Intel® Pentium® 4 Processor in the 423-pin Package Thermal Solution Functional Specification

November 2000
Order Number: 249204-001

Date	Revision	Description
11/00	1.0	▪ Add TTV-to-CPU thermal correction factor ▪ Advocate use of thermal grease ▪ Clarify requirements and recommendation on Direct Chassis Attach of RM

1. INTRODUCTION AND SPECIFICATION SCOPE

This document details the thermal, mechanical, and quality guidelines and requirements to design thermal solutions for the Intel® Pentium® 4 processor in the 423 pin package. With this information, a "Third Party" could design a thermal solution for the Pentium 4 processor.

2. COMPONENTS

Intel's reference thermal solution for the Pentium 4 processor consists of:

- Heat sink
- Fan
- Fan Attach
- Thermal interface material
- Heat Sink Clip (2)
- Retention Mechanism

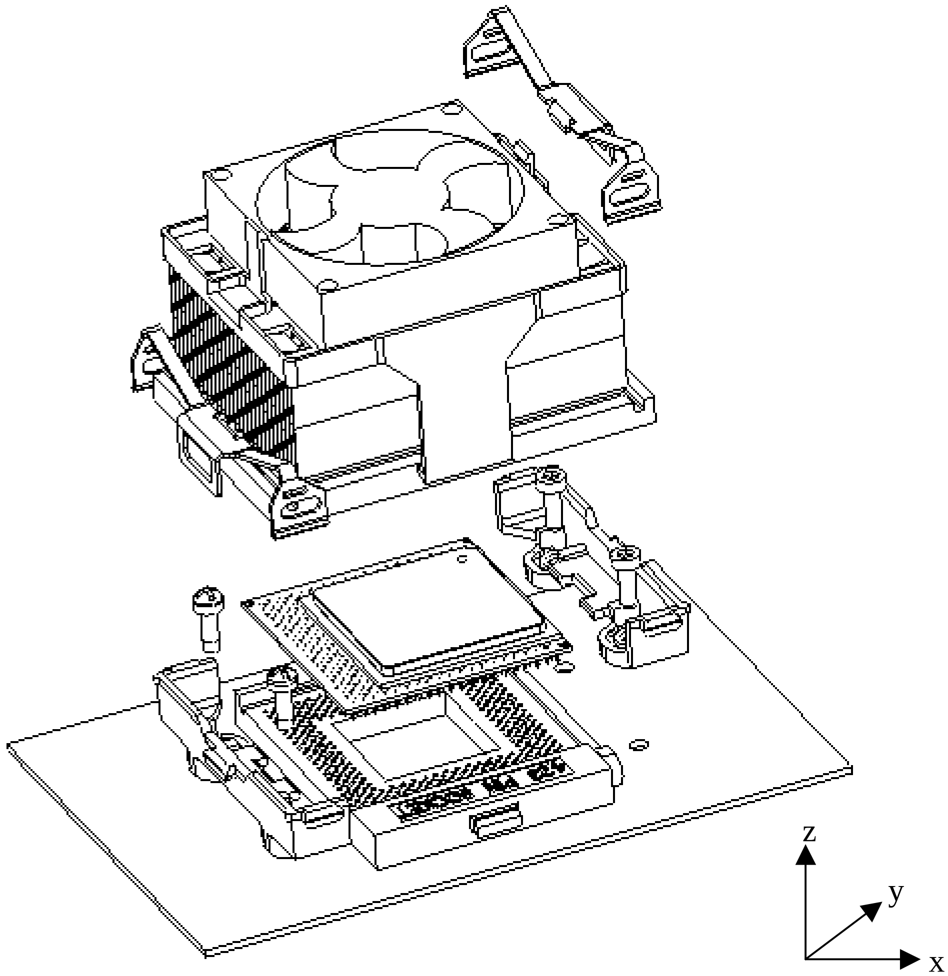


Figure 1 shows an exploded view of the thermal solution components.

3. THERMAL REQUIREMENTS

Active thermal solution components should be designed to be in compliance with Pentium® 4 processor thermal specifications and the design constraints identified in this document.

Figure 2 provides the temperature constraint at the case of the processor package (Integrated Heat Spreader, IHS). For a given chassis, the θca requirement is based on its own ambient characteristics and Intel's processor thermal specifications. The Pentium 4 processor solution is required to meet the overall θca requirement of the system that it serves. However, θcs and θsa are not individually constrained to any requirements. The following list of equations is used in calculating the thermal performance of the Pentium 4 processor thermal solutions.

$\theta sa = (Tsink - Tamb) / Q$
$\theta cs = (Tcase - Tsink) / Q$
$\theta ca = \theta cs + \theta sa$

Where,

θsa is the thermal resistance measured between the heat sink and ambient
Tsink is the temperature at the bottom of the heat sink base directly over the center of the IHS
Tamb is the temperature at ambient location
Q is the power from the processor
θcs is the thermal resistance measured across the thermal interface material
Tcase is the temperature at the top of the processor package (IHS) measured at its center
θca is the thermal resistance measured between the processor package (IHS) and ambient. This is also the sum of θcs and θsa.

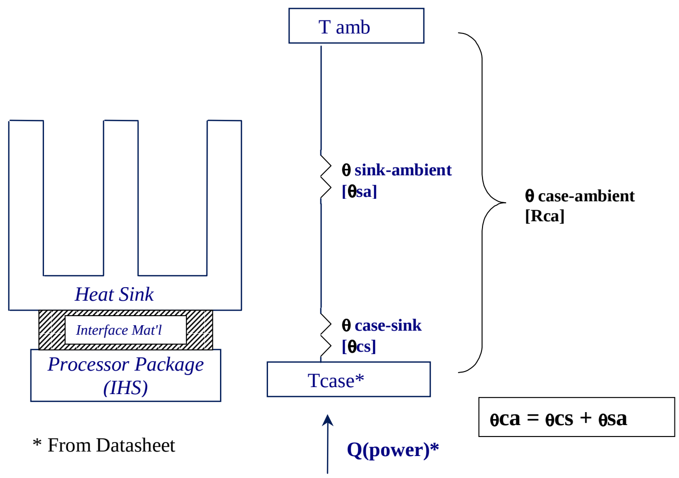


Figure 2: Overall Resistance for Thermal Solution

3.1. Pentium® 4 Processor Thermal Specifications

For complete processor thermal requirements at various core frequency levels, refer to the *Pentium® 4 processor in the 423-pin Package Datasheet.*

3.2. Thermal Test Vehicle –to- CPU Thermal Performance Correction Factor

Intel releases Thermal Test Vehicles for use by system and heat sink solution thermal designers prior to Processor availability. The Thermal Test Vehicles approximate the thermal behavior of the Processor; however, there is typically a difference in power density and power uniformity. Any thermal solution performance measured on Thermal Test Vehicles requires the application of a TTV-to-CPU correction factors in order to predict that thermal solution performance on a Processor. For the Pentium 4 processor, a correction factor is not required.

4. DESIGN REQUIREMENTS

4.1. Critical To Function Dimensions

Table 1 provides the Critical To Function (CTF) dimensions. **Figure 3** and **Figure 4** provide the drawings detailing the Critical To Function (CTF) dimensions.

Table 1: Critical To Function (CTF) Dimensions

Dimension	Letter	Minimum	Maximum
Location of Clip Attach Groove Far Edge from Heat Sink Edge	A	0.180in	0.200in
Width of Clip Attach Groove	B	0.080in	0.100in
Base Thickness in Zone A	C	0.245in	0.255in
Base Length	D	3.488in	3.512in
Base Width	E	2.488in	2.512in
Base Flatness in Zone B	F	---	0.002in/in
Width of clip attach area (Zone A)	G	0.200in	---
Height of Thermal Solution (Heat sink, fan, and fan attach shroud)	H	---	2.22in
Height of Fan Attach Shroud Clips (from bottom of heat sink base)	I	---	2.37in

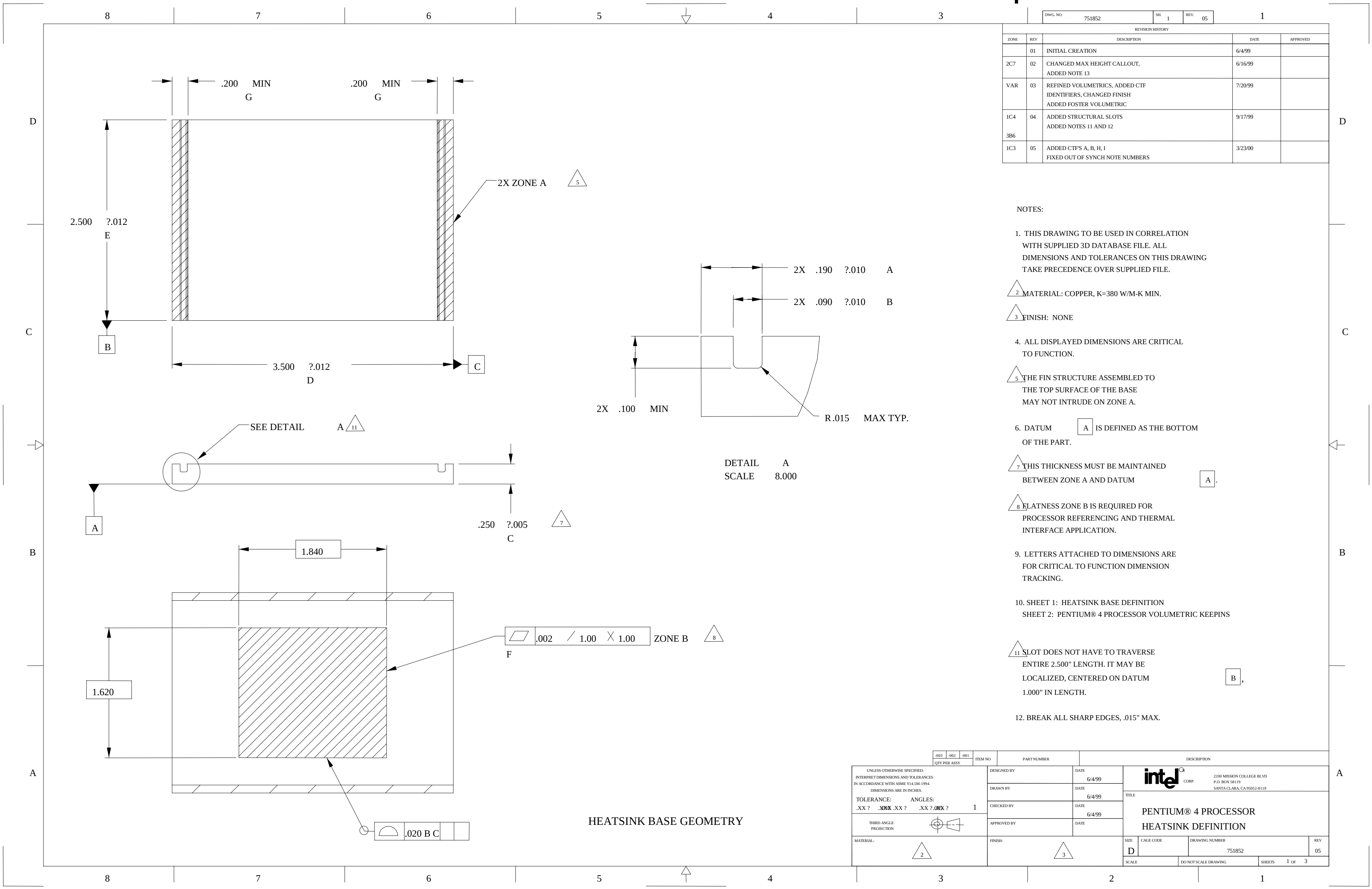


Figure 3 Heatsink base geometry

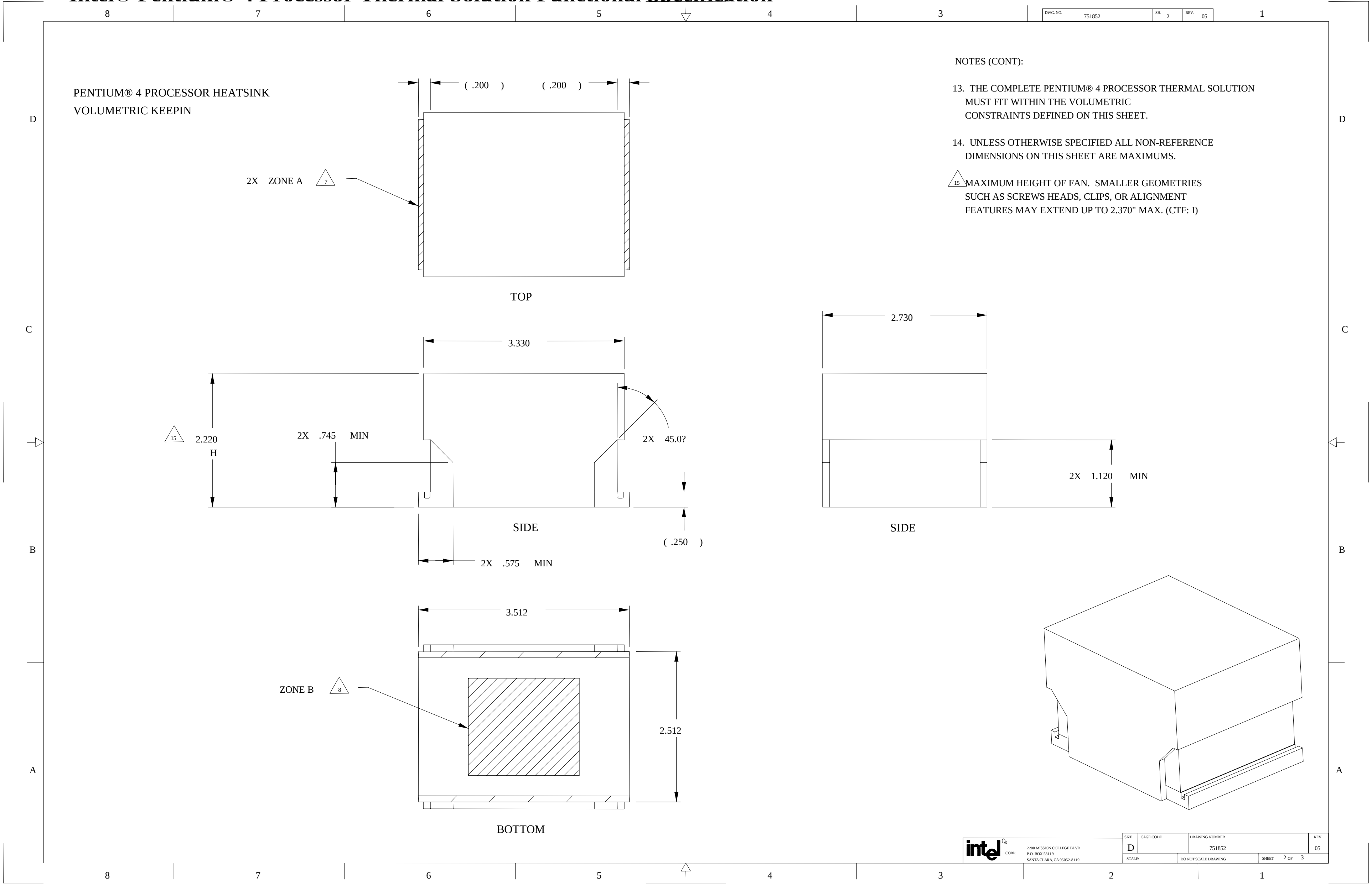


Figure 4 Heatsink volume geometry

4.2. Maximum Heat Sink Mass

Heat sink mass (including fan, fan attach, and thermal interface) may not exceed 450g.

4.3. Center of Gravity

The center of gravity of the Pentium 4 processor thermal solution should be over the center of gravity of the package. The height of the center of gravity must be 0.5in, maximum, from the bottom of the heat sink base.

4.4. Base Plate Requirements

The flatness of the base shall be maintained at 0.002in/in in the localized area (Zone B) as shown in **Figure 3**. The base plate contains no keying features and thus can be rotated 180 degrees. A heat sink supported by the Intel reference design Retention Mechanism (RM) must incorporate two clip attach areas with a minimum width of 0.200in (Zone A), as shown in **Figure 3**. The heat sink clip requirements are presented in **Section 4.8**.

4.5. Recommended Fan Requirements for the Pentium® 4 Processor Solution

The fan design is an integral part of an active thermal solution and will vary widely depending on the design of the heat sink. Therefore, only general requirements relating to the fan are prescribed.

Life requirement 40,000 hours (minimum) MTBF at 45°C.

The Pentium 4 processor thermal solution should be capable of meeting the thermal target specs presented in the *Pentium® 4 processor in 423-pin Datasheet* at 90% of the rated fan RPM at 12 Vdc.

The fan acoustic target is 32dB (measured at 1 meter at nominal RPM).

Fan cable connectors shall be 3-pin (power, ground, and signal -- open collector tachometer output signal requirement: 2 pulses per revolution) connectors capable of terminating to a vertical-mount printed circuit board (PCB) header (such as 640456-3 (AMP*), or equivalent).

4.6. Fan Attach Requirements

The fan attach must incorporate features to attach the fan directly to the heat sink base. It should not utilize the fins as an attachment anchor. Additionally, the fan attach should incorporate a shroud with side features to help prevent side-to-side motion of the fan attach.

4.7. Thermal Interface Material

Intel has determined through thermal characterization that it may be challenging to meet the thermal performance targets with the use of phase change thermal interface materials. The use of thermal grease in conjunction with high performance heat sink technologies (e.g. copper

base folded fin or high aspect ratio extruded aluminum with high performance attached fans) has been demonstrated to meet Intel thermal performance requirements.
The use of thermal grease is recommended. Intel's thermal solution reference designs use ShinEtsu* G749 thermal grease.

Intel has determined through mechanical characterization that the use of phase change thermal interface materials may lead to motherboard, processor, and /or surface mount component damage in mechanical shock or mechanical drop testing. Phase change thermal interface materials create a strong adhesive bond between the processor package and heat sink that can lead to large deflections and high loads. The damage induced is not always readily detectable.

The use of phase change thermal interface materials is not recommended. Intel's thermal solution reference designs use ShinEtsu* G749 thermal grease.

The thermal interface material must be sized and positioned on the heat sink base, covering Zone B shown in **Figure 3**, ensuring that the entire processor die area is covered. It will be important to compensate for heat sink to package attach alignment when selecting the proper size. If a pre-applied thermal interface material is specified, it may have a protective application tape, which must be removed prior to attaching the heat sink to the processor.

4.8. Heat Sink Clip Requirements

Heat sink attach clips apply force to the heat sink base to maintain desired pressure on the thermal interface material between the package and the heat sink and help to hold the heat sink in place under dynamic loading. The Intel reference design heat sink clip will attach to the heat sink base via the grooves at each end of the base, as shown in **Figure 3**. The Intel reference design heat sink clip is latched to the Intel reference design RM clip tabs, one at each end of the RM.

The heat sink clip reference design is presented in the appendix to this document.

4.9. Retention Mechanism Requirements

Intel has determined through extensive mechanical characterization that the use of direct chassis attach of the processor retention mechanism can mitigate the risk of mechanical damage to the motherboard, processor, and other surface mounted components in mechanical shock or mechanical drop testing. However, direct chassis attach may not mitigate that risk for all chassis and /or motherboard configurations. Mechanical shock or mechanical drop testing followed by functional and visual quality checks are required for each chassis-motherboard configuration.

Intel's thermal solution reference design uses direct chassis attach of the processor retention mechanism.

Intel recommends the use of 6-32 [x1/2-3/8"] pan head or round head screw [4 each] for direct RM-chassis attach. The screw head must be less than 0.284" diameter and less than 0.190" height.

4.10. EMI Ground Frame Requirements

An EMI grounding frame to reduce the electro-magnetic interference from the Pentium 4 processor is unnecessary.

5. ENVIRONMENTAL RELIABILITY REQUIREMENTS

The thermal solution assembly (including all of its components) shall be designed to meet the environmental reliability requirements as outlined in **Table 2**.

Table 2: Summary of Environmental Reliability Requirements

Test	Level
Mechanical Shock	30 G, ΔV=170 in/s, ~11 ms trapezoidal waveform 3 drops in each of 6 directions (±X, ±Y, ±Z). See Figure 5.
Vibration	Random vibration input of 0.001 g^2/Hz at 5 Hz, sloping to 0.01 g^2/Hz at 20 Hz, and maintaining 0.01 g^2/Hz from 20 Hz to 500 Hz. The area under the PSD curve is 2.20 g_{RMS}. The test duration is 10 minutes per axis in each of the three primary axes sequentially. See Figure 6.
Temperature Cycling	-25C to 100C, 10-30C/min ramp, 15min dwell, 192 cycles
Temperature Humidity	95C, 85%RH, 14 days
Bake Test	95C, 16days, nominal (<25%) RH

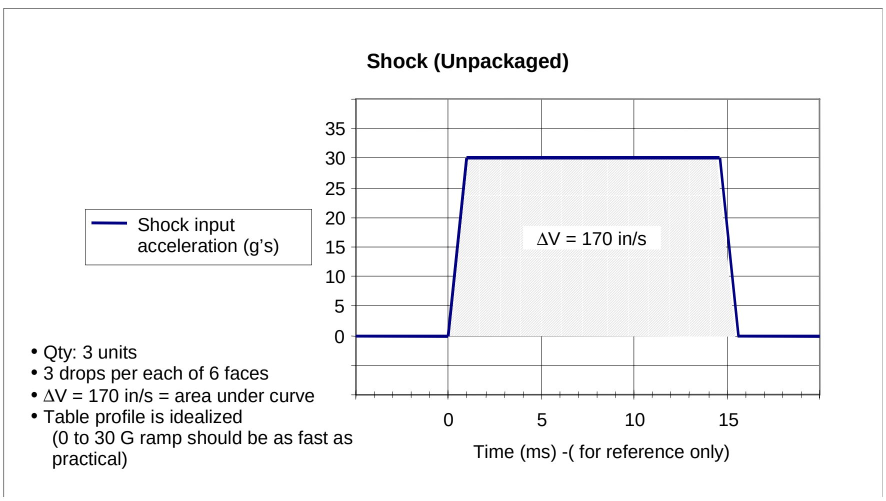


Figure 5. Unpackaged system shock input

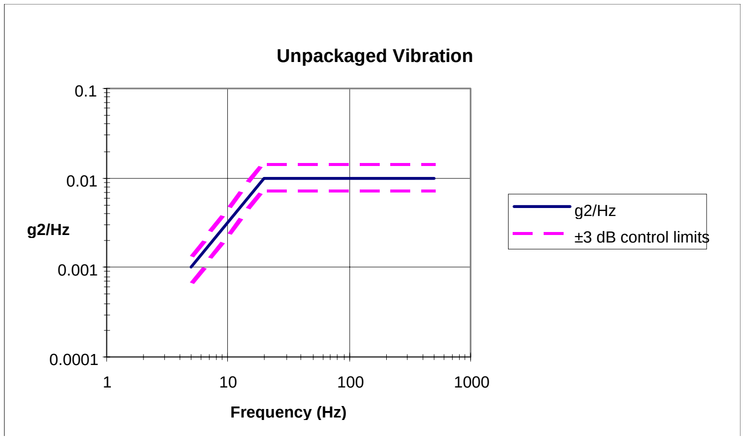


Figure 6. Unpackaged system vibration test input

6. OTHER REQUIREMENTS

6.1. Recycling Recommendation

It is recommended that any plastic component exceeding 25 grams be recyclable as per the *European Blue Angel* recycling standards.

6.2. Safety Requirements

Heat sink, fan and fan attachment shall be consistent with the manufacture of units that meet the safety standards:

- UL Recognition-approved for flammability at the system level - all mechanical-enabling components must be UL94V-0 approved, or equivalent.

6.3. Agency Requirements

The fan should be UL recognized with a locked rotor test conducted as part of the UL Recognition. The UL Recognition Mark should be placed in a location that can be seen after the assembly is attached to the processor.

If insulated wire is used, the wire should be UL Recognized and surface printed as such.

All edges should not be sharp when tested per UL 1439

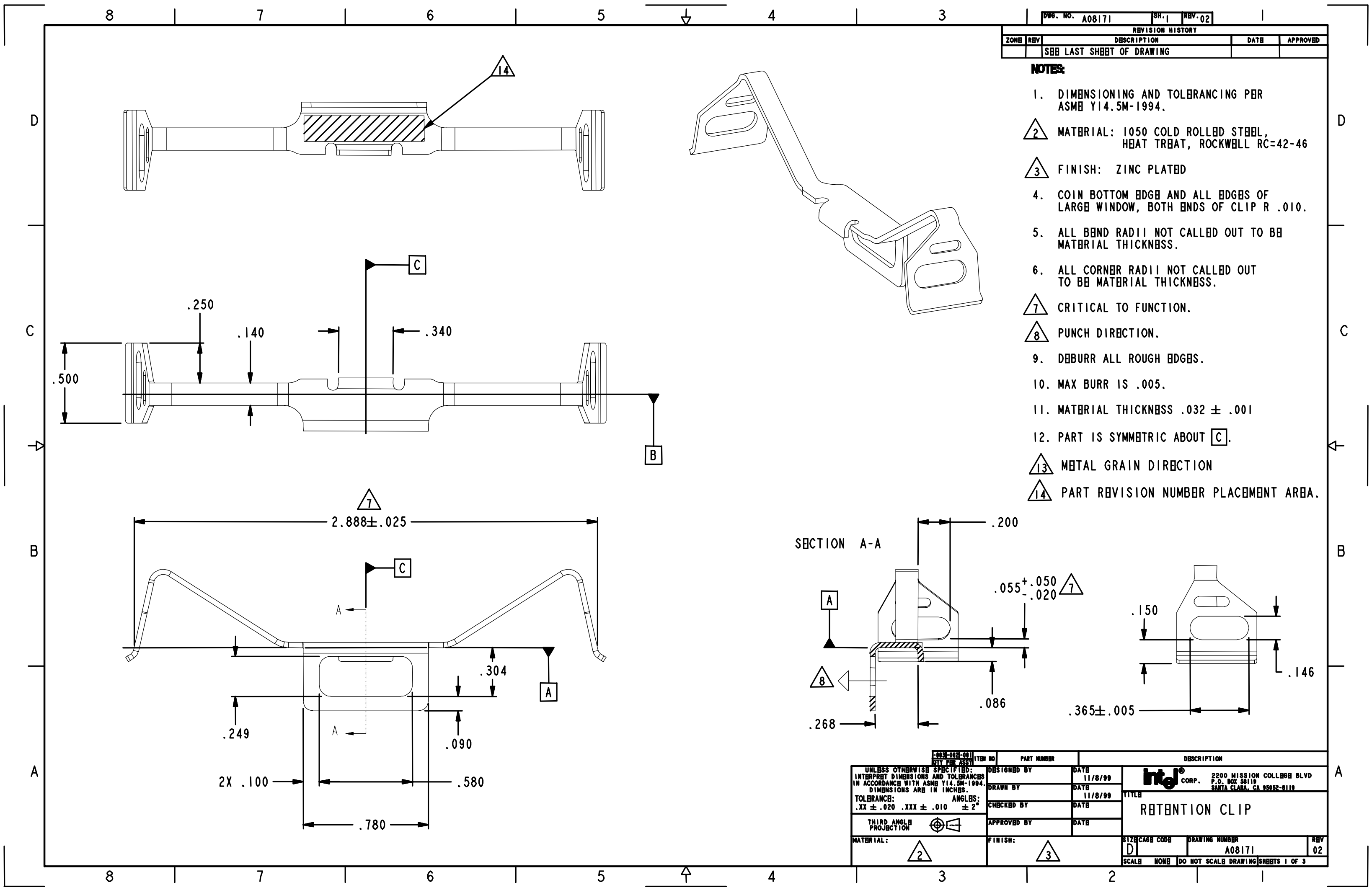
If the moving parts of the fan can be accessed by the International Accessibility Probe specific in IEC60950, the parts should pose no risk of personal injury to a small child's finger.

Intel Reference Designs for Enabled Components

The Intel reference design is composed of a copper base, aluminum folded fin active heat sink with Shin-Etsu* G749 as the thermal interface material. To ensure proper seating and spring force of the Intel reference design heat sink clip, the vertical stack-up of the socket and package is 0.407in +/- 0.016in, and the thermal interface material thickness was assumed to be a maximum of 0.005in after assembly. The thermal interface material for the reference design must be pre-applied at the factory. The Intel reference design heat sink clip will apply a pressure on the thermal interface material between 5psi and 16psi.

The heat sink clip must be designed in a way that minimizes contact with the motherboard surface during clip attach to the Retention Mechanism (RM) tab features; the clip should not scrape and/or scratch the motherboard. All surfaces of the clip should be free of sharp edges to prevent injury to any system component or to the person performing the installation. The force required to complete clip attachment (during clip engagement to the RM) should not exceed 6lbf per clip. The clip window should engage the side tab first, then attach one end tab followed by the last end tab.

The following figures present the Intel reference design for the heat sink clip and the retention mechanism. Contact your local Intel sales representative for the full models in either Pro Engineer* or IGES format.


DWG. NO. A08171 SH. 1 REV. 02
REVISION HISTORY
ZONE REV DESCRIPTION DATE APPROVED
SEE LAST SHEET OF DRAWING
NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
2 MATERIAL: 1050 COLD ROLLED STEEL, HEAT TREAT, ROCKWELL RC=42-46
3 FINISH: ZINC PLATED
4. COIN BOTTOM EDGE AND ALL EDGES OF LARGE WINDOW, BOTH ENDS OF CLIP R .010.
5. ALL BEND RADII NOT CALLED OUT TO BE MATERIAL THICKNESS.
6. ALL CORNER RADII NOT CALLED OUT TO BE MATERIAL THICKNESS.
7 CRITICAL TO FUNCTION.
8 PUNCH DIRECTION.
9. DEBURR ALL ROUGH EDGES.
10. MAX BURR IS .005.
11. MATERIAL THICKNESS .032 ± .001
12. PART IS SYMMETRIC ABOUT C.
13 METAL GRAIN DIRECTION
14 PART REVISION NUMBER PLACEMENT AREA.
SECTION A-A
.250
.140
.340
.500
2.888±.025
.304
.249
.090
2X .100
.580
.780
.200
.055 +.050 -.020
.150
.086
.268
.365±.005
.146
UNLESS OTHERWISE SPECIFIED: INTERPRET DIMENSIONS AND TOLERANCES IN ACCORDANCE WITH ASME Y14.5M-1994. DIMENSIONS ARE IN INCHES.
TOLERANCE: .XX ± .020 .XXX ± .010 ANGLES: ± 2°
THIRD ANGLE PROJECTION
MATERIAL:
FINISH:
DESIGNED BY DATE 11/8/99
DRAWN BY DATE 11/8/99
CHECKED BY DATE
APPROVED BY DATE
ITEM NO PART NUMBER DESCRIPTION
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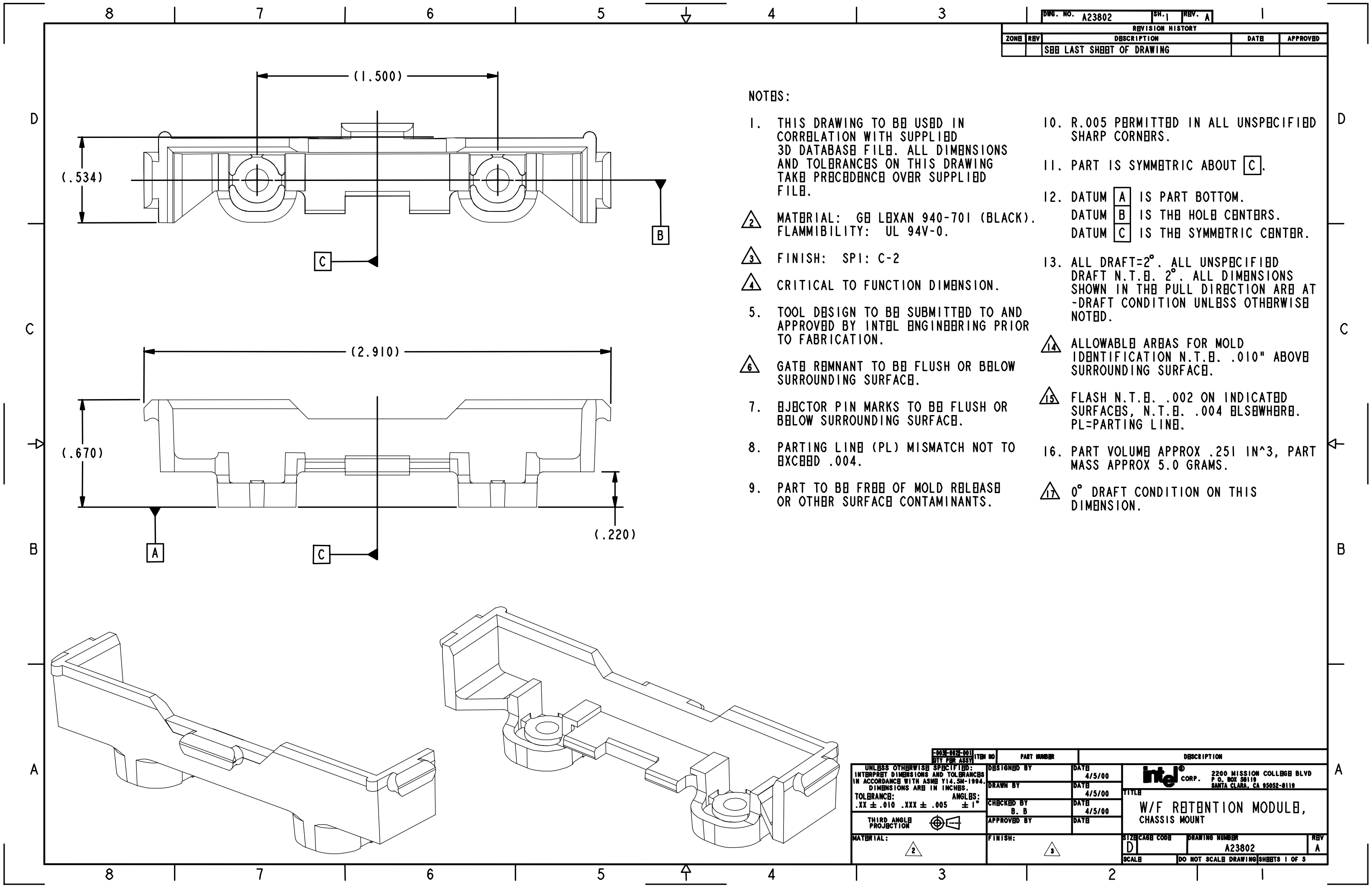
TITLE RETENTION CLIP
SIZE D CAGE CODE DRAWING NUMBER A08171 REV 02
SCALE NONE DO NOT SCALE DRAWING SHEET 1 OF 3


DWG. NO. A23802 SH. 1 REV. A
REVISION HISTORY
ZONE REV DESCRIPTION DATE APPROVED
SEE LAST SHEET OF DRAWING
(1.500)
(.534)
(2.910)
(.670)
(.220)
NOTES:
1. THIS DRAWING TO BE USED IN CORRELATION WITH SUPPLIED 3D DATABASE FILE. ALL DIMENSIONS AND TOLERANCES ON THIS DRAWING TAKE PRECEDENCE OVER SUPPLIED FILE.
2 MATERIAL: GE LEXAN 940-701 (BLACK). FLAMMIBILITY: UL 94V-0.
3 FINISH: SPI: C-2
4 CRITICAL TO FUNCTION DIMENSION.
5. TOOL DESIGN TO BE SUBMITTED TO AND APPROVED BY INTEL ENGINEERING PRIOR TO FABRICATION.
6 GATE REMNANT TO BE FLUSH OR BELOW SURROUNDING SURFACE.
7. EJECTOR PIN MARKS TO BE FLUSH OR BELOW SURROUNDING SURFACE.
8. PARTING LINE (PL) MISMATCH NOT TO EXCEED .004.
9. PART TO BE FREE OF MOLD RELEASE OR OTHER SURFACE CONTAMINANTS.
10. R.005 PERMITTED IN ALL UNSPECIFIED SHARP CORNERS.
11. PART IS SYMMETRIC ABOUT C.
12. DATUM A IS PART BOTTOM.
DATUM B IS THE HOLE CENTERS.
DATUM C IS THE SYMMETRIC CENTER.
13. ALL DRAFT=2°. ALL UNSPECIFIED DRAFT N.T.E. 2°. ALL DIMENSIONS SHOWN IN THE PULL DIRECTION ARE AT -DRAFT CONDITION UNLESS OTHERWISE NOTED.
14 ALLOWABLE AREAS FOR MOLD IDENTIFICATION N.T.E. .010" ABOVE SURROUNDING SURFACE.
15 FLASH N.T.E. .002 ON INDICATED SURFACES, N.T.E. .004 ELSEWHERE. PL=PARTING LINE.
16. PART VOLUME APPROX .251 IN^3, PART MASS APPROX 5.0 GRAMS.
17 0° DRAFT CONDITION ON THIS DIMENSION.
-003 -002 -001
QTY PER ASSY
ITEM NO
PART NUMBER
DESCRIPTION
UNLESS OTHERWISE SPECIFIED: INTERPRET DIMENSIONS AND TOLERANCES IN ACCORDANCE WITH ASME Y14.5M-1994. DIMENSIONS ARE IN INCHES.
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ANGLES: ± 1°
THIRD ANGLE PROJECTION
DESIGNED BY
DATE 4/5/00
DRAWN BY
DATE 4/5/00
CHECKED BY B. B
DATE 4/5/00
APPROVED BY
DATE
intel CORP.
2200 MISSION COLLEGE BLVD
P O. BOX 58119
SANTA CLARA, CA 95052-8119
TITLE
W/F RETENTION MODULE,
CHASSIS MOUNT
MATERIAL: 2
FINISH: 3
SIZE D
CAGE CODE
DRAWING NUMBER A23802
REV A
SCALE
DO NOT SCALE DRAWING
SHEETS 1 OF 5

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