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FM Slalom Tech Series

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"Stoked" - How Water Viscosity Defines your Ski's Performance

As a slalom ski is carving on the water, there is lift and friction created by the ski's running surfaces and drag from the ski, fin and wing.

The amount of lift on a ski and resistance on the rope we feel is determined by how much the water molecules want to cling together. The measure of a fluid's clinging-ness is called its viscosity. For example, thick gear oil is highly viscous while gasoline is much less viscous.

Viscosity (dynamic) is measured in the units of Poise, or Centi Poise (cP). As skiers we are interested in how much water changes with temperature and contamination.

Water at 20 Deg C (Room Temp) = 1.002 cP
Water at 99DegC (near boiling) = 0.2848 cP

As temperature increases to boiling, the viscosity of water is about 30% of its original value, or a very significant drop.

The laws of viscosity researched by **George Stokes** established the science of hydrodynamics. Stokes was a clever scientist that wrote papers on incompressible fluids and the friction of fluids in motion. The units for kinematic viscosity of a fluid are named after him as "Stokes" or Centi-Stokes (cSt).

Stokes' law of drag is of interest to skiers. Also of interest are the equations that describe flow such as those from **Osborne Reynolds**. According to their work, when the viscosity of water increases, the amount of drag and power required accelerate the ski through the water increases. For this reason it is harder to ski in highly viscous water.

But we don't really need to know all the sticky details. The purpose of this article is to discuss how to make compensatory changes for viscosity. In order to extract top performance, subtle changes must be made over the course of a season or when visiting other ski sites.

"Fast" Water and "Slow" Water

The feel of the water when riding a high performance slalom ski varies between sites around the world. Most skiers know this as "fast" water or "slow" water. Fast water is considered hard to ski in as the balls come up fast on the skier. Slow water gives the skier more space or time before the buoy and is generally easier to ski, if the ski is tuned for it.

Backwards from how it is termed, "fast" water is more viscous and there is more drag causing the skier to actually accelerate more slowly and to a lower top speed. "Slow" is less viscous and consequently has less drag. The skier can reach higher speeds and get across the course more quickly in the "slow" water.

The Problem With Water

Just as our ability to generate speed and turns changes with water viscosity, so does ski setup. Some examples of the effects of viscosity are:

The first cut of the year in the cold water of spring and you take a header through the wakes.

Or a hot spell has descended on your home lake and for some reason you are now in deep (literally) with a skiing slump.

Events are won or lost on the consequence of viscosity. Depending on where the ski was setup & tested, a change in viscosity will put the ski out of tune, hindering performance. The "factory" setting should come with a viscosity range as tested by R&D.

A key to analyzing the problem is determining whether or not the site you are skiing on is of a higher viscosity or lower than your home lake where you set your ski up.

Low viscous sites are typically warmer, shallower and have more plant life and growth.

Low viscous sites can also have a pH that is more basic with contaminents. High viscous sites are colder, deeper and clear/clean with a lot of visibility. High viscosity sites may also be charged with ions, minerals or sediments such as clays or may be acidic. Salt water has higher viscosity than plain water and so does vinegar.

How Viscosity Changes Affect the Ski

A change in viscosity affects how the ski behaves in all aspects of skiing, including trim on a plane, trim on edge (pre-turn), turning, hook-up and acceleration.

Moving from Low Viscous to High Viscous

A higher viscous site will do the following to your ski:

1. Raise the ski out of the water when on the plane reducing the amount of ski running surface contacting in the water
2. Raises the ski out of the water in the pre-turn
3. Lowers the tip of the ski at the finish of the turn, similar to a backward fin move, increasing line load and making the turns rounder.
4. Raises the tail of the ski.
5. Harder to obtain width and cross course speed due to increased drag.

To compensate for high viscous situations we suggest trying the following changes. Note that the magnitude of the viscosity change determines the magnitude of the ski setup changes. For larger swings a binding move is necessary. For small swings just a fin adjustment may be all that is required. The changes also depend on how sensitive the ski is to fin or binding adjustments. A ski that is more sensitive will suffer greater upset by changing water viscosity.

When going to a higher viscous site:

1. Consider moving bindings forward to restore the appropriate amount of ski contacting the water. Start with one notch, which is either 0.125” to 0.25” binding move depending on the ski (one notch). Also move the fin forward with the bindings.
2. Consider an increase in fin length and a reduction in fin depth, while keeping the fin area constant.
3. Move the fin toward the tip of the ski (increase DFT) to allow the tip to raise at the finish of the turn. In more viscous water, the tail of the ski does not dig as deep a hole lowering the tip. But when the fin is moved forward, the tip attitude at the finish of the turn is corrected.
4. Adjust wing to suit. Some skiers in high viscous areas run without a wing. Others have the wing installed in the “up” position.
5. In general skiers on viscous home sites will want to downsize the ski, run bindings center to forward and ski with more fin length and less depth. Expect to see a decrease in performance despite changes, due to the increase in work required to execute the course.

A lower viscous site does the opposite to your ski. Moving from high viscous to low viscous site does the following:

1. Increases the amount of ski in the water on the plane due to greater sink in the softer water.
2. Lowers the ski into the water in the pre-turn (tip increase)
3. Raises the tip of the ski at the finish of the turn, similar to a forward fin move, decreasing line load and creating an imbalance.
4. Lowers the tail of the ski.
5. Easier to obtain width and cross course speed due to reduced drag.

To compensate for low viscous situations we suggest the following changes:

1. Because the ski sinks lower, try a bindings move back to restore the

appropriate amount of ski contacting the water. This might be a 0.125” to 0.25” binding move, depending on the ski.

2. Consider a reduction in fin length and an increase in fin depth as required.
3. Move the fin backward toward the tail of the ski (increase DFT) to prevent the tip from getting too high at the finish of the turn. In less viscous water, the tail of the ski digs a deeper hole, but when the fin is moved back the tip attitude is corrected.
4. Consider a decrease the amount of wing to prevent the tail from being pulled downward too much. Skiers in less viscous areas tend to run with the wing in the down position.
5. In general, skiers on less viscous home sites will want to upsize the ski, run bindings center to back and ski with less fin length and more depth. There should be an increase in performance because there is less work or energy required to execute the course.

The magnitude of the viscosity shift determines the extent of the changes. A binding shift with a fin shift in the same direction may be all that is required. Be sure to shift the fin an amount calculated using a factor determined for the ski. For example 0.008 = 0.125/15 where the number 15 is what we have found suitable for the Goode’s.

Other Viscosity Tips

Be sure to re-calibrate your boat every few weeks throughout the summer if you lake changes significantly in temperature or plant growth. The boat will go faster in less viscous water for the same RPM’s.

Water viscosity changes the frequency of the slalom course. To truly compensate, a slalom course situated in high viscosity sites should have added length to compare equally with low viscosity sites.

High viscosity causes the turns to be rounder, even with a properly tuned ski. If you ski for the most part in cool, clear and deep lakes, consider using a smaller ski, with boots at or slightly forward of stock settings to get the necessary tip bite. Have the fin moved forward with the boots as well to suit. The turns and acceleration are impacted by high viscous water. The ski will be more sensitive to adjustments as well.

Low viscous sites look for the opposite – larger ski with bindings back a notch and fin with them.

Higher temperature or pH equals lower viscosity. Lower temperature or pH increases viscosity. Be aware that the lake temperature should be measured at a depth of about 3 feet. Document your changes as the season progress monitoring water temperature and feel so that you are not having to re-invent settings the following year.

The longer the water stays warm and the sun is present, the more waterborne life can grow. If the impurity is less dense than water it will lower viscosity. Plant life, gases, and green stuff lower viscosity. Shallow water supports more bottom life and therefore is typically of lower viscosity. Expect the best skiing to be in late season when the water is in full blown and noticeably “softer”.

There are cases where the suspended impurities are denser than water. Suspended solids such as clays or ions (salt water) may increase viscosity. Acids are also more viscous.

If adjusting your fin, it is important to maintain the same fin area. We are developing fin charts for popular skis such as the Mapple Sixam and the Goode skis. The FM Fin Chart for Goode and for the Mapple SIXAM is available on our website at www.jagersport.com/tech2004.htm

(2001) A stoked Chris Parrish conquers a northwest quarry lake. pH basic it skis much lower viscosity than other natural sites in the region, but is still “fast” compared to Florida.