Appendix A – Ice Safety

Procedure:

TEST IT FIRST… drill a hole and measure the ice before venturing out onto any frozen waterbody/waterway.

When working on or around ice, you should be aware of ice safety and the ways to reduce the risks.

Some of the best tools to stay safe and work safe are:

- Good communication between you and your team/co-workers, etc.
- A plan that has been discussed and was agreed by you and your co-workers/contractors/others
- The right PPE for the situation
- If you are not sure, ask.

A critical part of ice safety is knowing the thickness of the ice and its effective thickness which will help you to determine the weight bearing capacity of the ice.

The Recommended Minimum Ice Guidelines for lighter loads are as follows:

FIGURE 1. RECOMMENDED MINIMUM ICE THICKNESS FOR NATURAL ICE/BLUE ICE (LIGHTER LOADS <5,000KG)

MINIMIZE YOUR RISK

It is critical that the quality and type of ice is evaluated before you travel.

Properties of Ice Covers

Ice Formation

Generally, small lakes and slow-moving streams freeze over earlier than larger lakes or fast-moving streams. While there are many different types of ice, the types presented below are the most important:

- Natural ice or clear blue ice: formed by the freezing of water
- White ice or snow ice: formed when water-saturated snow freezes on top of ice, making an opaque white ice which is not as strong as clear ice. It is white because it contains numerous small air bubbles.
- Constructed Flood Ice: Ice constructed by pumping water directly on the surface of a bare ice sheet to build ice on the top of the ice sheet. Uniformity and quality depend on construction practices and can once completely frozen and inspected be considered as having similar strength to natural ice (assuming sound construction practices).

Ice Color

The color of ice, which may range from blue to white to grey, provides an indication of its quality and strength.

- Natural Ice or clear blue ice: It usually forms in vertical, columnar crystals that contain few air bubbles. It appears to be blue because it's clear enough to see the water underneath it.
- White ice or snow ice: has a relatively high air content, and its strength depends on the density: the lower the density the weaker the ice; but high-density white ice has a strength approaching that of blue ice.
- Grey ice: generally, indicates the presence of water as a result of thawing and must be considered highly suspect and should not be considered safe as a load-bearing surface.

Ice Types, Variability and Natural conditions that affect quality

See Table 1, for a list of the ice types and their variability.

TABLE 1, ICE TYPES AND THEIR VARIABILITY

<table>
<tr><th>Ice Type</th><th>Ice Thickness</th><th>Quality and Strength</th></tr>
<tr><td rowspan="2">Freshwater lake (blue) ice</td><td rowspan="2">Low variability over an area</td><td>Uniform ice quality</td></tr>
<tr><td>Higher strength due to low variability</td></tr>
<tr><td rowspan="2">River (blue) ice</td><td>Medium to high variability over an area</td><td>Fairly uniform ice quality</td></tr>
<tr><td>More prone to losing underside ice thickness to currents</td><td>Variable strength due to variable ice thickness</td></tr>
<tr><td>Natural overflow (white) ice</td><td>High variability over an area</td><td>Overflow ice, caused by natural water overflow onto the ice surface, usually contains high air content and is considered to be 50% as strong as freshwater lake ice when calculating</td></tr>
<tr><td rowspan="2">Constructed flood ice</td><td rowspan="2">Good practices can build uniform ice</td><td>Uniformity and quality depend on construction practices</td></tr>
<tr><td>If ice is constructed using sound construction practices, which may include pumping fresh water directly onto the surface of bare ice (flooding), then this ice, once completely frozen and inspected, can be considered as having similar strength to Freshwater lake ice</td></tr>
<tr><td rowspan="3">Peatland ice (Muskeg)</td><td rowspan="3">High variability</td><td>Strength is highly variable due to water chemistry and temperature</td></tr>
<tr><td>Frost depth depends on air temperature, peat composition/thickness and ground cover</td></tr>
<tr><td>Requires specialized analysis and investigation of ice conditions</td></tr>
</table>

Ice thickness and Strength

Guidelines in Canada are based on a technical paper published by Dr. Lorne Gold in 1971 titled "Use of Ice Covers for Transportation". (Gold, L.W., 1971. Use of ice covers for transportation. *Canadian Geotechnical Journal*, *8*(2), pp.170-181.)

Gold's formula is used to calculate the allowable load that can be placed on a floating ice cover.

The formula: P=Ah 2 or h= $\sqrt{P/A}$

P= allowable gross vehicle weight (GVW) in kilograms (kg) or the allowable load in kilograms (kg)

h= the effective thickness of good quality ice (cm) or the minimum ice thickness of good quality ice in centimetres (cm)

A= a parameter that depends on the strength of the ice OR the value assigned dependant on the operating level selected.

It is important to examine the type of load and the length of time it will be on the ice surface. Will the load be static, moving, or stationary for longer than 2 hours.

TABLE 2, SERIES OF A- VALUES (GOLD'S FORMULA) AND THEIR HAZARD CONTROLS.

A-VALUES AND HAZARD CONTROLS (NOT TO BE USED FOR LOADS LESS THAN 1500KG)					
A-value Lake Ice	**A-value River Ice**	**Level of Risk**	**Hazard Controls**		
			Monitoring Controls	**Maintenance Controls**	**Administrative Controls**
4	3.5	low	Manual ice measurements and checking of ice quality	Repairs and maintenance as needed	**Ice safety plan** • Orientation and instruction • Routine worksite observations
5	4	tolerable	Program of regular manual ice measurements and Ice quality monitoring	Repairs and maintenance as needed	**Ice safety plan** • Orientation and instruction • Routine worksite observations
6	5	moderate	Program of regular ice measurements or program for regular GPR ice profiling plus manual ice measurements/ice quality monitoring	Repairs and maintenance as needed	**Ice safety plan** • Orientation and instruction • Routine worksite observations
7	6	Substantial – special provisions	Program for regular GPR ice profiling plus manual ice measurements • Ice quality monitoring program – flexibility for alternate measurements	Daily program of repairs and maintenance	**Ice safety plan** • Orientation and instruction • Routine worksite observations

TABLE 3, THE ALLOWABLE LOADS IN KILOGRAMS FOR DIFFERENT A VALUES AND THE EFFECTIVE ICE THICKNESS PROVIDED IN CENTIMETRES AND INCHES.

Allowable Loads in kg for A-values and effective ice thickness					
h=effective ice thickness (inches)	h=effective ice thickness (cm)	A = 3.5	A = 4	A = 5	A = 6
		Low Risk (kg)	Tolerable Risk (kg)	Moderate Risk (kg)	Substantial Risk (kg)
8	20	1,400	*	*	*
10	25	2,200	*	*	*
12	30	3,150	*	*	*
14	35	4,300	4,900	6,120	7,350
16	40	5,600	6,400	8,000	9,600
18	45	7,100	8,100	10,100	12,100
20	50	8,750	10,000	12,500	15,000
22	55	10,600	12,100	15,100	18,100
24	60	12,600	14,400	18,000	21,600
26	65	14,800	16,900	21,100	25,300
28	70	17,100	19,600	24,500	29,400
30	75	19,700	22,500	28,100	33,700
31	80	22,400	25,600	32,000	38,400
33	85	25,300	28,900	36,100	43,300
35	90	28,300	32,400	40,500	48,600
37	95	31,600	36,100	45,100	54,100
39	100	35,000	40,000	50,000	60,000
41	105	38,600	44,100	55,100	**
43	110	42,300	48,400	60,500	**
45	115	46,300	52,900	**	**
47	120	50,400	57,600	**	**
49	125	54,700	62,500	**	**
51	130	59,100	**	**	**

* See **Figure 1** for minimum ice thickness for lighter loads ** Seek advice from P. Eng

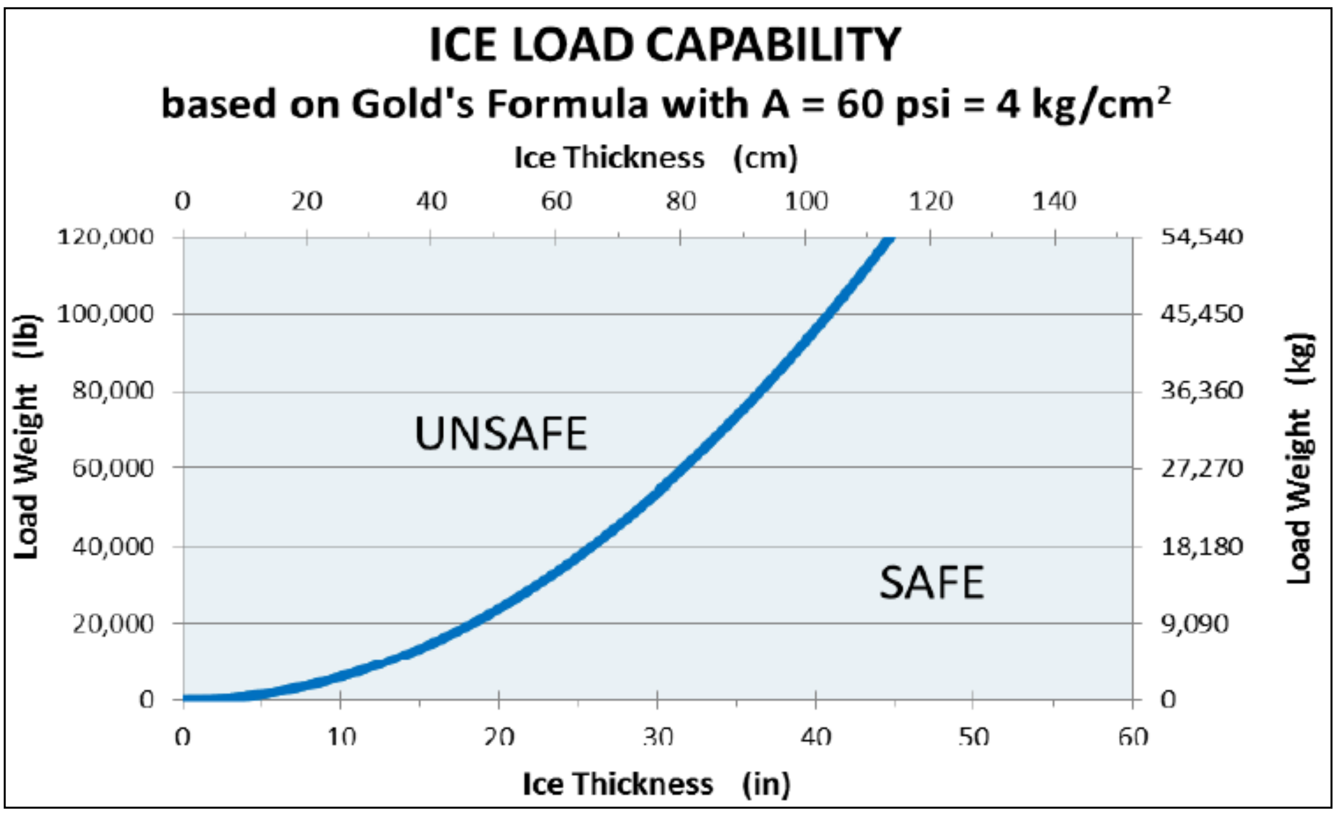
Equipment weights

Some of the most commonly used equipment and their approximate weights are presented in Table 4.

TABLE 4, COMMONLY USED EQUIPMENT WEIGHTS.

Equipment	Weight in lbs	Weight in kg
EF-50	22,000	9,979.1
EF-75	22,000	9,979.1
Sloop Loaded	18,000-20,000	8,164.7-9,071.9
Skid Steer	11,000	4,989.6
D-39 Komatsu	22,000	9,979.1
D-51 Komatsu	26,000	11,793.5
Pump Shack	6,000	2,721.6
pickup Truck	7,000	3,175.2

FIGURE 2, EXAMPLE OF LOAD CAPACITY OF ICE WITH AN A VALUE OF 4 (KG/CM2 OR 60 PSI).



Ice behaviour under loading

Natural ice is buoyant and floats on water because it is 8 to 10% less dense than water. It is this buoyancy that helps support the weight of loads placed on the ice. An ice cover may appear to be rigid, but it will bend under loading. The amount of bending will depend on the flexibility of the ice and magnitude of the load. The ice flexibility (elasticity) depends on its temperature. Heavier loads will cause more bending and displacement. As the ice cover itself bends under a load, it displaces a volume of water equal to the weight of the load (Archimedes principle). For acceptable loads, the ice covers will rebound and return to the original position when the load is removed or moves away. In these cases, the ice cover deforms and distributes the load over a larger area. The depression underneath the load is often described as the deflection bowl.

Bending of the ice generates flexural stresses—tensile stresses at the bottom and compressive stresses at the top. When excessive loads are placed on ice covers, the ice will bend to the point where the flexural stresses in the ice exceed the flexural strength at the bottom of the ice. Cracking occurs in these situations and these reduce the bearing capacity of the ice cover. Under the extreme load circumstances these cracks can grow, merge and cause the ice to collapse and allow the load to break through the ice.

Ice covers can fail for a variety of reasons. Some common reasons for failure are:

- Loading of poor-quality ice
- Overloading good quality ice
- Overstressing ice by operating at unsafe speeds
- Unintended stationary load on ice

Regular ice monitoring and ice thickness testing program, along with daily observations will provide the up-to-date information to calculate the load bearing capacity of the ice cover.

Ice monitoring/ ice thickness measurements

Ice thickness checks must be done prior to traveling on ice. Ice thickness measurements should be monitored using EDO-018 Ice Thickness Monitoring Form.

Manual measurements are made by cutting a hole in the ice cover with an auger, a saw or an ice chisel and then directly measuring the ice thickness. Record the characteristics of the ice (color and quality). Using a measuring tape or measuring stick, measure the total thickness of the ice and of the different layers/ types of ice. The thickness of each type of ice and the total thickness should be recorded at each hole. The depth of the water relative to the ice surface and if there are any air pockets of slush/water in between should also be noted.

For example: if a hole was drilled and the length of the hole was 35cm, but there was 20cm of good quality blue ice and 15cm of white ice, the total blue equivalent if 27.5cm. White ice/snow ice can only support about half the load of the blue/natural ice. The ice surface can safely take the load of a skidoo+ passenger or a small or light vehicle.

The formula is as follows: Blue + (White÷2) = Blue equivalent

Ice thickness monitoring should be completed at regular intervals (see **Table 2**). **Table 5** provides guidelines for the spacing between augered test holes for different types of environments.

It is essential that a systematic procedure be implemented to document all ice thickness measurements. Measurement locations should be taken either with a Global Positioning System (GPS) or marked with stakes, or other reliable system so that these locations can be tracked in future measurements or identified for repairs. The recommended frequency and spacing of augered ice measurement holes are presented in Table 6.

Pre-Construction Phase and Ice Thickness measurements

Pre-Construction is the time before construction and operations have begun. The ice thickness measurements can be considered some of the initial measurements to establish a baseline of the ice conditions.

The initial measurements may be completed on foot, by snowmobile/small UTV or amphibious vehicle. Testing should be representative of snow and non-snow-covered areas. While testing, the crew should also be checking the ice for cracks and noting the snow load. If vehicles are used, two separate vehicles must be used at all times and must be separated at a safe distance unless ice conditions are known. The route should be recorded on a map or with GPS coordinates; if others will follow the tested route, it should be marked so it is easily identified. Use items such as high visibility stakes or pylons or flagging tape.

High visibility (orange or red) survival/flotation suits or PFD must be worn at all times while on the ice for the initial ice thickness measurements (Survival/ floatation suit is preferable to Personal Flotation Devices/PFDs).

During pre-construction ice measurements, calculate the minimum ice thickness required for fully loaded vehicles being used during pre-construction, using a conservative value of A=4 in Gold’s Formula for initial use of the ice cover.

Construction phase and Ice Thickness measurements

Once the desired ice thickness and quality has been achieved for the required loads and work. Periodic ice thickness measurements should be conducted as the ice grows, to monitor its progress and approve the use of heavier vehicles (if required). Ice thickness measurements are carried out using manual methods at regular intervals to monitor conditions, ice thickness and quality. All measurements will be recorded in the Ice Thickness Monitoring form and GPS coordinates collected for each hole location.

Operations and Ice Thickness measurements

Ice profiling should continue for quality assurance purposes after the ice cover is opened to traffic or for other purposes. Ice covers used as work platforms (drill pads) may be serviced by snow-clearing and ice-flooding vehicles. The purpose of operational ice profiling is to confirm operational load limits over time and to allow those limits to safely increase with ice growth.

Ice thickness measurements will be carried out using manual methods at regular intervals during operations to monitor conditions, ice thickness and quality. All measurements will be recorded in the Ice Thickness Monitoring form and GPS coordinates collected for each hole location.

Once an area is no longer required for operations (all equipment and personnel have vacated the area), monitoring of the ice in that area is no longer required.

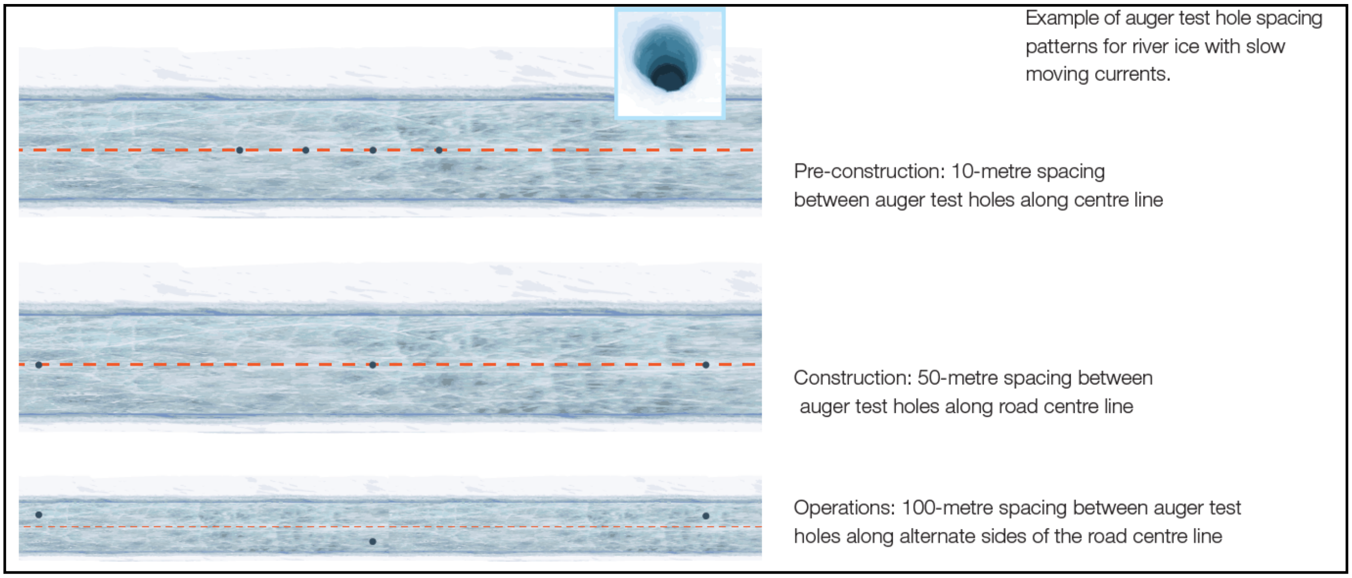
TABLE 5, RECOMMENDED MAXIMUM SCAPING OF AUGER TEST HOLES FOR MEASURING ICE THICKNESS.

Recommended Maximum Spacing of Auger Test Holes for Measuring Ice Thickness			
Water Body Type	**Pre-construction**	**Construction**	**Operations**
Rivers – fast moving or high currents	5 m between test holes along the centre line or a minimum of 5 holes	25 m between test holes along alternating sides of centre line	50 m between test holes along alternating sides of centre line
Rivers – slow moving and within 250 m of shore	10 m between test holes along centre line	50 m between test holes along centre line Check known thin areas.	100 m between test holes along alternating sides of centre line Check known thin areas.
Rivers – slow moving and more than 250 m offshore	20 m between test holes along centre line	100 m between test holes along centre line	200 m between test holes along alternating sides of centre line
Lakes – within 250 m of shore	10 m between test holes along centre line	50 m between test holes along alternating sides of centre line Check known thin areas.	100 m **between** test holes along alternating sides of centre line Check known thin areas.
Lakes – more than 250 m offshore	20 m between test holes along centre line	100 m between test holes along centre line	200 m between test holes along centre line

TABLE 6, RECOMMENDED MINIMUM FREQUENCY OF AUGER TEST HOLE MEASUREMENTS

Pre-Construction	**Construction**	**Operations**
Check every 4-7 days to monitor ice growth until minimum ice thickness is achieved to deploy heavier pieces of equipment	Check every 4-7 days or more frequently to monitor for specific ice requirements for construction equipment and operations	Test entire route prior to increasing load limits. Monitor thin areas every 2-4 days.
More frequent measurements may be required to monitor changes in ice conditions due to environmental effects (warming, currents) or changes in loads (heavier or more frequent loads).		

FIGURE 3, EXAMPLE OF AUGER TEST HOLE SPACING PATTERNS FOR RIVER ICE WITH SLOW MOVING CURRENTS.



Ice Pads (Diamond Drilling)

It is important to calculate the required safe effective ice thickness for any planned stationary load on ice pads or constructed ice surfaces.

Calculating safe ice thickness for drilling on ice

During drilling, additional forces are exerted on the ice. The ice deflects from the weight of the drill (and equipment); ice deflects even more when the drill pulls the rods up, especially when rods are stuck. It is essential to:

- **a)** Base calculations on the thinnest ice measurement in the test area.
- **b)** Use the correct allowable load tables and ice bearing capacity charts. Load bearing tables and charts for stationary loads (e.g., drills) differ from those for moving loads because ice beneath a stationary load will deform continuously (creep) until it fails.
- **c)** Calculate the total weight of the number of people + drill + maximum rod string + water in the rods if experiencing a “wet pull” + ancillary machinery + supplies that can potentially travel on ice and remain at the drill pad at one time + the pullback capability of the rig.

Regular ice thickness testing of diamond drill pad(s) will be completed until the necessary thickness and quality is achieved. This will be dependant on the load (drill size, etc. + length of time planned for operations). Once the desired thickness and quality is achieved, regular testing will be ongoing until the ice pad is no longer required to complete the work.

Prior to drilling the ice pad must be tested to ensure that it is safe. During drilling operations ice thickness and ice quality will be measured once daily. Several strategically placed holes will be tested daily. All measurements will be recorded and provided to the proponent and drill contractor to ensure that the site remains safe during drilling operations.

If cracks (dry) develop, they will be noted and monitored. If wet cracks, radial cracks, or circumferential cracks are observed, drilling operations should cease immediately, and all personnel should vacate the area and notify their supervisor. The area will require re-assessment prior to resuming operations.

Ice Bridges

Ice bridges are temporary crossings constructed of ice, snow, and logs for reinforcement. The following are guidelines for the protection of fish habitat and should be followed for the construction of ice bridges:

- Locate ice bridges where the winter stream flow is slow.
- Minimize disturbance by locating ice bridges at an area that requires the minimum approach grading and the shortest crossing route.
- Avoid using debris as reinforcement material, to prevent downstream siltation problems during spring break up.
- Ensure that any logs used for reinforcement are clean, delimbed, and placed on the surface of the ice.
- Chain logs together to facilitate removal.
- Prevent spring ice jams and flooding by removing any reinforcement logs and cutting a V-shaped notch into the middle of the ice bridge before thaw begins.

Maintenance of ice bridges includes post-construction inspections and repair or replacement of stream crossings. Throughout the life of the crossing, structures must be inspected periodically, especially prior to and during spring breakup or significant changed in temperature over a 24hr period.

(Department of Fisheries and Oceans Canada and Manitoba Natural Resources. 1996)

Personal Protective Equipment (PPE)

It is important to wear and have available the right PPE for the task.

Initial phase or pre-construction:

High visibility (orange or red) survival/flotation suits and other PPE must be worn at all times while on the ice for the initial measurements (preferable to Personal Flotation Devices/PFDs).

Once the ice surface is determined to be safe for the desired load, PFD is not required.

If working on Active subaqueous tailings consult tailings crews and follow safety procedures and wear required PPE (e.g.: survival/flotation suit/PFD).

Other safety equipment to consider (as required):

- Axe or ice chisel
- Buoyant polypropylene rescue rope (30m)
- Belt or harness with D rings
- A flotation suit
- Ice rescue picks
- Whistle
- Warm clothing
- Insulated gloves/mittens
- Sunglasses

Driving on Ice

When driving on the ice there are safety measures that shall be followed.

- Know the location of the window breaking tool or the window(s) shall be open
- Door unlocked or open
- No seat belt to be worn
- Slow approach to and off the shoreline, Maximum 10km/h
- Maximum speed of 25 km/h for vehicles < 5000 kg at the start of the season, as the season progresses and the ice cover thickens, light vehicles may be permitted to travel at higher speeds, provided road surface conditions allow for safe operations at the designated speed.
- Maximum speed of 15 km/h for vehicles > 5000 kg at all times
- Vehicles weighing more than 12,500 kg should maintain a minimum spacing of 500 m between vehicles to avoid exceeding allowable stress limits on the ice cover by inadvertently overloading the ice

How to Escape a Sinking Vehicle

A sinking vehicle may float on the water surface for up to 3 minutes, but you only have 1 minute to exit the vehicle safely.

Do not panic, and do not touch your cell phone. Follow these steps:

- Seatbelts: off or cut
- Windows: open or broken
- Get Out: through windows (back or front)

Source: https://umanitoba.ca/kinesiology-recreation-management/faculty-staff/gordon-giesbrecht

Effects of speed on Ice

When a vehicle travels over an ice cover, a hydrodynamic wave is set up in the underlying water. This wave travels at a speed that depends upon the depth of the water, the thickness of the cover and the degree of elasticity of the ice. If the speed of the vehicle coincides with that of the hydrodynamic wave, the stress on the cover (from the wave that reinforces the wave created by the vehicle) can increase the maximum stress in the ice to the point of failure.

Care must be exercised when approaching or traveling close to shore, or over shallow water, because of more severe stressing of the cover due to reflection of the hydrodynamic wave. Roads and vehicle approaches need to meet the shoreline at an angle of not less than 45 degrees. Speed should be reduced when approaching shore or when travelling close to shore (10-15km/hr).

Cold Water Immersion and Self Rescue

Contrary to popular myth, hypothermia does not occur in five to 10 minutes, and it is possible for the person to achieve self-rescue. Dr. Gordon Giesbrecht, a specialist in cold water immersion at the University of Manitoba, summarizes what happens to humans in a cold-water immersion situation with the expression “1 minute … 10 minutes … 1 hour … 2 hours”.

Emergency Self-Rescue

ONE MINUTE TO CONTROL YOUR BREATHING

For about one minute, the person will gasp for air in reaction to contact with the cold water. After one minute, the gasping subsides, the skin numbs and the sensation of intense cold decreases.

TEN MINUTES OF MEANINGFUL MOVEMENT
The person has about 10 minutes to get out of the water.

TREADING WATER
Do not panic and thrash about. Resist the urge to gasp, slowly tread water or grasp the edge of the ice to keep your head above the water.

KICK AND PULL
Keep your hands and arms on the ice and kick your feet. This brings your body to a horizontal position, parallel to the ice surface.

HORIZONTAL KICK AND PULL
Once horizontal, continue to kick your feet while pulling with your hands. Draw yourself up onto the ice.

ROLL ONTO THE ICE
Keep your weight spread out as you roll, crawl, and slide across the ice until it will support your weight.

ONE HOUR BEFORE LOSING CONSCIOUSNESS
If the person manages to hang onto the ice or stay afloat after 10 minutes, the muscles in their arms and legs will lose the strength to get them out of the water. Eventually they will lose consciousness as core body temperature decreases to about 30ºC. The actual time depends on the clothing worn, energy stores and body build. If arms, beard, or other part of the body is not frozen to the ice, the person will slip below the surface and drown.

TWO HOURS TO BE FOUND
If the person stays above the surface of the water, rescue is still possible within two hours. At about two hours, death due to hypothermic cardiac arrest will occur when the body’s core temperature falls below 28ºC.

Water Currents and Springs

Water currents have a direct impact on the temperature required to form ice. Rivers and channels with strong currents may remain open all winter despite low air temperatures.

Springs can be the source of warmer water, and cause currents which can change the ice thickness without changing the surface characteristics.

Temperatures

The strength of ice is increased by lower temperatures. The increase is progressive from zero to minus eighteen degrees Celsius and remains constant below this point. However, a marked drop in temperature can temporarily cause internal stress (thermal shock) in an ice cover and cause deep cracking which can reduce its bearing capacity. This can often occur during overnight periods when the temperature is much lower than the preceding average for the day. Alternatively, a sudden rise in temperature can contribute to thermal expansion and may cause the formation of pressure ridges.

High Winds

High winds can cause blowing snow and reduced visibility for traffic, often making it difficult to see the limits of the safe travel way on the road. In extreme cases, very high winds could aggravate existing cracks and cause damage to the ice cover.

Cracks

Ice usually has many cracks made by thermal contraction or movements of the ice cover. Except at the thaw, cracks do not necessarily indicate a reduction in the load-bearing capacity of the ice cover. The exception is wet or radial or circumferential cracks, which are associated with overloading the ice cover and greatly affect its load bearing capabilities.

Due to normal thermal contraction, cracks sometimes form at the middle of a road in the direction of travel; but these do not seriously reduce the bearing capability if they remain dry. Cracks forming parallel to the road (at the sides) may indicate over-stressing (perhaps by snowbanks from clearing operations) and possible fatigue due to excessive traffic. Wet cracks form, this area should be monitored, and traffic kept clear of the area until the flooded area has re-frozen.

A “wet” crack indicates that the crack penetrates completely through the ice cover. Therefore, the crack affects the load bearing capacity, which needs to be reduced by one-half in the case of a single wet crack. If two wet cracks meet at right angles the reduction is to one quarter of that for a good cover.

Fluctuating water levels may produce cracks near and generally parallel to the shoreline. These cracks are often “wet” and tend to occur around grounded ice features. It is best to avoid areas of grounded ice with water level fluctuations.

Spring thaw

Ice covers will begin to decay in the spring as the ice warms and begins to melt. Snow is a poorer thermal conductor than ice. A covering of 7.5 to 10 cm (3 to 4 inches) of clean snow on an ice bridge will reduce significantly the solar radiation penetrating the ice cover, thus prolonging the period of use.

Travel over ice / an ice bridge displaying water on the surface must be executed with great caution and only if necessary. If mild weather continues and the water disappears, it may indicate that the ice is honeycombed, in which case, use of the ice bridge must be discontinued immediately.

Definitions:

Gross Vehicle Weight (GVW): This is the total weight of a vehicle when loaded, i.e., includes the weight of the vehicle itself plus fuel, freight, passengers, attachments, and equipment.

Tare Weight: The empty weight of a vehicle or piece of equipment.

Operational Tare Weight: The scaled operating weight of a vehicle or piece of equipment used for construction on ice. This scaled weight will include the combined weight of the equipment, associated attachments, operator, and full load of fuel.

Effective Ice Thickness: The thickness of good quality, well-bonded, ice that is used to calculate the bearing capacity of the ice cover. Unless otherwise stated, the minimum ice thickness measured at a particular test point on an ice cover will be used as the effective ice thickness. Good quality, well-bonded, clear, and blue ice that is measured in an ice cover. Poor quality or poorly bonded ice should not be included in the measurement of ice thickness. White ice is considered to have 1⁄2 the strength of blue ice. Effective ice thickness is 100% blue ice + 50% white ice for a well-bonded layer.

Natural ice (clear blue ice): Ice that grows below the layer of surface ice under calm conditions. It usually forms in vertical, columnar crystals that contain few air bubbles. It appears to be blue because it's clear enough to see the water underneath it.

White Ice (Snow ice): Ice that forms on top of the surface ice by natural or man-made flooding of snow. It's white because it contains a significant number of air bubbles.

Natural Overflow Ice: Overflow ice, caused by natural water overflow onto the ice surface, usually contains high air content and should not be relied upon in calculating effective ice thickness.

Ice Cover: The portion of an ice surface that is floating (buoyant) on a river, lake, pond, or peatland and that is capable of carrying an external load. Natural ice is buoyant and floats on water because it is 8 to 10% less dense than water. It is this buoyancy that helps support the weight of loads placed on the ice.

Frazil ice (slush ice): Ice made up of disk-shaped ice particles that form and gather in agitated water. It is usually found in rivers or streams with turbulent waters.

Grey Ice: Grey ice gets its color from the presence of water. Grey ice is most common during the spring melt, although it can be found all winter long near moving water, such as where creeks and rivers enter or leave a waterbody. These same areas also often have underwater currents that can make ice unstable. This type of ice is not load bearing and is not safe.

Constructed Flood Ice: Ice constructed by pumping water directly on the surface of a bare ice sheet to build ice on the top of the ice sheet. Uniformity and quality depend on construction practices. If ice is constructed using sound construction practices, then this ice, once completely frozen and inspected, can be considered as having similar strength to natural ice.

Flooding: The pumping of water onto the surface of an area of ice that is free from snow to fill cracks or to increase the ice thickness (once frozen). When conducted by experienced crews, this will result in well-bonded ice that is free from significant air voids and can be considered to have strength equivalent to that of natural ice.

Spray Ice: Ice constructed by spraying water high into the air and using the ambient air temperature to cool the water and form a wet slush layer on the surface of a bare ice sheet. Uniformity and quality depend on construction practices. If spray ice is constructed using sound construction practices, then this ice, once completely frozen and inspected, can be considered as having similar strength to Natural ice.

Jam ice or River Jam ice: This is ice cover that is formed irregularly on rivers, normally due to the higher flow rate present on rivers. Often, large pans of ice stack atop one another and freeze in place during early season conditions. When fully frozen, this ice can be considered of good quality, however the ice thickness will be highly variable and extra caution is required in determining the minimum ice thickness for load bearing.

Freeboard: The difference between the height of the water level and the top of the ice surface in a hole drilled through the ice cover. Usually, the water level is below the ice surface because ice is less dense than water and it floats.

Ice Bridge: A seasonal crossing over a frozen river for the purposes of transportation.

Ice Profiling: Technique used to measure the thickness of floating ice. The standard for ice profiling within Department of transportation (DOT) is to use Ground Penetrating Radar (GPR). When GPR is used for profiling, regular calibration using manually drilled holes is required.

Ice Road: A seasonal road built over frozen lakes or along rivers for the purpose of transportation. It usually consists of floating ice and ice that is frozen to the ground.

Manual Ice Measurements: Technique used to measure the thickness of floating or grounded ice by drilling holes through the ice and taking direct physical measurements of the ice thickness.

Gold's Formula: A formula developed by Dr. Lorne Gold to calculate the allowable load that can be placed on a floating ice cover.

Radial Crack(s): A crack that forms on an ice cover when it is overloaded. It radiates away from the load area like a spoke on a bicycle wheel.

Circumferential crack(s): cracks that form in a circle around the load and are a warning that the load is about to break through.

Temporary Loads: are loads that are expected to be in one location for no more than two hours.

Stationary/Long Term Loads: are loads that are intended to remain in place for longer than six hours.

Load duration: The period of time that the load is stationary on the ice cover

Hazard controls: Controls that reduce either the consequence or the likelihood of a hazard; choice of controls depends on the risk level, degree of operator control over the use of the cover and the user's exposure.

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Dr. Gordon Giesbrecht: https://umanitoba.ca/kinesiology-recreation-management/faculty-staff/gordon-giesbrecht