

California Environmental Protection Agency  
Air Resources Board

Rulemaking to Consider Adoption of Proposed Cool Car Standards  
And Test Procedures – 2012 and Subsequent Model Year Passenger Cars,  
Light-Duty Trucks and Medium Duty Vehicles

June 25-26, 2009

**Comments of Exatec, LLC  
and  
Recommended Amendment to Permit Innovative Glazing Materials  
to Enhance Overall CO<sub>2</sub> Emission Reductions**

**Introduction**

Exatec, LLC (“Exatec”) appreciates the opportunity to comment on the proposed Cool Car standards and test procedures for light and medium duty vehicles beginning with model year 2012. Exatec is a wholly owned subsidiary of SABIC Innovative Plastics US LLC (“SABIC-IP”). SABIC-IP manufactures and compounds engineering thermoplastics, including polycarbonate. SABIC-IP’s dedicated automotive organization is a global supplier of plastic resins widely used in automotive and transportation applications. It offers leading plastic solutions for five key automotive segments: glazing and body panels, underhood applications, components, structures and interiors, and lighting.

Exatec is the SABIC-IP subsidiary dedicated to development and marketing of polycarbonate automotive glazing. With technology centers in Wixom, Michigan and Bergen Op Zoom, the Netherlands, Exatec services the global automotive industry. The Exatec product enables polycarbonate glazing through a unique coating system recently developed and currently under consideration for application by numerous global motor vehicle manufacturers.

Exatec polycarbonate glazing facilitates the achievement of the overarching goals of AB 32 to reduce greenhouse gas emissions by providing a lightweight alternative to traditional technology. The weight reduction provided by this alternative results in direct CO<sub>2</sub> reduction benefits. The Cool Cars initiative, while focused specifically on reducing CO<sub>2</sub> emissions by reducing air conditioning use, is one aspect of AB 32’s comprehensive CO<sub>2</sub> reduction plan. Exatec respectfully submits that the Cool Cars initiative should be implemented in a way to achieve the overarching goals of the AB 32 program, of which Cool Cars is a part, by permitting and encouraging innovative technology, such as polycarbonate glazing.

Exatec recommends a change to the proposed regulation so as to enable the maximum reduction of CO<sub>2</sub> emissions available through the Cool Cars initiative. The current proposal, as set forth in the ISOR, effectively precludes the adoption of polycarbonate glazing. Exatec is concerned that a delayed requirement, imposing the same requirements on polycarbonate as on glass as of a future date, would have the same effect by halting the adoption of polycarbonate glazing because there is not a current path to achieving the proposed solar transmittance requirements with polycarbonate's physical properties.

Exatec instead believes that appropriate requirements can be imposed on polycarbonate which recognize its unique properties (as compared to glass) and its capacity to reduce CO<sub>2</sub> emissions by decreasing vehicle mass. Each material should be judged on its own abilities to meet AB 32's goal of reducing CO<sub>2</sub> emissions.

Exatec has developed analyses that show that the overall CO<sub>2</sub> benefits associated with the reduced total solar transmission for glass can be translated into requirements for polycarbonate achieving an equivalent level of CO<sub>2</sub> reductions through reducing the weight of the glazing. Attached is an updated recommended amendment to the proposed regulation to incorporate these analyses into the regulation and to thereby enable the full potential for reduced CO<sub>2</sub> emissions through material-specific solar management requirements for both traditional and developing glazing technologies. Adopting this proposed amendment would be consistent with CARB's long history of encouraging innovative solutions and promoting them to the market.

### **Polycarbonate is Fundamentally Different from Glass**

Glass and polycarbonate are fundamentally different substances at the physical and chemical level, and the technologies necessary to increase solar performance while maintaining required visibility standards for each are fundamentally different. As a result, the solar reflective and absorbing technologies developed for glass are not compatible with polycarbonate glazing.

These differences stem from the organic nature of polycarbonate plastic and the relatively low temperatures at which it is processed, compared to the inorganic chemistry of glass and the higher temperatures at which it is processed. In addition, polycarbonate is injection molded in a full thickness three-dimensional shape to make car windows, which effectively precludes the incorporation of IR reflective films in a laminate construction. On the other hand, glass is not able to achieve the same level of weight benefits as polycarbonate, because of the physical properties of glass.

Because of these inherent physical and chemical differences, it is unreasonable to expect that polycarbonate windows could meet the same solar performance standards as glass can meet, using the same technologies as glass uses, just as it would be unreasonable to expect that glass could achieve the same weight benefits as polycarbonate plastic. This is why it is necessary to establish standards applicable to each technology, taking into account their unique properties and to ensure that the overall CO<sub>2</sub> benefits are equalized regardless of which material is used.

### **The Current Proposal Based on Glass Technology Effectively Precludes Polycarbonate Glazing**

As currently proposed, the regulation is premised exclusively on glass glazing technology. It specifies the total solar energy that may penetrate glass based on calculations that assume a glass-base IR reflective technology. By specifying requirements solely with regard to glass-based technology, the proposed regulation effectively precludes the use of polycarbonate backlites, sidelites, roofrites and windshields – and effectively excludes from the marketplace a lightweight material that can substantially enhance fuel economy and reduce CO2 emissions.

While Exatec acknowledges the possibility that, in the long term, innovation could potentially allow polycarbonate to achieve the same level of solar transmittance as glass, there is not a current technology path likely to achieve such invention within the foreseeable future. A temporary exemption is therefore not the best policy approach for this emerging technology that depends on the marketplace having assurance that the technology will be compliant in the longer term in order to induce investment and ultimately realize its potential impact on CO2 emissions.

While polycarbonate glazing cannot be assured of meeting the same solar management requirements being proposed for glass, polycarbonate, as a lighter weight material, immediately promotes CO2 reduction through weight reduction. Taking into account the weight reduction benefits of replacing glass glazing with polycarbonate glazing, the same CO2 reductions can be achieved as with limiting total solar transmittance through glass.

### **The Market for Polycarbonate Glazing to Reduce CO2 Emissions is Real**

A primary benefit of polycarbonate glazing when compared to glass is that polycarbonate weighs substantially less and yet provides substantial safety benefits. As the U.S. Environmental Protection Agency recently stated:

An additional area where we see opportunities for significant CO2 emissions reduction is in material weight substitution. The substitution of traditional vehicle materials (e.g., steel, glass) with lighter materials (e.g., aluminum, plastic composites) can provide substantial reductions in CO2 emissions while maintaining or enhancing vehicle size, comfort, and safety attributes. Several companies have recently announced plans to utilize weight reduction as a means to improve vehicle efficiency while meeting all applicable safety standards.

73 Fed. Reg. 44354, 4448 (July 30, 2008).

The automobile industry itself has confirmed the potential for polycarbonate glazing, requesting that the Cool Cars regulation not preclude its development and deployment. In comments to this proposed regulation, the Alliance of Automobile Manufacturers made clear that “the proposed regulation makes no allowance for evolving plastic window technologies, such as polycarbonates. While not widely used today, they have been an active area of research due to the large potential

weight savings.” See Comment Letter of the Alliance of Automobile Manufacturers dated March 11, 2009. Exatec continues to work with automotive original equipment manufacturers to deploy polycarbonate glazing. Automakers recognize polycarbonate’s potential to allow advanced aerodynamic design, reduce or offset mass, improve fuel economy and enhance occupant protection. In addition, safe reductions in vehicle weight allow for lighter structural components, offering the potential for secondary weight reduction and the associated CO<sub>2</sub> benefits.

Recent advances in polycarbonate glazing technology now make it possible for automotive manufacturers to specify polycarbonate for glazing. Nor is the motor vehicle industry’s interest in polycarbonate glazing likely to wane, unless polycarbonate is subjected to a regulatory standard, such as the one proposed, that it cannot meet. With the development of Pavley II and a new federal CO<sub>2</sub> regulatory program on the horizon, the demand for lightweight materials that can be safely incorporated into motor vehicles will continue to grow. Lightweight glazing materials also help enable advanced powertrains by counteracting weight penalties associated with batteries or other necessary equipment. Given the movement towards advanced powertrain vehicles and the regulatory environment, there is effectively no potential for automakers to negate the weight savings gained from polycarbonate glazing by adding weight elsewhere.

### **Exatec’s Recommended Amendment Would Permit Polycarbonate Glazing While Retaining the Same CO<sub>2</sub> Reduction Benefits as the Proposed Regulation**

CARB staff, recognizing that non-glass materials such as polycarbonate should be allowed, chose not to exempt such materials from the regulation but rather noted “that these materials can and should include solar management technologies.” See Staff Report: Initial Statement of Reasons, p. 18. Yet, the staff proposal does not itself present a pathway to permitting polycarbonate glazing because the proposed regulation specifies requirements applicable exclusively to glass.

Consistent with the staff’s suggestion, Exatec has developed analyses that show that the overall CO<sub>2</sub> benefits associated with the reduced total solar transmission for glass can be translated into requirements for polycarbonate achieving an equivalent level of CO<sub>2</sub> reductions through reducing the weight of the glazing. These analyses are described in detail below.

Exatec recommends an amendment to the proposed regulation to incorporate these analyses, to keep the marketplace open for competition among glazing materials, and – most significantly – to capture the substantial CO<sub>2</sub> reduction benefits available through polycarbonate glazing. The recommended amendment to the draft regulation would apply solar management requirements to polycarbonate glazing in a manner that achieves the same overall CO<sub>2</sub> reductions that are anticipated through the requirements for glass glazing technology. Thus, the recommended amendment proposes T<sub>ts</sub> requirements for polycarbonate that exceed the respective T<sub>ts</sub> requirements proposed for glass by an application-specific, calculated spread (“fff” in the analyses, rounded down, and discussed in detail below). The total amount of CO<sub>2</sub> emissions reductions remain the same, and the marketplace for continued innovation remains intact.

Setting a separate material-appropriate standard for polycarbonate glazing would recognize the inherent physical and chemical differences between glass and polycarbonate, and would be consistent with other CARB actions within the overall AB 32 program. For example, the Low Carbon Fuel Standard allows for compliance by low carbon ethanol, because of its greenhouse gas advantages over gasoline, despite the fact that ethanol has lower fuel efficiency than gasoline due to its chemical and physical properties. It would be inappropriate to encourage the adoption of low carbon ethanol production processes and at the same time require ethanol to meet a fuel efficiency standard that it cannot meet.

### **Exatec has Quantified and Verified through Testing the CO2 Reduction Benefits from Weight Reduction**

It is widely recognized that reducing weight enhances fuel economy, and that enhanced fuel economy results in less CO2 emissions. The first step in developing an equivalent solar management requirement for polycarbonate glazing is to quantify the CO2 reduction associated with the mass reduction achieved through replacing glass with polycarbonate glazing.

According to accepted estimates, approximately 6-7% miles-per-gallon gains can be had through vehicle weight savings of 10%. See, e.g., Massachusetts Institute of Technology, Laboratory of Energy and Environment Report, “Factor of Two: Halving the Fuel Consumption of New U.S. Automobiles by 2035,” Cheah et. al. (October 2007).

Exatec confirmed these estimates through vehicle testing conducted in accordance with the U.S. EPA’s Federal Test Procedure (FTP-75). Using a Jeep Commander vehicle, Exatec replaced the traditional glass in the two rear quarter panels, backlight, sunroof and both second row roof panels with polycarbonate glazing. The tests were conducted at Mercedes-Benz Research and Development North America, Inc., Mercedes-Benz TechCenter USA Division, with two configurations (vehicle with polycarbonate glazing and a vehicle with added weight to simulate the glass penalty). Using one vehicle for all tests, and using the same driver and the same fuel with both configurations, served to minimize variation in the testing. Replicate tests were conducted for each configuration to validate results.

The Commander testing confirmed the accepted estimates in a real world vehicle application using the EPA’s test procedure. A summary of the test data follows:

Tested: <b>2007 Jeep Commander</b>					
	<b><u>Veh Wt</u></b>	<b><u>CO</u></b>	<b><u>CO2</u></b>	<b><u>NOx</u></b>	<b><u>Fuel Economy</u></b>
	lb	g/mi	g/mi	g/mi	mpg
Glass	5119	1.3119	595.1660	0.1293	14.8320
PC	5093	1.2306	591.3775	0.1199	14.8775
Difference	-26	-0.0813	-3.7885	-0.0094	0.0455
%	-0.51%	-6.20%	-0.64%	-7.27%	0.31%

The opportunity for fuel savings relative to traditional materials depends on the opportunity for material substitutions. The more glazing available for substitution, the more mass reduction is available and the greater the CO<sub>2</sub> emissions benefits can be had. Polycarbonate glazing, therefore, is a compelling approach to reducing weight (and lowering the vehicle center of gravity) and thereby reducing CO<sub>2</sub> emissions, especially for vehicles with relatively large glazing volumes in relation to vehicle weight. Similarly, the CO<sub>2</sub> benefits to be gained through the reduced air conditioning use to be achieved through the Cool Cars regulation will also depend on the area of the glazing transmitting solar energy to the passenger compartment. As with materials substitution, the greater the glazing area of the vehicle the greater the potential benefits.

### **Exatec Recommends Equalizing the CO<sub>2</sub> Reduction Benefits Between Polycarbonate and Glass Glazing in the Cool Car Regulation**

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 CO<sub>2</sub> reductions as the proposed solar transmittance requirements are expected to achieve when applied to glass. The result of this analysis is a T<sub>ts</sub> requirement for polycarbonate that, while higher than that proposed for glass due to the physical properties of polycarbonate, results in the same CO<sub>2</sub> 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<sub>ts</sub> results in lower Cabin Breath Air Soak Temperature (CBAST), leading to reduced use of fuel for air conditioning and, in turn, reduced CO<sub>2</sub> 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 needed, Exatec ensured consistency by consulting with NREL.

Exatec developed analyses to establish T<sub>ts</sub> values achieving equivalent CO<sub>2</sub> 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.

A more detailed guide to the analyses is in the attached “Spreadsheet Explanation”. In summary, the first NREL configuration incorporates all of the special features and is the only configuration for which the reduction in air conditioning fuel use was quantified. However, annualizing and dividing this fuel-use reduction by the corresponding reduction in CBAST yields a ratio that can be multiplied by the CBAST reduction for another configuration to estimate the fuel use reduction for that configuration. The total solar transmittance (Tts) for the solar reflecting glass is less than Tts for the original glazing by 20 units. This measured difference is used to determine the annual fuel saving for each unit of Tts reduction in the sidelites and backlites.

Next the annual fuel savings 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 is relative to that of the baseline vehicle. From these values, Exatec was able to determine the equivalent Tts reduction 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 relative to glass.

Adding this figure to the Tts limit provided for glass in the proposed regulation determines the Tts limit 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 roofrites and windshields. The NREL study did not include configurations that isolate the reduction in CBAST due to IR glass in these locations. Exatec therefore developed the analyses in terms of a new intermediate parameter, namely, reduction in total transmitted power through the glazing. To keep the analyses internally consistent, the same vehicle context – the Cadillac STS V6 – is used throughout.

Regarding the Cadillac STS as a reasonable proxy for the broad fleet (as in CARB’s ISOR on page B-7), 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 version 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.

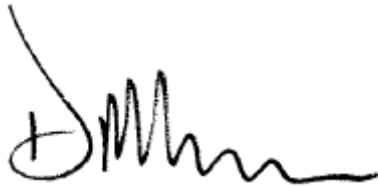
### **Exatec Urges the Board to Adopt Its Recommended Amendment**

Exatec's recommended amendment is aligned with the overall objectives of AB 32 by providing a means to reduce CO2 emissions while allowing for innovative new technologies. Without the recommended amendment, the proposed regulation will effectively preclude the market for polycarbonate glazing and derail both the current research and development being conducted to validate and advance use of polycarbonate in automotive glazing, and the current effort to deploy it in production vehicles. The recommended amendment is needed to allow continued development of an important new tool in the fight against climate change and in the initiatives for new motor vehicles to substantially reduce their contribution to greenhouse gas emissions.

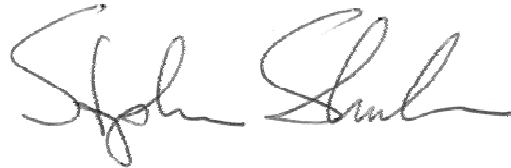
Exatec has carefully considered its recommended amendment, reviewed it with CARB staff and consulted with NREL in developing the analyses. The recommended amendment, while recognizing that the characteristics of polycarbonate require higher Tts values than glass, equalizes the overall CO2 reductions achieved by accounting for the reduced emissions associated with the reductions in mass available through polycarbonate.

Exatec and SABIC Innovative Plastics look forward to working with CARB and the State of California as they continue to promote advanced technologies to reduce greenhouse gas emissions.

Sincerely,



Dominic McMahon  
President  
Exatec, LLC



Stephen Shuler, PhD  
Chief Technology Officer  
Exatec, LLC

Attachments:

Recommended Amendment

Spreadsheet Explanation

Spreadsheets: CO2 Emission Reductions from Tts and Weight Reductions for:

- Sidelites and Backlites
- Rooflites
- Windshields