The Mendoza Line of Oil Analysis

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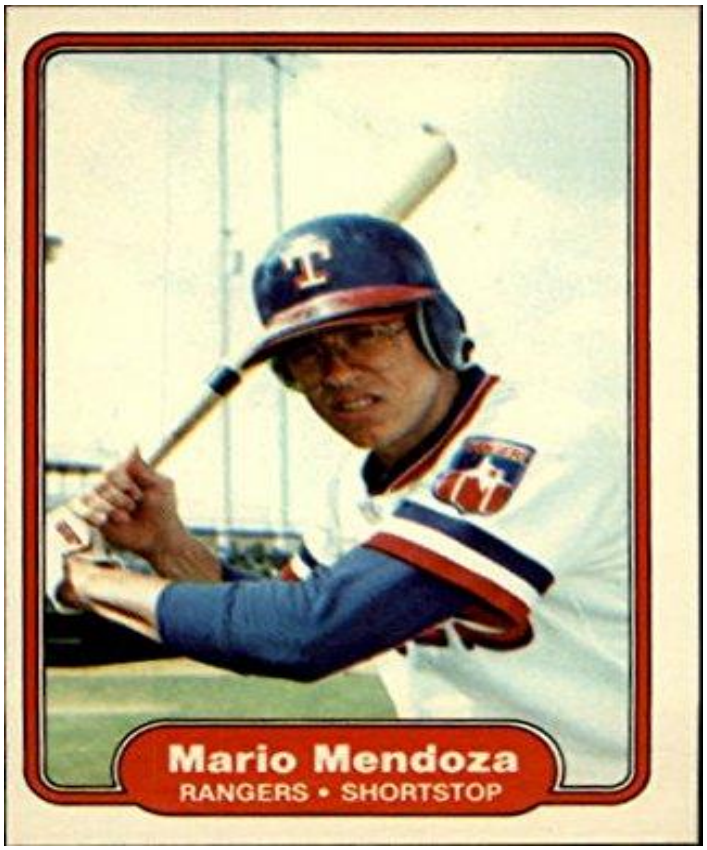


Most of us have heard of Mario Mendoza, the major league short stop who was a lifetime .215 hitter. That mark is now referred to as "The Mendoza Line" and is the universal threshold for batting aptitude – if you stay above it, you've got a shot at a sustained MLB career, fall beneath it, and it's back to the minors, small crowds, and bus rides for you. Much like the "Mendoza Line" in baseball, it is important to establish a "Mendoza Line of Oil Analysis" for your vital assets. You should establish a number as a goal for several tests, measuring each piece of equipment that you rely on. Establishing this as a lowest acceptable level or "Mendoza Line" for each piece of vital equipment, and then doing all you can to stay above that will lead to longer oil and equipment life and less chance of equipment failure and downtime.

Most of us know what the back of a baseball card looks like, with the hitters personal bio and his lifetime statistics – batting average, home runs, runs batted in, on bass percentage, slugging percentage, etc. Over time, those numbers equate to more runs and more victories for his team - the same way that a proper oil monitoring program results in longer oil and equipment life, lower costs, and higher production for your company. Within just a few seconds of looking at a hitters vital stats, we can tell if that player is all-star caliber or a journeyman. The same should hold true for your oil analysis program – if you can't quickly and accurately tell the health of your oil by looking at your oil analysis report, is it really doing you any good?

How many people actually use a 3 page report detailing the exact amount of 20 different wear metals and additives present, some highlighted as cautionary and others as OK? It is far more important to have a simplified analysis clearly identifying the piece of equipment, the type of oil, and current and past measurements of a few key indicators.

A 5 tool player in baseball means that a player possesses 5 vital skills, all at a high level – hitting for average, hitting for power, speed, arm strength, and fielding ability. The difference in checking 4 of those boxes instead of all 5 can lead to millions of dollars over the course of a career. And the same can be said for the maintenance professional – we'll call them a 5 tool player in the world of oil analysis. Being able to effectively measure and control:

- Viscosity
- Hard Particulates
- Moisture
- Varnish
- Oxidation – Oil Aging

Mendoza Line Oil Analysis Baseball Card

South Kiln Gear Box	Mendoza Line	10/15/17	7/12/17	4/15/17
Viscosity	220	217	216	219
ISO Code	17/15/12	16/14/11	17/15/13	17/16/14
Water	100 ppm	87 ppm	79 ppm	84 ppm
TAN	0.85	0.73	0.64	0.6
MPC	10	6	4	4

More in depth analysis tools are definitely warranted and critical in some instances, but to get a back of the baseball card quick analysis, these factors are key, especially if you have many pieces of equipment that must be monitored. Data that you don't use or don't understand is data that you don't need. Lets'

take a look at what Mario Mendoza's hitting coach would do if he were a maintenance or reliability professional.

The first step is to establish your "Mendoza Line" for these 5 factors on every piece of vital equipment that you perform oil analysis on. Use your manufacturer's recommendation along with your past industry experience and trade or peer input. For example, in a gear box a cleanliness code of ISO 17/15/14 might be perfectly acceptable, while the same ISO code maintained in a hydraulic application could cut the life of that equipment in half and cost thousands in lost production. And don't rely on "new oil" generic baseline data to compare your oil to, have a "Mendoza Line" that works for your application.

The second step is to establish a time frame for sampling – it may be monthly, it may be quarterly, once established, stick to it.

Step 3 is to strive for perfection in sampling techniques. The most important factor to hitting a baseball is to keep your eye on the ball. The most important factor in effective oil sampling is consistency. Have the same person sample the oil at the same time from the same place. Everyone on your team should be properly trained on Best Practices of oil sampling and follow them religiously.

Step 4 is to have your lab do only the testing that you require – "keep it simple" is the mantra here.

Step 5 is to review those results as soon as you get them – the back of the baseball card – and don't keep it to yourself, all stakeholders in that equipment should be involved, from your techs who have eyes and hands on the equipment, to management, to ops – everyone should know where that equipment stands and have the ability to offer input for why that equipment may be below your goals and/or how it can be improved.

Step 6 is to take action if a number falls below your "Mendoza Line." Whether that means more in depth oil analysis, review or training for your team, root cause analysis, implementing world class filtration, part replacement, etc. This will allow you to base your maintenance on performance indicators, not on time or hours.

Let's look at these 5 vital tools and how to easily measure them.

Viscosity

This is possibly the most vital number as it can cause quick and intense damage if left unchecked. It is amazing how many oil analysis reports don't check the viscosity of oil in relation to what it should be.

Viscosity should be measured every time you send a sample in. You can also check the viscosity fairly easily and quickly on site. Keep in mind there is a small range allowed (5 to 10 percent for most applications), so a 215 viscosity on a 220 gear oil may be acceptable. Know your high and low limits.

Many things can cause high or low viscosity, but by far the most common is contamination caused from poor oil handling practices. If the oil in your oil room and the fill ports on your equipment are not clearly marked with oil type and viscosity, fix that immediately. It could prove to be the most important few dollars you ever invest. No one should be allowed to add, monitor, or change oils or open any access to a reservoir that hasn't been properly trained in general best practices and your facilities procedures.

If you utilize mobile filtration, a filter cart should only be used only on a single type and viscosity of oil and clearly marked. If possible, homogenize the types and viscosity of oils you have in your facility to minimize risk.

Other reasons for improper viscosity (moisture, oxidation, particulates) are mainly due to contaminants and by implementing proper techniques in keeping them out and removing them should allow you to maintain the proper viscosity. It is inevitable that viscosity rises through aging as the molecules bond together over time. Use this viscosity centistoke reading as a basis for oil changes, not your calendar.

Hard Particulates

The universal measurement for hard particulates is cleanliness according to the ISO 4406. But keep in mind there are two types of testing commonly used – optical and pore blockage. It is vital that you use the same test every time as testing the same oil with both tests can reveal different ISO codes. The best for identifying your level of dirt is the pore blockage test as it isn't skewed by air bubbles or soft contaminants like the optical test can be. Make sure you know which test your lab is using and make sure they only use one and don't switch between the two.

ISO Code	NAS 1638	Description	Suitable for	Dirt/year
ISO 14/12/10	NAS 3	Very clean oil	All oil systems	17 lbs / 7.5 kg *
ISO 16/14/11	NAS 5	Clean oil	Servo & high pressure hydraulics	38 lbs / 17 kg *
ISO 17/15/12	NAS 6	Light contaminated oil	Standard hydraulic & lube oil systems	80 lbs / 36 kg *
ISO 19/17/14	NAS 8	New oil	Medium to low pressure systems	318 lbs / 144 kg *
ISO 22/20/17	NAS 11	Very contaminated oil	Not suitable for oil systems	> 1300 lbs / 589 kg *

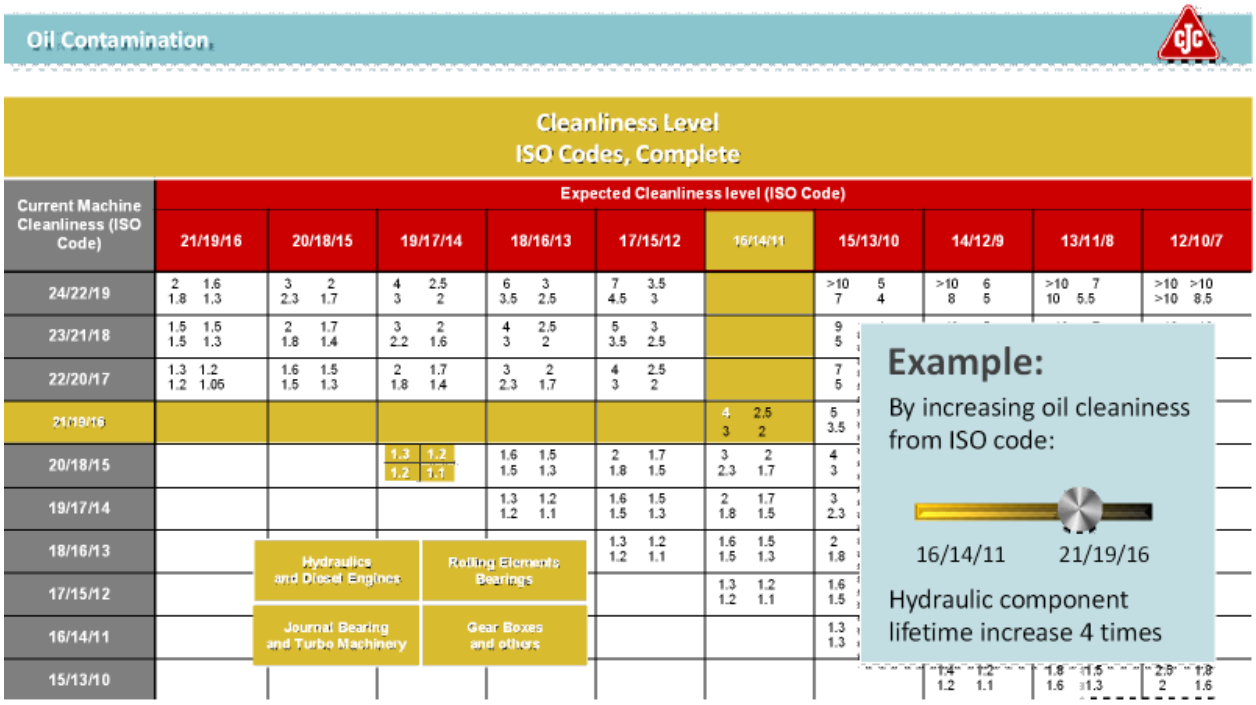
*Contamination guide for oil and fuel systems: * The amount of dirt passing the pump per year, if the oil passes with a capacity of 200 ltr/min, 18 hours a day, 340 working days per year.*

Once you have established your ISO code "Mendoza Line", consistently monitor the oil and make sure you stay beneath your max level. Make sure past results are on the same report so you can effectively monitor trends.

t is best and less costly to keep dirt out of the system than to remove it - quality breathers, highest quality seals, using the proper oil, and best practices on oil filling are absolutely essential. Again, your personnel should be trained and actively implementing these. A major league manager wouldn't send a player to the plate who doesn't spend hours in the batting cage, taking BP, and constantly working with the hitting coach – you shouldn't send your team out with anything less. How many of us have seen a dirty rag taking the place of a fill cap or that cap left off? Most problems are easy to fix but like a bad habit in hitting, over time if not dealt with, the harsh results will intensify.

If your ISO code level is below your "Mendoza Line," choose your filtration based on the ability to lower that number and keep it down. The proof is in the pudding, either your filtration method is keeping ISO codes in check, or it's not. Know the design parameters of your filtration system - inline surface filtration is designed to stop a small amount of large dirt to act as a last resort; offline depth filtration is designed to keep dirt to a certain size out of your system almost all the time. Even in the cleanest of systems, particulates are constantly generated and need to be removed as soon as possible to avoid those particles from circulating through the system over and over again. A keen focus on the smallest of contaminants is key as they typically make up the bulk of the dirt and cause most of the wear. Your filtration system should ideally remove particulates down to a single micron in size. Removing dirt to 3, 5, or 10 microns may be a wasted effort as the majority of the dirt in most systems is less than 3 microns in size and those particles can get into the tight tolerances of equipment and cause the most wear. If you are not removing these fine contaminants, they are circulating through your system repeatedly.

Your ISO code, particularly the 4 micron rating is the judge of whether that is working or not. The return on investment of most quality offline filters is typically very quick in both oil and filter savings, but the real benefit is the life extension of the equipment and downtime that is avoided. Your filtration expert should be able to provide an accurate ROI for any of your systems.



Water

There are many ways to show water on an oil analysis. A quick question to make my point. One oil has a 250 ppm water count, while another has .025 percent water present. Which has more water? A trick question, those 2 measurements are the same. Pick a measurement tool and stick to it – either ppm or %. Also know exactly how many gallons of oil are in each system so you can easily determine how much total water you have to remove to reach your acceptable limit.

Again, be consistent and use the same test consistently – there are two ways to conduct a Karl Fischer (volumetric and coulometric) stick with one. As in the case of dirt, it is easier and cheaper to keep moisture out than to remove it. Make sure you utilize top of the line desiccant breathers, avoid water wash downs and spraying on the system, and use best practices on seal and heat exchanger maintenance and monitoring. If there is a chance of a large and sudden influx of water into a system you should have a notification vehicle in place so you are notified at once. Have equipment available to effectively remove that large amount of water through filtration.

When water is present it is important to answer two questions:

- How much water needs to be removed?
- Does the oil have good demulsibility properties (will the water and oil easily separate)?

If the water levels are less than a few gallons or so, absorption is the best method. Most filter medias will not absorb water so make sure you utilize a raw cellulose media that absorbs water while still capturing dirt. If a large amount of water needs to be removed, separation via coalescence should be your first choice. Some oils will not allow the water to separate (e.g. high viscosity lubes, paper machine oils, and engine lube oil) in which case desorption or dehydration is the only option. It is important that your system can remove all 3 types of water - free, dissolved, and emulsified.

Oil Contamination

MOISTURE Level

Source: Noria Corp.

Current Moisture Level, ppm	Life Extension Factor								
	2	3	4	5	6	7	8	9	10
50,000	12,500	6,500	4,500	3,125	2,500				782
25,000	6,250	3,250	2,250	1,563	1,250				391
10,000	2,500	1,300	900	625	500				156
5,000	1,250	650	450	313	250				78
2,500	625	325	225	156	125				39
1,000	250	130	90	63	50				16
500	125	65	45	31	25				8
260	63	33	23	16	13				4
100	25	13	9	6	5				2

Example:

By reducing average fluid moisture levels from

156 ppm 2500 ppm

Bearing and gear liftetime is extended by a factor of 5

1% water = 10,000 ppm. Estimated life extension for gears and bearings utilizing mineral-based fluids

Valid for gears, pumps and rolling element bearings

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Varnish

Testing for varnish doesn't need to be done on all equipment on a regular basis, however on certain equipment it should be part of your routine (gas turbines, compressors, and high temperature hydraulics particularly). On other applications look for evidence of varnish – sticky valves, short pump life, visual varnish build up, and issues at start up, and test at that time. Varnish is probably the least understood contaminant and the Membrane patch Colorimetric test (MPC) is your best indicator for identifying its' concentrations. It provides a number that can easily be compared to your goal (you may get a wide array of acceptable limits here, but an MPC of 5 to 10 is a safe level). Varnish removal strategies are even more misunderstood than varnish build up. Varnish filtration techniques have advanced rapidly over the past years and soluble varnish (in solution) can now be removed almost as easily as insoluble

varnish (solids). The key here is permanent removal as insoluble solid varnish can go back into a soluble liquid state with rising temperatures and leave many filters to go back into the system. Removing varnish can be done with varying effectiveness by several methods, so the best strategy for varnish removal is to insist on a guarantee of success based on the lowering of your MPC to an established and agreed upon level.

Oxidation

Oxidation is the aging or deterioration of the oil, and is caused by the oils interaction with oxygen. Unlike the unavoidable eroding skills of an aging ball player (PED's not withstanding), oil oxidation can be slowed and controlled. Oxidation is best measured by your Total Acid Number (TAN) and should always be looked at in relation to the acid number of your oil when it was new. Oxidation is accelerated mostly by heat, but water, and dirt factor in as well. If you are maintaining best practices on keeping your oil clean and dry that is usually a good elixir for slowing oxidation and avoiding acidity, sludge, and increased viscosity. If these methods aren't enough there are filtration means available to lower the acidity. A quality kidney loop filtration system will have the flexibility to use several different filter medias that along with the main culprits, dirt and water, can also be used to eliminate acid and other soft contaminants. Temperature being the main cause of oxidation, a quality oil cooling mechanism is of the utmost importance if your equipment operates at elevated temperatures. Monitor acid and keep the oil as clean, dry, and cool as possible.

A note on additives (we'll call this the baseball pine tar of oil analysis). Oil additives are there for very important reasons and are extremely effective in doing what they are designed to do. By keeping contaminants out of the oil, those additives are free to do what they are there for. If your dirt or water numbers exceed your "Mendoza Line" then the additives are being used and thus there are no free additives left to do their job. For example, if your ISO codes are high, additives are holding onto the dirt so that it can be filtered out, but if all those additives are actively holding dirt in suspension, then the rest of the dirt will reach a saturation point and will deposit themselves throughout the system. Consistent, quality filtration will keep the contaminants out so the additives are free to do their job.

It is important to note that sampling and lab mistakes can and do happen and if a key indicator is heavily skewed, it may just be a sampling or testing issue. This should be verified by another test, don't just accept it as a bad test and wait for your next sampling period, verify it. Use an alternative testing facility on occasion to confirm your results. Roger Maris hit 61 home runs in one season, Barry Bonds hit 73, I ask you, are those numbers comparable?

Insist on using your "Mendoza Line" for all new oil deliveries before using them. Remember, new oil is not clean oil!

Insert CC Jensen Log Book from Clean Oil Guide here

Parameter	Baseline	Caution	Critical
Particle count ISO 4406	15/13/10 (pre-filtered)	17/15/12	19/17/15
Viscosity (cSt)	32	low 29 high 35	low 25 high 38
Acid number (AN, mg KOH/g)	0.5	1.0 - 1.5	above 1.5
Moisture (KF in ppm)	100	200 - 300	above 300
Elements (in ppm) Fe	7	10 - 15	above 15
Al	2	20 - 30	above 30
Si	5	10 - 15	above 15
Cu	5	30 - 40	above 40
P	300	220	150 and less
Zn	200	150	100 and less
Oxidation (FTIR)	1	5	above 10
Ferrous Density (PQ, WPC, DR)	-	15	above 20

Conclusion

I'll mention the old business adage "If you can't measure it, you can't manage it." Set a goal for 4 or 5 key factors of your oils health and then simply and consistently monitor those numbers to stay above your established "Mendoza Line of Oil Analysis." If you can't answer the question, "how is the oil in x piece of equipment" within a few seconds of looking at your last oil analysis, perhaps it is time to streamline and simplify your process. While all the time, striving to keep contamination out of your oil and addressing issues when they arrive. Don't be like Mario Mendoza and continue on a path of mediocracy, but measure, compare, and improve to get better results. As in baseball, the same holds true for industrial purposes.

More Information

For more information about Off-file Filter Systems for lubricated machinery, please contact C.C .JENSEN, Inc. at ccjensen@ccjensen.com, or call (800) 221 1430, or visit www.cciensen.com