RTA WHITE PAPER

ADVANCING PREVENTATIVE MAINTENANCE

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Introduction

This white paper is a collection of insights, best practices, tips and tricks that Ron Turley developed by consulting with thousands of fleet supervisors, managers, mechanics and drivers over several decades.

These insights represent methods of controlling and maintaining fleet systems and expenses.

CHAPTER 1

Cornerstones of a Successful PM Program

The 4 items necessary for a complete PM program are:

1. *An efficient form and system*
2. *An accurate schedule*
3. *A well-trained mechanic*
4. *A quality control program*

What is preventative Maintenance and How Does it Differ from Demand Maintenance?

The purpose of preventative maintenance is to keep a vehicle in satisfactory operating condition at the lowest possible cost. You do this by inspecting each vehicle thoroughly and systematically, at regular intervals, adding fluid, rerouting or clamping anything that is needed during the inspection. Replacement and repair is done after the inspection is completed if fleet or individual PM records indicate the useful life of an assembly or component is nearly finished. As a result, there are fewer part failures, with fewer emergencies and road calls.

Demand maintenance (unscheduled maintenance) on the other hand, is a system of regular lubrication, with repair and replacement only when the vehicle breaks down. Then is repaired enough to return the vehicle to the road. Unlike good PM, demand maintenance is also very difficult to budget, since there is no regular pattern for parts replacement and maintenance. Also, since failure of a part often causes damage to related surrounding parts and assemblies, it becomes even harder to anticipate the total repair cost. Planned maintenance makes it possible to accurately estimate your costs.

With demand maintenance, the unplanned shop visit or breakdown can cost money, downtime, cargo delays, cargo spoilage, accidents, road calls, expenses, lost customers and higher repair costs. Most bookkeeping systems do not take these items in consideration when figuring maintenance costs!

What is Necessary for a PM System?

It must be designed around the specific vehicles it is supposed to maintain. It must fit the conditions that these vehicles operate in. It must change when vehicles and conditions change. It includes checking all visible items on the vehicle or equipment and taking note of everything we can feel, touch or smell.

One of the biggest reasons to PM vehicles today is because of the possibility of lawsuit. If an organization operates equipment that is so poorly maintained as to allow failure, and if that failure results in the injury or death of an individual, then the costs are catastrophic. If it is proven that the organization was willfully and wantonly negligent in its adherence to a PM program, then the financial loss is even higher.

A second reason is the law. Years ago, a fleet operation received two bad "BIT" inspections. They failed the third. Their operating permit was almost revoked. The only thing that saved them was that they were able to prove they were not hauling hazardous material in most of their vehicles that were under 10,001 lbs GVW. If they had not proved this, they would have parked $100 million worth of equipment and buildings and gone bankrupt. Their financial loss would have been catastrophic.

Benefits of Paying More Attention to PM

1. **3 to 8 hours are saved for every 1 hour of PM investment.** This is due to the changing nature of repair work when a PM system is working. Most of these hours are the result of repairing items in conjunction with the PM. When small jobs are taken care of during the PM, then the vehicle or equipment does not have to be obtained several times between inspections to be repaired.

2. **Rust is controlled.** In many fleets, rust and corrosion is out of control. They either have no PM program, or the PM program does not address rust and corrosion. As the mechanic notices that rust is beginning to happen, there should be an appropriate counteraction to stop the rust. Too often, the rust is allowed to spread and grow. The result is vehicles with holes in fenders, doors, eyebrows, rocker panels, fender areas, mirrors, etc. Some of these repairs can be very expensive. The PM system should train the mechanics to identify these areas early when the beginning signs appear and plan a correction of applying coatings to the metal to stop the spread of rust.

3. **Small repairs are efficient.** If the PM is not working, it may be due to a lengthy schedule interval or to the fact that the quality is low. The result will be too much demand maintenance (unscheduled repairs).

4. **Failed lines and hoses eliminated.** As a vehicle gets older, the lines, hoses and wires begin to deteriorate and begin to rub and chafe. These eventually will fail, causing catastrophic damage in many cases. For example, a rubbing heater hose could fail, which almost always causes engine damage.

5. **Lube and oil changes protect equipment.** There are several functions that are happening with lube and oil. Oil changes take contaminates out of the engine that could be devastating to engine life. Acids, varnish and other combustion materials are removed. The oil is replaced which also replaces the additive package that has been added to clean the engine components, prevent foaming, prevent damage from high temperatures, etc. Grease not only lubricates, but often is used to flush out dirt and other foreign material that will ruin the metal surfaces.

6. **Electrical repairs are reduced.** The electrical system on a vehicle begins to deteriorate from the moment the vehicle is purchased. Items like the battery have a certain cycle life. The PM system should test the condition of the battery to see at what point the battery is in poor shape. If the battery is not replaced on the PM's, then it will be on a road call, or on a driver delay some cold morning where the vehicle has been parked. The wiring harness also is susceptible to corrosion with time. Wiring harnesses that are poorly designed can cause a lot of problems as the vehicle gets a little older. Most of this can be prevented by following some simple PM procedures along the way.

7. **Components can be replaced before failure.** A tune-up is a planned event to change spark plugs and test other ignition components before they are used up. This prevents road failure and saves fuel. The actual tune-up is considered to be a repair by many fleets, but is still scheduled by the PM scheduling system. This is usually performed on a "C" service perhaps, with the computer scheduling the tune-up, but the actual tune-up is a repair.

PM Affects Costs

As noted earlier, PM saves time and dollars. The changes in fleets that occur with good PM are remarkable. There are two classes of labor for a shop. The best is scheduled work or planned work. The other is unscheduled or unplanned work. We divide the unscheduled work in three categories. This is because each of them has a difference in operational expenses.

1. **Road calls.** Road calls are very expensive. First, the service of the organization is affected. This is especially true if the road call is on a piece of fire apparatus or an ambulance. It is also extremely bad for a bus. A fleet manager of a shipping organization may think that road calls are inexpensive because their trucks are only carrying packages and not people. However, the cost to the business in that case also comes in the form of unhappy customers whose packages arrive later than expected. Considering all of the costs of road calls makes it easier to devote time to preventing them.

2. **Driver delays (running repairs).** The second worst case of unscheduled work is delays. A driver or operator comes to work, climbs into or onto the vehicle or equipment and finds something wrong that will prevent the vehicle or equipment from performing its main function for all or part of the day. This is bad. The operator then takes it to the shop or reports it to the shop and waits around (while being paid). This is counted separately because it is not as expensive as road calls,
but it is still the second-highest category in terms of waste.

3. **Vehicle condition reports (driver gripe sheets).** This is the best type of unscheduled repair, because the driver usually goes home after signing the vehicle condition sheet and does not stand around. The shop has some time to respond if it has scheduled the mechanics correctly. On day-shift vehicles, most private fleets take care of the PM's on a swing shift. Some day-shift operations bring the mechanics in at 6:00 am so they can repair these small items and be on hand for the driver drop-ins that will occur shortly after the crews come to work.

CHAPTER 2

Advancing PM Forms and Inspections

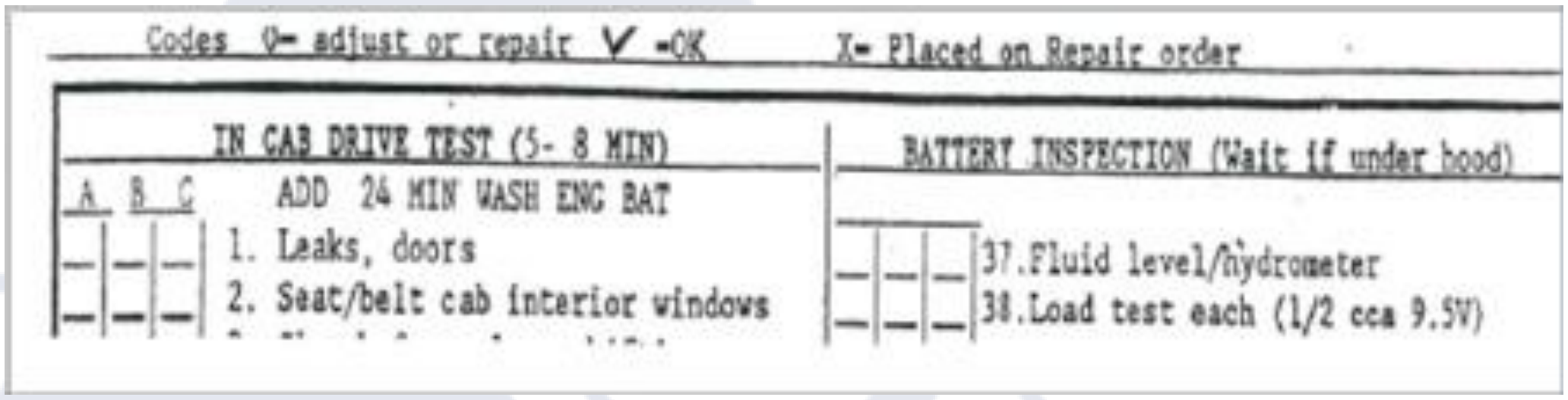
No PM system can function profitably without the support of good records.

Inspection Procedures (the Form)

A good PM form must provide a general road map to the detailed inspection of each vehicle: a list of items to be examined, adjusted, tested and if necessary, replaced before anticipated failure. The replacement of items nearly worn out can be planned for the next PMI interval, the parts obtained and then time scheduled for this activity.

A good inspection form must be a good communication device between mechanic and the management of the operation. It generally will have codes so longhand English notes do not have to be made, such as:

- Check mark for “O.K.”
- 0 for an adjustment or tightening had to be made
- X for more long-term repairs that will appear in greater detail on work orders or repair orders



Codes 0- adjust or repair ✓ -OK X- Placed on Repair order

IN CAB DRIVE TEST (5- 8 MIN)				BATTERY INSPECTION (Wait if under hood)		
A	B	C	ADD 24 MIN WASH ENG BAT			
			1. Leaks, doors			37. Fluid level/hydrometer
			2. Seat/belt cab interior windows			38. Load test each (1/2 cca 9.5V)

The form should be multi-purpose. It should cover several types of inspections. This can be accomplished by making columns to be checked off on appropriate inspections. The form can and should cover several different vehicles if they are somewhat similar. For example, a dump truck, a road tractor, and a concrete mixer will have nearly the same inspection points in the cab area, the engine area and the chassis area.

A good form does not need any wasted words. For example "check" should be understood and should not have to be placed on a PM form. There shouldn't be any explanations on the PM form. These should be in a backup document that describes the inspection in detail. The form should be as simple as possible but should include all the items required by law.

Regular Inspections (the Schedule)

PM inspections must have a regular schedule based on the needs of the individual unit. With this schedule, trouble can be more easily detected and shop time can be more economically scheduled. Generally, this timetable corresponds with oil changes or other lubrication intervals. Vehicles should be brought in as infrequently as possible. For more on scheduling, see Chapter 3.

REFURBISH AND PM

Refurbishing is counterproductive to preventative maintenance. If a vehicle has a good PM program, its condition will not vary greatly. Each component on the equipment or vehicle has a life cycle. Refurbish programs generally take a vehicle that has deteriorated to a very low point and through a very thorough inspection and repair program, bring it up to a near new condition.

If the PM program has been working, the vehicle never gets into a bad condition. The paint job may start getting shabby or an engine might wear out. These are scheduled to be painted or rebuilt as they are needed. In a refurbish program, many components are replaced even though they were recently replaced.

PM Levels of Competence

LUBE AND OIL JOCKEY

The lowest level of competence is simply lube and oil. The service attendant simply lubes and changes the oil and finds little or nothing wrong.

THE PROBLEM FINDER

The next level of competence is the mechanic who finds the items wrong. For example, the horn does not work. The air line is chaffed and is leaking. The tire is flat. The radiator hose is leaking. The battery won't start the vehicle.

THE TRAINED DIAGNOSTICIAN

The highest level of competence is the person who finds the loose horn button and repairs it. This is the person who finds the air line, heater hose or electrical wire that is rubbing and ties it back. This is the person who predicts when the tires will wear out.

This is the person who predicts when the brakes will wear out and does not replace them when they are only half worn out, or too late when they have ruined the rotors. This is the person who finds the weak battery.

One of the ways to determine whether a PM system is working is to look through the records and see how many batteries were replaced on PM's versus how many were replaced or won't start Monday morning after sitting for a weekend.

The Quick Lube Syndrome

Managers are increasingly influenced by commercials for a 10-minute oil change. There are several things wrong with this. First, they rarely find anything wrong with the vehicle and so the inspection is wasted. Secondly, they have been known to frequently charge for an oil change, when they simply change the filter. They have also been frequently known for charging for an air filer when they did not change the air filter. They also have been known to leave filters and drain plugs loose. Almost everyone you talk to who has used this type of operation has experienced one or more of these problems. Remember the saying, "you get what you pay for" (or less in this case).

Record Keeping

Any operating PM plan must produce a running record of all the mechanical work done on a vehicle. These records must be easy to keep, easy to read, readily available, and always up to date. These records will become necessary if there is an accident or other unplanned event. The PM record of an individual vehicle must be examined before any service work is done: to avoid repeat maintenance, to uncover related problems, to recheck previous adjustments and repairs.

Program Analysis

The entire PM plan must be reviewed periodically to see that it is performing as it should. Repetitive maintenance must be low. Road calls must be low. Unscheduled shop visits must be at a minimum. Maintenance costs must stay within the budget. One fleet of 40 vehicles wanted to extend their PM intervals. The result indicated that at some point in time, just the reduction of unscheduled repairs was enough to perform the PM.

Maintenance problems should stand out so that appropriate action can be taken rapidly. If components are found on PM to be worn or in need of lubrication more frequently, then the PM program must respond.

If there are road calls on fan belts for example, the PM program must be increased to find those problems before failure occurs.

Simplify Solutions

Problem analysis should be easier because repetitive or major repairs should be spotlighted by continuous vehicle history recording. New systems even check on previous repairs of the same nature automatically.

CONTROL COSTS
A good system will show you immediately when something is getting out of hand: costs are likely to go up unless action is taken at once!

ORGANIZE MAINTENANCE
By highlighting high-cost areas, poor utilization, inconvenience or delay, a good record system points out where maintenance changes are needed.

REDUCE LABOR
Good records pinpoint repetitive maintenance and unscheduled shop visits, and help to reduce both! Remember, a good PM system will reduce overall labor by 3 to 8 hours for every hour of good solid PM work.

SAVE DOLLARS
A PM plan should not be static. Conditions change vehicles age. Driver habits vary. Therefore, the only way a PM plan can know where it's going is to know where it's been! Without complete, easy-to-use records of the way your vehicles perform and the way your maintenance people service those vehicles, you cannot know how profitably your PM program is working. You cannot know the best ways to improve it! Since a good PM program is built on careful, continuous analysis of unscheduled shop visits, obviously you must have a complete record of those visits, including exactly what work was done.

CHAPTER 3

Advancing Scheduling

An advanced PM system spends 50% of the time on PM. A less effective system spends less time on PM, which leads to more time on road calls, drop-ins and unscheduled maintenance.

Scheduling Methods

There are several ways to schedule vehicles. The easiest on management but the most wasteful on mechanics is time. When management schedules on time, they can schedule every vehicle or piece of equipment in the shop every so many days. For example, one state brought their vehicles in every 30 days. These were very low mileage vehicles. The U.S. Postal Service in times gone by brought their small delivery vehicles in every 6 months. One was too short, the other too long, and neither related to the usage of the equipment.

Time is a good backup system when combined with other elements of scheduling. For example a vehicle is due in at 8,000 miles or every 120 days. This gets vehicles into the shop to be looked over even when they are not being utilized. They may not need attention in some areas, but the tires need to be inflated and the batteries checked over and recharged if necessary. Hydraulic systems need to be checked over.

Mileage is the most-used scheduling measurement, but it has a few problems. The largest problem is that mileage does not compensate for idle time or PTO time that a vehicle might be a large portion of a vehicle's utilization. Oftentimes a fleet will set the mileage interval high and capture the high-mileage units on a mileage basis and capture the low-mileage units on the time-interval basis.

The hours method is used where the vehicle or equipment works hard during every mile. Waste trucks, concrete trucks and other units are often scheduled on an hour-meter basis. The engine is working hard even though the chassis is averaging low mile per hour.

Some fleets schedule vehicles on the amount of gallons of fuel consumed. This can only be done if the fueling is accurate. It is a good system because it addresses the issue as to how hard the unit has worked. It still is used in conjunction with time intervals so that other issues can be addressed.

The type of operation and the type of engines will dictate the items to be serviced on each inspection as well as what type of service the vehicle is performing. For example a heavy diesel may have an 18,000-mile oil change. It likely will need a grease job at the halfway mark.

Recently a fleet of heavy over-the-road vehicles was not lubricating the chassis until 18,000 miles. Everything seemed to live a long time except front spring pins. They were in the front wheel wash area, so the grease likely was being washed out. It was determined that if the interval was moved to 9,000 for a grease job, the vehicle would cost another $70 to PM every 18,000 miles. The life of the spring pins was now 125,000 miles. If they were lubricated more frequently, the front spring pins would last 185,000 miles. It was decided that it was not cost efficient to do this.

Below you will find a brief idea of schedules. You will not be able to follow these schedules precisely because of your unique operation, but through oil analysis you can adjust these to fit your fleet. You of course must also depend on manufacturer's warranty provisions unless they are waived due to oil analysis.

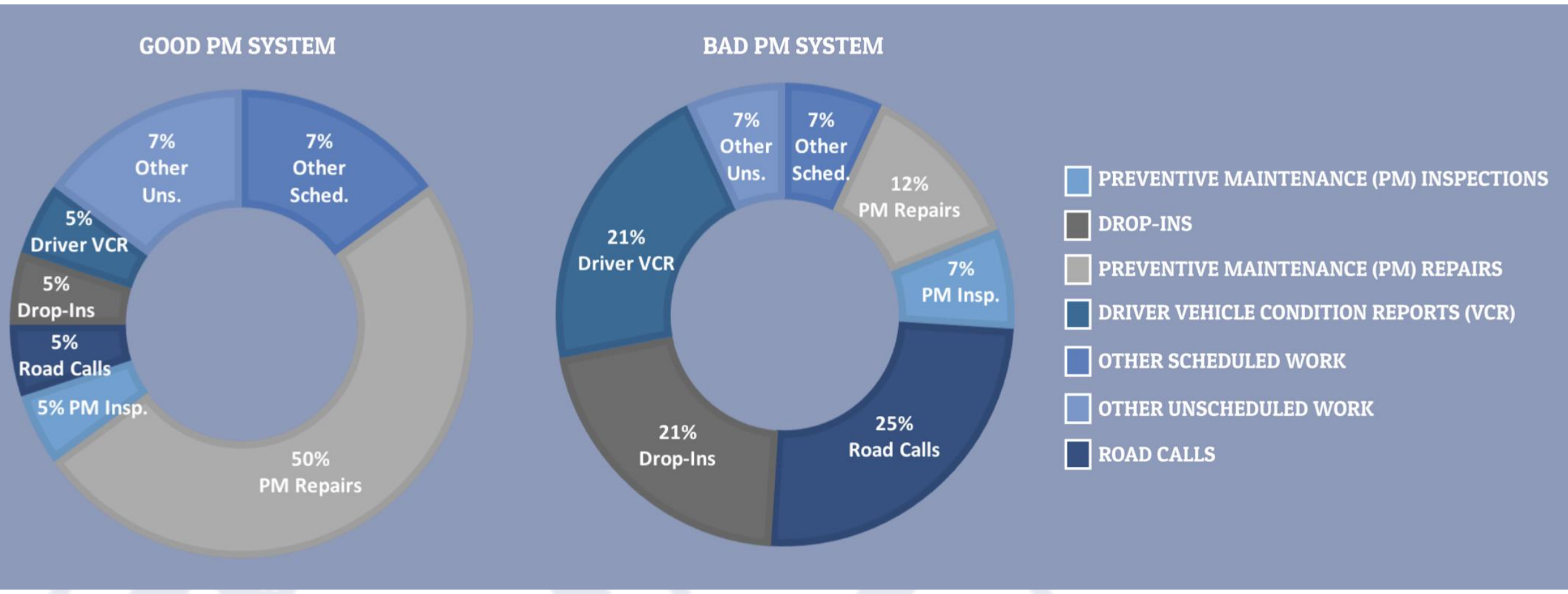
These are general assumptions and ideas. Oil changes intervals have a lot to do with service, oil pan capacities, and other factors. There are applications, for example, where small diesel engines have a 12-quart capacity and are allowed to go 600 hours (equivalent of 12,000 to 18,000 miles) between oil changes and it does not hurt them in the least.

Vehicle Type	Usage	PM Interval
Cars/pickups/light trucks*	60% highway 40% highway Urban & suburban Urban & idle	6,000 – 7,500 5,000 – 6,000 4,000 – 5,000 3,000 – 4,500
Medium trucks (diesel equipped)*	Highway 60% highway Urban & suburban Urban small city Urban large city	8,000 – 10,000 7,000 – 8,000 6,000 – 7,000 5,000 – 6,000 4,000 – 5,000
Heavy diesel trucks*	Highway 60% highway Urban & suburban Constant stopping urban	12,000 – 18,000 (some now 24,000) 10,000 – 14,000 8,000 – 10,000 5,000 – 8,000

Can PM Time Be Wasted?

Yes, it can. It can be wasted by having the schedule too close together. It can be wasted by being too comprehensive. For example, a fleet may not have any problems with wheel bearings but pull wheels every other inspection. That time could be better invested in electrical testing or another more pertinent task. It is wasted when the mechanic is not productive.

If the mechanic takes 4 hours to inspect a heavy vehicle that should have been inspected in 1.5 hours, a lot of time was wasted. A PM is partially wasted if the mechanic finds nothing wrong with the equipment. Almost all equipment has little things wrong. The major missed areas are rubbing lines and hoses that eventually will cause a catastrophic road call.



CHAPTER 4

Advancing Mechanic Training

Everything the mechanic needs to inspect should fit within a 3-foot diameter circle.

Who Should Perform preventative Maintenance?

1. Service attendant?
2. Apprentice?
3. Class B mechanic?
4. Class A mechanic?
5. Several people or just a few?

The most successful PM programs observed in the world have been those performed by qualified, authorized, fully fledged mechanics. The second-best system is the utilization of apprentices. The utilization of service attendants to perform inspection has many levels of success. Occasionally an organization is found where the service attendants are finding all the problems on the vehicles, but that is rare.

The total movement of vehicles and vehicle utilization are key elements of this problem. If one person performs the inspection and another performs the repair, the vehicle has to be moved to a waiting area and then returned to the shop. This takes both time and extends the vehicle out of service time. The best way is for the person who performs the inspection to also perform the repairs at least most of the time. This also results in the highest level of writing of all systems. If the person who performs the inspection also does the repair, there is less writing on repair documents.

One very large government fleet developed a new PM form for many thousands of vehicles they were purchasing. They paid their PM inspector the highest pay in the shop. They did not have this person perform the repairs, but it is interesting to note that the inspector was the highest-paid person in the shop other than supervision.

A Logical Approach

PM helps keep a truck out or the shop, particularly when it is supposed to be out working and making money! A logical PM inspection procedure will cut down the time that the vehicle must be in the shop to get PM protection. A PM inspection sequence is logical, if:

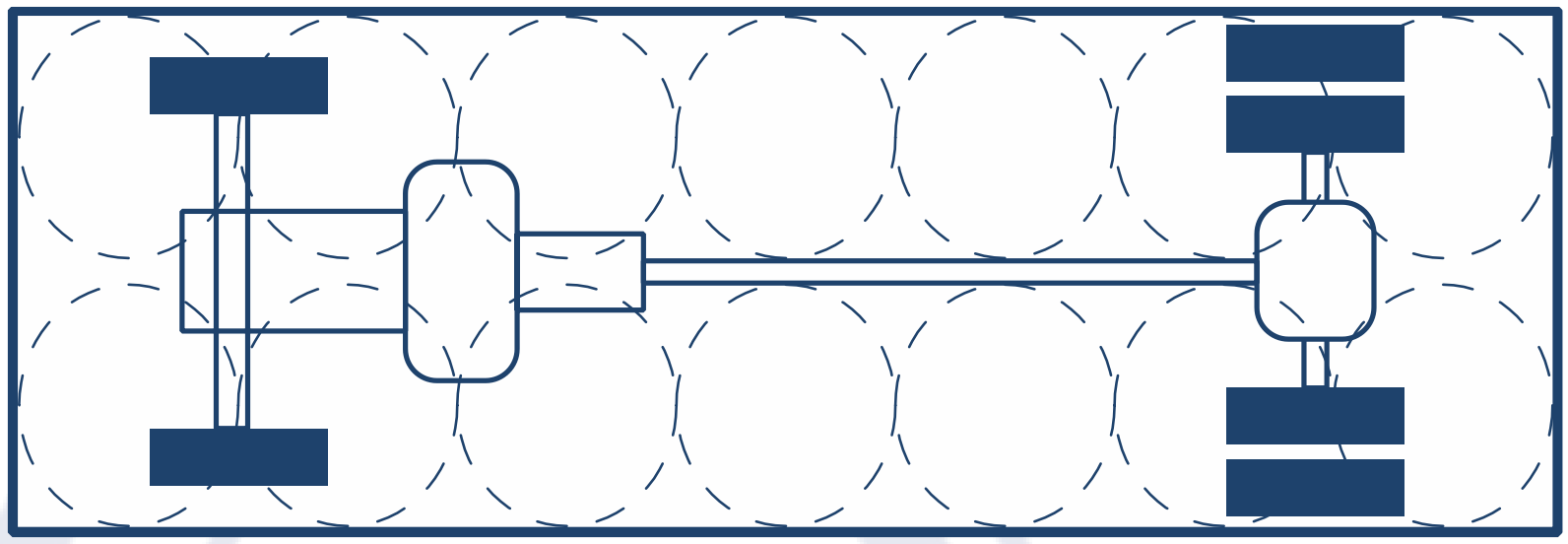
(a) A person does everything he can reach from one spot before he moves on to the next spot;
(b) One doesn't have to retrace his steps.

It doesn't matter which vehicle you're inspecting; you need one specific way of looking at it all over and a way that can be repeated, even if the item that is about to cause that trouble isn't even on the PM list! Many items will not be on the inspection list.

The Circle Concept

On a rough sketch of the vehicle, make marks to indicate the general locations of the items to be examined during the PM inspection.

Draw circles around each mark to represent areas two or three feet in diameter. If the circles overlap and all major areas of the vehicle are covered, you are already set up for the area method of inspection. If there are holes in your coverage, examine the vehicle at these points to select an item that can be included in the inspection. When all major areas are covered, your inspection list is complete. The mechanic is responsible for everything in the circle.



1. Start with the cab.
2. Move completely around the vehicle, inspecting wheels, sheet metal, frame and body and attached components such as waste body or dump body or digger, derrick or crane.
3. Get under it. Start the oil draining and lube it from front to back and inspect it. Put the plug back in and change the filters.
4. Open the hood; work one side of the engine compartment, then the front and other side.

Remember, the better the PM inspector is, the faster he or she will work, saving labor and vehicle time, and the more potential trouble will be spotted.

Train the Eyes to See

In addition to leading the inspector logically all around and under the vehicle, the PM inspection procedure also provides specific reasons to look at every area of the vehicle. This procedure is based on the plain fact that when a person looks at one part of a vehicle, his or her eyes should take in much of the surrounding area.

If one is a qualified inspector, following a regular inspection pattern, one will notice such things as water and oil leaks, cracked sheet metal or frame members, crimped or rubbing hydraulic lines, loose or lost bolts and other things that may appear on areas immediately adjacent to the specific items listed on his PM check sheet. This is another reason why it is extremely important to have a very good person as a PM inspector. As one goes through the inspection routine, one may not know exactly what one is looking for, but one does have the "know-how" and experience to see trouble when it's there!

PROPER TOOLS

Even though batteries and starting problems are high on the unscheduled repair lists, many large and small fleets have been found not load testing batteries on inspections. This is a horrible situation. Voltage drop can be read while the vehicle is being started, but this will not suffice when the vehicle begins to be started in cold weather. When batteries get about one year old, they need to be tested to see if they have lost their reserve.

TORQUE VALUES

Bolt Size	Grade 5 Torque	Grade 8 Torque
1/4"	7	11
5/16"	14	22
3/8"	25	37
7/16"	40	61
1/2"	60	92
9/16"	88	132
5/8"	120	180
3/4"	200	296
7/8"	307	475
1"	465	715

INSPECTION TIMES

Automobile & Pickup	45 minutes to 1 hour
Light Truck	1 hour to 1 hour 10 minutes
Medium Truck	1 hour 15 minutes
Heavy Truck (simple)	1 hour 40 minutes
Heavy Truck (complex, e.g. waste trucks)	2 hours 15 minutes

CHAPTER 5

Advancing Quality Control

You must have good maintenance records to profit by experience.

Quality control provides an opportunity to review your PM program and check that it is running properly.

Review Your Records

Since the best way to create a PM inspection form is from the obvious needs of the individual vehicle, you must know those needs. The day-to-day service and operating experience with a vehicle will give you some idea of the requirements for a vehicle fleet. But much will get overlooked. And often it is the overlooked things that cause downtime, the road calls and the unscheduled shop visits.

Remember, to develop a PM inspection form that fits a given vehicle or a given fleet, you need to know what service maintenance requirements are imposed by the conditions in which those vehicles operate.

You get this information from maintenance records—from well-written, accurately filed repair orders and driver reports.

Review Your Inspection Intervals

How do you establish correct intervals for regular PM inspections?

- Make an educated guess, based on vehicle manufacturer recommendations and on your own experience.
- Check with others operating similar vehicles.
- Increase or reduce intervals as you find out how the vehicles perform.
- PM intervals don’t have to be based on miles or days. Any uniform system of measurement can be used to set up a PM inspections schedule.

Review Your Forms

1. Is all work done being noted on the repair order?
2. Are you noting the amount of fluid being added on the form provision so the cause for fluid loss can be detected and checked next time?
3. Does each form apply to the specific vehicles being inspected?

4. Are inspections listed on each form in logical sequence, so the inspector seldom needs to retrace his steps?
5. Are actual inspections being performed in the sequence listed?
6. Are items that never seem to need attention being removed from the inspection list?
7. Are different forms developed for new vehicles?
8. How recently have the PM forms been studied and/or revised?

Review Your Target Times

Target times are being listed on the individual forms. These target times are goals. They will vary with walk distances to vehicles and other factors. A few companies even have the vehicles delivered to the garage by service attendants. This does not reduce the mechanic's time too much unless the attendants perform part of the inspection.

Additional Quality Control Tips

1. The mechanic begins the inspection before getting to the vehicle. Some mechanics bring the vehicle into the shop before they beep the horn or do the in-cab portion. The inspection should begin immediately as you approach the vehicle.

2. The mechanic does not begin to look around inside the cab. Since the item that will hold up the mechanic is the air brake test, bleed the air down to check low warning buzzer and light, hold the foot on the brake for about 20 seconds and watch the gauge to see if there are any dynamic air leaks. After the mechanic finds there is no air leak, he/she then checks the bottom and top clearance on the clutch (if equipped) and starts the vehicle. As the air pressure is building, then the items in the cab are checked. This gives you a snap shot to the approach.

3. The mechanic should not massage the vehicle but should quickly inspect it. It has been found that mechanics who look around a lot often do a poorer inspection than those who move quickly through the inspection. For example it only takes about 7 seconds to check a door, not 3 minutes.

4. One of the biggest wastes of PM time is the underneath. Mechanics have been observed walking back and forth looking for something wrong. There are important items underneath, but most of the important items are the tires and the electrical, cooling and fuel in or near the engine compartment. They are the key elements of the vehicle that can cause problems.

5. Performing road tests are questionable. Some people do not road test because of the area the shop is in, or because the shop would have to be locked up if they left it. Fleets that road test do no better on quality of inspections than those who do not.

6. Whether you wash the engine at all, or before or after brings up arguments. One of the best fleets in the country, UPS, washed engines before the inspection. They were very successful doing it this way. It was more important to them that the mechanic works in a clean environment than any other consideration.

7. Pulling wheels is controversial. Some states require some vehicles (school buses for example) to get a wheel pull. If you pull all the wheels, you double the inspection time and only get more seal leaks for your effort. Look at the brake shoes. Some operations have drilled small holes in drums and backing plates so they can do an inspection of the shoes and look for leaks. This is very satisfactory.