Intel® 915G/915GV/915GL/910GL Express Chipset

Thermal Design Guide

For the Intel® 82915G/82915GV/82915GL, 82910GL Graphics and Memory Controller Hub (GMCH)

February 2005

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Revision History

Rev. No.	Description	Date
-001	• Initial Release	June 2004
-002	• Added 82915GV GMCH	September 2004
-003	• Added 82910GL GMCH	September 2004
-004	• Corrected reference in Section 2.1.1	October 2004
-005	• Added 82915GL GMCH	January 2005
-006	• Added 6xx processor information to Section 1.2, Reference Documents	February 2006

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1 Introduction

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 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® 82915G/82915GV/82915GL/82910GL Graphics and Memory Controller Hub (GMCH) and discuss a reference thermal solution.

The simplest and most cost-effective method to improve the inherent system cooling characteristics of the GMCH is 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 has presented the conditions and requirements to properly design a cooling solution for systems that implement the 82915G/82915GV/82915GL/82910GL GMCH. Properly designed solutions provide adequate cooling to maintain the GMCH 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 GMCH case temperature at or below those recommended in this document, a system designer can ensure the proper functionality, performance, and reliability of this chipset.

Note: Unless otherwise stated, the term GMCH in this document refers to the 82915G, /82915GV, 82915GL and 82910GL.

1.1 Terminology

Term	Description
BGA	Ball Grid Array. A package type defined by a resin-fiber substrate where a die is mounted and bonded. The primary electrical interface is an array of solder balls attached to the substrate opposite the die and molding compound.
FC-BGA	Flip Chip Ball Grid Array. A package type defined by a plastic substrate where a die is mounted using an underfill C4 (Controlled Collapse Chip Connection) attach style. The primary electrical interface is an array of solder balls attached to the substrate opposite the die. Note that the device arrives at the customer with solder balls attached.
Intel® ICH6	Intel® I/O Controller Hub 6. The chipset component that contains the primary PCI interface, LPC interface, USB, ATA, and/or other legacy functions.

Term	Description
mBGA	Mini Ball Grid Array. A smaller version of the BGA.
GMCH	Graphic Memory Controller Hub. The chipset component that contains the processor and memory interface and integrated graphics core.
T_A	The measured ambient temperature locally to the component of interest. The ambient temperature should be measured just upstream of airflow for a passive heatsink or at the fan inlet for an active heatsink.
T_C	The measured case temperature of a component. For processors, it is measured at the geometric center of the integrated heat spreader (IHS). For other component types, it is generally measured at the geometric center of the die or case.
$T_{C\text{-}MAX}$	The maximum case/die temperature with an attached heatsink. This temperature is measured at the geometric center of the top of the package case/die.
$T_{C\text{-}MIN}$	The minimum case/die temperature with an attached heatsink. This temperature is measured at the geometric center of the top of the package case/die.
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. Unit of airflow speed.
Ψ_{CA}	Case-to-ambient thermal characterization parameter (Psi). A measure of thermal solution performance using total package power. Defined as (T_C – T_A) / Total Package Power. Heat source size should always be specified for Ψ measurements.
WSHS	Wave Solder Heatsink. A heatsink that is installed to a motherboard via wave solder process. Pins are fixed to the heatsink base and are held in place on the motherboard by solder. There are no associated retention clips or retention anchors.

1.2 Reference Documents

Document	Document Link
Intel® 915G/915GV/915GL/915P/915PL/910GL Express Chipset Datasheet	http://developer.intel.com/design/chipsets/datashts/301467.htm
Intel® I/O Controller Hub 6 (ICH6) Family Thermal Design Guide	http://developer.intel.com/design/chipsets/designex/302362.htm
Intel® Pentium® 4 Processors 560, 550, 540, 530, and 520$^{\Delta}$ Datasheet	http://developer.intel.com/design/Pentium4/datashts/302351.htm
Intel® Pentium® 4 Processor 660, 650, 640, and 630$^{\Delta}$ and Intel® Pentium® 4 Processor Extreme Edition Datasheet: On 90 nm Process in the 775-land LGA Package and Supporting Intel® Extended Memory 64 Technology$^{\Phi}$	http://developer.intel.com/design/pentium4/datashts/306382.htm

Document	**Document Link**
Intel® Pentium® 4 Processor on 90 nm Process in the 775-Land LGA Package Thermal Design Guidelines	http://developer.intel.com/design/Pentium4/guides/302363.htm
Various System Thermal Design Suggestions	http://www.formfactors.org

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2 Product Specifications

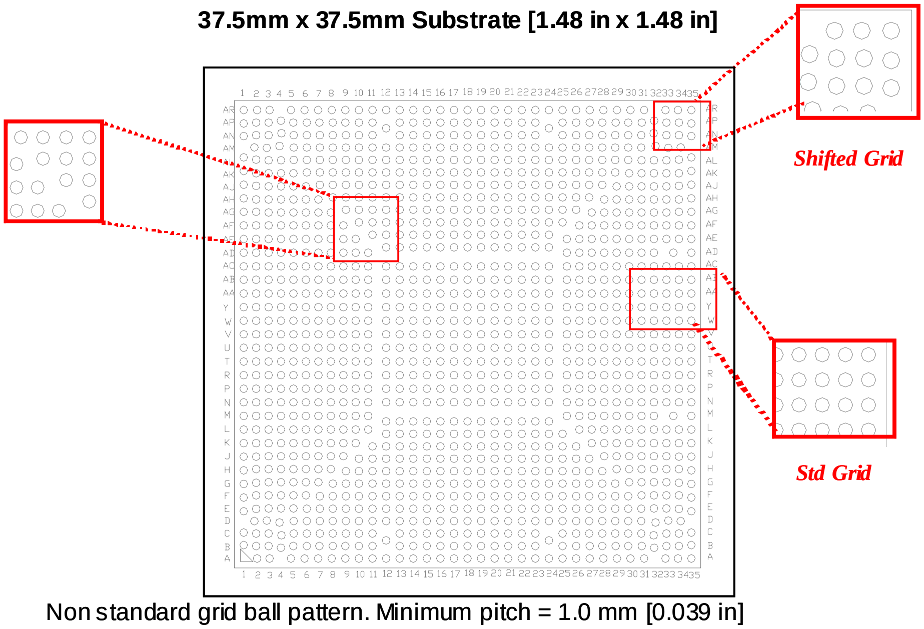
2.1 Package Description

The GMCH is available in a 37.5 mm [1.48 in] x 37.5 mm [1.48 in] Flip Chip Ball Grid Array (FC-BGA) package with 1210 solder balls. The die size is currently 12.29 mm [0.484 in] x 8.72 mm [0.343 in] and is subject to change. A mechanical drawing of the package is shown in Figure 6-1 (Appendix B: Mechanical Drawings).

2.1.1 Non-Grid Array Package Ball Placement

The GMCH package uses a “balls anywhere” concept. Minimum ball pitch is 1.0 mm [0.039 in], but ball ordering does not follow a 1 mm grid. Board designers should ensure correct ball placement when designing for the non-grid array pattern. For exact ball locations relative to the package, refer to the Grantsdale GMCH Ball Coordinates available within the *LGA775/Grantsdale/ICH6 Schematic and Layout Symbols*, Rev 1.1 archive through your Field Sales Representative.

Figure 2-1. GMCH Non-Grid Array



2.2 Thermal Specifications

To ensure proper operation and reliability of the GMCH, the temperature must be at or below the maximum value specified in Table 2-1. System and component level thermal enhancements are required to dissipate the heat generated and maintain the GMCH within specifications. Chapter 3 provides the thermal metrology guidelines for case temperature measurements.

The GMCH should also operate above the minimum case temperature specification listed in Table 2-1.

Table 2-1. GMCH Case Temperature Specifications

Parameter	Value
$T_{C\text{-MAX}}$	99 °C
$T_{C\text{-MIN}}$	0 °C

NOTE: Thermal specifications assume an attached heatsink is present.

2.3 Thermal Design Power (TDP)

Thermal design power (TDP) is the estimated power dissipation of the GMCH based on normal operating conditions including V_{CC} and $T_{C\text{-MAX}}$ while executing real worst-case power intensive applications. This value is based on expected worst-case data traffic patterns and usage of the chipset and does not represent a specific software application. TDP attempts to account for expected increases in power due to variation in chipset current consumption due to silicon process variation, processor speed, DRAM capacitive bus loading and temperature. However, since these variations are subject to change, the TDP cannot guarantee that all applications will not exceed the TDP value.

The system designer must design a thermal solution for the GMCH such that it maintains T_C below $T_{C\text{-MAX}}$ for a sustained power level equal to TDP. The TDP value can be used for thermal design if the chipset thermal protection mechanisms are enabled. Intel chipsets incorporate a hardware-based fail-safe mechanism to keep the product temperature in spec in the event of unusually strenuous usage above the TDP power.

2.3.1 Application Power

Designing to the TDP can ensure a particular thermal solution can meet the cooling needs of future applications. Testing with currently available commercial applications has shown they may dissipate power levels below the published TDP specification in Section 2.3.2. Intel strongly recommends that thermal engineers design to the published TDP specification to develop a robust thermal solution that will meet the needs of current and future applications.

2.3.2 Specifications

Assuming the GMCH is executing worst-case power-intensive applications, and is on the conservative end with respect to silicon process variation, the GMCH is estimated to dissipate the Thermal Design Power values provided in Table 2-2. The power value assumes the system is using two DIMMs of 400 MHz or 333 MHz dual channel DDR with a 533 MHz processor system bus speed. The graphics core is assumed to run at 333 MHz. FC -BGA packages have poor heat transfer capability into the board and have minimal thermal capability without thermal solutions. Intel requires that system designers plan for an attached heatsink when using the GMCH.

Table 2-2. GMCH Thermal Design Power Specifications

Parameter	System Bus Speed	Memory Frequency	TDP Value
TDP (DDR)	533 MHz	400 MHz or 333 MHz	16.3 W

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3 Thermal Metrology

The system designer must measure temperatures to accurately determine the thermal performance of the system. Intel has established guidelines for proper techniques of measuring chipset component case temperatures.

3.1 Case Temperature Measurements

To ensure functionality and reliability, the GMCH is specified for proper operation when T_C is maintained at or below the maximum temperature listed in Table 2-1. The surface temperature at the geometric center of the die corresponds to T_C. Measuring T_C requires special care to ensure an accurate temperature reading.

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, conduction through thermocouple leads, or contact between the thermocouple cement and the heatsink base (if a heatsink is used). To minimize these measurement errors a thermocouple attach with a zero-degree methodology is recommended.

Although the basic metrology is the same for a clip-attached heatsink and a Wave Solder Heatsink (WSHS), the removal and replacement of the WSHS requires additional guidelines for accurate thermal measurements. Refer to the WSHS rework procedure found in Section 4.3.2 for guidelines on installing a WSHS modified for a zero degree attach. Physical modifications to a WSHS are identical to modifications for a clip-attached heatsink. Sections 3.1.1 details the modifications required to measure package case temperature using both clip-attached heatsinks and WSHS.

Note: The rework procedure may not always produce a satisfactory bond line for the thermal interface material, and may therefore not give a performance as good as the initial installation of the heatsink in the factory. This could lead to reporting unexpected poor performance from the thermal test. In that case, rework procedure should be repeated again, making sure that enough load is applied to the heatsink during the soldering process.

3.1.1 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 3-2).
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 die using a 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 die** (see Figure 3-1).
6. Attach heatsink assembly to the GMCH, and route thermocouple wires out through the milled slot. For the Wave Solder Heatsink, refer to Section 4.3.2 for guidelines on proper heatsink removal and installation. Following the guidelines is critical to ensure an accurate and repeatable metrology.

Figure 3-1. 0° Angle Attach Methodology (top view, not to scale)

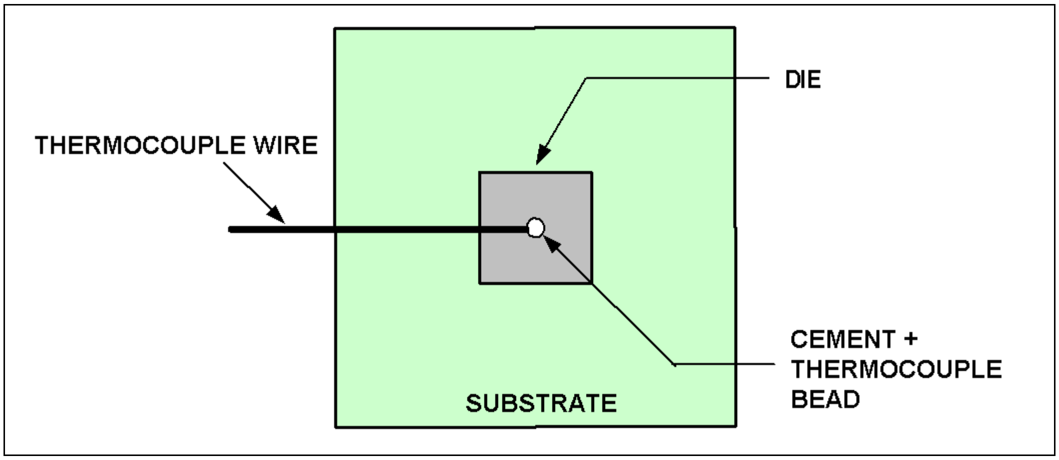
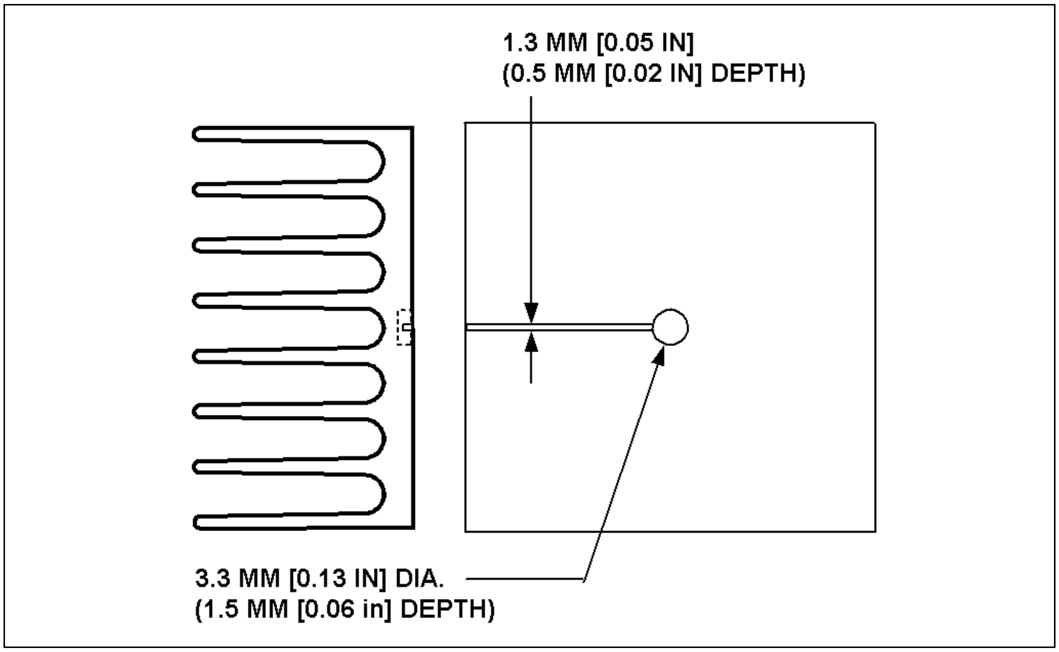


Figure 3-2. 0° Angle Attach Heatsink Modifications (generic heatsink shown, not to scale)



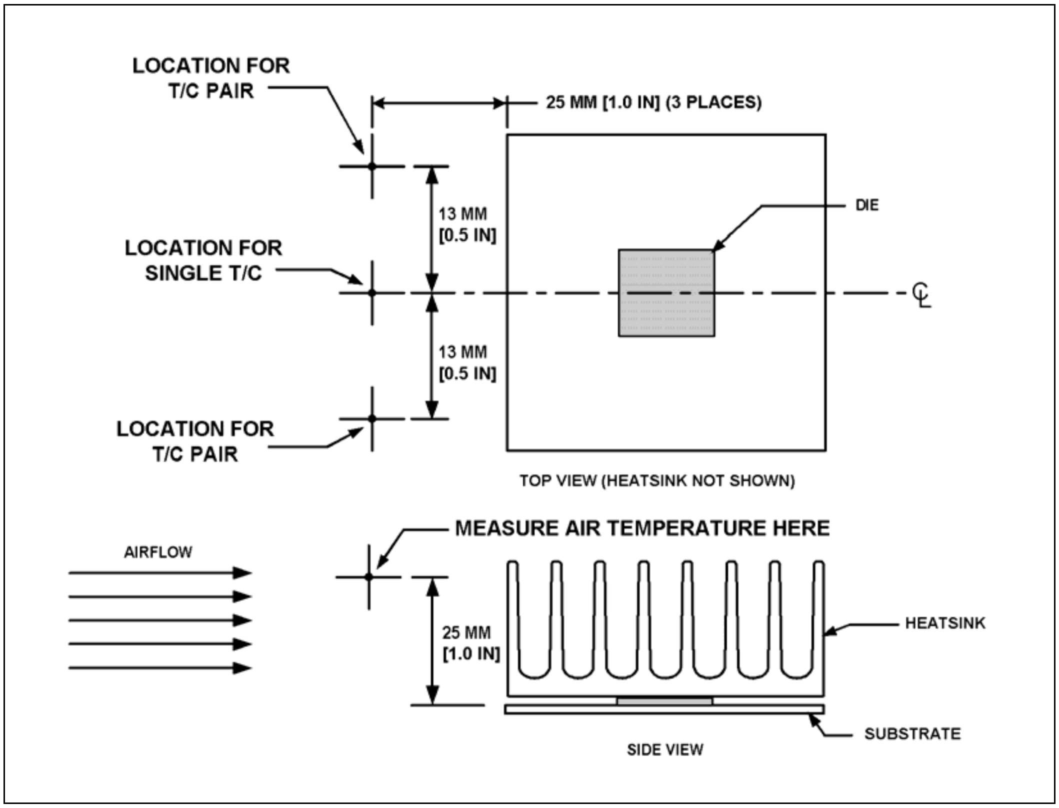
3.2 Thermal Mechanical Test Vehicle

A Thermal Mechanical Test Vehicle (TMTV) is available for thermal solution development. Contact your Intel Field Sales Representative for more information on the GMCH TMTV.

3.3 Airflow Characterization

Figure 3-3 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.

Figure 3-3. Airflow Temperature Measurement Locations



Airflow velocity should be measured using industry standard air velocity sensors. Typical airflow sensor technology may include hot wire anemometers. Figure 3-3 provides guidance for airflow velocity measurement locations. These locations are for a typical JEDEC test setup and may not be compatible with chassis layouts due to the proximity of the processor to the GMCH. 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.

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4 Reference Thermal Solution

The Wave Solder Heatsink (WSHS) is the reference component thermal solution for the GMCH. This chapter provides detailed information on operating environment assumptions, heatsink manufacturing, heatsink rework, and mechanical reliability requirements.

Intel recommends for those using Z-clip attach for the GMCH thermal solution on ATX/µATX motherboards to test and validate the solution in mechanical shock, and in test configuration and conditions representative of the usage conditions.

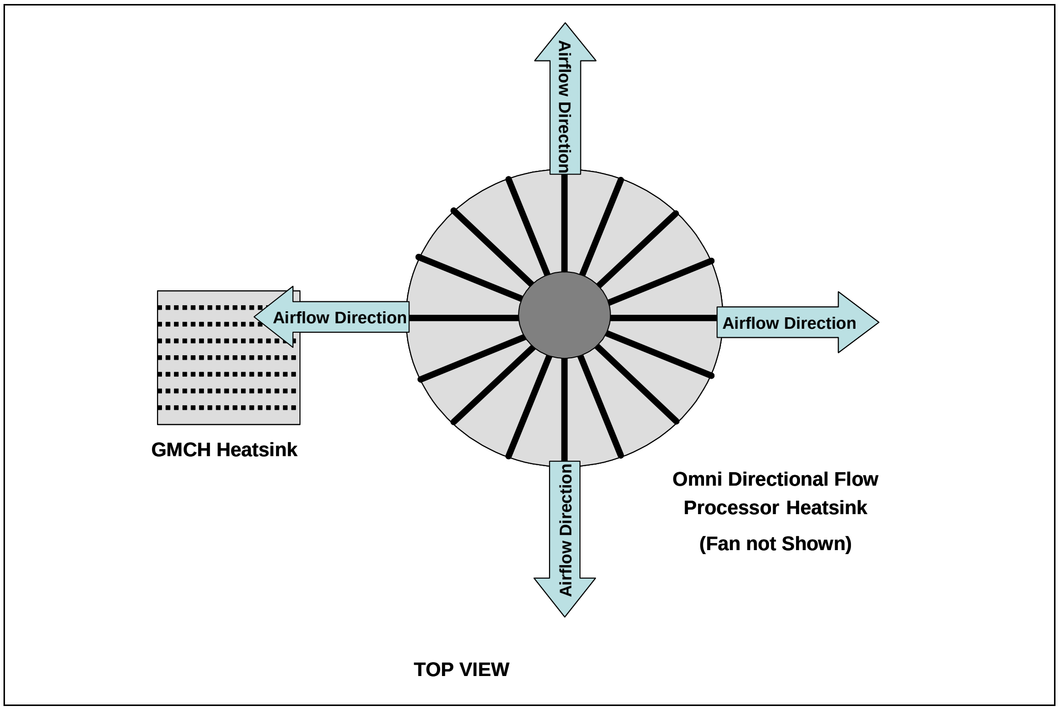
Note: The Intel BTX reference design enables a more robust set of load paths (as compared to ATX) through the use of the SRM. As a result, the BTX Reference design uses a Z-clip attach for the GMCH heatsink.

4.1 Operating Environment

An airflow speed of 0.76 m/s [150 lfm] is assumed to be present 25 mm [1 in] in front of the heatsink air inlet side of the attached reference thermal solution. The potential for increased airflow speeds may be realized by ensuring that airflow from the processor heatsink fan exhausts in the direction of the GMCH heatsink. This can be achieved by using a heatsink providing omni directional airflow (such as a radial fin or “X” pattern heatsink). Such a heatsink can deliver airflow to both the GMCH and other areas like the voltage regulator, as shown in Figure 4-1. In addition, GMCH board placement should ensure that the GMCH heatsink is within the air exhaust area of the processor heatsink.

Note that heatsink orientation alone does not guarantee that 0.76 m/s [150 lfm] airflow speed will be achieved. The system integrator should use analytical or experimental means to determine whether a system design provides adequate airflow speed for a particular GMCH heatsink.

Figure 4-1. Processor Heatsink Orientation to Provide Airflow to GMCH Heatsink



Other methods exist for providing airflow to the GMCH heatsink, including the use of system fans and/or ducting, or the use of an attached fan (active heatsink).

The local ambient air temperature, T_A, at the GMCH heatsink is assumed to be 47 °C. The thermal designer must carefully select the location to measure airflow to get a representative sampling. These environmental assumptions are based on a 35 °C system external temperature measured at sea level.

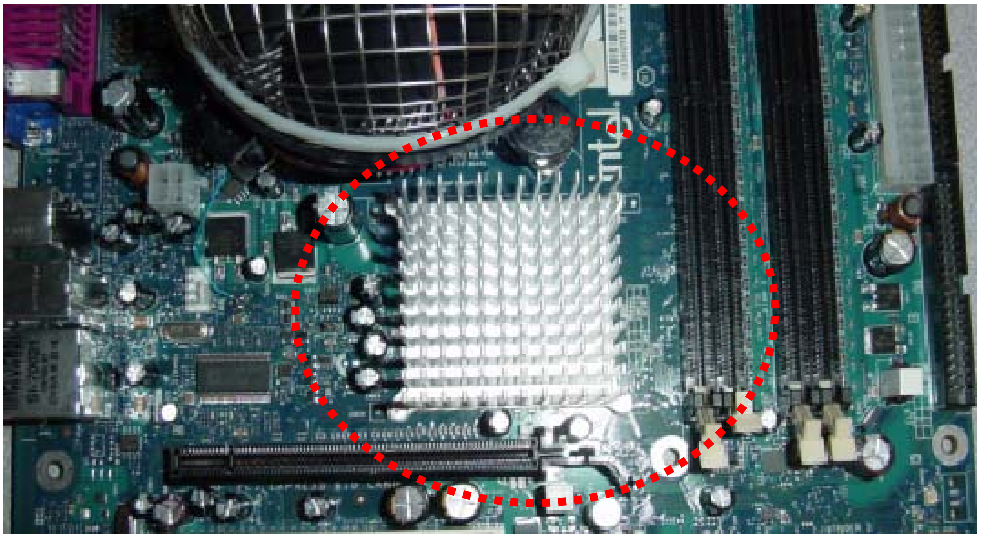
4.2 Mechanical Design Envelope

The motherboard component keep-out restrictions for the WSHS are included in Appendix B, Figure 6-2. The WSHS extends 35.1 mm [1.382 in] nominally above the board when mounted. System integrators should ensure no board or chassis components would intrude into the volume occupied by the WSHS.

4.3 Thermal Solution Assembly

The reference thermal solution will consist of a passively cooled Wave Solder Heatsink. The heatsink is comprised of an extruded aluminum heatsink with four mounting pins pressed into each corner of the heatsink base. A thermal interface material (Honeywell PCM45F*) is pre-applied to the heatsink bottom over an area in contact with the package die. The WSHS is shown in the installed configuration in Figure 4-2 (the GMCH cannot be seen in this view as it is hidden by the WSHS base).

Figure 4-2. Wave Solder Heatsink Installed on Board



4.3.1 Manufacturing with the WSHS

This section describes manufacturing related considerations for WSHS use in an HVM setting.

4.3.1.1 Assembly Process Settings

Table 4-1 provides recommended wave solder process settings for installation of the WSHS.

Table 4-1. Wave Solder Recommended Settings for WSHS

Process Factor	Value
Wave Solder Dwell Time	Minimum: 2.1 seconds Maximum: As required not to exceed 160 ºC topside temperature
Board Temperature Leaving the Last Pre-Heat Zone	105 ºC – 120 ºC
Solder	63 /37 % eutectic Sn-Pb
Solder Temperature	240 ºC
PCB Orientation through Wave	Normal (Processor socket on leading edge)
Pin Coating on WSHS Pins	90 / 10 % Sn-Pb

4.3.1.2 Inspection Criteria

After the WSHS is installed and exits the wave solder process, it should be visually inspected to ensure there are no gross tilt issues. Any gross tilt in the WSHS will impact the thermal performance of the heatsink. The recommended allowable observed tilt is approximately 0.50 mm [0.019 in] variation between pin gaps on opposite sides of the heatsink (~22 % difference in gap, nominal gap is 2.18 mm [0.086 in]). The pin gap is defined as the distance between the bottom of the heatsink base and the top of the motherboard. This amount of gap is easily detectable by trained inspectors. Gross tilt inspection results can allow for closer inspection and measurement of tilt.

To establish the initial wave solder process, a more detailed inspection may be used to confirm the process is robust and does not induce heatsink tilt. A detailed inspection may include the use of "feeler" gauges to measure the pin gap more precisely and assess the presence of heatsink tilt. The recommended allowable tilt can be used as criteria for determining the success of the wave solder process. Once a successful wave solder process is in place, the manufacturer may choose to use visual gross tilt inspection in an HVM setting.

4.3.2 WSHS Removal and Installation Procedure

Two methods exist for WSHS removal, lead clipping or de-soldering. Re-installation of the heatsink for rework or metrology purposes includes a single method.

4.3.2.1 Removal via Lead Clipping Methodology

Recommended equipment list

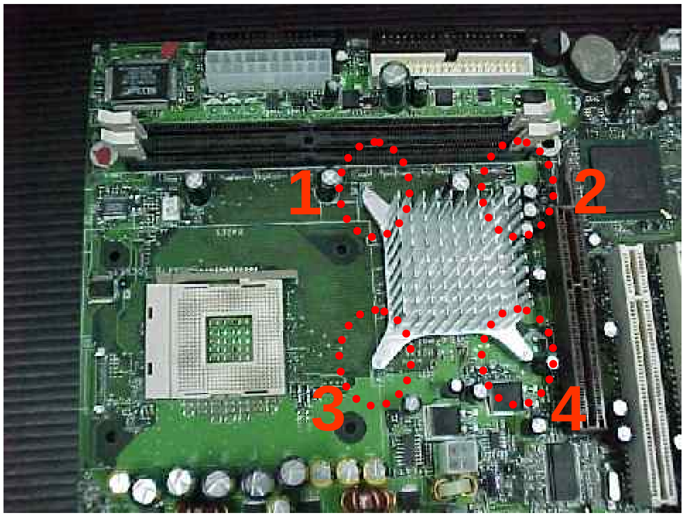
- 55-degree angle clippers (Figure 4-3)
- Solder wicking kit

Figure 4-3. 55-Degree Angle Clippers

Removal procedure

1. Remove processor heatsink retention mechanism.
2. Cut the WSHS leads using the 55-degree angle clippers. To reduce potential of damaging board and components, cut the leads in the order shown in Figure 4-4.
3. Flip the board over and remove the leads, using tweezers and a soldering iron with a STTC 137 tip.
4. Apply flux and remove any residual solder from each hole.
5. Inspect the board and ensure all holes are clean and completely free of solder. Make sure none of the adjacent components were damaged during the removal process.

Figure 4-4. WSHS Lead Clipping Order (Heatsink Shown Is Not GMCH WSHS)

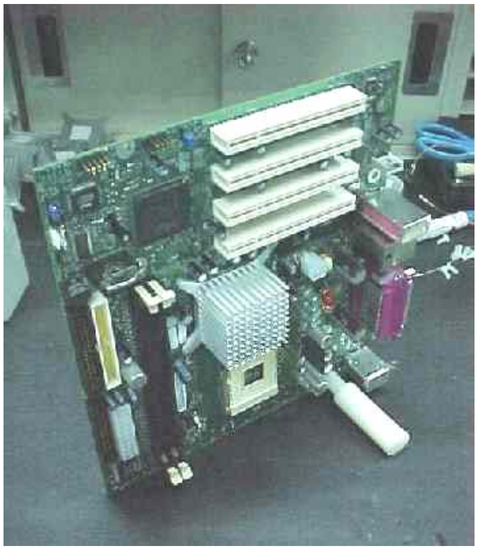


4.3.2.2 Removal via De-Soldering Methodology

Recommended equipment list

- De-soldering gun
- Solder wicking kit
- Vertical rework jig (Figure 4-5)

Figure 4-5. Example Vertical Rework Jig (Heatsink Shown Is Not GMCH WSHS)



Removal procedure

1. Remove processor heatsink retention mechanism.
2. De-solder the WSHS leads using a SMTC 104 tip. Use a small amount of solder to prime the tip if necessary.
3. Stand the board vertically using jig (Figure 4-5).
4. Use a soldering iron with an STTC 137 tip to loosen WSHS pins and remove the heatsink. Gently wiggle each lead loose while applying heat to lead.
5. Apply flux and remove any residual solder from each hole.
6. Inspect the board and ensure all holes are clean and completely free of solder. Make sure none of the adjacent components were damaged during the removal process.

4.3.2.3 Re-Installation Methodology

Recommended equipment

- WSHS rework target
- SMT rework tool such as an SRT 1000 or 1100

Installation procedure

1. Insert WSHS into board. Avoid scratching the board as the pins are placed into the mounting holes.
2. Ensure the WSHS “floats” on top of the GMCH. The WSHS should move freely. If it does not “float”, remove any residual solder that may be in the mounting holes.
3. Place the WSHS target on top of the WSHS fins.
4. Use the SMT rework tool to melt the TIM. Use 145 grams placement force and set the bottom temperature as required to heat the TIM to 50-90°C. For the SRT, a bottom heater setting of 220 °C for 90 seconds achieves the desired TIM temperature.
5. Cool the board to room temperature.
6. Stand the board vertically using jig.
7. Solder the WSHS leads using a soldering iron with a STTC 137 tip.

Figure 4-6. WSHS Target (Heatsink Shown Is Not GMCH WSHS)

4.4 Environmental Reliability Requirements

The environmental reliability requirements for the reference thermal solution are shown in Table 4-2. These should be considered as general guidelines. Validation test plans should be defined by the user based on anticipated use conditions and resulting reliability requirements..

Table 4-2. 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, 4.3 m/s [170 in/s] minimum velocity change. • Setup: Mount sample board on test fixture. Include 450 g processor heatsink.	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, 740 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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5 Appendix A: Enabled Suppliers

Enabled suppliers for the GMCH WSHS reference thermal solution are listed in Table 5-1.

Table 5-1. GMCH Intel Reference Wave Solder Heatsink Enabled Suppliers

Supplier	Intel Part Number	Vendor Part Number	Contact Information
CCI* (Chaun-Choung Technology Corp.)	C44993-001	00C860401A	Taiwan: Monica Chi Email: monica_chih@ccic.com.tw Tel: +886 - 2 2-995-2666 Ext 131 USA: Harry Lin Email: HLINACK@aol.com Tel: (714) 739-5797
Foxconn*	C44993-001	2Z802-008	USA: Jack Chen, PH.D Email: rongchechen@foxconn.com Tel: (714) 626-1233
AVC* (ASIA Vital Components Co., Ltd.)	C44993-001	S909600002	Taiwan: David Chao Email: david_chao@avc.com.tw Tel: +886-2-22996930 Ext 619

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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6 Appendix B: Mechanical Drawings

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

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Figure 6-1. GMCH Package Drawing

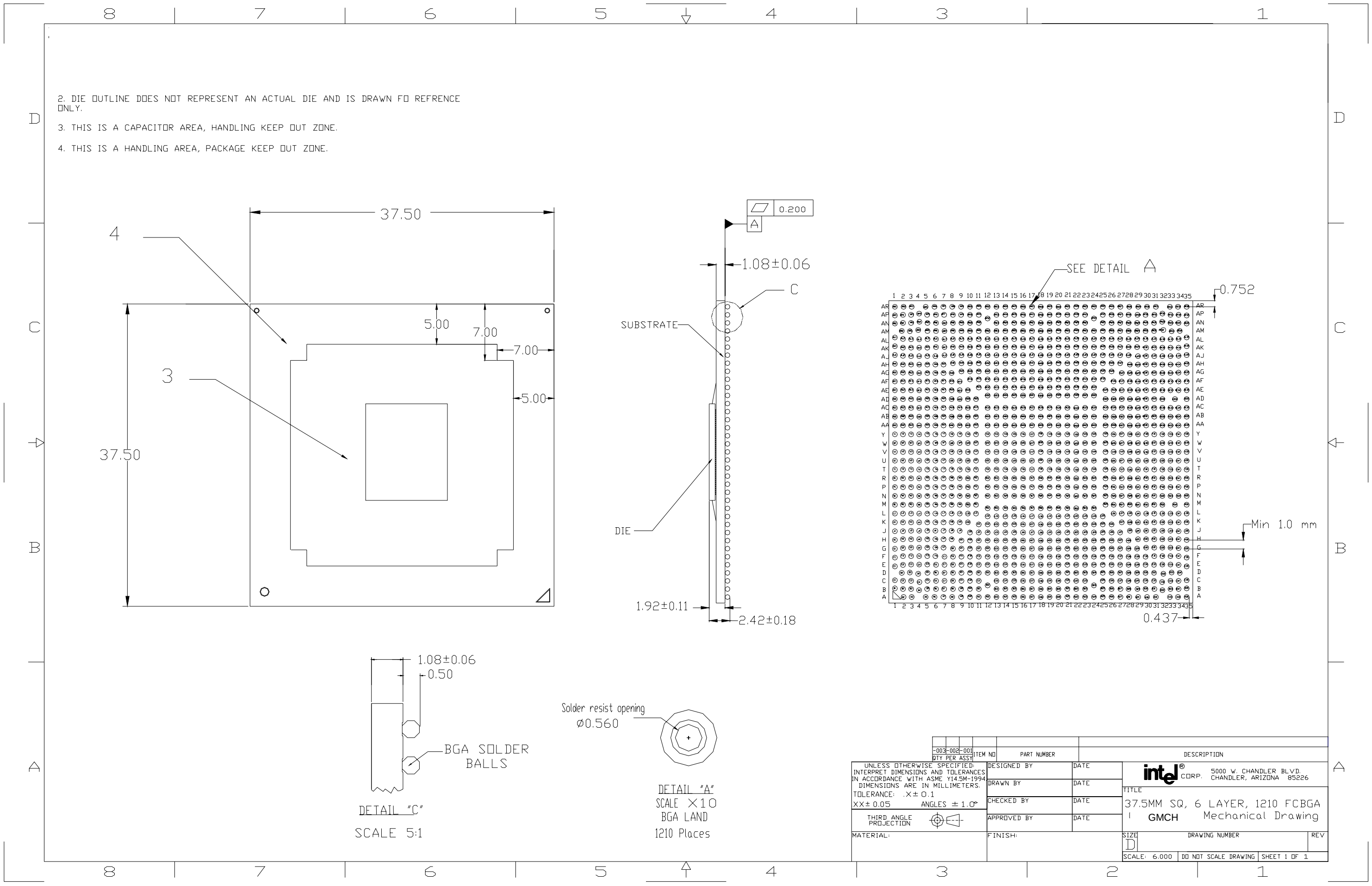


Figure 6-2. GMCH Component Keep-Out Restrictions

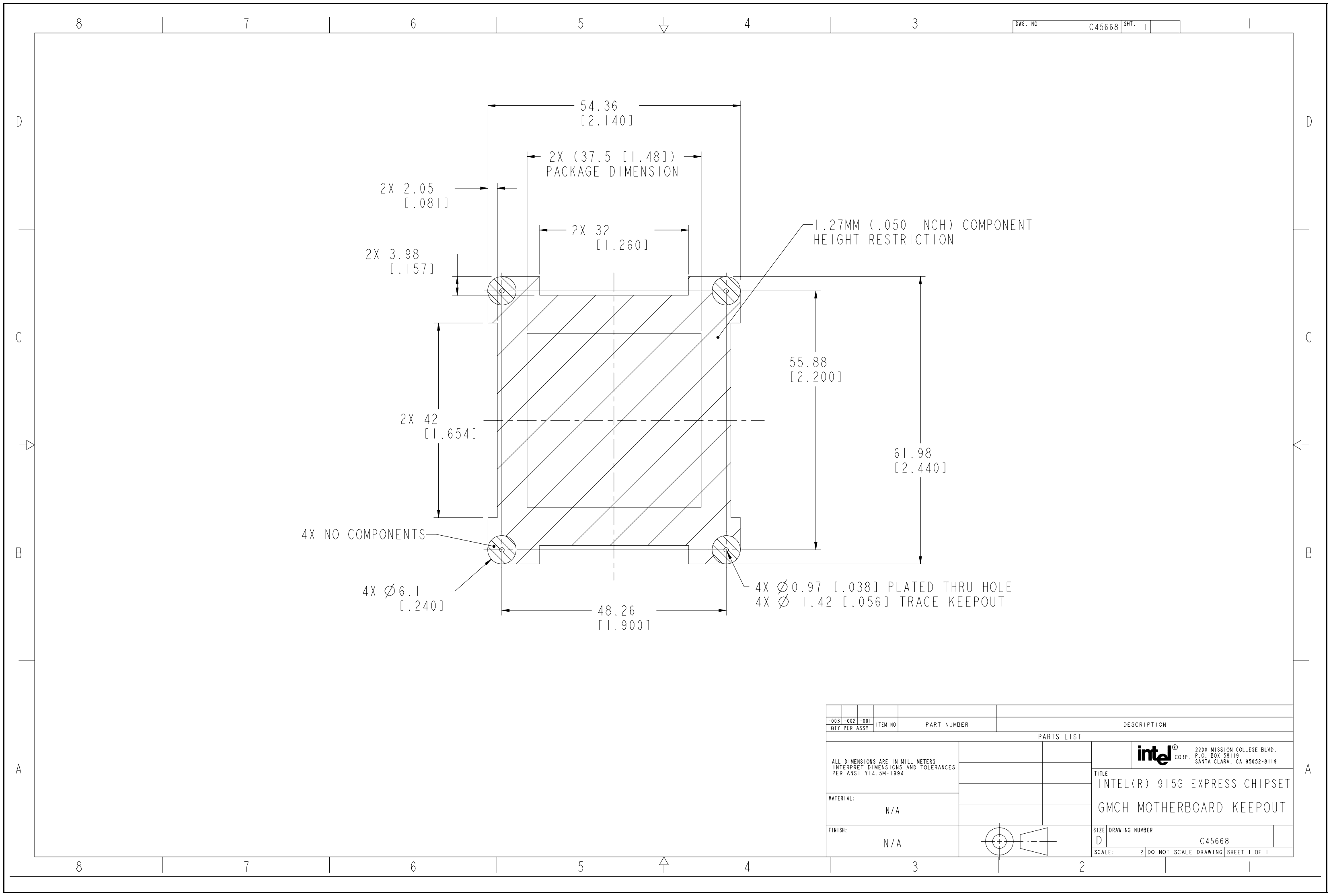


Figure 6-3. GMCH Reference Wave Solder Heatsink - 1

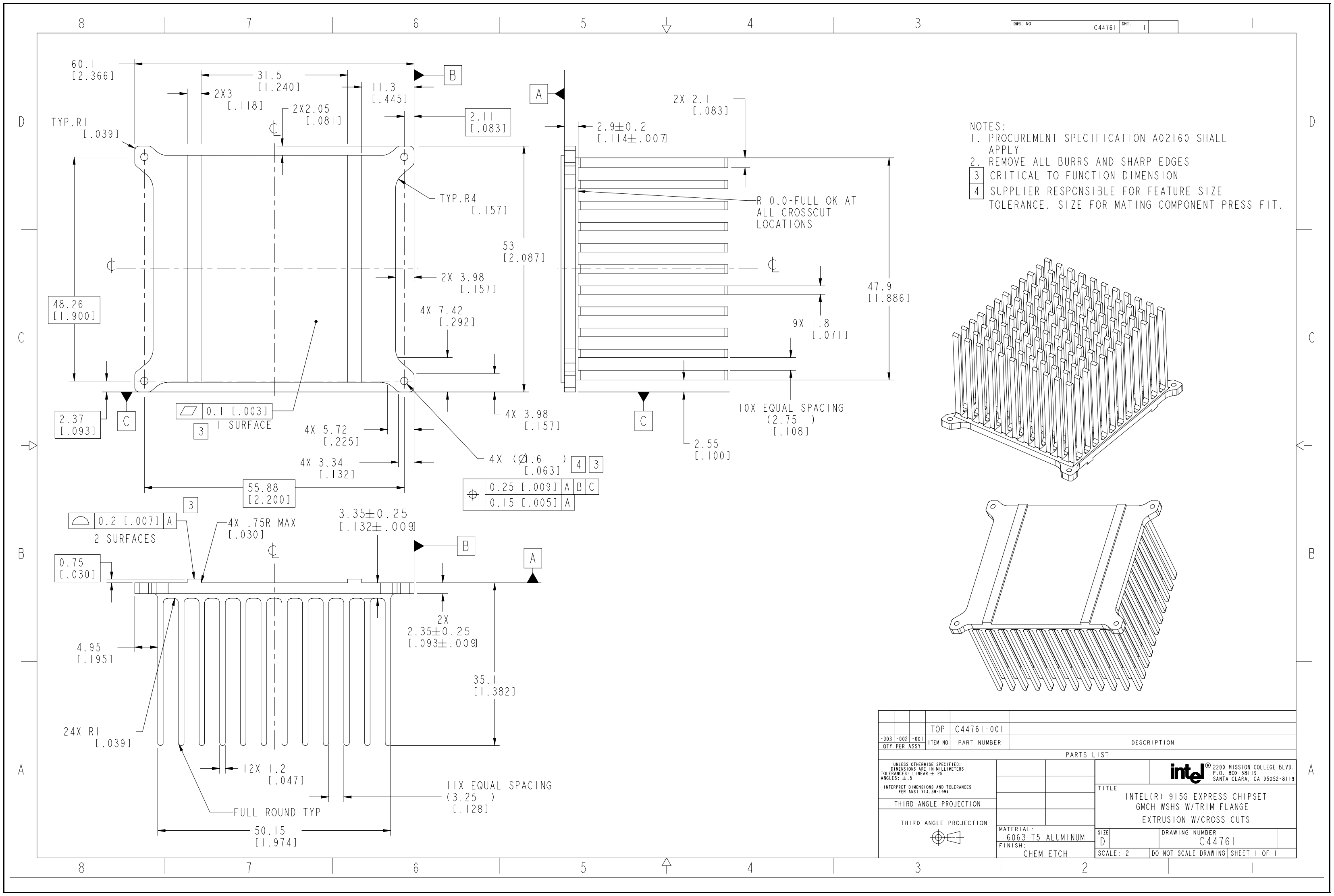
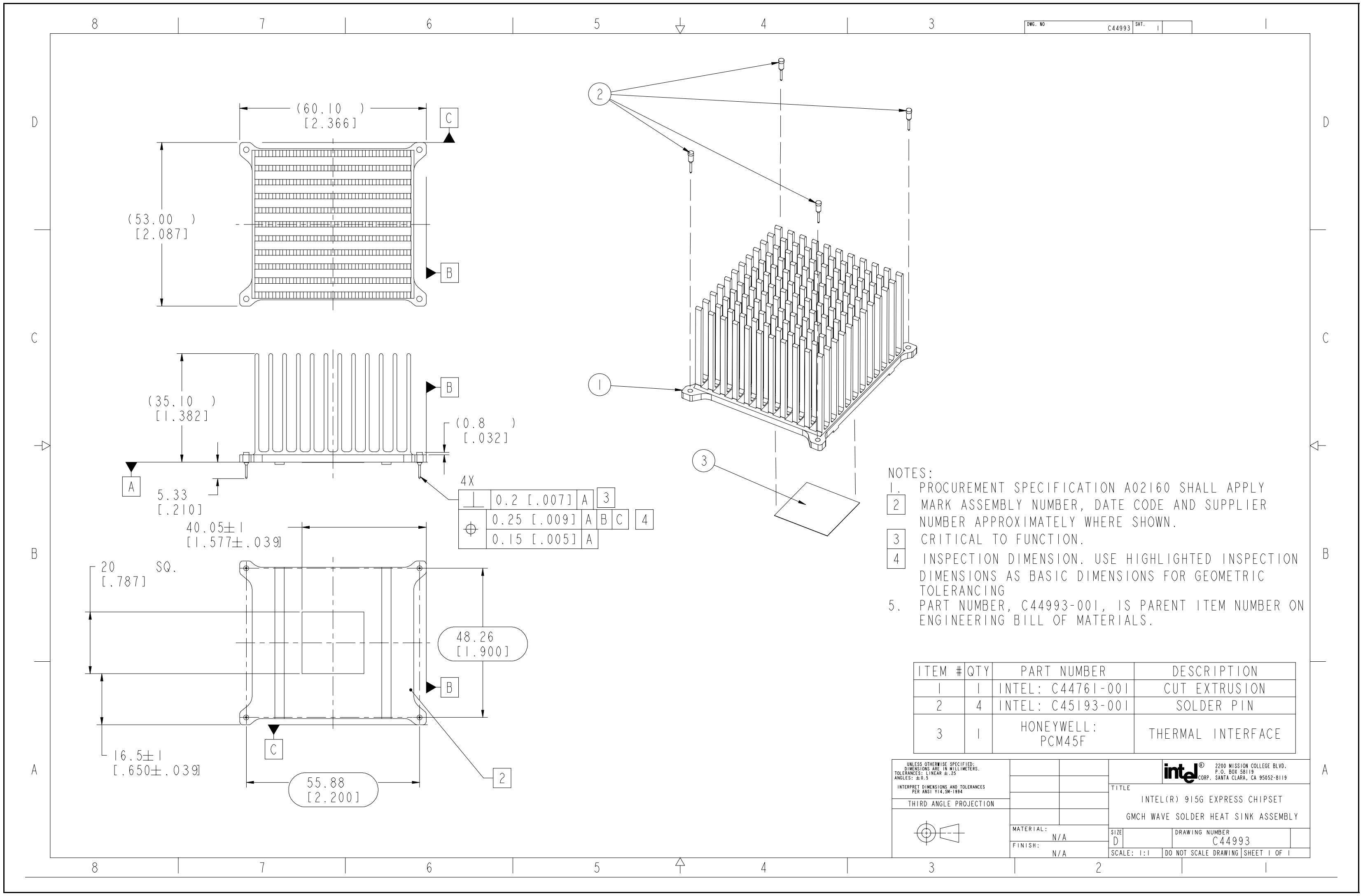


Figure 6-4. GMCH Reference Wave Solder Heatsink - 2



NOTES:
1. PROCUREMENT SPECIFICATION A02160 SHALL APPLY
2 MARK ASSEMBLY NUMBER, DATE CODE AND SUPPLIER NUMBER APPROXIMATELY WHERE SHOWN.
3 CRITICAL TO FUNCTION.
4 INSPECTION DIMENSION. USE HIGHLIGHTED INSPECTION DIMENSIONS AS BASIC DIMENSIONS FOR GEOMETRIC TOLERANCING
5. PART NUMBER, C44993-001, IS PARENT ITEM NUMBER ON ENGINEERING BILL OF MATERIALS.

ITEM #	QTY	PART NUMBER	DESCRIPTION
1	1	INTEL: C44761-001	CUT EXTRUSION
2	4	INTEL: C45193-001	SOLDER PIN
3	1	HONEYWELL: PCM45F	THERMAL INTERFACE

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS.
TOLERANCES: LINEAR ±.25
ANGLES: ±0.5
INTERPRET DIMENSIONS AND TOLERANCES PER ANSI Y14.5M-1994
THIRD ANGLE PROJECTION

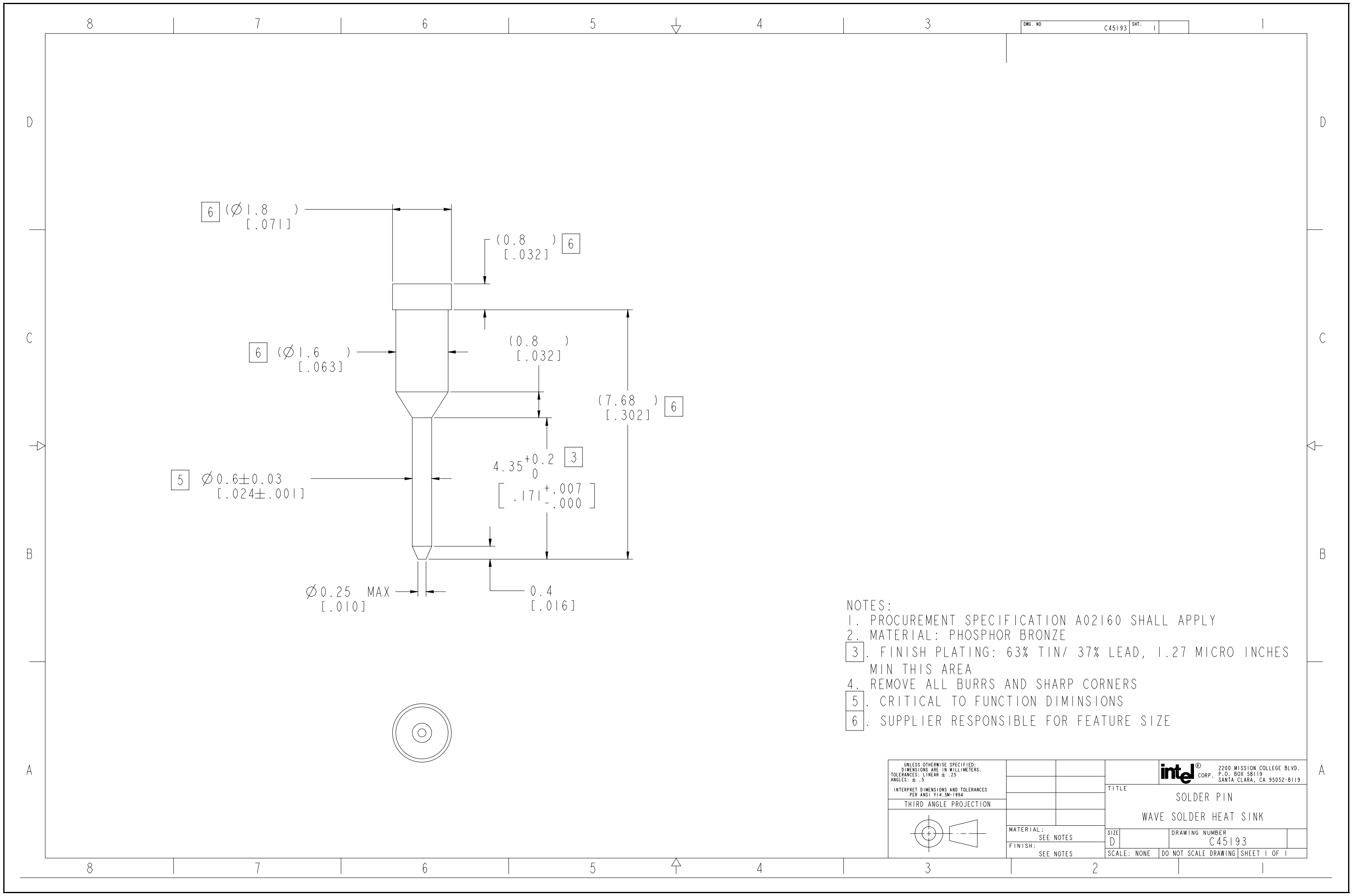
MATERIAL: N/A
FINISH: N/A

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

TITLE
INTEL(R) 915G EXPRESS CHIPSET
GMCH WAVE SOLDER HEAT SINK ASSEMBLY

SIZE D
DRAWING NUMBER C44993
SCALE: 1:1
DO NOT SCALE DRAWING
SHEET 1 OF 1

Figure 6-5. GMCH Reference Wave Solder Heatsink - 3



NOTES:
1. PROCUREMENT SPECIFICATION A02160 SHALL APPLY
2. MATERIAL: PHOSPHOR BRONZE
3. FINISH PLATING: 63% TIN/ 37% LEAD, 1.27 MICRO INCHES MIN THIS AREA
4. REMOVE ALL BURRS AND SHARP CORNERS
5. CRITICAL TO FUNCTION DIMINSIONS
6. SUPPLIER RESPONSIBLE FOR FEATURE SIZE