USGlass METAL & GLAZING
DEVOTED EXCLUSIVELY TO THE ARCHITECTURAL GLASS INDUSTRY

Volume 37, Issue 2, February 2002

ConsultantsCorner

Doing the Two-Step

Verifying Proper Aluminum Tempering

by Mark Baker

While most in the glass industry are familiar with the tempering process, many may not know how important it is in the design of aluminum glazing products and materials. Some readers have asked me about this so I am addressing various issues involved with aluminum tempering in this month's column. (If you have questions you would like me to answer in a future column, please e-mail me at mbaker@glass.com.)

Two-Step Process

Tempering of aluminum alloys increases its strength through a heat-treatment process. The two-step process is comprised of solution treatment followed by age hardening.

The solution treatment consists of heating the metal to a temperature around 500 C, which causes the alloying constituents to go into solid solution followed by quenching.

Unlike other alloys where the quenching temperature must be precisely controlled, the quenching temperature is not as critical with 6xxx series aluminum. For aluminum extrusions it is usually acceptable to simply spray-quench the metal as it comes out of the die. With some 6xxx extrusions it is even possible to air-quench.

Age hardening occurs after the quench. The aluminum material can be either aged naturally at room temperature over a period of days or it can be aged in an oven at a temperature of 150-180 C. The latter is known as artificial aging. The advantages of artificial aging are that the material ends up stronger than material that is aged naturally and the final properties are achieved in hours rather than days.

Hardness testers can be used to check aluminum extrusion alloy and temper.

T-Number

The temper of heat-treated material is specified by a T-number, which follows the alloy designation (i.e., 6063-T6). Possible conditions range from T1-T10. Following are the three that are of interest to those involved in structural design:

1. T4 solution treatment followed by natural aging;
2. T5 air quench filled by artificial aging;
3. T6 solution treatment followed by artificial aging.

T6 is the fully heat-treated condition that results in the maximum strength. T4 is more ductile and used when formability is a factor. T5 is often used for very thin extrusions, which would distort excessively if subjected to a water quench.

The temper of aluminum alloys can be distinguished by the material's hardness. Hardness of aluminum alloys is typically measured in the Rockwell E scale. Rockwell hardness testing is the most widely used method of determining hardness because it is fast and simple to perform and does not require specialized skills.

Verifying Temper

Starting the fabrication and assembly process is often chaotic, thus good quality-control practices are sometimes compromised. Don't overlook the importance of the temper of aluminum components and don't overestimate the ability of your material supplier.

While investigating the structural failure of a high-profile curtainwall mock-up in one particular job, we learned that aluminum anchorage components, which were imported from Asia, had prematurely failed. Analysis revealed that they were tempered improperly and as a result were not strong enough to carry the design loads. This was not the first, nor the last time that we were involved in a project where improperly tempered material was used. Fortunately, the errors were discovered during mock-up testing or random tests during quality control inspection before the curtainwall was installed, allowing the improperly treated material to be replaced.

Hardness testers measure hardness by measuring the depth on indentation made by a constant load impressed upon an indenter. The scale designator indicated the load and indenter combination, the Rockwell E-scale represents a 100 kg load with a 1/8-inch-diameter steel ball indenter. The aluminum extruder can provide a table or graph of the acceptable range for various alloy and temper combinations.

Each new delivery of material should be checked randomly for hardness, particularly structural components such as mullions and anchorage.

Portable hand-held testers are a quick alternative to the Rockwell bench model testers. Webster instruments manufacture a model B tester that can be used to check hardness. Although less accurate than the Rockwell scale, the Webster tester will provide an adequate check of material as it is unloaded, especially if it is used in conjunction with regular bench tests.

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