

# HP Hard Disk Drive Quality System – The Driving Force of Reliability



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# Purpose

This document informs customers of the various stages that SCSI, SAS, and SATA hard disk drive (HDD) product candidates must experience before they are HP-qualified.

## Introduction

HP has developed strong long-term working relationships with all of its HDD suppliers. HP engages with HDD suppliers in researching new technologies, product requirements, long-range product roadmaps, new features, and defining requirements for product designs. HP also works with HDD suppliers two to three years in advance of product availability to ensure technology feasibility and successful system integration.

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### HP's HDDQ benefits suppliers

"The HDDQ initiative is one that provides a sustainable advantage for HP through clearly-defined qualification expectations and deliverables. This in turn drives our (the supplier) resource management process to insure the correct level of human and equipment capital are in place to support HP's time-to-market product launch."

-Seagate Technology, Inc.

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In order to bring HDD product candidates to market, candidates must meet stringent requirements in an HDD product qualification process by HP to ensure that the HDD product is reliable, meets customers' requirements, and is time to market.

The HP HDD product qualification process assures customers that continuous improvement occurs in the current and future products and processes. These continuous improvement actions benefit the HDD supplier, HP, and more importantly, the customers.

These steps are defined in four specific areas:

1. Selection Evaluation
2. Development Validation
3. Supplier Production Qualification
4. Continuous Improvement/Performance Monitoring

When customers purchase HP Hard Disk Drives (HDD), they have the assurance that the HDDs have gone through one of the most disciplined and well-structured processes within the industry.

## Step One: Selection Evaluation

The Selection Evaluation phase's focus is in the following areas:

- Meeting customer requirements
- Research/development of specifications
- Research/development of potential sources
- Assessment feasibility of new technologies
- New technology development

During the Selection Evaluation step, HP typically receives early prototypes and development samples from HDD suppliers. Focus is on development and integration of new technologies, conformance to specification requirements, interface signal integrity analysis, and performance analysis. HP provides significant feedback and guidance to the HDD suppliers, which ultimately increases probability of a successful qualification and equates to a better product.

The HDD Advanced Engineering – Selection Evaluation phase is accomplished through a thorough assessment of the HDD Supplier. The device requirements and specifications are documented by HP's HDD industry-recognized Hard Disk Drive Qualification (HDDQ) System and provided to HDD suppliers during product conception phases. HP conducts HDD Technology Reviews, Product Design Reviews, and Product Readiness Assessment Reviews with all potential HDD sources.

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HP's HDDQ includes latest technology

“HP continues to extend their lead in the area of hard disk drive qualification methods by evolving their highly acclaimed HDDQ system to encompass the latest serial interface architectures such as SAS and SATA.”

-Fujitsu

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HDD product selection

HP uses a Core Team approach for assessing the HDD supplier's capabilities, technology, and products. This Core Team consists of members of Advanced Technology Engineering, Development Engineering, Program Management, Procurement, Procurement Engineering, and Marketing. HP provides the HDD supplier thoroughly documented requirements and deliverables far in advance of any product development. The Core Team assesses the HDD supplier's technology, product design, program plans, past track records, and manufacturing capabilities as part of the assessment of selection and then ultimately makes a decision on pursuing the best supplier and product.

HDD product candidates that are deemed viable from the requirements and schedule perspectives as determined by HP's HDD Advanced Engineering – Selection Evaluation phase are then submitted to HP's HDD Design Development – Product Validation phase. HDD products that are submitted to this phase typically have a good probability of making it to production.

## Step Two: Development Validation

The Development Validation phase's focus is in the following areas:

- Validate conformance to specification
- Validate system compatibility
- Measure initial product quality
- Measure initial product reliability

The HDD Development Validation phase is accomplished through a tight collaboration between HP and HDD suppliers in addition to an extensive system integration sequence covering all appropriate HP applications.

The device level development and validation requirements are documented by HP's HDDQ System via a set of specifications, procedures, and test software developed and maintained by HP. Then, HP authorizes select suppliers to have access to and have use of the HDDQ System by way of a licensing program.

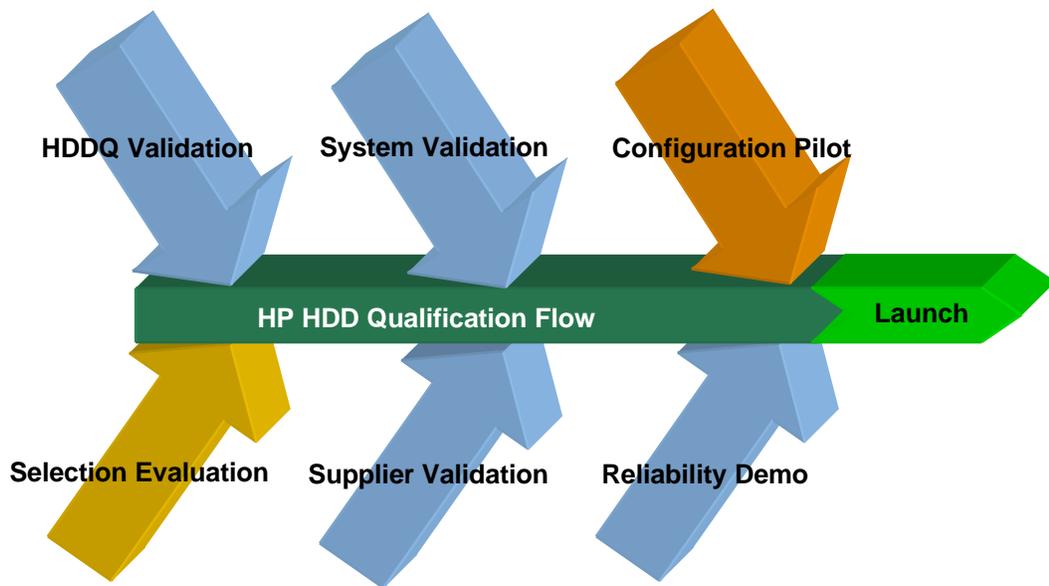
The HP system compatibility aspects of an HDD product are validated through a series of test sequences defined by a set of matrices that describe representative configurations, including both HP legacy and new storage applications. Typically, approximately 1,000 unique HDDs are used to evaluate a product family during the Development Validation phase, and approximately 2 million drive test hours occur during each family qualification.<sup>1</sup>

HP's HDD development team, in conjunction with HP's HDD suppliers, has the responsibility in the conformance to specification validation, in the measurement of initial quality, and in the measurement of initial reliability aspects of an HDD product.

In Figure 1 below, the system compatibility aspects of this phase are almost totally the responsibility of HP's HDD development and system integration teams. The blue segments are a graphical representation of where the Development Validation phase is in during an HP HDD qualification sequence flow.



Figure 1. HP HDD Qualification Flow.



<sup>1</sup>Numbers of drive and hours apply to SCSI and SAS drives; Numbers for SATA drives vary.

Just as in the Selection Evaluation Phase, HP has extremely close ties to select HDD suppliers during the Development Validation phase as well. From HP's and the supplier's perspective, it is a seamless transition from the Selection Evaluation step to the Development validation step. Each HDD qualification is a collaborative effort between HP and HDD suppliers. Each supplier has established an HP HDDQ lab and across all HP suppliers, there are a few hundred HP servers at supplier labs.

HP has a Supplier HDDQ licensing program and at HP's discretion, select HDD suppliers are licensed to receive and use HP's procedures and tools in the development and validation of HDDs. HP supplier testimonials document the value of HP's HDDQ System to HDD conformance to specification, quality, and reliability.

Where necessary, HP and suppliers collaboratively design, implement, and subsequently prove HDD features or functions to provide the most optimal HDD products for HP's applications. The HDD will still conform to industry standards, but these features or functions may result in an HP-tailored HDD product.

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#### HDDQ permits optimal, tailored products

"Hitachi GST has implemented the HDDQ process throughout our entire development, manufacturing, and quality processes. The HP HDDQ process allows us to develop and manufacture products that not only meet HP's high quality and reliability standards, but also helps us improve and insure our overall product quality."

- Hitachi Global Storage Technologies

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Some example areas include:

- Performance optimization enhancements for HP arrays
- Storage management features
- Pre-Failure Warranty
- Cross platform and legacy compatibility assurances
- Universal drive proofing
- Consistency and predictability across HP HDD products in error recovery and exception case handling which may be open to interpretation in industry standards.

This relationship facilitates timely market delivery of new capacities, speeds, and other feature/functions that keep HP the leader in HDD technology delivery to the storage marketplace.

#### HP's HDDQ system

HP's HDDQ System documents the device level segment of the Development Validation phase. It consists of an extensive set of HP developed and maintained documentation that includes specifications, procedures, software, and associated measurement criteria.

There are approximately 50 procedures and specifications that make up the HDDQ System. Each licensed select supplier has invested resources to the extent that they have the capability of executing all of these procedures in their labs. The specifications and conformance validation procedures used in an HP HDD qualification are not necessarily what one would find on supplier web sites or other sources of product information from suppliers. In several areas including electrical, mechanical, and firmware, HP has defined the test sequences and criteria such that the HDD performance and reliability will be optimized for HP's applications.

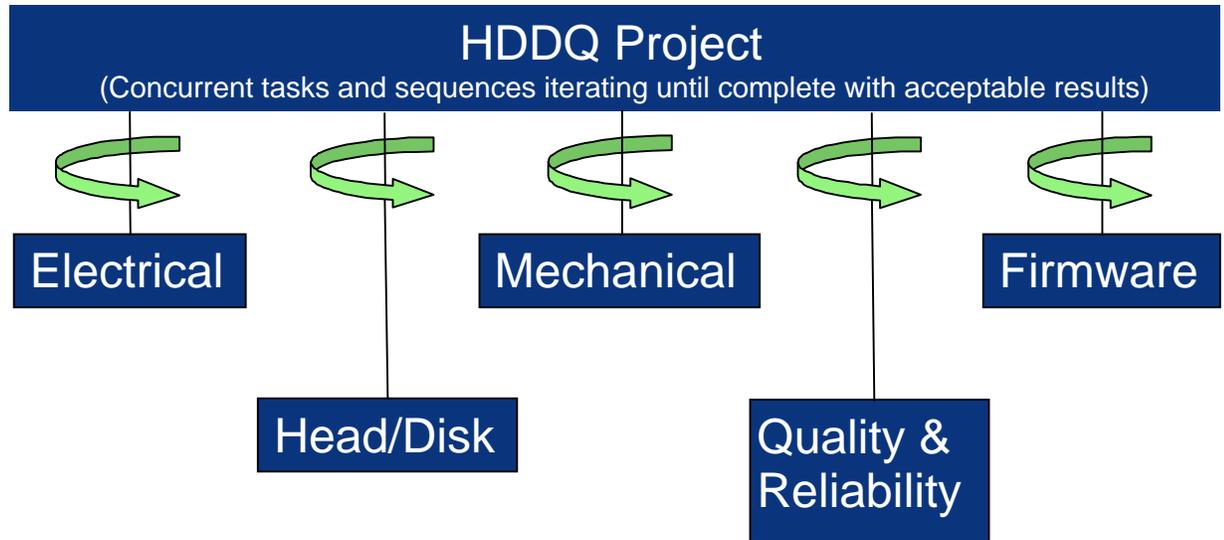
Disciplines and the associated validation coverage's contained in HP's HDDQ System are described in the following table.

Table 1. Disciplines and Validation Coverage in the HDDQ System.

Discipline	Validation Sequence		
Electrical	Signal integrity	Power consumption	Noise injection
	Power variation	EMI	Hot plug
Mechanical	Operational shock	Non-Operational Shock	Vibration
	Acoustics	Drive mounting analysis	Storage application mounting analysis
Firmware	Conformance to specification	Configuration establishment	Operational stress conditions
	Performance	Reliability and robustness	Typical approximate 100,000 drive hours
Quality and Reliability	Large quantity in a defined sequence of events	Statistical analysis of results with projections	Approximately 1,000,000 drive hours
Head/Disk	Durability	Longevity	Storage

As can be seen from the figure below, the HP HDDQ System architecture is such that the validation of the major functional disciplines of an HDD product can take place in parallel and iterate on their own schedule until project completion.

Figure 2. Major functional disciplines of an HDD project.



## Step Three: Supplier Production Qualification

Hard Disk Drive (HDD) product candidates that are submitted to HP's HDD Design Development – Product Validation phase are submitted, in parallel, to the Supplier Production Qualification phase. The Supplier Production Qualification step focus is in the following areas:

- Validate Supplier process capability
- Validate Supplier process controls
- Measure product quality

It is important for HP to determine the production and process capabilities of an HDD Supplier in order to ensure the quality requirements can be achieved. The Supplier Production Qualification phase requires a thorough analysis of the Supplier's capabilities. The analysis includes extensive review of the Supplier's process controls, closed-loop corrective action processes, and overall quality system. The final stage of the Supplier Production Qualification step includes a comprehensive analysis of the product's quality performance via the HP configuration pilot.<sup>2</sup>

Early in the qualification process, HP begins working with the HDD Supplier to understand and to develop production and process capabilities. This phase begins with a Process Design Review with emphasis placed on lessons learned from previous generation products. These lessons learned are then reviewed and verified to have corrective actions incorporated into the new product's process. The HDD Supplier's process capabilities are also evaluated thoroughly. This involves a weekly evaluation including HDD factory yields, Paretos, Cpk data, post-process test data, corrective action, and improvement plans. In addition, HP works closely with the HDD Supplier to ensure process control plans exist that will enable real-time quality monitoring, corrective actions, and improvement plans at every process step.

HP personnel validate the HDD Supplier's process capabilities and control plans through Supplier Factory Audits. This includes an on-site resident International Procurement Organization (IPO) resource that is available to assist with necessary audits, problem identification, and issue resolution.

One of the key aspects of the Supplier Production Qualification phase is the HP configuration pilot, which involves the building and testing of SCSI and SAS HDDs into HP-configured option kits. The objective of the configuration pilot is to demonstrate that the HDD Supplier's production volume will meet HP's quality requirements. HP uses statistical processes to establish pass criteria for the configuration pilot. The configuration pilot requires a significant quantity of HDDs, ranging from 3,000 to 4,000, in order to fully demonstrate HP's quality requirements will be achieved. The test parameters used to measure the product's performance to these criteria include:

- 10% OBA functional test
- 100% of the HDDs are tested through HP's Extended Quality Audit Test (EQAT)
- First article inspection (FAI) samples
- The results of the configuration pilot are directly linked to the product release decision.

Products that do not meet the configuration pilot criteria will require corrective actions and a subsequent configuration pilot will be run to verify the corrective actions prior to product release.<sup>3</sup>

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<sup>2</sup> HP configuration pilot requirements vary across hard drive interfaces.

<sup>3</sup> This HP configuration pilot phase of the qualification process applies only to SCSI and SAS hard drives

## Step Four: Continuous Improvement

HDD products that pass the extensive HP qualification process then proceed into HP's HDD Performance Monitoring – Continuous Improvement phase during volume production. The Performance Monitoring – Continuous Improvement phase's focus is in the following areas:

- Validate volume production is in process control
- Measure, analyze, and react to product quality data
- Deliver continuous product improvements

HP and the HDD Supplier accomplish the Performance Monitoring - Continuous Improvement phase through mutual execution of the HP HDD closed-loop quality system. The requirements and procedures of this phase are documented in HP's Supplier Management Process (SMP) System. The quality system helps ensure volume products meet HP quality and reliability requirements.

HP and the HDD Suppliers work closely together as a team during the volume production phase of a product. The team monitors the performance of each product through quality control methods at both the Supplier's factory and HP option kitting configuration sites.

HP and the HDD Supplier then review all product quality data on a daily, weekly, and monthly basis. The product quality data includes:

- Supplier factory yields
- Paretos
- Critical process parameters (Cpk)
- Drive out of box audit (OBA) DPPM
- Ongoing Reliability Test (ORT)
- Field reliability performance
- Option kit OBA DPPM<sup>4</sup>
- Option kit 36 hour extended quality audit test (EQAT) DPPM<sup>4</sup>

The performance is measured and reviewed against HP-established goals for all quality metrics. Quality and reliability improvement plans are then worked continuously between HP and the HDD Supplier to ensure all quality metric goals are achieved and exceeded.

An additional component of the volume production phase of a product is the ongoing change management. If a change is required to a product/process design, for any reason, the change request is submitted to HP by the HDD Supplier for review or by HP to the HDD Supplier. The changes are then validated through the HP HDDQ qualification process. The change management process helps ensure a product change does not negatively impact product quality, reliability, system compatibility, or conformance to the specification.

## Closed-loop Quality System

HP's closed-loop quality system includes multiple quality controls and monitoring systems. These quality controls and monitoring systems ensure the product meets HP's quality and reliability requirements. The controls will alert HP and the HDD Supplier to any "out of control" conditions and quality issues, allowing HP to contain nonconforming product and implement corrective actions prior to shipment of nonconforming product to customers.

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<sup>4</sup> This information only applies to SCSI and SAS hard drives

The closed-loop quality system consists primarily of the following three stages and their respective quality monitors (see Figure 3):

- HDD Supplier manufacturing
  - Quality monitors including in-process critical process parameters, Ongoing Reliability testing (ORT), and post-process out of box audit (OBA) testing.
- HP Option Kit Configuration Center
  - Quality monitors include functional testing, post-process out of box audit (OBA) testing, and post-process EQAT (36 hour) functional testing.<sup>4</sup>
- Customer Field Return Analysis
  - Quality monitors include root cause analysis of field returns.

The quality monitors and reaction plans associated with these monitors are all determined based on Statistical Process Control (SPC) and continuous sample plan methods. The test parameters and process controls associated with these quality monitors are described in more detail in the following table.

Figure 3. HP Closed-Loop Quality System.

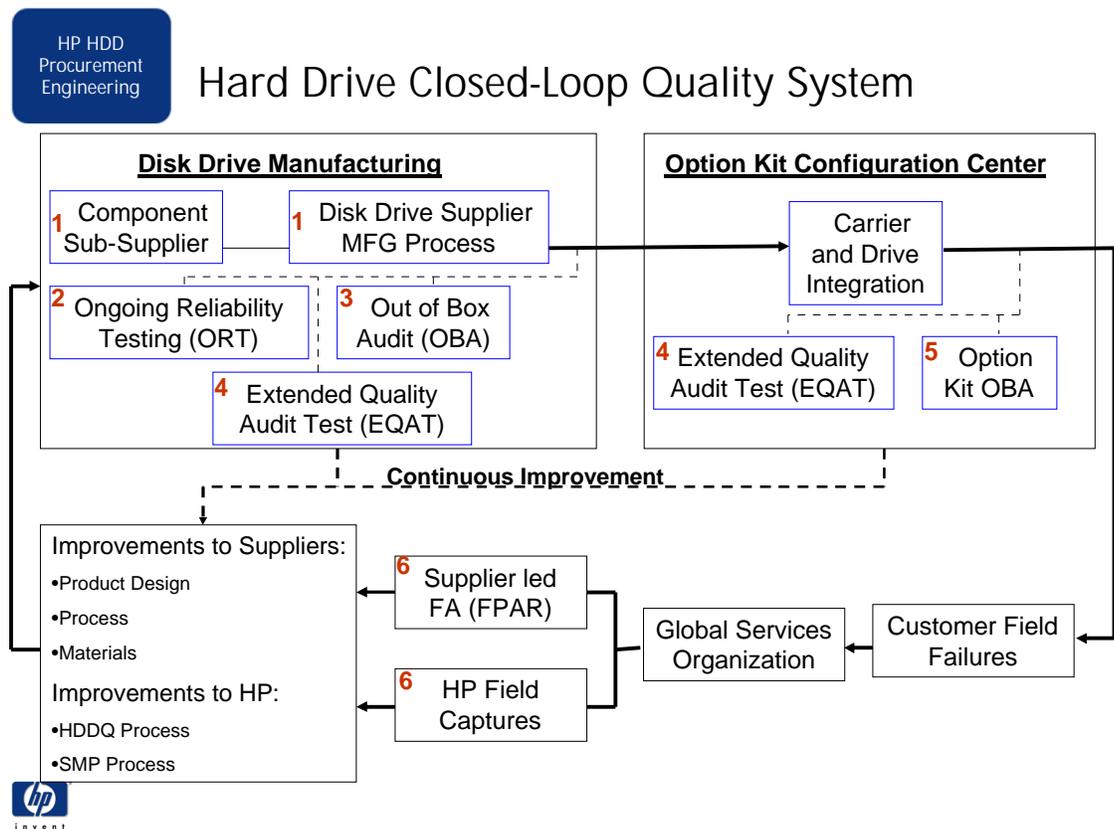


Table 2. Test parameters and process controls for quality monitors.

Item	Process Step	Test Parameter	Process Control
1	Component Sub-supplier & Disk Drive Manufacturing Process	Process Management Plan	Monitoring, controlling reaction of critical parameters
2	Ongoing Reliability Test (ORT)	Reliability Monitor	Per Supplier Plan
3	Out of Box Audit (Drive OBA)	Measure outgoing quality	Per Supplier Plan
4	Extended Quality Audit Test (36 hr)	Continuous sampling of drives every 36 hours. Testing under pre-merger CPQ H/W and S/W configuration	N=168 AOQL=0.50%
5	Out of Box Audit (Option Kit OBA)	BOM validation and functional test	Continuous Sample Plan (CSP-1) AOQL=1.22% 10% sample
6	Customer field returns	Field Pareto Analysis Reporting (FPAR)	Monitor of field Annualized Return Rate (ARR) performance. Improvement plans based on top Pareto returns

As can be seen from the closed-loop quality system, feedback mechanisms exist in each stage that allows continuous improvement to occur in the current and future products/processes. These continuous improvement actions benefit the HDD Supplier, HP, and HP customers.

A fundamental aspect of the HP closed-loop quality system is the HP Eight Discipline (8D) approach to problem solving. The 8D approach is utilized during all quality issues, quality monitor triggers, customer-escalated issues, or anytime a corrective action is required. The primary purpose of the 8D approach is to serve as a tool to facilitate the root cause understanding of an issue in order to prevent future recurrence.

## Summary

In order to bring HDD product candidates to market, the candidates must meet the stringent requirements of HP's Quality System to ensure that the HDD product is reliable, will meet the customer requirement, and is time to market. The four steps that HDD product candidates must experience assure customers that HP has developed and maintains one of the most disciplined and well-structured processes within the technology industry.

The following steps have been defined and must happen prior to the HDD product being considered HP qualified.

1. Selection Evaluation
2. Development Validation
3. Supplier Production Qualification
4. Continuous Improvement/Performance Monitoring

Working closely with HDD suppliers far in advance of product availability and qualifying HDD technology to the above four-step process, HP can ensure technology feasibility and successful system integration for its customers, thereby giving the customers what they really need at the end of the day - peace of mind. Customers can be at ease, knowing that HP has poured over 500 years of combined technical expertise into the selection, qualification, and ongoing support of their HDD product.

By purchasing HP HDD products, customers have bought into a tradition of excellence and commitment that consistently produces the highest quality at competitive price points, designed to fully integrate across the HP enterprise class line of servers and storage.

What better endorsement could we ask than from our own suppliers? As Hitachi put so meaningfully:

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"Hitachi Global Storage Technologies again thanks HP for providing us the HDDQ process. We believe the HP HDDQ is the leading hard disk drive qualification process in the industry. As such, the process helps not only us improve our quality, but it helps the entire industry improve."

- Hitachi Global Storage Technologies

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We couldn't have said it any better.

## For more information

<http://www.hp.com/products/harddiskdrives>

<http://www.hp.com/products/smartarray> and

<http://www.hp.com>

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