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CRITICAL REVIEW

TOXICOLOGY

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The PEth Blood Test in the Security Environment: What it is; Why it is Important; and Interpretative Guidelines

ABSTRACT: Testing for phosphatidylethanol (PEth) is a relatively new tool for detecting and grossly quantifying a person's use of alcohol in a variety of security, medical, and legal environments. The basic chemistry of PEth is explained with a particular focus on factors that make it highly suitable as a biomarker for alcohol use in such situations. This article meets the need for a literature review that synthesizes PEth laboratory findings and suggests updated guidelines for interpretation. Several ethanol biomarkers have been used for detection or monitoring alcohol use but have significant limitations. Based on this review, the authors propose three guidelines for evaluating PEth values: Light or no Consumption (<20 ng/mL), Significant Consumption (20–199 ng/mL), and Heavy Consumption (>200 ng/mL). These guidelines are important in employment and security environments, but also have applicability in such diverse activities as alcohol treatment programs, organ transplant decisions, and monitoring impaired medical professionals.

KEYWORDS: forensic science, phosphatidylethanol, ethanol biomarkers, security, guidelines, compliance monitoring

Among the threats to maintaining secrets or propriety information in businesses, financial institutions, national research facilities, and government institutions are employees who become alcohol intoxicated. Confidential or secret information is very difficult to protect, often due to the private agendas of employees who, for instance, wish to sway opinions about a congressional bill, discredit others, influence the debate about military weapon systems, or to reveal programs that are secret but which the employee may judge to be unethical. Just as important, however, is the leaking of private information due to the disinhibiting effect of excessive alcohol consumption. In an intoxicated state, the wish to impress others with insider information about special processes or the impressive capabilities of machines or weapons has been divulged. Sometimes sensitive information is shared inadvertently in competitive storytelling at a bar among work colleagues. At times, an employee can drink to the point of amnesia and not remember what he/she said while socializing in a professional engagement. Intoxication reduces inhibitions, making one more vulnerable to efforts to extract information. Sometimes, frequent intoxication is the only detectable indicator that the subject lies within the subset of people unwilling or unable to safeguard sensitive information.

The more frequently an employee drinks to a level of intoxication that impairs his judgment or awareness, the greater is the risk of inappropriate disclosures. When excessive alcohol use becomes a response to marital discord, financial pressures, or perceived unfair treatment at work, it sometimes has facilitated the purposeful criminal sharing of information or acting to sabotage computers and files. An employee who frequently uses alcohol excessively or binge drinks or who is addicted to alcohol, poses an elevated risk for a company, and is therefore important to identify.

Because companies and security institutions realize the heightened risk arising from the excessive use of alcohol, such employees, when discovered, can lose their position, status, or security access. The knowledge of such consequences makes it difficult for employees to be candid about their use of alcohol. In employment situations, interviews relying on the person's self-report of their alcohol use are unreliable (1–5). Evaluation protocols based on instruments such as the Substance Abuse Subtle Screening Inventory (SASSI-3), Alcohol Use Disorders Identification Test (AUDIT-C), CAGE (an acronym derived from the four questions that compose it), and the Michigan Alcohol Screening Test (MAST) are useful in clinical situations where the subject is a "patient" wishing to be helped by treatment, rather than an "employee" concerned about maintaining employment. The remaining option for determining an employee's use of alcohol is to include "alcohol sensitive" biomarkers in the evaluation. Direct biomarkers measure ethyl alcohol or its metabolites and include the blood and breath alcohol concentration tests, ethyl glucuronide (EtG) and phosphatidylethanol (PEth). Indirect biomarkers measure the effects of alcohol on the body and thus indirectly estimate the use of alcohol.

Indirect Biomarkers for Studying Alcohol Use

Indirect biomarkers of alcohol use become elevated when the consumption of alcohol is sufficiently large and occurs over a sufficiently lengthy period of time that it damages the body. Because the metabolites and enzymes measured by these tests

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do not contain ethanol, they are considered indirect measures. The most commonly used biomarkers for detecting excessive alcohol use are mean corpuscular volume (MCV), carbohydrate-deficient transferrin (CDT%), and the liver enzymes GGT, ALT, and AST. While medically useful, these tests generally require the daily consumption of over 60 g/day of alcohol over several weeks to cause clinically significant elevations (6–8). Sixty grams of alcohol is over four standard drinks. A "standard drink" in the United States is defined as one containing 14 g of pure alcohol and is equivalent to a 12-ounce bottle of beer, a 5-ounce glass of wine (12% abv), or a 1.5 ounce shot of distilled spirits (40% abv). Detecting sustained heavy drinking in employees is important, but sometimes the need is to detect lesser concentrations of alcohol and binge drinking such as required in the Code of Federal Regulations' Adjudicative Guidelines (9). Another problem with the indirect biomarkers is that they can be elevated due to a number of causes. For example, the GGT can be elevated by obesity, hepatitis B or C, diabetes, nonalcohol-related fatty liver or liver disease, hemochromatosis, a symptomatic acute illness, and hepatotoxic medications—including acetaminophen and antibiotics such as amoxicillin. In other words, these tests have a low specificity for alcohol. A final problem arises from the fact that different laboratories have different assay procedures and propose different ranges of "normality" (7).

Direct Measures: EtG, EtS, and Breath Alcohol Concentration Tests

The ethyl glucuronide test (EtG) is a urine test sensitive to recent ethanol consumption of any amount. EtG is a direct metabolite of ethanol, a compound made of glucuronic acid and ingested ethanol. After only one or two drinks, EtG can be detected for up to 48 h, but with heavy consumption, it can be detected up to 4 days (10). Because of its sensitivity to small amounts of ingested ethanol, the EtG is often used to confirm current abstinence in research control groups and alcohol rehabilitation centers. It is also useful in verifying an employee's claim of recent abstinence because nothing but ethanol will elevate it (11).

Measuring EtG in hair allows the monitoring of alcohol use over time. EtG is incorporated into the surface of the hair follicle as it grows and thus provides a long-term record of alcohol consumption. Given a rate of scalp hair growth of about 0.5 inches per month, a 1.5-inch proximal hair sample will detect alcohol consumed over the past 3 months. A consensus statement by the Society of Hair Testing during its meeting in Brisbane, Australia, in 2016 used the threshold of 7 pg EtG/mg hair in a 6 cm hair sample to indicate positive for drinking over the past 3 months, and a threshold of 30 pg/mg to indicate "heavy drinking" (over 60 g/day) over that time period. One serious drawback of hair EtG testing is that false negatives can occur if the hair is permed, bleached, or dyed. Also, ethanol-containing hairspray or hair lotions may cause false positives (12).

A urine test for ethyl sulfate (EtS) has a similar response pattern to the EtG. Testing for this second metabolite of ethanol can slightly improve the sensitivity and specificity of the EtG test. As Gonzalo et al. (7) state, it "has a longer detection window [but has] little practical advantage compared to the EtG." The EtS will not be further discussed here.

The EtG urine test is particularly useful in detecting alcohol consumption in a person who claims to be abstinent but who in fact drank 2 or 3 days prior to the evaluation. If, for example, a person drank heavily on a Friday night, the alcohol would likely be detected by a urine test on Monday morning. The magnitude of the EtG finding has been found to roughly correspond to the amount of alcohol recently consumed (10–13).

The EtG is subject to false positives due to "extraneous exposure" to ethanol-based hand sanitizers when used 20 or more times a day (such as by medical personnel), mouthwashes (when swallowed), and the consumption of "pralines, nonalcoholic beer, pharmaceutical products, fruit juice, [and] sauerkraut." (14) To effectively eliminate false positives, laboratories tend to use a high EtG minimum threshold of 250 ng/mL to indicate the intentional consumption of alcohol.

In contrast to the EtG, breath alcohol concentration tests report pure ethanol (as opposed to an ethanol metabolite) currently in the blood. The body will metabolize consumed alcohol within a few hours, so this test will remain positive for only these few hours. The liver metabolizes slightly less than about one standard drink per hour. As the body metabolizes alcohol, the blood Alcohol Concentration (BAC) declines at an average rate between 0.015 ($\pm$ 0.002) g/100 mL/h blood for men and 0.017 ($\pm$ 0.003) g/100 mL/h for women (15). For reference, the legal limit for intoxication for purposes of driving an automobile in most states is 0.08 g/100 mL. For regular heavy drinkers, the rate of alcohol metabolism can be as much as twice as fast as for infrequent drinkers since frequent exposure to alcohol can induce an increase in the production of alcohol-metabolizing enzymes. Because alcohol is metabolized so quickly, a person could drink to a BAC of twice the legal limit on Sunday evening, stopping at 8 pm, and then register a BAC of 0.00 g/210 L in a breath test at 9 am Monday morning. When the goal is to monitor sobriety at work, then the use of the breath test provides immediate information. As breath tests have such a small window of detection, however, their usefulness in detecting an employee's consumption outside of work (e.g., validating abstinence) is questionable.

The PEth Biomarker

The direct biomarker PEth is formed on the surface of the red blood cell, when ethyl alcohol reacts with phosphatidylcholine, in a reaction catalyzed by the enzyme phospholipase D (PLD). There are significant individual differences in concentration and activity of PLD which affect the rate of PEth formation. PEth requires ethanol for its production in the red blood cell membrane. There are several PEth molecule species or homologues, each containing the same glycerophospholipid central chain, plus two side chains of varying long-chain carboxylic acids. The PEth homologue 16:0/18:1, containing palmitic acid (16 carbon atoms and 0 double-bonds) and oleic acid (18 carbon atoms and 1 double bond), is the most common and accounts for between 36%, in mild-to-moderate drinkers, and up to 46% of total PEth in "heavy" drinkers (16). The amount and type of ingested fat in a person's diet and other factors can also affect the percentage of a particular homologue.

Attempts to determine how much alcohol concentration it takes to create PEth have a history coinciding with the increasing sensitivity of laboratory measurement techniques. Varga et al. (17) found that a single dose of 47 g for men and 32 g for women did not develop detectable PEth within a day after intake. That study, however, used measurement technology that was relatively insensitive, with a limit of quantification (LOQ) of 154 ng/mL PEth in whole blood.

While PEth forms at low doses of alcoholic beverages, it has been found to be relatively insensitive to incidental ethanol

exposures, such as mouthwash and antibacterial hand sanitizers (14,18). To protect against false positives, however, PEth is currently considered to be an indicator of purposeful alcohol ingestion at values > 20 ng/mL. According to the LabCorp Forensic Laboratory Director, the 20 ng/mL threshold has been established by a consensus among laboratories in the United States and, while reasonable, it is still an arbitrary threshold (personal communication with M. Lebard, August 2017). This is similar to the reported agreement among Swedish laboratories to interpret a PEth value of 35 ng/mL or less to indicate "low or no alcohol consumption" (19). While a positive finding (>20 ng/mL) reveals the ingestion of alcohol, inferring whether the amount was moderate or heavy is based on the magnitude of the PEth value.

Given the large individual differences in how much alcohol is necessary to create a specific amount of PEth, it is difficult to provide a specific benchmark for how many drinks it takes to create a PEth of 20 ng/mL (a "positive" laboratory finding). Rough approximations of the positive PEth value can be calculated, however, from data in the prospective study of Kechagias et al. (4). Using technology which had an LOQ of 3.7 ng/mL, they reported a mean PEth of 15.5 ng/mL for 21 subjects, 14 of whom consumed 32 g/day of ethanol (men) and seven of whom ingested 16 g/day (women) daily for 3 months. For men, it appears that a daily consumption averaging ~2.5 standard drinks of alcohol a day (35 g/day) could produce a positive (>20 ng/mL) laboratory PEth finding. For women, a positive PEth (>0.20 ng/mL) might be produced by the consumption of 1.5–2 standard drinks (21–28 g/day) a day. These are only rough extrapolations based on this data but they may be useful in estimating the number of standard drinks associated with a PEth of ~20 ng/mL. The often-cited notion that it takes at least 50 g/day of alcohol to register a positive PEth is not correct as that estimate was based on older, relatively insensitive detection technology (17).

PEth production begins as soon as ethanol is consumed and peaks within 8 h after alcohol ingestion (20,21). Once formed, it degrades very slowly, which is important for its utility as a biomarker. There are marked Individual differences in the degradation half-life of PEth. Schrock et al. (22) data indicated that subjects who had ingested a single dose of alcohol sufficient to produce a calculated BAC of 0.10 g/100 mL had a PEth elimination half-life of 3 days, and Javors et al. (23) determined a PEth half-life of 4.6 days. Helander et al. (24) found a mean half-life of 6.1 days. The shorter half-lives tended to be found in studies involving "alcoholics" or heavy drinkers (e.g., >5 drinks per day on a regular basis). In a meta-analysis of 12 studies, Viel et al. (16) concluded that the PEth elimination half-life was between 3 and 5 days. Gnann et al. (20) documented that among "social" drinkers who were dosed with enough alcohol to "simulate extensive drinking," the half-life varied widely, ranging between 4.5 and 10.1 days. That study involved only 11 subjects, and no measures of a central tendency were reported which would have made their findings possible to compare with other studies.

With liquid chromatography followed by tandem mass spectroscopy (LC/MS-MS), the technology used by modern laboratories, PEth can be determined at values as low as 2 ng/mL (20,25). This is over a hundredfold lower than 15 years ago. The capacity to detect very small concentrations of PEth will continue to be useful for research purposes but in security and clinical applications, using the threshold of 20 ng/mL protects against false positives (26).

Studies have found no gender differences in the *formation* of PEth (21,24,27,28,29). As women generally have a higher percentage of body fat (in which alcohol is insoluble) and a correspondingly lower percentage of body water, the number of drinks needed to attain a BAC high enough to register a positive PEth will usually be lower than for men of the same weight. The key factor seems to be differences in percentages of total body water rather than gender-based differences in the chemistry involved in PEth formation.

There is a significant correlation between PEth values and the number of drinks consumed for individuals with no liver disease (4,27,30). The correlations are sizable ($r = 0.57$ and $r = 0.69$) (4,32). Because of the factors discussed below, however, it is possible to make only broad generalizations between PEth values and the quantity, frequency, and recency of the person's drinking.

PEth is moderately correlated with the percentage of carbohydrate-deficient transferrin (CDT%) indirect test for ethanol ($r = 0.59$; $r = 0.62$) (24); poorly correlated with the liver enzyme gamma-glutamyl transferase (GGT) test ($r = 0.34$); and uncorrelated with mean corpuscular volume (MCV) ($r = 0.09$) (18). PEth is not perfectly correlated ($r = 0.74$) with the two other direct tests for ethanol: breath alcohol concentration (31) and urine EtG tests. The lack of a higher correlation among these three direct markers is due to the different detection thresholds and the different dissipation rates of the measured substances. Breath concentration tests rely on the presence of ethanol itself (not a metabolite of alcohol), which is metabolized within 8–12 h (10). The EtG metabolite of ethanol measured by the EtG test dissipates within 2 and 4 days (depending on the amount of ethanol consumed). PEth, on the other hand, can to be detected for 3 or 4 weeks, long after the ethanol and EtG metabolites have been metabolized.

Published research findings that attempt to associate PEth values with the amount of alcohol consumed are particularly difficult to interpret if they have not taken into account factors such as:

- The length of time prior to PEth testing that the subject had been alcohol abstinent. Some studies have used only a 2-week period of abstinence as their baseline, although PEth can be detected for up to 28-days (21). It is especially common for studies performed within clinical settings not to have a prior period of abstinence (4,18,27).
- Whether the amount of alcohol consumed was identified by quantity alone (e.g., three to five drinks per day) or dosed according to body weight (e.g., 1 g of alcohol/kg of body weight), or to attain a particular calculated BAC.
- Whether the data were based on patient self-report or carefully administered and monitored alcohol dosages.
- The comparison of nominally similar groupings that are in fact quite different (e.g., "moderate" drinking may be 1–2 drinks/day or 1–5 drinks/per day). As Weinmann et al. (33) point out, the somewhat arbitrary cutoff points or ranges used to define such levels make it difficult to compare studies.
- Because much of the work on PEth is done in Europe, the differences in the manner research are reported in Europe and in the United States needs to be appreciated. A "standard" drink in Europe contains 12 g of alcohol. In the United States, the "standard" drink is 14 g, which is 17% more alcohol than the standard drink reported in European studies. Also, the European unit of measurement for PEth is generally reported in micromoles per Liter (μmol/L) while in the United States, results are presented in nanograms per milliliter

(ng/mL). To translate European findings into U.S. units, the μmol/mL must be multiplied by 703 (the molecular weight of PEth).

- Some earlier studies were based on the "total PEth" (all PEth homologues combined) while others, usually more recent studies, focused on the single homologue 16:0/18:1. To compare the results of the "total PEth" studies to studies of the 16:0/18:1 homologue, the total PEth value needs to be multiplied by the percentage of the 16:0/18:1 homologue in total PEth. Several studies report that percentage to be about 36% but studies of heavy drinkers have found the percentage to be as high as 45–46% (25,34,35). Hahn et al. (26) suggested that overall the percentage approximates 40% and that will be used in our calculations estimating the conversion between total PEth and the 16:0/18:1 homologue.

While the literature can be difficult to integrate, the significant direct correlation of PEth with the amount of alcohol consumed provides a basis to assume that PEth values can indicate something about the general amount of consumed ethanol. Table 1 contains illustrative research findings (adjusted to U.S. standard drinks and ng/mL measurement dimensions) that can be used as a reference for grossly estimating alcohol consumption from PEth values. These papers were selected based on their having a minimum of 20 adult human subjects (due to the degree of variation), having external data connecting the amount of alcohol consumed to PEth, and being representative of values along the continuum of PEth findings. Studies that have fewer than 20 participants but which still contribute some perspective are placed in brackets and italicized. These findings show how PEth generally increases with the amount of alcohol

TABLE 1—*Research Established Relationships Between PEth and the Amount of Alcohol Consumed.*

PEth* Value	Ethanol Consumed†	Number of Subjects	Study Year and Reference	Comments
15	2.2 drinks/day (men), 1.1 drinks/day (women)	21	2015 (4)	Mean PEth after 3 month's drinking 2.2 drinks/day (men), 1.1 drinks/day (women); wide variability in PEth values (5–120 ng/mL)
<20	<2 drinks/day	–	–	"a PEth value in the low concentration range is useful to differentiate 'any drinking'... from abstinence... rather than indicate with confidence a specific amount of consumption" (33).
20	At least moderate drinking within past month			Suggested Guideline for a "Positive" PEth result; alcohol has been consumed in at least moderate amounts at some time(s) within the past month.
24	4.1 drinks/week	22	2015 (50)	The 4 weekly drinks were consumed in one or two sittings/week, ≤3 drinks per episode
28	2.4 drinks/day	21	2015 (4)	A 28 ng/mL threshold detected nonabstainers with 100% specificity (0 false positives); only 28% sensitivity for detecting nonabstainers within past month
48	4.2 drinks once a week over 4 weeks	30	2014 (30)	A study of women in early pregnancy.
73	Up to 4 drinks/day	1339	2012 (16)	The mean PEth for subjects arrested for DUI. Consumption was self-reported
100	–	56	2011 (48)	The threshold that distinguished "currently drinking" alcohol-dependent subjects from people who "did not drink"
127	2 or more drinks/day	80	2010 (48)	This value had high specificity in identifying women who drank more than 28 g (about two standard drinks) per day (44). Stranges, Freudenheim, Multi, Farinaro, Russell, and Noschajski (49) found that more than two drinks per day for women and three drinks per day for men were associated with a high risk of liver damage (n = 2943). NIAAA defines risky drinking for females as the consumption of more than three drinks per occasion or seven drinks per week (45,46).
141	4 or more drinks/day	40	2012 (24)	The threshold for "excessive" drinking used by Helander et al. (24) (n = 40). NIAAA defines excessive drinking for men as the consumption of four or more drinks a day (45,49).
186	Five or more drinks for men and four or more for women on at least two occasions per month	58	2015 (50)	The mean for "binge drinkers" (five or more drinks for men and four or more drinks for women per sitting on at least two occasions during the previous month)
202	4.3 drinks/day	1339	2012 (16)	202 is the Suggested Guideline for "Highly Positive" The mean PEth for people drinking up to 60 g/or 4.3 std. drinks/day.
253	–	56	2007 (48)	The threshold to identify alcohol-dependent subjects needing detox treatment, from abstainers. Study results were recalculated using the 14 g standard unit.
499	6 drinks/day	111	2015 (19)	This is the median number of drinks consumed per day by alcohol-dependent men and women entering treatment. The range was 3.6–7 drinks/day over 6 weeks.
863†	*5–7 drinks/day*	*4*	*2011 (25)*	*Total PEth ng/mL was multiplied by 40% to convert it to the 16:0/18:1 PEth homologue equivalent*
1000	7 drinks/day	144	2006 (18)	The mean PEth for those reporting about 7 drinks/day
1749	17 drink/day	57	2010 (28)	The study used alcohol-dependent patients who drank an average of 17 standard drinks per day over 7 days.
2165	14.5 or more drinks/day	144	2006 (18)	The mean for a group which reported averaging 14.5 or more drinks/day

*All PEth values are expressed as ng/mL of the 16:0/18:1 homologue. Total PEth measurements were converted by multiplying by 40%. PEth measurements in moles were converted by multiplying by 702 g/mole.

†Italics identifies this study as having fewer than 20 participants.

consumed but should not be understood as suggesting precise relationships.

Comparing the Laboratory PEth Value to Self-report

Over a 22-month period, National Security Psychological Services clinicians performed PEth tests on 53 consecutive male employees as a part of an evaluation of their alcohol use. Thirty-seven of those employees claimed to be alcohol abstinent. A positive PEth (>20 ng/mL) indicated that 12 of those 37 (32.4%) had in fact had been drinking. Of 16 employees who had admitted that they were consuming alcohol, 11 (69%) had PEth values suggesting that they had been drinking at a much heavier level than they had indicated, and one employee had a PEth lower than was anticipated by the clinician. Twenty-nine of the 53 employees (54.7%) tested either had a negative PEth (n = 25) or reported drinking about as much as their PEth value indicated (n = 4). A negative PEth does not verify abstinence but is consistent with an employee's claim of abstinence.

Legal Acceptance of PEth and Evaluating a PEth Result

The PEth has been accepted in administrative hearings across the United States (36–41). In a presentation to the United States 7th Circuit Court, a noted authority in family law stated, "the PEth in blood and EtG in nail/hair are in current use all over the world and have been accepted by the professionals in this specialized world... These tests are being used all over the country for family court matters as well." (42). The virtues of the PEth were also presented to the Texas Bar Association in 2017 (43). It is clear that the PEth has been judged to be meaningful in aiding in court decisions.

A "positive" PEth finding (>20 ng/mL) in the lower range (e.g., 20–80 ng/mL) indicates that the person has very likely consumed at least 2.5 or more standard drinks for several days prior to the test or had binged rather heavily. While a low PEth value does not reveal the pattern of consumption, the unassailable conclusion is that the employee has consumed alcohol within the past month or so.

When the PEth value is within the 80–200 ng/mL range, it is readily interpreted as the employee having ingested significant quantities of alcohol within the past few weeks, either by bingeing or regular consumption. As the laboratory PEth finding is the minimum concentration of the deteriorating PEth, the research findings noted above can provide some suggested intensities of the alcohol consumption, but for perspective only.

When PEth values are above 200 ng/mL, then the clinician can be confident that the employee has been drinking very heavily and likely frequently.

Estimating Past Alcohol Consumption from PEth

To estimate past drinking behaviors from a PEth result, one needs to consider quantity of alcohol consumed, rate of consumption, recency, and frequency of consumption.

Quantity of alcohol consumed affects PEth in a fairly straightforward manner. High levels of alcohol consumption produce high concentrations of PEth. Low alcohol consumption leads to low PEth concentrations.

When it is known, the *Recency* of alcohol consumption would be important in interpreting the drinking pattern suggested by a PEth concentration. A 6-day PEth elimination half-life can be used for purposes of making general estimates. Ten drinks consumed the day before the PEth test would yield a high PEth concentration, but ten drinks consumed a month before the PEth testing would be undetectable. In clinical pharmacology, five half-lives are commonly considered enough time for elimination of a drug from the body. In about 30 days (five 6-day half-lives), PEth will be eliminated, which is why the window of detection for the PEth test is often given as 1 month, or 4 weeks. A concomitant urine EtG can add to the utility of PEth. A negative EtG will rule-out any alcohol consumption within the past 2–4 days. If the PEth is positive, and no alcohol has been consumed within 3 days, a concomitant negative EtG provides the additional information that 3 days before testing, the PEth was approximately 50% higher (assuming a usual PEth half-life of 6 days).

Finally, the *frequency* of alcohol consumption can affect the PEth result. Ten drinks consumed in one episode will produce a high BAC, and a higher PEth concentration than if the ten drinks were consumed in five episodes of two drinks apiece.

Discussion and Proposed Guidelines

One indication of the employee's reliability and integrity is whether their PEth result is consistent with the employee's self-report of his/her drinking. In security situations where the excessive use of alcohol increases the risk of inappropriate disclosure of proprietary or classified information the following recommendations is made for the use of the PEth. The number of "drinks/day" should not be taken literally but only as reflective of research central tendencies. In professional reports, the nominal classifications suggested below can be reported and refined by adding relevant research findings. For example, "The employee's PEth of 305 ng/mL indicates that he is likely a *heavy* consumer of alcohol. Research has shown that PEth values in this range are found in people who regularly consume 4 or more standard drinks per day or who binge drink a total of 28 or more drinks over the course of a week."

PEth<20 ng/mL: "Light or No Consumption": Abstinence or light drinking (from not drinking to averaging less than two drinks/day for several days a week).

20–200 ng/mL: "Significant Consumption": Moderate level of drinking (averaging between 2 to 4 drinks/day for several days a week). This range corresponds to the *top* of National Institute of Alcoholism and Alcshol Abuse's (NIAAA) "low risk" category for men (males: no more than four drinks in a day or 14 drinks per week; females: 3 drinks/day or 7 drinks a week) (45,46). This range also encompasses the World Health Organization's "Low Risk" (males up to 40 g/day; females 20 g) and "Medium Risk" (males up to 60 g/day; females 40 g) categories (47).

>200 ng/mL: "Heavy Consumption"; Heavy drinking (at least 4 drinks/day several days a week). Anything above 4 drinks (56 g)/day begins what NIAAA and the Substance Abuse and Mental Health Services Administration (SAMHSA) term "Heavy Drinking" (13,45,46). The World Health Organization terms "High Risk" the daily consumption of 60 g/day for males and 41 g/day for females; Very High Risk (begins at more than 101 g/day (7.2 drinks) for males and more than 61 g/day (4.3 drinks) for females (47).

The literature is very consistent in concluding that PEth is a highly sensitive and specific biomarker for alcohol consumption.

In this article, the authors have discussed the use of the PEth test and issues with its interpretation. The PEth test is another tool that can be used to identify employees who have a heightened potential to leak proprietary or classified information due to frequent intoxication.

The PEth result can be used to validate or discredit an employee's claims about his/her alcohol consumption. In security settings where an employee's truthfulness is paramount, an employee's self-report about their use of alcohol becomes important data. If an employee claiming abstinence has negative breath and EtG tests, but a positive PEth, that indicates he is not being truthful about his use of alcohol. If he claims that he drinks no more than three beers a week but his PEth is within the "significant" or "heavy" consumption range then the employer should be concerned about trusting him.

Comparing PEth laboratory findings to an employee's claims about his use of alcohol should be understood as a barometer of his more *general* ability to be candid in situations that could negatively affect him. The meaning of significantly discrepant claims should not be concretely limited to the employee's use of alcohol but viewed as an indicator of the person's ability to be candid.

PEth laboratory testing can be useful in a wide range of settings beyond the security monitoring settings predominantly discussed in this article. Of particular, utility is the fact that PEth monitoring is especially effective for detecting chronic, heavy drinking. The subset of heavy drinkers who are not truthfully reporting their alcohol consumption pattern is of concern in many settings, such as among impaired physicians, persons entrusted with the custody of children, and persons being monitored for court-ordered alcohol-abstention due to driving violations. Even in treatment programs where reduced/controlled drinking is among the acceptable treatment goals, chronic heavy drinking patterns need to be identified and confronted. PEth testing has utility in monitoring abstinence in that there are no false positives in a finding that alcohol has been consumed in some amount. In security settings, and clinical settings, it is often particularly important to determine whether a person is trustworthy. Comparing a person's self-reported alcohol consumption to PEth results as discussed in this study can provide one objective indication of his/her reliability to be truthful. A PEth result will reflect the amounts, frequency, and recency of the subject's drinking over the past month. Such an interpretative tool is useful in a number of clinical, administrative, and forensic settings.

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