

# SLEEP DIAGNOSTICS: MANAGING THE RISKS OF DROWSY DRIVING

BY DR MURRAY JOHNS AND JOHN PRENDERGAST

Mine-sites are not the same as most other work-places. But like all work-places, most of their problems in relation to safety are caused by human errors. Of course, people at all levels need to be trained so they know what to do and how to do it safely. The equipment and materials used and the physical environment of the work-place should be safe. There are many rules and regulations to try and ensure safe work practices. Nevertheless, when all these things have been done and adhered to, human errors still occur, and all too often they have catastrophic consequences.

Drowsiness at work, especially when driving, is an important factor in safety because it greatly increases the risk of making errors unwittingly. Drowsiness is the intermediate state between alert wakefulness and sleep. We all go through this state whenever we fall asleep, whether intentionally when lying in bed, or unintentionally at other times when trying to remain awake to do something. Drowsiness typically lasts only a few minutes when we are lying in bed intending to go to sleep, but if we intend to remain awake, as when driving, it can last much longer. It is a dangerous state to be in when driving. It is associated with greatly increased risks of "performance failure" in general, which may mean driving off the road and crashing.

## The Risks of Drowsy Driving

Drowsy drivers are believed to cause about 20% of all highway crashes in Australia and elsewhere. The figures may be even higher, but this is hard to prove because, until now, the drowsiness of drivers could not be measured accurately. It is often difficult for drivers to assess their own state of drowsiness and the risks that it involves at any particular time. Because drowsiness intermittently reduces the awareness of everything, drivers will usually not be aware they are dozing at the wheel until after the event, when they rouse again (if they survive) and suddenly realize what has been happening.

That loss of awareness may last only a few seconds at a time, but that can be long enough to cause havoc. Four seconds is plenty of time for a drowsy driver to drive off the road and crash. Having dozed off once, and if the first episode happens to pass without incident, it is very likely that a drowsy driver will doze off again unless remedial action is taken. The consequences of drowsy crashes

are often the most serious in terms of death, injuries and property damage because the drowsy driver makes no attempt to avoid the impending crash e.g. no brakes are applied and the crash occurs at full speed.

That is why drowsy driving is so dangerous, more so than the state of fatigue which is often confused with drowsiness. Most of us will be fatigued after many hours of work, with feelings of weariness, possibly with muscle aches, and a sense of wanting to stop doing what we have been doing for too long without a break. Those feelings are annoying, and the more fatigued we are, the more aware we are of them. However, "Fatigue Management Schemes/Plans" need to address the more serious and dangerous problem of drowsiness specifically. They might more accurately be described as "Drowsiness Management Schemes", but that is a new idea that has not yet caught on.

Because of the very nature of the drowsy state, it can be difficult for drivers to decide when to take remedial action to avoid falling asleep at the wheel and crashing. That is where a new device called Optalert comes into play. Optalert does not replace "Fatigue Management Schemes". It adds another dimension to them, to be used in conjunction.

## What Causes Drowsiness?

The tendency to become drowsy at any particular time is determined by many different factors, including the following:

- How long you have been awake since the last period of sleep. The longer you have been awake, especially if more than about 17 hours, the more likely you will be to become drowsy and fall asleep.
- The time of day. Your body and brain have a circadian rhythm that determines that you will be more alert for part of the 24 hours (typically during the day and evening) and more drowsy at other times (typically overnight). It will nearly always be more difficult to remain alert between midnight and 5 am than at other times.
- The quality and duration of your last period of sleep. If you have had a poor night's sleep (either very little of it or very fragmented sleep) for whatever reason, you will be more drowsy next day.
- What you are doing at the time. If you standing up and being active, physically and mentally, you can remain alert much more readily than if you are sitting down and being inactive. Some jobs have been designed so there is little to do except sit and observe, making only occasional

movements. That may reduce the problem of fatigue, but it actually makes drowsiness worse. So does boredom when the task at hand is monotonous.

- Sleep disorders. There are several sleep disorders, including Obstructive Sleep Apnea (OSA), that make people excessively sleepy during the day no matter how many hours of sleep they have had. OSA involves repeated episodes of obstruction of the upper airway, particularly behind the tongue, during sleep. The sufferer is seldom aware of this, but the bed-partner is usually very aware of it because of loud snoring, then a period without breathing, followed by a loud gasping noise. OSA is common in the general community, and there are several other sleep disorders that make people drowsy during the day. If any driver suspects that he/she may have such a disorder, a visit to their general practitioner and perhaps referral to a specialist in Sleep Medicine can help with a diagnosis and successful treatment.

The most common reason for drivers to be excessively drowsy is simply not having enough sleep, for whatever reason. Some people seem to think that a good night's sleep is a waste of time, but it isn't. It is an important part of staying healthy. Optalert does not distinguish the cause of a person's drowsiness. It simply measures the driver's drowsiness from minute to minute, regardless of how much sleep he has had, the time of day, what he is doing at the time, whether or not he has a sleep disorder, and whether he is affected by alcohol or drugs at the time.

## Safety Devices

Optalert is a device that measures the drowsiness of drivers continuously and objectively while they drive. The driver doesn't have to do anything in particular to use Optalert apart from wearing a special pair of glasses. Optalert warns drivers when drowsiness first appears, so the most dangerous levels of drowsiness can be avoided.

Most drivers are happy to wear sunglasses in bright sunlight. Optalert glasses look like ordinary sunglasses or glasses, and they are worn the same way. However, they contain sensors that measure the driver's eye and eyelid movements unobtrusively.

Optalert can detect the very beginning of drowsiness from the pattern of those eye movements. Whenever Optalert detects drowsiness, and often before drivers become aware of it, they are warned by a loud



beeping noise and a voice-message. That allows drivers to take action, to manage their own drowsiness before falling asleep at the wheel and possibly crashing.

Optalert glasses have an extra arm that contains a very small source of invisible light. This emits very brief pulses of infrared (IR) light 500 times a second, directed up from below the left eye towards the upper eyelid. The light from each pulse is reflected back from the eye and eyelids and is measured by a sensor in the glasses frame. We are constantly exposed to similar IR light from other sources, including daylight and all kinds of artificial light. We cannot see this IR light because it is outside the visible spectrum. The very small additional amount of IR light from Optalert glasses does not pose a health risk to the user. The effects of extraneous IR light on the device are removed, so Optalert works in the dark and in all light conditions, even when the light is changing rapidly eg in sunlight filtered through a row of trees.

Optalert measures how quickly the eyelids close and reopen during blinks, and for how long the eyelids remain closed at a time. When we are drowsy, our eyelids move more slowly and the eyelids tend to stay closed for

longer during blinks and other eyelid closures than when we are alert. Most blinks are spontaneous and are controlled by reflexes that we are not aware of. Those reflexes are very similar in all of us, and are influenced by our level of alertness/drowsiness at the time. Optalert uses a combination of variables characterizing eye and eyelid movements to derive a measure of drowsiness every minute on the Johns Drowsiness Scale (JDS) which ranges from 0 to 10, where 0 = fully alert and 10 = very drowsy.

An example of some raw data that Optalert has recorded from a haul truck driver is shown in Fig 2.

This detailed information about individual eye movements is not normally available to users, but it can be reviewed later if there is doubt about a particular event that was recorded. However, all JDS scores are available to users. The Optalert system can also record video images of the driver, but only for research purposes, as was the case here.

JDS scores do not have to be calibrated for individual users. For alert people, JDS scores are usually within the range 0 to 4.5. With a JDS score of 5 or more, drivers have significantly increased risks of doing

dangerous things that they would not do when alert, such as unwittingly driving off the road and hitting a tree, another vehicle, or some other object. What they hit is a matter of chance alone.

Optalert measurements are made on the left eye only, and are not affected by the user wearing contact lenses. If prescription lenses are required, they can be made to fit into the Optalert lens-holder provided. Optalert comes also with its own sunglasses and with yellow lenses for night driving, if required. The glasses are fitted for each driver individually. They are not transferable to other people, but they will work in any vehicle fitted with Optalert.

#### Systems for Vehicles

Optalert is currently being used at mine-sites, especially in haul trucks, in Australia, South America and South Africa. Of course, this technology can also be used in most other vehicles and environments, including cars, 4-wheel drive vehicles, road transport vehicles, buses, and trains.

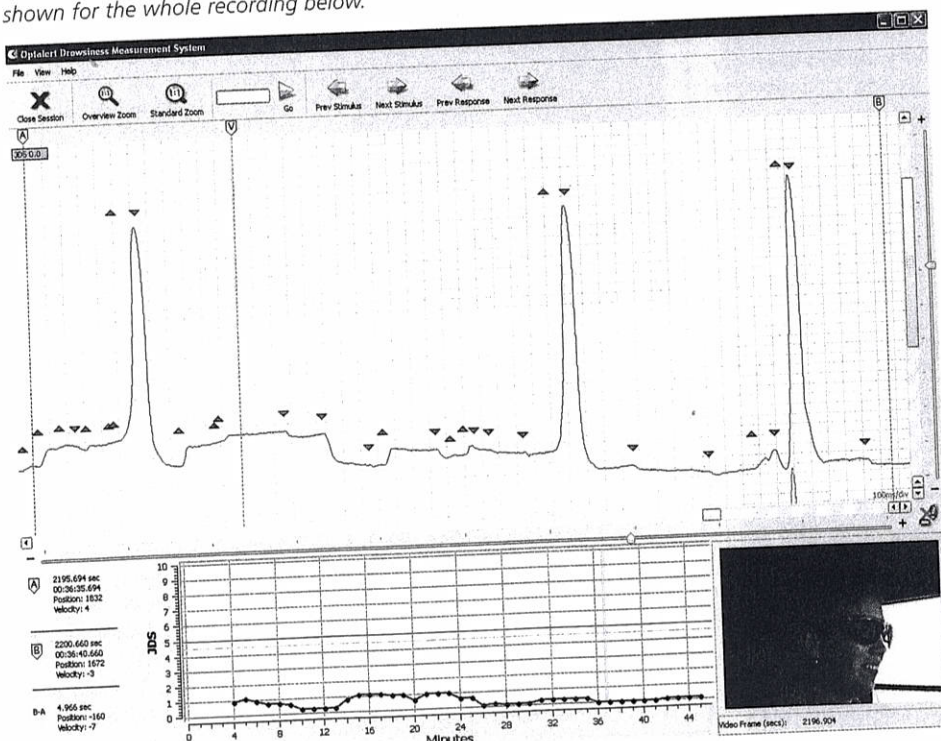
Fig 3 (Next Page) shows how the Optalert system is usually configured in trucks.

The Connection Point is where the driver plugs the Optalert glasses into the vehicle system. The glasses can be quickly disconnected, simply by pulling on the cable. The processor is the information hub of the system. It is a computer that continually processes all the data about eye and eyelid movements obtained from the glasses to calculate a measure of the driver's level of drowsiness. The speaker emits beeps and voice warnings when the driver's drowsiness approaches or exceeds a dangerous level. The indicator on the dash-board displays the operating On/Off/Signal status of the system continuously and also lights up when the driver's drowsiness becomes dangerous. There is normally no video camera used with Optalert in trucks.

#### Reports

Drivers are the most important people to be given information about their own drowsiness from minute to minute as they drive, information that could save their lives. They don't need a lot of other information that could distract them from their task of driving safely. However, that information is stored by Optalert, and summaries can be made later at the end of a shift for the driver and others to review. Summary reports can be prepared for individual drivers, particular shifts, or the whole work-force over periods of a few days to weeks (Fig 4). This clearly shows when the

Fig 2. Individual eye and eyelid movements of a haul truck driver recorded over 5 seconds (above) during the 36th minute of a 45 minute recording. The JDS scores, each minute, are shown for the whole recording below.





## Sleep Diagnostics: Managing the Risks of Drowsy Driving - continued

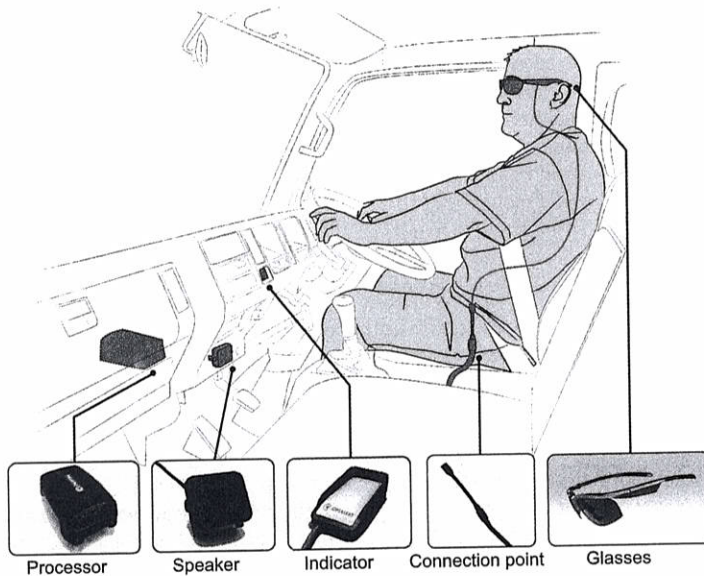


Fig 3. The components of the Optalert system in trucks

> risks of drowsy driving are greatest, and can help to manage that at a corporate level.

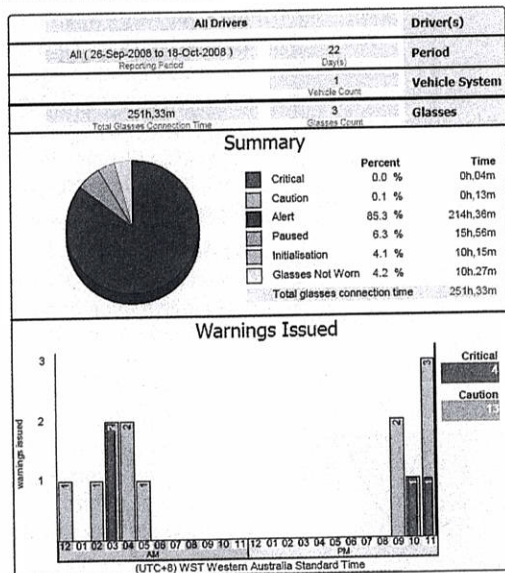
### Managing Drowsiness Detected

The safety device Optalert gives two different warnings about drowsiness. The first is a 'cautionary warning', given when drivers

show the early signs of drowsiness, often before they recognize it as a problem. Drivers should take note that things could get worse from this point quite quickly, and they should drive very carefully. They should plan their next stop and be prepared to implement a drowsiness strategy.

Fig 4. A summary report for a group of three drivers, each driving for several shifts for a total of 251 hours.

### OPTALERT™ Driver Activity Summary All Drivers



The second Optalert warning is a 'critical warning', at which point the driver is no longer fit to drive. The risks of a drowsy crash or "accident" at the time are greatly increased, by 10 times or more. That warning is not intended to keep the driver alert. It cannot do that for more than a few minutes, but in that time the driver should stop driving as soon as it is safe to do so.

How best to proceed from this point will depend on the circumstances within each organization and each mine-site. When drivers receive Optalert warnings, it is possible to send that information directly to a manager who can advise on the best course of action, if that is required. This is something that management have to decide at each mine-site, albeit with advice from experts at Optalert Pty Ltd. It may be feasible to replace the drowsy driver with another who is more alert, but that is not always possible. The best way to overcome drowsiness is to sleep – to have a nap for 15 or 20 minutes is usually sufficient, after which the driver may be fit to continue. Optalert will determine that. It is not enough simply to rest for a while, which may reduce fatigue but not drowsiness.

Drivers may choose to postpone their drowsiness for a while by taking some caffeine, for example as cup of coffee, a cola drink, an 'energy drink', or perhaps as pure caffeine (No Doz). Caffeine is one of the world's most commonly used substances in beverages and other forms, and it is usually effective in delaying the onset of both drowsiness and fatigue. Unfortunately, our bodies get used to it if we take too much. A cup of coffee may have anything from 40 to 120 milligrams or more of caffeine in it.

The amount in coffee from different sources is very variable, and is not easy to predict. A cola drink may have 40 milligrams and an energy drink 80. An advantage of using a tablet of pure caffeine is that you know how much you are getting, and it is considerably cheaper than the alternatives. If you regularly take more than about one gram (1000 milligrams) of caffeine in its various forms per 24 hours, it becomes less effective and can produce withdrawal symptoms later. When used judiciously, and not routinely in high doses, caffeine can be very helpful to drivers. When drowsy drivers receive a 'critical warning', they could take 100 milligrams of caffeine and then have a nap for 15 – 20 minutes, in that order. The caffeine takes about 20 minutes to work, and if drivers get some sleep during that time, they benefit from both.