Cylinder Lining Leakage – a known issue with Traction engines

At the launch of the Traction Avant in 1934, the revolutionary engine design was one of the much-praised features. It had overhead valves and so-called “wet” removable cylinder sleeves. The former contributed to a higher engine efficiency compared to the conventional L-head design (in simple terms: more power per cubic inch), the latter was said to make replacing worn pistons and sleeves easier. Well, they were right at that! We owe it to this design that our Traction engines are relatively easy to overhaul, even 70-80 years later. For Citroën, who for sure weren’t planning on building cars that would last as long as that(!), the lower cost of the less complex iron casting will no doubt have played an important role as well.

There is one consequence of having wet removable cylinder linings: the risk of coolant leaking into the oil sump through the foot seals. Contamination of the engine oil with water or engine coolant is highly undesirable, as the lubricating characteristics of the oil will deteriorate rapidly, with the possibility of serious engine damage as a result.

How is it meant to work?

In order to better understand what can go wrong, it is useful to have some idea of the general concept of wet cylinder linings. The cylinder linings themselves are made out of cast steel. The inside of the lining is bored to exactly the diameter of the piston (78 mm for most Tractions), which will fit inside the cylinder with a clearance of 0.05-0.07 millimetre.

The linings fit into the cast iron engine block and each of them has a machined rim that sits onto a machined flange inside the block¹. Topside the linings are held in place by the cylinder head which holds them down tightly onto their seats, creating a solid bond between the engine block, the linings and the cylinder head. The latter is quite important as the forces of the moving pistons and the energy that is released by the combustion process are quite considerable. It is obvious that the slightest movement of the linings would create all sorts of problems of which leakage of fluid or compression are only a minor ones. Even the most perfectly machined surfaces would not be able to prevent leakage of combustion air from inside the cylinders or leakage of the coolant that surrounds the linings from the outside. Air and liquid tightness is accomplished by using seals or gaskets made out of paper, rubber, cork, plastic or –in case of the cylinder head: heat-resistant material. There are many gaskets and seals to an engine but we will concentrate on the most important ones for the cylinder linings: the foot seals and the cylinder head gasket. The cylinder linings fit tightly in between them and from the above it will be clear that these gaskets are vital to ensure the proper separation of combustion air, oil and coolant.

¹ A slightly outdated design which was used by Citroën and Renault –and probably many other car makers until the mid-’70s. Nowadays wet sleeves are usually sealed by means of O-rings.
Gasket failures
Such gasket failures (rupture of a foot seal or a head gasket blowing out as a result of an overheated engine) unfortunately do happen with our engines from time to time, but can be largely prevented by ensuring a correct treatment and assembly of the various parts in the case of a repair or an overhaul. There are Traction engines still running which were never taken apart in their entire life, so here is nothing wrong with the design itself.

Alarming message from Switzerland
A friend from Switzerland sent me an e-mail explaining that the engine of his 15-Six had developed a serious leakage of coolant into the oil sump. The oil level float (only the Six engine has one of these) stood well above the top of its holder which indicated that several litres of water had been added to the oil. This was the more frustrating, since the engine had undergone a partial overhaul only two years before. The owner had been complaining about smaller leakages of water, but it appeared that after a strenuous trip in the summer where the engine had been really hot (although not overheated), all of a sudden the leaking had become a lot worse. One or more foot seals of the cylinder linings were our prime suspects. In order to not leave my friend to have to cope with such a problem all by himself, and understanding his frustration from my own experience several years ago, I offered to drive down to Switzerland and help him take the engine apart — which is always a tedious and usually quite dirty job to do.

The good news is that after only three days of hard work — the engine + gearbox had already been lifted out of the car before I arrived — the engine was back in the car and running nicely with oil and water now being kept separate as they should. Several hundred km have been driven with the car in the meantime and the situation has remained the same — which is good and encouraging, but there is still some care to be taken by the owner.

Our approach of the problem
For now I will concentrate on the matter of the cylinder linings and their seals as that appeared to be the cause of all the trouble with this engine — as expected. I know for a fact that other Traction engines suffer from the same problem which usually occurs after an engine overhaul or a replacement of the cylinder head gasket. The latter, head gaskets, usually blow through in between two cylinders when an engine is overheated. The gasket material is no longer capable of resisting the heat and disintegrates. As a result, the engine will start to run poorly and coolant is likely to leak into the combustion chambers and evaporate through the exhaust, leaving a trail of smelly white smoke. Foot gaskets will develop leaks if the sleeves are not held down to their seats with sufficient pressure from the cylinder head. This usually happens as a result of insufficient re-tightening of the cylinder head bolts after a gasket replacement. The sleeves will then be allowed to move on their seats and it takes only a fraction of
movement for a leak to develop. At first there will be only a few drops, but an occasion like a strenuous trip on a hot day, can be the final blow that opens the tap so to say.

When this engine had been overhauled two years before, the grinders had not removed the sleeves from the engine block, but had used M10 bolts and large washers to secure them to their seats while the block was being handled for the fitting of new main bearings. After its re-assembly the engine had been test-run at the repair shop and the cylinder head had been re-tightened a couple of times in the weeks that followed, but that may not have been enough to prevent the leakage from developing. On examination of the seats after we had taken the linings out, we learnt that even the most careful re-tightening could not have prevented this from happening.

When we inspected the head gasket after taking off the cylinder head, there appeared to be no traces of leakage through or past it, which once more pointed at the seals down inside the block. After removing the cylinder linings—they were rather stuck by rust so we had to use a self-made wooden tool to knock them out from below- there were a couple of things that struck me:

**Condition of the engine block and the cylinder sleeves**

First, the inside of the block was full of rust and rusty sludge. The cylinder sleeve on the picture shows how filthy it was on its outside. It also shows rusty traces of water leaking along its lower section, where the sleeve sits inside the lower part of the engine block. The primary cause of the rust was the fact that the owner appeared to be using water from the tap with anti-freeze as a coolant. I always strongly recommend to use only a ready-made cooling fluid, as these have anti-rust additives in them. The rusty sludge no only clogs the cooling jackets, it also creeps into the seams of the cylinder linings down below and adds to the risk of leaks developing an that area.

Second, the sleeve seats down inside the engine block did not look particularly good. They were quite dirty and—more worrying- their surfaces were quite severely pitted by corrosion. The original cast iron had been eaten away all around the edges of the seats. This type of corrosion happens to many metals and is enhanced by the minerals in the cooling fluid—particularly if water is used!- and by the constant temperature changes that occur inside the engine. There was no way we could just replace the foot seals and re-install the linings.

**How to rectify the surface of the seats**

Unless I would manage to hand-grind the seats sufficiently to create a level surface all around the circumference, the block would need to go to a machine shop to have the seats rectified mechanically. Depending on
the amount of material that would need to be ground off down below (which could be anything from a couple of hundredth to possibly tenths of millimetres) the top surface of the engine block might have to be machined as well, to avoid later problems with setting the linings to their correct height.

As can be seen from the pictures, I used an old cylinder sleeve and a hard wooden block which I had wedged into it, to grind the seats with the use of valve grinding paste. I did not use the “real” sleeves until the very end of the process when I fine-ground each one of them to ensure a perfect fit.

The first thing that needed doing was to grind off enough material from the surface of the seats to create an even surface all around, no matter how small this would be. That took some steady grinding with the use of as coarse an agent as possible. As can be seen from the pictures I did manage to get the job done without having to resort to mechanical grinding—which would have been an outsourced job. The pictures of the cleaned surfaces still show quite a lot of pit-corroded spots around the outside of the seats, but with the use of flexible sealing paste and of course new seat gaskets I believed it should be possible to create water-tight seals—which fortunately turned out to be true.

There are people who believe that the sleeves should be fitted with just the dry the foot gaskets, but with the pit-corrosion which is unavoidable in old engine blocks like these, this to me would be a recipe for disaster. Also the old-fashioned method—as per the workshop repair manual- of soaking
the paper gaskets in linezolid can no longer be used with the ultra-thin gaskets which are cut out of plastic foil.

**Measuring and ensuring the required over-stand**

Before the sleeves are re-installed onto their cleaned seats their height in relation to the face of the engine block needs to be checked and properly adjusted by varying the thickness of the foot gaskets. For the 15-Six engine the repair manual prescribes that the sleeves should stand over the face of the block by 0.09 – 0.14 mm with a variance of no more than 0.03 mm all around. In this particular case, foot gaskets of 0.15 mm resulted in the sleeves over-standing the engine block by about 0.12 mm, which is well within the tolerance.

**Use of Sealing Paste for the sleeve gaskets**

As can be seen from the pictures, a thin coat of sealing paste was applied to the sleeve, then the gasket was carefully slid around the lower part, upon which a second equally thin coat of sealing
Apply a thin coat of Sealing Paste before and after sliding gasket onto sleeve. Then carefully lower the sleeve into its proper bore hole in the block and allow it to settle down by its own weight.

Pistons with connecting rods are lowered into their respective cylinders from above. The piston ring slots are to be evenly spread and a ring compression collar is to be used. Make sure both the piston and the cylinder wall are well oiled and carefully slide the piston down by gentle tapping with a wooden piece. Connect rod bearings with their slots oriented the right way (= towards the camshaft) and tighten bolts at 5 kgm (49 Nm).

**Temporary hold-down of the sleeves during further assembly of the engine**

The latter is necessary to hold the sleeves firmly in place when the pistons are being lowered into the cylinders from above and the rod bearings are re-connected to the crankshaft. The crankshaft needs to be turned round to have the bearing taps in the right positions for fastening and tightening the caps\(^3\) and the linings would otherwise be pushed off their seats by the upwards-moving pistons during that process. Once all the pistons have been re-installed and during the time that the engine is being prepared for re-fitting the cylinder head, the crankshaft shall not be moved under any circumstance—at the risk of one or more sleeves being moved and leaks becoming unavoidable.

This particular engine still had stud-bolts with nuts for fixing the cylinder head (by no means a poor method of holding a cylinder head in place!) which meant that the temporary M10 bolts had to be

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\(^2\) As the existing cylinder sleeves, pistons and rod bearing shells were to be re-used, every part was meticulously marked and numbered upon removal. All parts should be kept together and re-installed in exactly the same places as previously.

\(^3\) Tighten at 5 kgm (49 Nm) for rods with loose shells.
removed and the stud-bolts had to be inserted and tightened (using moderate force only). The new head gasket is fitted with its smooth side facing downwards and the cylinder head is lowered over the bolts. A washer is to be fitted between each stud-bolt and the tightening nut. The (in this case: 18) nuts are to be tightened using a torque wrench precisely in the order prescribed in the workshop repair manual, in two consecutive rounds. First all the nuts are tightened at 3.0 kgm (29.5 Nm), at the second round they are further tightened at 5.5 kgm (54 Nm). Then the pushrods are re-inserted and the valve clearance is temporarily set at 0.20 or 0.25 mm for all valves.

Preparing the engine for operation
After the engine has been completely reassembled (make sure not to forget anything!) and the power plant has been re-installed in the car, together with the radiator and the coolant pipes, it is time to fill the engine with oil and coolant. Set the ignition timing as prescribed but leave out the spark plugs for the moment. Feed some engine oil into each cylinder through the spark plug hole. Now, crank the engine using the starter motor until you can see the oil pressure gauge (most cars have one nowadays) starting to read. Continue to crank for a short while to allow fresh oil to be fed into the bearings. This will ensure a proper lubrication of the bearings from the moment the engine fires and starts to run. Install the spark plugs and the cables and start the engine up. Some blue smoke will emerge from the exhaust as the oil inside the cylinders burns up, but this will disappear soon.

First re-tightening of cylinder head
Run the engine at slightly above idling speed for about 15 minutes (temperature
must have reached about 65° C), then turn it off and let it stand for a couple of minutes to allow an even spread of the heat through the cylinder head. Then, one after the other, unscrew each cylinder head bolt (or nut) by one-quarter turn in the prescribed order and re-tighten it at 5.5 kgm (54 Nm) again. The tightening turns will be considerably longer than the loosening turns—which indicates that the head is effectively being lowered and that the gasket is being compressed by this re-tightening action. Re-adjust the valve clearance, now to the prescribed values (0.15 mm for intake and 0.20 mm for exhaust on the 15-Six engine). One will notice that the valve clearance will have decreased significantly as a result of the re-tightening of the cylinder head. As the length of the pushrods will always remain the same, the head being pushed further down onto the block will always mean that the valve clearance will decrease as a result.

Re-tighten and keep re-tightening... Use Valve Clearance as an Indicator!

Now comes what I believe to be the crux of the entire operation—that is any engine repair job which has involved replacement of the cylinder head gasket. Repeated re-tightening of the cylinder head bolts (or –nuts) will be required until such time as the valve clearance will not have dropped as a result of the last re-tightening. That then indicates that the head gasket is fully compressed, and no further re-tightening will be required thereafter.

The following re-tightening schedule—with an increased number of rounds and initially with shorter intervals than prescribed in the repair manual—has proven to bring me good results:

<table>
<thead>
<tr>
<th>KM</th>
<th>Actions to be taken</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>Initial cold tightening of head bolts, first at 3.0, then at 5.5 kgm (29.5 and 54 NM respectively). Temporarily set valve clearance at 0.20 or 0.25 mm</td>
</tr>
<tr>
<td>0</td>
<td>After running engine for about 15 minutes (65° C), re-tighten at 5.5 kgm (54 Nm). Then set valve clearance at correct values (0.15 and 0.20 mm for intake and exhaust respectively on a 15-Six engine)</td>
</tr>
<tr>
<td>100</td>
<td>Run engine or let it cool down to 65° C and re-tighten at 5.5 kgm (54 Nm). Then set valve clearance as above. Checking and setting the valve clearance is an absolute must after each re-tightening of the cylinder head!</td>
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<tr>
<td>250 - 300</td>
<td>Same as 250 - 300 km</td>
</tr>
<tr>
<td>800 – 1,000</td>
<td>Same as 800 – 1,000 km. If upon re-tightening it is found that the valve clearance has remained the same, no further tightening will be necessary, else re-tighten once more at 1,500 km</td>
</tr>
<tr>
<td>1,500</td>
<td>Same as above. If needed, re-tighten once more at 2,500 km</td>
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Conclusion

As a conclusion I can state that the problem of leaky cylinder linings of a Traction engine is curable—and avoidable in the first place. It takes some understanding of the design, of the situation and of the fact that a 70-year old cast-iron engine block may have suffered from rust or pit-corrosion in the sections that are vital for keeping the situation air- and watertight. People who undertake to overhaul these engines—including professionals—should be aware of these and other issues which may have developed over time and should undertake to cure them—which is easiest to do if one has a fully dismantled “naked” block to work on. Cutting corners with the foot seats—in combination with poor or insufficient re-tightening of the cylinder head is likely to cause leakages sooner or later.

Avoid Risk when installing an engine that was rebuilt and then left unused for a long time

Any professional engine restorer should test-run an engine after it has been re-assembled. The initial re-tightening of the cylinder head bolts (or –nuts, see second box of schedule) should at least have

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4 The modern non-asbestos head gaskets appear to be of a softer material which requires more frequent re-tightening for them to be fully compressed. Once the new gasket is fully compressed it is supposed to last as long as an original one.
been done before the car sets off for the road, and the customer should be advised that re-
tightening will be necessary at regular and initially rather short intervals to avoid problems. If a
restorer does not have a test facility for engines he should tell the customer so. Sometimes rebuilt
engines haven’t been test-run and are stored for a long time before they are actually started up for
the first time. Unless the owner is exactly aware of what was and what was not done (he should
always try to attend the initial test-run and personally make sure the first re-tightening is carried out
properly), it is wise to remain on the safe side and act as though the cylinder head has never been re-
tightened. One will find out soon enough whether or not the valve clearance will have decreased
following a re-tightening. If it remained the same, you know there is no need for further action in this
respect. If it did decrease, after reading this article you will know what needs doing.

Karel Beukema toe Water

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The 15-Six (Familiale) during its initial test-drive