

# Virtium Industrial SSD Temperature Screening Process

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## Abstract

While there exists different classifications of NAND flash targeted for different applications, e.g. consumer/client, industrial/embedded, and enterprise/datacenter, this paper discusses the use of industrial/embedded in commercial (0°C to 70°C) and industrial (-40°C to 85°C) temperature ranges as part of solid-state storage devices.

This paper covers the standard temperature uprating process for the industry as well as the temperature uprating process for Virtium products and the benefits Virtium provides by screening commercial temperature rated components for use in industrial applications.

## Introduction

Solid State Storage Devices (SSD) play an increasingly essential role in both commercial and industrial applications, not only because of their size, weight, and power advantages but also because of their resilience to temperature.

Within the SSD, NAND is the primary flash-memory component and would be required to operate within specific temperature standards for the drive to be considered viable for industrial applications. Given the right temperature screening methodology, a process often referred to as “uprating”, commercial temperature NAND can be screened to verify their operability for use in high and low temperature industrial applications.

Leveraging a wealth of experience, Virtium has developed a comprehensive suite of screening and validation processes to produce SSDs that exceed industry standards for reliability and capability.

# NAND Flash Fabrication and Screening Overview

## NAND Flash Fabrication

A solid-state storage device, commonly referred to as a Solid-State Drive (SSD), consists of a controller, NAND flash, sometimes DRAM, and other electrical and timing components. Within these devices, NAND is the primary storage component of the drive.

During the fabrication process, individual NAND die are populated in quantity upon a single pure silicon wafer. Once fabrication is complete, each die on the wafer are probed-tested to assess its functional capability. During this classification, NAND die are sorted and binned based on their functional capability to ensure quality and reliability. NAND die deemed to be of the highest grade are typically reserved for use in data centers and other industrial applications.

Lower grade NAND die are often used for consumer-oriented applications where competitive pricing is of higher value than higher quality and reliability and where the usage characteristics are not as intense as would be with many data center and industrial applications.

Examples include retail USB and memory cards and lower end smart phones and tablets. Following probe-testing, the NAND wafer is cut into individual NAND die and then the die are packaged into either a ball grid array (BGA) or thin small-outline package (TSOP).

Additional burn-in processing may be performed once the NAND die are placed in the BGA or TSOP packages. From there, NAND may be re-rated to validate operating temperature ranges at the commercial grade range (0°C to 70°C) or industrial grade range (-40°C to 85°C). In general, a vast majority of NAND flash available in the market are only tested at the commercial temperature range while a smaller fraction may be screened at the higher industrial temperature required for industrial use.

## Industrial and Commercial Temperature Screening

Commercial and industrial grade NAND are derived from the same fabrication process, and thus possess the same intrinsic device reliability; however, these components are screened under different ranges of operating temperature. NAND approved for commercial use are screened to function within a temperature range between 0°C to 70°C, while industrial NAND are screened to operate between -40°C and 85°C.

Within the industry, SSD manufacturers may opt to use NAND components that are pre-screened for industrial temperature range by the NAND manufacturer. However, this typically comes at a higher cost. Because commercial and industrial temperature components share the same wafer and die characteristics, SSD manufacturers may also choose to upgrade commercial temperature components in-house by screening for the components' functional capabilities over the industrial temperature range.

In some cases, SSD manufacturers with strategic relationships with NAND manufacturers can follow approved NAND screening processes approved by the NAND manufacturer, thus providing identical outcomes.

## Industry Standard Temperature Screening

Temperature screening evaluates the capacity of the individual NAND or the complete drive to function beyond the temperature range screened by the manufacturer. It is also an accepted standard process across multiple industries. For instance, NASA and the US Department of Defense, which respectively holds the most stringent standards for components and utilizes its commercial off-the-shelf (COTS) program, are among the entities which accept temperature screening.

The temperature screening process is feasible because NAND die, regardless of rating, are fabricated together on the same wafer and designed to function within a significant temperature margin. While an individual NAND die may be approved by the manufacturer to operate within the commercial temperature range, with proper screening, inherently “stronger” die (fewer weak cells/bits) may also meet the specifications for industrial applications.

Temperature screening thereby validates that NAND currently approved for commercial applications are capable of meeting industrial applications as well. This process is critical to industry sustainability, as supply of commercial temperature NAND is generally greater and commands a lower cost when compared to the pre-screened industrial temperature rated NAND counterparts.

## The Virtium Screening Process

### Virtium Temperature Screening

Virtium screening involves an incorporated process that is executed at the module level to ensure the finished product performs reliably throughout its designated temperature range. By screening beyond individual component level, Virtium validates that each component of the drive works as stated and ensures that each finished product functions well within the Industrial temperature range.

Each SSD produced by Virtium is evaluated based on performance during a cold -boot test, which examines initiation of module operations at temperatures as low as -40°C and as high as 85°C.

In addition, each module is screened under extreme temperature and voltage conditions, including low temperature testing at low voltage, low temperature testing at high voltage, high temperature testing at low voltage and high temperature testing at high voltage. These conditions cover a wide range of conditions that mirror field applications and represent the most common points of drive failure cited by customers.

In addition, the Virtium screening process utilizes a proprietary thermal management technique. By adjusting the frequency of the SSD controller and NAND in addition to applying a heat spreader for thermal regulation, Virtium can examine the burn-in process for each module to verify high performance at low and high temperatures over an extended period of time. This is a critical step in the process as it aids in identifying the possibility of early failure of the SSD leading to lower chances of failure in the field.

Virtium also validates that each module is able to perform a cold-boot test at extreme temperatures. The cold-boot process, especially at low temperatures, results in the highest rate of drive failure in comparison to all other conditions examined during screening, as it puts extreme stress on the power delivery circuits of the SSD.

By evaluating the complete module under these extreme conditions and employing comprehensive testing at all temperature and voltage levels, Virtium SSDs are uniquely suited for industrial applications and provide the best overall balance of performance and reliability.

Furthermore, each new generation of NAND used in Virtium products also undergoes an additional 1000 hours of testing to ensure resiliency during temperature screening. Figure 1 below provides a high-level overview of Virtium’s temperature screening process.

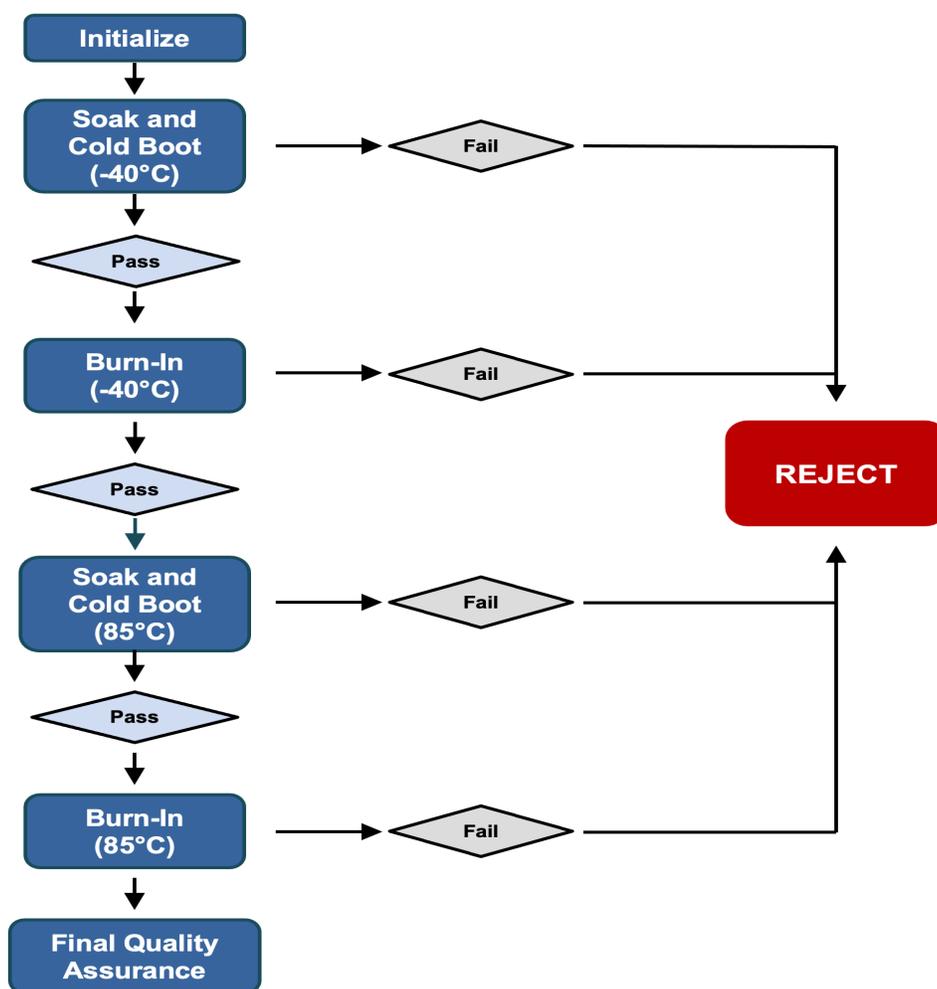


Figure 1. Virtium Temperature Screening Process.

## Benefits of Virtium Screened Products

Virtium has over 20 years of experience screening commercial temperature solutions to function reliably within industrial temperature environments and has been supplying these solutions in volume to many of the industry's largest and most well-respected OEM manufacturers.

The Virtium internal screening process has been validated for equipment used in industries such as industrial automation, medical, telecommunications, transportation, and military and aerospace and tests thoroughly beyond industry standards to assure comprehensive module performance.

Virtium screening and performance calibration techniques provides numerous benefits to our partners and customers. While many manufacturers only temperature screen NAND, Virtium performs screening at the finished SSD level to mitigate any escapes and to ensure quality before leaving the factory. In addition, by using commercial temperature NAND, Virtium can provide modules at a lower cost and shorter lead-time as these components are generally more readily available.

By stepping beyond industry standards and utilizing thorough screening processes, Virtium can reliably and consistently deliver high quality SSD solutions without sacrificing performance or reliability.

## Conclusion

Within the SSD, NAND are the primary flash-memory components and are rated to function within specific temperature ranges, with both commercial and industrial NAND fabricated in tandem. Through temperature upratingscreening, NAND flash rated for commercial temperature use by manufacturers may undergo additional screening to validate functionality at a wider temperature range to be used for industrial applications.

With a wealth of experience, Virtium's sole mission is to supply its partners and customers with the most reliable and capable products, screened and validated beyond industry standards, to support the toughest mission-critical applications, while also supporting lower cost and shorter lead time compared to solutions pre-screened by the NAND manufacturers themselves.

Visit [www.virtium.com](http://www.virtium.com) or contact your local Virtium sales, manufacturer's representative or distributor for more information, including how to request samples and pricing.

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Virtium manufactures memory and storage solutions for the world's top industrial embedded OEMs. For two decades we have designed, built and supported our products in the USA - fortified by a network of global locations. Our world-class technology and unsurpassed support provide a superior customer experience that continuously results in better industrial embedded products for our increasingly interconnected world.

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