

ATTACHMENT 2

**ANALYSIS OF PUBLIC COMMENTS ON THE
PETITION FOR RULEMAKING FILED BY BARRY QUIGLEY
SEPTEMBER 28, 1999
(64 FR 67202)**

Contents

OVERVIEW	1
SUMMARY OF COMMENTS	3
ANALYSIS OF COMMENTS	4
1.0 Adequacy of Current Guidance - Policy and Technical Specifications	4
2.0 Enforcement of Current Guidance	7
3.0 Interpretation of Current Guidance	8
4.0 Adequacy of Current Regulations – Part 26, “Fitness for Duty Programs”	9
5.0 Enforcement of Current Regulations – Part 26, “Fitness for Duty Programs”	11
6.0 Adequacy of Current Guidance - Other	11
7.0 Other Federal Regulation of Working Hours	12
8.0 Utility Restructuring/Cost Competition	13
9.0 Data Quality and Interpretation	14
10.0 Fatigue as a Contributor to Events	18
11.0 Burden	20
12.0 Backfit	22
13.0 Scope of Personnel	23
14.0 Limits	24
15.0 Sleeping Disorders — Part 26, “Fitness for Duty Programs”	26
16.0 Other Sources of Fatigue	27
17.0 Alternative Proposals	28
REFERENCES	30

OVERVIEW

The Nuclear Regulatory Commission (NRC) published for public comment a notice of receipt of a petition for rulemaking (PRM) dated September 28, 1999. The petition was docketed by the NRC on October 7, 1999, and was assigned Docket No. PRM-26-2. The comment period for the petition began on December 1, 1999, and expired February 14, 2000. Comments received after this date were considered, the last of which was received on July 5, 2000.

The petitioner requested that the NRC (1) add enforceable working hour limits to 10 CFR Part 26, (2) add a criterion to 10 CFR 55.33(a)(1) to require evaluation of known sleeping disorders, (3) revise the NRC Enforcement Policy to include examples of working hour violations warranting various NRC sanctions, and (4) revise NRC Form 396 to include self-disclosure of sleeping disorders by licensed operators. The petitioner also requested changes to NRC Inspection Procedure 81502, "Fitness for Duty Program."

One hundred and seventy-six comment letters were received, representing comments from the public, NRC licensed individuals, public interest groups, the Professional Reactor Operator Society, nuclear power plant licensees (utilities), the Nuclear Energy Institute (NEI), a consortium of utilities, and the petitioner (who provided two additional letters clarifying the petition). Each letter received was assigned a number (1 to 176) and specific comments contained in each letter were given a decimal designation (e.g., 1.1, 1.2, 2.1, 2.2, 161.3, 161.4). The comments were grouped into 17 subject matter categories. Within each category, the summarized comments are presented with their accompanying staff analyses. At the end of the document, there is a reference list of all citations mentioned in the staff's analyses. Copies of the letters are available for public inspection and copying for a fee at the Commission's Public Document Room located on the first floor of the NRC Headquarters Building (One White Flint North), 11555 Rockville Pike, Rockville, MD. The letters may also be viewed on the NRC's Web site, nrc.gov/NRC/rule.html, Rulemaking Web Site, "News, Information and Contacts for Current Rulemaking."

Though the Commission received many comments concerning the specific requirements proposed in PRM-26-2, the majority of the comment letters (157 of 176 [89%]) expressed support for amending the rules, generally following the objectives discussed by the petitioner. These letters of support (1) cited the importance of ensuring that personnel who perform safety-related functions are not impaired by fatigue, (2) expressed concern that the NRC did not have a regulation limiting working hours and the perception that the NRC lacked the authority to enforce the policy guidelines, (3) asserted that the guidelines were ambiguous and interpreted not to apply when the plant is in an outage, (4) asserted that "the NRC appears to look the other way" when licensee work scheduling practices appear inconsistent with the guidelines, and (5) expressed the concern that utility restructuring and cost competition will cause reduced staffing levels and increased working hours and fatigue. Several commenters noted that the Federal Government had established work hour limits for personnel in other industries and suggested that such limits should apply to nuclear power plant workers.

In general, comments in opposition to the petition (18 of 176 [10%])¹ expressed the opinion that existing regulatory requirements (i.e., technical specifications (TSs) and 10 CFR Part 26, “Fitness for Duty Programs”) were adequate for ensuring that personnel were not impaired by fatigue, that the proposed requirements would impose unnecessary and excessive burden that could not be justified through a backfit analysis, and that industry performance data refute the petitioner’s argument that a rule is necessary to prevent fatigued personnel from performing safety-related work.

¹One letter was assessed as neither supporting or denying the petition for rulemaking.

SUMMARY OF COMMENTS

The following table identifies the number of comments received by commenter affiliation:

Summary of Public Comments Received for Petition for Rulemaking PRM-26-2

<i>Number of comments received</i>	<i>Commenter affiliation</i>	<i>Comment number</i>
242	Public citizens	1.1; 2.1; 3.1; 4.1; 5.1; 6.1; 7.1; 8.1; 8.2; 8.3; 8.4; 8.5; 8.6; 9.1; 9.2; 9.3; 10.1; 10.2; 11.1; 11.2; 11.3; 11.4; 12.1; 12.2; 12.3; 12.4; 12.5; 14.1; 14.2; 14.3; 14.4; 15.1; 16.1; 16.2; 16.3; 16.4; 17.1; 18.1; 19.1; 19.2; 20.1; 21.1; 22.1; 23.1; 24.1; 25.1; 26.1; 27.1; 28.1; 29.1; 30.1; 31.1; 32.1; 33.1; 34.1; 35.1; 35.2; 36.1; 37.1; 38.1; 39.1; 40.1; 41.1; 41.2; 42.1; 43.1; 44.1; 44.2; 45.1; 46.1; 47.1; 48.1; 49.1; 50.1; 51.1; 51.2; 52.1; 53.1; 53.2; 54.1; 55.1; 56.1; 56.2; 57.1; 58.1; 59.1; 60.1; 61.1; 62.1; 62.2; 63.1; 64.1; 64.2; 64.3; 65.1; 66.1; 67.1; 68.1; 69.1; 70.1; 71.1; 72.1; 73.1; 74.1; 74.2; 75.1; 76.1; 76.2; 77.1; 77.2; 77.3; 78.1; 79.1; 80.1; 80.2; 80.3; 81.1; 82.1; 83.1; 84.1; 85.1; 86.1; 87.1; 87.2; 87.3; 87.4; 88.1; 89.1; 89.2; 89.3; 89.4; 90.1; 90.2; 91.1; 92.1; 93.1; 94.1; 95.1; 96.1; 97.1; 97.2; 97.3; 98.1; 99.1; 100.1; 101.1; 102.1; 103.1; 104.1; 105.1; 106.1; 107.1; 108.1; 109.1; 110.1; 111.1; 111.2; 111.3; 112.1; 113.1; 114.1; 115.1; 116.1; 117.1; 118.1; 118.2; 119.1; 120.1; 121.1; 122.1; 123.1; 124.1; 124.2; 124.3; 124.4; 125.1; 126.1; 126.2; 127.1; 128.1; 129.1; 129.2; 130.1; 131.1; 132.1; 133.1; 133.2; 133.3; 134.1; 134.2; 134.3; 134.4; 134.5; 134.6; 134.7; 135.1; 135.2; 136.1; 137.1; 138.1; 138.2; 139.1; 140.1; 141.1; 142.1; 143.1; 144.1; 145.1; 145.2; 145.3; 145.4; 147.1; 148.1; 148.2; 148.3; 148.4; 150.1; 154.1; 154.2; 154.3; 154.4; 154.5; 154.6; 154.7; 155.1; 155.2; 155.3; 155.4; 162.1; 162.2; 162.3; 176.1; 176.2; 176.3; 176.4; 176.5; 176.6; 176.7; 176.8; 176.9; 176.10; 176.11
10	NRC licensed individual	149.1; 149.2; 149.3; 151.1; 151.2; 152.1; 152.2; 152.3; 152.4; 152.5

<i>Number of comments received</i>	<i>Commenter affiliation</i>	<i>Comment number</i>
10	Public interest group	13.1; 13.2; 13.3; 13.4; 146.1; 146.2; 146.3; 146.4; 156.1; 156.2
4	Professional Reactor Operator Society	153.1; 153.2; 153.3; 153.4
47	Utilities	158.1; 158.2; 158.3; 158.4; 158.5; 158.6; 158.7; 159.1; 159.2; 159.3; 160.1; 160.2; 160.3; 160.4; 160.5; 160.6; 160.7; 160.8; 160.9; 160.10; 163.1; 164.1; 165.1; 166.1; 166.2; 166.3; 166.4; 166.5; 167.1; 167.2; 167.3; 167.4; 167.5; 167.6; 168.1; 168.2; 168.3; 168.4; 168.5; 169.1; 170.1; 171.1; 172.1; 172.2; 172.3; 174.1; 175.1
15	Nuclear Energy Institute	161.1; 161.2; 161.3; 161.4; 161.5; 161.6; 161.7; 161.8; 161.9; 161.10; 161.11; 161.12; 161.13; 161.14; 161.15
17	Consortium of utilities	157.1; 157.2; 157.3; 157.4; 157.5; 157.6; 157.7; 157.8; 157.9; 157.10; 157.11; 157.12; 157.13; 157.14; 157.15; 157.16; 157.17
9	The Petitioner	173.1; 173.2; 173.3; 173.4; 173.5; 173.6; 173.7; 173.8; 173.9

ANALYSIS OF COMMENTS

1.0 Adequacy of Current Guidance - Policy and Technical Specifications

1.1 Comment: Several commenters stated that the NRC lacked appropriate regulations to prevent excessive overtime (comments 8.2; 11.3; 14.3; 16.2; 30.2; 35.1) or that the NRC provided only guidelines and had no authority to enforce the guidelines (comments 12.3; 87.2; 89.2; 124.3; 176.1).

Analysis: The NRC currently does not have a regulation that limits the working hours of nuclear plant staff. Rather, in 1982 the Commission issued its “Policy on Factors Causing Fatigue of Operating Personnel at Nuclear Reactors.” The guidelines contained in the policy were subsequently implemented by most licensees through the adoption of plant TSs. Although the TS wording and details are not uniform across sites, the TSs, in general, require administrative procedures to limit the working hours of plant staff who perform safety-related

functions. The NRC has the authority to enforce the requirements of the TSs. However, the guidelines do not establish maximum limits on overtime and plant TSs allow the plant manager (or a designee) to approve deviations from the guidelines.

The staff also notes that the current standard TSs for plant staff working hours do not include specific guidelines for limiting working hours. Rather, the standard TSs requires administrative controls that include guidelines on working hours that ensure adequate shift coverage is maintained without routine heavy use of overtime. Although it is incumbent upon licensees with the current standard TSs to establish guidelines that meet this objective, licensees may implement guidelines that differ from those in the policy. The NRC has not defined the term “routine heavy use of overtime,” nor has it provided guidance concerning limits that would preclude “routine heavy use of overtime.” As a result, in these instances the NRC does not have a clear basis for evaluating the adequacy of licensee administrative guidelines relative to their TS requirements.

1.2 Comment: One commenter stated that there is so much ambiguity in the guidelines that the policy does not prevent misuse of overtime on a day-to-day basis (Comment 151.2). In contrast, many commenters stated that the NRC’s current overtime guidance is sufficient to ensure that overtime is not abused (comments 157.3; 161.3; 159.1; 160.1; 163.1; 164.1; 165.1; 166.1; 168.1; 169.1; 170.1; 171.1; 172.1; 174.1; 175.1).

Analysis: Certain key terms in the “Policy on Factors Causing Fatigue of Operating Personnel at Nuclear Reactors” and in plant TSs have not been defined. This is a likely contributor to inconsistent implementation of the policy among nuclear plant sites and to some instances of licensees controlling working hours in a manner that is inconsistent with the staff’s interpretation of the policy. As noted in the analysis of comment 1.1, whereas the TSs allow the use of deviations from the guidelines, it is not clear when such deviations are prohibited by the TSs because they constitute “routine heavy use of overtime.” Similarly, whereas the Commission provided guidelines that allowed deviations to the policy to be approved for “very unusual circumstances,” the frequency of deviations observed by NRC inspectors and data collected by the NEI suggests that this precondition for authorizing deviations results in differences in application because of a lack of uniform criteria for “very unusual circumstances.” A data collection effort by NEI concerning industry implementation of the policy guidance was conducted during July 2000. Approximately half of the plant sites provided deviation data. The analysis of the sites providing data disclosed that (1) during normal operations, about a third of the sites that provided data authorized more than 200 deviations annually and (2) during plant outages, about a third of the sites that provided data authorized more than a thousand deviations annually (NEI, August 29, 2000). The frequency of guideline deviations appears inconsistent with the intent of the policy.

1.3 Comment: One commenter stated that some licensees have pushed limits on overtime to the extent that they have and are creating error-likely situations (comment 134.2).

Analysis: The NRC, through issuance of the “Policy on Factors Causing Fatigue of Operating Personnel at Nuclear Reactors,” provided guidelines on working hours that were consistent with the objective of ensuring that the mental alertness and decisionmaking abilities of plant staff were not significantly degraded by fatigue. As noted in letters dated May 18, 1999, from former

NRC Chairman Shirley Ann Jackson to Congressmen Dingell, Klink, and Markey, a review of NRC inspection reports indicates that inspectors have found several instances each year of licensee work scheduling practices that did not appear to be consistent with the general objectives or specific guidelines of the policy statement. As discussed in the analysis of the previous comment, data collected by NEI concerning industry implementation of the policy guidance show that approximately a quarter of the sites have a substantial percentage of personnel covered by working hour limits working in excess of 600 hours of overtime annually. In addition, the percentage of personnel in the survey sample working in excess of 600 hours of overtime annually has increased since 1997 (NEI, August 29, 2000). Although the data alone are insufficient to demonstrate conclusively that “error-likely” situations have been created, the amount of overtime appears inconsistent with the intent of the policy. The data are sufficient, nonetheless, for the Commission to take action to preclude such “error-likely” situations from occurring.

1.4 Comment: One commenter stated that the guidelines are insufficient to prevent abuse of overtime and cited (1) concerns reported to the NRC in which it has been stated that some plants inappropriately exclude certain activities from working hour calculations, (2) instances in which individuals were authorized to work after reporting that they were unfit for duty because of fatigue, and (3) instances of disciplinary letters being placed in the files of individuals who have declined work because of fatigue. The commenter also stated that a plant planned an outage that required personnel to work 20 consecutive days of 12-hour shifts (comment 173.4). Another commenter identified that the cumulative effect of fatigue is ignored (comment 176.2).

Analysis: The NRC is aware of these concerns and has taken specific actions to fully understand and address each of them on a case-by-case basis. However, the examples raise important generic questions concerning the interpretation of the “Policy on Factors Causing Fatigue of Operating Personnel at Nuclear Reactors;” the applicable plant TSSs; 10 CFR Part 26, “Fitness for Duty (FFD) Programs”; and the interrelationship of these guidelines and requirements. For example, it is important to appropriately consider the range of activities that are considered in overtime calculations; for example, “on call” status can contribute to fatigue (Torsvall et al. 1987). With respect to the scheduling of 20 consecutive 12-hour shifts during an outage, the staff acknowledges that such practices are not consistent with guidelines for preventing fatigue that recommend no more than four consecutive 12-hour shifts (Electric Power Research Institute, 1990). Though it is likely that such schedules would cause cumulative fatigue effects (Rosa, 1995; Dinges et al. 1997; Totterdell et al. 1995), it is not clear that such a schedule would be prohibited by plant TSSs for personnel performing safety-related functions. The staff believes that such practices should be evaluated in the development of an agency approach to this issue.

1.5 Comment: One commenter stated that plant personnel would generally only be asked to work increased overtime to support outages once in 18 months (in most cases for about 30 days) (comment 160.10).

Analysis: Most overtime is worked during outages and the duration of outages has on average become shorter during recent years, with outage durations frequently on the order of 30 days. In some instances short outage durations are being achieved, in part, by scheduling workers for large numbers of consecutive days of work without intervening days off. A data collection effort

by NEI concerning industry implementation of the policy guidance was conducted during July 2000, which included data representing 68 individual refueling outages. During those 68 refueling outages, about a quarter of the outages had hundreds (341-997) of deviations to the policy guidance. More than another quarter of the outages involved thousands (1024-6733) of deviations to the policy guidance. Some of the outages, however, experienced relatively few deviations, and 17 involved under 100 deviations (NEI, August 29, 2000). There is also evidence to indicate that lack of adequate days off and extended workdays can result in a cumulative sleep debt and performance impairment (65 FR 25546, Colquhoun et al. 1996, Dinges et al. 1997, Tucker et al. 1999; Webb and Agnew, 1974). Insights concerning shutdown risk (NUREG-1449) and latent errors (NRC, March 6, 2000) suggest that human performance during outages can be an important influence on plant risk.

2.0 Enforcement of Current Guidance

2.1 Comment: Several commenters stated that the NRC seems to “look the other way” when plant owners abuse overtime guidelines (comments 8.3; 11.4; 14.4; 16.3; 30.3).

Analysis: The staff does not believe that the NRC “looks the other way” when licensee work scheduling practices do not appear to be consistent with the policy guidelines or plant TSs. Nevertheless, the staff acknowledges that the lack of clear guidance with respect to the use of deviations from overtime guidelines has contributed to difficulties in consistently enforcing the applicable plant TSs and administrative procedures.

Until the implementation of the NRC’s revised reactor oversight process,² NRC inspectors reviewed each licensee’s use of overtime approximately once every 18 months. The findings from these inspections were documented in NRC inspection reports. In general, inspectors documented the number of deviations from the TS limits that had occurred during the time period that they had sampled and noted whether any of the deviations occurred without proper written authorization. The NRC took enforcement action when it was clear that the number of deviations, or the failure to authorize deviations, was inconsistent with the licensee’s TSs or administrative procedures. The Commission acknowledges that lack of clear criteria in the TSs concerning the use of deviations from working hour guidelines may have contributed to the NRC’s determining that a violation could not be substantiated in instances that may have appeared, to some, to involve excess use of overtime.

2.2 Comment: Several commenters stated that the proposed rule is not necessary because working hours of individuals are controlled by site administrative procedures as required by TSs (comments 158.2; 160.9; 167.3; 172.3) and that the NRC has the authority to enforce the requirements of the TS (comments 145.4; 159.4; 161.14). One commenter stated that the

² The NRC discontinued routine inspections of overtime use with the transition to the revised reactor oversight process (RROP). This change is considered appropriate and consistent with the general design of the RROP which is intended to identify indications of plant safety problems and cause licensees and the NRC to initiate more focused analyses and inspections when program performance thresholds are exceeded.

petitioner did not adequately explain why existing requirements fail to minimize personnel fatigue (comment 167.2).

Analysis: With the exception of three nuclear plant units, licensees have plant TSs concerning the working hours of plant staff who perform safety-related functions. Although the TS wording and details are not uniform across sites, the TSs, in general, require administrative procedures to limit the working hours of plant staff who perform safety-related functions. The NRC has the authority to enforce the requirements of the TS. However, as noted in analyses of comments 1.1, 1.2, and 2.1, the NRC has not been able to consistently enforce the requirements of the TSs because of the lack of clear criteria in the TSs for permitting deviations from the established work hour limits. As a result, there have been instances in which the NRC has determined that it could not enforce compliance with the TSs though licensee practices (e.g., operating personnel working in excess of 80, 90, and even 100 hours in a week) appeared to be inconsistent with the objective of the Commission policy (on which the TSs were based), which is to ensure that personnel are not assigned to shift duties while in a fatigued condition that could significantly reduce their mental alertness or decisionmaking abilities.

The work hour limits contained in the TS requirements, even if enforced, may not ensure that personnel are not impaired by fatigue. For example, research indicates that the current guideline for a break of at least 8 hours between work periods (including turnovers) may not be adequate to prevent fatigue. This guideline does not allow for the 8 hours of sleep most individuals require because turnovers, commuting, and time to get to sleep and prepare for the next day of work are part of this 8-hour break (65 FR 25547). Research indicates that at least 16 hours between shifts should be provided in order to obtain a sleep duration of 7 to 8 hours (65 FR 25554, Kecklund and Akerstedt, 1995). In addition, substantial research indicates that other factors (e.g., sleep disorders, illness) can affect worker fatigue (Kryger, Roth, and Dement, 1994; Lewis and Wessely, 1992), and these factors are not effectively addressed by limits on working hours in the absence of other fatigue management practices.

3.0 Interpretation of Current Guidance

3.1 Comment: Several commenters stated that the guidelines of the policy are interpreted to apply only when the plant is running [operating] (comments 8.5; 12.4; 13.4; 19.2; 62.1; 97.3; 156.2), and several other commenters recommended that the NRC establish working hour limits that can be enforced whether the plant is running [operating] or not (comments 80.3; 87.4; 89.4; 111.2; 124.4; 133.3; 135.2; 162.3).

Analysis: The “Policy on Factors Causing Fatigue of Operating Personnel at Nuclear Reactors” sets forth an objective of a 40-hour week while a plant is operating. The policy also includes guidelines for the control of overtime in the event that “unforeseen problems” require substantial amounts of overtime to be used, or during extended periods of shutdown for refueling, major maintenance, or plant modifications. In addition, the policy states that if “very unusual circumstances” arise requiring deviation from the guidelines, such authorizations should be made by the plant managers, a deputy, or higher levels of management. The policy, therefore, provides guidance for both when the plant is operating and when the plant is shutdown. The Commission acknowledges that the use of authorized deviations from the guidelines, which

occurs more frequently when a plant is shutdown, may provide the appearance that the guidelines do not apply when the plant is shutdown. Clarification of the applicability of the content of the outline and work schedule limits consistent with plant conditions and risk will also be considered by the Commission as part of the proposed rulemaking. The frequency of guideline deviations does appear to be inconsistent with the intent of the policy.

3.2 Comment: One commenter stated that current guidelines are being interpreted as not including breaks or non-safety-related activities (comment 155.3). Two commenters stated that the limits should apply at all times that an employee is on the job (comments 90.2; 148.3).

Analysis: The “Policy on Factors Causing Fatigue of Operating Personnel at Nuclear Reactors” excludes shift turnover times from the policy working hour limits of 16 hours in any 24-hour period, 24 hours in any 48-hour period, and 72 hours in any 7-day period. The Commission did not explicitly exclude any other parts of a workday in the policy guidelines. The staff is aware of a limited number of instances of licensees excluding specific periods from working hour calculations. Such exclusions can (1) result in licensee working hour calculations of as much as 84 hours in a 7-day period of work without requiring an authorization to exceed the plant’s administrative limits on working hours, (2) do not appear to be consistent with the objective of the policy and, (3) may result in personnel impaired by fatigue. In addition, the exclusion of rest breaks on the basis that such time does not contribute to fatigue does not appear to be scientifically justified. In a proposed revision of its hours of service regulation for motor carriers, the Department of Transportation (DOT) concluded that “all time spent in any work must be counted as on-duty time, since all work can either induce fatigue or deprive the driver of sleep” (see 65 FR 25558, May 2, 2000). The DOT conclusion is based, in part, on the recommendations of an expert panel (Transportation Research Institute, 1998) and is consistent with a large body of research that indicates that the benefits of breaks (without sleep) are transitory (Akerstedt and Landstrom, 1998) and that fatigue accumulates throughout the work period, particularly on the night and morning shifts (Rosa, 1991; Tucker et al., 1998). Research indicates that recovery from fatigue on breaks, even when sleeping, is reduced if personnel are “on call” (Torsvall et al., 1987). Thus, rest periods provided during the work shift may provide temporary benefits but may not contribute to long-term recovery from fatigue. The staff recommends that the development of any regulation concerning personnel fatigue should address any time periods to be specifically excluded and the basis for the exclusion.

4.0 Adequacy of Current Regulations – Part 26, “Fitness for Duty Programs”

4.1 Comment: Four commenters supported the proposed rulemaking and noted that fatigue can produce decreases in worker fitness equivalent to a blood alcohol content of 0.05 percent. They reasoned that Part 26 should therefore explicitly address fatigue as it currently prohibits on-duty employees from having a BAC of 0.04 percent or higher (comments 8.4; 9.2; 12.1; 13.3).

Analysis: Research (Fairclough and Graham, 1999; Dawson and Reid, 1997) that indicates that personnel who are fatigued from sleep deprivation can have levels of impairment that are comparable to those of individuals with blood alcohol levels more than double the level prohibited by Part 26. Research suggests that comparable impairments occur whether the sleep deprivation occurs as loss of one night’s sleep or as a result of partial sleep loss accumulated over several

nights (e.g., Wesensten, Balkin, and Belenky, 1999). It is notable that this research indicates that sleep-deprived people are more aware of their performance declines than individuals under the influence of alcohol. Such research supports, and is consistent with, addressing personnel fatigue as a factor that can affect personnel FFD.

4.2 Comment: Many commenters stated that the proposed rulemaking is unnecessary because licensees are already aware of the need to limit overtime to reduce chances of fatigue. Some of these commenters noted that Part 26 general performance objectives already require that licensee FFD programs protect against fatigue. They recommended that the Commission continue to rely on these licensee programs in which supervisors are trained to detect fatigue and, when fatigue is detected, to take action to ensure that the fatigued employee is not a threat to safety (comments 145.3; 152.3; 153.1; 159.1; 160.1; 161.2; 163.1; 164.1; 165.1; 166.1; 168.1; 169.1; 170.1; 171.1; 172.1; 174.1; 175.1).

Analysis: The staff believes that the policy statement and the associated plant TSs have caused licensees to be aware of the need to reduce the chances of fatigue. However, as described in the analyses of other comments (e.g., comments 1.2; 1.3; 1.4), the staff is aware of work scheduling practices that do not appear to be consistent with the objective of ensuring that personnel are not impaired by fatigue. The staff notes that the general performance objectives of Part 26 require licensees to provide reasonable assurance that personnel are not impaired from any cause that in any manner impairs their ability to safely and competently perform their duties. As noted in some public comments, licensees have asserted that behavioral observation programs provide assurance that personnel are not impaired by fatigue. The staff, however, does not consider behavioral observation programs to provide, by themselves, adequate assurance that personnel are not impaired (see analysis of Comment 4.3).

4.3 Comment: Several commenters stated that the licensee behavioral observation programs already required by Part 26 are sufficient to detect fatigue. Two commenters disagreed with this assertion and stated that the supervisory oversight required by these programs is not sufficient to detect impairment. One commenter stated that supervisory training does not always occur and that reliance on behavioral observation may mean waiting for someone to make a mistake. Another commenter questioned how a supervisor who is potentially fatigued (as during a refueling outage) could be expected to detect a subordinate's fatigue (comments 158.6; 167.6; 172.2; 173.1; 173.2; 176.3; 176.6).

Analysis: Because of the limitations of behavioral observation for detecting and deterring personnel impairment (see analysis of comment 17.5), the staff has always maintained that behavioral observation programs should be only one element within multifaceted and comprehensive FFD programs (NUREG/CR-5227). Consequently, Part 26 has always required licensee programs to implement drug and alcohol testing, in addition to behavioral observation, as other important elements of their worker FFD programs. Similarly, behavioral observation could be an element of a licensee approach to addressing personnel impairment from fatigue, but behavioral observation by itself would not be sufficient. The staff also notes that current behavioral observation programs may be identifying individuals who appear to be impaired through the use of "for-cause testing" (i.e., drug and alcohol testing) but such testing for an individual impaired by fatigue would yield negative results. A licensee could subsequently return the individual to duty without identifying or correcting the cause of the impairment. As a result, the

staff does not believe that the requirements of Part 26 have ensured the implementation of effective measures to address fatigue.

5.0 Enforcement of Current Regulations – Part 26, “Fitness for Duty Programs”

5.1 Comment: Several commenters recommended that the petition for rulemaking be denied because they believe Part 26 already grants the NRC ample authority to ensure that licensees address potential workforce fatigue issues. They noted that 10 CFR 26.20(f) allows the Commission to review licensees’ written policies and procedures to ensure that they meet the performance objectives of Part 26 (comments 159.1; 160.1; 161.13; 163.1; 164.1; 165.1; 166.1; 168.1; 169.1; 170.1; 171.1; 172.1; 174.1; 175.1). One commenter (comment 173.9) disagreed with this assertion and stated that the protections provided by the performance objectives of Part 26 programs are currently not sufficient to address potential fatigue problems because Part 26 uses the word “should,” thus making the attainment of these objectives nonmandatory.

Analysis: The NRC has the authority under Part 26 to address potential workforce fatigue issues. However, 10 CFR 26.20 (f), which permits the NRC to “at any time review the licensee’s written policy and procedures to assure that they meet the performance objectives of this part [i.e., 10 CFR 26.10],” by itself does not provide the assurance that licensees are satisfactorily addressing potential workforce fatigue issues. Licensees may have written policies and procedures to address overtime and fatigue (e.g., TS requirements) but, as indicated in the analysis of comment 1.1, the NRC does not have a clear basis for evaluating the adequacy of these licensee policies and procedures. In addition, as indicated by a second commenter, the regulatory provision of 10 CFR 26.20, which states “licensee policy *should* also address other factors that could affect fitness for duty such as mental stress, fatigue and illness (emphasis added),” is a nonmandatory regulatory provision. Thus, the licensee’s written FFD policy may not explicitly address fatigue. This approach essentially allows licensees to address fatigue on an ad hoc basis and permits considerable variation and potentially ineffective actions by licensees with respect to fatigue issues.

6.0 Adequacy of Current Guidance - Other

6.1 Comment: One commenter stated that quality assurance programs at nuclear power plants require independent review of manipulations of safety-related equipment and changes to key procedures, thereby addressing the latent effects of fatigue, such as valve mispositioning and procedures with technical errors (comment 168.5).

Analysis: The staff acknowledges that independent verification is an aspect of licensee quality assurance programs. However, the staff considers it not judicious to rely on independent verification as a prevention of fatigue-related errors. Quality assurance provides independent verification of operator actions after the actions have been completed. These verifications typically relate to implementation of operator actions performed on a system that has been isolated for maintenance. In those cases, the verification provides an opportunity to correct errors before they have actual consequences for system operation. However, independent verification is a personnel

action, that is itself subject to fatigue-induced errors. In addition, operator fatigue may result in errors during routine system operation or during response to abnormal operating occurrences that have immediate consequences for system performance (U.S. NRC, March 6, 2000). Quality assurance programs do not include actions that would prevent the latter fatigue-induced errors. Therefore, it would be inappropriate for the NRC to rely on quality assurance programs to prevent human performance problems associated with overtime and operator fatigue.

6.2 Comment: One commenter stated that the use of human performance tools, such as self-checking, peer checking, place keeping, and three-way communications, provides a greater opportunity to minimize human error than does the proposed rule by the petitioner (comment 158.3).

Analysis: Human performance tools such as the ones listed by the commenter provide the opportunity to minimize human error. However, it is not judicious to rely solely on those tools to prevent fatigue-related errors because one reason individuals sometimes fail to use such human performance tools is that they are fatigued. Fatigue can cause individuals to be less communicative, have impaired short-term memory, and become more inclined to take risks (Dinges, 1995; Dinges et al. 1997). These factors can affect the likelihood that an individual will self-check, remember to self-check, or ask for peer verification. Other recent research (Dorrian, Lamond, and Dawson, 2000) suggests more accurate self-monitoring in fatigued individuals but only at a global level and only when specifically prompted. These results suggest that though such human performance tools indeed may be useful, several variables may affect their utility, thus indicating that they should not be relied on exclusively.

7.0 Other Federal Regulation of Working Hours

7.1 Comment: A few commenters stated that the NRC's approach to worker fatigue should be consistent with that of other Federal agencies (comments 146.4; 154.6; 162.2). Similarly, several commenters noted that the Federal Government has established working hour limits for other industries, such as the trucking and airline industries, and suggested that such limits be applied to nuclear power plant workers (comments 41.2; 44.2; 51.2; 53.2; 64.2; 74.2; 80.2; 97.2; 111.3; 118.2; 124.5; 129.2; 133.2; 138.1). Alternatively, two commenters stated that the transportation industry guidelines are not appropriate for the nuclear industry (comments 149.2; 152.2).

Analysis: As part of the assessment of this petition, the NRC reviewed the regulatory approaches and specific requirements of other Federal agencies that have addressed worker fatigue, as well as the approaches taken to address fatigue in other industries and countries. The staff acknowledges that tasks and task environments (e.g., whether an individual is working in isolation or as a member of a crew) can influence alertness; however, the NRC focused on identifying lessons learned through the implementation of other agency, industry, and country requirements and programs to gain insights that might be applicable to the nuclear industry. In addition, the staff notes that tasks and task environments may not be as important as such factors as how long an individual remains awake, how much sleep an individual receives, and the time of day (e.g., Kecklund et al. 1997). Research generally shows that fatigue is associated with performance decrements at a basic level; across a variety of tasks, fatigue has been shown to cause memory problems, slowed responding, lapses, and false responses (Dinges, 1992; Dinges,

1995). It is sometimes asserted that the work tasks and characteristics in nuclear power plants are different from the other occupations that have overtime controls; therefore information from other occupations may be inapplicable. Research has shown that the physiological effects of fatigue are largely independent of occupation (Kecklund et al., 1997). Research has also shown that team performance is affected by fatigue (Harrison and Horne, 2000; NTSB, 1994). In addition, the occupations regulated by the other Federal agencies are themselves different, ranging from marine officer and air traffic controller to maintenance personnel. Despite the diversity of occupations and tasks, the other Federal agencies have, in nearly every instance, set stricter limits on hours of work and rest and have given management less authority to deviate from those limits.

8.0 Utility Restructuring/Cost Competition

8.1 Comment: Several commenters indicated that cost pressures associated with utility restructuring will cause reduced staffing levels and a subsequent increase in working hours and worker fatigue at nuclear plants (comments 8.1; 9.1; 10.2; 11.2; 13.2; 14.2; 16.1; 126.1; 146.3; 148.4; 154.5).

Analysis: Deregulation and restructuring can impose economic pressures that could create the potential for a variety of consequences on the nuclear industry and its workers. For example, following deregulation in the United Kingdom, British Energy reduced staffing and increased overtime for certain personnel (Nuclear Installation Inspectorate, 1999). A Nuclear Energy Agency report (NEA, 2001) notes that it is common for owners of nuclear power plants to reduce operating and maintenance costs by reducing the size of plant staff and outsourcing some work to specialist contractor organizations. The report notes that such actions could result in a loss of technical competence and resources within the utility's organization. The NEA report also identifies excessive overtime causing operator fatigue as a potential direct safety challenge resulting from market competition. However, plant owners may vary substantially in the approaches they take to staffing and overtime in response to deregulation. In addition, although staffing shortages may cause overtime, other factors also contribute to overtime, and overtime is one of many contributors to fatigue. Regulatory options that ensure worker fatigue does not compromise plant operational safety, regardless of the cause of fatigue, would address the potential effects of deregulation on worker fatigue.

8.2 Comment: Two commenters stated that there has been an increase in overtime caused by cost containment pressure (comments 154.3; 155.2).

Analysis: The NRC has reviewed nuclear industry reported use of overtime for the past 3 years. NRC analysis of survey data collected by NEI concerning industry control of working hours indicates that for the sample of sites responding to the survey, the percentage of individuals working more than 600 hours of overtime was higher in 1999 than 1997 (NEI, August 29, 2000). The staff believes that it is prudent for the Commission to pursue a regulatory option that ensures that plant operational safety is not compromised by worker fatigue.

8.3 Comment: Several commenters indicated that licensees have sufficient incentive in a competitive electricity market to maintain staffing at sufficient levels and to develop reasonable

work schedules (comments 161.7; 157.1; 159.1; 160.1; 163.1; 164.1; 166.1; 168.1; 169.1; 170.1; 171.1; 172.1; 174.1; 175.1).

Analysis: A competitive electricity market provides licensees with incentives to ensure that their staffing levels support reliable energy production in a cost-effective manner. Many factors may influence a licensee's decisions concerning staffing, routine work scheduling, and use of overtime. Though the NRC can not predict with certainty the effects of a competitive electricity market, one possible result, as evidenced by deregulation of nuclear energy in the United Kingdom, is decreased staffing and increased overtime (Nuclear Installation Inspectorate, 1999; NEA 2001).

8.4 Comment: Three commenters indicated that the NRC has taken measures to ensure that its regulatory authority and programs are adequate to ensure public health and safety in a competitive electric industry environment (comments 157.2; 166.4; 168.2).

Analysis: The NRC has taken measures to ensure that deregulation does not compromise nuclear plant safety. Electric utility deregulation is an ongoing process. As some of the commenters noted, the NRC is assessing its regulatory programs and making adjustments as needed. For example, the NRC has issued a "Final Policy Statement on the Restructuring and Economic Deregulation of the Electric Utility Industry" (NRC Policy Statement 7590-01-P, October 20, 1997) that addresses potential safety impacts on NRC power reactors that could result from, specifically, the economic deregulation and restructuring of the electric utility industry. The Office of Nuclear Reactor Regulation (NRR) has revised its Standard Review Plan (SRP) (NUREG-0800) to provide the staff with guidance with which to implement the policy statement provisions. Additionally, the NRR has revised other parts of the SRP (e.g., Chapter 13, "Conduct of Operations," Sections 13.1.1, "Management and Technical Support Organization," and 13.1.2-1.3, "Operating Organization") to ensure that the technical qualifications of proposed organizations involved in mergers and license transfers continue to satisfy NRC requirements.

9.0 Data Quality and Interpretation

9.1 Comment: Two commenters disagreed with the petitioner's statement that NRC inspection reports listed 87 occurrences of staffing as less than adequate, while the industry, using data from the licensee event reports (LERs), listed only 11 for the same time period (comments 157.4; 168.2).

Analysis: The NRC's reporting guidelines and requirements for LERs are not the same as those for NRC inspection reports. Therefore, it is not appropriate to equate summary findings from inspection reports with findings from LERs.

9.2 Comment: Two commenters stated that the petitioner attempts to equate certain categories in the NRC's Human Factors Information System (HFIS) database to fatigue-related issues. The petitioner cites the following categories in the HFIS database to support his position.

- Work practices or skill of the craft less than adequate - 4913 occurrences

- Nonconservative decisionmaking or questioning attitude less than adequate -1805 occurrences
- Self-checking less than adequate - 618 occurrences
- Awareness or attention less than adequate - 2389 occurrences

The petitioner states that the 9725 occurrences included in these four categories account for almost 30 percent of the total HFIS entries for 1996 through 1998. The petitioner states that while there are certainly other causes for these occurrences, such as distractions and interruptions, fatigue most probably played a role in a respectable percentage of them (comments 157.5; 168.2).

Analysis: The NRC maintains an HFIS database that contains analyzed coded information from LERs and inspection reports involving human performance. Experienced contractor staff review each LER and inspection report and then assign specific codes that describe such items as the personnel department, work type, and human performance contributing factors. From the HFIS database, the percentage of items in the database that involved fatigue cannot be determined; however, most items in the HFIS are not the result of root cause analysis, and, therefore, it is reasonable to postulate that some percentage, particularly those items coded in categories such as “awareness or attention inadequate” or “self-checking inadequate” may have been caused by fatigue. Such an interpretation is supported by a large number of studies concerning the effects of fatigue (Dinges, 1995; Dinges et al. 1997) and is consistent with the DOT’s interpretation of vehicular accidents involving inattention (65 FR 25545, May 2, 2000). See also the analysis of comment 9.6.

9.3 Comment: Two commenters stated that the petitioner’s citation of an NTSB report and comparison of funds allocated for fatigue research by the DOT versus that of the NRC do not appear to be relevant to the nuclear industry (comments 157.6; 168.2).

Analysis: The staff understands the commenter as stating that NTSB findings concerning fatigue in transportation, or the amount of research conducted on fatigue in transportation, are not relevant to the nuclear industry because of differences between the industries in work environments and the use of other controls (e.g., independent verification) to ensure personnel errors do not adversely affect safety. Findings concerning fatigue from other industries must be interpreted with caution, as should the potential for safety consequences, but the lessons learned and research findings from other industries can be of value if considered with careful attention to the differences and similarities in the tasks and task environments. See also the analysis of comments 6.1 and 9.8.

9.4 Comment: Two commenters disagreed with the petitioner’s reference to the Peach Bottom incident in 1987 as fatigue related (comments 157.7; 168.2).

Analysis: The petitioner did not state that the Peach Bottom incident in 1987 was fatigue related. Rather, the petitioner stated that the Commission took action in response to operator inattentiveness (i.e., napping). The commenter pointed out that the Peach Bottom incident was caused by significant management deficiencies. The staff agrees that management deficiencies were the higher level cause. Although work schedules and staffing levels may have contributed to

personnel sleeping while on duty, the Commission cannot state with certainty why individuals were sleeping. As noted by the petitioner, few significant events can be precisely attributed to fatigue.

9.5 Comment: Two commenters indicated that the petitioner believes that some fatigue errors have latent effects that may not be discovered for quite some time. The commenters stated that if the effects of fatigue were substantial, or if fatigue errors contributed to a substantial number of errors, the traceability to fatigue would be obvious, or at least more direct and subject to confirmation (comments 157.8; 168.2).

Analysis: Errors caused by fatigue, like errors from any cause, may not be immediately discovered and could have latent effects. Identifying the causes of an error long after the error has been committed is difficult because memories and records of the specific activity leading to the error may be incomplete. As a result, fatigue may not be reliably identified as the cause of errors with latent effects. The commenters state that if fatigue contributed to a substantial number of events, the traceability of fatigue would be obvious, or at least more direct and subject to confirmation. The staff agrees that a large number of events from any cause provide more opportunities to identify the cause directly, or indirectly through trending and correlation. In fact, some studies reviewing large numbers of events at nuclear power plants have shown variations in event frequency that are consistent with daily variations in operator alertness (Bobko, 1998; Cox and Cox, 1996; Maloney, 1992). Although these studies provide indirect evidence of the influence of fatigue on operator performance, it is not clear that if fatigue contributed to a large number of events the traceability would be obvious or more direct (see analyses of comments 9.6 and 10.1).

9.6 Comment: One commenter stated that more incidents in the nuclear industry are attributable to fatigue and excessive working hours than the number actually reported. The commenter also noted that errors as a result of fatigue are likely not to be immediately identified. However, several commenters asserted that the lack of reported data does not establish that the NRC or licensees underreport fatigue as a root cause. In response, the petitioner refutes the statement that few events are attributed to fatigue because fatigue is a third-tier cause of an event and, therefore, if we do not look deep enough, we will not find fatigue as a root cause (comments 154.2; 161.6; 159.1; 160.1; 163.1; 164.1; 165.1; 166.1; 168.1; 169.1; 170.1; 171.1; 172.1; 174.1; 175.1; 173.3; 176.7).

Analysis: The staff considers it likely that fatigue is under reported as an event causal factor. There are a limited number of events at U.S. nuclear plants that have been attributed to fatigue. However, several factors affect the ability of the NRC and licensees to determine that fatigue is a cause of an event, including the level of detail provided in event reports and the depth of event analysis conducted. Also, employees are generally reluctant to freely admit that they were fatigued (e.g., Horne and Reyner, 1995), and research indicates that individuals are not necessarily good at estimating their physiological sleepiness (Dinges, 1995; Wylie et al, 1996). More importantly, whereas the effects of fatigue can be observed and documented (e.g., inattention to detail, nonconservative decisionmaking) fatigue cannot be objectively proven as the underlying cause. Given these considerations, and in light of findings concerning current work-scheduling practices at nuclear power plants and risk of personnel impairment, the Commission believes that the number of events attributed to fatigue should be interpreted with caution and cannot be reported with certainty. Other agencies and investigative bodies have come to similar conclusions concerning the attribution of fatigue to events. A letter from Jim Hall, Chairman of the

National Transportation Safety Board (NTSB), to DOT Secretary Rodney E. Slater, dated June 1, 1999, included the following statement.

Fatigue has remained a significant factor in transportation accidents since the Safety Board's 1989 recommendations were issued. Although generally accepted as a factor in transportation accidents, the exact number of accidents due to fatigue is difficult to determine and likely to be underestimated. The difficulty in determining the incidence of fatigue-related accidents is due, at least in part, to the difficulty in identifying fatigue as a causal or contributing factor in accidents. There is no comparable chemical test for identifying the presence of fatigue as there is for identifying the presence of drugs or alcohol; hence, it is often difficult to conclude unequivocally that fatigue was a causal or contributing factor in an accident. . . . Although the data are not available to statistically determine the incidence of fatigue, the transportation industry has recognized that fatigue is a major factor in transportation accidents.

Also, a recent study by the U.S. Coast Guard further suggests that direct measurement of fatigue may understate its true extent (McCallum et al. 1996).

In summary, these reports indicate (1) the need for detailed event investigation and root cause analysis to reliably identify fatigue as a causal factors, as well as (2) the likelihood that fatigue statistics based solely on accident reports that directly cite fatigue underestimate the true extent of fatigue-related incidents.

9.7 Comment: Several commenters refuted the statement by the petitioner that "fatigue most probably played a role in a respectable percentage" of certain occurrences in the NRC's HFIS database (comments 161.8; 159.1; 160.1; 163.1; 164.1; 165.1; 166.1; 168.1; 169.1; 170.1; 171.1; 172.1; 174.1; 175.1).

Analysis: Items coded in the HFIS database in categories such as "awareness or attention inadequate" or "self-checking inadequate" could have fatigue as a contributing factor. However, the HFIS database does not show what percentage of "awareness or attention inadequate" is due to fatigue.

Fatigue increases the likelihood that a worker will not pay sufficient attention to the task at hand. HFIS data show that "awareness or attention inadequate" contributes to a significant number of the total reported items. Though fatigue is not likely involved in all of these cases, the staff's review of (1) research concerning worker hours, fatigue, and fatigue effects, considered in conjunction with (2) industry work scheduling practices (see analyses of comments 1.3, 1.5), and 3.1, and (3) findings related to the estimation of fatigue-related incidents in other industries (see analysis of comment 9.6) lead the staff to conclude that fatigue is a probable contributor to some percentage of these items in the HFIS database.

9.8 Comment: Several commenters stated that the petitioner inappropriately compared fatigue-related events cited by the NTSB and the NRC. The commenters stated that it is not appropriate to assume that the fatigue experienced by truck drivers, who operate in a sedentary, isolated

environment, is relevant to nuclear operators, who are stimulated by other operators and various tasks that must be performed throughout the shift.

The petitioner responded to the commenters with additional comments stating that NTSB data are relevant because parallels can be drawn between control room crews and flight crews. Parallels can also be drawn between field operators, maintenance workers, engineers, and technicians who often work alone at boring tasks, and truck drivers and train operators (comments 161.10; 173.5; 159.1; 160.1; 163.1; 164.1; 165.1; 166.1; 168.1; 169.1; 170.1; 171.1; 172.1; 174.1; 175.1).

Analysis: In general, fatigue-related incidents are more likely to happen after more hours are worked, regardless of the type of task. Different tasks and task environments can influence the level of fatigue. However, the difference between different specific work tasks is small and, in most cases, not statistically reliable (Kecklund et al. 1999). Fatigue degrades performance at a basic level (attention and perception), and these effects are seen across a wide variety of tasks that require execution of complex responses (Dinges, 1992; Dinges, 1995).

10.0 Fatigue as a Contributor to Events

10.1 Comment: A few commenters indicated that, in their experience, fatigue has not been a significant contributor to events or issues at their plants and that data from the NRC attribute few significant events to fatigue (comments 158.4; 160.4; 167.4; 168.3).

Analysis: The NRC has attributed few events specifically to fatigue. However, fatigue may be a contributing factor to a larger number of events for the following reasons:

- Depth of assessment - Most incidents at nuclear power plants are not subjected to a root cause analysis, and, as a result, many events are attributed to proximal causes (e.g., inattention to detail), some of which may have fatigue as the underlying cause.
- Lack of tangible proof - When conducting a root cause analysis for events that involve personnel error, it is difficult to conclude that fatigue is a cause because there is little tangible proof, absent the person sleeping, that the individual was impaired by fatigue. Even when individuals have been found with their eyes closed, they have asserted that they were not asleep, and investigators have concluded that the individual was “inattentive.”
- Lack of accepted assessment criteria - There are no accepted criteria or structured approaches for evaluating the role of fatigue accidents (Rosekind et al. 1997).
- Relative prominence or ease of substantiating event causal factors - Fatigue degrades an individual’s abilities but does not necessarily cause the event by itself. For example, the alert individual recognizes an error in a procedure, whereas the fatigued individual does not and implements an incorrect procedure. As a result, it is easy for an investigator to focus on tangible contributing factors (e.g., the

procedure error) or to describe the behavior (e.g., cognitive error) without citing a contributor that is difficult to substantiate.

- Efficacy of post-event observations - When individuals are debriefed following an incident, they may appear alert because of the stimulation of responding to, or potential consequences of, the event. Impairment from fatigue would not be readily apparent in such circumstances.
- Accuracy of self-assessment - Although self-assessment of fatigue can often provide an indication of the level of fatigue, research suggests that other factors may influence such self-assessments (e.g., Dinges, 1995; Wylie et al. 1996). In addition, studies have shown that individuals may believe they are relatively more alert than indicated by physiological indices (e.g., Rosekind and Schwartz, 1988).
- Veracity of self-assessment - For various reasons, individuals may be reluctant to acknowledge that they were fatigued at the time of an event involving personnel error, including the implication that they were not fit for duty (e.g., Horne and Reyner, 1995).

See also the staff's analysis of comment 9.7 concerning the contribution of fatigue to certain items in the HFIS.

10.2 Comment: Several commenters stated that individual plant data on human performance events indicate that night shift work does not produce a greater number of errors or that events that occur on night shift are not due to fatigue (comments 159.1; 160.1; 161.11; 163.1; 164.1; 165.1; 166.1; 168.1; 169.1; 170.1; 171.1; 172.1; 174.1; 175.1).

Analysis: There is substantial scientific literature that clearly demonstrates the significant role that fatigue, sleep loss, and "circadian rhythms" (i.e., an individual's "internal timekeeper or clock") play in contributing to errors and accidents (Kryger, Roth, and Dement, 1994; Akerstedt, 1995; Dinges, 1995; Folkard, 1997). The circadian trough, or lowest levels of function (reflected in, for example, alertness, performance, subjective mood, and body temperature), occurs around 3:00 a.m. to 5:00 a.m., with many human functions showing reduced levels between 12:00 a.m. and 6:00 a.m.. Sleepiness shows the most severe low at 3:00 a.m. to 5:00 a.m., with a less marked but significant expression again at about 3:00 p.m. to 5:00 p.m.. Many studies have demonstrated the decreased performance and the increased errors and accidents associated with night work and the window of the circadian low point in operational settings. These findings range from reduced response speed on a variety of tasks to missing warning signals to minor hospital accidents. As described in the analysis of comment 10.1, for a variety of reasons event analyses may not be sensitive to fatigue as a contributing factor, and, consequently, plant data may currently fail to show higher rates of fatigue-related incidents on night shifts. The greater amount of work performed on day shifts, relative to night shifts, may also cause the appearance that night work does not cause a greater number of errors.

10.3 Comment: A number of commenters stated that industry performance data refute the petitioner's argument that the rule is necessary to prevent fatigued personnel from performing

safety-related functions (comments 159.1; 160.1; 161.12; 163.1; 164.1; 165.1; 166.1; 169.1; 170.1; 171.1; 172.1; 174.1; 175.1).

Analysis: The data referred to by the commenters, by and large, refer to overall nuclear industry performance and cite a trend of fewer events, in total, as having occurred from about the latter part of the 1980s through the middle of the 1990s. Though the data reported for plant performance may be indicative of an overall improvement, these data do not support or refute the effect of fatigue as a contributor to safety-significant events. Fatigue may remain a significant contributor to safety-related plant events, but the frequency at which it is a contributor may have diminished as a function of fewer plant events.

10.4 Comment: One commenter stated that the petitioner's claim that a "respectable percentage" of certain categories of events in the NRC's Human Factors Information System (HFIS) are likely due to fatigue is "pure speculation." Rather, the commenter noted that studies by utilities and independent consultants have shown that one of the predominant causes of human error is the failure of workers to verify or validate what they think is the right way to perform a particular task (comment 168.4).

Analysis: A common cause of errors is the failure to verify that an action or intent is correct. The NRC's HFIS database contains 5,326 cases of "awareness or attention less than adequate" in the past 3 years. However, individuals may fail to verify because they are fatigued. As indicated by recent research (Dinges, 1995; Dinges, 1992), fatigue can cause individuals to be less communicative, have impaired short-term memory, and become more inclined to take risks. A frequently observed effect of fatigue in complex operational settings is the progressive "disorganization" of behavior. Personnel begin to perform actions out of sequence, that is, doing the right things at the wrong time. All of these factors can affect the likelihood that an individual will self-check, remember to self-check, or ask for peer verification.

11.0 Burden

11.1 Comment: One commenter stated that the petition would require more mandatory overtime imposed on workers who traditionally do not work overtime and would adversely affect morale (comment 149.3).

Analysis: The petition for rulemaking does not propose requirements that would directly require mandatory overtime. However, licensees could choose to meet the petitioner's proposed limits on work hours by changing the distribution of overtime across personnel rather than using alternative approaches to reduce overtime. The staff acknowledges that licensees who choose to limit overtime for some personnel by establishing mandatory overtime for other personnel could adversely affect personnel morale.

11.2 Comment: One commenter stated that the petition would increase outage times and could affect the continued ability to meet outage schedules. Another commenter stated that extending outage durations could prove to increase risks with regard to shutdown safety (comments 152.4; 160.7).

Analysis: Many factors affect outage duration, and the amount of overtime allowed and worked is only one of these factors. Other factors that affect outage duration and risk include the experience of the outage staff, use of roving outage personnel, and the quality of outage planning. Limiting the number of hours worked will not necessarily change existing licensee outage policies and practices. The effect overtime has on outage duration and risk depends, in large part, on the actions taken by, and the policies and practices of, individual licensees as well as regulatory limitations.

11.3 Comment: Two commenters stated that keeping separate records of working hours of individuals performing safety-related work, as opposed to work that is not safety related, would be difficult and represents an unjustified and unnecessary regulatory burden (comments 157.9; 160.5).

Analysis: The petitioner did not propose any specific tracking requirements, nor did the petitioner propose any administrative obligation to maintain a system to record safety-related and non-safety-related hours worked. The staff acknowledges that licensees would likely implement a tracking process to assist personnel in maintaining their working hours within the proposed limits but anticipates that such tracking processes would not differ substantially from those implemented to meet existing TS requirements. The petition does not make a distinction between safety-related and non-safety-related work and, therefore, the staff does not understand the proposed requirements to imply a need to record hours accordingly.

11.4 Comment: Two commenters stated that the proposed requirement for initial and continuing mitigation training for all personnel performing safety-related work, their supervisors, and their managers is excessive and represents a significant regulatory burden. In addition, inasmuch as many facilities use overtime to conduct training, the training requirements of the petition would exacerbate the use of overtime (comments 160.3; 153.3).

Analysis: The staff is not aware of recurrent training that is normally conducted using overtime, and it is the staff's belief that the proposed training requirements would not require the use of overtime to conduct the training. It is likely that the proposed training would not require a substantive increase in existing FFD training.

11.5 Comment: One commenter stated that limiting the number of hours worked would result in a decrease in individual income for some personnel (comment 152.5).

Analysis: The petition limits overtime allows up to 75 percent overtime in any 7-day period and up to 30 percent overtime in a year.

11.6 Comment: Two commenters stated that working hours must remain flexible to allow management the ability to control operations and maintenance costs, as well as fulfill the needs and desires of professional employees. Conversely, granting the petition would constrain licensee flexibility and would compel licensees to increase staff at nuclear facilities (comments 160.2; 166.5).

Analysis: The proposed limits on working hours provide substantial flexibility. As noted in the analysis of comment 11.5, the proposed limits allow up to 75 percent overtime in any 7-day period and up to 30 percent overtime in a year.

11.7 Comment: One commenter stated that the petitioner's limits on overtime of the petition remove the incentive for contract workers to relocate for outages (comment 160.6).

Analysis: The limits on overtime could have the effect of decreasing an incentive for contractors to relocate for outage work. However, the petitioner's proposed limits would have a minimal effect on this incentive in that the limits would allow for as much as 75 percent overtime in a 7-day period. The Commission also notes that whereas the petition limits working hours to ensure that personnel are not impaired by fatigue, the petition in no way limits plant staffing or the recruitment or compensation of personnel.

11.8 Comment: One commenter stated that consideration of the cost of a proposed rule should include cost savings from reduction of overtime (comment 173.7).

Analysis: Should the Commission approve rulemaking, the economic impact of the rule will be evaluated in the regulatory analysis.

12.0 Backfit

12.1 Comment: Many commenters stated that new overtime requirements would constitute a backfit and could not meet the requirements of the backfit rule. The proposed new requirements would not fall into any of the three exceptions in the backfit rule. Further, the new requirements would not constitute a substantial increase in protection of public health and safety because existing licensee practices and procedures have been designed to address worker fatigue. Unless the NRC can demonstrate that fatigue is a root cause or a substantially contributing factor to significant plant events, the NRC cannot show that there is a significant safety issue that could be remedied by a proposed rule (comments 157.15; 159.1; 160.1, 161.15; 163.1; 164.1; 165.1; 166.1; 167.5; 168.1; 169.1; 170.1; 171.1; 172.1; 174.1; 175.1).

Analysis: The petitioner's proposal, if adopted as a rule, would constitute a backfit as defined in 10 CFR 50.109. However, the staff disagrees that none of the exceptions in the backfit rule would apply and also disagrees that the proposed rule could not result in a substantial increase in the protection threshold of the backfit rule.

The staff agrees with the general thrust of comments arguing that there must be a reasonable causative link between fatigue and adverse events. However, the staff takes issue with the commenters' implicit argument that unless the NRC has demonstrated that significant problems attributable to fatigue have occurred in the past, the Commission cannot adopt requirements intended to preclude occurrence of fatigue-induced or fatigue-aggravated problems. Nothing in the Atomic Energy Act of 1954, as amended, or in general administrative law suggests that the agency is so constrained.

The staff disagrees with the commenters' underlying contention that licensees' existing voluntary practices with respect to working hour limits legally preclude a Commission finding under the backfit rule that rulemaking requirements either (1) are necessary to provide reasonable assurance of adequate protection or (2) constitute substantial additional protection to public health and safety. The backfit rule itself contains no provision addressing the legal effect of voluntary practices, and the statements of consideration for the 1985 and 1988 rulemakings (50 FR 38097, September 20, 1985; 53 FR 20603, June 6, 1988) do not contain any discussion of the

significance, if any, of the existence of voluntary initiatives when making the appropriate findings under the backfit rule.

Indeed, there are two aspects of voluntary practices that the Commission regards as significant factors to be considered when determining whether the NRC should forego the adoption of mandatory requirements on the basis of the asserted voluntary practices.³ First, voluntary practices may not be uniformly implemented by all licensees; there may be great variation in the scope and quality of implementation of voluntary practices among licensees. A few licensees may have chosen not to implement a voluntary practice. Thus, an aggregate consideration of overall industry performance may obscure poor performance or high risk by individual licensees that chose not to implement a given voluntary practice (or an integrated set of practices). Second, by their very nature, voluntary practices are nonbinding and may be modified or discontinued by a licensee. In view of these characteristics of voluntary practices, the mere existence of voluntary practices *per se* does not legally preclude the Commission from adopting regulatory requirements addressing matters that are the subject of the voluntary practices. In determining *as a matter of policy* whether the Commission should forego the adoption of mandatory requirements on the basis of voluntary practices, it is appropriate to consider the extent to which written commitments exist with respect to the voluntary practice, the extent of implementation by licensees, and the likelihood of continuing implementation of the initiative by licensees.

12.2 Comment: A commenter suggested that the direct and indirect costs of the proposal are not justified, given the complexity of the proposal and the burdensome nature of its implementation (comment 161.5).

Analysis: The NRC will prepare a backfit analysis and a regulatory analysis for the proposed rulemaking that provides the NRC's estimate of the costs of implementing the proposed rule. Commenters will be requested to provide specific information to assist the staff in accurately determining these costs.

13.0 Scope of Personnel

13.1 Comment: Several commenters suggested that the scope of any proposed regulatory effort apply to all workers. Several other commenters suggested the scope also cover managers, safety inspectors, and engineers. One commenter requested that all maintenance workers be added (comments 12.2; 56.2; 76.1; 77.3; 87.3; 89.3; 124.2; 148.2; 176.5). One commenter stated that the scope of employees once voluntarily subject to Generic Letter 82-12 has been reduced in recent years by some licensees. Another commenter claimed that employees are being reclassified as management, in which case they do not have to be paid overtime, while doing the same job they have done for years (comments 154.4; 155.1). One commenter recommended that the scope of the additions to 10 CFR Part 26 be clarified from "personnel performing safety-

³ Guidance concerning the consideration of industry initiatives in regulatory analyses is provided in NUREG/BR-0058, Revision 3, "Regulatory Analysis Guidelines of the Nuclear Regulatory Commission," July 2000, which states that "two sets of value-impact estimates are to be derived: one based on "no credit" and the other based on "full credit" for industry initiatives. These results will have equal weight and will be presented for sensitivity analysis purposes."

related work” to “personnel covered by the licensee’s Fitness for Duty program” (Comment 146.2). One commenter and one other supporting commenter stated that the petitioner has proposed a scope that is arbitrary. For example, an engineer working at the site would be covered while the same engineer working for a contractor off site would not. The same commenter went on to state that the petitioner has not shown that any increase in the scope of workers is needed (comments 157.10; 168.2).

Analysis: An important element of a proposed regulatory requirement is the scope of personnel covered. The scope of personnel covered by overtime policy guidance and most licensee TSs are those individuals who perform safety-related functions. The NRC, in conjunction with an industry effort, collected information on the job categories currently subject to working hour controls required by plant TSs (NEI, August 29, 2000). The NRC is also aware that some licensees have decided not to apply the TS limits to employees they have determined do not perform safety-related functions. Should the Commission approve rulemaking, the staff will consider the petitioner’s comments and the information collected in determining the scope of personnel affected by any changes in the NRC’s regulatory approach.

14.0 Limits

14.1 Comment: Two commenters stated that the petitioner’s proposed limits on working hours are judged to be arbitrary (comments 157.11; 168.2).

Analysis: The staff does not view the petitioner’s proposed limits as arbitrary. The petitioner provided a rational basis for the proposed limits. In addition, the staff notes that the proposed limits are generally consistent with the limits currently in the policy, and with an expert panel’s proposed modification of the policy limits (NUREG/CR-4248).

14.2 Comment: In one commenter’s experience, employees who work the night shift rarely take full advantage of their day off to rest and relax, instead remaining awake during the day to be with their family. Returning to night shift work causes their bodies to try to adjust to a rapid change in shift schedule and may affect their ability to think clearly and work safely. [The staff understands the commenter to imply that the proposed requirements would cause personnel on the night shift to have a day off while working nights, and this effect could be detrimental (comment 160.8)].

Analysis: Shift workers, particularly those working nights, can be challenged by conflicting demands for sleep and spending time with family members, or attending to other life demands that must be accomplished during the day. The staff agrees that schedules should be designed to minimize frequent transitions between day and night schedules. Nevertheless, the staff believes that the proposed requirements can be complied with, through proper scheduling, without an undue frequency of daytime-to-nighttime transitions for workers.

14.3 Comment: Several comments indicated that the petition could cause a licensee to put a plant through a shutdown transient rather than exceed the overtime limits for one or two key maintenance staff (comments 159.1; 161.4; 163.1; 164.1; 165.1; 166.1; 169.1; 170.1; 171.1; 172.1; 174.1; 175.1). One commenter indicated that plant shutdowns caused by the unavailability of key maintenance staff would be the result of inadequate resource management and that plants could avoid a shutdown by requesting a notice of enforcement discretion (comment 173.8).

Analysis: The petition may have the potential for causing a plant to enter an unscheduled shutdown. However, the staff views this situation as having little chance of occurring and an even smaller chance of recurring at plants. The petition allows for up to two 16-hour shifts per week to accommodate such circumstances. If a plant experienced an unplanned shutdown because one or two key maintenance staff exceeded the overtime limits, this condition would likely warrant detailed follow up by the licensee as part of its ongoing corrective action program. Effective implementation of the corrective action program by the licensee would ensure that the problem would not recur.

14.4 Comment: Several comments indicated that the petition could result in many more turnovers and disruptions of teams working together, which could, in turn, lead to more personnel errors and ultimately to more events (comments 159.1; 160.1; 161.5; 163.1; 164.1; 165.1; 166.1; 168.1; 169.1; 170.1; 171.1; 172.1; 174.1; 175.1).

Analysis: The petition may have the potential of causing more turnovers and disruptions of teams working together, which could, in turn, lead to increases in personnel errors and ultimately to more events. However, the staff notes that the petition's proposed limits allow for routine use of 12-hour shifts. Effective scheduling should allow for most tasks to be conducted within a 12-hour shift. If time in excess of 12 hours is required, the staff notes that several studies have shown that personnel accident risks increase exponentially after 12 hours of work (65 FR 25544, May 2, 2000; Folkard, 1997). Consequently, the rate of error caused by turnovers and disruptions may not be significantly higher, and could be lower. In addition, if a licensee determined that turning over a task to a new crew was in its best interest, the petition's proposal allows up to two 16-hour shifts in a 7-day period to accommodate such instances.

14.5 Comment: Some commenters stated that the petitioner's bases for limits are flawed or unfounded, and some commenters proposed to modify the petitioner's limits as follows:

The basis for the 16-hour shift limit is flawed because their experience has shown that individuals finishing an overnight shift can, and do, sleep during the day (comment 166.2).

- The basis for the 16-hour shift limit is unfounded because the petitioner provided no evidence that the assumed 24-hour period of wakefulness associated with 16-hour shifts occurs (comment 166.3).
- The petitioner's limit of 60 hours per week during non-outage periods should be changed to 72 hours (comment 134.3).
- The petitioner's limit of 108 hours per 2-week period during non-outage periods should be changed to 132 hours (comment 134.4).
- The petitioner's limit of 132 hours per 2-week period during outage periods should be changed to 144 hours (comment 134.5).

Analysis: The staff disagrees that the petitioner's proposed limits for 16-hour shifts are unfounded and believes that the proposed limits have technical merit. A number of studies find performance declines after 12 to 16 hours on task (Rosa, 1991; Folkard, 1997; Dawson and Reid, 1997). Nevertheless, the staff acknowledges the importance of a sound technical basis for any limitations on working hours that the Commission may consider. Similarly, the staff acknowledges

that there are practical considerations that may warrant limits that could differ from those based solely on human physiology and fatigue. If the Commission directs the staff to develop or modify specific working hour limits, the staff would address these considerations as part of that effort.

14.6 Comment: Two commenters stated that the petitioner’s request to revise 10 CFR Part 26 to require that employees be specifically monitored for signs of fatigue had no value because Section 26.22 currently requires that managers and supervisors receive training to ensure that they understand behavioral observation techniques for detecting degradation in performance, impairment, or changes in employee behavior (comments 157.13; 168.2).

Analysis: The commenters’ characterization that the petition mandates that employees be specifically monitored for fatigue is incorrect. The petition would require licensees to provide training in the monitoring and detection of fatigue to supervisors of personnel who perform safety-related work. Although it is implicit that observation for fatigue would occur through current behavioral observation practices, the staff disagrees that the proposed requirement would have no value. Part 26 principally establishes requirements related specifically to drugs and alcohol. For example, 10 CFR 26.22(3) requires training in “techniques for recognizing drugs, and indications of the use, sale, or possession of drugs.” No comparable requirements or emphasis in Part 26 specifically addresses training related to fatigue. Consequently, the petitioner’s proposal for requiring training specific to the monitoring and detection of fatigue (which could differ substantively from training related to drugs and alcohol) has merit and is not inconsistent with the current structure and level of detail of Part 26.

14.7 Comment: Two comments were received indicating that the petitioner’s request to revise 10 CFR Part 26 (Section 26.20) to eliminate general reference to the issue of fatigue is unsupported, unwarranted, and of no value (comments 157.14; 168.2).

Analysis: The petitioner stated his purpose for proposing to remove the word “fatigue” from 10 CFR 26.20 as follows: “This change is necessary to eliminate conflict from the prescriptive working hour limits and inclusion of the word ‘fatigue’ in a statement that is essentially only a recommendation as indicated by the word ‘should.’” If an amendment to 10 CFR Part 26 is warranted, the staff will review 10 CFR 26.20 to ensure that the wording is appropriate, unambiguous, and internally consistent.

15.0 Sleeping Disorders — Part 26, “Fitness for Duty Programs”

15.1 Comment: One commenter and an endorser indicated that NRC Form 396 and 10 CFR Part 55 should not be revised to require self-disclosure and evaluation of known sleep disorders because the existing process already allows factors related to fatigue and sleep disorders to be raised and evaluated in the medical evaluation of an individual. The commenter noted that NRC Form 396 (1-2000) relating to “Certification of Medical Examination by Facility Licensee” requires the physician to certify that the applicant meets the “fitness for duty requirements for licensed operators” (comments 157.12; 168.2). In contrast, two commenters recommended revising NRC Form 396 to include disclosure of known sleeping disorders (comments 134.7; 145.2). In addition, another commenter stated that a criterion should be added to 10 CFR 55.33(a)(1) to require evaluation of known sleeping disorders (comment 145.1).

Analysis: The staff agrees that sleeping disorders can affect employee performance (Kryger, Roth, and Dement, 1994). Therefore, the staff agrees that requiring disclosure of known sleep disorders may be appropriate.

NRC Form 396, used by applicants for operator and senior operator licenses, states that a physician conducted a physical examination using the guidance contained in ANSI/ANS 3.4-1996 or ANSI/ANS 3.4-1983 as endorsed by the applicable NRC regulatory guide (Regulatory Guide (RG) 1.134, Revision 2 or 3). The form also provides spaces for the physician to recommend areas in which the applicant's operator license might be restricted (conditioned). Although the form does not specifically address or prompt the physician to consider sleeping disorders, American National Standards Institute/American Nuclear Society (ANSI/ANS) 3.4 does specify that the physician shall note whether the applicant has "an established history or clinical diagnosis of... any mental or psychological condition that could cause impaired alertness, judgment, or motor ability."

The NRC may consider revising NRC RG 1.134 to add an exception to Section C, "Regulatory Position," addressing sleeping disorders. If the regulatory guide was revised, then revision of 10 CFR 55.33(a)(1) would likely not be needed.

15.2 Comment: One commenter requested that references to sleep disorder symptoms (as in Section (3)(a)(iii) of the petitioner's proposed changes) should not be included because such diagnosis should be conducted by a medical professional (comment 134.6).

Analysis: Section (3)(a) of the petitioner's proposed changes refers to the petitioner's request for the proposed rule to require that licensees provide initial and continuing fatigue mitigation training to personnel performing safety-related work, their supervisors, and managers. The training would be provided so that individuals can be sensitized as to whether they might want to seek a medical diagnosis. It is not the staff's understanding that training would be for the purpose of self-diagnosis or in lieu of a diagnosis by a medical professional.

16.0 Other Sources of Fatigue

16.1 Comment: Several commenters argued that there are a number of other factors that affect fatigue. For example, activities outside of work, such as family obligations and lack of sufficient sleep, can contribute to fatigue. The commenters stated that the rule may, therefore, not be effective. One commenter specifically stated that imposing strict limits on working hours would not address the licensee's inability to control an individual's activities outside the work environment (comments 153.2; 158.5; 161.9; 159.1; 160.1; 163.1; 164.1; 165.1; 166.1; 168.1; 169.1; 170.1; 171.1; 172.1; 174.1; 175.1).

Analysis: Many factors, in addition to working hours, may affect an individual's level of fatigue. Whereas it is possible that an individual could diminish the "fatigue prevention" value of working hour limits by engaging in other activities during rest periods, it is certain that an individual will not obtain sufficient rest if his or her work schedule does not include adequate time for rest. As a result, working hour limits have shortcomings but are not without merit. Such limits are the principal means employed by the DOT for several modes of commercial transportation, despite acknowledging the same shortcomings for those workers (see 65 FR 25558, May 2, 2000). In addition, the proposed amendment to Part 26 addresses fatigue through other measures in

addition to working hour limits. These measures include training of personnel in fatigue mitigation, training of supervisors in fatigue monitoring and detection, and evaluating the contribution of fatigue for specific categories of events and incidents. These additional measures would serve to address fatigue from any cause, including failure of individuals to make effective use of available rest periods.

17.0 Alternative Proposals

17.1 Comment: One commenter proposed a simplified set of working hour limits, as follows:

1. No more than 28 hours in a 48-hour period
2. No more than 80 hours in any 7-day period
3. No more than 280 hours in any 28-day period
4. No more than 2,800 hours in any calendar year

The commenter also proposed that shift turnover time be limited as proposed by the petitioner (comment 154.7).

Analysis: The staff has reviewed the regulatory limits on working hours in other industries and in the nuclear industry of other countries. Should the Commission approve rulemaking, the staff will consider the commenter's proposed limits along with other regulatory limits and relevant findings in formulating a proposed regulatory approach.

17.2 Comment: One commenter proposed that working hour limits during plant shutdown should be 60 hours per week, as when the plant is running [operating], to prevent potential overtime abuse. For example, if there is a problem on the unit that is running [operating], technicians and operators from the unit that is shutdown may likely be required to work on the running [operating] unit even after having worked 70 hours on the other (i.e., shutdown) unit (Comment 176.9).

Analysis: The staff acknowledges the concern and recommendation provided by the commenter. Any regulatory approach that the staff develops related to fatigue and overtime will be sensitive to overtime issues that are particular to staffing at multi-unit sites.

17.3 Comment: One commenter agreed with the biweekly limit on overtime hours but recommended a cap on how many weeks of overtime should be allowed (Comment 176.10).

Analysis: The staff will take the commenter's concern into consideration in developing any potential change in the NRC's regulatory approach.

17.4 Comment: Two commenters stated that if the NRC is truly concerned about overtime, the NRC could track overtime in a manner that is nonintrusive on the license holder. The commenters suggested that overtime of key safety personnel could be tracked as an input to an indicator of plant risk (comments 153.4; 176.4).

Analysis: The burden imposed by any regulatory option that the Commission may consider must be evaluated relative to the potential safety benefits of the option. Although the NRC is evaluating whether it may be possible to use some measure of overtime as an input to an indicator of plant risk, it is not immediately apparent how this objective might be accomplished to obtain a valid

input. The staff also does not believe that such an approach, by itself, would be an effective means of ensuring that personnel are not impaired by fatigue.

17.5 Comment: Two commenters proposed that as an alternative to the petition, the Commission should consider reinforcing the existing standards and programs for behavioral observation (comments 157.16; 168.2).

Analysis: Behavioral observation, as an adjunct to other methods for ensuring that personnel are not fatigued, can be of value. However, the staff's preliminary review indicates that behavioral observation, by itself, would not provide reasonable assurance that personnel are not impaired by fatigue (see analysis of comment 14.6). As noted in NUREG/CR-5227, "Fitness for Duty in the Nuclear Power Industry: A Review of Technical Issues," behavioral observation in conjunction with "for-cause" testing was not considered to be an adequate basis for not using random testing to identify substance abuse, principally because of the limitations of behavioral observation. In the case of alcohol or substance abuse, personnel may be impaired without conspicuous changes in behavior that would be noticed by a supervisor (Emery, 1986; Barnes et al. 1988), and for various reasons, supervisors and workers may fail to act upon indications of abuse they do detect (Kurtz, Googins, and Williams, 1980). Similar, and perhaps more significant, deficiencies may occur in behavioral observation of fatigue given that there is no clear indicator of fatigue, such as smell, as there is to aid the detection of alcohol. In addition, individuals may be more reluctant to raise a concern about an individual's FFD as a result of fatigue because the reasons for this type of impairment (e.g., long work hours, night shifts) are likely to be viewed as more socially acceptable or unavoidable.

17.6 Comment: One commenter stated that if the NRC believes the petition is necessary, the NRC should first change the FFD inspection module to include fatigue observation, conduct several inspections using the revised module, and then determine the appropriate action (comment 158.7).

Analysis: As noted in the analyses of comments 14.6 and 17.5, behavioral observation is not likely to be sufficiently sensitive to identify impairment caused by fatigue. In addition, the alerting effect that NRC observation would likely have on most personnel would mask much of the appearance of any impairment personnel may be experiencing. Specifically, individuals can be subjectively alert in response to a stimulating condition (e.g., a conversation with their supervisor) while at the same time they are physiologically fatigued and have impaired cognitive functioning (Rosekind and Schwartz, 1988). As a result, a series of inspections that have the objective of observing whether personnel are impaired by fatigue would not be particularly useful.

17.7 Comment: One commenter stated that the NRC should study reaction times of people over 40 (comment 21.1).

Analysis: Safe nuclear power plant operations are not dependent on operators making manual responses within seconds. The staff does not believe that reaction time studies, which typically focus on small variations in response times, would provide meaningful insights with respect to ensuring safe nuclear power plant operations.

17.8 Comment: One commenter stated that the individual worker should have input in determining if he or she is too fatigued to work extended hours (comment 176.11).

Analysis: As mentioned in the analysis of comment 10.1, the reliability of correctly assessing one's own level of fatigue is questionable. Research has demonstrated that "there is a discrepancy between the subjective report of sleepiness/alertness and physiological measures"; in general, individuals will report higher levels of alertness than are indicated by physiological measures (Royal Aeronautical Society, 1997). While subjective reporting alone may not guarantee an accurate assessment of one's physiological state, together with other appropriate measures self-reports may contribute to an overall psycho-physiological assessment of an individual's ability to perform required tasks successfully.

REFERENCES

- Akerstedt, T. (1995). Work hours, sleepiness and the underlying mechanisms. *Journal of Sleep Research*, **4**: 15-22.
- Akerstedt, T., and Landstrom, U. (1998). Work place countermeasures of night shift fatigue. *International Journal of Industrial Ergonomics*, **21**: 167-178.
- ANSI/ANS-3.4, 1996, "Medical Certification and Monitoring of Personnel Requiring Operator Licenses for Nuclear Power Plants." American Nuclear Society, La Grange Park, IL 60525.
- Bobko, N., Karpenko A., Gerasimov A., and Chernyuk V. (1998). The mental performance of shiftworkers in nuclear and heat power plants of Ukraine. In: *International Journal of Industrial Ergonomics*, **21**: 333-340.
- Colquhoun, W., Costa, G., Folkard, S., and Knauth, P. (1996). *Shiftwork---Problems and Solutions*. Frankfurt am Main: Peter Lang GmbH.
- Cox, T., and Cox, S., (1996). Work-related stress and control-room operations in nuclear power generation. In Stanton, N., *Human Factors in Nuclear Safety*, London, Taylor & Francis Ltd.
- Dawson, D. and Reid, K. (1997). Fatigue, alcohol and performance impairment. *Nature*, **388**: 235.
- Dinges, D.F. (1995). An overview of sleepiness and accidents. *Journal of Sleep Research*, **4**: 4-14.
- Dinges, D.F. (1992). Probing the limits of functional capability: The effects of sleep loss on short-duration tasks. In: R.J. Broughton and R. Ogilvie (Eds.) *Sleep, Arousal and Performance*. Boston: Birkhauser-Boston, Inc.
- Dinges, D.F., Pack, F., Williams, K., Gillen, K.A., Powell, J.W., Ott, G.E., Aptowicz, C., and Pack, A.I. (1997). Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4 - 5 hours per night. *Sleep*, **20(4)**: 267-277.
- Dorrian, J., Lamond, N., and Dawson, D. (2000). The ability to self-monitor performance when fatigued. *Journal of Sleep Research*, **9**: 137-144.

Electric Power Research Institute, EPRI NP-6748, "Control Room Operator Alertness and Performance in Nuclear Power Plants," Palo Alto, California, February 1990.

Fairclough, S.H., and Graham, R. (1999). Impairment of driving performance caused by sleep deprivation or alcohol: A comparative study. *Human Factors*, **41**: 118-128.

Folkard, S. (1997). Black times: Temporal determinants of transport safety. *Accident Analysis and Prevention*, **29**: 417-430.

Horne, J.A., and Reyner, L.A. (1995). Driver sleepiness. *Journal of Sleep Research*, **4**: 23-29.

Kecklund, G., and Akerstedt, T. (1995). Effects of timing of shifts on sleepiness and sleep duration. *Journal of Sleep Research*, **4**:47-50.

Kecklund, G., Akerstedt, T., Gillberg, M., and Lowden, A. (1997). Task, shift and sleepiness: A meta analysis. Stockholm, Sweden: IPM and Karlinska Institute. 171-177.

Kryger, M.H., Roth, T., and Dement, W.C. (Eds.) (1994). *Principles and Practice of Sleep Medicine*. Philadelphia: W.B. Saunders.

Lewis, G., and Wessely, S. (1992). The epidemiology of fatigue: More questions than answers. *Journal of Epidemiology and Community Health*, **46**: 92-97.

Maloney, S. (1992). Evidence of circadian and extended shift effects on reactor transient frequency. In Transactions of the American Nuclear Society 1992 Annual Meeting, **65**: 512-513.

McCallum, M.C., Raby, M., and Rothblum, A.M. (1996). Procedures for investigating and reporting human factors and fatigue contributions to marine casualties. (Report No. CG-D-09-97). Washington, DC: U.S. Coast Guard.

Nuclear Energy Institute (2000). Letter from J.W. Davis to G.L. Tracy, August 29, 2000. [ADAMS Accession # ML003746495].

Nuclear Energy Agency, Organisation for Economic Co-operation and Development (2001). "Nuclear Regulatory Challenges Arising From Competition in Electricity Markets," Paris, France

Nuclear Installations Inspectorate (1999). An audit by the HSE [Health and Safety Executive] on British Limited and British Energy Generation (UK) Limited, 1999. *The Nuclear Installations Inspectorate* (<http://www.hse.gov.uk/nsd/beaudit.html>).

Rosa, R. (1995). Extended workshifts and excessive fatigue. *Journal of Sleep Research*, **4**(2): 51-56.

Rosa, R.R. (1991). Performance, alertness and sleep after 3.5 years of 12 h shifts: A follow-up study. *Work & Stress*, **5**: 107-116.

Rosekind, M.R., and Schwartz, G.E. (1988). The perception of sleep and wakefulness I: Accuracy and certainty of subjective judgments. *Sleep Research*, **17**: 89.

- The Royal Aeronautical Society (1997). From laboratory to flightdeck: Promoting operational alertness. *Proceedings of Fatigue and Duty Time Limitations - An International Review*. London.
- Torsvall, L., Casternfors, K., Akerstedt, T., and Froberg, J. (1987). Sleep at sea: A diary study of unattended machinery space watch duty. *Ergonomics*, **30**: 1335-1340.
- Toterdell, P., Spelten, E., Smith, L., Barton, J., and Folkard, S. (1995). Recovery from work shifts: How long does it take? *Journal of Applied Psychology*, **80**: 43-57.
- Transportation Research Institute, "Potential Hours-of-Service Regulations for Commercial Drivers: Report of the Expert Panel on Review of the Federal Highway Administration Candidate Options for Hours of Service Regulations," Ann Arbor, Michigan, September 10, 1998.
- Tucker, P., Smith, L., Macdonald, I., and Folkard, S. (1999). Distribution of rest days in 12-hour shift systems: Impacts on health, well-being, and on shift alertness. *Occupational and Environmental Medicine*, **56**: 206-214.
- Tucker, P., Smith, L., Macdonald, I., and Folkard, S. (1998). Shift length as a determinant of retrospective on-shift alertness. *Scandinavia Journal of Work and Environmental Health*, **24**(3): 49-54.
- U.S. Department of Transportation, Federal Motor Carriers Safety Administration, Hours of Service of Drivers; Driver Rest and Sleep for Safe Operations; Proposed Rule (49 CFR Parts 350, et al.) Federal Register, Vol. 65, No. 85, Tuesday May 2, 2000, pp. 25540 - 25611.
- U.S. Nuclear Regulatory Commission, Regulatory Guide 1.134, "Medical Evaluation of Licensed Personnel at Nuclear Power Plants," Revision 3, March 1998.
- U.S. Nuclear Regulatory Commission, "Shutdown and Low-Power Operation at Commercial Nuclear Power Plants in the United States," NUREG-1449, September 1993.
- U.S. Nuclear Regulatory Commission, "NRC Policy Statement, 7590-01-P, Final Policy Statement on the Restructuring and Economic Deregulation of the Electric Utility Industry," October 20, 1997 (<http://www.nrc.gov/opa/reports/drgstmt.htm>).
- U.S. Nuclear Regulatory Commission, NUREG/CR-5227, "Fitness for Duty in the Nuclear Power Industry: A Review of Technical Issues, Supplement 1," May 1989.
- U.S. Nuclear Regulatory Commission, NUREG/CR- 4248, "Recommendations for NRC Policy on Shift Scheduling and Overtime at Nuclear Power Plants," July 1985.
- U.S. Nuclear Regulatory Commission. Letter from J. Rosenthal to J. Larkins, March 6, 2000 [ADAMS Accession # ML003689518].
- Webb, W.B., and Agnew, H.W. (1974). The effects of a chronic limitation of sleep length. *Psychophysiology*, **11**: 265-274.
- Wesensten, N.J., Balkin, T.J., and Belenky, G. (1999). Does sleep fragmentation impact recuperation? A review and reanalysis. *Journal of Sleep Research*, **8**: 237-245.

Wylie, C.D., Shultz, T., Miller, J.C., Mitler, M.M., and Mackie, R.R. (1996). Commercial motor vehicle driver fatigue and alertness study. (Report No. FHWA-MC-97-002). Washington, DC: Federal Highway Administration.