Intel® Xeon™ Processor Thermal Solution Functional Specifications

Application Note

May 2001

Order Number: 249673-001

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Revision History

Rev.	Description	Date
-001	• Initial Release	May 2001

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1. Introduction and Scope

This document details the thermal, mechanical, and quality guidelines and requirements for designing Intel® Xeon™ processor thermal solutions. This includes environmental reliability requirements outlined in Section 5. With this information, a "third party" could design a thermal solution for the Intel Xeon processor.

1.1. Reference Documents

- Intel® Xeon™ Processor Datasheet
- Intel® Xeon™ Processor Thermal Design Guidelines
- 603 Pin Socket Design Guidelines
- Blue Angel Recycling Standards

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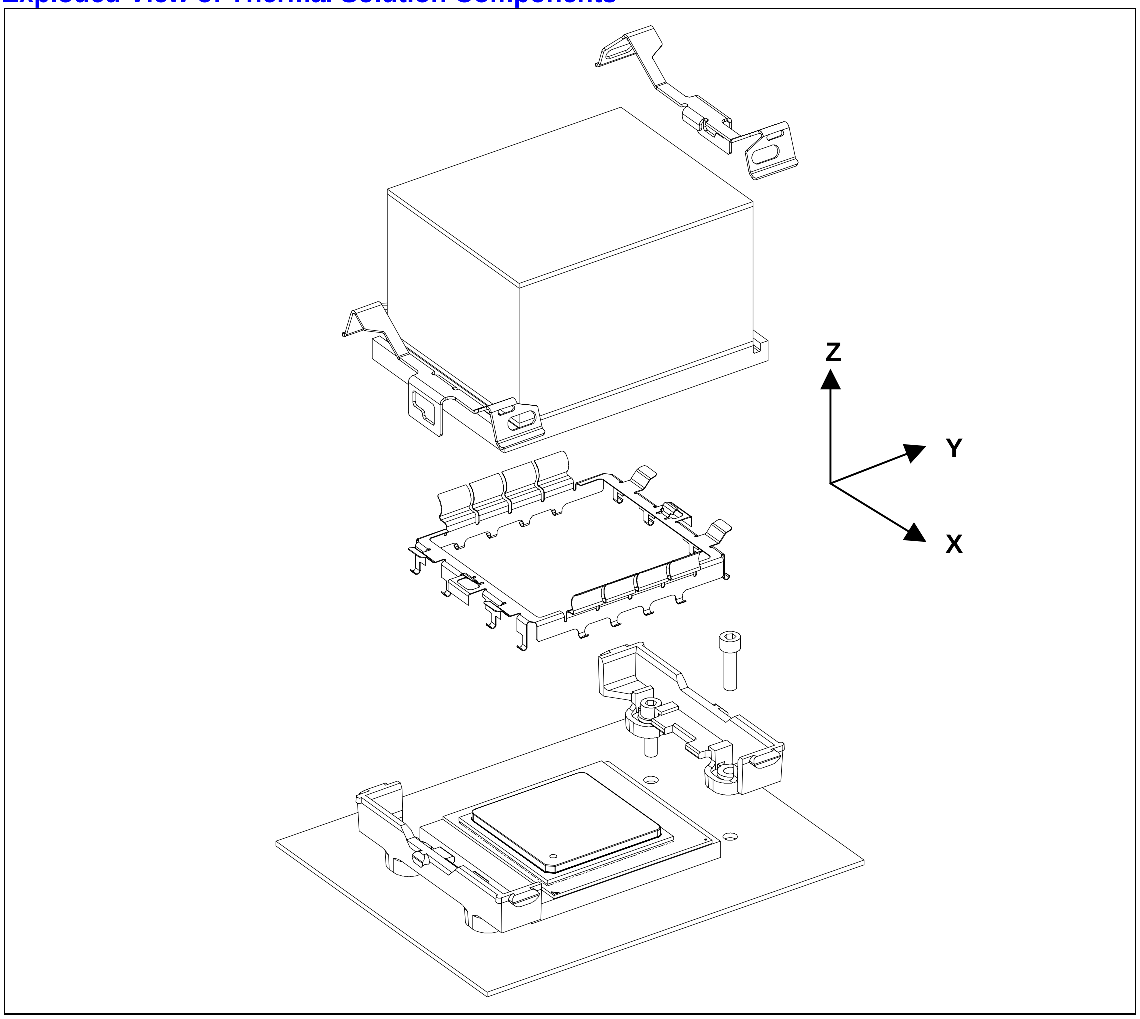
2. Components

The Intel® Xeon™ processor thermal solution(s) shall consist of:

- Heatsink
- Thermal interface material (TIM)
- Heatsink clips
- Retention mechanism (RM)

Figure 1 shows the fully assembled and exploded view of the thermal solution components (except for the TIM).

Figure 1. Exploded View of Thermal Solution Components



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3. Thermal Requirements

Thermal solution components should be designed to be in compliance with Intel® Xeon™ processor thermal specifications described in the *Intel® Xeon™ Processor Datasheet* and the design constraints identified in this document. Table 1 presents the airflow and pressure drop constraints that can be found in typical server and workstation chassis.

Table 1. Airflow and Pressure Drop System Design Constraints

Airflow (lfm)	Pressure Drop (inches H_20)
500	0.15

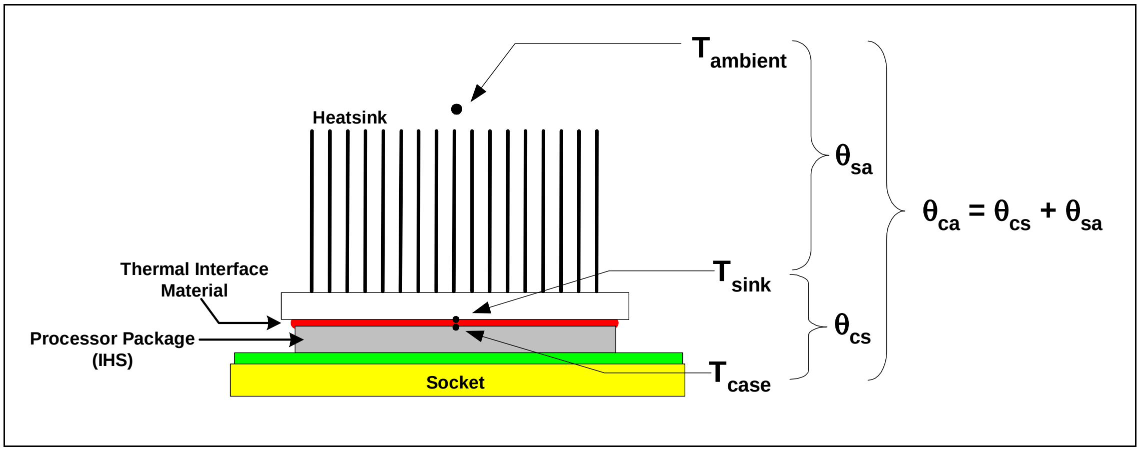
Figure 2 provides the temperature constraints at the case of the processor package (Integrated Heat Spreader, IHS). For a given chassis, the θ_{CA} requirement is based on the chassis local ambient characteristics and the processor's thermal specifications. The Intel Xeon processor solution is required to meet the overall θ_{CA} requirement of the system that it serves. While θ_{CA} is constrained to meet system and processor requirements, θ_{CS} and θ_{SA} are independently constrained. The following equations are used in calculating the thermal performance of Intel Xeon processor thermal solutions:

$$\theta_{SA} = (T_{sink} - T_{amb}) / Q$$
$$\theta_{CS} = (T_{case} - T_{sink}) / Q$$
$$\theta_{CA} = \theta_{CS} + \theta_{SA}$$

Where:

θ_{SA} = thermal resistance measured between the heatsink and local ambient
θ_{CS} = thermal resistance across the thermal interface material
θ_{CA} = thermal resistance measured between the processor package (IHS) and ambient.
T_{sink} = temperature at the bottom of the heatsink base directly over the center of the IHS
T_{amb} = temperature at local ambient location
T_{case} = temperature at the top of the processor package (IHS) measured at its center
Q = thermal design power (TDP) from the processor datasheet

Figure 2. Thermal Resistance Relationships



3.1. Intel® Xeon™ Processor Thermal Specifications

Refer to the Intel® Xeon™ Processor Datasheet for the processor thermal requirements at various core frequency levels.

4. Design Requirements

4.1. Heatsink Critical-to-Function Dimensions

Table 2 provides the critical-to-function (CTF) dimensions. Figure 3 and Figure 4 in the Appendix (Section 8) provide the drawings detailing the critical-to-function (CTF) dimensions.

Table 2. Critical-to-Function Dimensions

Dimension	Letter	Minimum	Maximum
Location of Clip Attach Groove Far Edge from Heat Sink Edge	A	0.180 in	0.200 in
Width of Clip Attach Groove	B	0.080 in	0.100 in
Base Thickness in Zone A	C	0.245 in	0.255 in
Base Length	D	3.488 in	3.512 in
Base Width	E	2.488 in	2.512 in
Base Flatness in Zone B	F	---	0.002 in/in
Width of clip attach area (Zone A)	G	0.200 in	---
Height of Thermal Solution	H	---	2.000 in

4.2. Maximum Heatsink Mass

Heatsink mass may not exceed 450g.

4.3. Heatsink Center of Gravity

The center of gravity of the Intel® Xeon™ processor thermal solution should be over the center of gravity of the package. The height of the center of gravity must be 0.5 in, maximum, from the bottom of the heatsink base.

4.4. Heatsink Base Requirements

The flatness of the base shall be maintained at 0.002 in/in at the localized area (Zone B) as shown in Figure 3 (Found in the Appendix, Section 8). The base plate contains no keying features and thus can be rotated 180 degrees. A heatsink supported by the RM must incorporate two clip attach areas with a minimum width of 0.200 in (Zone A), as shown in Figure 3. The heatsink attach clip requirements are presented in Section 4.6.

4.5. Thermal Interface Material

A thermal interface material must be applied between the package and the heatsink to ensure thermal conduction. Intel's thermal solution reference designs use Shin-Etsu* G749 thermal grease. The use of thermal grease in conjunction with high performance heatsink technologies (e.g. copper base folded fin) has been demonstrated to meet Intel thermal performance requirements.

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

4.6. Heatsink Clip Requirements

Heatsink attach clips apply force to the heatsink base to maintain desired pressure on the thermal interface material between the package and the heatsink , and help to hold the heatsink in place under dynamic loading. The Intel reference design heatsink clip will attach to the heatsink base via the grooves at each end of the base, as shown in Figure 3 in the Appendix (Section 8). The Intel reference design heatsink clip is latched to the Intel reference design RM clip tabs, one at each end of the RM. The clips may be susceptible to deformation during any rework or upgrade procedure where the heatsink assembly is disassembled. Intel's clip design was validated with unused clips that were not subjected to an assembly-disassembly cycle. The system integrator should exercise caution in re-using clips that have experienced one or more assembly-disassembly cycles.

The heatsink clip reference design is presented in the appendix of this document (Figures 5 and 6).

4.7. Retention Mechanism Requirements

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

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

Intel recommends the use of 6-32 [x 3/8-1/2"] pan head or round head screw [4 each] for direct RM-chassis attach. The screw head must be less than 0.284" diameter and less than 0.190" height.

4.8. EMI Ground Frame Requirements

Test results at Intel indicate that an EMI grounding frame is not necessary to reduce the electro-magnetic emissions from the Intel Xeon processor. As a result, Intel has not enabled tooling for the EMI grounding frame. The grounding frame is an optional component of the Intel reference design and is presented in the appendix to this document.

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5. Environmental Reliability Requirements

The thermal solution assembly (including all of its components) shall be designed to meet the environmental reliability requirements as outlined in Table 3.

Table 3. Environmental Reliability Test Conditions

Test	Level
Mechanical Shock	50G, 11 ms, Trapezoidal, 3 drops in each of 6 directions (±X, ±Y, ±Z). See Figure 1 for clarification of directions.
Vibration	5-500 Hz, 3.13g RMS, 10 min/axis
Temperature Cycling	-25°C to 100°C, 10-30°C/min ramp, 15 min dwell, 192 cycles
Temperature Humidity	95°C, 85% RH, 14 days
Bake Test	95°C, 16 days, nominal (<25%) RH

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6. Other Requirements

6.1. Recycling Recommendation

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

6.2. Safety Requirements

The Intel® Xeon™ processor heatsink shall be consistent with the manufacture of units that meet the safety standards:

- UL Recognition-approved for flammability at the system level - all mechanical-enabling components must be a minimum UL94V-0 approved.

6.3. Agency Requirements

All edges should not be sharp when tested per UL 1439.

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7. Intel Reference Designs for Enabled Components

The Intel reference design is composed of a copper base, aluminum folded fin passive heatsink with Shin-Etsu* G749 thermal grease as the thermal interface material. The recommended minimum amount of Shin-Etsu* G749 thermal grease is 250 mg. The reference design accommodates the vertical height of the Intel® Xeon™ processor, as specified in the *Intel® Xeon™ Processor Datasheet,* and the vertical height of the 603 pin socket, as specified in the *603-Pin Socket Design Guidelines*. The Intel reference design heatsink clip will apply a load on the thermal interface material of approximately 25 lbf.

The thermal resistance, θ_{CA}, of the Intel reference design for the Intel Xeon processor is 0.42°C/W.

The heatsink clip must be designed in a way that minimizes contact with the motherboard surface during clip attach to the retention mechanism (RM) tab features; the clip should not scrape and/or scratch the motherboard. All surfaces of the clip should be free of sharp edges to prevent injury to any system component or to the person performing the installation.

The figures in Section 8 present the Intel reference design for the heatsink clip, the EMI grounding frame, and the retention mechanism. The full IGES and ProE models of these components are available on http://developer.intel.com.

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8. Appendix: Mechanical Drawings

Table 4 describes the mechanical drawings included in this Section. Both heatsink volumetric constraints and enabled components are presented.

Table 4. Mechanical Drawing List

Figure 3. Heatsink Base Critical-to-Function Dimensions, Sheet 1 of 1

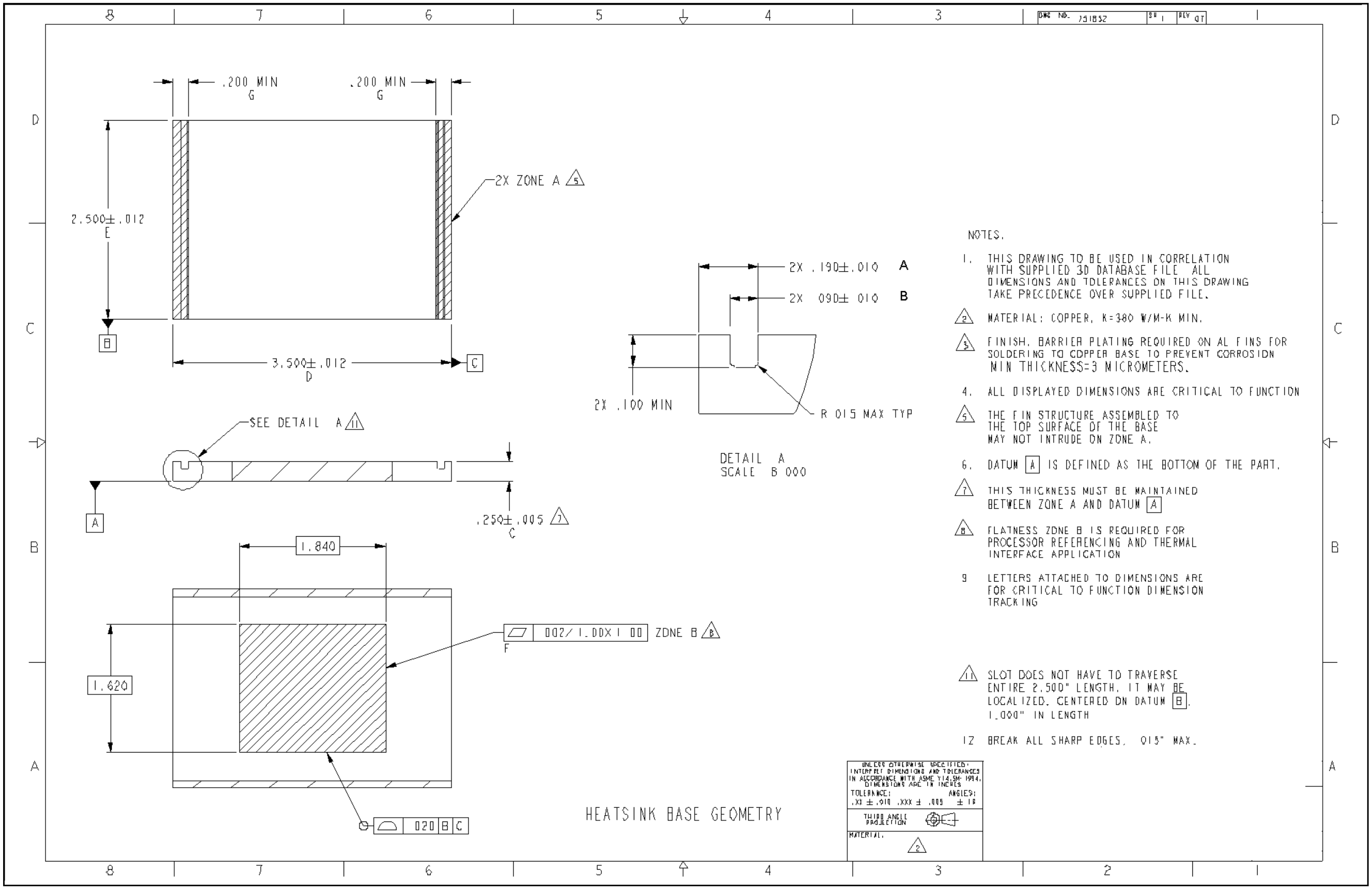

Figure 4. Heatsink Volumetric Constraints, Sheet 1 of 1

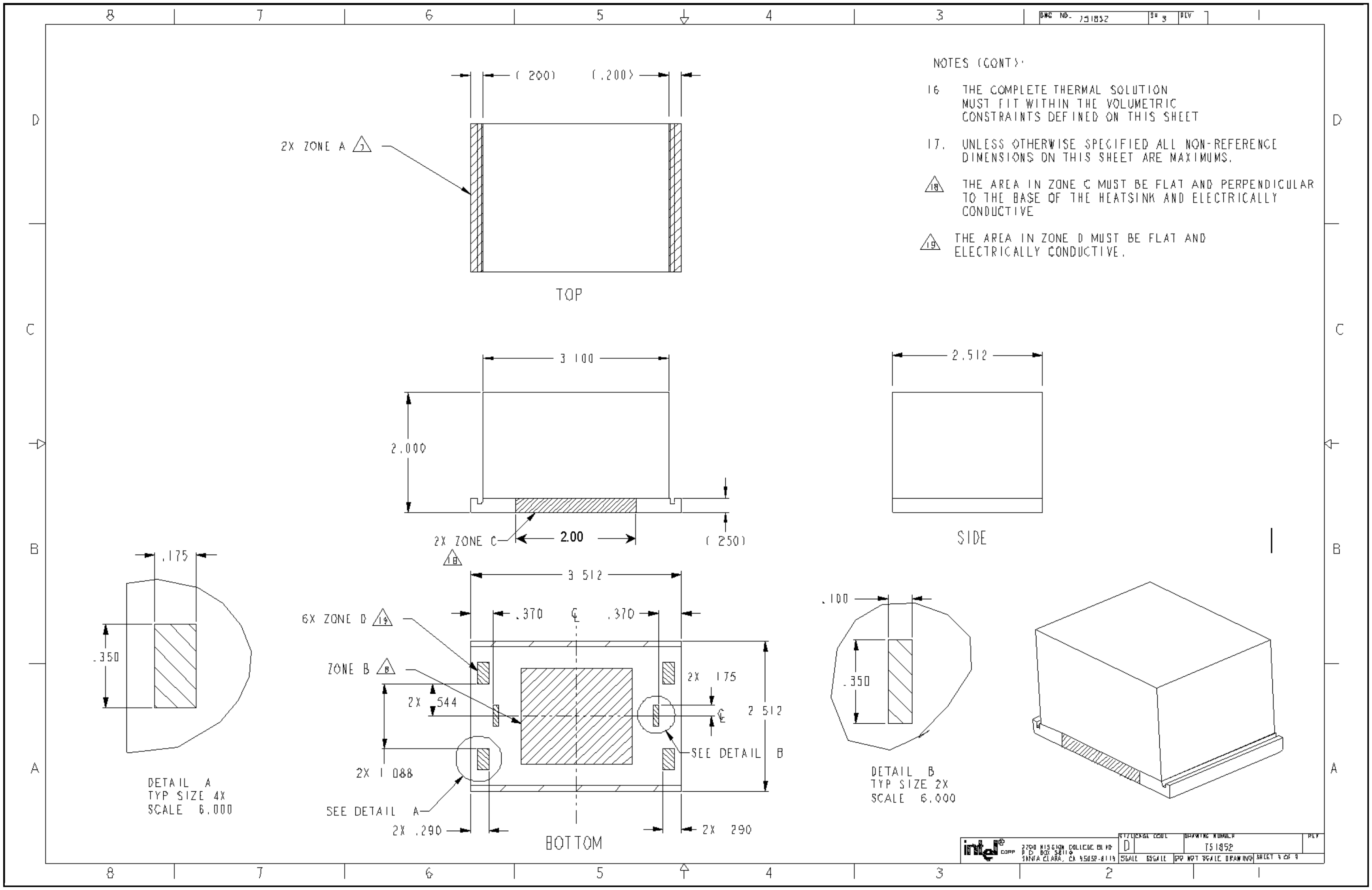

Figure 5. Enabled Heatsink Clip Drawing, Sheet 1 of 2

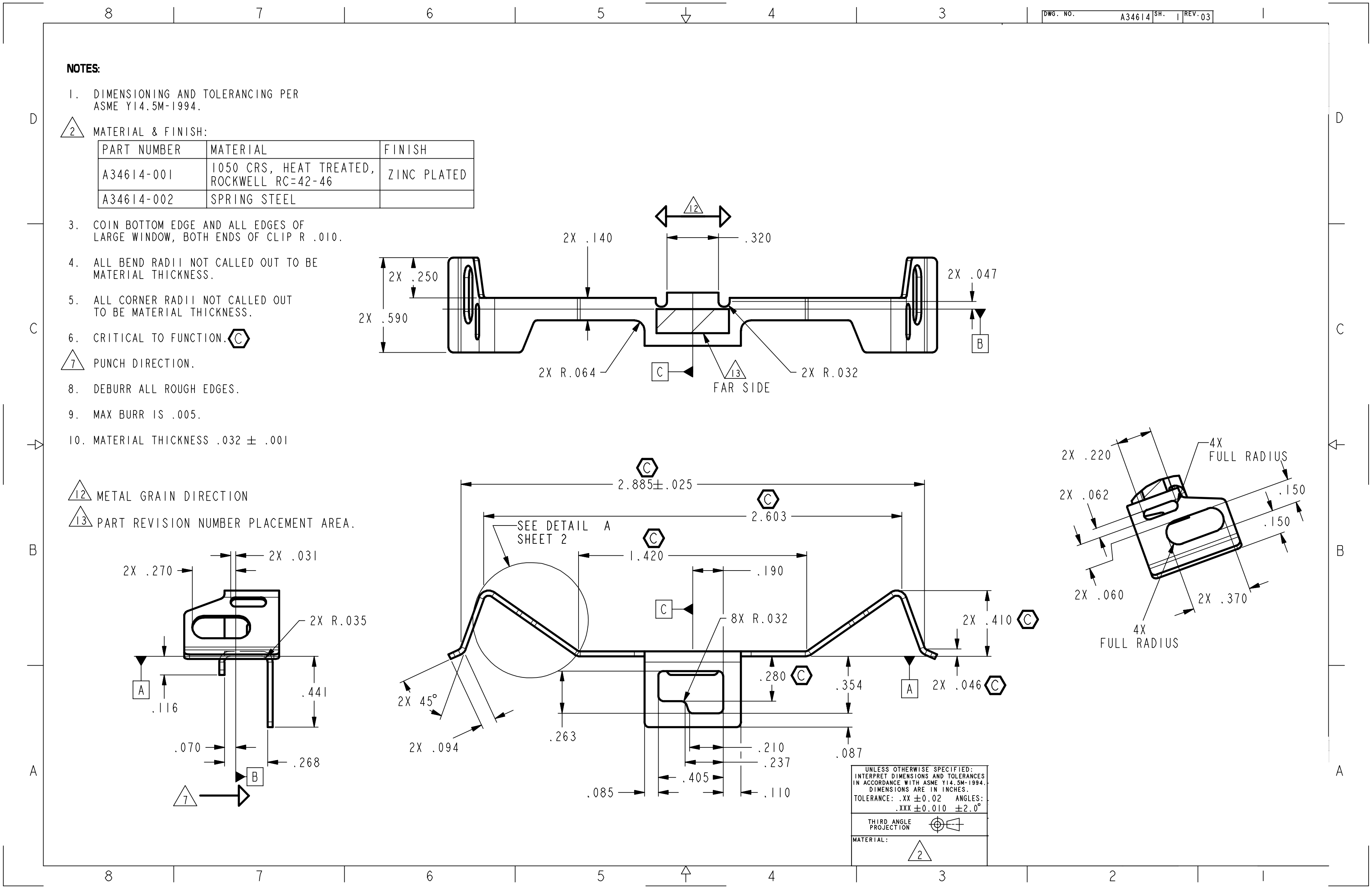

Figure 6. Enabled Heatsink Clip Drawing, Sheet 2 of 2

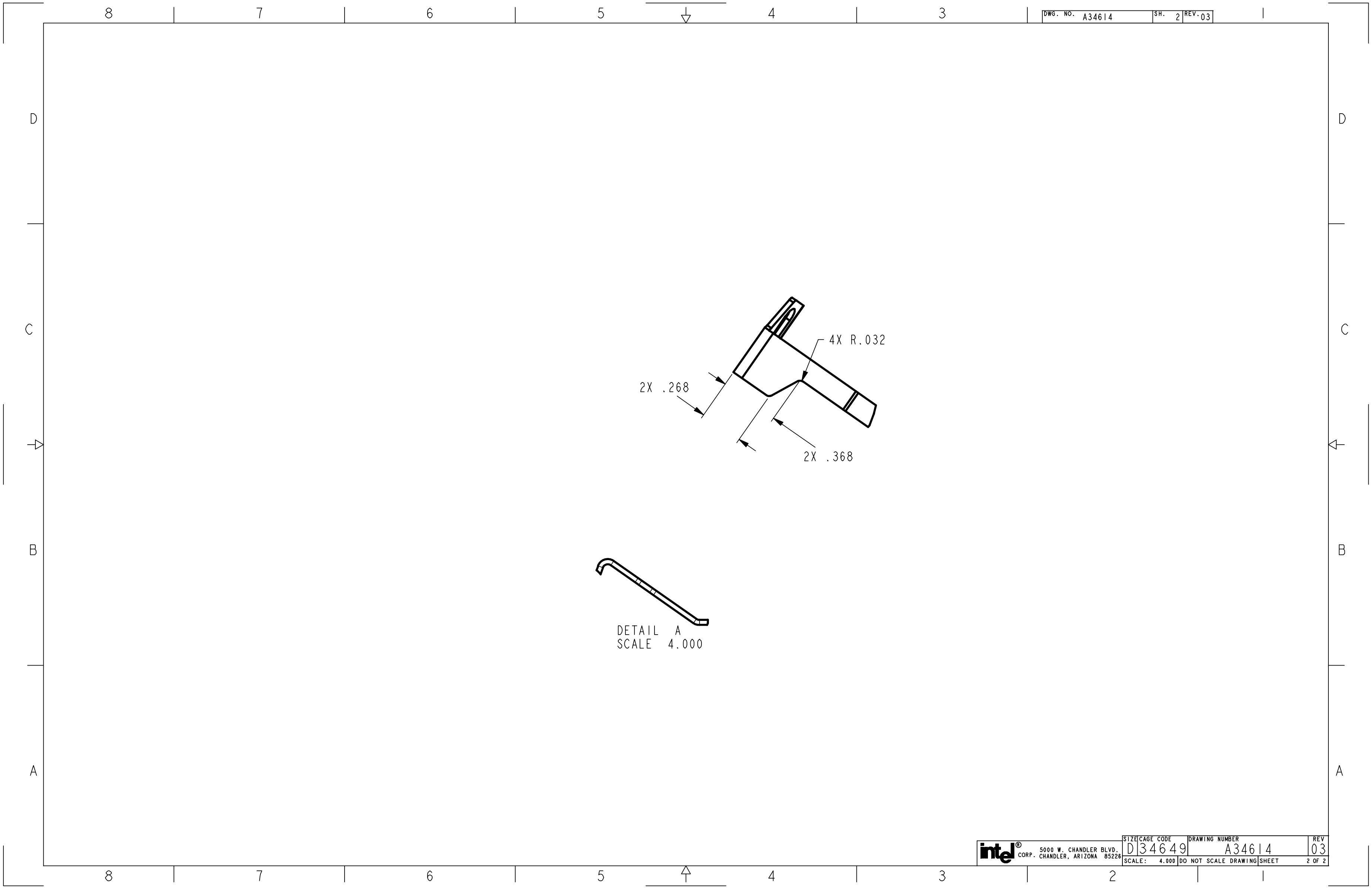

Figure 7. EMI Ground Frame Drawing, Sheet 1 of 1

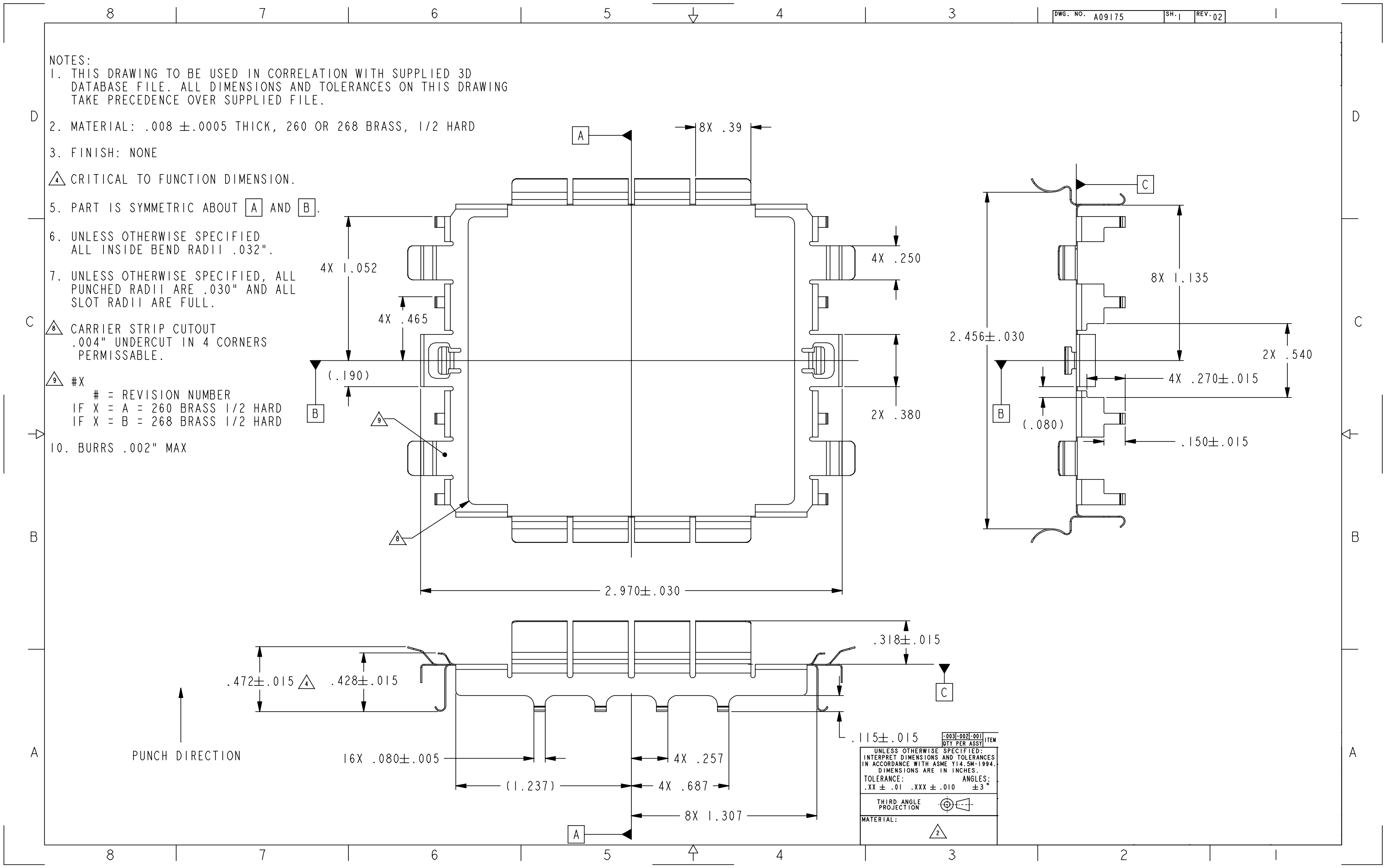

Figure 8. Enabled Heatsink Retention Mechanism, Sheet 1 of 4

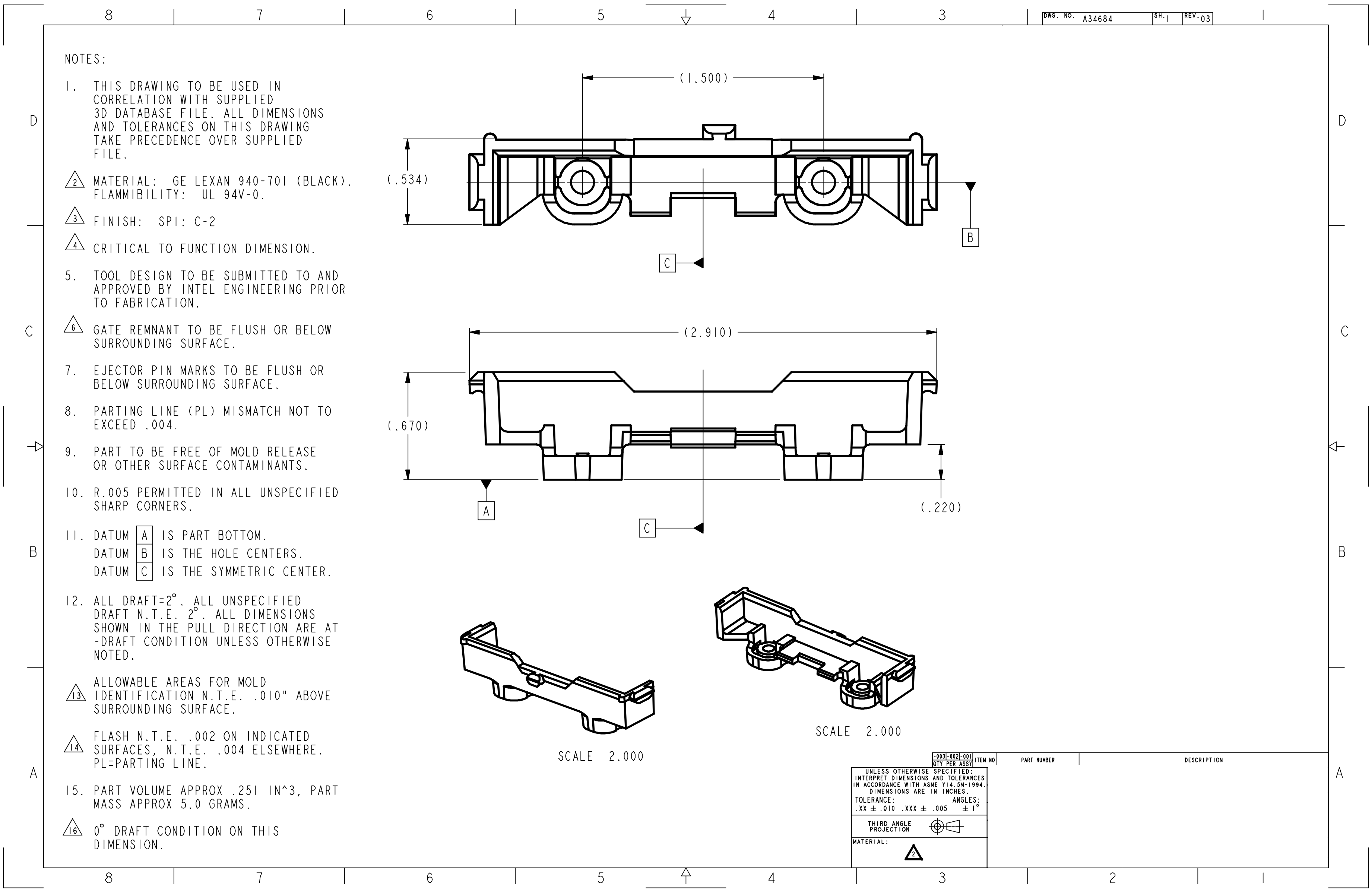

Figure 9. Enabled Heatsink Retention Mechanism, Sheet 2 of 4

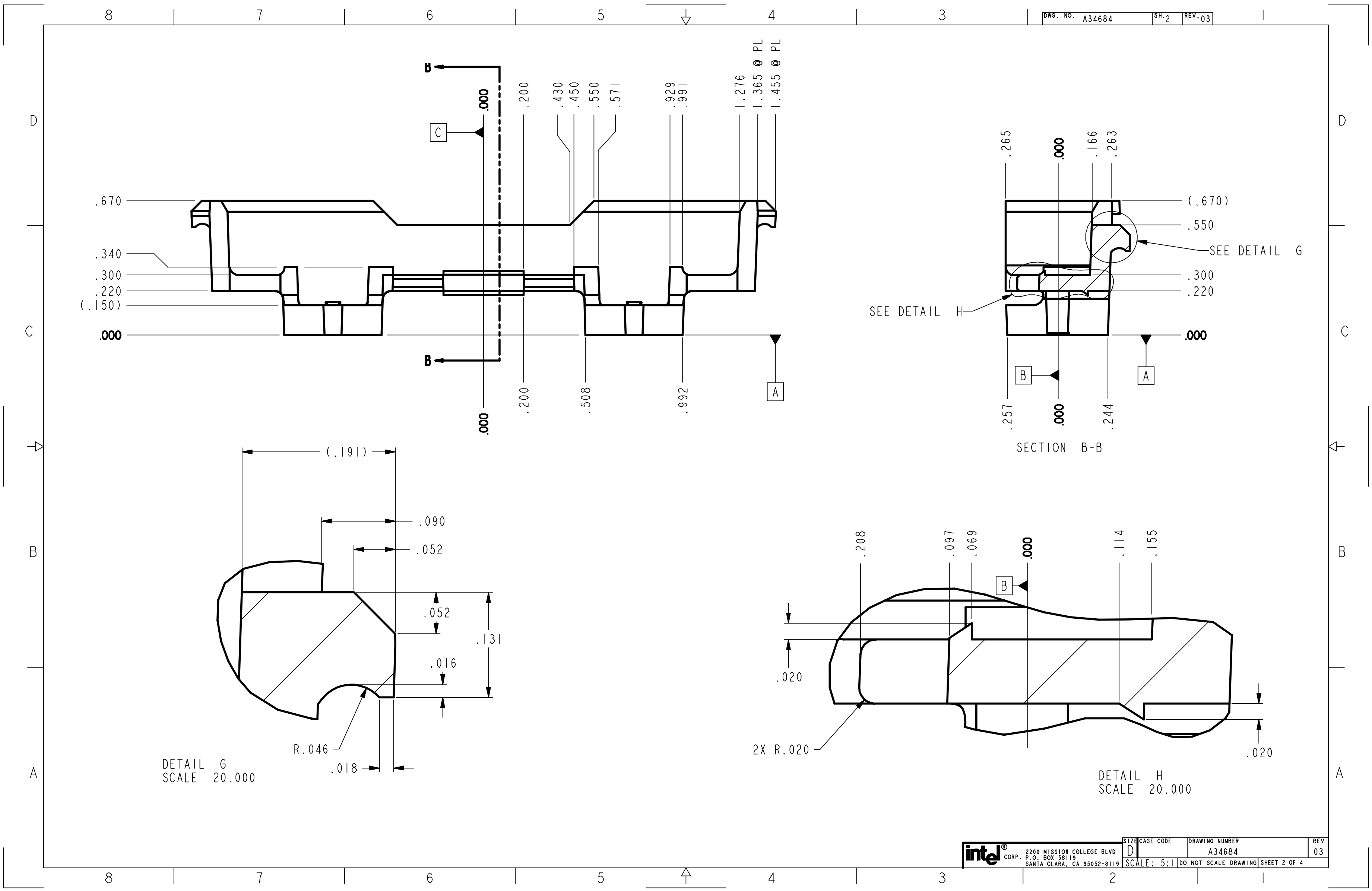

Figure 10. Enabled Heatsink Retention Mechanism, Sheet 3 of 4

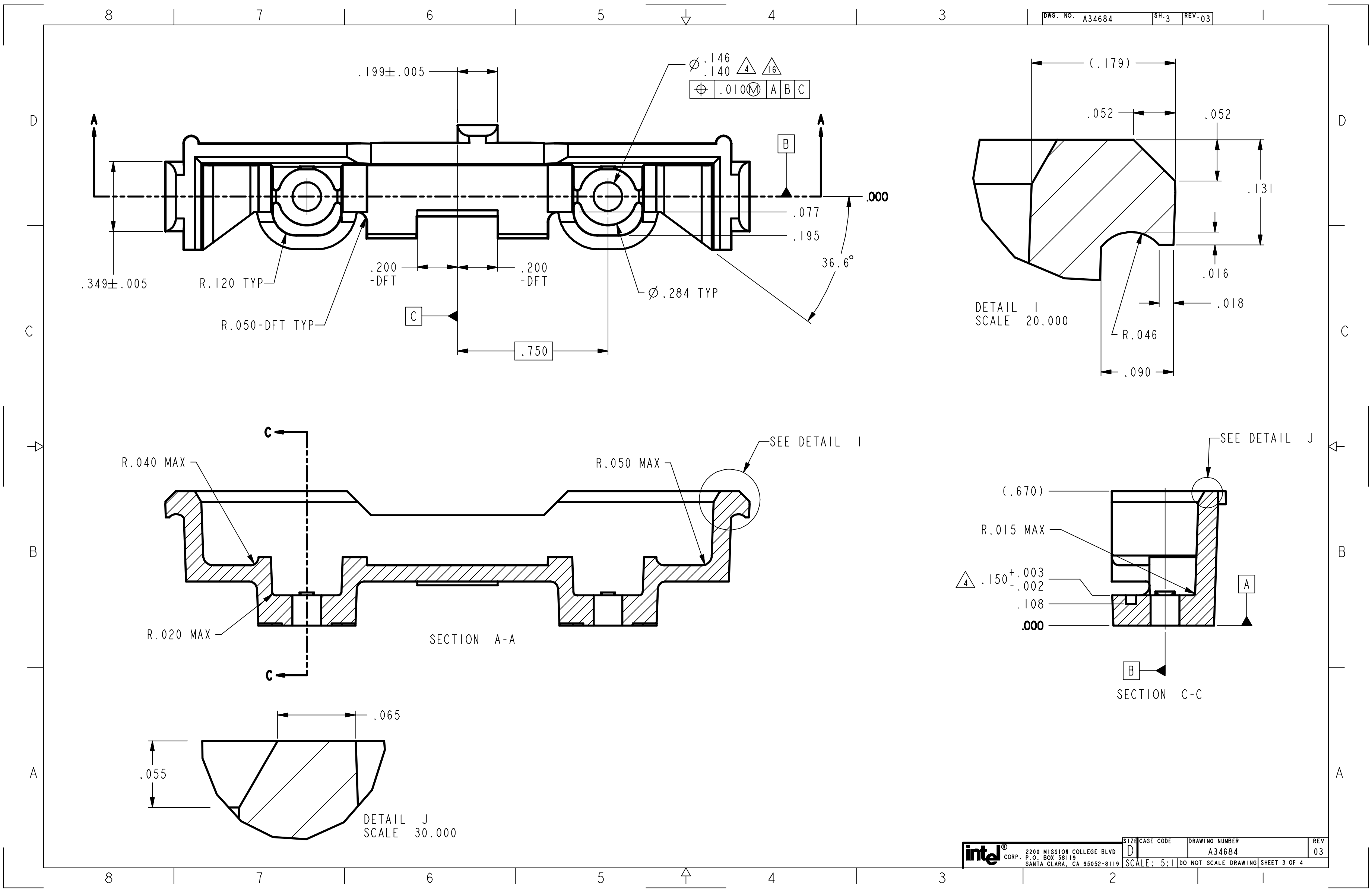

Figure 11. Enabled Heatsink Retention Mechanism, Sheet 4 of 4