

**Overtime and Staffing Problems  
In the  
Commercial Nuclear Power Industry**

**March 1999**

*My group spends a lot of time in the field, and so does the other groups and we see problems – working hours, overtime, fatigue. There are three quick examples that we're in between having a standard on how to deal with that and a problem that we know is lurking out there.*

NRC Staffer to Advisory Committee on Reactor Safeguards December 5, 1996

---

**UNION OF  
CONCERNED  
SCIENTISTS**

## Overtime and Staffing Problems in the Commercial Nuclear Power Industry

---

After the Three Mile Island accident, the Nuclear Regulatory Commission (NRC) recognized the role that worker fatigue could play in an accident. Unfortunately, that recognition did not lead to the problem's resolution.

An extensive review of NRC documents dealing with fatigue problems found a clear pattern of unenforceable ambiguity. The NRC's concern about worker performance problems caused by fatigue seems to be limited to their meekly encouraging plant owners to handle it. The NRC's inept treatment of this issue is baffling when compared to how successfully the agency dealt with another issue having similar impacts on worker performance – namely, substance abuse. For that issue, the NRC implemented a rule that has virtually eliminated substance abuse problems by nuclear workers.

Anecdotal evidence supports the conclusion of NRC ineffectiveness on the fatigue issue. Three members of the NRC's regional staff indicated that the agency feels that as long as nothing bad happens, it will take no action. That attitude, if reflective of NRC policy, would seem to be designed to – at best – prevent the *second* major reactor accident. It contradicts the NRC's mission, as defined by Congress, of providing adequate protection against the *next* major reactor accident.

The electric utility industry is undergoing restructuring. Nuclear power plant owners are cutting staffing levels in their efforts to generate electricity at competitive prices. As a result, workers at nuclear plants are working more overtime. For example, operators at a Midwest nuclear power plant logged 50,000 overtime hours in just one year's time – 1997. The worker fatigue problems are likely to get worse unless the NRC takes action to deal with the issues.

The full rationale for NRC's failure to meaningfully address overtime and staffing issues is not known, but a major part is simply "that nothing bad has happened yet." Using this unsound logic, the emergency core cooling systems and containment buildings at the nation's 103 nuclear power plants could be permanently removed since few events have required their use. Unlike the purported one in a hundred-thousand year or one in a million year chances of an accident requiring emergency core cooling systems and the containment building, worker fatigue is a minute by minute challenge to safe plant operation.

The NRC must establish clear requirements for working hours that reduce the potential for weary workers making grave mistakes.

## Overtime and Staffing Problems in the Commercial Nuclear Power Industry

---

### How Workers Affect Nuclear Safety

According to information provided to the NRC by nuclear plant owners, 50 to 80 percent of serious safety problems involve worker errors.<sup>1</sup> The NRC's analytical staff reviewed reports submitted by plant owners and NRC inspectors and concluded that the sequence of events leading to a major plant accident would most likely be initiated by a worker mistake.<sup>2</sup> Following its review of plant-specific safety assessments, the NRC staff concluded, "human actions are clearly important contributors to operational safety" and "human error can be a significant contributor to [serious reactor accidents.]"<sup>3</sup> Thus, nuclear plant workers make mistakes and their mistakes can have very serious safety implications.

What causes nuclear plant workers to make mistakes? While there is no single cause for the mistakes, fatigue is responsible for some significant ones. For example, the NRC reported that in October 1990, three workers at Braidwood Unit 1 in Illinois, were sprayed with 180°F water – one individual received second degree burns – from the reactor coolant loop when plastic tubing used for testing burst open. Over 600 gallons of water drained from the reactor coolant system before the leak could be stopped. NRC inspectors concluded that fatigue from excessive overtime was a main contributor to this event.<sup>4</sup>

### How Fatigue Affects Workers

Researchers have consistently found what Thomas Jefferson might have considered self-evident – that fatigue causes workers to make more mistakes and to perform less reliably.

The accident at Three Mile Island – the worst commercial nuclear plant accident in US history – occurred in the early morning hours of March 28, 1979. The following year, the NRC reported:

Studies indicate that with fatigue, especially because of loss of sleep, an individual's detection of visual signals deteriorates markedly, the time it takes for a person to make a decision increases and more errors are made, and reading rates decrease. Other studies show that fatigue results in personnel ignoring some signals because they develop their own subjective standards as to what is important, and as they become more fatigued they ignore more signals.<sup>5</sup>

The last part is particularly disturbing because it suggests that well-founded procedures and layers of emergency equipment can be defeated by weary workers discounting warning signs.

Concern about fatigued workers is not confined to the nuclear industry. Research in the aviation industry found that fatigue:

- slowed individuals' reaction time,
- impaired people's problem-solving ability,
- made people more likely to take shortcuts,
- made people more willing to accept higher than normal levels of risk.<sup>6</sup>

Here again, is the disturbing finding that fatigue prompts otherwise responsible people to take shortcuts and high risks.

## Overtime and Staffing Problems in the Commercial Nuclear Power Industry

The aviation study concluded that fatigue made it harder for people to solve problems. In 1992, researchers at Canada's Defence and Civil Institute for Environmental Medicine quantified this negative impact. They reported that after 18 hours awake, people's problem-solving ability declined by 30 percent.<sup>7</sup> Note that this degradation occurs after the time awake not just the time on the job.

Although fatigue was not shown to be a factor in the space shuttle *Challenger* explosion, the Rogers Report did find that worker fatigue had contributed to prior near-misses.<sup>8</sup> One specific example cited was the aborted launch of shuttle mission 61-C on January 6, 1986. Five minutes before the launch, workers misinterpreted a valve indication failure in the automatic fueling sequence. This caused the undetected loss of nine tons of the liquid oxygen fuel. A fortunate side effect of the loss was a drop in temperature to the shuttle main engines, but this degraded condition was noted only 31 seconds before the launch. The launch was aborted. The investigation found two significant points:

- Worker fatigue was one of the major factors of the error. The workers were 11 hours into their third consecutive 12 hour midnight shift when the error was made.
- Had the error not been discovered and the launch aborted in the final seconds of the countdown, it was seriously doubted that the shuttle would have reached orbit.

The Rogers investigation was very critical of the long hours worked by shuttle subcontractors because, in part, they regularly exceeded the recommended limits of an NRC report<sup>9</sup>. The ironic part is that

NRC never implemented its own recommendations.

Worker fatigue has even tarnished the golden arches. In 1983, an Oregon jury awarded \$400,000 to the driver of a car struck by a McDonalds employee who had worked three shifts within a 24-hour period. The jury determined that McDonalds failure to control working hours "unreasonably created a foreseeable risk of harm."<sup>10</sup>

The effects of fatigue on nuclear safety are best summarised in the NRC's own words:

The safety of nuclear power plant operations and the assurance of general public health and safety depend on personnel performing their jobs at adequate levels. Research on extended working hours indicates that the performance of individuals will degrade without adequate rest after long periods of work. Fatigue can degrade an operator's ability to rapidly process complex information such as that presented by off normal plant conditions. In addition, fatigue may jeopardize the ability to respond in a timely fashion. Furthermore, performance errors are more likely to occur as a result of lapses in short-term memory. Because individuals performing safety-related duties may be required to respond quickly to a plant emergency, it is important for plant management to carefully exercise control over overtime practices in order to ensure that plant personnel perform adequately.<sup>11</sup>

McDonalds was held accountable because it failed to properly deal with a foreseeable risk of harm. The NRC acknowledges that

## Overtime and Staffing Problems in the Commercial Nuclear Power Industry

worker fatigue represents a risk to nuclear plant safety. What have they done about it?

### What NRC Did About Fatigue

The NRC first attempted to deal with the fatigue problem with a policy statement on overtime issued in 1980.<sup>12</sup> The policy contained more restrictive working hour limits than currently exist, but even these 'limits' were diluted because they were presented as recommendations rather than as requirements. The policy also outlined the licensee's responsibility to "provide a sufficient number of trained personnel who are in the proper physical condition to operate and maintain the plant."

In 1982, the NRC sent all nuclear power plant owners information which forms the agency's current overtime policy. The major points of the policy are:

- Plant owners must have written procedures that formalize the working hour guidelines and prevent situations where fatigue could reduce the ability of operating personnel to keep the nuclear plant in a safe condition. The procedural controls should assure that personnel are not in a fatigued condition while at work that could significantly reduce their mental alertness or their decision-making ability.
- A sufficiently large work force should be used to prevent routine heavy use of overtime. The objective is a normal 8-hour day, 40-hour week while the plant is operating. If unforeseen problems require substantial amounts of overtime to be used, or during extended periods of shutdown, the following guidelines shall be followed:

1. An individual should not work more than 16 hours straight.
  2. An individual should not work more than 16 hours in any 24-hour period, nor more than 24 hours in any 48-hour period, nor more than 72 hours in any seven-day period.
  3. A break of at least 8 hours should be allowed between work periods.
  4. Except during extended shutdown periods, the use of overtime should be considered on an individual basis and not for the entire staff on shift.
- If very unusual circumstances arise that require deviation from the guidelines, such deviation shall be authorized by the plant manager, his deputy, or higher levels of management.

After the Three Mile Island accident, the NRC required nuclear power plant owners to revise their operating licenses to include administrative controls on staffing levels and working hours. Although the administrative controls language was somewhat ambiguous, its placement in plant operating licenses meant that the NRC focused at least some attention to the matter.

Beginning in 1996, NRC undermined what little rigor remained in overtime regulation by allowing plant owners to re-revise their operating licenses, this time to *remove* the administrative controls on staffing levels and working hours. For example, the NRC issued a Safety Evaluation Report for San Onofre Units 2 and 3 to allow the overtime controls to be removed from Tech Specs. The basis was "that few events at U.S. nuclear plants have been attributed to inadequate control of working hours."<sup>13</sup>

## Overtime and Staffing Problems in the Commercial Nuclear Power Industry

### How NRC Handled Substance Abuse

Ten years ago, the NRC issued the Fitness for Duty rule to address substance abuse in the nuclear power industry. The NRC imposed this rule because "scientific evidence is conclusive that significant decrements in cognitive and physical task performance results from drug and alcohol usage."<sup>14</sup>

During 1997, researchers at the University of Southern Australia compared the effects from fatigue to those from alcohol consumption.<sup>15</sup> They used standard eye-hand coordination test methods. After 17 hours awake, the decline in performance was equivalent to a blood alcohol content (BAC) of 0.05 percent (the legal limit set by the NRC for access to nuclear power plants is a BAC of 0.04 percent). At 24 hours awake, performance had decreased to a level corresponding to a BAC of 0.10 percent.

Curiously, although conclusive scientific evidence shows that fatigue causes measurable drops in cognitive and physical task performance and the NRC's own records are replete with examples of safety problems caused by weary workers, the agency views fatigue with in an entirely different light from substance abuse.

During the public comment period for the fitness for duty rulemaking, one person observed that fatigue could impair worker performance. Another commenter noted that workers could be disciplined or fired for errors due to fatigue.

The NRC responded to these comments by acknowledging that fatigue was an important issue but claimed that sound management practices could be expected to be more

effective than prescriptive regulations. Because it is more economical to get more work out of existing staff than to hire additional workers, the NRC's logic is wrong. The agency also did not explain why sound management practices would be inadequate to handle substance abuse. The NRC also took credit for the part of the rule that requires plant owners to ensure that workers are not impaired from any cause, arguing that fatigue was covered by this language. Given that this wording is even more nebulous than the NRC's guidance on overtime, the logic is fallacious. The NRC's guidance to inspectors when auditing fitness for duty programs at nuclear power plants makes no – zero – mention of fatigue and focuses solely on substance abuse.<sup>16</sup>

How effective is the fitness for duty rule? With respect to substance abuse at nuclear power plants, it has been very effective. Fewer than one percent of the 296,625 drug and alcohol tests administered to nuclear plant workers during 1996 and 1997 yielded positive results.<sup>17</sup> The rule has been less effective with respect to fatigue at nuclear power plants.

### Conclusions

Independent studies and nuclear industry experience both show that fatigue degrades the performance of workers. The NRC reports that worker mistakes can lead to serious nuclear plant accidents. The NRC attempted to limit fatigue among nuclear plant workers through restrictions on overtime and staffing levels, but these efforts have been ineffective.

The NRC's ineffectiveness in handling the fatigue problem is hard to understand given the agency's success in addressing substance

## Overtime and Staffing Problems in the Commercial Nuclear Power Industry

---

abuse problems. The NRC implemented a fitness for duty rule more than ten years ago that has effectively reduced substance abuse problems among nuclear plant workers. The NRC has been unable, or unwilling, to effectively address the fatigue issue.

The explanation for NRC's failure to address fatigue problems levels is not known. It may simply be that the agency feels "that nothing bad has happened yet" as if its mission were to protect the public from the *second* major reactor accident. Using this logic, the emergency core cooling systems and the containment buildings at nuclear power plants could be permanently removed since few events, *so far*, have required their use.

The restructuring of the electric utility industry makes proper control of worker fatigue more important. Nuclear power plant owners are cutting staff sizes as part of their efforts to generate electricity at competitive prices. As a result, the remaining workers are putting in longer and longer days as they pick up the load from those who have left. Fatigue problems in the nuclear power industry must be resolved soon.

Unlike the purported one in a hundred-thousand year or one in a million year chances of an accident requiring emergency core cooling systems and the containment building, worker fatigue is a minute by minute challenge to safe operation. Actions are said to speak louder than words, but in this case, the NRC's inaction speaks the loudest.

### Recommendations

The NRC must take actions to address worker fatigue at nuclear power plants. The NRC could either apply its fitness for duty

rule or implement a comparable rule. In any case, the NRC must establish clear requirements for working hours that reduce the potential for weary workers making grave mistakes.

Nuclear power plant owners must develop and consistently implement administrative controls to protect their workers from conditions causing fatigue. The NRC's working hour limits must not be routinely abused.

## Overtime and Staffing Problems in the Commercial Nuclear Power Industry

- <sup>1</sup> Nuclear Regulatory Commission, Transcript of 452<sup>nd</sup> Meeting of the Advisory Committee on Reactor Safeguards (ACRS), April 30, 1998.
- <sup>2</sup> Nuclear Regulatory Commission, Information Notice No. 92-36, "Intersystem LOCA Outside Containment," May 7, 1992.
- <sup>3</sup> Nuclear Regulatory Commission, NUREG-1560 Vol. 1, Part 1, "Individual Plant Examination Program: Perspectives on Reactor Safety and Plant Performance," October 1996.
- <sup>4</sup> Nuclear Regulatory Commission, Information Notice No. 91-36, "Nuclear Plant Staff Working House," June 10, 1991.
- <sup>5</sup> Nuclear Regulatory Commission, Circular No. 80-02, "Nuclear Plant Staff Working Hours," February 1, 1980.
- <sup>6</sup> Remi, Joly, Transport Canada, "A Study of the Impact of Shiftwork and Overtime on Air Traffic Controllers: Phase I," TP 12257E. October 31, 1994..
- <sup>7</sup> Angus, R.G., Pigeau, R.A., and Heselgrave, R., "Human Performance and sleep research: from the field to the laboratory," in C. Stampi (ed) *Why We Nap*. Boston: Birkhauser, 1992, pp 217-241.
- <sup>8</sup> "Report of the Presidential Commission on the Space Shuttle *Challenger* Accident, Vol. II, Appendix G, June 1986.
- <sup>9</sup> Nuclear Regulatory Commission, "Recommendations for NRC Policy on Shift Scheduling and Overtime at Nuclear Power Plants," NUREG/CR-4285 (PNL-5435), July 1985.
- <sup>10</sup> Ed Coburn, "Managing the Costs of Worker Fatigue," *Risk Management News*, July 29, 1996, pp. 3-4.
- <sup>11</sup> Nuclear Regulatory Commission, Information Notice No. 91-36, "Nuclear Plant Staff Working Hours," June 10, 1991.
- <sup>12</sup> Nuclear Regulatory Commission, Circular No. 80-02, "Nuclear Plant Staff Working Hours," February 1, 1980.
- <sup>13</sup> Nuclear Regulatory Commission, Safety Evaluation Report, "Issuance of Amendment for San Onofre Nuclear Generating Station," February 9, 1996.
- <sup>14</sup> Title 10 Code of Federal Regulations, Part 26
- <sup>15</sup> *Nature*, Vol. 388, 17 July 1997, pg 235

<sup>16</sup> Nuclear Regulatory Commission, Inspection Manual, Inspection Procedure 81502, "Fitness for Duty Program"

<sup>17</sup> Nuclear Regulatory Commission, Information Notice No. 98-39, "Summary Of Fitness-For-Duty Program Performance Reports For Calendar Years 1996 And 1997," October 30, 1998.