Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus in Embedded Applications

Thermal/Mechanical Design Guide

October 2004

Revision 1.0

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Contents

Figures

Tables

Revision History

Date	Revision	Description
October 2004	001	Initial public release of this document.

Introduction 1

This document describes thermal design guidelines for the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus in the Flip Chip Micro-Pin Grid Array (FC-mPGA4) package. Detailed mechanical and thermal specifications for these processors can be found in the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus Datasheet.

Caution: The information provided in this document is for reference only. Additional validation must be performed before implementing the designs into final production. The intent of this document is to assist each original equipment manufacturer (OEM) with developing thermal solutions for their individual designs. The final heat sink solution, including the heat sink, attachment method, and thermal interface material (TIM) must comply with the mechanical design, environmental, and reliability requirements delineated in the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus Datasheet. It is the responsibility of each OEM to validate the thermal solution design with their specific applications.

1.1 Document Goals

The goal of this document is to describe the thermal characteristics of the Low Voltage Xeon Processor and provide guidelines for meeting the thermal requirements imposed on single and dual processor systems. The thermal solutions presented in this document are specifically designed for embedded computing applications including the 1U Server System Infrastructure* (SSI).

1.2 Document Scope

This document discusses the thermal management techniques for the Low Voltage Xeon Processor, specifically in embedded computing applications. The physical dimensions and thermal specifications used in this document are for reference only. Please refer to the processor’s datasheet for the product dimensions, thermal design power, and maximum case temperature. In case of conflict, the datasheet supersedes any data in this document.

1.3 References

Consult your Intel representative to obtain the following reference documents:

- mPGA604 Socket Design Guidelines
- Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus Datasheet
- Intel® Xeon™ Processor with 800 MHz System Bus Thermal/Mechanical Design Guidelines

1.4 Terms and Definitions

Term	Definition
604 Pin Socket	The surface mount Zero Insertion Force (ZIF) socket designed to accept the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus
Δ	Delta; difference, or change, between two states
Ψ_{CA}	Case-to-ambient thermal characterization parameter (psi). A measure of thermal solution performance using total package power. Defined as ($T_C - T_{LA}$) / Total Package Power. Heat source should always be specified for Ψ measurements.
Ψ_{CS}	Case-to-sink thermal characterization parameter. A measure of thermal interface material performance using total package power. Defined as ($T_C - T_S$) / Total Package Power.
Ψ_{SA}	Sink-to-ambient thermal characterization parameter. A measure of heat sink thermal performance using total package power. Defined as ($T_S - T_{LA}$) / Total Package Power.
°C	Degrees in Celsius
CFD	Computational Fluid Dynamics
CFM	Cubic Feet per Minute (airflow rate)
DP	Dual Processing Capability
IHS	Integrated Heat Spreader
in.	Inches
in. H_2O	Inches of Water (measurement of pressure)
LFM	Linear Feet per Minute (airflow velocity)
LV	Low Voltage
PCB	Printed Circuit Board
T_{case}, T_c	Measured case temperature of the processor
$T_{case\text{-}max}$	Maximum case temperature of the processor, as specified in the processor datasheet
T_S	Heat sink temperature measured on the underside of the heat sink base, at a location corresponding to T_C.
T_{LA}	$T_{Local\text{-}Ambient}$ – Measured ambient temperature locally surrounding the processor.
TDP	Thermal Design Power (TDP) – A specification of the processor. OEMs must design thermal solutions that meet or exceed the TDP as specified by the processor's data sheet.
TIM	Thermal Interface Material – Thermally conductive compound between the heat sink and processor case. This material fills air gaps and voids and enhances spreading of the heat from the case to the heat sink.
U	A unit of measure used to define server rack spacing height. 1U is equal to 1.75 inches, 2U equals 3.50 inches, etc.
W	Watt
ZIF	Zero Insertion Force

Processor Thermal/Mechanical Information 2

The thermal solutions presented in this document were designed to fit within the maximum component height allowed by certain embedded form factor specifications, including the 1U server and AdvancedTCA* form factors. The thermal solutions may be valid for other form factors; however, individual applications must be modeled, prototyped, and verified.

In some cases, prototype parts have been fabricated for verification tests. The thermal verification information described in this document is not adequate for statistical purposes. The intent of testing was only to verify that the thermal components were performing within reasonable expectations based on computer modeling and component specifications.

2.1 Mechanical Requirements

2.1.1 Processor Mechanical Parameters

Table 1. Processor Mechanical Parameters Table

Parameter	Minimum	Maximum	Unit	Notes
Volumetric Requirements and Keepouts	See drawings in Appendix A for information.			
Heat Sink Mass	N/A	1000 2.2	g lbs	
Static Compressive Load	44 10	222 50	N lbf	1, 2, 3, 4
	44 10	288 65	N lbf	1, 2, 3, 5
Dynamic Compressive Load	N/A	222 N + 0.45 kg * 100 G 50 lbf (static) + 1 lbm * 100 G	N lbf	1, 3, 4, 6, 7
		288 N + 0.45 kg * 100 G 65 lbf (static) + 1 lbm * 100 G	N lbf	1, 3, 5, 6, 7
Transient	N/A	445 100	N lbf	1, 3, 8

NOTE: In case of discrepancy, the most recent processor datasheet supersedes the above table.

1. These specifications apply to uniform compressive loading in a direction perpendicular to IHS top surface.
2. This is the minimum and maximum static force that can be applied by the heat sink and retention solution to maintain the heat sink and processor interface.
3. These parameters are based on limited testing for design characterization. Loading limits are for the package only and do not include the limits of the processor socket.
4. This specification applies to thermal retention solutions that allow baseboard deflection.
5. This specification applies to thermal retention solutions that prevent baseboard deflection.
6. Dynamic loading is defined as an 11 ms duration average load superimposed on the static load requirement.
7. Experimentally validated test condition used a heat sink mass of 1 lbm (~0.45 kg) with 100 G acceleration measured at heat sink mass. The dynamic portion of this specification in product application can have flexibility in the specific values, but the ultimate product of mass times acceleration should not exceed this validated dynamic load (1 lbm x 100 G = 100 lb). Allowable strain in the dynamic compressive load specification is in addition to the strain allowed in static loading.
8. Transient loading is defined as a two-second duration peak load superimposed on the static load requirement, representative of loads experienced by the package during heat sink installation.

2.1.2 Processor Package

The Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus is packaged using the Flip-chip Micro Pin Grid Array 4 (FC-mPGA4) package. Refer to the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus datasheet for detailed mechanical specifications.

The package includes an Integrated Heat Spreader (IHS). The IHS transfers non-uniform heat from the die to the top of the IHS, out of which the heat flux is more uniform and spread over a larger surface area (not the entire IHS area). This allows more efficient heat transfer out of the package to an attached cooling device. The IHS is designed to be the interface for contacting a heat sink. Details can be found in the processor datasheet.

The processor connects to the baseboard through a 604-pin surface mount, zero insertion force (ZIF) socket. A description of the socket can be found in the *mPGA604 Socket Design Guidelines*.

The processor package has mechanical load limits that are specified in the processor datasheet and in Table 1. These load limits should not be exceeded during heat sink installation, removal, mechanical stress testing, or standard shipping conditions. For example, when a compressive static load is necessary to ensure thermal performance of the thermal interface material (TIM) between the heat sink base and the IHS, it should not exceed the corresponding specification given in the processor datasheet.

The heat sink mass can also add additional dynamic compressive load to the package during a mechanical shock event. Amplification factors due to the impact force during shock must be taken into account in dynamic load calculations. The total combination of dynamic and static compressive load should not then exceed the processor compressive dynamic load specified in the datasheet and in Table 1 during a vertical shock. It is not recommended to use any portion of the processor substrate as a mechanical reference or load-bearing surface in either static or dynamic compressive load conditions.

2.1.3 Heat Sink Attach

An attachment mechanism must be designed to support the heat sink since there are no features on the mPGA604 socket to directly attach a heat sink. In addition to holding the heat sink in place on top of the IHS, this mechanism plays a significant role in the robustness of the system in which it is implemented, in particular:

- Ensuring thermal performance of the TIM applied between the IHS and the heat sink. TIMs, especially ones based on phase change materials, are very sensitive to applied pressure: the higher the pressure, the better the initial performance. TIMs such as thermal greases are not as sensitive to applied pressure. Designs should consider possible decrease in applied pressure over time due to potential structural relaxation in enabled components.
- Ensuring system electrical, thermal, and structural integrity under shock and vibration events. The mechanical requirements of the attach mechanism depend on the weight of the heat sink and the level of shock and vibration that the system must support. The overall structural design of the baseboard and the system must be considered as well when designing the heat sink attach mechanism. Their design should provide a means for protecting mPGA604 socket solder joints as well as prevent package pullout from the socket.

A potential mechanical solution for large heat sinks is the direct attachment of the heat sink to the chassis pan. In this case, the strength of the chassis pan can be utilized rather than solely relying on baseboard strength. In addition to the general guidelines above, minimize contact with baseboard surfaces during installation to avoid baseboard damage.

All heat sink designs compatible with the Intel® Xeon™ Processor with 800 MHz System Bus are using such a heat sink attachment scheme. Refer to the *Intel® Xeon™ Processor with 800 MHz System Bus Thermal/Mechanical Design Guidelines* for further information regarding the reference mechanical solution.

Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus thermal solution designs compatible with the *Minimized Footprint Solution* use the same heat sink mounting scheme developed and currently available for Xeon processors. A custom mounting scheme has been developed for the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus when used in the AdvancedTCA* form factor.

2.1.4 PCB Keep-Out Zones

The following keep-out zones can be used depending on the end product design.

1. Minimized Footprint Solution. (Recommended for less stringent thermal management requirements.)
2. Common Enabling Kit (CEK) Solution. (Recommended for more stringent thermal management requirements.)
3. AdvancedTCA* Form Factor.

Refer to the *mPGA604 Socket Design Guide* for details on the keep-out zone required for the 604-pin socket. No components are allowed on either the top or bottom of the baseboard in this region. In addition, the following sections discuss constraints required to accommodate the heat sinks and mounting schemes for all thermal solutions.

2.1.4.1 PCB Keep-Out Zones for the Minimized Footprint Solution

This recommendation is for systems that require a reduced PCB footprint. These thermal solutions are compatible with the Low Voltage Xeon™ & Xeon processors with 512 Kbytes L2 cache. If a PCB is being designed specifically for use with the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus, then this keep-out zone can be used to minimize the PCB space required for the processor’s thermal solution. Heat sinks and retention modules that meet this boundary condition are available from thermal solution vendors.

Figure 23 on page 42 and Figure 24 on page 43 illustrate the PCB keep-out requirements needed to accommodate the Intel reference designs for the heat sink and retention hardware.

2.1.4.2 PCB Keep-Out Zones for Common Enabling Kit (CEK) Solutions

This keep-out zone is recommended for PCB designs that require compatibility with the Intel® Xeon™ Processor with 800 MHz System Bus.

Intel has developed a reference thermal solution and retention scheme, referred to as Common Enabling Kit (CEK), for the Xeon processor. The baseboard mounting holes for the CEK solution are in the same location as the holes used for previous Intel Xeon processors. However, the CEK assembly requires larger diameter holes.

Figure 25 on page 44 through Figure 28 on page 47 show the baseboard keep-out zones on the primary and secondary sides and height restrictions under the enabling component region. Figure 29 on page 48 shows the overall volumetric keep-in zone for the enabling component assembly. This volumetric space encapsulates the processor, the socket, and the entire thermal/ mechanical enabling solution.

2.1.4.3 PCB Keep-Out Zones for AdvancedTCA* Thermal Solution

The AdvancedTCA* keep-out zones are the same as the CEK keep-out zones, except the AdvancedTCA* form factor requires two additional keep-outs. These additional keep-outs require no components be placed on the baseboard in two areas, and a maximum component height of 10.8 mm in two other areas. These areas are shown in Figure 30 on page 49.

2.2 Thermal Specifications

The Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus must remain within a certain case temperature (T_{CASE}) specification to achieve optimal operation and long-term reliability. The thermal specification methodology for the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus family, referred to as the Thermal Profile, ensures long-term reliability of the processor and supports acoustic noise reduction through fan speed control.

2.2.1 Thermal Profile Concept

The Thermal Profile defines a linear relationship between a processor's case temperature and its power consumption as shown in Figure 1 on page 13. The equation of the Thermal Profile is defined as:

$y = ax + b$

where:

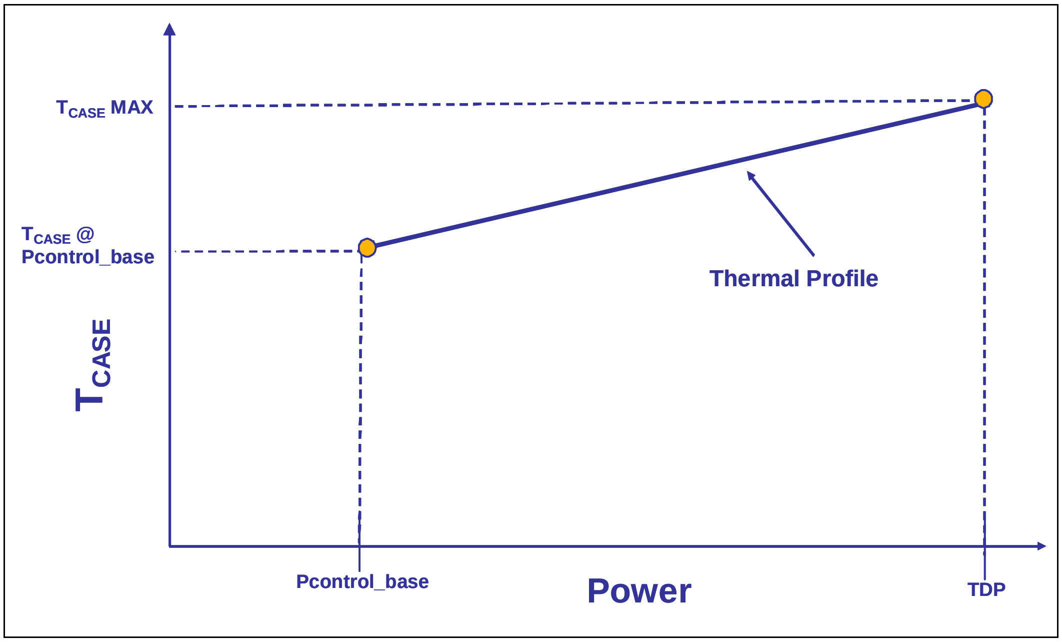
y = Processor case temperature, T_{case} (°C)

x = Processor power consumption (W)

a = Case-to-ambient thermal characterization parameter, Ψ_{CA} (°C/W)

b = Processor local ambient temperature, T_{LA} (°C)

Figure 1. Thermal Profile Diagram



The higher end point of the Thermal Profile represents the processor's thermal design power (TDP) and the associated maximum case temperature ($T_{CASEMAX}$). The lower end point of the Thermal Profile represents the power value ($P_{CONTROL\_BASE}$) and the associated case temperature (T_{CASE}@$P_{CONTROL\_BASE}$) for the lowest possible theoretical value of $T_{CONTROL}$ (See Section 2.2.3). This point is also associated with the $T_{CONTROL}$ value defined in Section 2.2.2. The slope of the Thermal Profile line represents the case-to-ambient resistance of the thermal solution with the y-intercept being the local processor ambient temperature. The slope of the Thermal Profile is constant between $P_{CONTROL\ BASE}$ and TDP, indicating that all frequencies of a processor defined by the Thermal Profile require the same heat sink case-to-ambient resistance.

To satisfy the Thermal Profile specification, a thermal solution must be at or below the Thermal Profile line for the given processor when its diode temperature is greater than $T_{CONTROL}$ (refer to Section 2.2.2). The Thermal Profile allows a trade-off between the thermal solution case-to-ambient resistance and the processor local ambient temperature that best suits the platform implementation. Multiple combinations of thermal solution case-to-ambient resistance and processor local ambient temperatures can meet a given Thermal Profile. If the case-to-ambient resistance and the local ambient temperature are known for a specific thermal solution, the Thermal Profile of that solution can easily be plotted against the Thermal Profile specification. As explained above, the case-to-ambient thermal characterization parameter represents the slope of the line, and the processor local ambient temperature represents the y-axis intercept. Hence the T_{CASE} values of a specific solution can be calculated at the TDP and $P_{CONTROL\_BASE}$ power levels. Once these points are determined, they can be joined by a line representing the Thermal Profile of the specific solution. If the line stays at or below the Thermal Profile specification, then that solution is compliant.

2.2.2 $T_{CONTROL}$ Definition

$T_{CONTROL}$ is a temperature specification based on a temperature reading from the processor's thermal diode. $T_{CONTROL}$ defines the lower end of the Thermal Profile line for a given processor, and it can be described as a trigger point for fan speed control implementation. The value for $T_{CONTROL}$ is calibrated in manufacturing and configured for each processor individually. For the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus family, the $T_{CONTROL}$ value is obtained by reading a processor Model Specific Register (MSR) and adding this offset value to a base value. The equation for calculating $T_{CONTROL}$ is:

$T_{CONTROL} = T_{CONTROL\_BASE} + \text{Offset}$

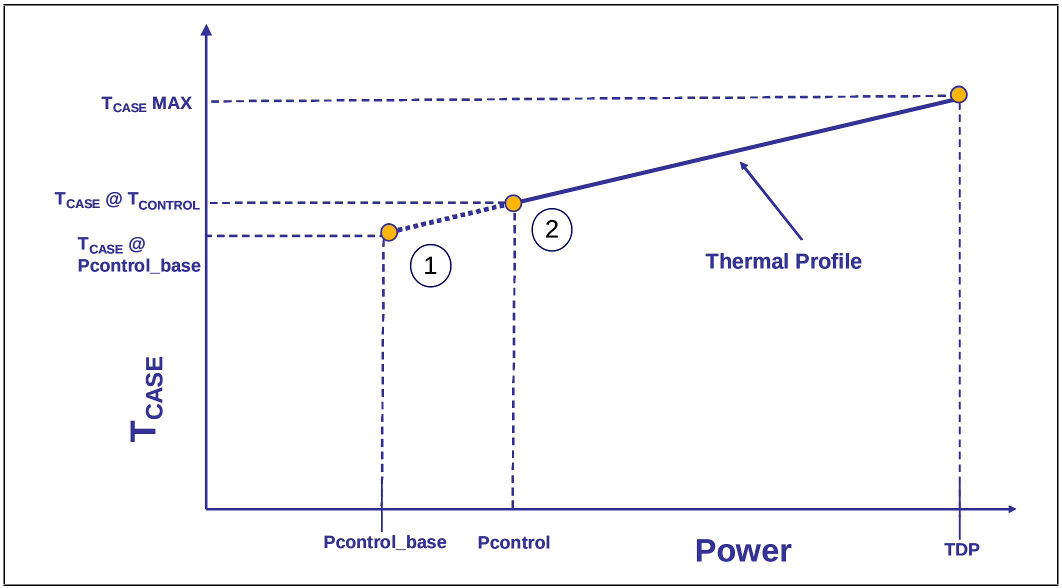
where:

$T_{CONTROL\_BASE}$ = A fixed base value defined for a given processor generation and published in the processor EMTS.

Offset = A value programmed into each processor during manufacturing that can be obtained by reading the IA32_TEMPERATURE_TARGET MSR. This is a static and unique value for each processor.

The $T_{CONTROL\_BASE}$ value for the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus is 50° C. The offset value, which depends on several factors (e.g., leakage current), can be any number between 0 and ($T_{CASEMAX}$ - $T_{CONTROL\_BASE}$). Figure 2 depicts the interaction between the Thermal Profile and $T_{CONTROL}$ for an offset value greater than 0 (i.e. $T_{CONTROL}$ greater than $T_{CONTROL\_BASE}$).

Figure 2. $T_{CONTROL}$ and Thermal Profile Interaction



Since $T_{CONTROL}$ is a processor diode temperature value, an equivalent T_{CASE} temperature must be determined to plot the T_{CASE} @ $T_{CONTROL}$ point on the Thermal Profile graph. Location 1 on the Thermal Profile represents a T_{CASE} value corresponding to an offset of 0 (the theoretical minimum for the given processor family). Any offset value greater than 0 moves the point where the Thermal Profile must be met upwards, as shown by location 2 on the graph. If the diode temperature is less than $T_{CONTROL}$, then the case temperature is permitted to exceed the Thermal Profile, but the diode temperature must remain at or below $T_{CONTROL}$. There is no T_{CASE} specification for the processor at power levels less than Pcontrol. The thermal solution for the processor must be able to keep the processor's T_{CASE} at or below the T_{CASE} values defined by the Thermal Profile between the $T_{CASE}@T_{CONTROL}$ and $T_{CASEMAX}$ points at the corresponding power levels.

Refer to the Intel® Xeon™ Processor with 800 MHz System Bus Thermal/Mechanical Design Guideline for the implementation of the $T_{CONTROL}$ value in support of fan speed control (FSC) as an option to achieve better acoustic performance.

2.2.3 Processor Case Temperature

The IHS provides a common interface and attach location for all processor thermal solutions. The IHS can improve thermal solution performance by spreading the concentrated heat from the core to a larger surface area. Techniques for measuring the case temperature are provided in the Intel® Xeon™ Processor with 800 MHz System Bus Thermal/Mechanical Design Guidelines. Consult the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus Datasheet for the maximum case temperature values for the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus family as defined by the thermal profile.

The case temperature is defined as the temperature measured at the geometric center of the top surface of the IHS. This point also corresponds to the geometric center of the package for the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus.

2.2.4 Processor Power

The majority of the processor power is dissipated through the IHS. Other than the die, there are no additional components that generate heat on this package. The amount of power that can be dissipated as heat through the processor package substrate and into the socket is negligible.

The processor's power specifications can be documented in two ways: Maximum Power and Thermal Design Power (TDP). Maximum Power is the theoretical limit of the processor power, which is rarely achieved. While running typical applications, maximum power is not usually reached. As a result, TDP is provided as the thermal design target for systems. This power specification is derived from profiling multiple workstation and server applications. In addition, a maximum power application is available that can be used to dissipate TDP. For any excursions beyond TDP, the Thermal Monitor feature is available to maintain the processor thermal specifications. Refer to the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus Datasheet for details regarding the TDP specifications and the thermal monitor feature.

2.2.5 Characterizing the Thermal Solution Requirement

A thermal characterization parameter, Ψ, is a convenient way to characterize the performance needed for the thermal solution and compare thermal solutions in identical situations (e.g., heating source, local ambient conditions, etc.). A thermal characterization parameter is convenient in that it is calculated using total package power, whereas actual thermal resistance, θ (theta), is calculated using actual power dissipated between two points. Measuring actual power dissipated into the heat sink is difficult, since some of the power is dissipated via heat transfer into the socket and board. Be aware, however, of the limitations of lumped parameters such as Ψ when it comes to a real design. Heat transfer is a three-dimensional phenomenon that can rarely be accurately and easily modeled by lump values.

The case-to-local ambient thermal characterization parameter value (Ψ_{CA}) is used as a measure of the thermal performance of the overall thermal solution that is attached to the processor package. It is defined by the following equation and measured in units of °C/W:

Equation 1. *Case-to-Local Ambient Thermal Characterization Parameter Value (Ψ_{CA})*

$$\Psi_{CA} = \frac{T_C - T_{LA}}{TDP}$$

Where:

Ψ_{CA} = Case-to-local ambient thermal characterization parameter (°C/W)

T_C = Processor case temperature (°C)

T_{LA} = Local ambient temperature near the processor (°C)

TDP = Processor total power dissipation (W); assumes all power dissipates through the IHS.

The case-to-local ambient thermal characterization parameter, Ψ_{CA}, is composed of:

- Ψ_{CS}, the thermal interface material thermal characterization parameter (°C/W)
- Ψ_{SA}, the sink-to-local ambient thermal characterization parameter (°C/W):

Equation 2. *Case-to-Local Ambient Thermal Characterization Parameter Relationships*

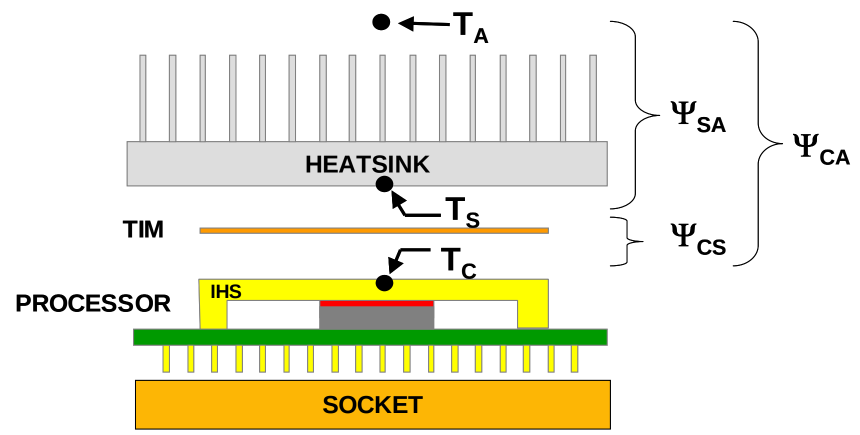
$$\Psi_{CA} = \Psi_{CS} + \Psi_{SA}$$

Where:

Ψ_{CS} is strongly dependent on the thermal conductivity and thickness of the TIM between the heat sink and IHS.

Ψ_{SA} is a measure of the thermal characterization parameter from the bottom of the heat sink to the local ambient air. Ψ_{SA} is dependent on the heat sink material, thermal conductivity, and geometry. It is also strongly dependent on the air velocity through the fins of the heat sink. Figure 3 illustrates the combination of the different thermal characterization parameters.

Figure 3. Processor Thermal Characterization Parameter Relationships



2.2.5.1 Calculating the Required Thermal Performance for the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus

Use the steps below to determine the required cooling performance, Ψ_{CA}, of a thermal solution.

1. Consult the Thermal Profile to define the target case temperature $T_{CASE\text{-}MAX}$ and corresponding TDP. This will be the higher end point of the thermal profile.
2. Define a target local ambient temperature at the processor, T_{LA}.

Note: T_{LA} must be less than or equal to the T_{LA} (y-intercept) specified in the Thermal Profile. If the defined T_{LA} is greater than required by the Thermal Profile, T_{CASE} will exceed the Thermal Profile requirements at low power dissipation while still meeting them at high power dissipation.

3. Calculate Ψ_{CA}.
4. Check for Thermal Profile adherence by plotting calculated Ψ_{CA} and target T_{LA} ($y = \Psi_{CA}*P + T_{LA}$) against the required thermal profile. If the line remains below the requirements, the solution adheres to the Thermal Profile.

The following provides an illustration of how one might determine the appropriate performance targets. The example power and temperature numbers used here are not related to any Intel processor thermal specifications and are for illustrative purposes only. Refer to the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus datasheet for processor-specific data.

Assume:

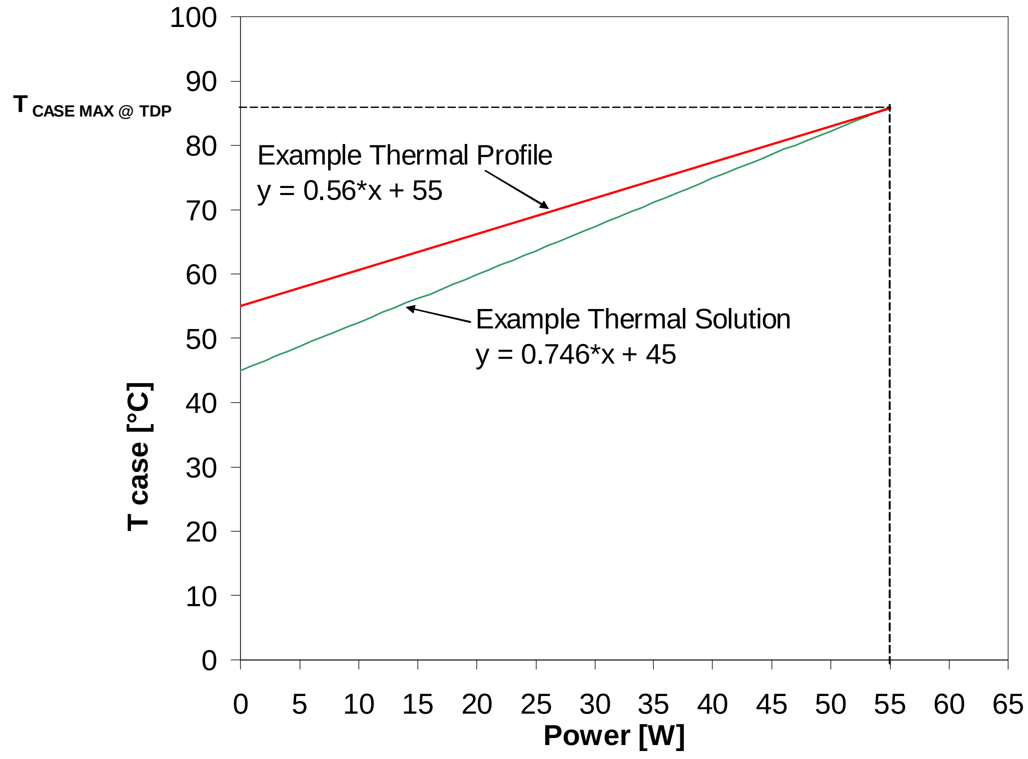
- $T_{CASE\text{-}MAX}$ = 86° C and the corresponding TDP = 55.0 W from the Thermal Profile.
- Local processor ambient temperature, T_{LA} = 45° C.

Then the following could be calculated using Equation 1:

$$\Psi_{CA} = \frac{T_C - T_{LA}}{TDP} = \frac{86 - 45}{55.0} = 0.746 \frac{^{\circ}C}{W}$$

Check for adherence to the Thermal Profile by plotting the calculated Ψ_{CA} and defined T_{LA} on the Thermal Profile as shown in Figure 4.

Figure 4. Checking for Thermal Profile Adherence - Example



Since the example thermal solution profile remains at or below the Thermal Profile at all power levels, the solution adheres to the profile.

Once the required Ψ_{CA} is determined, the required heat sink performance, Ψ_{SA}, can be determined by subtracting the TIM material contribution, Ψ_{CS}. A heat sink solution provider would need to determine Ψ_{CS} performance for the selected TIM and mechanical load configuration. If the heat sink solution were designed to work with a TIM material performing at $\Psi_{CS} \leq 0.1$ °C/W, solving from Equation 2, the performance of the heat sink required is:

$$\Psi_{SA} = \Psi_{CA} - \Psi_{CS} = 0.746 - 0.1 = 0.646 \frac{^{\circ}C}{W}$$

2.3 Thermal Metrology for the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus

2.3.1 Processor Thermal Solution Performance Assessment

This section discusses guidelines for testing thermal solutions, including measuring processor temperatures. In all cases, the thermal engineer must measure power dissipation and temperature to validate a thermal solution.

Thermal performance of a heat sink should be assessed using a thermal test vehicle (TTV) provided by Intel. The TTV is a well-characterized thermal tool, whereas real processors can introduce additional factors that can impact test results. In particular, the power level from actual processors varies significantly, even when running the maximum power application provided by Intel, due to variances in the manufacturing process. The TTV provides consistent power and power density for thermal solution characterization and results can be easily translated to real processor performance. Accurate measurement of the power dissipated by an actual processor is beyond the scope of this document.

Once the thermal solution is designed and validated with the TTV, Intel recommends that OEM’s use this tool in conjunction with other design and verification methods to verify that their cooling solution meets the specifications outlined in the product datasheet. A tool, by itself, should not be used to determine compliance of a thermal design to the processor’s thermal specifications.

2.3.1.1 TTV Correction Factor for the Low Voltage Xeon Processor

Thermal characterization parameter measurements made with a TTV must be corrected for the non-uniform power dissipation of actual processors. Table 2 provides the correction factor for using an Intel® Xeon™ processor with 512 Kbytes L2 cache TTV to assess the thermal characterization parameter of Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus heat sinks. This TTV must be used because there is no Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus-specific TTV. The value of a thermal characterization parameter is derived from the value measured on the TTV and the corresponding correction offset according to this equation:

$\{\text{Processor } \Psi_{CA}\} = \{\text{TTV } \Psi_{CA}\} + \text{Correction offset}$

The correction factor should be applied to a mean + 3sigma value when testing with a statistical sample size.

Table 2. Low Voltage Xeon Processor (800 MHz) Thermal Characterization Parameter Correction Offset for TTV

Thermal Characterization Parameter (°C/W)	Correction Offset Intel® Xeon™ processor with 512 Kbytes L2 cache TTV (°C/W)
Ψ_{CA}	0.02

2.3.2 Thermocouple Attachment, Air Temperature, and Velocity Measurements

Use Omega Omegabond 101* epoxy or equivalent for bonding thermocouples to heat sources. A good thermal bond between the thermocouple and the device being measured is essential. However, excessive bonding material can affect the measurement for small devices, particularly if the bonding material has a significantly different thermal conductivity compared to the device being tested. The standard thermocouple mounting location will be at the top, geometric center of the component unless otherwise noted.

Place velocity probes using hot glue with the face of the probe set perpendicular to the primary flow direction. To support these probes in the air stream, attach toothpicks or paper clips to the probes for stability.

Note: Velocity readings represent a single point in space and should not be used to calculate the volumetric airflow entering a given region. To calculate an approximate volumetric airflow, several measurements should be averaged to capture the velocity gradient in that region. Nevertheless, single velocity measurements are useful in making relative qualitative comparisons between regions. If the probe is close to the flow source (i.e. fans, blowers, etc.), a wide range of readings may be measured and result in the need for multiple velocity measurements.

Note: Pay special attention when mounting air velocity probes. The probe readings are extremely sensitive to alignment with the flow, and any misalignment will compromise measurement results.

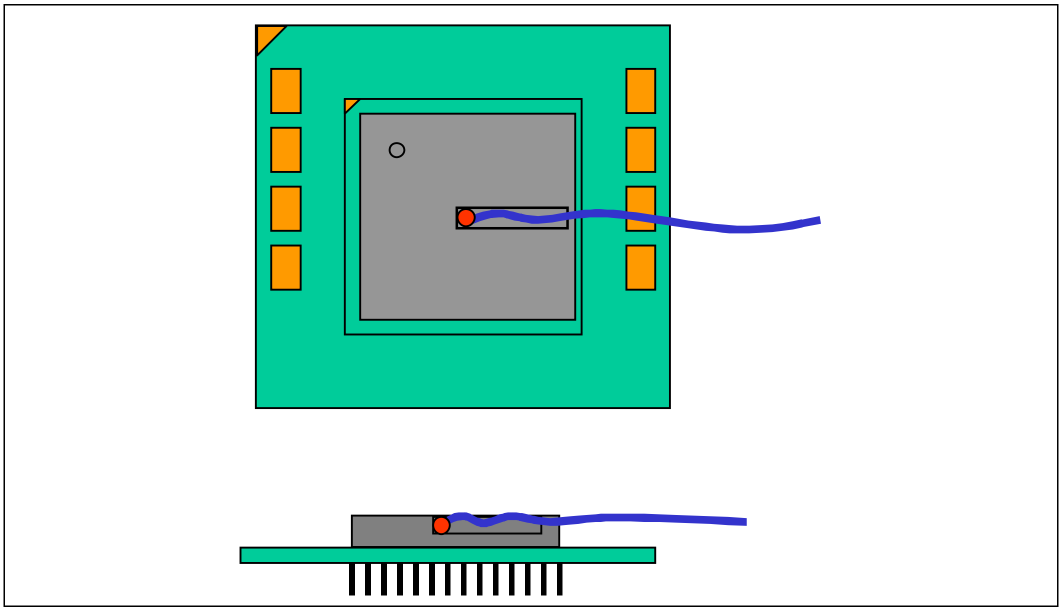
2.3.2.1 Processor Thermocouple Placement

Processor cooling performance is determined by measuring the processor case temperature using a 30-36 AWG thermocouple. The 0° attachment method is recommended for mounting a thermocouple (see Figure 5). This method consists of milling a slot into the top of the processor IHS. For a 36 AWG thermocouple, the recommended depth and width of the channel are 0.4 mm and 0.8 mm, respectively. If larger gauge thermocouple wires are used, the milled slot should only be large enough so that the thermocouple bead and wire do not protrude above the plane of the IHS.

Place the thermocouple in the milled channel with the tip bonded to the surface to be measured. Examine carefully the milled channel and thermocouple placement to ensure that the IHS surface is not compromised by any burrs or epoxy. To ensure direct contact of the thermocouple bead with the IHS channel surface, test for continuity between the thermocouple wire and the heat spreader.

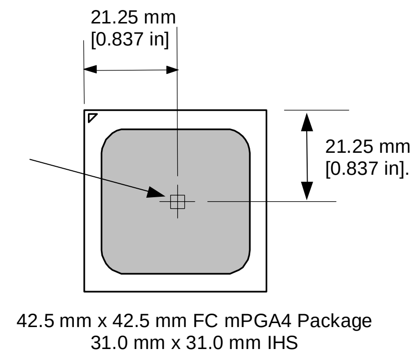
Note: The processor and TTV are extremely fragile components. To avoid damage, pay special attention when milling a channel into the IHS.

Figure 5. 0° Attachment Method



For illustration, the measurement location for a 42.5 mm x 42.5 mm [1.673 in. x 1.673 in.] FC-mPGA4 package with 31 mm x 31 mm [1.22 in. x 1.22 in.] IHS is shown in Figure 6. In case of conflict, the package dimensions in the processor datasheet supersedes dimensions provided in this document.

Figure 6. Processor Case Temperature Measurement Location

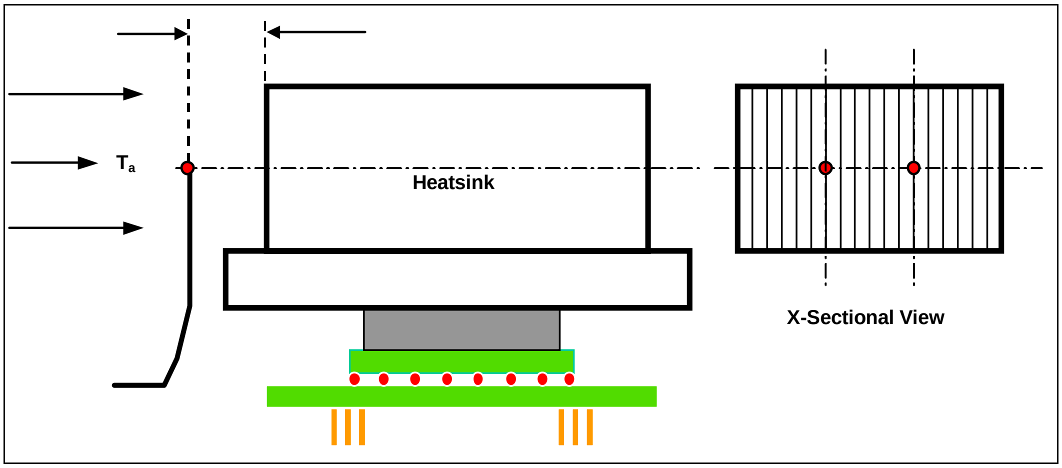


Note: Measure from edge of processor.

2.3.2.2 Processor Local Air Thermocouple Placement

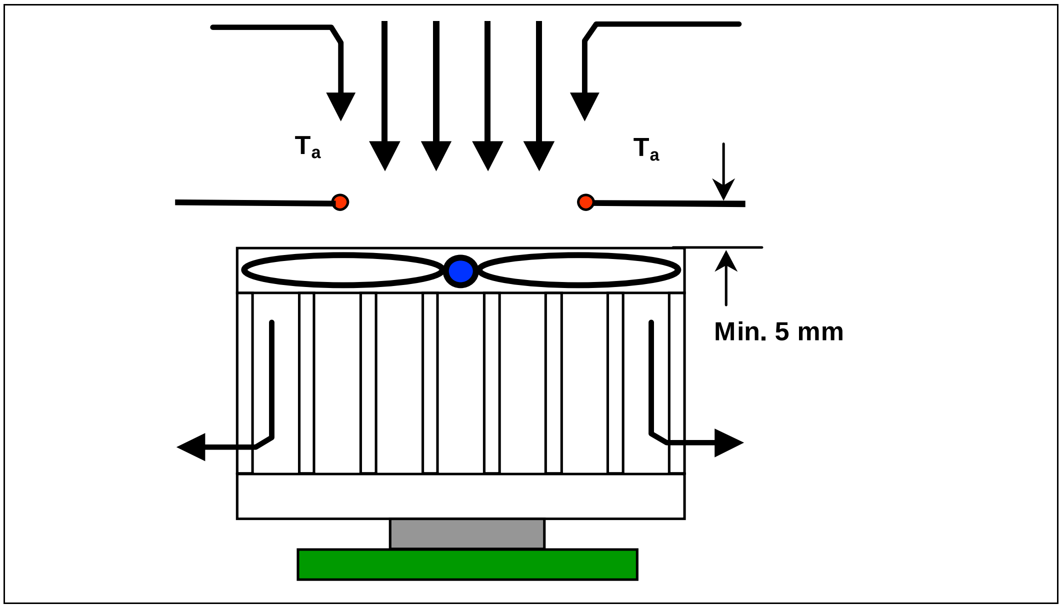
For passive heat sinks, place two thermocouples 10 mm upstream of the processor heat sink. Center the thermocouples with respect to the height of the heat sink fins and evenly across the width of the heat sink as shown in Figure 7.

Figure 7. Local Air Thermocouple Placement for Passive Heat Sinks



For active heat sinks, place four thermocouples on the fan inlet as shown in Figure 8. Mount these thermocouples between 5 mm and 10 mm above the fan. Use the average of these measurements to represent the local inlet temperature to the active heat sink.

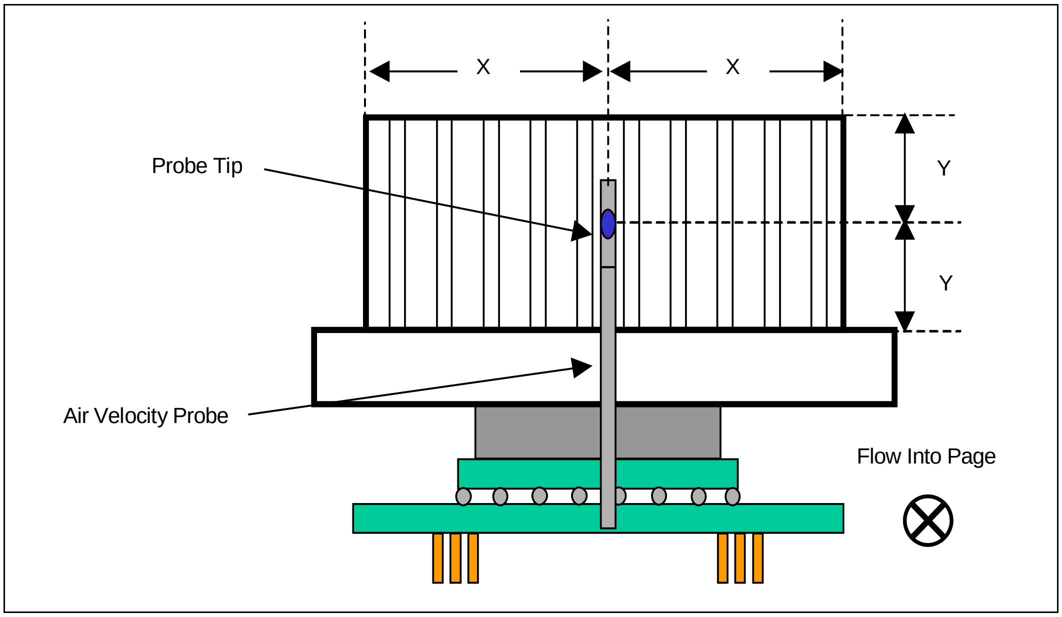
Figure 8. Local Air Thermocouple Placement for Active Heat Sinks (Side View)



2.3.2.3 Processor Local Air Velocity

If measuring the local air velocity is desired, place a single airflow probe no closer than 10 mm upstream of the processor heat sink. Center the probe with respect to the cross-section of the heat sink and the tip perpendicular to the direction of flow (see Figure 9). The recommended air velocity probe can be used to measure both local air temperature and air velocity. Using the dual capability of the probe is highly recommended to minimize the number of measurement devices that may disrupt flow to the processor heat sink.

Figure 9. Local Air Velocity Probe Placement for Passive Heat Sinks

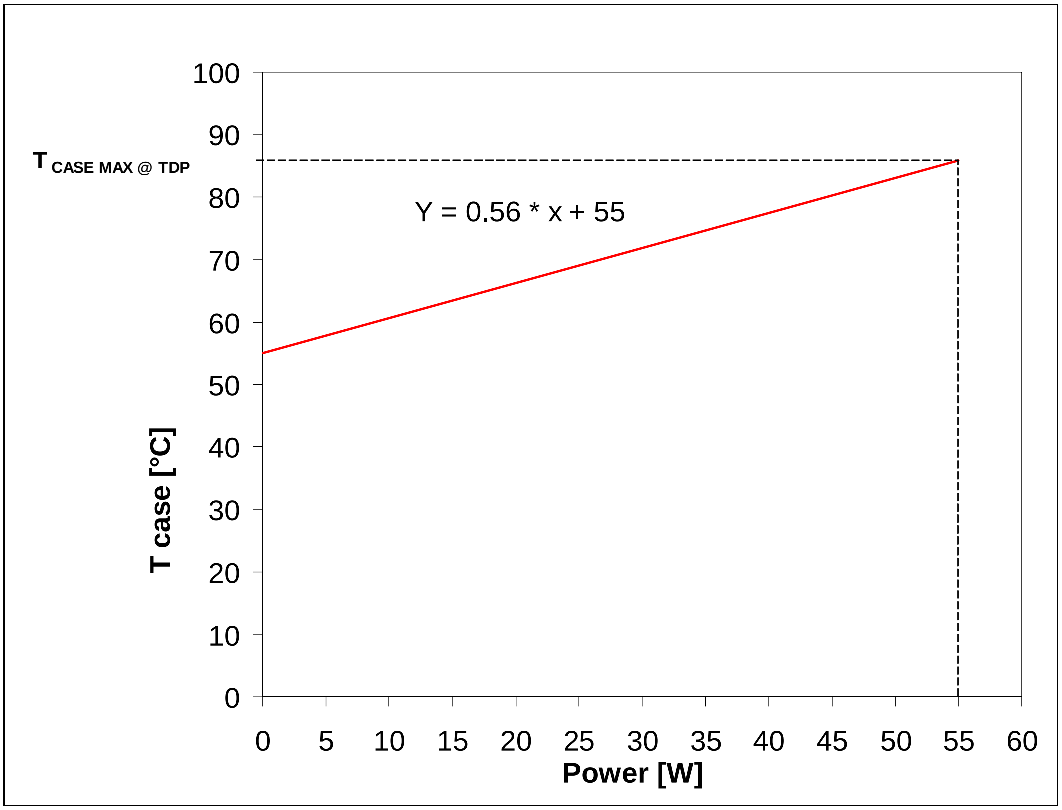


Intel Thermal/Mechanical Reference Designs 3

3.1 Thermal Specifications

The Thermal Profile specifications for the Low Voltage Xeon Processor are published in the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus Datasheet. These Thermal Profile specifications are shown as a reference in Figure 10.

Figure 10. Thermal Profile for the Low Voltage Xeon Processor (800 MHz)



Note: The thermal specifications shown in this graph are for reference only. The datasheet supersedes any data in this figure.

3.2 Reference Heat Sink Performance Targets

Table 3 shows estimates of the thermal performance targets for three distinct thermal solutions for the Xeon and LV Xeon processor family. The thermal solutions for these processors are discussed in more detail in the following sections. The table also includes the processor local ambient temperature (T_{LA}) assumptions for the reference thermal designs at the processor heat sink inlet as discussed Section 2.3.2.2.

Table 3. Intel Reference Heat Sink Performance Targets for the Low Voltage Xeon Processor (800 MHz)

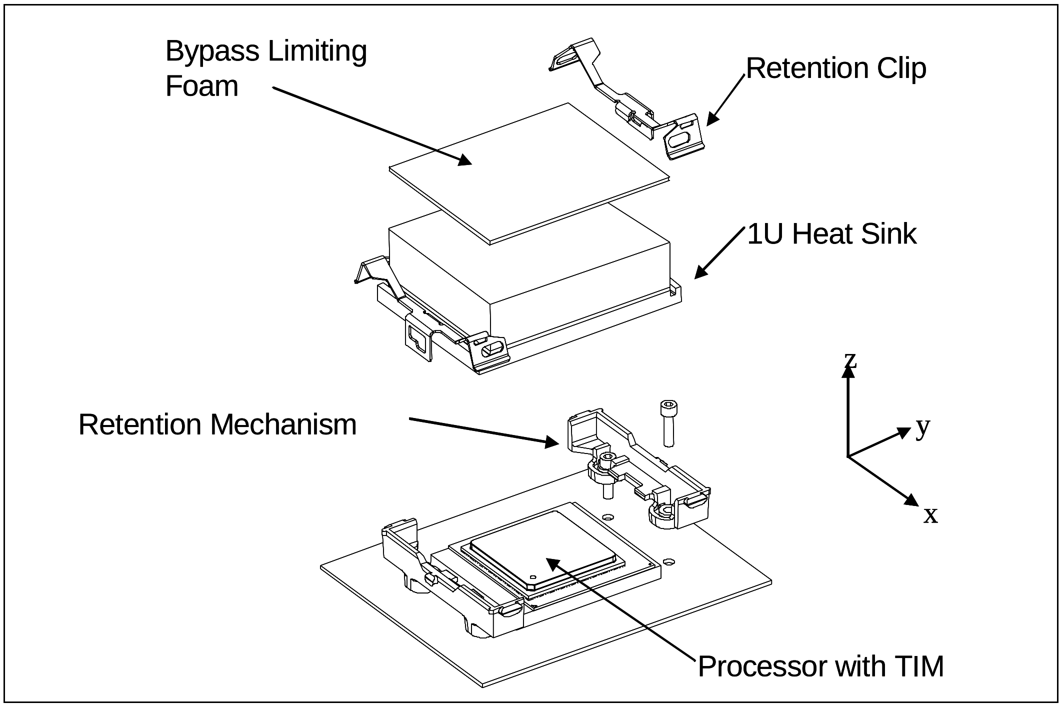
Thermal Solution Type	T_{LA} Assumption (°C)	Thermal Performance Target, Ψca (Mean + 3σ)(°C/W)
1U Form Factor, Minimized Footprint, Crimped Fin	55° C	0.53
AdvancedTCA* Form Factor	40° C	0.84
2U+ Form Factor	55° C	0.305
1U Form Factor	55° C	0.384

3.2.1 Recommended Heat Sink Designs

3.2.1.1 1U Copper Crimped-Fin Heat Sink Design

This 1U heat sink design is for use with the Minimized Footprint PCB keep-out zones and is the same heat sink enabled for the Intel Xeon™ processor with 512 Kbytes L2 cache. See Figure 11 for an exploded view of this thermal solution.

Figure 11. Exploded View of Thermal Solution Components for 1U



This heat sink was designed to meet the required thermal performance in the 1U Server System Infrastructure (SSI) form factor. The all copper passive heat sink with 32 fins is based on the crimped-fin technology, as shown in Figure 31. A Mylar* backed foam bypass limiter (Figure 32) is attached to the heat sink to achieve zero bypass at the top of the heat sink. The bypass at the sides is limited to 2.5 mm [0.1 in] maximum. ShinEtsu G751 thermal interface material is used for the heat sink.

Table 4 summarizes the case-to-ambient thermal resistance, Ψ_{CA}, and pressure drop of this heat sink.

Table 4. Thermal Performance of 1U Intel Reference Heat Sink

Volumetric Airflow (CFM)	Thermal Performance Target, Ψca (Mean + 3σ)(°C/W)	Heat Sink Pressure Drop (in H_2O)
10.0	0.53	0.12

3.2.1.2 Thermal Profile Adherence

The 1U copper crimped-fin heat sink reference thermal solution is designed to meet the Thermal Profile for the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus. From Table 4, the performance of the thermal solution is computed to be 0.53 °C/W at 10 CFM flow rate. As indicated in Table 3, the processor local ambient temperature (T_{LA}) for this thermal solution can be as high as 55° C. Hence, the Thermal Profile equation for this thermal solution is calculated as:

$y = 0.53x + 55$

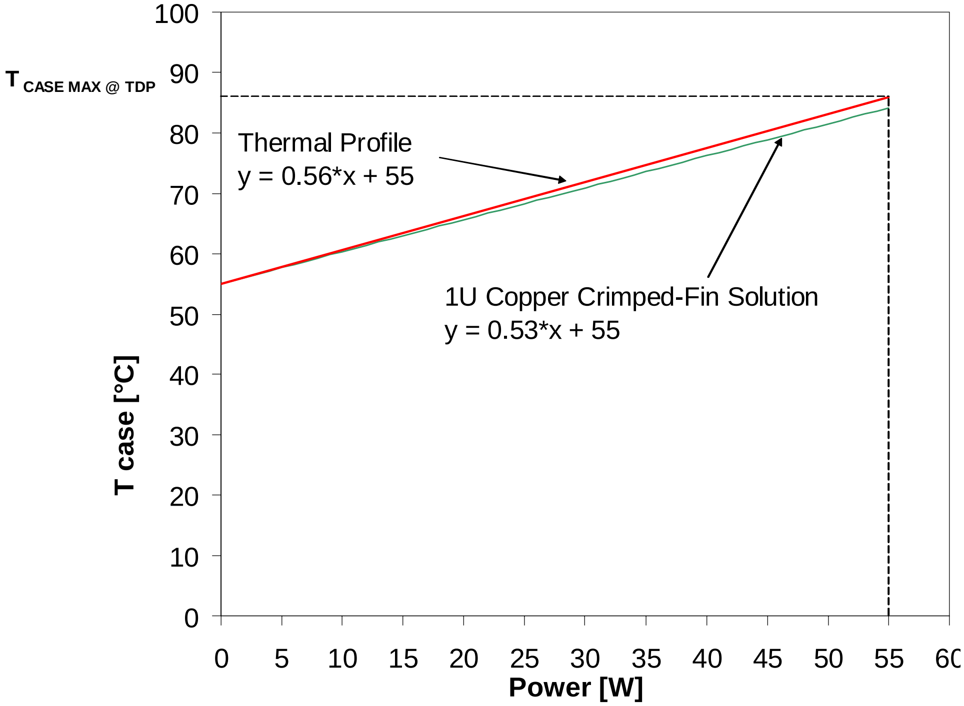
where:

y = Processor T_{CASE} value (°C)

x = Processor power value (W)

Figure 12 below shows the comparison of this reference thermal solution's Thermal Profile to the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus Thermal Profile specification. The 1U copper crimped-fin heat sink solution meets the Thermal Profile with no margin at the lower end and a 1.8° C margin at the upper end (TDP). Lowering T_{LA} will result in increased margin at both the upper and lower ends of the thermal profile.

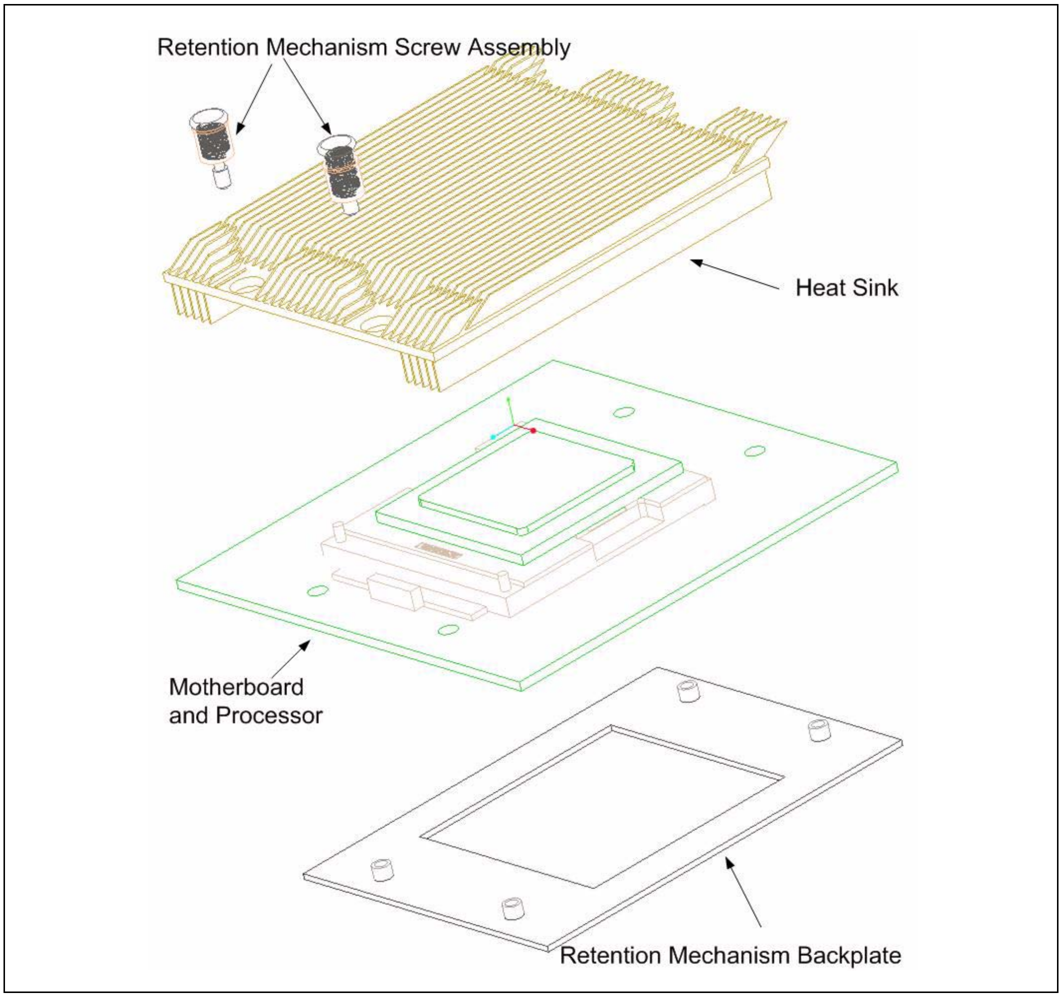
Figure 12. 1U Heat Sink Adherence to the Low Voltage Xeon Processor (800 MHz) Thermal Profile



3.2.1.3 AdvancedTCA* Heat Sink Design

Intel has developed a reference thermal solution and retention mechanism specifically for the AdvancedTCA form factor. See Figure 13 for an exploded view of this thermal solution and retention mechanism.

Figure 13. Exploded View of Thermal Solution Components for AdvancedTCA*



To use the Low Voltage Xeon Processor in the AdvancedTCA form factor, considerations must be made, including:

1. In a uniprocessor (UP) configuration, the amount of airflow required through a slot must be on par with AdvancedTCA requirement of approximately 28 CFM. This is based on the assumption that a PCB with one processor will dissipate approximately 150 W. This correlates to the required airflow needed to cool a slot with a given power load. The airflow requirement includes the pressure drop associated with the PCB and chassis.
2. In a dual processor (DP) configuration, the amount of airflow required through a slot is approximately 36 CFM. It is assumed that in a DP configuration, the total board power is approximately 200 W. Since total board power is limited to 200 W, care must be taken when designing a DP Low Voltage Xeon Processor AdvancedTCA blade so the power delivery limit

is not exceeded. Designing a DP Low Voltage Xeon Processor blade is as much a power delivery issue as a thermal issue.

The AdvancedTCA heat sink design presented in this document is based on the airflow condition for the UP configuration. Additional airflow provided in the DP configuration will further improve the performance of the heat sink. In the case of a DP configuration, the processors should be placed in the preferred orientation (parallel to airflow) as shown in Figure 22 on page 38. In the preferred orientation, the airflow velocity to each processor will be approximately the same. In addition, the processors will not negatively preheat the air of the other processor.

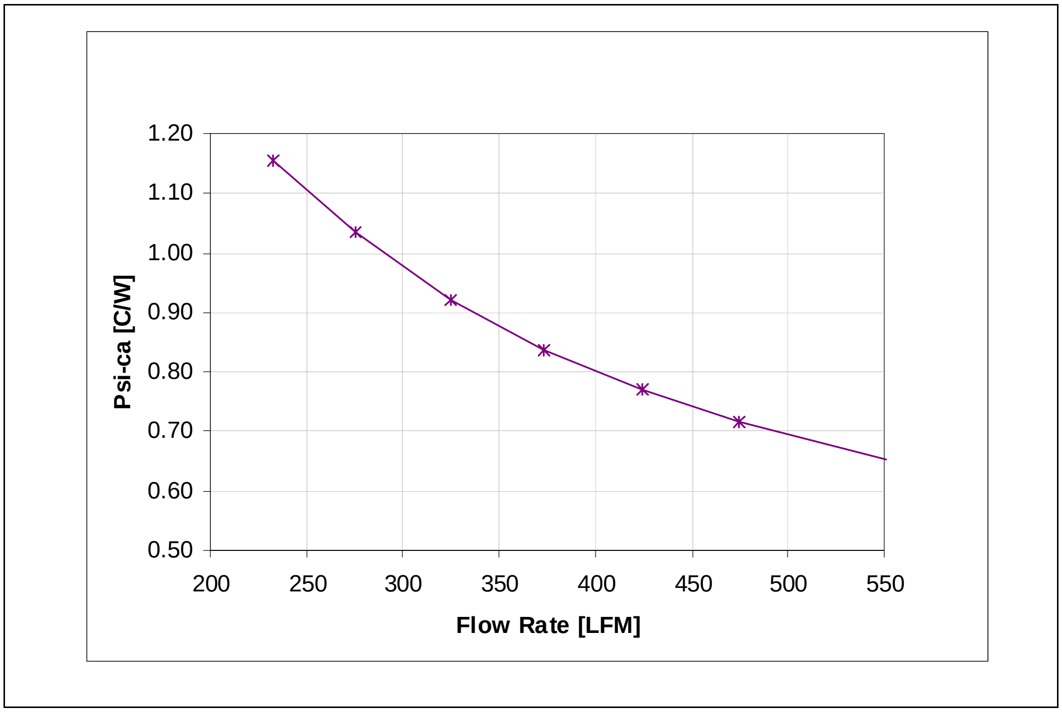
Note: This heat sink design is intended only for use with the Low Voltage Xeon Processor. It is not feasible for use with the full-power Xeon processor.

This heat sink was designed to meet the required thermal performance for the AdvancedTCA form factor (PICMG 3.0 Specification). The heat sink shown in Figure 33 on page 52 was optimized using computer-modeling software. The heat sink is optimized for non-ducted airflow as measured approximately one inch upstream from the processor.

Thermal modeling and verification tests indicate that this heat sink has a case-to-ambient thermal resistance of 0.84 C/W at 370 LFM inlet velocity. With careful processor placement, 28 CFM volumetric flow rate can provide greater than 370 lfm local inlet velocity to the heat sink. The thermal performance curve for different airflow approach velocities is shown in Figure 14.

The geometry of the heat sink is optimized for the high volume manufacturing method of skived fin technology. A list of enabled vendors is provided in Appendix , "Vendor List". Customers can also use their preferred heat sink supplier to manufacture this heat sink. Drawings are available upon request.

Figure 14. AdvancedTCA* Heat Sink Thermal Performance Curve



3.2.1.4 Thermal Profile Adherence

The AdvancedTCA Heat Sink reference thermal solution is designed to meet the thermal profile for the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus. From Figure 14, the performance of the thermal solution is computed to be 0.84 °C/W at 370 LFM. As indicated in Table 3, "Intel Reference Heat Sink Performance Targets for the Low Voltage Xeon Processor (800 MHz)" on page 26, the processor local ambient temperature (T_{LA}) for this thermal solution is 40 °C. Hence, the thermal profile equation for this thermal solution is calculated as:

$y = 0.84x + 40$

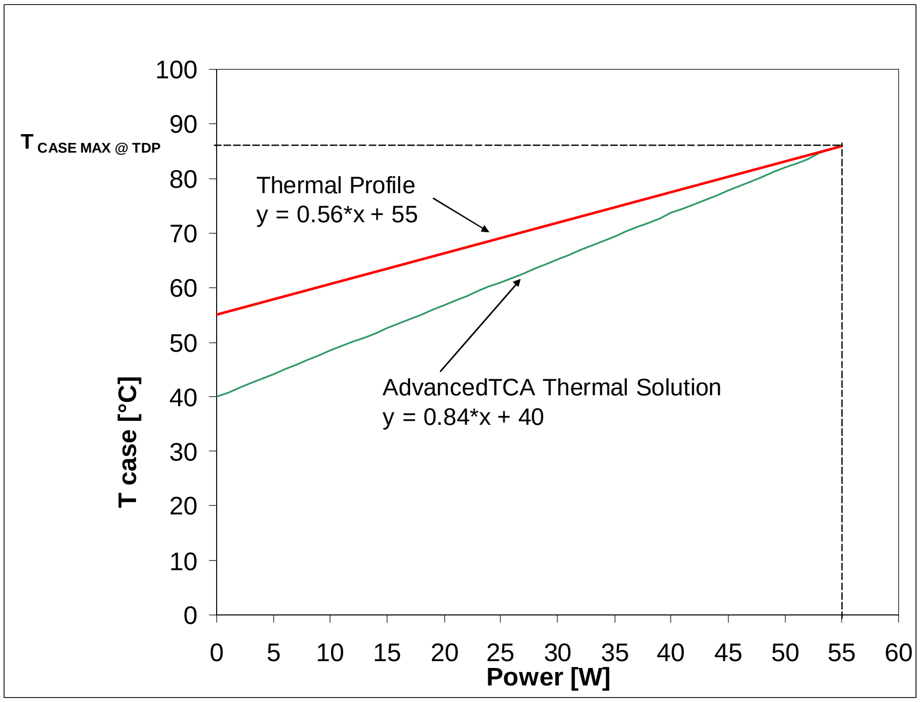
where

y = Processor T_{CASE} value (°C)

x = Processor power value (W)

Figure 15 shows the comparison of this reference thermal solution's thermal profile to the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus thermal profile specification. The AdvancedTCA heat sink solution meets the thermal profile with a 15 °C margin at the lower end and no margin at the upper end (TDP).

Figure 15. AdvancedTCA* Heat Sink Adherence to the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus Thermal Profile



3.2.1.5 1U, 2U, and Active Heat Sink Designs for Use with the Intel® Xeon™ Processor with 800 MHz System Bus Compatible PCB Keep-Out Zone

Intel has developed a reference thermal solution and retention scheme called the CEK. The CEK is designed to extend the air-cooling capability for the Xeon processors.

The CEK supports the thermal targets of for all Xeon processors and consists of the following components:

- Heat sink
- Thermal interface material (TIM)
- Hat spring
- Heat sink standoffs
- Heat sink screws

Figure 16 shows the exploded view of the thermal solution components (except for the TIM).

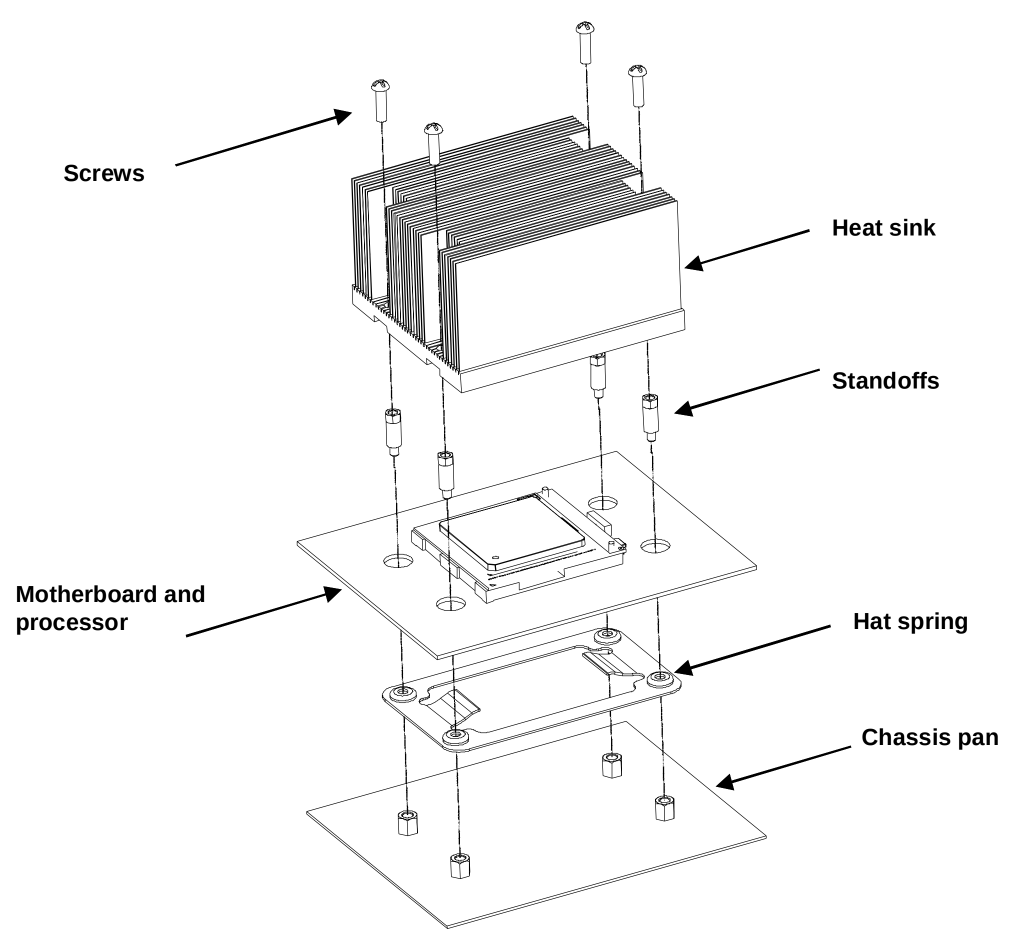
The CEK is designed to extend air-cooling capability through the use of larger heat sinks with minimal airflow blockage and bypass. The CEK enables the use of much heavier heat sink masses compared to legacy limits by using a load path directly attached to the chassis pan. The hat spring on the secondary side of the baseboard provides the necessary compressive load for the thermal interface material. The baseboard is intended to be isolated such that the dynamic loads from the heat sink are transferred to the chassis pan via the stiff screws and standoffs. This reduces the risk of package pullout and solder joint failures.

Although the CEK heat sink fits into the legacy volumetric keep-in, it has a larger footprint due to the elimination of retention mechanism and clips used in the older enabled thermal/mechanical components. This allows the heat sink to grow its base and fin dimensions, further improving the thermal performance. Due to the enlarged size and the use of copper for both the base and fins, the CEK heat sink is estimated to weigh twice as much as previous heat sinks used with Intel Xeon processors. However, the CEK's retention scheme is designed to support heavy heat sinks (up to approximately 1000 grams) when exposed to shock, vibration and installation.

The baseboard mounting holes for the CEK solution are in the same location as the holes used for previous Intel Xeon processors. However, the CEK assembly requires larger diameter holes.

Details of the CEK design for 1U, 2U, and 3U sized solutions can be found in the Intel® Xeon™ Processor with 800 MHz System Bus Thermal/Mechanical Design Guidelines. The heat sink screws and standoffs are commercially available standard parts.

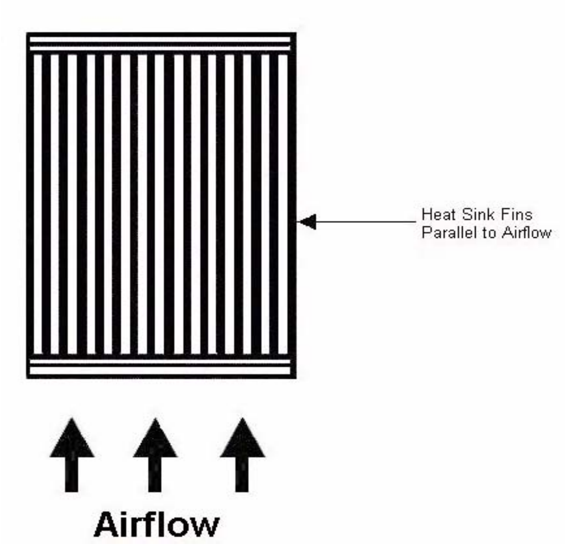
Figure 16. Common Enabling Kit (CEK) Thermal Solution Components



3.2.1.6 Heat Sink Orientation Relative to Airflow

All of the heat sinks were designed to maximize the available space within the volumetric keep-out zone and their respective form factor limitations. These heat sinks must be oriented in a specific direction relative to the processor keep-out zone and airflow. In order to use these designs, the processor must be placed on the PCB in an orientation so the heat sink fins will be parallel to the airflow. Figure 17 illustrates this orientation.

Figure 17. Heat Sink Orientation Relative to the Processor & Airflow



3.2.2 Recommended Thermal Interface Material (TIM)

It is important to understand the impact the interface between the processor and heat sink base has on the overall thermal solution. Specifically, the bond line thickness, interface material area, and interface material thermal conductivity must be managed to optimize the thermal solution.

It is important to minimize the thickness of the thermal interface material, commonly referred to as the bond line thickness. A large gap between the heat sink base and processor case will yield a greater thermal resistance. The thickness of the gap is determined by the flatness of both the heat sink base and the IHS, plus the thickness of the thermal interface material (i.e., thermal grease), and the clamping force applied by the heat sink attachment clips. To ensure proper and consistent thermal performance, the TIM and application process must be properly designed.

The heat sink solutions were optimized using a high performance phase change TIM with low thermal impedance. The heat sinks were prototyped and verified using ShinEtsu* G751 thermal grease with 400 ± 5 mg dispersed evenly over the IHS surface. Vendor information for this material is provided in Section 4, “Vendor List” on page 39. Alternative materials can be used at the user’s discretion. The entire heat sink assembly must be validated together for specific applications, including the heat sink, mounting hardware, and thermal interface material.

3.2.3 Recommended Heat Sink Attachment Method

The heat sinks for the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus compatible with the previous generation Xeon processor keep-out and mounting method are secured to the processor assembly with two pressure-loaded clips. The clips apply force to the heat sink base to maintain a desired pressure on the thermal interface material between the IHS and heat sink, and to hold the heat sink in place during dynamic loading. The reference design heat sink clip attaches to the heat sink base via the grooves at each end of the base. The clips are latched to the reference design retention mechanism (RM) clip tabs, which are located at each end of the RM. Two clips and RMs are required per heat sink assembly.

The CEK uses four screws and standoffs that are fastened directly to the computer chassis.

The AdvancedTCA thermal solution uses four screw/spring/retainer assemblies along with a backplate to maintain the desired pressure on the thermal interface material. The screw/spring/retainer assembly is designed to have a low profile to minimize blocking airflow through the heat sink and applies a maximum load of 50 lbs.

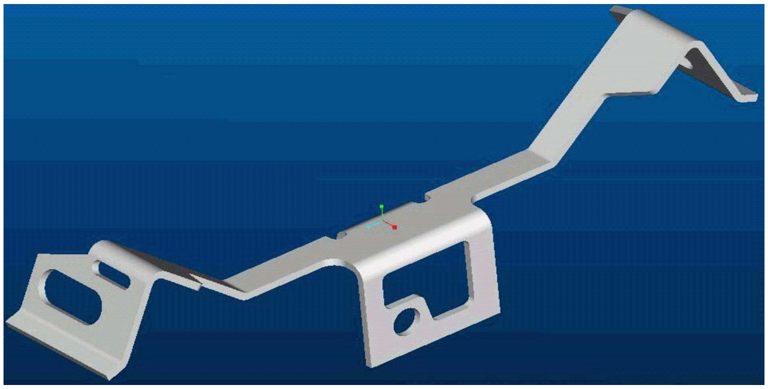
Detailed information for all three attachment methods is contained in the following sections.

3.2.3.1 Heat Sink Clip for Minimized Footprint Solution

This heat sink clip, Intel part number A74694, shown in Figure 18, is for use with the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus. This is the same clip used for the Low Voltage Xeon™ and Xeon processors with 512 Kbytes L2 Cache. The clips may be susceptible to deformation during any rework or upgrade procedure that requires the heat sink assembly to be disassembled. Therefore, the system integrator must exercise caution in reusing clips that have experienced multiple assembly-disassembly cycles.

Caution: To ensure adequate thermal performance, make sure the proper clip is being used, since a variety of similar clips is available for other processor packages. A list of vendors is available in Section 4, “Vendor List” on page 39.

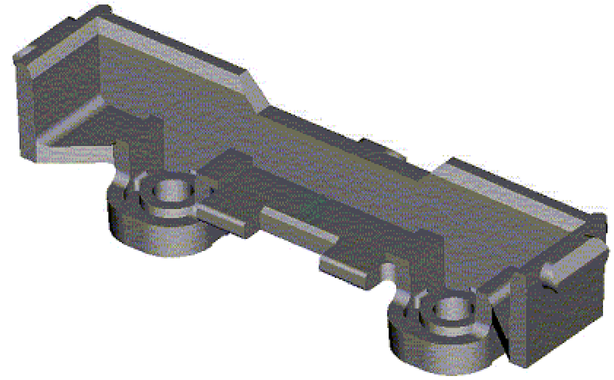
Figure 18. Heat Sink Clip (Intel P/N A74694)



3.2.3.2 Retention Mechanism for Minimized Footprint Solution

The reference design retention mechanism, Intel part number A34684, shown in Figure 19, is for use with the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus. This is the same retention mechanism used for the Low Voltage Xeon and Xeon processors with 512 Kbytes L2 Cache. A list of vendors is available in Section 4, “Vendor List” on page 39.

Figure 19. Retention Mechanism (Intel P/N A34684)



3.2.3.3 Hat Spring for CEK Solution

The hat spring, used with the CEK, is made from 0.030" thick (22 gauge) 1050 steel heat-treated to a Rockwell C of 40-42. The hat spring has four embosses, called hats, which, when assembled, rest on the top of the chassis standoffs. The purpose of the hat spring is to provide compressive preload at the TIM interface when the baseboard is pushed down upon it. This spring does **not** function as a clip. It is cradled in the back plate that resides beneath the baseboard. Refer to Figure 16 for an illustration of this component.

3.2.3.4 Standoffs & Screws for CEK Solution

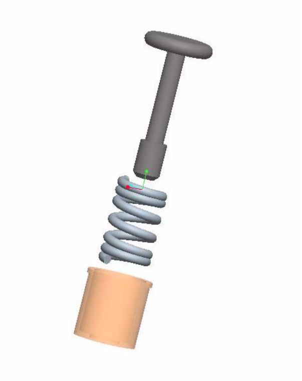
The standoffs and screws are used with the CEK. The standoff provides a bridge between the chassis and the heat sink for attaching and load carrying. When assembled, the heat sink is rigid against the top of the standoff, and the standoff is rigid to a chassis standoff, with the hat spring firmly sandwiched between the two. In dynamic loading situations, the standoff carries much of the heat sink load, especially in lateral conditions, compared to the amount of load transmitted to the processor package. As such, it is composed of steel. Refer to Figure 16 for an illustration of this component.

The function of the screw is to provide a rigid attach method to sandwich the entire CEK assembly together, activating the hat spring under the baseboard, thus providing the TIM preload. A screw is an inexpensive, low profile solution that does not negatively impact the thermal performance of the heat sink due to air blockage. Any fastener (i.e., head configuration) can be used as long as it is of steel construction, the head does not interfere with the heat sink fins, and it is of the correct length of 0.5". Refer to Figure 16 for an illustration of this component.

3.2.3.5 Screw/Spring/Retainer Assembly for AdvancedTCA* Solution

The screw/spring/retainer assembly (Figure 20) provides the desired load on the thermal interface material. The screw functions as a rigid attach method between the backplate and the heat sink. When the screw is tightened, it compresses the spring against the retainer and thus increasing the load applied to the heat sink and processor package. The four springs are designed to apply a combined load of 50 lbs. The retainer functions as a locating mechanism for the spring and screw and limits the spring compression to prevent coil bind via the screw head contacting the retainer.

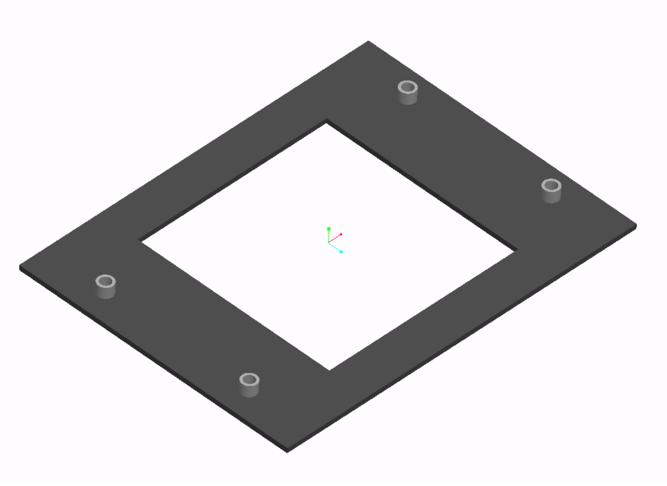
Figure 20. Screw/Spring/Retainer Assembly for AdvancedTCA*



3.2.3.6 Backplate for AdvancedTCA* Solution

The backplate secures the heat sink and fastener assembly to the motherboard. It also provides structural support to the motherboard. The backplate makes contact with the secondary side of the motherboard and cannot contact any components. See Figure 21.

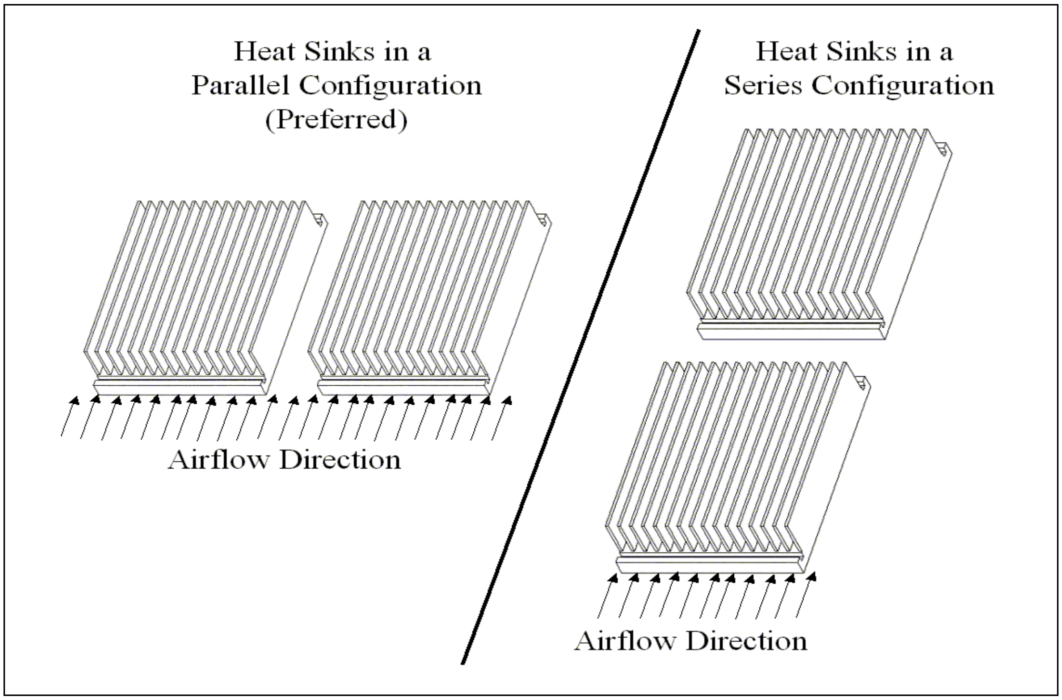
Figure 21. Backplate for AdvancedTCA*



3.2.4 Dual Processor Considerations

The heat sink designs presented are suitable for use in dual-processor configurations. However additional precautions must be taken with the orientation of the processors on the motherboard. The results of computer modeling and testing indicate that processors placed in series, that is one processor placed directly behind the other relative to the airflow, will have a higher CPU temperature when compared to processors placed in parallel (side-by-side relative to the airflow). As a result, it is strongly recommended that the processors be placed in the parallel configuration for optimized thermal performance. Figure 22 illustrates the preferred configuration.

Figure 22. Preferred Orientation for a Dual-Processor Application



Vendor List

4

Table 5 provides a vendor list. This list is for reference only.

Table 5. Vendor List

Part Description	Part Number	Vendor	Contact
1U Copper Crimped-Fin Heat Sink	Intel part # A78738	Furukawa America	(408) 232-9306
1U Heat Sink Bypass Gasket	Intel part # A88201	Boyd Corporation 6136 NE 87th Ave Portland, OR 97220	(503) 972-3181
Heat Sink Clips	Intel part # A74694	Foxconn 1699 Richard Ave. Santa Clara, CA 95050	(408) 916-6178
Retention Mechanism	Intel part # A34684		
Thermal Interface Material	Vendor part # G751	Shin-Etsu Micro Si, Inc. 10028 S. 51st St. Phoenix, AZ 85044	(480) 893-8898
AdvancedTCA Heat Sink	Vendor part # 600003890	Cooler Master 603 1st Avenue, Unit 2C Raritan, NJ 08869	(908) 252-9400
AdvancedTCA Screw/Spring Assembly	Vendor part # 600003900		
AdvancedTCA Backplate	Vendor part # 302002290		
AdvancedTCA Heat Sink/ Screw/Spring Backplate Assembly	Vendor part # ECC-00113-01		
CEK Heat Sinks and Components	Refer to the Intel® Xeon™ Processor with 800 MHz System Bus Thermal/ Mechanical Design Guidelines		

Mechanical Drawings 5

This section contains the mechanical drawings for the Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus.

Note: These drawings are provided for reference only. Intel reserves the right to change the design without notice.

Figure 23. Retention Mechanism Keep-Out Zone for the Intel® Xeon™ Processor with 512 KB L2 Cache Compatible Designs, Minimized Footprint

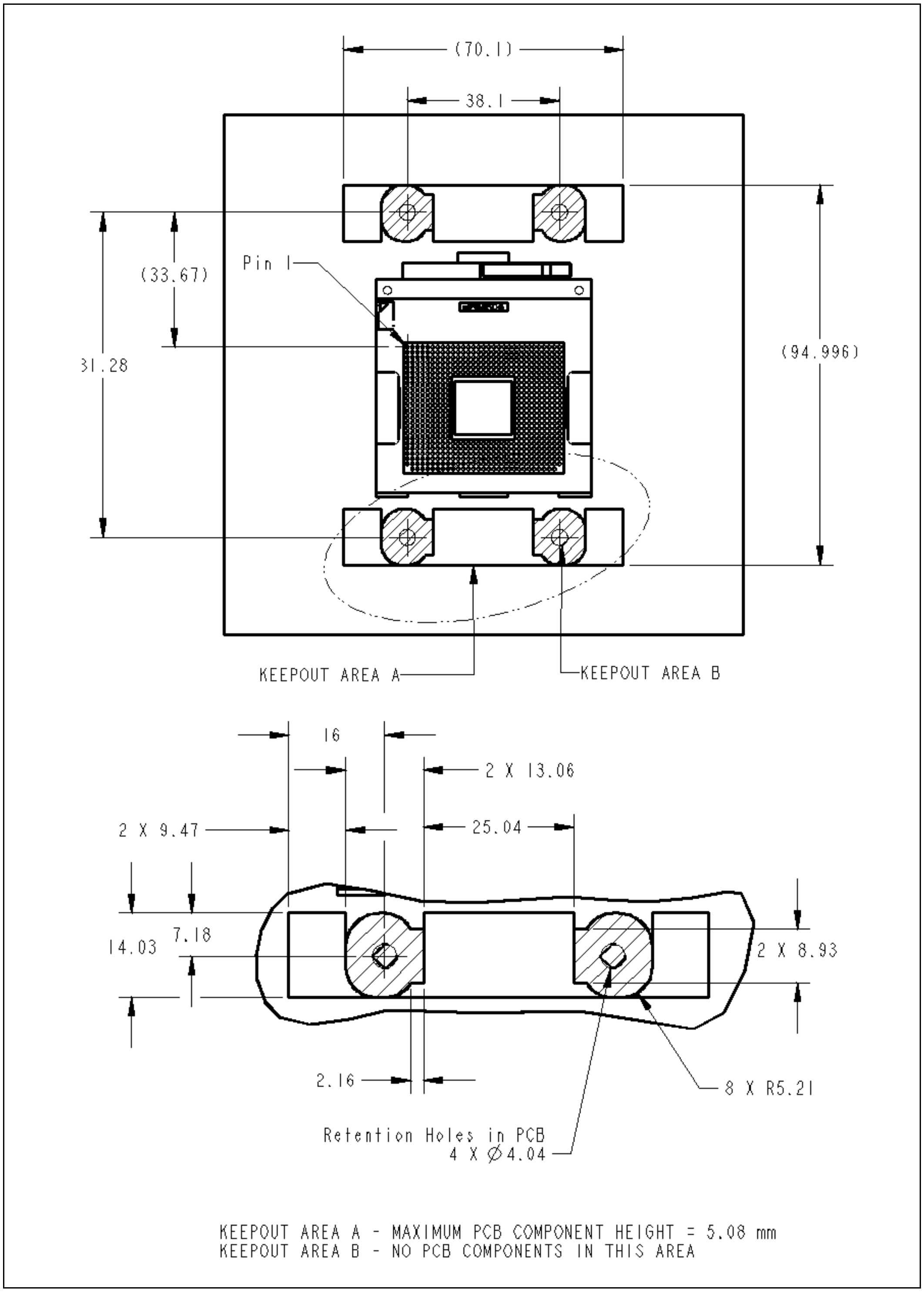
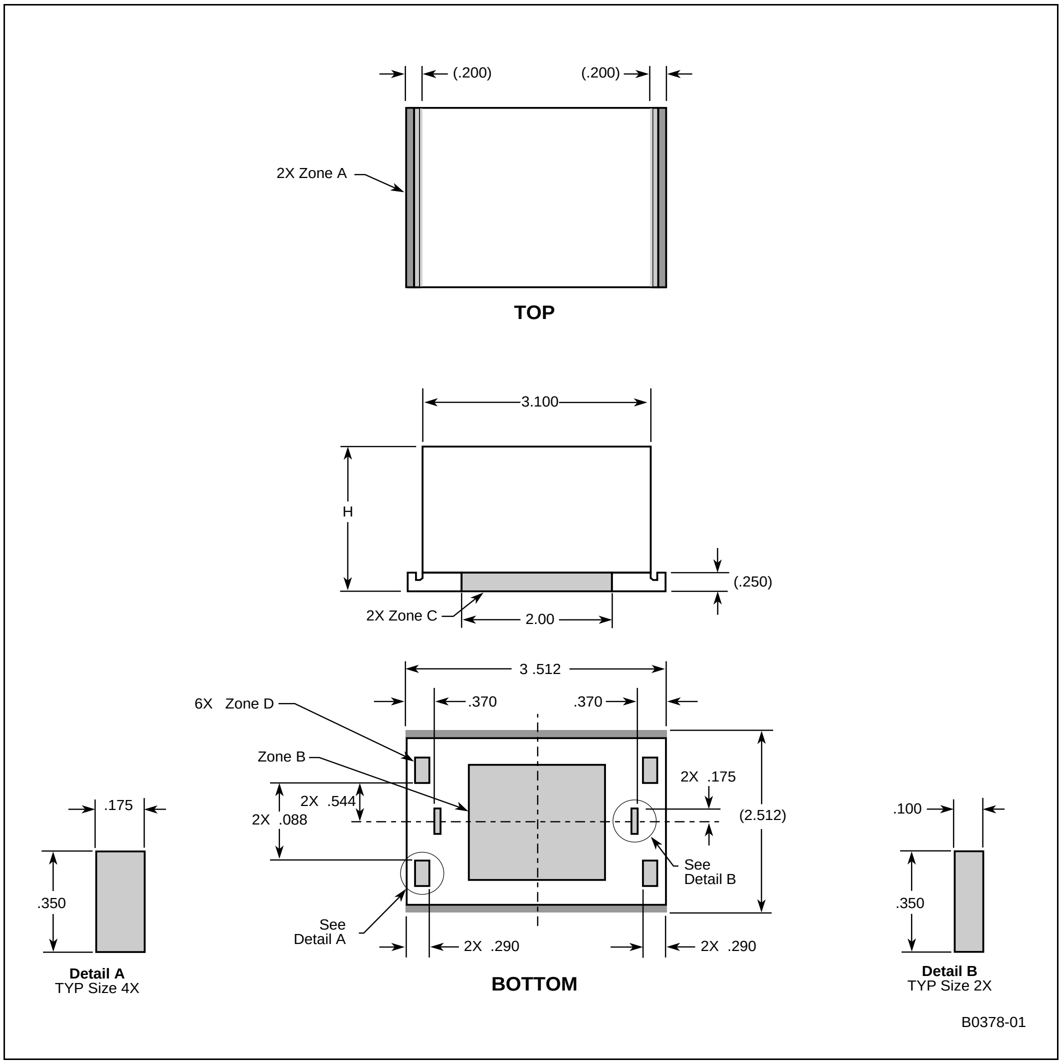


Figure 24. Heat Sink Keep-In Zone for the Intel® Xeon™ Processor with 512 KB L2 Cache Compatible Designs, Minimized Footprint



NOTES:

1. The fin structure assembled to the top surface of the base may not intrude on Zone A.
2. Flatness Zone B is required for processor referencing and thermal interface application.
3. The area in Zone C must be flat and perpendicular to the base of the heat sink and electrically conductive.
4. The area in Zone D must be flat and electrically conductive.
5. Units in inches.
6. H* is limited by embedded form factor.
7. 1U: H = 1.00”
8. AdvancedTCA*: H* = 0.46 in.

Figure 25. Baseboard Keep-Out Footprint Definition and Height Restrictions for the Intel® Xeon™ Processor with 800 MHz System Bus Processor-Compatible Designs (Sheet 1 of 5)

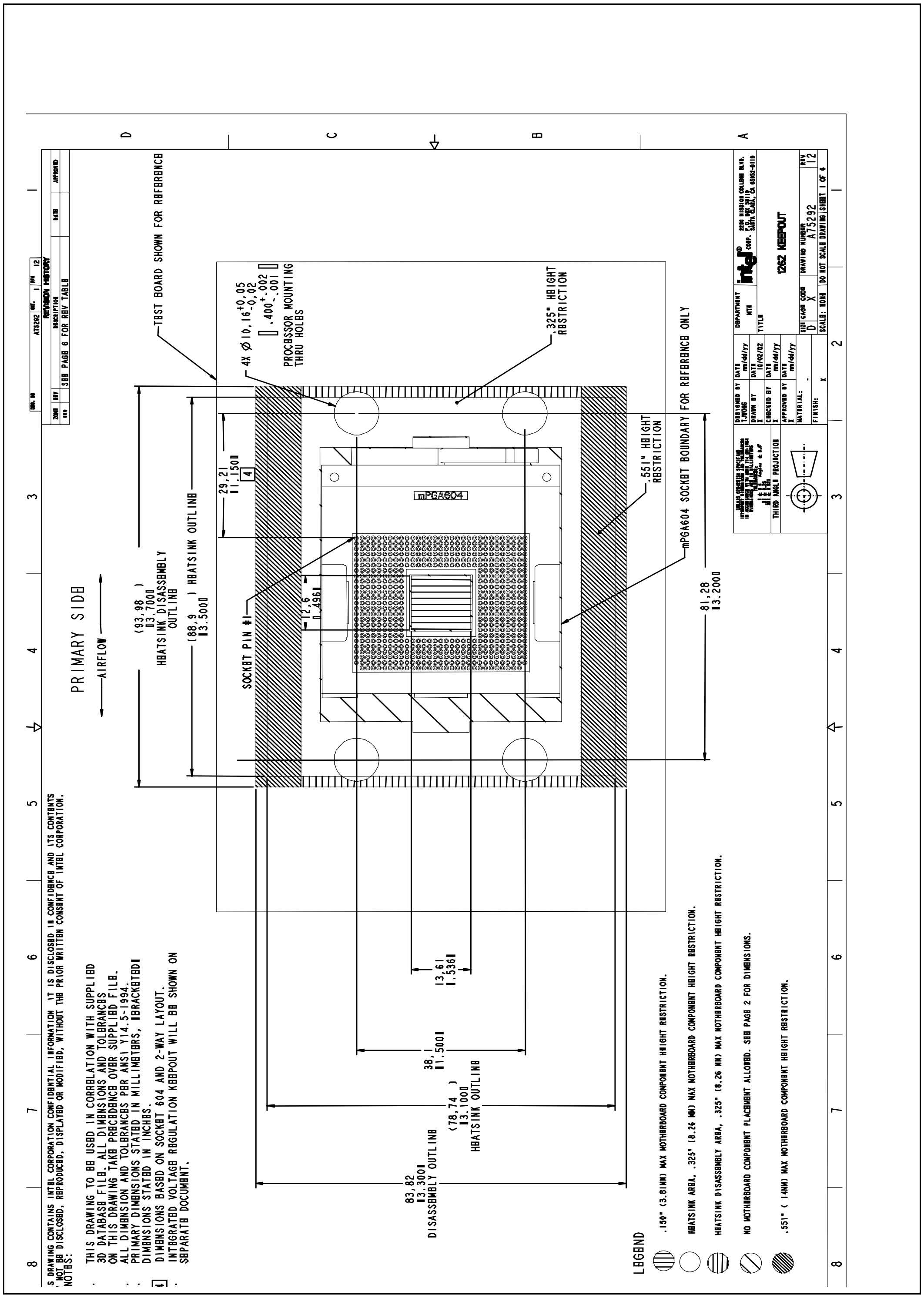


Figure 26. Baseboard Keep-Out Footprint Definition and Height Restrictions for the Intel® Xeon™ Processor with 800 MHz System Bus Processor-Compatible Designs (Sheet 2 of 5)

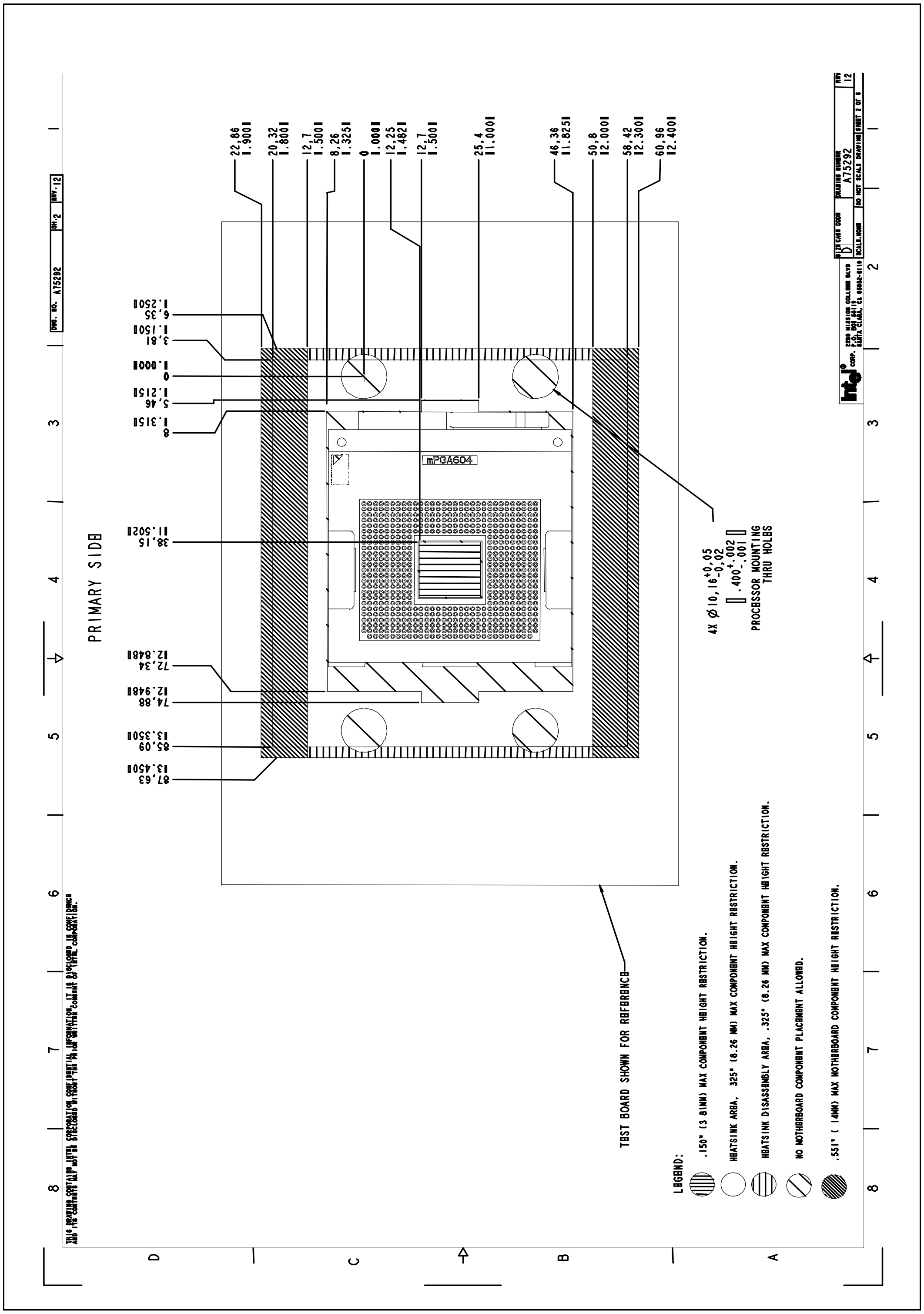


Figure 27. Baseboard Keep-Out Footprint Definition and Height Restrictions for the Intel® Xeon™ Processor with 800 MHz System Bus Processor-Compatible Designs (Sheet 3 of 5)

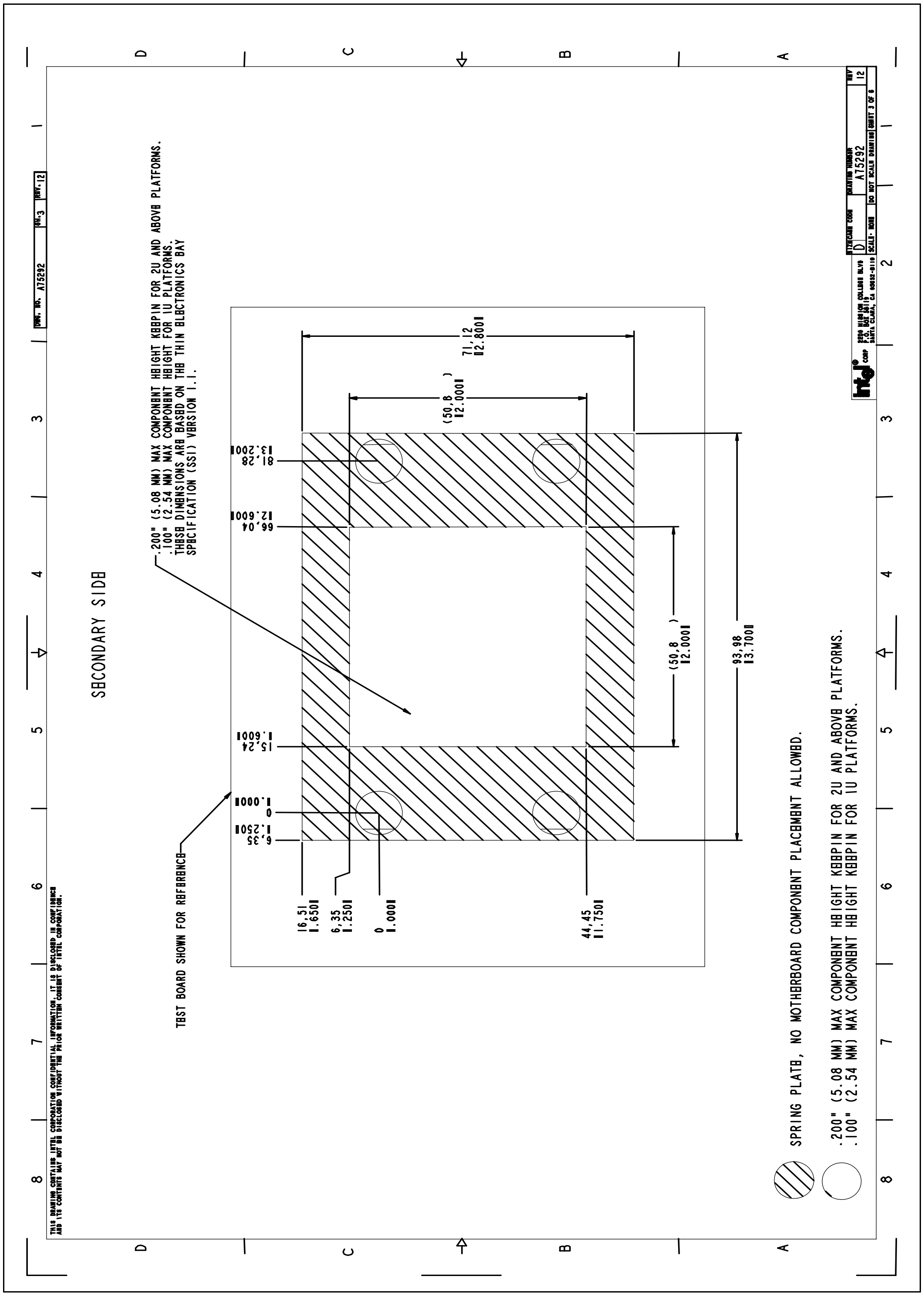


Figure 28. Baseboard Keep-Out Footprint Definition and Height Restrictions for the Intel® Xeon™ Processor with 800 MHz System Bus Processor-Compatible Designs (Sheet 4 of 5)

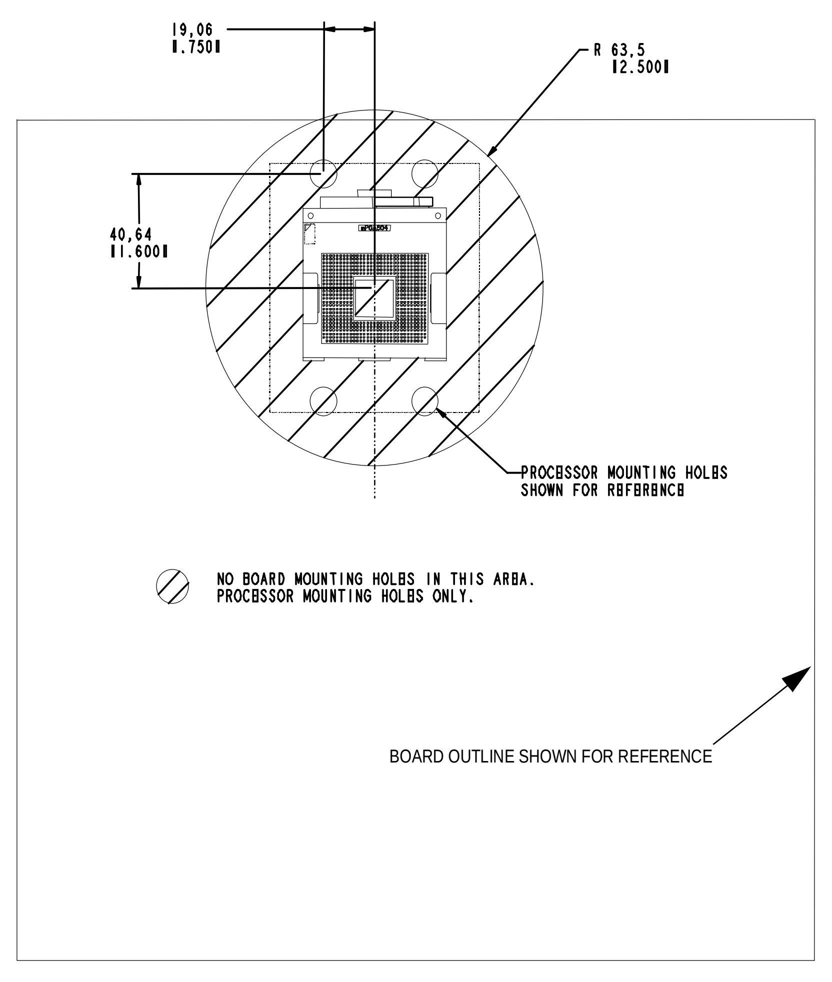


Figure 29. Baseboard Keep-Out Footprint Definition and Height Restrictions for Intel® Xeon™ Processor with 800 MHz System Bus Processor-Compatible Designs (Sheet 5 of 5)

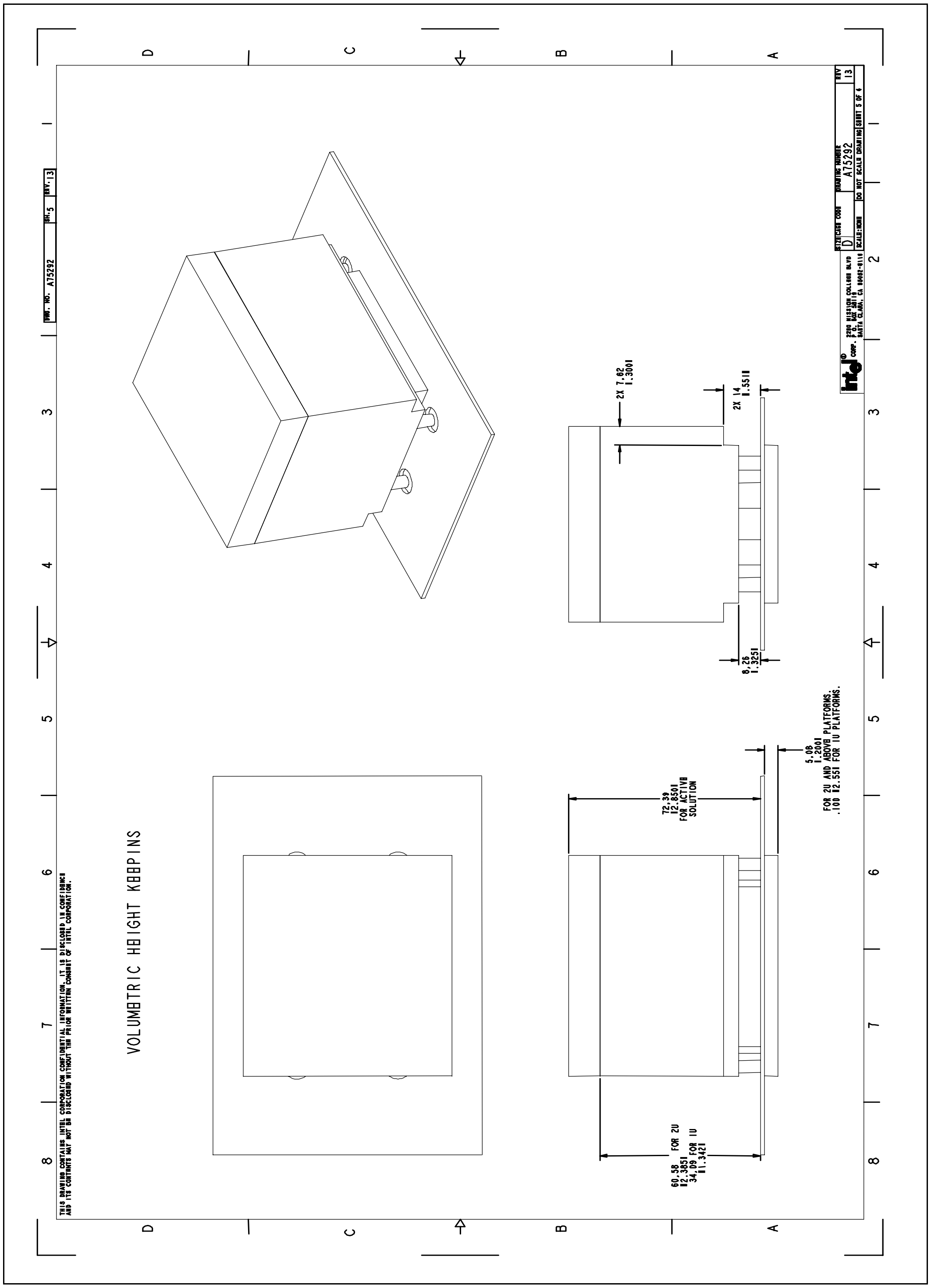


Figure 30. Baseboard Keep-Out Footprint Definition and Height Restrictions for Low Voltage Intel® Xeon™ Processor with 800 MHz System Bus AdvancedTCA* Form Factor Designs

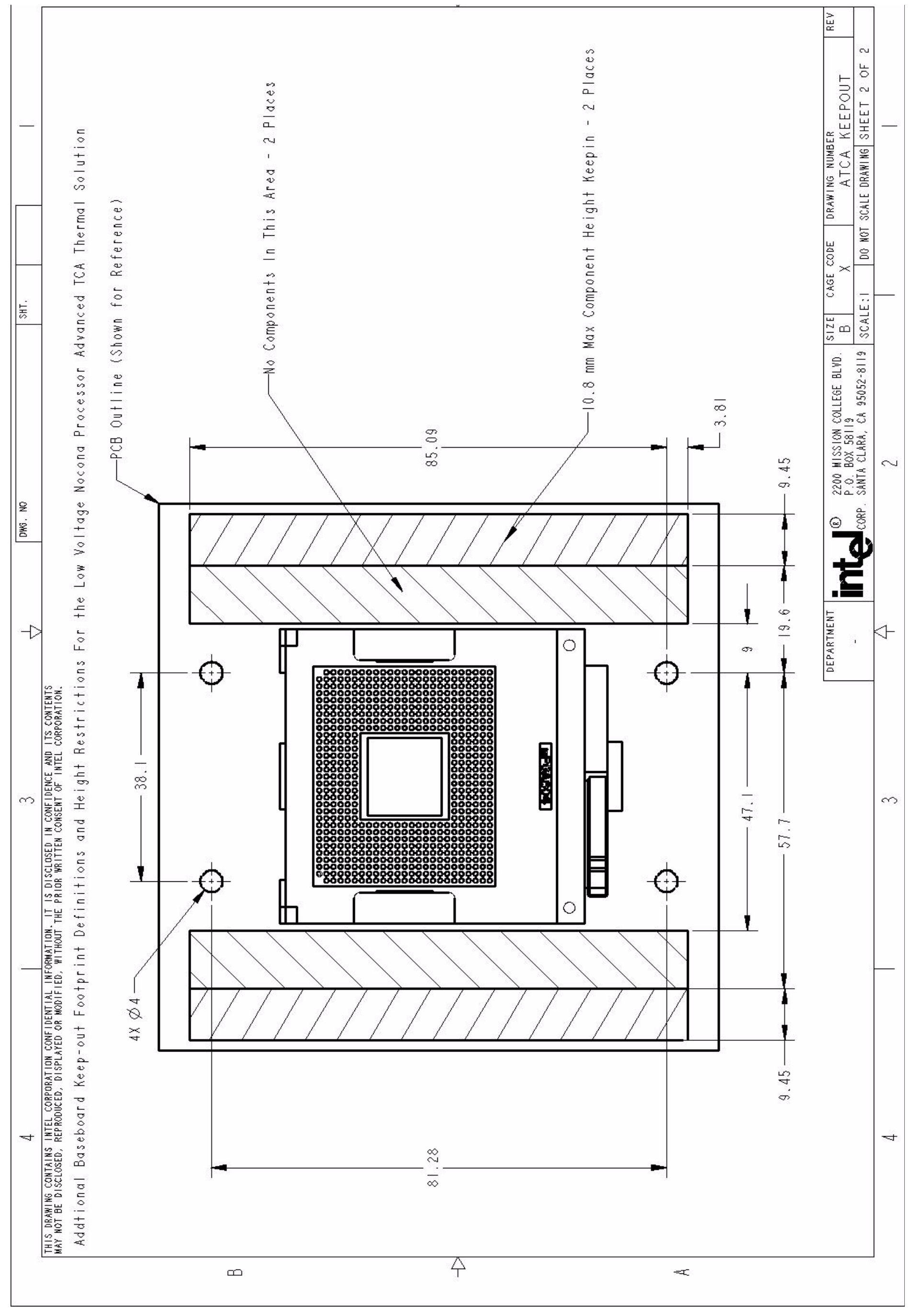
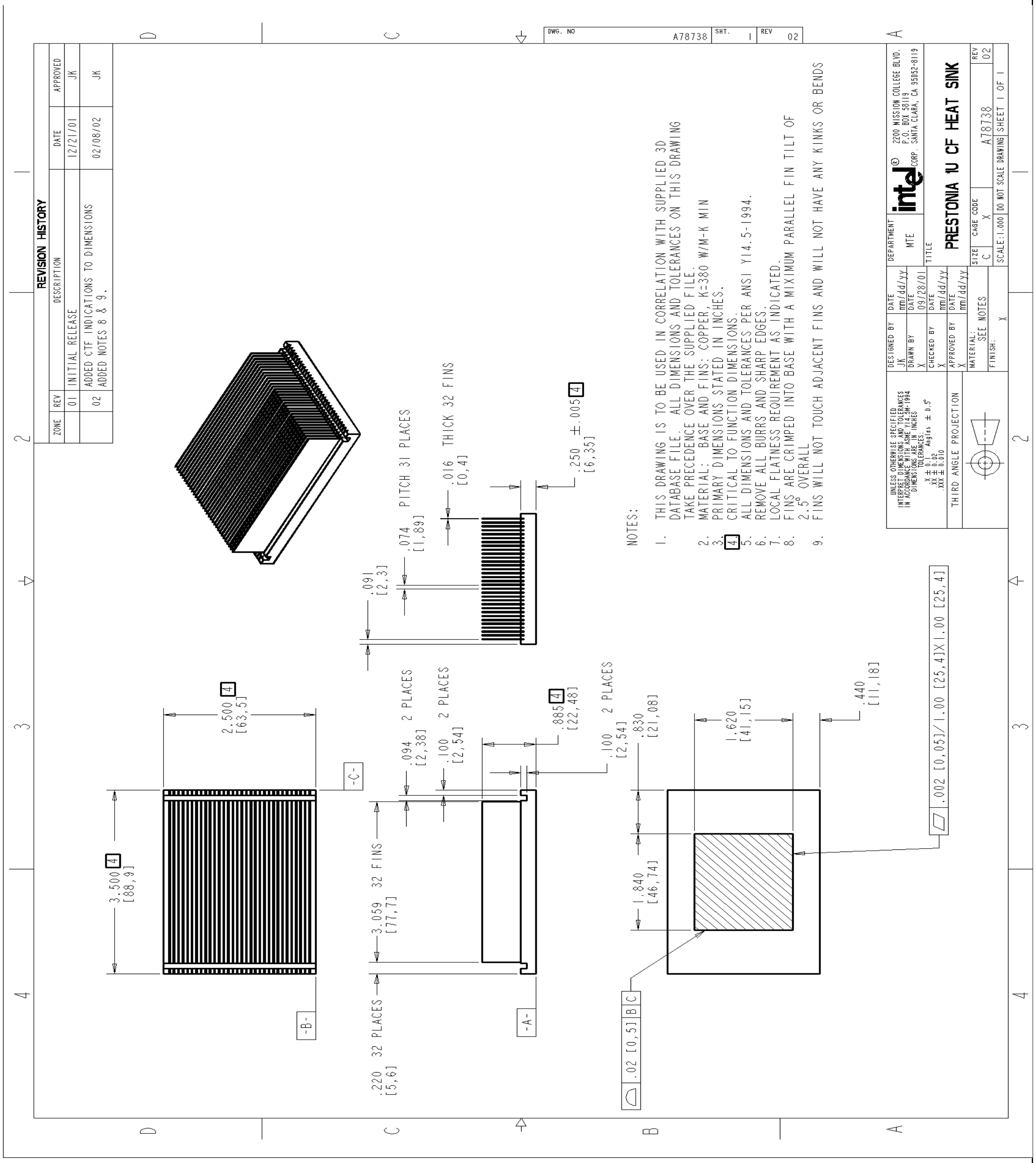


Figure 31. Intel® Xeon™ Processor with 512 KB L2 Cache Heat Sink (1U)



REVISION HISTORY

ZONE	REV	DESCRIPTION	DATE	APPROVED
	01	INITIAL RELEASE	12/21/01	JK
	02	ADDED CTF INDICATIONS TO DIMENSIONS ADDED NOTES 8 & 9.	02/08/02	JK

NOTES:

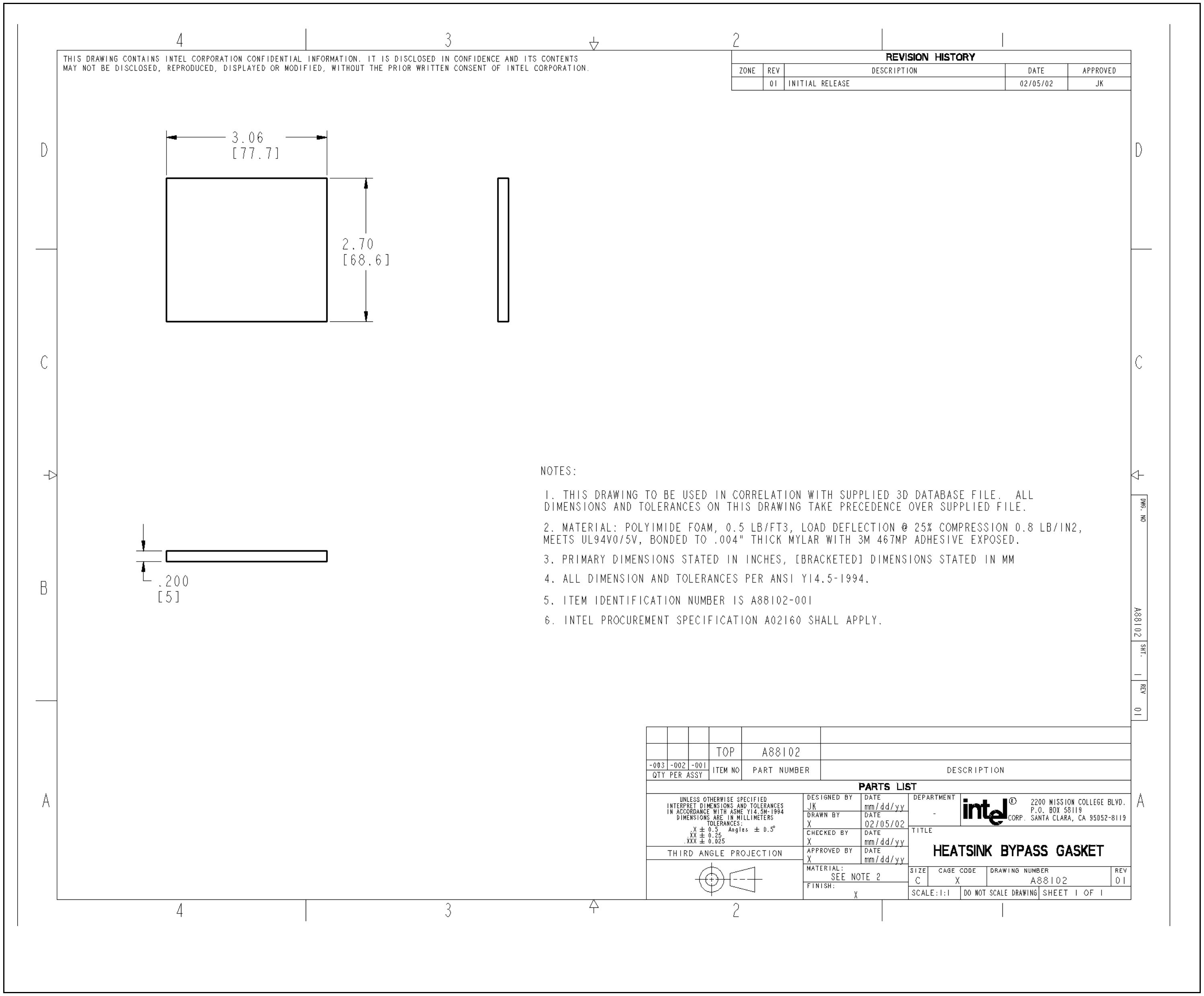
1. THIS DRAWING IS TO BE USED IN CORRELATION WITH SUPPLIED 3D DATABASE FILE. ALL DIMENSIONS AND TOLERANCES ON THIS DRAWING TAKE PRECEDENCE OVER THE SUPPLIED FILE.
2. MATERIAL: BASE AND FINS: COPPER, K=380 W/M-K MIN
3. PRIMARY DIMENSIONS STATED IN INCHES.
4. CRITICAL TO FUNCTION DIMENSIONS.
5. ALL DIMENSIONS AND TOLERANCES PER ANSI Y14.5-1994.
6. REMOVE ALL BURRS AND SHARP EDGES.
7. LOCAL FLATNESS REQUIREMENT AS INDICATED.
8. FINS ARE CRIMPED INTO BASE WITH A MIXIMUM PARALLEL FIN TILT OF 2.5° OVERALL
9. FINS WILL NOT TOUCH ADJACENT FINS AND WILL NOT HAVE ANY KINKS OR BENDS

UNLESS OTHERWISE SPECIFIED
INTERPRET DIMENSIONS AND TOLERANCES
IN ACCORDANCE WITH ASME Y14.5M-1994
DIMENSIONS ARE IN INCHES
TOLERANCES:
.X ± 0.1 Angles ± 0.5°
.XX ± 0.02
.XXX ± 0.010

THIRD ANGLE PROJECTION

DESIGNED BY JK	DATE mm/dd/yy	DEPARTMENT MTE	intel® CORP. 2200 MISSION COLLEGE BLVD. P.O. BOX 58119 SANTA CLARA, CA 95052-8119
DRAWN BY X	DATE 09/28/01	TITLE PRESTONIA 1U CF HEAT SINK	
CHECKED BY X	DATE mm/dd/yy		
APPROVED BY X	DATE mm/dd/yy	SIZE C	CAGE CODE X · A78738 · REV 02
MATERIAL: SEE NOTES		SCALE: 1.000	DO NOT SCALE DRAWING · SHEET 1 OF 1
FINISH: X			

Figure 32. Intel® Xeon™ Processor with 512 KB L2 Cache Heat Sink (1U) Bypass Gasket



THIS DRAWING CONTAINS INTEL CORPORATION CONFIDENTIAL INFORMATION. IT IS DISCLOSED IN CONFIDENCE AND ITS CONTENTS MAY NOT BE DISCLOSED, REPRODUCED, DISPLAYED OR MODIFIED, WITHOUT THE PRIOR WRITTEN CONSENT OF INTEL CORPORATION.

REVISION HISTORY

ZONE	REV	DESCRIPTION	DATE	APPROVED
	01	INITIAL RELEASE	02/05/02	JK

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: POLYIMIDE FOAM, 0.5 LB/FT3, LOAD DEFLECTION @ 25% COMPRESSION 0.8 LB/IN2, MEETS UL94V0/5V, BONDED TO .004" THICK MYLAR WITH 3M 467MP ADHESIVE EXPOSED.
3. PRIMARY DIMENSIONS STATED IN INCHES, [BRACKETED] DIMENSIONS STATED IN MM
4. ALL DIMENSION AND TOLERANCES PER ANSI Y14.5-1994.
5. ITEM IDENTIFICATION NUMBER IS A88102-001
6. INTEL PROCUREMENT SPECIFICATION A02160 SHALL APPLY.

PARTS LIST

-003	-002	-001	ITEM NO	PART NUMBER	DESCRIPTION
			TOP	A88102	

QTY PER ASSY

UNLESS OTHERWISE SPECIFIED
INTERPRET DIMENSIONS AND TOLERANCES
IN ACCORDANCE WITH ASME Y14.5M-1994
DIMENSIONS ARE IN MILLIMETERS
TOLERANCES:
.X ± 0.5 Angles ± 0.5°
.XX ± 0.25
.XXX ± 0.025

THIRD ANGLE PROJECTION

DESIGNED BY JK	DATE mm/dd/yy
DRAWN BY X	DATE 02/05/02
CHECKED BY X	DATE mm/dd/yy
APPROVED BY X	DATE mm/dd/yy
MATERIAL: SEE NOTE 2	
FINISH: X	

DEPARTMENT
-

intel® CORP. 2200 MISSION COLLEGE BLVD.
P.O. BOX 58119
SANTA CLARA, CA 95052-8119

TITLE
HEATSINK BYPASS GASKET

SIZE	CAGE CODE	DRAWING NUMBER	REV
C	X	A88102	01

SCALE:1:1 | DO NOT SCALE DRAWING | SHEET 1 OF 1

Figure 33. AdvancedTCA* Heat Sink

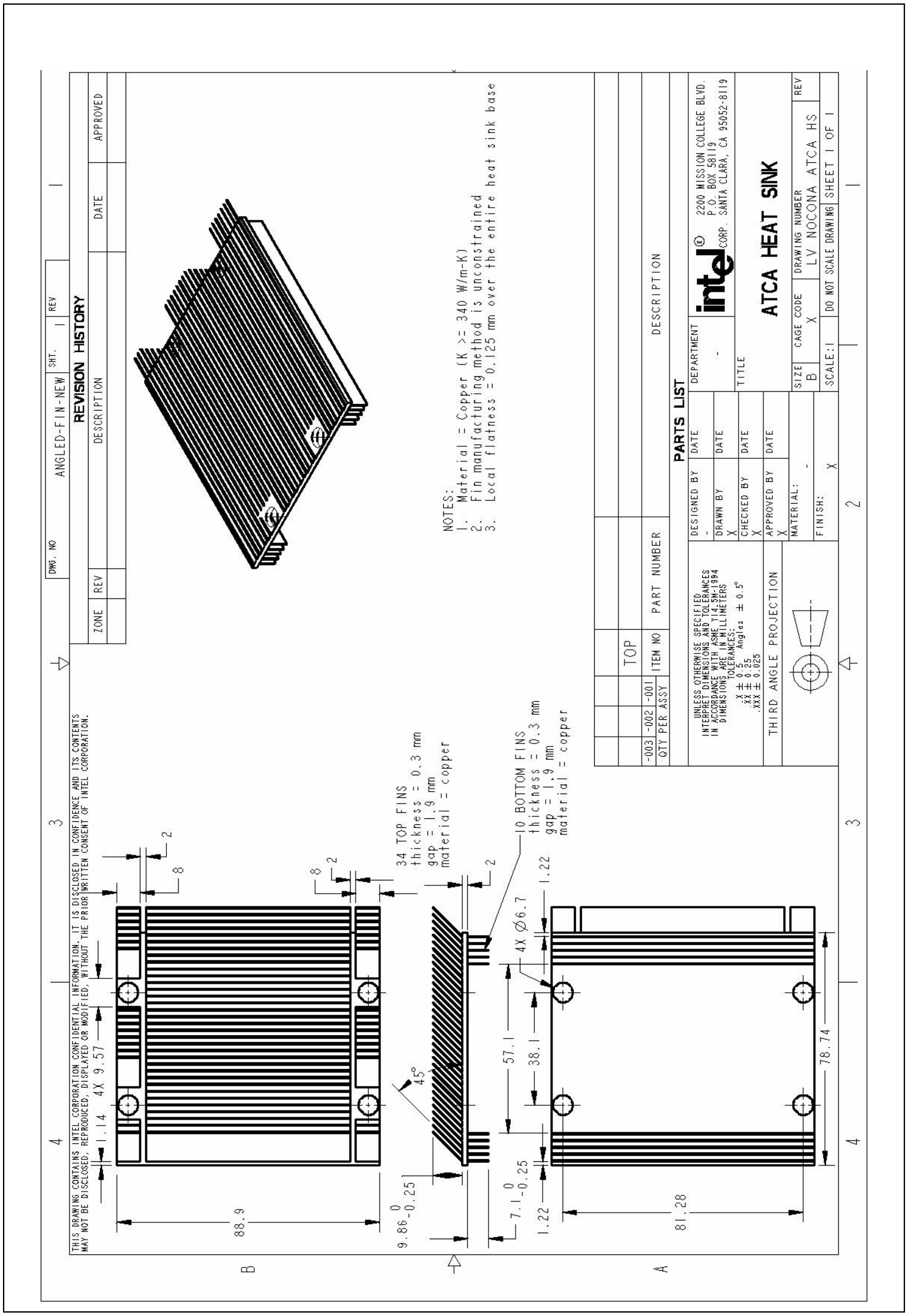


Figure 34. AdvancedTCA* Retention Mechanism Screw/Spring/Retainer Assembly

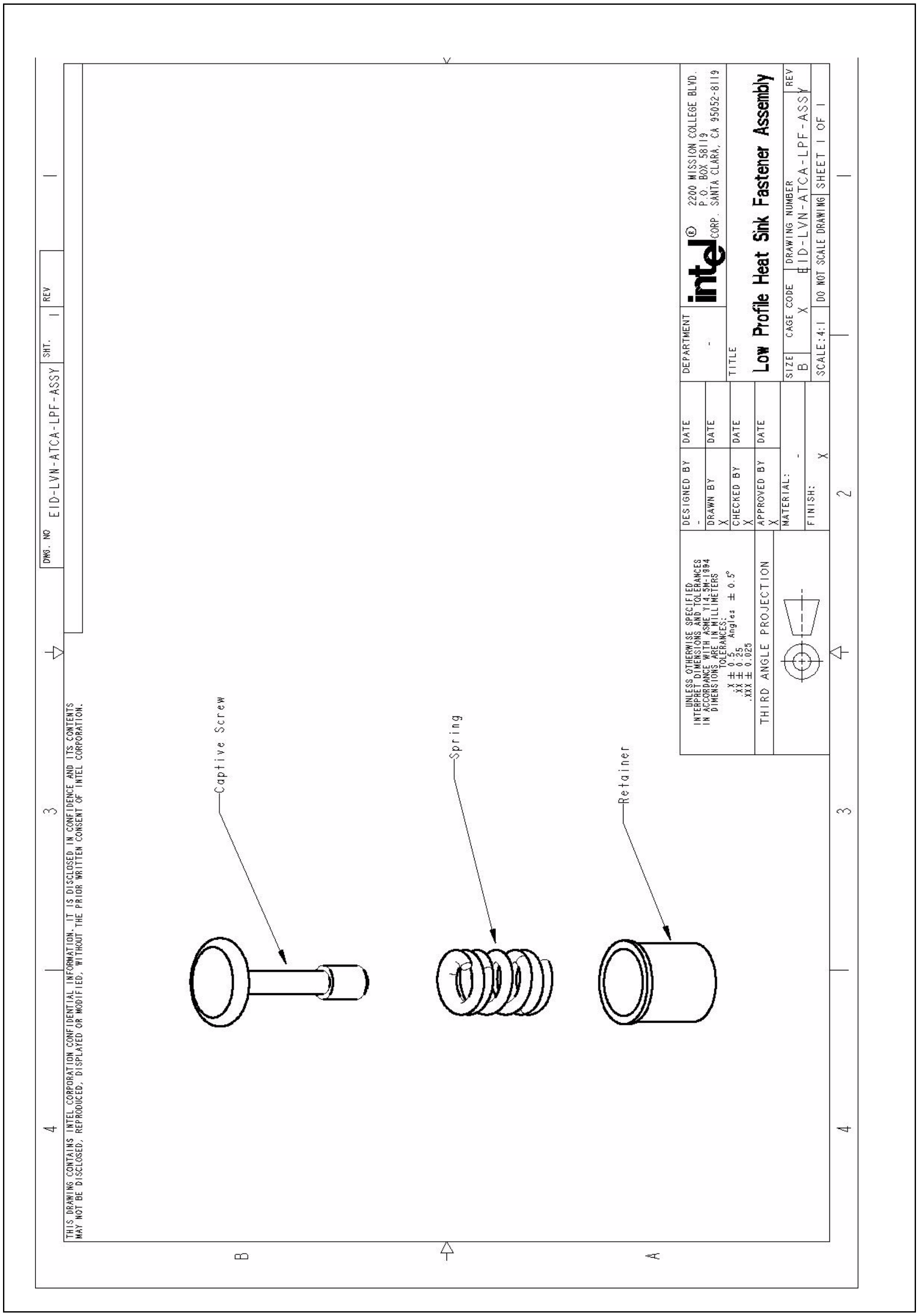


Figure 35. AdvancedTCA* Retention Mechanism Screw

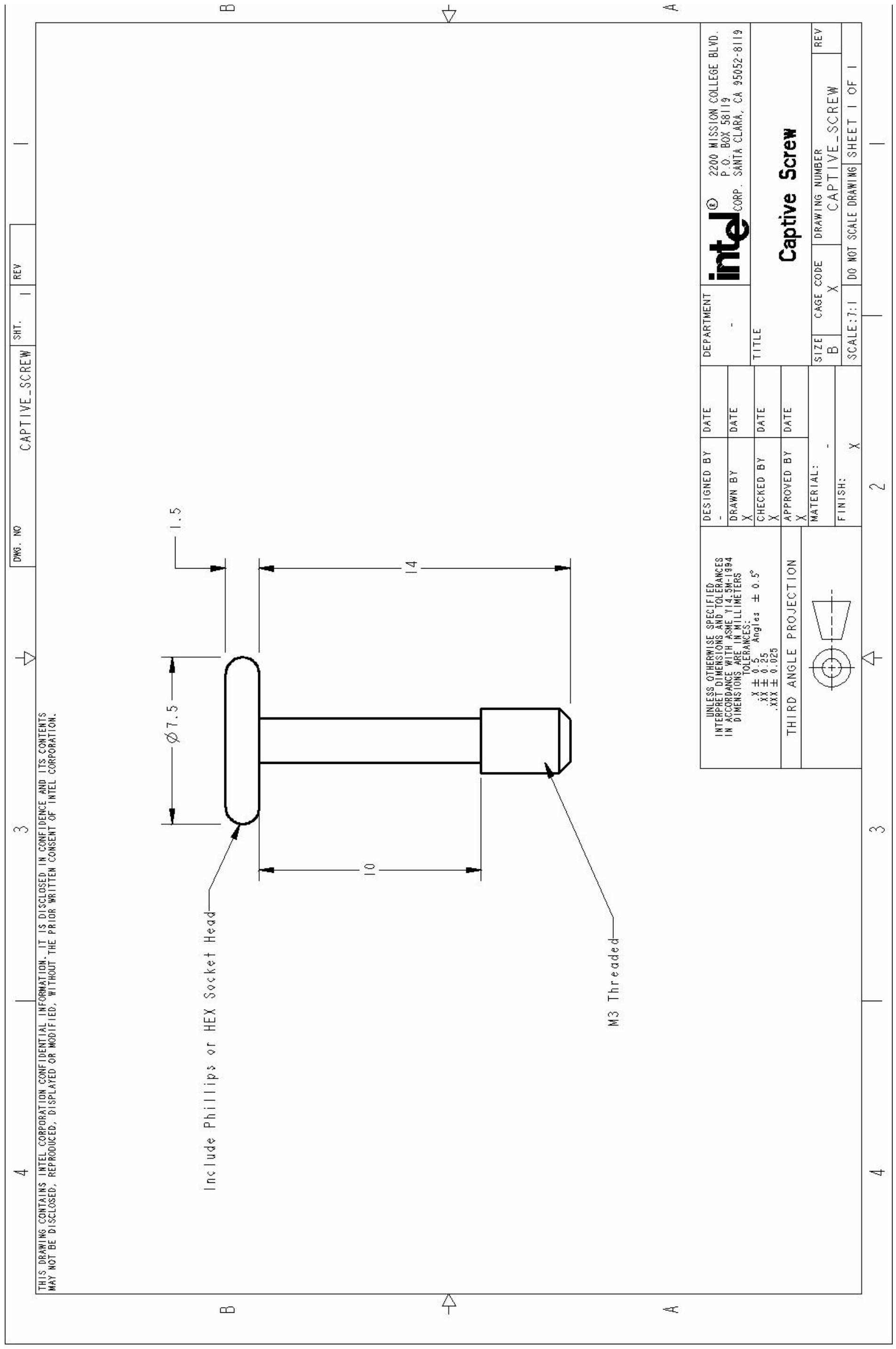


Figure 36. AdvancedTCA* Retention Mechanism Spring

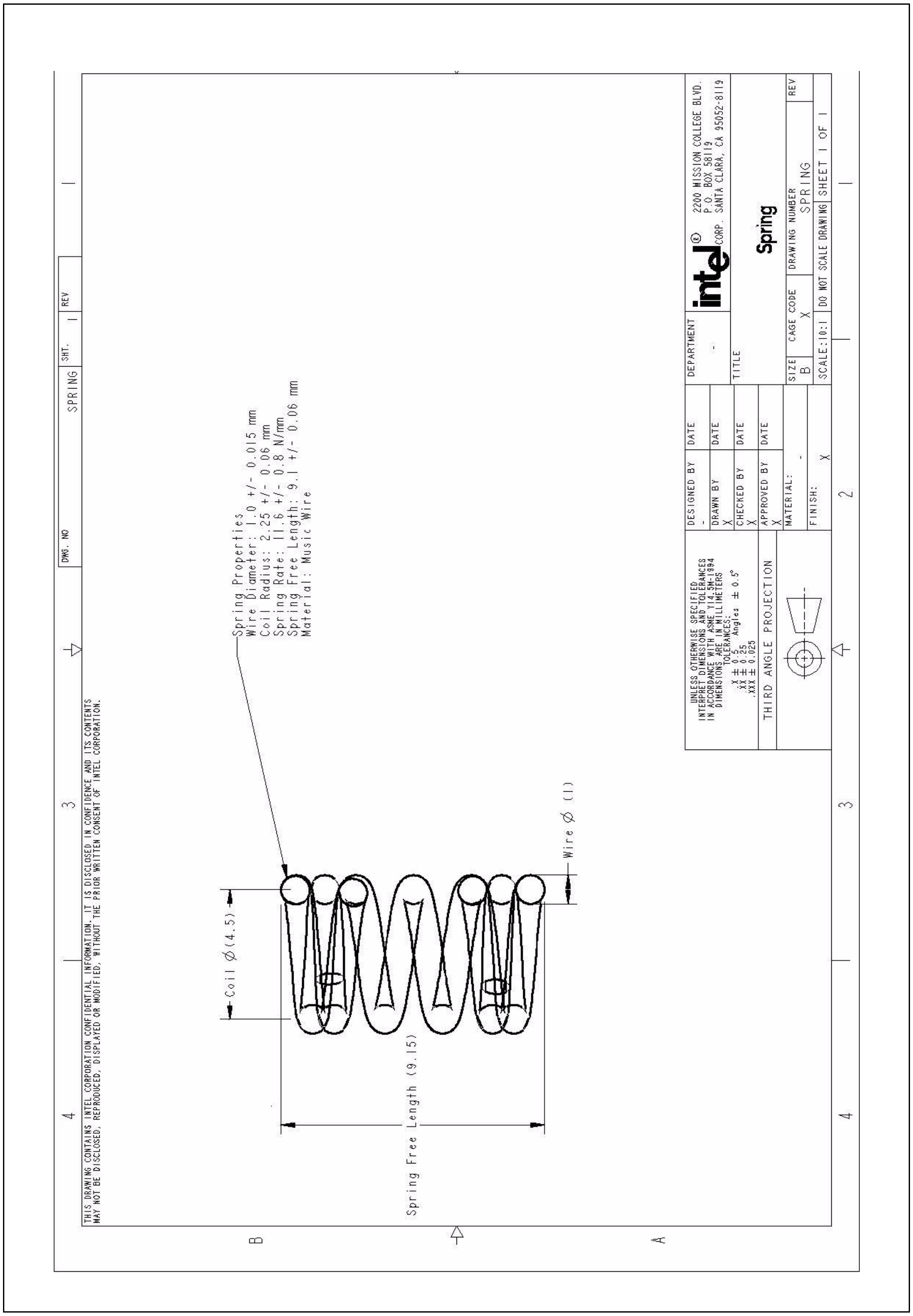


Figure 37. AdvancedTCA* Retention Mechanism Retainer

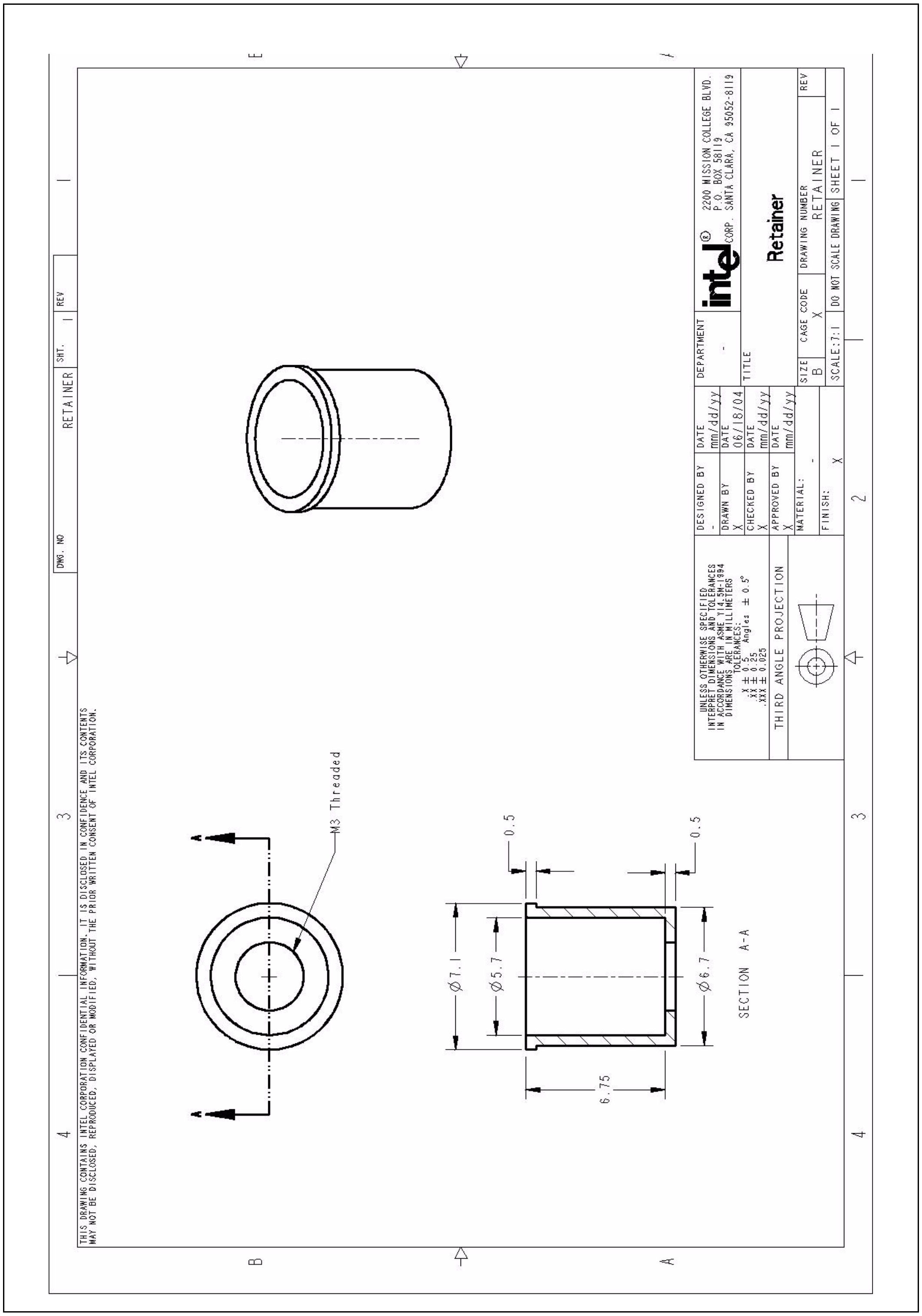


Figure 38. AdvancedTCA* Retention Mechanism Back Plate