Intel® 955X Express Chipset

Thermal/Mechanical Design Guide

– For the Intel® 82955X Memory Controller Hub (MCH)

April 2005

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Revision History

Revision Number	Description	Revision Date
-001	• Initial Release.	April 2005

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1 Introduction

As the complexity of computer systems increases, so do the power dissipation requirements. Care must be taken to ensure that the additional power is properly dissipated. Typical methods to improve heat dissipation include selective use of ducting, and/or passive heatsinks.

The goals of this document are to:

- Outline the thermal and mechanical operating limits and specifications for the Intel® 82955X Express Chipset Memory Controller Hub (MCH).
- Describe a reference thermal solution that meets the specification of the 82955X MCH.

Properly designed thermal solutions provide adequate cooling to maintain the MCH die temperatures at or below thermal specifications. This is accomplished by providing a low local-ambient temperature, ensuring adequate local airflow, and minimizing the die to local-ambient thermal resistance. By maintaining the MCH die temperature at or below the specified limits, a system designer can ensure the proper functionality, performance, and reliability of the chipset. Operation outside the functional limits can degrade system performance and may cause permanent changes in the operating characteristics of the component.

The simplest and most cost effective method to improve the inherent system cooling characteristics 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 addresses thermal design and specifications for the 82955X MCH component only. For thermal design information on other chipset components, refer to the respective component datasheet. For the ICH7, refer to the *Intel® I/O Controller Hub 7 (ICH7) Thermal Design Guidelines*.

Note: Unless otherwise specified, the term MCH refers to the Intel® 82955X Express chipset MCH.

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1.1 Definition of Terms

Term	Description
BGA	Ball grid array. A package type, defined by a resin-fiber substrate, onto which a die is mounted, bonded and encapsulated in molding compound. The primary electrical interface is an array of solder balls attached to the substrate opposite the die and molding compound.
BLT	Bond line thickness. Final settled thickness of the thermal interface material after installation of heatsink.
ICH7	I/O Controller Hub. Seventh generation I/O Controller Hub component that contains additional functionality compared to previous ICH components. The I/O Controller Hub component that contains the primary PCI interface, LPC interface, USB2, ATA-100, and other I/O functions. It communicates with the MCH over a proprietary interconnect called DMI.
MCH	Memory Controller Hub. The chipset component that contains the processor interface, the memory interface, and the DMI.
T_{case_max}	Maximum die temperature allowed. This temperature is measured at the geometric center of the top of the package die.
T_{case_min}	Minimum die temperature allowed. This temperature is measured at the geometric center of the top of the package die.
TDP	Thermal design power. Thermal solutions should be designed to dissipate this target power level. TDP is not the maximum power that the chipset can dissipate.

1.2 Reference Documents

The reader of this specification should also be familiar with material and concepts presented in the following documents:

Document Title	Document Number / Location
Intel® I/O Controller Hub 7 (ICH7) Thermal Design Guidelines	http://developer.intel.com//design/chipsets/designex/307015.htm
Intel® I/O Controller Hub 7 (ICH7) Datasheet	http://developer.intel.com//design/chipsets/datashts/307013.htm
Intel® 955X Express Chipset Datasheet	http://developer.intel.com/design/chipsets/datashts/306828.htm
BGA/OLGA Assembly Development Guide	Contact your Intel Field Sales Representative
Various system thermal design suggestions	http://www.formfactors.org

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2 Packaging Technology

The 955X Express chipset consists of two individual components: the MCH and the ICH7. The MCH component uses a 34 mm squared, 6-layer flip chip ball grid array (FC-BGA) package (see Figure 2-1 through Figure 2-3). For information on the ICH7 package, refer to the *Intel® I/O Controller Hub 7 (ICH7) Thermal Design Guidelines.*

Figure 2-1. MCH Package Dimensions (Top View)

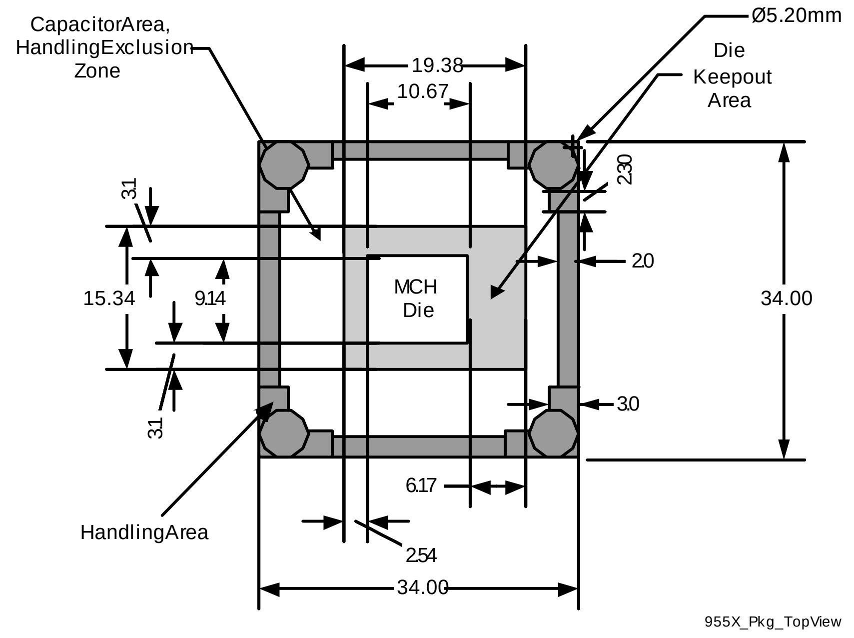
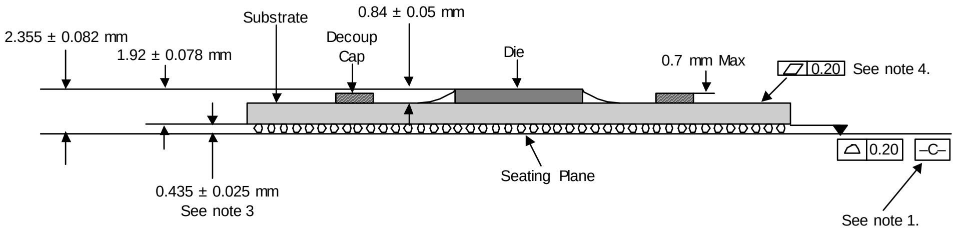


Figure 2-2. MCH Package Dimensions (Side View)



Notes:
1. Primary datum -C- and seating plan are defined by the spherical crowns of the solder balls (shown before motherboard attach)
2. All dimensions and tolerances conform to ANSI Y14.5M-1994
3. BGA has a pre-SMT height of 0.5mm and post-SMT height of 0.41-0.46mm
4. Shown before motherboard attach; FCBGA has a convex (dome shaped) orientation before reflow and is expected to have a slightly concave (bowl shaped) orientation after reflow

955X_Pkg_SideView

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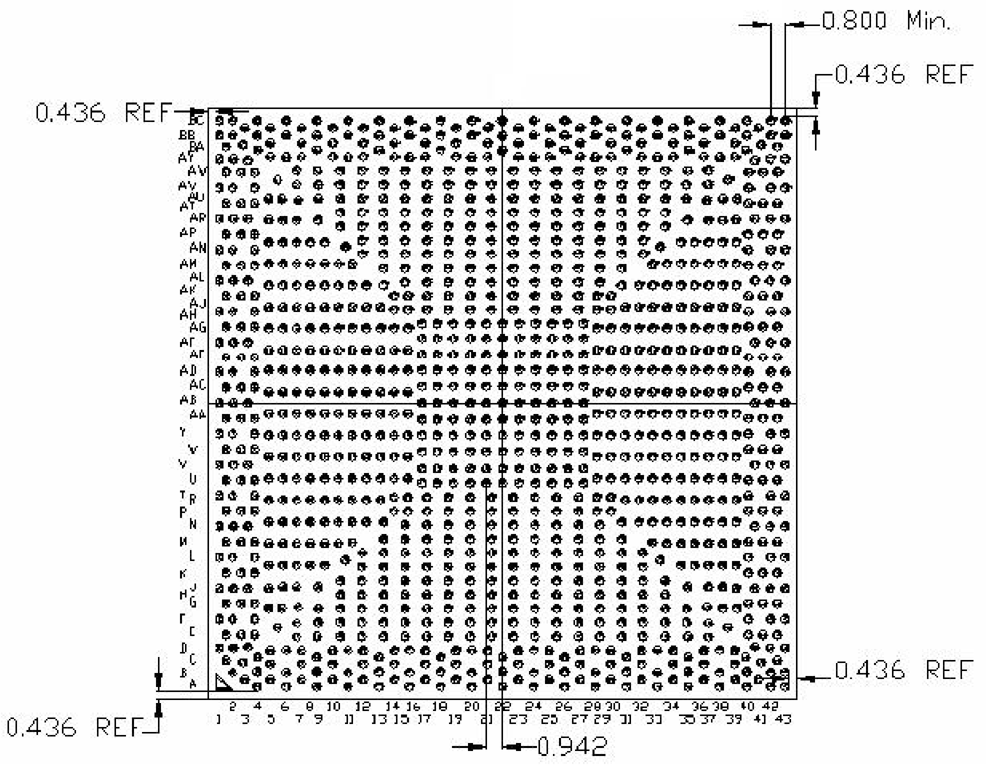
Figure 2-3. MCH Package Dimensions (Bottom View)



NOTES:

1. All dimensions are in millimeters.
2. All dimensions and tolerances conform to ANSI Y14.5M-1994.

2.1 Package Mechanical Requirements

The MCH package has an exposed bare die that is capable of sustaining a maximum static normal load of 10-lbf. The package is NOT capable of sustaining a dynamic or static compressive load applied to any edge of the bare die. These mechanical load limits must not be exceeded during heatsink installation, mechanical stress testing, standard shipping conditions and/or any other use condition.

Note:

1. The heatsink attach solutions must not result in continuous stress onto the chipset package with the exception of a uniform load to maintain the heatsink-to-package thermal interface.
2. These specifications apply to uniform compressive loading in a direction perpendicular to the bare die top surface.
3. These specifications are based on limited testing for design characterization. Loading limits are for the package only.

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3 Thermal Specifications

3.1 Thermal Design Power (TDP)

Analysis indicates that real applications are unlikely to cause the chipset MCH to consume maximum power dissipation for sustained time periods. Therefore, to arrive at a more realistic power level for thermal design purposes, Intel characterizes power consumption based on known platform benchmark applications. The resulting power consumption is referred to as the Thermal Design Power (TDP). TDP is the target power level that the thermal solutions should be designed to. TDP is not the maximum power that the chipset can dissipate.

For TDP specifications, see Table 3-1 for the 955X Express chipset MCH. FC-BGA packages have limited heat transfer capability into the board and have minimal thermal capability without a thermal solution. Intel recommends that system designers plan for one or more heatsinks when using the 955X Express chipset.

3.2 Die Case Temperature Specifications

To ensure proper operation and reliability of the MCH, the die temperatures must be at or between the maximum/minimum operating range as specified in Table 3-1 for the 82955X MCH. System and/or component level thermal solutions are required to maintain these temperature specifications. Refer to Chapter 5 for guidelines on accurately measuring package die temperatures.

Table 3-1. MCH Thermal Specifications

Parameter	Value	Notes
T_{case_max}	105 °C	—
T_{case_min}	5 °C	—
$TDP_{dual\ channel}$	13.5 W	DDR2-667

NOTE: These specifications are based on silicon characterization; however, they may be updated as further data becomes available.

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4 Thermal Simulation

Intel provides thermal simulation models of the 955X Express chipset MCH and associated user's guides to aid system designers in simulating, analyzing, and optimizing their thermal solutions in an integrated, system-level environment. The models are for use with the commercially available Computational Fluid Dynamics (CFD)-based thermal analysis tool “FLOTHERM”* (version 5.1 or higher) by Flomerics, Inc. Contact your Intel field sales representative to order the thermal models and user's guides.

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5 Thermal Metrology

The system designer must make temperature measurements to accurately determine the thermal performance of the system. Intel has established guidelines for proper techniques to measure the MCH die temperatures. Section 5.1 provides guidelines on how to accurately measure the MCH die temperatures. The flowchart in Figure 5-1 offers useful guidelines for thermal performance and evaluation.

5.1 Die Case Temperature Measurements

To ensure functionality and reliability, the T_{case} of the MCH must be maintained at or between the maximum/minimum operating range of the temperature specification as noted in Table 3-1. . The surface temperature at the geometric center of the die corresponds to T_{case}. Measuring T_{case} 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 errors 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, and/or contact between the thermocouple cement and the heatsink base (if a heatsink is used). For maximum measurement accuracy, only the 0° thermocouple attach approach is recommended.

5.1.1 Zero Degree Angle Attach Methodology

1. Mill a 3.3 mm (0.13 in.) diameter and 1.5 mm (0.06 in.) deep hole centered on the bottom of the heatsink base.
2. Mill a 1.3 mm (0.05 in.) wide and 0.5 mm (0.02 in.) deep slot from the centered hole to one edge of the heatsink. The slot should be parallel to the heatsink fins (see Figure 5-2).
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, ensure 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 5-3).
6. Attach heatsink assembly to the MCH and route thermocouple wires out through the milled slot.

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Figure 5-1. Thermal Solution Decision Flowchart

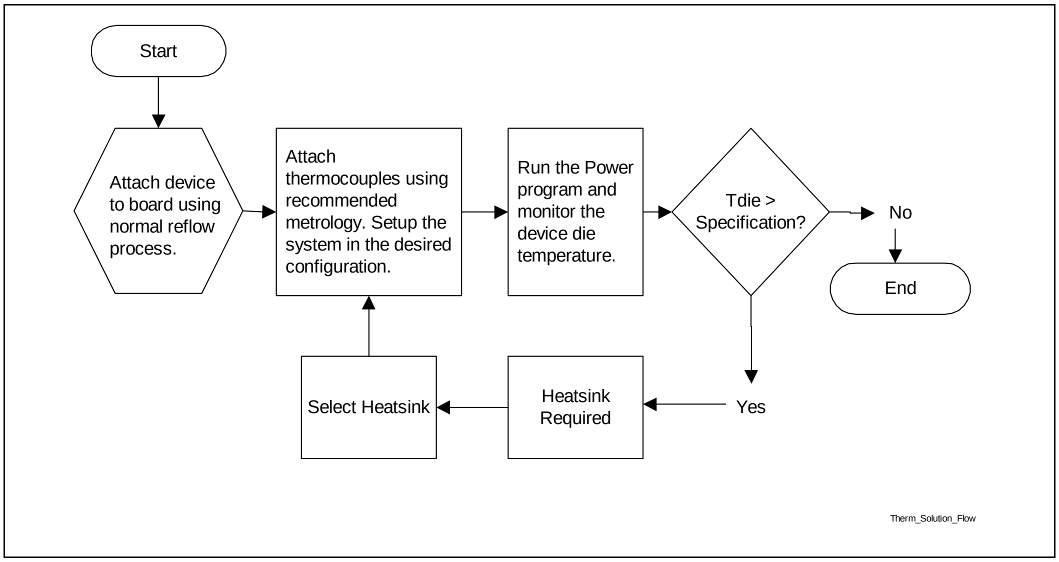


Figure 5-2. Zero Degree Angle Attach Methodology

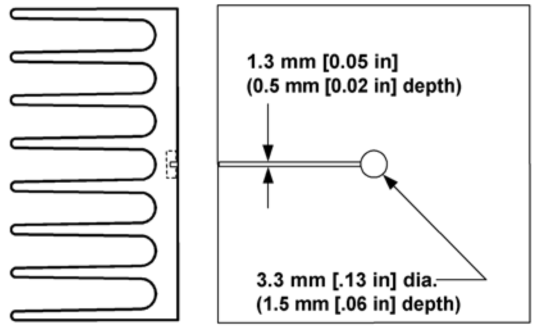
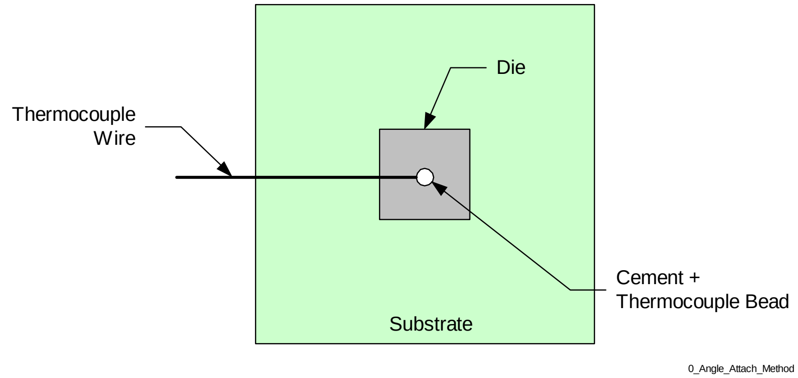


Figure 5-3. Zero Degree Angle Attach Methodology (Top View)



NOTE: Not to scale.

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6 Reference Thermal Solution

Intel has developed a reference thermal solution designed to meet the cooling needs of the MCH under operating environments and specifications defined in this document. This chapter describes the overall requirements for the Plastic Wave Soldering Heatsink (PWSH) reference thermal solution including critical-to-function dimensions, operating environment, and validation criteria. Other chipset components may or may not need attached thermal solutions, depending on your specific system local-ambient operating conditions. For information on the ICH7, refer to thermal specification in the *Intel® I/O Controller Hub 7 (ICH7) Thermal Design Guidelines*.

6.1 Operating Environment

The reference thermal solution was designed assuming a maximum local-ambient temperature of 55 °C. The minimum recommended airflow velocity through the cross section of the heatsink fins is 350 linear feet per minute (lfm). The approaching airflow temperature is assumed to be equal to the local-ambient temperature. The thermal designer must carefully select the location to measure airflow to obtain an accurate estimate. These local-ambient conditions are based on a 35 °C external-ambient temperature at sea level. (External-ambient refers to the environment external to the system.)

6.2 Heatsink Performance

Figure 6-1 depicts the measured thermal performance of the reference thermal solution versus approach air velocity. Since this data was measured at sea level, a correction factor would be required to estimate thermal performance at other altitudes.

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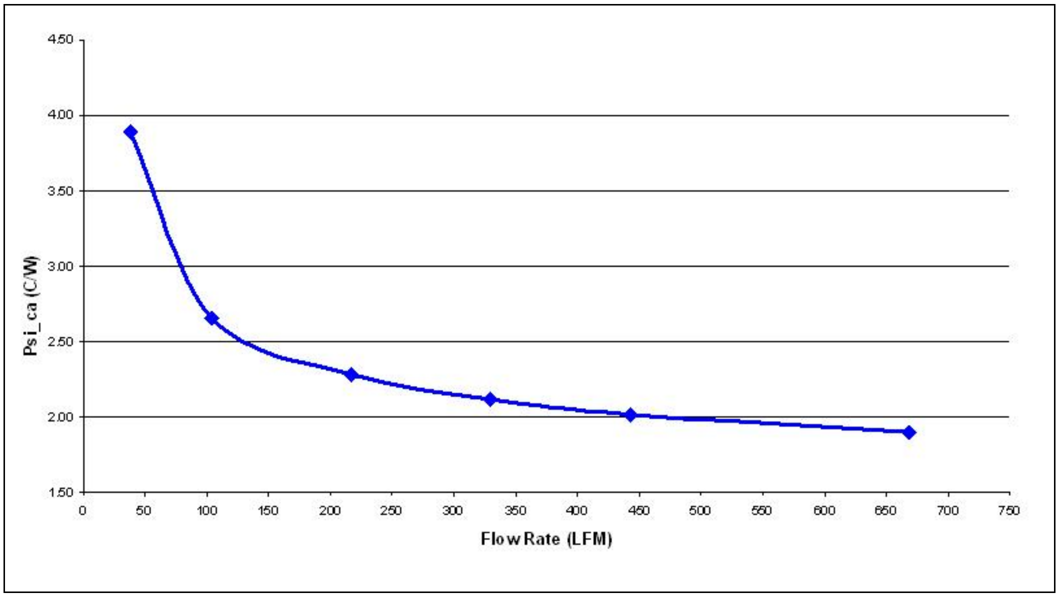
Figure 6-1. Reference Heatsink Measured Thermal Performance versus Approach Velocity



6.3 Mechanical Design Envelope

While each design may have unique mechanical volume and height restrictions or implementation requirements, the height, width, and depth constraints typically placed on the MCH thermal solution are shown in Figure 6-2.

When using heatsinks that extend beyond the MCH reference heatsink envelope shown in Figure 6-2, any motherboard components placed between the heatsink and motherboard cannot exceed 2.2 mm (0.087 in.) in height.

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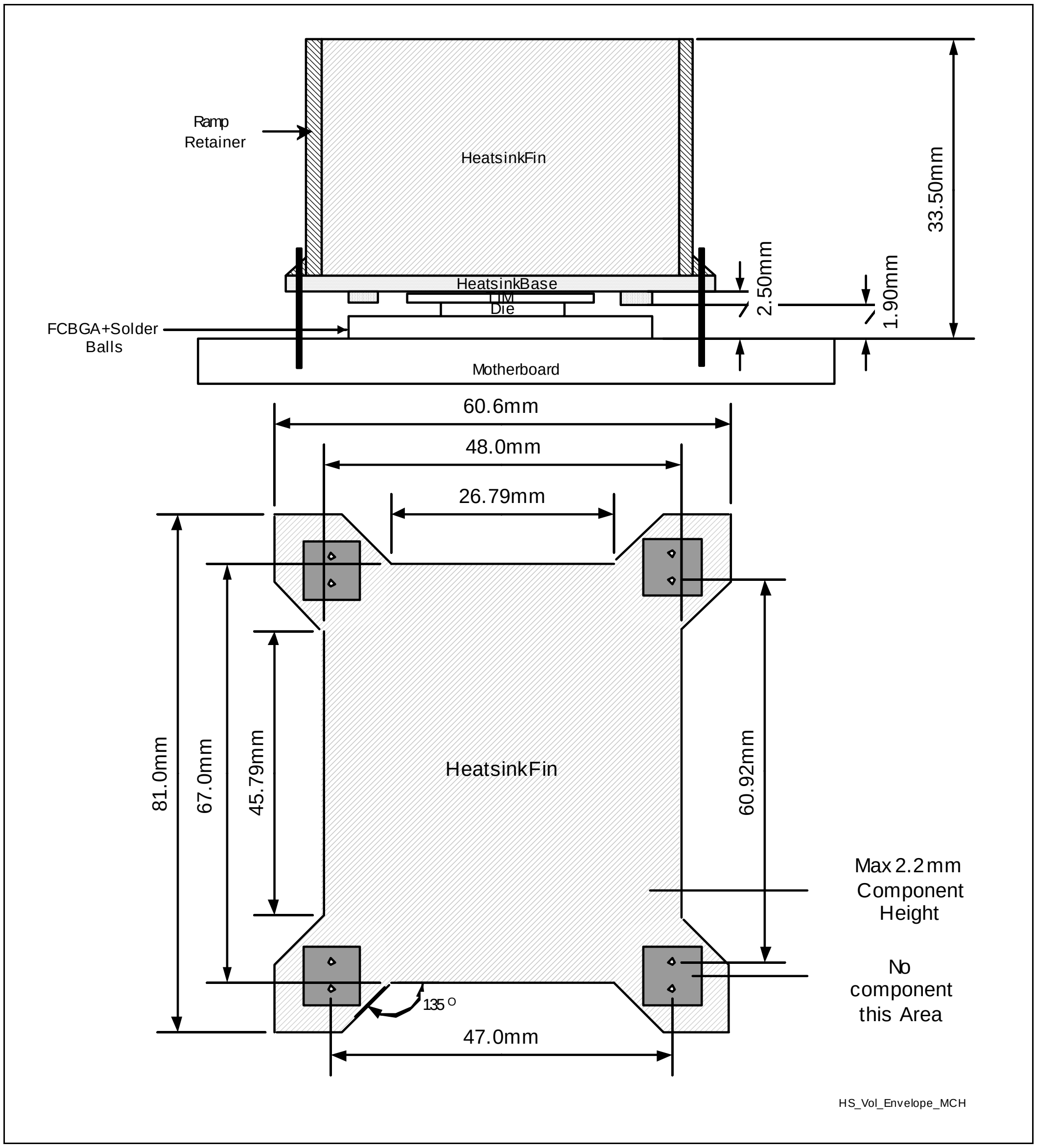
Figure 6-2. Heatsink Volumetric Envelope for the MCH



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6.4 Board-Level Components Keep-out Dimensions

The location of hole patterns and keep-out zones for the reference thermal solution are shown in Figure 6-3 and Figure 6-4.

Figure 6-3. MCH Heatsink Board Component Keep-out

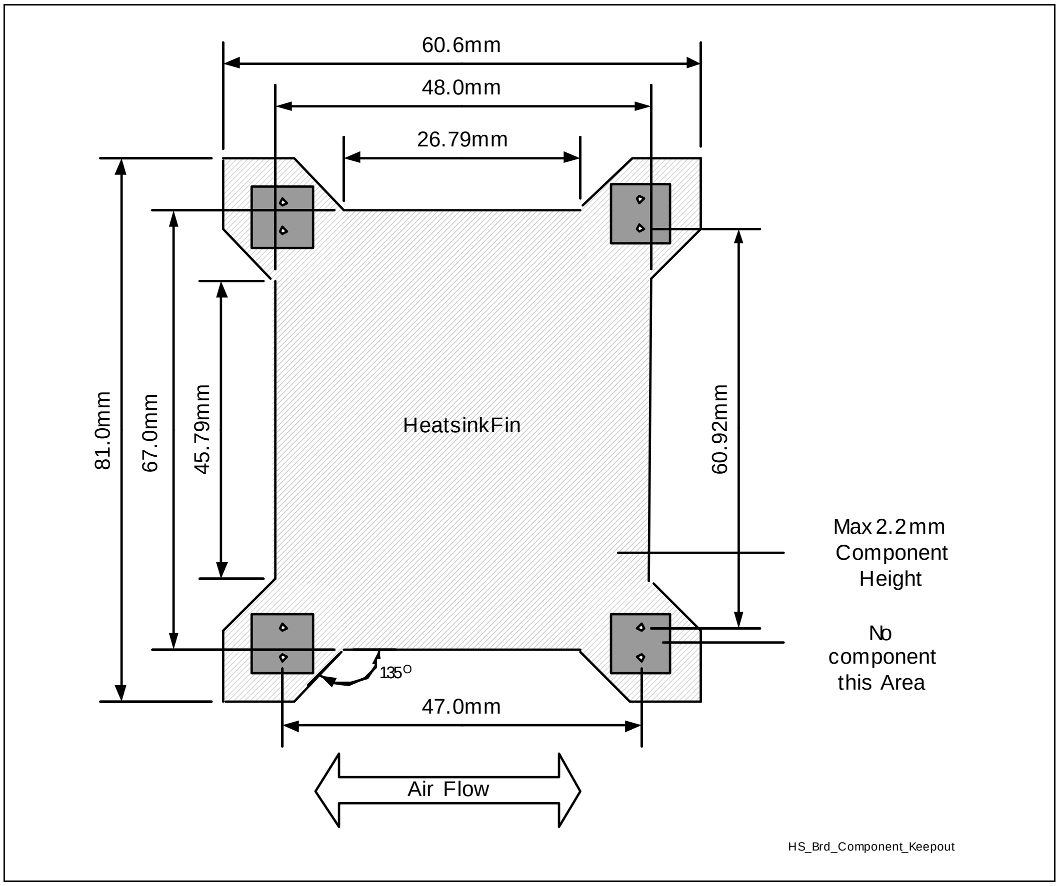

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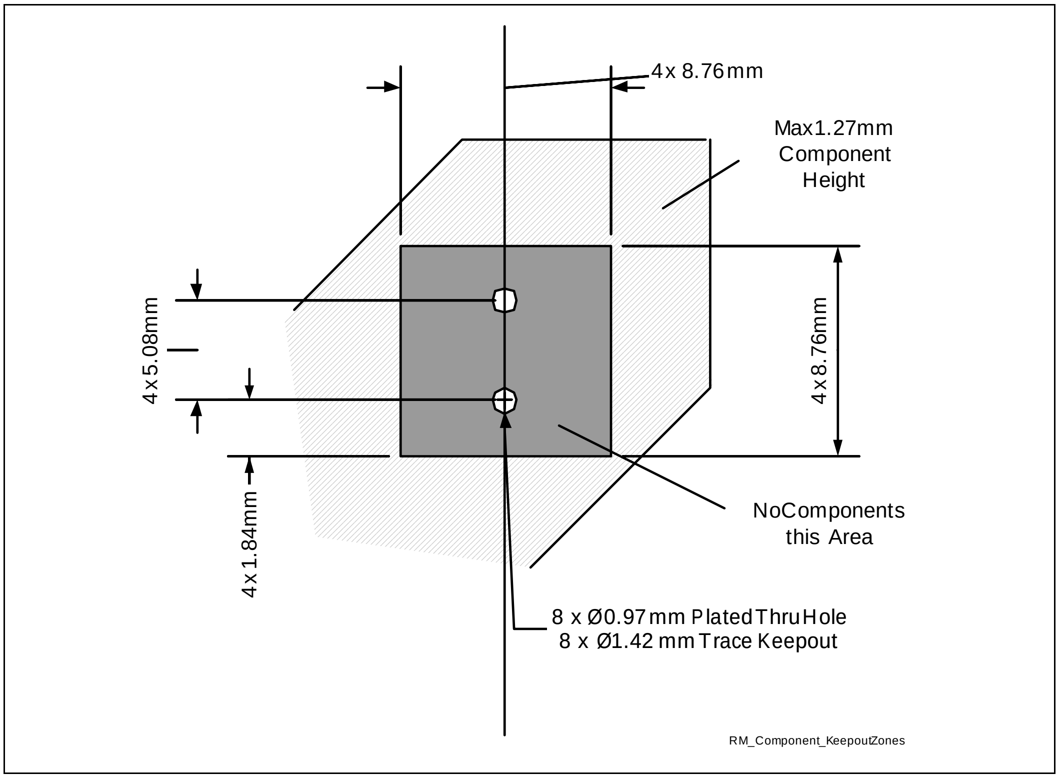
Figure 6-4. Retention Mechanism Component Keep-out Zones



6.5 Reference Heatsink Thermal Solution Assembly

The reference thermal solution for the MCH is a passive extruded heatsink with thermal interface. It is attached using a clip with each end hooked through an anchor soldered to the board. Figure 6-5 shows the reference thermal solution assembly and associated components.

Full mechanical drawings of the thermal solution assembly and the heatsink clip are provided in Appendix B. Appendix A contains vendor information for each thermal solution component.

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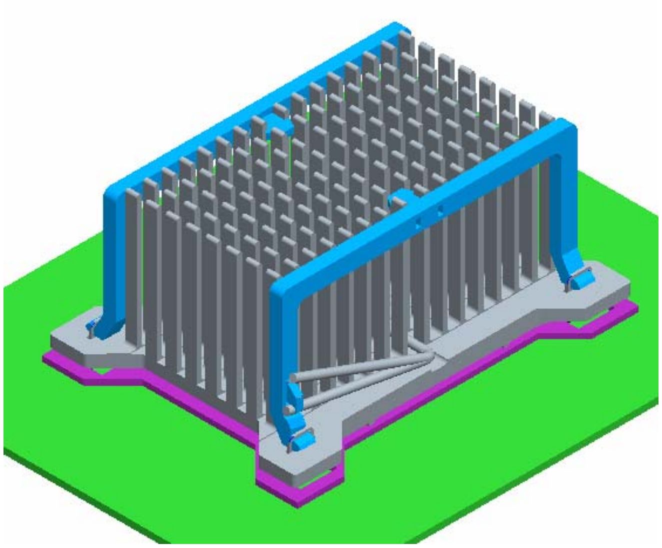
Figure 6-5. Plastic Wave Soldering Heatsink Assembly



6.5.1 Heatsink Orientation

To enhance the efficiency of the reference thermal solution, it is important for the designer to orient the fins properly with respect to the mean airflow direction. Simulation and experimental evidence have shown that the MCH heatsink thermal performance is enhanced when the fins are aligned with the mean airflow direction (see Figure 6-3).

6.5.2 Extruded Heatsink Profiles

The reference thermal solution uses an extruded heatsink for cooling the MCH. Figure 6-5 shows the heatsink profile. Appendix A lists a supplier for this extruded heatsink. Other heatsinks with similar dimensions and increased thermal performance may be available. Full mechanical drawing of this heatsink is provided in Appendix B.

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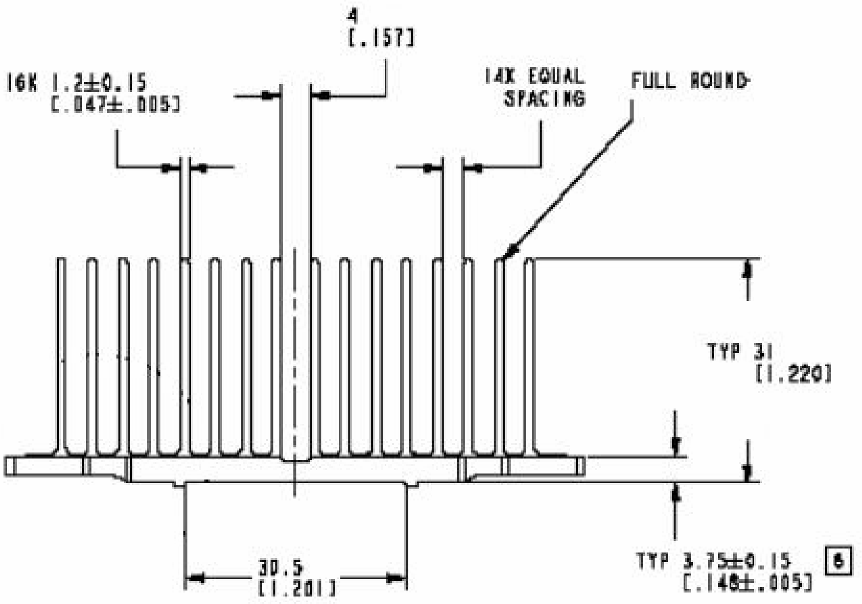
Figure 6-6. Plastic Wave Soldering Heatsink Extrusion Profile



NOTE: All dimensions are in millimeters, with dimensions in braces expressed in inches.

6.5.3 Mechanical Interface Material

There is no mechanical interface material associated with this reference solution.

6.5.4 Thermal Interface Material

A TIM provides improved conductivity between the die and heatsink. The reference thermal solution uses Honeywell PCM 45F, 0.25 mm (0.010 in.) thick, 15 mm x 15 mm (0.59 in. x 0.59 in.) square.

Note: Unflowed or “dry” Honeywell PCM 45F has a material thickness of 0.010 inch. The flowed or “wet” Honeywell PCM 45F has a material thickness of ~0.003 inches after it reaches its phase change temperature.

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6.5.4.1 Effect of Pressure on TIM Performance

As mechanical pressure increases on the TIM, the thermal resistance of the TIM decreases. This phenomenon is due to the decrease of the bond line thickness (BLT). BLT is the final settled thickness of the thermal interface material after installation of heatsink. The effect of pressure on the thermal resistance of the Honeywell* PCM45F TIM is shown in Table 6-1. The heatsink clip provides enough pressure for the TIM to achieve a thermal conductivity of 0.17 °C inch^2/W.

Table 6-1 Honeywell PCM 45F TIM Performance as a Function of Attach Pressure

Pressure (psi)	Thermal Resistance (°C × in^2)/W
5	0.049
10	0.046
20	0.045
30	0.044

Note: All measured at 50 °C.

6.5.5 Heatsink Clip

The retention mechanism in this reference solution includes two different types of clips; one is ramp clip and the other is wire clip. Each end of the wire clip is attached to the ramp clip that in turn attaches to anchors to fasten the overall heatsink assembly to the motherboard. See Appendix B for a mechanical drawing of the clip.

6.5.6 Clip Retention Anchors

For 955X Express chipset-based platforms that have very limited board space, a clip retention anchor has been developed to minimize the impact of clip retention on the board. It is based on a standard two-pin jumper and is soldered to the board like any common through-hole header. A new anchor design is available with 45° bent leads to increase the anchor attach reliability over time. See Appendix A for the part number and supplier information.

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6.6 Reliability Guidelines

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. Some general recommendations are shown in Table 6-2.

Table 6-2. Reliability Guidelines

Test[1]	Requirement	Pass/Fail Criteria[2]
Mechanical Shock	50 g, board level, 11 msec, 3 shocks/axis.	Visual Check and Electrical Functional Test
Random Vibration	7.3 g, board level, 45 min/axis, 50 Hz to 2000 Hz.	Visual Check and Electrical Functional Test
Temperature Life	85°C, 2000 hours total, checkpoints at 168, 500, 1000, and 2000 hours.	Visual Check
Thermal Cycling	–5 °C to +70 °C, 500 cycles.	Visual Check
Humidity	85% relative humidity, 55 °C, 1000 hours.	Visual Check

NOTES:

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

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7 Appendix A: Thermal Solution Component Suppliers

This list is provided by Intel solely as a convenience to customers. Intel has not tested, designed or validated these products and does not warrant user suitability or performance in any way. Customers are solely responsible for determining the suitability and application of these products for their designs.

Table 7-1. MCH Heatsink Thermal Solution

Part	Intel Part Number	Supplier (Part Number)	Contact Information
Heatsink Assembly includes: —Pin-Fin Heatsink —Thermal Interface Material —Ramp Clip —Wire Clip	C99237-001	CCI	Monica Chih (Taiwan) 866-2-29952666, x131 monica_chih@ccic.com.tw Harry Lin (CCI/ACK-USA) 714-739-5797 hlinack@aol.com
Pin-Fin Heatsink	C92139-001	CCI	Monica Chih (Taiwan) 866-2-29952666, x131 monica_chih@ccic.com.tw Harry Lin (CCI/ACK-USA) 714-739-5797 hlinack@aol.com
Thermal Interface (PCM 45F)	C34795-001	Honeywell PCM 45F	Scott Miller 509-252-2206 scott.miller4@honeywell.com
Heatsink Ramp Clip	C92140-001	CCI	Monica Chih (Taiwan) 866-2-29952666, x131 monica_chih@ccic.com.tw Harry Lin (CCI/ACK-USA) 714-739-5797 hlinack@aol.com
Heatsink Wire Clip	C85373-001	CCI	Monica Chih (Taiwan) 866-2-29952666, x131 monica_chih@ccic.com.tw Harry Lin (CCI/ACK-USA) 714-739-5797 hlinack@aol.com

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Part	Intel Part Number	Supplier (Part Number)	Contact Information
Solder-Down Anchor	C85376-001	Wieson	Rick Lin Deputy Manager/Project Sales Department Add.: 7F, No. 276, Section 1, Tatung Road, Hsichih City, Taipei Hsien, Taiwan Tel: 886-2-2647-1896 ext. 6342 Mobile: 886-955644008 Email: rick@wieson.com Website: www.wieson.com

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

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8 Appendix B: Mechanical Drawings

Table 8-1 lists the mechanical drawings included in this appendix.

Table 8-1. Mechanical Drawing List

Drawing Description	Figure Number
Plastic Wave Soldering Heatsink Assembly Drawing	Figure 8-1
Plastic Wave Soldering Heatsink Drawing (1 of 2)	Figure 8-2
Plastic Wave Soldering Heatsink Drawing (2 of 2)	Figure 8-3
Plastic Wave Soldering Heatsink Ramp Clip Drawing (1 of 2)	Figure 8-4
Plastic Wave Soldering Heatsink Ramp Clip Drawing (2 of 2)	Figure 8-5
Plastic Wave Soldering Heatsink Wire Clip Drawing	Figure 8-6
Plastic Wave Soldering Heatsink Solder-Down Anchor Drawing	Figure 8-7

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Figure 8-1. Plastic Wave Soldering Heatsink Assembly Drawing

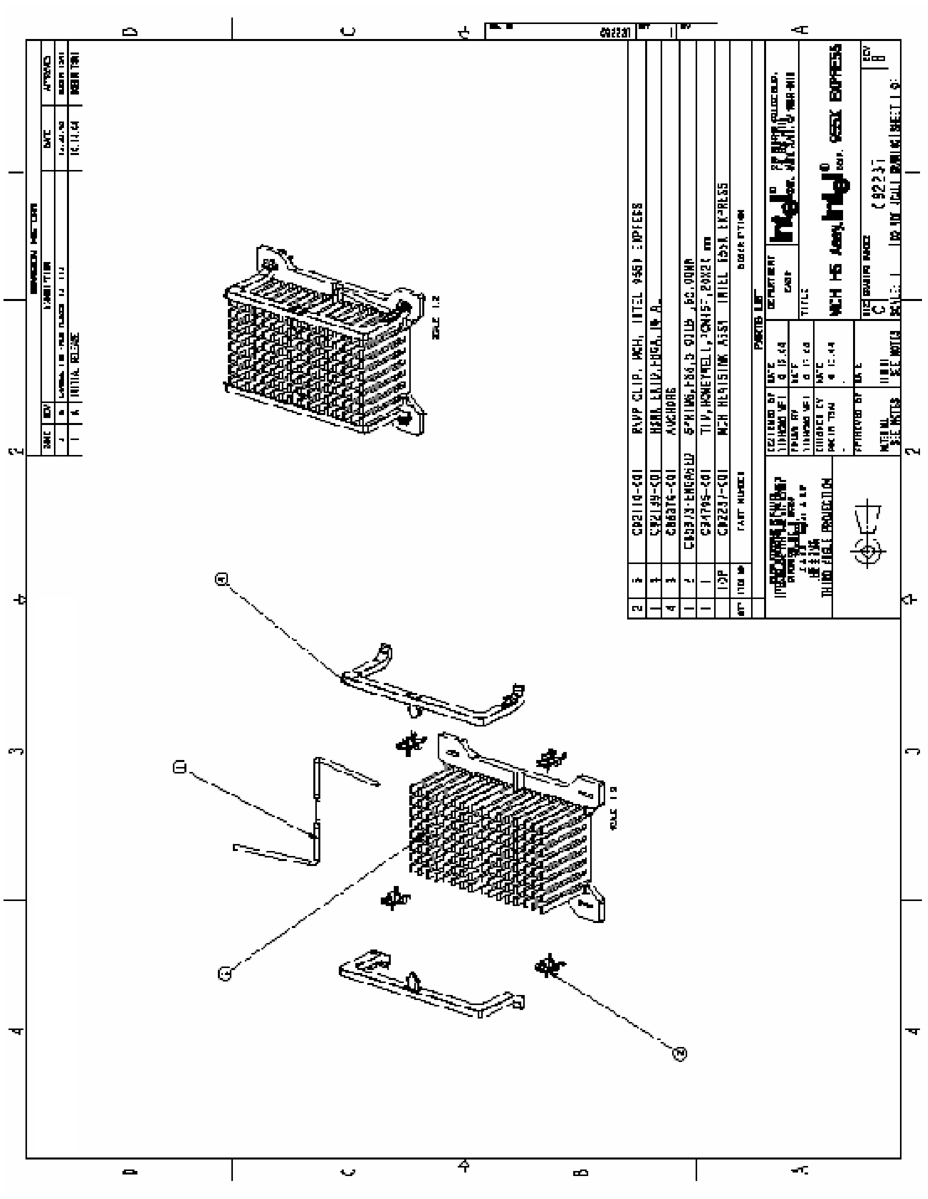

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Figure 8-2. Plastic Wave Soldering Heatsink Drawing (1 of 2)

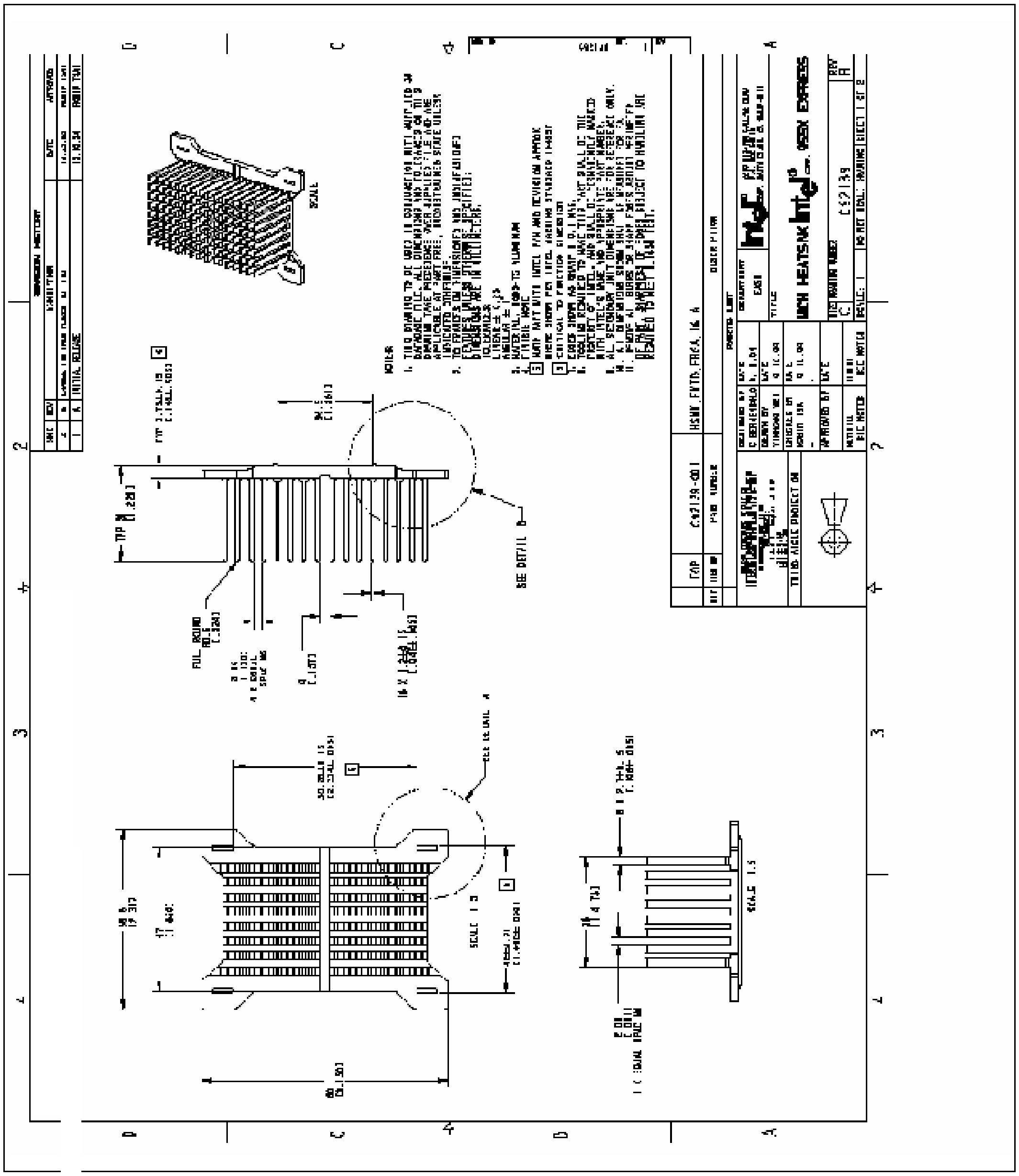

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Figure 8-3. Plastic Wave Soldering Heatsink Drawing (2 of 2)

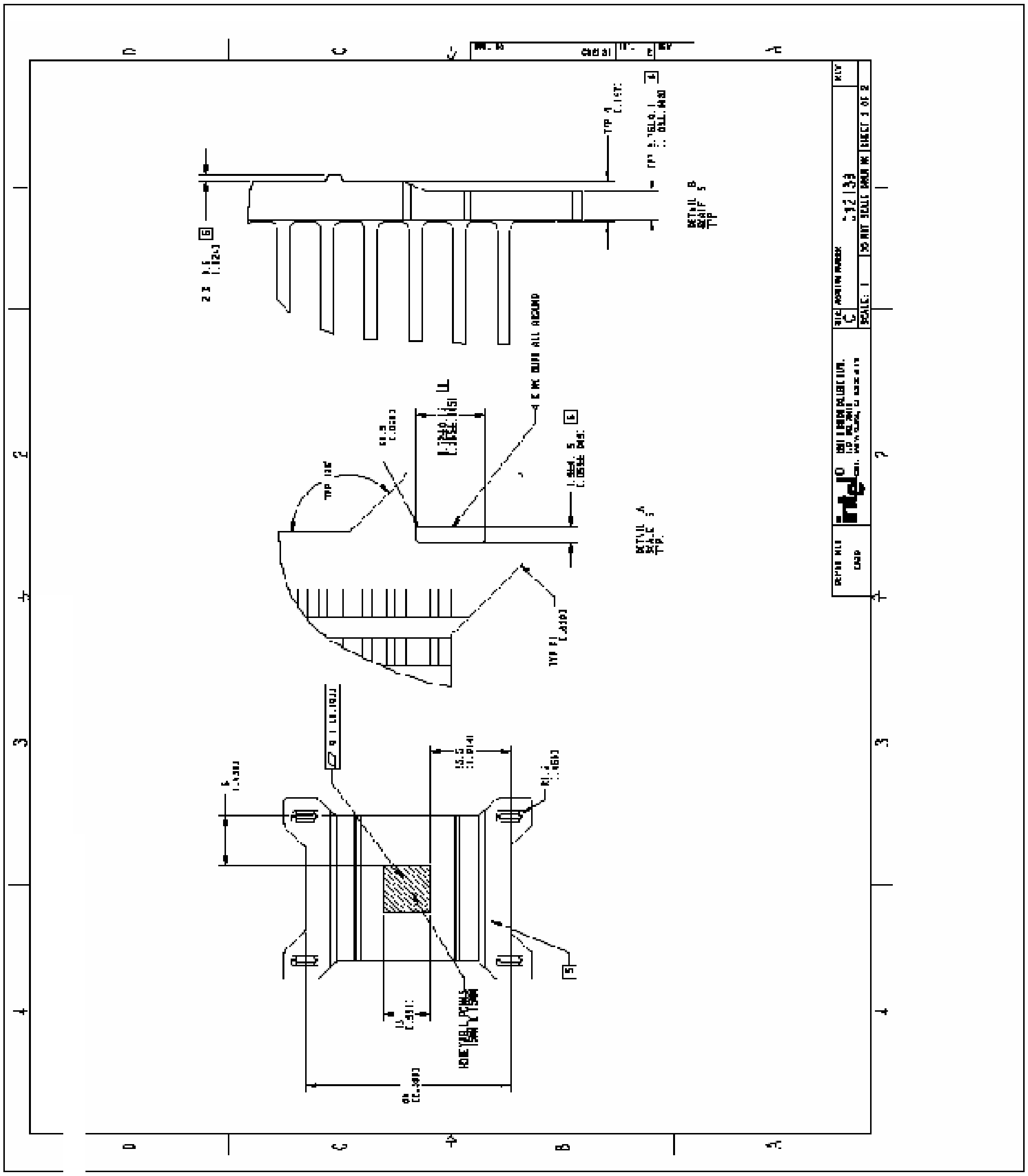

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Figure 8-4. Plastic Wave Soldering Heatsink Ramp Clip Drawing (1 of 2)

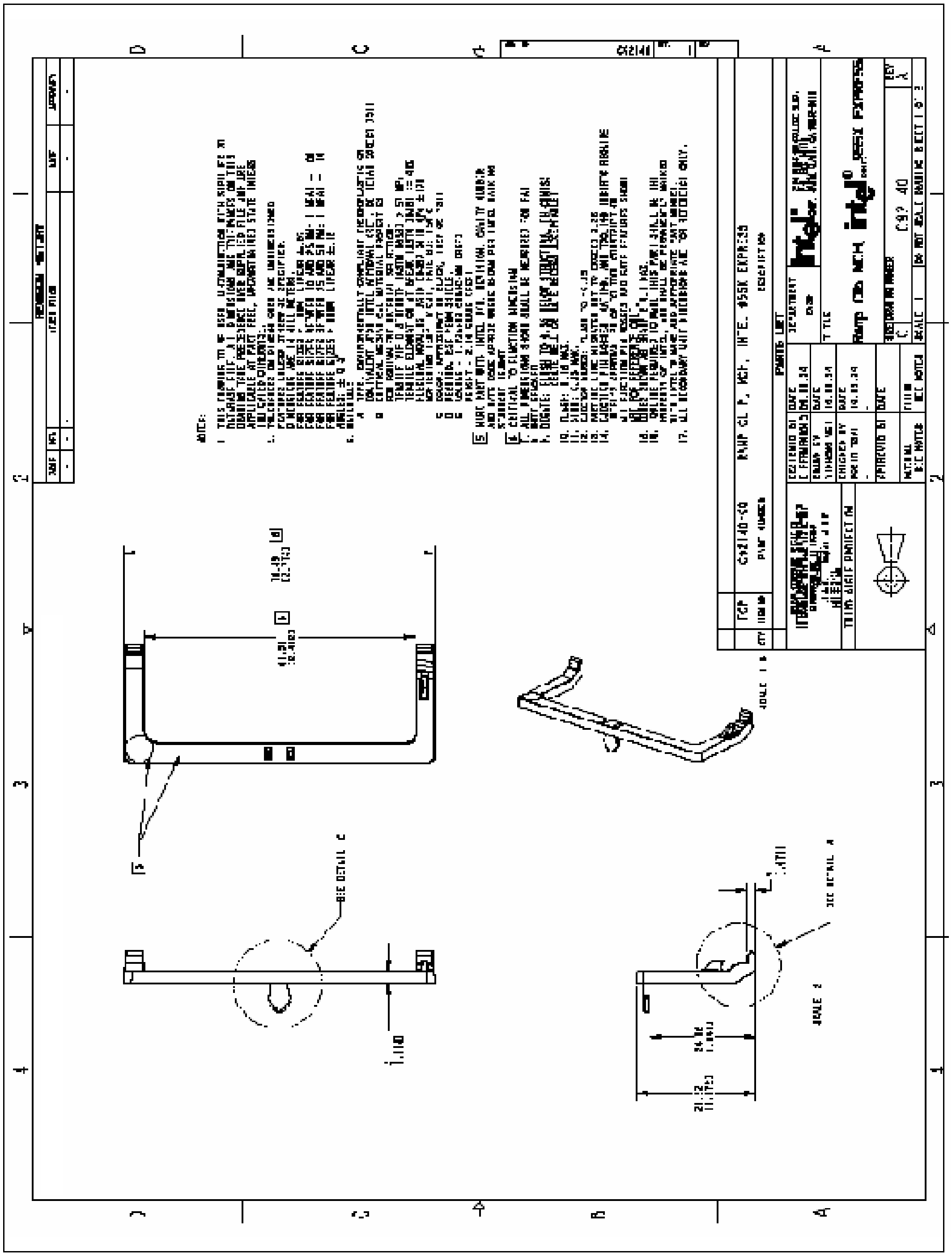

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Figure 8-5. Plastic Wave Soldering Heatsink Ramp Clip Drawing (2 of 2)

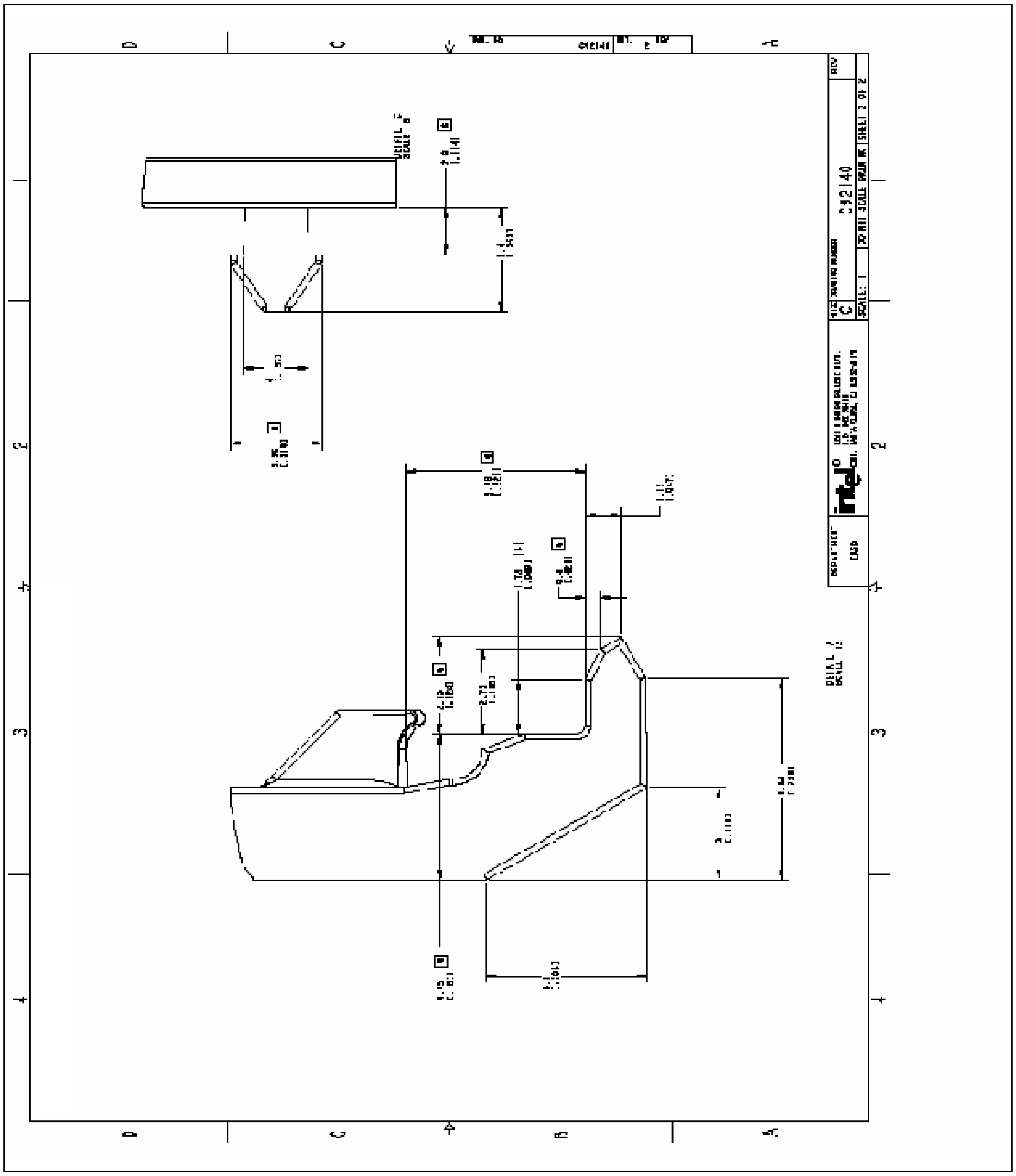

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Figure 8-6. Plastic Wave Soldering Heatsink Wire Clip Drawing

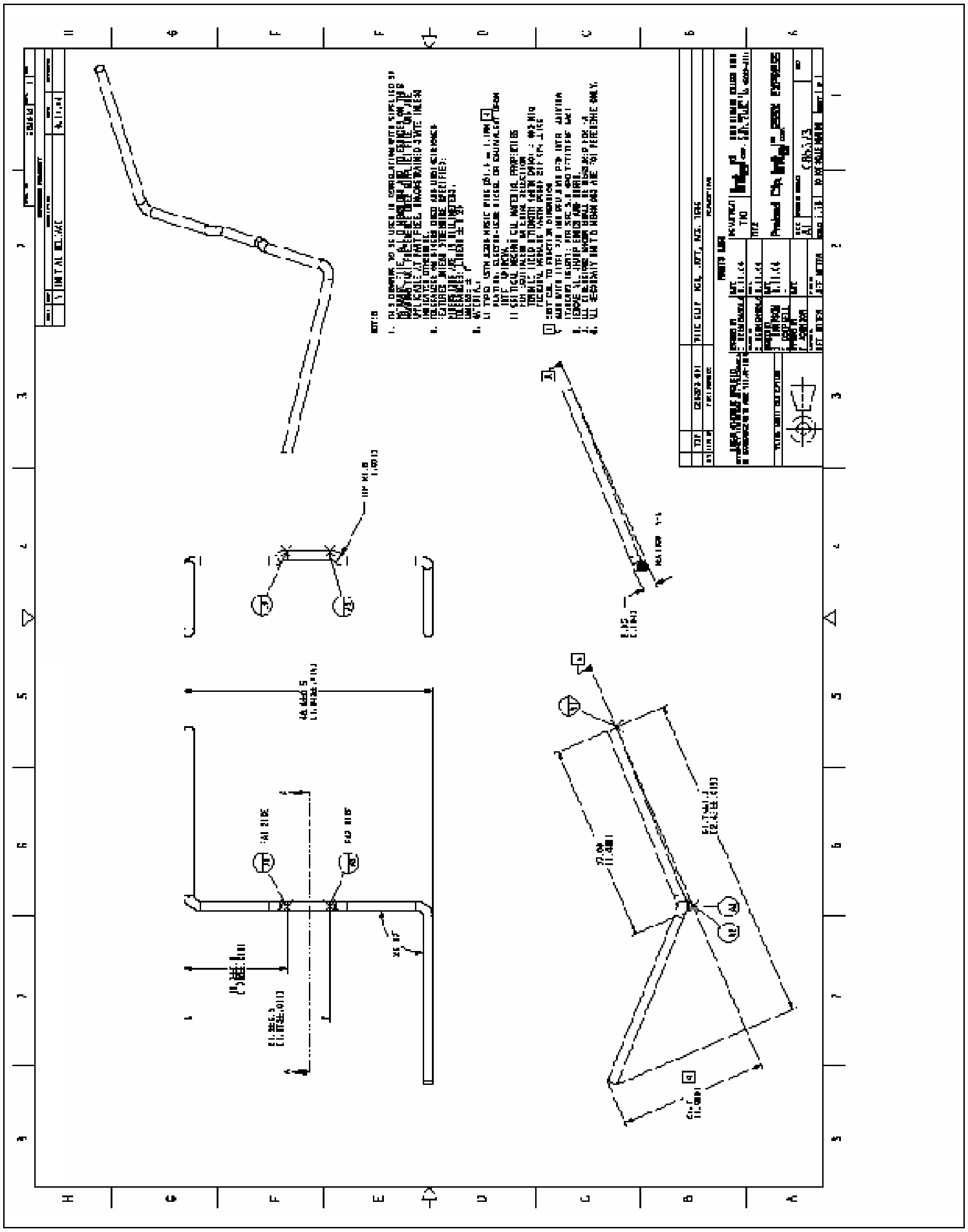

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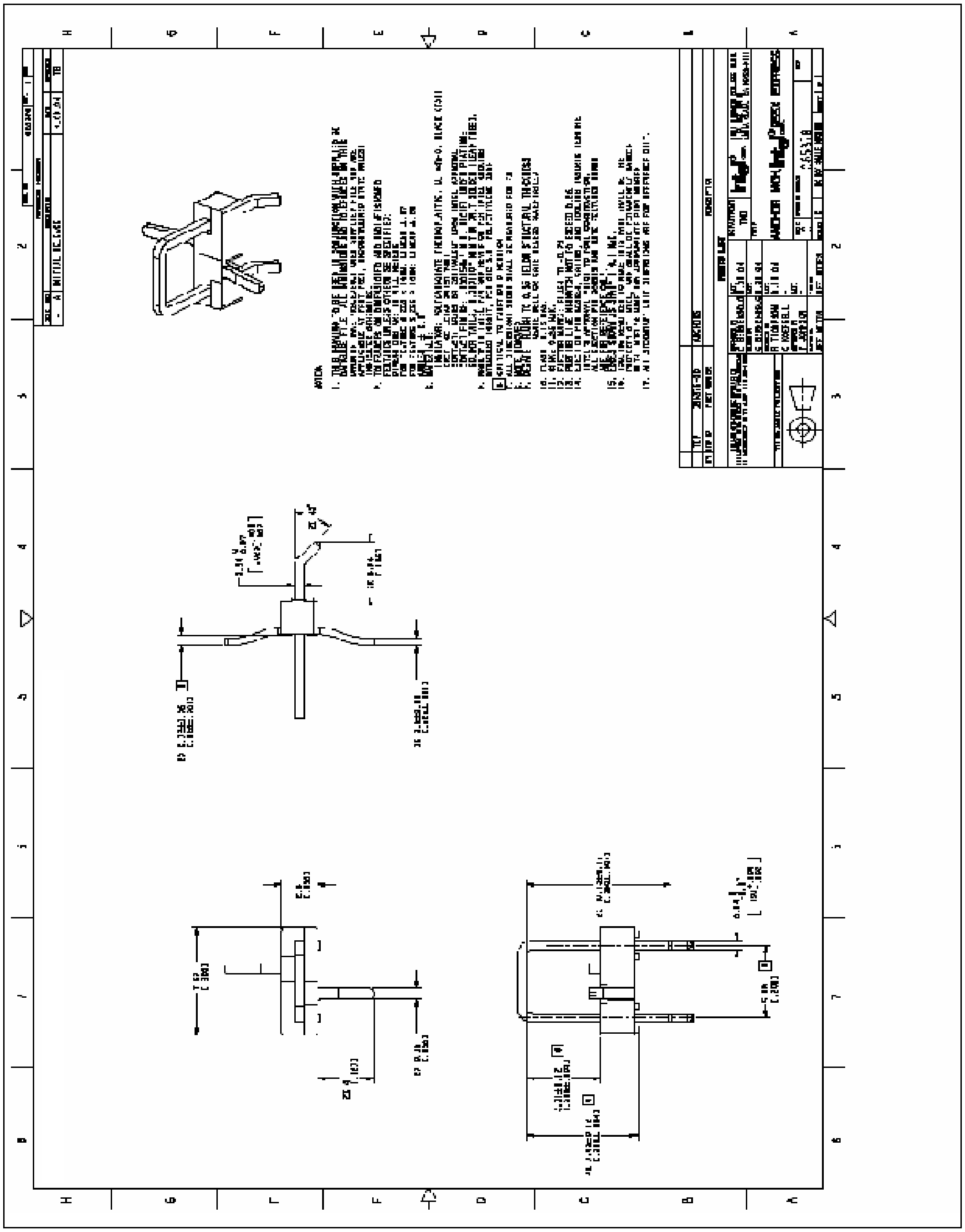
Figure 8-7. Plastic Wave Soldering Heatsink Solder-Down Anchor Drawing



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