

## DISCUSSION

---

*Question 1*—Considering the fact that the borate and nitrate inhibitors have insignificant depletion rates and that excessive concentrations of these inhibitors can be detrimental to cooling system metals, why do so many people still persist in recommending these inhibitors, on an indiscriminate basis, for the supplemental inhibitor package?

*Authors' response*—This is an inherent difficulty when applying a supplemental coolant additive in that additive loss can be the result of dilution or depletion. In the case of dilution of the coolant all the additive components are affected equally, whereas, with depletion, the loss of the more active or less stable components can be substantially higher. If we had a situation in the field where the rate of dilution and depletion was constant, a supplemental additive could be designed which would keep the level of ingredients at a more nearly constant level. However the relative amount of dilution and depletion vary widely in the field and, to be on the safe side, the supplemental additive is formulated to replenish each ingredient. There is a greater risk to the engine if too little borate and nitrate are present compared with too much. However, in the future, as we gain a better understanding of additive loss, there is a strong possibility that this information will result in a rebalancing of the various components of the SCA used as a service charge (for example, lower percentage of borate and nitrate and more silicate and MBT).

*Question 2*—Reference was made to the influence of impurities in industrial grade glycol. What is the chemical nature of these impurities and what was their concentration?

*Authors' response*—The industrial grade glycol which we used contained 10 to 15 ppm of dissolved iron. In addition there was a good chance of chloride contamination and the presence of glycol oxidation products (low molecular weight organic acids). We did not measure the concentration of the latter two contaminants but speculate that the iron coupled with organic acids initially present are what caused significantly higher solder corrosion rates. Also bear in mind that even analytical grade ethylene glycol will degrade to some extent under the conditions found in the cooling system and increase solder corrosion rates.

*Question 3*—Does cavitation of cylinder liners and cast-iron pump impellers go hand in hand? That is, if an inhibitor performs poorly for cylinder liner cavitation, does it generally perform poorly for pump impeller cavitation? If it performs well for pump impeller cavitation, does it usually perform well for liners?

*Authors' response*—First let us assume that the liner and impeller are made from the same material. The effectiveness of the inhibitor would then depend

upon the cavitation intensity at the liner or impeller surface. Corrosion inhibitors are effective only when the damage mechanism is cavitation accelerated corrosion. If the cavitation is too intense then the damage is purely mechanical in nature and corrosion inhibitors will have little effect. Therefore a corrosion inhibitor may or may not protect both a liner and impeller. It would depend upon the design of the water pump and the intensity of liner vibration. Both would be protected if the damage mechanism was cavitation accelerated corrosion.

*Question 4*—If tests show that inhibitors are depleted (nitrate, MBT) and new inhibitor additive is added, do the inhibitors continue to deplete as rapidly?

*Authors' response*—As far as additive depletion, it is most rapid in a new or clean system. Larger amounts of inhibitor are required to form a protective film or layer on the metal surface than maintain it. However other processes which lead to additive loss are constant or increase with the age of the vehicle. For instance coolant loss and leakage of combustion gases into the cooling system increase with time. Also mechanisms of inhibitor loss such as thermal or hydrolytic degradation will continue at a more or less constant rate.

*Question 5*—(a) Was there a difference in scale composition when pure water (corrosive or hard) is used in the diesel coolant system instead of the ethylene glycol/water system? (b) What is the composition of the scale which is formed?

*Authors' response*—(a) We have not tried to determine the difference in the nature of the scale formed in water as opposed to glycol/water mixtures. (b) As far as scale composition, we find that it is composed primarily of calcium, magnesium, silicate, phosphate, and carbonate.

*Question 6*—In your paper you stated corrosion rates are increased when metals (iron) are present in the industrial grade ethylene glycol. (a) When scale forms is that iron plated on surfaces? (b) If an iron dispersant were added would the corrosion rate decrease, in your opinion?

*Authors' response*—(a) The only time we have seen appreciable amounts of iron in scale is when there is a corrosion problem in the cooling system. The iron levels in commercial antifreeze are seldom as high as that in the industrial grade ethylene glycol that we used in some of our tests. We do not feel that the level of iron in a typical antifreeze is enough to cause scaling problems. (b) An iron dispersant might reduce corrosion rates by deactivating the iron or preventing its deposition resulting in under deposit corrosion.