Continuous Transdermal Alcohol Monitoring:
A Primer for Criminal Justice Professionals

TRAFFIC INJURY RESEARCH FOUNDATION
A DRIVING FORCE FOR SAFETY

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A Primer for Criminal Justice Professionals

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The mission of the Traffic Injury Research Foundation (TIRF) is to reduce traffic-related deaths and injuries. TIRF is an independent, charitable road safety institute. Since its inception in 1964, TIRF has become internationally recognized for its accomplishments in identifying the causes of road crashes and developing programs and policies to address them effectively.

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Executive Summary

Research

- Ensuring offender compliance with court orders of abstinence has been an elusive goal and a notoriously difficult condition to enforce using standard alcohol testing devices.
- New technology that permits continuous monitoring of alcohol consumption provides a means to overcome this problem.
- After more than 70 years of research and 22 peer-reviewed studies into the science underpinning this new technology, it has been clearly established that ingested alcohol can be validly measured in perspiration through the process of transdermal alcohol testing, i.e., testing of alcohol that is excreted through the skin.

- Research studies over the past 10 years have demonstrated that transdermal alcohol readings or results are correlated to blood alcohol concentrations. There is a recognized and measurable delay in the absorption and elimination of alcohol, so *simultaneous breath or blood and transdermal alcohol readings should not be expected to produce similar results at a specific point in time.*
- Transdermal alcohol testing is a valid way of determining whether an individual has consumed a small, moderate, or large amount of alcohol, and is designed to be used as a screening device to determine alcohol use. This testing method is not designed to produce a specific blood alcohol concentration (BAC) reading.
- Research studies conducted by the University of Colorado Health Science Center, the Michigan Department of Corrections, and Alaska Justice Statistical Analysis Center, involving testing with probation officers and offenders, conclude the SCRAM device is a valid and reliable way of testing for alcohol consumption and is a "fast-acting deterrent".
- While preliminary findings from these latter studies are promising, more research involving large scale quantitative surveys and case-control studies are needed to corroborate these initial findings.

Technology

- The SCRAM device is a passive, non-invasive tool that reliably and continuously monitors and measures alcohol consumption 24/7 for an extended period.
- The SCRAM device is a tamper- and water-resistant bracelet, containing an electrochemical sensor that is attached to the offender using a durable strap. The device captures transdermal alcohol readings from continuous samples of vaporous or insensible perspiration collected from the air above the skin.
- The SCRAM device has a number of anti-circumvention features including: a tamper clip or strap, obstruction sensor, temperature sensor, and communication monitoring to ensure that the bracelet is functioning normally and capturing and transmitting information related to the designated offender.
- The bracelet transmits testing information daily on a pre-determined schedule to a modem installed in the offender's residence or place of work using a radio-frequency (RF) signal. This information is encrypted and transferred via a standard analog phone line to a secure central website (SCRAMNET) managed by Alcohol Monitoring Systems (AMS).
- Criminal justice professionals can access SCRAMNET at their convenience, using a standard internet browser, to obtain a variety of progress reports specific to their caseload, and receive customized notifications of events and alerts.
- As with any alcohol testing device, some substances containing alcohol in sufficient quantities can act as an environmental interferant and produce a positive alcohol reading. AMS staff can generally distinguish between readings due to interferants and readings due to alcohol consumption (true alcohol readings) based on a comparison between the curve produced and the standard alcohol curve, and a comparison of absorption and elimination rates.

Program Applications

- Continuous transdermal alcohol monitoring is primarily intended to deter offenders from violating the terms of court-ordered abstinence through the constant monitoring of alcohol consumption and swift notification of violations.

- Criminologists and criminal justice practitioners are currently designing implementation guidelines to assist courts, probation, treatment, and correctional agencies with the use of SCRAM technology. These guidelines will emphasize accountability, streamlined practices and procedures, good communication and information exchange, and contain a structured evaluation that will assist agencies in developing evidence-based practices.
- Most challenges to the SCRAM device have occurred in evidentiary hearings in lower courts and resulted in unpublished opinions. SCRAM evidence and testimony have been ruled admissible in cases where AMS was permitted to provide evidentiary support, and SCRAM testimony has met the Frye standard of admissibility in Florida and Georgia and the Daubert standard in Louisiana. In general, the SCRAM technology has been and continues to be validated in bond and probation-revocation hearings.

- SCRAM technology is used to supervise a variety of offender populations including: impaired driving and domestic violence offenders, offenders actively tested for drugs, underage drinking offenders, adult offenders who supervise minors, and licensed, practicing professionals. Goals of implementation include: supervision of offenders and licensed professionals, and prison depopulation.
- SCRAM is relevant to a number of programs including: pre-trial, probation supervision, specialty courts, treatment, and re-entry and parole.
- Costs include an installation fee ($50.00-100.00) and daily monitoring fees ($10.00-12.00). This is less than the costs of incarceration and home arrest systems incorporating alcohol monitoring. Funding arrangements are generally offender-pay and often include some accommodation of indigent offenders.

Background

Almost all offenders convicted of impaired driving are ordered to abstain from consuming alcohol as a condition of sentencing or probation. Despite the variety of alcohol testing methods (e.g., blood, breath, urine) available to monitor compliance with this condition, compelling offenders to remain sober has been an elusive goal and a notoriously difficult condition to enforce.

Existing blood, breath, and urine testing protocols are used infrequently and are not consistently applied because of significant staffing, resource and cost implications. Recent findings from a national survey of 890 probation officers in 41 states revealed that officers spend less than 10% of their time engaged in random testing of offenders (Robertson and Simpson 2003). As such, the ability of officers to enforce this condition is limited, and, not surprisingly, offenders are able to engage in undetected drinking behavior.

In the past decade, alcohol testing technology has evolved, giving rise to a new generation of testing devices. To date, the most promising commercially available technology is Secure Continuous Remote Alcohol Monitoring (SCRAM). This device uses transdermal alcohol monitoring and allows for continuous monitoring of offenders 24 hours a day, seven days a week for the duration of the supervision period.

The rapid proliferation of these devices has created a need among criminal justice professionals for information about the research on continuous transdermal alcohol testing and monitoring, and its role in dealing with offenders. This document seeks to fulfill that need. It provides a comprehensive review of existing research on transdermal testing, describes current technologies, and identifies the various ways in which transdermal alcohol testing can enhance the supervision of substance abusing offenders, providing accurate assessments of alcohol use and compliance with court-ordered abstinence.

Research

Measuring alcohol consumption through perspiration

Since 1930, it has been well known and scientifically established that ingested alcohol diffuses throughout water in the body and is present in various bodily substances, including blood, breath, urine, and sweat (Swift 2000). Once alcohol has been ingested, most of it is metabolized in the liver, some is removed through exhaled air or breath, and some leaves the body unchanged in the urine. Only about 1% of ingested alcohol crosses the skin (Nyman and Palmlov 1936), either as sensible perspiration (sweat in the liquid phase) or insensible perspiration (constant, unnoticeable sweat in the vapor phase). This phenomenon, first studied and understood as early as 1936 (Nyman and Palmlov 1936), and later investigated in other studies (Brusilow and Gordes 1966; Pawan and Grice 1968; Johnson and Maibach 1971; Scheuplein 1978; Brown 1985a, 1985b), is known as t*ransdermal excretion of alcohol* or excretion through the skin.

Results obtained from the scientific research into measuring transdermal excretion of alcohol in the 1970s and early 1980s were also promising. It was concluded that the concentration of alcohol in the collected sweat rose with the amount of alcohol consumed and with the mean concentration of alcohol in the blood (Phillips 1980; Phillips and McAloon 1980; Phillips 1982; Phillips 1984a). Further research in the 1980s drew comparable conclusions, highlighting that the blood alcohol concentration at a specific point in time cannot be accurately estimated using sweat samples due to a time delay between absorption of alcohol in the blood and excretion through the skin (Brown 1985a, 1985b). Due to this time delay, it is recommended that transdermal alcohol testing be regarded primarily as a screening method for detecting and monitoring episodes of alcohol use (Brown 1985b; Giles et al. 1987), rather than for determining precise levels of alcohol in the body at specific points in time.

In the 1990s, when the most recent generation of test devices, the transdermal alcohol bracelet, became available, earlier findings regarding the accuracy of transdermal testing were again corroborated (e.g., Swift et al. 1992).

After more than 70 years of research and 22 independent, peer-reviewed studies, it has been established that ingested alcohol can be validly measured in perspiration through the process of transdermal alcohol testing. Research about the dynamics of *transdermal alcohol testing* is still ongoing (e.g., Swift 1993; Anderson and Hlastala 2006) and the dynamics of transdermal alcohol testing may vary both between subjects (Anderson and Hlastala 2006) and within subjects (Swift 1993). This means that some variation in repeated measures taken from a single subject can occur as the human body is not static, and that some variation in measurements from different subjects can occur, as no two people are alike. Such biological differences between and among individuals is not uncommon. For example, there are variations in blood partition ratios (used in blood alcohol testing) between individuals.

Studies over the past 10 years do conclude that transdermal alcohol concentrations reflect blood alcohol concentrations accurately, but with a measurable delay in absorption and elimination (Davidson et al. 1997; Swift 2003). *As such, simultaneous breath or blood and transdermal alcohol readings should not be expected to produce similar results at a specific point in time.*

“On average, the device shows discriminative validity as a semi-quantitative measure of alcohol consumption […]” (Sakai et al. 2006, p.26). This means that this technique is a valid way of determining whether someone has consumed a small, moderate, or large amount of alcohol and to gauge compliance with orders of abstinence.

Collection and testing of transdermal alcohol

Transdermal alcohol can be collected in the liquid phase (sensible perspiration) or the gaseous phase (insensible perspiration). Collection in the liquid phase may occur using a sweat patch (Phillips et al. 1977; 1978, 1995; Phillips 1984a, 1984b) or an alcohol band-aid (Roizman et al. 1990) applied to the skin to trap ethyl alcohol eliminated in perspiration. Collection in the gaseous phase can occur using a wide variety of techniques to capture an air sample directly above human skin (Brown 1985a; 1985b), or biological fluids (Giles et al. 1986; 1987).

Both liquid and gaseous perspiration samples can be analyzed or tested for ethyl alcohol using a variety of scientifically accepted techniques, including electrochemical sensors, colorimetric or integral, enzymatic, and chromatographic methods.

In the 1990s, technological advances led to the development of more sophisticated and practical methods of measuring transdermal alcohol by means of transdermal alcohol bracelets (Hawthorne and Wojcik 2006). These devices can be easily attached to an individual for extended periods and continuously collect insensible perspiration samples just above the skin. These samples are analyzed by an electrochemical sensor in the bracelet to estimate the concentration of alcohol in the body, and, thereby, provide an indication of alcohol use.

Comparing alcohol test results

Results from transdermal alcohol testing can be compared to the results of other alcohol tests such as blood or breath. While alcohol pharmacokinetics (the manner in which alcohol is metabolized in the body) in humans may be complex, the principle of transdermal testing is easily understood and not different from the principles that govern breath testing.

There is a general consensus that blood analysis is the "gold standard" because it provides the most reliable measure of blood alcohol concentration (BAC) and because behavioral impairment is most strongly correlated with the level of alcohol in blood (Verstraete and Puddu 2000).

Breath alcohol concentration (BrAC) measurements are accepted as surrogate blood alcohol measurements because of the scientifically established correlation between the concentration of alcohol in blood and in breath. This proven correlation has permitted the use of breath as a reliable estimate of blood alcohol concentrations by the police, courts, and probation since the 1970s (Swift 2003).

Transdermal alcohol testing relies on the same principle. Since alcohol is excreted unchanged wherever water is removed from the body (breath, urine, perspiration, and saliva), there also exists a correlation between the alcohol concentration in perspiration (i.e., transdermal alcohol concentration or TAC) and the alcohol concentration in the bloodstream (e.g., Davidson et al. 1997; Buono 1999).

It has been established that individual transdermal alcohol readings cannot be considered equivalent to blood alcohol concentrations. The main difference between blood or breath alcohol testing and transdermal alcohol testing is a time delay in the absorption, peak, and elimination of alcohol that occurs with transdermal testing. As noted previously, *simultaneous breath or blood and transdermal alcohol readings should not be expected to produce similar results at a specific time* (see Appendix II).

However, rather than using this method to quantitatively estimate precise alcohol levels, research shows that transdermal alcohol testing may be validly used as a method to qualitatively identify drinking episodes (Sakai et al. 2006).

Comparing alcohol test protocols

Transdermal testing compares favorably with other test protocols. Table 1 summarizes the advantages and disadvantages of testing blood, breath, and sweat, and their monitoring protocols (random vs continuous). Blood and breath testing are invasive and require active participation by the offender. Conversely, the transdermal collection of sweat is both non-invasive and passive - offenders are not actively involved in delivering a sample; nor are officers involved to collect the sample.

Blood and breath testing have a higher cost per test whereas transdermal alcohol testing has a lower cost per test -- the ease of transdermal alcohol testing enables more tests in a given time period for the same cost. For example, instead of one test per week with a probation officer or physician, or instead of several breath tests per day at home with an electronic test protocol, transdermal testing can occur every hour throughout the day, at any location. Although breath testing can be used as a random protocol (e.g., multiple times daily, weekly), a high frequency of testing rarely occurs due to associated staffing and resource costs. Conversely, transdermal monitoring of sweat is a continuous protocol, making it very difficult for the offender to avoid detection for non-compliance.

Finally, while each of the test protocols described has the power to discriminate between the consumption of small, moderate, and large quantities of alcohol and gauge alcohol use, only blood and breath testing provide a precise alcohol concentration at a specific point in time.

Table 1: Comparison of test protocols for different substances

	Blood (BAC)	Breath (BrAC)	Sweat (TAC)
Level of intervention	invasive/active	invasive/active	non-invasive/passive
Cost per test	high	medium/low	low
Number of tests	low	medium/low	high
Frequency of testing	intermittant	daily/weekly	hourly
Automated	no	no/yes (EAM)*	yes
Remote testing	no	at offender's home	anywhere
Continuous monitoring	no	no	yes
Discriminative power	yes	yes	yes
Measure	quantitative	quantitative	semi-quantitative/ qualitative

*Electronic Alcohol Monitoring

Another technology worth mentioning is the actigraphy-based substance abuse screening. Research demonstrates that alcohol consumption disrupts sleep (Dement 2000; Brower and Kirk 2001). Once baseline measures of normal sleep have been collected, sleep patterns are monitored using actigraphy for evidence of possible intoxication episodes. However, this approach is less than continuous because testing only occurs when sleep patterns occur and because possible intoxication episodes have to be confirmed using a corroborating source of evidence or, more precisely, biomarkers collected from the offender's blood or urine (e.g., ethylglucuronide or EtG). The advantages of the continuous monitoring element (the continuously monitored sleep disruptions) may be compromised by the disadvantages of the non-continuous monitoring element (taking of blood or urine samples at predetermined points in time).

Conclusions from the scientific research

As discussed previously, the scientific conclusions regarding transdermal alcohol testing in general are:

- Ingested alcohol can be validly measured in perspiration through the process of transdermal alcohol testing.
- TACs reflect BACs accurately and reliably, but with a measurable delay in absorption and elimination (see Appendix II). TAC readings can distinguish qualitatively between consumption of small, moderate or large amounts of alcohol; however, they are not intended to provide precise, quantitative estimates of alcohol consumption similar to evidential tests.
- The current validity and the level of accuracy of transdermal alcohol testing permit it to be used as a screening tool to verify compliance with orders of abstinence.

Effectiveness of transdermal bracelets

The following paragraphs provide a brief summary of the scientific research into transdermal alcohol testing using transdermal alcohol monitoring bracelets.

a) WrisTAS

The first prototype of the Transdermal Alcohol Sensor/Recorder (TAS), developed by Giner, Inc., was tested in the 1990s (Swift et al. 1992). It is a wearable device that senses ethanol vapor at the surface of the skin, using an electrochemical cell that produces a continuous current signal proportional to ethanol concentration. It served as a precursor for WrisTAS, the bracelet version of TAS, worn on the wrist.

The scientific evaluation results for TAS show that the transdermal sensor utilized by this product closely followed the pattern of the blood alcohol concentration curve, but with a time delay (Davidson et al. 1997; Swift et al. 1992; Swift 1993; Swift 2000). These promising results lead to the development of the bracelet version, which is not yet commercially available. It has been clinically tested, but is not currently designed for real-world settings. To date, it cannot withstand water submersion, is not resistant to tamper or circumvention attempts, and has no automated data collection or reporting capability.

b) Secure Continuous Remote Alcohol Monitoring (SCRAM)

The SCRAM device became commercially available in 2003 and, to date, it is the only available continuous transdermal alcohol monitoring bracelet on the market. The University of Colorado Health Science Center, under funding from the National Institute on Drug Abuse (NIDA), the National Institute of Mental Health (NIMH), and Alcohol Monitoring Systems, Inc. (AMS), conducted a scientific evaluation of the SCRAM device (Sakai et al. 2006). A total of 44 subjects participated in this study and wore the SCRAM anklet. This study corroborated the validity of transdermal alcohol testing as a screening method. On average, the device showed discriminative power to distinguish between sobriety and drinking and appeared to be comfortable for most users. Individual readings, however, often were not equivalent to simultaneous breath alcohol concentrations due to the recognized delay alcohol experiences when migrating through the skin.

An evaluation study by the National Highway Traffic Safety Administration (NHTSA) to obtain laboratory data on the precision and accuracy of transdermal alcohol devices (including SCRAM and WrisTAS described above) is being conducted. Results were not available at the time this 'primer' was published.

In addition to the experimental studies in laboratories discussed in previous sections, some promising results are available from a BETA test of the SCRAM System, carried out by the Michigan Department of Corrections (Bock 2003). Michigan officers and a select number of offenders wore the SCRAM Bracelet for a period of several weeks. Results from the BETA test indicate that "the product is able to detect circumvention of alcohol test sampling, reliably ensures that test samples are from the intended test subjects, and detects drinking episodes around the clock regardless of a subject's schedule or location" (Bock 2003, p.4). The Michigan Department of Corrections concluded that, overall, officers genuinely felt the SCRAM technology "has significant merit, is easy to use and has benefits over other monitoring equipment on the market" (Bock 2003, p.6). Response from offenders was very positive as well -- they reported that the system was "a fast-acting deterrent and a preferred method of testing because of the freedom to maintain work and family schedules" (Bock 2003, p.6).

A small pilot project in Alaska, proposed as a National Law Enforcement and Corrections Technology Center-Northwest (NLECTC-NW) project, and conducted by the Alaska Justice Statistical Analysis Center as an alternative approach to chronic alcohol abuse, turned into a full implementation with 176 participants in the first half of 2005. Overall, 319 clients conducted about 453,000 tests in 2003-2005 during a total of 18,787 monitored days. There were 408 confirmed alerts and the compliance rate with the orders of abstinence was 56%. Interviews conducted with the involved agencies and probation officers confirmed no failures of the equipment, even in extreme cold and other inclement conditions (McKelvie 2005).

In summary, findings from these initial studies conclude that SCRAM is a valid and reliable way of testing clients for alcohol use. It is not designed to provide a precise measure of an offender's alcohol concentration at a specific point in time, but it is a valid and reliable method to determine compliance with court-ordered abstinence.

Caveats to the research on transdermal alcohol testing

The technology that is available today has been developed with the sole purpose to use it as a *qualitative* screening device, i.e., to verify whether an offender is compliant with orders of abstinence and to estimate alcohol use. It is not intended to provide a precise, quantitative alcohol concentration or BAC result. If there would be a demand to use this technology as a quantitative screening device to provide a precise estimation of alcohol use, more *laboratory* and *clinical* research findings are needed to provide further insight into pharmacological differences between and within individuals.

The results from the University of Colorado study (Sakai et al. 2006), the BETA test on SCRAM from the Michigan Department of Corrections (Bock 2003) and the NLECTC-NW project (McKelvie 2005) are positive and encouraging. *Additional large scale, quantitative surveys and case-control studies should be conducted to corroborate these initial findings*. Agencies that have fully implemented the SCRAM device should undergo process and impact evaluations to answer questions regarding other issues, such as the extent of behavior modification, compliance rates, tampering, length of time required to moderate alcohol consumption, and influence on recidivism in the real world.

Technology

The SCRAM System

To date, only one continuous transdermal alcohol monitoring system (SCRAM) has been fully implemented and designed to withstand real-life circumstances. As such, this document mainly focuses on the SCRAM System.

The SCRAM System is a passive, non-invasive tool that reliably and continuously monitors and measures alcohol consumption 24 hours a day, 7 days a week for an extended period. It is based on transdermal alcohol detection and measures alcohol excreted through the skin in the form of constant, unnoticeable perspiration.

SCRAM Bracelet or Anklet. This tamper- and water-resistant bracelet or anklet contains an analog and a digital component that are attached to the offender using a durable strap (a custom engineered polypropylene blend). The strap houses electronic circuitry that allows the analog and digital sides to communicate.

The analog component is an electrochemical alcohol sensor -- the same sensor that is generally approved by the courts and found in some evidential breath testing devices, preliminary breath testing devices, and passive sensors. This sensor must be calibrated annually, according to the Draeger manufacturer. In most instances, the device is calibrated every 3-6 months when the bracelet is returned for regular servicing. This internal detector draws a sample of insensible perspiration every half hour from the air above an offender's skin into a chamber containing an electrochemical alcohol sensor. The sample is analyzed and measured for ethyl alcohol.

The digital component contains a flash memory chip to store alcohol readings, a circumvention detection device to monitor body temperature and detect tampers, and uplink features that can transfer these readings, via a wireless radio frequency (RF) signal, to the SCRAM Modem (RF signals are also used in most electronic monitoring equipment). At scheduled times set by the court or probation agency, the anklet will transfer these data to the modem.

Figure 1: The SCRAM Bracelet

SCRAM Modem. This standard modem requires access to a conventional phone line within the offender's residence or at work and can be easily connected. It communicates with the bracelet using RF signals, similar to home monitoring equipment. Once daily, or up to six times daily at a predetermined time, the bracelet sends its data to the modem. The offender must be within 30 feet of the modem for data transmission to occur. In addition to receiving the test data, the modem can also download monitoring protocols and reporting schedules to the SCRAM Bracelet.

Figure 2: The SCRAM modem and the SCRAM bracelet

SCRAM Internet Website (SCRAMNET). Alcohol Monitoring Systems, Inc. (AMS) manages a web-based application (SCRAMNET) that receives encrypted data (alcohol tests, tamper/circumvention attempts, servicing information) from the modem of every offender and stores it in a secured database. These data sets are reviewed and analyzed by trained and certified AMS staff[1], and any events (positive alcohol readings, tampers, malfunctions) are confirmed through data interpretation and analysis using conservative, well-defined criteria, and subsequently forwarded to court or probation staff. Authorized users can also easily login to access information about their respective caseload from any location using an Internet-accessible computer with a standard web browser. Agencies do not require software or information technology (IT) support to use this secure site.

1 Typically, AMS staff go through an intensive level of product training of up to 40 hours. Subsequently, staff will be mentored and trained for 3-6 months by senior monitoring personnel before alerts can be confirmed independently.

Judges, probation officers, or treatment professionals can access SCRAMNET at their convenience to customize the supervision of individual offenders. They can also receive automatic notifications of confirmed events and a variety of customized reports of compliance/non-compliance for every offender, caseload, and agency upon request.

Alcohol positive readings

The reliance of transdermal alcohol testing on an electrochemical sensor ensures that false positive readings due to organic hydrocarbon solvents or contaminants do not occur. Moreover, because it measures alcohol through the skin, this technology will not produce false positive readings due to the presence of mouth alcohol.

Some foods (e.g., chocolate donuts, certain types of breads) can produce endogenous (internally produced) alcohol. This alcohol is unlikely to be produced in sufficient quantities to result in a positive reading on a transdermal alcohol measuring device. For example, an article published in the Journal of Analytical Toxicology reported that an individual would be required to consume 3 lbs of bread to reach a BAC equivalent to that of a single 12 oz beer with 4% alcohol. As such, "the likelihood of anyone testing positive for alcohol from cooked bread consumption, let alone becoming intoxicated, is therefore remote" (Logan and Distefano 1998, p. 183). Similarly, certain medical conditions, such as diabetes, can also result in the internal production of alcohol. Individuals with diabetes are prone to vascular diseases in the extremities and are potentially at greater risk of discomfort and potential adverse side effects as a result of wearing the SCRAM bracelet. At this time, it is recommended that individuals with diabetes not use SCRAM.

There are many substances containing alcohol (e.g., perfume, hand sanitizers) that can act as environmental interferants and produce a positive alcohol reading. More research is needed to further measure the absorption and elimination rates exhibited by these interfering substances and the alcohol curves that are produced.

As a preventive measure, offenders are instructed to avoid such substances and provided with a list of common product interferants. However, when offenders do come into contact with interfering substances, the alcohol curve that is generated assists trained AMS staff in identifying the source of the alcohol. Positive alcohol curves that are generated by interferants are often clearly distinguished from true positive alcohol curves that occur due to consumption, based on differences in absorption and burnoff rates.

A true alcohol reading that results from consumption often occurs over a longer period and is more gradual (see Figure 3); a positive reading due to an interferant may be much shorter and steeper, especially in the absorption phase (see Figure 4). Hence, while environmental interferants result in positive alcohol readings, these positive readings are generally not falsely identified as occurring due to alcohol consumption, and do not result in a confirmed alert to supervising agencies. Supervising agencies are only notified of confirmed, true alcohol readings, although records of all alcohol readings are retained by and available from AMS.

Figure 3: Standard BAC absorption and elimination curve

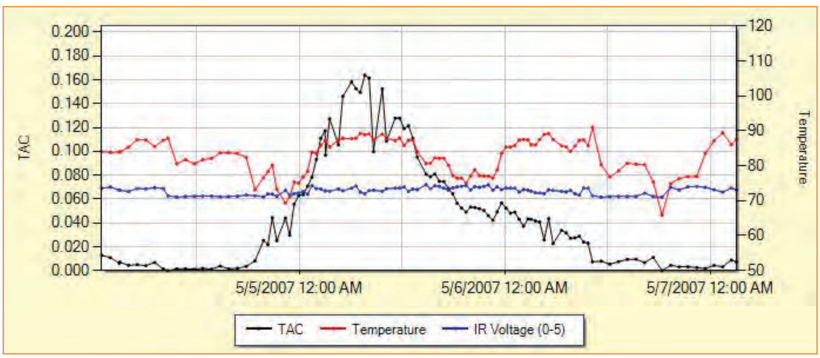
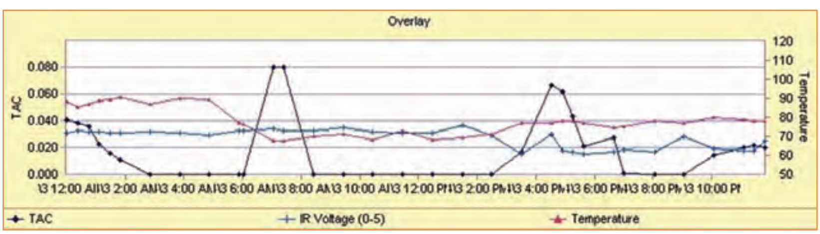


Figure 4: Interferant absorption and elimination curve



Anti-circumvention features

SCRAM has incorporated a number of anti-circumvention features to ensure that alcohol readings are accurate, that they are from the proper offender, and that they are transmitted to SCRAMNET.

Tamper clip or strap. The SCRAM device is attached to the offender by the service provider or court/probation agency using a special clip. Damaging, removing, or destroying the clip or strap once it is in place triggers anti-circumvention features.

Obstruction sensor. The obstruction sensor is an infra red (IR) sensor that measures the reflective intensity of an IR beam between the analog component of the bracelet and the offender's leg. It ensures the bracelet is continuously worn by the offender, and detects materials inserted between the bracelet and the leg through comparison with baseline IR readings taken when the device is first attached. Substantial changes in IR readings generate a potential tamper alert. Moreover, AMS staff can typically classify materials used to block the device (e.g., socks, plastic, bed sheets, etc.).

Temperature sensor. The temperature of the surrounding atmosphere of the offender's leg is also measured and compared to baseline readings taken at the time the bracelet is attached. A potential removal alert will be generated if a significant drop in temperature (suggesting removal of the device) combined with a significant change in IR readings occur for a period of time. In addition, the temperature sensor has been successfully tested under extreme weather conditions, such as those found in Alaska.

Communication monitoring. Communication between the bracelet and the modem and between the modem and the network is scheduled to occur at least once every 24 hours. A critical communication alert is generated and sent to the supervising officer if an offender misses a scheduled communication time, and has not uploaded the bracelet information for over 48 hours.

Program Applications

Offenders

Many substance abusing offenders are monitored using transdermal technology:

- first and repeat impaired driving offenders;
- domestic violence offenders where alcohol is identified as a contributing factor;
- illicit drug offenders who often return to alcohol when they are being actively tested for illicit drugs;
- underage drinking offenders who demonstrate reckless behavior;
- adults with a substance abuse issue who are responsible for the supervision of minors; and,
- licensed, practicing professionals with substance abuse issues.

Programs using transdermal alcohol monitoring technology

Agencies may incorporate continuous transdermal alcohol monitoring into a variety of supervision programs to accomplish one of three possible objectives:

- **Offender supervision** - monitoring offender drinking behavior and tailoring supervision through adjustments in testing and reporting schedules.
- **Prison/jail depopulation** - releasing incarcerated offenders while providing constant supervision and monitoring of drinking behavior.
- **Supervision of licensed professionals** - allowing licensed professionals with an alcohol problem to continue practicing without jeopardizing client safety.

Programs that can benefit from continuous transdermal alcohol monitoring include:

- **Pre-trial programs** - Continuous transdermal alcohol monitoring is a risk assessment tool that can provide clear indications of an offender's drinking behavior and guidance on sentencing issues based on objective evidence.

- **Probation supervision programs** - Supervision of specialized or mixed offender caseloads can benefit from tailored testing and reporting schedules (e.g., daily vs. weekly) and accommodate different levels of supervision as needed. Moreover, this tool can assist probation officers with identifying high-risk probationers through the regular reporting of non-compliance, attempted circumvention, and tampers, which would otherwise remain undetected.
- **Specialty court programs** - Offenders in these court settings may be higher-risk offenders with a serious substance abuse issue or may have custody of minor children. Continuous monitoring can reduce risk, act as an incentive for compliance, and provide an assessment of progress in treatment.
- **Treatment programs** - Continuous transdermal alcohol monitoring can provide an accurate and objective assessment of an offender's compliance with, and progress in, a treatment setting and allow professionals to tailor conditions based on progress. It can also promote rapid intervention when violations occur.

- **Re-entry, parole, or prison de-population programs** - Continuous monitoring of offenders for alcohol consumption can assist officers in identifying low-risk offenders, and ensuring that supervision conditions are tailored according to the level of risk an offender poses. It also allows officers to devote their attention to those offenders posing the highest-risk and requiring the greatest supervision.

Principles of sentencing

Continuous transdermal alcohol monitoring is primarily intended to deter offenders from violating the terms of court-ordered abstinence through the constant monitoring of alcohol consumption. *When non-compliance and drinking events are detected, agencies are promptly notified to allow for a swift and certain response -- i.e., specific deterrence. This facilitates proper action to prevent continued or future drinking events*. In turn, this assists with the rehabilitative process by providing constant monitoring of alcohol consumption. This gives courts and treatment agencies an assessment of compliance with, and progress in, treatment, as opposed to being forced to rely on self-reports from the offender.

Although continuous transdermal alcohol monitoring devices possess no inherent rehabilitative benefits, they have the potential to complement and facilitate behavior change by providing a continuous, independent assessment of compliance with, and progress in, a treatment program. These devices create opportunities for officers and treatment professionals to confirm instances of offender compliance and use positive reinforcement to encourage the desired changes in behavior, as well as to take action in instances when offenders demonstrate non-compliance. Probation officers report that it can be as important to "catch offenders doing things right" to encourage change as it is to "catch them doing things wrong."

There are also punitive qualities associated with continuous transdermal alcohol monitoring. In addition to inconvenience and financial costs, it provides a constant deterrent and reminder to offenders of the problem behavior that needs correction. However, it still permits offenders to remain employed, fulfill family obligations and responsibilities, maintain ties and support within the community, and participate in treatment.

Evidence-based practices

Criminologists and criminal justice practitioners are currently designing guidelines to assist courts, probation, treatment, and correctional agencies with the implementation of SCRAM devices. This set of guidelines will assist agencies in identifying critical steps in the implementation process and create a comprehensive supervision system that is compatible with existing practices. The guidelines will emphasize accountability, streamlined practices and procedures, and good communication and information exchange.

These guidelines will be continually refined and improved through an agency process evaluation that allows administrators and line staff to provide feedback to researchers. This serves to inform and improve the implementation of SCRAM, and ensure that the system meets the needs of criminal justice professionals. Agencies will also be provided with a framework that allows them to conduct their own independent impact evaluation. This evaluation can determine the effectiveness of the SCRAM System, and its impact on the agency's ability to supervise offenders in terms of the quality of supervision, the level of compliance, costs associated with the program, and any savings that have accrued. Such information is critical to allow agencies to make informed and objective decisions about the value of continuous transdermal alcohol monitoring to their respective programs.

Legal challenges

As with any new science or technology that is introduced in the criminal justice system, legal challenges are common. For example, despite the proven reliability of alcohol breath-testing instruments, these devices continue to be challenged in court. Both the science associated with transdermal alcohol testing as well as the technology of the SCRAM System have been challenged on multiple occasions in numerous jurisdictions. These challenges have been considered in evidentiary hearings in lower courts and have generated unpublished opinions (see Appendix III for a list of case law citations).

In general, the large majority of these decisions have been supportive of the science of transdermal testing as well as the technology of the SCRAM device. The SCRAM technology has been and continues to be validated in both bond and probation-revocation hearings across the U.S. Testimony about SCRAM has met the Frye standard of admissibility in both Florida and Georgia and the Daubert standard in Louisiana. Evidence and testimony regarding SCRAM have been ruled admissible in all of the cases where AMS was permitted to provide evidentiary support. Of some interest, AMS is currently developing a program that would allow probation officers to become certified in providing expert testimony about the SCRAM data in court hearings.

As of December 2007, there have been 49 evidentiary hearings involving offenders denying confirmed violations of the SCRAM System. AMS expert witnesses provided direct testimony for the prosecution when permitted. In each case involving AMS evidentiary support, SCRAM evidence and testimony were ruled admissible. In summary, there have been a total of 49 evidentiary hearings. Of these, 1 case was dismissed, 4 rulings are still pending, 39 rulings have supported the technology and 5 rulings have been against the technology -- although in 2 of these cases the defendant was ordered to remain on the device.

Length of monitoring period

The length of the monitoring period can vary according to the needs of the offender. Shorter periods in a pre-trial situation can provide the judge with information pertinent to sentencing. Longer periods are appropriate in a post-conviction supervision program depending on the ability of the offender to refrain from consuming alcohol. A performance-based approach is strongly recommended when applying the technology, as opposed to imposing a standard statutory period regardless of the offender's level of compliance. Agencies should tailor the length of the monitoring period based on risk/needs assessments, substance abuse assessments, and other pertinent factors. Agencies can reward good behavior by reducing the period of monitoring and respond to non-compliance by extending the period of monitoring. AMS typically recommends a minimum period of 90 days based on research on deficits in executive cognitive functioning following alcohol use (Zinn et al. 2004).

Costs

This technology relies on an offender-pay arrangement in which offenders bear the costs associated with the use of the technology. This scheme is consistent with the use of other technologies such as electronic monitoring and breath alcohol ignition interlocks. Such costs are frequently justified on the basis that offenders are able to afford alcohol, and the direct public safety benefits that occur when offenders refrain from alcohol consumption.

Indigent funding arrangements can be organized in cooperation with the vendor and should be encouraged. To date, different programs have been very creative in how they obtain additional funding and defer costs to offenders. Also, it should not be forgotten that offenders are able to afford the costs to purchase alcohol.

Some courts, depending on funding arrangements, may be willing to consider reducing or partially vacating fines in lieu of offenders accepting the SCRAM technology and demonstrating compliance with court orders. Due to the myriad of financial obligations already levied on offenders, courts are encouraged to be strategic in ordering fines and fees. It is noted that many states have mandated what costs and fines courts must include in sentencing, leaving courts few alternatives.

In general, fines and fees collected by a collection agency are more likely to be collected. In the case of continuous alcohol monitoring, SCRAM service providers are responsible for fee collection and generally report a high rate of collection. A survey of 890 probation officers in 41 states found that an estimated 42% of impaired driving probationers currently fail to pay fines and fees (Robertson and Simpson 2003). Collection by the service provider has benefits in that it allows courts and probation agencies to reduce costs associated with the collection process.

For a system like SCRAM, the offender may pay an initial installation fee averaging $50- 100, and a daily monitoring fee averaging $10-12/day. It should be noted that offender fees vary by court, service provider, and the offender's ability to pay. Additional costs may be incurred by some offenders not equipped with a conventional phone line or in case they willingly damaged or did not return the equipment. Over time, fees can also be reduced with high compliance rates and graduated programs.

By comparison, a home arrest system, incorporating an alcohol testing component, has an average installation fee of $150 and a daily cost of $10-15 per day (Barrasse 2005; BI Incorporated 2006). The average daily cost of incarceration in a state or federal prison is about $62 per day (Stephen, 2004). These costs should be weighed in relation to the value that offenders and communities derive from regular supervision and sobriety.

Conclusions

Research on transdermal testing for alcohol has been ongoing since the 1930s. Today, research findings continue to be accumulated and researchers are confident that transdermal alcohol testing can provide valid and reliable estimates of alcohol consumption, allowing supervision professionals to discriminate between consumption of small, moderate, and large amounts of alcohol, and gauge compliance with orders of abstinence.

Technological advances in the 1990s and the development of transdermal alcohol bracelets using electrochemical sensors have made the continuous testing of insensible perspiration for alcohol a reality. Today, offenders can be monitored 24 hours a day, 7 days a week to gauge their compliance with court-ordered abstinence. The transdermal bracelet is a unique tool that provides justice professionals with objective measures of alcohol consumption and evidence of compliance, allowing probation officers to tailor supervision to the needs of the individual.

To date, the research findings about transdermal alcohol testing bracelets are promising and encouraging. More research in the form of large-scale quantitative surveys and case-control studies is needed to further confirm and extend these initial findings and agencies should consider incorporating an evaluation component when implementing this technology.

This tool can be applied in a range of settings, including pre-trial, post-conviction, treatment, re-entry, and professional settings. It serves a valuable risk-assessment function that allows judges, probation officers, and treatment professionals to measure an offender's compliance with court-ordered abstinence, and can provide insight into an individual's potential to re-offend and the threat posed to public safety. Of considerable interest, the information collected by this device permits officers to reward compliance and good behavior by reducing restrictions or the level of monitoring, providing an incentive to offenders to remain compliant.

It can also provide guidance to officers and administrators regarding the allocation of limited resources - ensuring that only those offenders who require closer scrutiny or more intensive supervision receive it. Furthermore, it permits probation officers to place a greater emphasis on community integration and rehabilitation, allowing offenders to remain employed and maintain close relationships with family and positive role models.

Many states have already moved to implement SCRAM. Guidelines are essential to ensure that this technology is implemented in a consistent manner that will minimize loopholes in supervision, and allow the technology to reach its full potential and provide the greatest benefit to agencies. These evidence-based guidelines can inform the decision-making process and ensure that agencies receive solid evidence supporting their use of the technology.

**Guidelines for criminologists and criminal justice practitioners were presented in a subsequent document released in the fall of 2007.*

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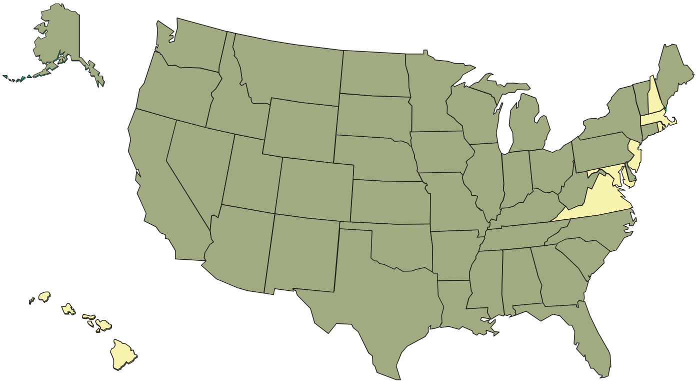
Appendix I: States using SCRAM

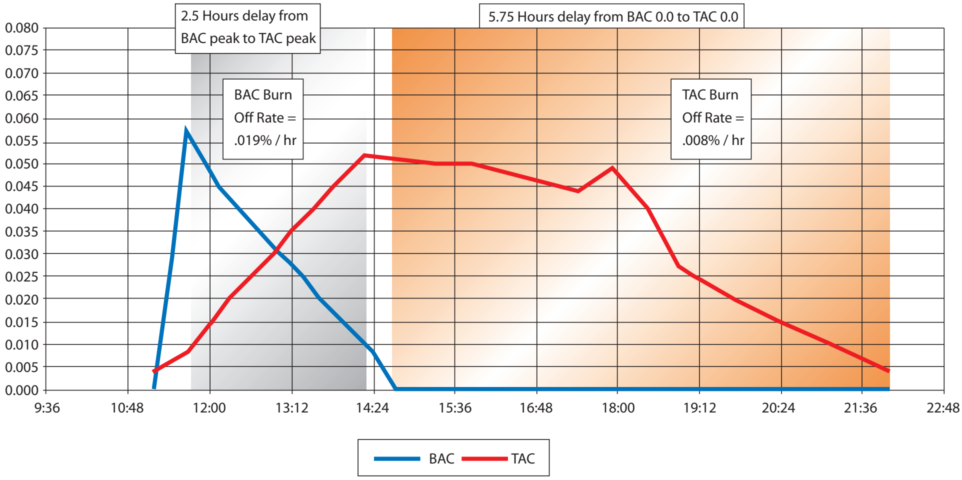
States listed below and shown in green on the map are using SCRAM.
(As of September 2006)



Alabama	**Georgia**	**Maryland**	**New York**	**Tennessee**
Alaska	**Idaho**	**Michigan**	**North Carolina**	**Texas**
Arizona	**Illinois**	**Minnesota**	**North Dakota**	**Utah**
Arkansas	**Indiana**	**Mississippi**	**Ohio**	**Vermont**
California	**Iowa**	**Missouri**	**Oklahoma**	**Washington**
Colorado	**Kansas**	**Montana**	**Oregon**	**West Virginia**
Connecticut	**Kentucky**	**Nebraska**	**Pennsylvania**	**Wisconsin**
Delaware	**Louisiana**	**Nevada**	**South Carolina**	**Wyoming**
Florida	**Maine**	**New Mexico**	**South Dakota**	

Appendix II: Time delay between breath and transdermal test readings

Readings taken from a 180lb male dosed to a .06% BAC.



Appendix III: Case law citations

	Court	Date	Jurisdiction	Case #
1	22nd Circuit Court	5/7/2003	Michigan	01-1909-FH
2	58th District Court	2/20/2004	Michigan	03-16029-SD
3	47th District Court	4/22/2004	Michigan	03C412666
4	29th District Court of Common Pleas	8/15/2004	Pennsylvania	211303
5	Kotzebue, Alaska Municipal Court	4/16/2004	Alaska	2KB-04-147CR
6	Cobb County Drug Court	Apr-04	Georgia	04-9-0975
7	Anchorage Superior Court	10/6/2004	Alaska	3AN-S04-4652
8	3rd Judicial District Court	12/3/2004	Utah	55100007
9	Superior Court, Maricopa County	12/13/2004	Arizona	CR2002-020361
10	Superior Court, Maricopa County	12/13/2004	Arizona	CR2003-027284
11	52-1 District Court	12/15/2004	Michigan	04-003877-FY
12	22nd District Court	12/16/2004	Michigan	CRW-04691-FH
13	382nd District Court	2/3/2005	Texas	02-00-28
14	Superior Court, Maricopa County	3/7/2005	Arizona	CR2003-035106-001
15	Superior Court, Maricopa County	5/9/2005	Arizona	CR2003-021561-001
16	West Juvenile Drug Court	7/8/2005	Florida	0404379
17	48th District Court	9/2/2005	Michigan	0420922
18	Circuit Court Okaloosa County	9/13/2005	Florida	04-224CFA 04-225CFA
19	Cherokee County State Court	9/28/2005	Georgia	04T3536
20	Escambia County Court/Div.2	10/5/2005	Florida	04-20282-MMA
21	County Court at Law #11	11/9/2005	Texas	CC 850837
22	22nd District Court	11/17/2005	Michigan	041875FH
23	Denver County Court	2/3/2006	Colorado	05M00543
24	Greeley Municipal Court	4/25/2006	Colorado	M191882
25	Lycoming DUI Court	5/16/2006	Pennsylvania	05891
26	Dallas County District Court	6/23/2006	Texas	F9823306-FT
27	Fairfield County Common Pleas Court	7/28/2006	Ohio	2005CR00252
28	Superior Court #3	Aug-06	Indiana	32D03-0506-CM-290
29	Fourth District	Aug-06	Minnesota	02064356
30	20th Judicial Circuit Court	Aug-06	Florida	05-001317CT-(ECT)
31	Wayne County Municipal Court	Sep-06	Ohio	TRC06021454
32	16th Judicial District Court	Sep-06	Louisiana	434-39-0993

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