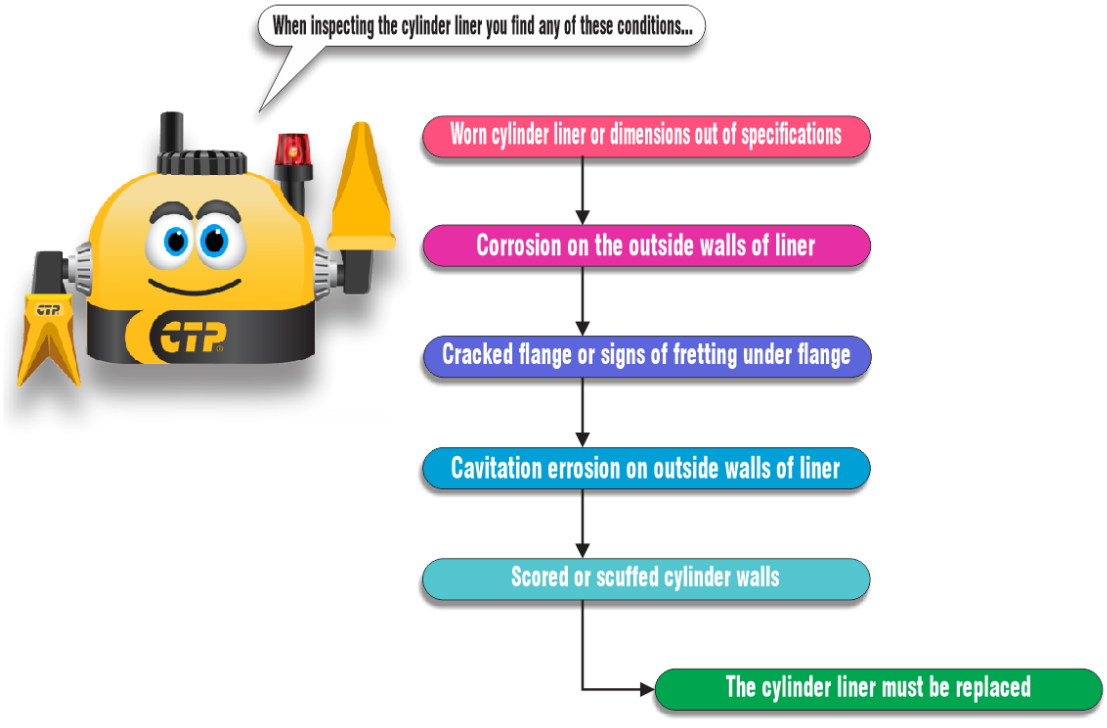
The engine liner is responsible for housing and creating a perfect seal for the piston ring assembly and containing the combustion pressures during operation. Due to these very important functions, the cylinder liners must be in excellent condition for the engine to run properly and economically, if they are not, they should be replaced.

But how do you determine if replacement is necessary?

After removing and cleaning each liner, examine the liner's condition carefully by looking for these signs:



Liners

There are two types of cylinder liners in diesel engines; Wet liners and Dry liners |repair sleeves|. The first thing to do is to determine the type of liners in the engine being rebuilt. Wet sleeves are in full contact with the coolant, they contain grooves for coolant/oil seals and are fairly easy to remove or pressed into the block. Dry liners, as the name implies do not make contact with the coolant and normally require machine shop work for replacement.

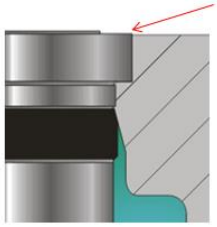
Wet or dry, they both have certain advantages and disadvantages.

Wet sleeves |wet liners|

A wet sleeve is essentially a stand-alone cylinder, supported at the top and bottom on the block, and surrounded by coolant, the engine coolant is in direct contact with the outside wall of the sleeve. There is no supporting bore structure around the sleeve, the sleeve has to be thick enough and strong enough to withstand the pressures and forces of the combustions.

Wet sleeves, or wet liners as they are often called, are different than dry sleeves |repair sleeves|. The main advantage of a wet sleeve is, that it allows any or all of the cylinders to be easily replaced, if one or more cylinders are worn out or damaged. Having this flexibility greatly extends the potential service life of the engine. A wet sleeve installation does not normally require any machining of the block.

Not requiring machining for installing new wet liners is a huge advantage. However, there is one critical requirement that must be checked in order to guarantee a perfect seal between engine block and liners, this is measuring the liner projection. Liner projection is the distance the cylinder liner flange extends above the deck surface of the engine block. This distance, when measured is about .004" (0.102mm) or the equivalent of the thickness of a dollar bill (check original equipment manufacturers specs) . This projection is what keeps the liner in place and seals the assembly. Liner projection is extremely critical to the engine's performance; too little projection will not provide enough "crush" on the fire ring of the head gasket this could lead to a burned head gasket. Too much projection, the body of the gasket will not have sufficient squeeze to seal properly and this could lead to a coolant leak. Distortion, wear, or breakage may also result if a liner flange is not properly seated. Causes of improper liner seating may be debris, metal chips, nicks, burrs, or improper machining **fi**llets under the liner flange.



Generally the top of liner flange must be .002-.005 in. (.005-.012 cm) above top surface of block

(A dollar bill is .004 in. thick)

Dry Liners |repair sleeves|

Some diesel engines like the Yanmar®, Cummins®, and Cat® (3208, 3116, C7), have no removable liners or sleeves. These engines are known as “Parent Bore” engines, in other words the cylinder is part of the block when the block was cast at the foundry. When the cylinders in these engines are worn out, become oval and out of spec, you simply cannot replace the liners. In order to rebuild these engines, the cylinders must be machine bored to accept a “Dry Liner”, also known as a repair sleeve. Repair sleeves are available in many thicknesses, the most popular sizes being 3/32” (0.094”) and 1/8” (0.125”) wall thickness. When the engine block is machined to accept a repair sleeve, the block must be bored to the diameter of the repair sleeve, minus .0005” per inch of bore. For example, when installing a 4” diameter O.D. sleeve, the cylinder [on the block] being bored must measure .002” less in diameter I.D. (3.998”) than the sleeve, this is known as “interference fit”. Interference fit is where the sleeve is slightly bigger in diameter than the bore. This interference fit tightness is what helps keep the sleeve in place and creates a good contact between the sleeve and the block for heat dissipation. This interference fit requires that the sleeve be pressed using a hydraulic press. Machine shops often use dry ice to super cool and shrink the sleeves, to aid pressing the sleeve into the bore.

To ensure proper cooling of the engine, the liners require a clean contact surface between the liners and the block. Particles of dirt between these surfaces cause air spaces, which are poor conductors of heat. It is also recommended to not use any oil lubricants to aid the installation of the liner, as films of oil or grease trapped on these mating surfaces can also impede the conduction of heat.

Material Used in Cylinder Liners

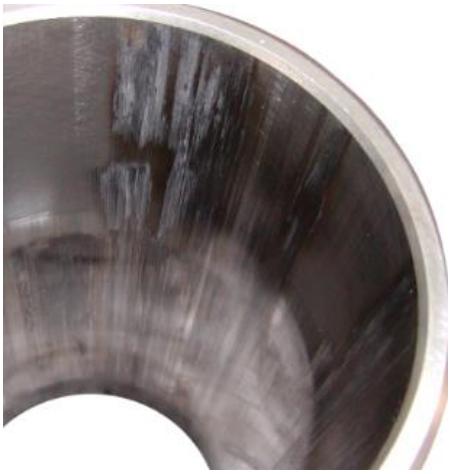
Cylinder Liners requires them to be made of high strength alloys. Wet Liners are generally made up of grey cast iron material, a very strong material for this application. Newer high horsepower engines require wet liners to be made out of high strength steel alloys. Dry Liners material composition mostly includes Cast Iron with Ceramic-Nickel compounds which gives it several strength features which are not found in wet Liners.

Removal & inspection

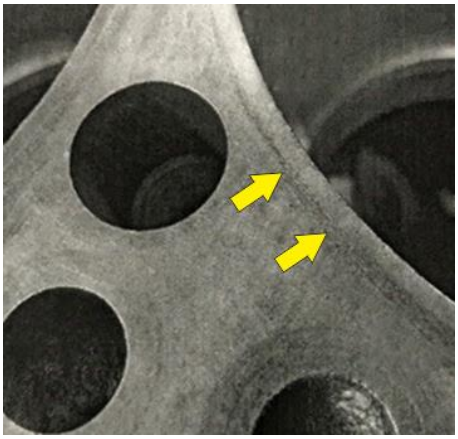
It is important to note that damage to the cylinder liner and to the block may occur if the proper tools and procedures are not used when removing the liners. If cylinder liners are going to be reused, you must mark each liner to the corresponding position and piston, so that they can be re-installed in the cylinders from which they were removed. Also note, whenever cylinder liners are taken out from an engine, they should be stored in an upright position, cylinder liners stored on their side for an extended period of time can become distorted.

Before inspecting the liner, it must be thoroughly cleaned. Once this is done, it is time to inspect the liner. Check the cylinder liners for cracks, scoring, fretting or cavitation erosion.

Cracks on wet liners usually occur under the flange area. This can be caused by numerous reasons. However, the number one cause for flange cracks, is improper seating of the liner flange on the engine block. Cylinder liners may also crack due to poor cooling. Improper cooling, which generally results from restricted cooling, or scale formation on the surface of the liner, may cause hot spots, resulting in cracks due to thermal stress.



Scoring or scuffing may be caused by broken piston rings, lack of lubrication, contaminated oil, or high piston temperatures. Lack of lubrication and high piston temperatures can cause the piston skirt to transfer metal between the piston and the cylinder wall. Debris entering the combustion chamber can also cause scoring. Dust particles drawn into an engine cylinder will mix with oil and become an effective but undesirable lapping compound that can cause extensive damage. The importance of keeping the intake air clean cannot be overemphasized.



Fretting is when the underside of the liner flange gradually wears by rubbing against the flange seating area when the liner is loose. Fretting is caused by improper liner projection, a lose liner can vibrate and move, this leads to fretting of the underside of the liner flange. The liner slowly wears away at the surface of the block, damaging the block by creating a ledge. The block will need to be machined in order to remove the depression.

Cavitation erosion results from poor cooling system maintenance or lack of Supplemental Coolant Additives (SCA). SCA's are chemical additives that are added to the coolant, as either a liquid or powder form, to charge the system's coolant and fortify the coolant's anti-corrosive properties. Cavitation erosion If uncorrected, will eventually perforate the liner. This can cause combustion gases to enter the cooling system, or coolant can enter the crankcase, and contaminate the engine oil. Worse yet, coolant can enter the combustion chamber and lock the engine. When this happens, since fluid cannot be compressed, the piston is prevented from reaching the top of its stroke. This effectively "locks" an engine's rotating assembly to a jarring halt. This is commonly referred to as 'Hydro-lock". In most cases the impact of this force can bend the connecting rod.

So how do I know when to replace engine liners?

If cracks, fretting, scoring or erosion are found, the liner must be replaced. Liner replacement is part of the engine remanufacturing process and if done correctly the engine will be 100% new.