East Bay batch color

Gaffer® Casting Crystal Annealing Schedules. Semi-Open and Open Forms *

Thickness (inches) (mm)	Anneal Soak Time @ 806°F @ 430°C	Initial Cooling Rate °F/Hr °C/Hr	Initial Cooling Range °F °C	Second Cooling Rate °F/Hr °C/Hr	Second Cooling Range °F °C	Final Cooling Rate** °F/Hr °C/Hr	Final Cooling Range °F °C	Total Elapsed Time
0.5 in 12 mm	2 hr	120 67	806 - 680 430 - 360	240 133	680 - 590 360 - 310	720 402	590 - 70 310 - 21	4hrs 10mins
0.75 in 19 mm	3 hr	52 29	806 - 680 430 - 360	104 58	680 - 590 360 - 310	312 174	590 - 70 310 - 21	8hrs
1.0 in 25 mm	4 hr	29 16	806 - 680 430 - 360	58 32	680 - 590 360 - 310	174 96	590 - 70 310 - 21	13hrs
1.5 in 38 mm	6 hr	13 7.2	806 - 680 430 - 360	26 14.4	680 - 590 360 - 310	78 43	590 - 70 310 - 21	26hrs
2.0 in 50 mm	8 hr	7.8 4.3	806 - 680 430 - 360	15.6 8.6	680 - 590 360 - 310	46.8 25.8	590 - 70 310 - 21	41hrs 30mins
2.5 in 60 mm	10 hr	5.2 2.9	806 - 644 430 - 360	10.4 5.8	680 - 590 360 - 310	31.2 17.4	590 - 70 310 - 21	2 days 13hrs
3.0 in 75 mm	12 hr	3.3 1.8	806 - 644 430 - 340	6.6 3.6	644 - 554 340 - 290	19.8 10.8	554 - 70 290 - 21	4 days 5hrs
3.5 in 88 mm	14 hr	2.5 1.4	806 - 644 430 - 340	5 2.8	644 - 554 340 - 290	15 8.4	554 - 70 290 - 21	5 days 12hrs
4.0 in 100 mm	16 hr	1.8 1	806 - 644 430 - 340	3.6 2	644 - 554 340 - 290	10.8 6	554 - 70 290 - 21	7 days 8hrs
4.5 in 113 mm	18 hr	1.6 0.9	806 - 644 430 - 340	3.2 1.8	644 - 554 340 - 290	9.6 5.4	554 - 70 290 - 21	8 days 5hrs
5.0 in 125 mm	20 hr	1.3 0.7	806 - 644 430 - 340	2.6 1.4	644 - 554 340 - 290	7.8 4.2	554 - 70 290 - 21	10 days 9hrs
5.5 in 138 mm	22 hr	1.1 0.6	830 - 644 430 - 340	2.2 1.2	644 - 554 340 - 290	6.6 3.6	554 - 70 290 - 21	11 days 20hrs
6.0 in 150 mm	24 hr	0.9 0.5	806 - 608 430 - 320	1.8 1	608 - 518 320 - 270	5.4 3	518 - 70 270 - 21	16 days
6.5 in 165 mm	26 hr	0.7 0.4	806 - 608 430 - 320	1.4 0.8	608 - 518 320 - 270	4.2 2.4	518 - 70 270 - 21	19 days 20hrs
7.0 in 175 mm	28 hr	0.6 0.33	806 - 608 430 - 320	1.2 0.66	608 - 518 320 - 270	3.6 2	518 - 70 270 - 21	23 days 19hrs
7.5 in 190 mm	30 hr	0.5 0.3	806 - 608 430 - 320	1 0.6	608 - 518 320 - 270	3 1.8	518 - 70 270 - 21	26 days 6hrs
8.0 in 200 mm	32 hr	0.47 0.26	806 - 608 430 - 320	0.94 0.52	608 - 518 320 - 270	2.8 1.56	518 - 70 270 - 21	30 days 4hrs
8.5 in 215 mm	34 hr	0.41 0.23	806 - 608 430 - 320	0.8 0.46	608 - 518 320 - 270	2.4 1.4	518 - 70 270 - 21	33 days 21hrs
9.0 in 225 mm	36 hr	0.35 0.2	806 - 608 430 - 320	0.7 0.4	608 - 518 320 - 270	2.1 1.2	518 - 70 270 - 21	38 days 22hrs
9.5 in 242 mm	38 hr	0.32 0.18	806 - 608 430 - 320	0.64 0.36	608 - 518 320 - 270	1.9 1.1	518 - 70 270 - 21	42 days 6hrs
10.0 in 254 mm	40 hr	0.29 0.16	806 - 608 430 - 320	0.58 0.32	608 - 518 320 - 270	1.74 0.96	518 - 70 270 - 21	47 days 15hrs

* Based on: Schedules for commercial annealing of ordinary ware. Corning Glassworks. Corning N.Y. 1950. **For forms that are able to cool reasonably equally on all sides.**

** Obviously cooling rates of thinner pieces are faster than ordinary kilns would lose heat. In those cases the kiln can be allowed to cool at its normal rate.

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Gaffer® Glass Annealing Schedule Notes

The annealing schedules should only be taken as a rough guide to follow for annealing a piece that is able to cool reasonably evenly on all sides. They are quite conservative, but one should always be guided by the temperature difference, ΔT, between two or more thermocouples in the firing. One thermocouple should be placed as close as possible to where you think the glass will cool slowest and the other in the open air of the kiln close to the centre of the mold. If the ΔT between the thermocouples is growing too large then the rate of cooling should be slowed down.

Ideally the kiln should have elements on the floor as well as the sides. For very large scale work, especially if it is very thick, two or three banks of elements controlled by separate controllers should be employed. One or more of the controllers should be a slave to the master controller. This will keep the kiln's temperature more even throughout.

The schedules start at the upper temperature end of the annealing range. In the past we have closely followed the original Corning equations where the 1st cooling range gets progressively wider as the glass gets thicker. However taken to its to its logical conclusion once the glass thickness reaches 250 mm (10") the first stage reaches zero degrees.

We cast 6 pieces at Gaffer in 2009 that weighed 250 kgs each and were up to 225mm thick (9"). Utilizing two slave circuits and 4 thermocouples we were confident that there was no need for the 1st stage of cooling to go all the way to 40oC which the original Corning formula called for. At 320oC we were confident that all of the glass mass was comfortably below the strain point so that we could move onto the 2nd stage cooling. The schedules now have 3 temperature ranges for Stage One cooling where the bottom temperature is 360, 340 and 320oC respectively depending on glass thickness. We think this is reasonably conservative but this speeded up schedule does rely heavily on using two or more thermocouples.

Gaffer casting crystal's low Young's Modulus means that the glass will allow a greater ΔT (nearly 20%) than an ordinary non-lead glass because it is more elastic. According to Dan Watson (see the accompanying article on annealing in this technical section which we strongly recommend you read) for 100 psi residual annealing stress levels Gaffer crystal can have ΔT of 1.3oC versus say Bullseye's glass of 1.11oC. We feel that 250 psi residual stress is an adequate level, in which case the ΔT could be 3.3oC or nearly 6oF.