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PORTABLE HEATER USE IN ICE FISHING SHELTERS AND THE POTENTIAL FOR CARBON MONOXIDE EXPOSURE

Kellie Hicks

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PORTABLE HEATER USE IN ICE FISHING SHELTERS AND THE
POTENTIAL FOR CARBON MONOXIDE EXPOSURE

By
Kellie Hicks

A thesis submitted in partial fulfillment of the
requirements for the degree of

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Abstract

Every year, more than 400 people in the U.S. die from accidental Carbon Monoxide (CO) poisoning. Carbon monoxide is a colorless, odorless, poisonous gas that results from incomplete burning of common fuels such as natural gas and propane. When CO is inhaled, it enters the blood stream and reduces the ability of blood to carry oxygen. The environment for ice fishing is cold and ice fishermen who use ice huts or tents commonly use portable propane heaters to heat their shelters.

During the 2012/2013 ice fishing season, random fishermen were selected to be part of a research study. Upon arrival, the fishermen were evaluated for blood carbon monoxide concentrations (carboxyhemoglobin) and their pulse rate was recorded using a CO Oximeter. In addition, the air inside the fishermen shelters was evaluated for CO, oxygen and flammable gases with a MultiRAE plus 4 gas monitor.

While COHb was measureable in 40% of the subjects when they arrived at the fishing sites, within one hour of fishing in a structure heated with a propane heater, eight of 10 (80%) of subjects revealed measureable COHb concentrations. The air CO monitoring within the structures supported this hypothesis with mean CO concentrations ranging from 2 -22 ppm. In addition, the majority of subjects had increased pulse rates as their duration in the structures increased.

This research implies that the use of portable propane heaters in ice fishing structures may result in elevated air CO concentrations within the enclosures and increased fishermen blood carboxyhemoglobin levels. Additional research to further explore this potential public health problem is recommended.

Keywords: Carbon Monoxide Exposure, Ice Fishing, Portable propane heater,

Carboxyhemoglobin

Dedication

I dedicate this thesis to my family. My husband Martin has been my biggest supporter throughout my education.

Acknowledgements

I would like to thank my committee members; Julie Hart, Terry Spear, Sally Bardsley, and Kelly Amtmann for all of their expertise and guidance throughout my journey. I would like to thank Trudy Tutt, Scott Trammell, Linda Hicks, and Barry Hicks for helping collect data at various lakes.

Table of Contents

ABSTRACT	II
DEDICATION.....	III
ACKNOWLEDGEMENTS.....	IV
LIST OF TABLES	VII
LIST OF FIGURES	VIII
GLOSSARY OF TERMS.....	X
PREFACE.....	1
1. INTRODUCTION	2
2. BACKGROUND	6
2.1. Standard Air	6
2.2. Carbon Monoxide Toxicology	7
2.3. Portable Propane Heaters.....	12
2.3.1. Single Burner Radiant Heaters	14
2.3.2. Radiant Heater/Cookers	15
2.3.1. ODS-Equipped Radiant Heaters.....	16
2.3.2. Catalytic Heaters	17
3. SAMPLING METHODS.....	18
3.1. Carbon Monoxide Air Sampling Methods.....	18
3.2. Non-invasive blood monitoring method for Carboxyhemoglobin	18
4. PUBLIC AND OCCUPATIONAL EXPOSURE LIMITS FOR CO	19
4.1. Occupational Exposure Limits	19
5. PREVIOUS STUDIES	21

5.1.	CO Emissions from Portable Propane Radiant Heaters	21
5.2.	CO oximeter	25
6.	METHODS.....	26
6.1.1.	Non-invasive blood monitoring method for Carboxyhemoglobin.....	26
6.1.2.	Air Sampling Methods	28
6.2.	Additional Measurements.....	30
7.	RESULTS	31
8.	DISCUSSION	35
8.1.	Limitations.....	36
9.	HYPOTHESIS TESTING.....	37
10.	CONCLUSION	38
11.	FUTURE WORK	39
12.	BIBLIOGRAPHY	40
13.	APPENDIX A: OCCUPATIONAL EXPOSURE LIMITS.....	43
14.	APPENDIX B: EFFECTS OF CO	44
15.	APPENDIX D: IRB APPROVAL.....	46

List of Tables

Table I : Effects of Oxygen-Deficient Exposure	7
Table II: Carboxyhemoglobin levels and related health effects on people	10
Table III: Portable propane radiant heaters that could be used in camping situations	13
Table IV: Ambient Air Standard for CO (United States Environmental Protection Agency, 2012)	19
Table V: Summary of the camp heater tests including which heaters complied to the revised standard (Tucholski, 2002)	22
Table VI: RAD 57 Limitations	28
Table VII: MultiRAE plus present alarm limits and calibration (RAE systems world headquarters, 2003).....	29
Table VIII: Description of Ice Fishing Structures	31
Table IX: Air Carbon Monoxide Readings (PPM) within Ice Fishing Shelters	32
Table X: Progressive COHb (units) readings of Ice Fishermen	33
Table XI : Ambient O ₂ (%) Readings within Ice Fishing Structures	33
Table XII: The exposure limits stated on NIOSH testing guide 6604 are as follows.....	43
Table XIII: Effects of Carbon Monoxide Exposure and CO Exposure Limits.....	44

List of Figures

Figure 1: Picture of a hole drilled through the ice (ice hole) that is approximately 12 inches wide and 18 inches deep.	3
Figure 2: Tent type portable ice shelter This ice shelter was manufactured by Quickfish. Pop up ice shelters are common.	4
Figure 3: Elaborate Commercial Ice Fishing House (2016 ICE Castle 8X24 Northern Exposure Hybrid, 2015).....	5
Figure 4: Carbon Monoxide Binding to Hemoglobin Retrieved from http://uvahealth.com/services/hyperbaric-oxygen-therapy/carbon-monoxide-poisoning	8
Figure 5: The correlation between CO in air and COHb % in blood. " (December 5, 2015). Retrieved from http://www.nano-sense.com/en/CO/dossier-on-the-carbon-monoxide.html "	9
Figure 6: Haldane Equation (Principles of Toxicology, 2000).....	11
Figure 7: Dissociate CO from hemoglobin. " (December 5, 2015). Retrieved from http://www.nano-sense.com/en/CO/dossier-on-the-carbon-monoxide.html	12
Figure 8: Single Radiant Heater.....	14
Figure 9: Radiant Heater/Cooker	15
Figure 10: Radiant heater equipped with an oxygen depletion sensor (ODS).....	16
Figure 11: Catalytic heater	17

Figure 12: Comparison of the maximum CO concentration in the chamber for each heater at the air exchange rates specified in the standard and at an air exchange rate that produced the maximum CO without causing the flame to self-extinguish (Tucholski, 2002)....	22
Figure 13: :-RAD-57 CO-Oxymeter (Masimo International, 2013).....	27
Figure 14: Pulse Rate	34

Glossary of Terms

ACGIH	American Conference of Governmental Hygienists
ANSI	American National Standards Institute
ATV	All Terrain Vehicle
CFR	Code of Federal Regulations
CO	Carbon Monoxide
COHb	Carboxyhemoglobin
CPSP	Consumer Product Safety Commission
PEL	Permissible Exposure Limits
EPA	Environmental Protection Agency
Hb	Hemoglobin
LEL	Lower Explosive Limit
NAAQ	National Ambient Air Quality
NIOSH	National Institute for Occupational Safety and Health
ODS	Oxygen Depletion Sensor
OSHA	Occupational Safety and Health Administration
PPM	Parts Per Million
REL	Relative Exposure Limit
TLV	Threshold Limit Value
TWA	Time Weighted Average

Preface

Montana is a beautiful state filled with many opportunities for extracurricular activities. One activity that is popular is ice fishing. The motivation for this project stems from personal experience. When my husband would return from ice fishing, he would have a moderately painful headache. After investigating his activities prior to the headache, it was postulated that the heater in his ice fishing shelter may be contributing to the headaches. The idea transitioned into this thesis.

1. Introduction

Ice fishing is as much about camaraderie and getting in a little recreation during the frigid winter months as it is about the sport. The sport originated in Scandinavia and was brought to Minnesota via Scandinavian settlers. An exact figure of how many people participate in ice fishing in the United States is unknown. Ice fishing is popular in northern Europe, as well as across North America (Alaska, Montana, Minnesota, Wisconsin, Vermont, New Hampshire, Ohio, New York and Canada). Some of the most popular North American ice-fishing lakes are Lake Simcoe in Canada (the self-proclaimed "ice-fishing capital" of the east), Mille Lacs Lake in Minnesota (where, in a typical winter, some 5,000 shelters crowd the ice), Lake Champlain in New York, Lake Houghton in Michigan and Lake Winnepesaukee in New Hampshire (Watson , 2008)

There are many ice fishing derbies in the colder states. The process of ice fishing is simple. During the coldest winter months when lakes and rivers freeze over, ice fishermen journey onto the ice. The means of travel on to the ice depends on the thickness of the ice. If the ice is around 18 inches thick, fishermen may pull their shelter out onto the frozen lake via a pick-up truck. If the ice is slightly more than 4 inches thick many ice fishermen will walk out onto the ice. If the ice thickness is between the 4 and 20 inches thick, fishermen will most often use an all-terrain vehicle (ATV) to haul gear on and off the ice.

Once a fisherman has found an ideal spot to fish, an ice hole approximately 8-10 inches wide will be cut using a hand auger or a power auger as illustrated in Figure 1. The fisherman will then set up the shelter around the hole and settle down to fish the hole. They use short poles

and usually jig the line to attract the fish. Shelters are used to provide relief from the unforgiving cold temperatures and the wind.

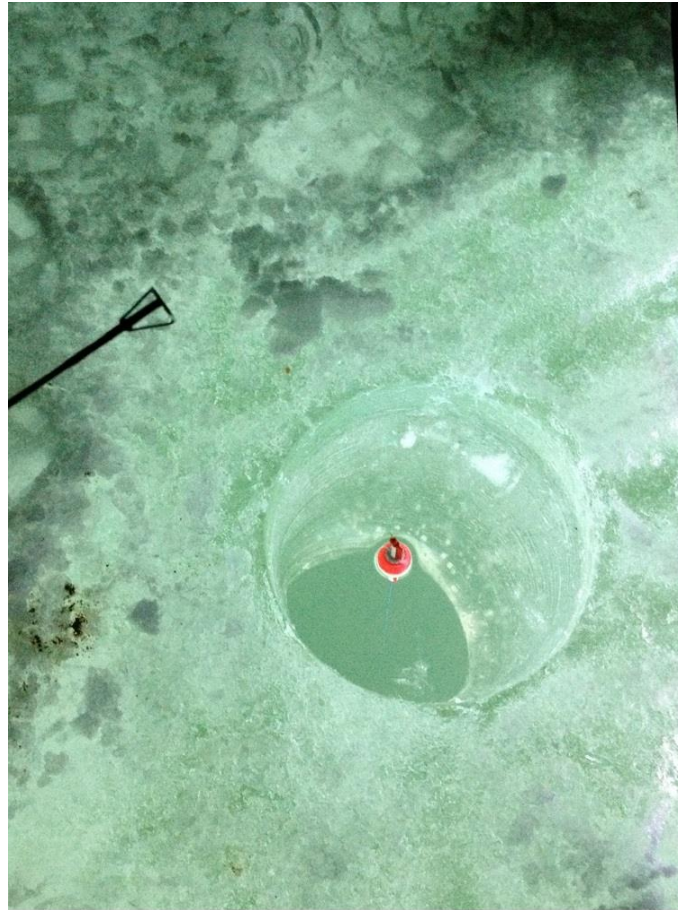


Figure 1: Picture of a hole drilled through the ice (ice hole) that is approximately 12 inches wide and 18 inches deep.

A typical commercially made portable ice fishing shelter looks a bit like a small tent as illustrated in Figure 2. This portable structure has an aluminum frame covered in 300 Denier polyester fabric, with zippered doors on both ends and clear vinyl windows. Some ice fishing shelters fold into a sled or bag so that they can be easily carried to the lake.



Figure 2: Tent type portable ice shelter This ice shelter was manufactured by Quickfish. Pop up ice shelters are common.

An ice shanty is a small shelter made of wood or plastic. It measures about 6 feet by 6 feet, and is tall enough for fishermen to stand upright. Some shanties have a bench inside.

The most elaborate shelter is the ice fishing house, which can tow on a trailer and lower down to the ice. Some are as big as 8 by 16 feet and can accommodate four or more people. This permanent structure has aluminum or wood siding, and comes equipped with many of the comforts of home such as propane heat, sleeping bunks, carpeting, lighting, a kitchen and bathrooms with a toilet and shower. Some models can cost as much as \$30,000 (2016 ICE Castle 8X24 Northern Exposure Hybrid, 2015) Castle 8X24 Northern Exposure Hybrid, 2015). These have luxurious accessories such as hardwood floors, cathedral ceilings and even satellite TV. The television can even be hooked up to an underwater camera to keep tabs on the fish's whereabouts as illustrated in Figure 3.



**Figure 3: Elaborate Commercial Ice Fishing House
(2016 ICE Castle 8X24 Northern Exposure Hybrid, 2015)**

Many ice fishermen utilize fuel burning appliances to heat their shelters. Fuel combustion within these enclosed shelters presents a risk for carbon monoxide exposure. Carbon monoxide is a colorless odorless gas that is generated from incomplete combustion of fossil fuels.

The objective of this research was to assess the potential CO exposure associated with propane heater usage in ice shelters. The following research hypotheses were developed to determine if there is a risk of CO exposure:

Hypothesis 1: There will be detectable CO in ice fishing shelters

H₀: The will not be detectable CO in ice fishing shelters.

Hypothesis 2: Fishermen COHb levels will be elevated from baseline COHb readings.

H₀: Fishermen COHb levels will not be elevated from baseline COHb readings

Hypothesis 3: Fishermen pulse rates will be elevated from baseline.

H₀ Fishermen pulse rates will not be elevated from baseline.

2. Background

Between 1980 and 1994, 80 deaths and several serious injuries are known to have resulted from propane radiant heaters. In the United States during 1990-1994, portable fuel-burning camp stoves and lanterns were involved in 10-17 CO poisoning deaths each year (MMWR Weekly, 1999). During this same time, an annual average of 30 fatal CO Poisonings occurred inside tents or campers (MMWR Weekly, 1999).

The potential for injury and death is quite simple. An Ice fisherman may spend a considerable amount of time inside a tent, camper, or ice fishing house, and for several hours they may heat their shelter with a propane heater that emits radiant heat for warmth. During the heating process two things may occur. The heater may consume oxygen in the air or the heater may have the potential to generate CO. Without adequate ventilation in the enclosure, toxic concentrations of CO may be present.

The potential dangers associated with portable propane heaters are not readily apparent. The average user, without a clear understanding of CO and its risks, would not understand that utilizing the heater in an enclosed space creates a potential for serious risk of injury or death.

2.1. Standard Air

The percentage of oxygen in standard air is 20.9 percent. The human body needs at least 19.5 % oxygen in the blood to function properly. If blood oxygen levels fall below 19.5 %, adverse health effects may occur. The minimal oxygen content allowed in a working environment is 19.5% as defined by OSHA (United States Department of Labor, 2016).

Table I : Effects of Oxygen-Deficient Exposure

Oxygen concentration (% vol)	Health effects of persons at rest
19	Some adverse physiological effects occur, but they may not be noticeable.
15–19	Impaired thinking and attention. Increased pulse and breathing rate. Reduced coordination. Decreased ability to work strenuously. Reduced physical and intellectual performance without awareness.
12–15	Poor judgment. Faulty coordination. Abnormal fatigue upon exertion. Emotional upset.
10–12	Very poor judgment and coordination. Impaired respiration that may cause permanent heart damage. Breathing of gas that will cause a fainting without warning, nausea and vomiting.
<10	Inability to move. Fainting almost immediate. Loss of consciousness. Convulsions. Death

Retrieved from: <http://www.airproducts.com/~media/files/pdf/company/safetygram-17.pdf>

A pulse oximeter measures the oxygen saturation in blood. Normal pulse oximeter readings range from 95-100 percent. Oxygen saturating under 90 percent is considered low (Mayo Clinic Staff, 2013).

2.2. Carbon Monoxide Toxicology

Inhaled carbon monoxide is transported to lung alveoli as result of convective forces in the respiratory tract and diffusion. The pressure difference in the lungs is how gas exchange occurs during a breathing cycle. The lungs will eventually reach equilibrium. Inhaled CO diffuses through alveolar membrane and attaches to hemoglobin on erythrocytes of red blood cells. Hemoglobin is a protein that ferries oxygen. Carbon monoxide possesses a 210-240 times greater affinity for hemoglobin compared to oxygen (Rose & Cohn, 2011). Carbon monoxide bonded with hemoglobin is referred to as carboxyhemoglobin (COHb). The principal toxic effect of CO exposure is tissue hypoxia because COHb blocks transporting and delivering

oxygen. Through similar mechanisms, carbon monoxide decreases O₂ storage in muscle cells by binding to, and displacing O₂ from myoglobin. Although all tissues are vulnerable to carbon monoxide-induced hypoxic injury, those having the highest O₂ demand are particularly vulnerable, including the brain and heart (U.S. Department of Health and Human Services, 2012).

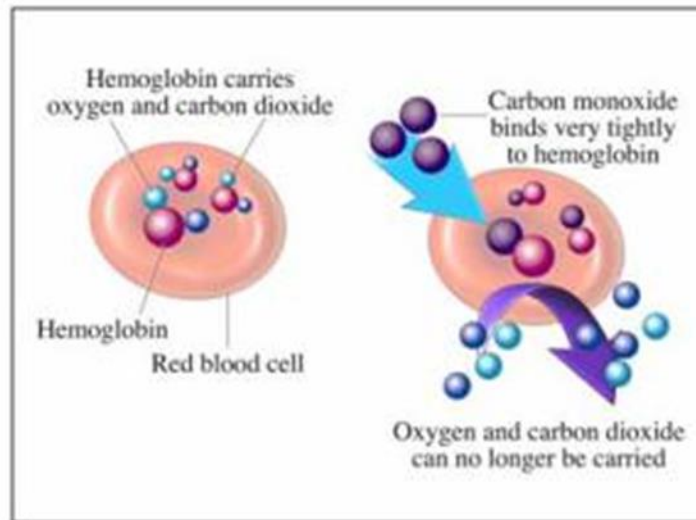


Figure 4: Carbon Monoxide Binding to Hemoglobin
Retrieved from <http://uvahealth.com/services/hyperbaric-oxygen-therapy/carbon-monoxide-poisoning>

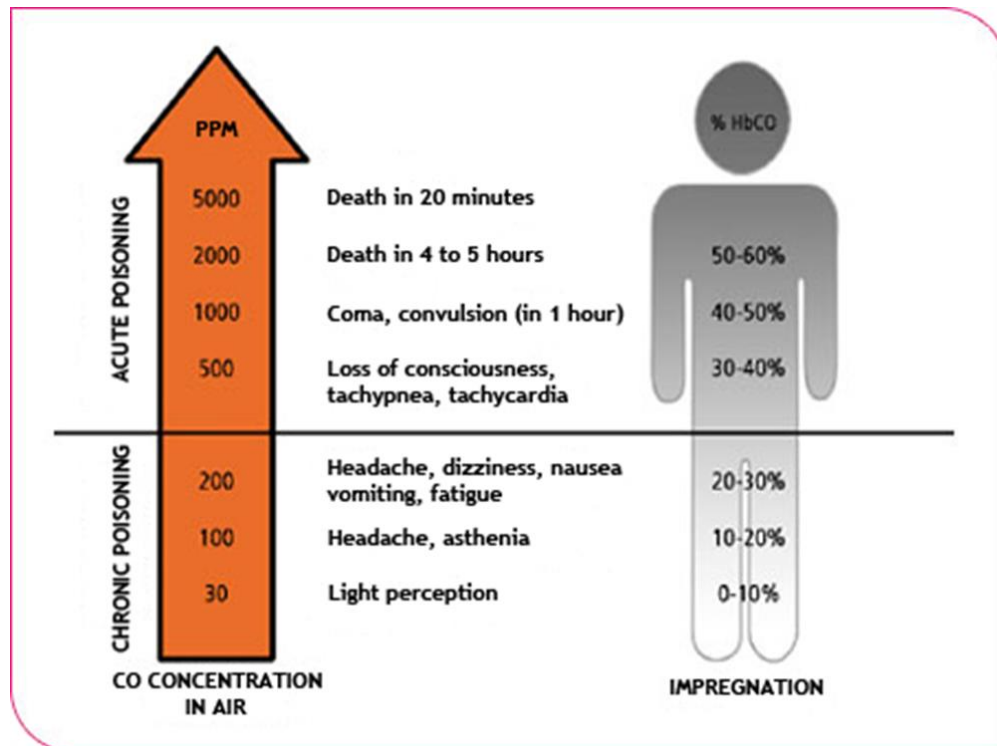


Figure 5: The correlation between CO in air and COHb % in blood. " (December 5, 2015). Retrieved from <http://www.nano-sense.com/en/CO/dossier-on-the-carbon-monoxide.html>".

Results of controlled clinical studies in patients with coronary artery disease show that acute-duration exposure to carbon monoxide at levels producing blood COHb levels between 2.4 and 5.9% exacerbates underlying cardiovascular disease, including enhanced myocardial ischemia and increased cardiac arrhythmias. (U.S. Department of Health and Human Services, 2012) Poisoning symptoms, such as headache, dizziness, and nausea, can be seen at COHb levels of greater than 10% in otherwise healthy persons. The relationship between COHb blood concentrations and health effects is illustrated in the table below.

Table II: Carboxyhemoglobin levels and related health effects on people

% COHb in blood	Effects Associated with this COHb Level
80	Death ^a
60	Loss of consciousness; death if exposure continues ^a
40	Confusion; collapse on exercise ^a
30	Headache; fatigue; impaired judgment ^a
7-20	Statistically significant decreased maximal oxygen consumption during strenuous exercise in healthy young men ^b
5-17	Statistically significant diminution of visual perception, manual dexterity, ability to learn, or performance in complex sensorimotor tasks (such as driving) ^b
5-5.5	Statistically significant decreased maximal oxygen consumption and exercise time during strenuous exercise in young healthy men ^b
<5	No statistically significant vigilance decrements after exposure to CO ^b
2.9-4.5	Statistically significant decreased exercise capacity (i.e., shortened duration of exercise before onset of pain) in patients with angina pectoris and increased duration of angina attacks ^b
2.3-4.3	Statistically significant decreased (about 3-7%) work time to exhaustion in exercising healthy men ^b

SOURCE: a U.S. EPA (1979); b U.S. EPA (1985)

Enhanced carbon monoxide-induced central nervous system toxicity has been reported to occur with concomitant exposures to alcohol, barbiturates, amphetamine, chlorpromazine, nicotine, diazepam, and morphine (EPA 1991).

At sea level the partial pressure of O₂ is at 1 ATM. At high altitude, the atmospheric pressure is less, therefore applying less pressure to cause oxygen to bind with hemoglobin. At ambient oxygen pressures of approximately 0.2 ATM, elimination of carbon monoxide occurs with a half-time of approximately 100– 300 minutes (U.S. Department of Health and Human Services, 2012). However, the elimination rate can be increased substantially by administering

100% oxygen. The general recommendation for reducing the body burden of carbon monoxide is administration of 100% oxygen through a face mask that does not allow rebreathing of expired air, at ambient pressure, and/or hyperbaric oxygen therapy (U.S. Department of Health and Human Services, 2012). The effects of fresh air, and oxygen hyperbaric therapy is illustrated in Figure 7.

The Haldane equation is a well-known equation to predict COHb in blood based on air CO concentrations. The simple equation relates the partial pressure of carbon monoxide in the air, the partial pressure of oxygen in the air, and the concentration of carboxyhemoglobin and oxyhemoglobin in blood. “M” is known as the Haldane Constant and is equal to approximately 200, representing the affinity of hemoglobin for CO vs. O₂. The Haldane equation is named after the scientist who studied the effects of carbon monoxide in the late 1800s (Principles of Toxicology, 2000).

See Figure 6: The Haldane Equation. COHb will be increased by increasing the partial pressure of CO (i.e. Increased ppm CO), and/or by decreasing the partial pressure of ambient oxygen (i.e., depleting oxygen). (Principles of Toxicology, 2000.)

$$\frac{[\text{HbCO}]}{[\text{HbO}_2]} = M \frac{(p\text{CO})}{(p\text{O}_2)}$$

Figure 6: Haldane Equation (Principles of Toxicology, 2000)

Fresh air, and oxygen hyperbaric therapy are both used to dissociate carbon monoxide from hemoglobin. Hyperbaric therapy substantially decreases the time for CO to dissociate from hemoglobin as illustrated in Figure 7.

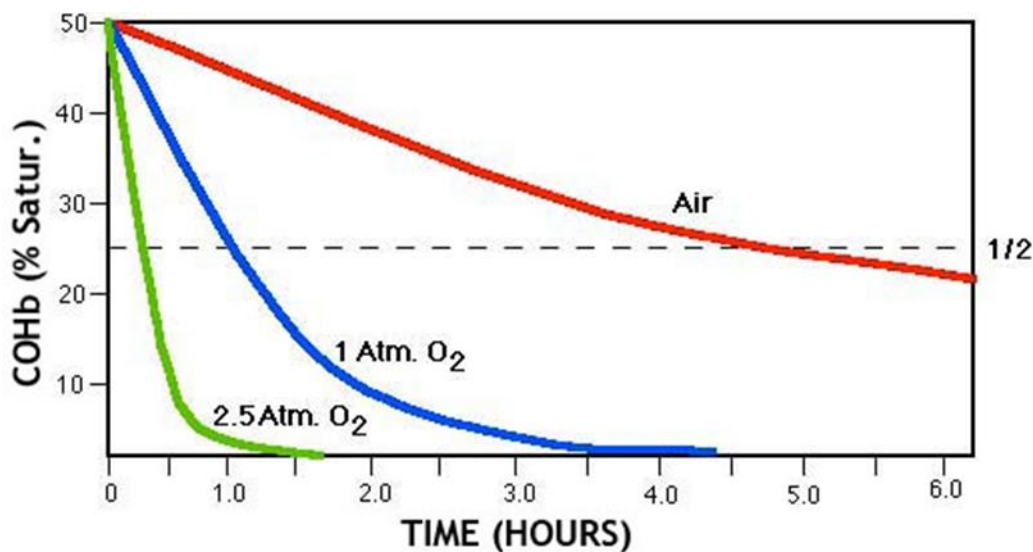


Figure 7: Dissociate CO from hemoglobin. " (December 5, 2015). Retrieved from <http://www.nano-sense.com/en/CO/dossier-on-the-carbon-monoxide.html>

2.3. Portable Propane Heaters

Portable propane radiant heaters are often referred to as camp heaters since the heaters were originally designed for use during outdoor activities such as camping, hunting, and fishing. The heaters use a disposable bottle of propane gas (most use a 1-pound bottle) as their fuel source. Gas-fired radiant heaters are intended for large open areas. When the heaters are operated in small enclosed areas that are poorly ventilated, such as a tent or trailer, they present a potential carbon monoxide (CO) poisoning hazard.

Since the 1970's several companies have manufactured and sold propane radiant camping heaters that are designed for indoor use. There are two types: Radiant heaters and catalytic heaters. Currently, there are three different types of portable radiant propane heaters: Single burner radiant heaters, radiant heaters that also function as cookers, and radiant heaters equipped with an Oxygen Depletion Sensor (ODS). Single burner and cooker heaters are designed for outdoor use only. The ODS- equipped heaters are designed for enclosed areas that are protected from the wind. Although the ODS-equipped radiant heaters can be used in confined spaces such

as a tent or trailer, the manufacturers still recommend that sufficient air be provided to the heater for the combustion process and for ventilation. Table III provides a summary of the different portable propane heaters currently available to consumers. Figures 8 through 11 are photographs that are representative of each type of heater. (Tucholski, 2002)

Table III: Portable propane radiant heaters that could be used in camping situations

Heater Style	Intended Use	Typical Energy-Input Rate	ESTIMATED RUN TIME	
			1-pound bottle (hrs)	20-pound tank (hrs)
Single Burner Radiant heater	Outdoor	Up to 3,000 Btu/hr	7.5	N/A
Radiant Heater/ Cooker	Outdoor	8,000 to 15,000 Btu/hr	1.5-2.8	29-55
ODS-Equipped Radiant Heater	Indoor	4,000 to 9,000 Btu/hr	2.5-5.7	49-110
Catalytic Heater	Indoor	1,220-3,700 Btu/hr	6.5	N/A

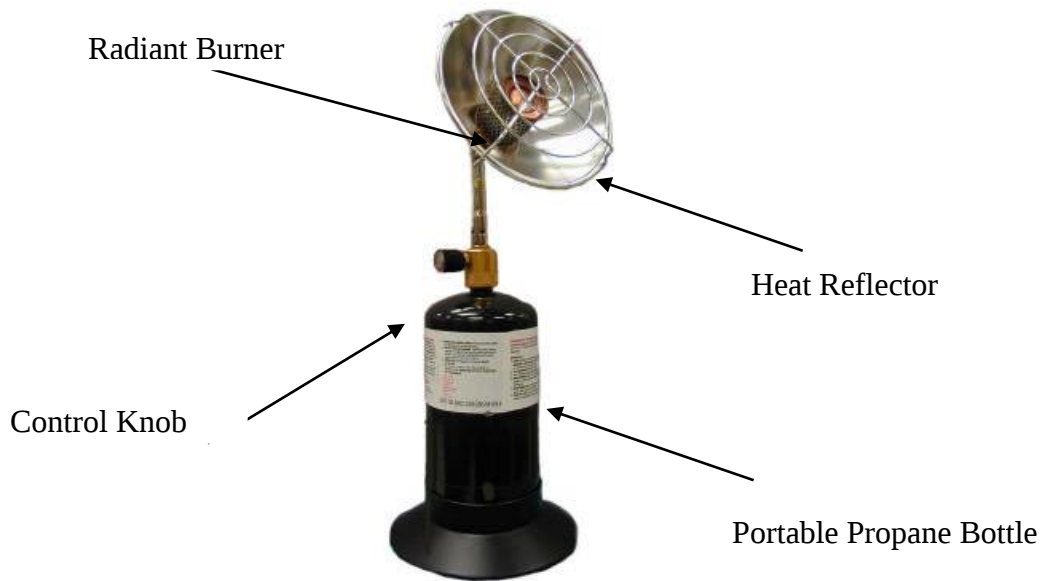


Figure 8: Single Radiant Heater

2.3.1. Single Burner Radiant Heaters

The single burner radiant heater (Figure 8) consists of a radiant burner surrounded by a heat reflector and a gas valve. The entire heater assembly attaches to the top of a portable propane bottle. Some of these heaters have a shut off device that will stop the flow of gas if the flame is extinguished. The shutoff device consists of a solenoid gas valve and a thermocouple mounted above the burner. When the thermocouple is heated, it generates the voltage and current necessary to hold the solenoid valve open. When the flame is extinguished, the thermocouple cools, causing a decrease in the generated voltage and closing the gas valve. (Tucholski, 2002)

Thermocouple

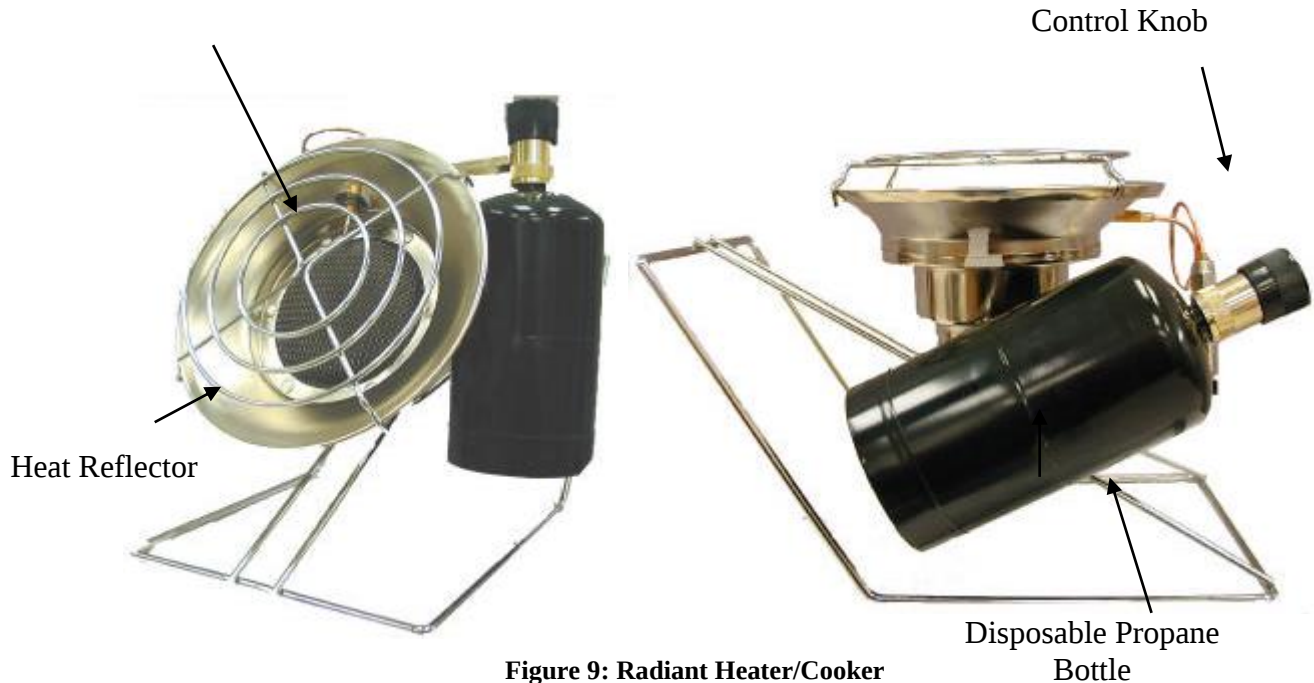


Figure 9: Radiant Heater/Cooker

2.3.2. Radiant Heater/Cookers

In addition to being a radiant heater this model can also be used as a cooker. This model shown in Figure 9, is the same as a single burner except it has a stand on which to position the unit for either heating or cooking. This heater may have pre-defined settings (e.g., Low, Medium, and High) or the settings may be variable. This device also has a safety shutoff similar to the single burner described in Figure 8.

Several of the heaters have an integral piezo-type electronic ignitor. These heaters are designed to be used with a disposable bottle of propane gas, however they can be attached to a bulk propane tank using a hose assembly, which must be purchased separately.

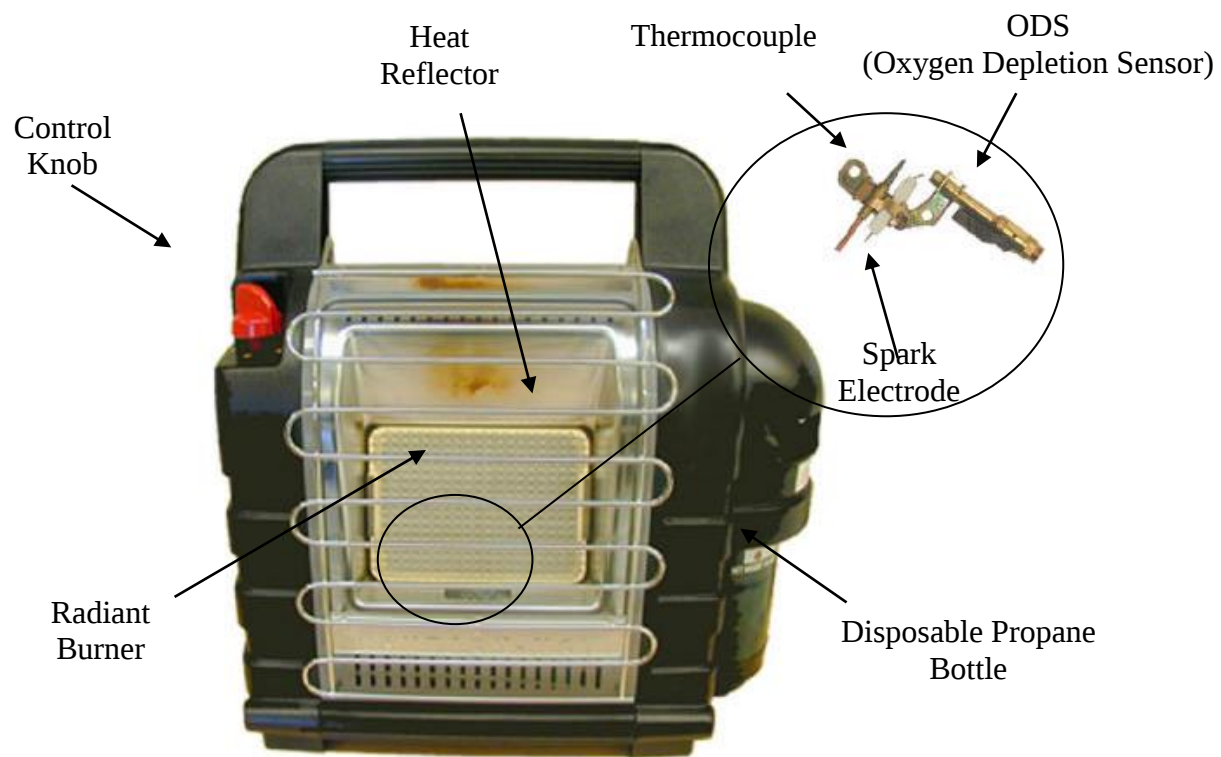


Figure 10: Radiant heater equipped with an oxygen depletion sensor (ODS)

2.3.1. ODS-Equipped Radiant Heaters

A “Buddy Heater” shown in Figure 10 is equipped with an Oxygen Depletion Sensor (ODS). The ODS differs from other thermally activated shutoff devices in that the thermocouple senses the temperature of a pilot flame instead of the main burner. The pilot flame is more sensitive to changes in the surrounding O₂ concentration than on the main burner. The pilot flame will lift off quicker when the O₂ level decreases. When the flame lifts off the burner, the thermocouple will cool causing the gas valve to close. Oxygen depletion sensors (ODS) have been used many years in unvented gas logs (Tucholski, 2002).

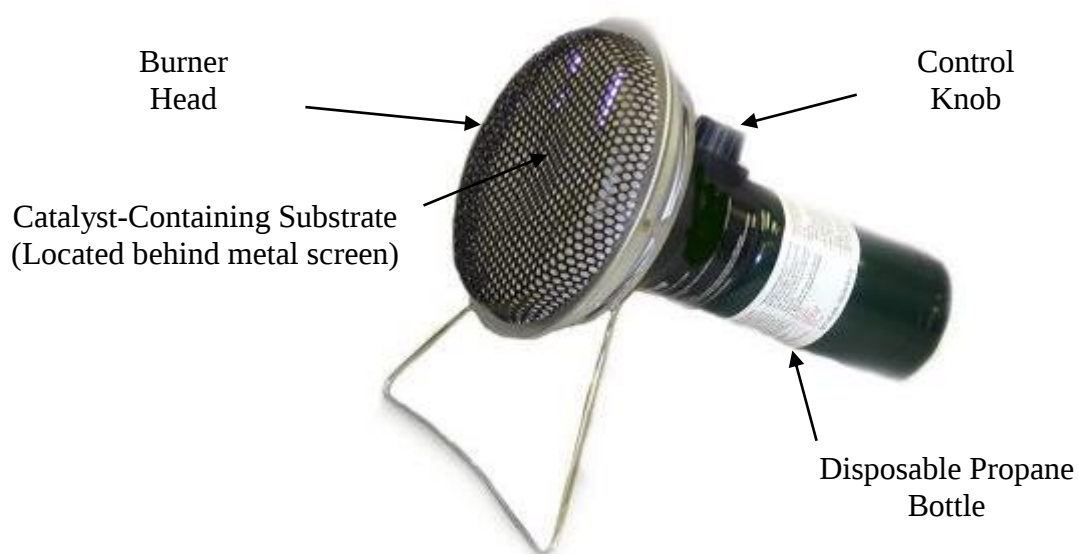


Figure 11: Catalytic heater

2.3.2. Catalytic Heaters

Catalytic heaters shown in Figure 11 generate heat through a flameless catalytic reaction involving propane and oxygen. Radiant heaters which generate a flame as described above are different from catalytic heaters. A chemical reaction occurs when propane and oxygen are converted to carbon dioxide and water vapor. The catalytic heater generates heat by bringing the propane and oxygen into contact with a platinum catalyst (Tucholski, 2002). During this chemical reaction heat is also produced. In order to start the reaction process a flame has to be ignited.

3. Sampling Methods

3.1. Carbon Monoxide Air Sampling Methods

Carbon Monoxide air concentrations are most commonly measured with direct reading instrumentation. One common method is to use a 4 gas monitor that has 4 different gas sensors. The sensors may consist of oxygen, Hydrogen sulfide, carbon monoxide, and a lower explosive limit sensor. This instrument is commonly used to measure gases in confined space, emergency response, industrial hygiene, and many other monitoring applications. This instrument can be used as a personal monitor, a hand-held real-time instrument, or as a continuous operational monitor. The monitor should be calibrated no less than every 30 days, or if it does not pass a fresh air reading, or a field verification. The monitor is calibrated in a two-step process using fresh air and span gas (a span gas contains a known concentration of a given gas).

3.2. Non-invasive blood monitoring method for Carboxyhemoglobin

Invasive monitoring is most commonly performed in a hospital. For field studies, a non-invasive monitoring method is used. Noninvasive samplers can measure the amount COHb % in blood by using wavelengths to acquire data based on light absorption. An example of this method is when a nurse places an oximeter on the finger to acquire the % oxygen. A CO-oximeter (shown in Figure 13) works the same way but has added technology to measure COHb in blood. The meter is placed on a finger of each individual. The meter stays on the finger until a result is generated. The result is presented in percent saturated oxygen and percent saturated carboxyl hemoglobin. This instrument requires no user calibration.

4. Public and Occupational exposure limits for CO.

The Clean Air Act, which was last amended in 1990, requires EPA to set National Ambient Air Quality (NAAQ) Standards (40 CFR part 50) for pollutants considered harmful to public health and the environment. The Clean Air Act identifies two types of national ambient air quality standards. Primary standards provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings. (United States Environmental Protection Agency, 2012). The NAAQ standards for CO are presented in Table IV.

Table IV: Ambient Air Standard for CO (United States Environmental Protection Agency, 2012)

Pollutant [final rule cite]	Primary/ Secondary	Averaging Time (hr)	Level (ppm)	Form
Carbon Monoxide [76 FR 54294, Aug 31, 2011]	primary	8	9	Not to be exceeded more than once per year
		1	35	

4.1. Occupational Exposure Limits

The following Occupational exposure limits were established for the healthy working population. Occupational Safety and Health Administration (OSHA) has established a permissible exposure limit (PEL) which is enforceable by law of 50 parts per million (PPM) of air as an 8-hour time weighted average.

The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) for carbon monoxide of 35 ppm (40 mg/m(3)) as an 10-hour

time weighted average (TWA) and 200 ppm (229 mg/m³) as a ceiling [NIOSH 1992]. This limit is based on potential cardiovascular effects.

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned carbon monoxide a threshold limit value (TLV) of 25 ppm (29 mg/m³) as a TWA for a normal 8-hour workday and a 40-hour workweek [ACGIH 1994, p. 15]. This limit is based on the risk of elevated carboxyhemoglobin levels.

5. Previous Studies

5.1. CO Emissions from Portable Propane Radiant Heaters

Volunteer Standards Staff at the U.S. consumer Product Safety Commission (CPSC) conducted in-depth investigations on 12 incidents that occurred between 1996 and June 2001 involving portable propane radiant heaters (Tucholski, 2002). The 12 incidents resulted in 18 deaths due to CO poisoning (Tucholski, 2002). All of the incidents occurred in tents, campers, trailers, or motor vehicles (passenger vans, passenger cars, and cabs of semi trucks). To address this potential CO poisoning hazard, the voluntary standard for portable Type Gas Camp Heaters (ANSI Z21.63) was revised in April 2000. (Tucholski, 2002). The revised standard specifies that when heaters are operated in a 100ft³ room at air exchange rates of 0.5, 1.0 and 1.5 air changes per hour, the CO concentration in the room cannot exceed 100 parts per million (ppm). The standard also specifies that the oxygen (O₂) concentration in the room cannot be depleted below 16 percent. The objective of the ANSI study was to document current CO emissions from currently available portable propane heaters and to determine if these heaters complied with the revised CO performance requirements of ANSI Z21.63(2000). (Tucholski, 2002)

Eight different heaters were tested. These heaters were divided into three groups: radiant single burner, radiant heater/cooker, and radiant heaters with oxygen depletion sensors (ODS). Although not all fell within the scope of ANSI Z21.63, all of the heaters could be used in typical camping situations. Therefore, all of the heaters were tested to the combustion requirements of ANSI Z21.63, since the standard provides guidelines for assessing whether a heater could present a CO poisoning hazard to consumers (Tucholski, 2002).

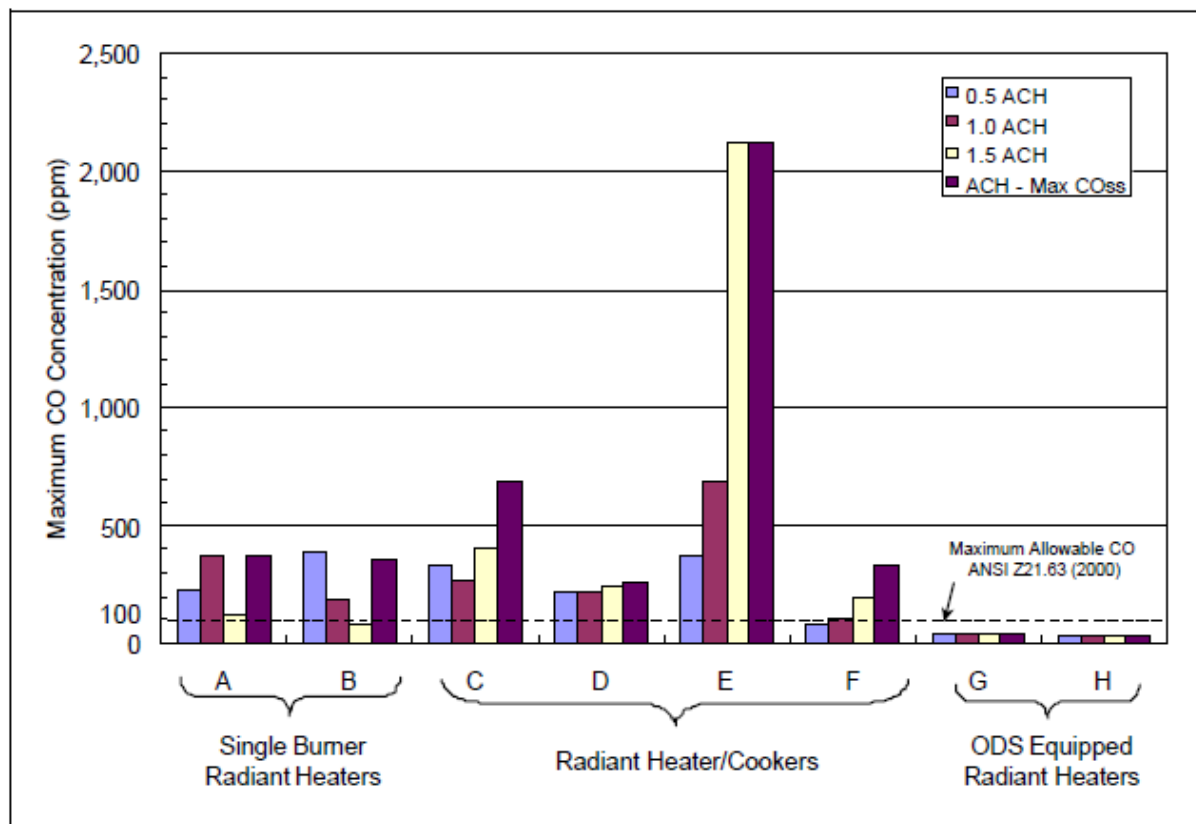


Figure 12: Comparison of the maximum CO concentration in the chamber for each heater at the air exchange rates specified in the standard and at an air exchange rate that produced the maximum CO without causing the flame to self-extinguish (Tucholski, 2002).

Table V: Summary of the camp heater tests including which heaters complied to the revised standard (Tucholski, 2002)

Heater Style	Test Sample	Complies with the Combustion Requirements of ANSI Z21.63 (2000)	Within the scope of ANSI Z21.63 (2000)	Certified to ANSI Z21.63 (2000)	Certified to a Different Standard
Single Burner Radiant Heater	A	No	Yes	No	No
	B	No	Yes	No	No
Radiant Heater/Cooker	C	No	No	No	No
	D	No	No	No	No
	E	No	No	No	No
	F	No	Yes	No	No
ODS- Equipped Radiant heater	G	Yes	No	No	Yes
	H	Yes	No	No	Yes

The Safety Commission also tested the portable propane catalytic heaters.

- The catalytic heater did comply with the combustion requirements currently specified in the draft version of the standard for catalytic camp heaters (ANSI Z21.62).
- The catalytic heater did not comply with the combustion requirements specified in the standard for infrared radiant camp heaters (ANSI Z21.63-2000). The heater depleted the O₂ concentration below 16 percent in the test chamber and also exceeded the 100 ppm limit for CO in the test chamber.

On January 24th 2011, in Sturgeon Bay Wisconsin two ice fishermen were near death when they were found unconscious in their ice house from CO poisoning (Bintz, 2011). The weather was extremely cold and the men had three propane heaters. One of the heaters had an emergency shut off but the other two did not. The neighboring fishermen that found the two men unconscious had just spoken to the men ten minutes prior to the event. The men had the vents in the shanty shut to keep the cold out, resulting in minimal ventilation.

In January of 2008, two men were found dead in their ice fishing house on The Lake of The Woods, Minnesota. They died from CO poisoning from a portable propane heater. The exact make and model of the heater was not listed (Blanchard, 2008). Another related article to this story states that the lake was super windy and cold the night of the deaths. The men were staying overnight. Sleeping in ice shelters is common. The sheriff who investigated the incident requested an ordinance requiring CO alarms in all ice fishing shelters (MTI Industries, 2008).

There have been numerous documented cases of CO poisoning in newspapers and other literature in the past 20 years. Summary examples of these are discussed below. In the winter

of 1992, Paul McWaters nearly died in his ice house. He recalled going fishing with his brother and friend. They noticed that there was enough propane exhaust in their ice house to sting their eyes but they thought they had fixed the problem and went to bed. McWaters woke up disoriented and sick and he managed to stumble to the vehicle and honk the horn for help. His brother and his friend both died from CO poisoning from their heater. The make and model of the heater was not listed (MTI Industries, Inc., 2008).

In 2011 a man was found dead in his ice house from CO poisoning. The make and model of the heater was not provided (MTI Industries, 2011). A similar incident occurred on Lake Winnebago Wisconsin, on Feb 2, 2013 A woman was found dead from CO poisoning . The make and model of the heater was also not provided (River Falls Journal, 2013).

A case study was published on the potential for carbon monoxide poisoning while using a small cooking stove in a tent (Collier & Goldsmith, 1983). The aim of the study was to investigate if burning a cooking stove inside a tent is a potential health hazard. Seven young men ages (18-38 years) healthy, non-smoking men with normal body weight (body mass index 19-24kg/m²) burned a kerosene camping stove in three tents for 2 hours. They were using the stove for snow melting. The tents were of the igloo type with enough space for three people. The tents were placed on snow covered ground. The study took place in April and there was no wind. The temp was 5-6 degrees Fahrenheit. The campsite was situated 200m (656.2ft) above sea level. For continuous readings in ambient air a Neotox-xl gas sensor was used. The sensor was placed at head level. Every 15 minutes, venous blood samples were taken.

The results of the analysis of the venous blood samples revealed significantly elevated COHb levels. In addition, all subjects experienced a significant increase in heart rate from a mean of 63 to a mean of 90 after 120 minutes (Thomassen, Brattebo, & Rostrup, 2004). This

study also revealed that while heating a kettle, the metal of the kettle bottom cooled the flame, resulting in the heater emitting 10-15 times more CO than without the kettle present (Thomassen, Brattebo, & Rostrup, 2004).

5.2. CO oximeter

Carboxyhemoglobin concentrations obtained with the RAD-57 have been compared to the primary standard of venous blood samples measured by multi-wavelength CO-oximetry (Zaouter & Zavorsky, 2012). The conclusion of the study was that the RAD-57 provides a reading that is between -6% and +4% of the true COHb value for 95% of all samples. RAD-57 appears to be a useful rapid and non-invasive method for initial screening of patients arriving to the emergency room with suspected carbon monoxide intoxication (Zaouter & Zavorsky, 2012).

6. Methods

Ten Ice fishermen at three different lakes were asked to participate in this study as they arrived at lakes to ice fish. All subjects signed a consent form prior to their participation in the study. This study was approved by the Institutional Review Board of The University of Montana.

Carbon monoxide, oxygen, and flammable gases (propane) lower explosive limit air concentrations were assessed in the shelters. In addition, fishermen blood COHb concentrations were measured immediately prior and during ice fishing events.

The study was conducted at three different lakes in Montana. These include; Georgetown Lake which has an altitude of 6,425ft and expands over 3700 acres and is located west of Anaconda, Mt in the Pintler mountain Range, Clark Canyon Reservoir with altitude 5,578ft and expands over 4935 acres and is located south of Dillon, Mt, and Canyon Ferry Lake with an altitude of 3,799ft and expands over 35,200 acres is located east of Helena, MT. The atmosphere pressure (based on altitude) at these three sites is estimated at 607 mmHg, 626 mmHg, 666 mmHg, respectively.

All participants were nonsmokers except one. The sampling methodologies remained consistent with each trial and each sampling session was performed in the same order.

6.1.1. Non-invasive blood monitoring method for Carboxyhemoglobin

A Rainbow-SET Rad-57 pulse CO-oximeter was used for noninvasive monitoring of COHb. (Masimo Inc., Irvine, CA). The Rainbow-SET Rad-57 pulse CO-oximeter is a new device that allows for a rapid non-invasive determination of the percentage of COHb% saturation in blood. The Rad-57's innovative noninvasive sensor technology uses more than 7 wavelengths of light to acquire blood constituent data based on light absorption (Masimo International, 2013).

Advanced signal processing algorithms and unique adaptive filters work together to isolate, identify and quantify various hemoglobin species. Blood measurement results are then displayed numerically. Standard pulse oximeters are composed of two wavelengths and can only measure arterial oxyhemoglobin saturation ($\%SaO_2$). The instrument is placed on the pointer finger unless the pointer finger does not fit, then it is placed on another finger. The finger fits inside the instrument. The Rad 57 uses light waves to identify different types of hemoglobin species in blood. The amount of time the meter is placed on the finger differs for each individual. The meter stays on the finger until a result is generated. The result is presented in percent saturated oxygen and percent saturated carboxyhemoglobin. This instrument requires no user calibration (Masimo International, 2013).



Figure 13: RAD-57 CO-Oxymeter (Masimo International, 2013)

Table VI: RAD 57 Limitations

Measurement Range		Accuracy
SPO2	0-100%	• Saturation 70-100% • No Motion Adults/Pediatrics $\pm$ 2 digits • Motion Adults/Pediatrics $\pm$ 3 digits
SpCO	0-99%	• 1-40% $\pm$ 3 digits
Pulse Rate (bpm)	25-240	• Pulse Rate 25-240 bpm • No Motion Adults/Pediatrics $\pm$ 3 digits • Motion Adults/Pediatrics $\pm$ 5 digits

A baseline COHb reading was taken before fishermen initially set up their shelter and every hour while they carried out their normal fishing activities. In addition to COHb measurements, blood oxygen levels and pulse rates were also assessed. The sensor was placed on a finger of the left hand. The digit was chosen according to the appropriate sized sensor for the subject. Per the manufacturer's instructions, the CO-Oximeter was left for one minute to stabilize the COHb reading. Immediately after the readings were recorded, the meter was removed from the subject's finger and turned off. None of the subjects were wearing nail polish during the time of the study. This was an important variable to consider. The manufacturer recommends taking readings from fingers free of nail polish.

6.1.2. Air Sampling Methods

A MultiRAE plus 4 gas monitor was used to measure the ppm of CO, O₂, and LEL of the ambient air concentrations within the ice fishing structures. This instrument is commonly used to measure gases in confined space, emergency response, industrial hygiene, and many other monitoring applications. This instrument can be used as a personal monitor, a hand-held real-time instrument, or as a continuous operational monitor.

The monitor should be calibrated no less than every 30 days, or if it does not pass a fresh air reading, or a field verification. The sensors are calibrated in a two-step process using fresh air and span gas (a span gas contains a known concentration of a given gas). The manufacturer recommends using RAE Systems MultiRAE Plus 4-gas calibration mix (50 % LEL methane, 20.9% oxygen, 25ppm H₂S, 50 ppm CO in a single gas cylinder). The monitoring measured the air within the structure for approximately 5 minutes using a RAE 4 gas monitor which was calibrated pre and post sampling using the manufactured recommended span gas. The CO ppm, O₂%, and % LEL levels were recorded.

Table VII: MultiRAE plus present alarm limits and calibration (RAE systems world headquarters, 2003)

Gas	Cal Gas/Balance	Unit	TWA	STEL	Low	High
CO	50/Air	ppm	35.0	100.0	35.0	200.0
O ₂	20.9/N ₂	%Vol	-	-	19.5	23.5
CH ₄	50/Air	%LEL	-	-	10.0	20.0

6.2. Additional Measurements

The physical dimensions of the structure were measured using a measuring tape and recorded as length x width x height. The cross sectional area of the vents were also measured using a measuring tape and it was noted if the vents were being utilized. During the research period, the wind speed and temperature of the ambient conditions of the lake were recorded with a Kestrel weather meter at 1 hour intervals.

The sampling procedures were repeated every hour until the ice fishing commenced. The Typical sample duration was 2 to 3 hours.

7. Results

All subjects utilized tents for shelter while ice fishing. The makes and model of the tents are illustrated in Table VIII, Column 1. In addition, sample date, location (lake or reservoir), shelter, volume, heater make and model, vent size, and the ambient air temperature in degrees Fahrenheit are provided in Table VIII.

The majority of tents were commercial models while one was homemade. One heater (number 5) failed to operate and is noted by an asterisk.

Table VIII: Description of Ice Fishing Structures

Subject Structure/ Brand	Location	Date	Volume Ft ³	Heater make and model	Vent Cross section area	Mean Ambient Air Temp F°
1	Georgetown	1-5-13	225.1	MR. Heater-Little Buddy 3,800 Btu/hr Radiant heater	2 square vents (.34 ft ²)	41.2
2 Eskimo Smoker	Clark Canyon	1-26-13	198.5	MR. Heater-Little Buddy 3,800 Btu/hr Radiant heater	2 square vents (.34 ft ²) not utilized at first	37.3
3 Red Quick Fish 3	Clark Canyon	1-26-13	198.5	MR. Heater-Big Buddy 18,000 Btu/hr Radiant heater	2 square vents (.34 ft ²) not utilized at first	35.5
4 Green Eskimo	Clark Canyon	1-26-13	225.1	MR. Heater-Little Buddy 3,800 Btu/hr Radiant heater	2 square vents (.34 ft ²) not utilized at first	35.7
5 Red Quick Fish	Clark Canyon	1-26-13	198.5	*N/A Heater Failed to start	4 square vents (.34 ft ²)	NA
6 Home made tarp	Canyon Ferry	1-27-13	123.9	Homemade/ Vintage	1 square vents (1.65 ft ²) Not utilized	34.6
7 Green Eskimo	Canyon Ferry	1-27-13	225.1	MR. Heater-Little Buddy 3,800 Btu/hr Radiant heater	2 square vents ((.34 ft ²)	35.1
8 Red Eskimo	Georgetown	2-10-13	216	MR. Heater-Big Buddy 18,000 Btu/hr Radiant heater	2 square vents (.61 ft ²) 2(square vents ,44 ft ²)	31.7
9 Green Eskimo	Georgetown	2-10-13	225.1	MR. Heater-Little Buddy 3,800 Btu/hr Radiant heater	2 square vents ((.34 ft ²)	28.7
10 Red Quick Fish	Georgetown	2-10-13	198.5	MR. Heater-Big Buddy 18,000 Btu/hr Radiant heater	4 square vents ((.34 ft ²)	29.0

Carbon monoxide concentrations (ppm) measured within the structure are illustrated in Table IX. Concentrations were recorded every hour. Several ice fishermen left within two hours; therefore, only one or two CO measurements were recorded for subjects 1, 6, 7, 8, 9, and 10. The mean CO concentration within the structures was 2-12 ppm, with the highest at 22 ppm.

Table IX: Air Carbon Monoxide Readings (PPM) within Ice Fishing Shelters

Subject Number	CO reading 1 hr	CO reading 2hr	CO reading 3hr	CO reading 4hr	Mean
1	4	3			3.5
2	0	20	7	8	11.6
3	1	8	22		10.3
4	0	5	4		4.5
5	N/A				
6	2				2.0
7	8				8.0
8	10	8			9.0
9	7	5			6.0
10	6	8			7.0

Blood COHb was measured with the MultiRae. The results are illustrated in Table X. The baseline reading was taken when the fishermen arrived at the destinations prior to setting up their shelters. Readings were then taken every hour after. As noted previously, some fishermen left after an hour of fishing. Subject 5's heater would not start, therefore there was no measurement taken after the baseline reading.

Table X: Progressive COHb (units) readings of Ice Fishermen

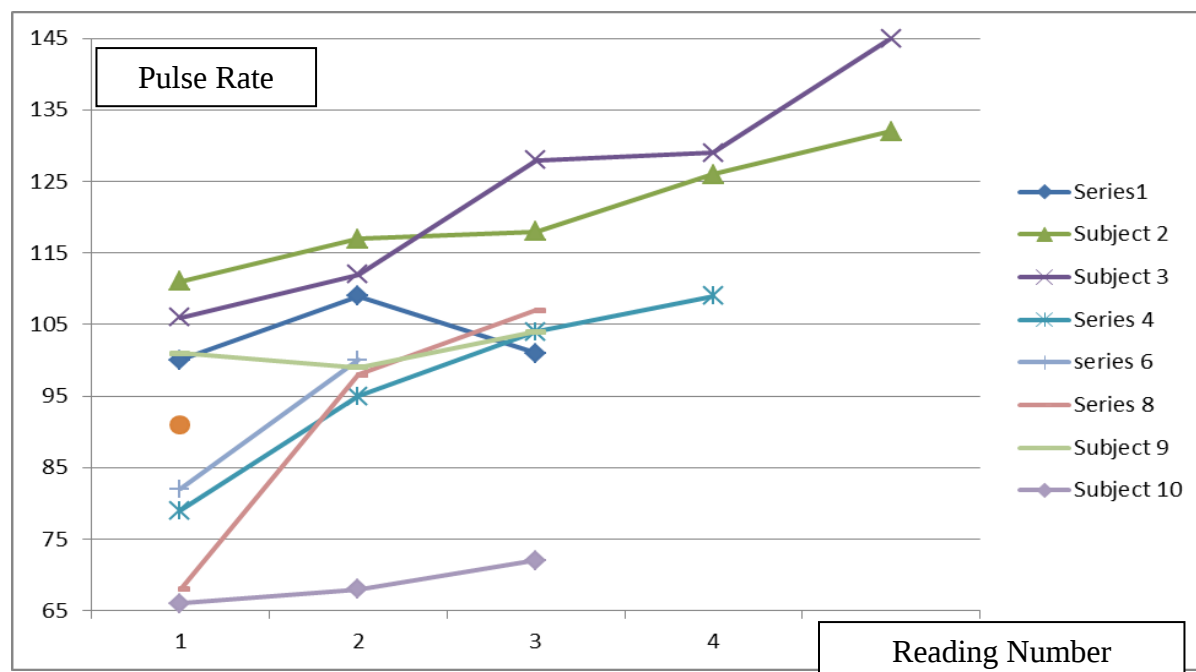
Subject Number	COHb baseline reading	COHb reading 1hr	COHb reading 2hr	COHb reading 3hr	COHb reading 4hr	Mean
1	ND	7	3			3.3
2	ND	ND	ND	4	4	1.6
3	ND	2	ND	ND	2	0.8
4	ND	ND	ND	ND		0.0
5	2					
6	2	4				3.0
7	ND	3				1.5
8	ND	2	2			1.3
9	3	8	8			6.3
10	1	3	4			2.7

Table XI illustrates the Oxygen concentrations within the shelters. The Oxygen percent was taken every hour. Subject 5's heater did not start so no measurement was taken.

Table XI : Ambient O2 (%) Readings within Ice Fishing Structures

Subject Number	O2 reading 1hr	O2 reading 2hr	O2 reading 3hr	O2 reading 4hr	O2 reading 5hr	Mean
1	20.9	20.9				20.9
2	20.6	19.6	20.6	20.3		20.27
3	20.9	20.5	20.9			20.6
4	20.9	20.5	20.4			20.6
5						
6	20.9					20.9
7	20.9					20.9
8	19.6	20.2				19.9
9	19.5	19.8				19.65
10	19.5	19.4				19.45

Figure 14 illustrates the pulse rates taken at baseline and every hour after. The pulse rate was measured using a Carboxy- Oxymeter. For most subjects (six), pulse rates increased from baseline as duration in the structures increased.

**Figure 14: Pulse Rate**

8. Discussion

The objective of this research was to assess the potential CO exposure associated with propane heater usage in ice shelters. This was evaluated via blood COHb monitoring and air monitoring within the ice fishing structures. Four of 10 (40%) of the subjects arrived at the ice fishing locations with measureable COHb concentrations. These data imply that ice fishermen may have measureable CO exposure associated with driving to and from lakes and reservoirs.

While COHb was measureable in 40% of the subjects when they arrived at the fishing sites, within one hour of fishing in a structure heated with a propane heater, eight of 10 (80%) of subjects revealed measureable COHb concentrations. These data suggest that the use of portable propane heaters contribute to increased blood COHb concentrations. The air CO monitoring within the structures supported this hypothesis with mean CO concentrations ranging from 2 -22 ppm and detectable CO in structures within an hour of fishing. Two subjects were exposed to CO above the EPA limit of 9ppm.

The pulse of 60% of the subjects continued to rise the longer they occupied the structures, even though there was minimal physical activity. This finding is consistent with previous literature regarding CO exposure.

The oxygen content within the structures was also measured. The potential for oxygen deficient atmospheres appeared to be most pronounced at Georgetown Lake, a site with the highest elevation. On one occasion, at Georgetown Lake, the oxygen alarm sounded on the gas monitor at 19.4% but the heater did not shut off even though it was equipped with an ODS.

8.1. Limitations

There are some limitations to this study. There were several variables that were difficult to control with this study. The first variable is shelter type. As illustrated in Table VIII, the shelters ranged from homemade tarps to manufactured huts with various sizes and shapes. In addition, the size of ventilation ports varied.

The activities of the fishermen varied. Some would leave their shelters for periods of time, while others would remain in the structures. Some would periodically open and close vents. The duration of their stay was a variable in amount of CO recorded. A couple of the subjects made sure to open their vents when they observed the CO readings on the gas monitor.

Each ice data recording session (air CO, air oxygen, COHb, pulse) in each structure took approximately 15 minutes. Therefore, the most that could be studied at one time was 4 shelters.

The investigator noted potential data recording issues with the COHb meter for subjects 1-4. It is hypothesized that this may have been due to the cold temperatures, although the testing was done within the manufacturer's parameters of temperature.

Future research should consider methods to reduce the variables observed in this study. In addition, a larger number of volunteer subjects is recommended.

9. Hypothesis Testing

H0 1: There will not be detectable CO in ice fishing shelters

Although there was not enough sampling data to show significance statistically, there is evidence that within 1 hour of fishing, CO was detected in 80% of the shelters. Therefore, the null is rejected.

H0 2: Fishermen COHb levels will not be elevated from baseline readings.

40% of the 10 subjects had COHb in their blood when they arrived, and within 1 hour 80% had detectable COHb readings. Therefore, the null is rejected.

H0 3: Fishermen pulse rates will not be elevated from baseline readings

The majority of subjects had elevated pulse rates. Therefore, the null of Hypothesis 3 is rejected.

10. Conclusion

Although there is not enough data to show significance statistically, there is evidence that there is potential for CO exposure when ice fishing while using a portable propane heater.

Although 40% of subjects arrived with detectable COHb readings, 80% had detectable COHb readings after fishing in structures heating with propane heaters after one hour. In addition, 80% of the structures revealed measureable CO concentrations in their shelters after one hour. Pulse rates of 60% of the participants increased as the duration in the shelters increased, even though the subjects' activity was described as minimal. Increased pulse rate is consistent with increased COHb concentrations.

The results of the study suggest that further research should be performed. Additional measures should be taken with future research to minimize the numerous variables noted in data collection for this study.

11. Future Work

Future studies could be conducted in two different ways. One method is to simply place radiant heaters in unoccupied tents and continuously measure air CO, flammable gases (propane) and oxygen concentrations throughout the trial period. This method would determine if propane heaters contribute to air CO concentrations within the structure during a typical winter day.

A second method is to repeat the study described in this paper, but take steps to minimize human variables. Only recruit volunteer subjects that plan to fish for at least three hours and ask the subjects to record when they open and close doors, windows, vents, etc. As with this study, it is crucial that subjects be trained to recognize warning alarms for CO, oxygen, and flammable vapors and to exit ice structures immediately in the event of an alarm or if they are experiencing any symptoms of CO exposure.

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13. Appendix A: Occupational Exposure Limits

Table XII: The exposure limits stated on NIOSH testing guide 6604 are as follows

OSHA (ppm)	50
NIOSH (ppm)	35
ACGIH (ppm)	25
Limits from (NMAM), NIOSH Manual of Analytical Methods ((NMAM), 1996)	

14. Appendix B: Effects of CO

Table XIII: Effects of Carbon Monoxide Exposure and CO Exposure Limits

PPM CO Exposure (ppm)	Effects of Exposure to Carbon Monoxide at this level	Source/comment
0	No effects, this is the normal level in a properly-operating heating appliance	No carbon monoxide should be detected in residential properties. Possible brief technical exceptions occur.
9	Maximum allowable short term exposure	ASHRAE
10-24	Investigation needed to find source;	Health effects on humans uncertain.
25	Maximum allowable TWA exposure limit	OSHA. Used in personal CO alarms.
35	Maximum allowable workplace exposure limit for an 8-hour work shift	NIOSH (40 hour work week)
50	Maximum allowable workplace exposure limit for an 8-hour work shift	OSHA (40 hour work week)
125	Workplace alarm must sound	OSHA
200	Evacuate the area immediately.	Exposure at 200 ppm of CO causes dizziness, nausea, fatigue.
400	Evacuate the area.	3 hour exposure may be fatal.
800	Evacuate the area.	2-3 hour exposure causes convulsions, loss of consciousness, death.
1600	Evacuate the area.	

NOTES to the Carbon Monoxide Effects Table: sources include OSHA, EPA, www.transducertech.com

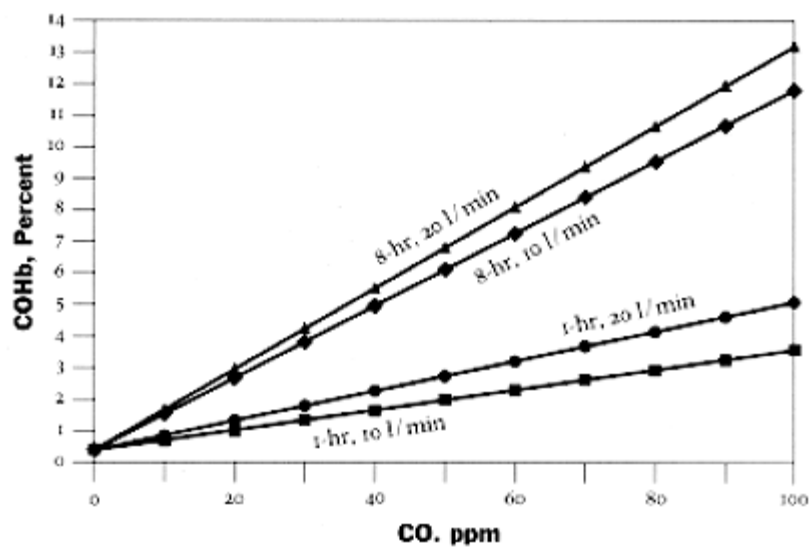


Figure 15: (2011, p. C5PC) Relationship between carbon monoxide (CO) concentrations and carboxyhemoglobin (COHb) levels in blood

15. Appendix D: IRB Approval



The University of
Montana

INSTITUTIONAL REVIEW BOARD
for the Protection of Human Subjects in Research
FWA 00000078

Research & Creative Scholarship
University Hall 116
The University of Montana
Missoula, MT 59812
Phone 406-243-6672 | Fax 406-243-6330

Date: January 23, 2013

To: Kellie Hicks, MT Tech SHIH
Julie Hart, MT Tech-SHIH

From: Paula Baker, IRB Coordinator

RE: IRB 13-13: "Carbon Monoxide Exposure From Fuel Burning Appliances in Ice Fishing Shelters"

Your IRB proposal cited above has been **APPROVED** under **expedited review** by the Institutional Review Board in accordance with the Code of Federal Regulations, Part 46, section 110. Expedited approval refers to research activities that (1) present no more than minimal risk to human subjects, and (2) fit within the following category for expedited review as authorized by 45 CFR 46.110 and 21 CFR 56.110:

4. Collection of data through noninvasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving x-rays or microwaves. Where medical devices are employed, they must be cleared/approved for marketing. (Studies intended to evaluate the safety and effectiveness of the medical device are not generally eligible for expedited review, including studies of cleared medical devices for new indications.)
Examples: (a) physical sensors that are applied either to the surface of the body or at a distance and do not involve input of significant amounts of energy into the subject or an invasion of the subject's privacy; (b) weighing or testing sensory acuity; (c) magnetic resonance imaging; (d) electrocardiography, electroencephalography, thermography, detection of naturally occurring radioactivity, electroretinography, ultrasound, diagnostic infrared imaging, doppler blood flow, and echocardiography; (e) moderate exercise, muscular strength testing, body composition assessment, and flexibility testing where appropriate given the age, weight, and health of the individual.

All consent forms used for this project must be date-stamped and signed by the IRB. Use the PDF sent with your approval notice as a "master" from which to make copies.

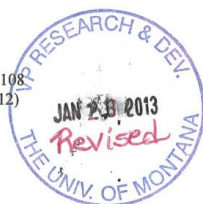
Amendments: Any changes to the originally-approved protocol must be reviewed and approved by the IRB **before** being made (unless extremely minor). Requests must be submitted using [Form RA-110](#).

Unanticipated or Adverse Events: You are required to timely notify the IRB if any unanticipated or adverse events occur during the study, if you experience an increased risk to the participants, or if you have participants withdraw from the study or register complaints about the study. Use [Form RA-111](#).

Continuation: Federal and University of Montana IRB policy requires you to file an annual Continuation Report ([Form RA-109](#)) for expedited studies. You must file the report within 30 days prior to the expiration date, which is **January 22, 2014**. *Tip: Put a reminder on your calendar now.* A study that has expired is no longer in compliance with federal or University IRB policy, and all project work must cease immediately.

Study Completion or Closure: Finally, you are also required to file a Closure Report ([Form RA-109](#)) when the study is completed or if the study is abandoned. See the directions on the form.

Please contact the IRB office with any questions at (406) 243-6672 or email irb@umontana.edu.

Form RA-108
(Rev. 05/12)

THE UNIVERSITY OF MONTANA-MISSOULA
Institutional Review Board (IRB)
for the Protection of Human Subjects in Research
CHECKLIST / APPLICATION

IRB Protocol No.:

13-13MT Tech

At The University of Montana (UM), the Institutional Review Board (IRB) is the institutional review body responsible for oversight of all research activities involving human subjects outlined in the U.S. Department of Health and Human Services' Office of Human Research Protection and the National Institutes of Health, Inclusion of Children Policy Implementation.

Instructions: A separate application form must be submitted for each project. IRB proposals are approved for no longer than one year and must be continued annually (unless Exempt). Faculty and students may email the completed form as a Word document to IRB@umontana.edu, or submit a hardcopy to the Office of the Vice President for Research & Development, University Hall 116. Student applications must be accompanied by email authorization by the supervising faculty member or a signed hard copy. *All fields must be completed. If an item does not apply to this project, write in: n/a.*

1. Administrative Information

Project Title: Carbon Monoxide Exposure From Fuel Burning Appliances in Ice Fishing Shelters	
Principal Investigator: Kellie Hicks	UM Position:
Department: SHIH Grad Student	Office location:
Work Phone: 406-565-9506	Cell Phone:

2. Human Subjects Protection Training (All researchers, including faculty supervisors for student projects, must have completed a self-study course on protection of human research subjects **within the last three years** (<http://www.umt.edu/research/complianceinfo/IRB/>) and be able to supply the "Certificate(s) of Completion" upon request. Add rows to table if needed.)

Research Team Members	PI	CO-PI	Faculty Supervisor	Research Assistant	DATE COMPLETED Human Subjects Protection Course
Name: Kellie Hicks Email: kahicks@mtech.edu	☒	☐	☐	☐	11/30/2012
Name: Julie Hart Email: jhart@mtech.edu	☐	☒	☒	☐	1/22/2013
Name: Email:	☐	☐	☐	☐	
Name: Email:	☐	☐	☐	☐	

3. Project Funding (If federally funded, you must submit a copy of the abstract.)

Is grant application currently under review at a grant funding agency? ☐ Yes (If yes, cite sponsor on ICF if applicable) ☒ No		Has grant proposal received approval and funding? ☐ Yes (If yes, cite sponsor on ICF if applicable) ☐ No	
Agency	Grant No.	Start Date	End Date
			PI

IRB Determination:

For UM-IRB Use Only

- ☐ Not Human Subjects Research
☐ Approved Exempt from Review, Exemption # _____ (see memo)
☒ Approved by Expedited Review, Category # 4 (see *Note to PI)
☐ Full IRB Determination
☐ Approved (see *Note to PI)
☐ Conditional Approval (see memo) - IRB Chair Signature/Date: _____
☐ Conditions Met (see *Note to PI)
☐ Resubmit Proposal (see memo)
☐ Disapproved (see memo)

*** Note to PI:** Study is approved for one year only. Use any attached IRB-approved forms (signed/dated) as "masters" when preparing copies. If continuing beyond the expiration date, a continuation report must be submitted. Notify the IRB if any significant changes or unanticipated events occur. When the study is completed, a closure report must be submitted. Failure to follow these directions constitutes non-compliance with UM policy and will have consequences.

Risk Level: MinimalFinal Approval by IRB Chair/Coordinator: [Signature] Date: 1-23-13 Expires: 1-22-14

SUBJECT INFORMATION AND INFORMED CONSENT

Study Title: Carbon Monoxide Exposure from Fuel Burning Appliances in Ice Fishing Shelters

Investigator(s):

*Kellie Hicks, Montana Tech 1300 W. Park Butte, MT 59701 (406)565-9506, Julie Hart,
Faculty Advisor, Montana Tech 1300 W. Park Butte, MT 59701 (406) 496-4115*

Special instructions:

This consent form may contain words that are new to you. If you read any words that are not clear to you, please ask the person who gave you this form to explain them to you. You must be 18 years or older to participate in this study.

Purpose:

- You are being asked to take part in a research study comparing blood-levels of carbon monoxide (carboxyl hemoglobin) to air concentrations of carbon monoxide.
- You have been chosen because you are utilizing an ice fishing shelter and operating a fuel burning appliance inside the shelter.
- The purpose of this research study is to learn if ice fisherman are exposed to levels of carbon monoxide while ice fishing inside a shelter and operating a fuel burning appliance.

Procedures:

If you agree to take part in this research study, you will have your base line carboxyl hemoglobin reading taken at the beginning of the sampling period of one hour. This involves a meter being placed on the finger. Similar to having your oxygen checked at a doctor's visit.

You will be asked if it is ok to monitor the air in your ice fishing shelter for 1 hour using a 4-gas monitor.

An inspection of the gas meter will be done twice, after 30 minutes of monitoring and at the end of the one hour sampling period.

Another Carboxyl hemoglobin reading will be taken after 30 minutes, and at the end of the hour.

The study will take place inside your ice fishing shelter.

The session will last for 60 minutes.

Your shelter and fuel burning appliance will be photographed with your permission.

Risks/Discomforts:

There is no anticipated discomfort for those contributing to this study, so risk to participants is minimal.

Benefits

Your help with this study may help understand if there is a risk for exposure from fuel burning appliances (heaters) in ice fishing shelters while ice fishing.

You will be provided with the readings from the 4-gas monitor. You will be advised of dangerous carbon monoxide levels and symptoms of poisoning to watch for. You will be advised of your personal exposure to carbon monoxide exposure over time.

Approval Expires On 1-22-14
Date Approved By UM-IRB 1-23-13
Paula H. Baker IRB-Chair

Confidentiality:

- Your records will be kept confidential and will not be released without your consent except as required by law.
- Your identity will be kept private.
- If the results of this study are written in a scientific journal or presented at a scientific meeting, your name will not be used.
- Your signed consent form will be stored in a cabinet separate from the data.

Voluntary Participation/Withdrawal

Your decision to take part in this research study is entirely voluntary.

Questions

If you have any questions about the research now or during the study contact: Kellie Hicks, Industrial Hygiene Grad Student at Montana Tech, at (406) 565-9506.

If you have any questions regarding your rights as a research subject, you may contact the Chair of the IRB through The University of Montana Research Office at (406)243-6672.

Statement of Consent:

I have read the above description of this research study. I have been informed of the risks and benefits involved, and all my questions have been answered to my satisfaction. Furthermore, I have been assured that any future questions I may have will also be answered by a member of the research team. I voluntarily agree to take part in this study. I understand I will receive a copy of this consent form.

Printed Name of Subject

Subject's Signature

Date

Statement of Consent to be photographed:

If applicable I understand that photographs of my shelter and fuel burning appliance may be taken during the study.

- I consent to having my shelter and fuel burning appliance photograph taken. I consent to use of the photograph in presentations related to this study.
- I understand that if photographs are used for presentations of any kind, names or other identifying information will not be associated with them.

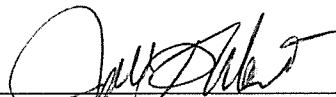
Subject's Signature

Date

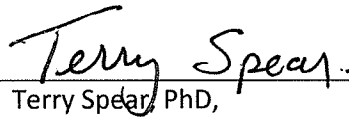
Approval Expires On 1-02-14
Date Approved By UM-IRB 1-23-13
Shirley A. Doherty IRB-Chair

SIGNATURE PAGE

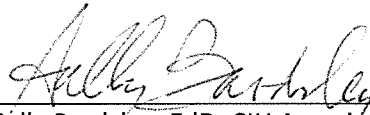
This is to certify that the thesis prepared by Kellie Hicks entitled "Portable Heater Use in ice fishing shelters and the potential for carbon monoxide exposure" has been examined and approved for acceptance by the Department of Safety, Health, and Industrial Hygiene, Montana Tech of The University of Montana, on this 10th day of January, 2016.



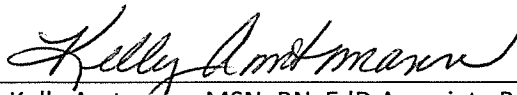
Julie Hart, PhD, CIH Associate Professor and Department Head
Department of Safety Health and Industrial Hygiene
Chair, Examination Committee



Terry Spear, PhD,
Department of Safety Health and Industrial Hygiene
Member, Examination Committee



Sally Bardsley, EdD, CIH Associate Professor
Department of Safety Health and Industrial Hygiene
Member, Examination Committee



Kelly Amtmann, MSN, RN, EdD Associate Professor
Department of Nursing
Member, Examination Committee