ADVANCED DRIVER ASSISTANCE SYSTEMS DRAFT RESEARCH TEST PROCEDURES

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Feedback by Mark Thrasher – Concerned Citizen and Former Test Engineer

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National Highway Traffic Safety Administration
US Department of Transportation
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Dear NHTSA and Driving Public:

As a former test engineer that worked at Robert Bosch LLC for 22 years and in particular in the chassis control division for the last 12 years, I would like to provide my feedback on these proposed test procedures. Specifically section 4.1.1 regarding the test temperature.

1 Outline of Concern

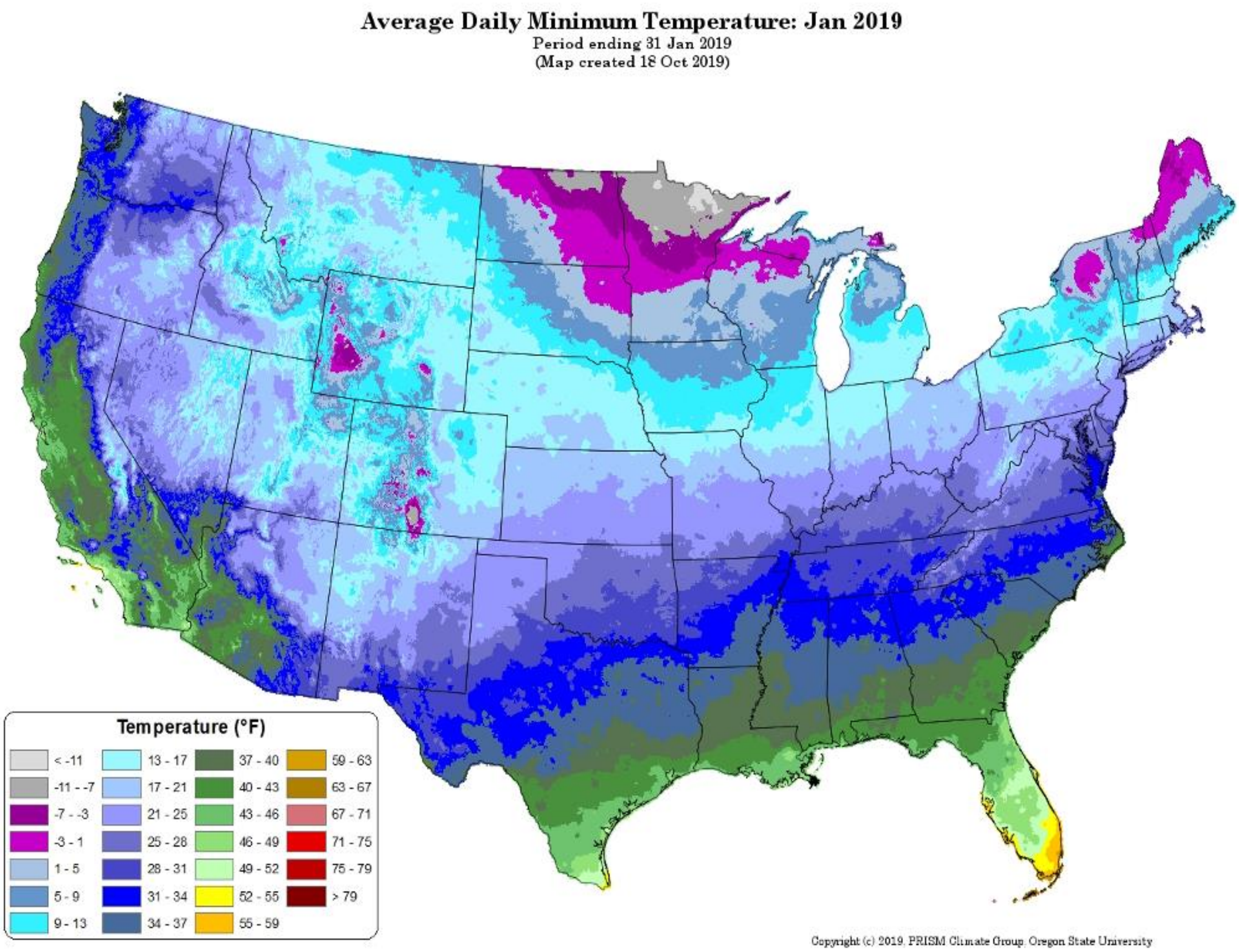
It seems that many new systems being developed for Pedestrian Automatic Emergency Braking (PAEB) are based on existing designs of Electronic Stability Control (ESC) devices. However, for PAEB applications, current ESC systems are not fast enough to autonomously brake a vehicle for the various incursion scenarios.

Because of this lack of dynamic response, it seems one option that is being attempted is to incorporate higher speed motors into current ESC designs so that they develop the needed flow rates to meet these new demands. However, a major flaw with this approach is that as temperature drops, brake fluid becomes more viscous and reduces the efficiency of these ESC units to the point where they may become ineffective below a certain temperature. A more detailed description of this claim will be discussed in section 3 below.

For ESC manufacturers that prescribe to this design philosophy, it would be of the utmost importance to request from regulatory agencies that the test temperatures are within the optimum performance of their ESC units. This seems to be what is happening as the lower temperature range of Euro NCAP[i] pedestrian protection tests is set at 5C (41F) and in this latest proposal from NHTSA is even higher at 7C (45F). This despite the fact that winter low temperatures in the US are well below these test temperatures as shown in the Figure 1 below[ii].

Application engineers in the industry might argue that the heat from the internal combustion engine will provide enough warmth to the brake components to optimum performance temperatures. I believe this is highly dependant on the brake system component locations as well as the heat-up time needed to achieve this temperature. In addition, this argument falls flat for completely electric vehicles.

Figure 1 - Actual US Low Temperatures Compared to Proposed Test Temperature (45F)



2 Suggestions for Revised Testing Strategy

Although weather conditions such as snow and rain will undoubtedly have an impact on the performance of a PAEB system because it is outside of its control (road/tire adhesion), normally encountered ambient temperature should not degrade the performance of a PAEB systems' inherent hardware in my view. No doubt this is problematic to duplicate in a test track setting.

One way to accomplish this is to have the PAEB system tested in an environmental chamber in a lab where the response of the system is measured at temperatures that would likely be encounterd by the driving population. The lab test data would then be used to limit the performance of the PAEB system during track testing to simulate the system peformance at a temperature that cannot be duplicated at the track.

For a hypothetical example the maximum flow rate that can be achieved at -5C (14F) in a lab test was found to be 12 cc/s at max rpm. At optimum conditions, the PAEB system can produce 22 cc/s at max rpm. During the track test, the ESC maximum rpm would be limited to obtain 12 cc/s to simulate the performance of the track test by limiting the maximum rpm that can be achieved by the ESC unit during the track test to simulate the low temperature performance of the unit on the tack.

This is something that is easilly capable by the ESC manufactures as I was involved with this type of testing for simulated low temperature ESC performance on the test track.

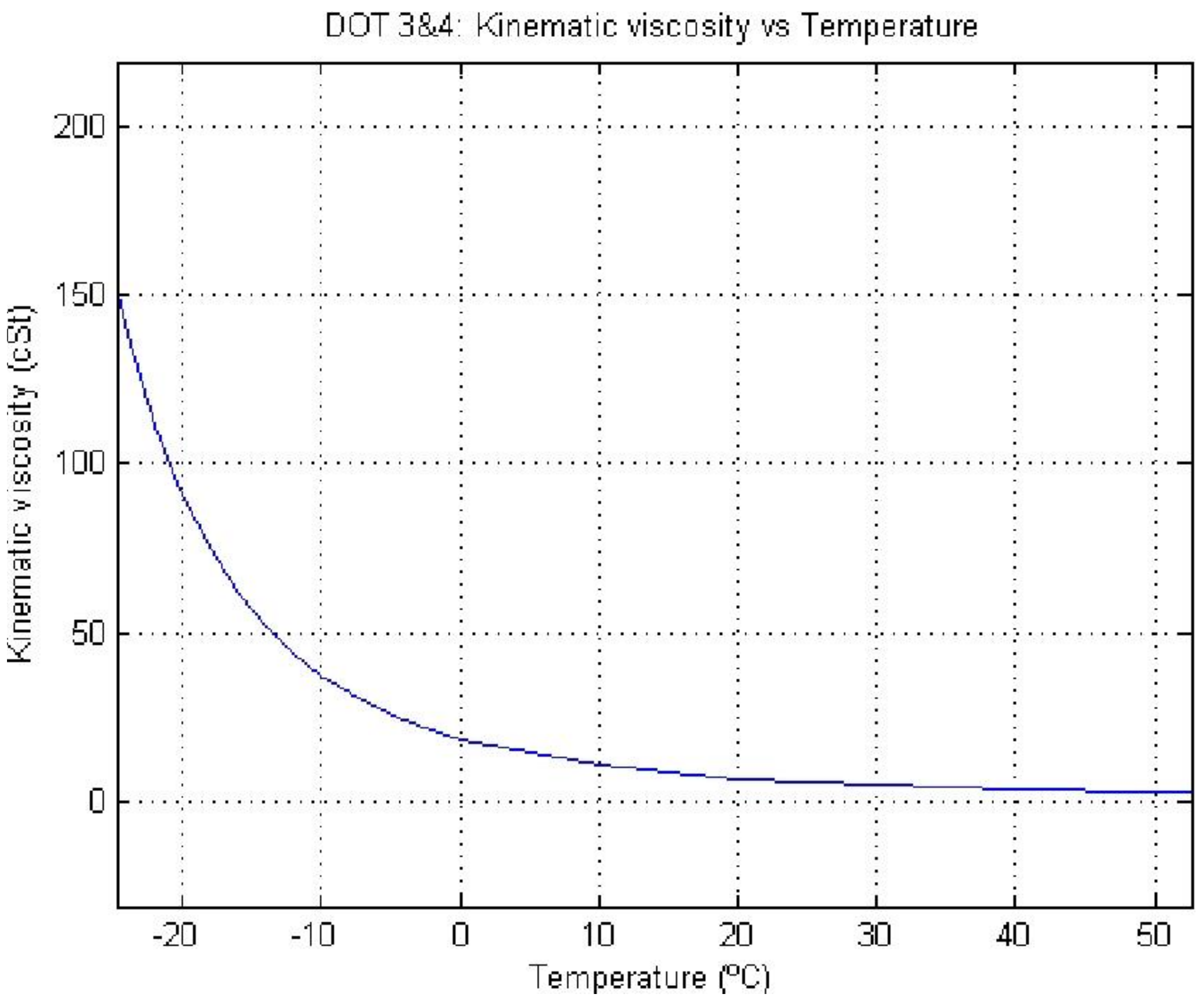
Likewise, the strategy can be implemented for motorised actuator based brakes systems (plunger or master cylinder) by limiting the maximum speed/acceleration of the plunger motor, etc. as low temperature brake fluid may impact these types of systems performance as well. This would identify if the actuator was built for 5C (Euro NCAP) optimum test performance as an example.

3 Detailed Description of Issue with Existing ESC and Improvement Thoughts

As discussed in the first section, in current ESC units that operate with radial positive displacement pumps, the increase in fluid viscosity prevents the pump elements from fully filling with brake fluid at lower temperatures. This is because the pistons are moving too fast for the more viscous fluid to fully fill the cylinder volume. This results in a lower efficiency[iii] of the device (less flow rate) at maximum rpm than that at higher temeratures. The pump elements are starved of fluid (there is no time for the cylinders to fill fully) even with an over optimised suction path.

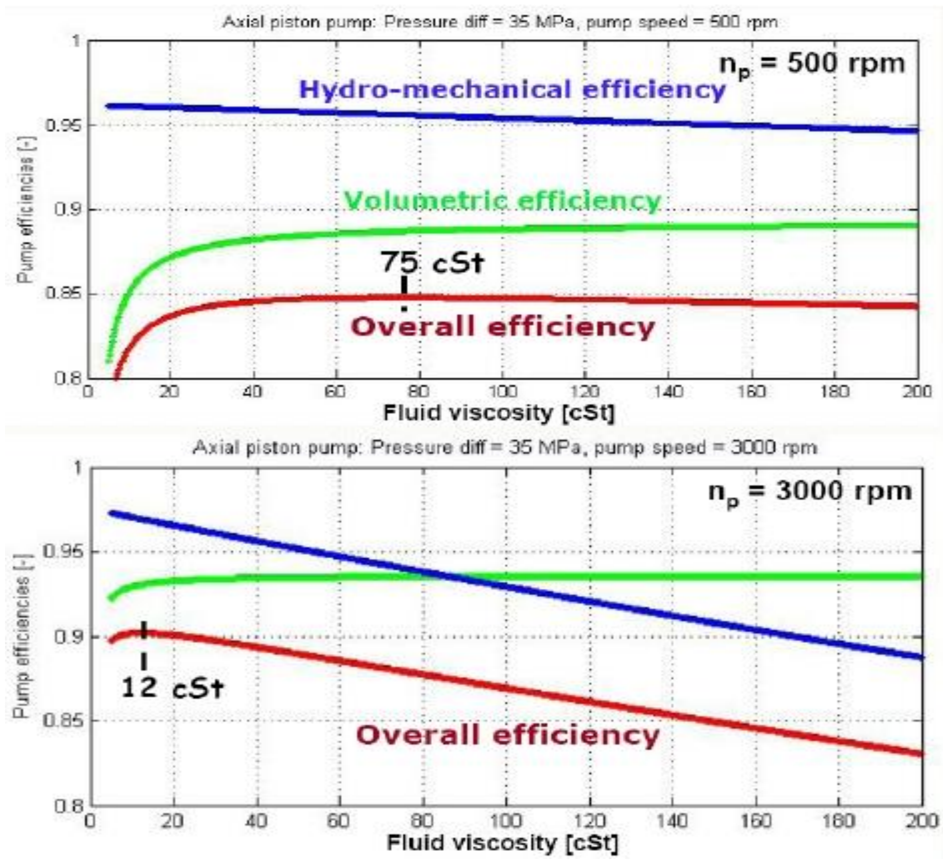
To explain the issue with current ESC systems, first I refer you to Figure 2 which shows what happens to the viscosity of brake fluid with temperature. As can be seen, there is a sharp increase in viscosity below 0C (32F). As the temperature further decreases, the brake fluid becomes increasingly more viscous. This viscosity change can be thought of the difference between water and honey at the extremes as an analogy.

Figure 2



The effect on a pump's efficiency is shown in Figure 3[iv]. In this case, at a speed of 1,200 revolutions per minute (rpm), the pumps efficency drops the more viscous the fluid gets. As discussed, this is because as the fluid gets thicker it cannot fill the piston cylinders the same as when the fluid is thinner. But in the case which the pump is running at 500 rpm, the efficiency is nearly constant across all fluid viscosities. This is because the pistons are moving slower allowing the cylinders to fill the same as they do with thinner fluid even when the fluid gets thicker.

Figure 3 - Viscosity Effect on Pump Efficiency Change at 2 Different Speeds



The point of this is that if you can slow down the speed of the pump while also increasing the displacement (more pistons) to keep the same flow rate, temperature changes should not effect the pumps performance.

However, doing this would require a shift to a different pump design. In the next section is an description of an attempt was made to look at the feasibility of this concept.

4 Attempts to Investigate a new Brake System Concept

At Bosch there was an initiative at the corpoate level to investigate new ideas through "innovation frameworks" for which I and other people were involved in a team. The intention of this team was to investigate a new type of pump[v] that may not have these low temperature issues in a conjunction with a patent I received for a new brake system[vi]. This new type of pump may be ideal in brake systems (if adapted to the automotive industry) because it allows more pistons to be used which would lower the operating speed while increasing flow.

I should also say that I submitted my concerns with these new ESC systems with high speed motors regarding low temperature performance through internal compliance channels as I believe this design stradegy could be problematic as outlined above. Bosch at the corporate level was emphasising compliance guidelines particularly after the diesel scandal at VW[vii]. In partucular, they wanted employees to scrutinize products that were being designed to meet a test and not for realworld conditions. These are known as "defeat devices". Although this is not the case for these new high speed ESC systems as no tests were mandated yet, I felt these types of systems could be problematic in real world conditions.

At any rate, the team was banned from the innovation framework to even determine if this idea had any merit. Later, I was prohibited from even talking about this idea and was going to have new application engineering duties assigned to me on top of my system testing tasks.

It seemed at the corporate level Bosch was very interested in exploring new ideas and promoted this culture heavilly, but in my view this is not accepted by everyone in the company which seems is not an unexpected phenomena[viii]. In the end, I felt Bosch is a company that I no longer wanted to work for and resigned in June of 2019.

5 Conclusion

The point of all of this is that is that I feel that these new safety systems should be evaluated at realistic conditions, not just ideal conditions. If the performance is lacking and rated as so, it gives the public better information on what to expect in their purchasing decisions. In addition, it gives manufacturers the incentive to continue to improve their systems to become better.

Indeed, with the advancement of sensor integration in future vehicles, more scrutiny of accidents will be undertaken to evaluate how these safety systems perform whether or not the manufacurers willingly provide this data.[ix] So I suspect the real world performance of these systems will become evident over time.

I applaud NHTSA in it's goal to reduce accidents as new technology arises. I share this goal also as close members of my family have died on our streets and I truly want too see accident free driving in the future. Hopefully the concerns I have brought to light may be considered if this helps enable this vision to become a reality.

Thanks,

Mark Thrasher

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