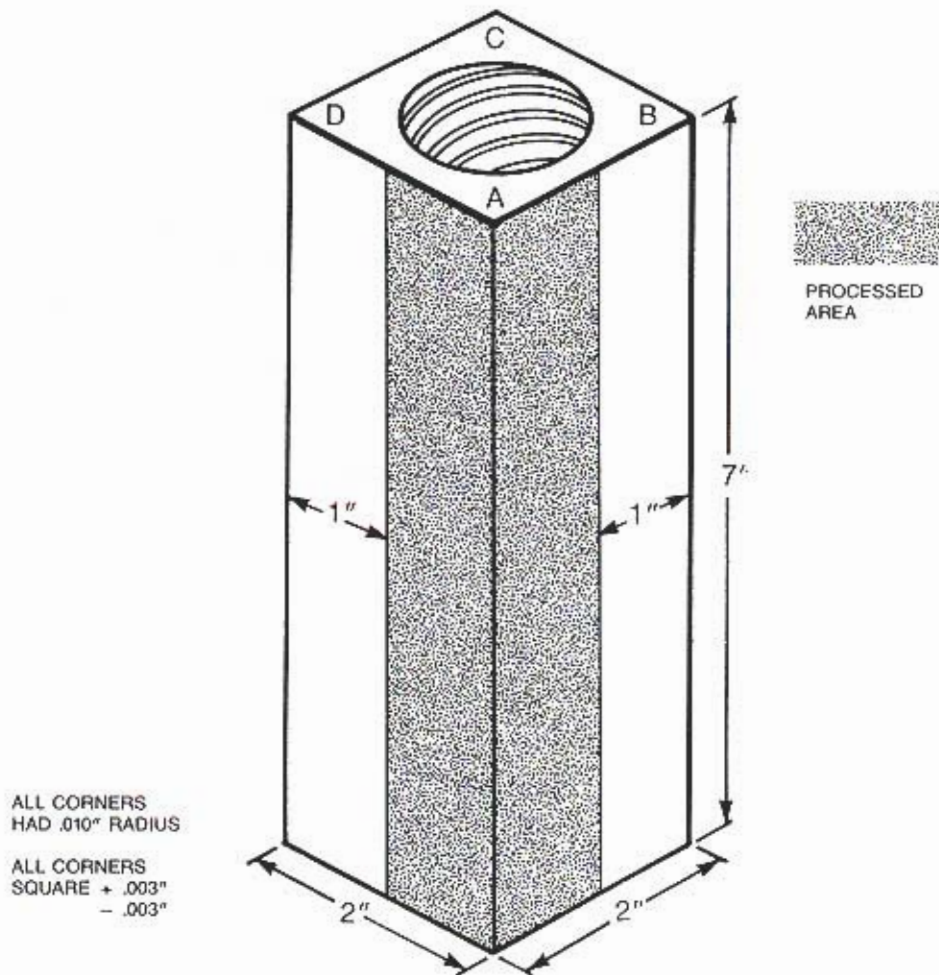


MetaLife®

LAB TEST

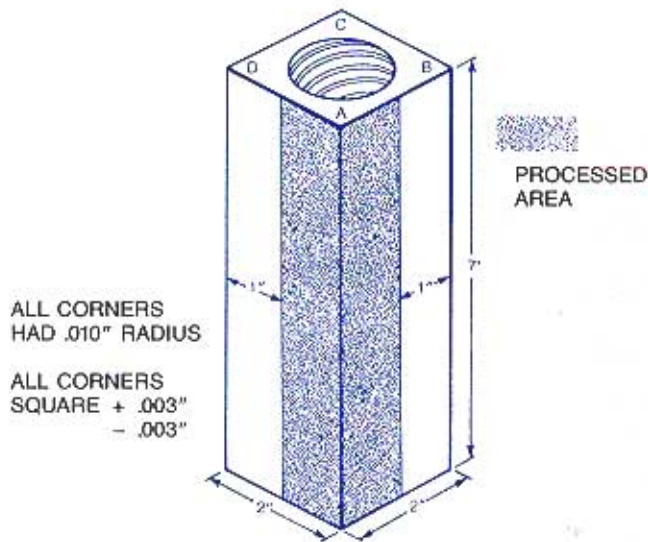


H13 THERMAL STRESS DIP TANK TEST

To further confirm the benefits that were being reported in numerous field tests, we requested Case Western Reserve University, under the auspices of Professor John Wallace, to conduct their traditional Dip Tank Test. This test evaluates the performance of the **MetaLife** process in relation to edge cracking of H13 materials.

TEST PARAMETERS

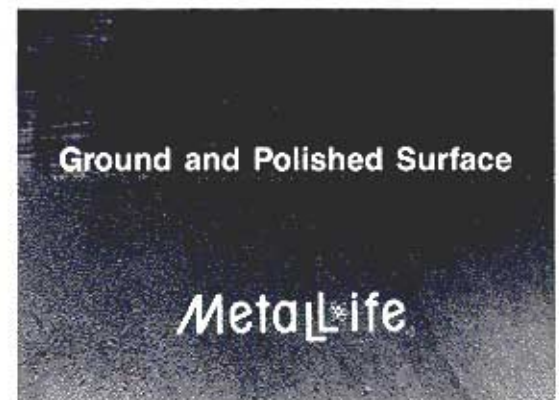
H13 TEST SPECIMEN 46 Rc



| | |
|--------------------|---|
| CORNERS A & C..... | RECEIVED MetaLife PROCESS |
| CORNER D | WAS LEFT UNPROCESSED |
| CORNER B..... | WAS MetaLife PROCESSED THEN ALL TEXTURING REMOVED BY POLISHING |

Each dip tank test cycle consists of a 12 second immersion in 380 aluminum alloy, followed by 24 seconds of air cooling out of the molten metal solution. The specimen is internally cooled at a rate of one gallon per minute. The aluminum alloy is maintained in a gas-fired crucible furnace at an average temperature of 1300°F which is monitored by two chromel-alumel thermocouples. Just before reimmersion, a water based die lubricant diluted to 50:1 is sprayed onto the specimen surface. This test is meant to simulate most of the conditions present in an aluminum die casting operation.

A specimen is prepared from H13 material that measures 2" x 2" x 7". The specimen is then austenitized at 1900°F for one and one-half hours and then oil quenched. This is followed by tempering cycles at about 1100°F for one hour and an oil quench to give the final hardness value of 46 HRC. The model is then surface ground and polished so each corner had a .010" radius with all corners square to within $\pm .003$ " of an inch. The corner radius is formed on each corner by manually stoning with successive grits of 240, 320, 400, and 600 grit papers along the length of the corners of the block. The papers are clamped in a V-notch block to achieve the required radius and checked with a radius gauge at each corner.



While molten metal heating and environment, internal water cooling, and lubricant spraying of the die material are present, the mechanical effects due to pressure against the die walls and die erosion due to high metal velocity are not. The thermal effects or differences in external and internal steel temperature obtained in this test, however, are more severe than conditions encountered in normal die casting operations.

The specimen is tested for a total of 15,000 cycles. After every 5,000 cycles the specimen is removed from the testing unit, and fatigue crack initiation and growth are evaluated. Oxide layers are removed by polishing in the same manner as previously described. Cracks that initiate along the edge of both the **MetaLife**, processed and unprocessed corners are measured within the center three inches of each corner to eliminate end effects. Crack measurements are obtained at a magnification of 100X using a Leitz micro hardness tester.

Two crack parameters are then calculated to characterize thermal fatigue behavior of the sample specimens. The average maximum crack length, d (in microns), is the sum of the longest crack initiated from the edge on each corner subjected to a specific treatment (**MetaLife**, v/s unprocessed) divided by the number of corners that received the treatment. Total crack area is the number of cracks (n) in each 25 micron (u) length interval multiplied by the square of the average crack length for that interval (d^2). These are then added to give Σnd^2 .

MetaLife TEST RESULTS

The Results of Thermal Fatigue for MetaLife Specimen

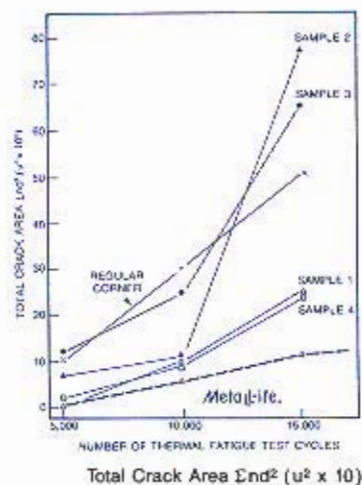
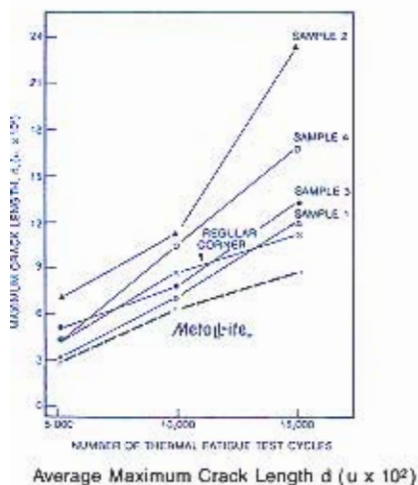
| Corner Code | Treatment | Maximum Crack Length (X 10 ⁻³ ") | | | Total Crack Area (X 10 ⁻⁴ ") | | |
|------------------------------|-------------|---|---------------|---------------|---|---------------|---------------|
| | | 5,000 cycles | 10,000 cycles | 15,000 cycles | 5,000 cycles | 10,000 cycles | 15,000 cycles |
| A | Treated | 2.5 | 5 | 9 | 0.9 | 2.7 | 8.24 |
| B | Not-treated | 2.5 | 7 | 10 | 6.9 | 13.4 | 24.46 |
| C | Treated | 3.5 | 6 | 9 | 3.9 | 5.6 | 18.43 |
| D | Not-treated | 5 | 9 | 12 | 17.5 | 41 | 72.02 |
| the average of corners A & C | Treated | 3 | 5.5 | 9 | 2.9 | 4.15 | 13.34 |
| the average of corner B & D | Not-treated | 4.25 | 8 | 11 | 10.2 | 30.2 | 50.74 |

After the 15,000 cycles were completed on the **MetaLife**, specimen, the total average crack area of corners "B" and "D" that were not treated averaged **50.74**. Corners "A" and "C" that were treated averaged only **13.34** total crack area. This amounts to **380.36%** less total crack area or a 3.8 times reduction in cracking. In addition the average Maximum Crack length was **22.22%** less on the **MetaLife**, processed corners.

It is important to also note that due to a specifications communication problem between the testing lab and Badger Metal Tech, it was necessary to polish and remove texturing on corner "B" so that opposite corners instead of adjacent sides would be used for the test. Even though the "B" corner was polished considerably to remove the **MetaLife**, texturing, this corner still had less soldering and **314.88%** less total crack area after 15,000 cycles than corner "D" which received no processing. Had this "B" corner never been **MetaLife**, processed, the total average crack area of treated to untreated would have been well over 400% or 4 times less, and the maximum crack length would have been 33.33% less. This gives strong confirmation that even after significant **polishing** to remove visual texturing that the **benefits** of the **MetaLife**, process **still remain**. This has been a frequently asked question by zinc die casters that require a hardware finish on their castings and want to polish the die after **MetaLife**, processing.

Our test results from the field have for some time confirmed **MetaLife**, does close and help keep closed thermal heat checks and minor cracks on **USED** dies. With this test there is now confirmation that **MetaLife**, also significantly retards the initiation of thermal stress heat checking on **NEW** tooling.

The results of the test were then plotted and compared with identical testing of various heat treat methods, steel types, and surface treatments. The graphs show that the **MetaLife**, corners have both a significantly lower total crack area and shorter crack length than other specimens tested under identical test conditions.



Independent testing is continuing. At Case Western Reserve University, the attributes of **MetaLife**, and its correlation to the thermal fatigue effects of H13 EDM surfaces are being evaluated. Ohio State's Net Shape Engineering Research Center is involved in a testing program to evaluate the benefits of applying **MetaLife**, to stop soldering and retard die erosion. Badger Bulletins will be published as more information regarding these tests become available. Please call us if you have any questions regarding this test or other aspects of the **MetaLife**, process. Our Toll Free Number is on the back of this brochure.



Badger Metal



WebSite - www.badgermetal.com