The “Softening Point” of Glass Is Not a Property of the Material but a Convention Fixing One Viscosity

— moving the convention by one decade of viscosity moves the point by **45.056493** K, so “the softening point” is **753.322627** °C if set at $\log_{10}\eta = 6.0$ and **702.099609** °C if set at **7.0** — the separator is whether a point comes from a jump or from a convention — [Paper 827]

Yuuki YAMAGISHI (山岸 勇輝)
Yamagishi Complexity Torus Lab, Japan
September 2026

— *From thinking to syncing.* —

Abstract

Tables of glass list temperatures such as the softening point and the annealing point.This paper counts that these are not temperatures at which something happens in the material but the result of fixing one value of viscosity.No new theorem or law is claimed. First, the four “points” are four values of viscosity——1017.050090 °C at $\log_{10}\eta = 3$, 721.250381 °C at 6.6, 551.345543 °C at 12 and 524.395384 °C at 13.5 (Section 2). **Second, and this is the core. Move the convention and the point moves——one decade of viscosity moves it by 45.056493 K** (Section 3). **Third, “the softening point” shifts by tens of degrees with the choice——753.322627 °C at $\log_{10}\eta = 6.0$ and 702.099609 °C at 7.0** (Section 3). **Fourth, the viscosity itself has no jump——$\log_{10}\eta$ falls smoothly from 8.978786 at 900 K to 3.758115 at 1200 K** (Section 4). **Fifth, so it is a different kind of point from a melting point——a melting point has a jump in the material; a softening point is a cut on the scale** (Section 4). **Sixth, the separator is whether a point comes from a jump or from a convention——both are called points, but one can be moved and the other cannot** (Section 4). **Keywords**: glass viscosity, softening point, convention, VFT equation, continuity, representative values.

Scope of this paper (scope note): **No new theorem or law is claimed——that the viscosity of glass varies continuously with temperature, that the working, softening, annealing and strain points are defined by viscosity values, and the VFT form itself, are all known.The constants are representative——$A = -2.585$, $B = 4215$ and $T_0 = 535.5$ K vary with composition; no temperature value is claimed here.The physics of the glass transition is not entered——relaxation, configurational entropy and fragility are not the subject.Cooling rate is not treated——that the transition temperature moves with the speed of measurement belongs to Paper 352.Manufacture is not discussed——forming, annealing schedules and factory practice are not treated.Melting points are not denied——the temperature at which a crystal melts is a point in the material, and it serves here only for comparison.Relation to earlier papers**: **Paper 95 separated convention from fact——this paper stands beside it: the softening point is a convention picking one place on a scale.Paper 352 showed that the glass transition temperature moves with the speed of measurement——there the measurement moves it under a fixed convention; here the convention itself is moved.Paper 300 showed that whether two things share a root is decidable——a melting point and a softening point are distinct roots and are not put under one word.**What is added is **listing the four conventional temperatures**, **measuring the shift of 45.056493 K per decade**, **showing the softening point at 753.322627 °C and 702.099609 °C under two choices**, and **placing the separator on jump versus convention**.

1. Notation and the Question

Setting: **the viscosity of glass falls continuously with temperature, and the VFT form is the usual fit.**

$$\log_{10}\eta = A + \frac{B}{T - T_0}, \qquad A = -2.585, \quad B = 4215, \quad T_0 = 535.5\ \mathrm{K}$$

The working, softening, annealing and strain points are defined as the temperatures at which the viscosity reaches 10^{3}, $10^{6.6}$, 10^{12} and $10^{13.5}$ Pa·s.

Question: **are these points in the material or points on the scale?**

2. Deriving the Four Points

Computation 2.1: **the VFT form was inverted for the four conventions.**

name	convention ($\log_{10}\eta$)	temperature
working point	**3**	**1017.050090** °C
softening point	**6.6**	**721.250381** °C
annealing point	**12**	**551.345543** °C
strain point	**13.5**	**524.395384** °C

> **Observation 2.2**
>
> **the four points are four values of viscosity.The working and annealing points differ by 465.704546 K, the softening and annealing points by 169.904838 K——what looks like a table of temperatures is a set of cuts on a scale of viscosity.**

3. Moving the Convention

Computation 3.1: **the convention for “softening” was changed and the temperature recomputed.**

convention ($\log_{10}\eta$)	“softening point”
6.0	**753.322627** °C
6.6	**721.250381** °C
7.0	**702.099609** °C

> **Observation 3.2**
>
> **this is the core. Move the convention and the point moves.One decade of viscosity moves it by 45.056493 K——“the softening point is 720 °C” means something only after $10^{6.6}$ Pa·s has been chosen.**

4. No Jump Anywhere

Computation 4.1: **the viscosity was listed against temperature.**

temperature (K)	$\log_{10}\eta$
900	8.978786
1000	6.489273
1100	4.881785
1200	3.758115

Observation 4.2

there is no jump anywhere.Between 900 K and 1200 K, $\log_{10}\eta$ falls smoothly from 8.978786 to 3.758115——at a crystal's melting point the material itself jumps; here nothing does.

Observation 4.3

the separator is whether a point comes from a jump or from a convention.A melting point does not move when the method changes, while the softening point moves by 45.056493 K per decade of the convention——both are called points, but one can be moved and the other cannot.

Observation 4.4

placed beside Papers 95, 352 and 300.Paper 95 separated convention from fact——the softening point is a convention picking one place on a scale.Paper 352 showed the glass transition temperature moving with the speed of measurement——there the measurement moves it under a fixed convention; here the convention moves.Paper 300 showed that sharing a root is decidable——melting and softening are distinct roots.

Observation 4.5

what is not said.The values of the VFT constants, the physics of the glass transition, cooling rate and manufacture are not treated——what is shown is that the point moves with the convention.

5. Census and Closing

1. **working point 1017.050090 °C** (Computation 2.1): $\log_{10}\eta = 3$**.**
2. **softening point 721.250381 °C** (Computation 2.1): 6.6**.**
3. **annealing point 551.345543 °C** (Computation 2.1): 12**.**
4. **strain point 524.395384 °C** (Computation 2.1): 13.5**.**
5. **working minus annealing: 465.704546 K** (Observation 2.2): **the span of the scale.**
6. **45.056493 K per decade** (Observation 3.2): **the core.**
7. **753.322627 °C at 6.0** (Computation 3.1): **the choice decides.**
8. **702.099609 °C at 7.0** (Computation 3.1): **fifty degrees apart.**
9. **8.978786 at 900 K, 3.758115 at 1200 K** (Computation 4.1): **no jump.**
10. **jump or convention** (Observation 4.3): **the separator; Papers 95, 352, 300.**

Closing: **The “softening point” of glass is not a property of the material but a convention fixing one viscosity.The four points come out at 1017.050090 °C, 721.250381 °C, 551.345543 °C and 524.395384 °C——cuts made at four places on a scale of viscosity.Moving the convention by one decade moves the point by 45.056493 K, so “the softening point” is 753.322627 °C at $\log_{10}\eta = 6.0$ and 702.099609 °C at 7.0——because the viscosity itself runs smoothly from 8.978786 at 900 K to 3.758115 at 1200 K with no jump.The separator is whether a point comes from a jump or from a convention.Placed among the earlier papers——standing beside Paper 95’s convention against fact, moving the convention where Paper 352 moved the measurement, and keeping Paper 300’s discipline between melting and softening.To be honest——the VFT constants are representative, and no temperature value is claimed.**

References

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Yuuki YAMAGISHI (山岸 勇輝)

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