The Oil Report
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Oil the News that's Fit to Print!

Have you heard our podcast? Covering everything from racing to flying to oil change intervals, SlickTalk is your home for all things oil. Available everywhere, incldiuing your favorite podcast platform.

Also, if you didn't catch the news, the cost of a sample went up $2 and is now $30. If you're a check writer, please note!

The Lower Unit Blues

by Ryan Stark

I wouldn't consider myself a nautical man, though growing up in northeast Indiana, fairly close to a lot of really nice lakes, I was able to go fishing, tubing, and water skiing every now and then. These are all things I still enjoy, and this type of hobby generally requires a boat. My grandfather gave me a fishing boat many years ago and while that doesn't need much maintenance, I do use my step-mother Kathy's speed boat once or twice a summer and that's a different story.

The Boat & its Lower Unit

The boat is a 1994 Starcraft 1700 with a 90 HP Mercury Force 2-stroke engine. It's large enough to carry six people comfortably and pull a tube around the lake. She bought the boat used in 2016 and it had obviously not seen a whole lot of use or maintenance in the preceding years, so I decided to help out with what little maintenance I could, which basically involved changing the oil in the lower unit.

Now for those of you who are even less nautical than me, the lower unit is a gear box that transmits power from the engine to the propeller. Technically, it can be called a transmission, but that doesn't really apply because it only has two gears — forward and reverse — and there isn't any sort of complicated clutching system involved to change the gears. It's basically a gear box, which tends to be extremely reliable and would have a super long life if it wasn't for the environment in which it has to operate — underwater.

Figure 1: Not good.

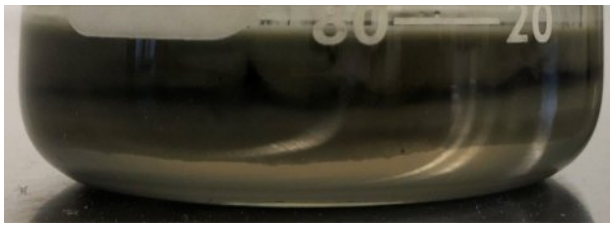
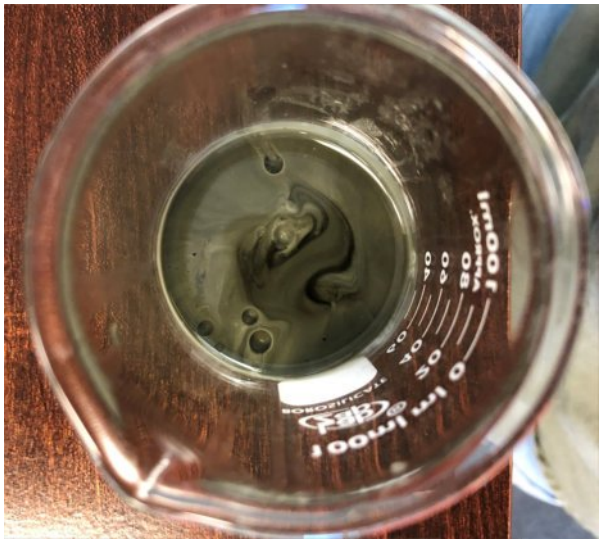


Figure 2: Not good at all.



The Lower Unit Blues

As you might have guessed, water contamination is a major problem with these units and when I first changed the oil in Kathy's boat, I could tell that water was getting in. Now, you don't have to have worked at an oil lab for

Figure 3: The lower unit, separated.

20+ years to know what serious water contamination looks like. Think milkshake, with the main color being whatever the color of the oil was to start with. When an oil with red dye gets water in it, it tends to look like strawberry milkshake. If the oil starts out blue, you end up with a blueberry milkshake. Start with brown oil and you get chocolate.

So the very first time I changed it, I grabbed a sample as the oil was draining out to see how bad the water contamination was (see the report below). Here at the lab, even though an oil might obviously have water in it, we don't just use the color to make that call; we use an actual method to identify water. The test is called the "crackle test." For that, you drop a small amount of oil onto something hot (400F) like a brass cup, and if the oil sizzles/crackles, then yes you have water. (We get the percentage from the insolubles test but that's another matter.) If you are crunched for time and can't sent your oil in to us, you can actually do this test at home in your kitchen using an old pan. Just don't cook up a batch of eggs on it afterwards.

The good thing about lower units is, if you keep the oil changed and no water is getting in, they will last for a very long time. And if water is getting in, frequent oil changes will keep any damage to a minimum. However, if you neglect one that does have water leaking in, the water will cause the steel parts to rust and that will allow for all kinds of bad things to happen. In my situation, I knew the lower unit in Kathy's boat was letting water in and that something should have been done about it, but life got in the way.

Live & Learn

So this year, when I went to try to put it in the lake I got quite the surprise when I found it the motor would not shift out of forward. Of course, I didn't know this until I was trying to back the boat away from the boat trailer at the ramp. Needless to say, I was very confused as to why the boat was going forward when I had it in reverse, and Kathy was even more confused (and profane) when she thought the boat was going to end up in the bed of her truck. I did start the engine prior to heading to the lake and it was running like a champ. I just didn't think to check to see if the motor would go into reverse, or even shift at all. Live and learn.

The lower unit report from Kathy's boat.

	MI/HR on Oil	10	UNIT / LOCATION AVERAGES						UNIVERSAL AVERAGES
	MI/HR on Unit								
	Sample Date	7/24/2020		11/11/2016	4/19/2016				
	Make Up Oil Added								
ELEMENTS IN PARTS PER MILLION	ALUMINUM	4	2	1	1				7
	CHROMIUM	0	0	1	0				2
	IRON	30	51	116	6				260
	COPPER	1	1	1	1				5
	LEAD	1	1	1	1				3
	TIN	0	0	1	0				0
	MOLYBDENUM	6	36	54	47				48
	NICKEL	0	1	2	0				2
	MANGANESE	0	0	1	0				2
	SILVER	0	0	0	0				0
	TITANIUM	0	0	0	0				0
	POTASSIUM	1	1	1	0				3
	BORON	2	7	1	17				13
	SILICON	2	3	3	**5**				2
	SODIUM	1	2	2	2				44
	CALCIUM	10	10	9	12				213
	MAGNESIUM	3	2	0	2				7
	PHOSPHORUS	24	183	285	240				356
	ZINC	10	9	15	2				20
	BARIUM	0	0	0	0				1

			Values Should Be*					
PROPERTIES	SUS Viscosity @ 210°F	-	75-90	89.3	-			
	cSt Viscosity @ 100°C	-	14.3-18.2	17.81	H20			
	Flashpoint in °F	SHORT	>380	**BOIL**	**BOIL**			
	Fuel %	-		-	-			
	Antifreeze %	-		-	-			
	Water %	**90.0**	<0.1	**1.0**	**2.0**			
	Insolubles %	0.0	<0.6	0.0	**6.0**			
	TBN							
	TAN							
	ISO Code							

So now the lower unit is in a partial state of disassembly in my garage, and let me tell you — nothing is a sadder sight in the middle of boating season. I find myself struggling with shame and regret about not having changed oil in it sooner, or better yet, just fixed the seal that was letting water in in the first place. My only hope is that you don't let the same thing happen to you. Change that lower unit oil and sleep easy at night. Meanwhile, I'll be learning the ***real*** meaning of the word boat - **B**ust **O**ut **A**nother **T**housand!

Report of the Month

If you look at the pictures, it's not too much of a mystery what happened to this 2001 Tohatsu 4-stroke engine. But take a guess anyway!
To learn more about where the elements are coming from, click here.

	MI/HR on Oil	1	UNIT / LOCATION AVERAGES							UNIVERSAL AVERAGES
	MI/HR on Unit									
	Sample Date	1/2/2018								
	Make Up Oil Added									
ELEMENTS IN PARTS PER MILLION	ALUMINUM	9	10							6
	CHROMIUM	0	0							1
	IRON	**57**	64							24
	COPPER	3	3							7
	LEAD	0	1							2
	TIN	0	0							0
	MOLYBDENUM	133	115							95
	NICKEL	0	0							0
	MANGANESE	0	0							0
	SILVER	0	0							0
	TITANIUM	0	0							0
	POTASSIUM	1	1							1
	BORON	78	84							48
	SILICON	4	6							11
	SODIUM	**20**	17							11
	CALCIUM	1519	1335							1692
	MAGNESIUM	33	248							68
	PHOSPHORUS	585	624							703
	ZINC	681	716							845
	BARIUM	0	0							0
			Values Should Be*							
PROPERTIES	SUS Viscosity @ 210°F	70.4	65-76							
	cSt Viscosity @ 100°C	13.05	11.6-14.8							
	Flashpoint in °F	400	>375							
	Fuel %	<0.5	<3.0							
	Antifreeze %	**?**	0.0							
	Water %	0.0	<0.1							
	Insolubles %	0.2	<0.6							
	TBN									
	TAN									
	ISO Code									

Top: Barnacles galore.
Bottom: Old zinc plate vs new.

This engine sat flooded, convered in barnacles, underwater on the bottom of a southern Califonia boat launch for about a year. Here's the story: "I originally found the sunk motor on Craigslist for sale by the marine biologist who recovered it. Judging by the size of some of the barnacles on the motor, I'm guessing it was underwater for up to a year - possibly longer. The clamps were stuck in a wide-open position so I think someone forgot to tighten them before they launched and the motor fell off the boat and sunk.

My plan was to use this as a parts motor for my Tohatsu 5 hp LS. When I bought the engine, it was covered in barnacles with sea water and grit sloshing around in the gear case. It was advertised as not seized, but it very much was. The prop spun in neutral, but that's about it. The condition of the outside of the motor was quite good. The zinc at the bottom of the drive leg was nearly completely dissolved and looked like Swiss cheese. But it had done a good job of protecting the motor. (Story continues on next report.)

Report of the Month

If you look at the pictures, it's not too much of a mystery what happened to this 2001 Tohatsu 4-stroke engine. But take a guess anyway!
To learn more about where the elements are coming from, click here.

ELEMENTS IN PARTS PER MILLION	MI/HR on Oil	1	UNIT / LOCATION AVERAGES					UNIVERSAL AVERAGES
	MI/HR on Unit							
	Sample Date	1/2/2018						
	Make Up Oil Added							
	ALUMINUM	**18**	10					6
	CHROMIUM	1	0					1
	IRON	**133**	64					24
	COPPER	4	3					7
	LEAD	1	1					2
	TIN	0	0					0
	MOLYBDENUM	82	115					95
	NICKEL	1	0					0
	MANGANESE	1	0					0
	SILVER	0	0					0
	TITANIUM	0	0					0
	POTASSIUM	1	1					1
	BORON	92	84					48
	SILICON	9	6					11
	SODIUM	11	17					11
	CALCIUM	998	1335					1692
	MAGNESIUM	679	248					68
	PHOSPHORUS	727	624					703
	ZINC	793	716					845
	BARIUM	0	0					0

Be glad your cylinders don't look like this.

PROPERTIES			Values Should Be*					
	SUS Viscosity @ 210°F	63.6	59-65					
	cSt Viscosity @ 100°C	11.22	9.9-11.9					
	Flashpoint in °F	405	>375					
	Fuel %	<0.5	<2.5					
	Antifreeze %	0.0	0.0					
	Water %	0.0	<0.1					
	Insolubles %	0.2	<0.6					
	TBN							
	TAN							
	ISO Code							

Story continues: I flushed out the power head with kerosene and scrubbed all the grit I could reach out of the valve train. I soaked the cylinder in a mix of SeaFoam and penetrating oil overnight. In the morning I was able to break the cylinder free by gently rocking the flywheel back and forth. After freeing the piston I flushed out the kerosene and put in fresh motor oil. Once the motor was moving freely I decided to put a spark plug onto the boot to see if the ignition system had survived being soaked in seawater for so long. And much to my surprise, it started making spark! The carburetor was in poor shape. It likely had ethanol gas in it when it went under and it had reacted with the salt water to nearly completely fill the interior of the carb and fuel system with a thick, white crystalline deposit. So I swapped on a spare 5 hp carb from my other Tohatsu and plugged a fuel tank directly into the replacement carburetor. I set everything up outside in a barrel full of of water. And after maybe 10 pulls and much coughing and sputtering, the motor started and ran! At that point I hadn't replaced any parts except the temporary carburetor.

The above sample was taken after repairing the broken valve spring (see the next part of the story). Doesn't look great, but most of the metal is from the wear-in process. Sodium has improved a lot.

Report of the Month

This is the lower unit on the Tohatsu unit that was recovered from a year underwater. No surprises here!

To learn more about where the elements are coming from, click here.

ELEMENTS IN PARTS PER MILLION									
	MI/HR on Oil		UNIT / LOCATION AVERAGES						UNIVERSAL AVERAGES
	MI/HR on Unit								
	Sample Date	1/10/2018							
	Make Up Oil Added								
	ALUMINUM	**111**	111						28
	CHROMIUM	**6**	6						2
	IRON	**610**	610						187
	COPPER	**38**	38						7
	LEAD	6	6						2
	TIN	3	3						1
	MOLYBDENUM	1	1						12
	NICKEL	5	5						2
	MANGANESE	4	4						2
	SILVER	0	0						0
	TITANIUM	1	1						0
	POTASSIUM	2	2						1
	BORON	39	39						26
	SILICON	5	5						4
	SODIUM	**38**	38						11
	CALCIUM	8	8						130
	MAGNESIUM	3	3						50
	PHOSPHORUS	925	925						529
	ZINC	418	418						131
	BARIUM	10	10						3

PROPERTIES			Values Should Be*					
	SUS Viscosity @ 210°F	50.8	49-82					
	cSt Viscosity @ 100°C	7.51	7.0-16.3					
	Flashpoint in °F	415	>405					
	Fuel %	-						
	Antifreeze %	**?**						
	Water %	**POS**	<0.5					
	Insolubles %	0.3	<0.8					
	TBN							
	TAN							
	ISO Code							

Story continues: The motor is still quite crusty inside, even with the cleaning. And I've since had a few parts failures. The first part to fail was the exciter coil under the flywheel. After ordering a new one and replacing it, the motor ran again. The next failure, after about an hour of run time, was the intake valve spring (see the initial Report of the Month). When that spring broke it released the half-moon clips that secured the valve and sent the intake valve into the combustion chamber, bending the valve and temporarily stopping the the engine. I removed the intake valve from the combustion chamber, ordered a new one, and replaced it along with the intake and exhaust springs (just for peace of mind).

Blackstone notes: The first and second samples in this series are the reports from right after the spring broke, then the follow-up sample after it was repaired. This sample is from the boat's lower unit, and you've already read in Ryan's article what a problem lower units can be. This one did not handle the submerging as well as the engine did. Iron and aluminum are high, and copper is out of line too. Significant water contamination is present though we're surprised sodium only read 38 ppm.

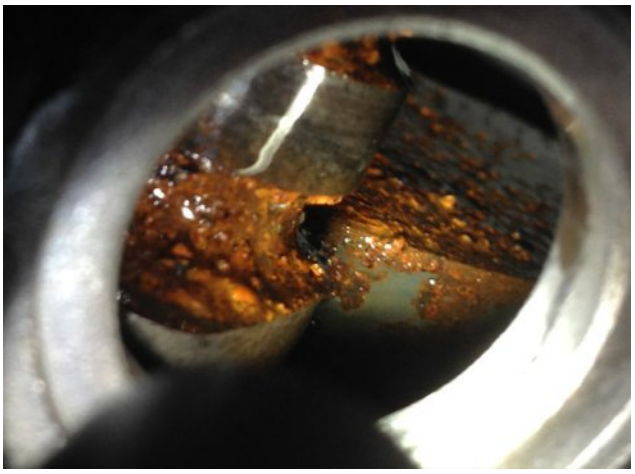
Report of the Month

What are we looking at in this report?

To learn more about where the elements are coming from, click here.

	MI/HR on Oil	2	UNIT / LOCATION AVERAGES						UNIVERSAL AVERAGES
	MI/HR on Unit								
	Sample Date	1/18/2018							
	Make Up Oil Added								
ELEMENTS IN PARTS PER MILLION	ALUMINUM	3	10						6
	CHROMIUM	0	0						1
	IRON	3	64						24
	COPPER	1	3						7
	LEAD	1	1						2
	TIN	0	0						0
	MOLYBDENUM	131	115						95
	NICKEL	0	0						0
	MANGANESE	0	0						0
	SILVER	0	0						0
	TITANIUM	0	0						0
	POTASSIUM	1	1						1
	BORON	82	84						48
	SILICON	5	6						11
	SODIUM	21	17						11
	CALCIUM	1488	1335						1692
	MAGNESIUM	32	248						68
	PHOSPHORUS	561	624						703
	ZINC	673	716						845
	BARIUM	0	0						0
			Values Should Be*						
PROPERTIES	SUS Viscosity @ 210°F	67.4	65-76						
	cSt Viscosity @ 100°C	12.25	11.6-14.8						
	Flashpoint in °F	385	>375						
	Fuel %	<0.5	<3.0						
	Antifreeze %	0.0	0.0						
	Water %	0.0	<0.1						
	Insolubles %	TR	<0.6						
	TBN								
	TAN								
	ISO Code								

Both images are from the fuel ports. Not pretty.



This oil sample is a reference sample from the owner's other Tohatsu engine, to see how metals should look. Maybe with a little luck and a lot of TLC, the submerged engine will eventually wear like this. Time will tell.

Story continues: To date, I've continued to run the motor periodically and I've got it to the point now that ir runs just about well enough to trust it out on the water. It will be an interesting experiment to see how long the engine keeps running.