U.S. ARMY COLD REGIONS RESEARCH & ENGINEERING LABORATORY
Hanover, New Hampshire

SAFETY ON FLOATING ICE SHEETS

For many of us in northern climates, working or playing on the frozen surface of a river or lake is part of winter. Knowing how to do so safely can be a matter of life or death. This handout presents general, common-sense precautionary measures that should be followed when you plan to be on a floating freshwater ice cover. Since it cannot cover every ice condition you may encounter, your judgement is critical. Remember: *Only you are responsible for your own safety!*

PREPARATION

There are four things to focus on when planning an outing on the ice: your **physical condition**, your **clothing**, your **equipment**, and your **procedures**.

Physical condition

Anyone who goes out on the ice should be in reasonably good condition and be able to sustain periods of intense exertion if an emergency arises—either falling through the ice themselves or rescuing someone who does. Being able to swim, or at least being comfortable staying afloat, is important in an emergency and can reduce the chances for panic.

Clothing

Naturally you should choose clothing that provides protection from low air temperatures, wind, and precipitation while at the same time allowing you mobility. But in addition, when you select clothing, keep in mind the possibility of falling through the ice. Clothing that would severely restrict your ability to swim or to stay afloat is not a good choice. Hip boots or waders should never be worn, as they can fill with water and restrict movement while adding weight. A personal flotation device (PFD) should be worn. This can be a vest or jacket, either inflatable or aturally buoyant.

Equipment

Include items for testing and measuring the ice thickness, as well as items for rescue or self-rescue. In the first category are a heavy ice chisel, an ice drill or auger (manual or powered), a measuring tape or stick that can be hooked under the bottom edge of the ice in an auger hole, and possibly a perforated ladle for cleaning ice out of the auger holes. In addition to the PFD, bring a rope or rescue throw bag containing a rope that floats. Ice rescue picks sold for ice fishermen are an excellent idea. They thread through your jacket sleeves like children's mittens and are immediately available in an emergency for pulling yourself out of the water onto the ice.

Procedures

- *Never go out on an ice cover alone, and never go out on the ice if there is any question of its safety.*
- While you are planning the outing, obtain the record of air temperature for the past several days and continue observing air temperatures while the ice will be used to support loads.
- Always let someone know of your plans and when you will return.
- When you arrive at the water's edge, visually survey the ice. Look for open water areas, and look for signs of recent changes in water levels: ice sloping down from the bank because the water dropped, or wet areas on the ice because the water rose and flooded areas of the ice that couldn't float because it was frozen to the bottom or the banks. (If the ice is snow-covered, look for wet areas in the snow.)
- Listen for loud cracks or booms coming from the ice. In a river this can mean the ice is about to break up or move; on a lake larger than several acres such noises may be harmless responses to thermal expansion and contraction.
- Look for an easy point of access to the ice, free of cracks or piled, broken ice.
- If you are taking a vehicle or other equipment on the ice, go out on foot first. Vigorously probe ahead of yourself with the ice chisel. If the chisel ever goes through, carefully turn around and retrace your steps back to shore, and try again some other day.
- Near shore, listen for hollow sounds while probing. Ice sloping down from the bank may have air space underneath. This is *not* safe; ice must be floating on the water to support loads.
- After getting on the ice, others in the group should follow in the leader's steps, but stay at least 10 feet apart.
- Only after you have learned the characteristics of the ice cover should any vehicle be taken on the ice.

WHAT YOU NEED TO KNOW ABOUT THE ICE

Once on the ice it is time to begin more systematic observations of the ice sheet you want to use to support a load. There may be many variations in the structure, thickness, temperature, and strength of a floating freshwater ice sheet.

How thick is the ice?

This is determined by drilling holes with the drill or ice auger. The technique is to drill a hole and check the ice thickness every 150 feet or so along the intended path. This should be done more frequently if the ice thickness is quite variable. Note whether the ice in each hole is clear (sometimes called black ice) or white (due to air bubbles—sometimes called snow ice). Measure the thickness of both kinds.

On rivers the ice thickness and quality can change a lot in a short distance; be particularly alert to variations in ice thickness due to bends, riffles or shallows, junctions with tributaries, etc. For both rivers and lakes, warm inflows from springs can create areas of thinner ice. The ice near shores can either be thinner (due to warm groundwater inflow or the insulating effect of drifted snow) or thicker (due to the candle-dipping effect of variable water levels).

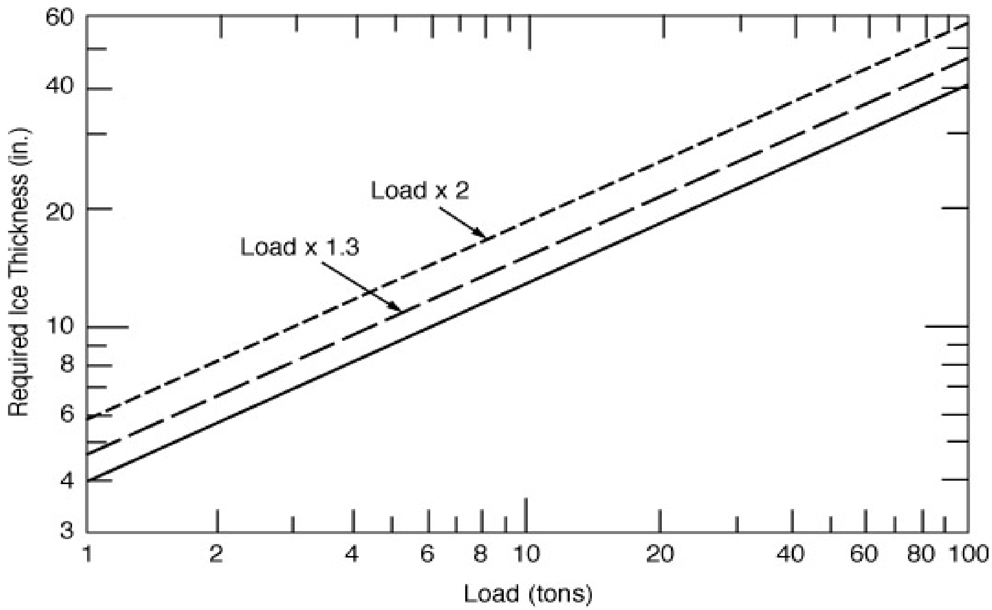
Measure the snow cover thickness on the ice cover; significant variations in thickness may mean highly variable ice thicknesses.

How thick does it need to be? A simple formula to estimate the minimum ice thickness required to support a load is

$$h = 4\sqrt{P}$$

where **h** is the ice thickness in inches and **P** is the load, or gross weight, in tons. You can also use the graph or table to determine the minimum thickness.

Remember that the load is the *total* load in tons (not a vehicle's load capacity).



Minimum ice thickness required to support a load

Load (tons)	*Required ice thickness (inches)*	*Distance between loads (feet)*
0.1	2	17
1	4	34
2	6	48
3	7	58
4	8	67
5	9	75
10	13	106
20	18	149
30	22	183
40	26	211

The equation, graph, and table are valid when the load (such as a person on foot, or a wheeled or tracked vehicle) is distributed over a reasonable area of a continuous ice sheet. The larger the load, the greater the area it should cover for the calculation to remain valid. *Neither large loads that are concentrated in relatively smaller areas, nor loads that are at or near the edge of a large opening in the ice, are safely described by the equation, graph, or table.* In such cases, *seek more advice.*

The equation, graph and table assume clear, sound ice. If white, bubble-filled ice makes up part or all of the ice thickness, count it as only half as much clear ice.

Any recent large snowstorm creates a new load on the ice. If the new snow is heavy enough, the ice sheet will sag and its top surface will be submerged below the water level. Then water will flood the top of the ice sheet through cracks, saturating the lower layers of the snow. Until this slush is completely frozen, *stay off* the ice sheet. When the saturated snow becomes frozen, it is an added thickness of white ice.

Contrary to what you would expect, a rapid, large air temperature drop makes an ice sheet *brittle,* and the ice *may not be safe* to use for 24 hours or more.

If the air temperature has been *above* freezing for at least 6 of the past 24 hours, multiply the load by 1.3 before you use the equation (or use the lower dashed line on the graph), obtaining a larger minimum ice thickness to account for any possible weakening. If the air temperature stays above freezing for 24 hours or more, the ice starts losing strength, and the equation, figure, and table no longer represent safe conditions. *Stay off the ice!*

You are likely to encounter cracks in the ice. Cracks are either wet or dry. If they are dry, they do not penetrate the ice sheet and are not a concern. If they are wet, multiply the load by 2, as shown on the graph, before you use the equation to obtain the required minimum ice thickness.

If you plan to leave a load on the ice for extended periods, usually more than two hours, multiply the load by 2 (as shown by the upper dashed line in the graph) before you use the equation to find the required minimum ice thickness.

SAFE OPERATIONS ON THE ICE COVER

If using an enclosed vehicle, *always* drive with the windows or a door open for quick escape.

If you drive across wet cracks, your path should be as close to perpendicular to them as possible, instead of parallel to them.

A load deflects the ice slightly into a bowl shape. When you drive on floating ice, this moving bowl generates waves in the water. If the speed of the waves equals the vehicle speed, the ice-sheet deflection is *increased* and the ice is much more likely to break. The problem is more serious for thin ice and shallow water. In general you avoid this danger by driving below 15 mph.

When there are two loads on the ice, the safe distance between them is about 100 times the ice thickness at the required minimum thickness. This is shown in the third column of the table. When the two loads are different, choose the spacing shown for the larger load. At ice thicknesses greater than the required minimum, this spacing can be reduced.

A loaded ice sheet will creep, or deform, over a long period of time, *without any additional load.* If an ice sheet has to be loaded for a long period, drill a hole near the load. If the water begins to flood the ice through the hole, move the load *immediately*. Remember this if your vehicle ever becomes disabled: if left for a few days, it may break through the ice as a result of long-term creep.

IN CONCLUSION...
Be sure you understand this information. Don't hesitate to seek the advice of others whose experience you trust. Be safe out on the ice!

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Updated August 2004 (dbh)