What Coolant To Use

By: Andy Wiedeman
Member of the Rocky Mountain A’s
March: 2008
Updated: September/October 2011

Synopsis
This report was written to shed some light on the use of modern coolants in the Model A Ford. The conclusions reached in this report may be controversial, since some Model A enthusiasts tend to be somewhat “married” to their own personal preferences with respect to what coolant they use. The Model A Ford owners community is divided into two camps, those that favor the use of modern Anti-Freeze coolants year round, and those who use water, or water with an additive, in the summer and drive or store the Model A in the winter with Anti-Freeze. I think it is high time that some studied analysis of “what coolant to use” is written to show the advantages and disadvantages of both approaches and the risks of using various coolants.

Most importantly, here in Colorado, the altitude robs us of considerable margin in temperature when operating the Model A. Depending on your Model A’s cooling system condition you may be operating with sufficient margin to prevent overheating, or you may be operating dangerously close to component damaging temperatures. At risk is depriving your engine cylinders of lubricating oil, causing excessive cylinder wear. Driving over high mountain passes, pulling long grades, being stuck in city traffic, or spending long periods idling in a parade, may lead to coolant boiling.

We find that the best coolant strategy is to use DISTILLED water plus Red Line Oil’s WaterWetter as a summer time coolant. Tests have shown that WaterWetter, a surface tension reducer, may lower bulk cooling fluid temperatures from 5 to 18 degrees F. at the entrance to the radiator depending on driving conditions. When winter rolls around, change to an Inorganic Additive Technology (common green color) antifreeze. Do not use Organic Acid Technology (OAT) “Extended Life” or “Permanent” antifreezes as they attack gaskets and gasket sealants.
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1.0 Why Not Just Use Plain Old Water?
The standard old saw among mechanics is "water cools best". This belief even has some scientific basis, since water has the highest specific heat and latent heat properties, providing the **highest heat transfer capacity**, among the available coolants. For this reason, until recent times, water was used for 50 years in automobile coolant design. But on the other hand, water has the **lowest boiling point** of common automobile coolants at 212 degrees F, or 200 degrees F average in the front range of Colorado, leading to driving frustration in severe use or hot weather temperature conditions.

**Why not use Modern Coolants with Antifreeze?**
A 50/50 mixture of water and anti-freeze has a higher boiling point of 225 to 250 degrees F depending on whether or not the cooling system is pressurized or not.¹ For the Model A Ford, which has a non pressurized system the presence of anti-freeze should raise the boiling point. Soooo, it seems to follow, if you can raise the boiling point by using a 50/50 mixture of anti-freeze your Model A cooling system should do a better cooling job and not boil over as much with anti-freeze in your radiator, … right? **Well, unfortunately this is wrong!** The boiling point of the bulk coolant is not the most important factor in cooling. In fact, we now know that the primary factors in engine cooling are the heat transfer properties of coolants and the surface tension property of the coolant. The critical parts of the engine to cool are the exhaust valves, and the oil film on the inside of the cylinders of your engine. In fact, the bulk coolant boiling point is the least of the important properties of the coolant. Antifreeze has lower heat transfer properties than plain water, therefore was not recommended by Ford in 1928 – 1931 as a coolant to use in the summer. In addition, modern coolants include silicate and phosphate corrosion inhibitors which react with water to form insulating layers (scale) on the hot metal surfaces, which in turn raise the temperature of engine. **BEWARE, DO NOT USE OAT “PERMANENT” or “LONG LIFE” ANTIFREEZE (the orange colored antifreeze) in your engine !** These types of antifreeze use organic compounds which attack the gaskets and sealants, and reacts with copper brass in your head gasket, leading to failure. ² These types are labeled OAT, HOAT, and NOAT. To learn why antifreeze solutions may lead to engine damage … read on.

**Can we improve on Plain Old Water?**
Yes! In this modern world of ours we now know that we can, easily, and affordably improve on mother nature’s water. The automobile racing crowd, with their engines churning out thousands of horsepower led the way, with companies like Red Line Oil, and Royal Purple Oil, sponsoring

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¹ At sea level, here in Colorado it is 212 at 5280 ft. altitude, non-pressurized Model A.
² The Antique Auto Club of America: AACA and the Rolls Royce Club of the UK
research into ways to improve the cooling of high horsepower engines. These companies discovered an inexpensive additive which reduces the surface tension property of water which increases the heat transfer capacity. This in turn, reduces the temperature of the coolant by up to 18 degrees. What? you say, has this to do with the puny 35 horsepower Model A. Plenty, I say, because here in high altitude Colorado we are robbed of temperature margin between the normal operating temperature of the Model A engine and the boiling of engine coolants. This means that our Model A’s get hot and overheat quicker than at most locations in the USA.

**Benefits of Modern Coolants**

Modern coolants, such as common antifreeze that you can buy almost anywhere, have been developed since the advent of using aluminum in engine blocks, heads, and other engine parts that come in contact with the coolant. Furthermore, it was recognized early in the development of the automobile, that mineral deposits caused by high heat conditions in the engine, reduced the capability of water to cool the engine due to scale buildup. To prevent scale, and corrosion, additives were formulated and added to modern coolants. Here are some of the additives found both in common antifreeze and in water additives such as Red Line WaterWetter;

**Anti-Corrosion**

Corrosion is caused by oxygen in aeration of the water which causes 30 times more corrosion at high temperatures than at 70 deg. F. In the Model A this equals rust which breaks loose and circulates in the coolant. These particles attract each other and deposits form on radiator cores, hoses, and recesses in the engine block. Modern coolants and additives employ proprietary corrosion inhibitors to resist corrosion. Avoid the use of coolants with silicates.

**Anti-Scaling**

Scaling is caused by precipitation of small mineral particles dissolved in water. During the cooling heat transfer process, these particles are deposited on hot metal surfaces inside your engine. Scale is often confused with rust corrosion because it takes on the color of the rust. Scale is a very poor conductor of heat, and reduces the ability of the coolant to keep the cylinder wall oil film from burning. Scale inhibitors can be reduced by using distilled water as a coolant, or by using antifreeze fortified with proprietary scale inhibitors.

**Water Pump Seal Lubricant**

While many antifreeze manufacturers indicate that they include water pump seal lubricants, modern automotive water pumps do not require any type of lubrication. In fact, if the coolant

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3 Using Redline WaterWetter additive, under test conditions of sustained freeway driving in hot summer weather
4 Dyke’s Automobile and Engine Encyclopedia; page 150. Published 1919
5 Glenn’s New Auto Repair Manual at page 113; Harold T. Glenn, Published by Chilton 1962
6 Ibid at page 113
7 Conventional inhibitors like silicates and phosphates work by forming a protective blanket that actually insulates the metals from the coolant. To prevent scale buildup use distilled water only. Under NO CIRCUMSTANCES USE EXTENDED LIFE ANTIFREEZE made with organic compounds labeled OAT, HOAT, or NOAT.
comes in contact with the bearing, the pump has failed. Marketer’s of cooling system products continue to claim that they provide water pump and thermostat lubrication which is probably not needed, and may contribute to gunk forming in radiators. But what about the Model A water pump?

Model A water pumps come in two varieties, those that are stock, and those that are of the “leakless” type. Stock water pumps use grease to lubricate the shaft and a brass bushing that is backed up by a packing seal on the exterior of the pump housing. This packing seal is either graphite lead, or is Teflon in modern rebuilt pumps. The “leakless” types have a sealed type bushing with seals of Neoprene or Teflon, depending on the manufacturer of the pump.

Compatibility of either antifreeze compounds or the additives in Red Line WaterWetter with the use of Grease, Graphite Lead, Teflon, or Neoprene is important to the long term wear out of your Model A water pump. Testing has shown that Teflon, brass, stainless steel, and grease are all “acceptable” as materials to use with antifreeze. This leaves “leakless” water pumps made with Neoprene seals, and stock water pumps using Graphite Lead packing as suspecting potential problems. Neoprene compatibility with antifreeze has only a grade “C” which means “fair” rating. \(^8\) With respect to the stock packing of Graphite Lead, not much information is available. Halford’s Antifreeze \(^9\) was contacted, the technical department answered “Don’t use antifreeze with lead materials, it will strip various alloys out of the lead solder, lead bushes etc, it’s only meant for very modern cars!” So, in older cars including the Model A where lead, lead solder, lead alloy bushes, and graphite/lead water pump lubricated rope are used, expect trouble. \(^10\)

What I would recommend if you have a stock water pump with Graphite-Lead packing, or if you have a leakless water pump and do not know what kind of seal was used (maybe it is Neoprene) I would stay away from using antifreeze as a coolant, especially the long life types. \(^11\)

### 1.1 What Does Altitude Have To Do With Overheating?

Cooling the Model A is a general problem for all of us. The familiar overheating of the engine during summer tours and parades, the time wasted waiting for the engine to cool down before continuing the tour, and the potential for ruining your precious Model A engine is always present. The fact is that here in Colorado, as well as in other high altitude areas of the USA, the need for an effective coolant is more critical than those lucky folks who live at or near sea level. The reason for this is simple. Water boils at 212 degrees Fahrenheit at sea level, but only at about 200 degrees F average in the front range of the Rocky Mountains of Colorado where the

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\(^8\) Chemical Compatibility Database; Cole Palmer Laboratories; www.colepalmer.com  
\(^9\) Halford’s is a British antifreeze manufacturer  
\(^10\) The right antifreeze for classic cars; www.da7.co.uk  
\(^11\) This only applies if you are operating your car. A car stored with antifreeze for the winter would not be susceptible to damage due to the lower temperatures in storage.
altitude of our operation is over 1 mile high. 12 This reduces the margin of safety by nearly 25%. The margin of safety, between boiling and the normal operating temperature of the engine of about 160 degrees F, at sea level is 52 deg F, but only 40 deg F in Denver. This means that it is more likely that the Model A enthusiast in Colorado is more likely to encounter overheating of his perfectly restored car than an owner who lives in the Midwest, or in the bay area of California.

**What Can We Do About Overheating?**

Well, there are some things you can do. Putting in a new radiator, thoroughly descaling and derusting your block and head, removing any obstruction (such as a thermostat) in your input and output water hoses, and ensuring that your water pump is in tip top condition will certainly help an old Model A that has not had maintenance in many years. However, the best approach is to use a 4 core radiator. This is the highest percentage wise improvement you can make. A 4 row core radiator used in a 1930 to 1931 Model A, based on the AA truck radiator, has about 100% more cooling capacity (double) than a standard 3 row core version. This is especially true for the 1928 – 1929 models with the smaller radiators where the improvement is even more dramatic. To learn more about improved radiator efficiency, visit the Restoration/Cooling System category of the Technical Data page at the RMA website www.rockymountainmodelaclub.org. Be prepared to spend some big bucks on this.

**What can I Do if I Don’t Want to Invest in A Four Row Core Radiator?**

If you are reluctant to change the radiator to a four row core version, the next best thing you can do is make sure that your radiator is as clean as a new one, flushed, and has no damage to the cooling fins. Finally, there is choosing the right cooling fluid and additives. While the choice of cooling fluid and additives may not improve the cooling capability significantly, it just may help enough to keep your engine from overheating and boiling on your next tour in downtown stop and go conditions, or going over that mountain pass at 11,500 feet! Some Model A enthusiasts have found some dramatic results in simply using an additive called WaterWetter. Many other automobile enthusiasts have reported that Red Line’s WaterWetter product reduced bulk cooling water temperatures from 5 to 18 degrees. Read …on!

1.2 **What Are Our Choices of Cooling Fluids?**

There are several choices of coolants that are available to the Model A enthusiast. Back in Henry Ford’s day there were only three, plain old water, water plus alcohol solutions, and water plus Ethylene Glycol anti-freeze solutions (called Glycerine in those days). The Alcohol or Ethylene Glycol solutions, both mixed with water, were the anti-freezes of the 1930’s. 13

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12 The boiling point of water goes up or down by 2 degrees for every 1000 feet of altitude. Example: the boiling point in downtown Denver is about 202 degrees F but at my home in the mountains it is 198 degrees F.

13 The Ford Service Bulletins each year recommended draining and flushing the cooling system each year before the winter and recommended a 50/50 mix of water and alcohol in 1928 and 1929. In December of 1930 the Service Bulletin was amended to add Ethylene Glycol in a 50/50 mix to the previous water and alcohol anti-freeze solution for Winter use. Ford was careful to
Alcohol evaporated quickly and needed replacing several times a winter. Some motorists also used alkali (calcium chloride) and kerosene, but these mixtures proved detrimental to the radiator, gaskets, and hoses used in the Model A. In those days the Glycerine “gummed” up the radiator (Motor Vehicles and their Engines, by Edward Fraser, published 1922), so it was recommended that the anti-freeze solution be drained in the spring for the summer season and not reintroduced until needed in the winter. We always can learn from the good old days as we will see in a few more paragraphs. In the 1930s there was not much choice in coolants, and none of the engine saving additives that we can use to get longer engine life. So as we will learn, in this case, the good old days are not really the best old days.

Today we have many choices of cooling fluids for the use in our Model A’s

<table>
<thead>
<tr>
<th>Coolant Choices</th>
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<tbody>
<tr>
<td>Coolant</td>
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<tr>
<td>Tap Water</td>
</tr>
<tr>
<td>Distilled Water</td>
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<tr>
<td>Distilled Water plus STR (2)</td>
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<tr>
<td>Ethylene Glycol (Inert Acid Tech)</td>
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<tr>
<td>Propylene Glycol Organic Acid Technology (OAT)</td>
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<tr>
<td>Engine Ice</td>
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<tr>
<td>Non-Aqueous Propylene Glycol</td>
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Notes:
(1) Per filling
(2) Surface Tension Reducer
(3) Antifreeze is mixed 50/50 with water
(4) Both IAT and OAT antifreeze can be purchased with Ethylene or Propylene Glycol

These choices can be reduced to just three basic concepts. (1) Plain Old Water from the tap or distilled water, (2) Water enhanced with a Surface Tension Reducer, and (3) an Anti-Freeze solution which is left in your Model A year round. If you choose (1) or (2) you must change the water in your Model A twice each year unless you have a heated garage that can maintain a temperature above freezing during the winter (be careful there could be a power outage that would cause your Model A to freeze). If you choose (3) and decide to run an Anti-Freeze

only recommend the use of anti-freeze in the Winter, and in the April 1930 Service Bulletin indicated that it was prudent to drain and flush the Model A cooling system at the beginning of warm weather. Model A Ford Service Bulletins Complete; 2003 Lincoln Publishing Company, Lockport NY.
solution year round in your Model A to avoid changing the coolant, you will have less cooling capability than water, due to its lower heat transfer properties, however you will get corrosion and anti-scale protection. Be warned though, antifreeze additives to reduce scale and corrosion in modern engines may lead to engine cooling system damage. On the other hand if you use choice (2) you have the benefit of the higher cooling capability of water and the corrosion and anti-scale protection of Anti-Freeze.

2.0 I Want To Skip the Technical Details ... Whats Best?
The best approach for a safer engine coolant is to use two different cooling fluids, one for summer touring, and one for winter storage and touring. This of course means that twice a year you will be draining and refilling the radiator and engine. A pain in the rear, you say! Well, … which is the worst pain, an overheated engine, or some maintenance time each year? Here in Colorado, as well as in most locations in the USA, we store our Model A’s in the winter, and break them out of storage in the spring. In October or November, when you are winterizing your Model A, is a good time to switch from the summer coolant, to the winter coolant. In the Spring, when all danger of freezing is past, is a good time to switch from the winter coolant to your summer coolant. This approach has the advantage that you can flush your radiator and engine of deposits twice a year.

2.1 Recommended Summer Coolant
We recommend the use of distilled water with the use of WaterWetter additive. Distilled water is sold at WalMart in 1 gallon containers for less than $1 per gallon. Use distilled water to ensure that the water does not have the minerals commonly found in tap water which create insulating scale deposits in the water jackets of your engine. The tap water in the front range of Colorado is high in alkaline content due to natural mineral content such as calcium, magnesium, iron, and fluorides. These minerals will plate out onto the hot metal surfaces of your Model A engine block and head, in the area of the combustion chamber and will cause long term clogging of your radiator due to the release of dissolved minerals during the cooling process.

The addition of the WaterWetter will cool your car more efficiently than plain water and gives you an additional margin of safety over boiling and perhaps prevent damaging your engine. Water wetting agents added to plain water reduce the surface tension of the water which normally occurs. Reduced surface tension produces an improved water to hot metal heat transfer since more water molecules are in direct contact with the metal surface. In addition, the WaterWetter additive contains the corrosion protection, scale reduction compounds, and water pump lubricants found in modern coolants.

14 Denver Hard Rock Water Company, Denver Colorado
15 An engine cooling additive manufactured by Red Line Oil company and sold at most auto supply companies
2.2 Recommended Winter Storage/Driving Antifreeze
We recommend anti-freeze coolant that can protect your Model A down to -35 deg F. Why -35 deg F? Here in Colorado, the temperatures outdoors or in an unheated garage or barn may get this low. If your Model A is stored indoors, in an unheated garage, or barn, the temperature may approach the ambient outdoor temperature on those long winter nights. Since you are not relying on the cooling performance of the anti-freeze coolant during summer time driving, the cheapest WalMart anti-freeze coolant will do. Save money by draining the anti-freeze coolant, from your radiator in the spring, into a container with a cap so that you can reuse it the next year. There is no limit on how many times you can reuse the anti-freeze coolant this way. I have been doing this for five years without a problem. If you want to save the effort to obtain distilled water you can buy PRE-MIXED antifreeze, which is mixed 50/50 with distilled water. If you are going to drive your Model A during the winter, be sure to use an Inorganic Additive Technology (IAT) antifreeze and not one of the Organic Acid Technology types (OAT).

3.0 Technical Details of Coolants for the Model A Ford
All right, you say that you want to know why I think that this Water plus WaterWetter additive thing is so much better than using plain old water or using a “permanent anti-freeze” and running it year round. To analyze and compare the differences we must understand the Model A Ford cooling system operation, and the chemistry of the coolant types we can use.

3.1 The Model A Ford Cooling System Operation
The Model A engineers used the design of the venerable Model T Ford thermo-siphon system but added a water pump to enhance the flow of the water through the system. The thermo-siphon action provided most of the cooling action with the water pump helping at high speeds to ensure that adequate water was flowing into the top of the radiator. The thermo-siphon concept, not used in modern cars, was a common cooling system in use from nearly the beginning of the automotive industry into the 1930’s. Thermo-Siphoning uses temperature differences between the engine and the radiator to move the cooling water through the circulation system. There are two elements, the hot engine and the cooler radiator. As the engine operates, the controlled explosions of the gasoline in the cylinder combustion chamber heats the surrounding cast iron of the head and cylinder block. Flame temperatures in the combustion chamber can reach 2000 to 4000 deg. F or more causing temperatures in the metal surrounding the combustion chamber and the exhaust valves to rise locally unless cooling by an external fluid (air or water) is employed. Temperatures of the localized area of the cylinder must be reduced to under 350

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16 The cost comes out about the same as buying distilled water and mixing it yourself.
17 The Model T Ford did not have a water pump when it came from the factory. However, due to customer dissatisfaction in hot climates and high altitudes, there was a brisk market in the 1920’s for after market water pumps. These pumps sold for about $3 to $10.50 in the 1920’s (about $40 to $135 in todays money). One method surprisingly injected hot exhaust gases from the exhaust manifold into the coolant water at the inlet to the engine. The company claimed a 30 deg F drop in temperature. Hmmm?
18 Stockel Auto Mechanics Fundamentals: page 75; Published by Goodheart – Willcox, 1969
degrees F to prevent lubricating oil film breakdown\textsuperscript{19}. Other parts of the engine, the combustion chamber in the head, and the valve seats and valve guides must also be cooled. Typically the automobile engine uses a bulk coolant flowing past these hot spots to exchange the heat in the head and block with the coolant. The mechanism for heat transfer uses the chemical properties of latent heat (a measure of the coolant’s heat transfer capacity), and specific heat (the coolant’s ability to absorb heat) to transfer the heat from the metal surfaces to the coolant and absorb the heat into the coolant. The heated coolant then is then delivered to the radiator where it is cooled by passing through a tube and fin arrangement, which releases the heat absorbed into the atmosphere.

There are two types of these heat exchangers, “Forced” and “Thermo-Siphon”. Forced heat exchangers depend on a water pump to deliver coolant to the engine, and are commonly used in modern cars. The thermo-siphon cooling system, used by the Model A Ford, operates on the principle that water when heated becomes less dense than the cooler water below it and rises to the top of the closed system. As the heated water reaches the top of the radiator it begins to cool, become denser, and it falls through the radiator, becoming even cooler. This cooler water, exiting the bottom of the radiator, is siphoned upward toward the cylinder/combustion chamber, to be heated again and begin its next cycle of heating and cooling. For a thermo-siphon system to work, the height of the cooling fluid at the top inlet of the radiator must be considerably higher than the heat producing engine, the radiator must be kept full, and no obstructions in the hoses to reduce coolant fluid flow. \textsuperscript{20} If the siphon action is impeded by a lack of continuous water in the system it stops flowing.

An engine using the Thermo-Siphon system does not need to have a water pump to move the coolant \textsuperscript{21}, however in the case of the Model A, a pump was used to ensure that the cooling fluid moves through the system unimpeded at high speeds. Model A engines were designed using the Thermo-Siphon system, therefore have smooth upward sloping passages with no blockages or dead ends that can trap super heated coolant. It is important to not use accessories such as a thermostat \textsuperscript{22} which impedes the natural thermo-siphon flow of coolant to the radiator.

\textsuperscript{19} Automotive Mechanics page 199; William Crouse; 1\textsuperscript{st} edition; McGraw Hill 1946
\textsuperscript{20} For this reason, the use of a thermostat in a Model A is not a wise choice.
\textsuperscript{21} The Thermo-Siphon cooling system of the Model T Ford did not use a water pump, the cooling balance is self regulating. The Model T when under load and hot siphons more water, thus cooling the engine, and as it slows the flow diminishes. As the engine heats back up, the siphon action increases once again. Balance is achieved by sizing the radiator and the engine pathways for the coolant. Not always effective, the Model T boiled its water coolant quite often. The Model A improved the thermo siphon system by adding the water pump. Initially, too well and the later models used a less efficient water pump.
\textsuperscript{22} A thermostat is used in modern cars to ensure that during the winter, the engine heats up rapidly to operating temperature. Thermostats operate by blocking the flow of water to the radiator until a small pellet of wax in a cylinder reaches a specified temperature and expands and changes from solid to liquid allowing a rod in this cylinder to push open the valve. A return spring closes the valve when it is below the specified temperature. If the engine overheats for some reason the wax can be forced out of the cylinder, or the rod can stick, or other failure mechanisms can prevent opening causing the valve to fail closed. Your engine can be ruined in minutes. Since we rarely use our Model A’s in the winter, there is no necessity to use a thermostat.
3.2 Can the Engine be Too Cool?

The answer is yes. If the engine cooling system is too efficient some of the heat energy developed by the combustion of the fuel will lower the engine’s thermal efficiency. Thermal efficiency of an engine is the relationship between power output and the energy in the fuel burned to produce that power output. The total energy in the fuel is used as shown in the diagram. Thermal efficiency for gasoline engines is about 20% to 25% with most lost in coolant, oil, exhaust gasses, and engine friction.

The early automotive industry found by experimentation and practical example that cooling the engine water to about 170 to 178 degrees F at the input to the radiator yielded an operating engine with an energy balance that kept the lubricating oil from burning, and produced a sufficient margin in cooling to prevent the engine from overheating except under hard driving conditions. Expectation of motorists during the Model A era was “Do not get alarmed if the water in your engine boils occasionally, this is to be expected in this modern motoring age”.

In our “modern” age of automobiles with pressurized cooling systems, and computer operated engines, if the coolant boils we are trained to think that there is “something wrong with the car”. While the early automotive engineers of the Model A era did not know about the physics of engine operation they designed the Model A engine to operate in the 160 to 180 deg F range due to previous experience. In the 1940’s and 1950s engineers found by experimentation and analysis that the basis for good engine performance required a similar temperature range. They found that temperatures over 150 deg F and especially near 200 deg F, will not only be more efficient, but will keep the engine crank case cleaner. Operating the engine below 150 deg F will cause condensation in the crank case, and create sludging, etching of parts, ring and valve sticking and bearing burning while operating above 150 deg. F will keep the engine clean. Laboratory measurements showed that an engine, operating at 180 degrees F yielded cylinder wear after 60 hours of continuous operation in the range of 0.0003 inches, and gas consumption in the range of 2.8 gallons per hour, with the engine yielding 29.5 horsepower. On the other hand, an engine operated at 140 deg F for the same period of time exhibited cylinder wear of 0.0010 inches (3

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23 Automotive Mechanics, William Crouse at page 76
25 Ibid
times the wear), gas consumption of 3.2 gallons per hour (14% less MPG), and 1 Horsepower less (3.2% less) than operation at 180 deg F.  

3.3 How to Choose a Coolant for your Model A
Choosing a coolant for your Model A requires some thought and tradeoffs and perhaps some testing. The choice depends somewhat on your location, driving habits, and how much maintenance you want to do. For example, if you mainly drive at near sea level, on relatively level ground, and your Model A cooling system is in good repair, your choice could be to use an antifreeze year round, changing it every 2 years. On the other hand, if you use your Model A in a mixed driving scenario of parades, high altitude, long grades, and during hot summer days, your choice could be to use water plus a surface tension reducer in the summer, and antifreeze during the winter. The choices are not without risks. To learn about the risks of various approaches read the section below on Cooling Fluids and How they Perform. The safest choice is to use distilled and de-ionized water plus a surface tension reducer such as WaterWetter.

For more technical details read section 4.4 Conclusions … Which Coolant is Better

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26 Continental Motors Engineering Test – Figure 4-1 in Stockel’s Automechanics Fundamentals at page 75
4.0 Cooling Fluids and How they Perform in the Model A

The Model A cooling system is shown in the diagram below. Water entering the engine is cool, having been reduced in temperature by the radiator. The cool water is circulated upward into the engine by the Thermo-Siphon action of the engine cooling design and aided by the water pump.

The cooling system of the Model A was designed to keep the warm engine bulk water temperature, at the inlet to the radiator, constantly at about 160 to 180 degrees F, primarily due to the Thermo-Siphon action. The combination of the Thermo-Siphon action and the water pump causes a fluid flow through the system of about 36 to 38 gallons per minute. As any Model A enthusiast knows, a design change in 1930 made the radiator taller which improved the thermo-siphon circulation, however it caused the pre 1930 cooling system to have too much flow of cold water during the cold weather months. This excess flow was reduced by changing the 5 blade impeller in the pump to only 2 reducing the flow rate. This increased the engine temperature on average, while retaining enough flow to keep the engine cool at high speeds in the summer.

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27 Model A Troubleshooting and Diagnostics, Les Andrews; at page 4-40
28 Ibid at page 4-39 The Model A water pump impellers in the 1930 model were reduced from 5 to 2 in order for the water pump to not impede the natural cooling feature of the Thermo-Siphon system. The smaller number of impeller blades reduced the cold water flow in a cold engine, and increased the water flow in a hot engine by reducing hot water cavitation in the pump.
Victor Page, a well respected technical writer, writing about the Model A Ford in late 1931 with the assistance of Ford Motor Engineers, stated in his renown book of the time; 29

“The best temperature to secure efficient operation is one on which considerable difference of opinion exists among engineers ... It is very important that the engine should not get too hot, and at the other hand is equally as vital that the cylinder should not be robbed of too much heat.”

The balance between too much flow and therefore lower engine temperatures, and too low a flow and overheating in the Model A’s non-pressurized cooling system requires careful consideration. Why is this balance such a problem? Can you have too much flow? How does the altitude here in Colorado affect the balance? These are all good questions, and we will attempt to answer these questions in the next section. But before answering, we must understand how heat is transferred from the combustion chamber to the coolant used in the engine … read on.

4.1 Heat Transfer Mechanism in the Model A Engine

There are many aspects to the cooling of a Model A Engine, however, we can concentrate on two of these, the cylinder and the exhaust valve as the most important since they contribute virtually all of the heat transfer to the coolant system. Exhaust Valve cooling is complicated since it involves exhaust air flow, manifold design, and the cyclic operation of the engine 30. The valve itself is not directly cooled by the water jacket system. On the other hand, the Valve Guides and Valve Seat areas are water cooled in a similar manner to the cylinder wall. The cylinder wall cooling can be used to describe the heat transfer mechanism for both areas. We will concentrate on the cylinder wall temperature distribution and cooling mechanism as typical for describing the heat transfer in the Model A Engine.

Total Heat Transfer Model

The burning of fuel in the Model A engine is typical of that experienced in all Spark Ignition Engines. The heat transfer is complicated, and not static as would be the case in a fixed engine running at a constant speed. A total heat transfer model would include the dynamic effects of varying speeds, external temperatures, carburetor and spark advance settings, and driving conditions. A model of this type is beyond the scope of this report. However, we can discuss a heat transfer model in general terms, and provide you with a typical heat transfer model for discussion purposes. The Model A Ford has a non-pressurized thermo-siphon cooling system, which is easily reduced to a five heat transfer path system. These are; power, friction, cooling losses, exhaust losses, and radiation losses. Radiation from the engine block, head, and exhaust manifold are small compared to the other losses, and can be ignored.

Shown in the diagram below are the typical heat transfer paths in the engine.

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29 Model A Ford, Construction, Operation, Repair; Victor Page, April 1931 at page 71.
30 The cooling and temperature distribution in the exhaust valve itself is beyond the scope of this report
The combustion of the fuel within the combustion chamber generates huge amounts of heat energy. Only about 20% to 25% of that energy is able to be used to deliver driving power to the wheels. The remainder is wasted in the exhaust gases, friction in the engine, transmission, and differential/wheel friction. We are concerned in this report with the approximate 35% of the wasted heat of combustion which is conducted through the metal of the combustion chamber and the cylinder walls to the coolant water. The actual dynamic heat transfer due to the alternating combustion fuel input, compression, burning, and exhaust output is beyond the scope of this report. There is both heating and cooling going on during the firing cycle. This alternating, cyclic heat input to the metal of the cylinder walls and the metal in the head surrounding the combustion chamber, since it is a rapid cycle, tends to bring the cylinder wall to a near constant temperature over short segments of time depending on the flow and chemical characteristics of the coolant on the other side of the cylinder wall. The primary heat transfer to the coolant at the boundary between the coolant and the hot cylinder wall and the heat of combustion is conduction and nucleate boiling (this will be discussed in more detail in the following paragraphs. The discussion below describes the heat transfer temperature differentials for a typical application at the engine cylinder wall. Other areas, such as the combustion chamber wall in the head, and the valve area are similar.

\[31\] Constant in this discussion is measured in seconds or minutes depending on the driving conditions.
4.2 Typical Heat Transfer in the Model A Cylinder

The following discussion is generic for the Model A engine cylinders, but represents a typical heat transfer situation in general within the engine. The cylinder heat transfer is critical to the operation of the engine, since the lubrication of the sliding surfaces of the piston rings, against the cylinder walls is critical to the wear out of the engine.

Cylinder Heat Transfer Model

The model shown in the diagram below illustrates the components of the engine in the area of the cylinder to piston. The piston operates in a cylinder which compresses a fuel-air mixture which is ignited by a spark generated by the ignition system of the Model A. In turn, the burning fuel generates a flame propagation effect causing combustion of the entire fuel-air mixture to combust, pushing the piston downward on the power stroke. After the power stroke, the burned gasses are pushed out of the cylinder, by the exhaust stroke, and new fuel is pulled into the cylinder by the intake stroke. Finally, the compression stroke squeezes the fuel-air mixture up into the combustion chamber, and the cycle repeats. In this cycle there is a heating process by combustion, followed by a cooling process resulting in complicated heat input to the cylinder walls. This process is dependent upon the speed and operation of the engine. Slow speeds such as in a parade, or traffic, have higher heating and reduced cooling. Incorrect fuel-air mixtures,
such as a too far retarded spark, or other engine ignition problems such as poor spark generation, worn spark plugs, carbon buildup, will also cause higher heating, and reduced cooling of the cycle. These effects are exacerbated by high weather temperatures, and altitude.

The combustion – exhaust – intake - compression cycle generates power, but also creates a boundary layer of stagnant gases at the cylinder walls (and other parts of the combustion chamber). This boundary layer at the surface of the cylinder wall is a very poor conductor of heat. Fortunately for the spark ignition cycle engine, this boundary layer exists, because it is this layer of stagnate gasses which reduces the very high 2,000 degree plus combustion gas temperature to a more manageable temperature at the cast iron cylinder wall of about 350 deg F. Without this very poor conduction, of this stagnate gas boundary layer, the internal combustion engine as we know it, would not be feasible.  

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The remaining elements of the heat transfer model are also shown in the diagram. The inner cylinder wall has a coating of lubricating oil placed there by the dip and splash operation of the crank shaft, and controlled by the oil rings on each stroke. It is this film which the coolant must maintain at below 350 degrees F. The Model A engine has varying thickness of cylinder wall, and head combustion wall thicknesses, however, most are a small fractions of an inch. The cylinder wall conducts heat from the hot inner wall to the cooler outer wall water jacket which is in contact with the coolant. On the outer surface of the cylinder wall water jacket there may be a layer of scale, caused by corrosion due to mineral deposits, rust, or the use of “hard water”. This scale layer is usually an insulator and is not desirable. Finally we see the coolant elements. The coolant is flowing at a relatively high rate of speed and is called the “Bulk Coolant Fluid”. At the surface of the outer cylinder wall there is a region of another boundary layer called the vapor film. It is this layer that causes the cast iron cylinder wall to give up its heat to the coolant fluid. The coolant fluid, water or anti-freeze/water mixture, is a good conductor of heat. Therefore, with a cold engine the heat transfer to the coolant is by forced convection from the surface of the metal to the bulk fluid. As the engine reaches operating temperature the heat transfer mechanism becomes nucleate boiling (discussed in the next paragraph) at the surface of the outer cylinder wall. The steam bubbles thus formed at the surface break free, dependent upon the surface tension of the coolant, and carry away most of the heat reaching the coolant to metal surface. The region where the steam bubble has been released is filled once more with coolant, repeating the process. Once released from the surface, the steam bubbles enter the bulk coolant stream and due to its lower temperature, are re-absorbed into the bulk fluid.

Since cold operation of the engine is of little interest to this report we will concentrate on the operating temperature range, where nucleate boiling occurs.

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33 Bulk Coolant temperatures in the 160 to 180 degree Farenheit range.
Nucleate Boiling

The heat transfer in the Model A engine, as in most engines, based on nucleate boiling. What do

Nucleate Boiling Near the Combustion Chamber

we mean by this? Consider the diagram above.

The process of forming steam bubbles within the coolant in micro-cavities of the wall of the cylinder is called nucleate boiling. **Wait a minute! Are you telling me that my engine coolant is boiling nearly all the time?** YEP, that is just exactly what I am telling you! The surface temperature of the metal at the coolant to metal boundary is controlled by the coolant chemistry and flow rate to be about 266 deg F at sea level to prevent burning of the lubricants 34. The metal temperature, being about 52 degrees hotter than the fluid causes localized boiling of the coolant causing steam bubbles to form. This is not undesirable, as most of the metal cooling takes place because localized nucleate boiling of the coolant extracts large amounts of heat from the metal. The steam bubbles formed, grow on the surface until they reach some critical size, dependent on the surface tension of the coolant, at which point they separate from the wall and are carried into the main coolant stream. Fortunately, in the main bulk coolant stream the bubbles collapse, and are absorbed back into the fluid, because the temperature of bulk fluid is not as high as at the heat transfer surface where the bubbles were created. Heat transfer during nucleate boiling has a significant effect on the heat transfer rate. This nucleate boiling heat transfer process helps quickly and efficiently to carry away the heat energy, created by the engines combustion, at the

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34 Heat Transfer in Engines, Dr. Allan Kirkpatrick; Professor of Mechanical Engineering, Colorado State University; see, paper at www.engr.colostate.edu. The temperature of the metal at the inside of the cylinder wall is of course much hotter.
metal to coolant interface. If the bubbles combine, and/or grow too large they reduce the amount of cooling fluid in contact with the hot spots, and form a vapor barrier causing a rapid rise in the bulk coolant fluid. When enough of the bulk fluid has reached the boiling point of the fluid the bulk fluid begins to boil. Thus large bubbles form, sometimes blocking the passage of the fluid. This results in a departure from nucleate boiling. These large steam bubbles create a vapor barrier on the solid surface of the water jacket, and bubbles dominate the water channel and the surface of the metal, and the heat flux dramatically decreases at the hot spot. This in turn raises the oil film temperature in the cylinder until it reaches the flash point, causing the cylinder lubricant to burn. Should this continue for a long period of time (e.g. minutes) excessive cylinder wear may occur, and the engine could seize. The coolant vapor barrier essentially insulates the bulk liquid from the hot surface. This results in steam appearing in the upper tank of the radiator, blocking the flow of hot water into the radiator core. The visual appearance is the familiar jet of white steam emitting from the radiator cap.

Typical Temperatures in the Model A Cylinder Wall

Considering the heat transfer model described above, and the process of nucleate boiling, we can now describe the typical temperatures found on the average in the cylinder wall of the Model A engine. Referring to the diagram below, the typical cylinder wall temperatures for normal driving conditions are shown.

The green layer represents the lubricant film on the interior of the cylinder. It is this film that is necessary to cool to below its flash point, leading to burning of the lubricating motor oil. The red line represents the temperature drops in the heat transfer model. When the fuel is combusting there are high temperatures formed, but the cyclic operation of the engine reduces the average temperatures considerably.

The bulk coolant in this example is water as originally designed by Ford engineers to cool the Model A engine. Typical operating temperatures of the bulk coolant are about 160 to 180 degrees F. The diagram uses the lower value for the example.

A thin gray layer on the water jacket side of the diagram represents scale deposits of rust, and minerals which tend to insulate the metal surface from the coolant. In this example, the film is assumed to be negligible. The temperature profile shows a 63 degree F. temperature drop at the metal to coolant boundary, this is due to the nucleate boiling process.

The white bubbles in the bulk coolant, represent nucleate boiling steam being absorbed into the coolant after breaking free from the hot metal to coolant boundary layer.

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35 This may be caused by a variety of factors, such as; Spark retarded to far; Poor ignition, Too rich a carburetor mixture, Brakes dragging; Driving in a parade, or a long time in stop and go traffic; or a defective cooling system.
36 Should you visibly see water vapor (steam) coming from the radiator cap, pull over immediately and stop. Continuing to drive could cause your engine to seize up.
While this diagram is at best a snapshot of what the temperature profile could be across the cylinder wall of your car’s engine it is not a definitive, absolute temperature diagram. The fact is that the temperature profile depends entirely on the driving conditions, the altitude of operation, the mechanical condition of the engine and cooling system, the type of coolant, the temperature of the ambient air outside, the fuel-air mixture, and the spark advance setting you are using. That having been said, the diagram is useful to illustrate what effects these factors would have on keeping your Model A engine from overheating.

You can see from the diagram the huge temperature drop in the stagnant gas boundary layer. It is this drop in temperature, and the coolant nucleate boiling that keeps the oil film on the cylinder wall from burning and causing severe damage to the cylinder wall by the piston rings.

Critical to the long term operation of your Model A engine is keeping the cylinder wear to a minimum. To accomplish this it is important to keep the cylinder walls lubricated during each stroke of the engine. The Model A uses dippers on the connecting rods to splash considerable oil around in the crankcase creating an oil fog that lubricates the pistons, cylinder walls, cam shaft and the timing gear. The piston has an oil ring which regulates the amount of oil on the cylinder surface and returns excess oil to the crankcase. An oil ring is the piston ring located in the ring groove closest to the crankcase. The oil ring is used to wipe excess oil from the cylinder wall during piston movement. Excess oil is returned through ring openings to the oil reservoir in

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37 Model A Ford Troubleshooting and Diagnostics; Les Andrews, at page 4-36
the engine block. In addition, the oil ring prevents “pumping” of oil into the cylinder during the intake stroke when a partial vacuum exists in the cylinder.

**Cylinder Wall Oil Temperature Regulation**

It is important to keep the oil deposited on the cylinder wall from burning. It is also important to keeping a film of lubricating oil on the cylinder wall to prevent wear from the piston rings as they move up and down within the cylinder. Oil is composed of hydrocarbons which can burn if ignited. The flash point of motor oil is the lowest temperature at which the oil gives off vapors which can ignite. The flash or ignition temperature of modern oils ranges from Amsoil at 507 degrees F to Exxon SuperFlow at 392 degrees F. Typically, motor oils have flash points in the 415 to 450 deg. F range. It is unknown what the engineers at Ford contemplated as a design set point to establish the cooling system design, but it is reasonable to assume that the design evolved from previously established design practices and not a lot of modern scientific analysis or laboratory experimentation. The accepted practice of the era, would lead to keeping the oil temperature on the cylinder walls at a maximum of 350 degrees.

**The Primary Factor in Keeping the Cylinder Lubricant Below 350 Degrees F**

As mentioned before, the factors leading to the temperature of the inner cylinder wall are many and varied. These are;

- Driving conditions, the altitude of operation, the temperature of the ambient air outside
- The mechanical condition of the engine and cooling system
- The type of coolant, and the flow rate of the coolant within the engine
- The fuel-air mixture and the spark advance setting

In order to have the most margin in operation of the engine to allow for varying driving conditions and variability in carburetion and spark setting, it is important to have the mechanical condition of the cooling system in tip top condition and no obstructions in the coolant flow hoses. Since the MAXIMUM flow rate of the coolant is fixed in the Model A at about 36 gallons per minute, the primary factor for enhancing the margin between the cylinder wall temperature under various driving conditions and the burning point of the lubricating oil is the choice of coolant. This choice today becomes one of using plain water, water with a surface tension reducer or using an anti-freeze coolant.

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38 www.micapeak.com; Results of a motor oil testing lab. Listed at this website are the flash points of oils by various companies
39 Much was known about Oils prior to 1931, the earliest knowledge was before the advent of the automobile. Oil flash points and burning was mentioned in the earliest book I have dated 1903.
41 For this reason we do not recommend the use of a thermostat.
The original design of the Model A engine used water as the coolant. Only in the winter, when cooling demands due to driving conditions were not high, did Ford recommend the use of anti-freeze solutions. This is important for the Model A, since it uses a non-pressurized coolant system and a non-forced flow system as in modern automobiles which utilize year round coolant.

4.3 The Physical Properties of an Engine Coolant for Heat Transfer

As we mentioned, in the discussion above, the surface tension of the coolant is one factor in determining the heat transfer capability of a coolant. There are other important coolant properties. The debate about which coolant to use revolves around the use of anti-freeze, pure water, or pure water with an additive to reduce surface tension.

**Specific Heat**

Specific heat is a property of coolant that determines its ability to absorb heat. Specific heat is defined as the amount of heat that it takes to raise the temperature of a standard amount of fluid a standard degree of temperature. For example, one BTU (British Thermal Unit) is the amount of heat needed to raise one pound of water one degree F. To raise the temperature of a pound of water ten degrees, we need ten BTUs. This is true any place between the freezing point and boiling point of water. **A fluid with a higher specific heat has greater capacity to absorb heat.** From the chart below you can see that the specific heat of anti-freeze (pure) is 40% less than water.

<table>
<thead>
<tr>
<th>Coolant</th>
<th>Specific Heat</th>
<th>Capability to Absorb Heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethylene Glycol</td>
<td>.57</td>
<td>Lowest</td>
</tr>
<tr>
<td>Propylene Glycol</td>
<td>.59</td>
<td>Low</td>
</tr>
<tr>
<td>Water</td>
<td>1.00</td>
<td>Highest</td>
</tr>
</tbody>
</table>

When anti-freeze is mixed 50/50 with water the heat absorbing capability of the combination is only 80% of water alone.

**Latent Heat**

The latent heat property of a coolant is a measure of a fluid that, when at the boiling point of a fluid, determines how much more heat must be extracted from the metal surface to cause nucleate boiling of the fluid. The latent heat effect is used in two ways in your cooling system. First, cylinder water jackets and heads heat very unevenly. For example, there are some very hot spots in the vicinity of the exhaust valves. Coolant coming in contact with these areas will instantly boil, drawing a great deal of heat from the component. As discussed above this local boiling is called "nucleate boiling". Generally, **a high latent heat is a property in a coolant that leads to high heat transfer capability.** Here are the latent heats of the three principal coolants:

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42 Model A Ford Service Bulletins; October 1928, October 1929, April 1930, December 1930.
Latent Heat of Automotive Coolants

<table>
<thead>
<tr>
<th>Coolant</th>
<th>Latent Heat of Vaporization</th>
<th>Ability to Efficiently Transfer Heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethylene Glycol</td>
<td>195 cal/gm</td>
<td>Low</td>
</tr>
<tr>
<td>Propylene Glycol</td>
<td>170 cal/gm</td>
<td>Lowest</td>
</tr>
<tr>
<td>50/50% Mixture with H₂O</td>
<td>375 cal/gm</td>
<td>Medium</td>
</tr>
<tr>
<td>Water</td>
<td>540 cal/gm</td>
<td>Highest</td>
</tr>
</tbody>
</table>

As you can see from this chart, water has the highest Latent Heat and therefore has the highest nucleate boiling capability. This means that a 50/50 mixture of anti-freeze and water will have less cooling capability than pure water.

**Boiling Point Temperature**

The boiling point of various coolants has an effect on the nucleate boiling of the coolant to cool your Model A engine. The boiling point temperature of common coolants is shown in the following chart. 43

<table>
<thead>
<tr>
<th>Coolant</th>
<th>Boiling Point (BP) of Various Engine Coolants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BP at Sea Level</td>
</tr>
<tr>
<td>Water</td>
<td>212 °F</td>
</tr>
<tr>
<td>50/50% Ethylene Glycol</td>
<td>225 °F</td>
</tr>
<tr>
<td>50/50% Propylene Glycol</td>
<td>222 °F</td>
</tr>
<tr>
<td>Pure Ethylene Glycol</td>
<td>387 °F</td>
</tr>
<tr>
<td>Pure Propylene Glycol</td>
<td>370 °F</td>
</tr>
</tbody>
</table>

*Note! The specific heat capacity of ethylene based water solutions are less than the specific heat capacity of clean water. For a heat transfer system with ethylene glycol the **circulated volume must be increased** compared to a system with clean water. In a 50% solution with operational temperatures above 36 °F the specific heat capacity is decreased with approximately 20%. The reduced heat capacity must be compensated by circulating more fluid.

** Note! this is only for an idealized non-pressurized system. Flow rates may be 3 (300%) times higher for pressurized, regulated systems as found in modern automobiles with higher horsepower.

As can be seen from the above chart, the point at which nucleate boiling occurs for common anti-freeze is about 13 degrees F higher than water. This means that the metal at the boundary between the coolant and the cylinder metal is likewise higher to cause boiling to occur. In addition the latent heat of vaporization for anti-freeze is much lower than water, the combination of these two effects causes need for increased flow rates to keep the heat transfer rate at nominally the same temperatures. Since this is not practical with the thermo-siphon cooling

43 The Engineering Toolbox at www.engineeringtoolbox.com
the use of antifreeze will result in higher cylinder and exhaust valve temperatures.

**Surface Tension**

Surface Tension is a property of coolants. The surface tension impacts the formation of steam bubbles at the hot metal to coolant boundary. The surface tension physical properties of water, water plus a surface tension reducer, and antifreeze are considerably different.

<table>
<thead>
<tr>
<th>Surface Tension Properties</th>
<th>Water</th>
<th>Water plus WaterWetter</th>
<th>Anti-Freeze</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>58.9  dynes/cm²</td>
<td>28.3 dynes/cm²</td>
<td>50.5 dynes/cm²</td>
</tr>
<tr>
<td>Baseline</td>
<td>52% less</td>
<td>14% less</td>
<td></td>
</tr>
</tbody>
</table>

It is clear from the chart that water with the additive of WaterWetter is nearly half that of antifreeze coolants. While this does not translate into double the cooling capacity of antifreeze, it serves to illustrate the point that the surface tension of water with WaterWetter is considerably lower than that of antifreeze and pure water. The higher the surface tension, the more readily the coolant forms large bubbles on the surface, preventing new coolant from contacting the hot metal surface. As the temperature rises, the surface tension can cause an insulating vapor barrier to form at the metal to coolant boundary, giving rise to overheating the engine. Surface tension reducers enhance the ability of the water coolant to remain in nucleate boiling, and keeps the formation of small steam bubbles longer under severe operating conditions.

**Other Properties of Coolants**

There are other considerations with respect to modern coolants. Water, while having the highest heat transfer capability is the most corrosive, and if distilled water is not used, the highest rate of depositing mineral scale. On the other hand modern anti-freeze solutions are fortified with chemicals to combat scale and other deposits in your cooling system, and most importantly on the walls of your water jacket. Surface tension reducing additives also have chemical compounds that will reduce scale and gunk buildup.

**4.4 Conclusion – Which Coolant is Better ...**

This conclusion will rest upon the remaining factors that influence the temperature margin of the oil film on your engine cylinders. There is no doubt that the coolant with the highest capacity to lower the temperature of your engine’s inner cylinder wall and its oil film is the use of distilled water with a surface tension reducer such as the Red Line WaterWetter product. The following

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44 While I have not researched this idea, one possibility would be to use a 1928 – 1929 water pump on the 1930 – 1931 Models to get more flow rate on these later model vehicles. Of course, this is not possible if you have a 1928 – 1929 vehicle with the proper water pump.
chart illustrates the differences between using the surface tension reducer and using modern antifreeze coolants.

This conclusion was not reached by a rigorous chemical/thermal heat transfer analysis, but we used relative values of heat transfer properties that would affect the ability of the thermo-siphon cooling system to cool the interior parts of the engine, specifically, the cylinder walls and the combustion chamber in the head. The baseline for this analysis was pure water, since this is what the Ford engineers originally used in the design of the Model A.

The use of antifreeze year round as recommended by automobile manufacturers began in the 1950’s and they began mandating the use of specific coolants to avoid warrantees in the 1970’s. The primary reason behind the use of a year round antifreeze/coolant was the use of metals such as aluminum for engine blocks and heads. These metals required a higher level of corrosion protection year round than the common water cooling used previously. Some manufacturers, like GM, even developed their own proprietary coolant.  \[45\]

As shown in the chart above, the only category which modern antifreeze coolant exceeds the performance of the water baseline is that of the bulk coolant boiling point. It is clear that a

\[45\] GM developed DexCool, however not without problems.
50/50% mix of Ethylene Glycol antifreeze coolant with its lower heat absorption, lower heat extraction, lower heat transfer coefficient and higher surface tension, is not as good a coolant as plain old water, and especially water plus a surface tension reduction compound in a Model A engine. So why do all modern automobile manufacturers recommend the use of a year round antifreeze coolant in their products? The answer is simple, the design of the modern automobile, since the 1950’s has incorporated a pressurized cooling system, and high output water pumps with forced pumped flow rates well above that of the thermo-siphon Model A cooling system.

The higher pressure, and the much higher flow rate compensate for the lower heat transfer performance of antifreeze coolants. However, the use of a modern antifreeze coolant brings with it additional benefits of scale and corrosion resistance, especially useful in aluminum heads and blocks. The evolution of Ford’s cooling system design from the Model T to the Model A and on to modern cars is shown in the chart below.

<table>
<thead>
<tr>
<th>Cooling System Design</th>
<th>The Model T</th>
<th>The Model A</th>
<th>Modern Autos</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thermo-Siphon No Water Pump</td>
<td>Thermo-Siphon Water Pump Aided</td>
<td>Forced Water Circulation by Water Pump</td>
<td>The Model A cools mostly as a Thermo Siphon system with the pump aiding at high speeds</td>
</tr>
<tr>
<td>System Coolant Flow</td>
<td>Varies - Self Regulating rate depends on heat</td>
<td>36 - 38 Gallons/Min.</td>
<td>100 or More Gallons/Min.</td>
<td>The Model A must have the input to the radiator higher than the engine</td>
</tr>
<tr>
<td>Pressurized</td>
<td>No</td>
<td>No</td>
<td>Yes - Usually 1 atmosphere (15 PSI)</td>
<td>The non-pressurized Model A has less margin against boiling</td>
</tr>
<tr>
<td>Regulated</td>
<td>No</td>
<td>No</td>
<td>Thermostat</td>
<td>A Thermo-Siphon system must not have an obstruction in the coolant flow</td>
</tr>
<tr>
<td>Design Coolant</td>
<td>Water</td>
<td>Water</td>
<td>Antifreeze</td>
<td>The primary coolant for the Model A is water, antifreeze Ok in winter when less cooling demand</td>
</tr>
</tbody>
</table>

To keep your Model A running cool and within the design parameters set by the designers in the late 1920’s and early 1930’s it is clear you should use water without anti-freeze and no thermostat to obstruct the flow of the coolant into the radiator. If you plan to drive at high altitudes, in parades, and in city traffic, it is best to use a water surface tension reducer. Some Model A enthusiasts have installed a pressurized cooling system, articles on how to do this still circulate today, however it is really not necessary, as long as you keep your cooling system in good repair, free of scale and mineral deposits, and use the best coolant [water] for your car.
5.0 How Can We Improve Water as a Coolant

Now that we have shown that water is the best coolant you can use, we will now show that we can improve on its heat transfer capabilities and gain back some of the temperature margin lost due to operation at the high altitudes of Colorado or in parades and heavy city traffic. The racing community has come to our rescue. In their desire to cool their engines more efficiently, owners and sponsors of racing machines sought an improvement by manufacturers of high performance racing oils in the ability to prevent cylinder wall oil failures under high heat producing conditions. Several of these oil companies have invented solutions 46, but one has risen to the top in the additive category. Red Line Oil company, a manufacturer of high performance oils for racing engines, developed a product they call WaterWetter. It first became widely known and used by drag racing enthusiasts, but recently has been found to be of high benefit in many modern cars used in very hot climates or at high altitudes. This product can be used in the Model A Ford to improve on the removal of heat from cylinder walls and combustion chambers.

5.1 WaterWetter Cooling Performance in a Model A Ford

To be written next spring after testing. will include temp reduction claims, test results.

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46 Other products are; Royal Purple Ice, Engine Ice, and Evans Non-aqueous Propylene Glycol (NPG). Only Royal Purple Ice is cost effective but offers no advantage over the more available WaterWetter, the other products are highly specialized in racing usage and extremely expensive. Royal Purple Ice has been found to fail the ASTM D2570 Severe Automotive Tests for corrosion protection.
5.2 WaterWetter Additional Benefits
Red Line WaterWetter includes anti-corrosion, anti-scaling, and water pump lubrication, as found in antifreezes. While there is much information on the Internet about compatibility of antifreeze with materials found in the cooling system of the Model A, there is little information independent of the Red Line Oil company information. Red Line provides a comparison of its product compatibility with that of antifreeze. In general, WaterWetter has better performance.

### Model A Ford Component Compatibility with Coolant Compounds

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
<th>WaterWetter Rating</th>
<th>ASTM D1384 Spec</th>
<th>Antifreeze 50/50 Solution IAT typical</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Block and Head</td>
<td>Cast Iron</td>
<td>0</td>
<td>10</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Shaft</td>
<td>Steel</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Bushing</td>
<td>Brass</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Housing</td>
<td>Cast Iron</td>
<td>0</td>
<td>10</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Impeller</td>
<td>Cast Iron</td>
<td>0</td>
<td>10</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Packing</td>
<td>Graphite/Lead</td>
<td>Compatible (1)</td>
<td>N/A</td>
<td>Fair</td>
<td>Antifreeze attacks Lead (2)</td>
</tr>
<tr>
<td>Seal</td>
<td>Teflon</td>
<td>Compatible (1)</td>
<td>N/A</td>
<td>Compatible “Leakless” Pump Only</td>
<td></td>
</tr>
<tr>
<td>Seal</td>
<td>Neoprene</td>
<td>Compatible (1)</td>
<td>N/A</td>
<td>Fair</td>
<td>“Leakless” Pump Only</td>
</tr>
<tr>
<td>Inlet Tubing</td>
<td>Steel</td>
<td>1</td>
<td>10</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Tanks</td>
<td>Brass</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Tubes</td>
<td>Brass</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Fabrication</td>
<td>Solder</td>
<td>Compatible (1)</td>
<td>N/A</td>
<td>Fair</td>
<td>Antifreeze attacks Lead (2)</td>
</tr>
<tr>
<td>Hoses</td>
<td>Rubber</td>
<td>Compatible (1)</td>
<td>N/A</td>
<td>Compatible</td>
<td></td>
</tr>
<tr>
<td>Head Gasket</td>
<td>Copper</td>
<td>1</td>
<td>10</td>
<td>5</td>
<td>Stock Gasket</td>
</tr>
<tr>
<td>Head Gasket</td>
<td>Steel Core Composite Silicone Bead</td>
<td>Compatible (1)</td>
<td>N/A</td>
<td>Compatible “Poly Pro Premium Head Gasket”</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. Passes ASTM D2570 Automotive Simulated Service Test for corrosion; according to Red Line Oil.
2. Antifreeze reacts with the lead in solder and depletes microscopic particles which circulate in the coolant until flushed and changed. The length of time necessary to produce damage to components is unknown.

5.3 Anti-Freeze vs. Water – A Comparison of Coolant Efficiency by Red Line Oil
I have not yet personally tested 47 or analyzed the comparative efficiencies of using Anti-Freeze year round versus using water for summer touring, and anti-freeze for winter storage. However, the manufacturer of WaterWetter has done extensive testing and analysis and concluded that

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47 I plan to do some testing next spring and summer.
water is far superior to anti-freeze with Ethylene Glycol 50/50 mixtures. The following comparison [reproduced here without editing] is posted on their website:

Water has amazingly superior heat transfer properties compared to virtually any other liquid cooling medium - far superior to glycol-based coolants. Water has almost 2.5 times greater thermal conductivity compared to glycol coolants. Mixtures of glycol and water have nearly proportional improvement due to the addition of water. Most heat is transferred in a cooling system by convection from hot metal to a cooler liquid as in the engine block or from a hot liquid to cooler metal surfaces, as in the radiator. The convection coefficient of liquids in a tube is a complicated relationship between the thermal conductivity, viscosity of the liquid, and the tube diameter which determines the amount of turbulent flow. Since 50/50 glycol solution has about 4 times the viscosity and only 70% of the thermal conductivity of water, the thermal convection coefficient for a 50/50 glycol solution is approximately 50% of the coefficient for water. Water in the cooling system is capable of transferring twice as much heat out of the same system as compared to a 50/50 glycol coolant and water solution. In order for a 50/50 glycol mixture to reject as much heat as water (amount of heat rejected is independent of the coolant), the temperature differentials at the heat transfer surface must be twice as great, which means higher cylinder head temperatures.

5.5 How Does WaterWetter Work to Get You More Cooling Capability?
WaterWetter provides two benefits over the use of plain water. The first is higher cooling performance due to reducing the surface tension of the water used in your system. The second benefit is that it adds important additives to water to reduce mineral deposits, and is reported to lubricate your water pump seals.

Higher Cooling Capacity
The surface tension property of water [or any other coolant] is an important factor in cooling your engine. It is important because of its effects on the heat extraction from the cylinder walls and combustion chamber in the engine head. Surface tension also has a minor effect on the heat transfer within your radiator. As we have discussed above, the critical cooling is the heat transfer from the hot cylinder wall to keep the cylinder oil film temperature lower than the flash point of the oil to prevent burning which leads to cylinder wear.

Surface tension plays an important part in the heat transfer by impeding the flow of cool bulk coolant fluid against the cylinder wall. The following diagram shows why.

The figure below shows two processes [not at the same time in the same engine]. Side A shows the condition for plain water or antifreeze. Side B shows how a surface tension reducer acts to reduce vapor barrier generation.

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48 This comparison is based on testing results in a modern engine with a cast iron block, aluminum heads, and a pressurized cooling system. However, results should apply to the Model A Engine as well.
49 Or other similar products
50 As does the advertisements for antifreeze
As we learned in the discussion on the properties of coolants, the surface tension physical properties of water, water plus a surface tension reducer, and antifreeze are considerably different.

<table>
<thead>
<tr>
<th></th>
<th>Water</th>
<th>Water plus WaterWetter</th>
<th>Anti-Freeze 50/50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Tension</td>
<td>58.9 dynes/cm²</td>
<td>28.3 dynes/cm²</td>
<td>50.5 dynes/cm²</td>
</tr>
<tr>
<td>Properties</td>
<td>Baseline</td>
<td>52% less</td>
<td>14% less</td>
</tr>
</tbody>
</table>

It is clear from the chart that water with the additive of WaterWetter is nearly half that of antifreeze coolants. While this does not translate into double the cooling capacity of antifreeze in a 50/50 solution with water, it serves to illustrate the point that the surface tension of water with WaterWetter is considerably lower than that of antifreeze and pure water.

**Considering Side A:**

As the temperature of the engine increases, heat transfer is initially by conduction from the hot cylinder wall to the coolant as it flows by. As the temperature increases, the coolant in contact with the cylinder wall reaches the boiling point. Steam bubbles caused by nucleate boiling begin to form on the surface of the water jacket next to the hot cylinder wall. As we learned in the discussion on heat transfer, nucleate boiling causes the maximum heat transfer capacity from the cylinder wall to the bulk coolant. The surface tension of the coolant causes these bubbles to

![Diagram](image-url)
“stick” to the surface and grow, until they gain enough energy and size to break free from the
surface and enter the main flow of the coolant. These “freed” bubbles are then absorbed into the
cooler bulk coolant. The bubble breaking free from the surface allows additional bulk coolant
fluid to contact the surface of the water jacket. As the heat increases, the size of the bubbles, due
to surface tension and merging of adjacent bubbles into each other, causes a vapor barrier to
form between the bulk coolant flow and the hot metal surface. In turn, the vapor barrier prevents
the bulk coolant from contacting the surface, causing an abrupt increase in temperature of the hot
metal, and an increase in the bulk fluid locally. This causes intense boiling of the bulk fluid
locally generating large steam bubbles in the fluid. As more and more of these large bubbles rise
in the coolant, rapid boiling occurs at the entrance to the radiator, blocking the flow of water into
the radiator, and causing the famous steam cloud to rise from the radiator cap.

**Considering Side B**
The process with WaterWetter is similar to that of side A, however, the much lower surface
tension due to the additive in WaterWetter, reduces the capability of the coolant to form large
bubbles, and therefore allows more cool bulk fluid to contact the surface of the hot metal. In
turn, this works to help prevent a vapor barrier from forming. However, under severe conditions,
the engine can still develop a vapor barrier and overheat. The reduced surface tension, in effect,
shifts the temperature point at which nucleate boiling stops and a vapor barrier is formed. The
end result is a better performing coolant, with increased cooling capacity that will keep your
Model A running longer under adverse conditions.

**Anecdotal Performance Testimonials**
I will be testing the performance of WaterWetter next spring and summer, however the following
anecdotal performance testimonials were obtained. Some reports were that the performance
under hot conditions approached the claim by Red Line of up to a 20 degree lowering of coolant
temperatures, however many claimed performances of less than 8 degrees. A few claimed
marginal to no improvement. The best test that I found was testing done by the Import Tuner
Magazine on a 1993 Miata. The tests showed, for the coolant temperatures, that under idling
conditions a reduction of 5 degrees F were obtained, under mixed driving conditions a reduction
of 10 deg F, and under sustained high speed freeway driving a reduction of 13 deg. F.

*Wayne Russert – Member of the Rocky Mountain A’s*
I use it regularly in my Model A for summer driving, switching to antifreeze in the winter.

*Red Line Oil Company – Manufacturer of WaterWetter*
Water has twice the heat transfer capability when compared to 50% glycol antifreeze/coolant in
water. Reduces or eliminates bubbles or vapor barrier that form on hot metal surfaces to reduce
coolant temperatures by up to 20°.
DYNAMOMETER TEST RESULTS

Dynomometer tests performed by Malcolm Garrett Racing Engines showed significant improvements in coolant temperatures using WaterWetter. These tests were performed with a Chevrolet 350 V-8 with a cast iron block and aluminum cylinder heads. The thermostat temperature was 160°F. The engine operated at 7200 rpm for three hours and the stabilized cooling system temperature was recorded and tabulated below:

<table>
<thead>
<tr>
<th>SAE 880266 Testing Measurements</th>
<th>Water + Red Line</th>
<th>50% Glycol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in Cylinder Head Temperature</td>
<td>Baseline</td>
<td>+45°F</td>
</tr>
<tr>
<td>Increase in Octane (RON) Requirement</td>
<td>Baseline</td>
<td>+3.5</td>
</tr>
<tr>
<td>Change in Spark Timing for Trace Knock</td>
<td>Baseline</td>
<td>-5.2°</td>
</tr>
<tr>
<td>Change in Torque</td>
<td>Baseline</td>
<td>-2.1%</td>
</tr>
</tbody>
</table>

The Truth About Cars; Michael Posner (www.truthaboutcars.com)

Strangely, Red Line’s own test results don’t square with their ad copy. Their technical literature only shows an eight degree Fahrenheit drop in a car with a 50/50 mix of water and coolant, and an eighteen degree Fahrenheit drop for a car running 100 percent water.

I used a VagCom system (reads sensor data directly from the ECU) for my tests. The pre-WaterWetter® installation delivered temperatures between 96 and 98 degrees centigrade (or 205 to 208 degrees Fahrenheit for the Americans). The post-installation temperature stayed steady at 96 degrees centigrade. Clearly, not the results advertised.

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51 By Redline Oil Company the manufacturer of WaterWetter
The Import Tuner [An Internet Magazine]

TEST RESULTS
Driving the same selection of deserted freeway three times over, the average temperature sustained by each coolant option was recorded at radiator outlet and cylinder head. The Water Wetter mix wins again; cooler all around.

<table>
<thead>
<tr>
<th>Coolant Type</th>
<th>Mean Coolant Temperature</th>
<th>Mean Head Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water/Glycol</td>
<td>160</td>
<td>172</td>
</tr>
<tr>
<td>Water/Water Wetter</td>
<td>147</td>
<td>166</td>
</tr>
</tbody>
</table>

Overall Results: Red Line's Water Wetter did lower the operating temperature of our Miata. Was it by as much as the bottle's 30 degree F claim? No, but we did see a difference of up to 13 degrees. As stated earlier, Water Wetter works by changing the boiling characteristics of an engine's coolant; its performance grows proportionately with how hot a particular engine runs. If the cooling system of your Miata's B6ZE engine is efficient enough to ward off high temperatures on its own-don't look for a coolant additive to work miracles. On the other hand, if the your 300 hp-per-liter 4G63 is running a little on the hot side and all the goodies under your EVO's hood limit space for a bigger radiator...a coolant additive like Water Wetter might be just what the tuner ordered.

Internet Forum Comments
The Corvette Forum: I added some Red Line Water Wetter and it [the temperature] dropped a good 9 + degrees!!! I was seeing 208-212 or so while cruizing in 95 degree weather now I'm at 199-201.

5.6 Why Not Add WaterWetter to Anti-Freeze and Have the Best of Both Worlds?
Red Line Oil, the manufacturer of WaterWetter claims that it is compatible with antifreeze. However, there is much discussion, in the Internet Forums, of the introduction of “sludge”, “crud”, “slimy stuff” that was found in the radiator and cooling system after the addition of WaterWetter. I contacted Red Line Oil’s technical department and received the following information on the issue of using WaterWetter with antifreeze.
If sludge or slime is present in cooling systems and hard to remove that is [because of] silicate drop out. Silicates from antifreeze can come out of solution becoming less soluble if not changed regularly, this can occur over time as the pH drops, it is accelerated by oxidation from various sources including combustion byproducts from leaking head gaskets. These are issues specifically with silicates not WaterWetter, it just happened to be in the system at the time, but did not occur to the presence of WaterWetter. WaterWetter is compatible with antifreeze and used extensively, though in a Model A where the best possible heat transfer is necessary, where temperatures are critical, it's use with just water, ideally distilled is beneficial. ... Greg at Red Line Oil Company.

There are MANY reports of this. Some reports claim that the “slime” cannot be removed, by any method yet tried. However, some reporters claim that there is no detrimental effect on their systems. When mixed with pure water, these effects do not seem to be present.

The primary component of WaterWetter is a “surfactant” [surface tension reducer] chemical of the family called siloxane polymers. While no clear evidence of a reaction with ethylene glycol antifreeze has been found, it is possible that these polymers react with other chemical additives in antifreezes that prevent corrosion, and scale buildup. It also may be that these polymers are reacting with plastics in modern cars to produce slime, crud, and sludge in cooling systems. It may also be that the owners claiming that they have problems are blaming it on WaterWetter when, as Red Line explains “These are issues specifically with silicates not WaterWetter, it just happened to be in the system at the time, but did not occur to the presence of WaterWetter.”

There is no clear reason that many users of this product have had problems, but is not deniable that problems do exist. Some classic car organizations are recommending that WaterWetter not be used with antifreeze. The old addage "all antifreezes are not made equal but contain the same glycol", seems to be the rule here. Therefore, it is NOT RECOMMENDED to mix Red Line WaterWetter with antifreeze coolants. In any case, you will get better cooling with Distilled Water plus WaterWetter.

5.7 How Do I Know if I need WaterWetter?
This is a good question. It depends on how well your Model A cooling system is doing its job, the maintenance you usually do, and how conservative you wish to be in protecting your investment from wear and catastrophic engine failure.

Testing for Cooling Capability
Balance can be determined experimentally by a couple of methods, either add a water temperature gauge (MotoMeters do not measure coolant temperatures) or you can use a kitchen thermometer or an infrared heat detector to measure the coolant temperature, inside the radiator, as it pours in at the top, just under the radiator cap.
### 6.0 Conclusion

We concluded that the Model A’s non-pressurized cooling system requires careful consideration of energy balance to keep from running too cool, but keeping the high altitude margin of cooling well below engine overheating. Why is this balance such a problem, can you have too much flow, and how does the altitude here in Colorado affect the balance?

The answer is: Model A’s do not have many variables to play with. The cooling system is not pressurized and is not thermostatically controlled, therefore you cannot simply run hotter and put in a higher flow restricting thermostat. In fact, a thermostat can be dangerous since it impedes the Thermo-Siphon action when closed. If the thermostat fails closed you probably will damage your engine severely. Even in normal operation the thermostat can impede the coolant flow and put your Model A at risk of overheating.

### THE MAIN POINTS

- Cylinder wear in the Model A engine is determined by the coolant efficiency. Normal operating temperatures between 160 and 170 degrees F for the bulk coolant are desirable.
- Temperature margin between normal operation and boiling here in the Front Range of Colorado is reduced by 12 degrees F compared to the same parameters at sea level. This margin can be recovered by the use of Red Line WaterWetter additive.
- For best coolant performance use distilled water plus Red Line WaterWetter. This additive is available at many retail autoparts stores, or on-line at www.RedLineoil.com
- Do NOT use tap water, either alone or as a mixture with antifreeze. Tap water contains minerals and chemicals which react within your engine to create an insulating film which results in rust and scale. ONLY USE DISTILLED DE-IONIZED WATER.
- Antifreeze has lower performance cooling capacity due to its chemical properties. It is OK in the lower winter temperatures, but stresses the engine in the summer. It is not recommended for use year round in the Model A Ford. Antifreeze is designed for use in modern engines that have 3 to 5 times the coolant flow rate than the Model A Ford’s thermo siphon systems low flow rate. It is for this reason that the Ford engineers recommended, in 1928 - 1931 changing from water to antifreeze in the winter and back to water in the spring.
- The use of two different coolants gives the Model A enthusiast a chance to flush the engine and radiator twice a year, preventing sludge, crud, and goo forming in the radiator leading to premature failure.
- If you insist on running antifreeze year round, you should change it yearly, or at least bi-yearly. ONLY USE INORGANIC ADDITIVE TECHNOLOGY (IAT) antifreeze, the green stuff, because the Organic Acid Technology, the orange stuff, “extended life” antifreezes attack older car gaskets, and gasket sealants. This applies to Hybrid OAT, and Nitrous OAT types of antifreezes and DexCool (GM).
• Antifreeze contains chemical compound additives which are useful for anti-corrosion and anti-scale in modern engines. These additives can be detrimental to components in older classic car engines. At risk in the Model A are components in the radiator, and the water pump. A survey of the material compatibilities show some low, but real, risk of degradation by antifreeze, especially the stock water pump packing and radiator solder. Most “leakless” water pumps use Teflon seals, which are compatible with antifreeze, however, some of the older “leakless” water pumps were manufactured with Neoprene seals, which are only classified as FAIR with respect to compatibility with antifreeze.

• Red Line WaterWetter also has similar additives, but puts your cooling system at less risk due to its not attacking the lead in solder or the graphite/lead water pump packing.

• While it may be attractive to add Red Line WaterWetter to antifreeze, it has been found by many users to form “gunk, goo, sludge, and other names” in the cooling system, radiator and water pump components. Red Line claims that it is compatible with antifreeze, but until these reports on MANY website forums subside, I would not recommend mixing WaterWetter with antifreeze.