Intel® I/O Controller Hub 8 (ICH8) Family

Thermal and Mechanical Design Guidelines

— For the Intel® I/O Controller Hub 8 (ICH8) Desktop Family.

June 2006

Document Number: 313058-001

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Revision History

Rev. No.	Description	Date
-001	• Initial Release.	June 2006

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1 Introduction

The objective of thermal management is to ensure that the temperatures of all components in a system are maintained within functional limits. The functional temperature limit is the range within which the electrical circuits can be expected to meet specified performance requirements. Operation outside the functional limit can degrade system performance, cause logic errors, or cause component and/or system damage. Temperatures exceeding the maximum operating limits may result in irreversible changes in the operating characteristics of the component. The goal of this document is to provide an understanding of the operating limits of the Intel® ICH8 component.

As the complexity of computer systems increases, so do power dissipation requirements. The additional power of next generation systems must be properly dissipated. Heat can be dissipated using improved system cooling, selective use of ducting, and/or passive heatsinks.

The simplest and most cost-effective method is to improve the inherent system cooling characteristics of the ICH8 through careful design and placement of fans, vents, and ducts. When additional cooling is required, component thermal solutions may be implemented in conjunction with system thermal solutions. The size of the fan or heatsink can be varied to balance size and space constraints with acoustic noise.

This document presents the conditions and requirements to properly design a cooling solution for systems that implement the ICH8 component. Properly designed solutions provide adequate cooling to maintain the ICH8 component case temperature at or below thermal specifications. This is accomplished by providing a low local-ambient temperature, ensuring adequate local airflow, and minimizing the case to local-ambient thermal resistance. By maintaining the ICH8 component case temperature at or below maximum specifications, a system designer can ensure the proper functionality, performance, and reliability of this component.

Note: This document only applies to the desktop implementation of the Intel® ICH8 component.

Note: Unless otherwise specified, the term ICH8 refers to the Intel® I/O Controller Hub 8 (ICH8) desktop family.

Note: References to RAID in this document only apply to the Intel® 82801HR ICH8R I/O Controller Hub with RAID capabilities.

1.1 Terminology

Term	Description
mBGA	Mini Ball Grid Array. Smaller versions of the BGA with a ball pitch of 1.07 mm. Wirebonded package with die encased with a mold encapsulant.
T_C	The measured case temperature of a component. It is generally measured at the geometric center of the die or case, as specified in the component documentation.
T_{C-MAX}	The maximum case/die temperature.

Term	Description
T_{C-MIN}	The minimum case/die temperature.
TDP	Thermal Design Power is specified as the highest sustainable power level of most or all of the real applications expected to be run on the given product, based on extrapolations in both hardware and software technology over the life of the component. Thermal solutions should be designed to dissipate this target power level.
TIM	Thermal Interface Material: thermally conductive material installed between two surfaces to improve heat transfer and reduce interface contact resistance.
LFM	Linear Feet per Minute. Units of airflow velocity.
PTC	Package Thermal Capability. The power level at which at or below its value, the component does not require a heatsink under the reference boundary condition assumptions.
Theta_CA	Thermal Resistance described using power dissipated between two points. Here, theta_ca is defined as: (Tc – Tambient)/($Power_{CA}$)

1.2 Reference Documents

Document	Comments
Intel® I/O Controller Hub 8 (ICH8) Datasheet	www.intel.com/design/chipsets/datashts/313056.htm
Various System Thermal Design Suggestions	http://www.formfactors.org

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2 Product Specifications

2.1 Package Description

The ICH8 component is available in a 652 ball, 31mm square mBGA package shown in Figure 5 in Appendix B.

2.2 Package Loading Specifications

Table 1 provides static load specifications for the ICH8 package. This mechanical maximum load limit should not be exceeded during heatsink assembly, shipping conditions, or typical use condition. Also, any mechanical system or component testing should not exceed the maximum limit. The chipset package substrate should not be used as a mechanical reference or load-bearing surface for the thermal and mechanical solution.

Table 1. Package Loading Specifications

Parameter	Maximum	Notes
Static	15 lbf	1,2,3

NOTES:

1. These specifications apply to uniform compressive loading in a direction normal to the chipset package
2. This is the maximum force that can be applied by a heatsink retention clip. The clip must also provide the minimum specified load on the ICH package.
3. These specifications are based on limited testing for design characterization. Loading limits are for the package only.

2.3 Thermal Specifications

To ensure proper operation and reliability of the ICH8 component, the case temperature T_C must be at or below the maximum value T_{C-MAX} specified in Table 2. If the temperature of the component exceeds the maximum temperature listed, system or component level thermal enhancements are required to dissipate the heat generated. The system designer must design a thermal solution for the ICH8 such that it maintains T_C below T_{C-MAX} for sustained power level equal to the Thermal Design power (TDP). Please note that the T_{C-MAX} specification is a requirement for a sustained power level equal to TDP, and that the case temperature must be maintained at temperatures less than T_{C-MAX} when operating at power levels less than TDP. This temperature compliance is to ensure chipset reliability over its useful life. Chapter 3 provides the thermal metrology guidelines for case temperature measurements. Chapter 4 provides information on the reference cooling solution for ATX systems.

Intel's reference boundary conditions for ICH8 in an ATX system are 60 °C inlet ambient temperature and 0.25m/s [50 lfm] of airflow. The ICH8 package will not require a heatsink when power dissipation is at or below 3.0 W. This value is referred to as the Package Thermal Capability, or PTC. Note that the power level at which a heatsink is required will also change depending on system local operating ambient conditions and system configuration. For example, the local inlet ambient air for the ICH8 component in a BTX system is projected to be approximately 55°C. For BTX platforms that have similar boundary conditions to what is stated above, ICH8 does not require a heatsink.

Note that the local ambient air temperature for BTX is a projection based on anticipated power increases on a 2005 platform and are subject to change in the next revision of this document.

It is important to note, however, that since the ICH8 package has a molded plastic encapsulant, and because plastic is such a poor heat conductor, the relative importance of the motherboard heat transfer characteristics increases. The heat transfer capability of the motherboard in the area of the ICH8 should be characterized. Knowledge of these heat transfer paths can be used to determine if an ICH8 heatsink is required.

In addition, high power PCI Express* graphic cards may alter the local ambient temperature as well as the airflow patterns in the vicinity of the chipset. Systems that have interface utilization less than that of the TDP configuration may be at power levels that may not require a heatsink.

In conclusion, thermal validation should be performed in your anticipated system environment, in particular measuring the ICH8 case temperature to ensure it does not exceed its maximum case temperature specification. To evaluate the capability of your system for cooling the ICH8, the following system level tests are suggested to assess ICH8 case temperature compliancy:

1. Shipping configuration(s) with expected end user add-in cards and I/O peripherals installed.
2. All available slots and IO ports populated (only worst case if all I/O is fully populated including SATA, USB, etc.).

For completeness, both room ambient conditions (approximately 23 °C, to simulate impact of fan speed control) and worse case maximum external temperature (35 °C) conditions should be considered in the validation test suite. If the ICH8 case temperature is above the published Tc-max in any test scenario, a heatsink is required.

If you determine that the ICH8 package requires a heatsink in your system configuration, please refer to Appendix A for the current reference ICH8 heatsink vendor information.

The component should be operated above the minimum case temperature specification listed in Table 2.

Table 2. Intel® ICH8 Component Case Temperature Specifications

Parameter	Value
$T_{C\text{-}MAX}$ (Note 1 below) for TDP condition of 4.1 W	See Table 3 for additional configurations No Heatsink Attached: 105 °C
	See Table 3 for additional configuration Heatsink Attached: 92 °C
$T_{C\text{-}MIN}$	0 °C
Storage Temperature	-10 °C to +45 °C

NOTES:

1. Without a heatsink, most of the heat dissipated by ICH8 goes through the PCB, acting as a heat spreader, and then into the ambient air. When a heatsink is installed on the package, more power is now being pulled through the case. As a result the maximum case temperature must be maintained at lower level than without a heatsink to remain within specification.

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2.4 Power Specifications

The ICH8 component is estimated to dissipate the Thermal Design Power (TDP) value provided in Table 3. This TDP value is estimated based on various factors including: system configurations, industry stress applications, die temperature and part-to-part variance.

Note that Table 3 reflects post silicon validated power numbers.

Table 3. Intel® ICH8 Thermal Design Power Guidelines

Configuration		Configuration 1	Configuration 2	Configuration 3	Configuration 4
Devices	DMI x4	X4	X4	X4	x4
	PCI	3	3	3	3
	PCI Express*	Two x1 s	Two x1 s	Two x1 s	One each x4 and x1
	LAN		Gigabit LAN Connect Interface (GLCI)	GLCI	GLCI
	SATA[2]	4	4	6	6
	USB (HS/FS)[1]	8/2	8/2	8/2	8/2
	HD Audio	Yes	Yes	Yes	Yes
Configuration Based Power[4]		3.0 W	3.3 W	3.7 W	4.1 W

NOTES:

1. USB HS = USB 2.0 High Speed Device (480 Mb/s), USB FS = USB 2.0 Full Speed Device (12 Mb/s)
2. 4 devices assume RAID 5 with 3 hard drives (3 Gb/s) and 1 optical drive (1.5 Gb/s).
   6 devices assumes RAID 5 with 4 hard drives (3 Gb/s) and 2 optical drives (1.5 Gb/s)
3. The number of devices refers to both the number of ports supported on the board as well as the quantity of devices attached. Any ports not routed to a connector is assumed to be functionally disabled according to Intel guidelines
4. Refers to the power of each listed configuration. Configuration 4 is the typical configuration for Thermal Design Power.
5. The Intel reference design supports Configuration 3.

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3 Thermal Metrology

The system designer must make temperature measurements in order to accurately determine the thermal performance of the system. Intel has established guidelines for measuring chipset component case temperatures.

3.1 Case Temperature Measurements

To ensure functionality and reliability, the chipset component is specified for proper operation when T_C is maintained at or below the maximum temperature listed in Table 2. The surface temperature at the geometric center of the mold encapsulant corresponds to T_C. Measuring T_C requires special care to ensure an accurate temperature measurement.

Temperature differences between the temperature of a surface and the surrounding local ambient air can introduce error in the measurements. The measurement errors could be due to a poor thermal contact between the thermocouple junction and the surface of the package, heat loss by radiation and/or convection, and/or conduction through thermocouple leads. To minimize these measurement errors, the approach described below titled 0° Angle Thermocouple Attach Methodology is recommended.

3.2 0° Angle Thermocouple Attach Methodology

1. Mill a 3.3 mm [0.13 in] diameter hole centered on bottom of the heatsink base. The milled hole should be approximately 1.5 mm [0.06 in] deep.
2. Mill a 1.3 mm [0.05 in] wide slot, 0.5 mm [0.02 in] deep, from the centered hole to one edge of the heatsink. The slot should be in the direction parallel to the heatsink fins (see Figure 2).
3. Attach thermal interface material (TIM) to the bottom of the heatsink base.
4. Cut out portions of the TIM to make room for the thermocouple wire and bead. The cutouts should match the slot and hole milled into the heatsink base.
5. Attach a 36 gauge or smaller calibrated K-type thermocouple bead or junction to the center of the top surface of the case using high thermal conductivity cement. During this step, make sure no contact is present between the thermocouple cement and the heatsink base because any contact will affect the thermocouple reading. It is critical that the thermocouple bead makes contact with the case (see Figure 1).
6. Attach heatsink assembly to the ICH8, and route thermocouple wires out through the milled slot.

Figure 1. 0° Angle Attach Methodology (top view, not to scale)

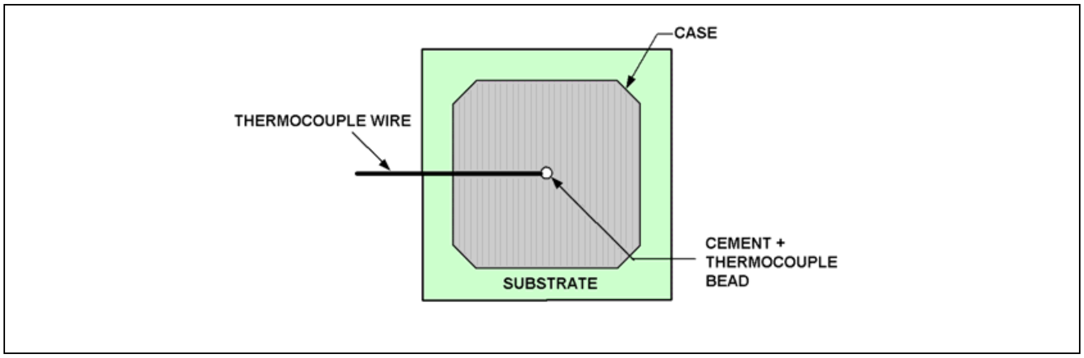
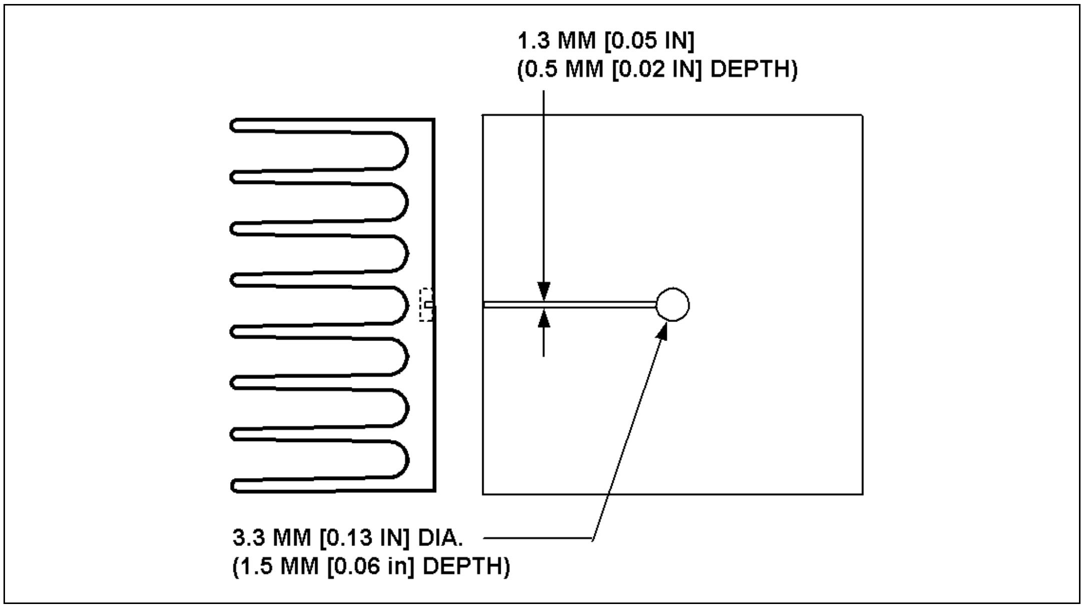


Figure 2. 0° Angle Attach Heatsink Modifications (generic heatsink shown, not to scale)



3.3 Ambient Temperature and Airflow Measurement

Figure 3 describes the recommended location for air temperature measurements measured relative to the component. For a more accurate measurement of the average approach air temperature, Intel recommends averaging temperatures recorded from two thermocouples spaced about 25 mm [1.0 in] apart. Locations for both a single thermocouple and a pair of thermocouples are presented.

Airflow velocity should be measured using industry standard air velocity sensors. Typical airflow sensor technology may include hot wire anemometers. Figure 4 provides guidance for airflow velocity measurement locations. These locations are for a typical JEDEC test setup and may not be compatible with all chassis layouts due to the proximity of the processor to the ICH8, PCI and PCI Express* add-in cards. The user may have to adjust the locations for a specific chassis. Be aware that sensors may need to be aligned perpendicular to the airflow velocity vector or an inaccurate measurement may result. Measurements should be taken with the chassis fully sealed in its operational configuration to achieve a representative airflow profile within the chassis.

Figure 3. Recommended Temperature Measurement Placement: Top View

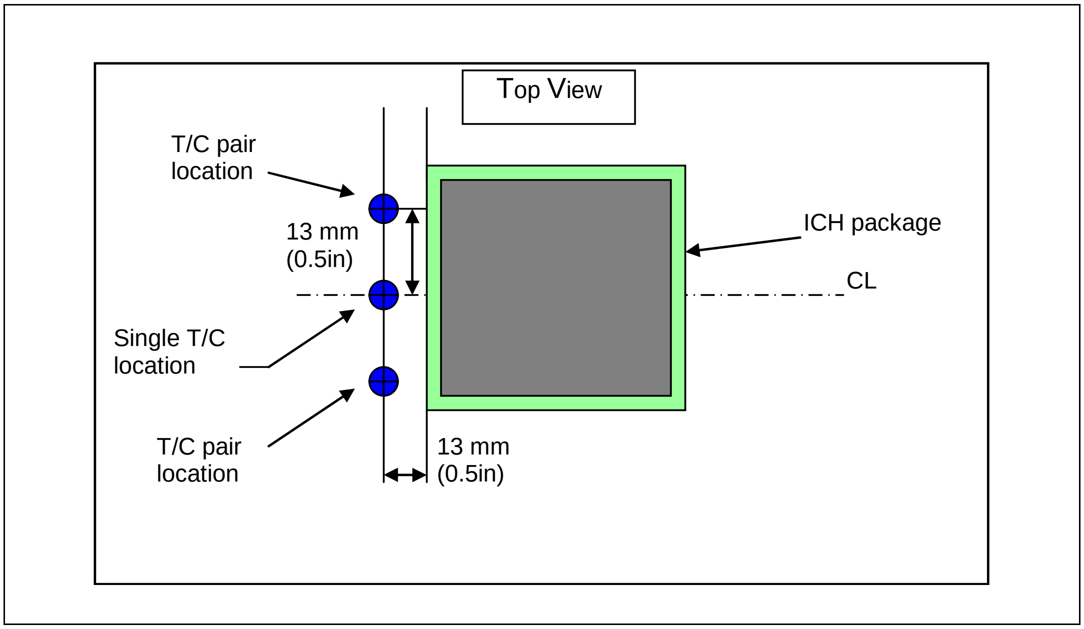
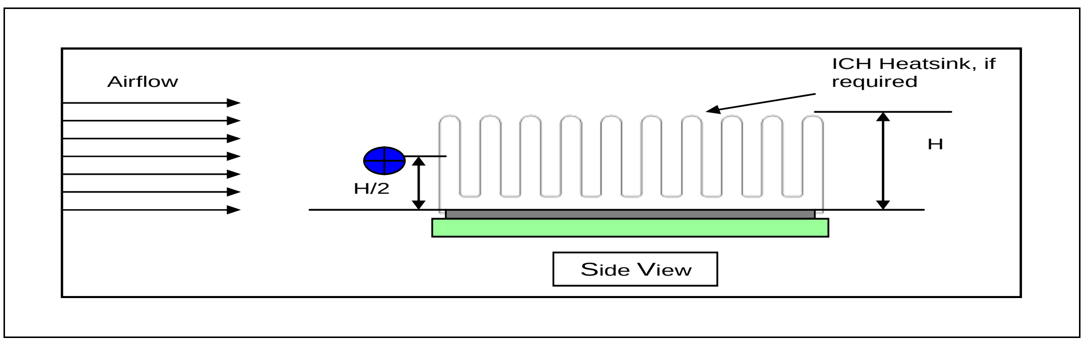


Figure 4. Recommended Airflow and Temperature Placement: Side View



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4 Reference Thermal Solution

The ICH8 reference solution on an ATX platform assumes a component local operating environment with a maximum local-ambient temperature of 60 °C and airflow of 0.25 m/s [50 lfm]. In these ambient conditions, with the configurations given in Table 3, the ICH8 component requires an attached heatsink to meet thermal specifications. The local-ambient conditions are based on a 35 °C external-ambient temperature at sea level, where external-ambient refers to the environment external to the system. Refer to Appendix A for currently enabled suppliers for the reference thermal solution and Appendix B for reference thermal solution mechanical drawings.

Note: The reference heatsink for the ICH8 is the same reference heatsink for the developed Intel® ICH6 which was also used for the Intel® ICH7.

Refer to Figure 6 for reference ATX/µATX motherboard keep-out information. The heatsink can be tape-attached, or attached with a Z-clip. The motherboard keep-out allows for a Z-clip heatsink attach.

Note: Intel has not completed thermal or mechanical validation with a tape-attached ICH heatsink solution.

4.1 Environmental Reliability Requirements

If an attached heatsink is implemented due to a severe component local operating environment, the reliability requirements in Table 4 are recommended. The mechanical loading of the component may vary depending on the heatsink, and attach method used. The user should define validation tests based on the anticipated use conditions and resulting reliability requirements.

Table 4. Reference Thermal Solution Environmental Reliability Requirements

Test[1]	Requirement	Pass/Fail Criteria[2]
Mechanical Shock	• 3 drops for + and - directions in each of 3 perpendicular axes (i.e., total 18 drops). • Profile: 50 G trapezoidal waveform, 11 ms duration, 170 inches/sec minimum velocity change. • Setup: Mount sample board on test fixture.	Visual\Electrical Check
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/Electrical Check
Thermal Cycling	• -40 °C to +85 °C, 1000 cycles	Visual Check
Temperature Life	• 85 °C, 1000 hours total	Visual/Electrical Check
Unbiased Humidity	• 85 % relative humidity / 55 °C, 1000 hours	Visual Check

NOTES:

1. The above tests should be performed on a sample size of at least 12 assemblies from 3 different lots of material.
2. Additional Pass/Fail Criteria may be added at the discretion of the user.

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Appendix A Currently Enabled Suppliers

The currently enabled suppliers for the reference thermal solution supporting the ICH6, ICH7 and ICH8 are listed in Table 5 and Table 6.

Table 5. Heatsink Enabled Suppliers for Intel® ICH6, ICH7, and ICH8

items	Intel PN	AVC	CCI	Foxconn
ICH 6, 7, and 8	C46655-001	S702C00001	00C855802B	2Z802-009

Table 6. Enabled Suppliers for the Intel® ICH6, ICH7, and ICH8 Reference Heatsink

Supplier	contacts	location	phone	email
AVC (Asia Vital Components)	David Chao	Taiwan	+886-2-2299-6930 ext. 7619	david_chao@avc.com.tw
	Raichel Hsu	Taiwan	+886-2-2299-6930 ext. 7630	raichel_hsi@avc.com.tw
CCI (Chaun Choung Technology)	Monica Chih	Taiwan	+886-2-2995-2666	monica_chih@ccic.com.tw
	Harry Lin	USA	(714) 739-5797	hlinack@aol.com
Foxconn	Jack Chen	USA	(714) 626-1233	jack.chen@foxconn.com
	Wanchi Chen	USA	(714) 626-1376	wanchi.chen@foxconn.com
Wieson Technologies	Andrea Lai	Taiwan	+886-2-2647-1896 ext. 6684	andrea24@wieson.com
	Edwina Chu	Taiwan	+886-2-2647-1896 ext. 6390	edwina@wieson.com

Note: 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. This list and/or these devices may be subject to change without notice.

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Appendix B Mechanical Drawings

The following table lists the mechanical drawings available in this document:

Figure 5. Intel® ICH8 Component Package Drawing

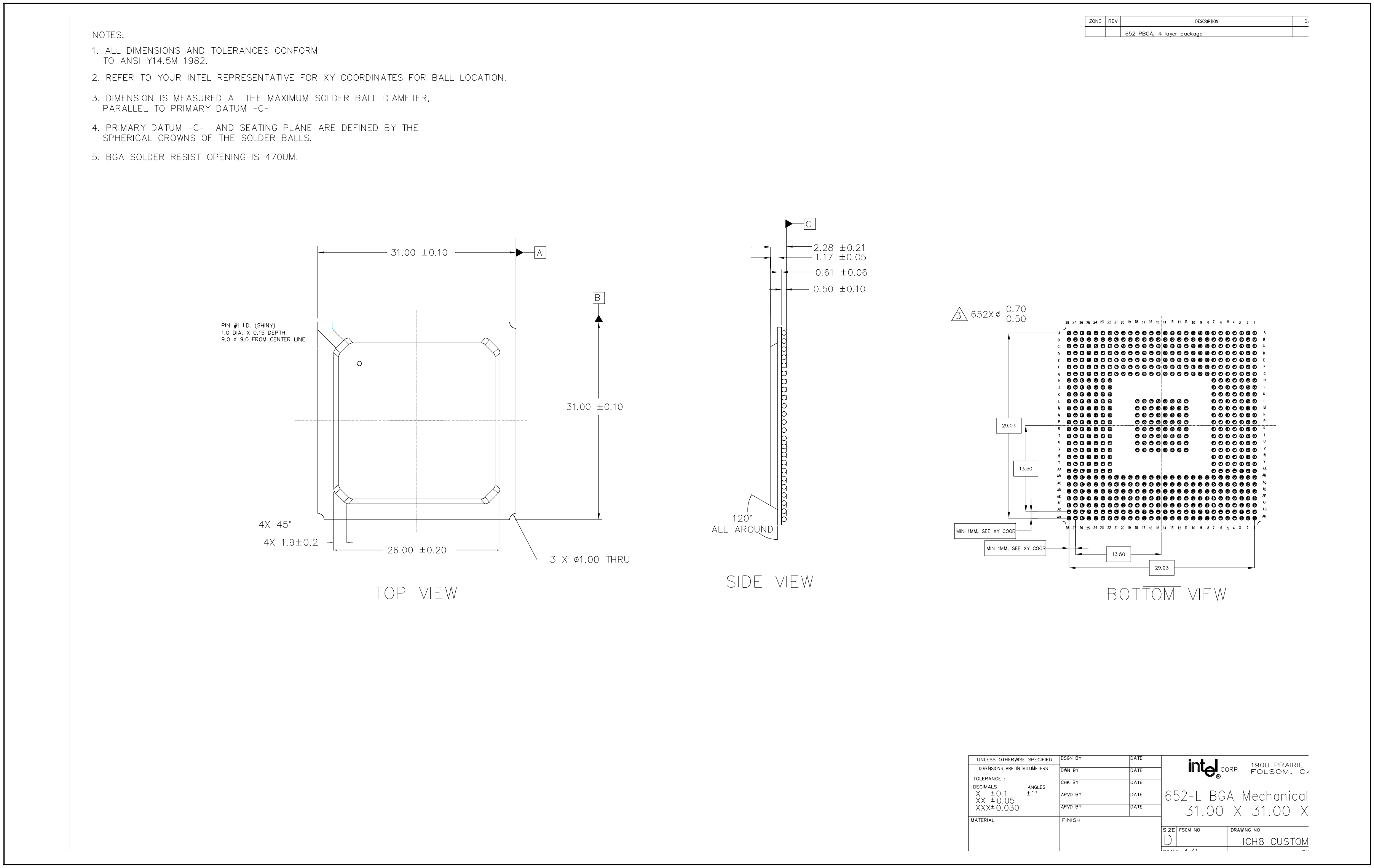

Figure 6. Motherboard Keep-Out for Reference Heatsink

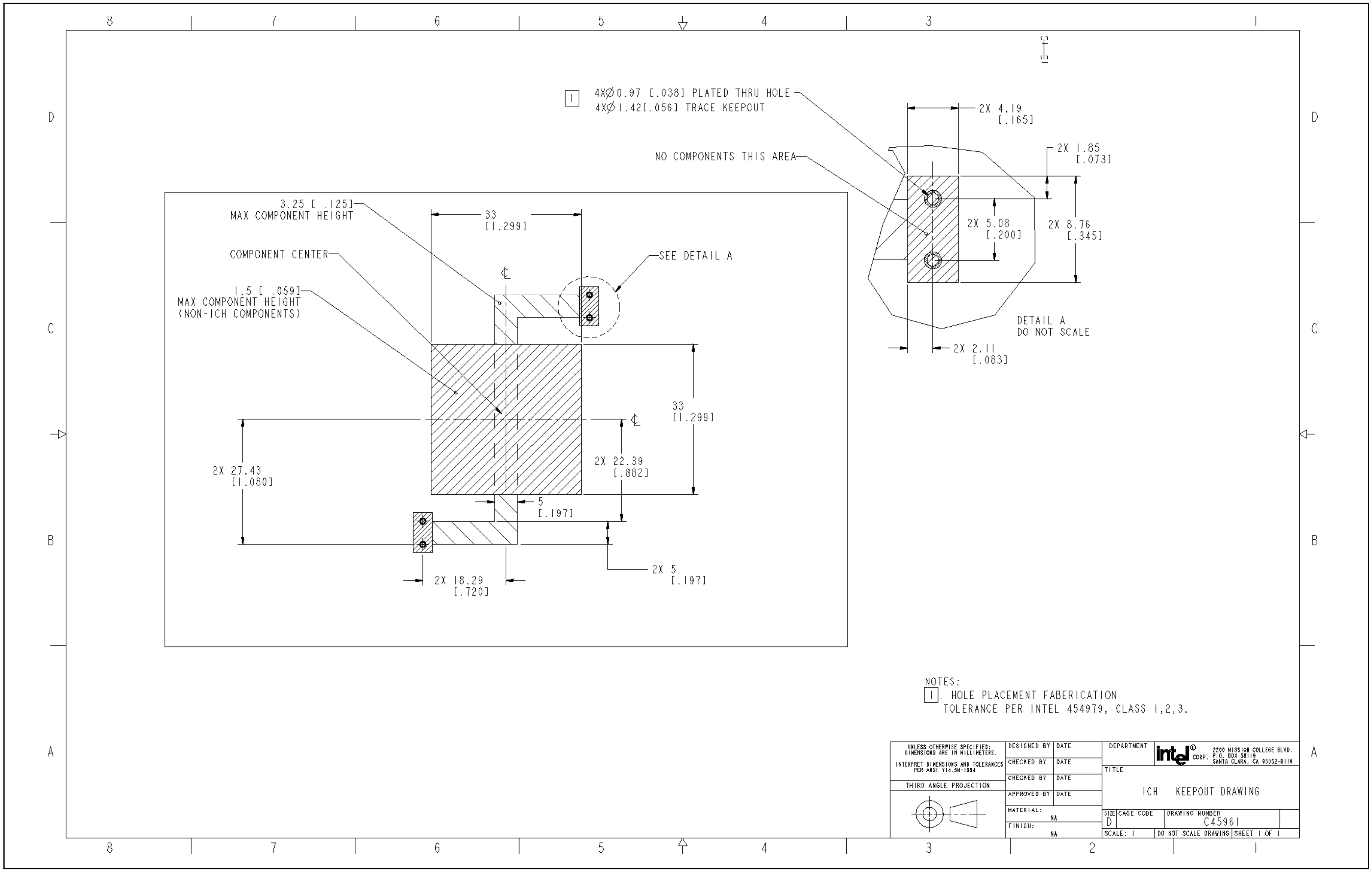

Figure 7. Reference Heatsink Extrusion

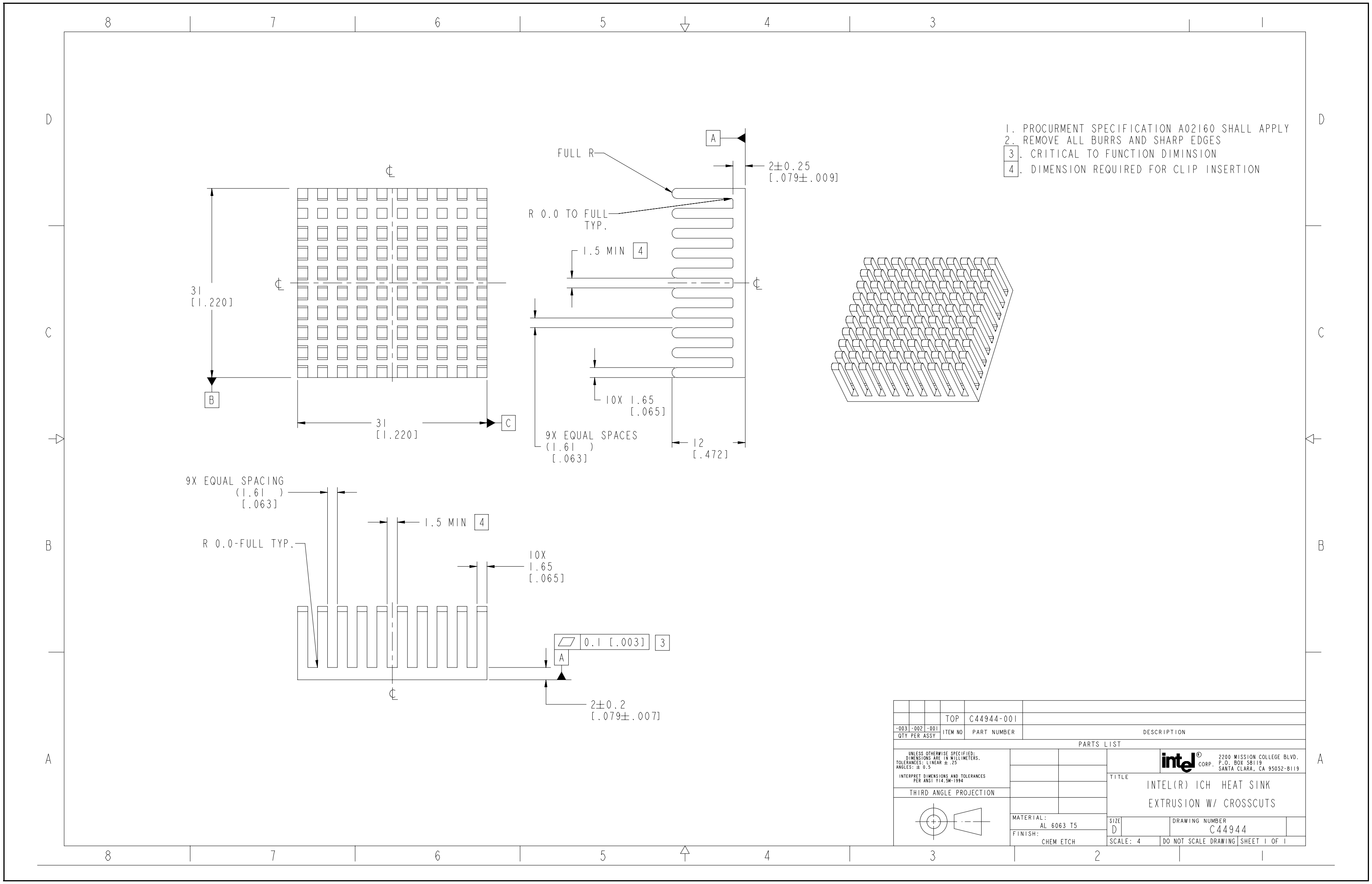

Figure 8. Reference Heatsink Clip

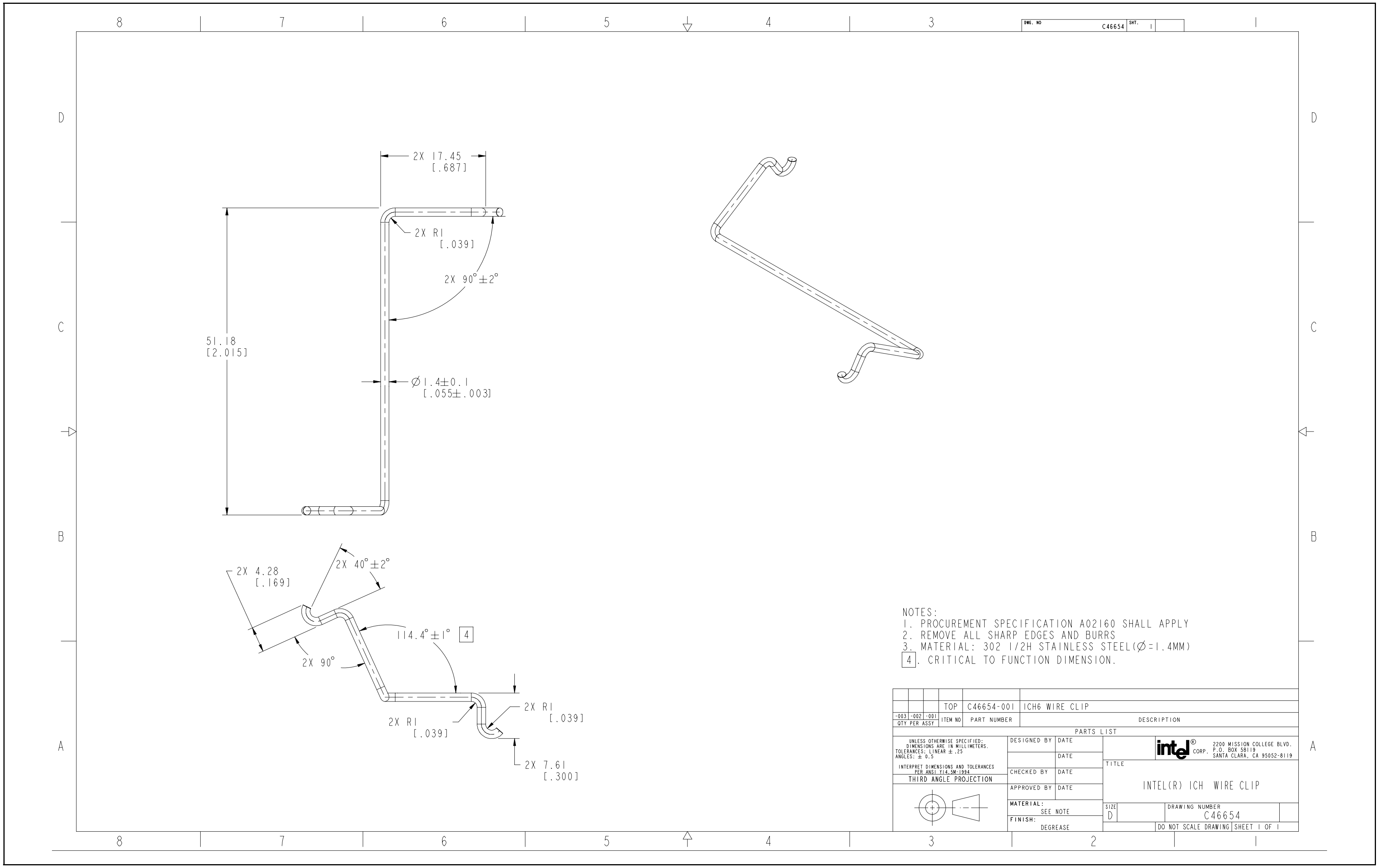

Figure 9. Reference Heatsink Assembly