

OCCUPATIONAL EXPOSURE TO SNOWMOBILE EMISSIONS AT YELLOWSTONE NATIONAL PARK

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ABSTRACT

In recent years, regulations regarding snowmobile recreation in Yellowstone National Park have become more restrictive. New regulations limit the number of snowmobiles entering the park, restrict the engine type, and require that all riders must utilize a licensed guide. Given these regulations, it is hypothesized that occupational exposures to the combustion products from snowmobile exhaust have decreased. This research project performed occupational exposure monitoring of National Park Service Employees while working at the West Entrance to Yellowstone National Park during the 2004-2005 winter season. Products of snowmobile exhaust including carbon monoxide, nitrous oxides, volatile organic compounds, fine particulates, and noise were sampled and the analytical results compared to the occupational exposures during previous years. The purpose of this research is to determine if compliance with current regulations regarding snowmobile recreation in Yellowstone National Park has any affect on the occupational exposures received by park employees during the performance of their normal job tasks.

INTRODUCTION

History of Snowmobile Use in Yellowstone National Park

Snowmobiles have been used to travel through Yellowstone National Park during winter for over 30 years. In an attempt to manage and plan for winter use, the National Park Service (NPS) developed a Winter Use Plan in 1990 projecting the number of winter visitors who would tour the park during winter over the next ten years. By 1993, the projected number of visitors had already been exceeded and in 1997 the NPS was embroiled in a series of lawsuits over its winter use management brought by various interest groups, including the Fund For Animals, Blue Water Network, Ecology Center Inc., Blue Ribbon Coalition, the International Snowmobile Manufacturer's Association, and the Wyoming State Snowmobile Association. As a result, winter use planning for Yellowstone National Park is still in a state of fluctuation and the current plan used to manage winter use is considered a temporary measure (NPS, 2004).

Current Winter Use Regulations

The winter use plan in place for the 2004–2005 winter season (the time frame of this study) was presented as the preferred alternative in the Temporary Winter Use Plans Environmental Assessment proposed in August 2004 by the NPS. The plan became official in November 2004 through a Finding of No Significant Impact and will remain in place through the 2006-2007 winter season (NPS, 2004). Snowmobile entries into the park were capped at 720 machines daily and historical records were used to establish the number of snowmobiles allowed to enter through each of the four entrances and for tours originating at the Old Faithful area in the park (Table 1). The West Entrance has historically been the busiest entrance for winter visitors, possibly due to easy access from the town of West Yellowstone, Montana, which is also a base for many outfitters and guides. The southern entrance is also popular, possibly due to the presence of Jackson Hole, Wyoming, and its popularity as a winter recreation area. Based on their popularity, daily caps of 400 and 220 snowmobiles were established for the West Entrance and the South Entrance respectively.

Table 1. Total daily snowmobile limits: winter seasons 2004 - 2007

Point of Origin of Trip	Commercially Guided	Unguided	Total
West Entrance	400	0	400
East Entrance	40	0	40
North Entrance	30	0	30
Old Faithful	30	0	30
South Entrance	220	0	220
Total	720	0	720

Under the current winter use plan, all snowmobiles used for touring must be powered by four-cycle engines and accompanied by a NPS approved outfitter or guide. Each guide may lead a group of up to ten snowmobiles. Snowmobiles, however, are not the only way for visitors to enjoy the park during winter. Visitors may enter on foot (via snowshoes or cross-country skis) and are not limited in number or required to be accompanied by a guide. Snowcoach tours are available on vans and small touring coaches using tracks and skids in place of wheels. Wheeled vehicles are not allowed into the park in the winter, so personal vehicles are not an option for winter touring.

Touring groups entering Yellowstone from West Yellowstone stop at the Madison Junction warming hut to allow visitors to take a break from riding, use the bathroom facilities, purchase snacks or hot drinks, and warm themselves at the wood-burning stove in the hut. Old Faithful is the turn-around point for the majority of these tours, with stops along the roadway to view wildlife and geyser activity. There are no other stopping points between the West Entrance and the Old Faithful area.

Current Entry Processes

Snowmobiles are allowed to enter the park between 7:00 a.m. and 9:00 p.m., although most groups tend to enter the park before 10:00 a.m. because of snowmobile rental schedules. Snowcoaches tend to enter on approximately the same time frame as snowmobiles, although during the sampling period there was a group of coaches that entered around noon each day. As each touring group approaches the park entrance from the town of West Yellowstone, the guide picks one of two entry lanes and has the group stop just as they reach the gate. The guide approaches the window of the entrance kiosk to give the group's entry paperwork and fees to the park ranger working at the entrance. The paperwork is supposed to be filled out for each entrant before the tour group reaches the entry area in order to minimize the amount of time spent at the window. If there is a problem with paperwork or the rangers have questions, the guide may spend several minutes parked in front of the kiosk window. Guides have been asked to turn off their snowmobiles in the kiosk area, but during the sampling period some were observed letting their machines idle while they spoke to the rangers.

After the ranger receives the paperwork, the guide signals the tour and they proceed through the kiosk area into the park. As each visitor passes the entrance kiosk, they may be asked to stop for a driver's license check or to show a park entry pass. When visitors were stopped at the entrance by the rangers, they were rarely observed turning off their snowmobiles while the ranger talked to them. Some license and pass checks are performed while the rangers stand at the window inside the kiosk and some while the rangers stand outside next to the driving lane. Snowcoaches and vans entering the park follow many of the same procedures as guided snowmobile tours. The paperwork is filled out in advance and given to the park rangers at the kiosk window. Most snowcoaches were observed letting their motors idle while they waited at the window.

MATERIALS AND METHODS

Sampling Protocols

Sampling was performed over a three-day weekend in January (January 15th through January 17, 2005 - Martin Luther King weekend) and over a three-day weekend in February (February 19th through February 21st, 2005 - Presidents' Day weekend). These weekends were chosen based on historical entry data showing them to be the busiest weekends for snowmobile use in the park. Personal sampling was performed on park rangers working at the West Entrance and patrolling the park on snowmobiles, and on personnel working at the Madison Junction warming hut area. Area sampling was performed in the West Entrance kiosks and the Madison Junction warming hut.

Most snowmobile traffic enters the park during the first half of the work shift, so sampling was performed during that time period in order to obtain worst-case exposure measurements. Employees at the West Entrance kiosks and the Madison Junction warming hut were selected for personal sampling because their job functions put them into greatest contact with snowmobile tours, resulting in greater exposure to snowmobile emissions than many other employees. Park rangers patrolling on snowmobiles were also selected for personal sampling because of the

amount of time spent riding a snowmobile as part of their duties and the amount of time spent around other snowmobiles.

Sampling

Sampling was performed for carbon monoxide (CO), nitrogen dioxide (NO₂), particulate matter (PM_{2.5} and PM₁₀) and noise exposure. Since the majority of motorized vehicles entering the park in winter are snowmobiles, they are considered to be the major source of each sampled product during the winter tourist season. Snowmobiles are also a major source of transportation in the park during the winter, whether used by tourists, park employees, contractors, vendors or rangers patrolling the park.

Sampling Instruments

Area and personal sampling for CO and NO₂ was performed using ITX multi-gas meters. The ITX gas meter was placed near the top of the sliding window of West Entrance Kiosk A for area sampling, and was worn on the chest of snowmobile riders as near as possible to their breathing zone. Area sampling for particulate matter was performed using both a DustTrak and a DataRam which were placed on the back counter directly opposite the sliding window of West Entrance Kiosk A. Personal sampling for noise was performed using Q400 dosimeters worn by Park Service employees during their work shift. All sampling was performed using sampling methods from the NIOSH Manual of Analytical Methods.

RESULTS

Snowmobile Entry Data

The number and type of snowmobiles and snowcoaches entering the park through the West Entrance were logged each sampling day. The number of snowmobile entrants on each sampling day was noticeably smaller than the number allowed under the winter use plan. The greatest number of snowmobiles entering the park during sampling (291) occurred on February 19, 2005, and was approximately 75% of the allowed entrants.

Table 2. Number of snowmobiles entering the West Entrance by date

Date	No. of Snowmobiles
1/15/05	205
1/17/05	124
2/19/05	291
2/20/05	247

Carbon Monoxide

CO sampling was performed at the West Entrance in Kiosk A on both sampling weekends. The time-weighted average (TWA) in January was 0.57 ppm and the TWA_{8-hr} was 0.34 ppm, while the TWA in February was 12.70 ppm and the TWA_{8-hr} was 1.39 ppm. No CO was detected in the Madison warming hut area in January. The TWA for the snowmobile ranger in February was

21.34 ppm with a TWA_{8-hr} of 3.33 ppm. None of the measurements were near the PEL or the TLV, with the greatest exposure measuring 7% (0.07) of the OSHA PEL and 13% (0.13) of the ACGIH TLV.

Table 3. Carbon monoxide sampling results

Location	Date	TWA	TWA 8-hr.	OSHA PEL	ACGIH TLV
West Entrance Kiosk A	1/15/05	0.57 ppm	0.34 ppm	50 ppm	25 ppm
Madison Warming Hut	1/17/05	0.00 ppm	0.00 ppm	50 ppm	25 ppm
West Entrance Kiosk A	2/19/05	12.70 ppm	1.39 ppm	50 ppm	25 ppm
Snowmobile Ranger	2/20/05	21.34 ppm	3.33 ppm	50 ppm	25 ppm

Nitrogen Dioxide

Sampling for NO₂ occurred at the West Entrance on both sampling weekends and at the Madison warming hut during the January period. All NO₂ samples were area samples. No NO₂ was measured at the West Entrance during any sampling period, and a very small amount of NO₂ (TWA = 0.02 ppm) was measured at the Madison warming hut. The NO₂ measured at Madison was so small that the TWA_{8-hr} was 0.00 ppm when the TWA was weighted for an occupational work shift. The occupational exposure to NO₂ appears to be almost non-existent.

Table 4. Nitrogen dioxide sampling results

Location	Date	TWA	TWA 8	ACGIH TLV	OSHA Ceiling
W. Entrance	1/15/05	0.00	0.00 ppm	3 ppm	5 ppm
Madison Warming Hut	1/17/05	0.02	0.00 ppm	3 ppm	5 ppm
W. Entrance Kiosk A	2/19/05	0.00	0.00 ppm	3 ppm	5 ppm
W. Entrance Kiosk B	2/19/05	0.00	0.00 ppm	3 ppm	5 ppm

Particulate Matter – PM_{2.5} and PM₁₀

Area samples for particulate matter measuring 2.5 microns in diameter (PM_{2.5}) were measured at the West Entrance and at the Madison warming hut using the DataRam (Table 5) and the DustTrak (Table 6). Area sampling for particulate matter measuring 10 microns in diameter (PM₁₀) was performed at the West Entrance during the January sampling period using the DataRam. The highest average concentration of PM_{2.5} sampled using the DataRam was 9.9 µg/m³ measured at the Madison warming hut. The highest average concentration of PM_{2.5} sampled using the DustTrak was 10.4 µg/m³ and was measured on February 19 at the West Entrance in Kiosk B. The amount of particulate matter measured peaked during the peak

entrance times, as seen in Figure 1. The greatest number of snowmobiles entering the park passed the entrance kiosks between 9:00 a.m. and 10:30 a.m. during each sampling day.

Table 5. Particulates measured with DataRam – PM_{2.5} and PM₁₀

Location	Date	Particle Size	Average Concentration (µg/m ³)
W. Entrance	1/15/05	PM _{2.5}	3.6
W. Entrance	1/16/05	PM ₁₀	5.2
Madison Warming Hut	1/17/05	PM _{2.5}	9.9
W. Entrance	2/19/05	PM _{2.5}	4.1
W. Entrance	2/20/05	PM _{2.5}	1.4

Table 6. Particulates measured with DustTrak – PM_{2.5}

Location	Date	Particle Size	Average Concentration (µg/m ³)
W. Entrance A	2/19/05	PM _{2.5}	7.3
W. Entrance A	2/20/05	PM _{2.5}	1.9
W. Entrance A	2/21/05	PM _{2.5}	0.1
W. Entrance B	2/19/05	PM _{2.5}	10.4
W. Entrance Office	2/20/05	PM _{2.5}	0.2

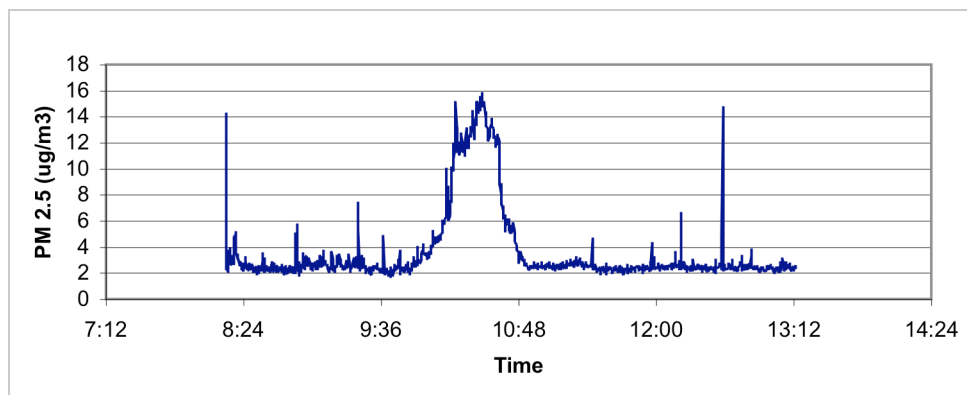


Figure 1. PM_{2.5} measured with DataRam January 15, 2005 at the West Entrance–Kiosk A

Noise

Personal sampling for noise was performed at the entrance kiosks, at the Madison warming hut area, and on snowmobile riders. Area sampling for noise was performed inside the Madison Junction warming hut. The eight-hour percent dose measured was minimal for the Madison area and the entrance kiosks during both sampling periods (Tables 7 and 8). There was a fairly significant exposure to noise for two snowmobile riders, but the eight-hour weighted exposure did not exceed the OSHA PEL of 90 dBA for either sample. The greatest percent dose measured (50%) was on January 16 at a TWA₈ of 85 dBA, a level triggering entry into a hearing conservation program. The noise exposure measured on February 21 was 83 dBA (TWA₈) for a dose of 39.5%. This level of exposure was not significant enough to trigger entry into a hearing conservation program, but suggests that workers riding snowmobiles as part of their job function should be carefully monitored for noise induced hearing loss. Noise exposure levels for

employees stationed at the entrance kiosks and at Madison Junction were under 10% dose, and would not require further monitoring.

A sound level meter was used to gather information about noise levels in the general vicinity of the entrance kiosks (Table 9). Sampling was performed at two locations. The first location was approximately 20 meters inside the park from the entrance kiosks on the road and the second location was at Kiosk A. During periods of snowmobile traffic, the highest sound level measured was 75 dBA at Kiosk A and 74 dBA on the road. These levels of noise exposure were much greater than the levels measured via personal sampling of the entrance employees. Area characterization was only performed during periods of snowmobile traffic, so there was no average noise level for the areas.

Table 7. Noise measured Martin Luther King weekend*

Date	Sample Type	Location	Run Time (Hr:Min:Sec)	TWA	TWA ₈	Dose (%)	Dose [8] (%)
1/15/05	Personal	Entrance Kiosks	4:27:50	62 dB	67 dB	2.2	3.9
1/15/05	Personal	Entrance Kiosks	4:33:06	69 dB	73 dB	5.2	9.2
1/16/05	Personal	Snowmobiles	4:57:16	81 dB	85 dB	29.8	50.0
1/16/05	Personal	Madison Warming Hut	2:19:48	64 dB	73 dB	2.8	9.5

*Weighting = A; 80 dB threshold; 5 dB Exchange; Criterion – 90 dB; Time Constant – Slow; UL – 115 dB

Table 8. Noise measured Presidents’ Day weekend*

Date	Sample Type	Location	Run Time (Hr:Min:Sec)	TWA	TWA ₈	Dose (%)	Dose [8] (%)
2/19/05	Personal	Entrance Kiosks	4:51:37	65 dB	69 dB	3.3	5.4
2/19/05	Personal	Entrance Kiosks	5:31:51	64 dB	67 dB	2.9	4.2
2/21/05	Area	Madison Warming Hut	2:46:56	44 dB	52 dB	0.2	0.5
2/21/05	Personal	Snowmobiles	5:24:12	80 dB	83 dB	24.8	39.5

*Weighting = A; 80 dB threshold; 5 dB Exchange; Criterion – 90 dB; Time Constant – Slow; UL – 115 dB

Area Noise Characterization

Table 9. Sound Level Meter Readings – Snowmobiles Present

Location	Sound Pressure Level dBA
Kiosk A	75
Road 20 m. from Kiosk A	71
Road 20 m. from Kiosk A	74
Road 20 m. from Kiosk A	71

DISCUSSION AND CONCLUSIONS

Most occupational exposures were well under the OSHA PELs and ACGIH TLVs, although some sampling results showed exposures approaching those levels. Snowmobile riders in particular had high noise exposures, most likely because of their proximity to the motor of the snowmobile. The rangers in the kiosks experienced peaks of noise exposure during peaks of

snowmobile traffic, but their TWA_8 was much lower due to working during periods of no snowmobile traffic at all. The area characterization was presumably louder because the sampling at Kiosk A was done on the east side of the kiosk, and measured the noise generated by snowmobiles accelerating away from the kiosk. Most snowmobile drivers did not accelerate until after they had passed the ranger working at the entrance. Area characterization on the road occurred where snowmobiles were passing at approximately 15 – 20 mph as they cleared the entrance area and joined the rest of their tour group before moving farther into the park. Area characterization was only performed during periods of snowmobile traffic in the kiosk and road areas.

The overall results of the sampling showed that the current level of snowmobile traffic in Yellowstone National Park is not causing employees to receive high exposures to snowmobile emissions. When compared to historical exposure data, it appears that regulating snowmobile traffic has demonstrably lowered employee exposure to snowmobile emissions in Yellowstone National Park. It should be noted that the results of this study should not be used to extrapolate environmental quality issues in Yellowstone as it was designed and carried out in accordance with industrial hygiene standards rather than environmental testing standards.

Additional Controls

During the sampling and observation period in the park, several key items were noted. First, the snowmobile guides changed their behavior at the entrance kiosks during the second weekend of sampling. They began stopping their snowmobiles approximately 15-20 feet (5-6 meters) from the kiosk window, where they would turn off the ignition and walk to the kiosk window with the paperwork for the rangers. This behavior suggested a possible administrative control that could be easily implemented and would effectively reduce the occupational exposure of the rangers working at the kiosks. Second, sampling inside the kiosks showed that it may be beneficial for employees to keep the kiosk windows closed whenever possible. It also appeared that it may be beneficial for employees to remain inside the kiosk when working rather than going outside and standing in or near the traffic lanes. This benefit appeared even if the window was left open. Ventilation in the kiosks seemed to decrease the amount of personal exposure to snowmobile emissions received by employees under these conditions.

REFERENCES

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