Predictive Safety

# Understanding AlertMeter®

## *How and Why AlertMeter® Testing Meets the Safety and Performance Needs of the Modern Workplace*


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Issues of worker fatigue and alertness present safety and productivity risks that companies are faced with daily. Whether related to a lack of sleep, intoxication, illness, or other causes of impairment, employees and companies must work to better understand and mitigate fatigue risk in order to sustain effective productivity and performance. Employers are also experiencing limitations of traditional drug testing and encountering new difficulties in finding and keeping qualified workers in the era of legally accessible marijuana. Consequently, employers have recognized the need for a practical and workplace-friendly way for assessing fitness-for-duty (FFD) on a daily basis and particularly before workers perform critical tasks. AlertMeter® is a graphical cognitive alertness test lasting 60-90 seconds and has been shown through both clinical and workplace analyses to satisfy this need. Originally validated in a NIOSH-funded 2009 clinical study, AlertMeter® has since been successfully deployed in a growing number of safety-sensitive organizations across industries, meeting the key requirements for a workplace-friendly alertness test, such as being brief, inexpensive to implement, portable, and not requiring proprietary hardware. AlertMeter® has been shown in real workplaces to increase productivity, reduce turnover, and lower costs of drug testing and workers' compensation insurance claims. AlertMeter® test scores have also been shown to correlate to time of day, indicating sensitivity to circadian cycles. AlertMeter® is involved in ongoing studies to continuously validate its efficacy as a tool to ensure worker fitness-for-duty. It is also being used as a tool for measuring cognitive change in a number of current and forthcoming studies by academic institutions.



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## Introduction

All human beings are susceptible to compromised alertness from sleep-related fatigue, impairment from drugs and alcohol, illness, emotional distress, and numerous other factors. This general concept of "fatigue risk" poses an area of concern when attempting to manage safety and productivity in the workplace. Proactive organizations that are committed to safety as a value do not wait for an employee to be a victim of fatigue or cognitive impairment. Rather, safety-conscious and value-based companies take proactive steps to implement new systems as they become available.

Lack of restorative sleep is a commonly cited cause of fatigue and cognitive impairment among workers, and it is known to increase employees' risk of injuries and illnesses.[1,2] Employees working at night, extended shifts, or irregular shifts are at the most risk. In fact, 62% of night shift workers claim to get insufficient sleep,[3] and accident and injury rates during night shifts are 30% higher than during the day.[4] This is not a coincidence. However, not all fatigue or contributing factors to fatigue are work-related.[2] A person working a regular day shift may still experience fatigue symptoms from sleep loss due to circumstances like illness, insomnia, or caring for a sick child. Regardless of the cause, the National Safety Council estimated that fatigue costs employers $136 billion every year in lost productivity. Despite common perception, people do not become accustomed to operating without sufficient restorative sleep. In fact, though fatigued people may not always feel sleepy, their performance is still diminished and their ability to recognize their fatigue level is also diminished.[5]

## Is Fatigue the Same as Impairment?

The National Transportation Safety Board (NTSB) provides a broad definition of fatigue:

> *Human fatigue is both a symptom of poor sleep and health management, and an enabler of other impairments, such as poor judgment and decision making, slowed reaction times, and loss of situational awareness and control. Fatigue degrades a person's ability to stay awake, alert, and attentive.*[6]

Following this definition, traditional connotations of fatigue related to sleep and impairment related to drugs and alcohol are outdated in the modern workplace. Perhaps a more profound insight or common thread relates to the effect on alertness shown from sleep-related fatigue or other sources of impairment. In fact, when considering human performance in the workplace, ***being fatigued or impaired is the same as experiencing impaired alertness.***

A typical connotation of impairment assumes a connection to drugs and alcohol. However, studies have shown an equally strong correlation between sleep loss and the effects of alcohol. Symptoms from both forms of impairment predict increased risk. Williamson and Feyer conducted a study to compare the relative effects on performance from sleep deprivation and alcohol. They found that response speeds and accuracy measures on tests among sleep deprived participants were equivalent or worse than when dosed with alcohol producing blood alcohol concentrations from 0.05% to 0.1%.[7]

Being fatigued has been shown to impair cognitive ability as much as moderate alcohol intoxication (Fig. 1).[1,8]

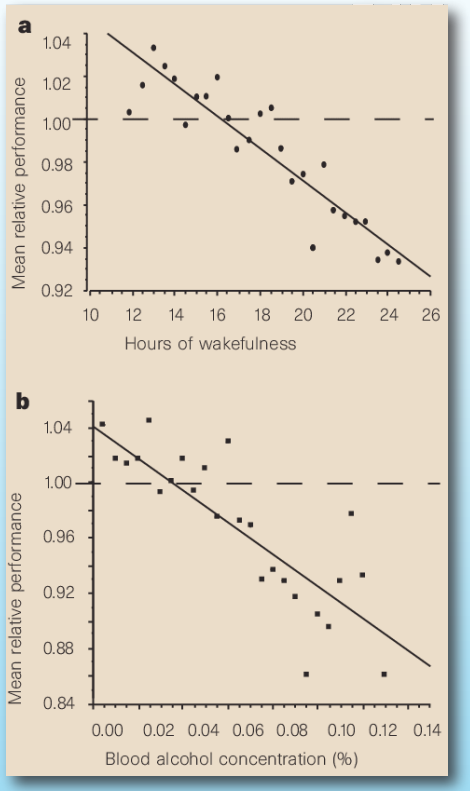



*Figure 1: Similarities of performance impairment between extended wakefulness and blood alcohol concentration.*[8]

In fact, Dawson and Reid found that even "moderate levels of fatigue produce higher levels of impairment than the proscribed level of alcohol intoxication."[8] Because our social culture views working through fatigue as necessary and even virtuous,[9] the impairment caused by fatigue is somehow considered more acceptable in the workplace. This cultural norm is unacceptable. Protections against fatigue-related impairment are just as important as other measures like drug testing meant to protect against the influence of intoxicants.

## Issues with Drug Testing

The rise of legally accessible marijuana presents a unique challenge to employers,[10,11] who are finding it more and more difficult to attract and retain qualified employees who can pass traditional drug screens including marijuana. Further, employers are recognizing that detection of marijuana use on a workplace drug screen is not necessarily correlated to job performance. There are many reasons for this. First, marijuana is metabolized differently from alcohol, so the detection of marijuana in body fluids does not necessarily indicate intoxication.[10,12,13,14,15,16] Second, urine test results are not an indication of performance capability.[14,17] Third, there is a delay in processing and receiving test results from traditional drug-testing methods (e.g., urinalysis, hair follicle tests, etc.).[17] Finally, employers are increasingly wary of discriminating against current or potential employees who have not broken the law and are not intoxicated at work.[11,18,19]

The safety risks that impairment and fatigue pose is often realized after it has already contributed to an incident. And although workplace drug screens may deter some people from using certain intoxicants, few people would argue that their efficacy as a safety measure is uncertain at best. The modern workplace deserves better solutions to reduce risk posed by fatigue and other forms of impairment. To do so, organizations must approach fatigue risk management in a preventative, rather than reactive, way.

## Background on Alertness/Impairment Testing

Alertness or impairment testing as a workplace safety measure is not a new concept. It has roots in the late 1980s and early 1990s, soon after the mandate for drug testing was introduced for Fed-

eral employees.[10] Workplace drug screens quickly became commonplace for much of the private sector as well, given the impression that the practice helps create and maintain a safe workplace.[10] However, researchers have long recognized their limitations as a safety measure.[12,13,14,15,20,21,22]

A rise in occupational impairment testing occurred simultaneously with a growing understanding of fatigue's role in workplace safety lapses and lost productivity, and specifically the negative effects of shiftwork on quality and quantity of sleep.[4,5,9,23,24,25] Consequently, researchers and entrepreneurs began seeking more effective, alternative methods for protecting against worker fatigue and cognitive impairment in the workplace. This work resulted in a number of computer-based cognitive tests designed to measure impaired performance and cognition.[15,17,18,20,22,26,27,28]

Despite developments in alertness testing, fatigue management remained a scarce component of workplace safety systems, and workplace drug screens endured as the most commonly applied method for identifying a potentially impaired employee beyond personal observation. This occurred primarily because, somewhat ironically, early alertness tests proved to be incompatible with the workplace environment.[18] The incompatibility was multifaceted, depending on the type of test and the workplace. First, the technology available for the earliest incarnations meant that each alertness test available required proprietary hardware, and it was not portable. Second, and unsurprisingly, alertness testing was expensive, often prohibitively so.[18] By extension, the third issue was the time needed for every employee to complete a test on a limited of number of testing units.

As a result of these incompatibilities and despite positive feedback from employees who experimented with the concept,[20] alertness testing returned to the conceptual drawing board, waiting for contemporary technology and a cultural shift to better facilitate its real potential as a practical workplace safety measure to reduce risk related to fatigue and cognitive impairment.

## A Modern Workplace Solution

The following sections describe a practical solution to worker fatigue and impairment called the AlertMeter® alertness test. It can be easily implemented in a wide variety of workplace environments and is accessible to virtually all types of employee. It is non-invasive, unlike a drug test, and it can be introduced to the workplace with minimal disruption to workers' routines and productivity.

AlertMeter® is a graphical cognitive alertness test lasting 60 to 90 seconds that workers complete at the start of their shifts and/or before performing a critical task. It can be taken on a touchscreen tablet, a smartphone, or a personal computer, and it quickly provides insight into individual workers' mental acuity. If an employee's test result falls below their established baseline, a supervisor can be notified. Prompting this type of interaction to learn possible explanations for an employee's diminished alertness level becomes a protective factor and an example of relying on leading indicators to effectively manage safety.

AlertMeter® has been shown to have safety, productivity, financial, and positive organizational culture benefits in real work environments.[22,29] This paper outlines these benefits along with a thorough explanation of how AlertMeter® works. In addition, this paper will show how AlertMeter® differs from other fit-for-duty tests, correcting the limitations of earlier incarnations of impairment/alertness testing, and how the concept makes sense for today's safety-sensitive work environment.

## History of AlertMeter®

With the rise and subsequent ubiquity of mobile technology in the mid-2000s, including wi-fi and broadband Internet, touchscreens, tablet computers, and smartphones, workplace alertness testing began to be re-examined. Having developed a computer-based test for measuring cognitive decline in patients with Alzheimer's dementia, Bowles-Langley Technology adapted the test for potential use in workplace environments. The prototype test was the subject of a NIOSH-funded study in 2009 that confirmed its ability

to detect cognitive impairment among sleep-deprived subjects.[26] Because the test was short, lasting two minutes or less, and could run on common, non-proprietary computer platforms, it immediately demonstrated more promise for real workplaces than previous fit-for-duty tests.

In 2010, the National Workrights Institute published a study on workplace impairment testing that involved various types of impairment tests, including Bowles-Langley's cognitive alertness test. The study's participants comprised several organizations and businesses who "faced serious safety problems if employees came to work impaired.... Most of these employers realized that drug testing had severe limitations and wanted something better."[22] Although the study included only a small sample, it yielded remarkable results:

> *100% of employers who used impairment testing considered their experience successful. 82% of employers found that impairment testing improved safety. 90% of employees accepted impairment testing. 87% of employers found impairment testing superior to urine testing.*[22]

Since 2010, advancements and updates to Bowles-Langley's test has undergone have kept it easy to use and suitable for virtually any workplace and employee. Now called AlertMeter®, the test is available in two formats, one on a touchscreen tablet or personal computer, and one for use on an Apple iPhone or Android smartphone. AlertMeter® represents a significant change in the way employers can manage impairment risk in the modern workplace, as it addresses key issues weighing on the minds of today's employers, managers, safety professionals, and worker's compensation insurance providers alike.

### AlertMeter® Today

Today, the AlertMeter® test takes less than 90 seconds to complete before the start of a shift or before undertaking safety-sensitive or high-precision tasks (Fig. 2). It is designed to provide employees and employers a trustworthy and non-invasive method for assessing employees' alertness before a potentially impaired employee can pose a safety or productivity risk.

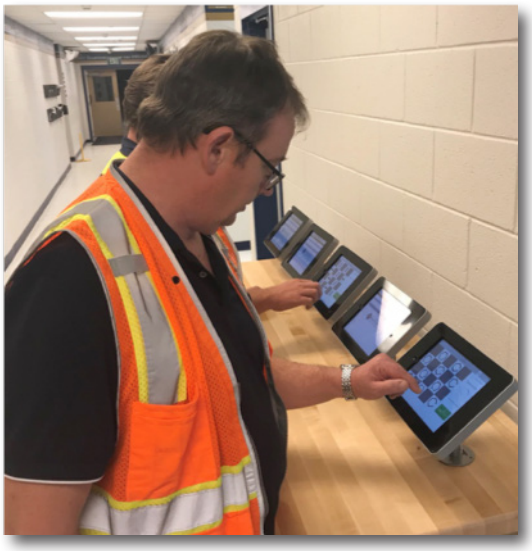


*Figure 2: A mine employee taking the AlertMeter® test at the start of shift.*

AlertMeter's® test interface displays different shapes that the user has to identify accurately and quickly. The patented design does not simulate any particular job function but challenges a number of key brain functions that are necessary for all jobs, measuring reaction time, decision-making speed, orientation, and hand-eye coordination. Users take the alertness test ten times to establish an initial baseline score, or individual performance standard. The scoring algorithm compares users' daily test results with their personal baseline scores. The system identifies compromised alertness when an employee's test result deviates significantly from his or her baseline. Psychological and physiological factors differ greatly between employees, so the only way to accurately measure individuals' cognitive states is to compare their performance in real time against their own personal baselines. By using a calculated baseline methodology, the system provides individual feedback rather than a score against an imposed standard.

Upon launching the test, the user is presented with an array of shapes. The user's task is to determine if all the shapes are the same (despite the shapes' rotation) or if one shape is different from the rest. If one of the shapes is different, the user then taps or clicks the one that is different. If all the shapes are the same, the user taps or clicks a green button that reads "They're all the same!" (Fig. 3).

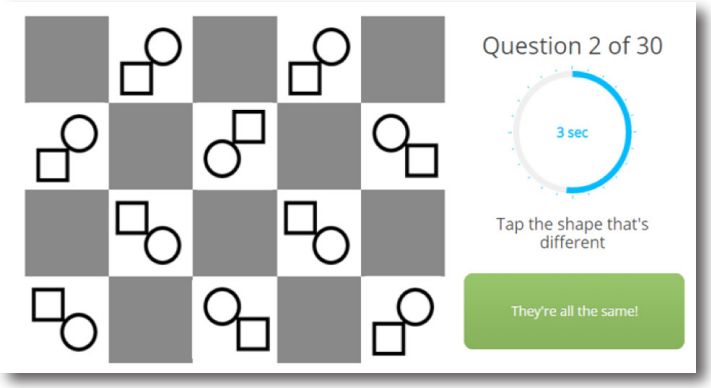



*Figure 3: AlertMeter® test screen.*

In most circumstances, employees take the test at the beginning of their shifts and before starting work. In some work environments or for certain jobs, employees may be asked to take the test at additional times throughout the shift, such as when returning from lunch or breaks, before undertaking a safety-sensitive or precision task, or during times when alertness is known to dip due to circadian rhythms, like between 2:00 and 4:00 p.m.[30]

When potential cognitive impairment is detected, the AlertMeter® system notifies the employee and their supervisor who can then take appropriate action. In most cases, employees may already know why they scored low on a test, and a conversation with the employee is all that is needed to understand the employee's state of mind and to assess how best to keep the employee and work environment safe and productive. Solutions may include altering the employee's work tasks by replacing high-hazard tasks with others, initiating drug or alcohol testing, allowing the employee to take a short rest and appropriate dose of caffeine, allowing the employee to make a phone call, or other solutions appropriate for the situation. Regardless of the cause of cognitive impairment, a post-test conversation between an employee and their supervisor is a control measure to ensure a safe and compliant workplace. AlertMeter® testing can also prevent an employee from acting on poor judgment that can result from being impaired. Plus, impaired employees may feel pressured to continue working for fear of embarrassment or reprimand. AlertMeter® can help alleviate such pressures by allowing a supervisor to intervene and protect the impaired worker and others from that affected judgment.

In 1995, Burns and Hiller-Sturmhöfel presented a selection of criteria that workplace impairment tests should meet to best influence safety in a real workplace environment. Principally, they advised that such tests must be designed to allow "meaningful assessment of performance in a variety of jobs. Another requirement is that the tests must be brief so that they do not keep employees away from their work duties for more than a few minutes."[13] The AlertMeter® test lasts 90 seconds or less and measures cognitive functions such as reaction time, decision-making, and hand-eye coordination, all of which are critical for any job. It therefore meets these two criteria. Burns and Hiller-Sturmhöfel continued: "The test must be sensitive to small changes in performance that occur after consumption of commonly used levels of AOD's [alcohol or drugs] or in the presence of other conditions (e.g., fatigue)."[13] AlertMeter® also meets this criterion, as the initial validation study of Bowles-Langley's cognitive test confirmed its sensitivity to impairment from sleep loss (fatigue).[26] Given that impairment from fatigue can be as pronounced as impairment from alcohol intoxication,[8] "a test that is sensitive to fatigue will also be sensitive to other causes of impairment."[26] Current research projects are underway to confirm AlertMeter's® sensitivity to alcohol and drugs, although anecdotal evidence from current AlertMeter® users suggests its sensitivity to impairment from post-alcohol intoxication (hangovers), prescription pain medicine, and emotional distress. In addition to those already underway, more studies are being planned to further confirm such anecdotes.

Burns and Hiller-Sturmhöfel also described that the test must produce "reliable measures; that is, the results must be reproducible from one time to the next. With the advent of computer-based FFD [fit-for-duty] tests, which are remarkably stable over time, this requirement can be fulfilled without difficulty."[13] As a computer-based test, AlertMeter® obviously fulfills this requirement. The next criterion is also satisfied given the test's brevity and the software's compatibility with commonly used computers and mobile devices like touchscreen tablets and smartphones. Burns and Hiller-Sturmhöfel explained, "The test should be simple to administer, thereby avoiding undue

economic and time burdens on the workplace and minimizing expensive training of personnel. It also should be brief and use equipment that is readily available and reasonably priced."[13]

Another advantage of the AlertMeter® design is its "face validity," or evident measurement of performance. Employees can see their performance being measured and can see when errors are made during the test. A high degree of face validity in a test results in greater trust in the test among users, compared to a test that measures physiological change like eye movement or pupil response.

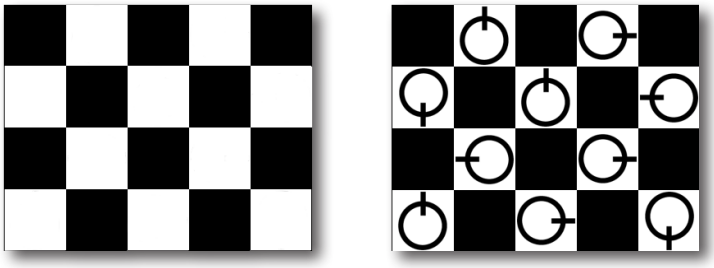
AlertMeter's® scoring algorithm and its "rolling baseline," which adjusts over time as users' familiarity and performance with the test improves, satisfy the next requirement that Burns and Hiller-Sturmhöfel described:

> *The test's scoring should adjust for the learning that occurs as employees perform the test repeatedly . . . Typically, this potential problem is handled by establishing a baseline performance level . . . This baseline is adjusted regularly to compensate for continued improvement due to practice or learning. To assess performance on any given day, the employee's score is compared with his or her adjusted baseline score.* [13]

Because today's technological environment differs greatly from that of 1995—specifically, the advent of widespread high-speed and wi-fi Internet connectivity, mobile devices, and touchscreens—AlertMeter® is able to entirely satisfy the requirements for an impactful fitness-for-duty solution, and in a time that it is needed most.

### AlertMeter® Technical Description

The AlertMeter® test interface displays graphic "items" or "screens" in sequence. Each item or screen comprises a modified checkerboard or grid (Fig. 4) with shapes presented in the white squares (Fig. 5). On some screens, all the shapes are identical; on other screens, one of the shapes will be different from the rest. The user's task is to determine whether all the shapes are the same (regardless of shape rotation). If they are all the same, the user taps or clicks a green button indicating "They're all the same!" and if one shape is different, the user taps or clicks on the different shape within the grid. Response times and accuracy are recorded, and a score is computed at the end of the test. A typical test displays 30 items and takes approximately 60–90 seconds.



*Figures 4 & 5: AlertMeter® static grid test interface checkerboard and a sample item.*

The required size of the checkerboard functions optimally on a touchscreen tablet or computer monitor with at least a 9-inch screen size. The software draws from a shape library consisting of 25 sets or "families" of shapes. When a particular item (screen) is constructed, the software draws from one of the 25 shape families. Certain items present a more difficult challenge than others, and the difficulty level of each item is quantified. Each item is then assigned a difficulty score using Item Response Theory (IRT), taking response time and accuracy into account. Each item is then assigned to a group, or "bin," based on difficulty so that items of similar difficulty are assigned to a specific bin. When the system generates a test sequence, it draws a corresponding number of difficult and easy items based on the available items from the bins. This process ensures that the difficulty of each test is of approximately the same. The goal of AlertMeter's® scoring algorithm is to show a statistically significant correlation between data from the alertness test and a person's ability to effectively perform critical and cognitive tasks.

As mentioned above, some shape combinations are more difficult than others, which was confirmed through examining user data and reporting during early in-lab validation studies[26] and applied workplace studies.[31] Consequently, Item Response Theory (IRT) was used to help quantify the difficulty of each shape combination. The array calculation

method considered only presentation opportunities and frequency of error, and a linear correlation between response time and accuracy according to shape combination became clear. The difficulty inherent in each shape family is a key to assessing individual performance, as response time and accuracy on more difficult shapes can vary more widely from person to person.

It is necessary for each individual AlertMeter® user to establish a baseline, or performance standard. Generally, a user's first ten tests are used to determine his or her individual baseline, but different populations may require more than ten tests to become familiar with the test-taking process. Allowing users to practice the test and to become familiar with the shapes is recommended. A "rolling baseline" is activated within the scoring algorithm after 20 to 25 tests are completed, which accounts for the "learning effect," or enhanced performance related to users' increased familiarity with the test.

Some people attempt to manipulate or "game" the test, for example by intentionally guessing the answers to achieve higher scores or purposefully answering incorrectly to intentionally lower their test scores. The software provides several internal settings that, when triggered, require the user to restart the test. For example, after a user records three consecutive incorrect answers, the interface displays a warning message, requiring the user to restart the test. The software's settings can be configured to generate a supervisor notification in the event of a user triggering multiple or repeated indications of potential "gaming."

The primary purpose of the AlertMeter® test is to inform system participants when they may be impaired. Because individuals react to various forms of impairment differently, determining the threshold for impairment needs to be associated with the individual's unique performance parameters. This is a best practice in measuring and attempting to manage risk from cognitive impairment. There are several strategies by which impairment thresholds can be set based on an individual's performance. AlertMeter® includes the ability to utilize parameters collected as part of the user's baseline to determine individualized impairment thresholds. These include setting minimum limits as a percentage of the baseline or using statistics and machine learning to determine outlier scores when compared to a person's past performance.

Feedback after a user completes a test is another key to AlertMeter's® effectiveness. Once a user's baseline is established, each test concludes by showing the user his or her score expressed as a percent of their established baseline. Also, the results screen can be configured to display messages appropriate to the settings for impairment or gaming. Depending on the client's selected workflow, secondary messaging can be displayed to provide instructions to the user based on the results of the particular test. The user can also view the current test's score in relation to his or her last several tests. Additional related information may be included such as highlighted milestones completed by the participant, such as:

- Total tests completed
- Highest score
- Percent of baseline increase over a given timeframe

This type of additional feedback is useful for motivating and encouraging users to remain engaged with the AlertMeter® system and to comply with companies' established processes for its use.

To accurately track personal or employee performance, key data are collected from each test taken. Minimally, these include user ID, date and time stamp for the test, raw score, and the associated baseline value. Other inter-test parameters may be specified for collection based on client requirements and/or custom survey question responses.

### How AlertMeter® Compares to Other Cognition Tests

Although a number of cognitive tests have been devised since the 1970s for various purposes, AlertMeter® stands apart for its specific applicability as a viable workplace safety tool. The AlertMeter's® uniqueness lies principally in its brevity and simplicity when compared to other forms of cognitive tests.

Because of its connection to sleep and fatigue research, the psychomotor vigilance task (PVT) might be considered a spiritual predecessor to AlertMeter®. The PVT lasts five to ten minutes, and the task is simple: press a button when the light appears.[32] While the PVT has been shown to provide much depth of insight regarding an individual's cognitive state, its five-to-ten minute duration is impractical in the workplace. In addition, although cognitive executive function can be assessed with the PVT, given its length and scope, it focuses on vigilance or reaction alone. The AlertMeter® test is a more comprehensive assessment of executive function as it incorporates a decision-making aspect (measured by accuracy) along with reaction time.

Another important method of assessing cognition is the battery of tests known as the Cambridge Neuropsychological Test Automated Battery, or CANTAB, originally devised in the 1980s at the University of Cambridge. A comprehensive battery of 25 neuropsychological tests examining learning, executive function, attention, reaction time, and different kinds of memory, CANTAB provides a thorough, medically valid assessment of a user's neuropsychological state.[33] However, such depth is unnecessary for a workplace environment. Cognitive assessments the size and scope of CANTAB exceed the needs and time allowances for the modern workplace. Lasting approximately one minute, the AlertMeter® test is more reasonable for today's workplace and it is focused on key elements of cognitive alertness required to ensure alert workers and a safe work environment.

The Automated Neuropsychological Assessment Metrics (ANAM) has similarities to CANTAB in that they are both batteries of tests. The tests in the ANAM library are sensitive to variance in cognitive functions like attention, concentration, memory, and reaction time, and were originally developed and patented by the U.S. Department of Defense. Currently, ANAM is licensed exclusively to the University of Oklahoma. Like CANTAB, ANAM was not designed for implementation as a workplace safety measure; a single test battery can take approximately 20 minutes to complete[34] and the depth of its results exceed the needs of a workplace safety system.

## How AlertMeter® Compares to Other Fit-for-Duty Tests

The term "fit-for-duty test" encompasses a wide category of assessment, an alertness/impairment test like AlertMeter® being one. Many fit-for-duty tests are implemented only when an employee is returning to work after having been away, often recovering from a work-related injury. In these circumstances, the components of the fit-for-duty test often reflect particular job functions or actions and the test is performed only once or twice. They are not meant to identify potential impairment risk daily, but only to confirm an employee's basic ability to undertake the tasks inherent in his or her job.

As part of a field study in 2000, two fit-for-duty tests that were commercially available at the time were implemented in actual workplace settings, but with mixed results. Although some employees reported a positive experience, some claimed the tests were incapable of detecting impairment or found them difficult to complete when not impaired.[20] One test, called the Delta-WP, is no longer available. The other, then called Factor-1000, was a more robust test and is still available in its newest iteration, now known as the FIT 2000.[35] Both tests have seen limited implementation, likely because they require proprietary hardware. Purchasing multiple units also may not be feasible for organizations with limited budgets. Conversely, AlertMeter® can be operated using common technologies already utilized in the workplace, such as computers, laptops, tablets, and even smartphones.

The same issue limiting the use of the FIT system was found when included in a study conducted by the National Workrights Institute in 2010. Alongside FIT and the Bowles-Langley BLT Tester (the original AlertMeter® prototype), was SafetyScope, a tool measuring subtle eye movements to detect changes in alertness levels.[22] Although SafetyScope showed promise, it appears to be no longer available, as it too may have proven ultimately incompatible with the workplace for requiring proprietary hardware. Because AlertMeter® is a software-based solution that uses mobile and Internet technology, it is automatically more feasible as a workplace safety solution.

Alertness testing is gaining traction as a contemporary workplace fit-for-duty standard. It shows value as a complement to workplace drug screens because alertness testing can detect potential impairment regardless of the cause. This includes fatigue, which factors more commonly in workplace accidents than drug use.[18,22] Employee drug and alcohol screening as a fit-for-duty measure is necessary to ensure a safe and productive workplace. However, there are many medications and illicit drugs that cause impairment (e.g., drowsiness), but they are not included in typical employment drug screens, such as over-the-counter medicines and "designer" or "club" drugs.[14] Alertness testing as a complement to drug testing and fit-for-duty assessment has the potential to increase employee wellness, improve communication between frontline workers and their supervisors, and reduce both absenteeism and deviant workplace behavior.[29,31]

### AlertMeter® in Real Workplace Environments

The issues presented by today's changing social landscape and workplace climate led Colorado-based manufacturer Vforge to embrace alertness testing with AlertMeter®.[29] "We were really struggling to hire people who could get in the door and pass a [drug] test," says Jon Young, General Manager of Vforge:

> *What we liked most about how AlertMeter® aligned with our philosophy of the workforce was that culturally it was a shift in how we respected the employee and their well-being, and the regard for their safety when they came to work. And that is a different message and tone than the options we had in drug testing.*[29]

Together with this cultural shift over a two-year period using AlertMeter®, Vforge saw a 35% reduction in employee turnover, an 11% increase in productivity, a 90% reduction in drug testing costs, and a staggering 70% reduction in workers' compensation insurance claims.[29] The reduction in expenses not only illustrates AlertMeter's® cost-effectiveness, but also that Vforge became a safer workplace. By extension, AlertMeter® is becoming attractive to workers' compensation insurance companies as an instrument to improve safety and drive down costs.

Gary Ostermueller with Prudential Stainless Pipe in New Jersey shared a similar experience with AlertMeter® at his company:

> *Our initial concern was two-fold. Workers reporting without an adequate amount of sleep, as well as a defense against substance impairment. We found the AlertMeter® to satisfy both of our needs.*

AlertMeter's® sensitivity to impairment related to shiftwork was recognized in data gathered and analyzed as part of a pilot project at an Ontario-based mining engineering company. The data was gathered over a 12-week period and focused on 15 employees who worked 12-hour rotating day/night shift cycles of 14 days each. Each employee was required to complete ten tests over five separate days to establish their initial baseline scores. While no individual showed an exceptionally high number of impaired test scores, eight of the 15 employees scored below the minimum threshold on more than one occurrence at the beginning of their shifts. Normalizing these results over all 15 employees revealed an overall 4% rate of below-threshold (impaired) scores at shift start.

Analyzing when the impaired scores occurred during the 14-day shift period, days posing higher levels of fatigue risk were observed. Comparing the number of below-threshold scores between day and night shifts did not show any statistical differences. However, as is expected with 14-day shift patterns, both day and night shift patterns showed a statistically significant ($p = \leq 0.05$) increase in the number of impaired scores for days 10 through 14 of the shift period when compared to the first nine days of the shift pattern (Fig. 6).

This can be seen when looking more closely at sample charts of individuals' test times (Fig. 7). The x-axis represents the date and the y-axis is the time of day. Each dot represents a completed AlertMeter® test, and a red dot represents a below-threshold (impaired) score. Below-threshold scores occur most frequently toward the end of a shift period, before a period of days off, and when rotating to the other shift in the cycle (Fig. 7).

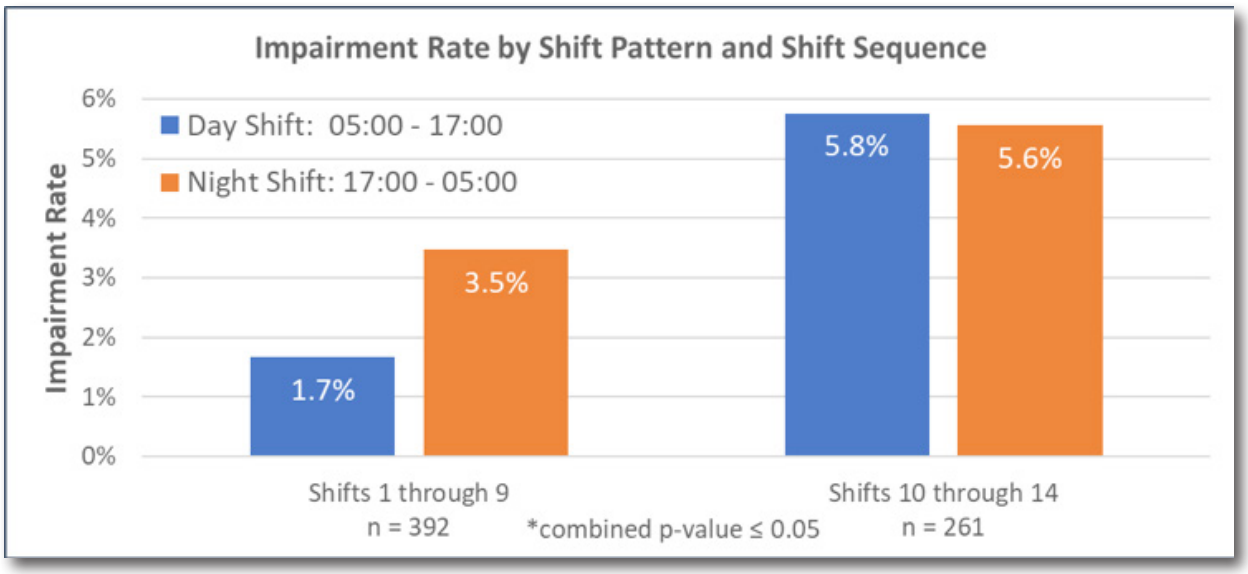



*Figure 6: Rate of below-threshold (impaired) AlertMeter® results comparing the first 9 shifts with the last 5 shifts worked in a 14-day shift pattern.*

An additional analysis of this pilot study data normalized scores by baseline percentage to determine if there were observable trends as employees worked through their 14-day schedules. A notable trend was observed for the morning shift: over the 14 consecutive shifts, alertness scores dropped by 7%. While this would not necessarily be concerning for fully-rested people, this decrease could suggest added fatigue risk experienced by employees already experiencing stress, illness, or a lack of sleep toward the end of the shift pattern. This negative trend correlated with the increase in the number of below-threshold test scores for the morning shift toward the end of the shift pattern (Fig. 7).


*Figure 7: Charts of three sample employees' AlertMeter® test times and dates on a rotating 14-day shift pattern. Red dots indicate a below-threshold (impaired) score.*

## Research Studies Involving AlertMeter®: Past, Present and Future

Since the prototype's inclusion in the National Workrights Institute's 2010 study,[22] AlertMeter® has been garnering attention among academics and has begun to be used in a variety of clinical and applied workplace research.

In 2016, AlertMeter® was used in a study among 300 emergency medicine residents at an academic hospital in the Midwest. The study showed a general correlation between average AlertMeter® scores and time of day; scores were generally lower during circadian "lulls" like the mid-to-late afternoon and between 3:00 and 5:00 a.m. In addition, the study showed a general correlation between residents' self-reported alertness levels and AlertMeter® test scores. The report of findings is currently under peer review for publication in an academic journal.

Beginning in 2017, another teaching hospital in the Northeast began using AlertMeter® alongside other forms of computerized assessments to investigate how acute marijuana intoxication impacts certain cognitive abilities. Presently, this study is underway.

Also beginning in 2017, researchers from Colorado State University began a research study in conjunction with a pilot project involving AlertMeter® at participating Colorado businesses, funded by a grant through the Total Worker Health initiative with the Center for Health, Work & Environment at the Colorado School of Public Health. Funding for this pilot study is supported by the National Institute of Occupational Safety and Health (NIOSH). The pilot project and associated research is also currently underway and projected to conclude by Fall 2018.

Numerous research activities are ongoing internally, including analyses regarding specific shape combinations and shape families used in populating AlertMeter® tests. A goal of this internal research effort is to identify and validate shape difficulty given differences in individuals' test-taking strategies.

Additional research being pursued internally deal with examining correlations between performance data from client data collected between 2016-2018 and the original clinical validation study in 2009.[26] Finally, graduate degree candidates in data science and related fields at the Colorado School of Mines recently analyzed de-identified AlertMeter® data from client companies to confirm the internal analyses related to shape combinations, scoring algorithms, and other key features of test design and use.

Planned future research activities include additional validation studies of AlertMeter's® grid and mobile platforms. Researchers from the Colorado State University, University of Colorado at Colorado Springs, and the University of Denver are interested in using AlertMeter® in various studies ranging from an inquiry into different baselining methodologies, examining fatigue and compromised alertness risk in the transportation industry, and effects of brain-based training interventions for police academy cadets. All planned studies are expected to commence in 2018 and 2019.

## Conclusions

Because non-alertness and cognitive impairment are not always apparent, the dangers they present are often recognized only after an incident occurs. Fatigue is a leading contributor to accidents in the workplace, but safety policies and regulations, by nature, cannot address these hazards commensurately with their impact on workplace safety. It is now becoming widely understood that impairment from fatigue can be the same as impairment from alcohol intoxication, causing poor judgment, delayed reaction, and compromised balance and motor skills. However, being fatigued is not illegal, taboo, nor often a matter of choice. Diminished alertness can develop from other causes like illness, over-the-counter and prescription medications, and distraction or preoccupation, like from dealing with a personal crisis or increased stressors from one's personal life. In spite of these facts, the majority of safety-sensitive workplaces still consider only the dangers presented by intoxication from drug use when addressing impairment risk.

AlertMeter® meets all criteria for a viable workplace-appropriate fit-for-duty test according to researchers Burns and Sturmhöfel,[13] and today's technological and cultural climate has begun to lead employers, their employees, and people in general to recognize not only the limitations in workplace drug testing, but the need for a viable, preventative safety solution that helps reduce risk from all types of impairment and in a way that respects employees' privacy while improving productivity, reducing turnover, and lowering costs.[29] AlertMeter® represents a way for organizations to be more proactive, rather than reactive, in their safety management. It allows for the reduction or elimination of potential human error and lapses in safety performance, which no safety policy, system, or regulation alone can do.

*AlertMeter® is an excellent tool for businesses looking for a "real-time" impairment testing solution . . . In the age of recreational marijuana, prescription drugs, alcohol use and workplace fatigue, determining an employee's cognitive ability and readiness for work has become complex and often requires more than a drug testing program alone. Based on the results of a pilot project, Pinnacol's Safety Services team anticipates AlertMeter® will yield positive results from customers looking to mitigate workplace accidents associated with employee impairment.*

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Predictive Safety

**About Predictive Safety**

*Predictive Safety SRP, Inc. is a Colorado-based company with a mission to improve safety in today's workplaces by integrating new technologies and science into existing practices. Predictive Safety's philosophy is that leading indicators of safety performance can be leveraged using aggregated data in automated platforms that enhance safety processes. Predictive Safety's data scientists and safety experts have spent their careers developing automated, easy-to-use platforms that help effectively manage risk while improving safety and productivity. Predictive Safety has offices in the United States, South Africa, Germany, Australia, Peru, Brazil, and Chile.*

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