Tenth International Conference on Managing Fatigue: Abstract for Review

Controller Cognitive Workload Levels and Fatigue

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Problem [72 words]
Operators of hazardous liquids, gas transmission, and gas distribution control rooms are required by the US Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) to monitor the general activity of their controllers to make sure they have enough time to analyze and to react to alarms. Controllers are responsible for the operation, monitoring and control of these high risk operations. Measuring the workload of these controllers is a yearly requirement.

Method [248 words]
Over the past five years Pipeline Performance Group (PPG) has conducted over 165 assessments measuring the mental workload of controllers. These assessments have been conducted with controllers in over 50 control rooms in the United States and Canada. We have developed a methodology to measure mental workload based on a modified NASA Task Load Index (NASA-TLX) as well as measures of task percentages. Last year we added an alertness measure to the workload assessments. Based on these assessments, we have created industry benchmarks for controller workload, alertness and controller general activities with particular attention to alarm response and abnormal and emergency condition responses.

We use a modified NASA-TLX to measure workload. The NASA-TLX is a multi-dimensional rating procedure that provides an overall workload score based on a weighted average of ratings on six subscales: 1) mental demand, 2) physical demand, 3) temporal demand, 4) effort, 5) performance and 6) frustration level. The measure combines weighted ratings on the six subscales to provide one integrated workload rating.

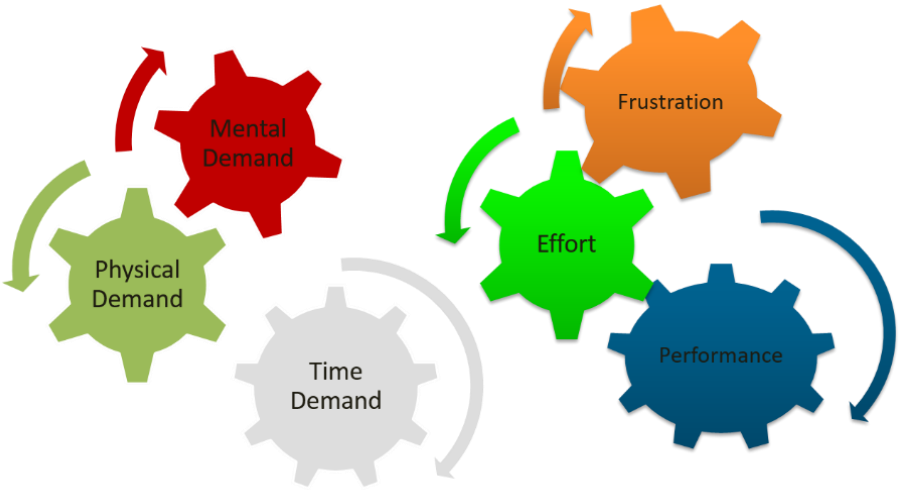

Figure 1 Dimensions of Workload

Last year we added the alertness measure to our workload assessment methodology. To measure alertness, we have adapted the Karolinska sleepiness scale (KSS) developed by the Karolinska Institute in Sweden. The 9-point scale is shown below:

1. extremely alert
2. very alert
3. alert
4. rather alert
5. neither alert nor sleepy
6. some signs of sleepiness
7. sleepy, it's no effort to stay awake
8. sleepy, some effort to stay awake
9. very sleepy, great effort to stay awake, fighting sleep

Results [236 words]

Our results address the relationship between controller alertness and workload levels. The authors collected alertness measure data from 29 nine workload assessments in 19 control rooms. These assessments included input from a total of 366 controllers. During a workload assessment, data was collected from controllers at the end of every hour during a 12-hour shift. Workload assessments were conducted on every day of the week for both day shifts and night shifts.

The average workload across the 29 workload assessments was 5.20 for day shift, 4.91 for night shift and 5.06 overall. During higher workload hours, where workload was rated as a 7.0 or above (on a 10-pt scale), the averages were: 8.30 for day shift, 8.38 for night shift and 8.33 overall.

The majority of the hours rated in the assessments were rated as “extremely alert,” “very alert,” and “alert” by the controllers, as shown in Figure 2. During the hours that were rated as higher workload, the percentage of “extremely alert” ratings increased.

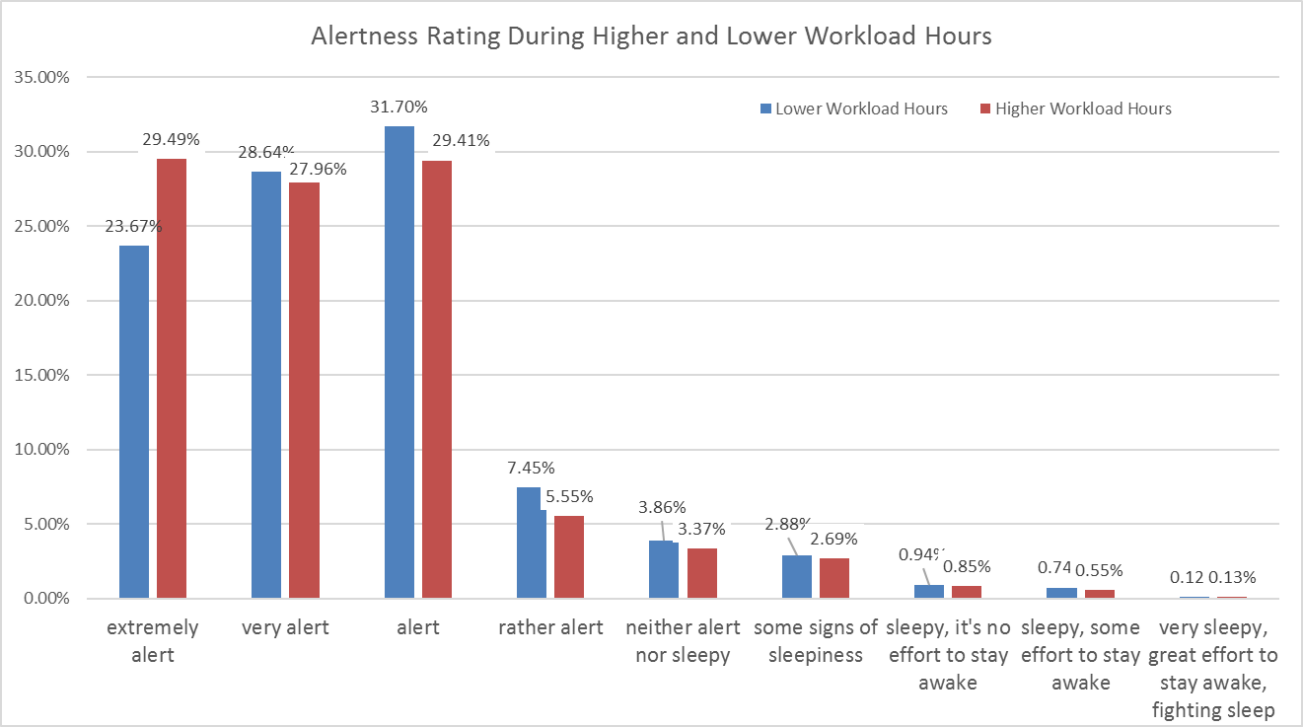

Figure 2 Pipeliner Alertness Ratings During Higher and Lower Workload Hours

The average workload rating was computed for each of the alertness scores. As shown in the table and figure that follow, during lower hours the highest workload averages were associated with alertness ratings at the top and bottom of the alertness scale - "extremely alert" and "very sleepy, great effort to stay awake, fighting sleep." During the higher workload hours, the workload averages did not vary much between the alertness ratings.

Table 1: Workload Averages by Pipeliner Alertness Scale

	Workload Averages	
Pipeliner Alertness Scale	**Lower Workload Hours**	**Higher Workload Hours**
extremely alert	4.69	8.23
very alert	4.65	8.48
alert	4.20	8.22
rather alert	4.02	8.58
neither alert nor sleepy	3.92	8.37
some signs of sleepiness	4.22	8.54
sleepy, it's no effort to stay awake	3.95	8.29
sleepy, some effort to stay awake	4.43	8.31
very sleepy, great effort to stay awake, fighting sleep	4.80	7.93
Total	**4.42**	**8.33**

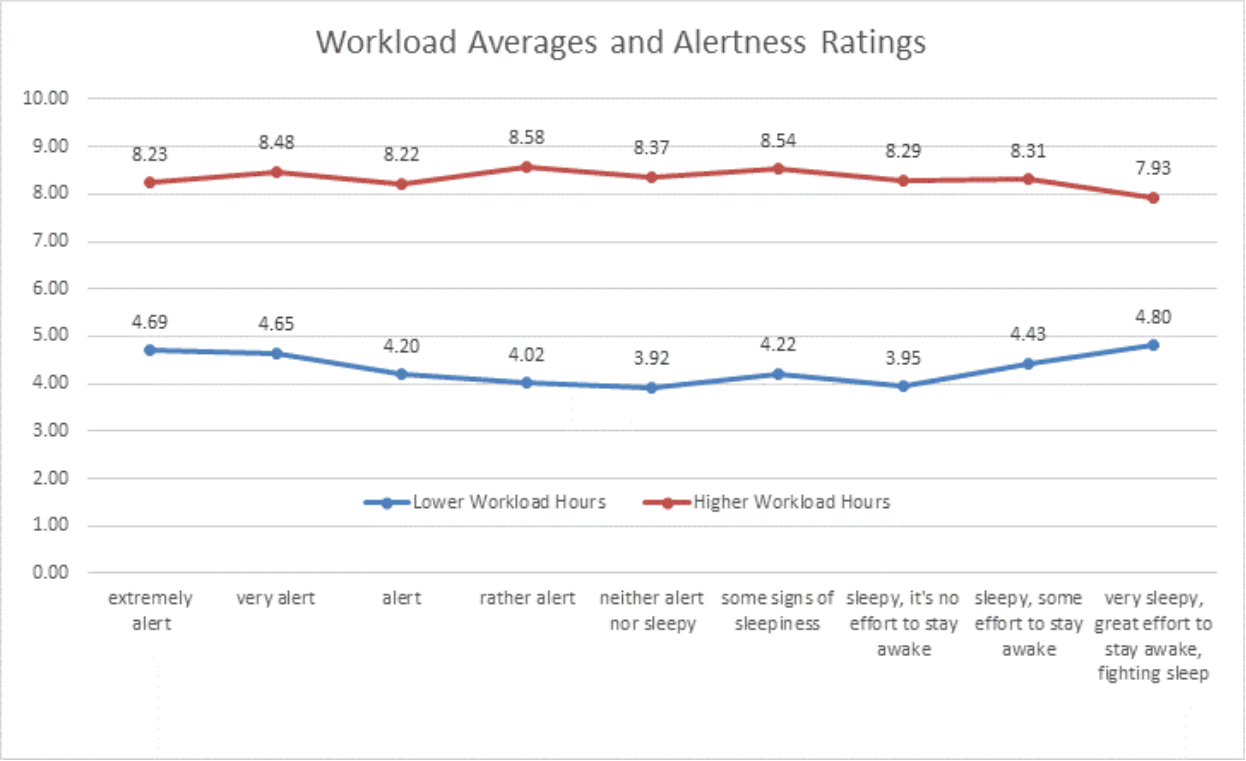

Figure 3 Pipeliner Alertness Ratings During Higher and Lower Workload Hours

Discussion [104 words]

The results show a relationship between controller alertness and workload levels. The greatest percentages of the alertness ratings were at the top of the alertness scale as "extremely alert" "very alert" and "alert." In higher workload hours, "extremely alert" ratings increased. This is expected due to higher levels of stress associated with higher workload hours.

During lower workload hours, the average workload was higher at the top and bottom ends of the alertness scale. These were the workload averages associated with alertness ratings of "extremely alert" and "very sleepy, great effort to stay awake." During higher workload hours the workload ratings were somewhat consistent.

Summary [94 words]

Controllers that operate hazardous processes work 12-hour shifts that require them to stay alert and maintain situation awareness throughout the shift. Optimally these controllers have an average amount of workload that is neither too high nor too low. Staying alert during this 12-hour shift is a challenge faced by most shift workers. As workload levels shift higher or lower, it is expected that alertness levels will shift also. As we gather more data we can better understand the relationship between alertness and workload during different times of the day and days of the week.