

Thermal Test  
Results for the  
COFAN Model WAK5012BO3  
CPU Cooler made for  
Intel Celeron (PPGA & FC-PGA), Intel  
Pentium III (FC-PGA), & AMD K6 Series  
(PPGA)  
Microprocessor

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## 1.0 Objective

The objective of this document is to explain to the computer industry how the COFAN model WAK5012BO3 CPU cooler exceeds the requirements for the Intel Celeron™ (PPGA & FC-PGA), Intel Pentium III™ (PPGA), & AMD K6 Series (PPGA) microprocessors in various thermal environments.

## 2.0 Scope

The purpose of this section is to define the commercial test equipment and test methodology used to thermally test the COFAN model WAK5012BO3.

### 2.1 Commercial Test Equipment

- 2.1.1 Thermotek Digital Thermometer, model D9013
- 2.1.2 LG Thermal Chamber, model T9031
- 2.1.3 Hewlett-Packard, Oscilloscope, model HP1740A
- 2.1.4 WanLass DC Power Supply, model Maverick II
- 2.1.5 Ono Sokki Digital Tachometer, model HT-1410
- 2.1.6 Fan Specification

| FEATURE                  | SPECIFICATION                            |
|--------------------------|--|
| Size                     | 50 x 50 x 12 mm                          |
| Air Flow                 | 12.8 CFM at 5100 RPM                     |
| Air Pressure             | 3.0 mmH <sub>2</sub> O                   |
| Acoustic noise           | 26 dB                                    |
| Input power              | 12VDC, max 0.11A                         |
| Tachometer Sensor output | Open collector, TTL signal, 2 pulses/rev |
| MTBF at 25 °C            | 100,000Hrs.                              |

## 3.0 Test Procedure

The test procedure is compliant with Intel Application Note, AP-586 that defines how to thermally test heat evacuation devices for microprocessors.

### 3.1 Cooler to CPU Mechanical Interface

- 3.1.1 The WAK5012BO3, shown in Figure 6.0 is manufactured to sufficiently tight tolerances that no thermal compound or thermal tape is required on the cooler to CPU mounting surface. The flatness of this interface is held to 0.001 inch TIR. This eliminates the inconvenience and cost of dealing with chemical compounds or thermal tapes.

### 3.2 Test Samples

3.2.1 Five different WAK5012BO3 CPU coolers were used in the test program.

### 3.3 Fan Failure Definition

3.3.1 A fan failure is defined as a change in revolutions per minute RPM, by more than 20% from its natural speed.

## 4.0 General Description

The test procedure utilizes the equipment defined in paragraph 2.1 and five COFAN WAK5012BO3 CPU coolers. All temperature measurements are in Celsius. A total of 240 data sets were taken using five different coolers.

### 4.1 Microprocessor Thermal Requirements

4.1.1 Each of the three microprocessors has specific maximum upper limit operational temperatures. Please refer to chart 4.1.1 below for details. The reliability of the microprocessor is enhanced if the temperature of the device is well below that limit. The 40+watt dissipation of each microprocessor can cause its thermal interface to exceed the maximum operating temperature if insufficient cooling is provided.

Chart 4.1.1

| MICRO-PROCESSOR        | SPEED (MHZ) | MAX WATTS | TC TEMP(°C) | RECOMMENDED COFAN PART # | ACTUAL TC TEMP AT AMBIENT |      | PASSIVE NO. |
|------------------------|-------------|-----------|-------------|--------------------------|---------------------------|------|-------------|
|                        |             |           |             |                          | 40°C                      | 45°C |             |
| Intel Celeron (PPGA)   | 300A        | 17.8      | 85          | WAK5012BO3               | 50.7                      | 55.7 | N/A         |
|                        | 333         | 19.7      | 85          | WAK5012BO3               | 51.8                      | 56.8 | N/A         |
|                        | 366         | 21.7      | 85          | WAK5012BO3               | 53.0                      | 58.0 | N/A         |
|                        | 400         | 23.7      | 85          | WAK5012BO3               | 54.2                      | 59.2 | N/A         |
|                        | 433         | 24.1      | 85          | WAK5012BO3               | 54.4                      | 59.4 | N/A         |
|                        | 466         | 25.6      | 70          | WAK5012BO3               | 55.3                      | 60.3 | N/A         |
|                        | 500         | 27.0      | 70          | WAK5012BO3               | 56.2                      | 61.2 | N/A         |
|                        | 533         | 28.3      | 70          | WAK5012BO3               | 56.9                      | 61.9 | N/A         |
| Intel Celeron (FC-PGA) | 533A        | 11.2      | 90          | WAK5012BO3               | 46.7                      | 51.7 | N/A         |
|                        | 566         | 11.9      | 90          | WAK5012BO3               | 47.1                      | 52.1 | N/A         |
|                        | 600         | 12.6      | 90          | WAK5012BO3               | 47.5                      | 52.5 | N/A         |
|                        | 633         | 16.5      | 82          | WAK5012BO3               | 49.9                      | 54.9 | N/A         |
|                        | 667         | 17.5      | 82          | WAK5012BO3               | 50.5                      | 55.5 | N/A         |
|                        | 700         | 18.3      | 80          | WAK5012BO3               | 51.0                      | 56.0 | N/A         |

Chart 4.1.1 cont.

| MICRO-PROCESSOR            | SPEED (MHZ) | MAX WATTS | TC TEMP(°C) | RECOMMENDED COFAN PART # | ACTUAL TC TEMP AT AMBIENT |      | PASSIVE NO. |
|----------------------------|-------------|-----------|-------------|--------------------------|---------------------------|------|-------------|
|                            |             |           |             |                          | 40°C                      | 45°C |             |
| Intel Pentium III (FC-PGA) | 500E        | 13.2      | 85          | WAK5012BO3               | 47.9                      | 52.9 | N/A         |
|                            | 533EB       | 14.0      | 85          | WAK5012BO3               | 48.4                      | 53.4 | N/A         |
|                            | 550E        | 14.5      | 85          | WAK5012BO3               | 48.7                      | 53.7 | N/A         |
|                            | 600E        | 15.8      | 82          | WAK5012BO3               | 49.5                      | 54.5 | N/A         |
|                            | 600EB       | 15.8      | 82          | WAK5012BO3               | 49.5                      | 54.5 | N/A         |
|                            | 650         | 17.0      | 82          | WAK5012BO3               | 50.2                      | 55.2 | N/A         |
|                            | 667         | 17.5      | 82          | WAK5012BO3               | 50.5                      | 55.5 | N/A         |
|                            | 700         | 18.3      | 80          | WAK5012BO3               | 50.9                      | 55.9 | N/A         |
|                            | 733         | 19.1      | 80          | WAK5012BO3               | 51.4                      | 56.4 | N/A         |
|                            | 750         | 19.5      | 80          | WAK5012BO3               | 51.7                      | 56.7 | N/A         |
|                            | 800         | 20.8      | 80          | WAK5012BO3               | 52.5                      | 57.5 | N/A         |
|                            | 800EB       | 20.8      | 80          | WAK5012BO3               | 52.5                      | 57.5 | N/A         |
|                            | 850         | 22.5      | 80          | WAK5012BO3               | 53.5                      | 58.5 | N/A         |
|                            | 866         | 22.9      | 80          | WAK5012BO3               | 53.7                      | 58.7 | N/A         |
| 933                        | 24.5        | 75        | WAK5012BO3  | 54.7                     | 59.7                      | N/A  |             |

| MICRO-PROCESSOR | SPEED (MHZ) | MAX WATTS | TC TEMP(°C) | RECOMMENDED COFAN PART # | ACTUAL TC TEMP AT AMBIENT |      | PASSIVE NO. |
|-----------------|-------------|-----------|-------------|--------------------------|---------------------------|------|-------------|
|                 |             |           |             |                          | 40°C                      | 45°C |             |
| AMD K6 (PPGA)   | 166         | 17.20     | 70          | WAK5012BO3               | 50.3                      | 55.3 | N/A         |
|                 | 200         | 12.45     | 70          | WAK5012BO3               | 47.5                      | 52.5 | N/A         |
|                 | 233         | 13.50     | 70          | WAK5012BO3               | 48.1                      | 53.1 | N/A         |
|                 | 266         | 14.55     | 70          | WAK5012BO3               | 48.7                      | 53.7 | N/A         |
|                 | 300         | 15.40     | 70          | WAK5012BO3               | 49.2                      | 54.2 | N/A         |
| AMD K6-2 (PPGA) | 266         | 14.70     | 70          | WAK5012BO3               | 48.8                      | 53.8 | N/A         |
|                 | 300         | 17.20     | 70          | WAK5012BO3               | 50.3                      | 55.3 | N/A         |
|                 | 333         | 19.00     | 70          | WAK5012BO3               | 51.4                      | 56.4 | N/A         |
|                 | 350         | 19.95     | 70          | WAK5012BO3               | 51.9                      | 56.9 | N/A         |
|                 | 366         | 20.80     | 70          | WAK5012BO3               | 52.4                      | 57.4 | N/A         |
|                 | 380         | 21.60     | 70          | WAK5012BO3               | 53.0                      | 58.0 | N/A         |
|                 | 400         | 22.70     | 60          | WAK5012BO3               | 53.6                      | 58.6 | N/A         |
|                 | 450         | 18.80     | 65          | WAK5012BO3               | 51.3                      | 56.3 | N/A         |
|                 | 475         | 19.80     | 65          | WAK5012BO3               | 52.0                      | 57.0 | N/A         |
|                 | 500         | 20.75     | 65          | WAK5012BO3               | 52.4                      | 57.4 | N/A         |
|                 | 533         | 20.75     | 70          | WAK5012BO3               | 52.4                      | 57.4 | N/A         |
| 550             | 25.00       | 70        | WAK5012BO3  | 55.0                     | 60.0                      | N/A  |             |
| AMD K6-3 (PPGA) | 400         | 18.1      | 70          | WAK5012BO3               | 50.8                      | 55.8 | N/A         |
|                 | 450         | 20.2      | 65          | WAK5012BO3               | 52.1                      | 57.1 | N/A         |

## 4.2 CPU Cooler Performance

4.2.1 The ambient cooling air of the computer system is the source of the cooling input. The cooler should keep the thermal interface to the microprocessor as close to ambient as possible.

## 4.3 Thermal Measurement points

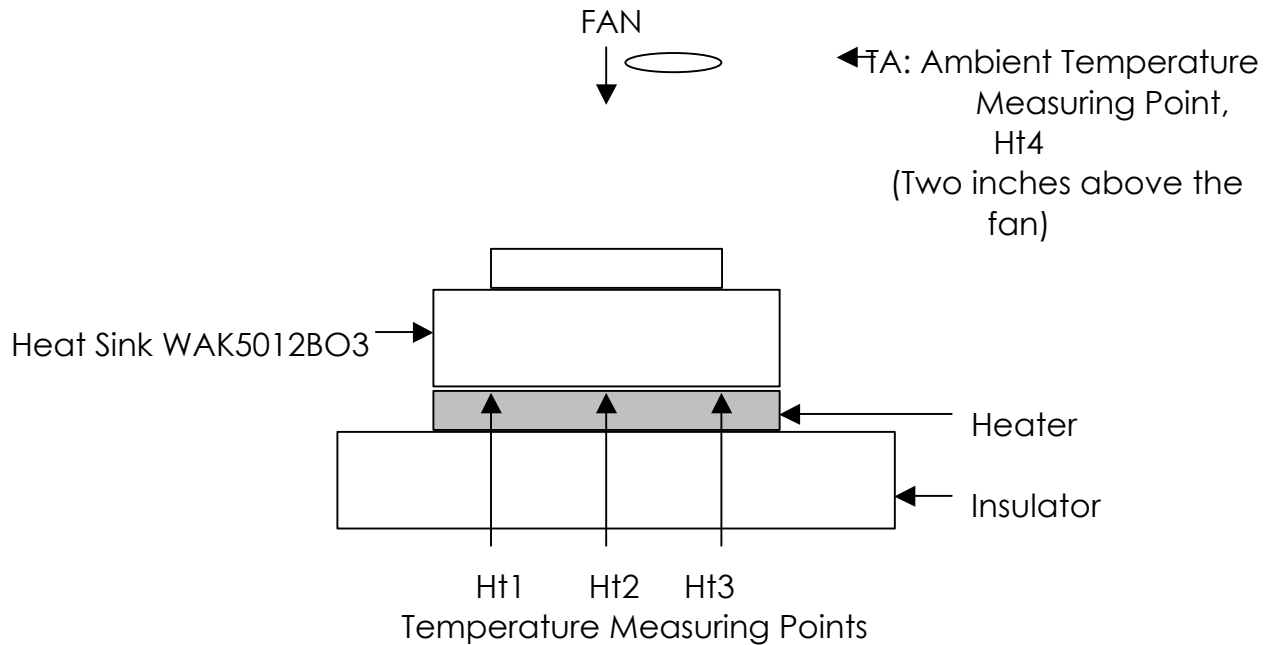


Figure 4.3

4.3.1 Four measurement sensors were utilized throughout the tests. One was placed at the ambient air inlet of the cooling fan. Three were distributed across the hot plate that mates with the machined surface of the CPU cooler.

## 4.4 Thermal Calculations

4.4.1 Ht1, Ht2, Ht3 : three hot plate sensors

Ht4 : TA

TA : ambient input to the fan

Pwr : power applied from the hot plate

The thermal resistance coefficient formula is  $[(Ht1 + Ht2 + Ht3)/3 - TA]/Pwr$ .

The resultant would be defined as degrees Celsius/watt. The smaller the number, the more efficient the cooler.

#### 4.5 Test Approach

4.5.1 The thermal coefficient of the CPU cooler was determined from measurements taken at five different ambient air inputs from 15°C to 45°C. Data was taken at 5°C increments. At each ambient temperature the hot plate was varied in temperature by increasing the power input in five steps. The power was stabilized at certain levels before measurements were made. The highest level represents the normal operating range for each microprocessor.

### 5.0 Test Results

#### 5.1 Fan Failures

5.1.1 There were no RPM variations detected of the WAK5012BO3 cooler fans (Model: D5012A12HO) during the test program.

#### 5.2 Test Data

5.2.1 The thermal coefficient data from the tests are illustrated in Table 5.2.1 below.

##### Intel Celeron

| POWER INPUT | THERMAL COEFFICIENT (°C/WATT) |           |           |           |           |               |
|-------------|-------------------------------|-----------|-----------|-----------|-----------|---------------|
| Watts       | Cooler #1                     | Cooler #2 | Cooler #3 | Cooler #4 | Cooler #5 | Avg.          |
| 11.2        | 0.5991                        | 0.5999    | 0.5993    | 0.5992    | 0.5997    | 0.5994        |
| 11.9        | 0.5994                        | 0.6005    | 0.5994    | 0.6004    | 0.5991    | 0.5997        |
| 12.6        | 0.5999                        | 0.5992    | 0.5999    | 0.6001    | 0.5999    | 0.5998        |
| 16.5        | 0.5998                        | 0.5997    | 0.5997    | 0.5997    | 0.6003    | 0.5997        |
| 17.5        | 0.5997                        | 0.5997    | 0.5999    | 0.5997    | 0.5998    | 0.5996        |
| 18.3        | 0.5996                        | 0.5996    | 0.5994    | 0.5998    | 0.5997    | 0.5999        |
| Avg.        | 0.5996                        | 0.5997    | 0.5996    | 0.5998    | 0.5997    | <b>0.5997</b> |

##### Intel Pentium III

| POWER INPUT | THERMAL COEFFICIENT (°C/WATT) |           |           |           |           |        |
|-------------|-------------------------------|-----------|-----------|-----------|-----------|--------|
| Watts       | Cooler #1                     | Cooler #2 | Cooler #3 | Cooler #4 | Cooler #5 | Avg.   |
| 13.2        | 0.5999                        | 0.5991    | 0.5993    | 0.5994    | 0.5999    | 0.5995 |
| 14.5        | 0.6005                        | 0.5994    | 0.5994    | 0.5997    | 0.5996    | 0.5997 |
| 15.8        | 0.5992                        | 0.5999    | 0.5997    | 0.5999    | 0.5994    | 0.5996 |
| 17.5        | 0.5997                        | 0.5998    | 0.5996    | 0.5997    | 0.5998    | 0.5997 |
| 19.1        | 0.5997                        | 0.5997    | 0.5993    | 0.5998    | 0.5996    | 0.5996 |
| 20.8        | 0.5996                        | 0.5997    | 0.5997    | 0.5996    | 0.5997    | 0.5996 |
| 22.5        | 0.5994                        | 0.5994    | 0.5991    | 0.5992    | 0.5993    | 0.5993 |
| 24.5        | 0.5999                        | 0.5996    | 0.5993    | 0.5993    | 0.5998    | 0.5996 |
| Avg.        | 0.5996                        | 0.5993    | 0.5995    | 0.5996    | 0.5997    | 0.5996 |

#### 5.2.1

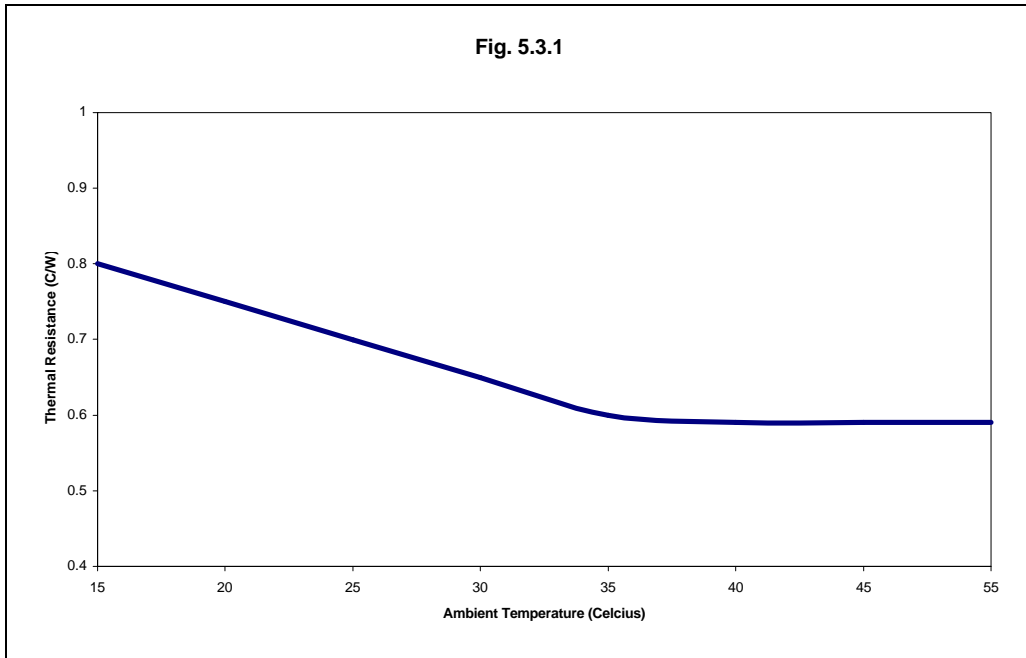
## 5.2.1 cont.

### AMD K6 Series

| POWER INPUT | THERMAL COEFFICIENT (°C/WATT) |           |           |           |           |        |
|-------------|-------------------------------|-----------|-----------|-----------|-----------|--------|
|             | Cooler #1                     | Cooler #2 | Cooler #3 | Cooler #4 | Cooler #5 | Avg.   |
| Watts       |                               |           |           |           |           |        |
| 19.0        | 0.5999                        | 0.5991    | 0.5993    | 0.5997    | 0.5992    | 0.5994 |
| 20.8        | 0.6005                        | 0.5994    | 0.5994    | 0.5991    | 0.6004    | 0.5997 |
| 22.7        | 0.5992                        | 0.5999    | 0.5999    | 0.5999    | 0.6001    | 0.5998 |
| 19.8        | 0.5997                        | 0.5998    | 0.5997    | 0.6003    | 0.5997    | 0.5998 |
| 25.0        | 0.5996                        | 0.5997    | 0.5994    | 0.5998    | 0.5998    | 0.5996 |
| Avg.        | 0.5997                        | 0.5996    | 0.5995    | 0.5997    | 0.5998    | 0.5997 |

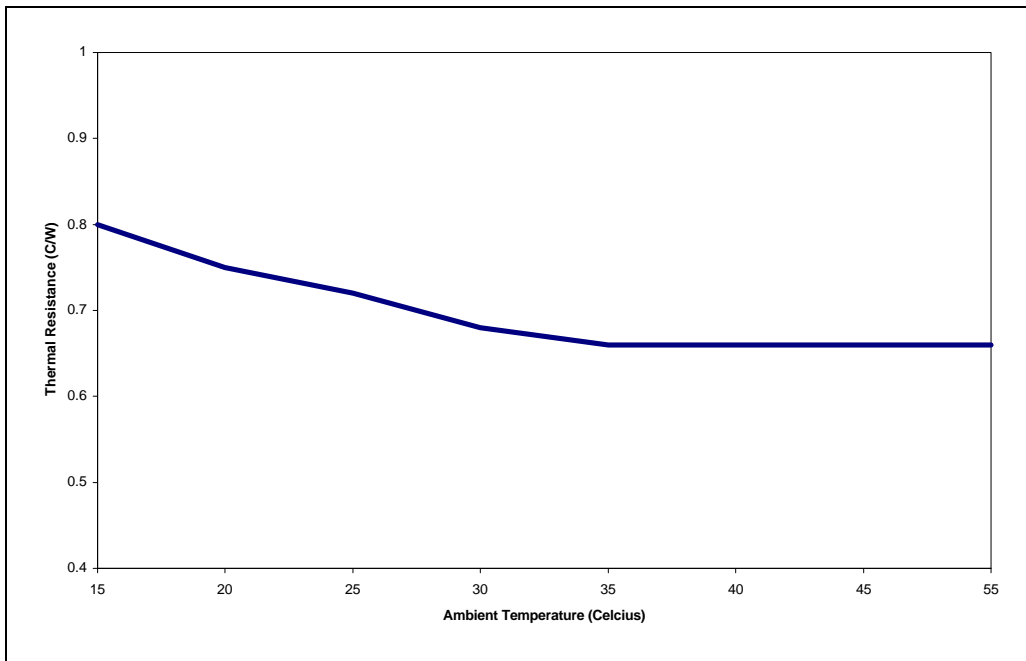
## 5.3 Thermal Coefficient Variance versus Temperature

5.3.1 The average thermal coefficient varied over the 15°C to 45°C range at the various power levels. In order to determine where the coefficient stabilized, further tests were conducted to 55°C. At about 35°C the coefficient stabilized at about 0.59 °C/watt. The graph shown below illustrates the test data gathered.

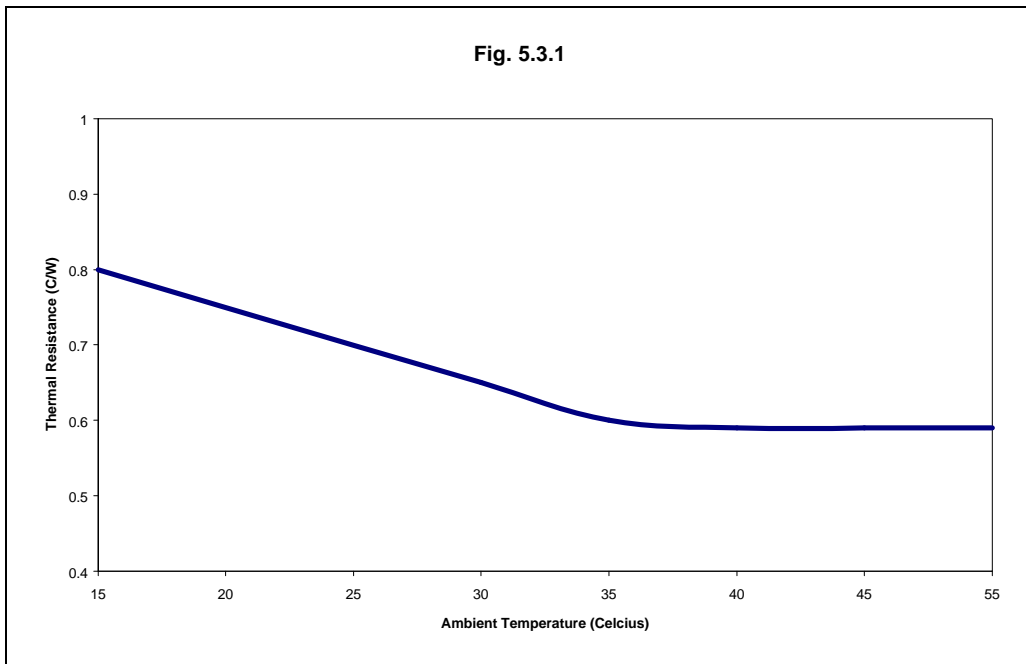


### 5.3.1 cont.

#### Intel Pentium III



#### AMD K6 Series



## 6.0 Conclusions

Test results show that the COFAN Model WAK5012BO3 CPU Cooler provides excellent cooling capacity for all three microprocessors. The 0.59 °C/watt thermal resistance coefficient provides for only a 10.8°C rises in temperature for the Intel Celeron. There is a 14.7 °C rise in temperature for the AMD K6 Series and Intel Pentium III. Most computer environments exist at less than 30°C. The temperature within the WAK5012BO3 is well below the maximum operating temperature for each of the processors and should provide failure-free environment for the life of the computer.

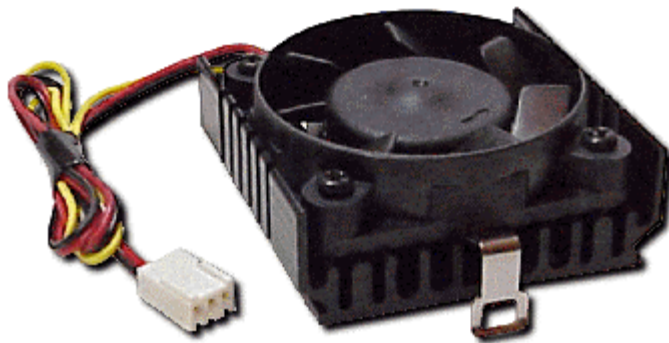


Figure 6.0. COFAN WAK5012BO3 CPU Cooler for the Intel Celeron (PPGA &FC-PGA), Intel Pentium III (FC-PGA), & AMD K6 Series (PPGA)