ANALYSIS OF LUE OIL – PART TWO

by John Martin and Robert Patton

In Issue 54 we started talking about the cause and effect of the lower 2007 diesel emission requirements. To examine the changes to lube oils we contracted with a "hired gun," John Martin, formerly (25 years of service) of Lubrizol Corporation.

For those not familiar with Lubrizol,it is one of a handful of companies that make and sell the additive package that goes into the finished product, the one gallon lube oil jug.

More on John's credentials: He holds several patents and has published many industry-related technical articles. he is a past Chairman of the Cleveland Section of the Society of Automotive Engineers (SAE) and both a Recognized Associate and a Silver Spark Plug (their highest honor) of the Technology and Maintenance Council of the American Trucking Associations. He is a recognized lubrication consultant to both the racing (NASCAR and NHRA) and trucking industries.

We were fortunate to have John's article addressing the CJ-4 lube oil specifications. Then in Issue 55 John wrote a three page article that debunked several lube oil myths.

Last issue we blindfolded John and sent him oil analysis data from eight unused lube oils and asked him to comment. Astutely he picked the CJ-4 oil out of the bunch, identified the Exxon/Mobil oil by its unique blend of additives, and used price logic to determine the lube oil from Wal-Mart. He didn't hold anything back when he stated, "I wouldn't cross the street for a free crankcase of oils 3 (the Exxon/Mobil Delvac 1300 Super CI-4 plus) and oil 4 (the Shell Rotella T that meets the new CJ-4 specification) unless I was running a fleet of busses or garbage trucks."

John commented on all eight of the lube oils with his favorites being oils 1 and 8. Oil 1 was the Cummins Premium Blue CI-4 plus and oil 8 was Shell Rotella T (synthetic) CI-4 plus. Price dependent, John's choice was oil 1.

At the conclusion of the article we promised that we would add more oils to the survey. And we did. From mail-order to tractor dealer, to truck stop, to European diesel oil, we added 13 more lube oils to the test.

Before I share the results it is necessary to establish the ground rules. For those of you that have good recall you can skip this section.

Ground Rules

I've been reminded that each quarter we have new members that may not have access to the previous material. Therefore, before you look at the results of the oil test (or any test or article written for your consideration) one has to wonder if there is an agenda hidden behind the data. Do I have a hidden agenda here?

Most assuredly, no. I have several friends in the lube oil manufacturing and retailing business. The TDR has lube oil advertisers. I cheer for race teams with lube oil sponsorship and livery emblazoned on the sided of the race car. Lube oil companies sponsor many of the diesel drag race and diesel sled pull competitions in which the TDR audience participates.

When new lube oil is analyzed you can get a good idea of the quality of the additive package that, as learned from Martin's experience, makes up 20-25% of the lube oil blend. Maintaining viscosity at higher temperature, maintaining high alkalinity and protecting against wear with the right blend of molybdenum, zinc, phosphorus, and boron are important lube oil attributes. Readings for calcium are a way to measure dispersion detergency.

In a blind-sampling-from-the-bottle test done by Trailer Life magazine in January 2005, I was greatly disappointed to see that Wal-Mart Super Tech 15W40 diesel oil stood toe-to-toe with other very respected brand names.

Why disappointment? First, consider what John Martin said in Issue 54, "Consequently there is less and less difference between engine oil that barely passes the API certification test and one that is designed to pass by a significant margin. Therefore, oils meeting a given performance spec (example API CI-4+) are approaching commodity status."

Second, I am not a big fan of Wal-Mart. I could go into a long tirade but I will refrain.

Third, for all of my vehicle ownership years (let's see, that is about 36 years) had I been duped? Had I fallen for the marketing hype? Or as we know, the focus on lube oil base stock versus the importance of the additive package changed over the years. Is this a good excuse? I do not want to believe that lube oil is just a commodity. Yet the Trailer Life grid did not lie.

Your thoughts? How about this, "Well, Mister Editor, you've established that the test is unbiased. But, if you are not going to change what a person believes, why bother?"

Good observation and question. The answer, "I'll spend the money on lube oils and analysis so that John Martin and I can have data to debate and discuss. If by chance the data might enlighten and educate others, then so be it."

JOHN'S COMMENTS

Well, I see my reward for interpreting oil analysis data on eight samples (TDR 56) is 13 more samples to analyze. Is the editor trying to trip me up or have me assassinated by irate oil company executives? Perhaps they will just try to buy me off – we all know they have plenty of money!

Before we start, I need to explain something about my interpretation of the oil analysis. I can only analyze how I think each oil will perform based on its additive composition because none of these properties helps analyze base stocks. Having said that, recent API performance categories (CI-4, CI-4 plus, and CJ-4) have demanded oil performance levels which can no longer be met by inferior quality base stocks. I would venture to guess there is not one Group I base stock used in any of these oils.

Base Stocks

Oops, I realize that I've introduced a new term to the audience—base stock. You know, we've beaten the Performance Package to death and it's 15-20% of your lube oil's contents will be thoroughly analyzed as you look at the data. So, is the choice of lube oil as simple as a price per gallon/Performance Package comparison? How about the balance of your lube oil, the base stock?

Reflect back to the editor's statements, "for all of vehicle ownership years (let's see that is about 36 years) had I been duped?" An understanding of the 69-80% of your lube oil's base stock will answer the duped question.

Let me attempt to explain base stock in terms someone other than chemical engineer might understand. Lube oil base stocks were traditionally compounds of a certain boiling temperature range which are recovered when crude oils were boiled in a huge distillation column. Heavier distillation compounds include material such as road tar, and lighter compounds include such materials as diesel fuel and gasoline. The composition of lube oil stocks coming off a distillation column were a function of the crude oil taken out of the ground. Oil company types used terms such as "sweet" and "sour" crude oils to describe different crude oil composition (and different crude oil performance). In that era base stock quality made a significant difference to lube oil performance. Pennsylvania crudes were particularly good performers.

Over time refiners learned they could develop refining techniques which would either remove some of the "bad actors" in lube oil base stocks or enhance some of the better performers. We started to see higher quality base stocks simply because the refiners spent more time and money refining them. Lower performing base stocks were referred to as Group I, and higher quality stocks were referred to as Group II. In those days Group III stocks were mainly synthetic base stocks.

Reflect back to the editor's statements, "for all of vehicle ownership years (let's see that is about 36 years) had I been duped?" An understanding of the 69-80% of your lube oil's base stock will answer the duped question.

But refiners continued to improve mineral oil base stock quality. Some highly refined base stocks met the performance requirements of Group III stocks. At the same time, better synthetic base stock formulations were developed. This necessitated the formation of Group IV and V base stocks in order to distinguish between the performances of very good synthetic base stocks. Keep in mind that as base stock performance improves, the cost of the stock (and the oil) increase accordingly.

Today I would avoid any oil which utilized Group I (and preferably Group II) base stocks. Today's engines need better oils than that! Group III and Group IV base stocks give the kind of performance (Group III mineral oil and Group IV synthetic) you need in your truck. Group V stocks aren't really needed here unless you have money to burn.

The only real base stock issue today is whether you want to utilize mineral oils, synthetics, or partial synthetics in your vehicle. I prefer mineral oils, because they cost so much less than synthetics. Synthetics are only needed under extremely high or low temperature conditions or when you are after maximum horsepower or fuel economy. Partial synthetic oils make a good compromise in terms of both cost and performance. I use partial synthetics in my motorcycles because air-cooled engines are subject to greater temperature variations than water-cooled engines.

Finally, don't fall for the statement that synthetics can be cost-justified because they can be used for twice the normal oil change interval. This is simply no longer true. The additive package, particularly detergent, dispersant, and antioxidant levels, is the primary determinant of oil change interval. Also consider that extending oil change intervals is a gamble. You can monitor used oil data to determine if sufficient additive is present to continue, but one of the main reasons to change oil is to get contaminants (soot, sludge, etc.) out of your engine. Some contaminants, such as glycol, can cause a lot of damage in a short time.

13 More Oils to Analyze

Here are the 13 new oils for John to analyze. Prior to his receipt of the data I reminded him of his Issue 54 comment about an oil meeting an API performance specification becoming a commodity. As John discerns the new specification CJ-4 oils from those that are CI-4 and CI-4 plus it will be interesting to see if he stands by the "lube oil as a commodity" statement.

The chart now has 21 lube oils. The data is presented below:

Sample Description	Viscosity @ 100°	TBN	Calcium	Magnesium	Phosphorus	Zinc	Boron	Molybdenum
1	15.3	11.60	3964	14	1468	1541	148	112
2	14.7	10.30	3562	10	1449	1501	146	110
3	15.2	8.99	1379	921	982	1028	62	49
4	15.7	8.77	2488	8	1108	1147	37	2
5	15.1	9.02	3016	9	1179	1226	0	0
6	15.0	9.35	3146	9	1283	1333	2	8
7	15.0	9.20	3119	9	1251	1297	2	6
8	14.6	11.50	3631	12	1403	1435	0	1
9	14.6	7.61	1999	8	817	947	0	0
10	13.9	10.40	3028	8	952	1130	0	0
11	14.7	7.74	2011	6	876	1035	0	0
12	14.6	11.90	3420	15	1242	1466	139	86
13	15.7	11.20	3098	13	1179	1296	0	0
14	15.9	11.40	3396	20	1284	1350	143	253
15	15.4	10.50	2834	345	1328	1402	0	0
16	14.8	10.30	2877	13	1103	1164	127	89
17	15.7	7.82	1593	416	1156	1268	83	570
18	14.3	10.40	2946	292	1266	1368	16	369
19	15.4	9.87	2461	318	1251	1287	0	0
20	14.0	13.10	4321	20	1496	1583	0	781
21	13.6	10.50	2738	569	1068	1141	0	0

Least Favorite

Okay, let's talk about the oils in the table the editor provided. The first thing I noticed was a lack of total base number (TBN) in three of the new samples. Remember, TBN is a good indicator of the amount of detergent in the oil. Take a look at oils 4, 9, 11, and 17. These are relatively low TBN's for diesel oils, but high for passenger car oils. Oils 9 and 11 also have very low phosphorus (P) and zinc (Z) contents. Oil chemistries are very similar. I'm guessing that these oils are CJ-4 oils, and when you look at the amount of additive, you are less than impressed!

More on oil 17: Although it also has a relatively low TBN, contains more P and Z and both boron (B) and molybdenum (moly) oxidation inhibitors. You can bet your socks this is a CJ-4 oil, which relies heavily on oxidation inhibitors to achieve the required performance. Years ago both Caterpillar and Cummins had cam follower roller pin problems (corrosion) with oils containing molydisulfide, so I'd be cautious about using this oil in older Caterpillar and Cummins engines. I don't care for this oil because of its low calcium (Ca) detergent content, which is an indicator of the oil's ability to neutralize acids. Think of calcium as "Tums" for your engine! I'm going to group these three (9, 11, 17) along with oil 4 from the last report and speculate that these four oils are the new CJ-4 products. These receive the name of "Ho-Hum" and are my least favorite lube oils.

Best

Let's transition to the lube oils that I like the best. Boy, do I like oils 12, 13, 14, and 20! They are all loaded with big slugs of calcium detergent (greater than 10 TBN) and contain lots of P and Z. I'll bet they are all CI-4 plus oils! My least favorite of this group is oil 13, because it lacks the supplemental inhibitors the other oils contain. However, it's still a high performing Diesel engine oil. Group these (12, 13, 14, 20) along with oils 1 and 8 from the last report and I give these oils the category of best.

Within this group oils 12 and 14 are also excellent diesel oils supplied by two different additive manufacturers (notice the different P to Z ratios). Both oils use supplemental moly and healthy doses of P and Z. Robert told me that Oil 12 was much more expensive than oil 14, so I'll guess oil 12 is a synthetic.

Oil 20 has the most additive of any oil we've seen. This is very likely an expensive, but great, Diesel engine oil! Since the additive package is so expensive, I'll also bet this oil is a full synthetic. This is the best Diesel oil in our comparison, but don't use it in passenger cars or light duty Diesels. Recall that really high detergent Diesel oils sometimes don't offer adequate protection for sliding cam followers in these engines.

Good

Oils 15, 16, 18, 19, and 21 all fall into a group of oils with a TBN value of approximately 10 (as do oils 2 and 10 from the last discussion), which are probably of API CI-4 performance (not CI-4 Plus). Oils 15, 16, and 18 are my favorites of this group because they contain the highest levels of calcium detergent. Oils 16 and 18 also contain supplemental oxidation inhibitors, so I would rank them highest in this group. But oil 15 has high P and Z, so it's right in there also.

Satisfactory

Oils 19 and 21 bring up the rear of the 10 TBN group (oil 19 doesn't even quite get up to 10 TBN). Both oils contain magnesium detergents, which I mentioned earlier were better at passing laboratory engine tests than providing good field performance. Looking back at last issue I'll put these in with the oils 3. 5, 6 and 7 from the last table.

Okay, Robert has provided me with such an array of sample data that I'm forced to make a table to rank order performance. I'll fill out what I think I know about these oils from TDR 56. The editor completed the table by noting the API specification for each lube oil.

I'm also guessing there isn't one API CJ-4 oil above the Ho-Hum performance level. Use these oils only if you have particulate traps on your vehicles! In fact, some large fleet operators are running API- CI-4 and CI-4 plus oils in their 2007 engines. They reason that it is less expensive to clean their particulate traps more frequently than it is to cut back on oil change intervals and stock two oils in their maintenance facilities.

I'm also guessing there isn't one API CJ-4 oil above the Ho-Hum performance level. Use these oils only if you have particulate traps on your vehicles!

Price $/gal.	Oil #	Brand/Description		API Performance Category My Estimate	Actual
		Best			
9.98	1	Cummins/Valvoline Premium Blue	15W40	CI-4 plus	CI-4 plus
17.36	8	Shell Rotella T Synthetic	5W40	CI-4 plus	CI-4 plus
21.89	12	Cummins/Valvoline Premium Blue Syn.	5W40	CI-4 plus	CI-4 plus
9.98	13	Pennzoil Long Life	15W40	CI-4 plus	CI-4 plus
10.88	14	Chevron Delo 400	15W40	CI-4 plus	CI-4 plus
35.00	20	Red Line Diesel Synthetic	15W40	CI-4 plus	CI-4
		Good			
10.36	2	NAPA Universal Fleet Plus	15W40	CI-4	CI-4
25.70	10	Amsoil	5W40	CI-4	CI-4 plus
13.51	15	Caterpillar DEO	15W40	CI-4	CI-4 plus
12.68	16	John Deere Plus-50	15W40	CI-4	CI-4
19.99	18	Lucas 15/40 Magnum	15W40	CI-4	CI-4
		Satisfactory			
9.68	3	Mobil Delvac 1300 Super	15W40	CI-4 plus	CI-4 plus
7.68	5	Wal Mart Super Tech Universal	15W40	CI-4	CI-4
9.52	6	Castrol GTX Diesel	15W40	CI-4	CI-4
9.52	7	Motorcraft Super Duty	15W40	CI-4 plus	CI-4 plus
9.99	19	Pilot Premium HD	15W40	CI-4	CI-4
12.00	21	LiquiMoly Diesel Special	15W40	CI-4	CF-4
		Ho-Hum (least favorite)			
10.96	4	Shell Rotella T Triple Protection	15W40	CJ-4	CJ-4
27.55	9	Amsoil Premium Synthetic	5W40	CJ-4	CJ-4
10.80	11	Castrol Tection	15W40	CJ-4	CJ-4
12.99	17	Chevron Delo 400 LE	15W40	CJ-4	CJ-4

JOHN'S CONCLUSION

Okay, now that Robert also put some pricing information in the table, I can draw a few additional conclusions. For example, look at the two Cummins/Valvoline oils I placed in my "Best" category. The mineral oil version costs less than half of the synthetic version; yet they both deliver equivalent performance. Do you really need that synthetic oil? I doubt it.

While we're at it, look at oils 18 and 20. These are goods oils, but are they really worth 100 and 200% more than their competitors because they are produced by "racing oil companies?" I doubt it. What can racing oil companies possibly know that diesel engine builders and oil companies don't already know?

In that same vein, are oils 15 and 16 really worth more than their competition because they carry the brand name of highly respected diesel engine builders? I don't think so! Compare these oils to oil 1 at $9.98 per gallon. That oil looks like a better deal. The only reason to use oil sold by your engine manufacturer is if you anticipate you will have warranty issues. Remember, these oils aren't actually produced by Cat, Cummins, or John Deere. They're produced by oil marketers such as Exxon, Mobil, or Valvoline.

Oil 21, LiquiMoly Diesel Special, doesn't look like much of a bargain to me. It's a fairly expensive oil with only API CF-4 credentials. There are better oils here to purchase. None of the CJ-4 oils look like much of a deal to me either. You should only utilize these oils if you have particulate traps on your vehicle. If you must use one of these oils, I think the Castrol Tection (oil 11) or the Shell Rotella T Triple Protection (oil 4) oils are the most cost-effective.

The best bargain on the table is the Wally World oil (oil 5) at $7.68 per gallon. But, if we're talking about a vehicle you want to keep in good shape for a long time, I would spend a little extra for better performing oils. Oils 1, 13, 14 and oil 2 are oils which should deliver above-average performance at a reasonable cost.

As to my earlier comments about oils becoming more like commodities with each new specification change, let's look at the table one last time. Notice all of the lower performing API CJ oils huddled in a group at the bottom of the table. Also, notice that most of the CI-4 plus oils are in a group at the high end of the performance spectrum. (I suspect that the Red Line oil doesn't have CI-4 plus credentials simply because it was never tested.)

So, what oil should you use? I have a buddy at Freightliner who has an interesting philosophy about purchasing engine oil. He goes to the store and looks at all the oils with the latest performance specifications (use CI-4 plus, not CJ-4). He then buys the oil that is on sale at the time. That's not a bad philosophy!

EDITOR'S CONCLUSION

(Just like Issue 56… this area is left intentionally blank. you will have to draw your own.)

HOW ABOUT MY 6.7-LITER ENGINE….

If you have a 6.7-liter '07.5 Turbo Diesel truck it is recommended that you use a CJ-4 lube oil. Why? Again, issue 54's article has the reason behind CJ-4 oils.

"The EPA tightened their exhaust emissions thumbscrew on diesel engines starting January 1, 2007, to reduce particulate matter (PM) and oxides of Nitrogen (NOx) emissions. To meet these requirements most diesel engine manufacturers are resorting to the use of diesel particulate filters (DPFs). A DPF differs from the catalytic converters we have used for years on gasoline engines in that a DPF actually filters the *entire* diesel exhaust stream.

"On the surface you wouldn't think this would be a big deal—Europeans have been using DPFs for years. The difference is that Europeans don't accumulate mileage like Americans and they will tolerate much more frequent service intervals. Our EPA has decreed that the new DPFs must go 150,000 miles before needing removal for cleaning. This means the soot collected in the DPF must be burned off in the exhaust system frequently if trap life is to exceed 150,000 miles without removal and cleaning.

"I don't have to tell you that diesel exhaust is relatively dirty. It consists of lots of soot (that's what turns your oil black) and unburned residues from both the fuel and the oil. Sulfur in the fuel can significantly hamper DPF performance. That's why ultra low sulfur diesel (ULSD) fuel was introduced in the fall of 2006. Phosphorus and sulfur in the lube oil can shorten DPF cleaning intervals considerably. Phosphorus (P) can 'glaze over' and plug the tiny holes in the DPF, making the openings effectively smaller and quicker to plug. Sulfur can 'mask' the DPF, making it temporarily less effective. Sulfated Ash (SA) in the lube is thought to build up deposits on the DPF over time. These deposits that originate from diesel fuel and lube oil then make the DPF effectively smaller and quicker to plug."

So the CJ-4 lube oil for the '07.5 engines is a compromise.

Low P means the Feds placed a limit on the amount of Zincdithiophosphate (Zinc and Phosphorus) additive which can be utilized. ZDP is the most effective oxidation inhibitor and anti-wear agent currently available. Additive manufacturers are now forced to use more expensive and less effective ashless oxidation inhibitors and antiwear agents.

Low sulfur means the new oils can't rely on some of the least expensive sulfur-based oxidation inhibitors they used in the past. And, once again, many of the new ashless oxidation inhibitors haven't been thoroughly field proven in heavily loaded trucks. Low S also means more highly refined base oils, which is a positive thing. Average base oil quality is now significantly improved.

Low SA (less than 1 percent weight) effectively places a limit on the amount of detergent (Calcium and Magnesium) which can be used in these oils. But diesels love detergents. In over 25 years of inspecting various diesel engines in the field, I've yet to see one which didn't perform better on oils with higher levels of detergency.

OIL SAMPLING AND EXTENDED DRAIN INTERVALS

by Robert Patton

This sidebar could go on for pages.

I will be brief.

Each sample of oil that we did with the Fleetguard CC2543 kit was about $20. You must use the more expensive CC2543 to get viscosity and total base number if you are going to use sampling to determine your oil change interval.

At $20 per sample you can purchase two of the required three gallons of lube oil for your truck. If you figure a $30 total investment you can put some of John's "Best" lube oils (numbers 1, 13, 14) in your truck.

The conclusion is clear to me. Do I want to be a lube oil engineer? I value the DaimlerChrysler warranty of 100,000 miles and I will change the oil at the suggested factory interval. Right?

Let's add some numbers to this overly simplistic conclusion. The Owner's Manual oil change recommendation for the new 6.7-liter engine in commercial Chassis Cabs:

Schedule A	6,000 miles
Schedule B	3,000 miles

For the 6.7 liter engine in 2007.5 consumer pickups:

Schedule A	15,000 miles
Schedule B	7,500 miles

For the 5.9 liter engine in 2003-2007 consumer pickups:

Schedule A	15,000 miles
Schedule B	7,500 miles

For other applications consult your Owner's Manual.

What Will Oil Sampling Tell You?

My Concrete Cowboy story goes like this. Influenced by the 3,000 mile-guy-on-TV for many years I adopted his mantra and needlessly changed lube oil on my vehicles. Needlessly? Yep, needlessly. I finally spent money to do lube oil testing and found that the lube oil was a-okay at <gasp> an extension of the oil change interval to a whopping 6,000 miles.

I changed the lube oil at that 6,000 mile interval. Then, I walked on the wild side…I changed the lube oil at 10,000 miles. The oil was still a-okay.

I got busy the next year and, forgetful me, changed the oil at 20,000 miles. I was so concerned that I purchased the CC2543 to check the viscosity and total base number. Alas, the sample was all-too-predictable, the wear metals were pretty much double what was shown in the earlier 10,000 mile sample. Big surprise? Viscosity and TBN were still more than adequate.

Should I go farther with my oil change interval?

The "Jeopardy" host says, "Mister Editor, would you like to play 'Double Jeopardy' for 40,000 miles?"

"No, Alex, I'll pass." In my efforts to become a lube oil analysis/lube oil engineer I learned that a 10,000 mile oil interval is okay, and that 20,000 miles is okay, too. And, as mentioned, with a capacity of only three-gallons, the cost of lube oil is close to the cost of the oil analysis. I'm comfortable changing the oil at 15,000 miles, which (oddly enough?) coincides with the factory's schedule A maintenance requirement.

Were I the owner of a big fleet of trucks with large engines/large oil capacities, you bet I would use an oil sampling and extended oil drain interval program.

It took a series of oil analyses samples before I was comfortable changing my 3,000 mile-guy-on-TV mentality. Then again, it took another series of 21 oil samples to change my mentality of lube oil by brand name versus lube oil as a commodity.

Where do you stand on this topic?

Robert Patton
TDR Staff