

STUDY: WORKER FATIGUE IN THE AUSTRALIAN GAS INDUSTRY

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EXECUTIVE SUMMARY

Fatigue can have disastrous effects when poorly mitigated and managed. Some of the most catastrophic disasters of the modern era have been attributed to fatigue and/or human error. As a consequence, there has been strong impetus to identify and manage fatigue-related risks in industries such as road transport, rail, aviation and mining.

The Australian pipeline industry is a safe industry. Some estimates suggest that safety incident rates in the Australian pipeline industry are considerably lower than in many overseas locations. This commendable achievement is reflected in the Australian Pipeline Industry Association's and member companies' commitment to ensuring safety through a number of industry safety initiatives including a safety standard and research centre. Nevertheless, it has been said that the pipeline industry has typically focused on technical issues of pipelines without the commensurate focus on the organisational causes of accidents and incidents. An extension of this therefore, is the nature of psychosocial and biological contributors to safety incidents, such as fatigue.

However, the level of adequate data on fatigue risk and management in the Australian pipeline industry is limited. This is a critical knowledge gap given the difficult working conditions for workers on many gas pipeline projects and the highly mobile nature of the workforces which rely extensively on public roads. Owing to this need, TMS Consulting Pty Ltd (TMS) was engaged by the Australian Pipeline Industry Association (APIA) to investigate the extent of occupational fatigue present in Australian gas pipeline projects. This project was named the Fatigue Management Study (FMS). The FMS had the primary goal of

quantifying fatigue based on a single, large-scale Australian gas pipeline construction project. This then serves as a basis for providing a range of suggested recommendations and areas of focus to aid effective fatigue management. These are based on the FMS's data and information from discussions with industry members, companies, and from data from comparable industries.

TMS was able to collect a broad range of data from over 400 pipeline industry employees over a period of approximately one year. The data collected included daily measurements of neurocognitive performance, sleep/wake characteristics using actigraphic 'sleep watches' and sleep logs, subjective sleepiness and fatigue scales, and extensive self-reported health and medical profiling. The FMS consisted of two study phases. Phase 1 involved daily objective and subjective measurements of a cohort of pipeline employees over a 28-day on-site work roster consisting of 10 hour day-shifts. Phase 2 of the FMS consisted of a generalised demographics, health and medical, and sleep and fatigue survey which was completed once only. The cohort of employees tested in this study was divided into three broad occupation groups. These occupation groups were 'field' (including labourers, welders, riggers, and other tradespeople), 'driver' (including general vehicle drivers, truck drivers, and mobile plant operators) and 'office' groups (including management, administrators, and safety advisors).

The primary results from both phases indicated that:

- Neurocognitive performance is gradually impaired over the entire work roster with little to no apparent stabilisation occurring. This result was statistically significant
- Sleep is statistically shorter and of poorer quality on-site compared to off-site
- It is probable that extended working hours, early morning wake times and poor sleep hygiene are primary contributors of impaired sleep quality and duration
- There is an elevated probability of sleep disorders in this sample based on the present

risk factors - loud snoring, obesity and weight management issues, smoking, and alcohol intake

- Drivers and mobile plant operators in particular have the highest probability of having sleep apnoea with 36% of the sample placed in the 'high-risk' category
- Increases in subjectively rated sleepiness and fatigue over the work roster, whilst statistically significant, were small and perhaps do not accurately reflect the magnitude of performance impairment
- A large percentage of this sample (54%) drive home using their own transport following the end of a work cycle, with an average commute time being 5-8 hours

Based on these findings, it is suggested that there is an increased probability of fatigue-related risks in this sample. These risks are more apparent in the driving group who had more pronounced risk factors for sleeping disorders (such as sleep apnoea and shorter average sleep durations per night). No direct advice was given on 'ideal' work roster lengths given that roster length is only one (indirect) contributing factor to fatigue; fatigue, in fact, can depend on a host of factors.

Overall the Australian pipeline industry can be considered a safe industry and the current findings do not detract from this achievement. In consideration of this point, a number of suggested recommendations for APIA and areas of focus for member companies have been provided to advance fatigue management practices and generally continue the already admirable effort towards safety as a top priority in the pipeline industry. These suggestions have been based on the current findings, interviews with industry professionals and stakeholders, existing published pipeline fatigue guidelines, and best practice fatigue management practices from comparable industries.

Through improved understanding of fatigue, and application of key fatigue management principles in this growing industry, both APIA and its member companies can ensure that fatigue risk is effectively mitigated and managed.

**Please note this study was completed on behalf of APIA and the full report is only accessible to APIA members. This paper is based on the published report, a condensed version of full report that has been made available to the public.*

TMS Consulting would like to thank the Australian Pipeline Industry Association for their continued support and funding to ensure this industry-funded fatigue study could be undertaken.

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Review and advice on protocol design, data findings, and draft and final manuscript was provided by Dr Lee Di Milia, Professor of School of Management & Marketing at Central Queensland University.

DISCLAIMER

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1 BACKGROUND

Excessive fatigue and its associated impairments can result in dire consequences. The grounding of the Exxon Valdez tanker, the sinking of the Estonia ferry, the Three Mile Island and Chernobyl power plant incidents, and the Rhine chemical spillage all had fatigue and/or human error attributed as causal factors.⁴ Statistics from Australian road transport are no less confronting; estimates from 2007 identified fatigue as a significant contributor in around 20% of major vehicle accidents.⁵

The Australian pipeline industry is a safe industry. Some estimates suggest that safety incident rates in the Australian pipeline industry are about an order of magnitude lower than in many overseas locations.¹ This commendable achievement is reflected in the Australian Pipeline Industry Association's and member companies' commitment to ensuring safety, the industry-developed AS2885 Australian Pipeline Standard and research by the Energy Pipelines CRC (EPCRC), which was established in 2009, continuing and expanding the industry association's Research and Standard Committee's work. However, as noted by Hayes, Tuft and Hopkins (n.d.)² of the EPCRC, the pipeline industry has typically focused on technical issues of pipelines without the commensurate focus on the organisational causes of accidents and incidents. An extension of this therefore is the nature of psychosocial and biological contributors to safety incidents, such as fatigue.

To date, little published evidence exists relating to the extent of occupational fatigue present in the

Australian pipeline industry. This is a critical knowledge gap given the often difficult working conditions encountered in large-scale pipeline construction projects. These conditions can include extreme environmental heat, dehydration, large and mobile plant equipment, uneven and unstable terrain, long distance driving, poisonous fauna and extended shiftwork schedules. As with the mining industry, many pipeline construction projects are notable for their long shiftwork schedules with some extending up to 28 continuous 10-hour work days and often in remote locations.

In 2010, TMS conducted a desktop work cycle review on the Australian pipeline industry focussing on a large-scale coal seam gas pipeline construction project. This review³ involved an extensive review of the scientific literature in the areas of roster design, fatigue, sleep, and work-life balance. The 2010³ review concluded that limited evidence existed on the links between work schedule length, fatigue and the frequency and severity of injuries, and accidents specifically within the Australian pipeline industry.

Based on research from other industries with similar working conditions and work schedules (such as fly-in/fly-out and drive-in/drive-out mining, off-shore oil and gas) the 2010 review concluded that underlying levels of fatigue, such as those expected in most extended hours working schedules, need to be effectively managed with proactive fatigue management policies.³ It also identified serious gaps in the knowledge-base of fatigue, sleep, health, and safety profiles within the Australian pipeline industry. In the review paper,³ TMS recommended a future research project to address these knowledge gaps. This recommendation was accepted by APIA, who commissioned TMS to conduct the study through the FMS. The primary goal of the FMS was to quantify sleep and fatigue, and variables relating to health and safety using a single, large-scale coal seam gas pipeline construction project in the Queensland Surat Basin as a "representative" Australian pipeline construction project.

Quantifying the extent of fatigue and fatigue risk factors in the pipeline industry will help to identify key risk areas and aid the development of industry-specific fatigue management guidelines. This project also provided a range of suggested recommendations and areas of focus to aid the industry in improving fatigue management policies, and subsequently improving safety. These recommendations are based on the findings, discussions with key stakeholders and industry professionals, and on existing guidelines and research from comparable industries.

It is important to note that the purpose of the FMS was not to validate any particular work roster, such as the use of the 28/9 roster commonly employed in the Australian pipeline industry. Indeed, there is a general belief in the industry that this report will give a definitive position on the ‘ideal’ work roster length. This however is not the case, as it is appreciated that a number of different factors contribute to the causation of fatigue, with roster length being (indirectly) one of these. It can be argued that, in actual fact, almost any work roster can be worked safely given sufficient controls are put in place to manage risk. Thus, the focus in this report is not on the length of the work roster in and of itself, but of the inherent and often interacting risk factors present in a given working environment. This point is emphasised in the full report* with the key message that for effective fatigue risk management companies need to look beyond the isolated focus on hours of work and work roster schedules.

The following report is a heavily condensed version of the full report, providing only the most salient findings from the FMS study (e.g. this condensed report has around 20% of the original content). As such, readers are strongly urged to consult the full report for clarity on scientific links between work and non-work factors and fatigue, for expansion on the testing methods, results and statistical analyses, and the study findings and recommendations.

2 FMS METHODOLOGY

2.1 PURPOSE

This study was designed to collect detailed information from a single pipeline construction project to determine the degree of fatigue that is present in operations within the Australian pipeline industry, with a view to the development of effective fatigue management strategies. Thus, the primary aims of the study are to:

- Determine the extent of occupational fatigue
- Determine the prevalence of risk factors relating to fatigue, sleeping disorders, and poor health
- Provide guidance to APIA and the industry to aid the effective identification and management of fatigue in the Australian pipeline industry

2.2 METHODS

The research methodology in this project was divided into two phases. Phase 1 was designed to test three cohorts of volunteers twice daily (pre- and post-shift) on each day of the 28-day work cycle. Phase 2 consisted of a generalised questionnaire which was distributed across multiple work sites on the same project. Testing was conducted at a single work site camp (‘on-site’) on a large-scale gas transmission pipeline construction project in a remote Queensland location. Each work roster (‘cycle’) is made up of 28 continuous on-site days (10 hour daily shifts). Testing was conducted in two separate phases.

Phase 1

A total of 143 participants out of around 500 (28.7% of total) employees at camp volunteered for Phase 1. Participants were asked to self-select their primary area of work to facilitate comparison between occupation groups. These occupation groups were ‘field’ (including labourers, welders, riggers, and other tradespeople), ‘driver’ (including general vehicle drivers, truck drivers, and mobile plant operators) and ‘office’ groups (including management, administrators and safety

advisors). After accounting for participant drop-outs, there were 65 participants in the field group (53% of total), 28 participants in the driver group (23% total), and 30 participants in the office group (24%).

Phase 2

The Generalised Questionnaire (GQ) for Phase 2 was printed in large numbers (1000 copies) in order to reach as many members of the project workforce as possible (which was at the time approximately 1000 employees across the entire project). From 1000 distributed surveys, 417 were completed and returned (41.7% return rate); 230 of these were from field group (55% of total), 117 from driver group (28% of total), and 70 from office group (17% of total).

2.3 MEASUREMENTS

Phase 1

Baseline Questionnaire (BQ): Baseline data was collected from all participants using a custom questionnaire prior to initial testing. The BQ included questions relating to gender, height and weight (for calculation of Body Mass Index, BMI), marital status and number of children at home. Health-related questions were also included blood pressure, usual alcohol and coffee/caffeinated beverage intake, sleeping patterns on- and off-site, self-reported medical history (e.g. previous or current health conditions), occupational history and self-rated safety perceptions. In addition a host of other surveys were used detailing sleep apnoea risk factors, subchronic/ chronic occupational fatigue, hydration knowledge, sleep hygiene practices and burnout.

Daily questionnaires: These forms were completed by participants prior to and following each daily work shift in a dedicated room and asked participants to report on the following:

- Caffeine intake prior to questionnaire
- Alcoholic beverage intake on the previous day
- Minutes of exercise performed on the previous day
- Sleeping patterns (see diaries and actigraphs)

- Subjective sleepiness (Karolinska Sleepiness Scale, KSS, sleep quality, SQ), and fatigue (Samn-Perelli Fatigue Scale, SPC)
- Objective neurocognitive performance (5-min Psychometric Vigilance Task, PVT)

The post-shift (i.e. afternoon) questionnaire asked participants to report on the following:

- Caffeine intake prior to questionnaire
- Start time of shift that morning
- Total hours of work that day
- Subjective sleepiness and fatigue
- Objective neurocognitive performance
- If the participant nodded off during working hours

Finally, measurement of urine specific gravity (USG) with a digital handheld refractometer was obtained to permit reliable assessments of hydration status.

Phase 2

Generalised Questionnaire (GQ): This item is a three page questionnaire designed to evaluate a range of topics. These include:

- Demographics
- Lifestyle
- Basic health and medical history
- Sleep apnoea screening (MAP questionnaire)
- Sleep/wake cycles
- Acute assessment of fatigue on-site and off-site (SPC scale)
- Chronic/sub-chronic assessment of fatigue (FAS)
- Hydration and sleep hygiene knowledge (H2O-Q & SHI)

2.4 RESULTS: PHASE 1

Because this version of the report is a heavily condensed version of the full report*, most statistical output data (such as: significance p values, degrees of freedom, power values) and also in many cases standard deviations (SD) have been omitted for clarity. Also note that a considerable proportion of findings relating to fatigue, health,

and workforce demographics have been omitted from this version of the report. For the full statistical outputs and data findings please see the full report*.

2.4.1 Population Demographics

A summary of key demographic mean information of the participants tested in Phase 1 (the main study period) over the 28-day work cycle are listed in Table 1.

2.4.2 Sleep Duration

Average nightly sleep duration for field, driver, and office groups were 6.4 hours (SD 1.1 hours), 6.2 hours (SD 0.95 hours), and 6.5 hours (SD 1.1 hours) respectively (Figure 1). Mean sleep hours did not appear to significantly change over the cycle (not pictured.)

2.4.3 Self-rated sleep quality

No statistically significant changes in sleep quality (Figure 2) across the cycle was noted for either the field group or the office group, however, changes across the cycle were noted for the driver group. Little discernible change in sleep quality is noted when all group data is pooled together.

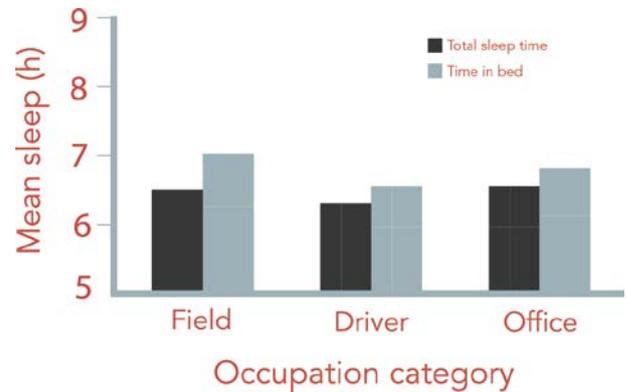


Figure 1: Comparison of mean time in bed versus total sleep time (with SD) from all averaged sleeping periods over the work cycle, stratified by occupation group.

Variable	Occupation Group					
	Field		Driver		Office	
	Male	Female	Male	Female	Male	Female
Gender (% of group total)	100	0*	100	0*	71.5	28.5*
Age (years)	34.4 (SD 11.6)		37.8 (SD 9.9)		35.3 (SD 10.8)	
Body Mass Index (kg/m ²)	27.5* (SD 3.65)		30.1* (SD 3.9)		27.7 (SD 6.3)	
Pipeline experience (years)	2.3 (SD 2.6)		3.6 (SD 5.6)		3.2 (3.8)	
Units of alcohol on-site per day	3.2 (SD 1.7)		4 (SD 1.5)		3.1 (SD 1.7)	
Number of daily cigarettes on-site	5.5 (SD 9.6)		8.8** (SD 10.5)		2.8** (SD 5.7)	

* indicates a significant difference between indicated groups at $p < .05$; ** indicates an association just outside of significance ($p = 0.06$). Note: These values represent the mean values for the Phase 1 sample only; the results from Phase 2 represent the mean values for a larger sample of the project workforce. SD = standard deviation.

Table 1: Phase 1 study average values for demographic and lifestyle parameters

2.4.4 Performance Measures

Only limited changes were found between pre- and post-shift scores on the 1/RT, raw RT and lapse variables. That is to say, the daily work shift had little discernible impact on these performance measures when each shift was viewed in isolation.

A gradual and consistent reduction in 1/RT performance occurred over the work cycle (Figure 3), with the greatest change occurring approximately between days 8 and 20. Significant changes in mean reaction time (Figure 4) was observed over the work cycle, with a gradual worsening of performance between baseline on day 1 and day 28. Few statistically significant group differences were observed.

2.4.5 Subjective Measures

In general, inconsistent changes were observed over the work cycle relating to differences in pre- and post-shift subjective sleepiness and fatigue ratings. On both scales a gradual increase occurred over the work cycle but these changes are of a limited magnitude (Figure 5 shows the change in SPC scores).

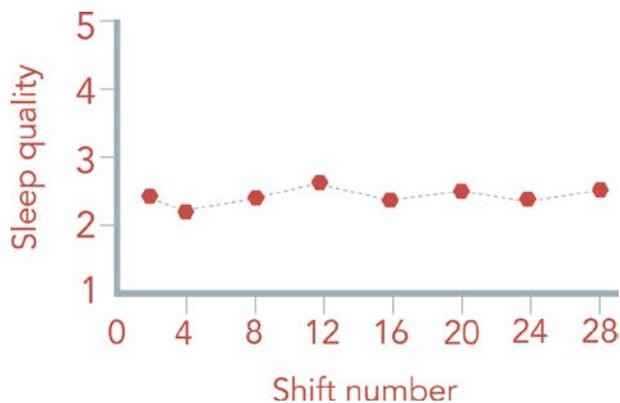


Figure 2: Comparison of mean sleep quality over the work cycle. Sleep quality is a 5-point scale, with 1 being 'very good' and 5 being 'very poor', such that lower numbers indicate better quality sleep.

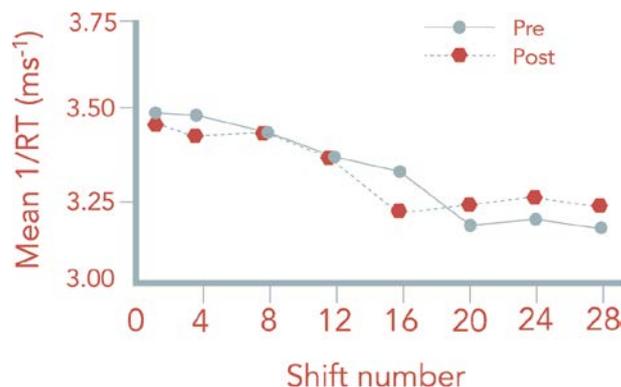


Figure 3: Daily mean reciprocal reaction times plotted over the work cycle. Lower reciprocal reaction time values (Y-axis) indicate slower reaction times, e.g. greater performance impairment.

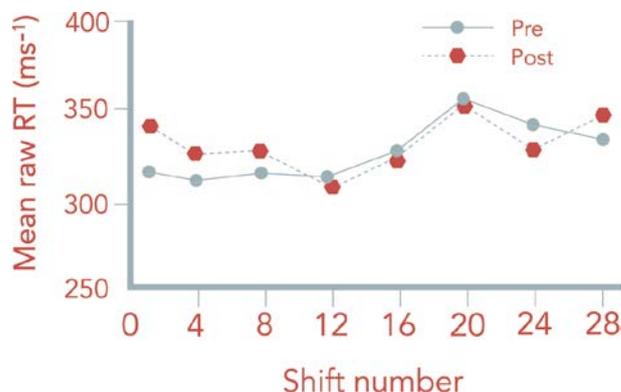


Figure 4: Daily mean raw reaction times plotted over the work cycle, stratified by occupation group. Higher reaction time values (Y-axis) indicate slower reaction times, e.g. greater performance impairment.

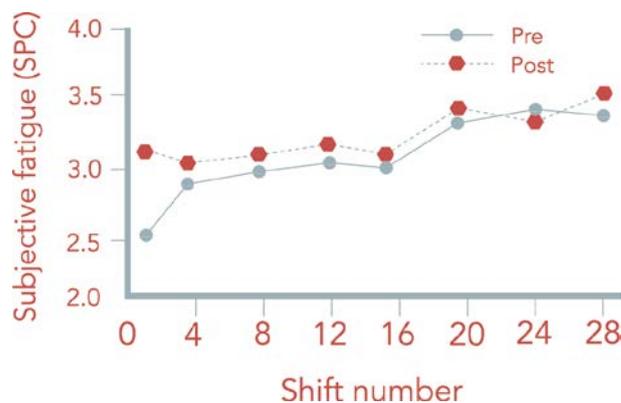


Figure 5: Daily mean raw reaction times plotted over the work cycle, stratified by occupation group. Higher reaction time values (Y-axis) indicate slower reaction times, e.g. greater performance impairment.

2.4.6 Summary

A number of objective and subjective measurements were obtained and analysed in Phase 1 of the FMS study. The effects of these measurements over the course of a work cycle were not entirely consistent between the occupation groups; however, while occupations-specific differences were observed, many of these measurements underwent a similar overall trend over the work cycle. The primary statistical findings from Phase 1 of the FMS are:

- Average nightly sleep for the occupation groups ranged between 6.2 and 6.5 hours with a statistically significant difference between the office and driver groups
- Average nightly sleep duration did not appear to change over the work cycle
- Significant changes in average sleep quality were not found to occur over the cycle, however, improvements in sleep quality was approaching significance in the driver group which may be suggestive of a trend
- In general, limited differences were found between pre- and post-shift performance measurements, save for differences that occurred on day 28 of the work cycle
- In general, performance measurements were found to be impaired over the cycle when pre- and post-shift scores were averaged into single daily values for each performance measure, although some group differences were noted
- In general, changes in subjective measures over the work cycle were less consistent between the occupation groups, but were observed to be gradually impaired over the work cycle
- The 1/RT measurement was found to be the most sensitive metric to the effect of shift number based on the calculated effect sizes
- Urine specific gravity measurements were generally found to be within acceptable limits, with the exception of approximately 25% of readings which were in dehydrated categories

2.5 RESULTS: PHASE 2

The following section summarises the most relevant project-wide survey findings from Phase 2 of the FMS. This section has been heavily condensed from the full report and interested readers are urged to consult the full report for the complete data outputs and findings.

2.5.1 Demographics

For years of experience in the pipeline industry (Figure 6), the highest observed mean was for the driver group at around 6.5 years (standard deviation [SD] 9.2 years), compared to 3.4 years (SD 4.9 years) in field, and 4 years (SD 4.5 years) in office. Other trends are noticeable when years of experience are grouped into time periods. For example it is evident that a sizeable percentage of the surveyed participants had less than one year of pipeline industry experience.

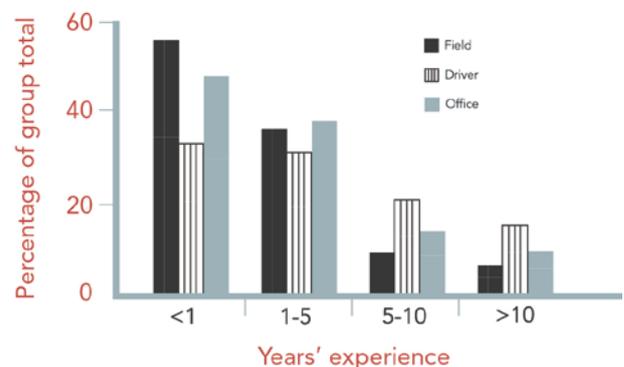


Figure 6: Experience brackets (years) by percentage of total, stratified by occupation group.

2.5.2 Work Schedule Characteristics

Mean rostered working hours were similar between occupation groups, with a pooled weekly average of 69.4 hours (SD 6.6 hours) and no significant group differences. This figure aligns with the project's official roster which is generally set at 70 hours per week. Yet for actual hours that are worked per week, the field group work 80 hours (SD 10.3 hours), the driver group 78.4 hours (SD 9 hours), and the office group 82.6 hours (SD 9.7 hours), again with no significant group differences (Figure 7).

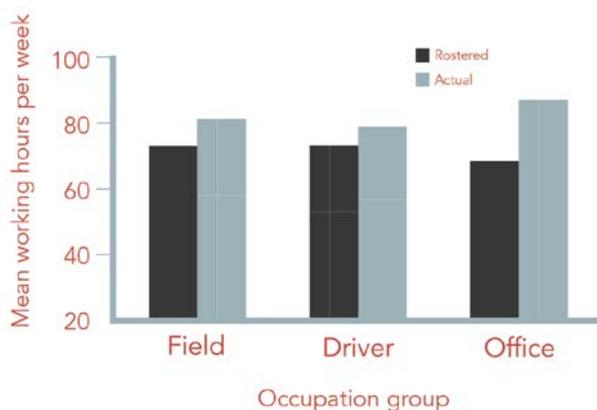


Figure 7: Rostered versus actual mean hours worked per week stratified by occupation group.

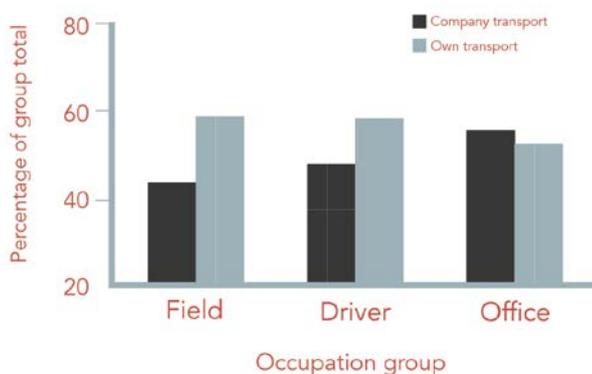


Figure 8: Percentage of total sample (stratified by occupation group) that commute to and from camp using their own transport versus commuting via company transport.

On this project, approximately 56% of all participants commute to and from the camp site using their own transport (mean travel time = 8.1 hours, SD 5 hours) instead of using company-provided transport (Figure 8).

2.5.3 Health and Lifestyle Factors

For BMI (Figure 9), significant differences exist between the driver group (M = 30.5, SD 5.6), and both field (M = 27.6, SD 3.7) and office (M = 27.9, SD 5.8) groups. For the driver group, 50.9% of the participants were classified as obese. This is in contrast to 31.9% obese in field and 27.1% obese in office. Percentage overweight in both field and office groups were, however, the most prevalent BMI categories at 50.6% for field and 40% for office group.

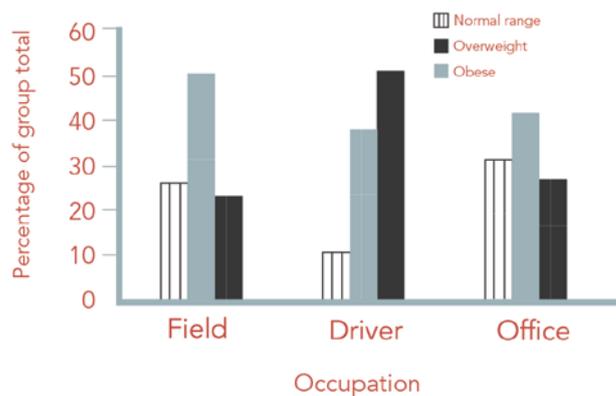


Figure 9: Percentage of total sample (stratified by occupation group) that are in normal, overweight, and obese BMI ranges, respectively.

In addition to BMI, waist circumference (WC) measurements were taken to help gauge the degree of fatness in this workforce. The mean WC was 100 cm (SD 11.8 cm). Figure 10 shows the percentage of participants in each WC risk category. Notably over 40% of the sample is designated as high-risk (i.e. > 102 cm), and over 20% as elevated risk (i.e. > 94 cm).

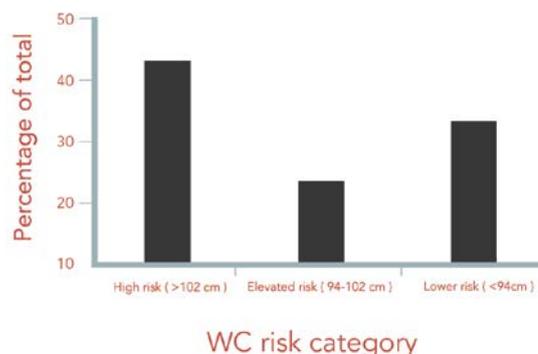


Figure 10: Percentage of total sample in high risk, elevated risk and lower risk categories based on their WC measurement.

2.5.4 Sleep Duration

Figure 13 details mean (+SD) sleep between the three occupation groups while on-site. Specifically, the driver group were noted to obtain the most sleep at 7.1 hours (SD 0.9 hours) per night, compared to 6.9 hours (SD 0.9 hours) in the field group, and 6.7 hours (SD 1 hour) for the office group.

2.5.5 Sleep Apnoea

To predict the relative risk of sleep apnoea, MAP index scores (that are calculated from sleep apnoea survey responses, age, gender and BMI) were calculated. Scores of > 0.5 were stratified into the high risk group, and scores < 0.5 were stratified into low risk group. From Figure 11 it can be observed that the percentage of high risk participants in the driver group (36.2%) is significantly greater than those in the high risk group for field (18.9%).

2.5.6 Degree of Subjective Fatigue

Participants were asked to rate (on the Samn-Perelli fatigue scale) their general level of fatigue/exhaustion following the cessation of a full work cycle (Figure 12). For field, 'Extremely tired' was the most reported feeling (22.2%) following the cessation of a work cycle, with 'Moderately tired' second (18.2%). For the driver group, the most reported feeling was 'Okay' (30.9%), with 'A little tired' second at 20.2%. In the office group, 'Extremely tired' and 'Moderately tired' were approximately equal at 20.5%.

2.5.7 Perceptions of Fatigue and Safety

On average, it was found that the office group required the least amount of nightly sleep to work safely (7.1 hours, SD 1 hours), compared to field and driver groups (7.5 hours, SD 0.9-1 hours). The average duration of objectively (actigraphs in Phase 1 main study) and subjectively (self-reported) assessed hours of sleep are considerably less than the perceived amount of sleep needed to work safely (Figure 13). Stated another way people are sleeping less than they believe they require.

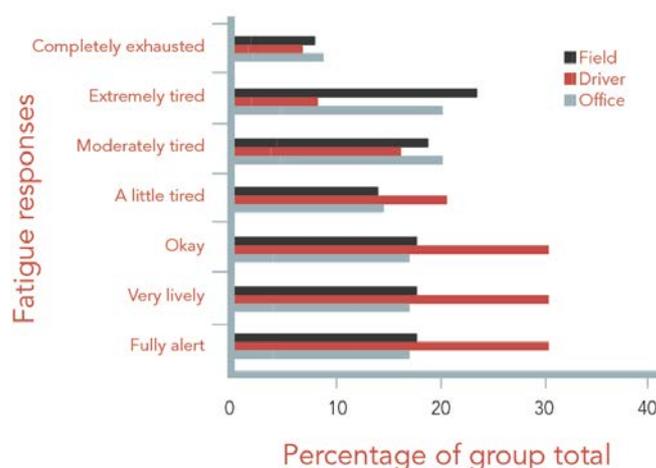


Figure 11: Sleep apnoea risk categories expressed as a percentage of total responses and stratified by occupation group.

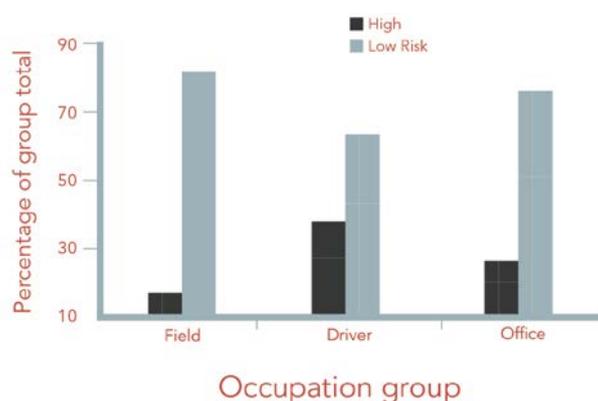


Figure 12: Percentage distribution of responses on the Samn-Perelli fatigue scale (stratified by occupation group) following the cessation of a 28-day work cycle.

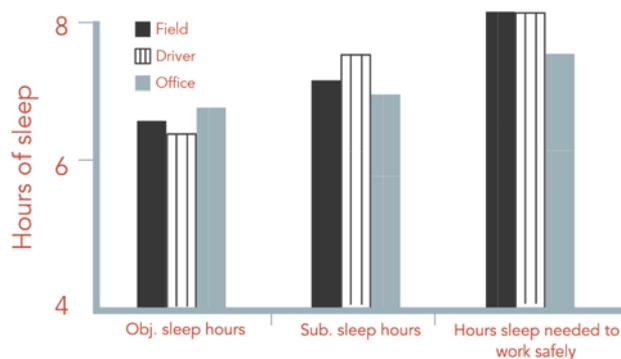


Figure 13: Comparison of sleep obtained versus sleep needed to work safely. Note: Obj. = objective sleep hours (sleep recorded with actigraphs in Phase 1 main study), sub. = subjectively reported sleep hours, and the final column indicates the amount of sleep participants perceive they require each night to work safely the following day.



Figure 14: Perceived degree of unsafe levels of fatigue in the Australian pipeline industry, expressed as percentages by occupation group.



Figure 15: Analysis of incidents and near-misses over a six month period collapsed into four discrete time periods over the day.

Figure 14 expresses the perceived extent of unsafe fatigue in the Australian pipeline industry. This figure suggests that the majority of respondents believe unsafe levels of fatigue are common in the industry, with drivers on average perceiving the risk to be lower.

2.5.8 OHS Incidents

OHS incident and near-miss data from this project over a period of six months was made available for analysis. Results for incident and near-miss trends over the work day (presented in Figure 15) show a marked increase between 8 and 12 hours into the work shift, with this period accounting for 49% of all daily incidents.

Heightened rates of incidents are also notable for less than 4 hours into the work shift. The hours

between 4 to 8 and over 12 hours had the least absolute percentage of reported incidents although a higher probability of incidents in the >12 shifts may exist based on relative analyses.

2.5.9 Summary

Phase 2 of the FMS aimed to characterise the general demographics, fatigue and safety risk factors, and health and lifestyle factors of the project workforce using a comprehensive survey. Some of the key findings of this sample suggest that:

- the average age is around 35 years and with a considerable proportion aged between 40 and 60 years
- males predominate (~ 99% of total)
- a large proportion of participants have 1 year or less experience in the pipeline industry
- self-commuting to and from the worksite (instead of using company provided transport) is the primary method of transport at around 56% of total
- most participants are overweight or obese (particularly the drivers)
- alcohol is consumed in amounts exceeding the recommended guidelines
- a high proportion of participants are current smokers
- most participants rise at early times in the morning (on average 4:30am)
- key risk factors for sleep apnoea are prevalent, with up to 36% of drivers being designated as 'high risk' of having sleep apnoea
- most participants feel exhausted following the completion of a 28-day work cycle
- most participants obtain less sleep (on average) per night than the minimum amount of sleep they report to require in order to work safely
- most participants believe that unsafe levels of fatigue are common in the industry
- OHS incident and near-miss events occur most frequently between 8 and 12 hours on-shift.

3 DISCUSSION

Occupational fatigue is thought to exist in most extended shift schedule FIFO environments. This project evaluated fatigue in a large-scale coal seam gas pipeline construction project in remote Queensland. A number of fatigue risk factors, and health and safety information were collected and evaluated. Given the increasing number of coal seam gas pipeline construction projects around Australia, research addressing the status of fatigue, health and safety in this industry is an important step in ensuring safe and effective future growth. This is particularly important given the working conditions that are often present in these projects, including extended working hours, camp-based accommodation, high ambient temperatures and the lack of specific research pertaining to Australian pipeline operations. Moreover, the highly mobile nature of the pipeline workforces demands an examination of potential risk exposure to individuals, companies, and the community more broadly.

Several indicators in this study suggest the typical work schedules and work environments in the industry may carry a high level of risk for companies and employees. Probable risk factors for excess fatigue, sleep disturbances and disorders, impaired health, and possible adverse impacts on safety were observed. In particular, risk factors such as extended daily work hours, sleeping disturbances and early rise times may explain the increased lapses and slower reaction times. Employees also self-reported tiredness and the need for additional sleep in order to work safely.

One of the most compelling pieces of evidence for excessive accumulated fatigue (as reflected by performance decrements) is in Figure 16 whereby pre- and post-shift 1/RT measurements for each group have been collapsed into pooled single daily averages for several time points over the work cycle. These findings suggest that in general, across the entire sample, steady declines in neurocognitive performance occur and with little evidence of stabilisation. Figure 16 Panel B displays percentage change of 1/RT performance

over the work cycle. The decrement in neurocognitive performance seen in the FMS is similar in magnitude to performance decrements obtained at 0.05% alcohol intoxication.

An assessment of sleep/wake profiles discovered that on average most of this sample obtained around 6.2 to 6.5 hours of sleep per night. Approximately 34% of participants obtained less than 6 hours of sleep on any given night. In conjunction, it appears that a reasonable probability of sleep apnoea is present in this sample. This risk is focused particularly around the driving group who on average obtain the least sleep, and who generally have the highest rate of risk factors for sleep apnoea. The protection of quality sleep opportunity is of paramount importance in working environments such as these.

Another potential risk factor identified in this study is the extended working hours prevalent in this sample (>80 hours a week); hours that are of a long and monotonous nature for drivers. This point is considered in light of the possibility that the long working hours may simply be an artefact of this particular pipeline construction project, as with any of the other findings.

A significant percentage of this sample commute to and from the work site using their own transport which is on average a long commute (approximately 5-8 hours each way), and may involve considerable time in the high risk times for driving in the early morning hours. This may be an important area of risk for companies to identify and mitigate.

Finally, a pronounced peak in OHS incident and near-miss events were evident between 8 and 12 hours on-shift. While this is not evidence of fatigue or fatigue-related events, it does align with predictions regarding when fatigue would be at a relative peak during the working shift and suggests that this period of the shift may be higher risk and therefore should be subject to close review in the company safety management approaches.

3.1 SUMMARY

The data in this study suggest that consistent and statistically significant impairments in neurocognitive performance occur over the 28-day work cycle in this sample of Australian pipeline construction employees. This performance decrement showed little evidence of stabilisation.

Other potential risk factors were also identified. These include consistently short nightly sleep durations; an elevated probability of sleep apnoea in drivers; long working hours; long commutes home following the cessation of a work cycle and also potentially during the early morning hours; and a pronounced peak of safety incidents between 8 to 12 hours on shift.

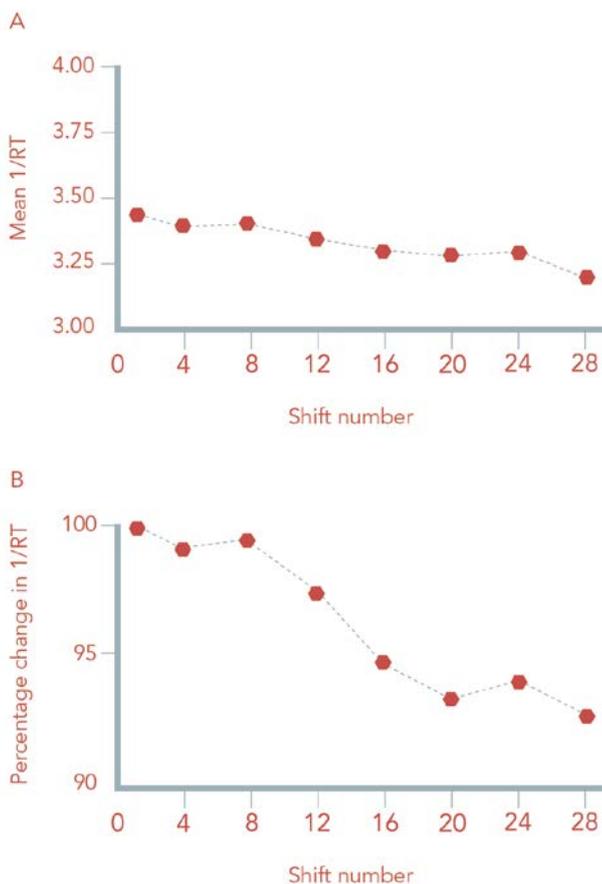


Figure 16: In panel A the mean change of all pooled 1/RT data per shift number over the work cycle is displayed. In panel B the percentage change of pooled 1/RT performance over the work cycle, relative to baseline on day 1 is displayed.

4 LIMITATIONS

Like any field-based study, limitations are present in this study and must be acknowledged. The study limitations that are present in this study that contextualise the findings are explained in detail in the full report* but the following list is a summary of some of the identified limitations that need to be read in conjunction with the outcomes:

- Small sample size that was taken from a single project
- Possible selection bias of participants such that less fatigued, or conversely more fatigued people, may have been more likely to take part in testing. This indeterminable factor could result in an underestimation or overestimation of fatigue impairment
- Field-based measurement may have lacked sensitivity for measuring reaction time and sleep
- Inability to review long-term and detailed data on workforce burnout and stress
- Limited ability to evaluate OHS incident and near-miss information
- Inability to determine if there is corroborating evidence linking fatigue impairment to increased OHS incidents or driving risk

5 THE NEXT STEPS

In order to further inform work on fatigue management policies and procedures in the Australian pipeline industry, several recommendations have been made for APIA's consideration. These recommendations are based both on the study's findings and interpretive extrapolation of the findings, which are specific to a single project. The following APIA recommendations use the current study's findings as a guide, in combination with interviews with industry professionals and key industry stakeholders, and based on existing published pipeline fatigue guidelines and also on best practice fatigue management practices from other comparable industries. In addition to the APIA recommendations additional areas of focus are

suggested for member companies to consider in assessing their own fatigue management approach and if any further action is required.

5.1 APIA

Recommendations are suggested for APIA to consider in relation to the outcomes of the FMS. The first recommendation for APIA to consider was releasing the FMS findings report to the industry and further supporting fatigue and safety research projects. Another key suggestion for APIA is to convene a Fatigue Subcommittee that is made up of representatives from member companies within the industry. It is suggested that considerable expertise, knowledge transfer, and 'lessons learnt' can be accessed through this type of forum from member companies through industry collaboration and the aim of continuously improving safety. Industry collaboration, in conjunction with fatigue and sleep expertise can be seen as positive actions to direct this industry towards even higher fatigue management awareness and safety maturity industry wide.

5.2 MEMBER COMPANIES

It is appreciated that while APIA may have influence amongst the industry at a high level, change must still be recognised and effected at a local level. Therefore, a number of suggested areas of focus for member companies were provided in the full report. These areas are provided to support member companies in assessing their fatigue risks and to use the report to assess their operations. Key focus areas include: reviewing how fatigue is currently identified, managed, and incorporated into risk assessments, including determining whether a fatigue risk management system is beneficial for operations; greater examination of driving and plant operation fatigue hazards or any other safety-critical tasks, which may include evaluating current journey management system approaches and in-vehicle monitoring systems; greater focus on identifying sleep disorders and ensuring that working conditions provide sufficient opportunity for

sleep; reviewing the provision of fatigue and sleep training and whether these are achieving their desired outcomes; and reviewing the potential benefit of creating fatigue-related safety performance indicators.

References

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**Please note this study was completed on behalf of APIA and the full report is only accessible to APIA members. This paper is based on the published report, a condensed version of full report that has been made available to the public.*