Mechanical Enabling for the Intel® Pentium® 4 Processor in the 478-Pin Package

October 2001

Order Number: 290728-001

Disclaimers

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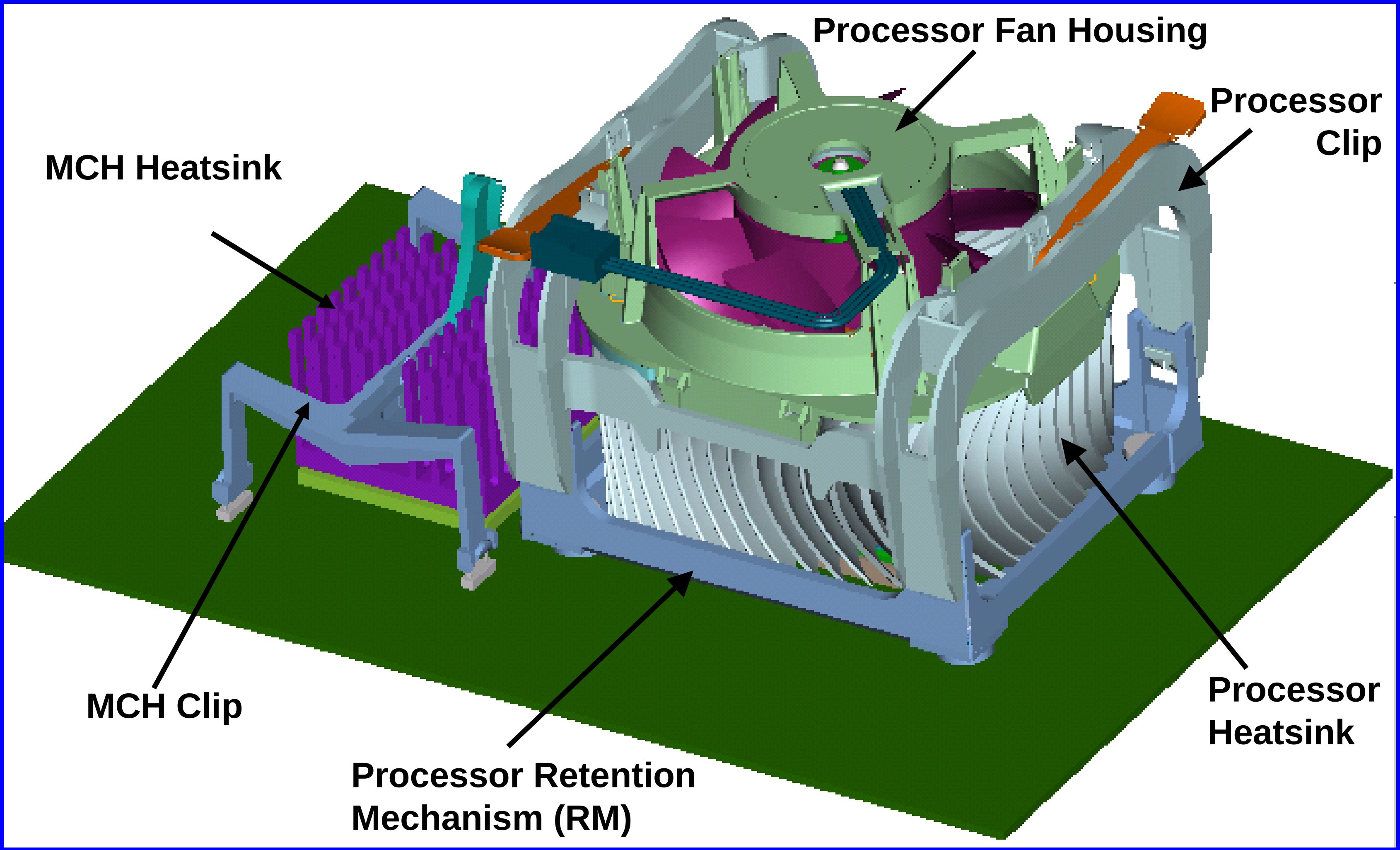
Reference Design Overview

- Mechanical Enabling Reference Design is:
  - Intel-developed enabling solution for the Intel® Pentium® 4 processor in the 478-pin package and the Intel® 845 MCH
  - Developed for general industry use
  - Targeted at low-cost, high volume manufacturing & integration approach

Full Assembly



Critical Design Requirements

- Power Dissipation
  - Traditionally the driving design requirement

- Mechanical Retention
  - Strongly impacted by power dissipation requirements
  - Has gained importance with increasing heatsink mass

Mechanical Requirements

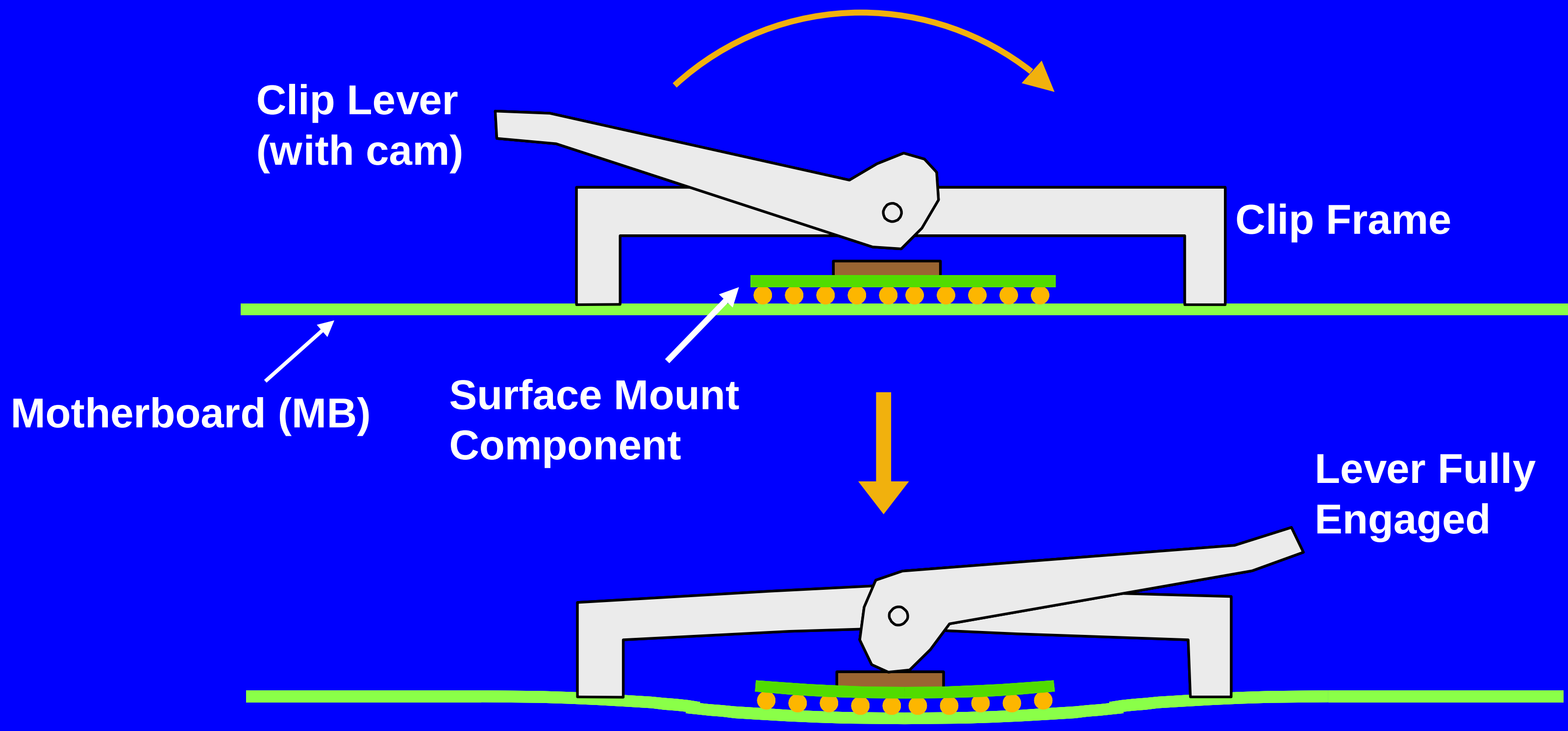
- Withstand environmental load conditions
  - 50g board-level mechanical shock
  - 3.13g RMS board-level random vibration
  - Driving factors:
    - ✓ Processor heatsink mass
    - ✓ Prevalence of surface mount components
- Sustain thermal performance
  - Provide adequate pre-load for TIM (thermal interface material)
  - Center pre-load within specified tolerance

Design Challenges

- During shock and vibration events:
  - Avoid processor package pull-out
  - Protect against processor socket solder joint damage
  - Protect against MCH solder joint damage
- Prevent Thermal Interface Material (TIM) thermal performance degradation
- Allow chassis-independent solution

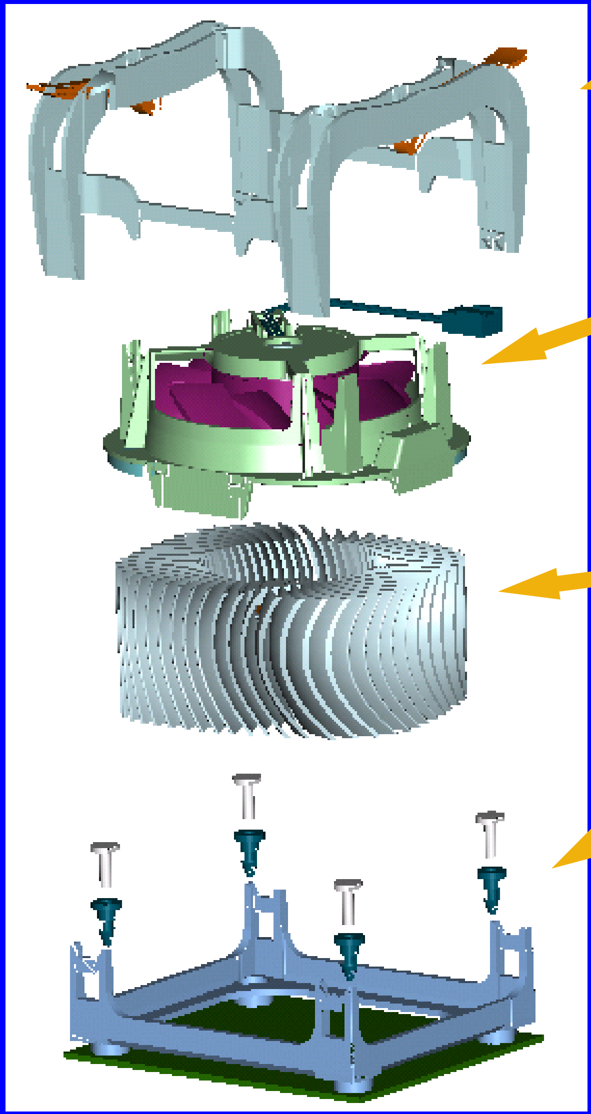
Engineering Strategy

- Compressive Preload
  - Induced through cam rotation
  - Helps protect against package pull-out and solder joint damage
  - Improves thermal performance



For additional information on Reference Solution Assembly, see reference [6] slide 25.

Intel® Pentium® 4 Processor in the 478-Pin Package Enabling Assembly



- Clip
  - Generates preload
  - Comprised of frame and mechanical advantage levers
- Fan/Housing
  - Provides clip bearing surface and load transfer to heatsink
  - Comes pre-assembled to clip
- Heat sink
  - Carries preload through fins to processor
- Retention Mechanism
  - Engages clip hooks through windows
  - Attaches to board with Tuflok* fasteners

Note: The weight of the Intel Reference Solution is approximately 370 grams.

For additional information on Reference Solution Assembly, see reference [6] slide 25.

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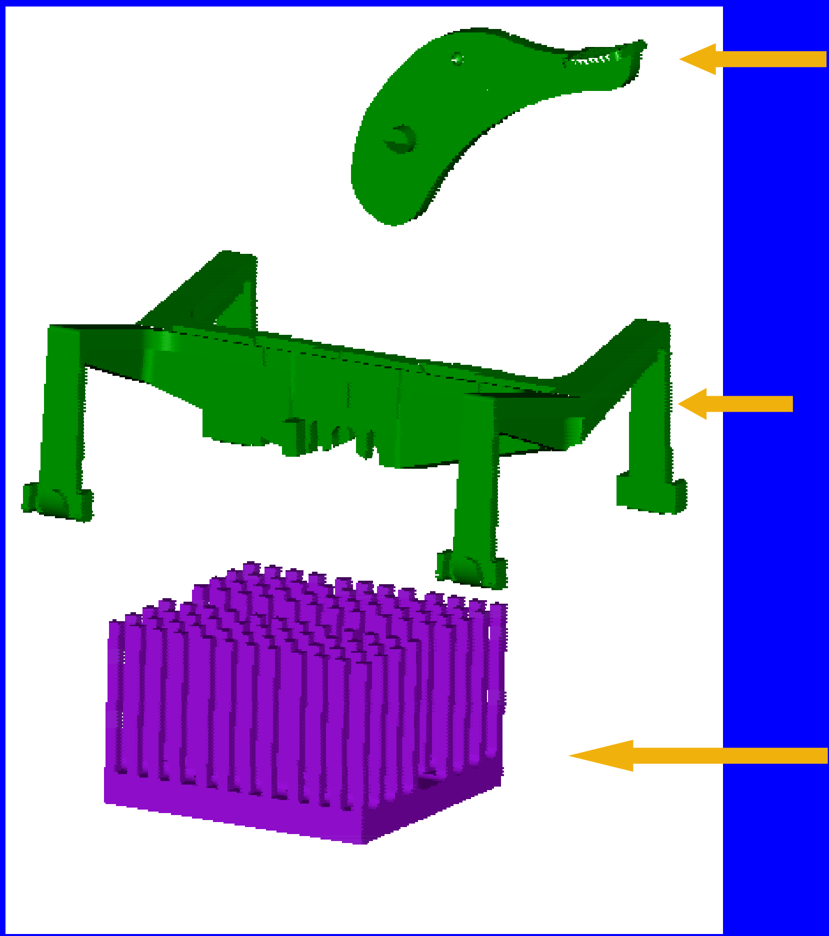
*Other names and brands may be claimed as the property of others.

Reference Design Overview

Intel® 845 MCH Enabling Assembly



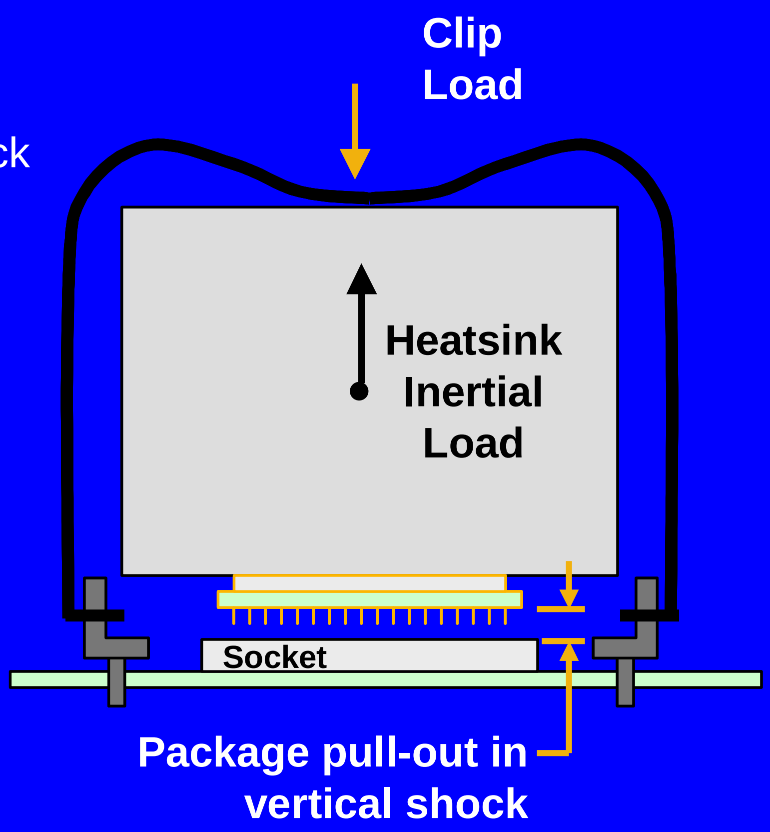
- Clip Lever
  - Generates preload
  - Engages with clip frame
  - Point contact to heatsink, centered on die
- Clip Frame
  - Carries preload to board
  - Attaches to board using through-hole mount anchors
  - Maintains heatsink position on die
- Heatsink
  - Distribute the load evenly onto the die

Design Effectiveness

- How does the Intel reference design meet these challenges?
  - Avoid processor package pull-out
  - Avoid socket solder joint damage
  - Avoid MCH solder joint damage
  - Prevent TIM (thermal interface material) thermal performance degradation
  - Allow chassis-independent solution

Processor Package Pull-Out - 1

- Both vertical and lateral shock conditions can produce pull-out
  - Pull-out occurs when heatsink moves up or shifts laterally excessively during shock
- Primary factors
  - Heatsink mass
  - TIM adhesion
  - Package Integrated Heat Spreader (IHS) area
  - Package pin geometry
  - Socket retention force
- ***Current solution approach:***
  - ***Compressive preload***
  - ***Stiff retention clip***



Processor Package Pull-Out - 2

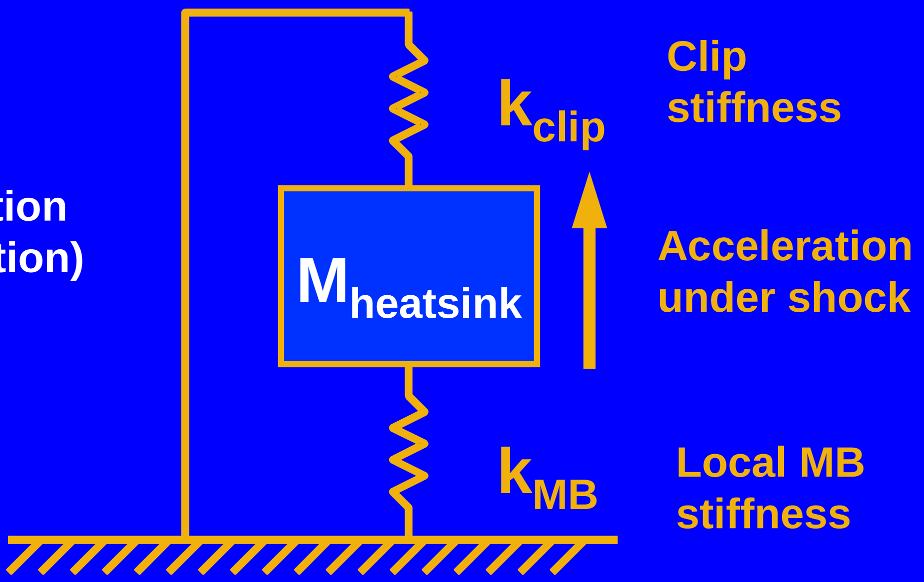
- How much preload is required?
  - Linear spring-mass model used for 1st order assessment
  - Assume zero socket retention force

Heatsink inertial load

F_{HS} = (Heatsink Mass)*(Acceleration input)*(dynamic amplification)

Required preload

$$P_{req} = F_{HS}\left(\frac{k_{MB}}{k_{clip} + k_{MB}}\right)$$

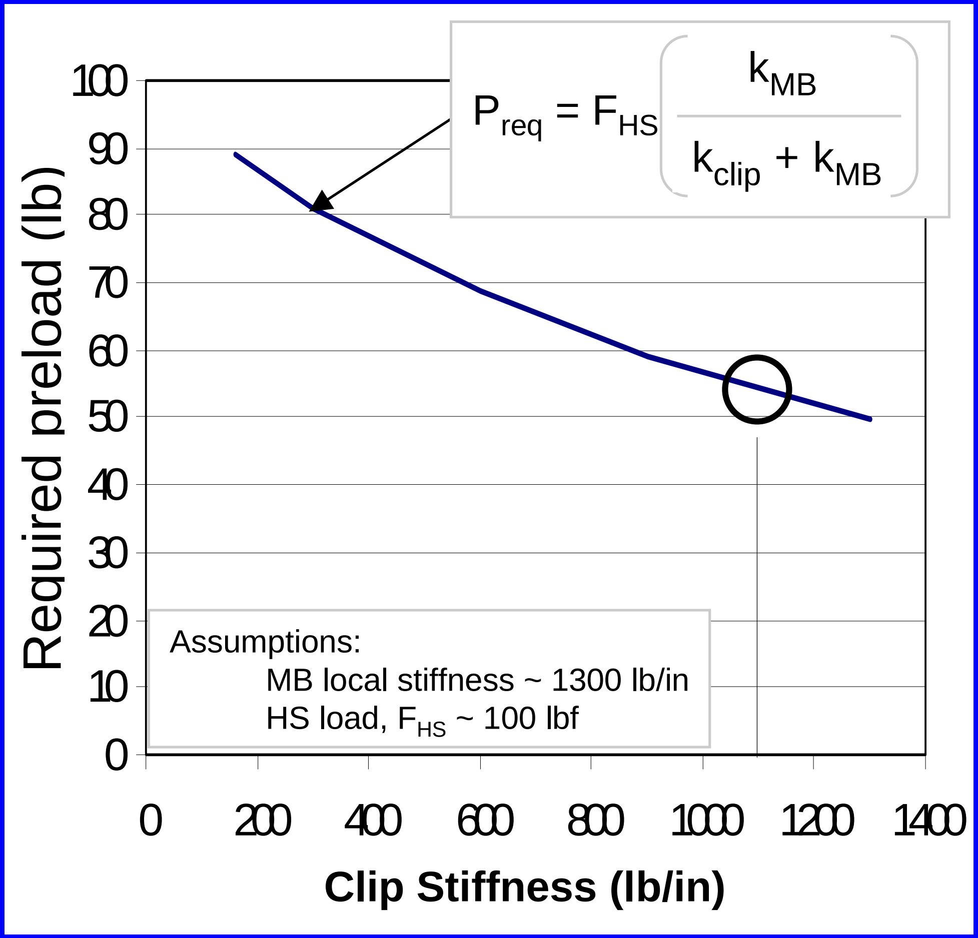


Required Preload is a Function of Clip and Board Stiffness

Processor Package Pull-Out - 3

- Increase in clip stiffness
  → ***Allows reduction in required preload***

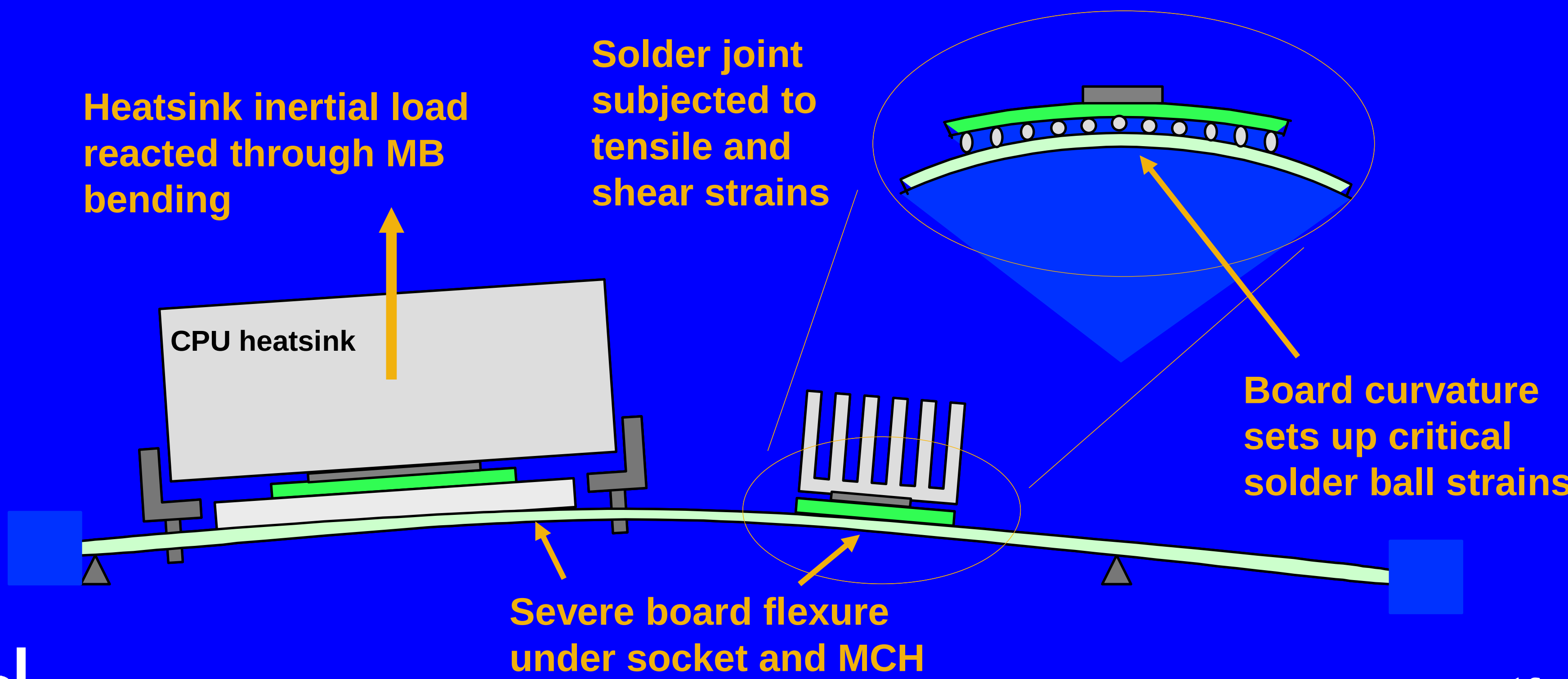
- Reference design leverages this relationship to minimize required preload:
  - Clip stiffness = 1100 lb/in
  - Required preload
    - ✓ ~ 55 lb minimum
    - ✓ ~ 70 lb nominal



*Note: Linear analysis: Not fully representative. Requires non-linear finite element analysis for accurate assessment.

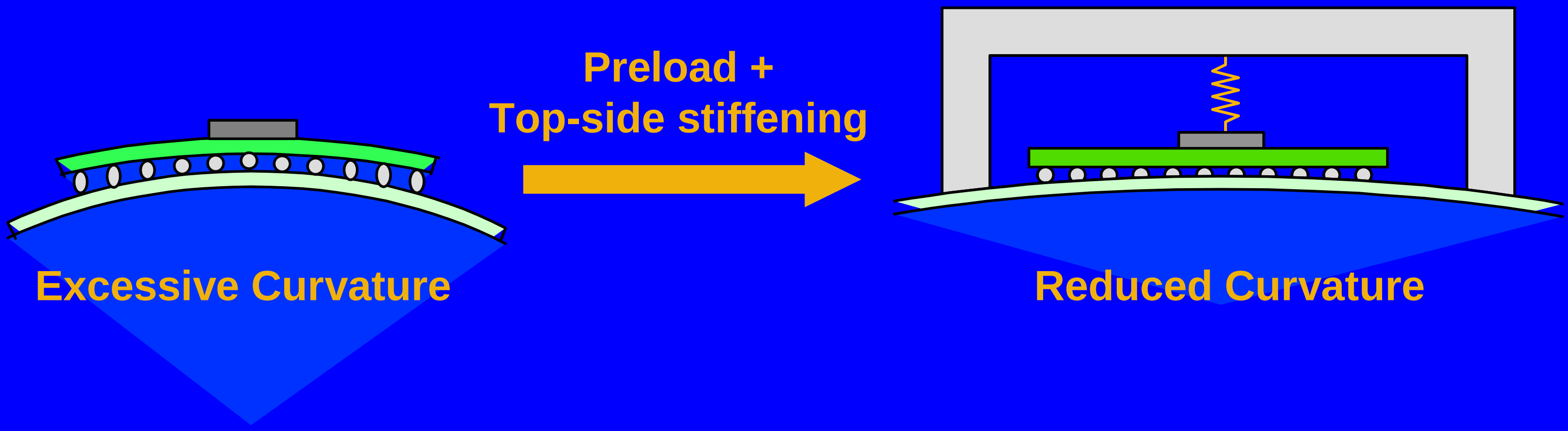
Solder Joint Considerations - 1

- Solder ball damage
  - Caused by MB flexure under mechanical shock loads
  - Heatsink inertial load reacted through MB bending



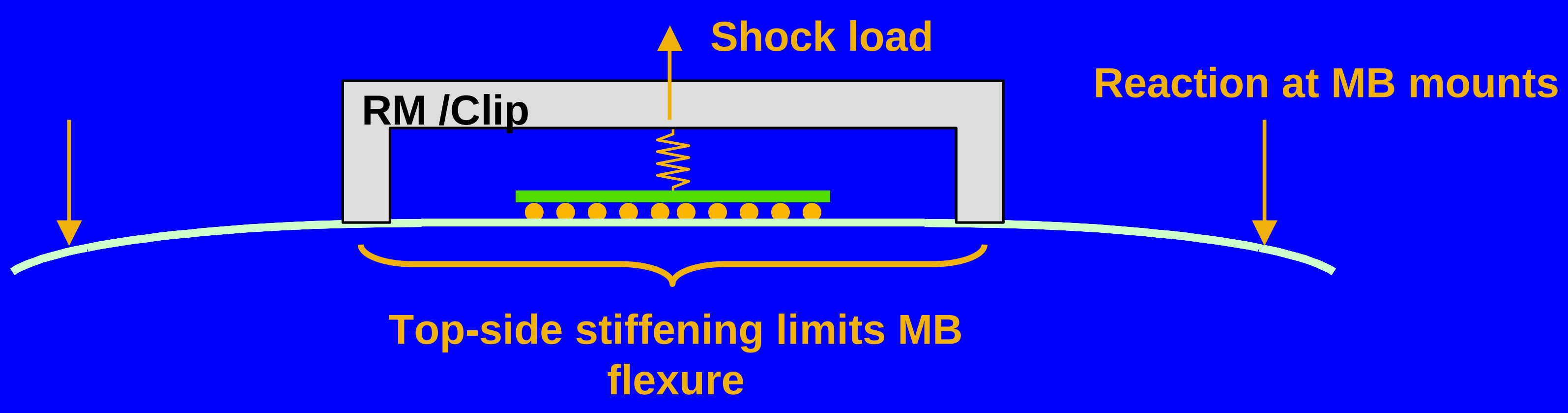
Solder Joint Considerations - 2

- Current Reference Solution Strategy
  - Limit local board curvature in critical areas through two-point strategy:
    1. Top-side stiffening of the MB provided by the clip
    2. Compressive preload
  - Applicable to socket *and* MCH



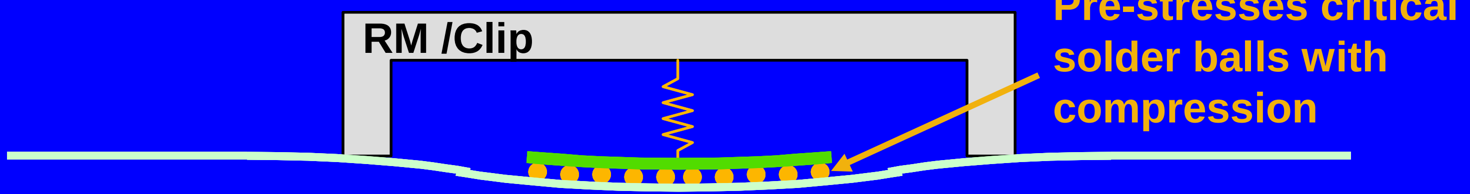
Solder Joint Considerations - 3

- Local Board Stiffening
  - RM and clip create stiff load path between board and package
  - Limits amount of local board flexure during +z shock condition



Solder Joint Considerations - 4

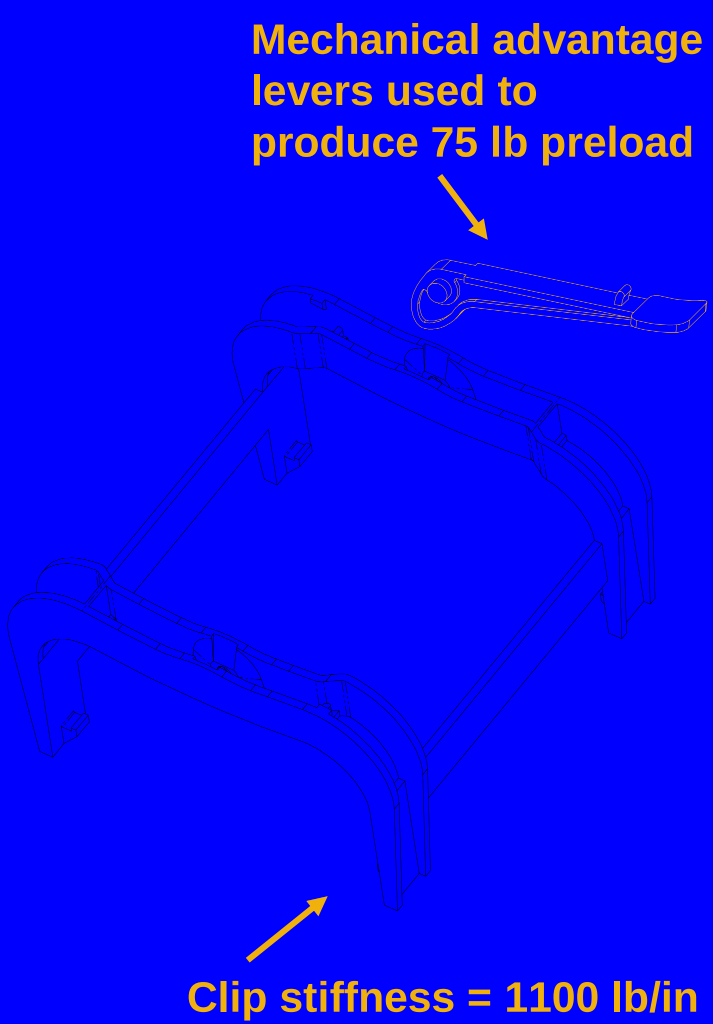
- Compressive Preload
  - Places MB into concave curvature in local region surrounding socket and MCH
  - Outer row solder balls placed in compression
  - Delays onset of critical tensile load during shock



Note: Applying a compressive preload on the processor package and on the MCH creates a bow to the board as described reference [6], slide 25. The Intel reference mechanical system designed for the Intel® Pentium® 4 processor in the 478-pin package has passed shock, vibration and long term reliability tests defined by Intel. Intel reference designs were tested in conjunction with the reference Intel® 845 MCH heatsink assembly. No platform failures related to board flexure were identified in long term reliability testing. This conclusion assumes that there is no change to the elements of the reference design assembly, and that it is used in conjunction with the reference Intel® 845 MCH assembly. Customers are responsible to fully validate the design they intend to use.

Intel® Pentium® 4 Processor in the 478-Pin Package Clip Design

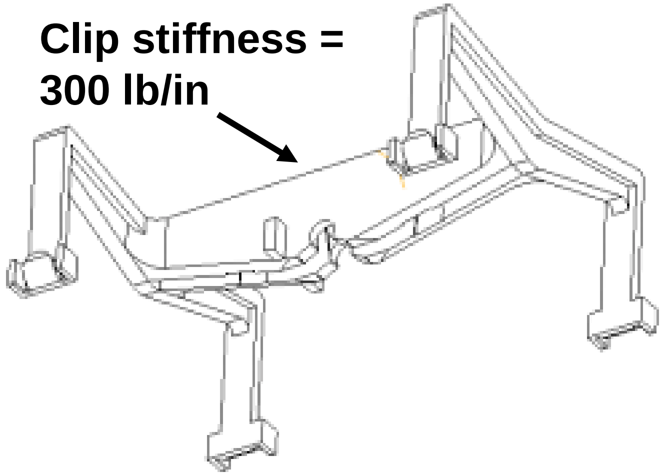
- Clip design tailored to achieve target stiffness:
  - 1100 lb/in
- Mechanical advantage levers generate preload:
  - 60 lb minimum
  - 75 lb nominal
- Performance under shock load (+z):
  - Compressive load between heatsink and package maintained: no package pull-out
  - Solder ball load prevents from excessive tensile loads, and provides protection to socket solder joint.

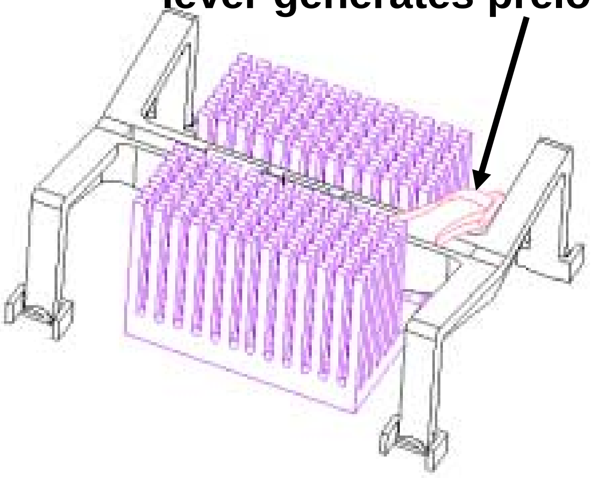


Design Effectiveness

Intel® 845 MCH Clip Design

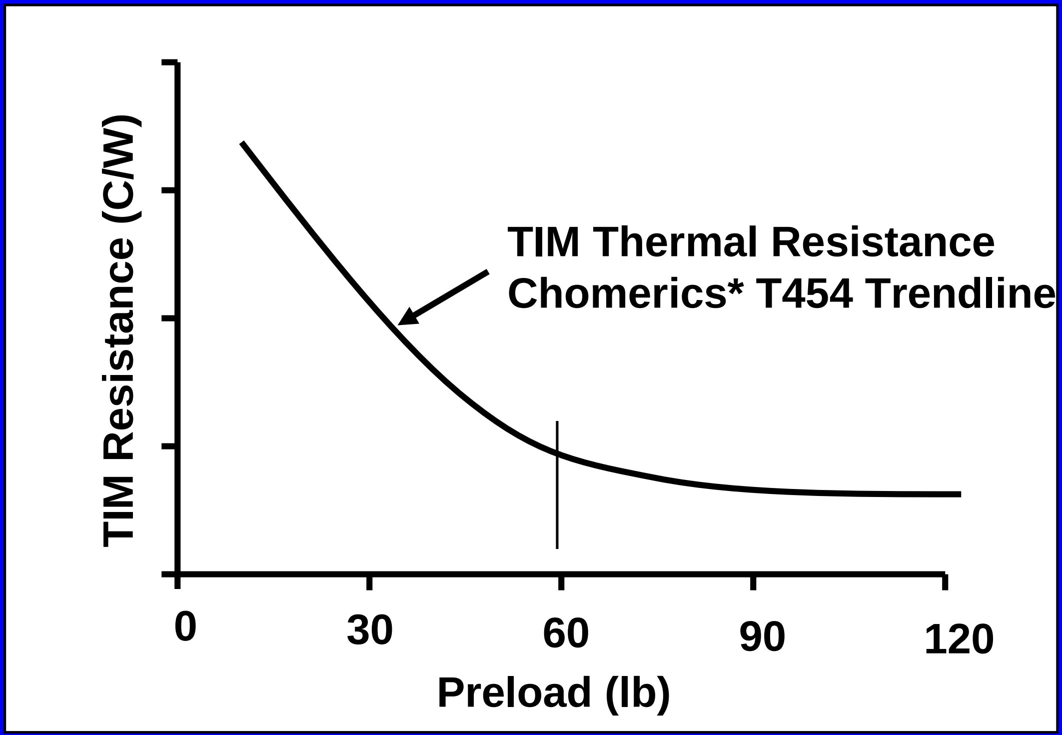
- Clip design tailored to achieve target stiffness of 300 lb/in
- Mechanical advantage levers used to generate 36 lb preload
- Performance under shock load (+z):
  - Local board flexure is reduced
  - Solder ball load prevents from excessive tensile loads, and provides protection to MCH solder joint.





Thermal Performance

- Test data indicates 60+ lb preload necessary to optimize TIM performance (Chomerics* T454 - phase change)
- Reference design preload target:
  - 60 lb minimum
  - 75 lb nominal



Design Effectiveness

Summary

- Processor Package Pull-Out
  - Use preload coupled with stiff clip to prevent pull-out
- Socket Solder Joint Protection
  - Use preload coupled with stiff clip to avoid excessive tensile loads on solder joint
- MCH Solder Joint Protection
  - Use preload coupled with stiff clip to avoid excessive tensile loads on solder joint
- Thermal Requirements
  - Use preload to achieve TIM performance
- Chassis-Independent Solution
  - Allows motherboard design flexibility
  - Supports horizontal building block approach

Intel Reference Design Meets the Primary Mechanical Challenges

In Summary

- Five primary challenges addressed:
  - During shock and vibration events:
    - ✓ Avoid processor package pull-out
    - ✓ Protect against socket solder joint damage
    - ✓ Protect against MCH solder joint damage
  - Prevent TIM thermal performance degradation
  - Allow chassis-independent solution
- Preload is critical element in addressing each challenge
- Stiff clip is critical in preventing package pull-out and protecting solder joint
- Intel Reference Design combines both strategies to meet all critical requirements

Collateral

- Vendor information for the Intel Thermal Mechanical Enabling Reference design is available at the following web site: **http://developer.intel.com/design/Pentium4/components/478pin.htm**

- The following collateral is available in the Pentium® 4 Processor section of the developer.intel.com web site (**http://developer.intel.com/design/pentium4/**):

1. Intel® Pentium® 4 Processor in the 478-pin Package at 1.50 GHz, 1.60 GHz, 1.70 GHz, 1.80 GHz, 1.90 GHz, and 2GHz Datasheet
2. Intel® Pentium® 4 Processor in the 478-Pin Package Thermal Design Guidelines
3. Intel® Pentium® 4 Processor Specification Update
4. Intel® Pentium® 4 Processor Support Components (478-pin)
5. Intel® Pentium® 4 Processor 478-Pin Socket (mPGA478) Design Guidelines
6. Assembling Intel Reference Components for the Intel® Pentium® 4 Processor in the 478-Pin Package

- The following collateral is available in the Chipset section of the developer.intel.com web site (**http://developer.intel.com/design/chipsets/**):

7. Intel® 845 Chipset Thermal and Mechanical Design Guidelines
8. Intel® 850 Chipset: Thermal Considerations Application Note AP-720

- The following collateral is available at **http://www.formfactors.org** web site:

9. System Thermal Design Suggestions

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