



PHMSA Control Room Management

Fatigue Mitigation

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Fatigue Mitigation

- Through Control Room Management portion of the regulations in 49 CFR Sections 192.631 & 195.446.
 - a) General
 - b) Roles and Responsibilities
 - c) Provide Adequate Information
 - **d) Fatigue Mitigation**
 - e) Alarm Management
 - f) Change Management
 - g) Operating Experience
 - h) Training
 - i) Compliance Validation
 - j) Compliance and Deviation



CRM Code Differences

	Description	192.631 Gas	195.446 Hazardous Liquids
(a)	Procedures and Applicability	Certain exclusion criteria for LDC's	No exclusions
(c)(1)	Adding, expanding, replacing the SCADA System	API RP-1165 only Sections 1,4,8,9,11.1,11.3	API RP-1165 et al.
(c)(5)	Different Controller assuming Responsibility	No RP reference	API RP-1168 Section 5
(e)(3)	Alarm Set-Point Verification	Annual verification	Annual verification & when field inst. are calibrated or changed
(f)	Coordination with Field Work	No RP reference	API RP-1168 Section 7

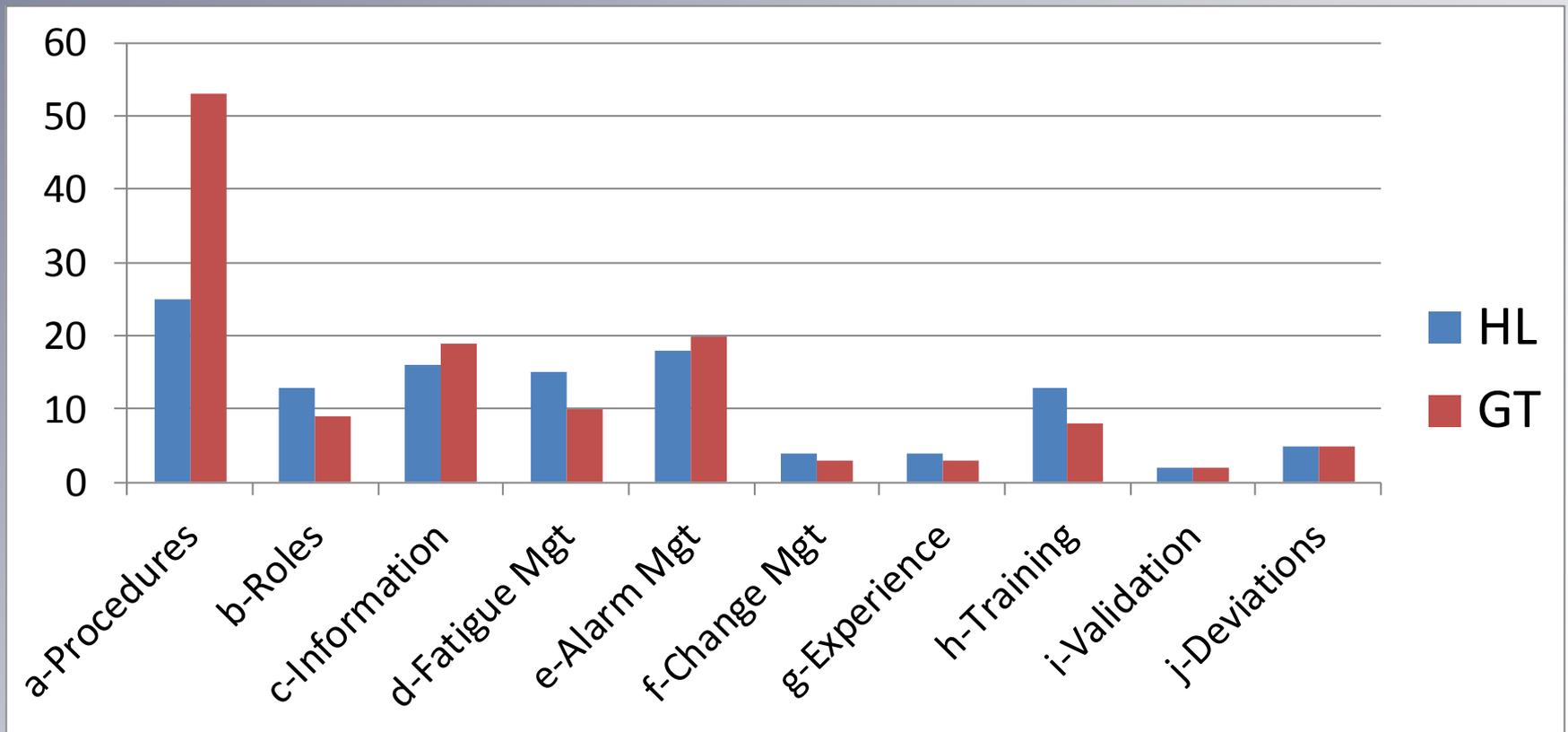


CRM Compliance Cases Issued thru 4Q13

- **13 – HL, Notice of Amendments**
- **7 – GT, Notice of Amendments**
- **1 – HL, Warning Letter**
- **1 – GT, Warning Letter**
- **3 – HL, Notice of Probable Violation**



25 Compliance Cases : Items Cited





High-Count Enforcement Items

Cited Code	Count
(a)(1), Procedures	46
(b)(4), Recording Shift Change	4
(c)(1), Implementing API RP1165	4
(c)(2), Point-to-Point Audits	6
(d)(1), Shift Lengths and Schedules	5
(d)(4), Max Limit for HOS	8
(e)(1), Review SCADA Alarms	6
(e)(2), Off-Scan, etc. Reviews	4
(e)(3), Verify Alarm Set-Point Values	5
(e)(5), General Activity	5
(f)(1), Field Work Coordination	4



Top Findings

- (c)(2) : Provide Adequate Information
- (d)(4) : Fatigue Mitigation
- (e)(1) : Alarm Management

Through 4Q12...

Top findings were all in Alarm Management



Fatigue Related Incidents

- 6/26/96 - Fork Shoals, SC: A 36-inch-diameter pipeline ruptured where a corroded section of the pipeline crossed the Reedy River at Fork Shoals, South Carolina. Released about 957,600 gallons of fuel oil into the Reedy River and surrounding areas.
- Fatigue not cited as probable cause, but was identified amongst findings.
- Fatigue Issues: Shift work; circadian disruption; time since awakening
- NTSB Accident/ Report # DCA96MP005/ PAR-98/01



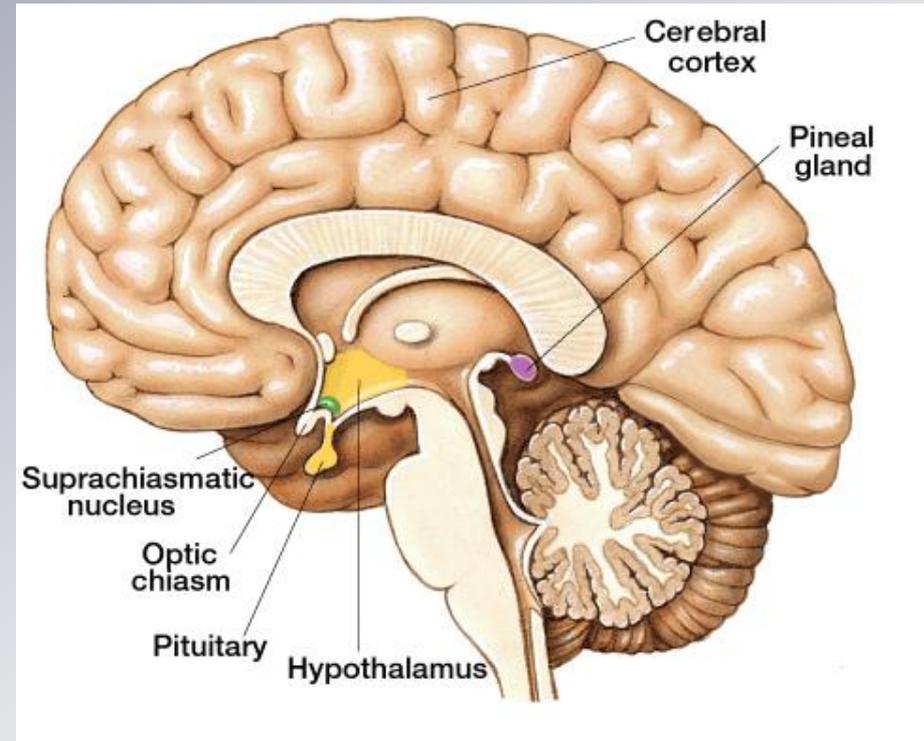
Fatigue Multi-Modal Issue

- Human factors issues, in general (including fatigue), continue to be looked at by all transportation modes in DOT
- DOT Human Factors Coordinating Committee (HFCC) includes others outside DOT
- NTSB Most Wanted List for years through 2011
 - Addressing Human Fatigue
 - Safety Management Systems
- Operator Distraction
- Safety Culture



Circadian Rhythms

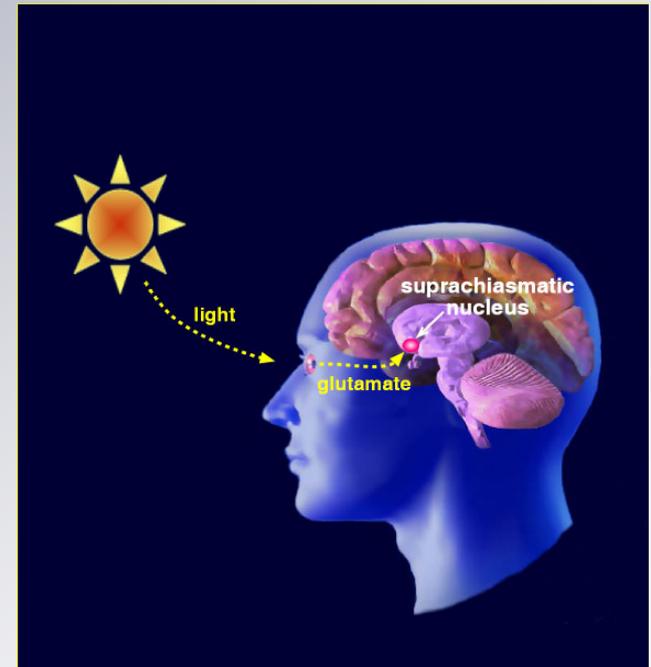
- Latin: *circa* (about), *dian* (a day); one cycle per day
 - Physiological day is slightly more than 24 hours long
- Circadian “body” clock in the brain coordinates hundreds of daily physiological cycles (*suprachiasmatic nucleus*, or SCN)
 - Sleep-wake cycle
 - Body temperature cycle
 - Digestive cycle
 - Hormonal cycles
 - And others





Circadian Rhythms

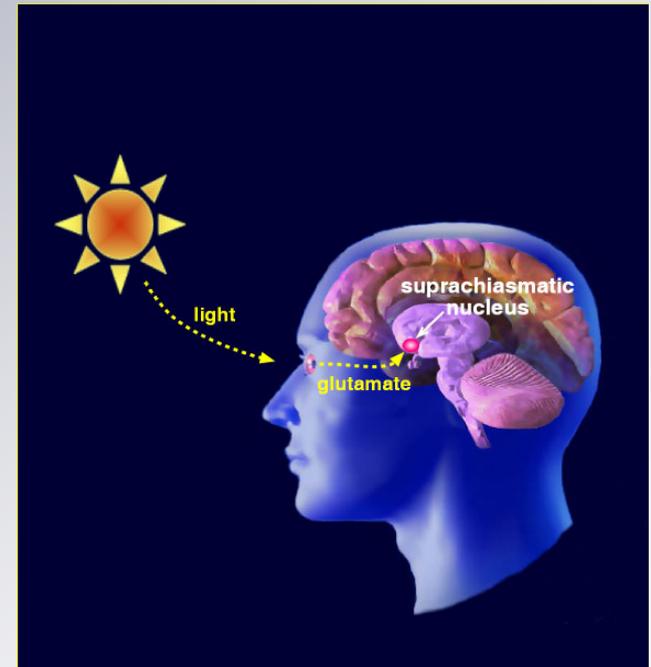
- The SCN is synchronized daily by environmental cues
 - Mainly the daylight-darkness cycle
 - Body rhythms persist even in the **absence** of external time cues





Circadian Rhythms

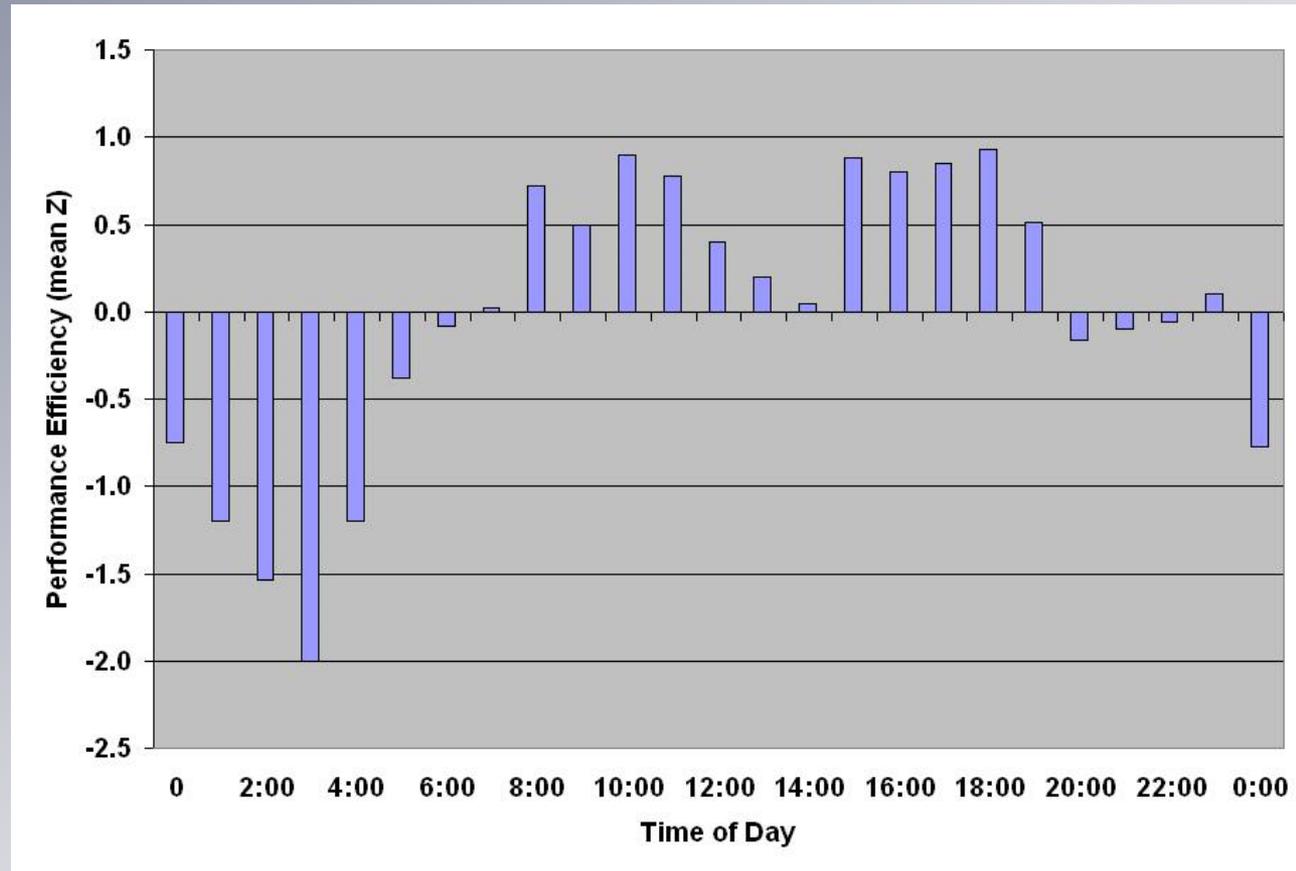
- The SCN pacemaker cannot reset immediately to:
 - Rapid time zone changes (> 1 hr/day; **jet lag**)
 - Inverted work/rest schedules (**shift lag**)
- When circadian rhythms are disrupted, cognitive performance is impaired and a feeling of *malaise* occurs until they are realigned





Circadian Rhythm Effects

"... 'real-job' speed and accuracy measures are only above average between 07:00 h and 19:00 h, at all other times efficiency is likely to be relatively impaired, especially so during the early hours of the morning." (Folkard & Tucker, 2003, three studies)

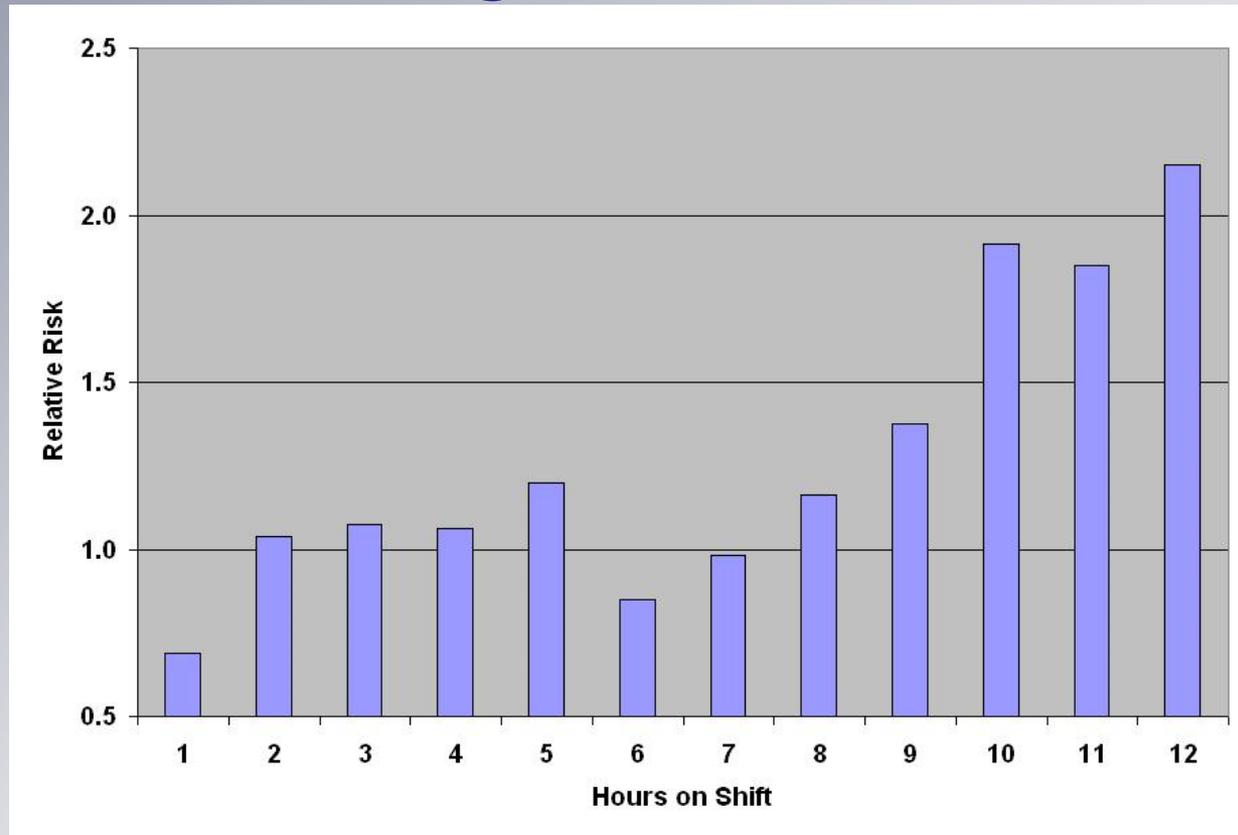


Folkard S, Tucker P. Shift work, safety and productivity. *Occupational Medicine*, v. 53, no. 2, pp. 95-101, 2003.



12-Hour Shift Length Effects

“...risk increased in an approximately exponential fashion with time on shift such that in the twelfth hour it was more than double that during the first 8 h.”
(Folkard & Tucker, 2003, four studies).



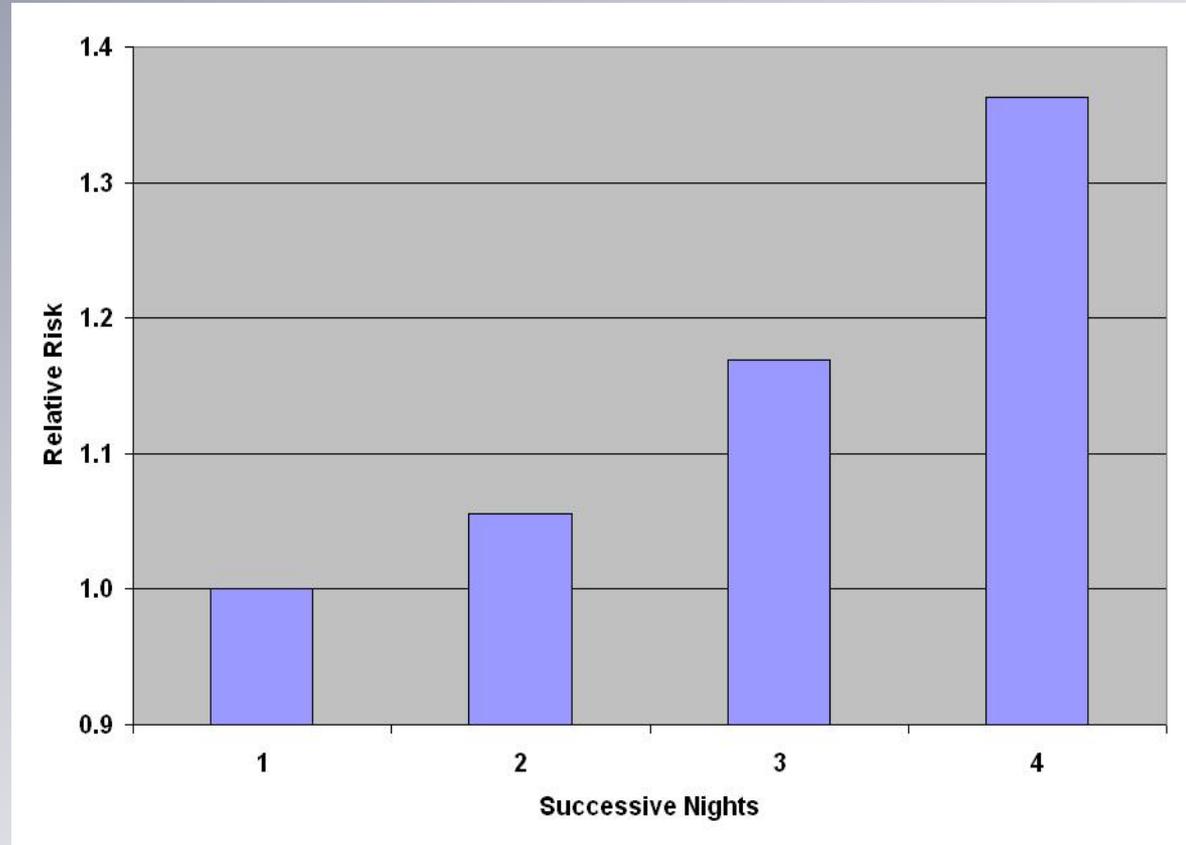
Folkard & Tucker, 2003.



Multi-Night Effects

"... risk was ~6% higher on the second night, 17% higher on the third night and 36% higher on the fourth night."
(Folkard & Tucker, 2003, seven studies)

Note increasing jumps of 6, 11, and 19%.



Folkard & Tucker, 2003.



Fatigue Effects

1. Individual Differences

2. Basic Cognitive Functions

- 2a. Working memory impairment
- 2b. Anterograde amnesia
- 2c. Retrograde amnesia
- 2d. Cognitive impairment
- 2e. Slowed response time (RT) and reduced response accuracy
- 2f. Impaired manual control
- 2g. Vigilance impairment
- 2h. Narrowed attention
- 2i. Hypnagogic hallucinations

3. Complex Cognitive Functions

3a. Willingness to accept greater risk

3b. Loss of situation awareness

4. Mood & Motivation Impairment



Fatigue Effects

5. Physiological

- 5a. General malaise
- 5b. Reduced aerobic capacity
- 5c. Drowsiness
- 5d. Sleep debt and need for recovery sleep
- 5e. Falling asleep on the job
- 5f. Dizziness
- 5g. Decreased altitude tolerance
- 5h. Decreased thermal tolerance
- 5i. Decreased acceleration tolerance
- 5j. Cardiovascular health effects
- 5k. Gastrointestinal health effects

6. Physiological Interactions

- 6a. Worsening of alcohol effects
- 6b. Modulation of drug effects

7. Interpersonal/Team Interactions

- 7a. Reduced interpersonal communications
- 7b. Impairment of shared situation awareness



49 CFR Sections 192.631(d) & 195.446(d)

Each operator must implement the following methods to reduce the risk associated with controller fatigue that could inhibit a controller's ability to carry out the roles and responsibilities the operator has defined:

- (d)(1) Establish shift lengths and schedule rotations that provide controllers off-duty time sufficient to achieve eight hours of continuous sleep;
- (d)(2) Educate controllers and supervisors in fatigue mitigation strategies and how off-duty activities contribute to fatigue;
- (d)(3) Train controllers and supervisors to recognize the effects of fatigue; and
- (d)(4) Establish a maximum limit on controller hours-of-service, which may provide for an emergency deviation from the maximum limit if necessary for the safe operation of a pipeline facility.



Fatigue as a Factor in Incidents

- Can learn a lot from incidents and near misses.
- If operator is subject to more extensive CRM program, specificity required through operator experience in §192.631(g)/ and §195.446(g).
- Even if not subject to more extensive program, fatigue as a factor is still an item in incident report forms 7100 and 7000-1 in accordance with §191.9 and §191.15 (Gas), and §195.54 (Liquid).
- White paper entitled “Investigating the Possible Contribution of Fatigue to Pipeline Mishaps” provides more guidance “meat” of the fatigue factors to consider in accident/incident investigations. <http://primis.phmsa.dot.gov/crm/fm.htm>



Key Aspects of Paragraph (d)

- Key aspects:
 - Identify the fatigue risks present that could impact a controller's ability to safely monitor and control the pipeline, including all potential issues with people, control room environment and/or procedures.
 - Identify what is being done to reduce those risks, in the context of the required methods.
 - Opportunity for eight hours of continuous sleep between shifts?
 - How are shift schedules, hours of service limits, emergency deviations, and training and education incorporated into overall program?
- Operator should help identify these in their program. If not, inspector may need to dig a bit.



General PHMSA Approach for Fatigue

- Regulations are performance-based in nature
- Other than the eight-hour requirement for continuous sleep in (d)(1), no explicit limits in code for hours-of-service, shift lengths, etc.
- Suggested limits have been established in PHMSA guidance based upon relevant science and research
- Any program must be able to demonstrate it is sufficient to reduce risk(s) associated with fatigue
- In addition to looking at procedures and implementation, encourage visiting the control room and interviewing controllers



Keep in Mind

- We're all human and research has shown general commonalities with respect to fatigue.
- However, no "one size fits all" solution...
 - No two programs or systems alike.
 - No two control rooms alike, even under same operator.
 - No two individuals alike.
- Cannot eliminate fatigue risks, but can manage and reduce the risks effectively.
- Extremely few can say they have no fatigue risks.



Relative Risks of Different Shifts

- More inherent risks associated with 24/7 type schedules, but...
- May be fatigue issues with any schedule, even if “traditional” Monday-to-Friday 8-to-5 schedule.
- A prudent operator can manage a 24/7 schedule with many nights very well. A not-so-prudent operator could mismanage a Monday-to-Friday 8-to-5 schedule.



Keep in Mind

- Duty schedules are only part of the equation. How is fatigue risk being managed overall?
- Consider the concept of “risk factors”
 - Any issue identified adds to the overall relative risk.
 - An issue in one area of fatigue mitigation program may or may not be compensated by another.
- Consider all elements of people, environment, and procedures before rendering final decision.
- Other factors could influence decisions, such as unions or the presence/absence of a healthy safety culture



FAQs and Litmus Tests

- Limits were requested and have been established in guidance to inspectors, based upon relevant research.
 - <http://primis.phmsa.dot.gov/crm/faqs.htm>
- Intended to be “soft” limits to provide a basis for discussion beyond the “hard” limit of opportunity for eight hours of sleep between shifts.
- Will they work for every operator? Likely not.
- Can PHMSA provide guidance on what will work for every operator? Likely not.
- The inspector needs to understand the operator’s entire fatigue mitigation effort.



Soft Limits for HOS (FAQ D.07)

- Fourteen (14) duty hours in any sliding 24-hour period, which includes shift hand-over time and any on-duty time.
 - 14 = up to 12 hr shift + additional time for handover, etc.
- Sixty-five (65) duty hours in any sliding 7-day period.
 - 65 = up to five x 12 hr shifts (or 7 x 8s) + some time for handover, etc.
- At least thirty-five (35) continuous hours spent off-duty when any limits reached:
 - 35 = 24 hrs + 12 minus one hr to adjust for handover.
 - Intended to provide at least two nocturnal sleep cycles (studies and others set this anywhere from 34 to 48 hrs).



Shift Handover & Other Time

- Guidelines assume most shift hand-overs are completed within 30 minutes. If not, then compensate accordingly.
- Some operators may not have a clear, distinct handover period, such as multiple controllers per desk with staggering sign-on/sign-off times.
- Other time factored in as well; e.g., some companies require employees come in X minutes before shift. Is that time accounted for in HOS limits?
- The key is to insure that all work time is included in HOS considerations and whether HOS impacts fatigue.



Increased Fatigue Risk in any HOS

- Certain times generate increased fatigue risk or reduced alertness concerns for which operator should have specific mitigation measures in place:
 - Any and all shift duty hours worked after first eight hours (day or night, but night a greater concern).
 - Any and all hours worked between 2 AM and 6 AM (in general “dawn”). Some studies say up to 10 AM can be an issue at the end of a night shift.
 - Any and all night shifts following three successive night shifts in a row.
 - Too many successive shifts in a row without adequate time off to combat cumulative effects.



Other considerations

- Commute time
 - PHMSA recommends at least ten hours between shifts. Shorter or longer commute times or the availability of nearby sleep facilities may influence the appropriate amount of off-duty time.
- On-call issues
- Is all time an individual is required to work for the company, even if not in controller status, being factored into HOS?



The Inspection





Flow of Inspection Questions

Not in numeric order. Better flow of discussions.

- (d)(0) (general) – general questions about overall program, how they [you] manage the program, etc.
- (d)(1) – how do they [you] establish and manage shift lengths and schedule rotations to ensure opportunity for eight hours of uninterrupted sleep?
- (d)(4) – how do they [you] establish and manage hours of service in terms of shift lengths and schedule rotations?
- (d)(2) – fatigue education
- (d)(3) – fatigue training



192.631(d) & 195.446(d)

“Each operator must implement the following methods to reduce the risk associated with controller fatigue that could inhibit a controller’s ability to carry out the roles and responsibilities the operator has defined.”

- PHMSA: Comprehensive plan(s) (procedures) should be in place that, at a minimum, includes all the elements or “methods” in the rule.



What We're Looking For

- Do the operator's plans and procedures cover all of the elements?
- How do they establish their limits or other methods?
- Do those limits or methods reduce the risk associated with controller fatigue?
- Since fatigue risks still exist, how do they mitigate those risks?



(d)(1) Opportunity for Eight Hours of Sleep

(d)(1) “Establish shift lengths and schedule rotations that provide controllers off-duty time sufficient to achieve eight hours of continuous sleep.”

- i.e. operator must provide individuals an opportunity for eight continuous hours of sleep between shifts.
- Responsible for factoring in any on-duty time the individual is working for them (time can add up).



(d)(1) Objectives

- How do they establish shift lengths and schedule rotations?
- Does it provide opportunity for eight hours of continuous sleep?
- Does it reduce risks associated with fatigue?
- Since fatigue risks are still present, how do they mitigate them?



(d)(4) – Maximum Limit on Hours-of Service (HOS)

(d)(4) “Establish a maximum limit on controller hours-of-service, which may provide for an emergency deviation from the maximum limit if necessary for the safe operation of a pipeline facility.”

Key questions to consider

- Has the operator established a credible and justified maximum limit on HOS?
- Do they provide for rare emergency deviations from maximum limit if needed?
- Do they justify how emergency deviations are needed for safe operation of the pipeline?



(d)(4) Objectives

- How do they [operators] establish their HOS limits?
- Do those limits reduce risks associated with fatigue?
- Since fatigue risks still exist, how do they mitigate?
- How do they track to insure that all time worked by employees complies with limits?
- Do they provide for rare emergency deviations from maximum limit if needed?
- If deviations occur, do they consider additional risks for fatigue and how they need to further mitigate risks?
- If deviations are needed, do they justify how they're needed for safe operation of the pipeline?



Emergency Deviations

- Operator should have some means to define their emergency deviations and how they address them. PHMSA does not define, but:
 - Should align with other parts of code(s) for emergencies; e.g., in case of fire/evacuation, does the controller have to stay on, and just get a firesuit while others run away?
 - Should have examples specific to fatigue; e.g., someone calls out sick, incident occurs during shift and person needs to stay on, etc.
 - Should have some exception approval process in place that considers fatigue impacts and mitigation measures needed.
 - Does NOT get them out of the 8 hours requirement in (d)(1).



Useful Items for Emergency Deviation/Exception Form

- Completed by (name, title, etc), date
- Reason for exception
- Date and time work schedule was changed
- Work schedule change affected the following employee(s)
- What the new schedule is/was after the exception
- What risks are/were associated with the exception
- Measures taken to mitigate the risks for fatigue
- Approved by (name, title, etc), and date if different than above



(d) (2) Education

(d) (2) "Educate controllers and supervisors in fatigue mitigation strategies and how off-duty activities contribute to fatigue."

What we're looking for:

- Content of the education; at a minimum the education must include the elements, above.
- Does timing of education appear reasonable?
- Does it include other information to help show how to reduce the risks associated with fatigue?
- Does it appropriately roll in other aspects of their program, and if risks exist, how to mitigate?



(d)(3) Training

(d)(3) "Train controllers and supervisors to recognize the effects of fatigue."

What we're looking for:

- Content of the training; at a minimum the training must include how to recognize effects.
- Does timing of training appear reasonable?
- Does it include other information to help show how to reduce the risks associated with fatigue?
- Does it appropriately roll in other aspects of their program, and if risks exist, how to mitigate them?



Recognizing Effects is Difficult!

- You need to know an individual quite well to detect changes in behavior. Thus, you must depend upon front-line managers to know their controllers well, and controllers should be trained and willing to self-report fatigue effects.
- This is a detection that, if practical in the workplace, would best be based upon quantitative human performance or physiological measures.
- A more practical approach is to train controllers to track their own hours of sleep debt. When that total reaches ten hours, they should self-report their potential impairment by fatigue.
- A healthy safety culture is key.



Fatigue Mitigation Training

FAQ D.04 What are some specific elements that should be included as part of a fatigue mitigation training and education program?

The following are examples of elements that should be considered as part of fatigue mitigation training and education:

- Sleep physiology, sleep hygiene and sleep pathologies
- Sleep deprivation effects on work performance
- Circadian rhythm effects on work performance
- Time on task fatigue effects on work performance
- **The effects of prescription and over-the-counter drugs on sleep and performance**



FAQ D.04, cont.

- Fatigue countermeasures
- Fatigue modeling
- Quantifying the potential contribution of fatigue to incidents and accidents
- How off-duty activities contribute to fatigue
- **Fatigue effects on highway driving performance**
- Employer-specific policies and procedures related to fatigue management
- Individual-specific employee differences that may impact fatigue
- Fatigue mitigation strategies based upon the preceding information



Fatigue Mitigation Tactics

- Examples of Fatigue Mitigation Tactics (besides actually sleeping) (D.05)
 - Provisions for on-the-job napping
 - Tactical caffeine use
 - Procedures for double-checking checklist completion
 - Exercise areas
 - Activities intentionally injected at specific times in the shifts when the risk of fatigue is high
 - Mechanisms in place for controllers who self-identify or are identified by supervisors as being fatigued
 - Mitigation tactics that may work for specific individuals
 - Standing up



Fatigue Mitigation Tactics

- Provide means for controller to get up and walk around and still be able to monitor and control pipeline as needed
 - Projection on a wall if they walk away from screen.
 - If they need to walk away from the room, for a bio break or otherwise, provide cell phones, monitors throughout the building, or potentially have alarms patched into PA system (particularly at night with single controller setups).



Compliance Issues Thus Far

- Procedural issues
 - Level of detail in plans/procedures not adequate. Operator verbally augmented with additional explanation on what is actually done when and by whom, but not reflected in procedures.
 - Lack of connecting the dots in all aspects of fatigue mitigation procedures, or tying in to other aspects like operator qualification
 - Lack of fatigue countermeasures, particularly during period known to increase risk of fatigue
- Implementation Issues
 - Lack of substantiation for maximum limits on controller hours-of-service
 - Lack of substantiation that shift schedules and maximum hours of service provide opportunity for 8 hours of continuous sleep
- More detail in later slides



Additional Operational Risks that are a Reality

- Single desk/controller operations, particularly with smaller systems
- 7-on/7-off shift or beyond plans, typically in use in more remote field operations in north slope Alaska, off-shore drilling rigs, etc.
- Additional issues in Alaska and other northern latitudes



Single Controller Ops

- The ability to mitigate the effects of nighttime controller fatigue is sharply limited with only one controller on duty.
- If single-desk operations at night are unavoidable, the operator should be prepared to demonstrate that workload is easily manageable and that appropriate fatigue mitigation measures (countermeasures) are in place to reduce fatigue risks.
- If managed properly and sufficient justification is provided, one controller/single-desk shift operations at night may be acceptable.
- Pros and cons...



Single Controller Pros

- Positives:
 - Small number of controllers may allow efficient coordination of on-call issues within HOS limits.
 - Fewer distractions from other controllers, managers, phone calls to the desk if a controller helps with 811 calls, etc. during the night shift.
 - Some operations may have less pipeline activity in general at night; others may have more, or it may depend upon the season.



Single Controller Cons

- Negatives:
 - Difficult or impossible to replace a controller who becomes excessively fatigued or ill in the middle of a night shift without interrupting the sleep of an on-call controller.
 - Difficult to take a break at night. On-duty napping is typically not possible unless the operator has a means to insure the controller can still take a nap while being able to react to an alarm if one occurs.
 - No controller with whom to discuss potential solutions to system problems that arise at night.



Single Controller – What If?

- Questions to ask operators:
 - How do you insure that the controller is not overly fatigued?
 - How do they inform you if overly fatigued?
- “What if” they become too fatigued (or die) (Dead-man switch)
 - How do you know?
 - How do you insure someone’s watching the store at all times?



7-On/7-Off Shift Plans

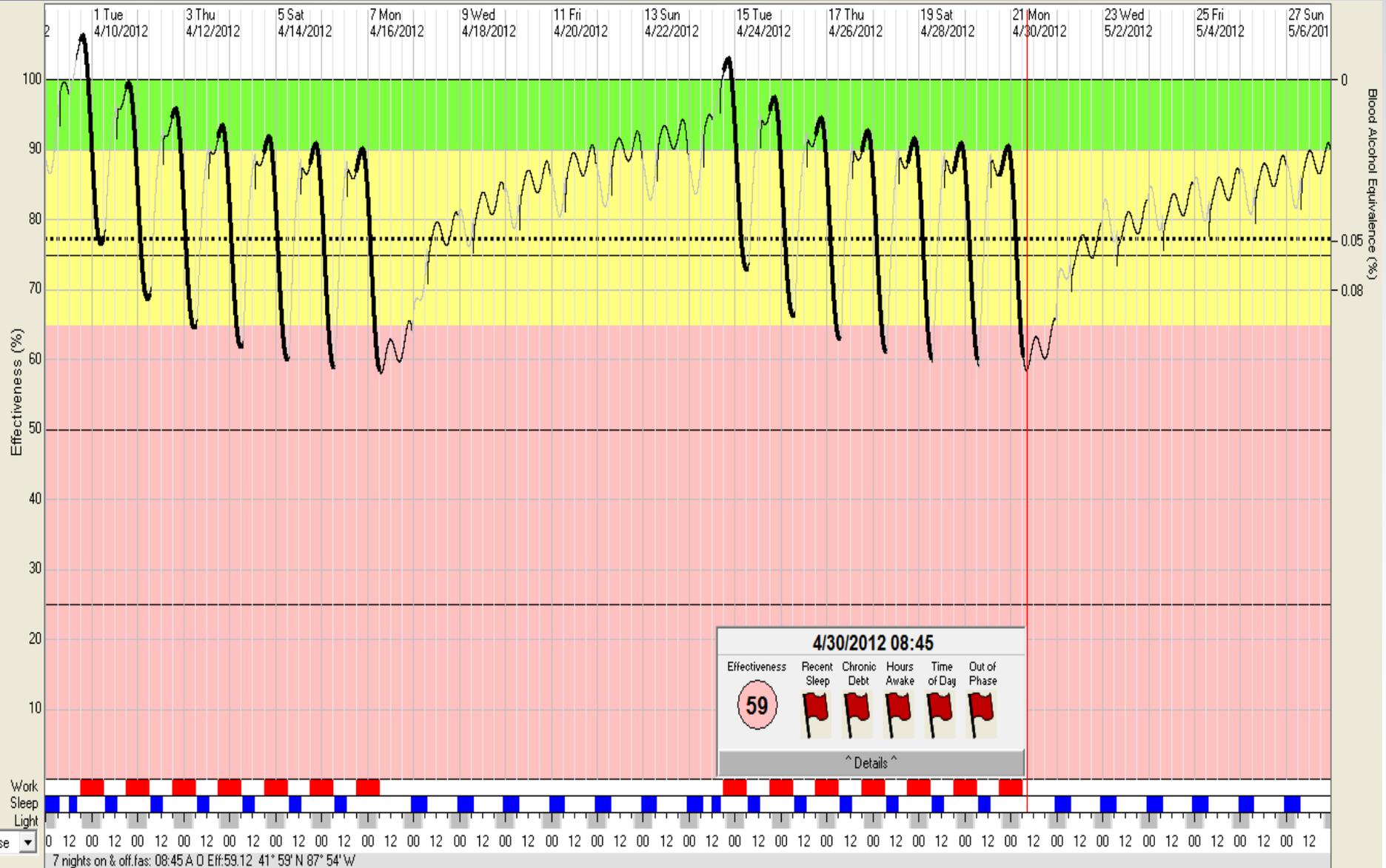
- Specific operational demands may dictate the use by control rooms of a 7-on/7-off shift plan.
- For example, the need for continuity with remote field operations when a previous attempt to use a rapid rotation was not successful for continuity.
- By remote is meant operations such as those in Alaska in which a field worker commutes regularly hundreds of miles to and from the work site.



7-On/7-Off Shift Plans

If a 7-on/7-off plan is in use, then expect to see:

- Excellent overall fatigue mitigation measures being taken; and
- Excellent, specific fatigue mitigation measures being taken during the:
 - 6th and 7th successive day shifts;
 - 4th through 7th successive night shifts; and
 - Last 4 hours of any 12-hour shift, especially during the midnight-to-dawn period.
- FAST graph of night shifts...





Industry Standards/Guidance

- Three industry documents have been developed:
 - API RP 755: “Fatigue Risk Management Systems for Personnel in the Refining and Petrochemical Industries”
 - SGA Framework Document: “Gas Pipeline Industry Control Room Management Rule Compliance Framework Document”
 - APGA guidance for smaller operators
- Other existing documents are being enhanced, such as API RP 1168 “Pipeline Control Room Management”
- These documents contain valuable but insufficient content.
- Operators typically need to supplement them with additional information for comprehensive program.



Program & Inspection Information

- Inspection Guidance and Forms on the Web
- Topical Presentations
- Reference Materials and Research

<http://primis.phmsa.dot.gov/crm/index.htm>

Additional fatigue guidance:

<http://primis.phmsa.dot.gov/crm/fm.htm>



Thank you!

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