

Aging and Fatigue Issues for Nuclear Power Plant Operators



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Workforce Aging

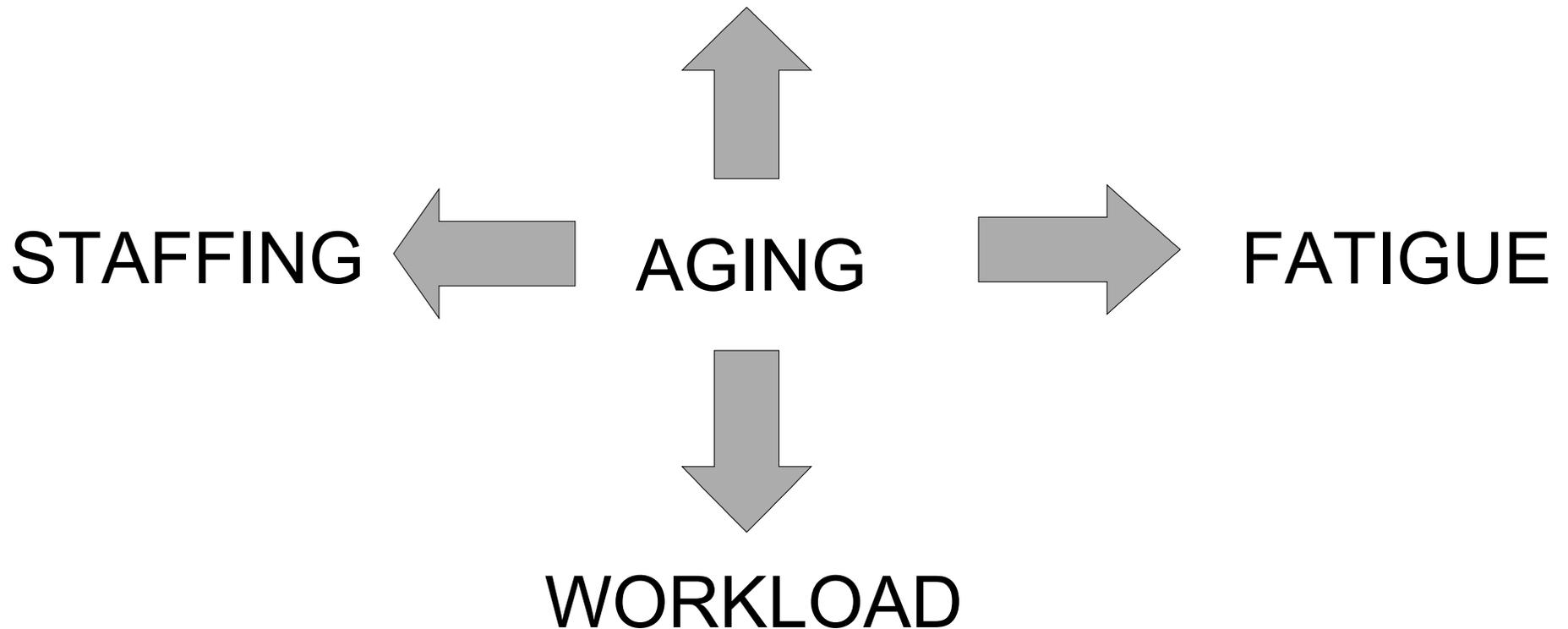
Affects more than the hair line

- ⇒ Experience
- ⇒ Retirement
- ⇒ Health
- ⇒ Stamina
- ⇒ Benefits

Workforce Aging in Nuclear Power Plants

Safety Perspective

SKILL OF THE CRAFT



Recent Environment

(1990s)

- More than one-half of all US nuclear power plants came on-line over 20 years ago
- Several plants decommissioned, all before end of license
- No serious discussion of new nuclear power plants
- Deregulation - consolidation, cost containment
- Downsizing of US naval nuclear program

Current Environment

(2000s)

- Electric power supply shortage is national news
- Increase in applications for plant life extensions
- Current administration's energy policy
- Heightened interest in building nuclear power plants in US

Implications

- Reduced incentive to join or remain in nuclear power industry
- Reduced incentive for universities to maintain nuclear training programs
- Reduced pipeline of personnel with navy nuclear training
- Increased age of workforce
- Increase in annual leave (decrease in staff availability)

Implications

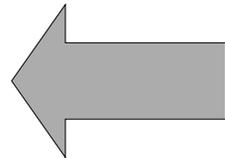
- Loss of experienced personnel through retirement
- Potential decrease in contractor availability
- Increased emphasis on efficiency
- Potential increase in demand for experienced operators

Workforce Aging in Nuclear Power Plants

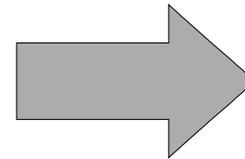
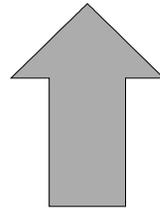
Safety Perspective

SKILL OF THE CRAFT

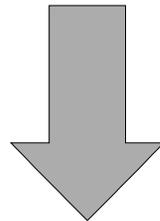
STAFFING



AGING



FATIGUE



WORKLOAD

Operator Staffing

- NRC reviewed operator staffing levels in response to congressional interest regarding effect of deregulation on staffing
- Number of licenses per unit has remained relatively constant
- RI and RII anticipate increased demand for new license exams

Operator Licensing

- NRC requests licensees to project operator licensing needs annually
- NRC budgets for operator licensing examinations accordingly
- NRC anticipates more candidates per class
 - mid 90s averaged 6-7 candidates / exam
 - currently averaging 10-11 candidates / exam
- NRC anticipates increased need for examiners to support operating tests

Licensing Examinations

- Streamlining exam development process
 - ▶ Removed 25% limit on items from past exams
 - ▶ Eliminates burden of tracking question usage in past exams
- Future Directions
 - ▶ Staff considering common exam for ROs and SROs as an option
 - ▶ Successful candidate would not need to take a subsequent “SRO” written test

Operator Fatigue

Impairments

- Attention / ability to divide attention
- Reasoning / problem solving
- Computational skills
- Oral communications
- Decision making

Operator Fatigue

Principal Factors

- Work scheduling
 - ▶ Number of hours worked
 - ▶ When hours worked
- Individual differences (including age)
- Other work and non-work related factors

Operator Fatigue

Regulatory Framework

- Generic Letter 82-12, “Nuclear Power Plant Staff Working Hours”
- Policy on Factors Causing Fatigue of Operating Personnel at Nuclear Reactors
- Plant Technical Specifications
 - ▶ 16 hours straight
 - ▶ 16 hours in any 24-hour period
 - ▶ 24 hours in any 48-hour period
 - ▶ 72 hours in any 7-day period
 - ▶ Minimum 8 hour break between work periods

NRC “Fatigue” Policy

GL 82-12

- 40-hour week objective while plant operating
- Guidelines provided for limiting work hours for unforeseen circumstances and during extended periods of shutdown
- Guideline deviations to be authorized for “very unusual circumstances”
- Paramount consideration for authorizing deviations - “significant reductions in the effectiveness of operating personnel would be highly unlikely”

Operator Fatigue

Recent Events

- Letter from Congressmen (2/99)
 - ▶ Potential effects of deregulation on staffing and overtime
- Union of Concerned Scientists Report (3/99)
 - ▶ Address worker fatigue as a fitness-for-duty issue
- PROS Survey (Fall 1999)
 - ▶ Concerns regarding workload and overtime
- Petition for Rulemaking (PRM- 26-2) (9/99)
 - ▶ Enforceable limits and controls
- 2.206 Petition (4/01)
 - ▶ Conditions of employment and fitness-for-duty

Petition for Rulemaking

Major elements

- **Work hour limits for 1-week and 2-week periods**
 - Vary depending on whether plant is in an outage period, non-outage periods, or extended shutdown
- **Annual limits on work hours**
 - Vary depending on whether you hold an operating license and whether you are a shift worker
- **Limits on the use of 16-hour shifts**
- **Limited exclusion of turnover time**
- **Training for fatigue mitigation**
- **Self-disclosure and evaluation of sleep disorders**

Petition for Rulemaking

Public Comments in Favor

- Cited importance of ensuring personnel are not impaired by fatigue
- Expressed concern NRC did not have regulation limiting overtime
- Asserted guidelines were ambiguous and not applied during outages
- NRC “appears to look the other way”
- Concerned restructuring and cost competition will reduce staffing and increase overtime

Petition for Rulemaking

Public Comments Opposed

- Existing regulatory requirements are adequate
- Proposed requirements would impose unnecessary burden and could not be justified through a backfit analysis
- Industry performance data refute assertion that rule is necessary to prevent fatigued personnel from performing safety-related work

Petition for Rulemaking

Process

- Analysis of Public Comment (6/00)
- Policy Assessment (12/00)
 - ▶ Technical adequacy
 - ▶ Regulatory framework assessment
 - ▶ Implementation assessment
 - ▶ Review of regulations and practices in other industries and countries
- Proposed resolution of petition (6/01)
- Commission review and decision (in progress)

Policy Implementation

Scope of Personnel

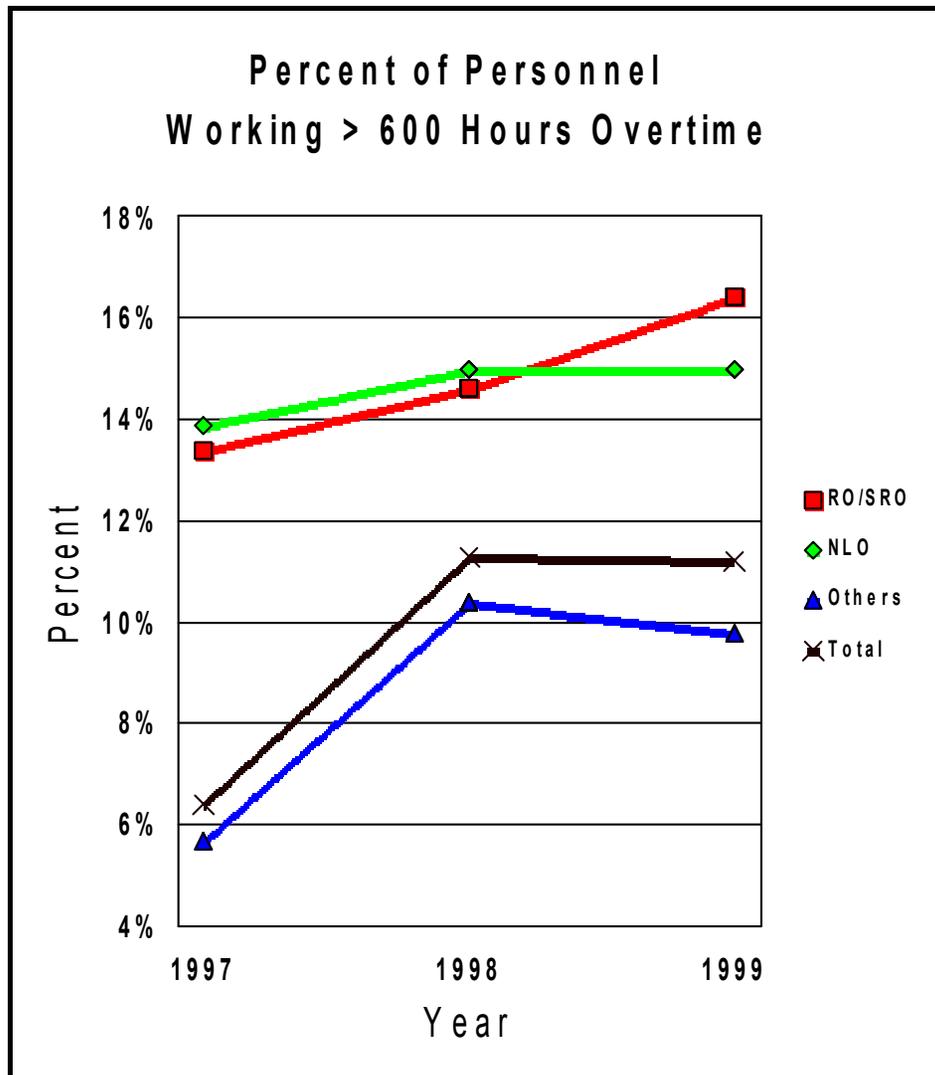
- Policy applies to personnel who perform safety-related functions
- There is inconsistency among sites in the scope of personnel covered by plant work hour limits
- A few sites do not cover any maintenance personnel which appears contrary GL 83-14

Policy Implementation

Use of Overtime

- Policy objective is “maintain adequate shift coverage without routine heavy use of overtime”
- 8 of 36 sites providing data had more than 20% of personnel covered by policy working in excess of 600 hours of overtime per year
- The percentage of personnel working in excess of 600 hours of overtime increased from 7% in 1997 to 11% in 1999

Overtime



Policy Implementation

Benchmarking

- NRC policy guidelines generally less restrictive than the regulatory limits of other US regulatory agencies
- NRC policy guidelines generally less restrictive than the limits of nuclear regulatory authorities in other countries

POLICY IMPLEMENTATION

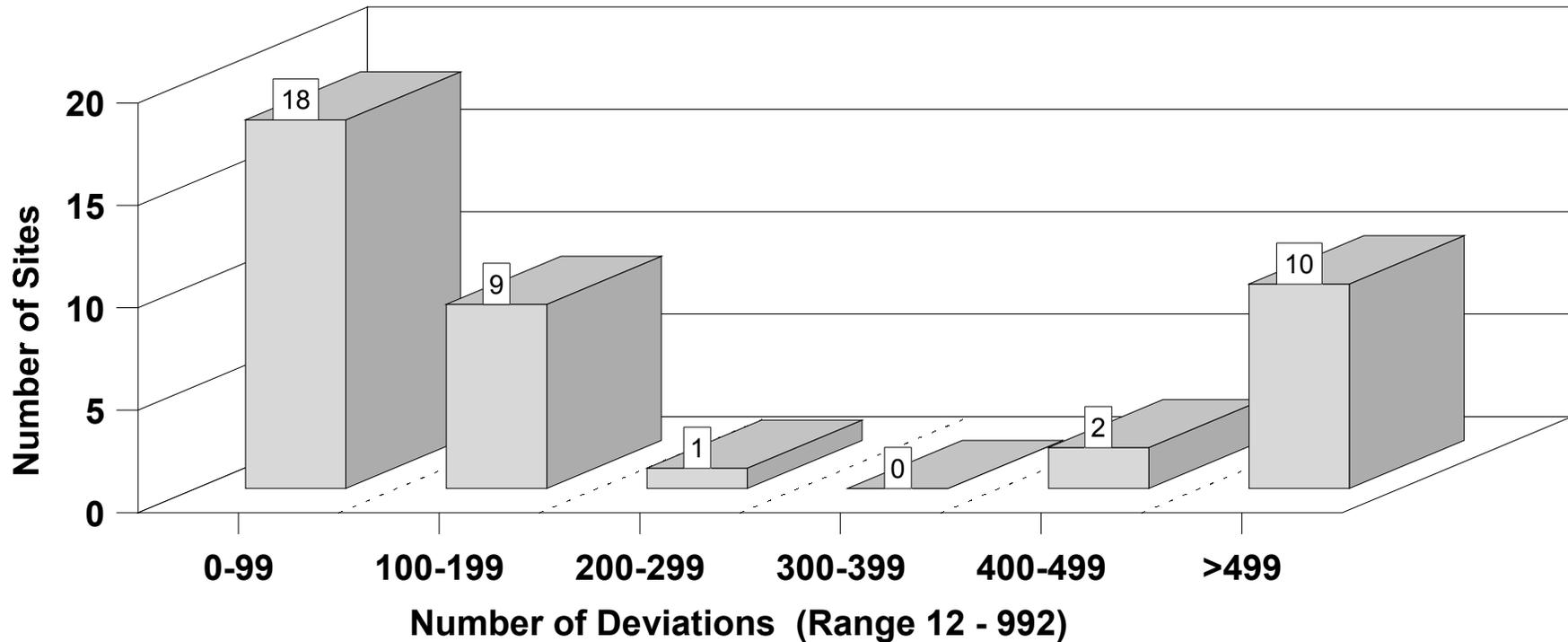
Guideline Deviations

- Policy provides for deviations in “very unusual circumstances”
- At one quarter of the sites that responded, 1,000 to more than 6,000 guideline deviations are authorized annually

Guideline Deviations

Non-outage Periods - 1999

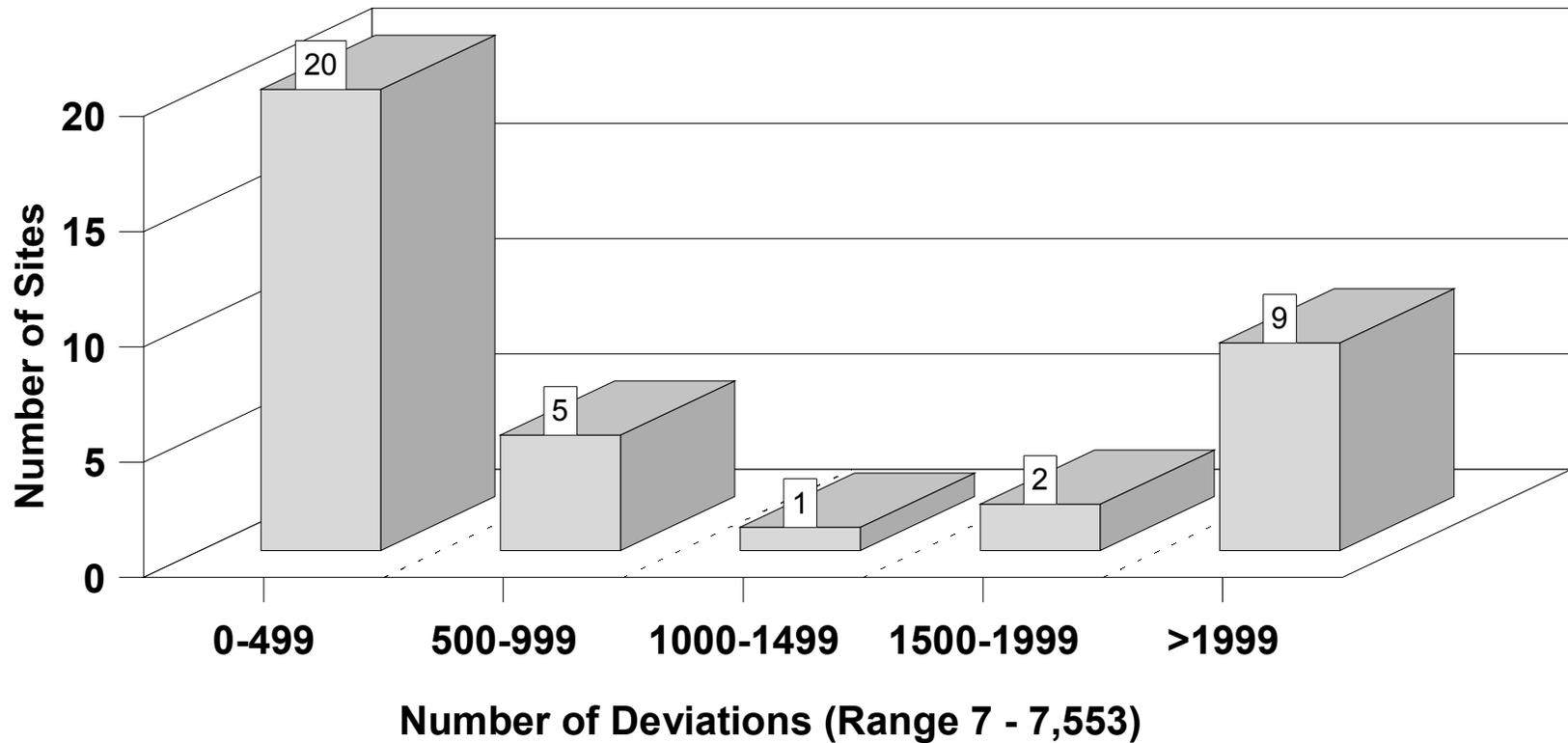
Distribution of Sites by Number of Deviations Authorized



Guideline Deviations

Outage Periods - 1999

Distribution of Sites by Number of Deviations Authorized



Why Deviations are a Concern

- **Fatigue Impairs**
 - Attention / ability to divide attention
 - Reasoning / problem solving
 - Computational skills
 - Oral communications
 - Decision making
- **Deviations increase risk of fatigue**

Why Deviations are a Concern

Convergent Validation

- Large sample studies show an exponentially increasing accident risk after 9th hour of work
- Studies indexing sleep deprivation to BAC show a precipitous drop in performance after 13 hours of wakefulness
- Brain scans of sleep deprived individuals show marked decreases in brain glucose metabolism
- Common experience

Extended Working Hours

Relative Risk of Fatigue Crash as a Function of Hours
Driving

Image of Relative Risk of Trucks in Fatal
Accidents (TIFA)

Extended Working Hours

Relative Risk of Accidents by Hours on Shift

Image of exponentially increasing risk using data from various industries including engineering firms and transportation

Extended Working Hours

Operations Department Errors as a Function of whether the individual was in the beginning, middle, or last “third” of a 12-hour shift

Image of number of errors as a function of third of shift

Circadian Rhythms - Performance

Number of LERS resulting in a plant trip attributed to operator error (cause of operator unknown) as a function of time of day

Image of percentage of LERs as a function of time of day

Circadian Rhythms - Performance

Performance errors at a nuclear power station as a function of time of day

Image of total error rate and failure to follow procedure error rates as a function of time of day. Highest peak shows workload effect and secondary peak shows degraded alertness in early morning hours.

Shiftwork Tolerance and Age

Air traffic controllers (ATC) ratings of their perceived level of impairment. Data presented as a function of the age of the ATC and whether they are working day, evening, or midnight shifts

Image of ratings of impairment by age and shift

Shiftwork and Disease

Percentage of personnel with circulatory system and digestive system disease as a function of whether they are day workers or shiftworkers and the number of years on the job.

Image of percentages of diseased workers for day workers and shift workers as a function of years work experience

Conclusion

- Aging of nuclear plant workers presents challenges for individuals, licensees, and NRC
- NRC is working to ensure that we can support an increased demand for license exams and will continue to ensure that licensed operators are appropriately qualified
- NRC is re-evaluating its regulatory framework with a focus on the fundamental issue of fatigue (not just working hours) to ensure that a worker's ability to remain alert is not unduly challenged