FATIGUE PREVENTION IN THE OIL AND GAS INDUSTRY

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Using WOMBATT's innovative voice-based AI fatigue prediction and FRMS App to comply with the technical requirements of ANSI/API Recommended Practice 755, Second Edition May 2019
'Fatigue Risk Management Systems for Personnel in the Petroleum and Petrochemical Industries'

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WOMBATT
Worldwide Online Monitoring By Alerting Tired Travellers

Introduction

At 1.20 pm on March 23, 2005, a column of highly flammable material being pumped over a 12 hours period into a narrow, 30 metres tall tower tank at BP's Texas City refinery in Texas, USA overflowed, creating a fast-expanding ground level mass of liquid and gas that was ignited by exhaust pipe sparks from a nearby diesel pickup truck, which had been left running, causing a massive explosion. The accident left 15 people dead and 180 injured. A gauge which measured the height of material in the tank stopped working at 3 metres, so the single control centre operator (the day board operator) who was remotely monitoring the operation that morning assumed that the height of the material in the tank was 3 metres at a time when it was already at 25 metres. He and other external operators did not notice information showing that the material continued to be pumped into the tank, and for many hours failed to cognitively connect that the tank was still receiving material long after the gauge had stopped rising at 3 metres.

The subsequent investigation over the following two years by the US Chemical Safety and Hazard Investigation Board (CSB) found that the day board operator who was monitoring the operation that morning had been working a 12 hour's shift for the past 29 days, and had been getting an average of 5 to 6 hours sleep per night over that period, although he reported feeling rested only after 7 hours sleep. The night lead operator, who had initiated the filling of the tank during the previous night shift, had worked for 33 consecutive days, The day lead operator, who was busy doing other work that morning, had been on duty for 37 consecutive days, while a fourth external operator had worked 31 consecutive days. All of these highly experienced operators were working daily 12 hours shift schedules.

The day board operators' daily commute took 30 to 45 minutes each day, providing him with 10.5 to 11 hours off work each day. He spent this time for family duties, meals and other things. Based on these facts, the CSB investigation found that the day board operator had built up a sleep debt of 43.5 hours by the time of the incident, and concluded that the incident had been in part caused by the fatigue of the day board operator in the control centre, and of three external operators involved with the tank that morning.

Root Causes

The fatigued day board operator and the also fatigued external operators did not notice that material was still entering the tank but not being removed, that the tank was overfilling, and they therefore did not foresee that the consequences could be catastrophic. Nobody made the cognitive connections required to see that all was not well. This was, according to the CSB report, because people experiencing fatigue are more rigid in their thinking, are slower to respond to changing circumstances, and take longer to reason correctly than fully rested people. During the course of the morning of March 23, repeated pressure spikes occurred in the tank indicating that all was not well, but operators tried to relieve the pressure without asking why it was occurring. They were focused on the immediate problem, not the underlying cause. This is called cognitive tunnel vision or cognitive fixation and is a typical effect of fatigue. It is possible that as it was the high energy morning period of the daily circadian rhythm, the operators may have actually felt fit at the time, but individuals are poor self-assessors of fatigue, and are often unlikely to admit or even to recognize that they are too fatigued to work safely. The CSB report concluded that both the day board operator and the external crew were experiencing significant sleep deprivation fatigue during the leadup to the incident, degrading judgement and causing cognitive fixation.

Outcomes

The CSB report recommended that the American Petroleum Institute (API) and the United Steelworkers International Union (USW) work together to develop two new standards for the American National Standards Institute (ANSI).

1) Create leading and lagging performance indicators for process safety in the refinery and petrochemical industries
2) Develop fatigue prevention guidelines for the refining and petrochemical industries that at a minimum, limit hours and days of work and address shift work.

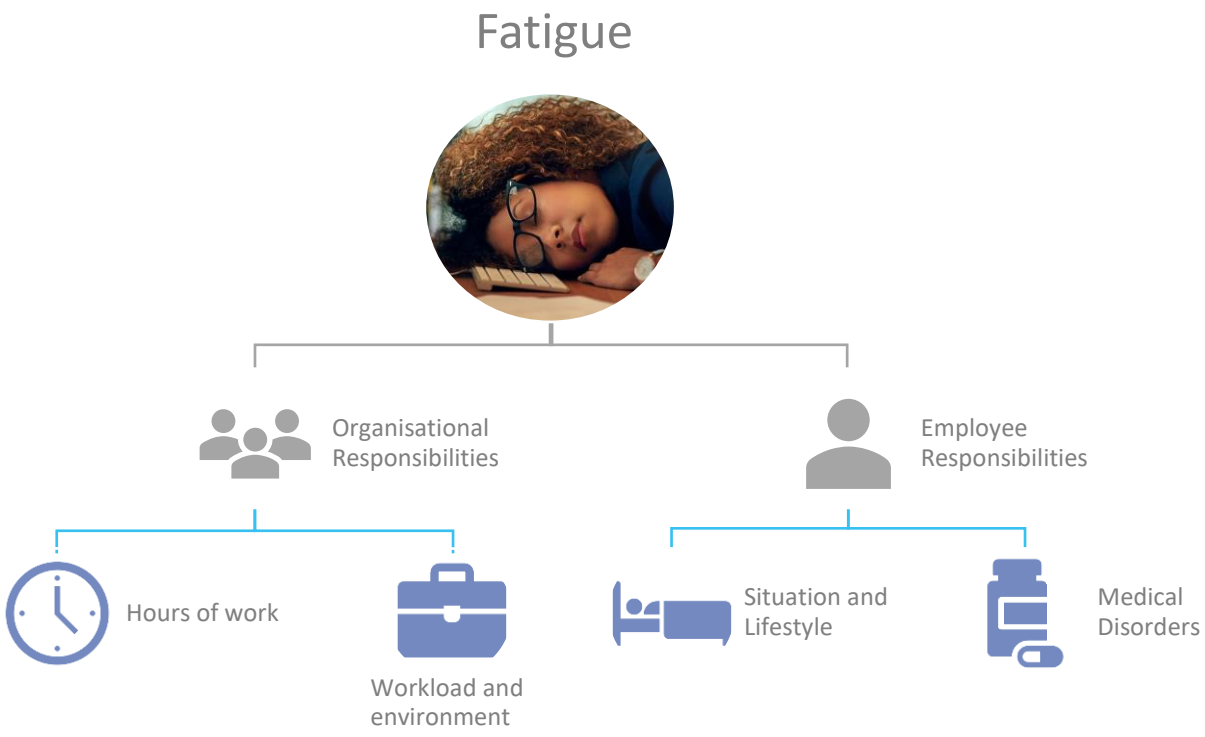
These recommendations resulted in ANSI/API Recommended Practice 755 First Edition 2010. This was followed up with ANSI/API Recommended Practice 755 Second Edition 2019.

Key element of ANSI/API RP 755 2nd Ed is to provide guidelines to setting up a Fatigue Risk Management System (FRMS) for the Oil and Gas industry, which did not have any standard FRMS up until that time.

Fatigue Risk Management System (FRMS)

The FRMS was first conceived in Space by NASA during the 1980s for long duration Space missions, as astronaut fatigue is one of the top five risk factors in Space. The worst fatigue related Space disaster was the Challenger Space Shuttle in 1986, where some key launch managers had only had 2 hours of sleep in the prior 24 hours before launch. Poor judgement and human error in the launch sequence due to sleep deprivation were listed among the causes of the disaster. The NASA originated FRMS was first implemented in the aviation industry by Air New Zealand in 1993 for ultra long-haul Auckland to London flights, and later by Singapore Airlines in 2003 for ultra long haul A340 flights from Singapore to New York.

The FRMS components are 1) Predictive - monitoring sleep hours and work schedules, predicting fatigue risk, 2) Proactive – monitoring real-time worker fitness for duty and real time incidence of fatigue, and 3) Reactive - incident review and after the fact analysis. All FRMS installations include these 3 components.



ANSI/API Recommended Practice 755 Second Edition 2019

The main emphasis underlying API RP 755 (see Appendix 1) is proactivity, where both workers and management work together to ensure that workers get sufficient sleep, as sleep deprivation is the major cause of fatigue at work. This can be summarised as follows:

1) **Shift schedules planning**. The best shift schedule from a sleep and fatigue view is the 8 hours shift, which leaves 8 hours for sleep and 8 hours for other things. But workers prefer the 12 hours shift which now comprises the majority of shift schedules in process industry, because it provides longer blocks of free time. However, a 12 hours shift does not provide enough time for 8 hours sleep opportunity, plus commuting, meals and family time. Generally, it is sleep opportunity time that suffers, as was the case with the day board operator at BP Texas City, who needed at least 7 hours sleep per night, but only got 5 to 6 hours over a long period, resulting in 1.5 hours of sleep debt being built up each night, and 10.5 hours of sleep debt each week. Workers will start experiencing sleep deprivation fatigue with only 2 to 3 hours of cumulative sleep debt.
2) **Self Awareness and Self Reporting of Fatigue**. Clause 4.6 of the Standard, *Individual Risk Assessment and Mitigation*, states that 'companies shall encourage individuals to be continuously aware of their level of fatigue'. If employees feel fatigued, they should report this to their supervisor, which requires a culture of fairness to exist between workers and management. Workers should also report signs of fatigue in other workers.
3) **Fitness for Duty**. Restricted sleep, stress, medical conditions and certain medications may affect fitness for duty, and systems must be in place to determine whether a worker is fit to start work.
4) **Supervisors Role**. Supervisors need to watch for signs of fatigue among their subordinates, and where they find fatigue, take immediate action.
5) **Near Miss Investigation**. All near miss investigations must include an assessment of whether fatigue played a role in the incident.

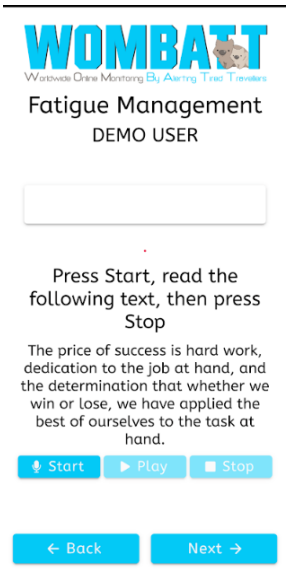
WOMBATT Voice Based Fatigue App Enables Compliance with ANSI/API RP 755

WOMBATT Fatigue Management was founded by Prof. Jean Verhardt at the University of South Australia in 2000 to develop the worlds first FRMS designed specifically for the mining industry, with assistance from the university's Centre for Sleep Research. In 2009/2010 WOMBATT joined the European Space Agency technology incubator in Noordwijk, the Netherlands under an ESA Business Solutions grant, to develop WOMBATT's mining FRMS into a fully-fledged, satellite based remote driver fatigue monitoring system using truck mounted third party fatigue detection technology at a test site at the STRACON El Brocal mining operation in Cerro de Pasco, Peru. With input from the Centre for Sleep Research, the El Brocal trial was designed from the outset to be fully compliant with the Oil and Gas Industry's FRMS Standard ANSI/API RP 755 First Edition, which was published in 2010. From 2015 to 2020, WOMBATT developed the WOMBATT-VOZ voice-based AI fatigue prediction and FRMS mobile App under the European Space Agency Artes 20 programme, with mining haul truck data gathered at the La Arena mine in 2015, another STRACON mining site in Peru, and tested at the Fort Knox mine in Alaska in 2019. For the Fort Knox trial, the WOMBATT FRMS App was updated to be fully compliant with ANSI/API RP 755 Second Edition, which was published in May 2019.

WOMBATT-VOZ AI Voice based FRMS APP is compliant with the ANSI/API RP 755 Standard, and follows the ISO 31000 Standard

According to the API Standard notes, the term 'SHALL' in the text denotes a minimum requirement to conform to the standard. The term 'SHOULD' denotes a recommendation but is not essential to conform to the standard. 'MAY' is a permissible course of action, and 'CAN' denotes a statement of possibility or capability.

The definition of 'fatigue' in the API RP 755 Standard is '*Reduced mental and physical functioning caused by sleep deprivation and/or being awake during normal sleep hours. This may result from extended work hours, insufficient opportunities for quality sleep, failure to use available sleep opportunities, or the effects of sleep disorders, medical conditions or pharmaceuticals that reduce sleep or increase sleepiness'.*

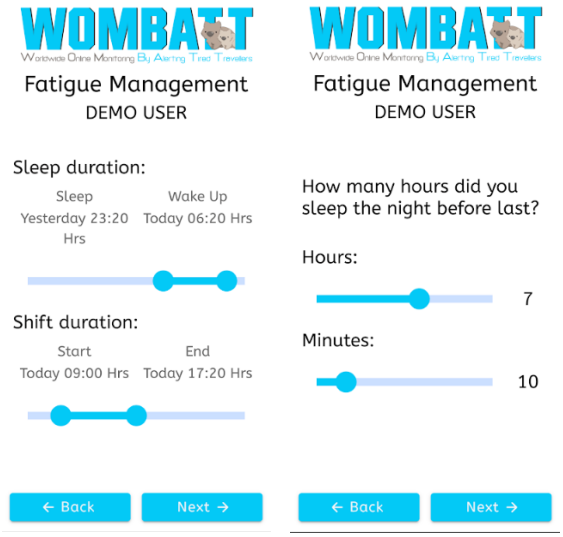


The ISO 31000 fatigue risk management standard recognises that *'fatigue risk is generally based on a combination of analysis of work schedule structure, prior sleep/wake behavior, and self-assessment'.*

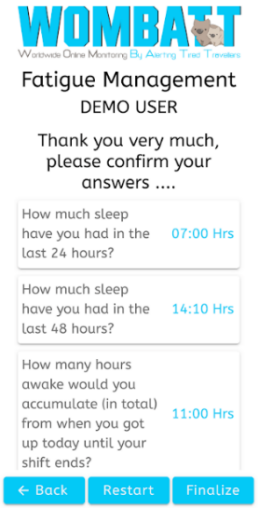
The WOMBATT-VOZ AI voice-based fatigue prediction App and system are compliant with both standards, and include two elements a) the voice recording, which gives an estimate of risk of fatigue up to 5 hours ahead, and b) the questionnaire, where the worker/driver enters details such as sleep/wake data, diet, medications and shift schedule.

ANSI/API RP 755 Standard.

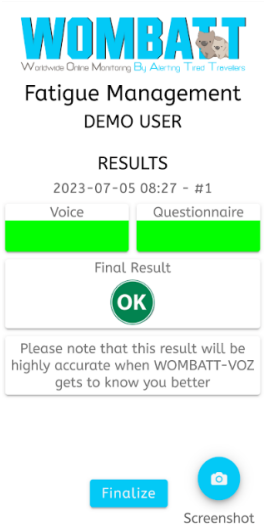
1) Real time shift schedules planning. The WOMBATT-VOZ App asked workers/drivers at the start of each shift or day to enter the time they go to sleep, the time they wake, and the time their shift starts. The system then gives them the hours they have been awake this day/night, with the daily limit of hours awake being 17 hours. Both management and worker/driver are alerted when long shift times result in workers/drivers being awake for more than 17 hours while still on shift. 17 hours awake is equivalent to a blood alcohol content of .05%.



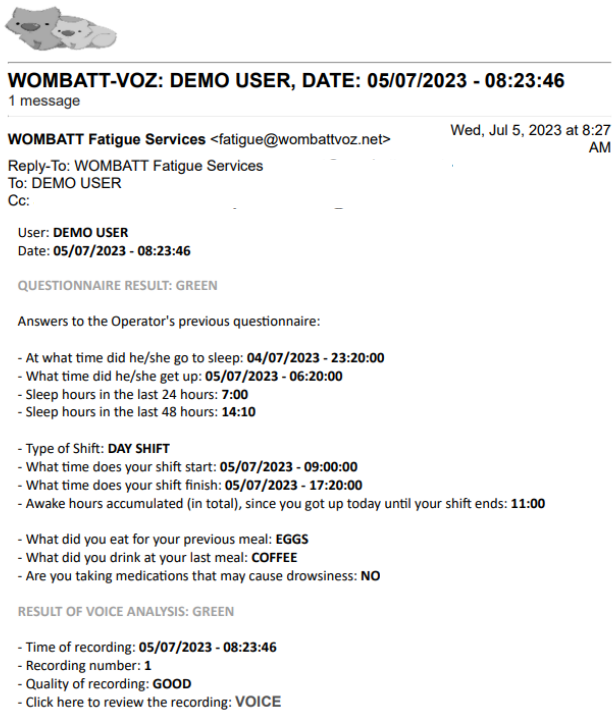
2) Self awareness and self reporting of fatigue. Where a worker/driver self reports via the App that they have received less sleep than normal on any particular day or shift, then both worker/driver and management are immediately alerted.



3) Fitness for duty. The worker/driver enters their sleep/wake data during the first 8 seconds voice recording of the day or the shift, where the minimum is 3 recordings per day or per shift. The first in the beginning of the sift or of the day/night, the second around the middle of the shift or day, and the third around the end of the shift/day. When the first recording and or questionnaire shows Red, then this serves as a fitness for work test which is immediately communicated via the system to both the worker/driver and management.



4) Supervisors Role. As soon as there is an Orange or Red alert for any particular worker/driver, the system sends an SMS or email to the supervisor, and anyone else nominated by management. This means that supervisors are immediately aware of each worker/drivers fatigue status at all times.



WOMBATT-VOZ: DEMO USER, DATE: 05/07/2023 - 08:23:46
1 message

WOMBATT Fatigue Services <fatigue@wombattvoz.net> Wed, Jul 5, 2023 at 8:27 AM
Reply-To: WOMBATT Fatigue Services
To: DEMO USER
Cc:

User: **DEMO USER**
Date: **05/07/2023 - 08:23:46**

QUESTIONNAIRE RESULT: GREEN

Answers to the Operator's previous questionnaire:

- At what time did he/she go to sleep: **04/07/2023 - 23:20:00**
- What time did he/she get up: **05/07/2023 - 06:20:00**
- Sleep hours in the last 24 hours: **7:00**
- Sleep hours in the last 48 hours: **14:10**

- Type of Shift: **DAY SHIFT**
- What time does your shift start: **05/07/2023 - 09:00:00**
- What time does your shift finish: **05/07/2023 - 17:20:00**
- Awake hours accumulated (in total), since you got up today until your shift ends: **11:00**

- What did you eat for your previous meal: **EGGS**
- What did you drink at your last meal: **COFFEE**
- Are you taking medications that may cause drowsiness: **NO**

RESULT OF VOICE ANALYSIS: GREEN

- Time of recording: **05/07/2023 - 08:23:46**
- Recording number: **1**
- Quality of recording: **GOOD**
- Click here to review the recording: **VOICE**

5) Near miss Investigations. The system provides all the data necessary to discover the role that fatigue may have played in any near miss incident.

6) **ISO 31000 Standard**.

The ISO 31000 definition of fatigue risk is based on a combination of analysis of work schedule structure, prior sleep/wake behavior, and self-assessment.

The WOMBATT-VOZ system automatically records and advises both worker/drivers and management of prior sleep/wake data, work schedule structure on a daily basis, and opportunity forself assessment via a self reported analysis of other key factors contributing to fatigue, such as diet and medication.

Conclusion

An effective fatigue management strategy that complies with both the API standard and the ISO standard, must combine a technological, objective measure of fatigue risk at the start of a shift, and during the shift. This must be accompanied by an effective provision of accurate and timely data to both management and worker/drivers, enabling both to take effective action in real time to eliminate the risk of a fatigue event occurring during the current shift.

The WOMBATT-VOZ system provides groundbreaking artificial intelligence voice based fatigue prediction technology as an objective measure of current fatigue risk for the hours ahead, and also a comprehensive submission of sleep/wake data, shift duration information and diet/medications information which result in a go or no go decision for management.

Prof. Jean S Verhardt

July 5th, 2023

Appendix 1 – *Extract from ANSI/API Recommended Practice 755 Second Edition 2019*

4.6 Individual Risk Assessment and Mitigation

Companies shall encourage individuals to be continuously aware of their level of fatigue and take appropriate steps to enhance their alertness while on duty. If and when individuals determine that they are too fatigued to work safely, they shall report this to their supervisor. Individuals should also be alert to evidence that others in the workplace may be fatigued and bring their concerns to the employee and their supervisor. In order to encourage fatigue awareness, a culture of fatigue risk management should be created. This culture should instill confidence in workers and contractors to disclose their personal sleep or fatigue status, and seek assistance consistent with the company protections afforded to reporting other safety concerns.

A FRMS shall take into account the type of work that is being done. Adequate opportunity for work breaks should be made available, based in part on the nature of the work. Individuals working in shifts and others who may be involved in working extended hours/days should be encouraged to use their time off the job to get appropriate sleep and maintain their alertness and fitness for duty.

Factors that may affect alertness and fitness for work include restricted sleep, stress, medical conditions, and the use of certain medications. A fitness-for-duty assessment may be used to detect fatigue-related impairment regardless of the underlying cause. Consideration should be given to validated objective assessment approaches that may aid in making fitness-for-work determinations.

Supervisors shall be alert to signs of excessive fatigue in employees and contractors. Supervisors shall be given the responsibility and the authority to take appropriate steps to ensure employees are alert enough to safely perform their work. Individuals who experience repeated bouts of excessive fatigue should be referred to their health professional or medical department for further evaluation and advice regarding actions they can and should take to maximize their alertness.

Because illness, stress, and physical fitness impact fatigue, programs that are designed to encourage prevention and management of medical conditions, including sleep disorders, and promote psychological and physical fitness should be implemented.

4.7 Incident/Near-miss Investigation

The investigation of incidents shall be conducted in a manner that facilitates the determination of the role, if any, of fatigue as a root cause or contributing cause.

Each company shall define criteria for when incident investigations should consider the role of employee fatigue. Information collected should include: the time of the incident; the shift pattern (including the number of consecutive shifts worked); the number of hours awake; the number of hours of sleep in the past 24 hours and 48 hours by the individuals involved; the shift duration (and any overtime worked); whether the incident occurred under normal operations or an extended shift; whether an outage was occurring; and other fatigue factors. It should be noted that, for specific incidents, often no definitive conclusion regarding the role of fatigue may be possible. However, aggregate analysis of incidents may reveal patterns suggestive of the role of fatigue that is not apparent by evaluating incidents individually.

4.8 Hours-of-service Limits

The FRMS shall specify hours-of-service limits that shall not exceed those in this section, taking into account the exception process discussed below. These limits have been developed in the context of the existence of