Thermally Advantaged Small Chassis (TASC) Design Guide

*For Ultra Small Form Factor (uSFF) PCs with mini-ITX motherboards

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Revision History

Document Number	Revision Number	Description	Revision Date
E60781	01	Initial release.	1/09

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1 Introduction

1.1 Scope

This design guide explores the generic application of chassis features (vents and fans) to adequately cool the internal components of a small form factor personal computer with an Intel Mini ITX motherboard. Design recommendations are presented for implementation within mini desktop and mini tower style enclosures with CPU TDP below 95 Watts. The target audiences for this document are: computer enclosure engineers, designers, and system integrators. This document is intended to facilitate the thermal design of small form factor chassis intended for the use of Intel's mainstream Mini-ITX socketed motherboards. It is not specifically optimized solution for Intel's Low Cost Intel Architecture based Mini-ITX motherboards.

1.2 Overview

Small form factor has been evolving quickly in the last several years and expected to continue at a fast pace. The mATX platform has been reduced in size reaching its minimum at around 10 Liters, with smaller options even available using mobile components. As this size limitation is pushed, Intel has adopted the mini-ITX board size specified by Via Technologies, Inc. As the chassis size can now be reduced greatly between 4 and 8 Liters (depending on feature set and components), this design guide is intended to aide in satisfying thermal requirements for Intel's 2008 mini ITX platform and beyond for this size range.

Proper thermal management of PC enclosure design is critical to the performance and functionality of internal PC components as well as achieving desirable acoustic noise levels. There are many different ways to provide proper chassis thermal management. The design approach described in the document is one such method that if implemented correctly will provide a single, cost effective solution for a wide range of PC platform generations.

Recommendations are based on these considerations:

- Address the 2009 platform CPU location change and remove the dependency on CPU location entirely
- Generic application to small form factor chassis sizes 4-8 liters
- Maintain relaxation of the FHS inlet ambient spec from 39C to 40 C
- Not impose ducting, baffles, or other cost adders to the chassis
- Attempt to optimize chassis thermal performance for all critical areas, not just the CPU inlet temperature.

1.3 Terminology

Term	Description
SFF	8-19 liter chassis (IDC definition)
Ultra SFF (uSFF)	4-8 liter chassis (IDC definition)

1.4 Reference Documents

Document / Resource	Document Location
ISO 7779-Acoustics–Measurement of Airborne Noise Emitted by information Technology and Telecommunications Equipment	**http://www.iso.org**

2 Section 2

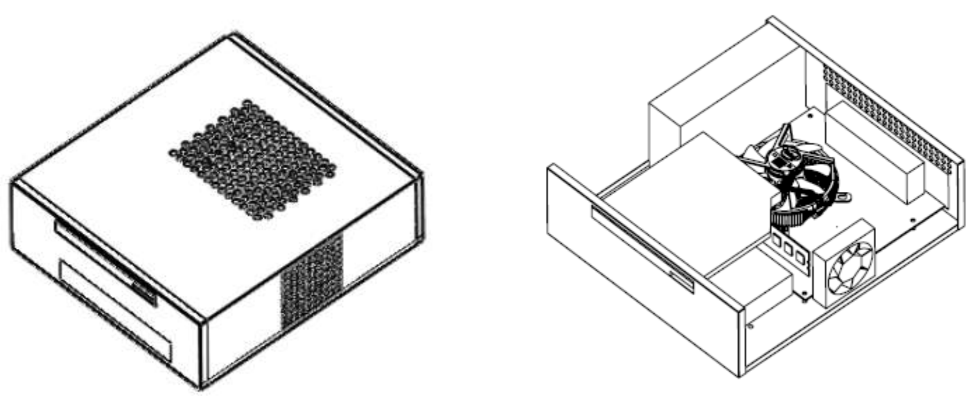
2.1 Thermally Advantaged Small Chassis Description

The critical thermal objective for processor cooling is to achieve a temperature rise from external ambient to the inlet of the processor thermal solution fan to be less than 5 °C during a worst case system power load. This would equate to a 40°C fan inlet at the maximum recommended room ambient temperature of 35°C. By meeting this objective, fan heat sink solutions should have adequate boundary conditions to properly cool the CPU and provide sufficient airflow to nearby components. Details on thermocouple placement for CPU fan heat sink inlet temperature measurement can be found in applicable Thermal Design Guide (TDG) documents.

It is a key feature in this design guide not to use special ducting or other features beyond a vent location and pattern to meet thermal objectives. This allows platform flexibility between legacy and future CPU locations without requiring chassis tooling changes.

This design guide intends to provide guidance on the critical features that have greatest impact on thermal performance. These are side vent size and location, free area ratio, chassis height (or distance between fan inlet and chassis vent), and system fan. The following will describe each of these features and the recommended specifications to maintain an internal temperature condition below 40°C.

Figure 1. Generic Chassis Representation



2.1.1.1 System Fans

System Exhaust Fan:

It is necessary that heat generated within the chassis be effectively exhausted and therefore requires the use of an exhaust fan. It is the responsibility of chassis manufacturer to ensure the performance of the exhaust fan and ensure that an appropriate balance of performance and acoustics is met. While the location of the exhaust fan may be dependent on the chassis design, there are a few considerations that should be made in determining its location.

- Fan placement should be as free from obstruction as possible to minimize flow impedance and provide sufficient exhausting airflow. It is particularly important to provide means of cable management that does not interfere with or block fan inlets and exhausts.
- It may be desirable to put the fan in line critical components to provide airflow.
- If the addition of an add-in card would obstruct the system fan, it would not be recommended to put the exhaust fan on the West wall of the chassis (Side nearest PCI slots).
- If chassis is designed to accommodate a mini tower configuration, a fan exhaust should not be blocked by either the floor or chassis stand.
- Generally, the East side of chassis is most convenient and effective for exhaust fan placement as shown in Figure 2.

With the above considerations, the most generic location seems to be the East side of the chassis in line with the DIMM slots.

Note: Some enclosure designs may utilize system pressurizing via intake fans for thermal management. This is a design choice that is not intended or recommended in this Design Guide.

Power Supply Exhaust Fan

There are several options available for type of power supply to be used in small form factor systems. No changes or special considerations beyond air flow direction are intended for power supplies in this design guide.

Use of a standard desktop power supply such as Flex ATX, or TFX type may be beneficial for cost, availability, and established reliability. In addition, it may be the case that a standard desktop power supply has sufficient exhaust capability to relinquish the need of a system fan, but this must be carefully verified by the designer and is not without risk depending on system layout and components.

When a standard desktop power supply is used, it should be ensured that it is placed so that it exhausts outside of the chassis. A power supply fan that only circulates air within the chassis will not be a good design choice. Likewise, a chassis power supply fan that pressurizes the chassis would render the vent location and size recommended by this guide ineffective.

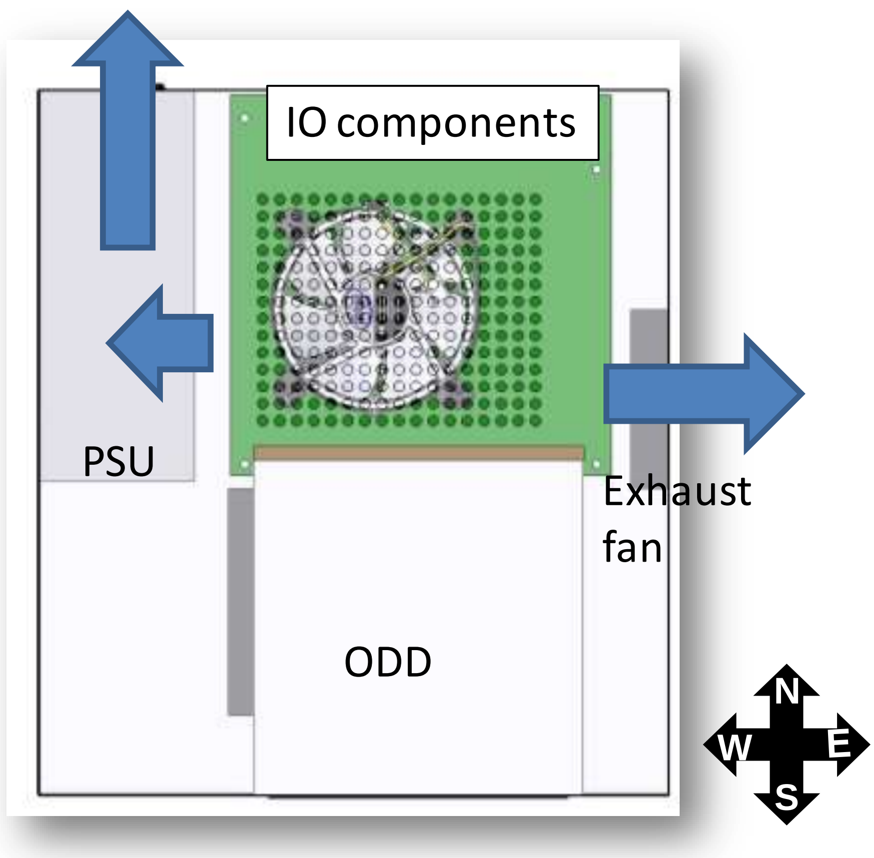
The use of external power supply is an obvious way to reduce system size. In this case, a properly sized system fan is especially important as the primary exhaust mechanism and its location should be placed to provide airflow over critical system components per the manufacturers' specifications.

Processor Active Fan Heat Sink:

Much the same as the rear system and power supply exhaust fans, the processor cooling fan remains a critical piece of the overall system cooling solution. An active CPU fan heat sink with airflow directed towards the main board is assumed in this Design Guide and is needed to properly cool the processor and surrounding components.

Because the processor fan heat sink draws cool air into the system, it is highly recommended to not block the fan inlet at all with cabling or components such as optical disk drive. Figure 2 illustrates placing components (in this case the optical disk drive) clear of the fan inlets.

Figure 2. Chassis Exhaust Example (Chassis Top View)



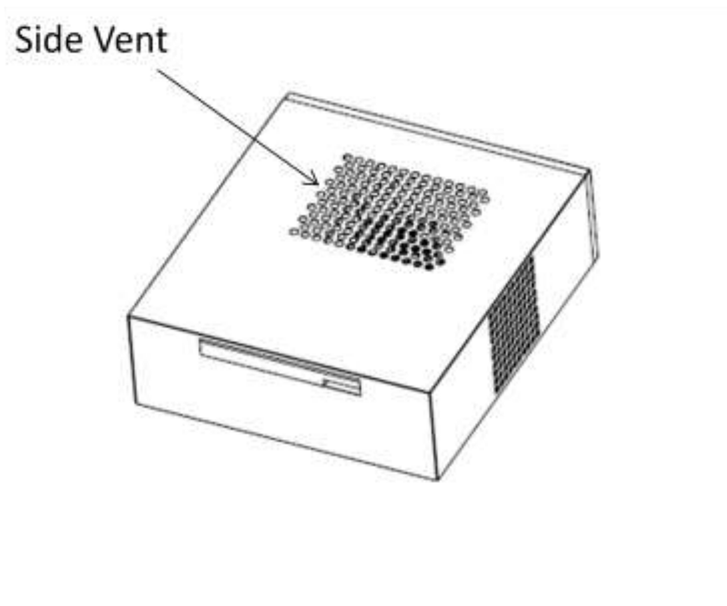
Note: Side vent acts as inlet and remaining vents are air outlets

2.1.1.2 Side Vent Description

Location and size

The Design Guide requires a side vent as seen in Figure 3. The vent directly over the CPU fan heat sink is most critical for CPU cooling. The location also allows the CPU fan to draw cool air in most effectively and thereby helps with overall internal cooling. This vent configuration has been optimized by means of extensive system level testing. The size of this vent is recommended to be 130mm wide and 100mm tall. The side vent is best located with respect to a subset of the standard ATX mounting holes as defined in the ATX Specification. Refer to Section 5 for detailed vent size and location dimensions.

Figure 3. Side Vent Illustration



Free Area Ratio

Free area ratio (FAR) is defined as the total vent open area, divided by the vent area. It is recommended that this vent have an effective open area of at least 53%. This will maximize the effectiveness of the vent and should still contain EMI effectively. Higher FAR's will improve airflow into the chassis but are at the expense of aesthetics, safety, and increased EMI emissions. Lower open area percentages will degrade thermal performance but may still be effective depending on the entire system design. These are design choices the chassis designer must understand and make appropriate compromises for the performance

The chassis designer may want to provide features on the chassis side panel to mitigate vent blocking if the system should be placed against a wall, desk or other obstruction.

Other Venting:

Besides the side vent, other vent locations are more difficult to specify as configurations will vary and aesthetic opinions are diverse. While the side vent is most critical, it is also important to ensure the total system is appropriately vented. As the fans are specified as exhausting, vents will become inlets, drawing cool air in. It is therefore beneficial to place venting near critical components, such as the hard drive and power supply. In addition, the rear of the chassis should be well vented as it generally has less aesthetic requirements as well as noise emission concerns.

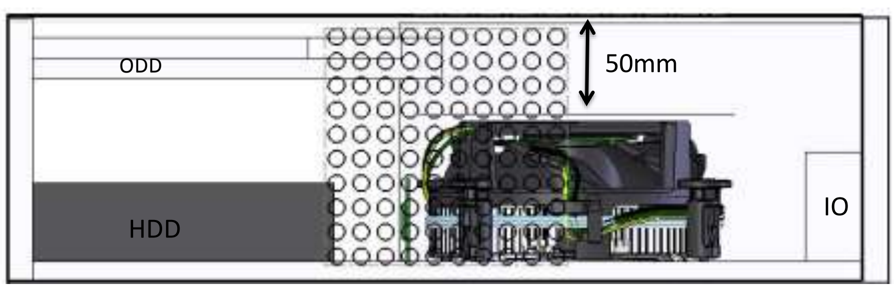
Dust Considerations:

Depending on region, dust accumulation can pose a challenge as dust accumulates, blocking fan inlets and degrading heat sink performance. For these concerns, removable screens that may be cleaned by the user are the simplest option. While there is associated air flow impedance by adding a screen, it is generally the best option for dust prevention.

2.1.1.3 Chassis height

The distance between the CPU fan inlet and the side vent will impact thermal performance. As the distance grows, recirculation within the chassis is worsened as less cool air is drawn in from the exterior and directly into the heat sink. Distances above 50mm are not recommended to maintain within T rise specification.

Figure 4. Recommendation of Chassis Height (Chassis Side View)



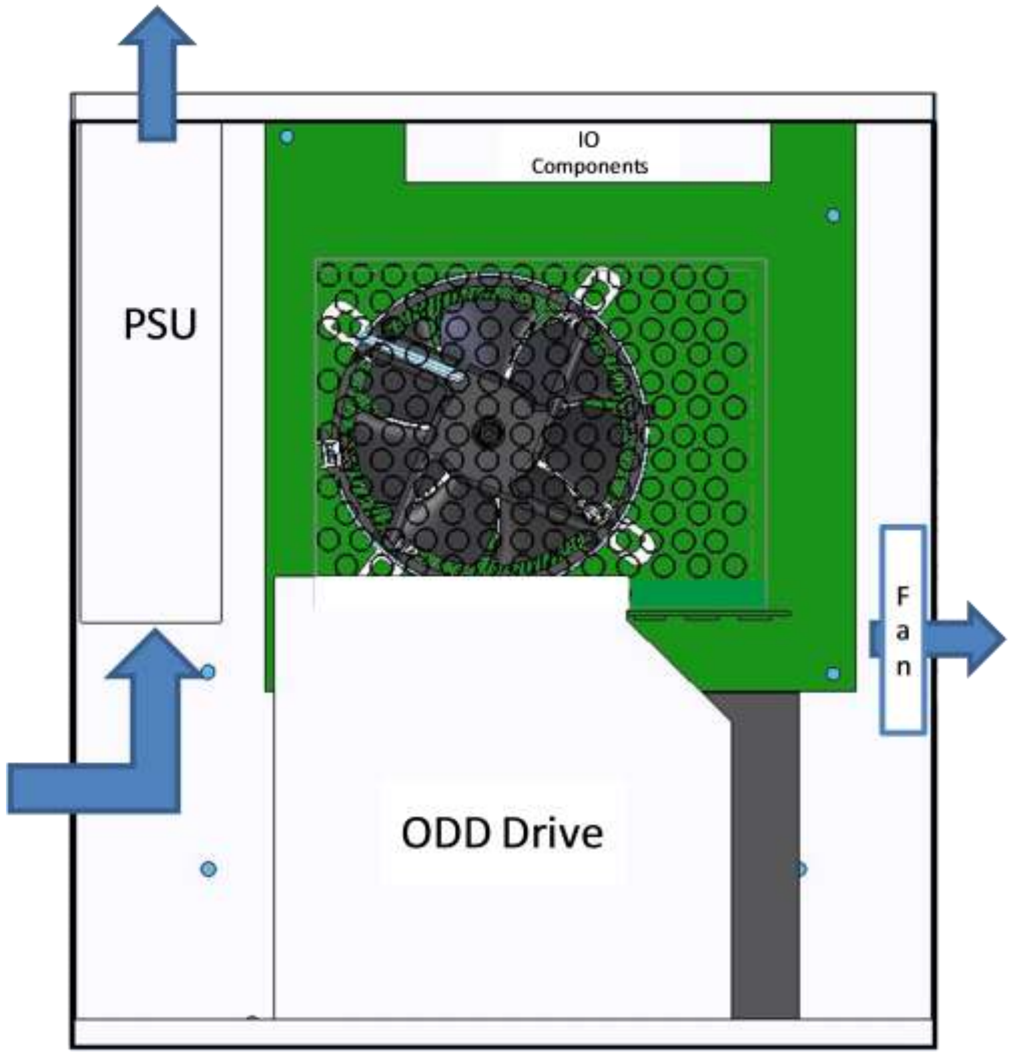
Note: distance between fan inlet and side vent should be less than 50mm unless custom air guide is utilized.

2.1.1.4 General Component Layout

Component layout is specifically left open to the chassis manufacturer to maintain flexibility and ability to provide differentiation. Besides height and vent size and location recommendations, the final comment is to keep the zone between the vent and the fan heat sink clear from obstruction. This includes, to the best ability, allowing for cables to be routed around the fan heat sink, and not over the top of it. By not obstructing the fan inlet, the fan is able to draw cool air into the fins, as well as not impose added impedance to the fan.

Add in cards dissipating less than 20 Watts have been shown viable with the recommended venting pattern and correct fan implementation. If a higher powered graphics card is targeted, two exhaust system fans or a combination of 1 system fan and 1 power supply exhaust fan is needed to meet Tambient specifications.

Figure 5. Component Layout Example



Note: Zone between fan inlet and side vent should be free from component obstruction as shown. Arrows illustrate airflow direction.

2.2 Summary of Design Recommendations:

- Key Ingredients
  - 100x130 vent above CPU as defined in drawings section
  - 53% Free Area Ratio recommended minimum
  - Appropriately balanced (speed/size) exhaust fan
  - Distance between fan inlet and vent <50mm
- Tradeoffs of these ingredients are possible and responsibility of chassis manufacturer
- Other components need sufficient venting on East and West sides to remain within operating limits.
- Component operating temperatures vary greatly and must be verified by chassis manufacturer

3 Dynamics

While this design guide requires no additional discrete chassis components it is recommended that the chassis is able to withstand the dynamic stress conditions listed below without displaced or damaged components.

3.1 Shock Test

Unpackaged

25 g, 11 ms trapezoidal; ~ 170 in/s

Two drops in each of the six directions applied to each of the test samples

3.2 Vibration Test

Unpackaged

Sine sweep: 5 Hz to 500 Hz @ 0.5 g ±10%; @ 0.5 octaves/min; Dwell 15 min at each of three resonant points

Random Profile: 5 Hz @ 0.01 g^2 /Hz to 20 Hz @0.02 g^2/Hz (slope up)

20 Hz to 500 Hz @ 0.02 g^2/Hz (flat)

Input acceleration: 3.13 g RMS

10 min/axis for all axes on all samples

Random control limit tolerance is ±3 dB

3.3 Pass Criteria

- No visible or functional damage.
- No displaced or dislodged components.

4 Regulatory Considerations

The PC must meet a number of regulatory Safety, EMC and Ecology concerns. Specific requirements for Information Technology Equipment vary somewhat by country, however, the overall standards are somewhat unified and are based upon the following standards: Note: Certain countries may require formal certifications and many require a Declaration of Conformance (DOC) be placed in the manual or on the box. In Europe the CE mark and a DOC is required for every computing device.

4.1 Electromagnetic Interference Radiation

The recommended vent size and free area ratio is not expected to pose a challenge given current motherboard wavelength emissions for EMI performance. However totals chassis design with appropriate grounding, seam and aperture features contribute to EMI and are the responsibility of chassis designer to consider.

The Electromagnetic Interference (EMI) performance of a system is determined by the degree of noise suppression designed into the system motherboard and the provisions for EMI containment in the chassis design, including placement of internal subsystems and cables. Requirements call for compliance to stringent electromagnetic compatibility (EMC) limits such as the CISPR-22 European standards or the FCC "B" United States standard. Open chassis requirements for board manufacturers suggest that most EMI needs to be suppressed at the board level. The chassis, however, should provide at least 6 dB of EMI attenuation or Shielding Effectiveness (SE) throughout the spectrum. The goal of 6 dB assumes the board complies with FCC Part 15 (Open Box Test). Boards that have higher expected emissions will likely require additional containment. These standards, along with higher processor and video frequencies, call for additional chassis containment provisions. Basic design principles have not changed, but as frequencies increase, the shorter wavelengths require more frequent ground contacts and smaller apertures in the chassis design.

EMC Standards:

- 47 CFR Parts 2 and 15 (USA)
- ICES-003 (Canada)
- EN55022:1998 (European Union Emissions)
- EN55024:1998 (European Union Immunity)
- Other International requirements based upon CISPR 22

4.2 Safety

This design guide is not intended to cover all safety aspects that may pertain to different countries and regulatory bodies. The safety standards listed below are a starting point for reference however, the manufacturer is ultimately responsible to ensure that all applicable safety standards are adhered to.

Safety Standards:

- IEC 60590 (International)
- UL/CSA 60950 (USA and Canada)
- EN60590 (European Union)

4.3 Ecology

This design guide is not intended to cover every aspect of designing a product to meet every International regulation, however, the following standards and programs may cover Ecology issues that may or may not apply to your product.

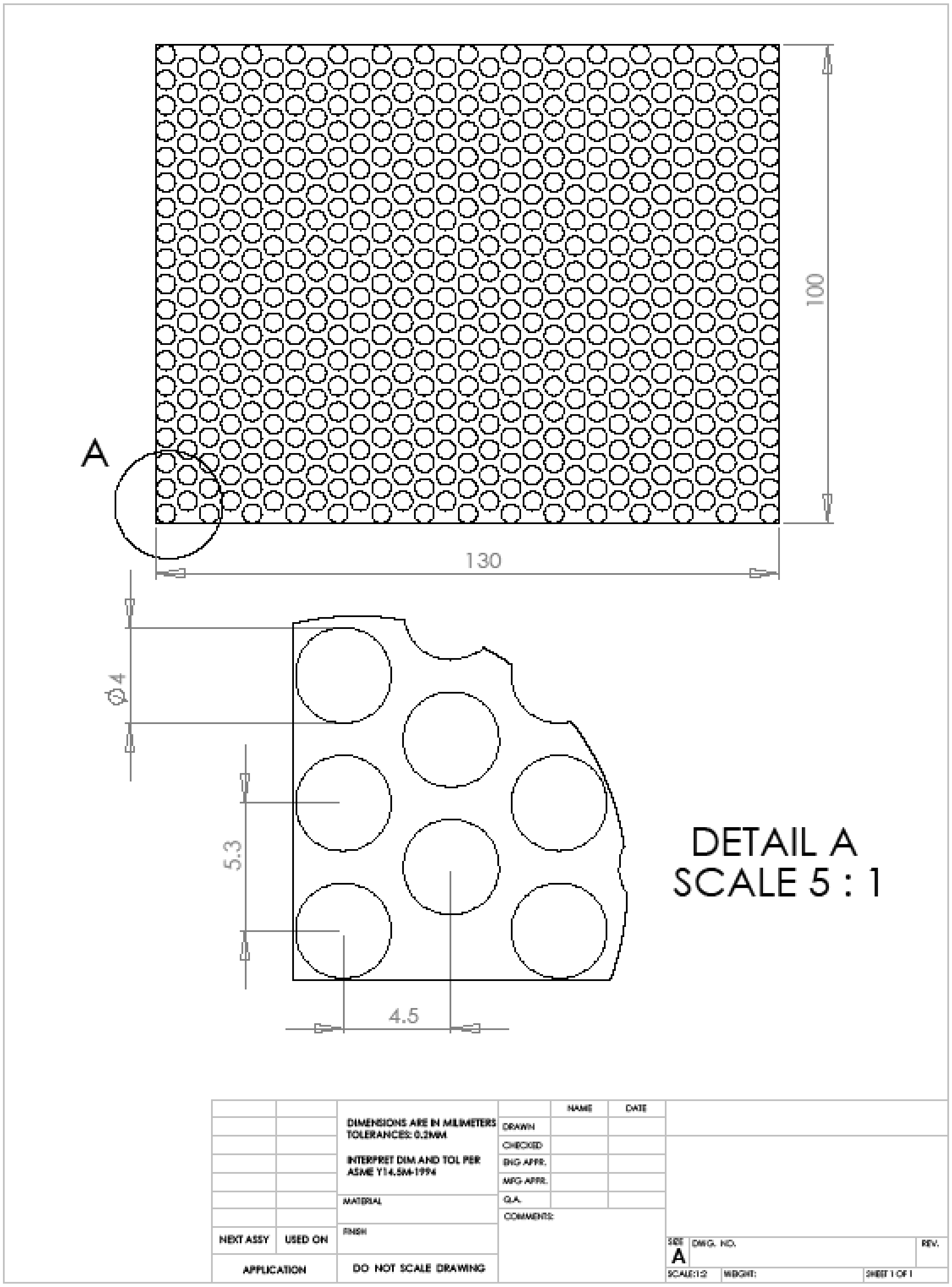
Ecological Standards

- ECMA TR70:
- Energy Star
- TCO '99, Blue Angel
- RoHS

Ecological Programs

- Participation in waste electronics recycling program.
- Participation in a packaging-recycling program.

5 Mechanical Drawings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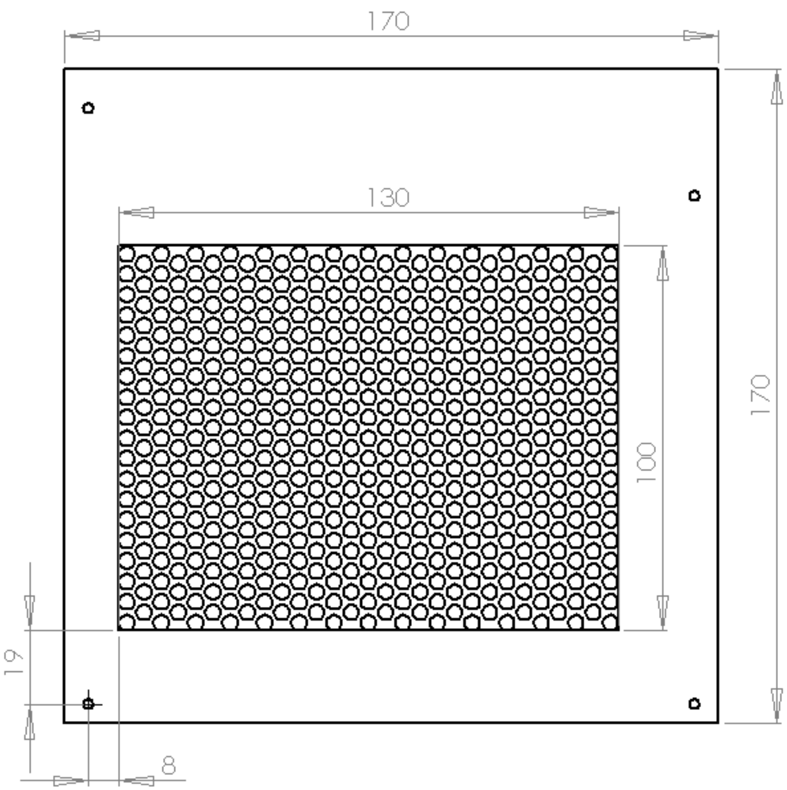

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