

Quick Reference Guide:

Environmental Factors Causing Fatigue in Equipment Operators during Winter Operations

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The final report presents the results of a three-part data collection effort to investigate causes of fatigue in operators during winter emergencies. Naturalistic driving and actigraph data were collected from four winter maintenance operators, and questionnaires were collected from 1,043 winter maintenance operators and 453 winter maintenance managers. More than 368 hours of valid on-road data were collected, including 338 hours (24 days) of winter emergency operations and approximately 30 hours of non-winter emergency operations. Additionally, more than 6,600 hours of actigraph data were collected from the four winter maintenance operators. An analysis of the literature review, naturalistic and actigraph data, and questionnaires resulted in the several cost-effective, realistic recommendations for reducing/eliminating operator fatigue. General recommendations are provided rather than specific recommendations as the latter may not be feasible in some organizations and/or each Department of Transportation (DOT) is different. Thus, each DOT must know their organization and which strategies work best for their organization.

A brief summary of the results included in the final reports are provided to add context. Please consult the final report for more specific information.

RESULTS

Naturalistic Driving Data

Ninety-two safety-critical events (SCE) were observed during the three months of data collection. Noteworthy results from the naturalistic driving data collection are presented below.

- Out of the 92 SCEs, 3.26 percent were crashes, 17.39 percent were crashes with low-hanging branches covered with snow/ice, 3.26 percent were avoidable curb strikes, 22.83 percent were near-crashes, and 53.26 percent were crash-relevant conflicts.
- Drivers were at least moderately drowsy during 35.9 percent of the SCEs.
- The majority of the drowsy driving SCEs (63.6 percent) occurred in the circadian low between 2:00 a.m. – 6:00 a.m.
- Fatigue was the critical reason in 28.3 percent of the SCEs.

Actigraph Data

A total of 516,867 minutes of actigraph data were collected during a three-month period. Table 1 shows a summary of the mean sleep for each participant. Overall, drivers averaged less sleep during winter emergencies versus non-winter emergencies. However, as shown in Table 1, much of the difference was likely due to Participant #1.

Table 1. Actigraph Sleep Summary (in hours)

Participant #	Daily Sleep	Daily Sleep during Non-Winter Emergency	Sleep 24 Hours Prior to Winter Emergency	Sleep during Consecutive Winter Emergency Shifts	Sleep 24 Hours Prior to SCE
1	8.05	8.63	6.31	7.48	4.55
2	10.04	10.66	8.58	8.71	8.83
3	8.12	8.10	8.26	8.32	8.02
4	8.64	8.53	8.31	8.73	7.81
Average	8.71	8.98	7.87	8.31	7.30

Questionnaire Data

Data from the winter maintenance operator and safety manager questionnaires provided valuable insight into the perceptions and opinions of winter maintenance operators and managers regarding fatigue in winter maintenance operations. Below are some of the key results.

- The majority of winter maintenance operators and managers indicated fatigue had a “moderate impact” on winter maintenance operations. Winter maintenance operators were more likely than managers to report greater impacts of fatigue, and younger winter maintenance operators were more likely to report lower impacts of fatigue compared to older winter maintenance operators.
- Most winter maintenance operators and managers reported that fatigue was “sometimes” experienced while operating a snow plow during winter emergencies. However, managers indicated fatigue was experienced more frequently by winter maintenance operators than winter maintenance operators’ self-reports. Additionally, winter maintenance operators that experienced fatigue while operating a snow plow were more likely to report greater impacts of fatigue.
- Managers indicated that winter maintenance operators had more frequent lapses in concentration while operating a snow plow during a winter emergency when compared to the winter maintenance operators’ self-reports.
- Vibration, seat type, noise, heavy traffic, lights, too much technology, and nighttime operations were all reported to be important sources of fatigue by winter maintenance operators and managers.
- Managers were more likely than winter maintenance operators to indicate that winter maintenance operators prefer driving to taking a break.
- In general, winter maintenance operators and managers indicated adequate knowledge concerning effective strategies to combat fatigue. However, winter maintenance operators

reported limited use of those strategies shown to be most effective in reducing fatigue (e.g., taking breaks, moving one's body, and naps).

RECOMMENDATIONS

The following list of cost-effective, realistic recommendations for reducing or eliminating winter maintenance operator fatigue were derived from the literature review, naturalistic and actigraph data, and the winter maintenance operator and manager questionnaires (the recommendations are listed in no specific order).

- **Encourage use of breaks/naps:** Management should continue to encourage winter maintenance drivers to take breaks/naps when fatigued/tired. Results from the questionnaires revealed there was little emphasis on the use of body movement and naps to reduce fatigue.
- **Encourage winter maintenance operator fatigue reporting:** A system, possibly confidential, should be developed to encourage and reinforce winter maintenance operators' self-reports of fatigue. Questionnaire results showed that managers underestimated the impact of fatigue in winter maintenance operators. This may be due to winter maintenance operators underreporting fatigue and fatigue-related incidents.
- **Increased vehicle maintenance:** Winter maintenance operators and managers suggested increased vehicle maintenance as a method to reduce unnecessary truck vibrations and noise. Updated equipment (e.g., rubber blades) was frequently reported as a method to reduce vibrations and noise. Care should be taken to ensure that components used to reduce fatigue, such as those that reduce outside noise and minimize whole-body vibrations, are kept in a good state of repair.
- **Investigate winter emergency shift start/end times (including shift length):** Research shows an increased risk of winter maintenance operator fatigue during circadian lows (between 2:00 a.m. and 6:00 a.m.). Thus, starting or ending a shift during these times may be dangerous. This may also be the best time to encourage drivers to take a break. Furthermore, winter maintenance operators may be at an increased risk of fatigue at the start of a shift and after an extended period of driving. Shift start and end times should be assigned with consideration of circadian lows. As non-driving activities impact the winter maintenance operator's level of fatigue, shift length should take into consideration any possible non-driving responsibilities.
- **Offer shift options:** Winter maintenance operators' rest periods preceding their shifts should be taken into account when scheduling shifts. Research shows sleep schedules that do not correspond to the circadian rhythm tend to provide inadequate amounts of rest. Therefore, if the winter maintenance operator was required to work a night shift just prior to being scheduled, this should be considered by management before requiring another night shift.
- **Involve winter maintenance operators in the decision-making process:** Managers suggested involving winter maintenance operators in the decision-making process. Winter maintenance operators have first-hand knowledge of the impact of fatigue and often have thoughtful suggestions about operational improvements. Additionally,

involving winter maintenance operators in the decision-making process will help develop an effective safety culture that minimizes operator fatigue.

- **Increase personal interactions with winter maintenance operators:** Managers suggested increased personal interactions with winter maintenance operators as a method to reduce fatigue. This interaction will help managers identify fatigued winter maintenance operators and additional methods to combat fatigue. Such interaction will also help develop an effective safety culture that minimizes winter maintenance operators' fatigue.
- **Free Resources:** There are several education and training resources available to assist safety managers in dealing with fatigue and implementing some of the recommendations described above. The first is the North American Fatigue Management Program (NAFMP, www.nafmp.com). The NAFMP is designed to address the issue of driver fatigue using a comprehensive approach on corporate culture, fatigue education, sleep disorders screening and treatment, driver and trip scheduling, and fatigue management technologies. Also, the Commercial Motor Vehicle Driving Safety (<http://cmvdrivingsafety.org/>) website has a training module on driver drowsiness and fatigue.