EVANS
WATERLESS ENGINE COOLANTS

In Technical Partnership with
Honda Racing
World Motocross Team

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Dear Peter,

Evans UK – A detailed response to No-Rosion

Following our recent communications I have prepared this detailed response to the NR document, which will be posted in modified/generic form on our website.

Introduction and the need to respond...

We would respectfully request all those that have read and been concerned by the contents of NRs document on Evans, to carefully study our detailed response prior to reaching any conclusion on the efficacy of or need for Waterless Engine Coolants.

Evans coolants represent a major evolution in engine cooling technology and from NR's point of view a direct challenge to their business and a century of 'water-based' thinking. Water is the best heat transfer fluid, readily available in most countries and cheap. Its adoption as an engine coolant early in the 20th century was logical but complicated by the fact it freezes at $0^{O}C$ and boils at $100^{O}C$. Furthermore water is universally recognised as the root cause of corrosion and erosion inside engine blocks and cooling systems. Over the last 100 years there have been many attempts to constrain and counteract the physical and chemical affects of water. However, substantial evidence of on-going component failure and the critical need for regular fluid maintenance, indicate that water-based coolants remain far from the 'ideal solution'. The BTC Testing Advisory Group, who include BP, BASF, Arteco and Perkins among their members, confirmed in 2011 that "up to 60% of engine failures can be attributed to cooling system failure". It is logical therefore that engineers and scientists should thoroughly investigate alternatives that look to eradicate the cause of these problems rather than toil constantly and expensively against the effects. Future IC engine development and specifically higher operating temperatures (that improve combustion and reduce emissions) will benefit hugely from a coolant that does not require pressures of circa 3 Bar (45 psi) to maintain it in a liquid state. Already many diesel engines generate >2 Bar vapour pressure and most of the F1 fleet >3 Bar, which is placing excessive demands on materials and responsible for an increasing number of 'explosive' bursts and severe scalding.

The prospect of a hermetic cooling system – sealed for an engine lifetime - and the benefits of a coolant proven to eliminate overheating, corrosion, erosion and pressurisation justifies objective investigation and a more diligent evaluation than NRs one-off flawed test and report. Fortunately a significant number of respected engineers, race teams, restorers, fleet operators and engine manufacturers have taken the time (ranging from 6 months to several years) to thoroughly and assiduously evaluate Evans WEC prior to adoption. Evans recent appointment as a technical partner and coolant supplier to Honda, following 9 months R&D evaluation in Japan and Italy, provides another excellent point of reference. Similarly Rotax aircraft engine manufacturers specify Evans WEC for use in their liquid cooled aero engines. Need we say more?

Normally we would let the extensive list of Evans converts and adopters 'speak for us', but as the NR document is causing confusion on several forums it is prudent to address their erroneous claims in a constructive manner. It would be much appreciated if any readers still having questions following this response could contact us directly for the answers.

Kind regards,

Steve Hickson

Managing Director, on behalf of
Hydra Technologies Ltd. incorporating Evans Coolants.

Detailed technical information follows below and attached.

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1. Competence and Credibility aligned with Due Diligence...

In 2011 Hydra Technologies Ltd. was appointed the UK licensee to manufacture and distribute Evans WEC throughout the UK, Europe and Middle East. HTLs core business is the formulation and manufacture of specialist heat transfer fluids, supplied to OEMs, distributors and end users in the Refrigeration & HVAC, Solar Thermal & Geothermal sectors. HTL also designed, built, installed and operated large fluid processing equipment for Pepsi-Walkers and Co-Op dairies. Via its Marine & Offshore Supplies division HTL has extensive experience in designing and packaging mechanical and marine equipment, including; engine driven generators and fire-pump sets, process cooling, filtration and fresh water systems.

Prior to establishing Evans UK HTL spent 14 months in due diligence reviewing all the claims, data and test reports, collated by Evans USA over an 18 year period. Similar due diligence procedures were performed by Allianz, Chubb and Lloyds of London (product liability insurers) and UK Steel Enterprise division of TATA (share holding investors). It would be reasonable to say, that none of the above mentioned companies would have proceeded if the product was flawed in the way NR purports.

2. Formulated from experience...

Jack Evans and Tom Light, the men who perfected Evans WEC, are innovative engineers and their specialty had been the design and manufacture of high performance engine cooling systems. For many years Jack and Tom improved pump and cooling system design for a wide range of racing and production engines, working with Nascar, Ferrari, General Motors etc. During this investigative era they proved that water-based coolants were often restricting engine performance and operating beyond waters physical and chemical limits, even with additional pressure and inhibitors added. By replacing water with 100% glycol they eliminated the boiling and vapour issues, but were unable to remove sufficient heat energy to prevent a gradual increase in engine temperature. Over several years, experimenting with various glycols, synthetic and organic diols plus non-aqueous corrosion inhibitors, Jack and Tom formulated a patented WEC that is; non-toxic, has low viscosity and pour point, boils above 180ºC, protects below -40ºC, generates little vapour pressure, does not retain dissolved oxygen and has very low electrical conductivity. All of these properties combine to ensure Evans WEC eliminate the boiling, corrosion and erosion issues associated to water-based coolants, whilst effectively cooling the engine.

3. Empirical versus theoretical...

Engineers often request Specific Heat, Thermal Conductivity and Viscosity data from us which is logical, but for Evans coolants can be misleading. Water has the best heat transfer characteristics (provided it is water not vapour) and theoretical calculations often indicate that using Evans will require a larger cooling system. This is the undoubted reason why OEM design engineers have persevered with water for all these years. In reality the 20 years of empirical data gathered by Evans backed up by >500,000 engine conversions proves there is much more going on inside an engine cooling system than $Q = M \times Cp \times \Delta T$ might suggest. Therefore we would always recommend testing Evans in a working engine to fully realise its extensive benefits.

4. Corrosion Prevention and ASTM Test Procedures

The corrosion tests carried out by NR are not relevant because they were performed following ASTM D1384 procedures which require 67% water to be mixed with 33% Evans. Evans is a Waterless Engine Coolant and therefore should not be mixed with water, for use or testing purposes.

Evans Global have commissioned several independent labs to perform bespoke corrosion tests that use ASTM D1384 procedures but without water present. The results (please refer to the attached documents) confirmed extremely low corrosion rates. Formalising a non-aqueous coolant testing procedure is included in the remit of ASTM sub-committee D15.22 for use by all manufacturers of waterless engine coolants. Tom Light, Evans USA CEO, has been appointed by other members of D15 to head-up the D15.22 sub-committee, which also includes members from several coolant manufacturers and Evans UK.

Whilst we have no reason to refute NRs results for their own inhibitor formulation, the fact remains that all inhibitors mixed in to water-based coolants fail over time. This is mainly due to the cyclical re-oxygenation of the coolant every time it heats and cools, which is exacerbated by galvanic activity. Hence the need to replenish inhibitors and/or coolant every 1 to 4 years.

Evans UK – A detailed response to No-Rosion

5. Effective removal of water-based coolants prior to filling with Evans

NR are correct in stating Evans coolants operate most effectively when at 97% to 100% concentration....otherwise they would not be waterless. However, they are wrong to state that it is difficult to reach this desired concentration and it is very easy to achieve >97% and for most engines a >99% concentration.

To achieve >97% concentration it is necessary to flush through a 'wet' engine with Evans Prep Fluid, as this will hygroscopically scavenge any remaining water from the cooling system simply, quickly and effectively. The flushing process is well within the capability of a DIY car enthusiast and easy for any apprentice mechanic.

Worse-Case Conversion Example: *To convert a 10L cooling/heating system from 50:50 coolant.*
After draining* of the 50:50 coolant 2.5L is left behind, which equates to 25% volume of which 12.5% is water = 1.25L.
(*A gentle blow-thru with low pressure compressed air will always prove beneficial in removing 'trapped' coolant.)
Add 7.5L of Evans Prep Fluid and run engine until thermostat opens and heater matrix has been exercised.
Stop engine, allow to cool and drain Prep Fluid.
Again assume 2.5L is left behind, which now equates to 0.313L of water remaining.
Add 7.5L of Evans Classic Cool 180 waterless coolant and run engine until thermostat opens.
The remaining 0.313L of water equates to 3.125% of the total cooling system volume. This is acceptable.

Standard Conversion Example: *To convert a 10L cooling/heating system from 50:50 coolant.*
After draining* of the 50:50 coolant 1L is left behind, which equates to 10% volume of which 5% is water = 0.5L
(*A gentle blow-thru with low pressure compressed air will always prove beneficial in removing 'trapped' coolant.)
Add 9L of Evans Prep Fluid and run engine until thermostat opens and heater matrix has been exercised.
Stop engine, allow to cool and drain Prep fluid.
Again assume 1L is left behind, which now equates to 0.05L of water remaining.
Add 9L of Evans Heavy Duty Coolant and run engine until thermostat opens.
The remaining 0.05L of water equates to 0.5% of the total cooling system volume. This is normal.

6. Payback and the Avoidance of False Economy

Evans WEC have been long-term proven to eliminate many of the problems and on-costs associated to water-based coolants. Specifically the prevention of;

a) Downtime and recovery costs associated with overheating, boil-over and after-boil.
b) Replacement and maintenance of components damaged by corrosion, erosion and cyclical pressurisation.
c) Premature devaluation and/or scrapping of engines, which have suffered accelerated wear and tear by water.
d) Year on year change-out of water-based coolants.
e) Constant coolant top-ups throughout the year....which often equates to between 100 - 300% of cooling system volume!

Once converted to Evans there is no need to change the coolant again, ever! Recently Joe Umstead, who has driven a DDA powered truck for 20 years and more than a million miles on a single fill of Evans Heavy Duty Coolant, was asked how the cost compared with standard coolant. His reply was *"he had no idea because it had been so long since he bought any!"* Joe's original reason for switching to Evans was radiator failure caused by corrosion inhibitor drop-out.
(Please Note: In the event of cooling system or engine maintenance Evans WEC can be drained and reused.)

Currently, as documented by the BTC Testing Advisory Group, 60% of all engine failures are caused by cooling system failure and during 2012 the AA responded to >56,000 breakdowns caused by overheating and cooling system failure.

Cause and Effect: Based on these facts we hope all engine and vehicle operators will appreciate the opportunity to completely eliminate the causes of overheating, corrosion etc. rather than employing temporary measures that partially delay those effects.

In conclusion; the difference in cost between Evans WEC and water-based coolants is rapidly offset by the life-long operational savings and improved reliability gained. A 24 month Return-on-Investment is reasonable to expect.

Evans UK – A detailed response to No-Rosion

7. Running Temperatures with Evans – is often lower than with water (vapour).

No-Rosion's findings on engine temperatures are, to put it constructively, very confused and bear no relation to the extensively proven and documented reality. By necessity Evans must refute NR's statements based on >0.5M successful conversions carried out over a 20 year period and we are happy to provide our customers with lists of highly credible end users and distributors.

In our technical literature we explain that water is the best heat transfer fluid.....provided it is water and not vapour. As confirmed in tens of thousands of cases, engines are regularly suffering from vapour pocket formation around the combustion zone. This leads to erosion, cavitation, over-heating, detonation, loss of power and other combustion issues.

When an engine cooled with a water-based coolant is at low load and there is no vapour production, then it will run 2 - 10 Deg.C cooler than with Evans. As the engine load increases and vapour pockets develop (in water-based coolants) it is common to see the temperature gauge register an increase – whereas with Evans the gauge will remain steady at all loads. This is because with Evans there is always liquid coolant in contact with metal. With the 2 - 10 Deg.C increase in coolant temperature there is a similar increase in the lube oil temperature, but it remains well within acceptable operating parameters.

Other than the inference in NR's report, which hypothesises about the possibility of erosion to valve seats and guides, there is no scientifically gathered proof to corroborate their claim. In reality the opposite is often true, with Evans eliminating these problems in engines previously suffering from localised metal failure due to vapour formation. Our assumption is that NR did not properly convert their one-off test engine and left air pockets and/or water in the head – subsequently their findings were at odds with 99.99% of Evans conversions.

It is also worth mentioning that engines filled with Evans reach operating temperature more quickly than water cooled engines. This is known to reduce emissions from diesel engines.

8. Evans and the need for ECU Reprogramming

As previously mentioned engines filled with water-based coolants often vary in operating temperature range more than those filled with Evans, especially around the combustion zone. Specifically, due to vapour formation a water-cooled combustion zone is regularly operating outside of the predicted or intended parameters and subsequently the ECU program can be expected to over or under-fuel the engine based on incorrect temperature feedback.

Substantial research and corroboration based on thousands of Evans conversions confirms there is no necessity to adjust ECU settings following a 'fluid-only' conversion and many customers confirm an improvement in performance and/or MPG. As Evans is adopted by more OEMs there may be some adjustments that can be made to take additional advantage of the improved cooling around the combustion zone.

As detailed in Evans UK Economax brochure and www.economax.co.uk , installing Evans waterless coolant facilitates the opportunity to increase engine running temperature. Increasing heavy duty engine coolant temperature from approx 85 -90 Deg.C to 110 – 125 Deg.C has been proven to;

a) Improve fuel combustion and reduce exhaust emissions.
b) Reduce fan-on time by up to 50%, achieved through widening the Delta-T.

Attached to this communication are two independent reports corroborating these statements and providing evidence of the incentive for Veolia and others to convert their fleets from water to Economax.

9. Evans Coolants and Nucleate Boiling

Nucleate boiling is the phase change state where micro-bubbles of vapour are formed on the hot metal surface and then move off in to the main coolant flow, where they are condensed (collapse). Nucleate boiling is the most efficient means of heat transfer from a metal to a liquid and is used in nuclear power plants where the loading conditions (heat generation) can be precisely predicted and controlled. Unfortunately these perfectly balanced conditions are rarely found in IC engines, as the load, speed, driver behaviour, fuel quality (RON) and ambient conditions are constant variables (*oxymoron*).

Nucleate boiling can exist from time to time in an engine, but often the heat transfer balance moves towards Critical Heat Flux and Transition Boiling which leads to Film and finally Ebullient Boiling. When film boiling occurs a thin layer of vapour separates the liquid coolant from the metal to be cooled. As described in the attached technical bulletin by Tom Light, the vapour bubble formed in water-based coolants is part water, part ethylene glycol and the latter will readily recondense leaving behind a pure water-vapour bubble. This water vapour bubble will not recondense until the engine metal temperature drops below 95 – 115 Deg.C.

Evans has a much lower vapour pressure compared with water-based coolants and this is manifested in a boiling point above 180 Deg.C. As with water-based coolants nucleate boiling conditions will not occur on a predictable basis with Evans, but what is certain is that Evans will not reach CHF except in the most extreme conditions. Subsequently film boiling does not develop and there is always liquid in contact with the hot metal, maintaining effective heat transfer.

NR provide data relating to the reduction in surface tension of water using their additive, a common surfactant. Surfactants are already present in most 'off the shelf' antifreeze solutions and can increase heat transfer.....up to a point. When water phase changes from Nucleate Boiling to Film Boiling the energies and forces present cannot be controlled by surfactants. This is corroborated by the number of engines that continue to overheat and boil-over.

If, as NR imply, Evans did not perform more effectively than water-based coolants then surely Honda, Veolia, LA Metro, Kamaz-Master etc. etc. would have identified its limitations and not made the change.

10. Evans and Viscosity

Evans is more viscous than water at all temperatures....up to the point where water boils and vapourises - here viscosity is irrelevant. Evans viscosity has proven to be no issue for all but a few pre-1920's engines, that use a siphon system instead of a pump and occasionally engines where the cooling impeller is already eroded or the radiator blocked with corrosion debris. In the latter scenarios cooling system failure is usually imminent, e.g. pump, radiator, head or hose failure, and to avoid a reoccurrence of such failure(s) Evans should be considered during and/or after repairs have been completed.

For the remaining 99.99% of engines with factory fitted coolant pumps Evans works without issue....again the proof of 0.5M conversions corroborate this (apologies for repetition!).

11. Evans Reduces Cavitation, Cylinder Head and Liner Erosion

Apart from eliminating corrosion Evans WEC are proven to reduce the formation of the small vapour bubbles that constantly form and collapse on the surface of liners. This is a major problem for heavy duty engines fitted with wet liners and the subject of many SAE papers. Many measures have been tried to counteract the internal wear (combustion side) and external pitting (wet side), but liner porosity and cracking continue to cause catastrophic engine failure. In the new ASTM D7583 Liner Cavitation Test, as developed by John Deere, Evans WEC excelled in comparison with all other water-based coolants and achieved the lowest result (21 pits) ever recorded. This test was performed by the Southwest Research Institute, an independent, non-profit applied R&D organisation in San Antonio, Texas. As with all test findings Evans have disassembled many engines to verify the same results are achieved in working vehicles and plant. I.E. Evans does not just rely on one or even several lab tests, but has always proven the product in the field and over many years.

The issue of vapour bubble formation on liner surfaces is a manifestation of entrapped vapour coming out of solution where pressure drops occur. A similar thing happens in tortuous path cooling channels and impeller pump volutes. Specifically where the water-based coolant rapidly changes direction there will always be a pressure drop and this provides the entrapped vapour with an opportunity to escape, or phase change. Another word for this process is Cavitation, which is often responsible for poor/reduced circulation rates and erosion to metal and plastic (gaskets) parts, leading to eventual failure. In comparison to water and water-based coolants Evans has a much reduced vapour pressure and subsequently is much less prone to vapour bubble formation or phase changing inside the cooling system.

It is this low vapour pressure of Evans that reduces internal operating pressures by 75% E.g. from approx 1.2 Bar down to approx 0.25 Bar. Evans users, distributors and advocates often like to prove this unique characteristic by removing the coolant cap whilst the engine is hot or still running! We would always advise 'safety first' when dealing with hot liquids but it really does surprise most people. On a practical note the lower operating pressure also reduces internal cyclical stresses on hoses, clips, radiator seams and head gaskets.

12. Health & Safety

NR's comments and bias are very much race-track orientated where, as they point out, glycol based coolants are sometimes banned. This is because Evans and 50-50 water-glycol coolants are synthetic based and slippery if spilt. Although Evans market is 99.9% non-track orientated and 90% of non-track engines are filled with a mixture of water and toxic ethylene glycol there is more to the track story.....

As detailed above and in Evans product literature many engines and especially racing engines are operating at or beyond the physical limit of water. This often requires engine tuners to de-rate performance. In racing, performance is everything and for this reason Evans has been finding its way in to all categories of racing machines for more than a decade. Admittedly sometimes it's been done on the QT but we expect the need for secrecy to change over the coming years. Because Evans generates substantially less pressure than water-based coolants, there is little potential for it to spray anywhere in the event of a hose or radiator failure. In this respect we have received several accounts from 'Evans racers' about crashes and impacts that have holed their radiator but not prevented the driver from completing the race....because the coolant did not spurt from the leak and instead gently dribbled out. I.E. they lost little coolant and could carry on.

During the 2012 season several Evans sponsored racing teams attended dozens of events at Brands Hatch, Oulton Park, Donnington, Snetterton etc. and not once did we witness a coolant spill from any of those cars or bikes. Rather, most race suspensions were due to lube-oil, brake-fluid or fuel leaks.

Because Evans offers racing teams such a measurable advantage (see Honda, Kawasaki, KTM, Yamaha, Mosler etc.) we will be working with these teams and the appropriate authorities to review current racing legislation. If, as with lube-oil connections, racing cooling systems employed threaded-unions, and for belt-and-braces a braided metal over-hose, the risk would be even further reduced and provide far less concern compared with fuel, lube-oil, clutch and brake-fluid. When risk is properly assessed and the benefits (of Evans) carefully considered, then evolution dictates where there is a will there is always a way to manage the risks and move performance forward.

Towards the end of their report NR refer to the issues of flammability. Neither 50-50 water-antifreeze/coolant mixtures nor Evans WEC are classified as flammable and both have very high auto-ignition temperatures. However, under abnormal conditions not intended or predicted to occur by engine designers, both 50-50 and Evans coolants pose an exceedingly small risk of fire. There are a number of reported incidents of engines catching fire with 50-50 coolants sited as the fuel source. Specifically, 50-50 coolant under pressure has sprayed out from a burst hose etc. on to a red-hot (glowing) exhaust manifold, where the water element is instantaneously evaporated leaving behind neat ethylene glycol. As detailed in the attached report the odds of such an event occurring are considered too remote to be considered as a quantifiable risk, or for insurance companies to adjust any premiums. Evans coolants pose a smaller risk of fire in comparison to 50-50 coolant, as they will not spray under pressure and are far less lightly to cause a burst hose.

In comparison to the other fluids found within an engine compartment, neither 50-50 nor Evans coolants come close to the risks associated for; fuel, lube-oil, brake or clutch fluid and electrical shorts.

Evans USA will be asking NR to correct or remove their claims and we would always encourage potential customers to verify their questions with Evans UK directly. Thank you.

Steve Hickson

Managing Director, on behalf of
Hydra Technologies Ltd. incorporating Evans Coolants.

www.evanscoolants.co.uk