

# LUBE-TECH

NO.41

## Part 2 of a series of 3 LUBE Tech articles **UNDERSTANDING HOW THE TRANSMISSION FLUID RESPONDS TO DAILY OPERATIONS.**

By Allison Transmission, General Motors Corporation

### INFRARED (IR) SCAN

An IR scan is most often obtained by differential analysis. This procedure basically measures the differential between the amount of IR light absorbed by a used fluid sample and a reference (new) sample. It involves an IR light source inside an opaque box that is directed simultaneously through the used and new fluid samples as shown in Figure 5 below. Pocketed cells control the thickness of the fluid samples. After passing through the fluid samples, the IR light is reflected through a rotating chopper and into a detector where it is analysed. The rotating chopper alternately blocks one of the two signals so the detector is only receiving one signal at any given time. The analyser compares the signals from the new fluid to that of the used fluid and reports the difference as absorbance units per centimetre of fluid thickness. IR light at various wavelengths (in microns) may be used and the amount of light absorbed at each wavelength can reveal information about water, glycol, minerals, organic acids (oxidation), synthetic additives, and nitrates, as shown in Table 1 (see Part 1). This procedure is accurate within approximately 1/100 of an absorbance unit.

(Figure 6 was incorrectly included in Part 1 of the series)

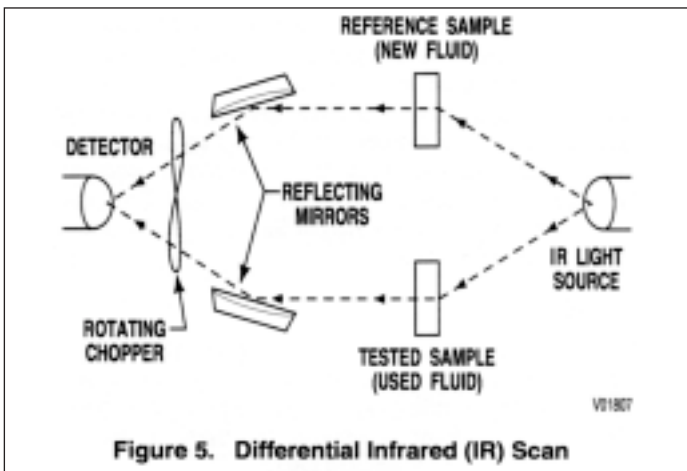


Figure 5. Differential Infrared (IR) Scan

### EMISSION SPECTROSCOPY

Spectrographic analysis is done by a very specialised instrument that burns a small sample of the fluid between two electrodes as shown in Fig 6 (Column 2).

The lower disk electrode rotates with the lower half of the disk submerged in the fluid. As it rotates, a thin coating of fluid is carried up between the two electrodes where it is burned to a vapour. During the burning process, atoms of a given element are excited by energy absorption to the point of actually releasing electrons. As soon as the vaporised element passes out of the electric field, the atom recaptures the electrons and they give off, as light, the energy they absorbed in the separation. This light or energy and its wavelength varies with each element. Thus, the element present can be identified by the wavelength of the light emitted. The efficiency of this process is dependent on particle size as graphed in Fig 7 (Column 2).

### OTHER PARTICLE WEAR METAL MEASUREMENTS

#### Particle Count, Visual

In this procedure, a small amount of fluid (usually 100 ml) is passed through a standard filter disk. The disk is examined under a microscope, and the particles of different size ranges are counted manually. The results are expressed as the number of particles in a particular size range, such as 180,000 per 100 ml in the 5-15 micron range.

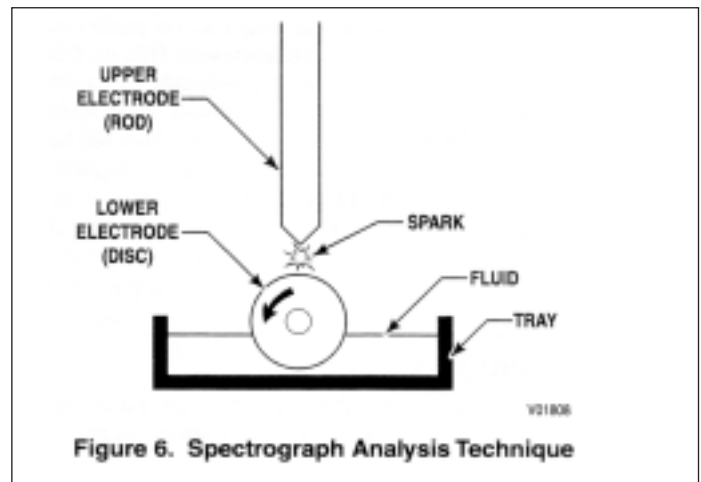


Figure 6. Spectrograph Analysis Technique

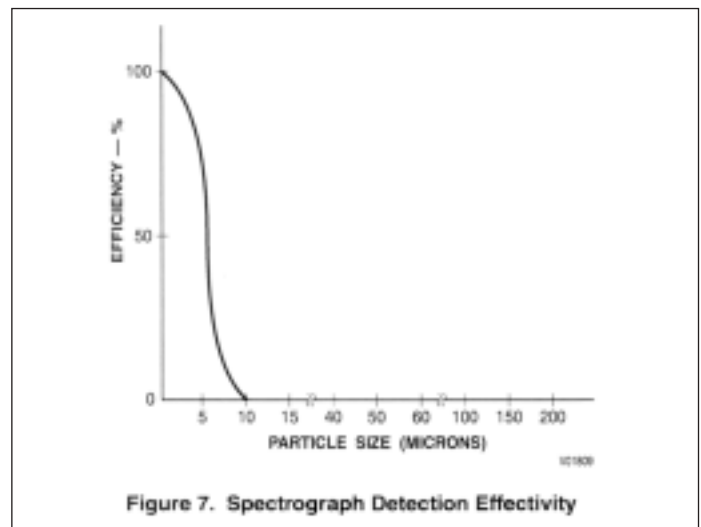


Figure 7. Spectrograph Detection Effectivity

The test is subjective in that it requires the operator to visually determine the relative sizes of the particles, aided by grid markings on the eyepiece of the microscope. Also, the test may take several hours to set up and carefully run each sample. One major benefit is that the operator can visually identify some contaminants such as metal chips or dirt, and in some cases, identify the source of the contamination. This may be of particular value in the quality control of high performance fluids.

#### Particle Count, Electronic

In this procedure, the fluid sample is placed in the path of a controlled light beam. The number and size of the particles in the fluid will determine how much light is blocked or reflected, and how much passes through to a photo-detector. The system then calculates the number of particles in pre-determined size ranges and displays the count.

The test is considerably faster than the visual method, with data available in a few minutes for each sample. The accuracy will depend on the types of particles present, as some translucent particles may not be detected. The count

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and size will also vary according to the orientation of the particle in the light beam, especially for unusually shaped particles such as those that are long and thin. By and large, however, the method is relatively accurate and reproducible, and is frequently used when prompt results are important. It does not provide any information on types or sources of contamination.

## Atomic Absorption

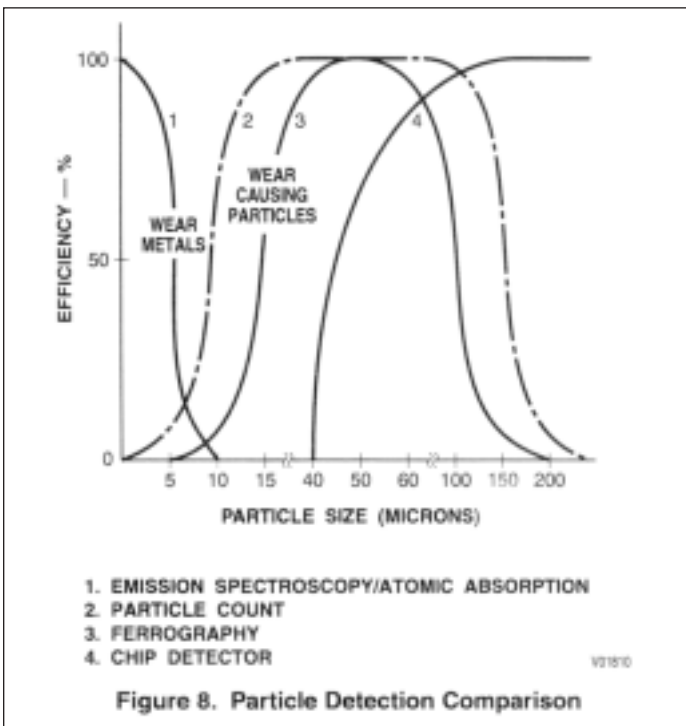
In this procedure, the fluid sample is burned in a high temperature flame, and an analytical instrument measures how much energy was absorbed by a particular chemical element detector such as iron or tin. The instrument is specifically calibrated at different ppm levels for different elements, and as such, provides a high degree of accuracy for each element examined. An analysis for ten wear metals would, therefore, require ten passes through the equipment.

This procedure provides the greatest level of accuracy per metal analysed, but it is time consuming. Running several dozen fluid samples for a specific element and then changing the equipment to the next element can save some time. Some labs run so many samples that they can provide same day service on a routine basis.

## Ferrography Analysis

In this procedure, a small sample of fluid is allowed to flow over a glass slide, which has been placed in a magnetic field. The larger particles tend to collect at the entrance end of the slide, while the smaller particles collect at the exit end. In general, normal rubbing wear produces enough small particles so that the optical density at the exit end of the slide is about the same as that of the entrance end. A rapid increase in the number of particles (as measured by the optical density), and in particular, the ratio of large to small particles, indicates the beginning of a more serious wear process. Further visual analysis of the metallic wear particles can indicate what type of wear process is occurring, and with special heat analysis, the type of metal can be identified.

This is perhaps the most sophisticated procedure for wear metals analysis, and certainly the most expensive with individual sample analysis costing several hundred dollars. The value, however, is in its early detection of component wear, in isolating the type of wear that is occurring, and in identifying the worn component. It has found particular application with gas turbines and large, multi-cylinder diesel engines.



## Chip Detector

Finally, a lesser-used technique, ferrous chip detection, is used when larger particles are suspected present. This is actually a magnet inserted into the hydraulic system (usually in place of the drain plug) which has the ability to attract particles of assorted size. These particles may then be examined for identification or weighed for relative comparison purposes.

Figure 8 (bottom left) is a Particle Detection Efficiency Comparison of the four major detection techniques.

## DESIGNING A FLUID ANALYSIS PROGRAM

Designing an effective fluid analysis program and interpreting the results is no easy task. Because the highly technical nature of fluid analysis and the complexity of automatic transmissions, the serious company should utilise only an analyst trained in both oxidation and contamination analysis. A carefully planned analysis program should include 1) a specific sampling plan and 2) selected tests including results of and reactions to those tests.

## SAMPLING

Developing a proper sampling technique is the first step toward meaningful fluid analysis. The importance of this function is often overlooked, resulting in reduced program effectiveness. To maximise program affectivity, the sample should be representative, timely, and well documented as shown in Table 2.

Table 2. Sampling

A fluid analysis program is most effective if fluid samples are:

### Representative:

- Operating Temperature - Proper Location
- Clean

### Timely:

- When submitted
- When analysed

### Documented:

- Transmission unit - Sampling method

### Representative

A good sample must be representative of the fluid in service if the analysis result is to be meaningful. First, the sample should be taken at operating temperature and while the system is in operation or immediately thereafter. This will ensure that wear and dirt particles will not have settled, and that water and coolant have not yet separated. Second, the location from which the sample is drawn must be carefully selected and the sample drawn in a manner that ensures cleanliness. Some systems have a sample valve located on a low-pressure return line but such a valve is not necessary.

A suction gun inserted into the dipstick tube will also provide a good sample. In either case, great care should be taken to avoid contaminating the sample with any external debris from around the valve or dipstick tube. If the sample is being drawn from the dipstick tube, the sample tube should be inserted only far enough to draw the sample. No contact should be made with the bottom of the reservoir nor should the sample be drawn any closer to the bottom than necessary. Sludge and dirt collect on the reservoir bottom and sampling there will result in an inaccurate assessment of the operating fluid. No sample should be taken from the fluid filter assembly. Third, the sample container is just as important as the sample itself. Old paint or coffee cans may be great for pain thinner, but they just won't work for fluid analysis. Most laboratories will supply suitable sample containers and a dipstick draw system.

All tests are most meaningful when compared to a like test on a new sample of the used fluid being evaluated.

### Timely

A fluid sample is drawn and analysed to provide information on the condition of the fluid for the express purpose of protecting the unit and providing early warning. Therefore, it is important that the sample be submitted for analysis in a timely manner, preferably the day the sample is drawn. Competent labs will analyse the sample and respond promptly. Excessive delays between sample draw and sample analysis reduces the significance and advantage of any analysis program.

### Documented

The final important step to effective sampling is documentation and identification. Analysis results from a sample will be of little value if they

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cannot be related to the transmission from which the sample was drawn for necessary action, for comparison to previous results, and storage for future comparisons. Since comparisons will be made, all samples must be drawn in the same manner, under the same conditions, from the same location, sent to the same lab, etc. Only then will comparative results be meaningful.

## Test Selection and Utilisation

Analysis laboratories offer an almost unlimited variety of tests through which a customer must sort and select appropriate tests. Some laboratories may understandably be sales oriented and attempt to sell testing beyond the economical needs of the customer. The most useful and economical tests are those that monitor oxidation and viscosity change, contaminant levels, and wear metal levels of the fluid. While usefulness will vary according to individual customer needs, the typical program should place emphasis on monitoring oxidation and viscosity changes.

**Determining the specific fluid change interval sufficient to protect the transmission in any application remains the responsibility of the customer. Failures resulting from operating with oxidised fluid likewise are the responsibility of the customer.**

## Monitoring Oxidation State

Fluid oxidation can be monitored by testing for viscosity, and total acid number. Transmission protection and fluid change intervals can be optimised by monitoring oxidation according to the tests and limits shown in Table 3. Notice that most of the limits are a reference from new fluid; all tests are most meaningful when compared to a like test on a new sample of the used fluid being evaluated. A fluid is considered to be suitable for use as long as it meets all four limits listed in the table, regardless of colour or odour. However, if one of the limits is exceeded, the fluid in the subject transmission should be sampled again immediately to verify the exceeded limit. If verified, the fluid should be changed regardless of time or mileage. Oxidised fluid will lead to transmission malfunction and failure. While fluid change intervals are typically recommended by component manufacturers, they are, by necessity, only broad recommendations. As severity of service application increases, fluid life decreases through oxidation. The importance of monitoring fluid condition cannot be overemphasised.

**Table 3. Fluid Oxidation Measurements Limits**

CONDITION	LIMIT
Viscosity	+/- 25% Change from New Fluid
Carbonyl Absorbance	+/- 25% Change from New Fluid
Total Acid Number (TAN)	+/- 25% Change from New Fluid
Solids	2% By Volume Maximum
* Carbonyl Absorbance units/cm	
** mg of KOH required to neutralise a g of fluid	
<i>Variation in oxidation rates of fluids within a given component and application is a function of the fluid, not the component.</i>	

## Monitoring Contaminant Levels

The presence of fluid contaminants in an automatic transmission can be detrimental to continued operation. Identifying the contaminants and their quantity is most often useful in post-failure investigation. Its usefulness in pre-failure investigation is limited by fluid sample delivery, test, and response time. Depending on the contaminant and its level, failure may occur before the

contaminant presence is known. Nonetheless, the information can still be useful in changing a policy, activity, or defect, thus preventing a repeat of the problem. Water and glycol are probably the most common and harmful contaminants found in a transmission. Water is a very poor lubricant and promotes rust, both of which lead to failure. Perhaps the greatest danger, however, lies in its effect on clutch plates. Water can penetrate the facing of a clutch plate and rust the steel core. This rust causes core and facing separation, leading to clutch pack failure. Glycol also causes core and facing separation by attacking the bonding material used to join them. The result is the same - clutch pack failure. Detecting these contaminants prior to failure requires rapid testing and response; value of the tests is most often realised in failure identification. Prior to failure, if water or glycol is detected, the fluid should be changed and the source of the contaminant identified and corrected.

Abrasive debris such as road sand or dirt can accelerate wear of the transmission and can be monitored prior to failure. Debris testing is not as important as other tests since a maintained filtering system will usually remove the bulk of the damaging abrasive particles.

In some applications, engine oil can leak past the rear engine seal and eventually overfill the transmission. Since most engine oils are compatible with transmission fluids, the engine oil itself is not harmful, but an overfill condition is. Through aeration, overfill can lead to reduced clutch pressure, erratic shifting and subsequent clutch failure. If engine oil contamination is suspected, emission spectroscopy analysis of a sample of new engine oil should be compared to a sample of new transmission fluid. An element unique to the engine oil should be evident. Subsequently, presence of that unique element can be monitored in used transmission fluid samples. If the element unique to the engine oil is present in the used transmission fluid, then engine oil contamination is confirmed. In addition, two ASTM tests will detect the presence of soot, a by-product of engine combustion. Those tests are the Cleveland Open Cup (though it has been questioned) and the Pentane Insolubles. If engine oil is detected, transmission fluid level must be carefully monitored and maintained. Once the engine leak has been corrected, the transmission fluid should be changed.

Finally, a completely alien fluid, i.e., brake fluid, inadvertently introduced into the transmission, can be detected by a radical change in value on an IR scan at wavelengths of 3.5 and 5.8 microns. If an alien fluid is suspected, the transmission fluid should be changed. Table 4 on Contaminant Limits provides a listing of typical contaminants and comments on limits.

**Table 4. Contaminant levels**

CONTAMINANT	LIMIT
Water	0.2% Maximum
Glycol	0; No Trace Allowed Fluid
Road Debris	No Limit Established (Maintain Filtering System)
Engine Oil	No Limit, Provided Transmission Level is Maintained
Alien Fluids	No Limit Established. If Detected, Change Transmission Fluid

Part 3 of this article will be included in the next issue of LUBE.





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## THE PERFECT STORM... ARE YOU SECRETLY WAITING?

It is no surprise that those who enter the maintenance field are mechanics at heart. These are people who possess a native love for machinery and the thrill that comes from making broken things run again. Those of us who lack mechanical aptitude have great appreciation for the craftsman who instinctively knows just where the problem is and how to fix it.

Yet today's reliability-conscious world is changing the maintenance persona, taking it in a direction away from the macho image of the past. It's no longer politically correct to yearn for the meltdown or the perfect storm. Fading too is the sense of pride that came with going into battle, wrench in hand, to press the limits of one's mechanical proficiency. Perhaps a sad reality to some, but a reality nonetheless.

Today, we see many organisations that have already gone through the transformation, while others have yet to begin. Understandably, there has been resistance to tinkering with past routines and practices. It's a behemoth task to deprogram and then reprogram the DNA of the corporate maintenance culture, including that of management.

What does this really mean and why should you care? Let me rephrase my main point.

Have you heard of proactive maintenance? Plainly stated, the approach supplants the maintenance philosophy of "failure reactive" with "failure proactive" by avoiding, or eradicating, the underlying conditions that lead to machine faults and degradation. Unlike predictive/preventive maintenance, proactive maintenance commissions actions aimed at failure root causes, not just symptoms. Its central theme is to extend the life of mechanical machinery as opposed to making repairs or inspections when often nothing is broken, accommodating failure as routine and normal, or pre-empting crises failure maintenance in favour of scheduled failure maintenance.

Proactive maintenance is at the very heart of how the maintenance mindset must change. What exactly are these things that must change? Companies must stop positioning their maintenance job skills upside-down. This sends mixed signals to those involved, and in a very real sense, makes failure a self-fulfilling prophecy. For instance, if what you want most is to avoid machine failure, then

what you need most are maintenance skills that foster intrinsic machine reliability. This strategy is opposed to the practices of many companies that structure their highest maintenance pay grades for those who detect and respond to failure.

Let's look at how this relates specifically to lubrication. Who is more important to machine reliability: mechanics, vibration analysts, wear debris analysts or the lube tech? To answer this, bear in mind the fragile state of the microscopic oil film that separates a machine's internal frictional surfaces. Who will protect and nurture this critical film throughout the months and years of machine operation?

Will this be done by the vibration analyst with accelerometer and data collector in hand? Perhaps the wear debris analyst will be able to use his microscope to ensure optimum lubrication. Or maybe it's the mechanic... how will a wrench and screwdriver ensure that the critical surfaces are continuously bathed by quality lubricants? In the realm of the modern maintenance organisation, these are all vitally important jobs, but none are strategically positioned to pilot a proactive maintenance program better than the lubrication technician.

Does your organization embrace high quality lubrication? How much training has your maintenance staff received on the essence of world-class lubrication in the past year? Are your lube techs certified in the same way as your vibration analysts? Do you have well-documented lubrication procedures for each task that have been reviewed by subject-matter experts? Is your company attracting and paying for high-achievers in a lubrication career path? Is there a strong sense of pride among those who serve in this important job - a job that's fostered and supported by management?

It's the dawn of a new day in machinery lubrication.

Jim Fitch



## HAZARDOUS WASTE REGULATIONS - LIST OF WASTES REGULATIONS 2005

Are your lubricant end-users customers aware that under the new Hazardous Waste Regulations (HWR) they become hazardous waste producers? They should have registered their premises by 17th July 2005 provided they are producing hazardous waste at premises and the waste will be removed / disposed of after 16th July 2005.

**Premises** - that includes most industrial premises (other than those with an exemption) that produce hazardous waste will need to be notified to the Environment Agency, irrespective of the amount of hazardous waste they produce.

All waste lubricants (used oils and lubricants that are surplus to requirements) are classified as 'Hazardous Waste' under the new Hazardous Waste (England and Wales) Regulations 2005 (which replaced the Special Waste Regulations) and the List of Wastes (England) Regulations 2005. The Welsh regulations will be separate though effectively identical, plus Scotland and Northern Ireland will have their own regulations.

All Industrial premises needs to know about these regulations if they produce, dispose of, or carry or receive hazardous wastes, which include: acids, alkaline solutions, batteries, oil fly ash, industrial solvents, oily sludges, pesticides, pharmaceutical compounds, waste oils, wood preservatives, computer monitors, paint and fluorescent tubes.

To obtain a copy of DEFRA's leaflet on the new regulation use the link below: - <http://www.defra.gov.uk/environment/waste/special/pdf/hazwasteleaflet.pdf>

