Diagnostics

DIA 207 Failure Analysis Examples

The following pictures and explanations are meant to give the service technician some examples to use for comparison or to better understand how faults can lead to failures.

There are no rules when it comes to failures. One engine may survive circumstances that another may not.

The important thing is to use a systematic approach to identify faults and look for evidence that may be helpful in coming to a valid conclusion regarding a failure.

What happened?

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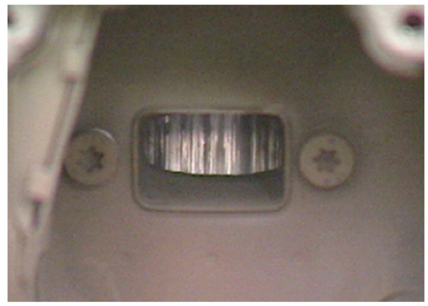
- If the piston is scored major repairs will be necessary
- To know for sure what the cause of the failure is, the STIHL Engine Check procedure should be used, if possible, to verify the presence or absence of any faults
- Once all faults on the engine are known, the exact cause of a scored piston can be determined



If the exhaust side is scored or in bad shape, this is most likely the reason why the unit doesn't run, or runs poorly.

The next step is to determine why it is scored.

Look for excessive carbon buildup and be sure the rings are free in the piston.

Depending on the unit in question, it may be decided that the unit is too costly to repair and not worth spending any more time on.

However, the customer may want to know why it failed, whether it is repaired or not.

If the unit is under warranty, then the STIHL Engine Check will allow verification of whether or not normal warranty applies.

If it is an expensive piece of equipment, you will need to determine the cause of the failure and be able to make an accurate repair estimate.

Did this piston fail because of a restricted fuel filter, carb problems, lack of oil, or an air leak.

Does the unit have a considerable amount of run time on it, or is it fairly new? These are the kind of things to be considered by the service technician as the unit is worked on.

Lean Running

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- Chain Saw - Damage is typically concentrated on the exhaust side
- Little or no damage on the intake side

In the combustion chamber, lean is lean; it does not matter if air entered the engine somewhere other than the carb, leaning out the mixture, or if the fuel flow was restricted, leaning out the mixture. If the engine does not have a rev-limiter, lean running will cause over-revving. A saw with a lot of run time will get a polished, buffed appearance on the bottom of the intake skirt, but over-revving will advance this buffing effect considerably, as the picture on the right indicates.

Fuel provides piston cooling, so a lean mixture allows the piston to overheat. However, damage is usually worse on the exhaust side.

Also be aware that a new engine with little buildup of residual oil in the porosity of the piston and cylinder wall will score differently than an engine with a lot of run time.

Detonation on the Exhaust Side

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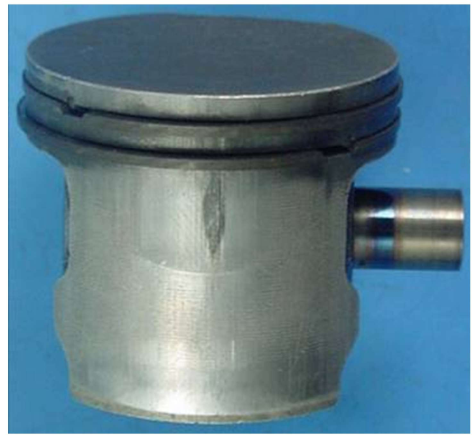
- Detonation is due to lean combustion
- Lean combustion can be caused by many things



When an engine is running lean, less fuel is coming into the combustion chamber to vaporize and extract heat, and what fuel is present will burn extremely fast. If conditions are right, detonation may occur, which will be evidenced on the exhaust side of the piston by the pitted, eroded areas where the piston is actually burned away.

When you see detonation burning of the piston, it is most likely caused by lean running. The fuel filter or tank vent may be restricted, or there may be an air leak in the crankcase. In some cases it may be due how the unit was operated. A chain saw being constantly operated in a part throttle RPM range may run lean and hot, and in some cases fail, even though there is no actual fault with the unit.

Typically, lean running damage will be concentrated on the exhaust side of the piston. There may be some scoring on the intake side if the unit runs long enough for the damage on the exhaust side to push the piston back against the intake side of the cylinder.

A STIHL Engine Check should identify some sort of lean fault, which would be confirmation of why the piston is damaged.

Other Failures: MS 180 Used for Carving

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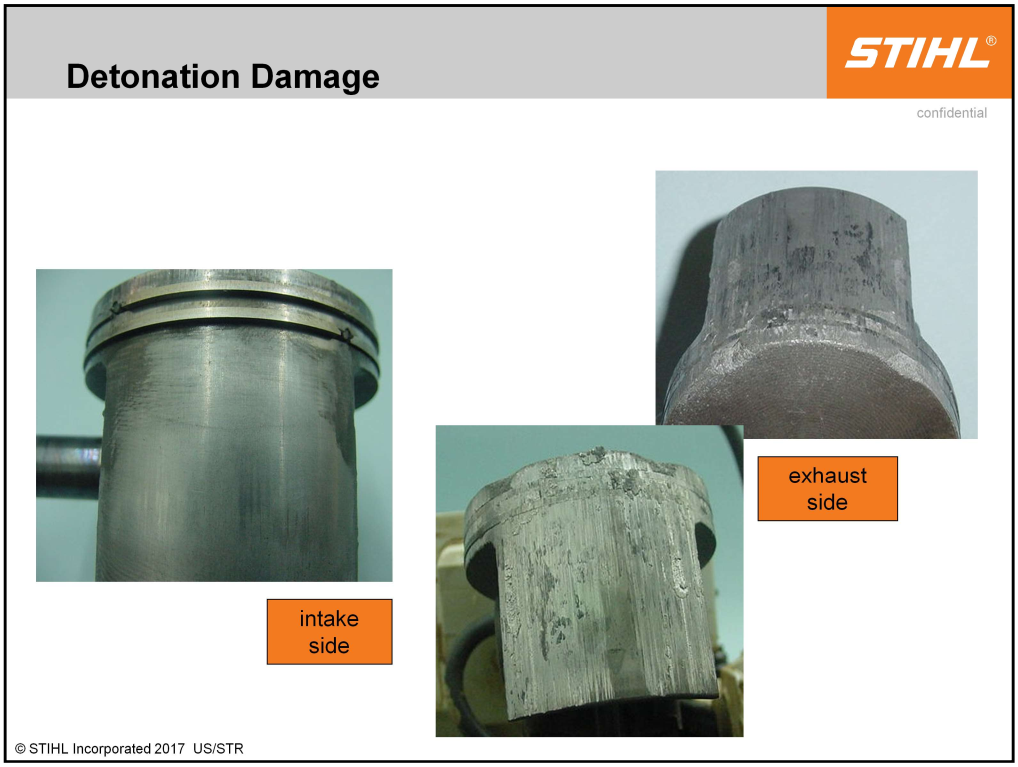
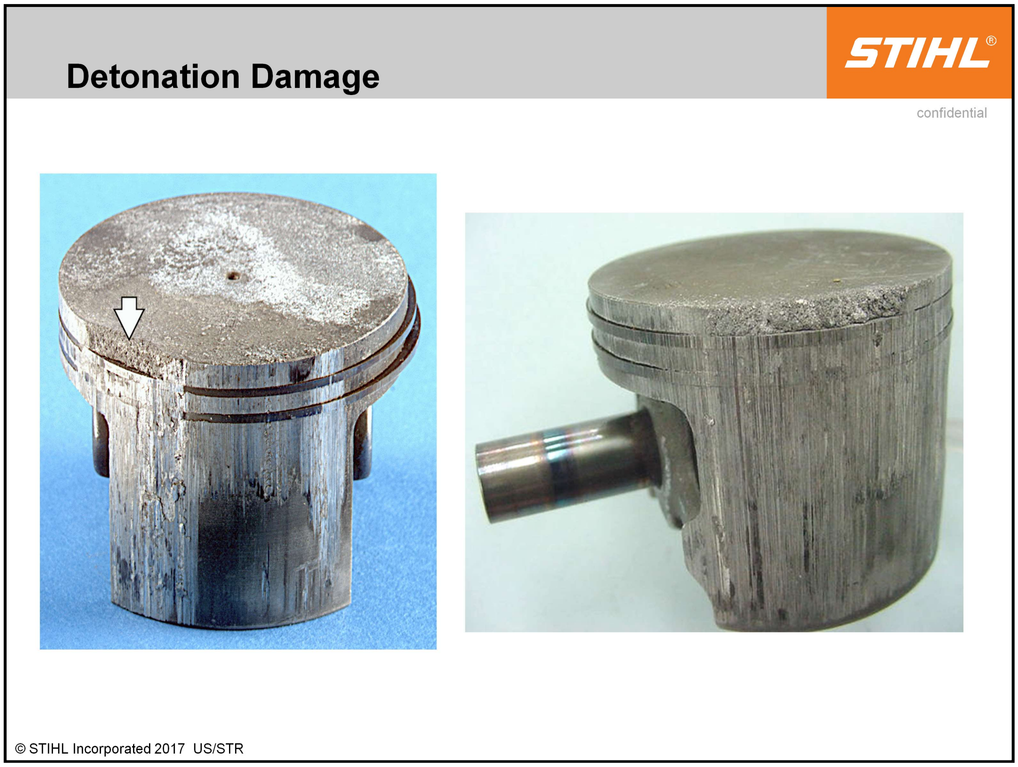
The STIHL Engine Check found no faults on this saw, which had less than 20 hours of run time on it. Detonation damage like this is almost certainly due to lean running conditions, yet none were found. When the operator was questioned as to how the saw was being used, it was explained that the saw was being used for artistic carving. This engine was seldom being held at WOT, and the throttle was constantly being “blipped” open and held in the mid range RPM to do the carving, which puts the engine in a lean running state most of the time.

This model of saw does not have an accelerator pump and has fixed jets for both the L and H side of the carb, so no adjustments could be made to compensate for how it was being used.



With less fuel available for combustion, the flame front speed will become excessive and may lead to detonation, usually concentrated at the exhaust side of the piston or under the spark plug.

Detonation will cause the piston to actually melt and burn away, and a considerable amount of metal transfer will then occur between the piston and cylinder wall.



These examples show the burned edge and damage that is typical of detonation.

Detonation is nearly always caused by lean operating conditions, so if the engine is to be repaired, the cause of the lean operating condition must be located and corrected.

Machining Flaw MS 440

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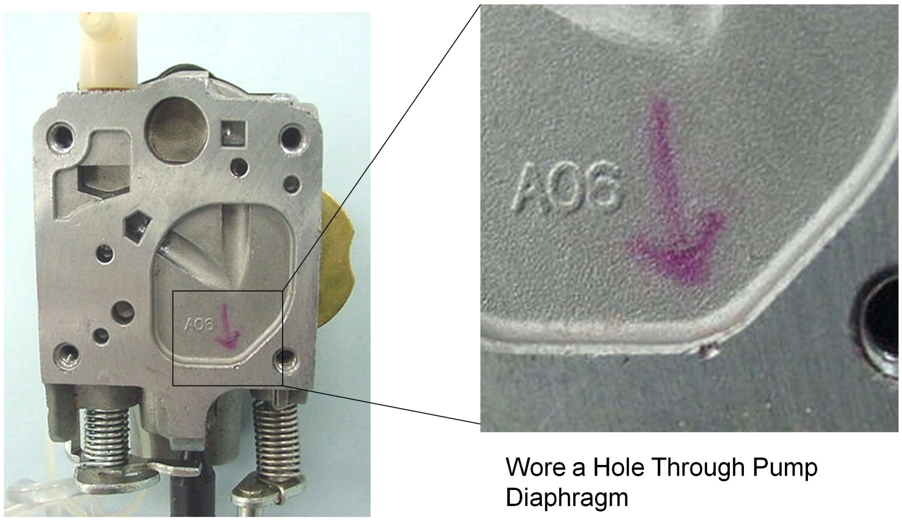
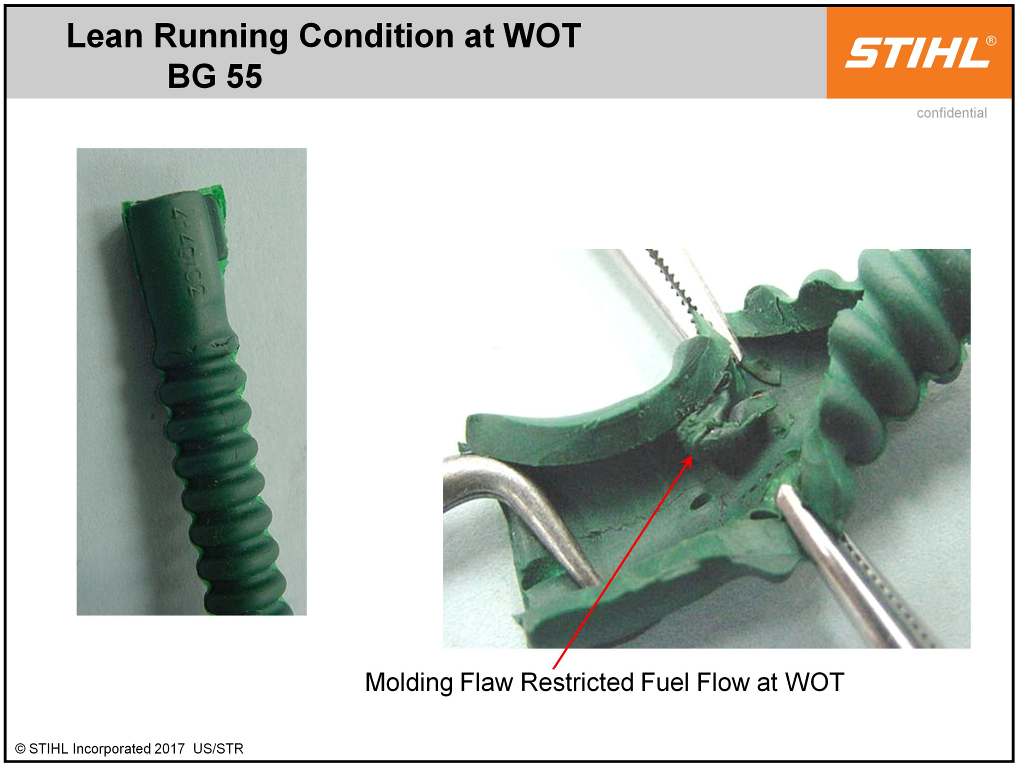


Wore a Hole Through Pump Diaphragm

This carb failed the pressure test, and was leaking out the impulse hole, which is actually a rare fault. A machining flaw caused a nick in the milled surface of the carb body which rubbed a hole in the diaphragm. This is an example of a defective part and would be covered under warranty.

With the fuel pump not working the saw would start on choke easily and may idle well but starve for fuel under load. That was the complaint when the saw came in for service.



This fuel line was installed on a BG 55 blower. The dealer stated that when it was set up, that it would start and idle fine, but would go lean at WOT. The carburetor was the first thing checked and no faults were found. By process of elimination it was discovered that the engine ran fine once the fuel line was replaced. The cut open end was at the carburetor fitting, and the flap of material flash would restrict fuel flow enough at WOT to cause the engine to run lean. This is a very rare fault and was challenging to locate but in some cases a process of elimination may be necessary to locate the fault.

Compensator Fitting Restriction TS 400 4223

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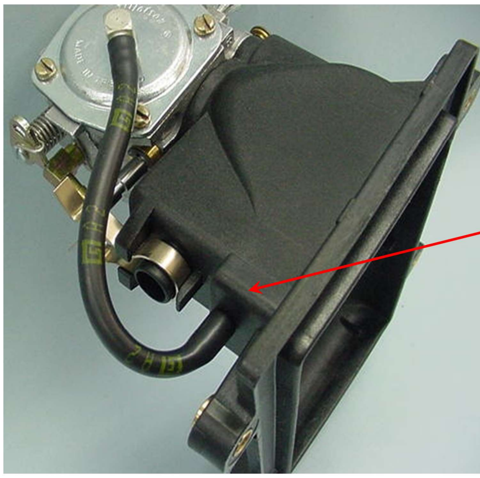

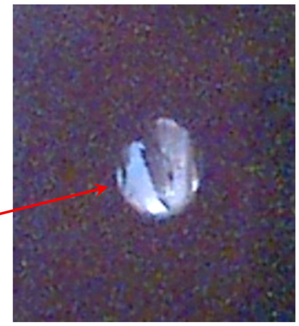

Thin Plastic Flash in Port
Caused Lean Running at WOT

If an air filter becomes restricted, it will cause the engine to run rich. The compensator carb design allows the engine to run with the mixture being leaned out automatically, up until the point that the filter is so restricted that the operator notices that the engine has poor performance. The picture shows a new filter housing where some plastic flash was covering the compensator port. This caused the carb to respond as if the filter was dirty, so the engine ran lean, even though the filter was clean.

The first thought would be a fault in the carb, but that wasn't the problem. Understanding the systems on a machine and how they work is very important when troubleshooting a running problem. The technician found that when the compensator hose was removed from the filter housing the engine ran fine.

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Over-revving

- FS 100 RX: electronic rev-limiter in microprocessor controlled ignition module

- BR 430: no rev-limiter required as there is no clutch and the impeller always provides a load

- TS 760: early models had a vibration control valve in the carb, later models were electronically controlled

Shafted power tools since the 4137 series design have had a built in electronic rev-limiter. Some earlier models had carb equipped control valves to prevent over-revving by dumping fuel into the venturi if the RPM exceeded a certain speed. The TS 510 and TS 760 were equipped with some means to prevent over-revving, and all subsequent models of TS have an electronic rev-limiter.

It is rare, but not impossible, for a lean running condition to cause severe piston scoring on a line trimmer or any other power tool with a rev-limiter. If the unit is lean it just will not have any power or run very well, and that will be the complaint when the operator brings it in for service.

A blower cannot be over-revved from a lean fault due to the constant load the impeller always puts on the engine. A blockage to the airflow will cause RPM to go up, but the engine will usually fail due to overheating as a result, if the blockage is left in place long enough.

When a chain saw is in the wood cutting it is under a load that is preventing it from over-revving. A dull chain can allow the RPM to become excessive even in the wood if the cutters are not really biting in and pulling chips. Starting with the 1138 series MS 441 and all subsequent saw series since then, there is some electronic means built into the ignition module or control unit to protect the engine from over-revving that could be caused by lean running. However, lean running can still occur and could still cause piston damage. The damage might not be as severe as caused when over-revving also takes place.

FS 85, 4137 Crankcase Vacuum/Pressure Test

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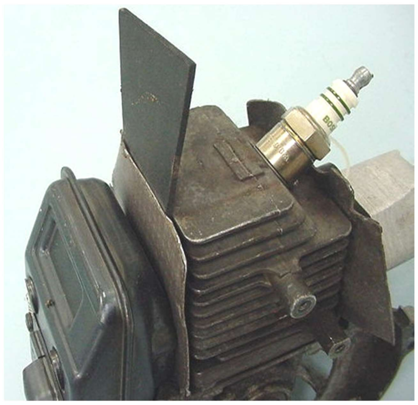

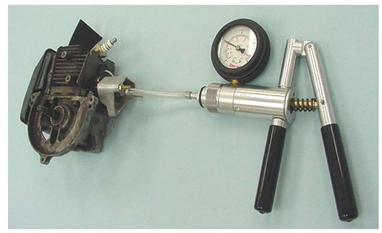

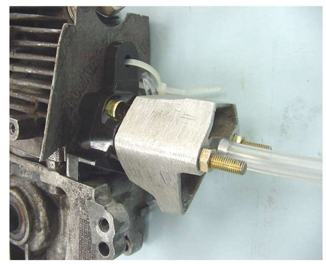

To verify if the crankcase is leaking or not, for any two stroke engine, as well as the STIHL Four-Stroke engine, a vacuum/pressure test is done. The exhaust port is blocked off, the spark plug is in place, and an adapter is installed to the intake flange. In some cases the impulse hose will need to be blocked as well. For the 4137 series engine, the specification is to pull a vacuum of 0.5 bar (7 PSI) and it should not rise to more than 0.3 bar within 20 seconds. Always rotate the crankshaft back and forth slightly to make sure the seals are holding vacuum properly. If the engine will not hold vacuum, do the pressure test to see if there are any other leakage areas. If not, then one or both seals are leaking, and will need replaced.

Then pressure test the crankcase to 0.7 bar and it should hold for at least 20 seconds. If not use soapy water to find where the leak is. If the pressure test is done first, the pressure may cause a defective seal to seal tighter to the crankshaft, and pass the vacuum test.

If a pressure leak is found and repaired, repeat the tests to verify that no other vacuum or pressure leaks are present.

4137 Crankcase Leak

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When the engine was vacuum tested it failed. Then when it was pressure tested, it also failed, and soapy water indicated that the crankcase was leaking along the seam.

A leaking crankcase can be compensated for by tuning the carb rich. But the unit will not perform well under load and may have erratic idle from one day to the next.

This test is often overlooked. When evaluating a machine for running problems it is just as important to know what faults are not present as it is to find some. Knowing the crankcase is tight allows the technician to rule that out as a fault and concentrate elsewhere. Finding a leak and repairing it now means that the focus can move on to any other faults present or finish the repair.

066 Failure, Repair, and Failure Again

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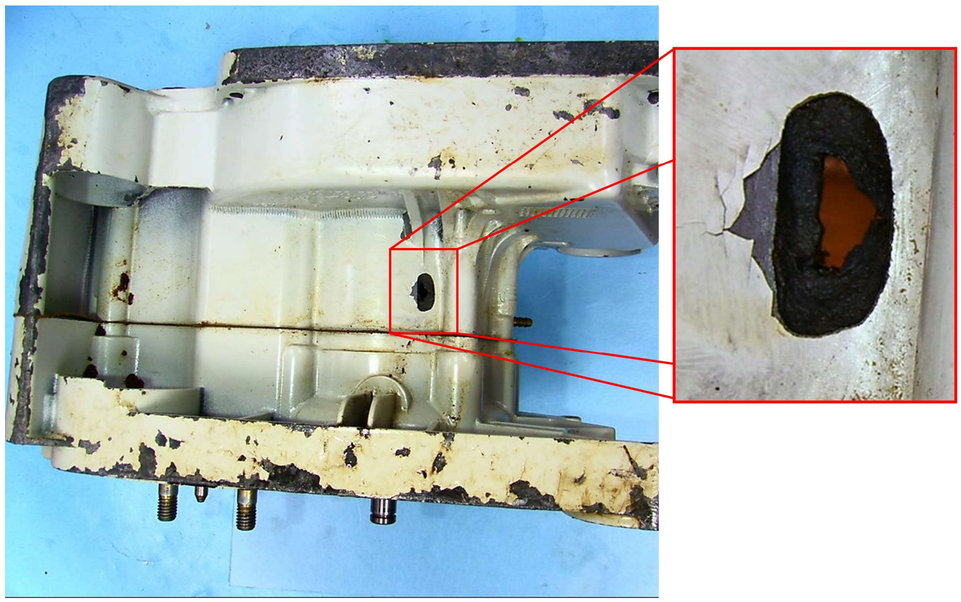

The saw was brought in for repair. It quit in the cut and would not start. Compression was low so a new piston and cylinder was installed, the carb tuned but no test cut was made. The customer paid the $500 repair bill and took the saw home to use. The saw failed again in the first cut When returned to the dealer a second piston and cylinder was installed at no charge. When the customer got home and used the saw it failed again in the first cut.

The service technician never did a pressure / vacuum test. It should be done before tear-down to identify if there is a problem, and during assembly to make sure the crankcase is tight with the new parts installed.

The carb was adjusted rich and masked the leak with no load on the engine but once it was in the cut the air leak in the crankcase leaned out the air-fuel mixture enough to cause the engine to fail.

The first failure damaged the piston so severely a piece of the skirt got caught between the crankshaft and the case and knocked the hole through the bottom. Had the pressure test been done to the crankcase before the first teardown this would have been found, and two piston and cylinder assemblies would not have been wasted as well as the time and effort to install them.

Overheating Failure

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- Overheating led to swelling through the ribs of the piston, pushing out the skirt at the corners

This chain saw was being used for limbing. The operator had a long coat that was being sucked up against the starter side air intake, restricting the airflow. The oil molecules burn off at high temperatures, and the piston swelled at the rib areas, causing seizure. Notice that there is no evidence of detonation. Sometimes you will see a typical three or four point scoring in the areas of the piston skirt ribs, as the piston swells more in that area due to the thicker amount of material. If the engine runs long enough, the exhaust side may score all the way across, but the intake side will usually only have the 2 scores at the rib area, or show some push over scoring directly opposite heavy damage on the exhaust side.

A typical overheat failure will usually have some scoring on the intake side at the ribs, and there will usually be some melt damage to any plastic near or touching the cylinder.

Overheat BR 420

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- Overheating led to intake scoring top to bottom at ribs
- Exhaust is scored all the way across due to multiple seizures

If the engine was allowed to cool and then the engine restarted, multiple layers of scoring may be present, indicated by blackened areas with fresher, shiny scoring on top. It is also common to see a buildup of scoring on the exhaust side to push the piston over against the intake side of the cylinder wall and cause scoring in the middle of the intake side of the piston.

Again, the clue that overheating may have happened is the 3 or 4 point scoring in the rib area of the piston. There was also melt damage to the shroud which would not have happened if the blower was operated on fuel with no oil in it.

On this example, the machine marks are still present between the scoring on the intake side. There is evidence of multiple scoring on the exhaust side, indicating that it may have happened several times. If the unit was allowed to run out of gas while being operated, it would also run lean for a moment before it died, adding to the heat buildup in the piston.

No evidence of lean running was found, or any other major faults, but there was some leaf residue in the bottom of the impeller housing. This failure occurred in the fall, after large leaves start falling and these machines start seeing more run time. It is likely that some leaves got drawn up behind the back plate and partially blocked the air intake. Because the BR 420 engine is cooled from the impeller housing, this may have been what ultimately led to the failure.

This is sometimes referred to as “4 point scoring”, implying that the piston swells at the four corners where the support webs for the skirt are located.

On a saw, the intake side of the piston nearest the flywheel may not be scored, because it is getting the cooling air first.

Typically, the exhaust side of the piston will be scored all the way across, with the intake side showing damage mainly at the skirt webs.

The wrist pin will usually be blue, and the underside of the piston may be black with burned oil residue.

Overheat Damage

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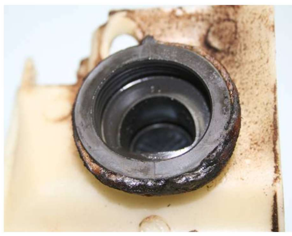
- Melted plastic will typically only happen in an overheat situation
- A careful inspection may be needed to verify if there is any melt damage on the unit



Sometimes melted plastic will be obvious, while other times you may have to look carefully or remove shrouds or other parts to locate any damage.

While doing a STIHL Engine Check of a unit with a scored piston keep an eye out for any melt damage as the unit is taken apart.

Melted plastic on or near the cylinder is proof the engine saw abnormal operating temperatures. An engine failure due to a lean fault, or operated on un-mixed fuel, or allowed to ingest dirt will never get hot enough to melt any plastic.

Overheating may cause the crankcase to develop an air leak which would be found when doing the pressure/vacuum test, but if melted plastic is present now we know the crankcase air leak did not cause the failure but is the result of an overheating situation.

Overheat Causes

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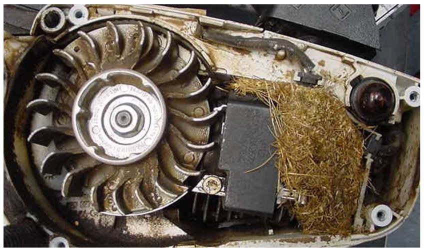
- Sometimes the reason for an overheating situation is obvious, sometimes it is not



The MS 192 in the upper picture was used to trim palm trees and the fine fibers completely blocked the airflow under the starter housing. This is a maintenance concern that is the operator’s responsibility.

The same is true for the FS 110 in the bottom picture.

The cylinder on the right is from a MS 660, used to cut 55 gallon plastic barrels in half. Using the saw this way allowed the engine to run at full throttle under basically no load, so the RPM was excessive. The plastic pieces from cutting the barrels accumulated under the shroud and melted into a mass that obviously led to overheating and failed the engine.

Not every overheat failure will be as obvious as these. If whatever blocked the cooling air is not present on the unit when it comes in for evaluation, a careful analysis will be needed to verify if overheating is the cause of engine damage.

MS 211 Overheat Failure

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- Overheating led to abnormal combustion

Stratified scavenge engine designs may not show the typical four corner scoring that a conventional piston port engine does. This MS 211, when overheated, caused detonation in the combustion chamber which damaged the exhaust side of the top of the piston and also overheated the spark plug which caused pre-ignition. Pre-ignition then caused a hole to burn through the top of the piston where it is very thin.

At first glance this might seem like a lean running fault, but it is lean running caused by overheating which led to vaporizing of the fuel in the crankcase and abnormal combustion in the combustion chamber.

No lean faults are present.

Lean running alone would not get the engine hot enough to melt the spark plug lead clip that is attached to the top of the cylinder. The shroud is not damaged because it does not contact the cylinder.

Melted plastic that was touching the cylinder is an indication of overheating due to lack of cooling air. Straight gas or lean running alone will not usually create enough heat to melt any plastic touching the cylinder.

FS 56 Overheat

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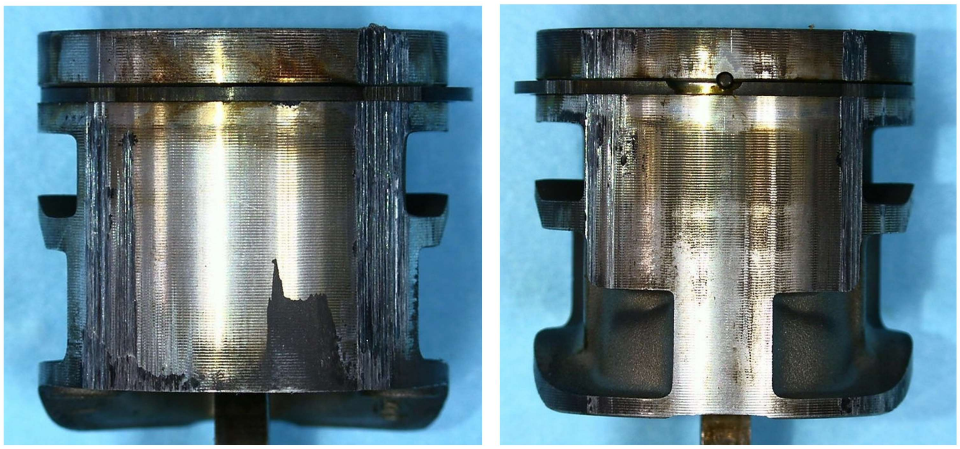

This is a stratified charge engine design with the control recess on both sides of the piston skirt on the intake side. This design has a longer skirt on the intake side and has more material spread out as part of the skirt than a conventional piston port two-stroke does.

This engine design runs cooler due to the fresh air being diverted around the skirt through the control recess on each side, when the piston is at TDC.

Even the stratified scavenge piston shows scoring more or less on the “corners” of the piston. There is more material around the sides of the piston where the wrist pin slides in and as the heat soaks down the skirt this area may swell faster than the skirt does at the intake and exhaust port.

The SEC did find melted plastic on the top shroud where the bolt fastens to the cylinder.

1139 Series MS 211 Overheat Failure

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- The cooling air was restricted through the starter side of the unit
- Notice that the intake side does not show the same sort of corner scoring as a conventional piston port design usually shows
- There is more skirt to spread out the heat, and the detonation damage caused the engine to stop running before any further skirt scoring developed

In some cases an overheat situation may lead to heat buildup in the fuel tank and carburetor, which may cause a vapor lock situation in the fuel system. This leads to lean running in the combustion chamber.

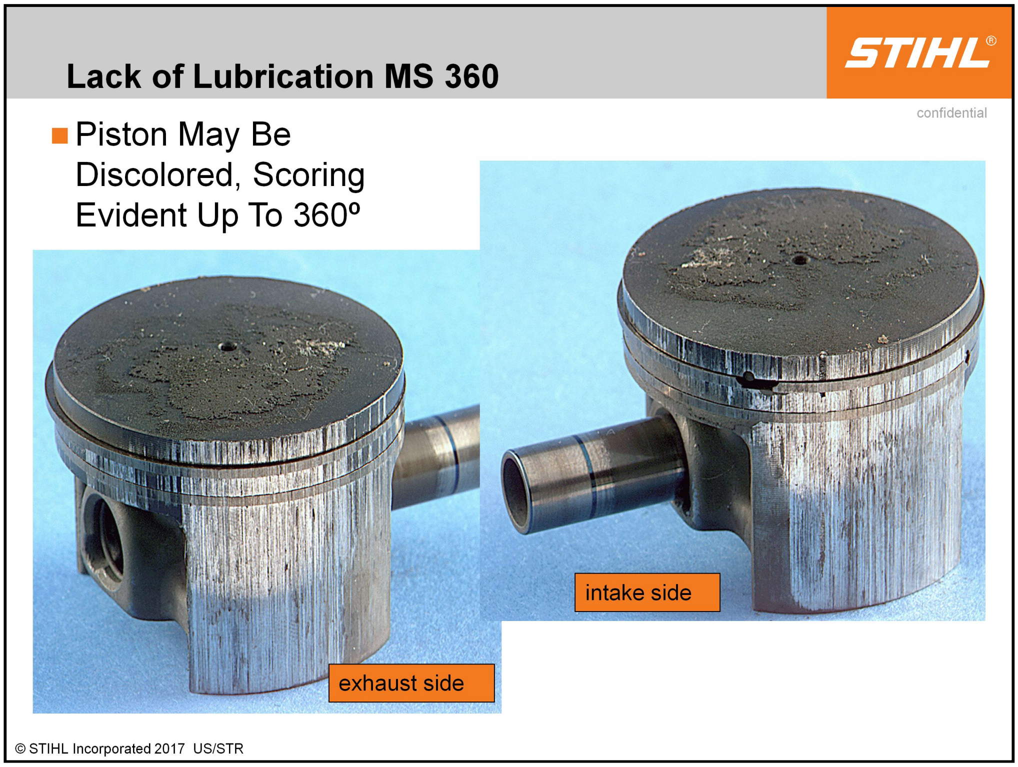
The carburetor is designed to flow liquid fuel and will not flow a vapor at the correct ratio. Recall that the piston is cooled by the fuel changing from a liquid to a vapor, extracting heat in the process. If the fuel is already vaporized when it gets inside the engine, then it cannot provide any additional cooling.

Most small saws today use a lightweight piston with a thin crown, to provide less reciprocating mass at high engine speed. A lean running condition in the combustion chamber can lead to detonation and pre-ignition and result in piston failure such as this picture shows.

The STIHL Engine Check did not find any obvious lean faults, but the spark plug wire clip on the top of the cylinder was melted, which would not have happened if lean running was the only fault that caused piston damage.

This is another example of a saw that was overheated by the operator's long tailed shirt getting sucked up against the air intake on the starter housing, while he was limbing a fallen tree.

The owner’s manual advises that an operator should not wear loose fitting clothing as a safety concern, so there is less risk of the clothing getting entangled in the saw or brush.



Typical damage from lack of lubrication will be up to 360º scoring around the piston. It may be due to no oil, the wrong type of oil, or not enough oil in the fuel. Old fuel may also contribute to this.

Winter fuels or fuel with high levels of alcohol may indicate failures similar to those observed from lack of lubrication.

If a STIHL Engine Check is done on the engine and no lean faults or overheat indicators are found, then the piston is removed and has scoring on both sides or even all the way around, it is most likely a lack of lubrication related failure. The only way to be sure is to see what faults are present, and if none are found then by process of elimination, it is most likely lack of lubrication.

FS 56 Lack of Lubrication

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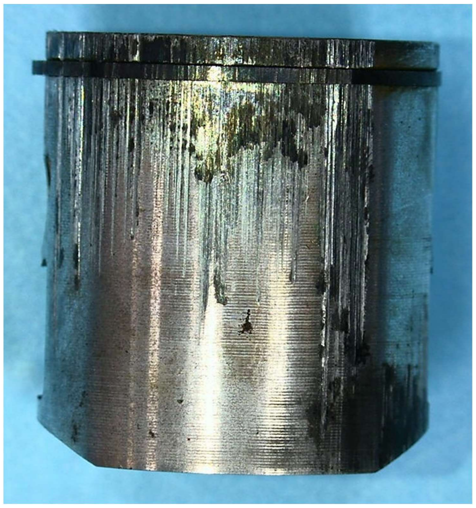

This is a stratified charge engine design with the control recess on both sides of the piston skirt on the intake side. This design has a longer skirt on the intake side and has more material spread out as part of the skirt than a conventional piston port two-stroke does.

This engine design runs cooler due to the fresh air being diverted around the skirt through the control recess on each side, when the piston is at TDC.

We see heavy scoring on the exhaust side which is always hotter then the intake side. There is also some scoring on the left side of the piston on the intake side.

There was no melted plastic evident nor were there any faults such as dirt ingestion or air leaks.

In most cases if the SEC does not show any obvious faults and there is scoring on both sides of the piston it is usually due to lack of lubrication.

4229 Series BG 55 No Oil in Fuel

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- This unit had several tanks of mixed fuel ran through it
- It would not re-start after 1 1/2 tanks of un-mixed fuel

There is no rule or standard regarding how long it takes for a lack of lubrication to cause piston damage.

This engine only lasted $1^{1/2}$ tanks before the damage was severe enough to cause the engine to lose compression. If the engine has a residual oil buildup from being operated with a quality oil at the right ratio, it may extend how long the engine will survive.

Notice the black discoloration and scuffing and scoring is present nearly all the way around the skirt.

The STIHL Engine Check showed no faults. If the customer is told that the unit was operated on fuel with no oil in it, and that is why the engine is damaged, the service technician needs to be able to prove it. Showing the customer the completed evaluation worksheet, and being able to say that the unit was carefully examined and no obvious faults are present, yet the piston is scored nearly everywhere, gives good evidence that lack of oil is the cause of failure.

4241 Series BG 86 No Oil in Fuel

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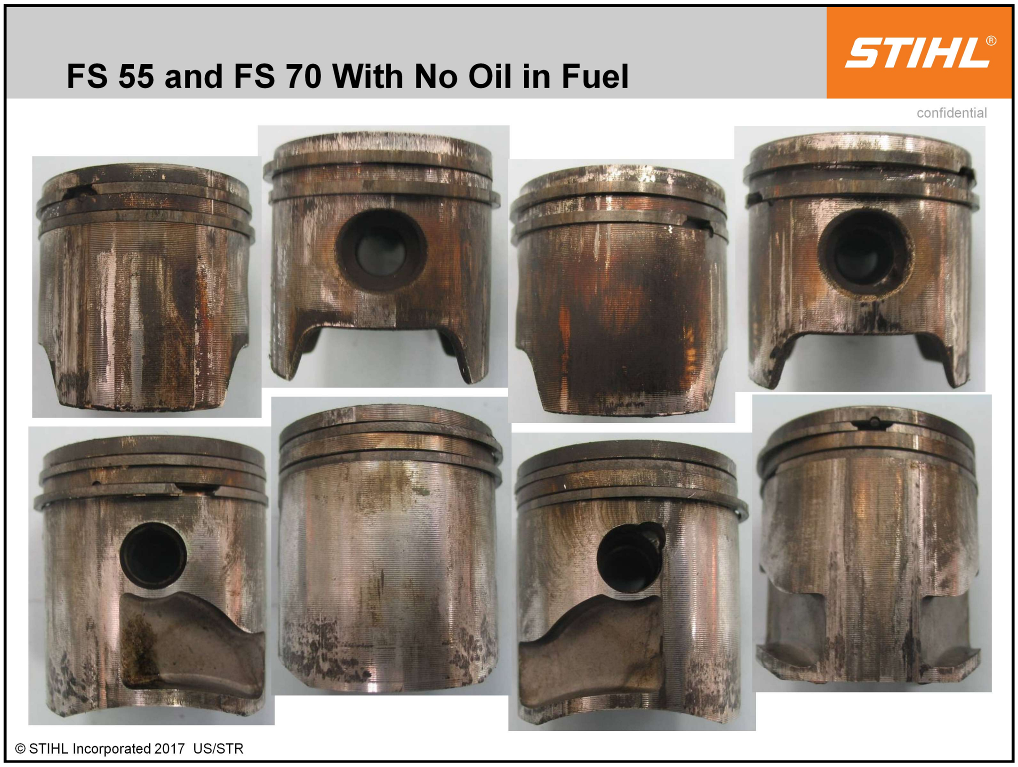
- New unit with no run time, started on un-mixed fuel, throttle locked at WOT, ran for 3 minutes and would not re-start

This engine had no residual oil soaked into the metal surfaces, so it did not last very long.

This is a stratified scavenge engine design. Notice that the lack of lubrication caused scoring on the intake and both sides of the piston first and led to a loss of compression when the rings were pinched by the material wiping across the lands.

Regardless of the engine design, no oil leads to piston contact with the cylinder wall and scoring and metal transfer.

The crankshaft bearings are fine, and all it would take to repair the unit is a new piston and cylinder assembly.



Both of these trimmers had several tanks of mixed fuel ran through them, and then each was operated on fuel without any oil. The FS 55 ran through seven tanks of un-mixed fuel before it would not restart. The FS 70 stopped on the third tank of un-mixed fuel.

Again we see damage spread all the way around the piston skirt.

FS 110

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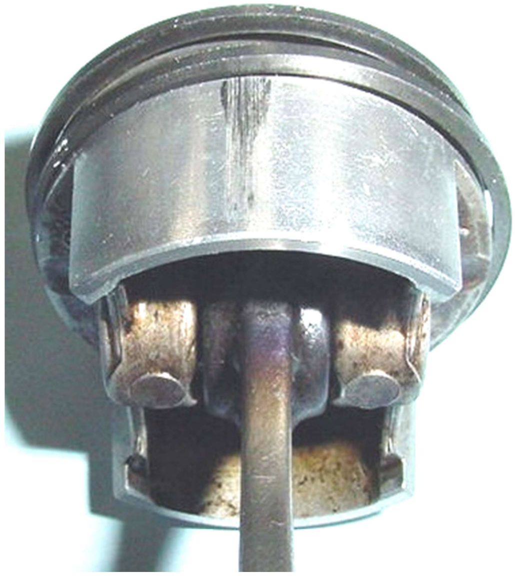

Notice the blue discoloration on the connecting rod. The piston is seized to the wrist pin, and will not rotate at all. There is a slight amount of scoring on the piston.

This engine was operated on un-mixed fuel. The four-cycle engine operates considerable cooler than a two cycle, so the piston does not show as much damage as might be expected. The wrist pin on a 4180 engine is a plain bearing design, and was the first area to overheat. This engine had very little run time.

Dirt Ingestion

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- There will always be evidence of dirt on the clean side of the air filter

Notice the sandblasted, dull look of the intake side of the piston on the left, compared to the one on the right. In the close-up, you can see the scratch marks and tell that the machine marks are worn off. An engine with long term dirt ingestion may continue to run until it has so little power that the operator will complain about the performance. The dirt may cause the lower rod bearing to fail since that is the first place it hits as it comes into the crankcase.

There is usually plenty of evidence to confirm an engine that has ingested dirt. The air filter may be missing or damaged. There may be evidence of dirt or grit on the clean side of the filter or on the choke plate of the carb.

A worn piston eventually leads to lean running, as the intake side of the piston acts as the valve that closes the intake port. This is a close tolerance, and if the skirt is worn down from abrasive ingestion it no longer seals well. The engine will have excessive spit-back through the carb. The air filter may get saturated with fuel in some situations.

4137 Series FS 80 Dirt Ingestion Measurements

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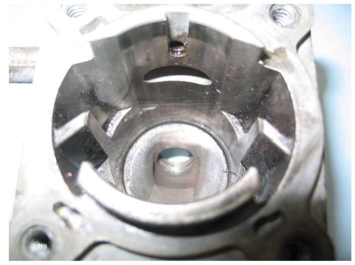
	New	After Failure	Difference
Ring end gap:	0.011”	0.021”	0.010”
Piston Skirt diameter:	1.337”	1.330”	0.007”
Crankshaft side play:	0.000”	0.011”	0.011”



This FS 80 was operated on several tanks of mixed fuel, then had a measured amount of fine grit fed slowly fed through the carburetor. It was operated for two tanks of fuel after the grit was introduced. The wear is worst on the intake side of the piston and the chrome is worn away from the cylinder on the intake side as well.

Notice that the wear has affected all moving parts in the engine.

4144 Series FS 56 Dirt Ingestion Measurements

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	New	After Failure	Difference
Ring end gap:	0.012”	0.052”	0.040”
Piston Skirt diameter:	1.336”	1.330”	0.006”
Crankshaft side play:	0.000”	0.011”	0.011”

This FS 56 was operated on several tanks of mixed fuel, then had a measured amount of fine grit fed slowly fed through the carburetor in the same manner as the FS 80 on the previous page.

The FS 56 has a single piston ring and the dirt caused significantly more wear to the ring.

Because the stratified scavenge engine design exposes about 230º of the piston skirt to the incoming air, the abrasive is spread out over a greater surface area, so the damage is also spread out across more of the cylinder wall and piston skirt.

Again because the abrasive is coming through the crankcase all moving parts see wear.

4144 Series FS 70 Dirt Ingestion Measurements

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	New	After Failure	Difference
■ Ring end gap:	0.012”	0.055	0.043”
■ Piston Skirt diameter:	1.336”	1.321”	0.015”
■ Crankshaft side play:	0.000”	0.011”	0.011”

This engine was also operated on mixed fuel and then had the same amount of fine abrasive fed through the carb at full throttle with the line at the full length.

The FS 70 has two rings on the piston, but again the damage is spread out more because of the port design, and the ring wear is about the same.

4180 Pole Pruner

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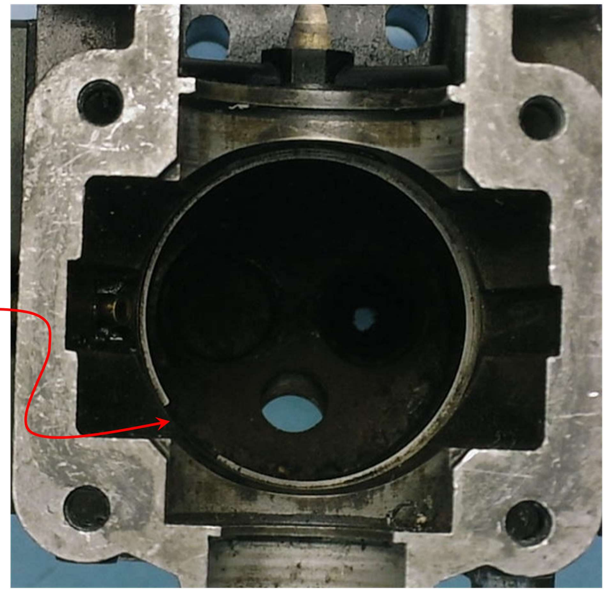
- Notice ring end gap: 3/8”



This HT 101 Pole Pruner was used to trim any hanging branches or other debris off logging trucks in Florida before they pulled out on the highway to travel to a pulp mill. The area is an open dirt lot with skidders and trucks moving around constantly. The operator left the unit sitting on the ground idling when not in use because he did not want to restart it every time.

A dealer submitted it for warranty after 6 weeks of use.

The cause of failure is dirt ingestion due to lack of maintenance in dusty operating conditions.

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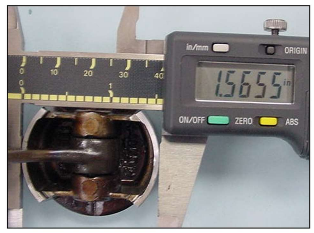
Piston Wear
From Dirt Ingestion

HT 100



0.008” Measurable Wear on Piston Skirt

When comparing the worn piston with a new piston, notice that all the machine marks are completely worn away, and there is even a wear pattern indicating the piston was rocking back and forth, or “slapping” in the cylinder.

This is evident by comparing the dial caliper measurements of the new piston at the bottom of the skirt, with the worn one. A new piston measures 1.573” in diameter, compared to the worn piston, which is 1. 565” in diameter, indicating that 0.008” has been worn away from the piston skirt.

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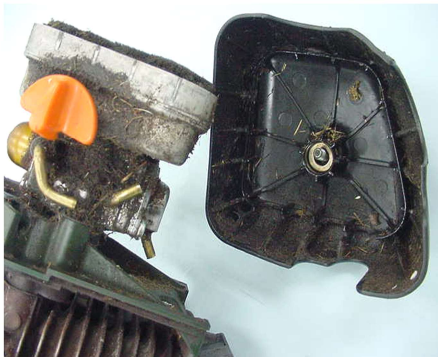
Dirt Ingestion **HT 100**



This is what the air filter box looked like when the element was removed. This pole saw was used in a logging yard to trim any branches hanging off of the truck after it was loaded. The loading area was just a dirt lot, with lots of dust being stirred up by the trucks and loaders. The operator would sit the pole saw on the ground, and leave it idling.

The owner's manual says to knock out the filter on your palm or blow it out with compressed air. This unit uses a felt element, and it should not be washed with solvent or water. In dusty conditions it should be serviced or replaced more often.

Lack of Maintenance

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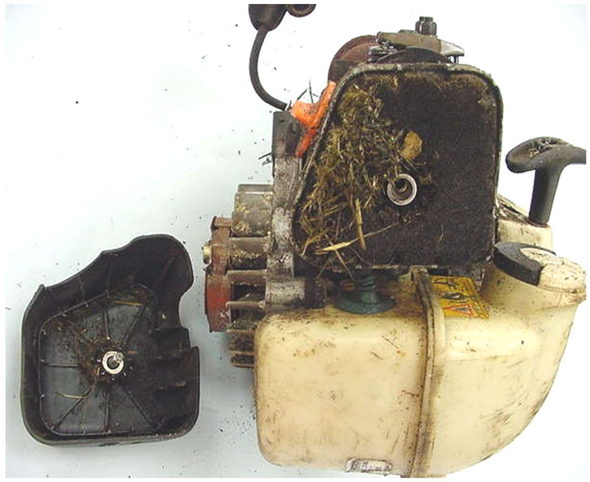
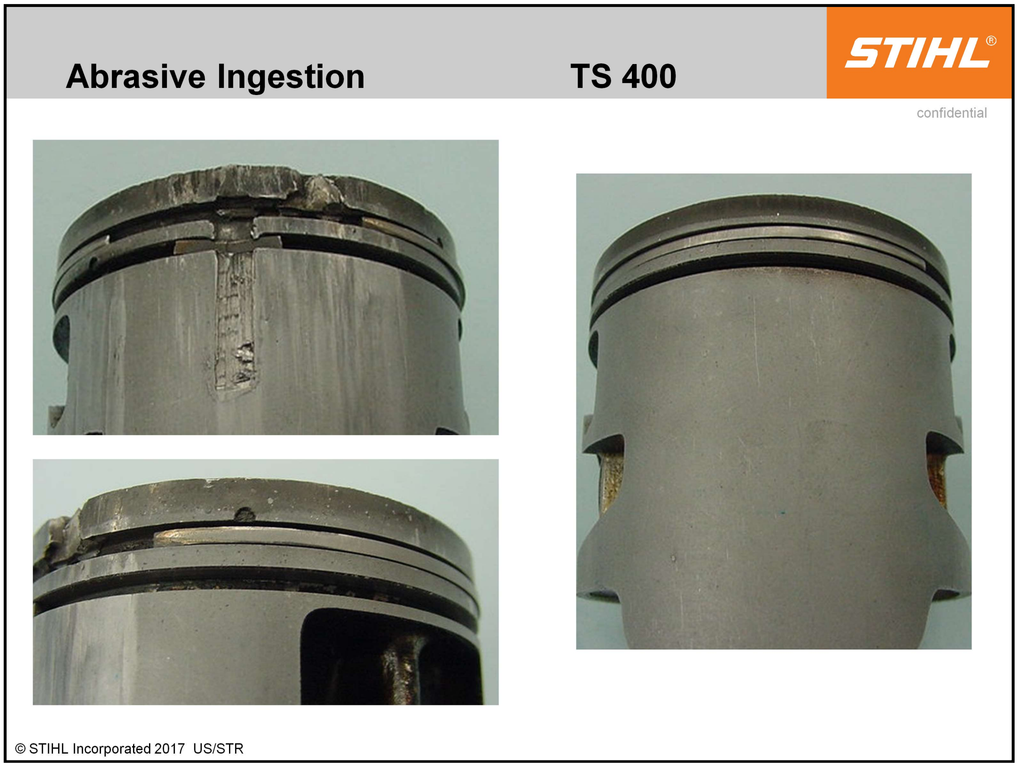


Filters should be cleaned regularly. There is no suggested average time to do it, just inspect it weekly to start, and clean more often if needed. The foam over felt element such as this one on a FS 110 should never be cleaned in solvent, just knock off heavy debris and blow it out with compressed air. Replace at least once a year, or if the foam is damaged. Always verify that there is no dirt on the clean side of the filter. If there is, replace the filter and be sure the filter housing is not damaged allowing a dirty air leak past the filter element.

This engine had a considerable amount of run time on it, with evidence of long term dirt ingestion and very little maintenance. Notice how dull the piston surface is. There are no machine marks present on the piston. The needle cage is broken in several places on the big end of the connecting rod, due to the dirt ingestion and the piston being loose in the cylinder.



This TS 400 was used for five years by a stone mason for cutting decorative landscaping blocks. The long term ingestion of masonry dust wore the indexing pins that prevent the rings from rotating in the groove, as well as causing a considerable amount of wear to the rings and the piston. The pins were eventually worn away enough to allow the ring to rotate around and the end of the ring got caught in the exhaust port, causing the catastrophic damage that finally stopped the engine from running.

The amazing thing is that the engine ran as long as it did with the amount of wear present. As the intake side of the piston skirt gets worn away, it no longer provides a good seal to the cylinder wall as the piston moves down in the bore, to seal off the intake port to the crankcase. This allows the pressure in the crankcase to leak out towards the carb, commonly known as "spit-back." A worn piston will cause lean running due to the leakage of the air-fuel mixture back towards the carb.

The nylon mesh filter on the left is not for dry, dusty cutting conditions. This filter is for wet, snowy, winter cutting, and is designed to help reduce icing in the carb. The operator will need to maintain the saw well, and prevent cutting dust from the bar and chain from accumulating. Wood dust will go through this element.

The flocked filter is recommended for most chain saw cutting applications. It will need to be brushed off carefully and inspected for wear. When the flocking is worn away as in the picture on the right, then the element will need to be replaced.

4203 Bearing Failure Due to Dirt Ingestion

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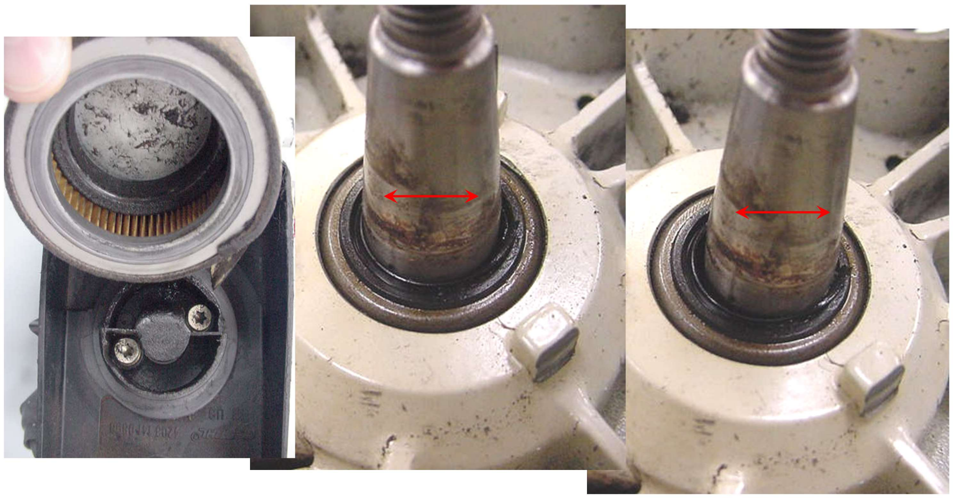

This BR 400 has three years of commercial run time on it. It has also suffered from a considerable amount of dirt ingestion due to lack of maintenance of the air filter.

Both bearings are extremely loose, allowing the crankshaft to move, which caused the starter side seal to fail. This created an air leak, which let the unit run lean and lose power.

The failure also allowed excess vibration, and on the impeller side of the crankshaft the bearing is loose in the case, so the cost of repair exceeds the value of the unit.

Maintenance and service would have allowed this machine to last longer than it did.

Dirt vs. Run Time

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The piston on the right from a TS 420 is a good example of long term fine concrete dust ingestion. All the machine marks are worn away, the ring end gap is excessive, and even the dowel pins that prevent the rings from rotating are worn away which is why the engine finally failed, due to the ring clipping in a port.

The piston on the left is from a BR 400 used by a homeowner almost daily to blow off a tennis court, for several years. While the machine marks are worn away and the piston actually rocks back and forth in the cylinder, notice how shiny the surface is. This is just wear and tear from run time. When the starter rope is pulled through the piston makes a clapping sound due to the slapping action of the skirt hitting the cylinder wall. The air filter was soaked with fuel because much of the air fuel charge was pushed back through the carb as spit back, because the skirt was so worn it could not seal off the intake port when trying to build primary compression in the crankcase.

Improper Heat Range Spark Plug Installed
BR 420

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Spark plug heat range is very important to an engine. Always verify if the plug installed is the right one when doing an evaluation of an engine.

Both of these plugs were installed in a BR 420. The complaint was that the engine ran erratically at WOT, and when the stop switch was turned to the off position, the engine continued to run. Then it popped and backfired before stopping completely. The tip of the plug was glowing so hot it continued to ignite the fuel mixture after the ignition was no longer providing any spark to the plug.

Too hot of a heat range will cause these kinds of problems, and if the plug tip melts away, as in the picture on the right, damage to the piston and cylinder may occur. It is also possible to burn a hole in the top of the piston.

Too cold of a heat range may cause hard starting, or foul out easily.

No Deflector, Line Length Excessive

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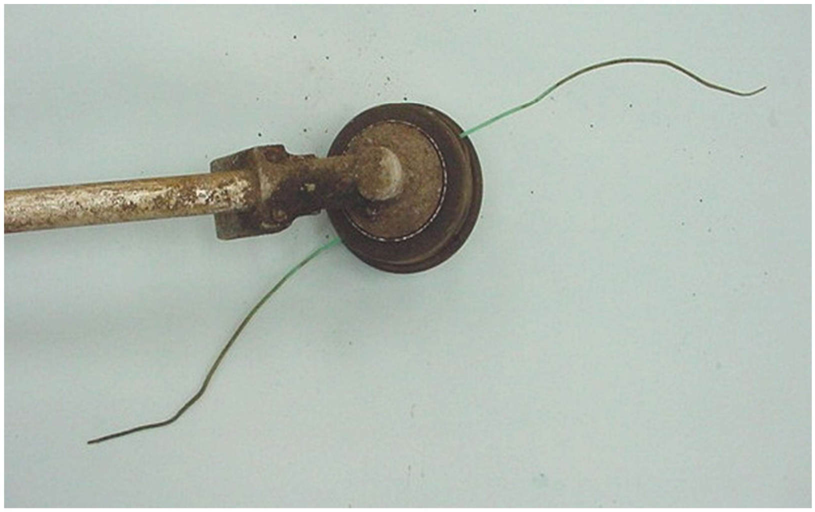

The deflector is necessary not only to provide some protection to the operator from thrown debris, but to limit the line length. Running the line longer than specification will drastically lower engine RPM, increase spark plug temperature, and increase fuel consumption and emissions.

Improper Line Length FS 80

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- Wrist Pin is Extremely Loose

This example is from a trimmer that was operated without a deflector so the line was too long, causing the engine to run well below it's rated speed. The oil was also mixed too rich. The carbon buildup is so severe that it caused the wrist pin bore to wear and the piston is extremely loose. When the engine is lugged the temperature goes up, in some cases by as much as 100º F, which causes the oil to "coke" and burn, and creates the deposits seen here. The transfer ports are so clogged that the port timing has been changed: they now open late and close early. An air cooled engine needs to run at the rated speed to keep cool and be efficient. For a FS 80, the rated speed is around 9500 RPM.

The chart below shows the results of a test done to determine the spark plug temperature and engine RPM as the line length was extended beyond what STIHL recommends on a FS 80 trimmer.

Line Length	Engine RPM	Spark Plug Temperature º F
.095 Line Correct Length	9500	431
.095 2" too long	8200	504
.095 4" too long	5400	511
.105 2" too long	7600	514
.105 4" too long	5400	542

FS 85 Exhaust Port Carbon Buildup

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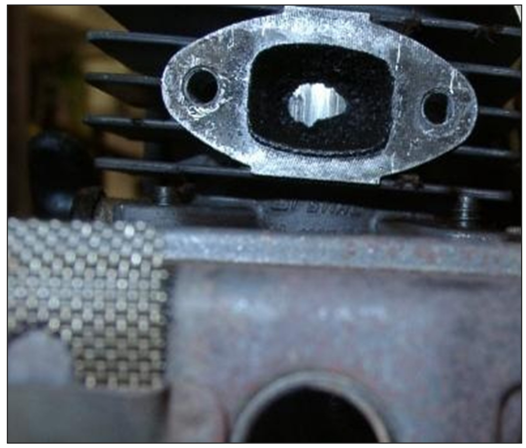

Exhaust port blockage can be caused by several factors, or a combination of things. Low quality fuel will cause carbon buildup. Stihl recommends 89 octane name brand fuel be used in all products. Mixing the oil too rich, or using a water cooled outboard oil or any oil not meant for mixing with fuel for air cooled engines can cause excessive and rapid carbon buildup.

Pre-measured oil should always be mixed in an empty fuel can. If even a small amount of fuel is left in the can it will increase the oil to fuel ratio, and if it happens repeatedly over time, can lead to an oil to fuel ration well below the 50:1 recommended by Stihl.

If the deflector is removed and the line length is too long, this will cause the engine to run well below it's rated speed of around eight to nine thousand RPM, and will cause the engine to run much hotter than it should, which will cause the oil to "coke" and lose it's lubricating ability.

MS 250

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- Notice that the rings are stuck flush and the skirt is heavily coked with carbon

Have you ever had a customer say, “Well, I’m an engineer and…”

This gentleman, an engineer, bought the MS 250 to cut some firewood. He carefully read the instruction manual and decided that the recommended oil ratio of 50:1 must be a typo because he believed the engine must need more oil than that to survive.

He used STIHL HP oil and mixed it with fuel at a ratio of 25:1.

After 2 cords of wood he brought the saw to his dealer with a no start complaint. The saw had no compression due to the rings being carbon seized in the lands. Even a good quality oil will coke up and cause this sort of problem when mixed too rich.

Other Failures: Carbon Scoring BR 420

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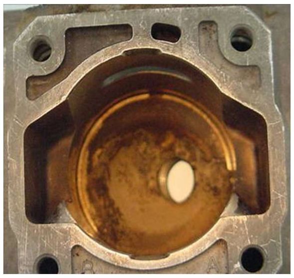

Carbon buildup in the exhaust port breaks off and is caught between the skirt and cylinder wall.

The piston is softer than the cylinder wall so most of the damage is to the piston.

This type of scoring is usually found on the exhaust side of the piston skirt, and there is usually no metal transfer to the cylinder wall.

Blowers are more prone to carbon buildup due to long running at a steady RPM under load.

Thermal shock will lessen carbon buildup in trimmers and saws, but they can still be damaged if carbon buildup is excessive, due to incorrect oil mix ratio, low quality fuel, or not operating at the rated RPM under load. Carbon buildup does not necessarily come from oil alone, unless it is mixed too rich. Lugging the engine, such as having the line too long on a trimmer, will increase carbon buildup. Low quality fuel will cause excessive carbon buildup. All STIHL engines should be operated on 89 octane fuel from a brand name source.

Other Failures: Water Scoring 044

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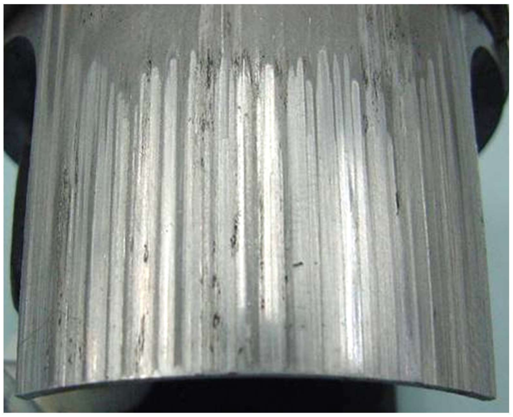

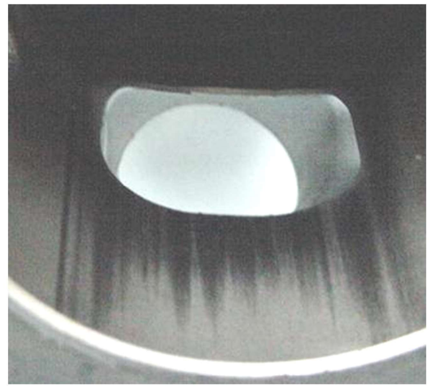

Water scoring will always be located on the intake side of piston.

This typically occurs on saws, mainly due to using an open mesh air filter while cutting in snow or wet conditions.

It can be caused by operating the unit in the rain, or in high humidity; moisture condenses out of the air due to the carb being cold from the pressure differential caused by the high velocity air in the venturi.

Carb icing occurs in the same situation, and if the carb doesn’t ice up enough to cause the engine to stop, enough moisture may accumulate to cause water scoring.

Water rinses off the oil film, causing a lack of lubrication and allowing metal to metal contact.

Similar effects may be caused by alcohol and ether.

TS 410 Water Ingestion Through Stratified Scavenging Ports

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- This unit was being used to cut the bottom of a pipe in a hole with standing water, and the air filter was being submerged in the water which clogged up the filter

The filter was removed and the saw was operated without the filter, so the engine ingested dirty water.

The damage is spread around approximately 250º of the piston skirt.

The exhaust side is not scored. The water rinses away the lubricating oil and the dirt did what dirt does, and caused wear and scoring.

Other Failures: FOD (Foreign Object Damage)

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Often this kind of damage is mistaken for detonation, especially when the piston looks like the one on the left. Detonation will always be focused on the exhaust side of the piston, not all the way around the top. However, the damage may lead to sharp edges and hot spots that can cause pre-ignition and detonation, if the engine continues to run after the foreign object passes into the muffler or is ground up.

This damage is caused by the foreign object getting pinched in the squish band area of the combustion chamber. The piston in the middle picture was damaged by a ball from a main crankshaft bearing that came apart.

The foreign object may be a wrist pin circlip, or more commonly a piece of the big end rod bearing cage. It could be from the spark plug. It may be something from the carb or air filter area, such as a piece of a filter cover twist lock retainer, as is the case with the picture on the right, from a MS 200 T. In some cases a piece of metal may break off from inside the muffler and find it’s way back into the combustion chamber.

In many cases what the actual piece is or where it came from may never be determined, as it gets ground up and ejected, just leaving the damage behind.

“Bad” Fuel

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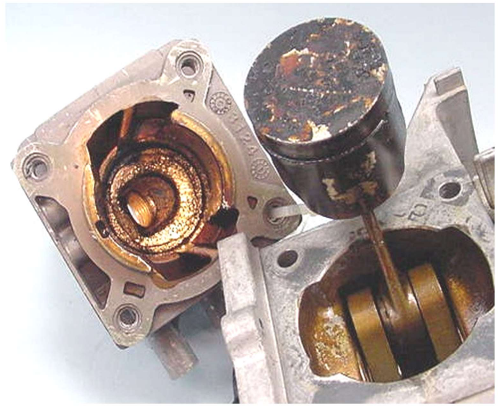

- This unit sat for 6 months
- The fuel oxidized and leaked into the combustion chamber and crankcase
- The engine was locked up and difficult to take apart

What happens when fuel goes bad, or becomes stale? Gasoline is a complex blend of chemicals, and as mentioned, the hydrocarbon chains are several carbon atoms in length. If any of those molecules break up into shorter lengths, which will happen with age, they are now light enough to evaporate off, or even work their way through a poly gas can or tank.

If fuel is open to the atmosphere, it reacts with the oxygen in the air, and oxidizes, or breaks down. Some molecules evaporate, some link up to form the gummy, varnish buildup and leads to the sour smell. Fuel will become darker as it oxidizes, and will overcome the dye in the oil mix, if it was present. A carb with an open float bowl vent is more likely to gum up than one with a closed vent. A gas can half full has more air in it than one full to the top.

Fuel stabilizer slows down the oxidation of gasoline, and extends the “shelf life” as well as controlling gum formation. It does not change the octane or fix fuel that is already stale or old. STIHL fuel stabilizer also provides fuel detergency, corrosion prevention, and water removal, and will help keep the entire fuel system clean.

FS 80 Operated on Stale Fuel

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- This unit was operated on fuel that was over 6 months old
- It was hard to start and the mixture screws had to be opened to keep it running
- After 2 tanks of fuel the engine died due to a fouled spark plug
- Notice the heavy deposits on the piston and plug

This was a new engine that was running fine and was tuned properly.

Oil was mixed with some fuel that had sat in a poly five gallon fuel container for two years. The fuel had a very sour smell, was dark red in color and was thicker than fresh fuel. The can was full when it was purchased, but the fuel level had dropped almost half, due to permeation losses.

The trimmer would run on this mix, after the carb had the H screw richened to keep it running, however, it smoked heavily, had very low power and stalled often when trimming grass. The RPM was very erratic at WOT. When the engine stalled while trimming, it had to be choked to get it started again. Two tanks of the stale fuel was run through the engine, and then it was disassembled to inspect it.

This is what the top of the piston and the spark plug looked like. There was no evidence of detonation or scoring. The piston and cylinder were cleaned thoroughly and put back together, and with fresh fuel, a new spark plug, and a carb adjustment it ran fine.

Carburetor Failures

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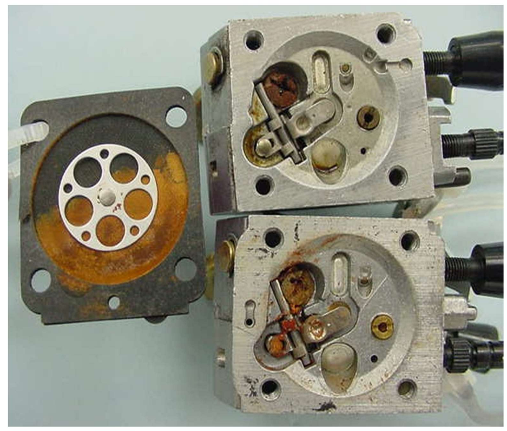
Operated With Mounting
Screws Loose

Evidence of Water in Fuel



When evaluating a carb, always give it a good visual inspection. The carb on the left was from a trimmer that was operated for a long time with the mounting screws loose, so it had an air leak, as well as ruining the carb body.

The carbs on the right sat with water in them. No attempt should be made to repair any of these carbs. Always open up a carburetor and inspect the fuel pump side filter screen and verify that it is not restricted.

On the metering side inspect the small screw that holds the inlet lever shaft in place. It should always be bright and shiny. If it is discolored or rusty the carb should be replaced. This is just the damage that can be seen on the outside. The passageways and internal check valves will most likely be corroded as well.