

Spreadsheet Explanation

Once having confirmed the traditional fuel economy estimates associated with weight reduction, the next step in the analysis is to calculate the solar transmittance applicable to polycarbonate necessary to achieve the same CO₂ reductions as the proposed solar transmittance requirements are expected to achieve when applied to glass. The result of this analysis is a T_{ts} requirement for polycarbonate that, while higher than that proposed for glass due to the physical properties of polycarbonate, results in the same CO₂ reductions due to the weight reductions achieved by replacing glass with polycarbonate.

This analysis is premised on the study led by the National Renewable Energy Laboratory (NREL) and summarized in Paper # 2007-01-1194 presented at the SAE 2007 World Congress. The NREL study concluded that lower T_{ts} results in lower Cabin Breath Air Soak Temperature (CBAST), leading to reduced use of fuel for air conditioning and, in turn, reduced CO₂ emissions. In developing its own analysis, Exatec used the NREL study as a starting point and consulted with NREL to confirm the logic and application of its analysis. Significantly, to derive the comparison between weight and solar load effects, Exatec used the same vehicle and basic assumptions used by NREL to ensure that the comparison is valid; where additional inputs were necessary, Exatec ensured consistency and confirmed that consistency by consulting with NREL.

Exatec developed analyses to establish T_{ts} values achieving equivalent CO₂ reductions with regard to (i) backlites and sidelites, (ii) roofrites, and (iii) windshields. Although polycarbonate is not currently categorized for use in windshields, Exatec applied its analysis to windshields since future technology and regulatory developments may enable that application with polycarbonate. The spreadsheets setting forth the analyses are attached, and the results of the analyses are incorporated into Exatec's recommended amendment to the proposed regulation.

The backlite and sidelite analysis utilizes the same vehicle that formed the basis of the NREL study, the 2006 Cadillac STS V6. The NREL study measured reduction in CBAST for four configurations of the Cadillac STS, each relative to a baseline version. Each configuration represented a different combination of special features intended to reduce solar load and air conditioning use. The specific effect of sidelites and backlites was estimated from three of the actual configurations. All sidelites were treated as being subject to the CARB standard for AS2 application.

The first NREL configuration incorporates all of the special features. This is the only configuration for which the reduction in air conditioning fuel use was quantified (compare "p" and "k"). However, annualizing and dividing this fuel-use reduction by the corresponding reduction in CBAST yields a ratio ("t") that can be multiplied by the CBAST reduction for another configuration to estimate the fuel use reduction for that configuration. The expected CBAST reduction for AS2 sidelites and backlite can be determined from the difference in measured CBAST reductions for two of the configurations (2 and 4 – "w"). Using the ratio ("t"), the expected annual fuel savings ("x") is determined. The total solar transmittance (T_{ts}) for the solar reflecting glass is less than T_{ts} for the original glazing by 20 units ("y"). These last two parameters determine the annual fuel saving for each unit of T_{ts} reduction in the sidelites and backlites ("z").

Next the annual fuel savings (“eee”) resulting from replacing the tempered glass sidelites and backlite of the vehicle with polycarbonate glazing is determined, based solely on the associated reduction in vehicle weight. Consistently, the air conditioning fuel use is assumed to be the same as in the baseline vehicle, so that the improved fuel economy (“bbb”) is relative to that of the baseline vehicle (“i”). The values of “eee” and “z” combine to determine the equivalent Tts reduction (“fff”) relative to polycarbonate’s Tts that would allow glass to provide the same annual fuel saving via CBAST reduction and reduced air conditioning use that polycarbonate glazing would provide by weight reduction alone.

Adding this figure (“fff”) to the Tts limit provided for glass in the proposed regulation (“ggg”) determines the Tts limit (“hhh”) that can be applied to polycarbonate to generate an equivalent level of CO2 emissions reductions. In other words, the same CO2 reduction benefits accrue through the use of tempered glass meeting the Tts requirements in the proposed regulation, or alternatively through the use of polycarbonate meeting the Tts requirements included in Exatec’s recommended amendment.

Exatec conducted similar analyses for roofites and windshields. The NREL study did not include configurations representing the reduction in CBAST due to IR glass rooflite. Exatec therefore developed an intermediate parameter: reduction in total transmitted power through the glazing. As a result, the analyses for roofites and windshields are the same as that for sidelites and backlites through the “x” parameter on the spreadsheets. Beyond that point, the intermediate parameter is calculated in slightly different forms for sidelites and backlites (“ll”) than for roofites and windshields (“oo”), using NREL’s software application VSOLE (Vehicle Solar Load Estimator).

The steps following “z” are fully analogous to those for sidelites and backlite. Notably, there was no need to refer to specific rooflite or windshield glazing because a key universal ratio (“mm”) could be derived from results for the specific baseline and IR glazing used in the NREL study and then applied to the rooflite and windshield. To keep the analysis internally consistent, the same vehicle context – the Cadillac STS V6 – is used throughout all of the analyses. Each Tts requirement proposed for polycarbonate in the recommended amendment exceeds its glass counterpart by the application-specific spread “fff”, rounded down to the nearest multiple of 5%.

These analyses provide an objective, scientific method to determine the equivalent Tts level that should be applied to polycarbonate glazing to achieve the same CO2 emissions reductions sought through the proposed regulation for glass. This approach is consistent with the Staff Report because it imposes on polycarbonate a requirement for solar management technology. Yet, unlike the current iteration of the proposed regulation, adoption of this approach will not preclude polycarbonate or other materials that can provide equally effective mechanisms for meeting the intent of the regulation to reduce CO2 emissions.