrument reaches 500 tests (59T11).

Because Brettell opted to use the laser jet desk printer, the instrument's internal printer has been disabled (58T23-58T24). However, it can be reactivated by a coordinator with the black-key function if the instrument is unable to print externally (60T30). If the coordinator switches to the internal printer, the instrument subsequently would be taken out of service for repair (60T30).

The ADTU trains operators that they can not charge subjects under *N.J.S.A.* 39:4-50 with test results between .05 and .08, unless there are other sufficient strong indicators of intoxication but that they should charge subjects with DWI with readings under .05 (56T7;59T82;59T89;60T28). If an officer or trooper prematurely issues a ticket for a subject with a low reading, the officer must go to court to have it dismissed (56T8).

During his testimony, Flanagan conducted a three-part demonstration of the Alcotest 7110 including: (1) a normal test sequence with no errors using a fresh bottle of .10 simulator solution; (2) a test sequence with induced errors (minimum volume not achieved, blowing time too short, blowing not allowed, sucking, and control gas supply error); and (3) a blind test sequence using a solution with a concentration known only to this court (52T5-52T6;53T41-53T79). For a detailed discussion, this court refers the reader to the videotape (S-69;S-69a).

Of particular interest are the results from the blind test. For this demonstration, the State asked this court to select one of four bottles with concentrations of .04, .08, .10 and .16 (53T70). Unknown to the parties or amici, this court selected the bottle with an alcohol concentration of .16 (53T73;S-63). Before all the testing began, Flanagan performed a solution change with a fresh bottle of .10 solution which included: a purging (which used the internal pump to flush room air through the cuvette and breath hose to make sure there was no residual alcohol); an ambient air check (which tested an air sample from the cuvette using the fuel cell); control test one (which pumped air through the hose into the simulator and then introduced the sample through the rear of the cuvette); a purge; an ambient air check;

control test two; purge; ambient air check; control test three; and final purge (53T41-53T45).

For the blind test, Flanagan blew through the breath hose which was hooked up to the front of the simulator, and produced the following results: .151 EC and .153 IR for breath test one; and .151 EC and .155 IR for breath test two (53T73;S-62). At the request of defense counsel, Flanagan repeated the test using the same bottle of solution and produced results of .150 EC and .152 IR for breath test one and .150 EC and .152 IR for breath test two (53T72;S-64). Both tests underestimated the labeled concentration of .16 (53T75).

Flanagan then used the same .16 solution, but introduced his breath vapor through the rear of the instrument as part of the control test (53T79-53T83;55T47;60T52-60T53). Because the instrument was calibrated to read a labeled .10 solution, the control test failed but the instrument still produced a printout showing results of .152 EC and .153 IR (53T85;S-65). Flanagan thought that the low results could be due to solution depletion, which he attributed to blowing six times at over 3.0 liters each (53T85). He also suggested the results were influenced by variation in his blowing time and the fact that he used a training instrument which had not been calibrated since May 12, 2006 (54T5-54T7;60T54).

The following day, Flanagan ran another test using a fresh bottle of .16 solution with the hose pumping air into the instrument through the simulator (54T6-

54T16;56T33;56T41;60T29). Before he started the test, however, Flanagan performed a solution change using a fresh bottle of .10 solution, and got results of .097 EC and .099 IR for both control tests one and two, and .098 EC and 0.10 IR for control test three (55T52-55T55;S-58). Next, he disconnected the simulator and hooked up the .16 solution to the back of the instrument (55T55;60T29). After the instrument aborted the control test, it printed out results using the .16 solution of .155 EC and .158 IR (55T56).

When asked to explain why the results were lower than .16, Flanagan again suggested they were caused by depletion (56T41;60T29). He explained that a concentration of .16 tended to deplete more quickly than .04, .08, or .10 because it contained more alcohol (60T51-60T52). Flanagan also observed that he blew for 18.2 seconds the first day whereas the hose pumped air into the simulator for fifty-five seconds the second day when the results were higher (54T13-54T14). On redirect, however, he concluded probably that the readings were higher the second day because he had used a new bottle (56T39;60T29).

Regarding Draeger's optional breath temperature sensor, Flanagan believed that its purchase would create administrative and financial problems (54T41). In New Jersey, each police department buys its own breath-testing instrument (54T37;54T39).[32] In addition to

32. Flanagan explained that the State of Alabama owned the individual breath-testing instruments and kept fifteen spares in the laboratory to rotate with those in the field (54T39-54T40).

sensors, this option also requires calibration equipment including a square plexiglas chamber which holds fifty gallons of water, weighs 400 pounds, and costs about $32,000 (54T37-54T38;54T74;S-66). Because such a chamber would not be portable, the calibration procedure would have to take place at a central location or the instrument would have to be sent back to Draeger (54T37-54T38). If the instrument was sent to Draeger, the local police departments would have to take their DWI arrestees, in the interim, to neighboring towns (54T72;54T75).

If the State purchased the equipment, Flanagan estimated that it would need more than one chamber to accommodate the anticipated 600 State-wide instruments when the program was fully implemented (54T38;54T73). The State currently has over 400 Alcotest 7110s in the field (54T89).

Flanagan also offered explanations for alleged errors on some alcohol influence reports (AIRS). For example, in the case of an AIR from the East Brunswick police department which allegedly was missing a sequential file number, he explained that the coordinator was doing a linearity test, encountered a problem with the simulator, and hit the reset button causing a sequential file number to be issued but no report (54T45;D-58). In another East Brunswick case where a subject provided a valid breath test but then had two subsequent readings of .000, Flanagan explained the results were caused by sucking air through the instrument (54T46-54T48;D-129;D-130). He gave a similar explanation for an AIR from the Haddonfield police department where a subject had a reading of .000 followed by two other readings of .14 (54T48-54T49;D-130).

In two other cases from Hopatcong and Chatham Borough, Flanagan noted that the officers had reported difficulty in entering times and dates (54T49). In Chatham, the operator could not enter the data because someone had checked the solution earlier and failed to hit the quick reset button, so instead the operator took the subject to another police department for testing (54T50). In Hopatcong, when the instrument would not allow the officer to enter the correct date and time of arrest, the officer intentionally entered the wrong date (54T51). Flanagan noted that the officer failed to follow his ADTU training to hit the quick reset button (54T51).

Flanagan also found that an operator in Middlesex Borough had violated training procedures by not waiting a full twenty minutes after the instrument reported a mouth alcohol error (54T52-54T58;54T67;D-134;D-135). In another case, he found that the number "4" repeatedly appeared on AIRs from Princeton Borough in the serial number space for the calibrating unit due to a problem with the side keyboard (54T63-54T64;D-142). Similarly, in Milltown Borough, he found that a control test failed to abort because the tolerances had been improperly set allowing the instrument to default to 10% (54T64-54T65;D-144).

Flanagan also addressed the issue of tolerance between two breath samples. In October 2005, the operator manual changed the explanation of tolerance to read "plus or minus .010 percent or plus or minus 10 percent of the average, whichever is greater" (57T96-57T97). The earlier manual had omitted the "plus or minus" (57T96;60T16). Prior to distribution of the revised manual, the training class coordinators taught the corrected version and wrote it on the board (57T97). The actual tolerance in NJ 3.11 never changed (60T16).

During the course of his testimony, Flanagan indicated that he would like to see several changes on the next firmware version, including the following additional information on the AIR: (1) the temperature probe serial number and probe value; (2) the serial number of the Ertco Hart temperature device used by the coordinator; and (3) the firmware version (53T36;60T23-60T24). He also recommended that the firmware be locked (meaning that if someone modified the software, it would be reported as modified on the AIR) and that the public receive some form of notice of future firmware changes (60T25-60T26;60T86-60T87).

Sergeant Flanagan was an excellent witness. This court finds him very honest and very reliable. He has an impressive knowledge of the Alcotest 7110 and has obviously worked very hard to master the nuances of the program and the instrument. From his testimony this court concludes that the Alcotest 7110 is far superior to the breathalyzer because it functions independent of operator influence and provides a detailed, accurate contemporaneous printout of all test sequences and results independent of any operator influence or possible subjective interpretation.

4. *Summary of Testimony of State's Expert, Edward Conde*

The State first presented the testimony of Edward Conde, a chemical engineer employed by Volpe in Cambridge, Massachusetts (1T41). As part of the Research and Innovative Technologies Administration, U.S. Department of Transportation (USDOT), Volpe conducts transportation-related projects including the testing and evaluation of evidentiary breath-testing instruments for government and private entities (1T41;1T81;2T40-2T41).[33] In 1996, 2003, and 2006, Volpe tested different firmware versions of the Alcotest 7110 to determine if they met the model specifications recommended by NHTSA (1T82;1T88;1T111;2T40). Conde participated in the 2003 and 2006 evaluations with New Jersey firmware versions 3.8 and 3.11, respectively (1T89;1T110-1T111;2T54;2T92-2T93;2T107;3T66).

Conde holds a Bachelor of Science degree in chemical engineering from Manhattan College (1T41). For twenty years, he has worked at Volpe in a variety of positions culminating in his January 2006 appointment as program manager of the Alcohol Countermeasure Support Laboratory, replacing Dr. Arthur Flores (1T41-1T43;1T101). Conde is a member of the International Association of Chemical Testing (IACT) and the United States working committee evaluating the recommendations for international breath-testing

---

33. According to Conde, an instrument performs measurements whereas a machine performs work (1T98;1T107).

instruments set forth in a document prepared by the OIML (1T44).

The State offered Conde as an expert in the chemistry of breath testing (1T44). This is a summary of his testimony dealing with the NHTSA model specifications and the Alcotest 7110's scientific reliability.

Evidential breath-testing instruments precisely measure the concentration of alcohol from a human subject or a simulator (1T45). Volpe tests these instruments in the laboratory using a simulator or breath alcohol sample simulator (BASS), and does not perform human testing for a variety of reasons including, but not limited, to safety issues arising from alcohol dosing (1T46;1T52-1T53;1T109-1T110; 1T112;2T17;3T62).

Volpe's testing protocol conforms to NHTSA's model specifications drafted in 1993 by Dr. Flores in conjunction with the National Institute of Standards and Technology (NIST), the government agency that controls measuring devices (1T47;1T57;2T23). Those specifications revised the 1984 version to accommodate work-place testing, to add testing for acetone interference,[34] and to meet new zero tolerance laws for underage offenders (2T22-2T23;3T52).[35] If an instrument

34. Acetone is a ketone found on the breath of diabetics and people on severe weight loss programs, which can produce false readings of breath alcohol (1T61-1T63).

35. *See* 58 *Fed. Reg.* 48705 (Sept. 17, 1993).

successfully meets the model specifications to measure breath alcohol, NHTSA adds it to the conforming products list (CPL), which is amended periodically (1T49). NHTSA publishes the specifications and CPL in the *Federal Register* as recommendations to assist states in their purchasing decisions (1T47).

Generally, manufacturers contact NHTSA in writing to request testing of new instruments for type approval or re-testing where changes are proposed (1T76;1T78). Because NHTSA designed the model specifications to determine whether an instrument is accurate and precise, Volpe will only perform re-testing if the proposed changes are likely to affect an instrument's accuracy or precision (2T17-2T18;3T14-3T15). Conde defined accuracy as a measure of how close the results get to the concentration that is being tested, and precision as a measure of the spread of data (1T53). As he explained, "if you're measuring at .080 and you [get] 10 measurements around .075, the instrument may not be accurate, but it is precise because it's giving you the same result every time" (1T54).

If deemed appropriate, NHTSA also will require testing upon special request by a state (1T80). The testing follows the same protocol used on instruments submitted by manufacturers (3T65). Thus, NHTSA requires re-testing of proposed hardware or software changes only if they are likely to affect an instrument's ability to return an accurate and precise result (1T77;1T79-1T80). For example, NHTSA did not require testing of the Alcotest 7110 MKIII-C because the sole change involved the instrument's capability to communicate with a computer (1T88). Conde pointed out that the model specifications encourage end-users to report any problems encountered in the field that may require re-testing (3T35).

Volpe conducts its tests under government contract and without any charge to the manufacturer (2T42). The manufacturer must submit a single instrument, operational and maintenance manuals, and any other relevant information such as basic diagrams or drawings (1T78-1T79;2T41;2T65;2T96). Volpe relies upon the schematics, among other things, to insure that the device remains essentially unchanged over time (1T79;2T27). If Volpe determines that an instrument no longer conforms to the CPL, it may be removed (1T80).

Volpe's protocol consists of eight steps or conditions: (1) precision and accuracy testing at alcohol concentrations of .02, .04, .08, .16, and .30 grams per 210 liters of breath; (2) interference testing for low and high levels of acetone, which can cause false readings; (3) blank testing to insure that a zero breath alcohol concentration does not produce a positive test result; (4) BASS testing to mechanically simulate a human subject blowing into a device at flow rates of .2, .3 and .5 liters per second, with durations of blow at six, ten, and twelve seconds; (5) power variation or voltage testing at 108 and 123 volts; (6) temperature testing at 20 and 30 degrees C for in-door bench-top devices such as the Alcotest 7110 as distinguished from hand-held devices; (7) post-vibration testing at the .080 level at three different orientations; and (8) basic electrical safety testing (1T53-1T54;1T60-1T67;1T69-1T70;1T73; 1T77;1T106-1T107;2T46;2T97-2T98). For each condition, Volpe runs a series of ten tests and requires that the measurements be taken to three decimal places, that the mean falls within .005 or 5%, whichever is greater, and that all tests fall within a standard deviation of less than or equal to .0042 (1T74-1T75;3T50).

Volpe also does informal testing for RFI utilizing a Motorola HT 220 police-style walkie talkie operated at 170.4 megahertz from a distance of six feet in all four orientations (1T70-1T71). NHTSA does not require RFI testing because studies performed in the early 1980s found that such interference had a limited effect on breath-testing devices (1T71;2T10-2T13). Conde performed the informal RFI testing in 2003 only (1T72).

Additionally, Volpe tests the wet bath simulators used for control tests that introduce a certain concentration of alcohol into a breath-testing device (1T55-1T58). Control tests generally are performed by the end user who then compares the breath concentration of a human subject with the control test results (1T59). To get the proper concentration, the simulator temperature must be 34 degrees C (1T57).[36] With regard to human

36. On direct, Conde testified that the temperature had to fall within a range of plus or minus .01 (1T57). On cross, however, he said the range was plus or minus .1 (1T117). According to the Aloctest 7110 MKIII-C User Manual-Technical, the water-alcohol solution in the wet-bath simulator must be maintained at 34 degrees C plus or minus 0.2 degrees C (S-49 at 14).

subjects, however, Conde acknowledged that a subject with a temperature higher than 34 degrees C who blew into a breath-testing device would tend to have an elevated breath alcohol content (1T119). Nonetheless, he did not recommend the use of breath temperature sensors (1T121).

Conde described the Alcotest 7110 as a bench-top breath alcohol device which uses IR and EC or fuel cell sensors to independently measure breath alcohol content in contrast to the Intoximeter EC/IR which uses the IR sensor to check for mouth alcohol only (1T85;1T87). He further noted that the Alcotest 7110 currently operates at a wavelength spectrum range of 9.5 microns in which acetone is virtually unnoticed (1T87).

In 1996, at the request of Draeger Safety Diagnostics, Inc., Volpe successfully tested a generic Alcotest 7110 MKIII (1T82;1T85;1T88;3T42-3T43). In 2003 and 2006, New Jersey requested special testing of the Alcotest 7110 MKIII-C with NJ versions 3.8 and 3.11 (1T89;1T93;3T62-3T64).

Of importance, Conde performed tests on NJ 3.11 from December 2005 to February 2006 (2T92;2T102). With Draeger's assistance, he bypassed the initial data entry field, claiming that it had no bearing on the instrument's accuracy and precision, and relied upon the internal printer so he did not have to do all the typing between tests (2T35-2T36;2T67-2T68;2T107). Conde's tests generated AIRs with sequential files numbers from

00059 through 00189, although some AIRs were not produced in discovery (2T102-2T105;3T10-3T14). With regard to gaps in the sequence, Conde explained that the instrument ejected pages whenever he started to enter data and was interrupted (3T10-3T16). He also discarded AIRs if they did not contain any data needed for type approval such as control test failures or if he did obtain the data point that he sought (3T9;3T21). Conde further explained that the model specifications only required him to retain AIRs which contained data needed for type approval or disapproval (3T11;3T15).

Conde acknowledged that there is a small range of error with any instrument used to measure breath alcohol in terms of discrepancies between an expected result and the one that the instrument actually returns (1T112;2T94;3T24). The model specifications, therefore, allow for some systematic or analytical error to account for any uncertainty with regard to an instrument's accuracy and precision (1T113-1T114;2T111). Nonetheless, Conde concluded that based upon his training and experience and the tests he performed, all three cycles of testing on the Alcotest 7110 met the model specifications, thereby indicating that the device — including NJ 3.11 — was suitable for use in an evidential environment to a reasonable degree of scientific certainty (1T93).

This court finds Conde very credible and candid, and was quite impressed with his testimony. This court accepts Conde's explanations that the discarded AIRs were simply incompleted test runs, bearing no relevance to the scientific reliability of the instrument. Conde was vigorously cross-examined by able counsel. His testimony was candid, forthright and impressive in every respect.

5. *Summary of Testimony of State's Expert, Rod G. Gullberg*

Rod G. Gullberg retired last year from the Washington State Patrol (State Patrol), where he held the rank of sergeant (7T58;7T61). He worked in the crime laboratory division and for twenty-three years, supervised the State Patrol's breath testing program (7T61;8T98). Gullberg currently works for the State Patrol in a civilian position as a research analyst (7T58). He writes curriculum for, and trains technicians in, the use of the Datamaster BAC and CDM, Washington State's breath-testing instrument (7T58;8T108). He also works closely with Barry K. Logan, the Washington State Toxicologist, on the formulation and development of breath-testing policy (7T59). Gullberg collects and analyzes breath alcohol data and prepares reports for police and traffic safety organizations (7T58-7T59).

Gullberg holds a Bachelor of Science degree in animal science from Washington State University (1971), a Master's Degree in public administration from Eastern Washington University (1978), and a Master's Degree in biostatistics from the University of Washington in Seattle (2003) (7T57;C-14, Gullberg CV). He is a member of the Northwest Association of Forensic Scientists and the American Academy of Forensic

Sciences — Toxicology Section, and serves on the National Safety Council's subcommittee on alcohol and other drugs (7T59). Gullberg defined forensic toxicology as a "mandated science," meaning that it was a science practiced within a legal environment consisting of statutes, case law, administrative rules, and policies (11T111-11T112).

He also teaches twice a year at the well-recognized Robert F. Borkenstein course at Indiana University and has written many articles on such subjects as breath alcohol measurement and blood-breath ratios (7T58-7T59;7T60;7T62). He is a qualified breathalyzer operator, technician, and instructor who testified as an expert on the breathalyzer numerous times in Washington state courts and on the blood-breath ratio in *Downie* (7T58;7T60;8T99-8T100;8T103). Additionally, in 2004, he performed several months of testing on an Alcotest 7110 instrument which Draeger loaned to the State Patrol for evaluation purposes (8T105-8T106;10T76-10T78). He is very competent and experienced in the areas of breath testing and biostatistics.

Prior to 1985, the State of Washington (Washington) used the breathalyzer which relied upon a partition ratio of 2100:1 to convert the alcohol-in-breath reading to an alcohol-in-blood reading, meaning that the alcohol concentration in the blood was 2100 times that in the breath (8T98-8T99;8T107;

12T52;13T19).[37] The partition ratio derives from Henry's law, which applies to closed systems such as a simulator or the deep alveolar region of the lungs (11T90-11T91). Henry's law states that in a closed system and at a given temperature, there is a fixed ratio between a volatile substance, such as alcohol, in a liquid and the same volatile substance in a gas (7T83-7T84;11T90-11T92).

The partition ratio describes the equilibrium which exists when a gas (ethyl alcohol) is placed in a simulator (closed container) containing a solution heated to 34 degrees C with air in the headspace above it (7T84; 7T87;11T92-11T94). Because alcohol is volatile, it will partition itself between the solution and air (7T84). The resulting equilibrium is known as the partition coefficient or ratio of the concentration of alcohol molecules in the solution to the concentration of alcohol molecules in the air in the headspace (7T84).

A similar process exists in the alveolar area of the lungs where alveoli (tiny air sacs at the end of the respiratory track) come into contact with capillary blood, which contains alcohol (11T94-11T96;12T21-12T22). At the higher alveolar temperature of 37 degrees C, the partition ratio is 1756:1, or 1756 parts of alcohol in the blood to one part in the air (7T85-7T86). As the temperature rises, more alcohol molecules will emerge into the vapor (11T96). It is noted here that Gullberg

---

37. In the fall of 2006, the State Patrol planned to begin the evaluation of newer versions of breath-testing instruments including the Datamaster, Alcotest, Intoxilyzer and Intoximeter (8T108-8T110).

was aware of the theory that alcohol in breath samples also came from the airways, not the alveoli (12T46). He noted that interaction of alcohol with the airways was one factor in why breath alcohol concentration could vary (12T46).

While the partition ratio applies to the deep lungs, Gullberg said it does not apply to measurements of end-expiratory breath and venous blood which do not come into contact with each other (8T5). To describe the relationship between those two independent measurements, Gullberg preferred the term "blood-breath ratio" which he described as the ratio of two measurements consisting of blood alcohol concentration divided by breath alcohol concentration (8T5;9T8; 13T58-13T59). Because a person's blood-breath ratio varies from time to time and even within the same breath exhalation, Gullberg emphasized that that there was no uniform agreement among populations about this ratio (8T16;9T7;10T103;11T105). Thus, he testified that Great Britain and the Netherlands use 2300:1; Norway and Finland use 2100:1; and Austria and France use 2000:1 (10T101-10T102).

To support his testimony concerning the range of blood-breath ratios, Gullberg cited a single-breath study conducted by Dr. A.W. Jones of 793 individuals in Sweden who were arrested for driving under the influence and found that the mean ratio was approximately 2411:1 with a standard deviation of 205

(8T6-8T7;8T15).[38] Jones' study found that thirty-four individuals or 4.3% had a blood-breath ratio below 2100, meaning that their breath measurement overestimated their blood alcohol values (8T7-8T9).

After plotting Jones' raw data on a graph, Gullberg observed that for most of these thirty-four subjects the overestimations were harmless false positives because the breath exceeded the blood and both were over .08 (8T10;12T104). For those individuals with false positive results (such as a breath alcohol reading above .08 and a blood alcohol reading below .08), Gullberg agreed that more weight could be given to clinical observations drawn at and after the time of arrest (8T12).[39]

Over the years, Gullberg has conducted a series of studies on individuals involving the near-simultaneous taking of breath and venous blood samples, the latter of which were read by gas chromatography in his toxicology laboratory (8T22-8T23). In one side-by-side study, a twenty-eight-year old volunteer gave a very long

---

38. *See* A.W. Jones and Lars Anderson, *Variability of the Blood/Breath Alcohol Ratio in Drinking Drivers*, 41 *J. Forensic Sci.* 916 (1996) (D-19).

39. In support of his statement that the blood-breath ratio varied among populations, Gullberg briefly mentioned a study in New Zealand which analyzed single and double breaths from 21,000 subjects (8T15). He evidently was referring to A.R. Gainsford, et al., *A Large-Scale Study of the Relationship Between Blood and Breath Alcohol Concentrations in New Zealand Drinking Drivers*, 51 *J. Forensic Sci.* 173 (2006).

exhalation which showed a rise in the breath alcohol curve with a corresponding horizontal line representing the blood alcohol (8T22-8T23;S-11). In another study, a subject was dosed with a specified alcohol concentration and every fifteen minutes over a seven-hour period, technicians collected duplicate blood and breath samples (8T25-8T26;10T109;S-10).

Gullberg's studies confirmed that the blood-breath ratio was not the same for every individual, that it was not constant within an individual, and that it tended upwards over the course of an exhalation as alcohol was eliminated (8T21-8T23;8T25-8T26). In any event, Gullberg did not consider the ratio to be a fundamental element of the breath instrument or to effect its ability to make accurate measurements (12T128-12T129).

Given the range of extant calculated partition ratios, Gullberg recommended that drunk-driving statutes avoid the blood-to-breath comparison by adopting a breath alcohol standard and if not, that courts give greater weight to the clinical picture at and after a subject's arrest along with the surrounding circumstances (8T11-8T12). In any event, he agreed that the 2100:1 ratio usually underestimated the amount of alcohol in the blood, thereby favoring the defendant (8T15). New Jersey's protocol of taking four breath measurements from two separate samples, selecting the lowest reading, and truncating the results to two decimal places further benefited the defendant by producing more results on the low side, with truncation alone favoring the defendant 90% of the time (9T9;10T63-10T64).

In some cases, however, Gullberg recognized that the 2100:1 partition ratio resulted in readings on the high side (8T18). He was unwilling to predict how often that would happen in a general population, noting that it depended upon several factors such as the analytical methods used (8T18).

Unlike the variation in breath samples, Gullberg testified that blood alcohol sampling was more precise primarily because an individual cannot influence the results (8T61;9T7). Both methods, however, are analytically equal with the gas chromatograph (used to take blood alcohol readings) and the Alcotest 7110 of equal precision (8T61;9T7). With regard to New Jersey's breath-testing protocol, he stressed the importance of ambient air blanks to purge the instrument, control tests which relied on reference standards traceable back to the NIST to insure its accuracy, and two separate breath samples to account for any biological variability, insuring the precision or repeatability of the measurement process (8T59-8T60).

Gullberg further explained that the use of a tolerance standard within the four tests on the two separate samples allowed for the increasing variation that existed in breath alcohol measurement (8T65-8T66;8T68). Gullberg testified that New Jersey's tolerance or agreement standard varied for values below and above .10 (8T65). Specifically, he stated that the tolerance between four tests (two IR and two EC) with a mean below .10 must be within .01 grams per 210 liters, but at .10 or greater, it must be within plus or minus

10% of the mean (8T63;9T67;12T12). In comparison, Washington's tolerance was plus or minus 10% of the mean of duplicate breath alcohol measurements throughout the entire range (8T63;9T27-9T28).

Gullberg thought that New Jersey's and Washington's tolerances were too imprecise, noting that New Jersey's tolerance of plus or minus 10% was "rather broad" and Washington's tolerance also was "a little too generous" (8T66-8T67;10T72). He preferred a plus or minus 5% standard which would have a greater power to detect errors (10T90;12T15). He noted that the National Safety Council recommended that duplicate breath test results should have an absolute — as opposed to relative — tolerance of .02, which other states have adopted (8T68-8T69;12T109;12T120;D-27).

Gullberg analyzed the data from Middlesex County in order to estimate the standard deviation in breath alcohol measurement (8T42-8T43). He examined only those individuals who had acceptable first and second breath tests, which consisted of 1334 duplicate breath alcohol results out of the total sample of about 1900 tests (8T65;9T20;13T5). For those individuals, Gullberg plotted a scattergram showing that 95% fell below .02 and about 5% fell outside of the tolerance of plus-or-minus 5% of the mean (8T70;13T58;S-18). Gullberg explained that subjects whose tests fell outside the tolerance should be retested (13T58).

Gullberg also analyzed unpublished Alabama data to determine minimum breath volume (8T71).

Specifically, he examined first and second breath samples taken on an Alcotest 7110 (IR readings only) provided by individuals who were about to be released the morning after their arrests (8T73;10T22). Of the 15,000 subjects who provided the first breath samples and 14,300 subjects who provided the second breath sample, only 4.1% and 2.5% respectively had volumes below 1.5 liters (8T75). Based on the presumption that those subjects willingly provided the samples in anticipation of their release, Gullberg concluded that most people have the biological capability of meeting New Jersey's minimum volume requirement (8T79).

Gullberg did acknowledge, however, that females tend to have difficulty achieving 1.5 liters as they get older (10T34). Specifically, his analysis showed that breath volume of females dropped dramatically around age seventy-five (10T34). He further acknowledged that a study of 4000 subjects in Germany showed that females between the ages of sixty and sixty-nine years produced on average 1.4 liters of air (10T35;AB2). Other biological factors affecting the delivery of a breath sample included lung capacity and how a subject exhaled (12T30-12T31). Washington, like New Jersey, has a minimum volume requirement of 1.5 liters (8T119).

Gullberg also concluded that New Jersey's protocol had adequate safeguards against mouth alcohol, including: a twenty-minute observation period which he considered the most critical; duplicate breaths tests which had to fall within predetermined acceptable limits; and a slope detector which monitored each exhalation

(8T82;12T87). Gullberg relied in part on an experiment in which he repeatedly administered mouth alcohol to a single individual who then spit it out and exhaled directly into the Datamaster (8T82-8T83). After collecting several samples, Gullberg found that it took seven minutes for depletion of mouth alcohol in an individual with a reading of .103 (8T86). He concluded that a fifteen-minute observation or deprivation period was more than sufficient (8T87-8T89). He also observed that slope detectors could be "fooled" by someone who had consumed alcohol (12T80).

In addition to New Jersey's protocol for detecting mouth alcohol bias, Gullberg wrote in his expert report that the protocol for detecting RFI, electronic component failure, and interfering substances ensured a high probability of error detection (C-14, Gullberg report at 5). He stated that the instrument's algorithms monitored for the presence of other errors (C-14, Gullberg report at 5). Specifically, he calculated that errors occurred approximately 3.8% of the time (C-14, Gullberg report at 5-6). After quantifying all relevant sources of uncertainty, Gullberg concluded that a high degree of confidence could be assigned to breath test results arising from a full analytical run which complied with all quality control criteria (C-14, Gullberg report at 17). When asked if he agreed with a 1987 article written by Dr. Gerald Simpson who concluded that the error for all subjects in post-absorptive breath alcohol testing was as high as 22% (for 99% confidence) or 15% (for 95% confidence), Gullberg declined to do so without more information on how error was defined (12T114-12T115).

With regard to breath temperature, Gullberg noted that it varied within a population (9T44). He was aware of recent studies showing that normal breath temperature was closer to 35 degrees C, and not the 34 degrees C assumed by the Alcotest 7110 (9T44;11T107-11T108;AB2). Nevertheless, Gullberg considered temperature to be "totally irrelevant" to the measurement of breath alcohol (12T34). Thus, he opined that it was not necessary to subtract 6.8% (used in Alabama) or 6.59% (advocated by Schoknect and Stock) from the recorded breath result to account for a higher temperature because the breath instrument was designed to accurately measure the alcohol concentration in the sample it received (9T13-9T14;9T33-9T34;9T37-9T38;13T60). Thus, both readings — at 34 and 35 degrees C — are analytically correct and even if there is some uncertainty in the measurement, they are fit for purpose or appropriate in the context for which they are being used (9T38-9T41;10T102). Indeed, Gullberg testified that there was uncertainty and error in all measurements, and that all technology was limited (11T112;12T103).

As for software-related issues, Gullberg testified that he did not know anything about the technical details and did not care if algorithms varied among instruments (13T8-13T9). He also did not care if software or hardware was different for purposes of evaluating a breath instrument's accuracy and precision (13T55). Instead, he cared about final test results and if they met his expectations after completion of New Jersey's thirteen-step protocol (13T9;13T12;13T14). If a critical error occurred which would affect his confidence in the analytical result, he would expect the Alcotest 7110 to abort the test (13T15). While he did not necessarily care if a record was made, he later admitted that error reports might be useful (13T15;13T50). Prior to the purchase of new breath-testing instruments, however, Gullberg advised that the software should be checked for reasonable integrity by an independent laboratory (13T52-13T53;D-16).

Since the Datamaster's introduction in Washington, Gullberg reported that it had undergone several changes in software and hardware (13T29;13T32). To check the instrument's measurement system for possible errors, Gullberg and others studied information sent to a central computer, reviewed reports from officers in the field indicating possible errors, and performed experimental tests in the laboratory on human subjects to explain invalid samples such as the misidentification of mouth alcohol (13T26;13T29-13T31). National Patent Analytical Systems, Inc., the Datamaster's manufacturer, also provided him with details of its algorithm and, upon request, has provided others with the source codes under protective order (8T110-8T111;13T36-13T38). Gullberg, however, never felt it necessary to examine them (13T55).

Gullberg concluded that test results obtained from the Alcotest 7110 were reliable when all of the criteria were met (8T96). He was confident in the instrument's measurement results based upon his review of New Jersey's protocol, training program, documents, and the printout of test results (13T60-13T61).

This court found Gullberg a very sincere and forthright witness and technically very well-qualified. This court considers him very honest and reliable.

6. *Summary of Testimony of State's Expert, Samuel E. Chappell*

Samuel E. Chappell holds a doctoral degree in physics from Pennsylvania State University and spent thirty-eight years at the National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards, United States Department of Commerce (3T70-3T73). He started working at NIST as a bench scientist in the Radiation Physics Division; he retired in 2000 as head of NIST's Office of Technical Standards Program (3T74). From 1987 until his retirement, Chappell served as the NIST-appointed United States' technical representative on the OIML and vice-president of its international committee (3T75-3T77;3T168). Beginning in 1994, Chappell also served on OIML's subcommittee which developed recommendations for evidential breath analyzers (3T79; 3T86).

Chappell currently is a consultant in legal metrology and radiation physics (3T70). He has written more than fifty peer-reviewed technical publications — albeit none of them addressed breath-testing instruments — serves on the appeals board of the American National Standards Institute (ANSI), and is an honorary member of OIML's international committee (3T81-3T83). Based upon Chappell's training and experience, this court found he was experienced and competent in the field of legal metrology which includes evidential breath-testing instruments (3T87).

Legal metrology is the study of instruments used for legal measurements (3T70). As our national metrology laboratory, NIST is responsible for establishing, maintaining and publishing basic standards of measurement consistent with their international counterparts (3T73;3T87). NIST also engages in research and development projects for other federal agencies regarding needs for standard measurements (3T73).

Chappell described evidential breath analyzers as instruments that sample a subject's breath to determine the concentration of alcohol (3T87). To obtain confidence in any legal measuring instrument, Chappell outlined a three-step process of metrological control: (1) type evaluation or approval; (2) initial verification; and (3) subsequent verification (3T88).

Type evaluation refers to tests performed on an instrument by an entity in accordance with documented standards (3T89;3T157-3T158). It also involves the preparation of a report which appropriate officials then can use to issue type approvals (3T89). In the United States, NHTSA is responsible for type evaluations of evidential breath-testing instruments including the development of model specifications, the preparation of a report on each instrument it tests, and the dissemination of a conforming products list (CPL) to assist end users such as states which use these instruments (3T89-3T91;3T93-3T94).

Chappell reviewed the summaries of the three type-evaluation tests performed by NHTSA on the generic Alcotest 7110 MKIII, and New Jersey firmware versions 3.8 and 3.11 (3T95-3T97). Successfully passing these tests, the Alcotest 7110 satisfactorily completed the first step in the metrological control process (3T97).

Chappell also offered testimony on international type evaluation and approval standards recommended by OIML, an international treaty organization established in 1955 to address issues relating to the application of common legal measurements by its member countries (3T76;3T97;3T156-3T157). The organization has 113 members with fifty-nine full voting members, including the United States which joined in 1972, and fifty-four corresponding or non-voting members (3T99). Under the OIML certificate system, legal measuring instruments must be evaluated in accordance with certain performance criteria and testing methodology, and results must be reported in a standardized format (3T98).

In 1998, OIML published Recommendation 126, which applies to evidential breath analyzers that automatically measure the mass concentration of ethanol in exhaled breath (D-4). The recommendation incorporated the framework of the OIML certificate system by establishing metrological characteristics required of such instruments, specifying methods and equipment for checking their conformity, and mandating a test report format (3T98-3T99;D-4). To be OIML certified, the evidential breath analyzer must successfully pass the tests performed at one of five OIML-approved laboratories. If so, the International Bureau of Legal Metrology in Paris will include it on the list of qualified instruments (3T99;3T105).

Chappell said that OIML's standards are more stringent than NHTSA's 1993 model specifications currently in use (3T101;3T104;3T170-3T173). For example, Recommendation 126 advises testing for nine interferents; NHTSA tests only for acetone (3T104). Recommendation 126 also recommends tests for RFI or electromagnetic compatibility over a range of electromagnetic frequencies and at specified field strengths, which NHTSA does not require (3T104). Additionally, OIML's recommendation includes tests for such physical disturbances as vibration, mechanical shock, electrostatic discharge, damp heat cycles, and storage ambient conditions, among other things (3T183-3T185).[40]

In Chappell's opinion, the international standards reflect the European preference for more rigorous legal measurement and uniformity in metrological control (3T178-3T179). For NHTSA to adopt the more rigorous OIML standards, it would, among other things, have to

---

40. For a full description of all mandatory tests for physical disturbances, *see* "Annex D" of OIML Recommendation 126 (D-14 at 18-21).

acquire additional equipment at a significant investment (3T104-3T105). While acknowledging that the OIML standards were more complete, Chappell did not consider an instrument which met the NHTSA standards any less reliable (3T174;3T185-3T186).

A manufacturer, however, may elect at its own expense to have its instrument tested for OIML compliance (3T105). In 1994, Draeger submitted an Alcotest 7110 MKIII — without NJ firmware — to the National Measurement Laboratory for the Netherlands (3T106). This OIML-compliance testing was undertaken in accordance with both British regulations which followed the third or 1993 draft of the OIML which, unlike Recommendation 126, required testing for sixteen interfering substances and with Dutch regulations which required testing for an additional seven or so compounds (3T113-3T114;3T163). The Alcotest 7110 passed the more rigorous Dutch OIML test (3T114).

With regard to the second and third steps in the metrological control process, Chappell reviewed documentation concerning New Jersey's breath-testing protocol relating to the initial verification performed on each new instrument and the subsequent verification performed at least once a year or after an instrument has been repaired or a component replaced (3T114;3T136). The initial verification confirms that the manufacturer is capable of making an instrument that meets the model specifications; the subsequent verification confirms that the instrument did, in fact, meet them (3T115). In Chappell's opinion, New Jersey's verification of the Alcotest 7110 went beyond the normal requirements of metrological control (3T138). Chappell, however, noted that OIML's tolerance recommendation for initial verification was equivalent to New Jersey's 5% requirement for control tests but for subsequent verification, it was smaller (4T33). He also noted that OIML's member nations rejected a proposal by German experts to require breath temperature measurements (4T28-4T29).

Based upon his training and experience, and his review of the NHTSA standards, the OIML recommendations, and New Jersey's protocol, Dr. Chappell concluded that the Alcotest 7110 MKIII-C was suitable for its intended scientific purpose (3T138). His testimony was fully credible in every respect.

7. *Summary of Testimony of State's Expert, Barry K. Logan*

Barry K. Logan received his doctoral degree in forensic toxicology from the University of Glasgow, Scotland in 1986, and is board-certified by the American Board of Forensic Toxicologists (4T35-4T36). Since 1990, he has been the Washington State Toxicologist and since 1999, the Director of the Washington State Patrol (4T36-4T37;6T33). For the last sixteen years, Logan also has been a clinical assistant professor in the Department of Laboratory Medicine at University of Washington's School of Medicine (5T10-5T11).

During his lengthy career, Logan has been a member of many professional societies, taught extensively on issues related to drug and alcohol testing, trained personnel throughout the United States in blood and breath alcohol programs, and published numerous peer-reviewed articles on breath alcohol testing as shown on his impressive curriculum vitae (4T38-4T39). One of his recent publications described a proposed proficiency-test program based upon the evaluation of several instruments including the Alcotest 7110 (4T39-4T40). He also has extensive experience in state and federal courts as an expert in blood and breath alcohol measurements (4T36;4T40-4T41).

As the Bureau's director, Logan oversees eight laboratories with a staff of about 180 people who specialize in a range of areas including, but not limited to, forensic science and toxicology (4T36). He manages the laboratory system, works with the state's Legislature on issues relating to blood, breath and drug testing, and writes administrative rules for breath testing (4T37). As state toxicologist, Logan also is responsible for approving protocols used in blood, breath and drug testing programs (4T41-4T42).

Although he is not an expert in physiology, Logan described the various stages of alcohol absorption, distribution, and elimination. After being ingested orally, he explained that the alcohol enters the stomach, is absorbed through the walls of the intestine, and then is carried by the bloodstream to the liver, the right side of the heart, the lungs, and the left side of the heart (4T42-

4T44). The arterial system distributes the alcohol to all the water-bearing tissues including organs, muscle, and the brain (4T43-4T44). When it reaches the brain, the alcohol's effect on a person's performance begins (4T45). The alcohol then returns through the venous system in a lower concentration to the liver, the heart, the lungs and back into the arterial system (4T44). Some of the alcohol is excreted in urine (4T45). During the absorptive (pre-peak) phase, the arterial blood going to the brain has a higher concentration of alcohol than venous blood (4T46-4T47). After peak absorption, however, venous blood alcohol is higher (4T47-4T48). Generally, the rate of absorption depends upon a number of factors including the amount of alcohol consumed and the rate of drinking (4T49). The faster the rate of absorption, the more substantial the difference between the arterial blood and the venous return (4T49).

Blood sample alcohol laboratory testing almost always relies on venous blood because it is easier and safer to collect (4T50). Because alcohol remains stable in blood for a long period of time, blood specimens are ideal for legal measurements because they can be retested (4T50-4T51). As with any measurement, however, blood testing is subject to error and variability depending upon the equipment and protocol in use (4T51). Blood is more difficult to collect in the field, requires a trained person to collect the sample, and should be refrigerated prior to testing (4T51). After testing, it should be frozen (4T51). For legal purposes, blood should be drawn in vacuum tubes with anti-coagulant and anti-bacterial agents to avoid contamination (4T51-4T52). Moreover, each time a tube of blood is opened, some vaporized alcohol is lost from the headspace above the liquid (4T52). Blood samples also do not yield immediate results (4T52).

In contrast, breath samples can be taken much more easily using a highly-automated procedure which permits very little, if any, operator influence over the results (4T53). The results are available immediately to police officers who use them to decide whether to charge a subject with intoxication (4T53).

As Logan explained, when blood is forced from the right side of the heart to the lungs any volatile substances such as alcohol will pass through the very thin membranes of the air sacs called alveoli and escape into the inhaled air (4T53). Some of that alcohol eventually passes out through the body when a subject exhales (4T53). The initially exhaled breath comes from a subject's upper airway, i.e., mouth and throat, and typically has only small amounts of alcohol (4T54-4T56). The concentration rises rapidly as a subject evacuates the upper part of the airway, but rises more slowly as the air comes from deeper in the lungs and the rate of increase in the end-expired breath is very low (4T55-4T56;6T44). Breath alcohol concentration never completely reaches a plateau but continues to increase as long as a person exhales (6T42). The actual shape of the curve (or the exhalation profile), however, is influenced by such factors as how fast a subject blows into the breath-testing instrument or the presence of mouth alcohol (6T106;6T109-6T110). To obtain a sample that is as close as possible in equilibrium with the arterial blood, Logan advised using end-expiratory breath (4T56).

Logan preferred the term "blood-breath ratio" to describe the correlation between the concentrations of alcohol in the breath and blood (4T58). He did not suggest using the term "partition ratio" given its meaning in physical chemistry to explain the degree to which a volatile substance will partition between two phases, typically air and water (4T57). Whereas there is a defined air/water partition coefficient for alcohol (or ethanol) in the simulator used to calibrate the Alcotest, many different variables, physiological and environmental, influence the concentration of alcohol in breath verses blood in the lungs (4T57-4T58;6T20). The blood-breath ratio differs among individuals and to some extent from breath-to-breath in the same person (4T58). While researchers generally agree there is a range of blood-breath ratios for the population at large, they disagree about the limits or extremes (6T120).

Logan relied upon two side-by-side (or simultaneous) blood and breath studies conducted on impaired drivers which concluded that the true (or average) post-absorptive blood-breath ratio was approximately 2400:1 (4T59-4T60;4T69-4T71;4T73; 6T120-6T121;6T132;7T55). Specifically, he cited a 1996 study by A.W. Jones and L. Andersson which placed the blood-breath ratio at 2407:1, and a 2006 study by Gainsford and others which reported ratios of 2510 plus or minus 256; 2370 plus or minus 240; 2520 plus or minus

280; and 2440 plus or minus 260 (4T73).[41]

Logan testified that the 2100:1 ratio as adopted by the Court in *Downie*, 117 *N.J.* at 468, underestimates a subject's true blood alcohol concentration by ten to fifteen percent (4T74). For legal purposes, therefore, a lower conversion ratio favors the accused in most cases (6T123;6T131). By reporting more breath test results on the low side, the lower ratio compensates in part for the range of physiological variables such as length of exhalation time, breath volume, and body temperature (6T118-6T119;6T122-6T132). Logan noted, however, that Jones' study also found that 4.3 percent of his study population had an actual blood-breath ratio less than 2100:1 and for them, the Alcotest overestimated the blood alcohol in their breath (7T33).[42]

---

41. Among others, Logan was referring to the following studies:

> A.W. Jones and L. Andersson, *Variability of the Blood/Breath Alcohol Ratio in Drinking Drivers*, 41 *J. Forensic Sci.* 916 (1996) (D-19); and A.R. Gainsford et al., *A Large-Scale Study of the Relationship Between Blood and Breath Alcohol Concentrations in New Zealand Drinking Drivers*, 51 *J. Forensic Sci.* 173 (2006)

42. The State of Washington does not use the blood-breath ratio because the applicable driving-under-the-influence statute specifies that a per se offense consists of a blood alcohol concentration of .08 grams per 100 mass or a breath alcohol concentration of .08 grams per 210 liters, thereby eliminating the requirement for a blood-to-breath conversion (5T11-5T14;7T29).

Although Washington State uses the Datamaster, Logan was familiar with the Alcotest 7110 and its two technologies: IR and EC (4T74;4T82-4T83;4T86-4T87;6T56). IR technology has been used since the late 1970s and is universally found a reliable technique in evidential breath testing (4T75). The breath sample is placed into a chamber, or cell, where one side admits infrared energy and the other side detects or measures how much of that energy is transmitted through the chamber (4T74). The alcohol molecules absorb the selected infrared wave length which shines through the cell to a degree proportional to the alcohol concentration in the chamber (4T74-4T75). To reduce the risk of the "only universally accepted meaningful potential interferent," the Alcotest 7110, NJ 3.11 uses an infrared wave length of 9.5 microns which prevents the absorption of acetone by the alcohol molecules (4T76;4T84;4T110;4T112). IR monitors over real time how the breath alcohol concentration changes in the chamber (4T83). Logan pointed out that the Datamaster uses IR technology, but not at the 9.5 micron frequency (7T28).

Likewise, EC technology is a well-established technology used for many years in screening devices (4T82). In the Alcotest 7110, after a sample is measured by IR absorption, a portion of that sample is aspirated or sucked into a one cc chamber containing the fuel cell (4T83). The fuel cell is a porous ceramic matrix containing a carbon metal catalyst which oxidizes or breaks down when it interacts with alcohol and in the process emits electrons which are measured to determine alcohol concentration (4T77;4T83;5T83). As fuel cells wear down over time, they respond more slowly and may become contaminated (5T84). Their performance, however, can be assessed by looking at the data generated (5T85). While recognizing the general reliability of both technologies, Logan also acknowledged that any quantitative measurement has some inherent error given the range of human biological variability (5T16-5T17).

Although he did not personally conduct any testing on the Alcotest 7110, Logan reviewed the reports of test results performed on the instrument by Volpe in 1996, 2003, and 2006 in connection with NHTSA's type-approval (4T86;5T61). He noted that the instrument repeatedly met the requirements during all three cycles of testing, but he did not actually review the underlying data (6T114-6T115). Logan also relied upon the results of New Jersey's testing program using known vapor phase standards from a wet-bath simulator which showed that the Alcotest 7110 was capable of making measurements within 5% of the reference or control value (4T89).

Additionally, Logan assessed the findings of tests conducted in connection with his recently-published proficiency study by an unnamed state jurisdiction on the Alcotest, using various undisclosed concentrations of ethanol including one containing acetone (4T87). According to Logan, the results indicated that the Alcotest accurately read the alcohol in the unknown specimens and was not influenced by the presence of acetone (4T88).

With regard to the instrument's precision, Logan recognized that the Alcotest 7110 tested for two kinds: precision between two readings in the same sample; and precision between four readings in the two samples (7T43). Regarding the latter, he expressed some confusion over the formula but believed that all four results must lie within plus or minus 10% of the mean for results above .10, but within .01 of the mean for results below .10 (7T18;7T53). Because there is greater variability at higher breath alcohol concentrations, Logan recommended using a variable standard to avoid the risk of too readily getting legally inadmissible test results (7T24). Moreover, he thought that the range of 20% around the mean was scientifically reliable given that the variable had a biological component (7T53).

Logan also reviewed elements of New Jersey's breath testing program (4T89). He observed that New Jersey's protocol of conducting control tests during each subject's testing was sufficient to verify the instrument's ability to accurately measure the sample, and was the "best scientific practice" (4T90). Logan also said that New Jersey's practice of conducting duplicate tests was good scientific practice (4T96). For example, he said that the use of two separate breath tests served as a check on accuracy by showing that even with significant biological variation in breath exhalation, the measurement was reproducible within limits (4T96).

Additionally, he said that New Jersey's testing sequence is an automated process over which an operator had very little influence (4T91;4T96). In his opinion, the testing sequence which consisted of five air blanks, two control tests (Washington State does one), and two subject tests was one of the most rigorous protocols in the United States (4T90-4T95).

According to Logan, New Jersey's minimum volume requirement of 1.5 liters was common practice among the states (4T100). While he was aware that Alabama's minimum requirement was 1.3 liters, Logan noted in his expert report that the most comprehensive data set on this issue came from an Alabama study showing that 97% percent of more than 15,000 test subjects were able to provide breath samples of 1.5 liters (4T100).

Moreover, he said that the 1.5 liters requirement ensured that, on average, the breath sample came from a fairly level phase of the exhalation curve (6T45-6T46). Logan reached that conclusion based in part on his study over an eight-to-ten-year period of 100 individuals who provided several hundred breath-exhalation profiles after being administered alcohol in an experimental setting and about a dozen individuals who had been arrested for drunk-driving (6T45-6T51). Of those individuals, approximately forty also submitted venous blood samples for testing (6T52). While acknowledging that breath volume could be effected by a person's size and that a person with a longer exhalation could have a higher reading, Logan maintained the 1.5 liter minimum requirement ensured that the subject was delivering end-expiratory breath (6T118;6T141;7T54-7T55).

He also said that New Jersey's twenty-minute waiting period was "more than acceptable" to allow for the dissipation of mouth alcohol and noted in passing that Washington's "acceptable" waiting period was fifteen minutes (4T104;4T107-4T108;5T32). During that time, however, Logan stressed that there should be face-to-face observation to make sure that the subject does not have access to anything that could influence the test results (6T144-6T145). Logan viewed New Jersey's two-minute lockout between duplicate tests and a slope detection system as additional safeguards to ensure against mouth alcohol interference by allowing time for dissipation and monitoring of abnormal breath profiles (4T104-4T106;7T34-7T35;7T54).

Logan did not believe that there was any reason to monitor breath temperature with a sensor (4T101;6T151). Noting that average breath temperature of human beings had not changed in at least twenty years, Logan explained that it was just one component that explained variability and that it already was accounted for by adopting a blood-breath ratio of 2100:1 instead of the true ratio of 2400:1 (4T102-4T103). He is aware of only one state, Alabama, which measures breath temperature (5T18). Nonetheless, Logan acknowledged that if all other factors are equal between two individuals, the one with the higher temperature would have a higher breath alcohol concentration (6T124).

Logan also did not believe that it was necessary to review the source codes and algorithms in order to determine a breath-testing instrument's reliability

(5T23-5T24). Instead, he relied upon the data that the instrument produced (5T24). For example, Logan believed that Washington State's quality assurance program consisting of control tests, linearity tests, and calibration checks provided all the information necessary to determine how an instrument was performing (5T24). Logan assessed an instrument's performance by presenting it with a variety of samples of known alcohol concentrations and then reviewing the results to see if they agreed with his expectations for accuracy and precision (5T73;5T90).

Logan has never asked for the Datamaster's source codes and even if an expert analyzed them, Logan doubted that the exert could tell him whether the instrument would, in fact, provide accurate results (5T24). He noted, however, that on at least two occasions, the manufacturer did provide under court-order copies of Datamaster's source codes to Washington's defense bar and, over the years, provided his state with the algorithms used to calculate various aspects of the test results (5T25;6T57).

Based upon the materials he reviewed, his training, and experience, Logan concluded to a reasonable degree of scientific certainty that the Alcotest 7110, NJ 3.11 was accurate and reliable, and that New Jersey's program was scientifically sound (4T121-4T122). In his opinion, the program had the necessary procedural and administrative elements, including: the collection of data with every breath test showing the instrument was operational; the use of periodic linearity testing demonstrating the instrument was properly calibrated; the agreement of breath test results indicating the instrument's ability to measure reproducibly; and the use of two control tests showing the instrument read accurately and precisely at the time the subject was tested (4T122). Logan was an impressive witness and his testimony was concise, understandable and persuasive.

8. *Summary of Testimony of State's Expert, J. Robert Zettl*

Zettl has a Bachelor of Science degree in bacteriology with a minor in physical chemistry from Pittsburg State University in Kansas (1964), and a masters degree in public administration from the University of Colorado (1991) (13T64;14T78). For thirty-three years, he worked in the alcohol test unit, later known as the toxicology unit, at the Colorado State Department of Public Health and Environment (13T64-13T65). As the unit's first employee and its chief for many years, Zettl developed rules and regulations relating to the taking of blood, breath and urine specimens which the Board of Health (BOH) promulgated under the state statute for driving under the influence of alcohol or drugs (DUI statute) (13T65-13T66;13T68-13T69;14T95).[43]

---

43. While the BOH held public hearings as part of Colorado's rule-making process, New Jersey did not hold any such hearings in connection with its adoption of the Alcotest 7110 (13T67-13T68).

After retiring in 1998, Zettl established Forensic Consultants, Inc. to provide assistance in the development and implementation of breath alcohol test programs (13T66). Among other things, his consultant work includes: inspecting laboratories for compliance with the National Laboratory Certification Program; teaching at various venues including the Borkenstein School in Bloomingdale, Indiana where he provides instruction on the Alcotest 7110, Intoxilyzer 5000 EN, Datamaster CDM, and the Intoximeters I and II; and training law enforcement officers, forensic scientists, and attorneys on breath alcohol and other drug-testing devices (13T66;13T70-13T72;15T52-15T55). Robert Borkenstein invented and patented the breathalyzer instrument in 1954 (13T71;15T56).

Zettl belongs to several professional organizations, serves as an executive board member on the National Safety Council Committee on Alcohol and Drugs, and has written six peer-reviewed articles on alcohol testing (13T71-13T73). He has testified numerous times as an expert in alcohol-related cases in Colorado (both jury and bench trials) and thirteen other states (13T74). He qualified here as an expert in forensic toxicology specifically relating to alcohol breath testing (13T75;13T90).

Beginning in the mid-1970s, the State of Colorado has used intoxilyzers to measure breath alcohol (13T80). It currently uses the Intoxilyzer 5000EN manufactured by CMI, Inc. in Owensboro, Kentucky (13T96;13T98; 14T54). CMI does not reveal its source codes nor did

Zettl believe it was necessary to see the code in order to complete Colorado's validation of the instrument (13T96-13T97). In fact, he admitted that he would have no use for it (13T100).

Zettl also has worked with a generic Alcotest 7110 MKIII-C in Colorado and received limited exposure to New Jersey firmware version 3.11 on June 8 and 9, 2006 (13T80-13T81). At that time, Zettl went to the New Jersey State Police Bordentown Station and Forensic Science Laboratory where he evaluated New Jersey's protocol, observed fifteen to twenty tests performed on several instruments, and interviewed selected staff including, but not limited to, Brettell and Flanagan (14T75-14T76;15T21;D-34 at 5). He did not conduct any scientific testing (15T11). Despite exhaustive questioning on cross-examination, Zettl maintained that the Alcotest 7110 was not a computer although it employed computer technology (15T23-15T26).

Zettl assessed the Alcotest 7110's performance primarily by relying on the outcome of calibration tests using known alcohol solutions (13T81-13T82;15T8). If the instrument gave the expected breath alcohol results, he assumed that it was working properly (15T8). He used the analogy of a snow blower to explain that if the machine started when he turned the key, it worked (13T82). Zettl admitted, however, that he also relied in part on the integrity of the manufacturer to provide the instrument it promised (15T9).

Zettl described New Jersey's validation of the Alcotest 7110 as extensive, noting that some states simply buy their breath-testing instruments off the shelf and put them into use without first verifying them through analytical testing for accuracy and precision (13T95-13T96;13T102). On the other hand, New Jersey's validation consisted of a thirteen-step testing sequence, including ambient air checks which ensured that a subject's test results were not unduly influenced by contaminants in the surrounding room air; control tests which required the tolerance between them must be .005 or 5% for a .10 solution, and duplicate breath samples (13T104-13T106).

With regard to the acceptable tolerance agreement between two breath samples, Zettl relied on the Alcotest 7110 manual[44] to conclude in his expert report that when there were two valid sets of breath-testing data, the average of the four readings (two from the IR and two from the EC technologies) must be plus or minus .01 at or below a blood alcohol concentration (BAC) of .10 or plus or minus 10% for BAC's above .10, whichever is greater (13T108;14T110;D-34 at 6-7). During the hearing before this court, however, Sergeant Flanagan informed Zettl that the manual incorrectly stated the tolerance and that the correct formula required the resulting values of the IR/EC duplicate breath samples to agree within .01 or plus or minus 10% of the mean of the four readings, whichever is greater (13T108;14T5;

---

44. We assume here that Zettl was referring to the Alcotest 7110 MKIII-C User Manual-Operator, V 1.1 (Oct. 11, 2005) (D-15 at 13).

14T110).[45] In any event, Zettl observed that the plus or minus 10% standard allowed for greater divergence between the two readings than the .01 standard articulated in *Downie*, 117 *N.J.* at 455, 457, thereby making it easier for a subject to give two samples within the acceptable tolerance (14T130). Zettl further observed that New Jersey's range was tighter than the National Safety Council's recommendation that two breath samples fall within .02 (13T107;14T129).

Zettl agreed that there is debate among the breath-testing community about the use of a constant blood-to-breath partitioning ratio for all subjects (14T84). He further agreed the magnitude of variation of the ratio between subjects and from time-to-time within the same subject was important to document whenever blood alcohol concentration was estimated indirectly by analyzing breath (14T84;D-19 at 920). Because an "ordinary" partition ratio was about 2280:1 for potentially sixty to sixty-eight percent of the population, Zettl thought that the use of the lower 2100 figure would substantially benefit a typical defendant (14T27-14T28).

---

45. There was considerable testimony at the hearing regarding the correct tolerance calculation. Zettl suggested that the confusion might stem from the Law Division's misunderstanding of Brettell's testimony in *State v. Foley*, 370 *N.J. Super.* 341 (Law Div. 2003) (14T126-14T128). Brettell testified that the tolerance between the readings (generated by the IR and EC technologies) must be within .01 or 10% of the average of the highest and lowest readings, whichever is greater (14T121-14T122). The *Foley* court essentially doubled Ryser's standard by finding that the acceptable tolerance was .01 or *plus or minus* ten percent of the average of the highest and lowest of the IR and EC values.

Asked his opinion on breath temperature sensors, Zettl said that he no longer believed that they had any value (14T6;14T94;15T12;15T96-15T97). He readily admitted that he initially was overly optimistic about their potential importance, but that over the years only Alabama had adopted them (14T6). In fact, Zettl suggested that a temperature sensor actually might create analytical and jurisdictional problems related to its addition as another part of the breath-testing equipment (14T7).

While an elevated body temperature theoretically would drive more alcohol off the lungs and into the breath than in the bloodstream, Zettl agreed with Gullberg that the instrument still "reads what it reads" (14T7;14T20-14T21). Thus, a rise in breath temperature is irrelevant for breath-testing purposes unless a state requires a conversion from breath to blood alcohol concentration (14T21). For example, in New Jersey the Alcotest 7110 is set to read an alcohol concentration at 34 degrees C so when the temperature rises, the calculation is thrown off (14T21;14T26).

To avoid miscalculations, Zettl suggested that New Jersey rewrite its statute to eliminate the need for any conversion or compensate by taking a certain percentage off a person's breath alcohol concentration whenever the temperature rises (14T21-14T22). For example, an Alabama study of about 12,000 subjects who used the Alcotest 7110 showed that the average breath temperature was 34.9 degrees C, not the historically accepted 34 degrees C, and concluded that there should be an downward adjustment of 6.8 percent for every increase of one degree (14T24-14T26). Colorado addressed the temperature issue by including a question on its alcohol influence reports which required the officer to ask if the subject was ill, thereby allowing the person to argue in court that she had a temperature which might have affected the reading (14T7).

Additionally, a test result might be affected by how a subject blows into an instrument (14T26). According to Zettl, a long, full exhalation of deep lung air produces a higher breath alcohol concentration (14T27;14T108-14T109). Likewise, a subject who holds her breath will potentially have a higher test result (14T28). On the hand, a test result will be lower if a subject breathes shallowly or hypoventilates (14T28).

For forensic purposes, Zettl was satisfied with New Jersey's minimum requirements. Based upon research and evaluation of other instruments, Zettl opined that 1.5 liters was the minimum volume needed to obtain a "fairly accurate determination" of breath-to-blood alcohol (14T10). He also said that New Jersey's safeguards against mouth alcohol — twenty-minute observation period, two breath tests a few minutes apart, and a slope detector — were sufficient to detect contamination from the stomach or extraneous sources which could potentially elevate a subject's presumed breath alcohol concentration (14T10-14T11;14T40-14T41).

Zettl further expressed that the Alcotest 7110's dual system of IR and EC technologies was capable of detecting interferents introduced into a subject's breath (14T11-14T12). He acknowledged, however, that certain interferents, such as acetone and acetaldehyde, would not be detected in healthy individuals to any measurable degree (14T53-14T54). For example, he never saw a positive acetone reading from a normal subject despite testing approximately 10,000 to 20,000 subjects on the Intoxilyzer 5000 (using IR technology) and reviewing another 4000 to 5000 monthly records in Colorado (14T53-14T54).

Some people, however, have unhealthy conditions that can impede their ability to metabolize food causing very high levels of endogenous or naturally occurring interferents such as acetone, acetaldehyde, and ketones (14T61-14T62;14T65-14T66). In particular, Zettl observed that diabetics and people on special diets can have those substances present in sufficient concentrations to generate spectra in the presence of IR light (14T62). To detect their presence, the Intoxilyzer 5000EN used five points on the spectrogram — unlike the one point used in New Jersey — to test for five major interferents including, but not limited to, acetone, acetaldehyde, and ethyl methyl ketone (14T57-14T58). In Zettl's opinion, the more points of identification the greater the likelihood that interfering substances will be detected (14T58). He recognized, however, that New Jersey used 9.5 microns to detect such endogenous interferents along with an IR detector which took measurements 128 times a second, and an electrochemical detector (14T63-14T64). Moreover, he pointed out that New Jersey's ambient air checks would detect the presence of exogenous interferents in room air (14T65-14T66).

Regarding RFI, Zettl said that the Alcotest 7110 had a number of safeguards including: a built-in radio frequency detection; minimal non-scientific testing by the state and federal governments; extensive testing by the manufacturer; a requirement by the NJSP that no communication devices be present in the room during the administration of a breath test; and a thirteen-step protocol which would detect such interference and abort the testing sequence (14T12-14T13;14T30;15T30-15T33;15T64). Zettl acknowledged, however, that he would have more confidence in the field instruments if New Jersey collected the data in a central computer, as in Colorado (15T15). Specifically, he said that the Alcotest 7110 was capable of having data remotely reported to a central computer, that data retrieval was useful in determining a field unit's "reliability, accuracy, failure rates, down time," and that the technology needed to download the information was available (15T16;15T18-15T19).

Overall, Zettl thought that the State Police had maintained a high standard of quality assurance by checking the instrument upon delivery to make sure it was fit for service, by implementing the thirteen step testing sequence each time a subject was given a test, and by periodically checking it in the field to make certain the instrument was accurately reading the alcohol concentration (14T14). Specifically, he said that New Jersey's periodic inspections were sufficient and that the Alcotest 7110 accurately measured breath alcohol samples (15T107-15T108). He concluded that New Jersey's program was "probably one of the top in the United States" (14T14-14T15). This court finds Zettl a very credible and helpful witness.

9. *Summary of Testimony of State's Expert, Patrick M. Harding*

Patrick M. Harding holds a Bachelor of Science degree in biochemistry from the University of Wisconsin (26T39). He has been a chemist at the Wisconsin State Laboratory of Hygiene (Hygiene Lab) for many years and currently supervises the Toxicology Section which is responsible for blood alcohol testing (26T40-26T41;26T46). Since 1983, Harding also has served as a scientific consultant for the breath alcohol testing program administered by the Wisconsin Department of Transportation's Division of State Patrol (State Patrol) (26T41). In that capacity, he has conducted research, evaluated breath-testing instruments, drafted statutes, revised the administrative code, recommended testing protocols, and trained breath test program supervisors and operators (26T42). Since December 2002, Harding has been on the faculty of the Robert F. Borkenstein Course on Alcohol and Highway Safety (26T42-26T43).[46]

46. This summary incorporates facts and opinions from Harding's expert report dated June 27, 2006 (C-14).

Harding is a founding member of the International Association for Chemical Testing (IACT)[47] and belongs to several other professional organizations (26T43). He has published three articles in peer-reviewed journals and numerous articles in IACT newsletters (26T44-26T45). Harding has testified many times as an expert in Wisconsin, Florida, Michigan, and New Jersey in *Downie* (26T45). The State offered Harding as an expert on breath testing and forensic chemistry (26T45).

Wisconsin has a per se statute which relies upon blood or breath to define the offense of operating while intoxicated (OWI) (27T14-27T15;27T17;28T98). Under that state's implied consent statute, the arresting officer or the suspect may request a blood test after the breath test has been completed (28T70;28T72-28T73). In either case, the police officer must take the suspect to a hospital for the blood test (28T75). The blood standard ranges from .08 grams of alcohol per 100 milliliters of blood for first, second and third offenses, .02 for fourth and higher offenses, .01 for absolute sobriety, and .04 for commercial drivers (27T14). While blood testing offers greater accuracy, Harding noted that it required the withdrawal of a sample, a central laboratory, expensive equipment, and a lot of court time by the eighteen analysts who work in the Hygiene Lab's toxicology section (27T62-27T63).

Wisconsin uses the Intoximeter EC/IR for evidential breath testing (26T106;27T84). It previously used the

47. Harding described IACT as an organization for government employees whose job responsibilities include alcohol testing (27T42).

Intoxilyzer 5000 (1984 to 1999) and the Breathalyzer 900A (pre-1984) (26T84;26T106;26T109). Following the recommendations of Harding and the National Safety Council Committee on Alcohol and other Drugs, Wisconsin's breath testing program requires that two breath readings agree within plus or minus .02 (26T118;29T10). For duplicate analysis of blood, Wisconsin adopted a tolerance criteria of plus or minus .005 or 5% (26T118-26T119).

Harding has participated in two blood and breath comparison studies, which led him to conclude that the average blood- breath ratio was higher than the 2100:1 ratio used in the United States (26T62-26T67;26T98; 27T66). One study consisted of a joint NHTSA and IACT multi-state research project, which involved six breath-testing instruments (three Intoxilyzer models, BAC Datamaster, Alco Monitor, and Alco Sensor IV), four states, and subjects dosed with alcohol on five different occasions (26T63;26T94-26T95). In addition to measuring breath alcohol, the study simultaneously collected two venous blood samples from each subject (26T63;26T95-26T96). The blood samples were sent to laboratories in Wisconsin (the Hygiene Lab), Colorado, Iowa, and Arkansas (26T63-26T64). The results indicated that all the instruments generally underestimated the blood alcohol using the 2100:1 ratio and that the average blood-breath ratio was around 2300:1 (26T65;28T104;29T11).

In another study ongoing since 1983, Harding has worked with the State Patrol in their breath testing operator training courses where the participating police officers were dosed with alcohol (26T66;26T97). Over the years, Harding compared breath tests administered by the Intoximeter EC/IR, Intoxilyzer, Alco Sensor IV, and Breathalyzer with blood samples taken almost contemporaneously (26T97). The officers were given about an hour to imbibe in a controlled setting (26T102). In about thirty minutes, blood samples were taken (26T101-26T103;27T12). At that point, the alcohol concentration in the breath was generally lower than in the blood, with a corresponding ratio of approximately 2300:1 or higher (26T103). The study revealed that all instruments underestimated the blood alcohol concentration in ten to eleven percent of the cases and overestimated in one to two percent of the cases (26T97-26T98).

Harding was familiar with a 1995 peer-reviewed article by by M.D. Taylor and B.T. Hodgson which similarly found that three breath-testing instruments — Alcotest 7110, Intoxilyzer 5000C, and Breathalyzer 900A — underestimated blood alcohol concentration by about eight percent (27T63;29T14-29T15;29T20-29T21;AB-12).[48] Eighteen subjects were given measured amounts of alcohol and then tested on all three instruments for a period up to five-and-a-half hours

48. *See* M.D. Taylor & B.T. Hodgson, *Blood/Breath Correlations: Intoxilyzer 5000C, Alcotest 7110, and Breathalyzer 900A Breath Alcohol Analyzers*, 28 *J. Can. Soc'y of Forensic Sci.* 153 (1995) (AB-12). This study did not employ the Alcotest 7110 MKIII or MKIII-C, but an earlier model that only used IR technology (27T75;18T52).

after their last alcohol consumption (29T14). Blood samples also were taken about an hour apart (29T15). Among other things, a comparison of the breath and blood results, using linear regression analysis, revealed there was no statistical difference between the performance of the Alcotest 7110 and the Breathalyzer (29T15;29T20).

Harding described the three phases of physiological absorption of alcohol into the bloodstream (26T100;27T10). During the absorptive phase, the body is absorbing alcohol faster than eliminating it (27T111). The actual rate of absorption, however, varies in the same subject from time to time and under similar conditions depending upon various biological factors, such as the amount of food in the stomach (27T13). During this phase, the concentration of alcohol in arterial blood is higher than that of venous blood (28T104).

Controlled studies that compare blood-breath alcohol concentrations in the absorptive phase generally dose subjects with fairly large amounts of alcohol in short periods of time, and then test them shortly afterwards (26T100). In non-controlled settings, however, drivers are unlikely to be in the absorptive phase by the time they get to the second breath test given the time elapsed since their arrest, transport to the police station, and twenty-minute observation period which, in Wisconsin, takes place at the station, not in the car (29T25). Arrestees also generally consume alcohol over a longer period of time before driving (26T100). Thus, laboratory studies tend to produce greater differences between breath and blood alcohol readings (26T100).

In the peak phase, alcohol concentration reaches its highest level when it exists at a plateau where absorption and elimination occur at the same rate, in equilibrium (27T11). Harding found that under controlled conditions, peak alcohol concentrations were reached about thirty minutes after the subjects stopped drinking (26T102). At that point, subjects enter the post-absorptive phase when their bodies are eliminating alcohol faster than absorbing it, thereby producing a more realistic estimate of a blood-to-breath comparison (26T102;27T11-27T12).[49] Approximately 95% of the alcohol consumed is metabolized in the liver while the remaining 5% is eliminated by excretion, some through the breath (27T21-27T22). During post-absorption, alcohol concentration in venous blood (used for drunk-driving cases) is higher than arterial blood (usually used only for forensic research purposes) (28T104-28T105).

Harding was aware of the Alcotest 7110's dual technology (26T104). He noted that IR technology has been employed in commercial breath-testing instruments since the 1970s and that the Alcotest 7110's use of one wavelength at 9.5 microns was more specific for ethyl alcohol and eliminated the need for tests at multiple points on the IR spectrum (26T105-26T106). He further noted that EC technology was introduced for evidential purposes in the 1990s and that the small size of the fuel cell permitted use in hand-held screening

49. This court believes that Harding was referring to the fact that by the time drivers typically are tested following their arrest, they are in the post-absorptive phase.

devices, as well as in evidential breath testers (26T106). While the Alcotest 7110 is the only instrument that uses both technologies to provide a documented analytical result, Harding pointed out that the Intoximeter EC/IR relied upon EC technology to detect alcohol and the IR component to monitor the breath sample (26T106).

Harding reviewed NHTSA's initial type evaluation for the Alcotest 7110 in 1996 and its subsequent evaluations of New Jersey's firmware changes in 2003 and 2006 (26T108). Although he was unaware that some AIRs from the 2006 evaluations were missing, Harding did not consider it necessary for purposes of his testimony to know why these reports had been discarded or why these tests had failed completion (26T140-26T141). He also reviewed New Jersey's protocol and concluded that it was essentially the same as the one he had written for Wisconsin (26T109). Specifically, he found that the ambient air checks and quality control tests, and the requirement that two breath samples agree within predetermined criteria were sufficient to show that there were no aberrant errors in the instrument and that there was no inconsistency in the sampling process (26T116-26T118).

Harding defined the acceptable tolerance in New Jersey as the greater of plus or minus .01 or 10% of the mean (26T118). In Wisconsin, however, the tolerance or agreement criteria for breath samples was plus or minus .02, and for blood was plus or minus .005 or 5%, whichever was greater (26T118-26T119).

Asked his opinion on RFI, Harding stated that all breath-testing instruments were protected against electromagnetic interference (26T120). For example, in Wisconsin, the Intoximeter EC/IR — like the Alcotest 7110 — did not include an RFI detector but had its case redesigned to shield it from such interference (26T120). For RFI to remain undetected, it must adversely effect every single test the same way (26T123). Thus, Harding said that New Jersey's use of ambient air blanks, control tests, and two breath samples made RFI "astronomically" unlikely (26T123-26T124). He also said that New Jersey's use of dual technology would detect exogenous interferents, and that endogenous compounds were unlikely to affect the Alcotest 7110 or any other breath-testing instrument based upon the results of two literature surveys he conducted with Dr. Kurt Dubowksi[50] for the Committee on Alcohol and Other Drugs, most recently in 1999 (26T124-26T105;27T80-27T81).

With regard to the issue of mouth alcohol detection, Harding thought that New Jersey's twenty-minute observation period, its two-minute lockout between breath tests, and its use of a slope detector were sufficient safeguards (26T128;28T11). He reached this opinion based in part on a peer-reviewed study that he performed with the Intoxilyzer 5000 in conjunction with three dentists and his co-author, Mary McMurray

50. Among other things, Dr. Dubowksi was the Director of Tests for Alcohol and Drugs for the State of Oklahoma when he testified in 1989 in *Downie*.

(26T127;27T81;D-109).[51] The study gave measured amounts of brandy to twenty-five subjects with various combinations of dentures and adhesives, and essentially found that dentures did not retain alcohol (26T128;26T146;27T82). The study further found that mouth alcohol could be ruled out after fifteen minutes (26T128).

Harding testified that it was sufficient for the two breath tests to be taken two to ten minutes apart, and that it would not matter if the lockout was several seconds short (26T129-26T130;27T10;28T11;29T18). However, he considered the slope detector less accurate on subjects who actually had been drinking when the alcohol in their bodies exceeded the amount in their mouths (27T96-27T97;28T13-28T14;28T17-28T18).

Harding also testified that Wisconsin, like New Jersey, used a minimum breath volume of 1.5 liters (27T69). Unlike New Jersey, Wisconsin collected and stored data in a central computer (28T55).

Harding confirmed what other experts found with regard to breath temperature; it was not necessary to measure (28T99-28T100). Specifically, he said that there were no studies showing a direct correlation between breath temperature and blood alcohol concentration and, in any event, the 2100:1 ratio already accounted

---

51. *See* P.M. Harding et al., *The Effect of Dentures and Denture Adhesives on Mouth Alcohol Retention*, 37 *J. Forensic Sci.* 999 (1992) (D-109).

for temperature variability by measuring breath alcohol at a lower level than the corresponding blood alcohol concentration for most people (28T99-28T100).

Based upon his training and experience, his review of tests performed on the Alcotest 7110 by NHTSA and New Jersey, his observations during a two-day visit in June 2006, and his review of relevant documents and scientific literature, Harding concluded that the Alcotest 7110 was a scientifically reliable instrument (26T131;27T85). He further concluded that New Jersey operated the Alcotest 7110 as part of a scientifically acceptable program which followed guidelines commonly used by other jurisdictions throughout the world (27T85;28T43). Harding offered his opinions to a reasonable degree of scientific certainty (28T42-28T43). This court finds Harding a very credible witness and was impressed with his qualifications, experience, and lucidity.

10. *Summary of Testimony of State's Expert, Norman J. Dee*

Norman J. Dee graduated from the Juilliard School with a Bachelor of Arts degree in music (30T7-30T8;30T54). After teaching at the University of New Hampshire and working as a professional musician for several years, he received a certificate in computer programming from New York University (30T7-30T8;30T29;30T33). He has worked as a computer professional for the last twenty-eight years (30T14).

Dee currently works as a senior consultant for the CMX Group (CMX), a boutique of system programmers who specialize in capacity planning, performance analysis, system audits, and the process of data management (30T9;30T14). CMX specializes in finance industries especially Fortune 1000 companies (30T15). Dee also has served as chief technology officer for such companies as Scholastic Publishing in its internet division and 1-800-Flowers (30T22). He previously taught COBOL and Assembler business languages at Pace University (30T23;30T44;30T46).

Dee holds several professional memberships, gives numerous presentations, and publishes mostly "white papers" for marketing promotion purposes (30T24-30T25;30T50-30T51). He is certified in the industry standard of IT Infrastructure Library (ITIL), in systems management from the IBM Systems Sciences Institute, in MICS installation and maintenance, and in Sybase FastTrack (30T9-30T13;30T31;30T40). Dee considers himself a specialist in cost recovery and the business side of planning, cost accounting, and data processing (30T24;30T48).

Prior to this hearing, Dee never testified in court on technology matters nor did he have any experience in breath testing (30T25;30T40;30T52-30T53). The State offered him as an expert in computer science, particularly in systems auditing and computer measurement (30T25). This court qualified him as an expert in data management business systems (30T60-30T61).

As a systems programmer, Dee evaluates and audits computer hardware and software, and reviews source codes (30T15-30T17;30T37). He described source code as "human-friendly" language which is put through a compiler to generate machine executable code (30T69-30T70). The computer's operating system then loads the machine language into memory (30T69). There are multiple languages of source code ranging from English (Cobol) to mathematical expressions (C or C++), each with its own syntax (30T69-30T70). Computer applications (which are developed using source codes) are considered proprietary because they cost a lot to develop (30T78).

When a system works properly and produces the expected results, an external review by a customer of the source code is not necessary (30T73). A manufacturer, however, may want to review the source code to ensure that the programmers followed the correct standards (30T73).

Source code review becomes necessary when a system fails to produce the expected outputs (30T73). As Dee explained in his report, source code review may be warranted when there are performance issues (such as slow responses or the persistence of overly high utilization), integration complexities in getting several systems to interface with each other, or inaccurate results (31T22;C-13,Dee report at 5).

If a particular function was not operating properly, a customer generally would contact the vendor or manufacturer to find out why the anomaly happened (30T83;31T22-31T23;31T65). The manufacturer could ask the programmer who wrote the code to look at it, could ask an independent programming team from another department to look at it (sometimes called "walk-throughs"), or could use an independent outside agency (31T21-31T22).

It is a time-consuming process to review a source code for its actual function and execution, especially if the review is undertaken to "debug" a system (30T82-30T83). Source code review also can be confusing especially where a programmer, in dealing with the hardware, has to change the code to respond to predictable results (30T137-30T138).

In complicated applications (or programs), Dee explained that he would search for the component that was not performing as expected and then proceed to a further "drill-down" into the suspect area which often would reach the source code level (30T73). Specifically, he would get computer dumps (stacks of hexadecimal code) which would lead him to various areas in the operating system where there were faults (30T17). After finding a failing instruction (which was represented in the hexadecimal code), Dee would look it up on the microfiche card containing the assembler or source codes (30T19). Dee would report the problem to the vendor, who might ask him to put in a "patch" or a "hot fix" to get around the area (30T20). Dee acknowledged that errors in coding were rampant and for that reason, a lot of systems had self-checking capabilities (30T83-30T84).

Dee also said it was the expectation in the industry that no one shared source codes (32T52). In cases where sources codes were made available, it was fairly common practice for the review to take place in a segregated area at the manufacturer's location without cameras and copying devices (32T50-32T51).

Unlike multiple-function computers, an embedded (or targeted) system has a sole purpose (30T62). It operates by running a very reduced logic code which is sufficient to support what it has to do and has fairly limited interface sensors (30T63-30T64). Dee described the Alcotest 7110 as an embedded system with a very specific dedicated function even though its display screen allowed some input and output, and it used a printer like a computer (30T64;32T71). He explained: "You can't play Atari games on it. Can't browse the Internet on it. You can't do word processing on it. It's a very focused instrument for one purpose and, therefore, it is a black box" (32T71). Specifically, he treated the Alcotest 7110 as a black box because it had "highly certified" known inputs whose outputs could be evaluated (30T105;30T144-30T145;32T67-32T68).

To evaluate the Alcotest 7110's single-function technology, Dee used the black-box testing approach which he compared to a "truth table-type evaluation," meaning that if the instrument produced accurate results, he concluded it was working (30T64;30T66; 30T84-30T85). He determined how the Alcotest 7110 operated by reviewing six controlled inputs and seeing if they produced the expected outputs (30T55-

30T56;30T66-30T68;30T145-30T146). Dee also reviewed the process of administering the breath tests and the environment in which the Alcotest 7110 was used (30T85-30T87;32T69).

Dee determined that New Jersey used the Alcotest 7110 in a controlled environment which allowed no deviation from the testing sequence (30T88). He further determined that there was no way to change or alter the instrument's database, thereby ensuring data integrity and access security (30T89-30T90). The use of certified bottles of simulator solution for the calibrations also ensured the instrument's baseline performance (30T91). Dee then set up scenarios to test the system by putting in data which did not fulfill the requirements, and found that the instrument would not allow certain things to happen such as incomplete or interrupted blowing and that everything was recorded (30T91;30T94).

Based upon his training, experience, and the actual system testing that he performed, Dee concluded that the Alcotest 7110 was accurate and produced predictable results (30T95). He further concluded that the breath tests were administered in a well-defined process, most of which was automatically controlled by the instrument (30T95). Because the inputs to the Alcotest 7110's single-function system produced the expected and desired results, Dee concluded that source code review was not necessary (30T69;30T84).

This court finds Dee's testimony very credible and reliable. Dee helped greatly in understanding the function of the electronic processing and computer aspects of the Alcotest 7110.

11. *Summary of Testimony of State's Expert, Stephen B. Seidman*

Stephen B. Seidman is a mathematician by education with a Ph.D. from the University of Michigan (16T17;16T26). After receiving his degree in 1969, Seidman taught mathematics and computer science, and worked in administrative positions at various academic institutions (16T20-16T21). He currently serves as dean of the College of Natural Science and Mathematics at the University of Central Arkansas in Conway (16T21). For the last ten years, he also has engaged in academic consulting primarily in the area of computer science education (16T21-16T23).

Seidman considers himself a specialist in software architecture (16T23). He is a member of the Institute of Electrical and Electronic Engineers (IEEE), the IEEE Computer Society, the Association for Computing Machinery (ACM), and the American Association for the Advancement of Science (16T17-16T18;16T25). He also is an IEEE Computer Society Certified Software Professional (16T17-16T19). Seidman has published extensively on mathematical and software-related issues as listed on his curriculum vitae (16T23-16T24). Although he never testified previously as an expert, this court found him qualified in the areas of software engineering and computer science (16T26;16T60-16T61;16T69).

Seidman has no experience with breath-testing instruments (16T28;16T59). His only contact with an evidential breath tester occurred when he visited the New Jersey State Police Laboratory in August 2006 to evaluate the Alcotest 7110 (16T28). Seidman believed that the State retained him to testify as an expert based upon his IEEE certification as a software professional (16T64-16T65).

Seidman described a computer as a device that can be programmed to do things by and for the user (16T71). It consists of a central processing unit (CPU) (which does the actual computations), memory, and some way of communicating or interfacing with the outside world (16T79;17T40).[52] Seidman distinguished a computer from an embedded system, which can be found in many aspects of contemporary life ranging from microwave ovens and televisions to braking systems in cars (16T71-16T72). Unlike a computer, an embedded system contains a computational component used to control other machines, has a specific purpose, often is pre-loaded with operating software, and does not allow communication to introduce new functionality (16T71-16T72;17T42). Seidman described the Alcotest 7110 as an embedded system because it performed a particular task (16T115;17T40;17T42).

52. The Alcotest 7110 uses a processor identified by Draeger as a Motorola M68HC11 (18T27-18T28;D-42).

Appendix D

A computer (or an embedded system) contains hardware and software components (17T43). On the Alcotest 7110, the physical components comprising the hardware (internal and external) include a signal processor, microprocessor, motherboard, memory, optics (an infrared absorption cuvette), sampling system, sensors (both flow and pressure), keyboard, and printer (17T43-17T46;17T55-17T56;17T58;C-14, Seidman report at 1). Software components include firmware for the microprocessor and software to handle data retrieval, data communications, and operator input (18T54). Firmware consists of easily accessible software loaded into a processor's memory so that it can quickly execute the signal processing algorithms entered by the system's designer (16T108-16T109;17T70;C-14, Seidman report at 3). Algorithms are the buildings blocks or formula for creating the software's intended results (17T97;18T53).

To determine if firmware correctly implements the algorithms, a designer should adhere to industry standards for software development by: (1) determining the requirements based upon the customer's needs; (2) designing software architecture; (3) constructing the code; (4) testing the system containing the software; (5) obtaining the customer's acceptance; and (6) performing any necessary maintenance (16T75-16T77;17T28). The same steps should be followed for development of a system such as the Alcotest 7110 (16T75;C-14, Seidman report at 4). Seidman explained that adoption of a standardized process was the best way to assure the quality of software products (16T92;18T91).

There also are international standards for the software development (16T79). The International Standardization Organization (ISO) in Switzerland and the International Electrotechnical Commission (IEC) formed the Joint Technical Commission I (JTC I) to address standards relating to information technology (16T81). JTC I, in turn, established “Sub-committee 7” to deal with software engineering (16T80). In 1995, ISO/IEC Standard 12207 proposed a list of thirteen software development activities which roughly corresponded to the six steps identified by Seidman (16T81). Other relevant standards include ISO 9001 (general quality standard) and ISO/IEC 9003 (guidelines for applying ISO 9001 to computer software) (16T89-16T90;C-14, Seidman report at 6).

Certain organizations such as “TUV” in Germany and the American National Standards Institute (ANSI) will certify for a fee a company’s software development process for conformance to a given standard (16T82-16T83;16T94). Of interest here, Draeger obtained verification of its process by obtaining a certificate of compliance with ISO 9001 (16T92-16T94;17T110;S-22). That certification led Seidman to conclude that Draeger’s process for creating software met international standards of quality (16T100-16T101).

Software also may be validated and verified by an external audit team (16T101). External audits seek to (1) verify that the tests performed can be traced to the design requirements, and (2) validate that the software satisfies its intended use (16T102;C-14, Seidman report at 6). They do not require the performance of actual tests nor do they usually require a review of source codes (16T102). Seidman acknowledged that his confidence in the Alcotest 7110 would be higher if Draeger had obtained independent testing and evaluation of the Alcotest 7110's software (18T15;18T23).

Seidman, however, considered it unlikely that the Alcotest 7110's software was subject to malicious manipulation (16T110-16T112;C-13, Seidman report at 6). He explained that the presence of such "malware" required collaboration between malicious developers and users and significant resources, and found it difficult to construct a scenario containing these elements (16T117-16T118;C-14, Seidman report at 9). In contrast, Seidman used electronic voting systems as an example where someone might have an economic incentive to alter the outcome of an election by using malicious software to override election results (16T118;C-14, Seidman report at 7). In any event, he noted that source code examination would be insufficient to rule out such a possibility and that the cost of more intensive investigations was unjustified (C-14, Seidman report at 9).

Source code consists of computer language readable by a person with appropriate expertise and consists of a list of steps for implementing the algorithms (17T98). Software companies generally are reluctant to release these codes given the competitiveness of the industry (16T103-16T104). Seidman did not consider it necessary to review Draeger's source codes to reach an opinion regarding its software development process for several reasons (18T92). First, he explained that it was more important to focus on the process, not the product (18T92). To assess the process, it was important to know if the software conformed to the expected quality standards (18T23). For example, Seidman would want to know if the software was certified in conformance with ISO 9000 and 9003 (18T92).

Second, Seidman explained that the approximately 60,000 lines of source codes for the Alcotest 7110 would be very difficult to review and that it would not benefit anyone other than a competitor or someone with experience in the domain (16T119;18T93). Third, he did not believe that examination of source codes was necessary to detect errors in the system (18T94;C-14, Seidman report at 9). Instead, Seidman said that errors could by detected by performing "black-box" testing at the system level by putting solutions of known strength into the system and checking to see if they produced the expected output (16T94;18T20).

Seidman also relied upon the results of successful tests performed in 1996, 2003, and 2006 by NHTSA to infer that the Alcotest 7110 correctly implemented the underlying algorithms and computations (17T5-17T9;17T14;C-14; Seidman report at 7, 9). Seidman acknowledged, however, that he did not review the data underlying the test results, that the two earlier tests were not conducted on the same firmware version of the Alcotest 7110 currently used in New Jersey, and that he trusted NHTSA to do good science in the same way that he trusted other federal agencies to do their jobs (17T7-17T9;17T121). He further acknowledged that he was unaware of the fact that NHTSA had discarded forty-nine incomplete AIRs printed during the third test (17T7-17T12).

If there were errors in the software, Seidman would want to know about them as they would raise questions in his mind about the instrument's accuracy (18T67). When shown several AIRs with apparent errors, Seidman said that he would want to understand the reasons for them before he gave an opinion on the accuracy of New Jersey's breath-testing program (18T77;D-59;D-60;D-61;D-62;D-63;D-64). However, he did not believe that the errors or irregularities affected the instrument's "core functionality" but rather addressed the input/output information that governed communication with the outside world (18T95-18T96). For example, he wondered why an officer would submit an AIR which showed the letter "y" in place of the specific information requested and suggested that the problem might be the result of a keyboard that was improperly connected rather than a problem with the firmware (18T96;D-64). In any event, he agreed that a municipal court judge should not rely on an alcohol test where the AIR showed an irregularity (18T96).

Based upon his training and experience and the reviews he conducted in this case, Seidman concluded that: an examination of the source code was not necessary to determine the Alcotest 7110's reliability;

the software development process met industry standards; there was sufficient external testing by NHTSA, the New Jersey State laboratory, and law enforcement officials who regularly operated the instrument; and there was no reason to suspect the presence of "malware" (16T119-16T121;17T5-17T6;17T14-17T15;17T19).

This court finds Dr. Seidman very believable and well-qualified to express the opinions he was called upon to render. He was very helpful in explaining the computer aspect of the case.

12. *Summary of Testimony of Defendants' Expert, Gerald D. Simpson*

After receiving his Ph.D. in physical chemistry in 1970 from the University of California, Santa Barbara, Gerald D. Simpson spent three years as a post-doctoral fellow at the Florida State University Institute of Molecular Biophysics where he did research in molecular and laser spectroscopy (62T12-62T14;D-247).[53] He then worked for Rockwell International until he retired on disability from the Rocketdyne Division in the early 1980s (62T12-62T13).

Shortly after his retirement, Simpson became interested in the technology used to measure breath

53. Simpson testified by satellite video on December 14 and 15, 2006, and by telephone conference call on December 19, 2006.

alcohol concentrations including infrared spectroscopy (62T14-62T15). He reviewed the literature and, in 1987, published his first article addressing the margin of error in breath test results (62T14). As his curriculum vitae indicates, he continued to publish articles on breath alcohol measurements through 1996 (D-247). He is a past member of several scientific societies, but presently does not belong to any such organizations (62T35-62T36).

Simpson has testified for the defense as an expert in breath testing about thirty to forty times, mostly in California but also in *Downie* (62T20;62T39-62T40;64T16). He generally did not receive a fee except in one or two cases (64T13). Defendants here in *Chun* offered him as an expert in breath testing and breath testing error analysis (62T20).

Simpson has designed and performed tests on the Intoxilyzer 4011-A and the Alco Sensor III fuel cell pocket breath testers, but has not performed any tests on an Alcotest 7110 (62T23-62T25). He also has not conducted any original experiments, but relied instead upon the published data of others (62T44).

Simpson essentially was of the opinion that the Alcotest 7110 worked as well as any other breath-testing instrument, but that the scientific theory behind all breath test results was flawed (62T44;64T61-64T62). He identified the following problems inherent in all instruments: (1) the margin of error approached 50%; (2) the underlying assumption that alveolar air in the lungs was in equilibrium with the blood was incorrect;

(3) the standard calibration method did not ensure accuracy of breath test results; (4) there was no blind third-party proficiency testing; and (5) there was a lack of adequate validation testing (62T44-62T49;64T46-64T48;67T25-67T26).

Simpson recognized that there was uncertainty in every scientific measurement (62T53;62T55). To calculate the margin of error in breath alcohol measurements, he adopted a statistical approach based upon the use of a standard deviation from a mean for a particular sample (62T52-62T53).

According to Simpson, all evidential breath-testing instruments in the country assumed a 2100:1 blood-breath ratio (63T25). He concluded, however, that only 8% of the population fit that average and that the academic scientific community — as opposed to the forensic science community — would not generally accept that ratio without better testing (63T25-63T27;64T6-64T7).

Simpson relied heavily upon Dr. Dubowski's data in a 1985 article showing that the average blood-breath ratio in his population sample of healthy fully post-absorptive adult males was 2280:1 (62T62;62T69;63T42-63T43;67T5;D-235). Given one standard deviation of 242 (rounded up from 241.5), Simpson calculated that at two standard deviations, 95% confidence limits would require the test results to fall between 1796 to 2764 (62T67).

Simpson recommended using confidence limits of 99% (62T66;63T11). At 2.58 standard deviations, 99% confidence limits would be 1656 to 2904 (62T68;62T70-62T71). He then determined that the coefficient of variation was 10.6% (the standard deviation (242) divided by the mean (2280) times 100), which when multiplied by 2.58 resulted in a margin of error of 27% (62T73). Because the Alcotest 7110 assumed a blood-breath ratio of 2100:1, Simpson determined that the conversion would drop the margin of error to about 22% (62T79). In other words, if the test result fell within the margin of error, Simpson proposed correcting by 22% to account for the uncertainty (62T82).

On cross-examination, Simpson acknowledged that Dubowski testified in *Downie* that the standard deviation actually was 201, not 241.5 as reported in his article (67T12-67T13;67T15;D-235). Simpson further acknowledged that the change would significantly affect his own calculations (67T15). Because he was not aware of any published correction by Dubowski, Simpson felt he had properly relied upon the 1985 peer-reviewed article (67T31).

Simpson also calculated the margin of error for data from absorptive and post-absorptive populations reported in an article by Ulrich Heifer in Germany and in an article he co-authored with William Giguiere (62T52;D-243).[54] Again, Simpson determined the mean

54. The article by Heifer was not translated into English. Simpson evidently relied on Figure 1 in that article (64T64-64T65). *See* Ancillary Bioliography.

blood-breath ratio for the sample populations, the standard deviations, and the coefficients of variation (62T53). Applying the same calculations to data from the population studied by Giguiere, Simpson obtained an even wider margin of error of 46% for 2.58 standard deviations at 99% confidence limits, without taking into account the 2100:1 conversion (62T87-62T88;62T94; 63T11;D-243). To account for the uncertainty, Simpson advocated adding 46% (62T94-62T96). In other words, an .08 reading must be potentially as high as .117 (by taking 46% of .08 and adding it to .08) to avoid error (62T96;63T29).

According to Simpson, Heifer studied 1150 blood and breath pairs and found that two hours after the subjects stopped drinking, their blood-breath ratio was close to 2100 (64T65). Sixty minutes after they stopped drinking, Heifer found the ratio was 1910 (64T65-64T66). It is interesting to observe that Simpson was not aware of anyone else in the breath-testing field who cited the Heifer study (62T108). Simpson said: "They seem to have completely ignored him" (64T67).

Simpson recognized Dubowski as a leading figure in the breath-testing community, but noted that Dubowksi had never acknowledged his work (62T109). Simpson explained that the forensic science community had different standards of scientific rigor than "mainstream" scientists, probably because forensic science was applied in a way that was more consistent with law and public policy, rather than scientific method (63T35-63T36).

Simpson, however, was aware that Jones of Sweden — acknowledged as another leading figure in the breath-testing community — had written rebuttals to several of his articles (63T36-63T37;D-241;D-252). He rejected Jones' conclusions as well, noting that they lacked sufficient sample size or were poorly designed (64T57). Simpson also testified that other breath test studies had similar problems (67T17).

With regard to calibration, Simpson conceded that the Alcotest 7110 accurately measured the concentration of a known alcohol solution (62T91;64T5). However, he contended that the calibration method contributed only a small percentage to the total margin of error (62T91). By calculating the standard deviation or coefficient of variation, Simpson found that the expected error from the calibration method and the instrument itself contributed only about 2% to the total error (62T89-62T91;D-241). In contrast, he estimated that about 90% of the total uncertainty came from biological factors associated with the blood-breath ratio, at least during the post-absorptive stage (62T90-62T91;64T4;D-241 at 262).

Because the largest source of error came from biological variables associated with the blood-breath ratio and not from the instrument, Simpson believed that the various safeguards in the Alcotest 7110 (such as taking the lowest of four readings and truncating the final result) and potential corrections (such as adjusting 6 or 7% for breath temperature) would only lower the total error from all sources by a small amount (63T30-

63T31;63T48). Nonetheless, he said that temperature correction — upwards and downwards — was reasonable to avoid "false high" readings (63T49;67T29).

Simpson also believed that the use of a 9.5 wavelength on the IR spectrum reduced or eliminated all interferents (63T52). For example, he explained that one of the few interferents at 9.5 microns was dimethylsufoxide (DMSO), which he did not believe had ever been studied (63T52). Because there were many other potential interferents with low partition ratios which could affect a breath test reading, he recommended the use of a gas chromatograph to test part of the breath sample to make certain they were not present (63T54).

Simpson considered the Alcotest 7110 as a black box, which was not amenable to scientific methodology (63T56-63T57). Because a microprocessor and software controlled the operation of the instrument, he said there was no way to know whether the instrument did what it was supposed to do for each subject (63T56-63T57).

We add Simpson's comments about *Downie* from this "Letter to the Editor" at 14 *J. of Analytical Toxicol.* 263-64 n.6 (1990), where he said:

> In *Downie*, the court also misinterpreted testimony about the blood/breath ratio. It was concluded that "calculated blood/breath ratios are worthless for forensic purposes. They are subject to so many variables as to be unusable

> except for gross estimates . . . and only then at a particular moment." At this time, no model is available that permits calculation of blood/breath ratios. They have always been derived from experimental measurements of alcohol concentration of blood and air (or breath) under either in vitro or in vivo conditions. Consequently, at least for forensic purposes, there is no such thing as a calculated blood/breath ratio: there are only experimental or empirical blood/breath ratios. The Court confused calculated blood/breath ratios with the calculated BACs produced by the Breathalyzer. Based on the scientific evidence given, a correct conclusion would have been as follows: Because the value of the blood/breath ratio for any given individual is subject to so many variables, a BAC calculated from breath alcohol concentration, using an assumed value of 2100.1, is unreliable unless it can be proven that the individual was "fully postabsorptive" at the time of the test, in which case the uncertainty in a particular result is at least +/— 15%. . . .

[D-237.]

We conclude that Simpson either misunderstood or misrepresented the Court's ruling in *Downie*. As did Judge McGann as the trial judge in *Downie* in his findings of fact, we find Simpson's thesis and testimony "simply not reliable and reject it."[55]

13. *Summary of Testimony of Defendants' Expert, Michael Hlastala*

Michael Hlastala is a professor at the University of Washington where he holds appointments in the Department of Medicine (Division of Pulmonary and Critical Care) and the Department of Physiology and Biophysics (65T4-65T5). He also is an adjunct professor of bioengineering (65T5). He has a doctoral degree in physiology from the State University of New York at Buffalo (65T5;65T12).

As his extensive curriculum vitae shows, Hlastala is a member of several professional organizations and has received a number of awards including a John Simon Guggenheim Foundation Fellowship and an honorary medical degree from the University of Linkoping in Sweden (65T7). He has given lectures at universities both within and outside of the United States, and has written numerous articles on physiology including several on breath testing, as well as one book on respiratory physiology (65T7-65T9;65T14;65T17-65T18).

Hlastala's primary field of study deals with gas exchange physiology, especially the way in which highly

---

55. Findings of fact by Judge McGann in *Downie* are on file in Judge King's chambers, as provided by the State.

soluble gases, such as alcohol, exchange in the lungs (65T9-65T10). In his laboratory, Hlastala has used a Breathalyzer 900A, Datamaster, and Intoxilyzer 5000, but not an Alcotest 7110 (65T12-65T13). He also has experience with pulmonary function testing as well as gas chromatography and mass spectrometry with respect to the measurement of alcohol and other substances (65T11-65T12).

Hlastala has served as an expert witness in more than 1400 cases, including *Downie* (65T5-65T6;65T9-65T10). Defendants offered him as an expert in physiology as it relates to breath testing (65T10). Hlastala offered testimony in three areas: (1) the exchange of alcohol in the lungs; (2) the detection of mouth alcohol; and (3) the presence of interferents (65T26-65T27). Each area is discussed below.

Alcohol Exchange

The old paradigm assumed that the breath sample tested at the end of a full exhalation was the equivalent of alveolar air in equilibrium with the blood (65T29). Hlastala disagreed, stating that the end-exhaled breath was not the same as deep lung air because of the exchange of alcohol in the airways (65T29).

Briefly, the respiratory system consists of airways which travel from the nasal cavity down the throat to the trachea, then split into two branches just above the heart, and continue to branch or split more than twenty times until they fill the chest cavity (65T31;D-172). The airways are lined with mucus, and gradually get smaller in size causing air movement to slow down (65T31-65T32). At the end of the airways, there are alveoli or air sacs surrounded by blood vessels where gas exchange takes place, meaning oxygen enters the blood and carbon dioxide leaves it (65T31-65T32;D-172).

Because alcohol is highly soluble, it adheres to the water-laden mucus on the surface of the airways (65T32). During inhalation, breath air picks up alcohol from the airway surfaces which increases the alcohol concentration to the point of saturation by the time the air reaches the alveoli (65T32-65T34;65T36).

During exhalation, however, the alcohol concentration decreases as the alcohol interacts with the airway tissue on its way to the mouth (65T34-65T38;65T43-65T46;66T5). The amount of interaction varies among individuals based upon certain physiological factors such as breathing patterns (65T34-65T35;65T44-65T45). Citing studies by A.W. Jones and others, Hlastala noted that subjects who held their breath or blew longer caused a warming of the airway tissues which resulted in less alcohol deposited there during exhalation and higher readings (65T40-65T43). Conversely, subjects who hyperventilated before their breath tests would cause additional cooling of the airway surfaces which would result in a greater loss of alcohol during exhalation and lower readings (65T41-65T43).

Another factor is temperature, both body and breath (65T43;65T56-65T57). For example, Hlastala cited a study by Dr. Fox showing that a higher body temperature caused higher breath test values and vice versa (65T55). To compensate for the higher alcohol readings, Dr. Fox apparently found that there should be an adjustment of 8% for every degree that body temperature rose above normal (65T55-65T56).[56] Hlastala also relied upon other researchers who reported breath temperature changes could cause alcohol readings to vary by 6.5% (65T69). Hlastala, however, did not recommend correcting for breath or body temperature without more experiments (65T69-65T70).

A third factor was hematocrit, which Hlastala described as the relationship between red cells and plasma (a watery substance) in the blood (65T57). According to Hlastala, females had a slightly lower hematocrit resulting in lower breath test values as more alcohol was retained in the plasma (65T57-65T58). Hlastala, however, acknowledged that there were no studies showing hematocrit differences relating to variations in breath alcohol concentrations (66T40).

Relying upon experimental work performed by other researchers, Hlastala also found that people with smaller lung volumes had higher readings and concluded that breath testing discriminated against them (65T62-65T67;66T14-66T15;66T40;D-256;D-261). He recommended more tests to understand the difference and correct for it (65T67).

---

56. Dr. Fox's study was not marked into evidence.

Hlastala agreed that the 2100:1 blood-breath ratio used in the Alcotest 7110 tended to underestimate blood alcohol (66T37). While recognizing that the ratio varied among populations, he used Jones' finding that the actual ratio of blood and air in a closed container was approximately 1756:1 to conclude find that, on average, exhaled breath lost 20% of the alcohol to the mucosal surface of the airways (65T75-65T77;D-265).

To compensate for the physiological variables under the "new paradigm," Hlastala suggested using a blood-breath ratio of 1750:1 (66T6-66T9). While a 1750:1 ratio would favor more defendants, Hlastala pointed out that it would favor some (such as those with higher lung volume, lower temperature or lower hematocrit) more than others (65T83).

Hlastala also took issue with the breath-testing concept that a subject had reached alveolar air expulsion when the breath leveled off or reached a plateau (66T63-66T64). Instead, he claimed that a breath-testing instrument actually was measuring the level at which the subject stopped exhaling (66T64). He also did not see a need for truncating test results and recommended taking the average of the four readings, not the lowest (66T37-66T38).

Because end-expired breath was never the same as deep lung air, Hlastala recommended taking blood samples and if that was not practical, using an isothermal re-breathing device which required a subject to breathe in and out of a heated bag about five or six times (65T50-

65T51;65T80). As he explained, the device produced more uniform breath alcohol measurements which better represented blood alcohol (65T50-65T54).[57] A single breath exhalation, however, underestimated an isothermal rebreathing sample, requiring a change in the blood-breath ratio from 2100 to about 1950:1 (66T22-66T23;66T25). To date, no state has used an isothermal rebreathing device (66T26).

Hlastala explained that he proposed the new paradigm in response to anomalies in the old one (66T16). He recognized, however, the need for more experiments to confirm the new paradigm or create another (66T16). He explained, "it's new information. It's only a decade or decade-and-a-half old and we need to do those experiments to validate it" (66T17-66T18). He also recommended further experiments on breath temperature before advocating a particular deduction (66T39).

Hlastala was aware that forensic scientists, unlike the medical community, did not accept the new paradigm (66T16;66T63). Because forensic scientists failed to consider the physiological variables, Hlastala observed that all breath-testing programs had similar biases (66T16).

---

57. For a more detailed discussion, *see* J. Ohlson, D.D. Ralph, M.A. Mandelkorn, A.L. Babb, and M.P. Hlastala, *Accurate Measurement of Blood Alcohol Concentration with Isothermal Rebreathing*, 51 *J. of Studies on Alcohol* 6 (1990) (S-74). For that study, Hlastala and his co-authors dosed fourteen volunteers with alcohol to examine such breathing parameters as hyperventilation (66T13-66T14;66T23-66T24).

Mouth Alcohol

Hlastala recognized that the presence of mouth alcohol can result in false higher breath alcohol readings (65T91). Such elevations can be caused by recent drinking, regurgitation or gastroesophageal reflux disease (GERD), or by the presence of dentures or other materials that absorb alcohol (65T92).

He also recognized that the Alcotest 7110's infrared technology used a slope detector to detect mouth alcohol (65T89). In Hlastala's opinion, however, the slope detector was not "foolproof" because it did not work properly when alcohol was present both in the bloodstream and the mouth (65T85-65T88). In his report, he wrote:

> The simple explanation is that the decreasing slope for alcohol coming from the mouth offsets the rising (positive slope) on alcohol exhaled from the lungs. Since a negative slope is not detected, the slope detector will not identify mouth alcohol under this situation. While the slope detector is an important check against mouth alcohol, it does not work well when alcohol is also present in the body.

[C-15, Hlastala report at 3.]

While Hlastala tested the slope detectors on the Datamaster and Intoxilyzer 5000, he never actually tested the slope detector on the Alcotest 7110 (66T46;D-257).

In Hlastala's opinion, the two-minute lockout between breath tests and the twenty-minute observation periods also did not provide complete safeguards against mouth alcohol (65T92-65T93). When asked if the combination of the slope detector, two-minute lockout, and twenty-minute observation period was sufficient, Hlastala responded that they would be helpful but it still would be difficult to detect internal regurgitation or GERD (65T94-65T95). He stated, however, that twenty minutes was a sufficient period of time to wait to stabilize the saliva concentrations if there was any vomiting (65T96).

Interferents

Relying upon the instructor training manual for the Alcotest 7110, Hlastala noted that it described ethyl alcohol and other alcohols, but did not explain how the instrument differentiated between ethanol and methanol, or any other alcohol especially when there were only trace amounts present (65T98-65T101;D-7). In particular, he expressed concern that there was no data showing the effect of small amounts of other contaminants such as isopropyl alcohol (65T102-65T103).

On cross-examination, Hlastala admitted that he did not know NHTSA had tested a generic Alcotest 7110 and firmware versions 3.8 and 3.11, that he was not familiar with NHTSA's model specifications relating to acetone, that he was unaware of OIML Recommendation 126 (which applied to evidential breath testers), and that he did not review the data from Brettell's study on interferents (66T53-66T55).

Hlastala was aware that the instrument detected interferents by comparing the tests results of the IR and EC methods of analysis (65T104). In his opinion, the real issue was how sensitive those two methods were for making the requisite measurements (65T104). He recommended Draeger perform experiments with different levels of interferents to determine the sensitive activity for minimum amounts (65T104-65T105). If contaminants existed, he recommended that the State consider subtracting .01 from the readings in every case (65T105). In the State of Washington, defense counsel argued for a similar adjustment in cases with close readings (65T105).

In his opinion and to a reasonable degree of certainty within his field, the scientific reliability of the Alcotest 7110 could not be assessed because Draeger failed to measure interferents or define the minimum value for uncertainty with regard to potential contaminants (66T10-66T11). Such information would have enhanced his understanding of the instrument (66T11).

We do not doubt Hlastala's sincerity or his integrity but he concedes that his "new paradigm" for evidential breath testing is in the developmental or experimental phase. We are not persuaded that these theories are correct or sufficiently documented at present. As in *Downie*, 117 *N.J.* at 454, Hlastala "outlined potential physical variables that could affect the blood-breath partition ratio." *Ibid.* We are not convinced by his testimony here to reject the conclusions of *Downie* and adopt his theory that evidentiary breath testing is currently unreliable.

V. FINDINGS AND CONCLUSIONS OF LAW

1. *In the wake of Downie*

We consider this Alcotest 7110 "scientific reliability" hearing against the background of *Downie*, decided by the Supreme Court in January 1990. *Downie* considered the scientific reliability of the now virtually extinct breathalyzer. In *Downie* the Court said "specifically defendants challenge the accuracy of the breathalyzer test results based on partition-ratio variability." 117 *N.J.* at 451. The Court accurately explained in *Downie*:

> The breathalyzer, the machine the State employs to ascertain blood alcohol, measures the amount of alcohol in the breath and multiplies that by 2100 to arrive at the level of alcohol in the arterial blood supplying alcohol to the brain. This 2100:1 partition ratio presumes that every 2.1 liters (2100 milliliters) of expired alveolar air (or air expired in the last 1/3 portion of a deep breath) contains approximately the same quantity of alcohol as one milliliter of blood. If a person's actual blood-breath ratio is lower than 2100:1, the breathalyzer will overestimate blood alcohol, and vice-versa.

[*Id.*]

The Court in *Downie* rejected the challenge that because "people have broadly divergent ratios of breath alcohol relative to blood alcohol, the 2100:1 partition ratio is inaccurate," *id.*, and the consequent breath test results are scientifically unreliable.

The evidence presented to us at this extensive hearing basically raised two issues:

1. Is the Alcotest 7110 reliable in measuring breath alcohol?

2. Is the adoption of the 2100:1 breath-blood ratio, used in *Downie*, still a valid conversion method?

The *Downie* Court in detail described law enforcement problems in obtaining arterial, venous or capillary blood in the field. *Id.* at 458-59. These practical problems created the need for breath testing, an alternative but concededly less efficacious or precise method of determining blood alcohol. In discussing the 2100:1 partition ratio, the *Downie* Court perceptively said:

> The 2100:1 partition ratio, in its absolute simplicity belies the fact that each subject's partition ratio is affected by a host of complex physiological variables. Henry's law, in physical chemistry, states that when a liquid that contains a volatile substance, such as alcohol, makes contact with air in a closed container and at a known temperature, a certain amount of alcohol will escape into the air space above in the form of vapor. The rate

at which the alcohol vaporizes will depend on the concentration of the alcohol in the liquid and on the temperature. The higher the temperature, the more alcohol will escape to the vapor. When there is a fixed temperature and concentration of alcohol, a state of equilibrium will result in which the amounts of alcohol in air and liquid are static.

The breathalyzer applies Henry's law to the blood which courses through the lungs carrying alcohol. As the arterial blood passes through the lungs, some of the alcohol will become vaporized in the alveolar air and expelled in the breath. The breathalyzer is calibrated to presume that at 34 degrees Celsius, a solution of .121 grams of alcohol per 100 milliliters of water will give off alcohol to the vapor of .10 grams per 210 liters of vapor. Thus, we arrive at the current 2100:1 partition ratio.

Dr. Dubowski found that individual partition ratios vary greatly. In one experiment, Dubowski paired blood and breath samples from experimental subjects. He found that the partition ratio of samples from different people ranged from 1706:1 to a high of 3063:1 despite each having ingested the same amount of alcohol. A person's partition ratio may vary from time to time. Moreover, it may be that no two people have

> the exact same partition ratio. Thus, the 2100:1 partition ratio is merely an estimate that roughly approximates most people's ratio and that is calibrated to give the benefit of the doubt to the subject in most instances.

[*Id.* at 459-60.]

Dr. Dubowski did not testify before us in the *Chun* case but this summary of his testimony in *Downie* fairly expresses in general terms the testimony and literature presented to us by the State on the partition-ratio issue. The State has made the record in *Downie* available to us.

In sum, the Court in *Downie* seemed confident that in only 2.3% of the cases, at the very most, "does the breathalyzer materially over estimate the blood-alcohol level potentially to the detriment of the accused." *Id.* at 462. And, the Court was skeptical indeed of the accuracy of this estimate of error, as too high, "subject to question," and "not established." *Ibid.* Various factors favor the accused in this conversion process and protect from overestimates of alcohol in blood: (1) the ratio in most people is closer to 2300:1; (2) the reading is truncated to the second decimal place, not "rounded off" to the nearest hundredth (.089 = .08); (3) a suspect may not provide a deep enough breath to register all of the alcohol present in the alveolar air, and (4) only the lowest of two tests, fifteen minutes apart, counted on the breathalyzer. *Id.* at 460. (The Alcotest 7110 counts only the lowest of the four IR and EC readings.) The Court in *Downie* found that these, among other less-significant factors, "caused the breathalyzer to render many more breath test results on the low side than on the high side." *Ibid.*

Dr. Borkenstein, the inventor of the breathalyzer, testified in *Downie* that "breathalyzer researchers and members of the National Safety Council adopted the 2100:1 partition ratio instead of the more accurate 2300:1 ratio because they wanted to err on the low side and have almost no errors on the high side." *Id.* at 461. We also must here remember that these possible errors would impact guilt or innocence only at or near the critical levels, i.e., .04 (commercial license), .08 (usual DWI) and .10 (enhanced sentencing of first offenders). Errors on relatively high or low readings, not tending towards the critical levels, are generally forensically irrelevant. This is the reason we recommend close attention by a fact-finder to the clinical findings and observations of the suspect at the time of apprehension, because a possible, but improbable, overestimated .08 breath reading regarding blood level may conceivably obscure and mislead a judge to an erroneous conclusion where the clinical data in the field sobriety test (FST) might otherwise strongly suggest innocence. Given the lack of absolute scientific certainty of breath-testing, we urge caution by the trial judge at the critical levels, .04, .08 or .10, when interpreting a close reading in the context of otherwise persuasive exculpatory clinical evidence.

This caution was well expressed by Judge Patrick J. McGann, Jr., the trial judge in *Downie* where he summarized his findings of facts on Dr. Dubowski's testimony for the Supreme Court:

> Even though Oklahoma [Dubowski's jurisdiction] does have a per se law — that is a conviction based solely on a breath alcohol or blood alcohol reading in excess of the stated standard — Dr. Dubowski believes it to be a mistake. It places over-emphasis on a single piece of evidence. He believes that the whole traditional evidential picture should be presented, i.e., evidence of inadequate driving, evidence of impairment of the driver (physical coordination tests), physical indicia of alcohol consumption and then a properly conducted breath alcohol analysis (even with a converted blood/alcohol reading). In that way neither conviction (nor exoneration) will depend on just one item of evidence, in his opinion. He believes that too much emphasis is placed on the test instead of on the person and the performance. That opinion is more strongly held as the penalties for drunk driving become increasingly harsh.[58]

We fully agree with Dr. Dubowski on this point where the reading is at the critical level, i.e., .08 or .10, in the

58. Material from the *Downie* record supplied by the State and retained in Judge King's chambers.

usual DWI prosecution, because of the error margin of .004 or .005 described by Ryser and the inevitable influence of analytical and biological variation on a particular test.

Gullberg, speaking of the small percentage (5 or 6 out of 793 subjects he discussed) which clustered about the critical threshold, had a similar response.

> THE COURT: What about on the threshold there?
>
> THE WITNESS: This is the critical false/positive we want to avoid. Well, the percent that that occurs is going to be far less than 4.3 because the 4.3 percent — these 34 individuals span the range. So maybe there's five or six that are here.
>
> MR. SACHS: Objection. Far greater, far lesser, maybe. He's been qualified as statistician. He's given us numbers on all these spots.
>
> THE COURT: That's the way they talk.
>
> MR. SACHS: I want to see numbers there.
>
> THE COURT: We'll get to that. We're concerned about the people on the margin.

THE WITNESS: That's right. That's exactly right. That's the false/positive area you want to avoid. And the point is that it's less than 4.3 percent because part of these people are down here. Part are up here. And one of the interpretations of these numbers and ratios needs to consider where in the concentration range are we?

THE COURT: Is it untoward for me to inquire what Jones or you or anybody else do about those marginal subjects?

THE WITNESS: Well, no. There's nothing that can be done.

THE COURT: In the legal sense, I mean.

THE WITNESS: Right. Unless you want to define the statute differently in terms of breath alcohol concentration only so you avoid this blood/breath comparison. In my opinion that would be the ideal way to go.

MR. MENZEL: I'm going to ask that opinion be stricken. It's legislative determination.

THE COURT: It's interesting.

MR. REISIG: It is interesting, but it's a legal conclusion. He's an expert.

THE COURT: I know it is. So you think out of that population of 793 there might be four or maybe five people on — in that threshold?

THE WITNESS: That's right.

THE COURT: And that would be some kind of societal or legal judgment. What do you do with them?

THE WITNESS: That's right. That's the risk. Certainly you want to avoid and minimize that from ever happening, but it is a small risk.

THE COURT: Now, suppose I were to suggest that the people fall in that range clustered around .08, that special attention be paid to the clinical picture derived from the subject at arrest and subsequent to it. What do you think of that?

THE WITNESS: The only circumstances surrounding the arrest, the driving, the physical sobriety test, things of this sort could be given more weight perhaps.

[Gullberg 8T10-8T12]

Against this background, we reach these conclusions of fact and law.

1. Because of the strong evidence presented by the State on the scientific accuracy of the Alcotest 7110, we find the instrument acceptable for evidentiary breath tests in New Jersey, when accompanied by the appropriate foundational proofs. Indeed, we find the Alcotest 7110 with proper foundational proofs much more scientifically reliable and independent of operator influence, intentional or inadvertent, than the breathalyzer. Of course, the multiple-step testing protocol must be meticulously followed before the test result is admitted in evidence.

2. The State's proofs on the question of the reliability of the partition or blood-breath ratio largely mirrored the State's presentation in *Downie*. We do not doubt the integrity and sincerity of any witness in this proceeding, presented either by the State or defense. At most, there were shades of differences about interpretation of scientific data or understandable dispute over *au courant* scientific theory. We find no reason in the evidence to doubt the continuing validity of the underlying theory of a 2100:1 blood-breath ratio. The testimony of Dr. Hlastala and Dr. Simpson, on the Heifer (Bonn) and other data, presented by the defense is interesting but certainly not convincing. It perhaps may represent the next frontier in the forensic science of evidential breath testing if eventually supported by sufficient proofs — but it is not yet vigorous enough, if it ever will be, to up-root the science explicated and found persuasive in *Downie* and fortified by the extensive proofs before this court. Thus we reject the defense witnesses' basic premise that the 2100:1 ratio

and present breath-testing technology is fundamentally unreliable, especially when adopted, as it has been in New Jersey, with caution and appropriate leeway, so as not likely to ensnare the innocent. Of course, here the defendant has the benefit of the lowest of four independent readings (two IR and two IC) derived from two separate breath samples. This is the foremost safeguard.

2. *Administrative Safeguards*

In order to provide the State and defendants with necessary information regarding the instrument used in each test, the State plans to add, in the next upgrade and modification of the firmware, additional administrative safeguards which this court finds must include:

a. The State must list the temperature probe serial number and probe value of that temperature probe on any report where such information is relevant, including the AIR, New Standard Solution Change Report, and Calibration Check documentation — Calibration, Control Test Part I, and Linearity Part II Reports.

b. The State must publish any firmware revisions through some reasonable mechanism, including placing this information on the State Police web site.

c. In order to ensure quality control and firmware version control, the State must continue the practice of strictly limiting access to or “locking” the firmware so that changes to the firmware can be done only by the manufacturer or one of the State Police breath test coordinators authorized pursuant to *N.J.A.C.* 13:51-2.

d. All valid breath test results are reported on the AIR to three (3) decimal places. When a final breath test result is reported and recorded on the AIR, that value is always the lowest value of the acceptable readings within tolerance. That value is reported and recorded as a truncated number on the AIR to only two (2) decimal places. We reject the defenses' contention that the AIR should not be admitted into evidence.

e. In instances where a defendant is tested on an Alcotest 7110 and there is no reportable breath test value on the AIR for that defendant, the AIR must clearly show the source and reason why no breath test result was reported for that breath sample. This non-reportable test event in itself shall not constitute a legal determination of refusal to submit to chemical breath testing under the implied consent statutes.

f. The firmware currently in the Alcotest NJ Version 3.11, and any future modifications or upgrades of that present firmware, does not impact upon or affect the scientific reliability, accuracy or precision of the Alcotest evidential breath test instrument to detect, analyze and accurately report a breath alcohol reading. In sum, the Alcotest 7110, NJ 3.11 currently in use is scientifically reliable.

g. This court recognizes that the Alcotest 7110 is not dependent on the breath test operator to record the breath test reading or result. Operator involvement is limited to inputs of administrative information. The operator must strictly follow the test protocol and the instructions or "prompts" on the LED screen during the testing process. All analytical functions after this are performed by the Alcotest 7110, and are outside of and beyond the control or influence of the breath test operator. This is a significant advantage over the breathalyzer. If the test protocol or instructions are violated in any respect, the BAC reading must be rejected as evidence.

h. As to discovery data, the collected centralized historical data described in V(7) shall be provided for any Alcotest 7110 relevant to a particular defendant's case in a digital format readable in Microsoft Access or similar program generally available to consumers in the open market. When such data includes tests from cases concerning defendants not part of the requesting defendant's case, the information provided will include departmental case numbers, ages, and breath temperatures or other relevant scientific data on those other defendants' tests but not their personal identifying information, such as name, address, birth date, drivers license number, license plate number, or social security number.

i. The revised firmware shall require that the Ertco-Hart Digital Temperature Measuring System or other similar device traceable to the National Institute of

Standards and Technology is in proper operating condition and that the serial number of such devices be listed on all reports where such information is relevant, including calibration, certification, and linearity reports.

j. The State shall provide regular, continuing, and meaningful training for attorneys and their experts consistent with that provided for certification of breath test operators and breath test coordinator instructors pursuant to the New Jersey Administrative Code at *N.J.A.C.* 13:51-1.1 to 1.14 and *N.J.A.C.* 13:51-2.1 to -2.2, respectively.

3. *Source Codes*

The discovery of the source codes by the defense pursuant to a reasonable protective order was rejected by Draeger from the outset. Conventional discovery was made difficult because Draeger was not a formal party and declined this court's invitation to intervene and defend its product in the customary manner. Eventually, Draeger offered to explain the source code aspect to this court *in camera* without a record. The defense understandably rejected such an arrangement. Draeger than suggested a very restricted review of the source codes under highly-controlled conditions, in Durango, Colorado. This offer was understandably spurned by the defense as impractical and unhelpful.

Finally, during this trial Draeger offered its source codes of some 896 pages and 53,774 lines for examination in New Jersey at the trial site by defense experts. By this time, it was too late. Such an examination would have taken weeks and considerable expense for the defense, which did not then have qualified electronic experts at hand, was ostensibly without adequate financial resources for the task, and would have delayed the trial perhaps into the summer. The parties seemed at a stand-off concerning the source code issue and this court was left to decide whether or not the so-called "black box" verification of the computer system in the Alcotest 7110 was scientifically reliable.

At this point the defense and Draeger decided to attempt negotiating a resolution to this stand-off. This court had warned Draeger that it could make a negative inference against the reliability of the Alcotest 7110 because of the withholding of relevant information. We stress here that the State was always most cooperative in discovery and never had possession of the source codes to turn over to this court or defense.

Finally, the defense and Draeger agreed to terms to insure the on-going integrity of the software/firmware codes and algorithms in a document termed ADDENDUM A. These terms were agreed to by Draeger and its counsel. Therefore, we conclude that the software and firmware, which is integral to all functions, is presumed reliable in our courts but only if the terms expressed in the attached ADDENDUM A are scrupulously followed by Draeger.

ADDENDUM A

(1) The software source code will be examined by an independent software house agreeable to Draeger and the parties in this case. This software house will examine the source code for obvious concerns within the code, and also for consistency with the algorithms as documented in the software. The source code, with the algorithms as documented in the software, will be provided to the independent software house under a confidentiality agreement acceptable to Draeger and will not be disclosed to the public, thereby preserving whatever trade secrets Draeger asserts. However, the software house will certify to the State and the public that the software properly employs the algorithms and that no errors exist in the source code.

(2) The software will be programmed so that it will be "locked" and incapable of change without such change being printed out on any alcohol influence report produced by an Alcotest 7110 MKIIIC in which it is employed. The "software lock" will be verified by the independent software house specified in (1) and any subsequent revisions made under the process contemplated which result in subsequent software versions will be reflected by the printout of the new version numbers on the alcohol influence report.

(3) The Alcotest 7110 MKIIIC using the newly-created software version, after undergoing the source code review as specified in (1), will be tested against and measured in compliance with the O.I.M.L. specifications adopted and current at the time of such tests. This examination will be undertaken by a laboratory in the United States, and the software will be revised, if necessary, in accordance with any deficiencies in the event that the O.I.M.L. specifications are not met for anticipated version NJ 3.12. In the event the O.I.M.L specifications are not met and the software is modified, the modified software will be presented to the independent software house indicated in (1) for its review and certification. It is expected that if the software house is satisfied the changes necessary are minor, the secondary review will be substantially modified compared to the initial review.

(4) Draeger agrees to sell to New Jersey attorneys and experts Alcotest 7110 MKIIIC units on the same terms as are in force with the State of New Jersey at the time the purchase was made with the then-current version of the New Jersey software. Draeger also agrees to offer training to the purchasers and the purchaser's employees in regard to use of the Alcotest 7110 MKIIIC on reasonable monetary terms and to warrant

and service the instruments at the same rates as paid by the State of New Jersey. In the event that future software revisions take place, Draeger will facilitate upgrades of purchased Alcotest 7110 MKIIIC units to the then-currently available New Jersey software version. (Although Draeger understands that this entire agreement is subject to review and reasonable approval by the State of New Jersey, this power is clearly within the State's purview. However, the intent of this clause is to make all current versions available to all non-governmental owners for a reasonable administrative fee.)

(5) Further, it is contemplated that in the future when the State of New Jersey requires any further software revisions, the State would give notice of such to the public and the independent software house would examine the source code changes and determine whether a complete review is necessary or whether the software house could certify that the changes made would not require an additional software review and O.I.M.L. testing. In the event of any major changes in the operational conditions of the instrument, a new and complete O.I.M.L. procedure laboratory examination, or such subset of such tests as the laboratory may determine are appropriate in light of the extent of the changes per the revision, would be required.

> To the extent possible, the parties envision using the same software house and testing lab so as to have the benefits of institutional memory; the future stability of those organizations is an important element to consider in deciding which to retain for these purposes.

This court will not indulge in any negative inference against Draeger because of its grudging attitude earlier with respect to disclosure of the source codes. The negotiated ADDENDUM A, and Ryser's forthright testimony, encourages this court to have confidence in Draeger's good faith with respect to the source codes which record and communicate the scientific findings which in turn become the Alcotest 7110's AIR. This court also finds that the "black box" testing of the computer system and source codes used to date is scientifically reliable. This court is convinced that the entire system is indeed reliable for breath testing and reporting breath alcohol measurements when the prescribed protocols are strictly followed by the operator. This conclusion is fortified by the parties' agreement to this reliability undertaking to insure fairness to the State and future defendants. The expense of the examination of the codes, and upgrades described in (1) to (5) will be on the account of Draeger. The reasonable administrative cost of making these current versions and changes generally available shall be at the cost of the persons desiring same, *e.g.*, defendants, attorneys, Alcotest 7110 purchasers, and educational associations.

4. *RFI-EMI Interference*

The Alcotest 7110 used in New Jersey is well-shielded against electronic interference. The New Jersey process and procedure of administration of evidential breath tests provides adequate protection against both radio-frequency and electro magnetic interference. In addition to the carrying-case's shield, Draeger designed the instrument's five-layer motherboard to suppress RFI. During training, operators are instructed that cell phones or hand-held radio transmitters should not be used or stored in the area where the test is administered. Interference or abnormal test result signals are available to the operator visually through immediate information on the display screen (LED) and then on the AIR printout with an error message. BAC test result is reported on the AIR. The shielded Alcotest 7110 case has passed various tests for interference, including OIML, Volpe Lab, and State police testing. In order to further avoid potential interference a policy has been established and promulgated to all State and local police departments that any possible sources of RFI or EMI, such as walkie-talkies and cell phones, be banned from any area in proximity to the Alcotest instrument. The shields in the casing, the motherboard, these warnings, and the instrument's error messages provide adequate safeguards to insure scientific reliability in this regard.

5. *Foundational Evidence*

This court concludes that a proper foundation for the admission of an Alcotest 7110 reading shall include these elements.

a. The testimony of the operator that the customary procedures have been meticulously followed and the production of the operator's credentials.

b. These listed documents must be provided by the municipal prosecutor in discovery and may be admitted into evidence without formal proof in the discretion of the judge, if kept in the normal course of the State's business. In the event of a trial with an unrepresented defendant, these foundational documents must be placed in evidence. These documents are:

> i. Calibrating Unit, New Standard Solution Report, most recent change and the operator's credentials of the officer who performed that change;
>
> ii. Certificate of Analysis 0.10 Percent Solution used in New Solution Report;
>
> iii. Draeger Safety Certificate of Accuracy Alcotest CU34 Simulator;
>
> iv. Draeger Safety Certificate of Accuracy Alcotest 7110 Temperature Probe;

v. Draeger Safety Certificate of Accuracy Alcotest 7110 Instrument unless more relevant NJ Calibration Records (including both Parts I and II) are offered;

vi. Calibration Check including both control tests and linearity tests and the credentials of the operator/coordinator who performed the tests;

vii. Certificate of Analysis 0.10 Percent Solution (used in Calibration-Control);

viii. Certificate of Analysis 0.04, 0.08, and 0.16 Percent Solution (used in Calibration-Linearity);

ix. Calibrating Unit, New Standard Solution Report, following Calibration;

x. Draeger Safety Certificate of Accuracy Alcotest CU34 Simulator for the 3 simulators used in the 0.04, 0.08, and 0.16 percent solutions when conducting the Calibration-Linearity tests;

xi. Draeger Safety Certificate of Accuracy Alcotest 7110 Temperature Probe used in the Calibration tests; and

xii. Draeger Safety, Ertco-Hart Digital Temperature Measuring System Report of Calibration, NIST traceability.

6. *Breath Volume and Flow Rate*

A suspect must deliver breath samples of a minimum volume of 1.5 liters. The minimum blowing time is 4.5 seconds. The minimum flow rate is 2.5 liters per minute. The breath sample when analyzed by the IR detector must reach or approach an equilibrium — that is the infrared measure of the breath alcohol in the sample must not differ by more that 1% over .25 seconds. These are *minimum* criteria.

The defense argues for a minimum volume of 1.2 liters for all suspects. There is substantial credible evidence in the record that women over age sixty consistently have difficulty in reaching the 1.5 liter minimum. We agree with the defense to this extent only and so find. The minimum for women age sixty and over should be 1.2 liters. We find no credible evidence to support the theory that the minimum should be lower than 1.5 liters for the general population. The State has stressed persuasively that 1.5 liters and upwards provides a good deep breath sample for testing.

We also see no need to impose an overall maximum of 2.5 liters in volume as suggested by the defense. As we understand the evidence, the maximum volume usually tested is up to 3.0 liters. We find no evidence that a sample up to that 3.0l liters or higher is unreliable as a measure of the breath alcohol in the subject, or that the mantra, "The longer you blow the higher [BAC result] you go" is scientifically unfair to tested subjects. We are convinced that a higher volume than 1.5 liters simply presents a better sample of deep lung air for analysis by the instrument.

The State has assured us that the Alcotest 7110 can be programmed to set a minimum of 1.2 liters for women over age sixty when this information is obtained in the personal identification data from the subject and when so programmed and properly alerted, the instrument in the particular case will print out a valid BAC result.

7. *Centralized Data Management*

The Alcotest 7110 has the ability to communicate through the modem port with a central server by using a dedicated telephone line. This is not done presently. The State should promptly implement this improvement. This would allow daily or weekly uploads of all data from each Alcotest 7110 in the State automatically. The centralized data then can be viewed from a compatible data base program.

Breathalyzers were routinely checked in the field every six to eight weeks by State Police coordinators. Presently, the Alcotest 7110s are physically checked only once a year or sooner, if needed. This proposed transparent, easy access to State-wide digital data will help very much to assure quality control and alert the State Police to problems arising in the field. Dr. Brettell testified that this central data collection was desirable and the State should and intended to so proceed promptly.

This court strongly recommends that the State obtain and deploy a software program to create and maintain a centralized data base of digital information stored by all Alcotest 7110s throughout the State. This data should be uploaded, either daily or weekly, by a modem or internet connection to a central State location and maintained for at least ten years.

8. *Non-Operator Dependent*

Unlike the breathalyzer, the Alcotest 7110 is not operator dependent. With the breathalyzer, the reading and recording of BAC was based only on the observations of the operator as to where the needle indicator stopped on the dial. The operator simply wrote down his observation of the reading. No contemporaneous, machine-generated permanent record was produced by the breathalyzer.

With the Alcotest 7110 a permanent record, the AIR, is printed out and a copy given to the suspect after the test is completed. The AIR provides a complete explanation of the multiple-step test procedure as well as historic information about the arrest event and the subject, and some history about the use and testing of the Alcotest 7110 instrument. The Alcotest 7110 does not require manipulation of the physical components of the instrument by the operator to reach a BAC result, as does the breathalyzer. Once the Alcotest 7110 is activated, the entire process is automatic until the BAC result is printed out, unless the test is aborted without any BAC results. The operator has no control over the testing process itself or the result.

The objectivity of the Alcotest 7110 compared to the breathalyzer is a considerable advantage: it combines both accuracy, contemporary documentation of the result, and elimination of the ability of the operator to falsify or exaggerate the test outcome. This independence from potential operator influence and a permanent machine-printed record are decided advantage over the breathalyzer. These features are very helpful in avoiding situations like *State v. Gookins*, 135 *N.J.* 42 (1994), where the arresting officer falsified the breathalyzer results in drunken-driving cases to improperly coerce guilty pleas and obtain convictions.

9. *Breath Temperature Sensor*

Most breath analyzers used in the United States operate on the assumption that the temperature of an expired breath sample is 34 degrees C. Recent scientific research supports the proposition that the temperature of an expired breath sample is actually almost 35 degrees C. For each degree above 34 degrees C, breath tests will increase BAC results by 6.58%. While the relevant scientific community at this time does not generally accept breath temperature monitoring as necessary, this court finds that the technology to control this variable is accurate and readily available — both Germany and Alabama currently use the breath temperature sensor available from Draeger.

We strongly recommend that New Jersey employ Draeger's breath temperature sensor. Unless such breath temperature sensing is implemented, all breath test results should be reduced downward by 6.58%, as done currently in Alabama. This will serve to reduce the overall margin of error from the Alcotest 7110 and increase confidence in the reported BAC as more accurate to support a finding of guilt. This court finds that until recently this technology was not used because it was either not available, too expensive or inconvenient to implement, or simply too much trouble but these reasons to abjure use of the breath temperature sensor are no longer persuasive to us. We find this is a biological variable which can and should be controlled.

10. *Tolerances for the Two Breath Tests*

The two breath samples when tested must be within a certain tolerance of each other for the breath test to be considered reliable. There has been considerable confusion and dispute over the appropriate allowable tolerances between the two breath samples. If the two samples are not within the tolerance range a third test is forced to determine if the tolerance can be met and the tests are reliable.

The *Downie* tolerance standard was .01 but this was enlarged by Dr. Brettell in the NJ 3.8 version of firmware to .01 or 10% of the difference between the highest and lowest of the four readings (two EC and two IR), whichever is greater. NJ 3.8 was used in the Pennsauken pilot program which culminated in the *Foley* decision.

In his testimony before this court, Dr. Brettell confirmed that the written opinion in *Foley* mistakenly reported that he had testified that the NJ 3.8 software had a precision tolerance of .01 or plus or minus 10% of the mean of all four readings, whichever is greater. He testified before us that the NJ 3.8 formula was actually as described above, ".01 or 10% of the difference between highest and lowest of the four, whichever is greater."

Dr. Brettell then changed the formula for the NJ 3.11 firmware. He expanded the precision tolerance to "+/-.01 or +/—10%" of the mean of the four readings (two EC and two IR) whichever is greater. This doubled the allowable tolerance between readings from NJ 3.8 (10%) to NJ 3.11 (20%). With a mean of 0.20, for example, the allowable tolerance in NJ 3.11 is 0.04, while with NJ 3.8 it is 0.02 and under *Downie* only 0.01.

In testimony before us Dr. Brettell said that he now has reconsidered the tolerance formula and concluded that it should be reduced or "tightened up." We now recommend a tolerance of plus or minus .005 or plus or minus 5% (10% overall) of the mean of the four readings (two EC and two IR) whichever is greater. We consider this a reasonable tolerance range in all of the circumstances. Of course, only the lowest of the four readings will be admitted in evidence, if all are within this tolerance range.

We concur fully with Dr. Brettell that a tightened tolerance range is the best result to use for purposes of precision and accuracy, we hope without forcing unnecessary third tests. Use of the earlier formulas does not invalidate the test results rendered in those cases. They were not improper and inadmissible but our recent recommendation is simply a better, tighter range for precision and accuracy.

VI. THE END

This court finds that the Alcotest 7110, NJ 3.11 version is and has been scientifically reliable, under the clear and convincing evidence standard, when the test protocol is carefully followed by the operator and the instrument is functioning properly. This court is of the view that if our recommendations are followed any possible doubt on the accuracy of the instrument will be minimized.

Incorporation of the dual IR and EC technologies enhances analytical accuracy for alcohol (ethanol) and provides reassurance of a quality result. We are convinced that the Alcotest 7110 is the state-of-the-art technology available and if implemented with our suggestions will provide suspects and the general public the best possible assurance for the protection of individual rights and for public safety.

The recent motion filed on behalf of Draeger to appear as amicus is denied without prejudice, of course, to Draeger's right to make a prompt application to the Supreme Court for that relief.

* * * * *

We attach a bibliography, part recommended and part ancillary, which may be helpful in understanding this very technical subject. We also express our gratitude for the very valuable contribution by our Appellate Division Staff Attorney Olga Chesler, Esquire, for her excellent contribution to completing this difficult task both throughout the 41-day hearing and the opinion preparation process. Many thanks, Ms. Chesler.

APPENDIX A — TRANSCRIPTS

1T - transcript of September 18, 2006 (morning)

2T - transcript of September 18, 2006 (afternoon)

3T - transcript of September 19, 2006

4T - transcript of September 20, 2006 (morning)

5T - transcript of September 20, 2006 (afternoon)

6T - transcript of September 21, 2006 (morning)

7T - transcript of September 21, 2006 (afternoon)

8T - transcript of September 25, 2006 (morning)

9T - transcript of September 25, 2006 (afternoon)

10T - transcript of September 26, 2006 (morning)

11T - transcript of September 26, 2006 (afternoon)

12T - transcript of September 27, 2006 (morning)

13T - transcript of September 27, 2006 (afternoon)

14T - transcript of September 28, 2006 (morning)

15T - transcript of September 28, 2006 (afternoon)

16T - transcript of October 3, 2006

17T - transcript of October 4, 2006 (morning)

18T - transcript of October 4, 2006 (afternoon)

19T - transcript of October 5, 2006

20T - transcript of October 10, 2006 (morning)

21T - transcript of October 10, 2006 (afternoon)

22T - transcript of October 11, 2006 (morning)

23T - transcript of October 11, 2006 (afternoon)

24T - transcript of October 12, 2006 (morning)

25T - transcript of October 12, 2006 (afternoon)

26T - transcript of October 16, 2006 (morning)

27T - transcript of October 16, 2006 (afternoon)

28T - transcript of October 17, 2006 (morning)

29T - transcript of October 17, 2006 (afternoon)

30T - transcript of October 18, 2006 (morning)

31T - transcript of October 18, 2006 (afternoon)

32T - transcript of October 19, 2006 (morning)

33T - transcript of October 23, 2006 (morning)

34T - transcript of October 23, 2006 (afternoon)

35T - transcript of October 24, 2006 (morning)

36T - transcript of October 24, 2006 (afternoon)

37T - transcript of October 25, 2006 (morning)

38T - transcript of October 30, 2006 (morning)

39T - transcript of October 30, 2006 (afternoon)

40T - transcript of October 31, 2006 (morning)

41T - transcript of November 6, 2006 (morning)

42T - transcript of November 6, 2006 (afternoon)

43T - transcript of November 8, 2006 (morning)

44T - transcript of November 8, 2006 (afternoon)

45T - transcript of November 9, 2006 (morning)

46T - transcript of November 9, 2006 (afternoon)

47T - transcript of November 13, 2006 (morning)

48T - transcript of November 13, 2006 (afternoon)

49T - transcript of November 14, 2006 (morning)

50T - transcript of November 14, 2006 (afternoon)

51T - transcript of November 15, 2006

52T - transcript of November 27, 2006 (morning)

53T - transcript of November 27, 2006 (afternoon)

54T - transcript of November 28, 2006 (morning)

55T - transcript of November 28, 2006 (afternoon)

56T - transcript of December 4, 2006 (morning)

57T - transcript of December 4, 2006 (afternoon)

58T - transcript of December 5, 2006 (morning)

59T - transcript of December 5, 2006 (afternoon)

60T - transcript of December 11, 2006

61T - transcript of December 12, 2006

62T - transcript of December 14, 2006

63T - transcript of December 15, 2006 (morning)

64T - transcript of December 15, 2006 (afternoon)

65T - transcript of December 18, 2005 (morning)

66T - transcript of December 18, 2006 (afternoon)

67T - transcript of December 19, 2006

68T - transcript of January 9, 2007 (morning)

69T - transcript of January 9, 2007 (afternoon)

70T - transcript of January 10, 2007

Appendix D

APPENDIX B-1

RECOMMENDED BIBLIOGRAPHY

(*These are very helpful articles*)

1. Kurt M. Dubowski, *Absorption, Distribution and Elimination of Alcohol: Highway Safety Aspects*, 10 *J. of Studies on Alcohol* 98 (Supp. July 1985) [D235]

   General comments on difficulties with per se drunken driver laws.

2. Allan R. Gainsford, Dinusha M. Fernando, Rodney A. Lea, & Allan R. Stowell, *A Large-Scale Study of the Relationship Between Blood and Breath Alcohol Concentrations in New Zealand Drinking Drivers*, 51 *J. Forensic Sci*. 173 (2006) [C16]

   A very recent study and article brought to our attention. Although not placed into evidence, probably by inadvertence, the article was mentioned by several witnesses and is available in Judge King's chambers. The abstract describes the sample as "21,582 drivers apprehended by New Zealand police" over a period of fifteen years. *Id.* at 173. This article confirms that the breath test at the 2100 ratio gives a significant advantage over the blood test:

   > It has been noted that the use of the BAC/BrAC ratio of 2100, implicit in

> jurisdictions expressing BrAC in terms of g/210L, gives drivers an approximately "10% advantage" over drivers who give blood samples. In NZ this advantage is even greater. The ratio of the respective legal limits for blood and breath alcohol in NZ is 2000. Our data suggest that the average BAC/BrAC ratio measured in the field is 19-25% higher than this.

[*Id.* at 177.]

This 2006 article confirms our expressed view that the Alcotest 7110 as used in New Jersey provides a comfortable cushion for any margin of analytical or biological error, 10%. The conclusion fortifies our reluctance to recommend reduction of the ratio in New Jersey below 2100.

3. Rod G. Gullberg, *Breath Alcohol Measurement Variability Associated with Different Instrumentation and Protocols*, 131 *Forensic Sci. Int'l* 30, 34 (2003) [D23]

   Alcotest 7110 "yielded S.D. [standard deviation] and confidence interval estimates that were very acceptable forensically." Draeger out-performed Intoxilyzer, Datamaster and Intoximeter. *See* Figure 1, *id.* at 33; Figure 2 (using Alabama data), *id.* at 34.

4. R.G. Gullberg, *Common Legal Challenges and Responses in Forensic Breath Alcohol Determination*, 16 *Forensic Sci. Rev.* 92, 92 (July 2004) [D25]

   Discussion of issues arising in DWI addressed best by "prudent construction of administrative rules and employing forensically sound breath test protocol."

5. R.G. Gullberg, *Determining an Appropriate Standard for Duplicate Breath Test Agreement*, 39 *Can. Soc'y Forensic Sci. J.* 15 (2006) [AB11]

   On preference of plus or minus 5% of the mean for duplicate breath test agreement reference to probability of error detection. *See* Figure 4, *id.* at 21.

6. P. Harding, Ronald H. Laessig, & Patricia H. Field, *Field Performance of the Intoxilyzer 5000: A Comparison of Blood- and Breath-Alcohol Results in Wisconsin Drivers*, 35 *J. of Forensic Sci.* 1022, 1026 (Sept. 1990) [C1]

   Blood and breath both tested within one hour of each other for 395 pairs. Underestimated bias described:

   > Intoxilyzer 5000 results correlated well with blood alcohol concentrations, while demonstrating a low bias. The 11.5% overall systematic

> underestimation of BAC found in this study is consistent with the 11% low bias found when police officers operated Breathalyzer Models 900 and 900A under similar conditions[]. This bias appears to be primarily due to physiological variables and could be substantially reduced if the instruments were calibrated using a blood/breath alcohol ratio of 2300:1 instead of the currently used 2100:1. This is an unlikely, and perhaps undesirable option from a forensic science point of view, however.

See also Figure 3. *Ibid.*

7. B.T. Hodgson, & M.D. Taylor, *Evaluation of the Draeger Alcotest 7110 MKIII Dual C Evidential Breath Alcohol Analyzer*, 34 *Can. Soc'y Forensic Sci. J.* 95, 101 (2001) [C2]

> Overall, the [Alcotest 7110] MKIII Dual C met the ATC [Alcohol Test Committee] standards for Approved Instruments. Both the precision and accuracy of this instrument were well within the ATC standards for acceptance throughout the range of simulator alcohol concentrations tested. The human subject testing demonstrated confidence intervals well within the ATC criteria when compared to two Approved Instruments. The

MKIII Dual C is able to distinguish other potentially interfering substances from ethanol and able to detect ambient air contamination that might contribute to an apparent blood alcohol concentration.

The MKIII Dual C maintained its initial calibration throughout the evaluation, a period of approximately 5 months No mechanical or electrical problems were encountered and the instrument performed without breakdown.

. . . .

The volunteer drinkers are thanked for their participation and cooperation in this study.

8. Alan Wayne Jones & Lars Andersson, *Variability of the Blood/Breath Alcohol Ratio in Drinking Drivers*, 41 *J. Forensic Sci*. 916, 920 (1996) [D19]

Dr. Jones described the conclusion of tests on 799 individuals in Sweden, that those tested with breath alcohol methods enjoyed a 10% advantage compared to those tested with venous blood.

The introduction of evidential breath-alcohol analyzers in Europe has meant that prosecution for DUI can now be based on the person's BAC or BrAC depending on the sample taken. Under some circumstances, the option to provide a breath-alcohol test is not available, e.g., if a person is involved in an accident and needs treatment at a hospital, or when a breath analyzer is not available for use, or for various other reasons. This creates a dilemma for those close to a critical legal alcohol limit because of the roughly 10% advantage obtained by those who were tested on a breath-alcohol analyzer (Fig. 4) compared with analysis of venous blood. The consequences for the individual might be guilty or not guilty depending on whether a breath-alcohol or blood-alcohol test was used for forensic purposes.

9. L. Lindberg, S. Brauer, P. Wollmer, L. Goldberg, A.W. Jones, & S.G. Olsson, *Breath Alcohol Concentration Determined with a New Analyzer Using Free Exhalation Predicts Almost Precisely the Arterial Blood Alcohol Concentration*, *Forensic Sci. Int'l* (forthcoming 2006) [D18]

    Breath and blood tests in fifteen volunteers reflect very accurately the concentration of alcohol reaching the brain and supports the use of breath alcohol analysis for medical and legal purposes.

10. G. Schoknecht, G. & B. Stock, *The Technical Concept for Evidential Breath Testing in Germany*, *Institute for Biophysics*, Freie Universitat, Berlin, Germany http://www.druglibrary.org/schaffer/Misc/driving/s5p6.htm. (1995) [AB2]

German field test in 1993 using Draeger Alcotest 7110 produced this conclusion.

> Six instruments were passed to the police authorities at various locations in Germany for a field test starting in Sept. 93 and lasting for 15 months. Before the test the instruments were adjusted to 0.48mg/L at a liquid standard with an ethanol concentration of 1.21 g/L H2O held at 34°C. Calibration checks were performed regularly every six month. The instruments were mainly operated at police stations but two of them were also tested in mobile use for several weeks. More than 700 tests have been successfully performed during the testing period where for approx. 300 tests additional blood samples were taken. The comparison between the *b*lood *a*lcohol *c*oncentration (BAC) and the corresponding BrAC is shown in Fig. 3. No corrections have been made for the time delay (a few minutes up to two hours) between breath and blood alcohol analysis because in general it is not known whether the subject is in the absorption or desorption phase. Despite this fact, the data show a very good agreement

with a correlation coefficient of 0.98 and nearly all of the data points are within a

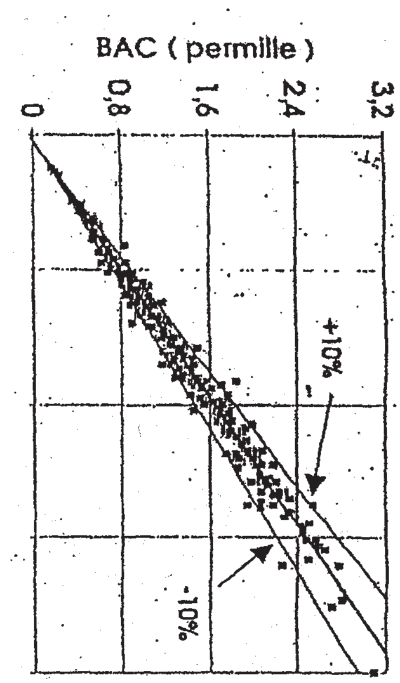

Fig.3: BrAC vs. their corresponding BAC values. The linear regression and the ± 10% range are indicated by the solid lines.

0 0.4 0.8 1.2 1.6

BrAC (mgL)

+/— 10% (rel.) distribution centered around the also plotted regression line. No outliers are observed. The regression line intercepts the BrAC axis at 0.02 mg/l which we attribute to an average time delay of 15 min. between BAC and BrAC analysis. From our data we calculate a BAC versus BrAC ratio of 2090. Where the ratio is only 1960 if breath temperature correction is not taken into account.

. . . .

In addition our data clearly point out in accordance with that breath temperature measurement improves the performance of breath alcohol analysis with respect to an equal treatment of the subjects. The data strongly support the OIML recommendation that breath temperature has to be taken into account for evidential roadside testing. But perhaps as the most important result the field trial revealed that the problem of BAC versus BrAC outliers has been overcome. Because of these outliers, which have been reported occasionally from pretest devices, breath alcohol analysis in general has been often blamed to be unreliable and not to meet the necessary requirements of evidential purposes for law enforcement in Germany.

11. M.D. Taylor & B.T. Hodgson, *Blood/Breath correlations: Intoxilyzer 5000C, Alcotest 7110, and Breathalyzer 900A Breath Alcohol Analyzers*, 28 *Can. Soc'y Forensic Sci. J.* 153, 153 (1995) [AB12]

In this recent study the Alcotest was compared to the Intoxilyzer and the Breathalyzer with these conclusions in the abstract:

> Two infrared (IR) breath alcohol analyzers, the Alcotest 7110 and the Intoxilyzer 5000C, were evaluated against blood results and against the Breathalyzer 900A currently used by Canadian police agencies. A total of 18 healthy human subjects were used for the breath to breath comparisons while 15 of those subjects each provided two blood samples approximately one hour apart for blood/breath correlations. The IR analyzers and the Breathalyzer showed a high degree of correlation with blood samples (n = 15: r = 0.974 for the Breathalyzer, r = 0.971 for the Intoxilyzer, and r = 0.989 for the Alcotest). All three instruments underestimated the blood results (mean differences, blood minus breath: 12 mg% for the Breathalyzer, 18 mg% for the Intoxilyzer, and 9 mg% for the Alcotest). In breath to breath comparisons the Intoxilyzer underestimated the Breathalyzer (n = 18, mean difference Breathalyzer minus Intoxilyzer = 4 mg%) while the Alcotest

> overestimated the Breathalyzer (n = 17, mean difference Breathalyzer minus Alcotest = -3 mg%).

See Figure 6, *id.* at 626. The linear regression analysis for the Alcotest 7110 was most impressive.

APPENDIX B-2

ANCILLARY BIBLIOGRAPHY

1. Joseph C. Anderson & Michael P. Hlastala, *Breath Tests and Airway Gas Exchange*, 20 *Pulmonary Pharmac. & Therapeutics* 112, 117 (2005) [D255]

   6. Conclusions

   Airway gas exchange significantly impacts the interpretation of breath tests, particularly for gases with a blood-air partition coefficient greater than 100. The absorption-desorption kinetics of airway gas exchange cause the end-exhaled gas concentration to be less than the blood value by up to 30%. Additionally, factors such as airway perfusion and diffusion that govern airway gas exchange are intrinsic to the lung and affected by lung disease. Other factors like inspired air temperature and breathing maneuver should be carefully controlled to ensure accurate and repeatable breath measurements.

2. William Giguiere & G. Simpson, *Medicolegal Alcohol Determination: In Vivo Blood/Breath as a Function of Time*, 27 *Int'l Assoc. Forensic Toxicol., Chemistry Centre*, 494 (V.J. McLinden & D.J. Honey eds., 1992) [D243]

   No summary is attempted.

3. Ulrich Heifer, *Breathalcohol-Concentration/ Bloodalcohol-Concentration: Utopia of a Forensically Usable Means of Evidence*, 23 *Alcohol, Drugs and Behavior* 229, 238 (July 1986) [D244]

This article is in German and is untranslated. In the English summary the author states:

Summary

> With the help of the results of 133 drinking tests with 1150 pairs of measurable values as well as with the help of experiments with animals we must answer in the negative to the question, asking for the physiological definite answer and the legal usefulness of the alcoholic concentration in blood indirectly found out by way of breathing. The area of the alveoli is an instable compartment for the distribution of ethanol, at least until an equilibrium is reached after reaching the maximum area of venous alcohol in blood.
>
> The handling of "Alcotest 7310" by the police causes a tendency "to filter" so-called unnecessary blood-tests of low concentrations. The lack of coordinating an alcoholic concentration in blood indirectly found out by way of breathing is demonstrated by the insufficient conformity of 1,000 pairs of measurable values (BAC [AT] and BAC [blood]), taken from the experiences gained by the police.

The author seems to conclude that breath testing is not reliable.

4. Michael P. Hlastala, *The Alcohol Breath Test — A Review*, 84 *J. Applied Physiology* 401, 406-07 (1998) [D254]

Authors reject the theory of the alcohol breath test (ABT) and call for a new wave of research to improve the accuracy of BrAC measurement.

Implications for the ABT

> For years, forensic scientists have struggled to explain the variability in BrAC. The problem followed directly from the tenaciously held belief that the last part of the exhaled BrAC was equal to the alveolar alcohol concentration. Recent experimental and theoretical studies dealing with the gas exchange of highly soluble gases have led to a new model for pulmonary alcohol exchange. This new model is based on the airway exchange of alcohol and can be used to explain the large observed variability in BrAC.
>
> The theory of the ABT is old and outdated. In principle, the ABT, as currently used, is based on the respiratory physiology of the 1940s and 1950s. The physiological understanding of pulmonary alcohol exchange has gone through a tremendous evolution in

the past 50 years, revealing that physiological variability has a great impact on the ABT. It is now clear that most of the variability is due to physiological parameters that may change from one ABT to the next. Recognition that alcohol exchanges in the airways, rather than the alveoli, opens up the ABT for a new wave of research to improve the accuracy of BrAC measurement.

5. Michael P. Hlastala, *Invited Editorial on "The Alcohol Breath Test"*, 93 *J. Applied Physiology* 405 (2002) [D261]

   No summary is attempted.

6. Michael P. Hlastala, Wayne Je Lamm, & James Nesci, *DWI*, *NACDL* 57 (2006) [D257]

   No summary is attempted.

7. Michael P. Hlastala, *The Impact of Breathing Pattern and Lung Size on the Alcohol Breath Test*, 35 *Annals of Biomed. Eng'g* 264, 272 (2006) [D256]

   In conclusion, alcohol exchanges between the respired air and the airway tissue during both inspiration and expiration. This airway gas exchange causes the exhaled alcohol concentration to always be less that the ACC [alveolar air concentration]. A consequence of this airway exchange is that BrAC depends on lung size and the amount of effort provided by the subject.

8. Dominick Labianca & G. Simpson, *Statistical Analysis of Blood- to Breath-Alcohol Ratio Data in the Logarithm-Transformed and Non-Transformed Modes*, 34 *Eur. J. Clinical Chem. Clinical Biochem.* 112 (1996) [D245]

   Authors assert results are consistent with a blood breath ratio of 2300:1.

9. Dominick A. Labianca, *The Flawed Nature of the Calibration Factor in Breath-Alcohol Analysis*, 79 *J. of Chem. Educ.* 1237 (2002) [D249]

   The author is very skeptical of current methods of breath testing as flawed.

10. G. Simpson, *Accuracy and Precision of Breath Alcohol Measurements for Subjects in the Absorptive State*, 33 *Clinical Chem.* 753, 756 (1987) [D252]

    The author is very skeptical of current methods and says:

    > But more importantly, if it is not known whether a subject is in the absorptive or postabsorptive state, then it is not possible to know how reliable the AAC [the BAC result from a quantitative evidential breath alcohol

analyzer (AAC = BrAC x 2100)] result is. Overestimates of actual BAC can be anywhere from 15% to more than 100%. Errors of this magnitude raise questions about satisfying legal criteria for due process.

. . . .

Too few data are available to establish statistical limits for the accuracy and precision of breath testing results in the absorptive state. However, results from data in the literature indicate that breath testing is not a reliable means of estimating a subject's BAC during absorption. The results also indicate that there is a significant likelihood that a given subject will be in the absorptive state when tested under field conditions. Because of large differences in arterial BAC and venous BAC during absorption, breath test results consistently overestimate the result that would be obtained from a blood test — by as much as 100% or more. In order to have some idea of the reliability of a given breath test result, it is essential to determine by some objective means whether the subject is in the absorptive or postabsorptive state. In the absence of such information, an appropriate value for the uncertainty associated with the absorptive state should be applied to all breath test results.

11. G. Simpson, *Accuracy and Precision of Breath-Alcohol Measurements for a Random Subject in the Postabsorptive State*, 33 *Clinical Chem.* 261 (1987) [D241]

    See #10 above.

12. G. Simpson, *Medicolegal Alcohol Determination: Widmark Revisited*, *Clinical Chem.* (1988) [D250]

    See #10 above.

13. G. Simpson, *Do Breath Tests Really Underestimate Blood Alcohol Concentration?*, 13 *J. of Analytical Toxicol.* 120 (1989) [D248]

    See #10 above.

14. G. Simpson, *Medicolegal Alcohol Determination: Comparison and Consequences of Breath and Blood Analysis*, 13 *J. of Analytical Toxicol.* 361 (1989) [D250]

    See #10 above.