Intel® Xeon® Processor 3500 Series

Thermal / Mechanical Design Guide

March 2009

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Revision History

Revision Number	Description	Revision Date
-001	• Initial release	March 2009

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1 Introduction

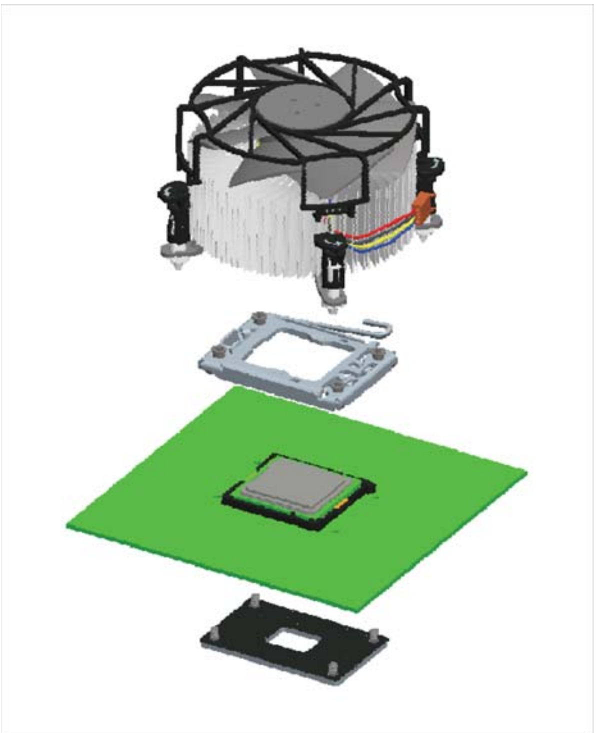
This document provides guidelines for the design of thermal and mechanical solutions for the:

- Intel® Xeon® Processor 3500 Series

Unless specifically required for clarity, this document will use “processor” in place of the specific product names. The components described in this document include:

- The processor thermal solution (heatsink) and associated retention hardware.
- The LGA1366 socket and the Independent Loading Mechanism (ILM) and back plate.

Figure 1-1. Processor Thermal Solution & LGA1366 Socket Stack



The goals of this document are:

- To assist board and system thermal mechanical designers.
- To assist designers and suppliers of processor heatsinks.

Thermal profiles and other processor specifications are provided in the appropriate processor Datasheet.

1.1 References

Material and concepts available in the following documents may be beneficial when reading this document.

Table 1-1. Reference Documents

Document	Location	Notes
Intel® Xeon® Processor 3500 Series Processor Datasheet, Volume 1	321332	1
Intel® Xeon® Processor 3500 Series Processor Datasheet, Volume 2	321344	1
Intel® Xeon® Processor 3500 Series Processor Specification Update	321333	1

Notes:
1. Available electronically

1.2 Definition of Terms

Table 1-2. Terms and Descriptions (Sheet 1 of 2)

Term	Description
Bypass	Bypass is the area between a passive heatsink and any object that can act to form a duct. For this example, it can be expressed as a dimension away from the outside dimension of the fins to the nearest surface.
DTS	Digital Thermal Sensor reports a relative die temperature as an offset from TCC activation temperature.
FSC	Fan Speed Control
IHS	Integrated Heat Spreader: a component of the processor package used to enhance the thermal performance of the package. Component thermal solutions interface with the processor at the IHS surface.
ILM	Independent Loading Mechanism provides the force needed to seat the 1366-LGA land package onto the socket contacts.
IOH	Input Output Hub: a component of the chipset that provides I/O connections to PCIe, drives and other peripherals
LGA1366 socket	The processor mates with the system board through this surface mount, 1366-contact socket.
PECI	The Platform Environment Control Interface (PECI) is a one-wire interface that provides a communication channel between Intel processor and chipset components to external monitoring devices.
Ψ_{CA}	Case-to-ambient thermal characterization parameter (psi). A measure of thermal solution performance using total package power. Defined as ($T_{CASE} - T_{LA}$) / 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 ($T_{CASE} - T_S$) / Total Package Power.
Ψ_{SA}	Sink-to-ambient thermal characterization parameter. A measure of heatsink thermal performance using total package power. Defined as ($T_S - T_{LA}$) / Total Package Power.
T_{CASE}	The case temperature of the TTV measured at the geometric center of the topside of the IHS.
T_{CASE_MAX}	The maximum case temperature as specified in a component specification.
TCC	Thermal Control Circuit: Thermal monitor uses the TCC to reduce the die temperature by using clock modulation and/or operating frequency and input voltage adjustment when the die temperature is very near its operating limits.
$T_{CONTROL}$	$T_{CONTROL}$ is a static value below TCC activation used as a trigger point for fan speed control.

Table 1-2. Terms and Descriptions (Sheet 2 of 2)

Term	Description
TDP	Thermal Design Power: Thermal solution should be designed to dissipate this target power level. TDP is not the maximum power that the processor can dissipate.
Thermal Monitor	A power reduction feature designed to decrease temperature after the processor has reached its maximum operating temperature.
Thermal Profile	Line that defines case temperature specification of the TTV at a given power level.
TIM	Thermal Interface Material: The thermally conductive compound between the heatsink and the processor case. This material fills the air gaps and voids, and enhances the transfer of the heat from the processor case to the heatsink.
$T_{AMBIENT}$	The measured ambient temperature locally surrounding the processor. The ambient temperature should be measured just upstream of a passive heatsink or at the fan inlet for an active heatsink.
T_{SA}	The system ambient air temperature external to a system chassis. This temperature is usually measured at the chassis air inlets.

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2 LGA1366 Socket

This chapter describes a surface mount, LGA (Land Grid Array) socket intended for Intel® Xeon® Processor 3500 Series. The socket provides I/O, power and ground contacts. The socket contains 1366 contacts arrayed about a cavity in the center of the socket with lead-free solder balls for surface mounting on the motherboard.

The socket has 1366 contacts with 1.016 mm X 1.016 mm pitch (X by Y) in a 43x41 grid array with 21x17 grid depopulation in the center of the array and selective depopulation elsewhere.

The socket must be compatible with the package (processor) and the Independent Loading Mechanism (ILM). The design includes a back plate which is integral to having a uniform load on the socket solder joints. Socket loading specifications are listed in Chapter 4.

Figure 2-1. LGA1366 Socket with Pick and Place Cover Removed

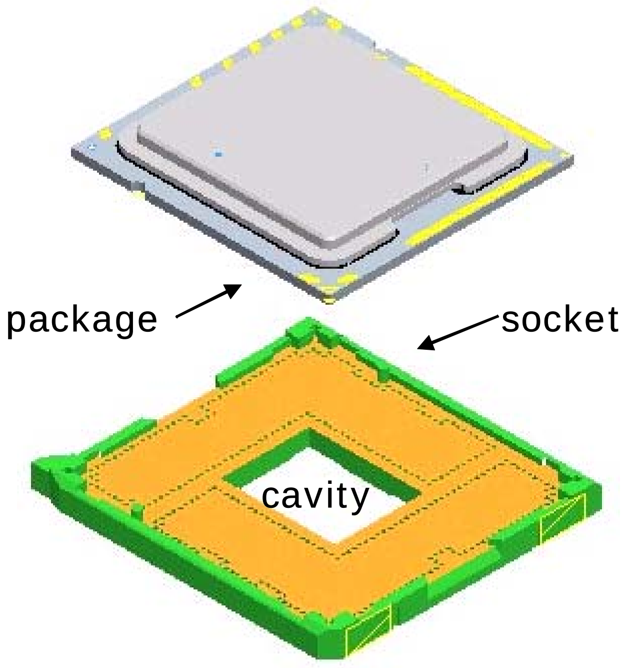
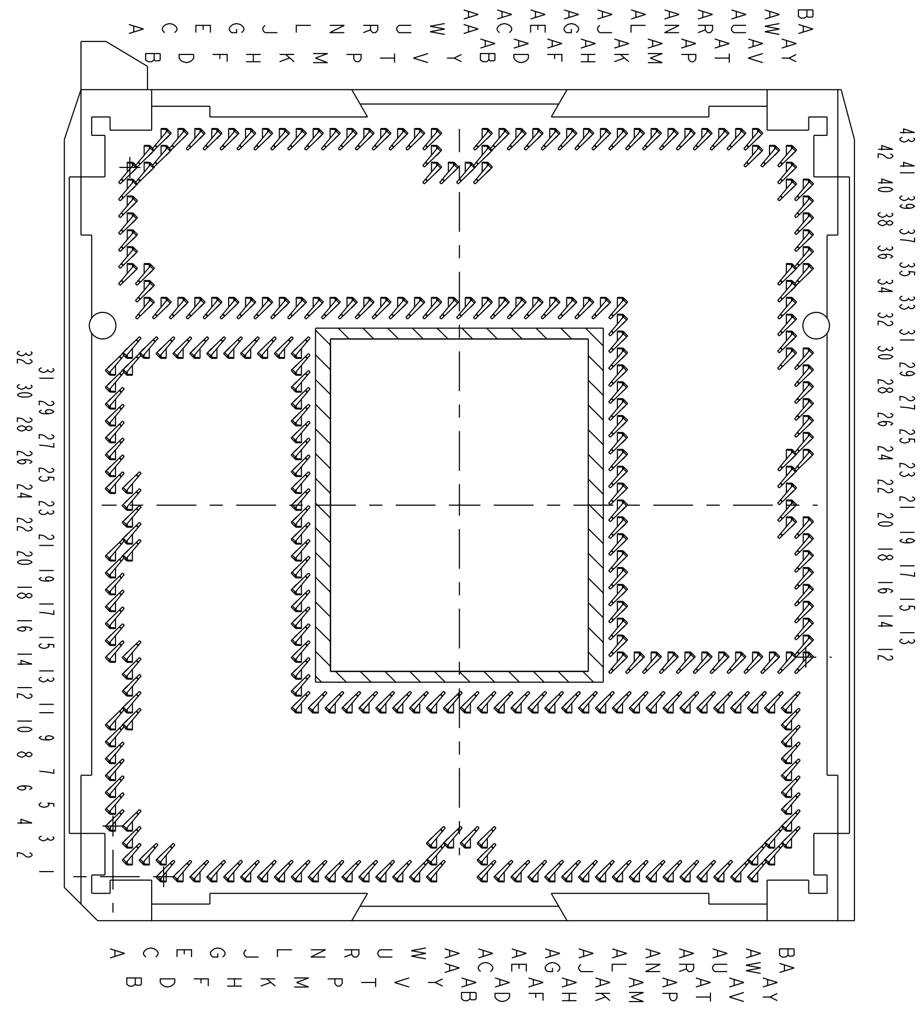


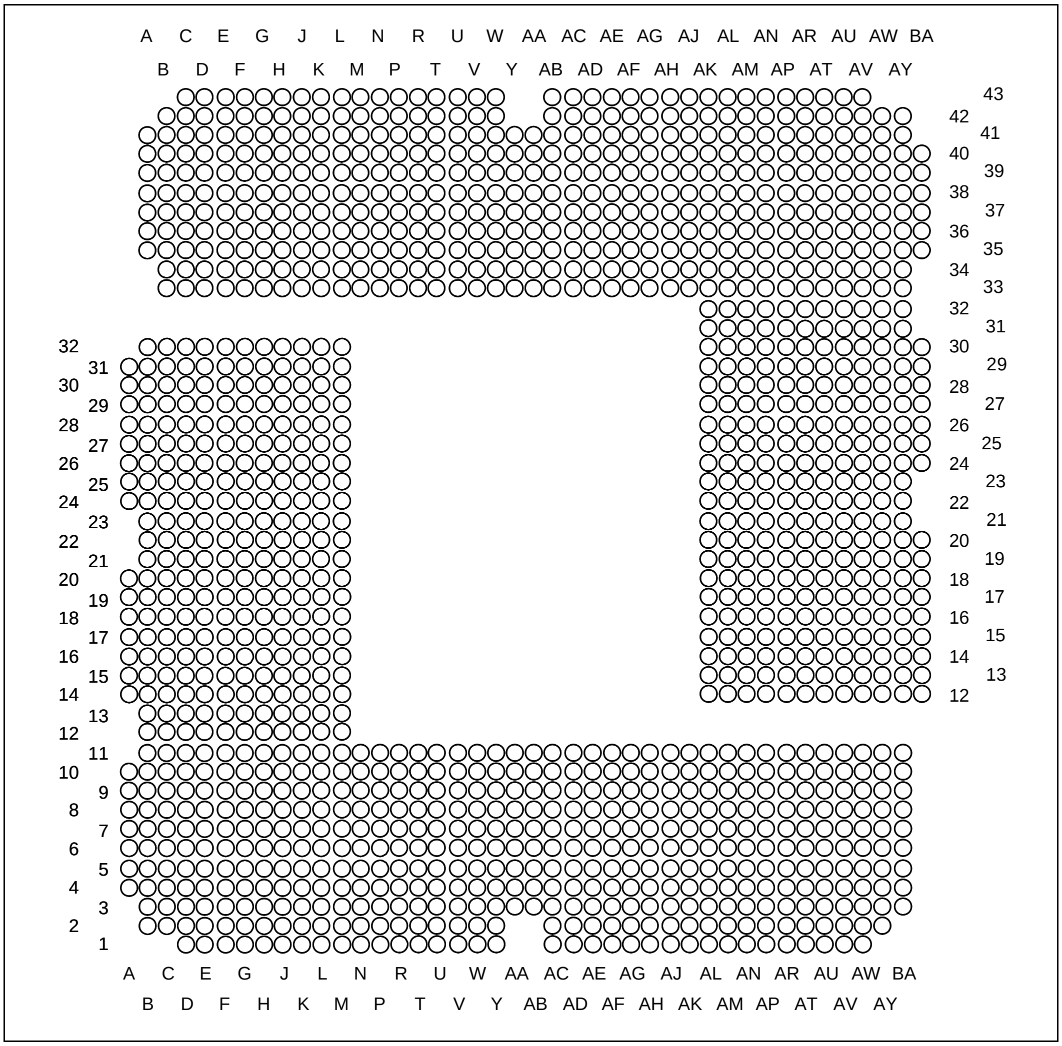
Figure 2-2. LGA1366 Socket Contact Numbering (Top View of Socket)



2.1 Board Layout

The land pattern for the LGA1366 socket is 40 mils X 40 mils (X by Y), and the pad size is 18 mils. Note that there is no round-off (conversion) error between socket pitch (1.016 mm) and board pitch (40 mil) as these values are equivalent.

Figure 2-3. LGA1366 Socket Land Pattern (Top View of Board)

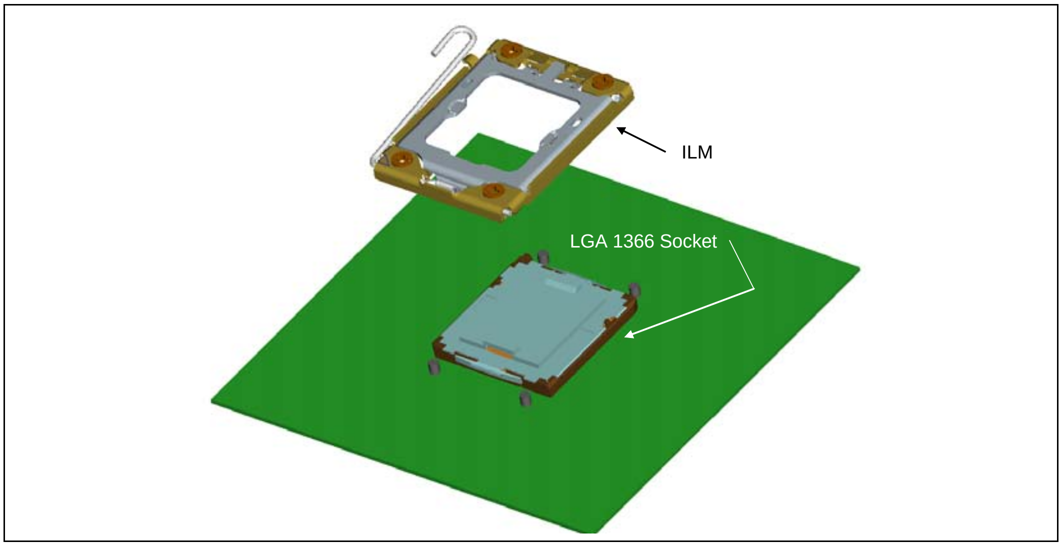


2.2 Attachment to Motherboard

The socket is attached to the motherboard by 1366 solder balls. There are no additional external methods (that is, screw, extra solder, adhesive, and so on) to attach the socket.

As indicated in Figure 2-4, the Independent Loading Mechanism (ILM) is not present during the attach (reflow) process.

Figure 2-4. Attachment to Motherboard



2.3 Socket Components

The socket has two main components, the socket body and Pick and Place (PnP) cover, and is delivered as a single integral assembly. Refer to Appendix C for detailed drawings.

2.3.1 Socket Body Housing

The housing material is thermoplastic or equivalent with UL 94 V-0 flame rating capable of withstanding 260 °C for 40 seconds (typical reflow/rework). The socket coefficient of thermal expansion (in the XY plane), and creep properties, must be such that the integrity of the socket is maintained for the conditions listed in Chapter 7.

The color of the housing will be dark as compared to the solder balls to provide the contrast needed for pick and place vision systems.

2.3.2 Solder Balls

A total of 1366 solder balls corresponding to the contacts are on the bottom of the socket for surface mounting with the motherboard.

The socket has the following solder ball material:

- Lead free SAC (SnAgCu) solder alloy with a silver (Ag) content between 3% and 4% and a melting temperature of approximately 217 °C. The alloy must be compatible with immersion silver (ImAg) motherboard surface finish and a SAC alloy solder paste.

The co-planarity (profile) and true position requirements are defined in Appendix C.

2.3.3 Contacts

Base material for the contacts is high strength copper alloy.

For the area on socket contacts where processor lands will mate, there is a 0.381 µm [15 µinches] minimum gold plating over 1.27 µm [50 µinches] minimum nickel underplate.

No contamination by solder in the contact area is allowed during solder reflow.

2.3.4 Pick and Place Cover

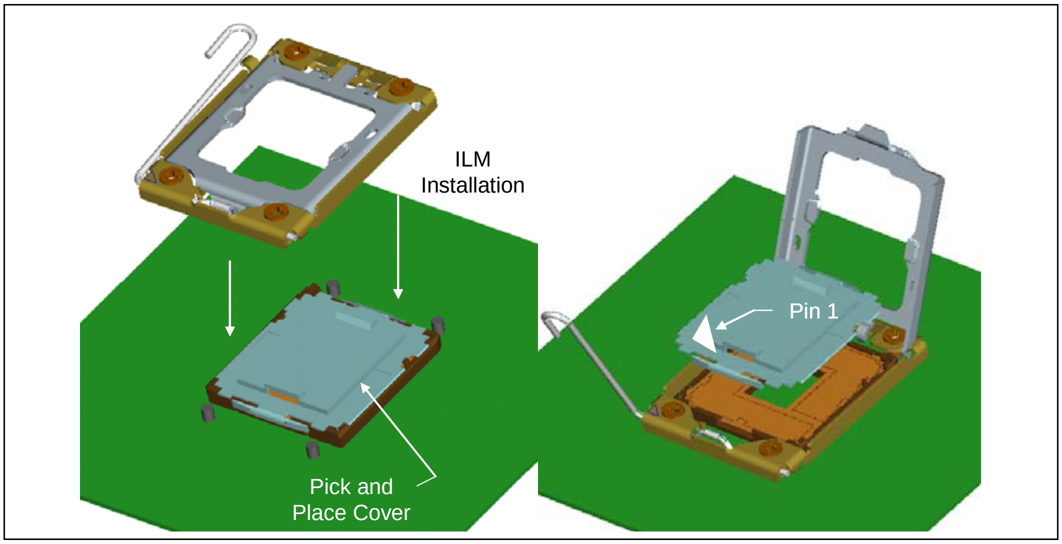
The cover provides a planar surface for vacuum pick up used to place components in the Surface Mount Technology (SMT) manufacturing line. The cover remains on the socket during reflow to help prevent contamination during reflow. The cover can withstand 260 °C for 40 seconds (typical reflow/rework profile) and the conditions listed in Chapter 7 without degrading.

As indicated in Figure 2-5, the cover remains on the socket during ILM installation, and should remain on whenever possible to help prevent damage to the socket contacts.

Cover retention must be sufficient to support the socket weight during lifting, translation, and placement (board manufacturing), and during board and system shipping and handling.

The covers are designed to be interchangeable between socket suppliers. As indicated in Figure 2-5, a Pin1 indicator on the cover provides a visual reference for proper orientation with the socket.

Figure 2-5. Pick and Place Cover



2.4 Package Installation / Removal

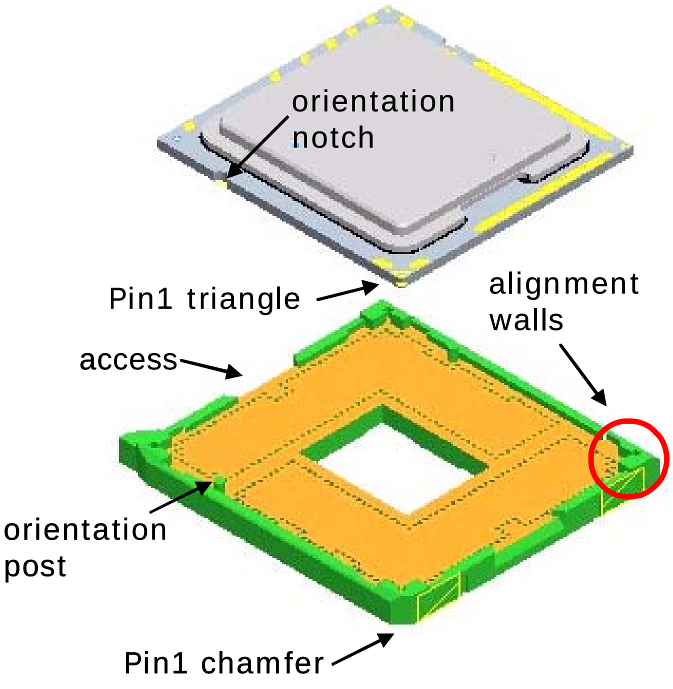
As indicated in Figure 2-6, access is provided to facilitate manual installation and removal of the package.

To assist in package orientation and alignment with the socket:

- The package Pin1 triangle and the socket Pin1 chamfer provide visual reference for proper orientation.
- The package substrate has orientation notches along two opposing edges of the package, offset from the centerline. The socket has two corresponding orientation posts to physically prevent mis-orientation of the package. These orientation features also provide initial rough alignment of package to socket.
- The socket has alignment walls at the four corners to provide final alignment of the package.

See Appendix D for information regarding a tool designed to provide mechanical assistance during processor installation and removal.

Figure 2-6. Package Installation / Removal Features



2.4.1 Socket Standoffs and Package Seating Plane

Standoffs on the bottom of the socket base establish the minimum socket height after solder reflow and are specified in Appendix C.

Similarly, a seating plane on the topside of the socket establishes the minimum package height. See Section 4.2 for the calculated IHS height above the motherboard.

2.5 Durability

The socket must withstand 30 cycles of processor insertion and removal. The max chain contact resistance from Table 4-4 must be met when mated in the 1st and 30th cycles.

The socket Pick and Place cover must withstand 15 cycles of insertion and removal.

2.6 Markings

There are three markings on the socket:

- LGA1366: Font type is Helvetica Bold - minimum 6 point (2.125 mm).
- Manufacturer's insignia (font size at supplier's discretion).
- Lot identification code (allows traceability of manufacturing date and location).

All markings must withstand 260 °C for 40 seconds (typical reflow/rework profile) without degrading, and must be visible after the socket is mounted on the motherboard.

LGA1366 and the manufacturer's insignia are molded or laser marked on the side wall.

2.7 Component Insertion Forces

Any actuation must meet or exceed SEMI S8-95 Safety Guidelines for Ergonomics/ Human Factors Engineering of Semiconductor Manufacturing Equipment, example Table R2-7 (Maximum Grip Forces). The socket must be designed so that it requires no force to insert the package into the socket.

2.8 Socket Size

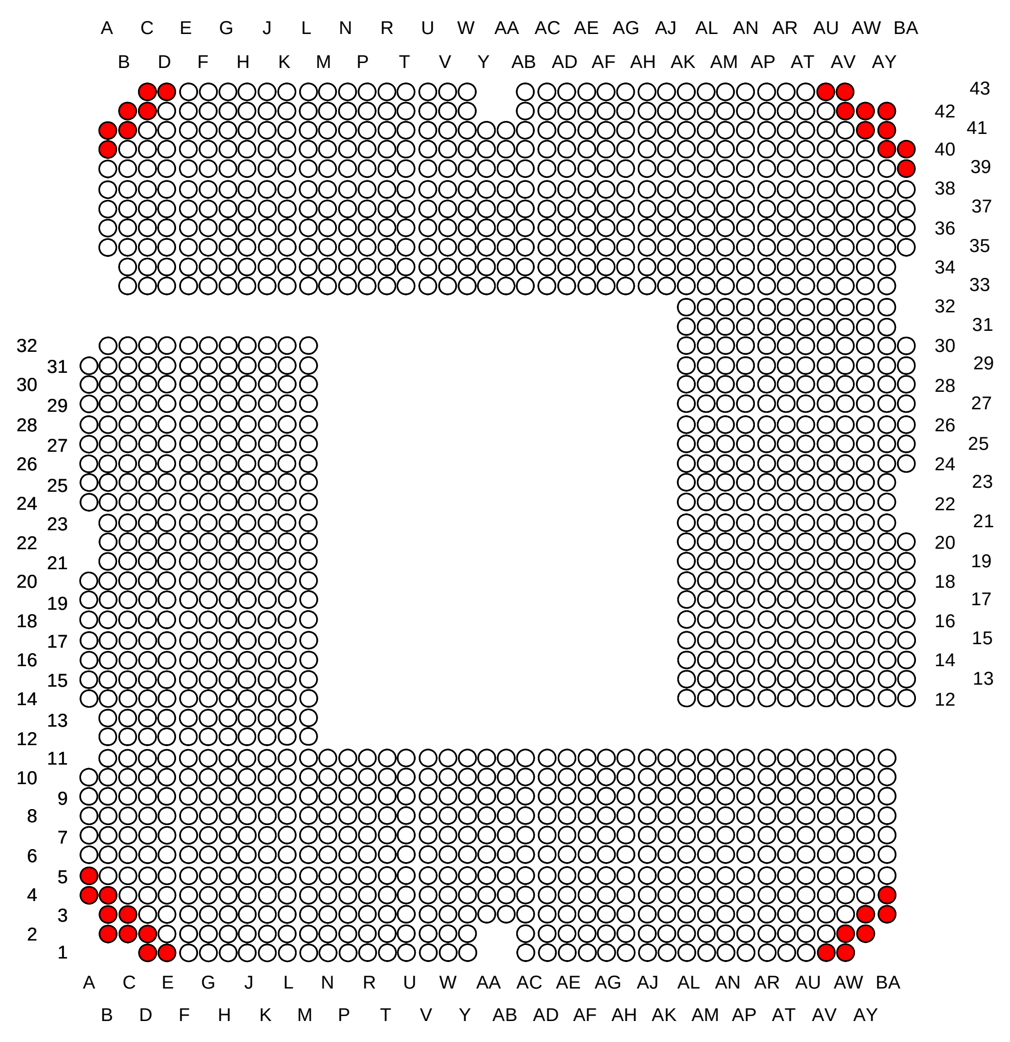
Socket information needed for motherboard design is given in Appendix C.

This information should be used in conjunction with the reference motherboard keep-out drawings provided in Appendix B to ensure compatibility with the reference thermal mechanical components.

2.9 LGA1366 Socket NCTF Solder Joints

Intel has defined selected solder joints of the socket as non-critical to function (NCTF) for post environmental testing. The processor signals at NCTF locations are typically redundant ground or non-critical reserved, so the loss of the solder joint continuity at end of life conditions will not affect the overall product functionality. Figure 2-7 identifies the NCTF solder joints.

Figure 2-7. LGA1366 NCTF Solder Joints



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3 Independent Loading Mechanism (ILM)

The Independent Loading Mechanism (ILM) provides the force needed to seat the 1366-LGA land package onto the socket contacts. The ILM is physically separate from the socket body. The assembly of the ILM to the board is expected to occur after wave solder. The exact assembly location is dependent on manufacturing preference and test flow.

Note: The ILM has two critical functions: deliver the force to seat the processor onto the socket contacts and distribute the resulting compressive load evenly through the socket solder joints.

Note: The mechanical design of the ILM is integral to the overall functionality of the LGA1366 socket. Intel performs detailed studies on integration of processor package, socket and ILM as a system. These studies directly impact the design of the ILM. The Intel reference ILM will be “build to print” from Intel controlled drawings. Intel recommends using the Intel Reference ILM. Custom non-Intel ILM designs do not benefit from Intel's detailed studies and may not incorporate critical design parameters.

3.1 Design Concept

The ILM consists of two assemblies that will be procured as a set from the enabled vendors. These two components are ILM cover assembly and back plate.

3.1.1 ILM Cover Assembly Design Overview

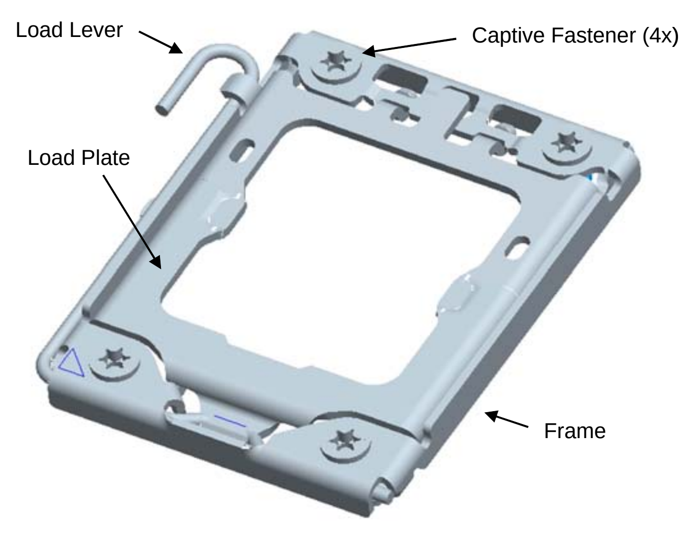
The ILM Cover assembly consists of four major pieces: load lever, load plate, frame and the captive fasteners.

The load lever and load plate are stainless steel. The frame and fasteners are high carbon steel with appropriate plating. The fasteners are fabricated from a high carbon steel. The frame provides the hinge locations for the load lever and load plate.

The cover assembly design ensures that once assembled to the back plate and the load lever is closed, the only features touching the board are the captive fasteners. The nominal gap of the frame to the board is ~1 mm when the load plate is closed on the empty socket or when closed on the processor package.

When closed, the load plate applies two point loads onto the IHS at the “dimpled” features shown in Figure 3-1. The reaction force from closing the load plate is transmitted to the frame and through the captive fasteners to the back plate. Some of the load is passed through the socket body to the board inducing a slight compression on the solder joints.

Figure 3-1. **ILM Cover Assembly**



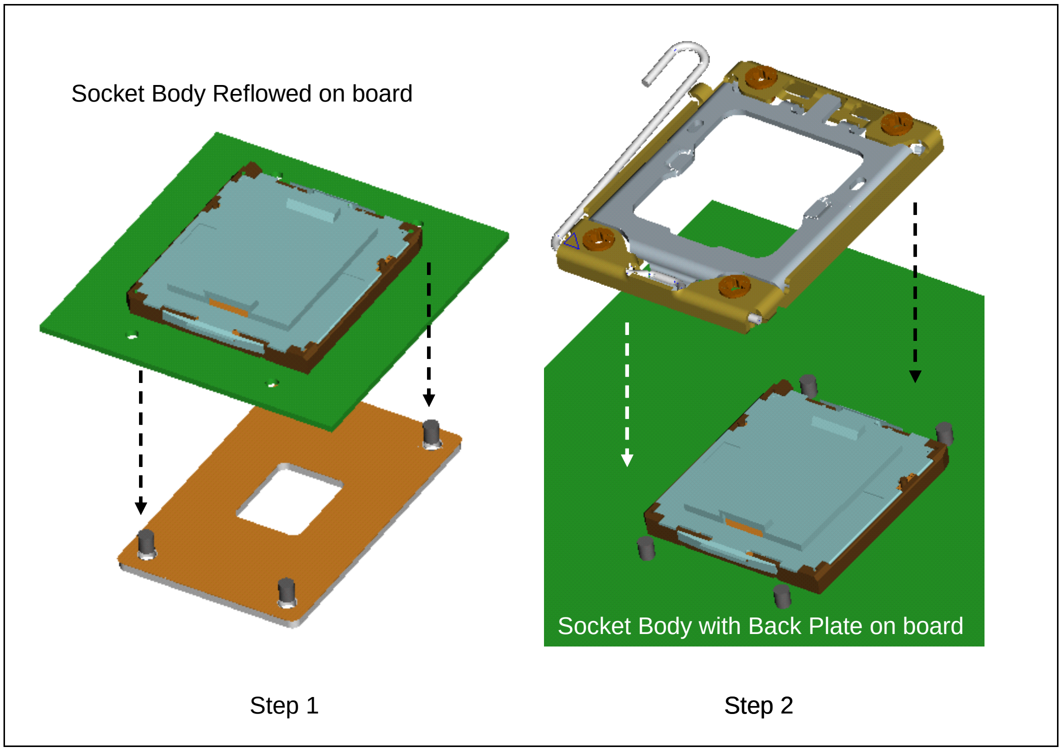
3.1.2 ILM Back Plate Design Overview

The back plate for single processor workstation products consists of a flat steel back plate with threaded studs for ILM attach. The threaded studs have a smooth surface feature that provides alignment for the back plate to the motherboard for proper assembly of the ILM around the socket. A clearance hole is located at the center of the plate to allow access to test points and backside capacitors. An insulator is pre-applied.

3.2 Assembly of ILM to a Motherboard

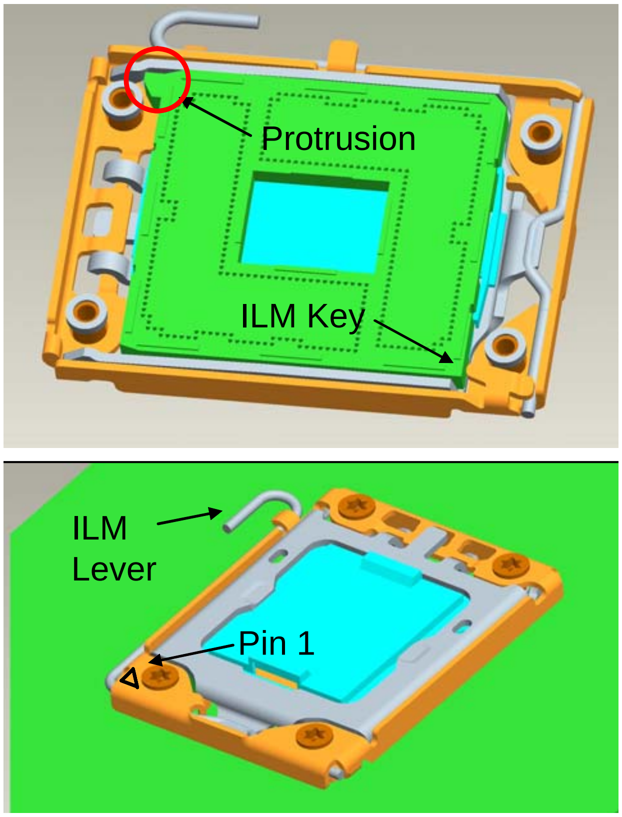
The ILM design allows a bottoms up assembly of the components to the board. In step 1, (see Figure 3-2), the back plate is placed in a fixture. Holes in the motherboard provide alignment to the threaded studs. In step 2, the ILM cover assembly is placed over the socket and threaded studs. Using a T20 Torx* driver fasten the ILM cover assembly to the back plate with the four captive fasteners. Torque to 8 ± 2 inch-pounds. The length of the threaded studs accommodate board thicknesses from 0.062” to 0.100”.

Figure 3-2. ILM Assembly



As indicated in Figure 3-3, socket protrusion and ILM key features prevent 180-degree rotation of ILM cover assembly with respect to the socket. The result is a specific Pin 1 orientation with respect to the ILM lever.

Figure 3-3. Pin1 and ILM Lever



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4 LGA1366 Socket and ILM Electrical, Mechanical, and Environmental Specifications

This chapter describes the electrical, mechanical, and environmental specifications for the LGA1366 socket and the Independent Loading Mechanism.

4.1 Component Mass

Table 4-1. Socket Component Mass

Component	Mass
Socket Body, Contacts and PnP Cover	15 g
ILM Cover	43 g
ILM Back Plate	51 g

4.2 Package/Socket Stackup Height

Table 4-2 provides the stackup height of a processor in the 1366-land LGA package and LGA1366 socket with the ILM closed and the processor fully seated in the socket.

Table 4-2. 1366-land Package and LGA1366 Socket Stackup Height

Integrated Stackup Height (mm) From Top of Board to Top of IHS	7.729 ± 0.282 mm

Notes:
1. This data is provided for information only, and should be derived from: (a) the height of the socket seating plane above the motherboard after reflow, given in Appendix C, (b) the height of the package, from the package seating plane to the top of the IHS, and accounting for its nominal variation and tolerances that are given in the corresponding processor datasheet.
2. This value is a RSS calculation.

4.3 Socket Maximum Temperature

The power dissipated within the socket is a function of the current at the pin level and the effective pin resistance. To ensure socket long term reliability, Intel defines socket maximum temperature using a via on the underside of the motherboard. Exceeding the temperature guidance may result in socket body deformation, or increases in thermal and electrical resistance which can cause a thermal runaway and eventual electrical failure. The guidance for socket maximum temperature is listed below:

- Via temperature under socket < 96 °C

4.4 Loading Specifications

The socket will be tested against the conditions listed in Chapter 7 with heatsink and the ILM attached, under the loading conditions outlined in this chapter.

Table 4-3 provides load specifications for the LGA1366 socket with the ILM installed. The maximum limits should not be exceeded during heatsink assembly, shipping conditions, or standard use condition. Exceeding these limits during test may result in component failure. The socket body should not be used as a mechanical reference or load-bearing surface for thermal solutions.

Table 4-3. Socket and ILM Mechanical Specifications

Parameter	Min	Max	Notes
Static compressive load from ILM cover to processor IHS	470 N [106 lbf]	623 N [140 lbf]	3, 4, 7
Heatsink Static Compressive Load	0 N [0 lbf]	266 N [60 lbf]	1, 2, 3
Total Static Compressive Load (ILM plus Heatsink)	470 N (106 lbf)	890 N (200 lbf)	3, 4
Dynamic Compressive Load (with heatsink installed)	N/A	890 N [200 lbf]	1, 3, 5, 6
Pick and Place Cover Insertion / Removal force	N/A	10.2 N [2.3 lbf]	
Load Lever actuation force	N/A	38.3 N [8.6 lbf] in the vertical direction 10.2 N [2.3 lbf] in the lateral direction.	

Notes:

1. These specifications apply to uniform compressive loading in a direction perpendicular to the IHS top surface.
2. This is the minimum and maximum static force that can be applied by the heatsink and it's retention solution to maintain the heatsink to IHS interface. This does not imply the Intel reference TIM is validated to these limits.
3. Loading limits are for the LGA1366 socket.
4. This minimum limit defines the compressive force required to electrically seat the processor onto the socket contacts.
5. Dynamic loading is defined as an 11 ms duration average load superimposed on the static load requirement.
6. Test condition used a heatsink mass of 550 gm [1.21 lb] with 50 g acceleration measured at heatsink mass. The dynamic portion of this specification in the product application can have flexibility in specific values, but the ultimate product of mass times acceleration should not exceed this dynamic load.
7. Conditions must be satisfied at the beginning of life and the loading system stiffness for non-reference designs need to meet a specific stiffness range to satisfy end of life loading requirements.

4.5 Electrical Requirements

LGA1366 socket electrical requirements are measured from the socket-seating plane of the processor to the component side of the socket PCB to which it is attached. All specifications are maximum values (unless otherwise stated) for a single socket contact, but includes effects of adjacent contacts where indicated.

Table 4-4. Electrical Requirements for LGA1366 Socket

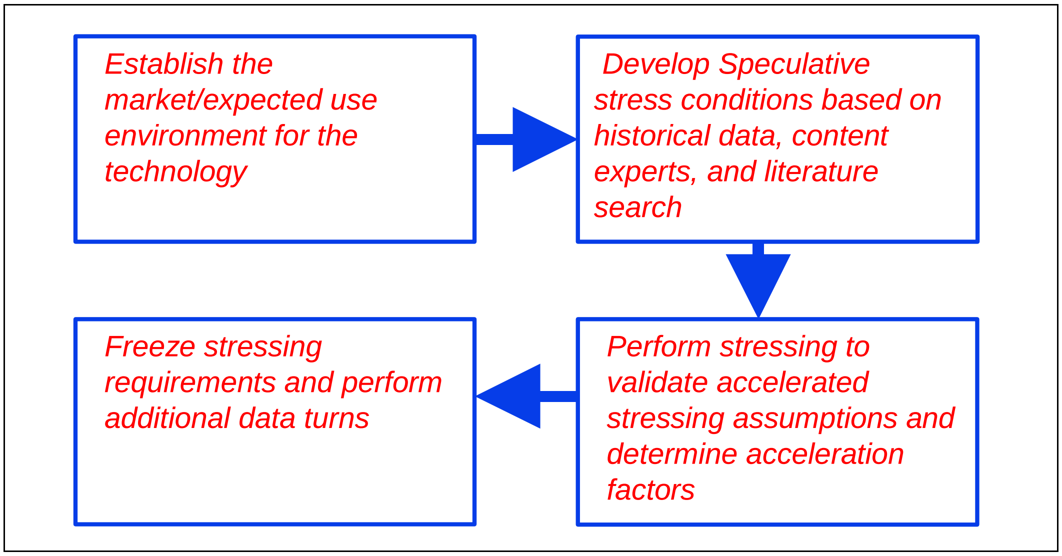
Parameter	Value	Comment
Mated loop inductance, Loop	<3.9nH	The inductance calculated for two contacts, considering one forward conductor and one return conductor. These values must be satisfied at the worst-case height of the socket.
Mated partial mutual inductance, L	NA	The inductance on a contact due to any single neighboring contact.
Maximum mutual capacitance, C.	<1 pF	The capacitance between two contacts
Socket Average Contact Resistance (EOL)	15.2 mΩ	The socket average contact resistance target is derived from average of every chain contact resistance for each part used in testing, with a chain contact resistance defined as the resistance of each chain minus resistance of shorting bars divided by number of lands in the daisy chain. The specification listed is at room temperature and has to be satisfied at all time. **Socket Contact Resistance:** The resistance of the socket contact, solderball, and interface resistance to the interposer land.
Max Individual Contact Resistance (EOL)	≤ 100 mΩ	The specification listed is at room temperature and has to be satisfied at all time. **Socket Contact Resistance:** The resistance of the socket contact, solderball, and interface resistance to the interposer land; gaps included.
Bulk Resistance Increase	≤ 3 mΩ	The bulk resistance increase per contact from 24 °C to 107 °C
Dielectric Withstand Voltage	360 Volts RMS	
Insulation Resistance	800 MΩ	

4.6 Environmental Requirements

Design, including materials, shall be consistent with the manufacture of units that meet the following environmental reference points.

The reliability targets in this chapter are based on the expected field use environment for these products. The test sequence for new sockets will be developed using the knowledge-based reliability evaluation methodology, which is acceleration factor dependent. A simplified process flow of this methodology can be seen in Figure 4-1.

Figure 4-1. Flow Chart of Knowledge-Based Reliability Evaluation Methodology



A detailed description of this methodology can be found at:

ftp://download.intel.com/technology/itj/q32000/pdf/reliability.pdf.

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5 Sensor Based Thermal Specification Design Guidance

The introduction of the sensor based thermal specification presents opportunities for the system designer to optimize the acoustics and simplify thermal validation. The sensor based specification utilizes the Digital Thermal Sensor information accessed using the PECI interface.

This chapter will review thermal solution design options, fan speed control design guidance & implementation options and suggestions on validation both with the TTV and the live die in a shipping system.

5.1 Sensor Based Specification Overview

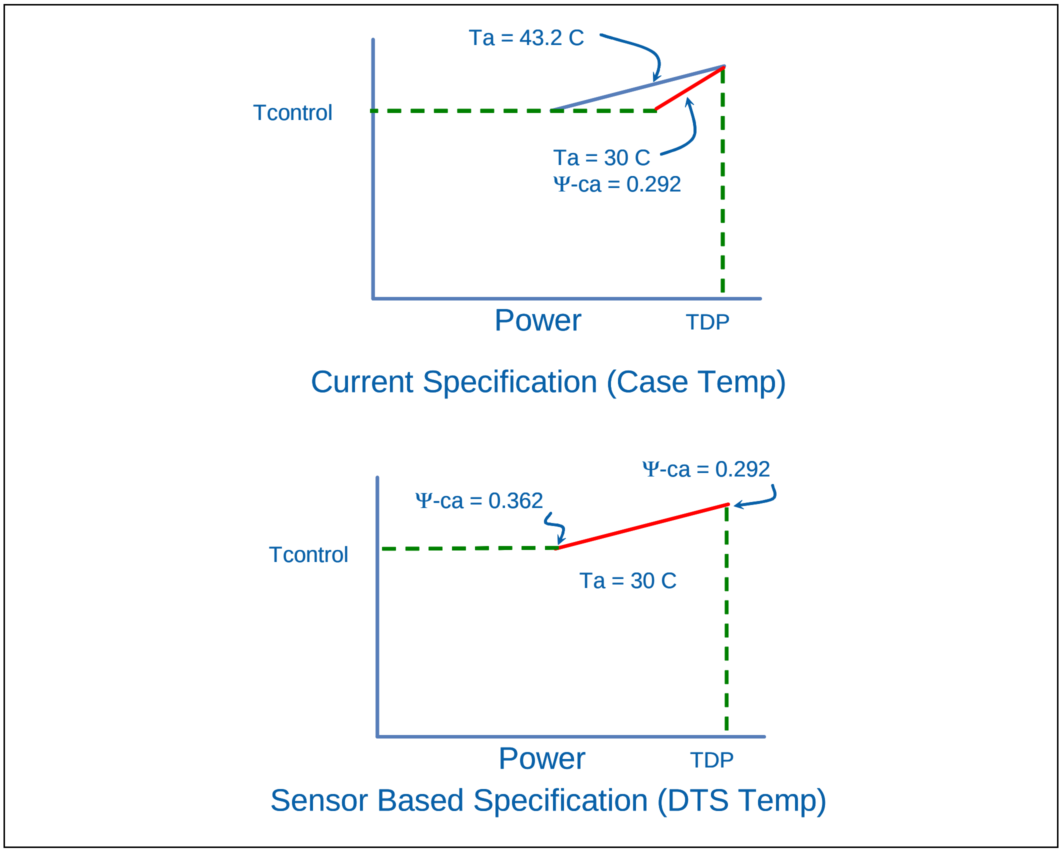
Create a thermal specification that meets the following requirements:

- Use Digital Thermal Sensor (DTS) for real-time thermal specification compliance.
- Single point of reference for thermal specification compliance over all operating conditions.
- Does not required measuring processor power & case temperature during functional system thermal validation.
- Opportunity for acoustic benefits for DTS values between $T_{CONTROL}$ and -1.

The current specification based on the processor case temperature has some notable gaps to optimal acoustic design. When the ambient temperature is less than the maximum design point, the fan speed control system (FSC) will over cool the processor. The FSC has no feedback mechanism to detect this over cooling. This is shown in the top half of Figure 5-1.

The sensor based specification will allow the FSC to be operated at the maximum allowable silicon temperature or T_J for the measured ambient. This will provide optimal acoustics for operation above $T_{CONTROL}$. See lower half of Figure 5-1.

Figure 5-1. Comparison of Case Temperature vs. Sensor Based Specification



5.2 Sensor Based Thermal Specification

The sensor based thermal specification consists of two parts. The first is a thermal profile that defines the maximum TTV T_{CASE} as a function of TTV power dissipation. The thermal profile defines the boundary conditions for validation of the thermal solution.

The second part is a defined thermal solution performance (Ψ_{CA}) as a function of the DTS value as reported over the PECI bus when DTS is greater than $T_{CONTROL}$. This defines the operational limits for the processor using the TTV validated thermal solution.

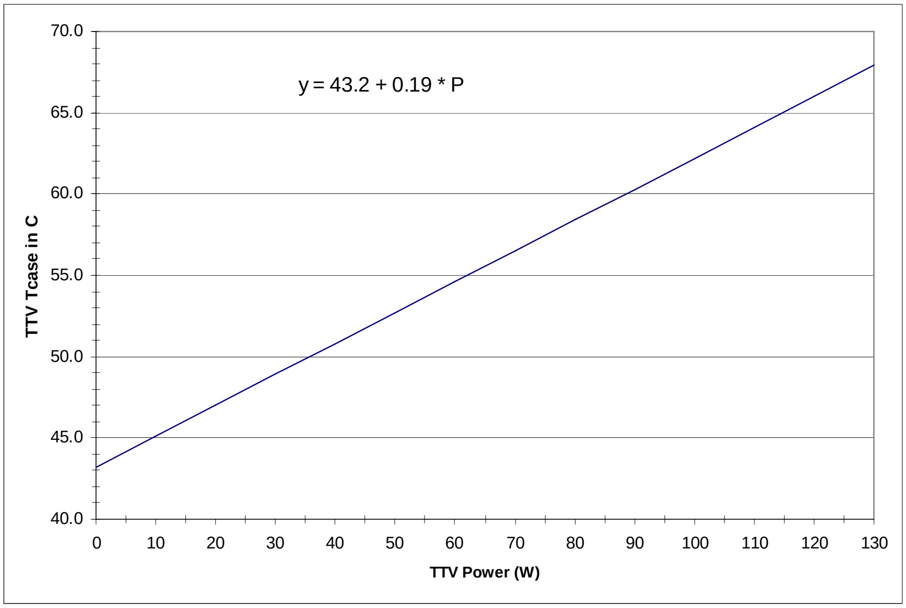
5.2.1 TTV Thermal Profile

For the sensor based specification the only reference made to a case temperature measurement is on the TTV. Functional thermal validation will not require the user to apply a thermocouple to the processor package or measure processor power.

Note: All functional compliance testing will be based on fan speed response to the reported DTS values above $T_{CONTROL}$. As a result no conversion of TTV T_{CASE} to processor T_{CASE} will be necessary.

As in previous product specifications, a knowledge of the system boundary conditions is necessary to perform the heatsink validation. Section 5.3.1 will provide more detail on defining the boundary conditions. The TTV is placed in the socket and powered to the recommended value to simulate the TDP condition. See Figure 5-2 for an example of the processor TTV thermal profile.

Figure 5-2. Thermal Profile



Note: This graph is provided as a reference. Please refer to the appropriate processor datasheet for the specification.

5.2.2 Specification When DTS value is Greater than $T_{CONTROL}$

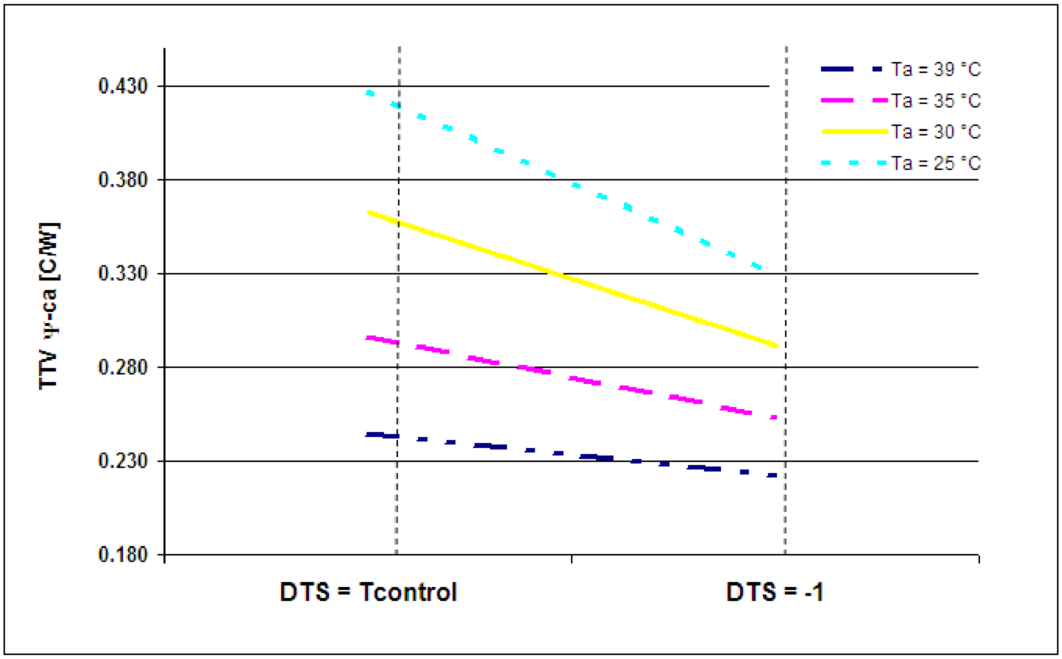
The product specification provides a table of Ψ_{CA} values at DTS = $T_{CONTROL}$ and DTS = -1 as a function of $T_{AMBIENT}$ (inlet to heatsink). Between these two defined points, a linear interpolation can be done for any DTS value reported by the processor. A copy of the specification is provided as a reference in Table 5-1 of Section 5.6.

The fan speed control algorithm has enough information using only the DTS value and $T_{AMBIENT}$ to command the thermal solution to provide just enough cooling to keep the part on the thermal profile.

As an example, the data in Table 5-1 has been plotted in Figure 5-3 to show the required Ψ_{CA} at 25, 30, 35, and 39 °C $T_{AMBIENT}$. The lower the ambient, the higher the required Ψ_{CA} which means lower fan speeds and reduced acoustics from the processor thermal solution.

In the prior thermal specifications this region, DTS values greater than $T_{CONTROL}$, was defined by the processor thermal profile. This required the user to estimate the processor power and case temperature. Neither of these two data points are accessible in real time for the fan speed control system. As a result, the designer had to assume the worst case $T_{AMBIENT}$ and drive the fans to accommodate that boundary condition.

Figure 5-3. Thermal solution Performance



5.3 Thermal Solution Design Process

Thermal solution design guidance for this specification is the same as with previous products. The initial design must take into account the target market and overall product requirements for the system. This can be broken down into several steps:

- Boundary condition definition
- Thermal design / modelling
- Thermal testing

5.3.1 Boundary Condition Definition

Using the knowledge of the system boundary conditions (e.g., inlet air temperature, acoustic requirements, cost, design for manufacturing, package and socket mechanical specifications and chassis environmental test limits) the designer can make informed thermal solution design decisions.

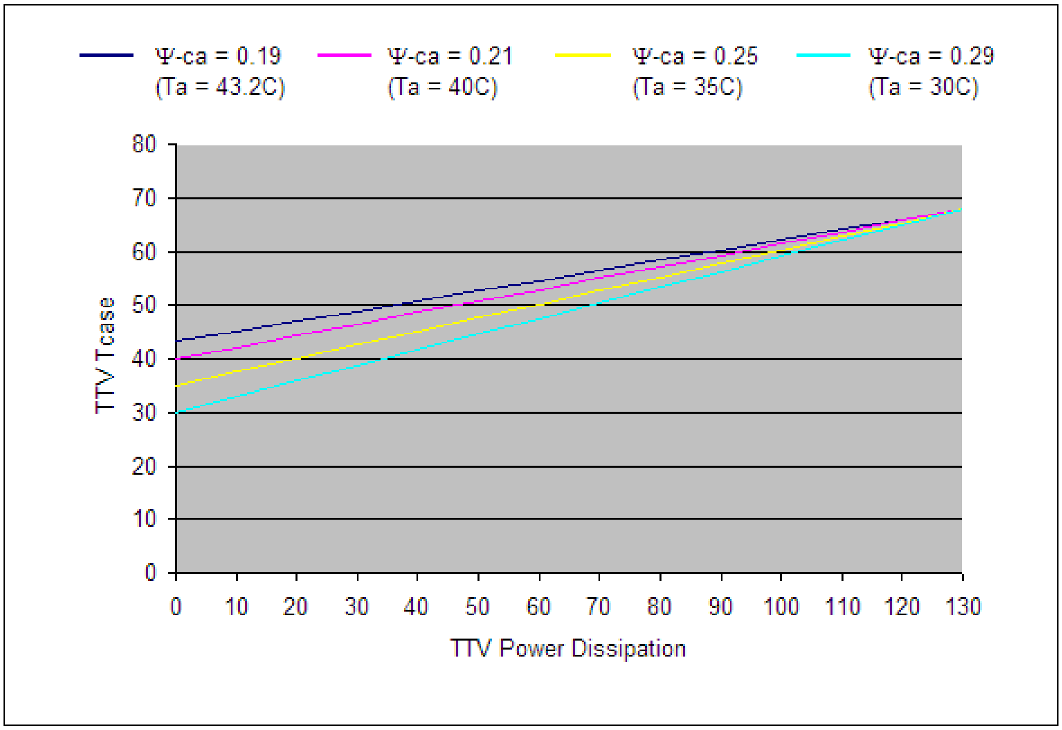
The thermal boundary conditions for an ATX tower system are as follows:

- $T_{EXTERNAL}$ = 35 °C. This is typical of a maximum system operating environment
- T_{RISE} = 4 °C. This is typical of a chassis compliant to CAG 1.1
- $T_{AMBIENT}$ = 39 °C ($T_{AMBIENT} = T_{EXTERNAL} + T_{RISE}$)

Based on the system boundary conditions, the designer can select a $T_{AMBIENT}$ and Ψ_{CA} to use in thermal modelling. The assumption of a $T_{AMBIENT}$ has a significant impact on the required Ψ_{CA} needed to meet TTV $T_{CASEMAX}$ at TDP. A system that can deliver lower assumed $T_{AMBIENT}$ can utilize a design with a higher Ψ_{CA}, which can have a lower cost. Figure 5-4 shows a number of satisfactory solutions for the processor.

Note: If the assumed $T_{AMBIENT}$ is inappropriate for the intended system environment, the thermal solution performance may not be sufficient to meet the product requirements. The results may be excessive noise from fans having to operate at a speed higher than intended. In the worst case this can lead to performance loss with excessive activation of the Thermal Control Circuit (TCC).

Figure 5-4. Required Ψ_{CA} for various $T_{AMBIENT}$ Conditions



Note: If an ambient of greater than 43.2 °C is necessary based on the boundary conditions a thermal solution with a Ψ_{CA} lower than 0.19 °C/W will be required.

5.3.2 Thermal Design and Modelling

Based on the boundary conditions the designer can now make the design selection of the thermal solution components. The major components that can be mixed are the fan, fin geometry, heat pipe or air cooled solid core design. There are cost and acoustic trade-offs the customer must make.

To aide in the design process Intel provides TTV thermal models. Please consult your Intel Field Sales Engineer for these tools.

5.3.3 Thermal Solution Validation

5.3.3.1 Test for Compliance to the TTV Thermal Profile

This step is the same as previously suggested for prior products. The thermal solution is mounted on a test fixture with the TTV and tested at the following conditions:

- TTV is powered to the TDP condition
- Thermal solution fan operating at full speed
- $T_{AMBIENT}$ at the boundary condition from Section 5.3.1

The following data is collected: TTV power, TTV T_{CASE}, and $T_{AMBIENT}$, and used to calculate Ψ_{CA}, which is defined as:

$$\Psi_{CA} = (\text{TTV } T_{CASE} - T_{AMBIENT}) \;/\; \text{Power}$$

This testing is best conducted on a bench to eliminate as many variables as possible when assessing the thermal solution performance. The boundary condition analysis as described in Section 5.3.1 should help in making the bench test simpler to perform.

5.3.3.2 Thermal Solution Characterization for Fan Speed Control

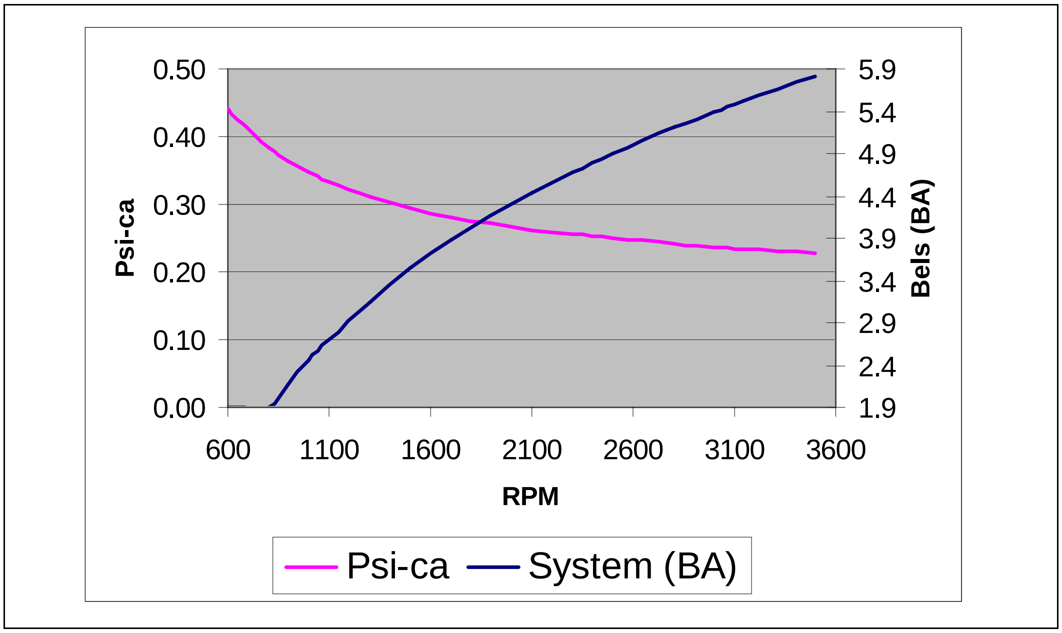
The final step in thermal solution validation is to establish the thermal solution performance,Ψ_{CA} and acoustics as a function of fan speed. This data is necessary to allow the fan speed control algorithm developer to program the device. It also is needed to asses the expected acoustic impact of the processor thermal solution in the system.

The characterization data should be taken over the operating range of the fan. Using the RCHF5 as the example the fan is operational from 600 to 3500 RPM. The data was collected at several points and a curve was fit to the data see Figure 5-5. Taking data at 6 evenly distributed fan speeds over the operating range should provide enough data to establish a 3-variable equation. By using the equation from the curve fitting a complete set of required fan speeds as a function of Ψ_{CA} be developed. The results from the reference thermal solution characterization are provided in Table 5-1.

The fan speed control device may modulate the thermal solution fan speed (RPM) by one of two methods a pulse width modulation (PWM) signal or varying the voltage to the fan. As a result the characterization data needs to also correlate the RPM to PWM or voltage to the thermal solution fan. The fan speed algorithm developer needs to associate the output command from the fan speed control device with the required thermal solution performance as stated in Table 5-1. Regardless of which control method is used, the term RPM will be used to indicate required fan speed in the rest of this document.

Note: When selecting a thermal solution from a thermal vendor, the characterization data should be requested directly from them as a part of their thermal solution collateral.

Figure 5-5. Thermal Solution Performance vs. Fan Speed



Note: This data is taken from the validation of the RCBF5 reference processor thermal solution. The Ψ_{CA} vs. RPM data is available in Table 5-1 at the end of this chapter.

5.4 Fan Speed Control (FSC) Design Process

The next step is to incorporate the thermal solution characterization data into the algorithms for the device controlling the fans.

As a reminder, the requirements are:

- When the DTS value is at or below $T_{CONTROL}$, the fans can be slowed down; just as with prior processors.
- When DTS is above $T_{CONTROL}$, FSC algorithms will use knowledge of $T_{AMBIENT}$ and Ψ_{CA} vs. RPM to achieve the necessary level of cooling.

This chapter discusses two implementations. The first is a FSC system that is not provided the $T_{AMBIENT}$ information and a FSC system that is provided data on the current $T_{AMBIENT}$. Either method will result in a thermally compliant solution and some acoustic benefit by operating the processor closer to the thermal profile. But only the $T_{AMBIENT}$ aware FSC system can fully use the specification for optimized acoustic performance.

In the development of the FSC algorithm it should be noted that the $T_{AMBIENT}$ is expected to change at significantly slower rate than the DTS value. The DTS value will be driven by the workload on the processor and the thermal solution will be required to respond to this much more rapidly than the changes in $T_{AMBIENT}$.

An additional consideration in establishing the fan speed curves is to account for the thermal interface material performance degradation over time.

5.4.1 Fan Speed Control Algorithm without $T_{AMBIENT}$ Data

In a system that does not provide the FSC algorithm with the $T_{AMBIENT}$ information, the designer must make the following assumption:

- When the DTS value is greater than $T_{CONTROL}$ the $T_{AMBIENT}$ is at boundary condition derived in Section 5.3.1.

This is consistent with our previous FSC guidance to accelerate the fan to full speed when the DTS value is greater than $T_{CONTROL}$. As will be shown below, the DTS thermal specification at DTS = $T_{CONTROL}$ can reduce some of the over cooling of the processor and provide an acoustic noise reduction from the processor thermal solution.

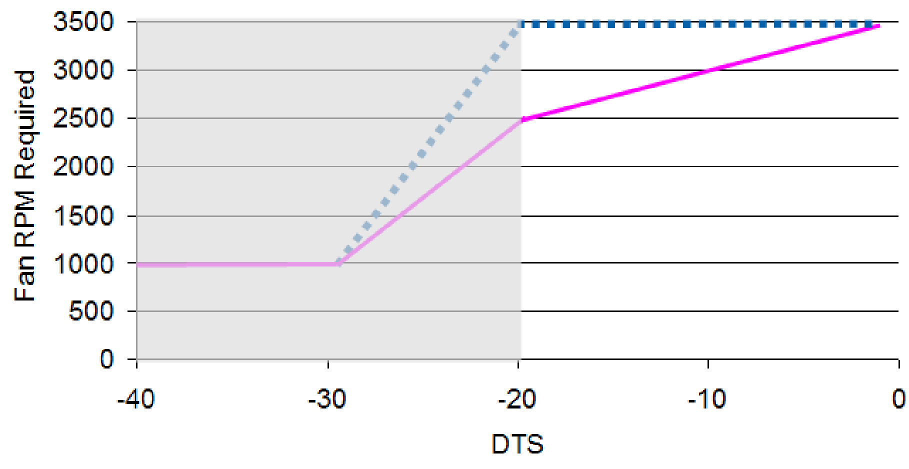
In this example the following assumptions are made:

- $T_{AMBIENT}$ = 39 °C
- Thermal Solution designed / validated to a 39 °C environment
- $T_{CONTROL}$ = -20
- Reference processor thermal solution (RCFH5)
- Below $T_{CONTROL}$ the fan speed is slowed down as in prior products

For a processor specification based on a T_{CASE} thermal profile, when the DTS value is equal to or greater than $T_{CONTROL}$, the fan speed must be accelerated to full speed. For the reference thermal solution full speed is 3500 RPM (dashed line in Figure 5-6). The DTS thermal specification defines a required Ψ_{CA} and therefore the fan speed is 2500 RPM. This is much less than full speed even if the assumption is a $T_{AMBIENT}$ = 39 °C (solid line in Figure 5-6). The shaded area displayed in Figure 5-6 is where DTS values are less than $T_{CONTROL}$. For simplicity, the graph shows a linear acceleration of the fans from $T_{CONTROL}$ – 10 to $T_{CONTROL}$ as has been Intel's guidance for simple fan speed control algorithms.

As the processor workload continues to increase, the DTS value will increase and the FSC algorithm will linearly increase the fan speed from the 2500 RPM at DTS = -20 to full speed at DTS value = -1.

Figure 5-6. Fan Response Without $T_{AMBIENT}$ Data



5.4.2 Fan Speed Control Algorithm with $T_{AMBIENT}$ Data

In a system where the FSC algorithm has access to the $T_{AMBIENT}$ information and is capable of using the data the benefits of the DTS thermal specification become more striking.

As will be demonstrated below, there is still over cooling of the processor, even when compared to a nominally ambient aware thermal solution equipped with a thermistor. An example of these thermal solutions are the RCFH5 or the boxed processor thermal solutions. This over cooling translates into acoustic margin that can be used in the overall system acoustic budget.

In this example the following assumptions are made:

- $T_{AMBIENT}$ = 35 °C
- Thermal Solution designed / validated to a 39 °C environment
- $T_{CONTROL}$ = -20
- FSC device has access to $T_{AMBIENT}$
- Reference processor thermal solution (RCFH5)
- Below $T_{CONTROL}$ the fan speed is slowed down as in prior products

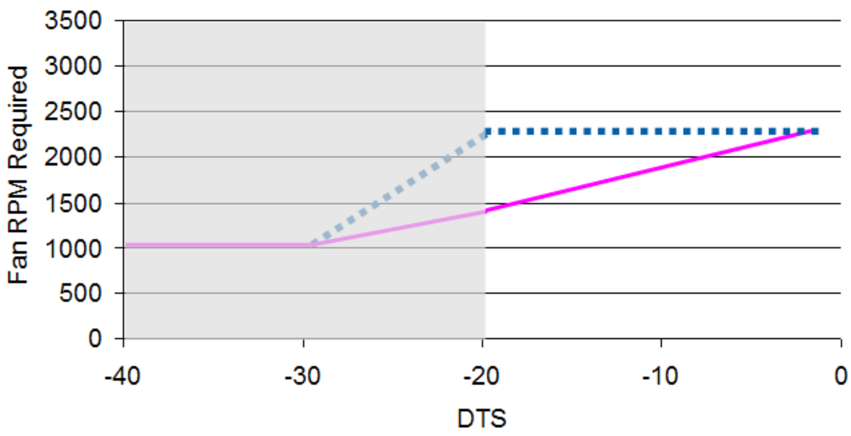
For a processor specification based on a T_{CASE} thermal profile, when the DTS value is equal to or greater than $T_{CONTROL}$, the fan speed is accelerated to maximum fan speed for the $T_{AMBIENT}$ as controlled by the thermistor in thermal solution. For the RCFH5, this would be about 2500 RPM at 35 °C. This is graphically displayed as the dashed line in Figure 5-7.

This is an improvement over the ambient unaware system but is not fully optimized for acoustic benefit. The DTS thermal specification required Ψ_{CA} and therefore the fan speed in this scenario is 1450 RPM. This is less than thermistor controlled speed of 2500 RPM - even if the assumption is a $T_{AMBIENT}$ = 35 °C. This is graphically displayed in Figure 5-7.

The shaded area displayed in Figure 5-7 is where DTS values are less than $T_{CONTROL}$. For simplicity, the graph shows a linear acceleration of the fans from $T_{CONTROL}$ - 10 to $T_{CONTROL}$ as has been Intel's guidance for simple fan speed control algorithms.

As the processor workload continues to increase, the DTS value will increase and the FSC algorithm will linearly increase the fan speed from the 1450 RPM at DTS = -20 to 2250 RPM at DTS value = -1.

Figure 5-7. Fan Response with $T_{AMBIENT}$ Aware FSC



5.5 System Validation

System validation should focus on ensuring the fan speed control algorithm is responding appropriately to the DTS values and $T_{AMBIENT}$ data as well as any other device being monitored for thermal compliance.

Since the processor thermal solution has already been validated using the TTV to the thermal specifications at the predicted $T_{AMBIENT}$, additional TTV based testing in the chassis is not expected to be necessary.

Once the heatsink has been demonstrated to meet the TTV Thermal Profile, it should be evaluated on a functional system at the boundary conditions.

In the system under test and Power/Thermal Utility Software set to dissipate the TDP workload confirm the following item:

- Verify if there is TCC activity by instrumenting the PROCHOT# signal from the processor. TCC activation in functional application testing is unlikely with a compliant thermal solution. Some very high power applications might activate TCC for short intervals this is normal.
- Verify fan speed response is within expectations - actual RPM (Ψ_{CA}) is consistent with DTS temperature and $T_{AMBIENT}$.
- Verify RPM vs. PWM command (or voltage) output from the FSC device is within expectations.
- Perform sensitivity analysis to asses impact on processor thermal solution performance and acoustics for the following:
    - — Other fans in the system.
    - — Other thermal loads in the system.

In the same system under test, run real applications that are representative of the expected end user usage model and verify the following:

- TCC activation is not occurring.
- Verify fan speed response vs. expectations as done using Power/Thermal Utility SW.
- Validate system boundary condition assumptions: Trise, venting locations, other thermal loads and adjust models / design as required.

5.6 Specification for Operation Where Digital Thermal Sensor Exceeds $T_{CONTROL}$

Table 5-1 is provided as reference for the development of thermal solutions and the fan speed control algorithm.

Table 5-1. Thermal Solution Performance above $T_{CONTROL}$

$T_{AMBIENT}$[1]	Ψ_{CA} at DTS = $T_{CONTROL}$[2]	RPM for Ψ_{CA} at DTS = $T_{CONTROL}$[5]	Ψ_{CA} at DTS = -1[3]	RPM for Ψ_{CA} at DTS = -1[5]
43.2	0.190	N/A	0.190	N/A
42.0	0.206	N/A	0.199	N/A
41.0	0.219	N/A	0.207	N/A
40.0	0.232	3250	0.215	N/A
39.0	0.245	2600	0.222	3500
38.0	0.258	2200	0.230	3150
37.0	0.271	1900	0.238	2400
36.0	0.284	1700	0.245	2500
35.0	0.297	1450	0.253	2500
34.0	0.310	1300	0.261	2100
33.0	0.323	1200	0.268	1900
32.0	0.336	1100	0.276	1700
31.0	0.349	1000	0.284	1650
30.0	0.362	900	0.292	1550
29.0	0.375	850	0.299	1450
28.0	0.388	800	0.307	1350
27.0	0.401	700	0.315	1250
26.0	0.414	700	0.322	1200
25.0	0.427	650	0.330	1100
24.0	0.440	600	0.338	1050
23.0	0.453	600	0.345	1000
22.0	0.466	600	0.353	950
21.0	0.479	600	0.361	900
20.0	0.492	600	0.368	900
19.0	0.505	600	0.376	850
18.0	0.519	600	0.384	800

Notes:

1. The ambient temperature is measured at the inlet to the processor thermal solution
2. This column can be expressed as a function of $T_{AMBIENT}$ by the following equation: $\Psi_{CA} = 0.19 + (43.2 - T_{AMBIENT}) * 0.013$
3. This column can be expressed as a function of $T_{AMBIENT}$ by the following equation: $\Psi_{CA} = 0.19 + (43.2 - T_{AMBIENT}) * 0.0077$
4. This table is provided as a reference please consult the product specification for current values.
5. Based on the testing performed a curve was fit to the data in the form
   Psi_ca = (1+a*RPM)/(b+c*RPM) where
   a = 0.000762, b = 0.667637, c = 004402

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6 ATX Reference Thermal Solution

Note: The reference thermal mechanical solution information shown in this document represents the current state of the data and may be subject to modification.The information represents design targets, not commitments by Intel.

The design strategy is to use the design concepts from the prior Intel® Radial Curved Bifurcated Fin Heatsink Reference Design (Intel® RCBFH Reference Design) designed originally for the Intel® Pentium® 4 processors.

This chapter describes the overall requirements for the ATX heatsink reference thermal solution including critical-to-function dimensions, operating environment, and validation criteria.

6.1 Operating Environment

Table 6-1 provides the target heatsink performance for the ATX heatsink reference thermal solution supporting the processor at several system and ambient conditions.

The exhaust air flow from the processor thermal solution is the inlet air flow to the IOH reference thermal solution and other components such as the voltage regulator. This airstream is assumed to be approaching the IOH heatsink at a 30° angle from the processor thermal solution, see the *Intel® X58 Express Chipset Thermal and Mechanical Design Guide* for more details.

Table 6-1 summarizes the boundary conditions for designing and evaluating the processor thermal solution. In addition to the power dissipation a set of three system level boundary conditions for the local ambient T_A and external ambient will be used.

- Low external ambient (25 °C)/ idle power for the components (Case 3). This covers the system idle acoustic condition.
- Low external ambient (25 °C)/ TDP for the components (Case 2). The processor thermal solution fan speed is limited by the thermistor in the fan hub.
- High ambient (35 °C)/ TDP for the components (Case 1). This covers the maximum fan speed condition of the processor thermal solution.

Table 6-1. Processor Thermal Solution Requirements & Boundary Conditions

Case	External Ambient	IOH Power	Processor Power	$T_{A\text{-Local}}$	Target Psi-ca	Output Airflow
1	35 °C	TDP	TDP	39 °C	0.23 °C/W	756 LFM[3.8 m/S]
2	25 °C	TDP	TDP	30 °C	0.30 °C/W	420 LFM[2.1 m/S]
3	25 °C	Idle	Idle	30 °C	1.54 °C/W	163 LFM[0.83 m/S]

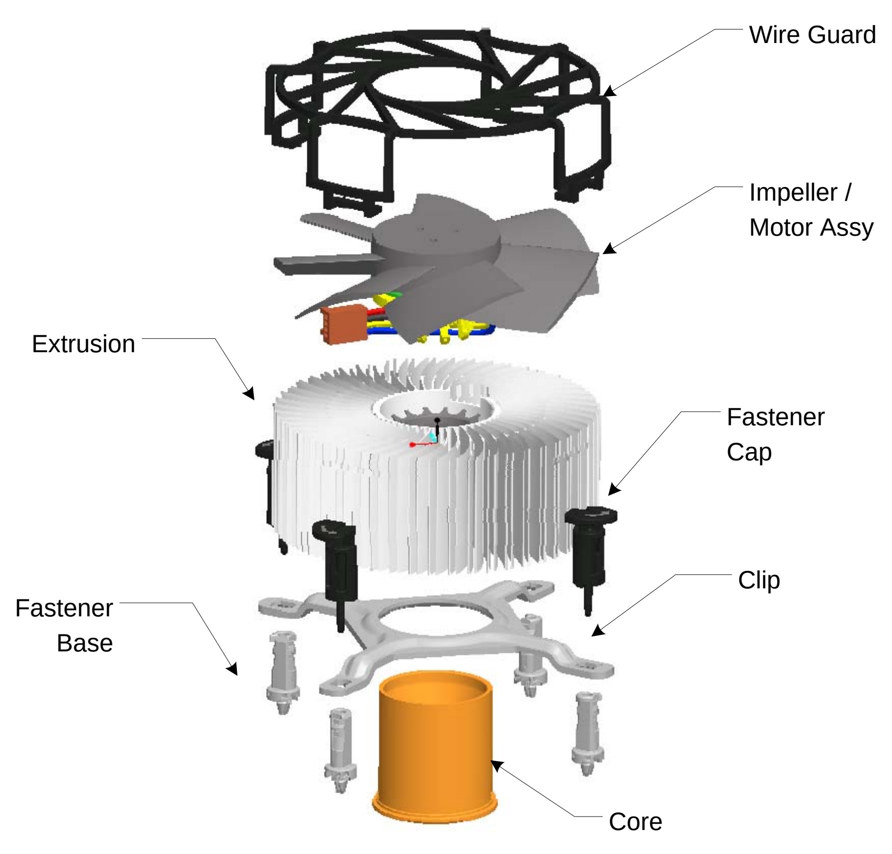
Notes:
1. The values in Table 6-1 are preliminary and subject to change.
2. Output airflow targets are the minimum inlet requirements for the IOH.
3. For Case 3 the minimum fan speed is projected to deliver 0.54 °C/W.
4. All measurements will be evaluated at sea level.

6.2 Heatsink Thermal Solution Assembly

The reference thermal solution for the processor is an active fan solution similar to the prior designs for the Intel® Pentium® 4 and Intel® Core™2 Duo processors. The design uses a copper core with an aluminum extrusion. It attaches to the motherboard with a fastener design reused from the RCBFH3 and RCFH4. The clip design is new to span the larger size of the LGA1366. The thermal solution assembly requires no assembly prior to installation on a motherboard. Figure 6-1 shows the reference thermal solution assembly in an exploded view.

The first step in assembling the thermal solution is to verify the fasteners are aligned to the mounting holes on the motherboard. The fasteners are pressed firmly to lock the thermal solution to the motherboard.

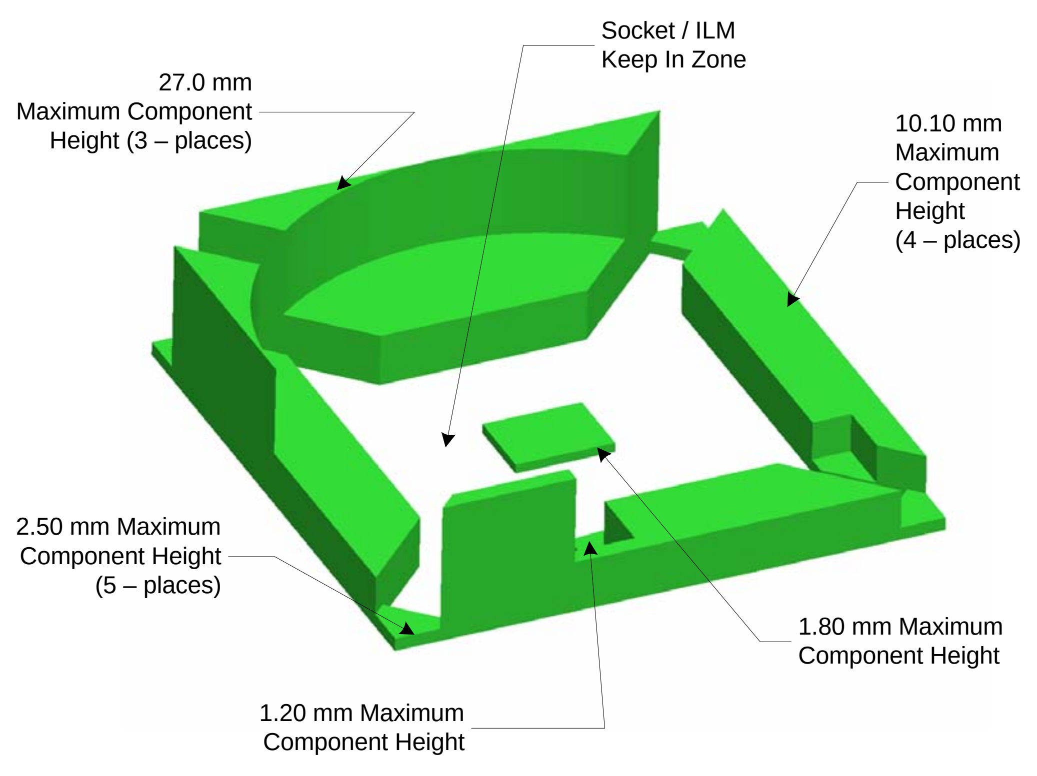
Figure 6-1. ATX Heatsink Reference Design Assembly



6.3 Geometric Envelope for the Intel® Reference ATX Thermal Mechanical Design

Figure 6-2 shows a 3-D representation of the board component keep out for the reference ATX thermal solution. A fully dimensioned drawing of the keepout information is available at Figure B-1 and Figure B-2 in Appendix B. A DXF version of these drawings is available as well as the 3-D model of the board level keep out zone is available. Contact your field sales representative for these documents.

Figure 6-2. ATX KOZ 3-D Model Primary (Top) Side



The maximum height of the reference thermal solution above the motherboard is 71.12 mm [2.8 inches], and is compliant with the motherboard primary side height constraints defined in the *ATX Specification* and the *microATX Motherboard Interface Specification* found at http://www.formfactors.org.

The reference solution requires a chassis obstruction height of at least 81.28 mm [3.2 inches], measured from the top of the motherboard. This allows for appropriate fan inlet airflow to ensure fan performance, and therefore overall cooling solution performance. This is compliant with the recommendations found in both ATX Specification and microATX Motherboard Interface Specification documents.

6.4 Reference Design Components

6.4.1 Extrusion

The aluminum extrusion is a 51 fin 102 mm diameter bifurcated fin design. The overall height of the extrusion is 38 mm tall. To facilitate reuse of the core design the center cylinder ID and wall thickness are the same as RCFH4.

Figure 6-3. RCBF5 Extrusion

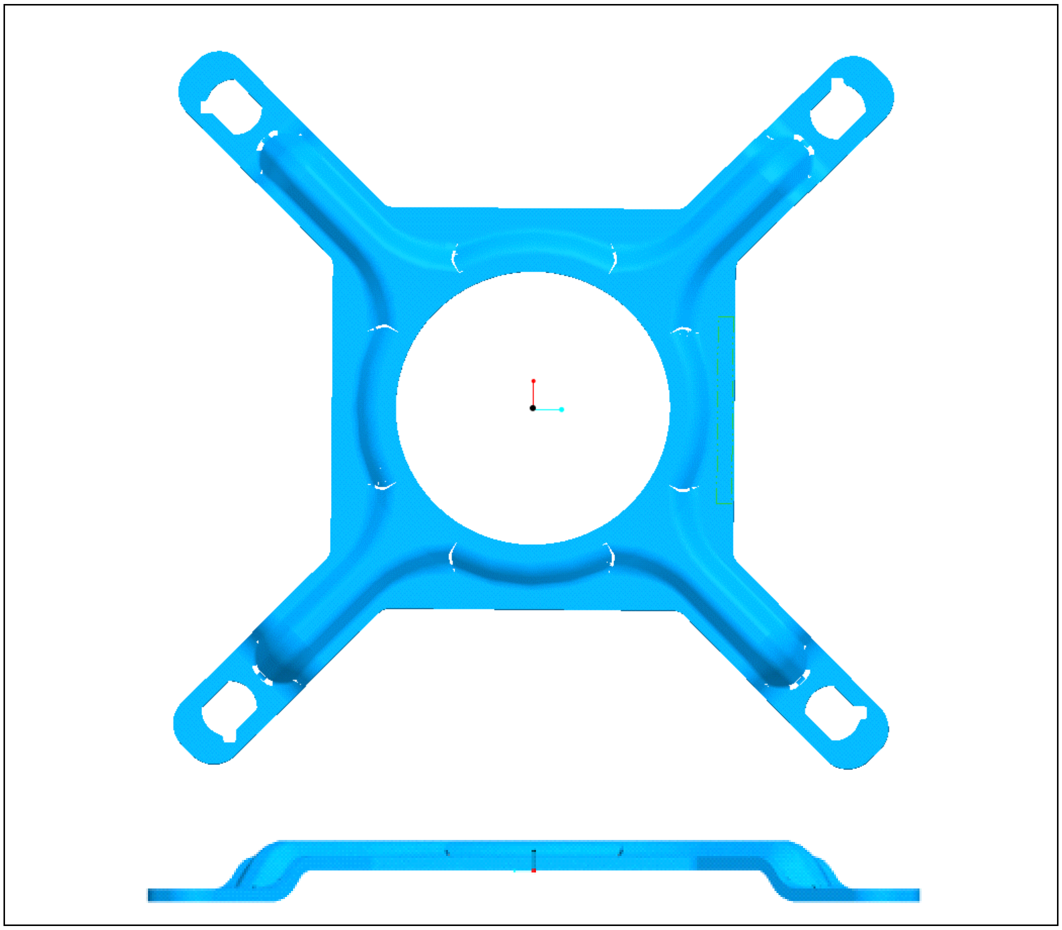
6.4.2 Clip

Structural design strategy for the clip is to provide sufficient load for the Thermal Interface Material (TIM).

The clip is formed from 1.6 mm carbon steel, the same material as used in previous clip designs. The target metal clip nominal stiffness is 376 N/mm [2150 lb/in]. The combined target for reference clip and fasteners nominal stiffness is 260 N/mm [1489 lb/in]. The nominal preload provided by the reference design is 191 N ± 42 N [43 lb ± ~10 lb].

Note: Intel reserves the right to make changes and modifications to the design as necessary to the Intel RCBF5 reference design, in particular the clip.

Figure 6-4. RCBF5 Clip



6.4.3 Core

The core is the same forged design used in RCFH4. This allows the reuse of the fan attach and if desired the same extrusion as used in RCFH4. The machined flange height has been reduced from the RCFH4 design to match the IHS height for the Intel® Xeon® Processor 3500 Series when installed in the LGA1366 socket. The final height of the flange will be an output of the design validation and could be varied to adjust the preload. See Section 6.5 for additional information on the critical to function interfaces between the core and clip.

Figure 6-5. Core

6.5 Mechanical Interface to the Reference Attach Mechanism

The attach mechanism component from the Intel RCBF5 Reference Design can be used by other 3rd party cooling solutions. The attach mechanism consists of:

- A metal attach clip that interfaces with the heatsink core, see Figure B-11 and Figure B-12 for the clip drawings.
- Four plastic fasteners, see Figure B-7, Figure B-8, Figure B-9, and Figure B-10 for the component drawings.

Figure 6-6 shows the reference attach mechanism (clip, core and extrusion) portion of the Intel RCBF5 Reference Design. The clip is assembled to the heatsink during copper core insertion, and is meant to be trapped between the core shoulder and the extrusion as shown in Figure 6-7.

The critical to function mechanical interface dimensions are shown in Figure 6-7 and Figure 6-8. Complying with the mechanical interface parameters is critical to generating a heatsink preload compliant with the minimum preload requirement for the selected TIM and to not exceed the socket design limits.

Figure 6-6. Clip Core and Extrusion Assembly

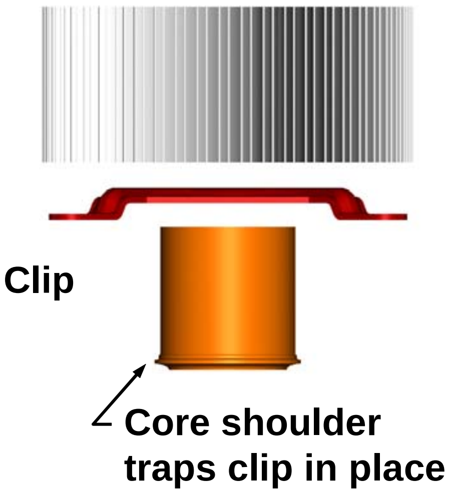


Figure 6-7. Critical Parameters for Interface to the Reference Clip

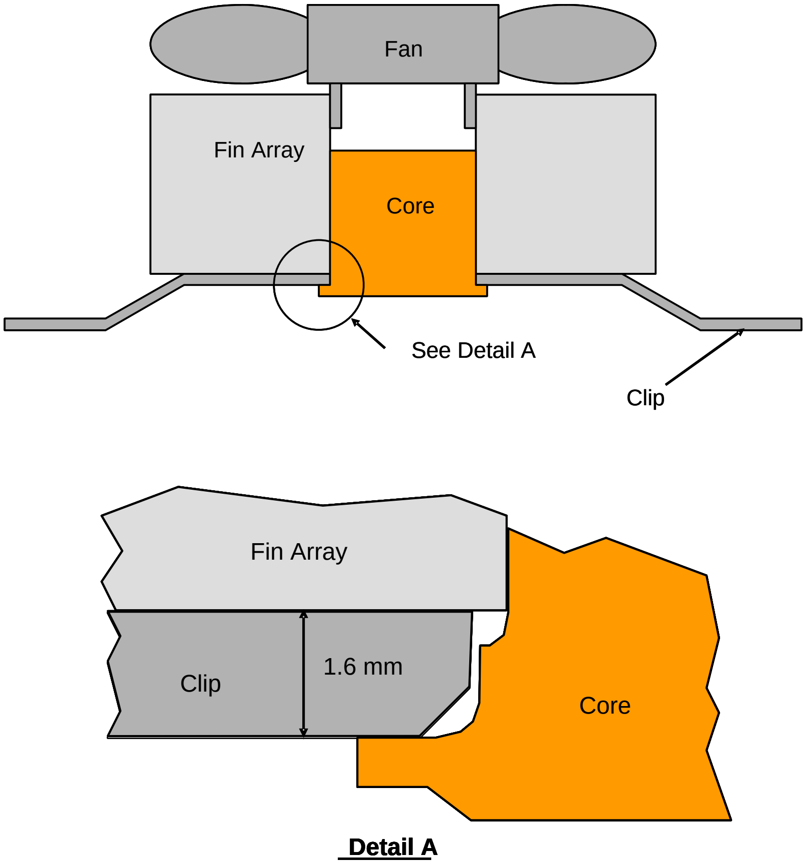
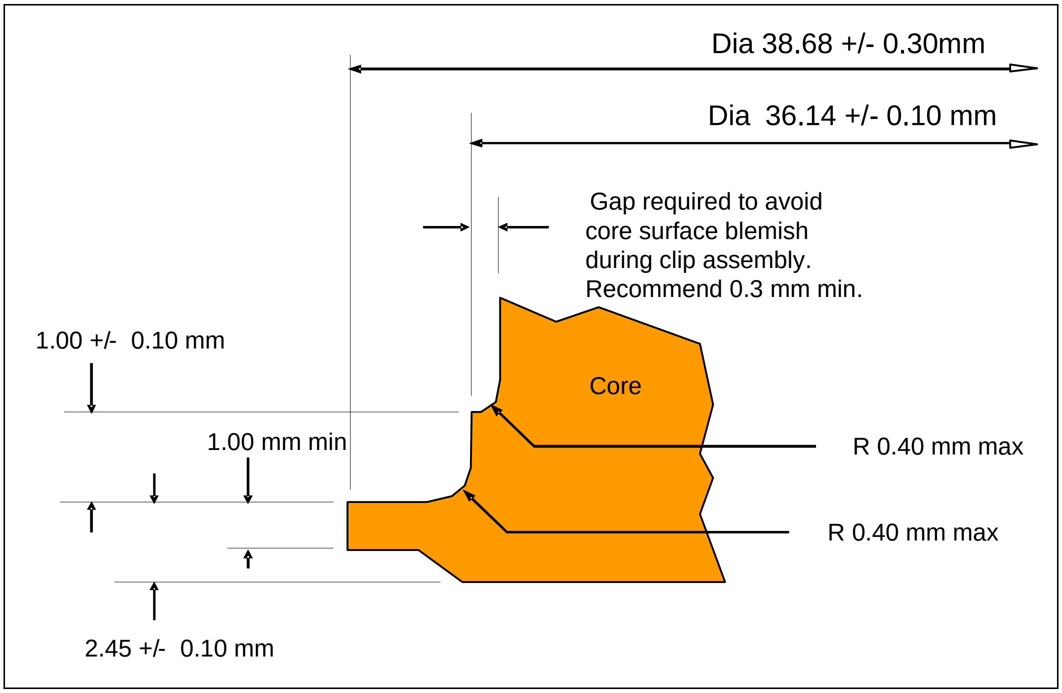


Figure 6-8. Critical Core Dimensions



6.6 Heatsink Mass and Center of Gravity

- Total assembly mass ≤ 550 gm (grams), excluding clip and fasteners
- Total mass including clip and fasteners < 595 g
- Assembly center of gravity ≤ 25.4 mm, measured from the top of the IHS

6.7 Thermal Interface Material

A thermal interface material (TIM) provides conductivity between the IHS and heat sink. The reference thermal solution uses Shin-Etsu G751*. The TIM application is 0.25 g, which will be a nominal 26 mm diameter (~1.0 inches).

6.8 Absolute Processor Temperature

Intel does not test any third party software that reports absolute processor temperature. As such, Intel cannot recommend the use of software that claims this capability. Since there is part-to-part variation in the TCC (thermal control circuit) activation temperature, use of software that reports absolute temperature can be misleading.

See the processor datasheet for details regarding use of IA32_TEMPERATURE_TARGET register to determine the minimum absolute temperature at which the TCC will be activated and PROCHOT# will be asserted.

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7 Thermal Solution Quality and Reliability Requirements

7.1 Reference Heatsink Thermal Verification

Each motherboard, heatsink and attach combination may vary the mechanical loading of the component. Based on the end user environment, the user should define the appropriate reliability test criteria and carefully evaluate the completed assembly prior to use in high volume. The Intel reference thermal solution will be evaluated to the boundary conditions in Table 7-1.

The test results, for a number of samples, are reported in terms of a worst-case mean + 3σ value for thermal characterization parameter using real processors (based on the TTV correction offset).

7.2 Mechanical Environmental Testing

The Intel reference heatsinks will be tested in an assembled condition, along with the LGA1366. Details of the Environmental Requirements, and associated stress tests, can be found in Table 7-1are based on speculative use condition assumptions, and are provided as examples only.

Table 7-1. Use Conditions (Board Level)

Test (1)	Requirement	Pass/Fail Criteria (2)
Mechanical Shock	3 drops each for + and - directions in each of 3 perpendicular axes (i.e., total 18 drops) Profile: 50 g, Trapezoidal waveform, 4.3 m/s [170 in/s] minimum velocity change	Visual Check and Electrical Functional Test
Random Vibration	Duration: 10 min./axis, 3 axes Frequency Range: 5 Hz to 500 Hz Power Spectral Density (PSD) Profile: 3.13 g RMS	Visual Check and Electrical Functional Test

Notes:
1. It is recommended that the above tests be performed on a sample size of at least ten assemblies from multiple lots of material.
2. Additional pass/fail criteria may be added at the discretion of the user.

7.2.1 Recommended Test Sequence

Each test sequence should start with components (i.e., baseboard, heatsink assembly, etc.) that have not been previously submitted to any reliability testing.

Prior to the mechanical shock & vibration test, the units under test should be preconditioned for 72 hours at 45 ºC. The purpose is to account for load relaxation during burn-in stage.

The test sequence should always start with a visual inspection after assembly, and BIOS/Processor/memory test. The stress test should be then followed by a visual inspection and then BIOS/Processor/memory test.

7.2.2 Post-Test Pass Criteria

The post-test pass criteria are:

1. No significant physical damage to the heatsink and retention hardware.
2. Heatsink remains seated and its bottom remains mated flatly against the IHS surface. No visible gap between the heatsink base and processor IHS. No visible tilt of the heatsink with respect to the retention hardware.
3. No signs of physical damage on baseboard surface due to impact of heatsink.
4. No visible physical damage to the processor package.
5. Successful BIOS/Processor/memory test of post-test samples.
6. Thermal compliance testing to demonstrate that the case temperature specification can be met.

7.2.3 Recommended BIOS/Processor/Memory Test Procedures

This test is to ensure proper operation of the product before and after environmental stresses, with the thermal mechanical enabling components assembled. The test shall be conducted on a fully operational baseboard that has not been exposed to any battery of tests prior to the test being considered.

Testing setup should include the following components, properly assembled and/or connected:

- Appropriate system baseboard.
- Processor and memory.
- All enabling components, including socket and thermal solution parts.

The pass criterion is that the system under test shall successfully complete the checking of BIOS, basic processor functions and memory, without any errors. *Intel PC Diags* is an example of software that can be utilized for this test.

7.3 Material and Recycling Requirements

Material shall be resistant to fungal growth. Examples of non-resistant materials include cellulose materials, animal and vegetable based adhesives, grease, oils, and many hydrocarbons. Synthetic materials, such as PVC formulations, certain polyurethane compositions (e.g., polyester and some polyethers), plastics which contain organic fillers of laminating materials, paints, and varnishes also are susceptible to fungal growth. If materials are not fungal growth resistant, then MIL-STD-810E, Method 508.4 must be performed to determine material performance.

Material used shall not have deformation or degradation in a temperature life test.

Any plastic component exceeding 25 grams should be recyclable per the European Blue Angel recycling standards.

The following definitions apply to the use of the terms lead-free, Pb-free, and RoHS compliant.

Lead-free and Pb-free: Lead has not been intentionally added, but lead may still exist as an impurity below 1000 ppm.

RoHS compliant: Lead and other materials banned in RoHS Directive are either (1) below all applicable substance thresholds as proposed by the EU or (2) an approved/pending exemption applies.

Note: RoHS implementation details are not fully defined and may change.

§

A Component Suppliers

Note: The part numbers listed below identifies the reference components. End-users are responsible for the verification of the Intel enabled component offerings with the supplier. These vendors and devices are listed by Intel as a convenience to Intel's general customer base, but Intel does not make any representations or warranties whatsoever regarding quality, reliability, functionality, or compatibility of these devices. Customers are responsible for thermal, mechanical, and environmental validation of these solutions. This list and/or these devices may be subject to change without notice.

Table A-1. Reference Heatsink Enabled Components

Item	Intel PN	AVC	Delta	Nidec	ITW
Heatsink Assembly (RCBF5) (Core, Fan, Extrusion, TIM)	D95135-005	Z1ML005001	N/A	N/A	N/A
Heatsink Assembly (DBX-A)	E31964-001	N/A	E31964-001	N/A	N/A
Heatsink Assembly (DBA-A)	E29477-002	N/A	E29477-002	E29477-002	N/A
Clip	D94152-002	A208000308	N/A	N/A	N/A
Fastener	Base: C33389 Cap: C33390	N/A	N/A	N/A	Base: C33389 Cap: C33390

Table A-2. LGA1366 Socket and ILM Components

Item	Intel PN	Foxconn	Tyco
ILM	D92428-002	PT44L12-4101	1939738-1
Back Plate	D92430-001	PT44P11-4101	1939739-1
LGA1366	D86205-002	PE136627-4371-01F	1939737-1

Table A-3. Supplier Contact Information

Supplier	Contact	Phone	Email
AVC (Asia Vital Corporation)	David Chao Rachel Hsu	+886-2-2299-6930 ext. 7619 +886-2-2299-6930 ext. 7630	david_chao@avc.com.tw raichel_hsi@avc.com.tw
ITW Fastex	Roger Knell	773-307-9035	rknell@itwfastex.com
Foxconn	Julia Jiang	408-919-6178	juliaj@foxconn.com
Tyco	Billy Hsieh	+81 44 844 8292	billy.hsieh@tycoelectronics.com

The enabled components may not be currently available from all suppliers. Contact the supplier directly to verify time of component availability.

§

B Mechanical Drawings

Table B-1 lists the mechanical drawings included in this appendix.

Table B-1. Mechanical Drawing List

Drawing Description	Figure Number
“Socket / Heatsink / ILM Keepout Zone Primary Side (Top)”	Figure B-1
“Socket / Heatsink / ILM Keepout Zone Secondary Side (Bottom)”	Figure B-2
“Socket / Processor / ILM Keepout Zone Primary Side (Top)”	Figure B-3
“Socket / Processor / ILM Keepout Zone Secondary Side (Bottom)”	Figure B-4
“Reference Design Heatsink Assembly (1 of 2)”	Figure B-5
“Reference Design Heatsink Assembly (2 of 2)”	Figure B-6
“Reference Fastener Sheet 1 of 4”	Figure B-7
“Reference Fastener Sheet 2 of 4”	Figure B-8
“Reference Fastener Sheet 3 of 4”	Figure B-9
“Reference Fastener Sheet 4 of 4”	Figure B-10
“Reference Clip - Sheet 1 of 2”	Figure B-11
“Reference Clip - Sheet 2 of 2”	Figure B-12

Figure B-1. Socket / Heatsink / ILM Keepout Zone Primary Side (Top)

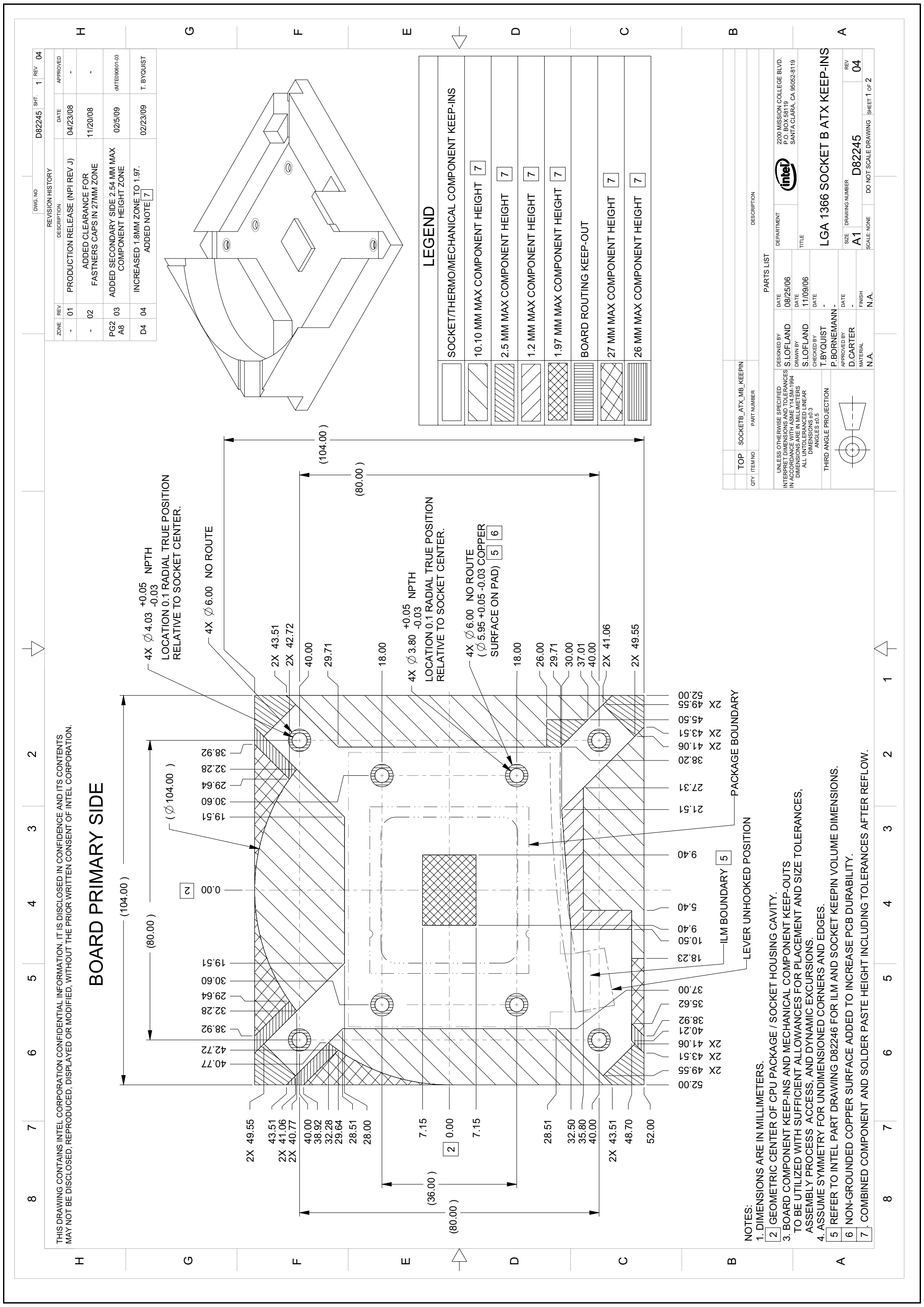


Figure B-2. Socket / Heatsink / ILM Keepout Zone Secondary Side (Bottom)

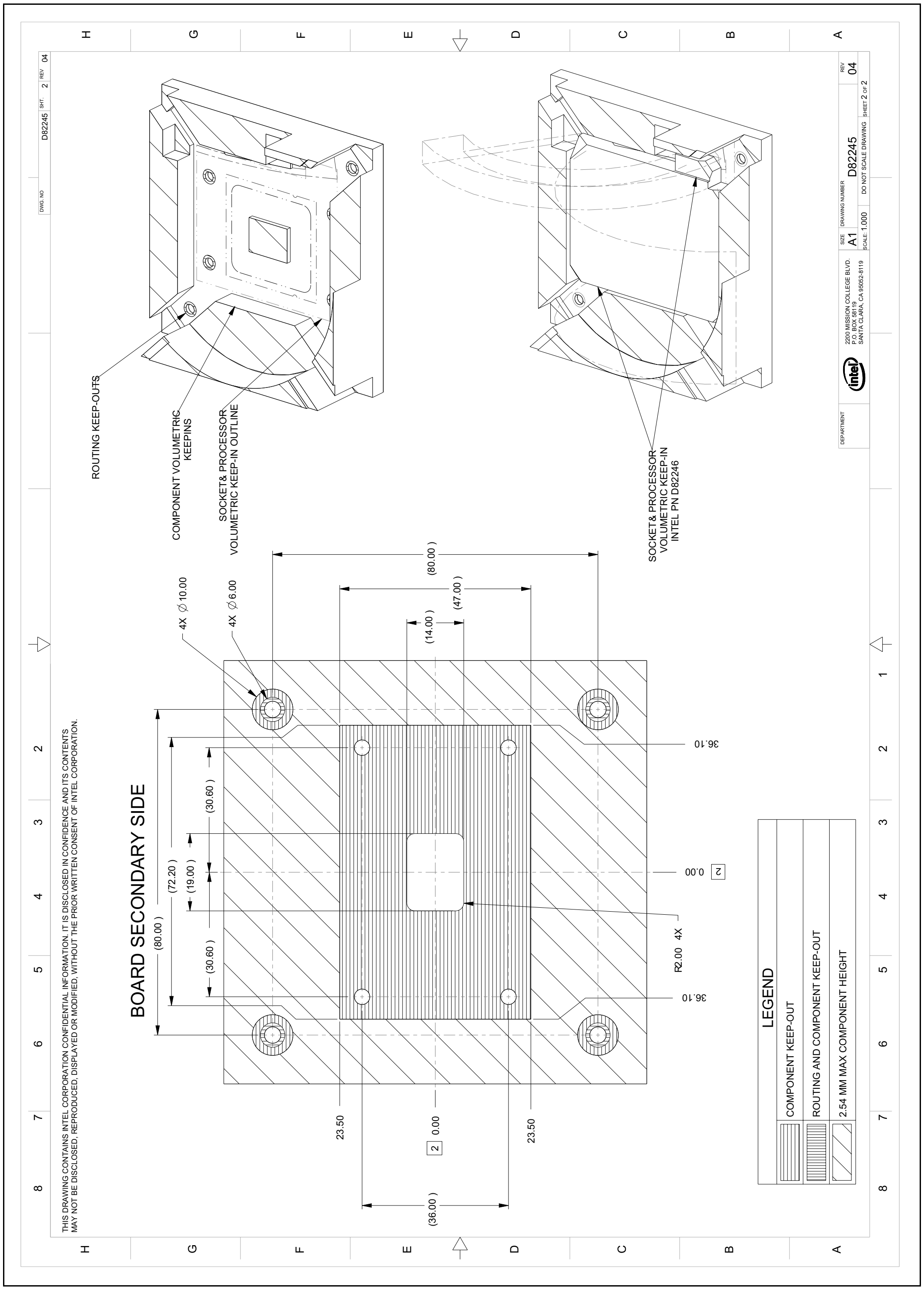
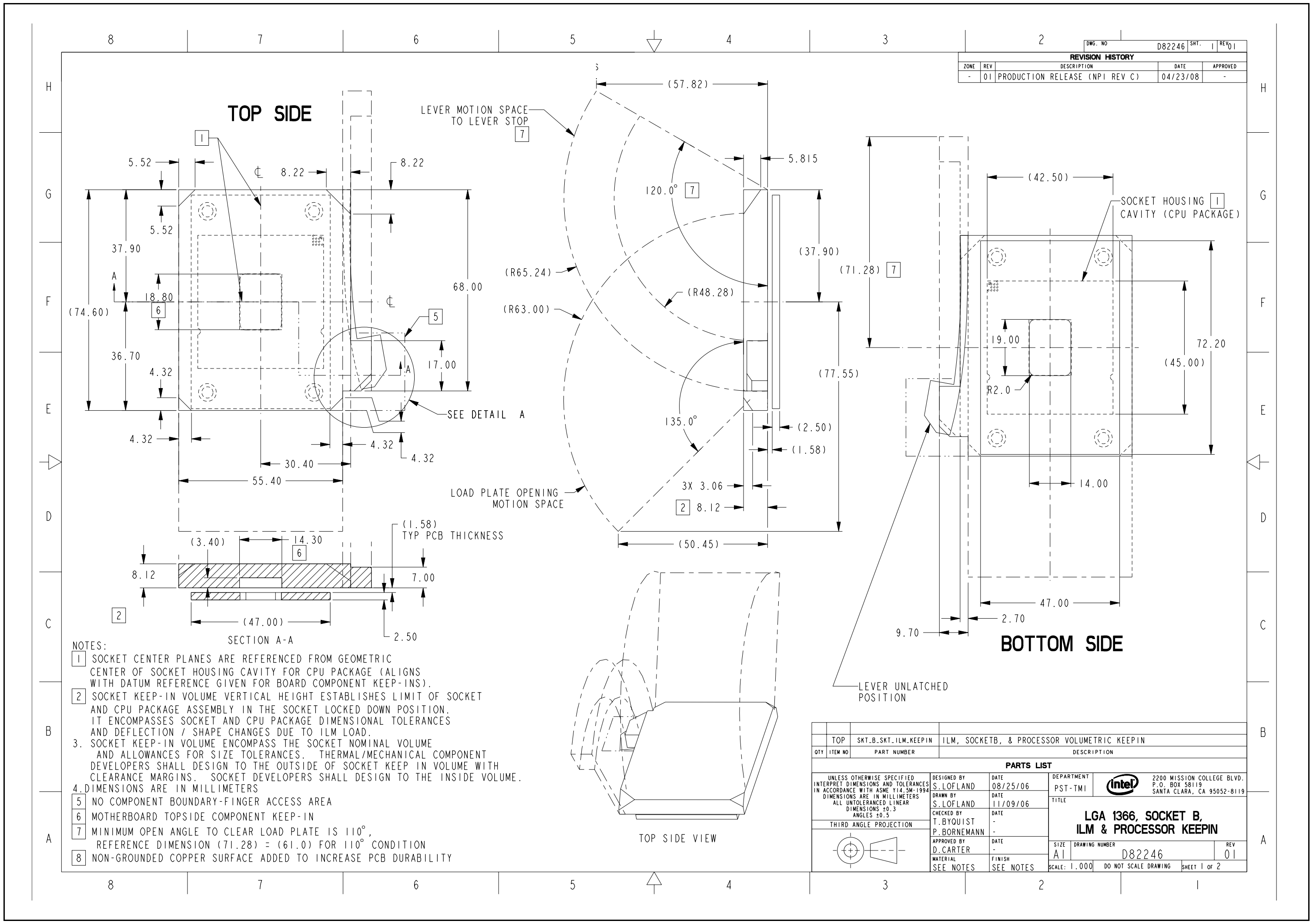


Figure B-3. Socket / Processor / ILM Keepout Zone Primary Side (Top)



NOTES:

1 SOCKET CENTER PLANES ARE REFERENCED FROM GEOMETRIC CENTER OF SOCKET HOUSING CAVITY FOR CPU PACKAGE (ALIGNS WITH DATUM REFERENCE GIVEN FOR BOARD COMPONENT KEEP-INS).

2 SOCKET KEEP-IN VOLUME VERTICAL HEIGHT ESTABLISHES LIMIT OF SOCKET AND CPU PACKAGE ASSEMBLY IN THE SOCKET LOCKED DOWN POSITION. IT ENCOMPASSES SOCKET AND CPU PACKAGE DIMENSIONAL TOLERANCES AND DEFLECTION / SHAPE CHANGES DUE TO ILM LOAD.

3. SOCKET KEEP-IN VOLUME ENCOMPASS THE SOCKET NOMINAL VOLUME AND ALLOWANCES FOR SIZE TOLERANCES. THERMAL/MECHANICAL COMPONENT DEVELOPERS SHALL DESIGN TO THE OUTSIDE OF SOCKET KEEP IN VOLUME WITH CLEARANCE MARGINS. SOCKET DEVELOPERS SHALL DESIGN TO THE INSIDE VOLUME.

4. DIMENSIONS ARE IN MILLIMETERS

5 NO COMPONENT BOUNDARY-FINGER ACCESS AREA

6 MOTHERBOARD TOPSIDE COMPONENT KEEP-IN

7 MINIMUM OPEN ANGLE TO CLEAR LOAD PLATE IS 110°, REFERENCE DIMENSION (71.28) = (61.0) FOR 110° CONDITION

8 NON-GROUNDED COPPER SURFACE ADDED TO INCREASE PCB DURABILITY

Figure B-4. Socket / Processor / ILM Keepout Zone Secondary Side (Bottom)

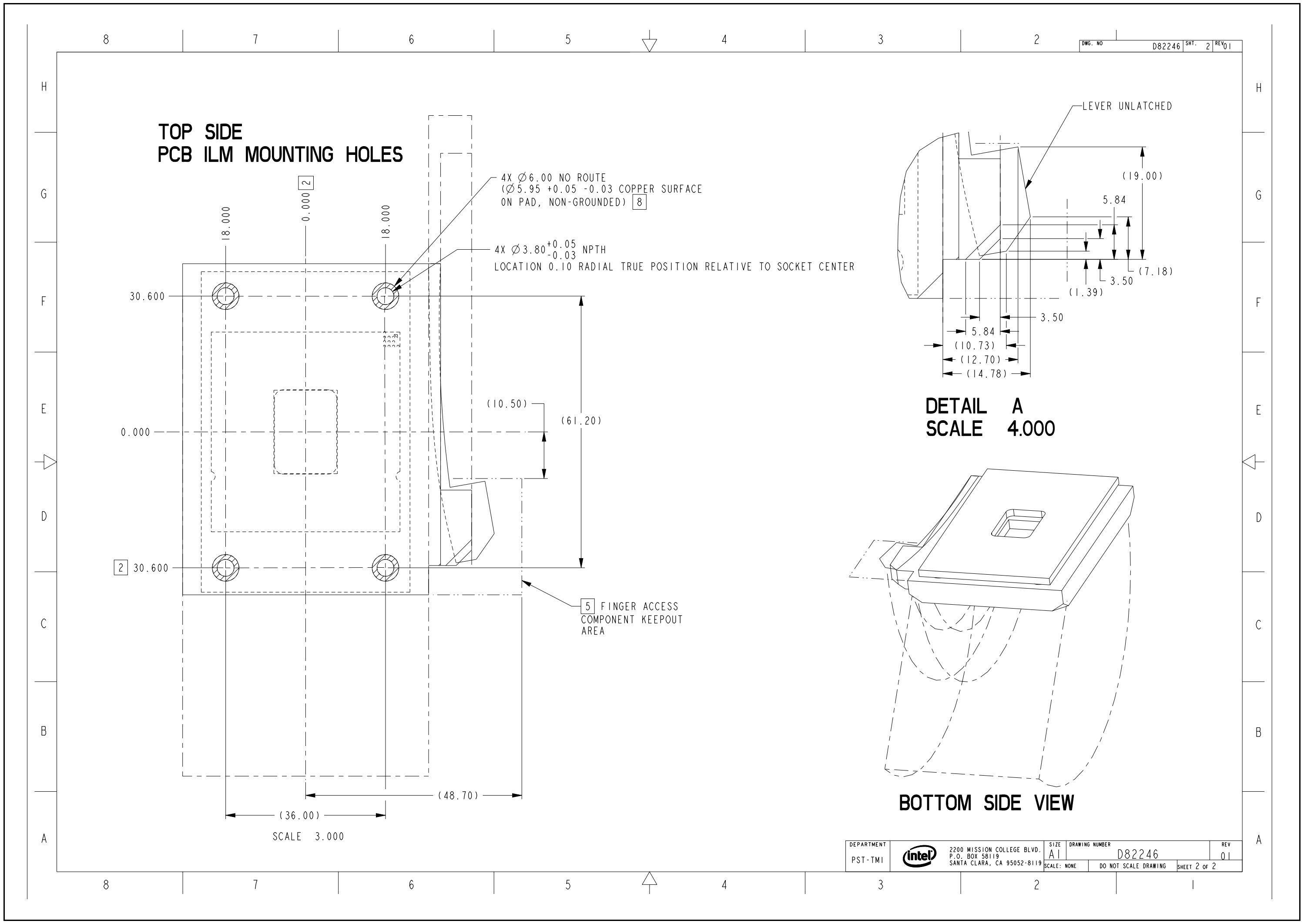
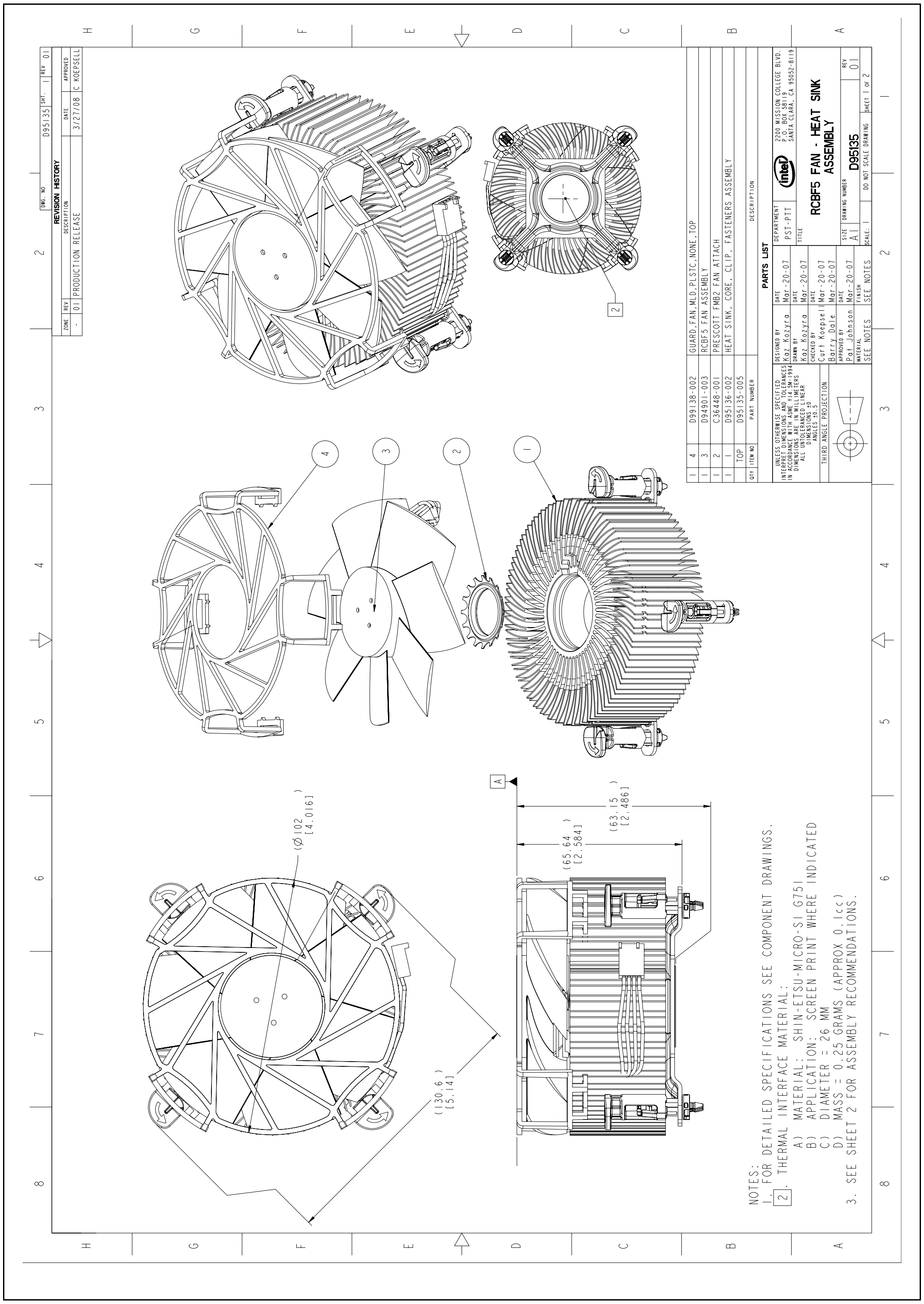


Figure B-5. Reference Design Heatsink Assembly (1 of 2)



REVISION HISTORY

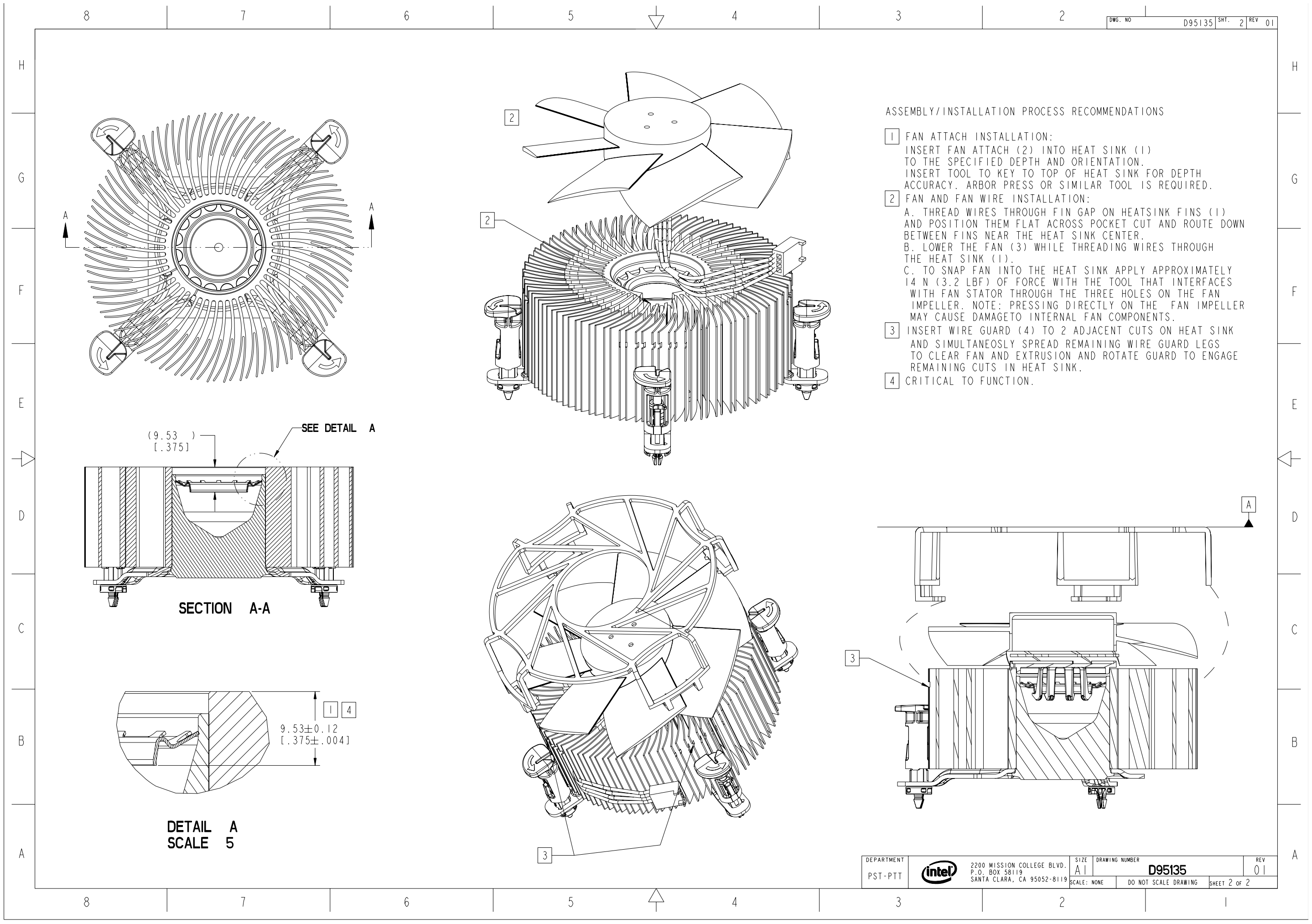
ZONE	REV	DESCRIPTION	DATE	APPROVED
-	01	PRODUCTION RELEASE	3/27/08	C KOEPSELL

PARTS LIST

QTY	ITEM NO	PART NUMBER	DESCRIPTION
1	4	D99138-002	GUARD,FAN,MLD,PLSTC,NONE,TOP
1	3	D94901-003	RCBF5 FAN ASSEMBLY
1	2	C36448-001	PRESCOTT FMB2 FAN ATTACH
1	1	D95136-002	HEAT SINK, CORE, CLIP, FASTENERS ASSEMBLY
	TOP	D95135-005	

NOTES:
1. FOR DETAILED SPECIFICATIONS SEE COMPONENT DRAWINGS.
2. THERMAL INTERFACE MATERIAL:
   A) MATERIAL: SHIN-ETSU-MICRO-SI G751
   B) APPLICATION: SCREEN PRINT WHERE INDICATED
   C) DIAMETER = 26 MM
   D) MASS = 0.25 GRAMS (APPROX 0.1cc)
3. SEE SHEET 2 FOR ASSEMBLY RECOMMENDATIONS.

Figure B-6. Reference Design Heatsink Assembly (2 of 2)

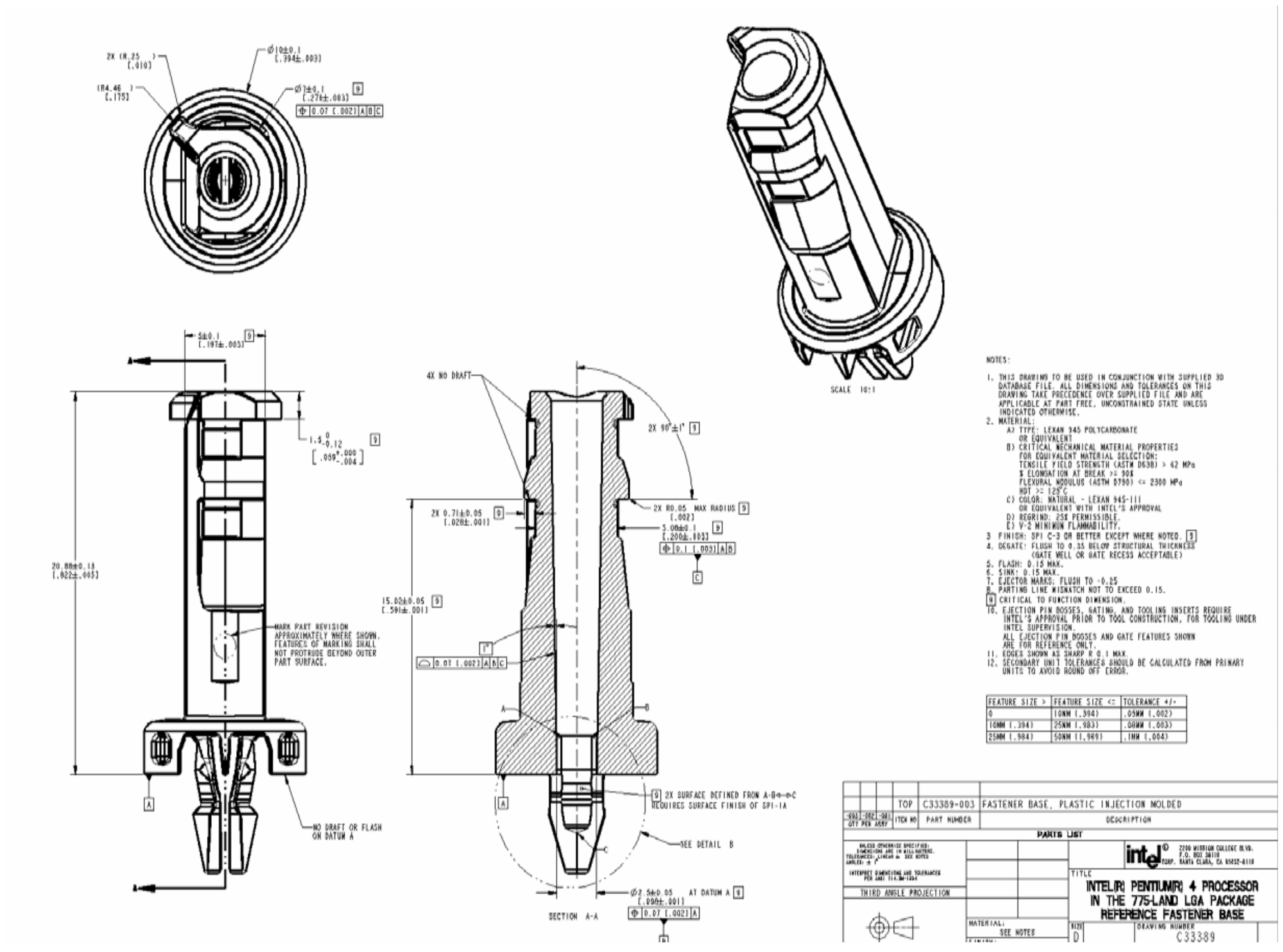


ASSEMBLY/INSTALLATION PROCESS RECOMMENDATIONS

1. FAN ATTACH INSTALLATION:
   INSERT FAN ATTACH (2) INTO HEAT SINK (1) TO THE SPECIFIED DEPTH AND ORIENTATION.
   INSERT TOOL TO KEY TO TOP OF HEAT SINK FOR DEPTH ACCURACY. ARBOR PRESS OR SIMILAR TOOL IS REQUIRED.
2. FAN AND FAN WIRE INSTALLATION:
   A. THREAD WIRES THROUGH FIN GAP ON HEATSINK FINS (1) AND POSITION THEM FLAT ACROSS POCKET CUT AND ROUTE DOWN BETWEEN FINS NEAR THE HEAT SINK CENTER.
   B. LOWER THE FAN (3) WHILE THREADING WIRES THROUGH THE HEAT SINK (1).
   C. TO SNAP FAN INTO THE HEAT SINK APPLY APPROXIMATELY 14 N (3.2 LBF) OF FORCE WITH THE TOOL THAT INTERFACES WITH FAN STATOR THROUGH THE THREE HOLES ON THE FAN IMPELLER. NOTE: PRESSING DIRECTLY ON THE FAN IMPELLER MAY CAUSE DAMAGETO INTERNAL FAN COMPONENTS.
3. INSERT WIRE GUARD (4) TO 2 ADJACENT CUTS ON HEAT SINK AND SIMULTANEOSLY SPREAD REMAINING WIRE GUARD LEGS TO CLEAR FAN AND EXTRUSION AND ROTATE GUARD TO ENGAGE REMAINING CUTS IN HEAT SINK.
4. CRITICAL TO FUNCTION.

DEPARTMENT PST-PTT
2200 MISSION COLLEGE BLVD.
P.O. BOX 58119
SANTA CLARA, CA 95052-8119
SIZE A1 | DRAWING NUMBER D95135 | REV 01
SCALE: NONE | DO NOT SCALE DRAWING | SHEET 2 OF 2

Figure B-7. Reference Fastener Sheet 1 of 4



NOTES:

1. THIS DRAWING TO BE USED IN CONJUNCTION WITH SUPPLIED 3D DATABASE FILE. ALL DIMENSIONS AND TOLERANCES ON THIS DRAWING TAKE PRECEDENCE OVER SUPPLIED FILE AND ARE APPLICABLE AT PART FREE, UNCONSTRAINED STATE UNLESS INDICATED OTHERWISE.
2. MATERIAL:
   A) TYPE: LEXAN 945 POLYCARBONATE OR EQUIVALENT
   B) CRITICAL MECHANICAL MATERIAL PROPERTIES FOR EQUIVALENT MATERIAL SELECTION:
      TENSILE YIELD STRENGTH (ASTM D638) > 62 MPa
      % ELONGATION AT BREAK >= 90%
      FLEXURAL MODULUS (ASTM D790) <= 2300 MPa
      HDT >= 125°C
   C) COLOR: NATURAL - LEXAN 945-111 OR EQUIVALENT WITH INTEL'S APPROVAL
   D) REGRIND: 25% PERMISSIBLE.
   E) V-2 MINIMUM FLAMMABILITY.
3. FINISH: SPI C-3 OR BETTER EXCEPT WHERE NOTED. 9
4. DEGATE: FLUSH TO 0.35 BELOW STRUCTURAL THICKNESS (GATE WELL OR GATE RECESS ACCEPTABLE)
5. FLASH: 0.15 MAX.
6. SINK: 0.15 MAX.
7. EJECTOR MARKS: FLUSH TO -0.25
8. PARTING LINE MISMATCH NOT TO EXCEED 0.15.
9. CRITICAL TO FUNCTION DIMENSION.
10. EJECTION PIN BOSSES, GATING, AND TOOLING INSERTS REQUIRE INTEL'S APPROVAL PRIOR TO TOOL CONSTRUCTION, FOR TOOLING UNDER INTEL SUPERVISION.
    ALL EJECTION PIN BOSSES AND GATE FEATURES SHOWN ARE FOR REFERENCE ONLY.
11. EDGES SHOWN AS SHARP R 0.1 MAX.
12. SECONDARY UNIT TOLERANCES SHOULD BE CALCULATED FROM PRIMARY UNITS TO AVOID ROUND OFF ERROR.

FEATURE SIZE >	FEATURE SIZE <=	TOLERANCE +/-
0	10MM (.394)	.05MM (.002)
10MM (.394)	25MM (.983)	.08MM (.003)
25MM (.984)	50MM (1.969)	.1MM (.004)

Figure B-8. Reference Fastener Sheet 2 of 4

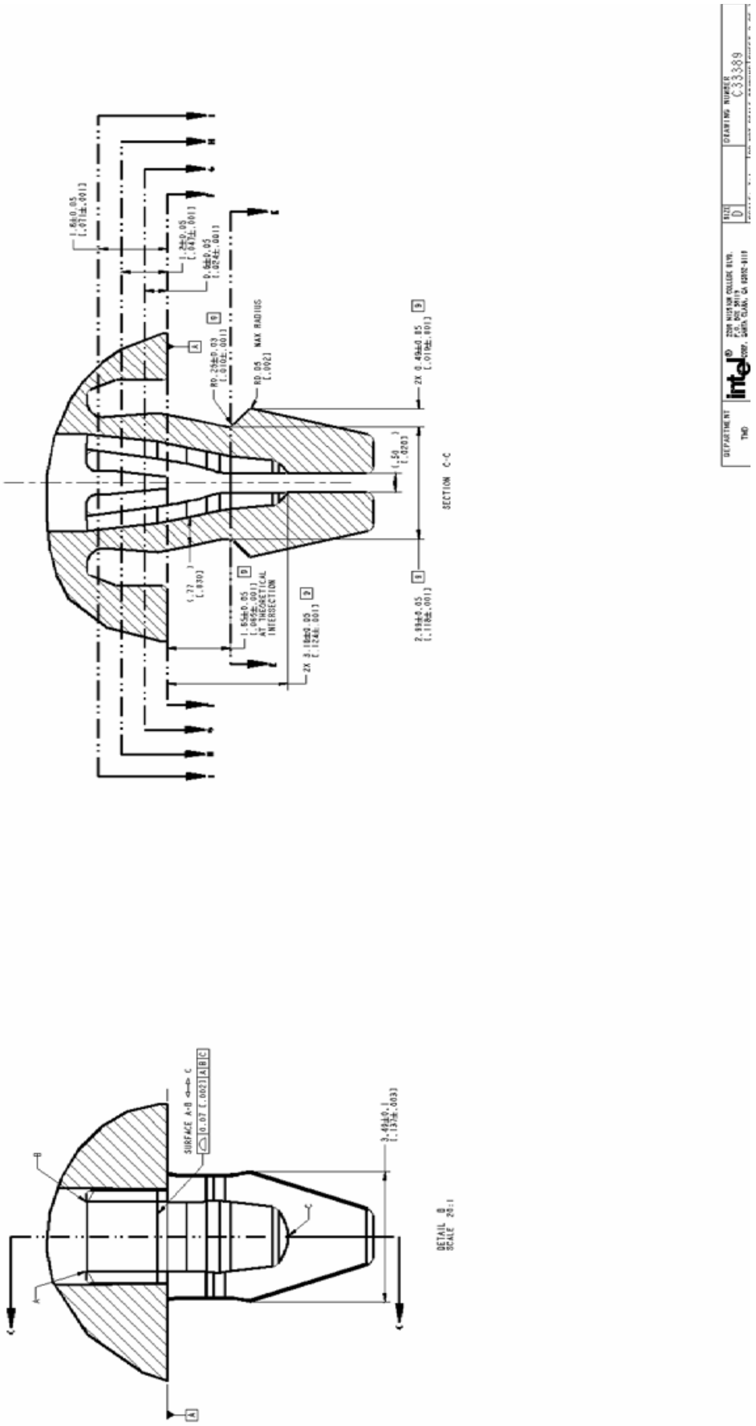


Figure B-9. Reference Fastener Sheet 3 of 4

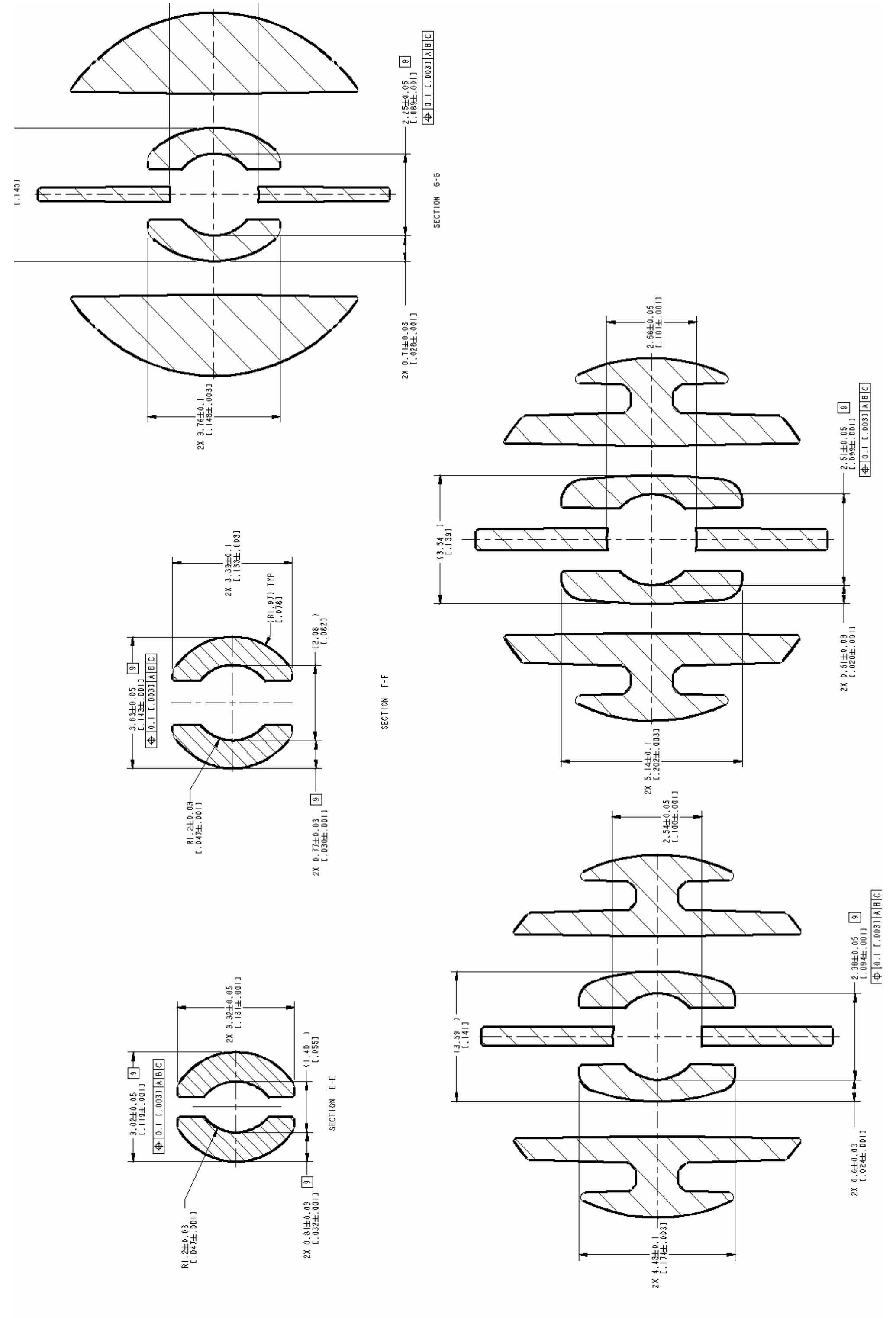
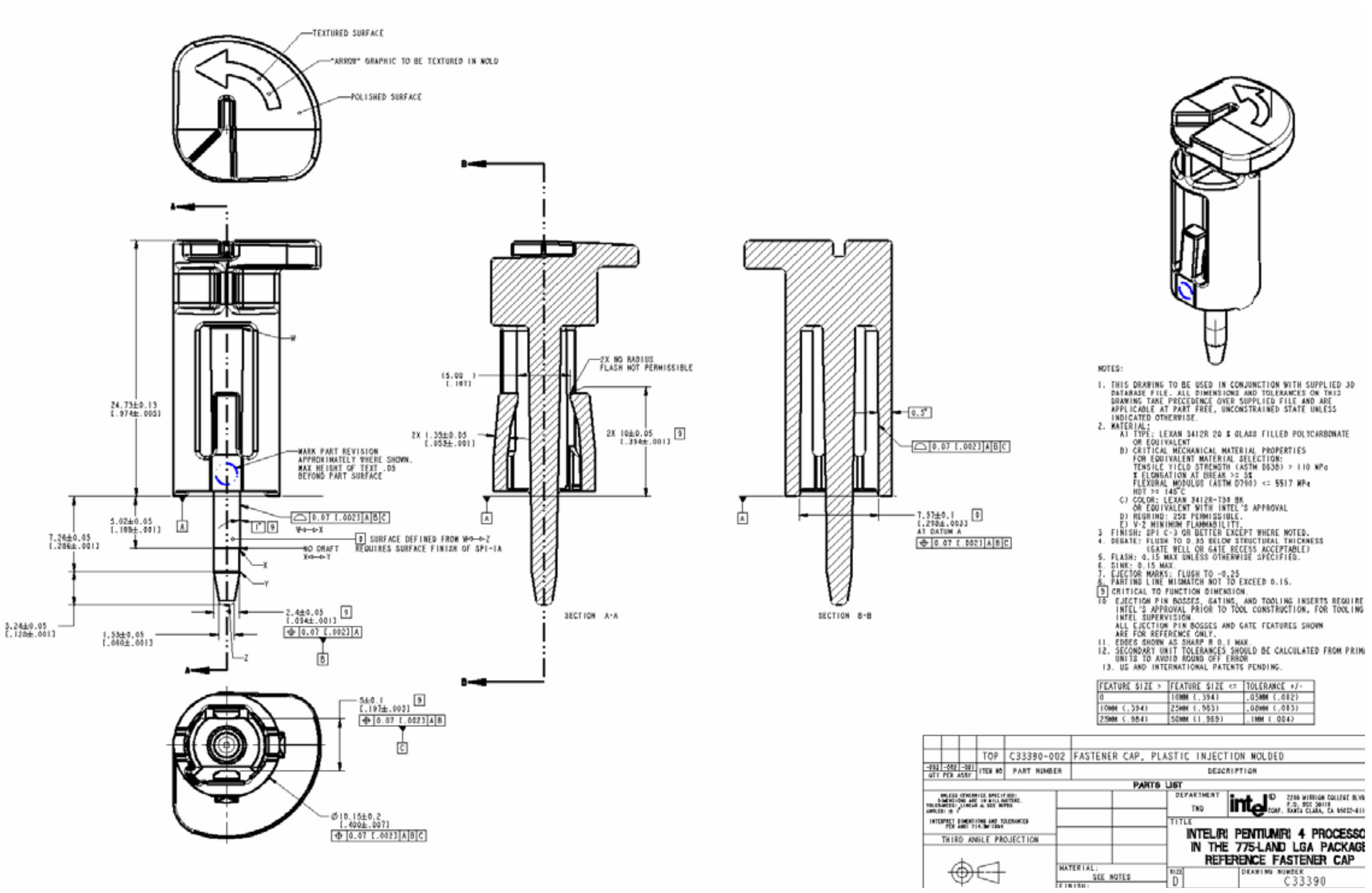


Figure B-10. Reference Fastener Sheet 4 of 4

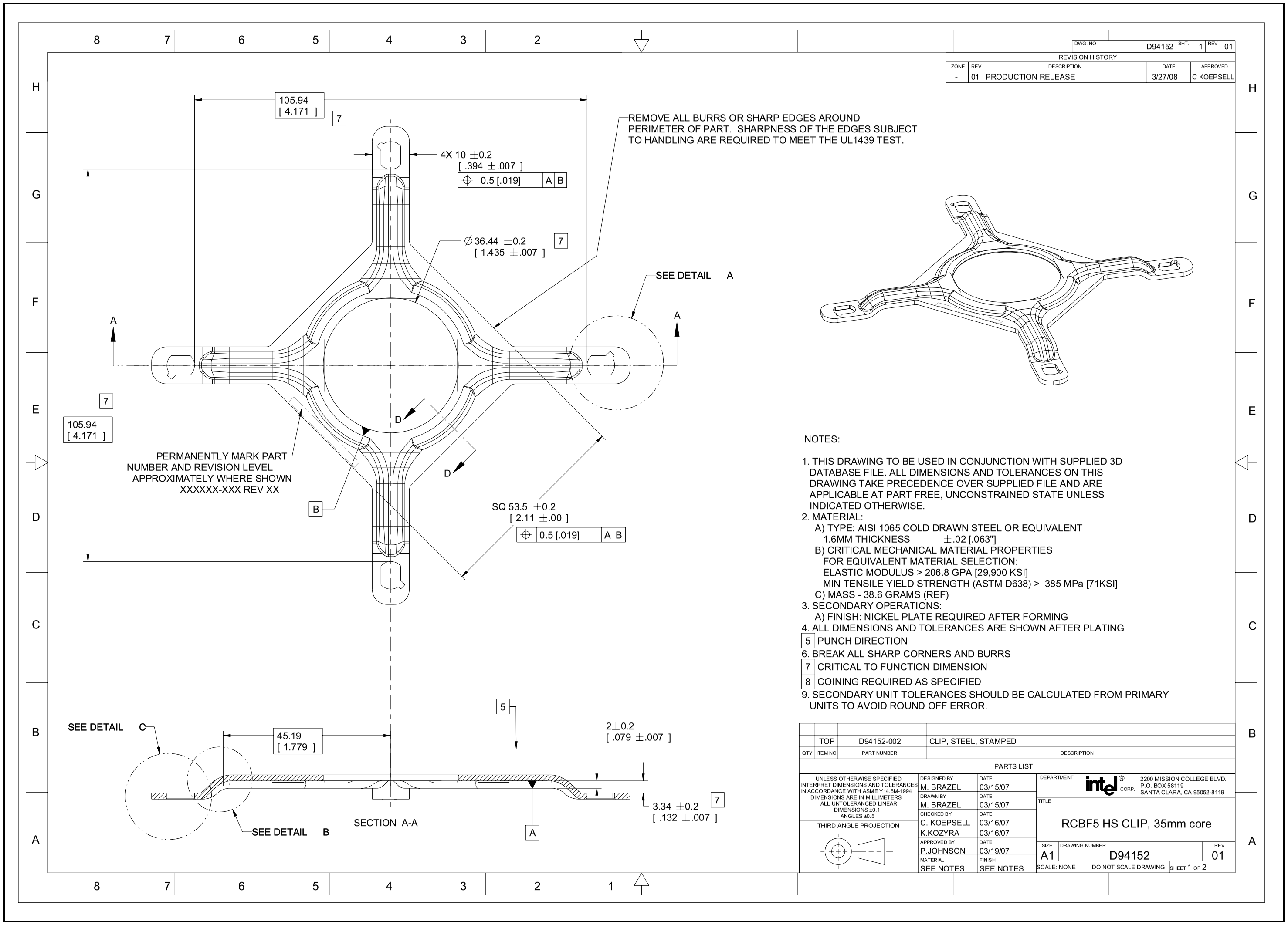


NOTES:

1. THIS DRAWING TO BE USED IN CONJUNCTION WITH SUPPLIED 3D DATABASE FILE. ALL DIMENSIONS AND TOLERANCES ON THIS DRAWING TAKE PRECEDENCE OVER SUPPLIED FILE AND ARE APPLICABLE AT PART FREE, UNCONSTRAINED STATE UNLESS INDICATED OTHERWISE.
2. MATERIAL:
   - A) TYPE: LEXAN 3412R 20 % GLASS FILLED POLYCARBONATE OR EQUIVALENT
   - B) CRITICAL MECHANICAL MATERIAL PROPERTIES FOR EQUIVALENT MATERIAL SELECTION:
     TENSILE YIELD STRENGTH (ASTM D638) > 110 MPa
     % ELONGATION AT BREAK >= 5%
     FLEXURAL MODULUS (ASTM D790) <= 5517 MPa
     HDT >= 146°C
   - C) COLOR: LEXAN 3412R-739 BK OR EQUIVALENT WITH INTEL'S APPROVAL
   - D) REGRIND: 25% PERMISSIBLE.
   - E) V-2 MINIMUM FLAMMABILITY.
3. FINISH: SPI C-3 OR BETTER EXCEPT WHERE NOTED.
4. DEGATE: FLUSH TO 0.35 BELOW STRUCTURAL THICKNESS (GATE WELL OR GATE RECESS ACCEPTABLE)
5. FLASH: 0.15 MAX UNLESS OTHERWISE SPECIFIED.
6. SINK: 0.15 MAX.
7. EJECTOR MARKS: FLUSH TO -0.25
8. PARTING LINE MISMATCH NOT TO EXCEED 0.15.
9. CRITICAL TO FUNCTION DIMENSION.
10. EJECTION PIN BOSSES, GATING, AND TOOLING INSERTS REQUIRE INTEL'S APPROVAL PRIOR TO TOOL CONSTRUCTION, FOR TOOLING INTEL SUPERVISION.
    ALL EJECTION PIN BOSSES AND GATE FEATURES SHOWN ARE FOR REFERENCE ONLY.
11. EDGES SHOWN AS SHARP R 0.1 MAX.
12. SECONDARY UNIT TOLERANCES SHOULD BE CALCULATED FROM PRIM UNITS TO AVOID ROUND OFF ERROR
13. US AND INTERNATIONAL PATENTS PENDING.

FEATURE SIZE >	FEATURE SIZE <=	TOLERANCE +/-
0	10MM (.394)	.05MM (.002)
10MM (.394)	25MM (.983)	.08MM (.003)
25MM (.984)	50MM (1.969)	.1MM (.004)

Figure B-11. Reference Clip - Sheet 1 of 2



DWG. NO	D94152	SHT. 1	REV 01

REVISION HISTORY

ZONE	REV	DESCRIPTION	DATE	APPROVED
-	01	PRODUCTION RELEASE	3/27/08	C KOEPSELL

NOTES:

1. THIS DRAWING TO BE USED IN CONJUNCTION WITH SUPPLIED 3D DATABASE FILE. ALL DIMENSIONS AND TOLERANCES ON THIS DRAWING TAKE PRECEDENCE OVER SUPPLIED FILE AND ARE APPLICABLE AT PART FREE, UNCONSTRAINED STATE UNLESS INDICATED OTHERWISE.
2. MATERIAL:
   - A) TYPE: AISI 1065 COLD DRAWN STEEL OR EQUIVALENT
     1.6MM THICKNESS ±.02 [.063"]
   - B) CRITICAL MECHANICAL MATERIAL PROPERTIES FOR EQUIVALENT MATERIAL SELECTION:
     ELASTIC MODULUS > 206.8 GPA [29,900 KSI]
     MIN TENSILE YIELD STRENGTH (ASTM D638) > 385 MPa [71KSI]
   - C) MASS - 38.6 GRAMS (REF)
3. SECONDARY OPERATIONS:
   - A) FINISH: NICKEL PLATE REQUIRED AFTER FORMING
4. ALL DIMENSIONS AND TOLERANCES ARE SHOWN AFTER PLATING
5. PUNCH DIRECTION
6. BREAK ALL SHARP CORNERS AND BURRS
7. CRITICAL TO FUNCTION DIMENSION
8. COINING REQUIRED AS SPECIFIED
9. SECONDARY UNIT TOLERANCES SHOULD BE CALCULATED FROM PRIMARY UNITS TO AVOID ROUND OFF ERROR.

QTY	ITEM NO	PART NUMBER	DESCRIPTION
	TOP	D94152-002	CLIP, STEEL, STAMPED

PARTS LIST

UNLESS OTHERWISE SPECIFIED INTERPRET DIMENSIONS AND TOLERANCES IN ACCORDANCE WITH ASME Y14.5M-1994
DIMENSIONS ARE IN MILLIMETERS
ALL UNTOLERANCED LINEAR DIMENSIONS ±0.1
ANGLES ±0.5

THIRD ANGLE PROJECTION

DESIGNED BY	M. BRAZEL	DATE 03/15/07
DRAWN BY	M. BRAZEL	DATE 03/15/07
CHECKED BY	C. KOEPSELL K.KOZYRA	DATE 03/16/07 03/16/07
APPROVED BY	P.JOHNSON	DATE 03/19/07
MATERIAL	SEE NOTES	FINISH SEE NOTES

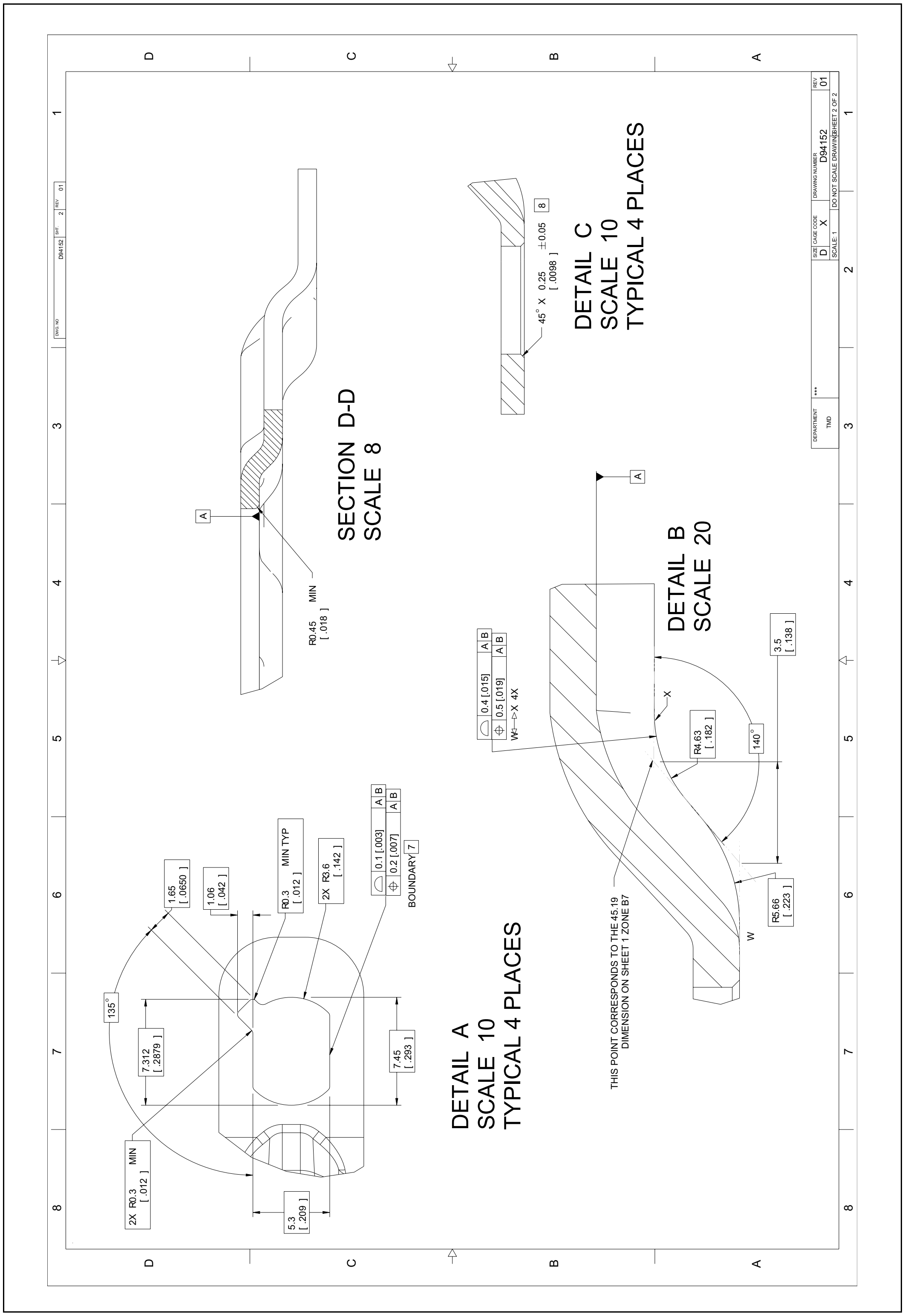
DEPARTMENT

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

TITLE: RCBF5 HS CLIP, 35mm core

SIZE: A1
DRAWING NUMBER: D94152
REV: 01
SCALE: NONE
DO NOT SCALE DRAWING
SHEET 1 OF 2

Figure B-12. Reference Clip - Sheet 2 of 2



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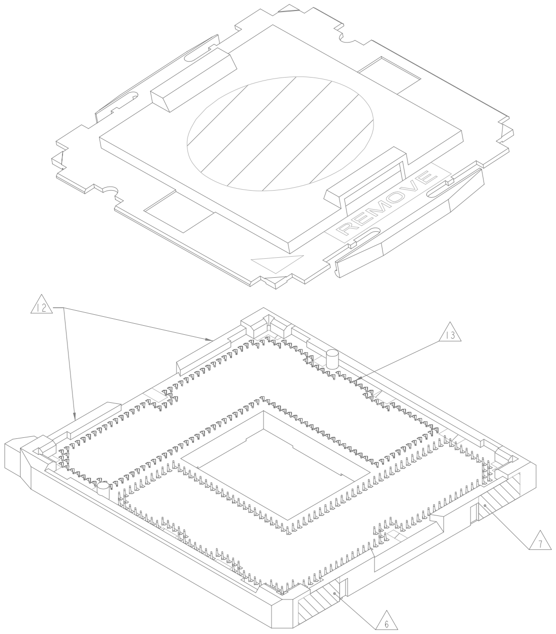
C Socket Mechanical Drawings

Table C-1 lists the mechanical drawings included in this appendix.

Table C-1. Mechanical Drawing List

Drawing Description	Figure Number
"Socket Mechanical Drawing (Sheet 1 of 4)"	Figure C-1
"Socket Mechanical Drawing (Sheet 2 of 4)"	Figure C-2
"Socket Mechanical Drawing (Sheet 3 of 4)"	Figure C-3
"Socket Mechanical Drawing (Sheet 4 of 4)"	Figure C-4

Figure C-1. Socket Mechanical Drawing (Sheet 1 of 4)



NOTES:

1. THE PURPOSE OF THIS DRAWING IS TO ESTABLISH THE MECHANICAL FORM FACTOR OF THE SOCKET. THIS DRAWING IS NOT INTENDED TO SHOW INTERNAL DETAIL OF THE SOCKET WHICH MAY VARY FROM SUPPLIER TO SUPPLIER.

2. MATERIAL:
BASE AND CAP: HIGH TEMPERATURE THERMOPLASTIC. UL94V-0
CONTACT: HIGH STRENGTH COPPER ALLOY
POSTS: 18-8 STAINLESS STEEL, NICKEL PLATED BRASS OR HIGH TEMPERATURE THERMOPLASTIC UL94V-0
SOLDER BALL: LEAD FREE SAC

3. FINISH: NONE

4. CONTACT MUST REMAIN ON LAND THROUGHOUT ACTUATION STROKE.

5. REMOVE ALL BURRS AND SHARP EDGES R0.05 MAX.

6 SOCKET NAME TO BE INDICATED IN THIS AREA.

△7 LOT NUMBER SHALL BE INDICATED IN THIS AREA.

△8 MEASURED FROM CONTACT TIP AT THE FREE STATE OF THE CONTACT TIPS.

△9 CHANFER INDICATES THE CORNER CLOSEST TO PACKAGE PIN A1

△10 CONTACT MUST REMAIN OUTSIDE THE CENTRAL CAVITY THROUGHOUT THE ACTUATION STROKE.

△11 PICK-AND-PLACE TOOLING KEEP-IN ZONE.

△12 SOCKET MANUFACTURER NAME SHOWN ON EITHER SIDEWALL.

△13 ONLY THE LGA CONTACTS/SOLDER BALLS ALONG THE BOUNDARIES OF THE TWO "L" ARRAYS ARE SHOWN IN THE DRAWINGS.

DWG. NO. D81673 SHT. 1 REV 5

UNLESS OTHERWISE SPECIFIED
INTERPRET DIMENSIONS AND TOLERANCES
IN ACCORDANCE WITH ASME Y14.5M-1994
DIMENSIONS ARE IN MILLIMETERS

THIRD ANGLE PROJECTION

DESIGNED BY	DATE 11/20/06	DEPARTMENT DPD/ATTD	2200 MISSION COLLEGE BLVD. P.O. BOX 58119 SANTA CLARA, CA 95052-8119
DRAWN BY	DATE 11/20/06	TITLE SOCKET LGA 1366	
CHECKED BY	DATE		
APPROVED BY	DATE	SIZE A1	DRAWING NUMBER D81673 · REV 5
MATERIAL SEE NOTES	FINISH SEE NOTES	SCALE: 2	DO NOT SCALE DRAWING · SHEET 1 OF 4

Figure C-2. Socket Mechanical Drawing (Sheet 2 of 4)

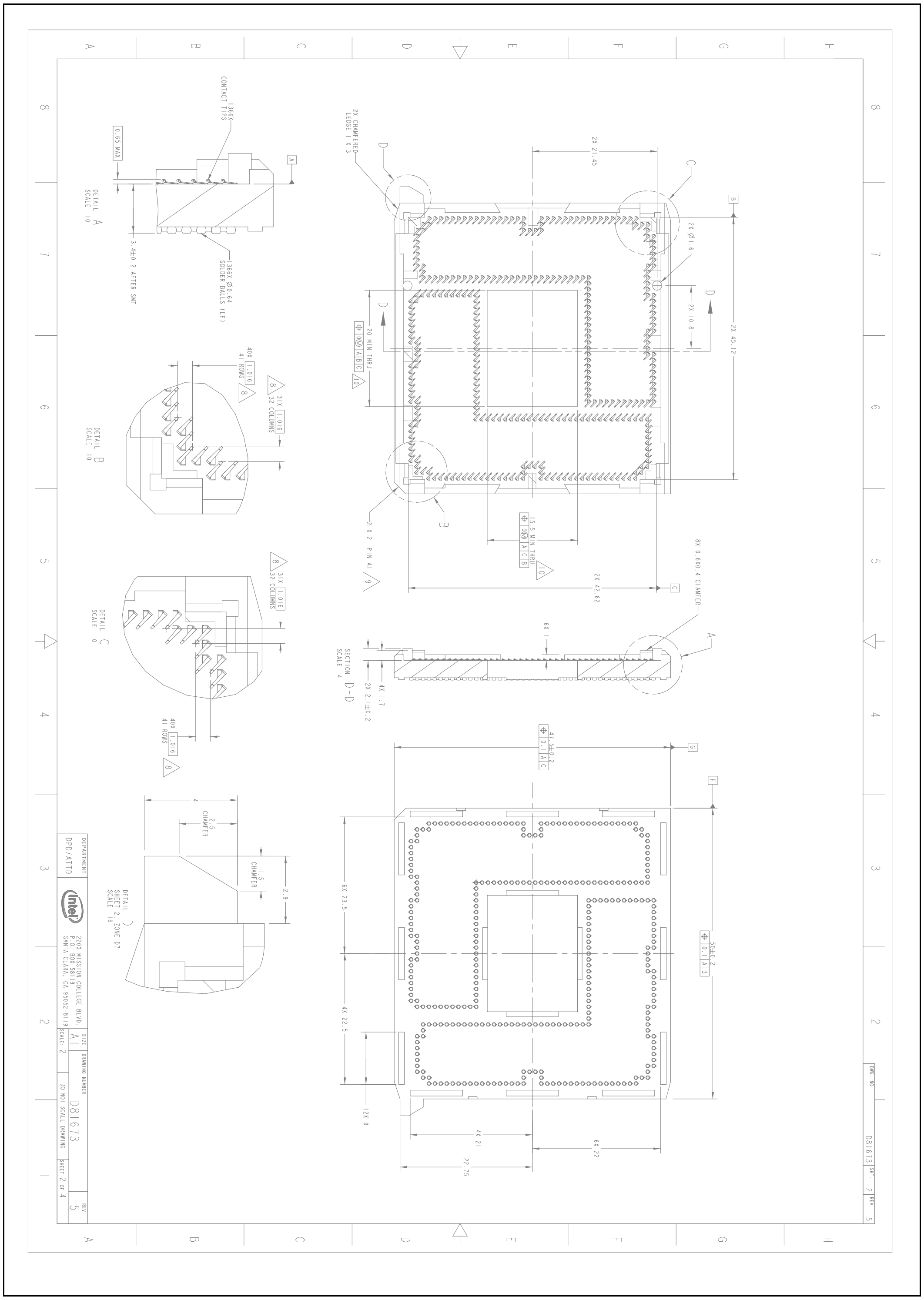


Figure C-3. Socket Mechanical Drawing (Sheet 3 of 4)

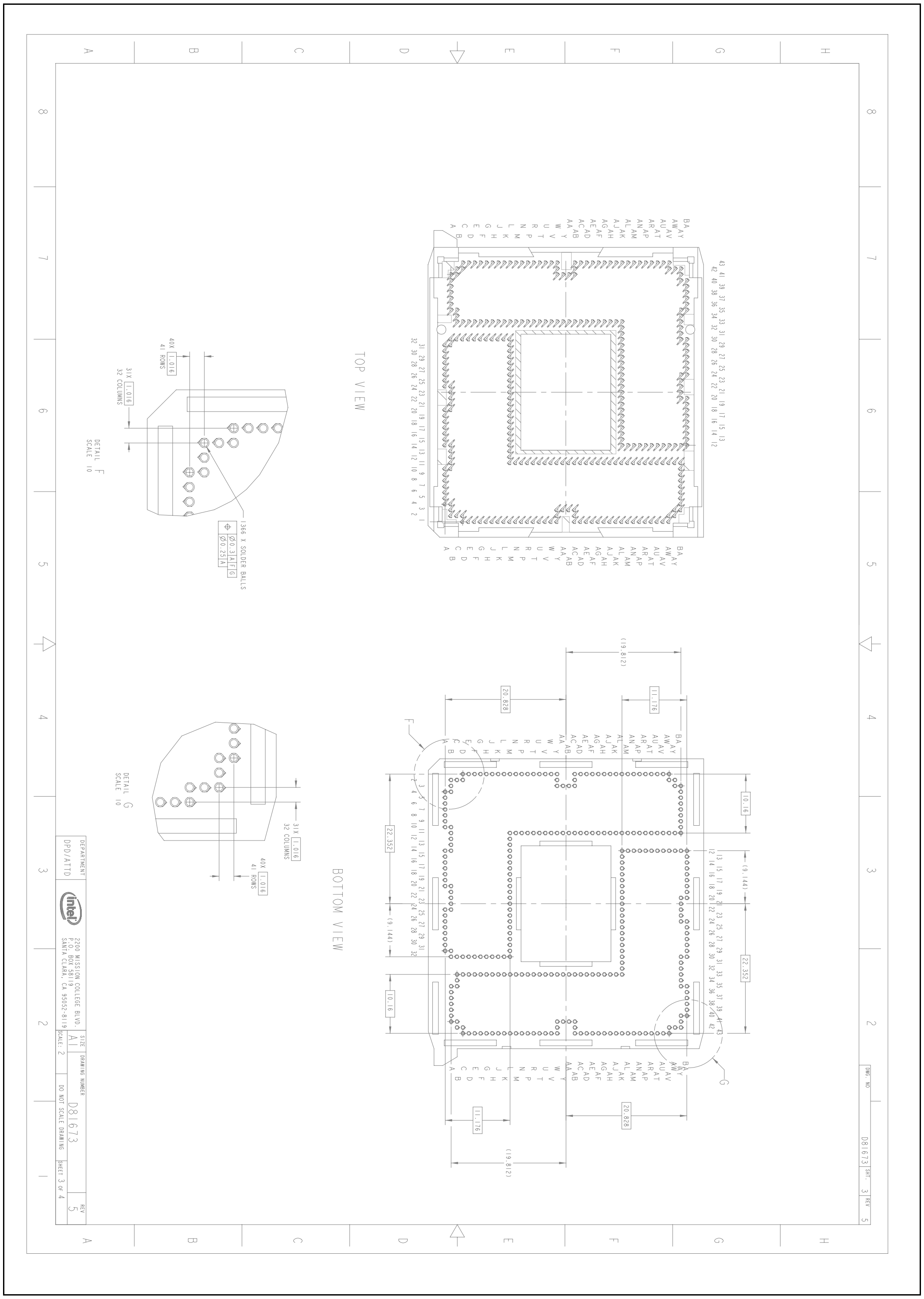
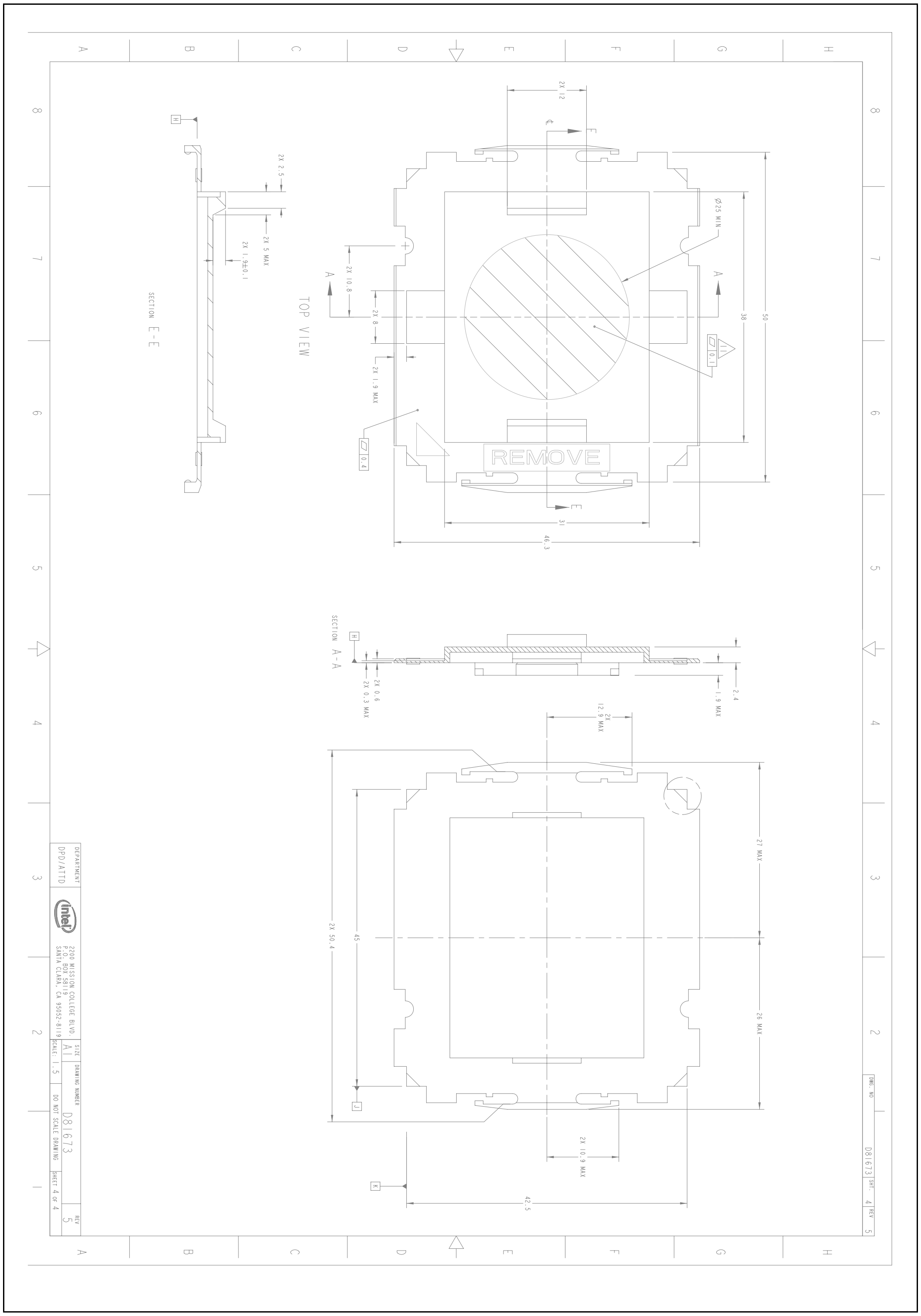


Figure C-4. Socket Mechanical Drawing (Sheet 4 of 4)



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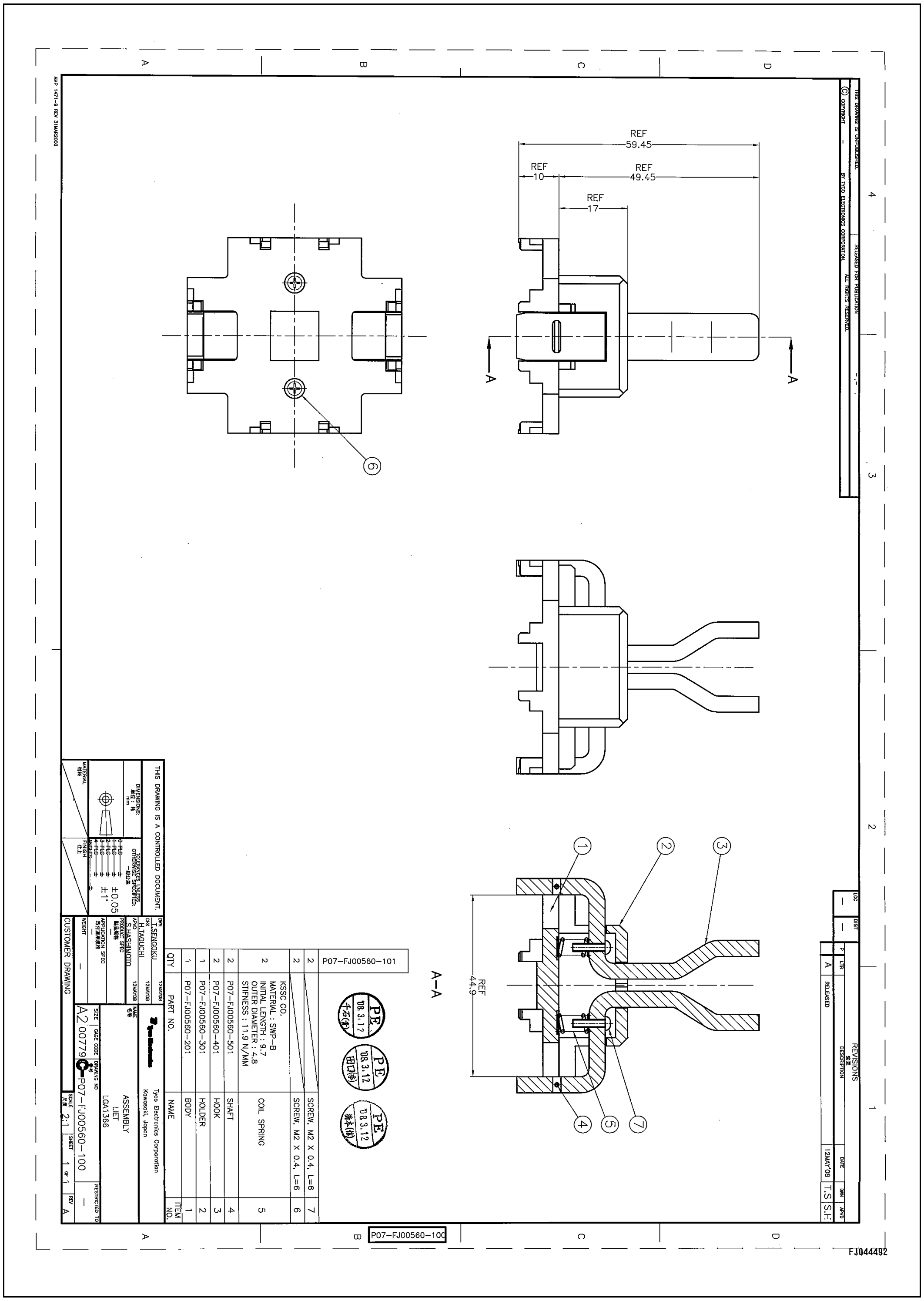
D Processor Installation Tool

The following optional tool is designed to provide mechanical assistance during processor installation and removal.

Contact the supplier for availability:

Billy Hsieh
billy.hsieh@tycoelectronics.com
+81 44 844 8292

Figure D-1. Processor Installation Tool



§