Mechanical model for Saflex® DG structural interlayer

Saflex® DG structural PVB interlayer is a tough, resilient film produced from plasticized polyvinyl butyral resin (PVB). It is designed specifically for applications where increased interlayer rigidity and high glass adhesion are required relative to conventional glazing interlayers. The designed high adhesion may render this product inappropriate for lamination with thin annealed lites of glass when used as a single layer interlayer if penetration resistance is required.

Saflex DG structural PVB combines a stiffer interlayer, versus conventional PVB interlayers, with features such as glass containment upon breaking, UV screening, low haze and the ability to laminate thick multi-ply glass. Storage, assembly and lamination properties similar to other Saflex brand PVB interlayer products, along with the aforementioned properties, make Saflex DG structural interlayer an excellent choice for most structural applications. Information regarding the safe handling and storage of Saflex DG PVB can be found in the Safety Data Sheet that is available from Eastman or at www.saflex.com. Lamination procedures are documented in the Saflex Lamination Guide which is available by contacting your Eastman Technical Service representative.

Specific applications of Saflex DG structural PVB interlayer include its use in structural glass applications such as: balconies, floors, fins and stair treads. It may also be used to adhere the glass layer closest to the witness (spall layer) for bullet resistant glazing, in glass applications where creep at higher temperatures is a concern, and in areas where the edge effects from sealants or exposed laminate edges need to be minimized. When used as part of a multi-interlayer laminate glazing system in place of one layer of standard PVB, Saflex DG structural interlayer can provide increased infill retention due to lower deflection as compared to a similar laminate system without Saflex DG interlayer. Saflex DG structural interlayer can be layered with Vanceva and Saflex colors. The modulus of the interlayer should be adjusted accordingly for calculations and color mottle should be verified through mock up panels.

The general physical and mechanical properties of Saflex DG structural PVB interlayer are provided in the Product Technical Datasheet. The information in this document is solely directed to providing a model for calculating shear relaxation modulus G(t,T) of Saflex DG structural PVB interlayer. The shear relaxation modulus obtained from this calculation can be used in Finite Element Modelling software that models stresses and deflections occurring in laminated safety glass under load. Actions on buildings have typical durations of 3s to 1 month; use of this model data outside this range may require further validation. The model in this document is applicable to Saflex DG and Saflex DG XC.

The basic data for the model provided were generated when executed as described in *Zhang et al. Glass Performance Days 2015*[1], using DMA frequency sweeps with the frequency range of 0.01-100 Hz with eight (8) datapoints per decade at 5°C intervals. Time-temperature superposition principles were applied using the Williams-Landel-Ferry equation to determine shift factors a_T. The relaxation spectrum was directly generated by the instrument software from the measured shear and loss storage modulus data. The relaxation spectrum was determined from the obtained master curve, at a reference temperature of 20°C, using a model containing ten (10) relaxation times and shear relaxation moduli. During the fitting process both parameter sets were considered as variables. The resulting relaxation data were interpolated to relaxation times regularly spaced in decades for user convenience and associated with the corresponding shear relaxation modulus values. The results of the model were compared to automatically generated mastercurves at different temperatures for reasonable fit. Although the data generated by the model are believed to represent acceptable values for shear relaxation modulus of Saflex DG for glass design purposes, they are not to be used in isolation to review fitness-for-use for particular glass designs. Design safety practices and applicable codes and standards need to be observed.

The shear relaxation modulus model for Saflex DG comprises a shift function (1) and an equation for shear relaxation modulus (2)

[1] *Zhang et al. proceedings of Glass Performance Days 2015, Tampere, Finland p 148-152 and references cited therein.*

$$\tau_{T;i} = 10^{-\left(\frac{C_1 \times (T_g - T_0)}{C_2 + (T_g - T_0)}\right)} \times \tau_{ref;i} \quad (1)$$

$$G_{tl} = G_\infty + (G_0 - G_\infty) \times \sum_{i=1}^{n} \left((G_i / G_0) \times e^{-t/\tau_{T;i}} \right) \quad (2)$$

Where G_{tl} is the shear relaxation modulus in MPa at a load duration t in s and temperature T_g, with:

$\tau_{T;i}$ the relaxationtime of the interlayer at temperature T_g in s
$\tau_{ref;i}$ the relaxation time of the interlayer at the reference temperature in s
T_g the temperature of the glass during the duration of the load
T_0 is the reference temperature (20 °C)
G_∞ = 0.23 MPa (plateau value of modulus)
G_0 = 576 MPA (maximum value of modulus)
C_1 = 21.3 and C_2 = 66 (WLF parameters)
n is the iteration factor (10 for this model), the count value is given by *i*
t the duration of the load in s
G_i/G_0 is the dimensionless shear relxation modulus. Note that $\Sigma(G_i/G_0) = 1$
Relaxation times $\tau_{ref;i}$ and the dimensionless shear relaxation modulus G_i/G_0 are given in table 1, for evaluation of the model.

Table 1. Model parameters for the evaluation shear relaxation modulus G(t,T) for Saflex DG and Saflex DG XC interlayers

i	relaxation time	relaxation modulus (G_i/G_0)
	(s)	
1	1.000E-01	0.1713
2	1.000E+00	0.1960
3	1.000E+01	0.2101
4	1.000E+02	0.2054
5	1.000E+03	0.1503
6	1.000E+04	0.0543
7	1.000E+05	0.0101
8	1.000E+06	1.79E-03
9	1.000E+07	4.78E-04
10	1.000E+10	2.93E-04

For assistance on model evaluation, please contact your local Eastman Technical Service representative.

Keywords: Architectural, Modulus, Model, Relaxation Modulus, Saflex, Saflex Structural

The data presented is derived from samples tested. Results are not guaranteed for all samples or for conditions other than those tested. Data and its respective measured, calculated or estimated single number ratings is for glass panels only – glazing installed in frames may differ significantly in performance.