HDV300 & HDV400

Benchtop Horizontal Digital Video Comparators

User Manual

Starrett Kinemetric Engineering

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1. PREFACE

1.1 Welcome

Thank you for purchasing an HDV300 or HDV400 Benchtop Horizontal Digital Video Comparator. We are pleased that your search has led you to Starrett Kinemetric Engineering, a subsidiary of the L.S. Starrett Company. This manual is intended to maximize your satisfaction with your system and ensure the best operating performance. Please feel free to contact Starrett Kinemetric at any time. We value your feedback and your satisfaction as a customer.

1.2 Safety Symbols & Terminology

The following symbols and terms are used in this manual to call attention to important safety issues. Heed these notices carefully in order to avoid personal injury or damage to the system.

Symbol or Term	Meaning
	**CAUTION:** Failure to heed this message may result in personal injury or equipment damage.
	**WARNING:** Dangerous voltage. Risk of electrical shock. Failure to observe this warning may result in equipment damage, personal injury or death.
	**WARNING:** Disconnect equipment from power source. Failure to observe this warning may result in equipment damage, personal injury or death.
	**CAUTION:** Pinch Point - Keep hands clear. Failure to observe this warning may result in personal injury or equipment damage.
DANGER	Immediate hazard which could result in severe personal injury.
WARNING	Hazard or unsafe practice which could result in personal injury.
CAUTION	Hazard or unsafe practice which could result in equipment damage or injury.
NOTE	Information that is helpful in properly operating the equipment.

1.3 Warranty

Starrett Kinemetric products carry a one-year (from date of purchase) warranty against defects in material and workmanship (parts and labor), subject to factory inspection. The L.S. Starrett Company will repair or replace, at its option, any part or parts found to be defective in workmanship or material. Starrett warrants repaired or replaced parts for the balance of the original warranty period or 90 days, whichever is longer. Parts returned to the factory under warranty will be repaired at no charge. Freight charges to the factory will be paid by the customer. Return freight charges to the customer will be paid by Starrett.

This warranty does not cover damages from such causes as abuse, accident, neglect, fire or freight damage. It does not apply to defects resulting from modifications made by the customer or improper use of the system or its components.

1.4 Regulatory Compliance

CE HDV300 and DV400 metrology system have been tested to comply with Council Directives 2006/42/EC - Machinery when installed and operated in accordance with this manual, and they are allowed to carry the CE mark. The Product Safety, EMC Testing and Evaluations were provided by International Compliance Engineering (ICE), San Juan Capistrano, California, USA. The systems are also certified to be free from hazardous materials per comply 2002/95/EC RoHS.

EMC Standards

EN 55011 Class A	Conducted Electromagnetic Emissions
EN 55011 Class A	Radiated Electromagnetic Emissions
EN 61000-4-2	Electrostatic Discharge (Contact)
EN 61000-4-2	Electrostatic Discharge (Air)
EN 61000-4-4	Electrical Fast Transients (Direct Coupled)
EN 61000-4-4	Electrical Fast Transients (Capacitive Coupled)
EN 61000-4-6	Radio Frequency Conducted Immunity (150 kHz-80 MHz)
EN 61000-4-5	Surge (for control computer, et al)
EN 61000-4-11	Voltage Dips, Short Interrupts and Voltage Variations Immunity

Safety Standards

EN 292-1	Safety of Machinery, General Principles for Design (Referenced)
EN 60204	Safety of Machinery, Electrical Equipment of Machines
EN 12100	Safety of Machinery, Principles for Risk Assessment

1.5 Disclaimer of Liabilities

The L.S. Starrett Company shall have no liability or responsibility to the customer or any other person or entity with respect to any liability, loss or damage caused or alleged to be caused directly or indirectly by this documentation, or the hardware and software described in it. This includes, but is not limited to, any interruption of service, loss of business or anticipatory profits, or consequential damages resulting from the use or operation of hardware or equipment.

1.6 Copyright & Trademark Information

2. HDV PRODUCT LINE DESCRIPTION

The HDV300 with 300 mm (or 12”) of travel and HDV400 with 400 mm (or 16”) of travel are horizontal digital video comparators which combine the best features of a vision metrology system and a horizontal optical comparator. They come with a 5-megapixel digital video camera and are available with a choice of seven telecentric lenses that provide micron-level resolution and optical distortion as low as 0.001% across the field of view (depending on the lens) for accurate field-of-view (FOV) measurements. They are also available with 6.5:1 zoom optics. Six of the seven telecentric optics and the zoom optics are mounted by means of a bayonet fitting and can be changed by the user in a matter of seconds.

HDV300 and HDV400 systems are available in a manual version, where X-Y-Z positioning is by means of handwheels, and in a CNC version, where motion is motorized and under computer control. With the CNC version, X-Y motion can be under full software control, or under manual control by means of a joystick unit. X-Y travel is 12” x 6” (300 x 150 mm) with HDV300 systems and 16” x 6” (400 x 150 mm) with HDV400 systems.

All HDV systems come with MetLogix M3 touch screen software with the M3 DXF/FOV option pack. With this software, they can import DXF CAD files over a network and make automatic 2D go-no-go comparisons to an engineering design by using video edge detection (VED), with no need for the screen overlays that would be required with an optical comparator. 2D geometric functions include points, lines, circles, arcs, rectangles, distances, slots, angles and skew.

With 0.14X telecentric optics, field-of-view measurements can encompass an entire small part up to 63 x 47 mm (2.47” x 1.85”) or a feature of a larger part. Field-of-view measurements can also be seamlessly integrated with stage motion to measure larger parts.

HDV systems are rugged benchtop machines that are equally at home in a quality lab or on the shop floor. The housing is built of welded steel like a Starrett comparator. The workstage of the HDV300 is the same as for Starrett’s HB400 horizontal optical comparator, and the workstage of the HDV400 is the same as for Starrett’s HD400 horizontal comparator. The stage is made of machined hardened aluminum and has two dovetail slots to allow the clamping of parts and fixtures. Maximum workload capacity is 50 kg (110 lbs). Linear glass scales provide 0.5 µm (0.00002”) of resolution to read stage motion. The computer and M3 controller are located inside the comparator housing, resulting in a clean design with minimal external wiring. Air circulation and a slightly positive pressure are maintained inside the housing by a filtered fan. The system’s standard 24V fan system is designed to provide cooling in relatively clean environments. An optional Clean Air Kit comes with a more powerful 12V fan system and a large 300 x 300 mm (12” x 12”) filter designed to trap dust and oil particles in dirtier environments, such as machine shops.

The main operator interface is a 24” touch screen video monitor, which displays a live video image of the part in addition to geometry tools and digital readings. The image of the part can be resized using pan and zoom, and measurements are taken by simply tapping a feature on the screen. An environmentally sealed keyboard with an integral touchpad is also provided.

2.1 Ordering Options

Standard HDV300 and HDV400 systems come with a bayonet socket which allows optics to be changed by the user in seconds. Available optics are telecentric optics with fixed magnifications of 0.3X, 0.5X, 0.8X, 1.0X, 2.0X or 4.0X, and zoom optics with continuously adjustable magnification from 0.7X to 4.5X.

The HDV 300 and HDV400 are also available as a dedicated system with non-changeable 0.14X telecentric optics, which provides the system’s maximum of view of 2.47” x 1.86” (63 x 47 mm).

A cabinet stand is a required option if a customer-furnished benchtop is not available. Stands are available with 24” (61 cm) or 32” (81 cm) height. A depth of 32” (81 cm) is required for mounting.

2.2 HDV System Specifications

Disclaimer: Due to continual product improvements, specifications may change without notice.

Caution: Exceeding the maximum load capacity of 50 kg (110 lbs) will reduce accuracies of your system and may damage the mechanical structure.

Feature	Specification						
Measurement Range, X-Y (X is horizontal, Y is vertical)	HDV300: 300 x 150 mm (12” x 6”) HDV400: 400 x 150 mm (16” x 6”)						
X-Y Motion Control	Handwheels (manual models) or computer control (CNC models)						
Stage Dimensions, X-Z	540 x 130 mm (21.3” x 5.1”) (X and Z are horizontal)						
Stage Load Capacity	10 kg (22 lb) for negligible deflection, 50 kg (110 lb) maximum						
Scale Resolution, X & Y	0.5 µm (0.00002”)						
Accuracy, X-Y	E1 = 3.0 µm + L/33 mm						
Focus Travel (Z axis)	50 mm (2”)						
Skew Adjustment	±15°						
Surface Illumination	75 mm (3”) diameter LED ring light mounted around body of lens. Coaxial through-the-lens LED light for 0.14X telecentric lens.						
Contour Illumination	50 mm (2”) collimated LED backlight 90 mm (3.5”) collimated LED backlight for 0.14X telecentric lens						
Operator Display	600 mm (23.6”) diagonal touch-screen monitor, 1920 x 1080 pixel resolution						
Camera Type	5 megapixels (2448 x 2058) on 2/3” array, 15 frame/sec update rate						
Telecentric Lens Mag.	0.14X	0.3X	0.5X	0.8X	1.0X	2.0X	4.0X
Telecentric Field of View (mm and inches)	60 x 51 2.36”x2.0”	28 x 24 1.1”x.94”	17 x 14 .67”x.56”	10.5 x 8.9 .41”x.35”	8.4 x 7.1 .33”x.28”	4.2 x 3.7 .16”x.14”	2.1 x 1.8 .08”x.07”
Pixel Size	25 µm	11.6 µm	7 µm	4.4 µm	3.5 µm	1.75 µm	.88 µm
FOV Measurement Uncertainty per Lab Tests	± 9 µm	± 5 µm	± 3 µm	± 2.3 µm	± 2.1 µm	± 1.6 µm	± 1.3 µm
Resolution on Monitor, LP/mm	9	18	35	45	57	101	181
Magnification on 24” Monitor M3 Software	4.7X	10X	16.4X	27X	33X	69X	137X
Optical Distortion (ΔH/H)	0.001%	0.003%	0.018%	0.009%	0.003%	0.006%	0.005%
Telecentric Depth of Field	16.4 mm	6.2 mm	3.0 mm	1.3 mm	0.42 mm	0.27 mm	0.11 mm
Telecentric Free Working Dist.	110 mm (4.3”)						
Zoom Optics	6.5:1 manual zoom (continuous zoom from 0.7X to 4.5X)						
Zoom Magnification at Detents	0.7X	1.0X	2.0X	3.0X	4.0X	4.5X	
Zoom Field of View (mm and inches)	12 x 10.1 .47” x.40”	8.42 x 7.04 .33” x.28”	4.21 x3.54 .17” x.14”	2.78 x 2.35 .11” x.92”	2.1x 1.76 .83” x.70”	1.87 x 1.56 .74” x.62”	
Viewed Resolution	32 LP/mm	57 LP/mm	102 LP/mm	144 LP/mm	181 LP/mm	202 LP/mm	
Mag on Monitor (1:1 Pixel)	58X	81X	161X	242X	324X	363X	
Zoom Working Distance	88 mm (3.5”)						
Operator Controls	On-off switch, touch-screen monitor, sealed keyboard, touchpad						
Computer Hardware	64-bit CPU, 250 GByte hard disk and Ethernet port, 3 USB ports						
Operating System	Windows® 10 Professional						
Application Software	MetLogix M3 touch-screen software with FOV/DXF option pack						
System Cooling, Standard	24V, 1.6 m^3/min (57 cfm) fan with washable 114x144 mm (4.5”x4.5”) filter						
System Cooling, Clean Air Kit	12V, 5.2 m^3/min (184 cfm) fan w/ washable 292x292 mm (11.5”x11.5”)filter						

3. HDV System Components

3.1 Manual System Components

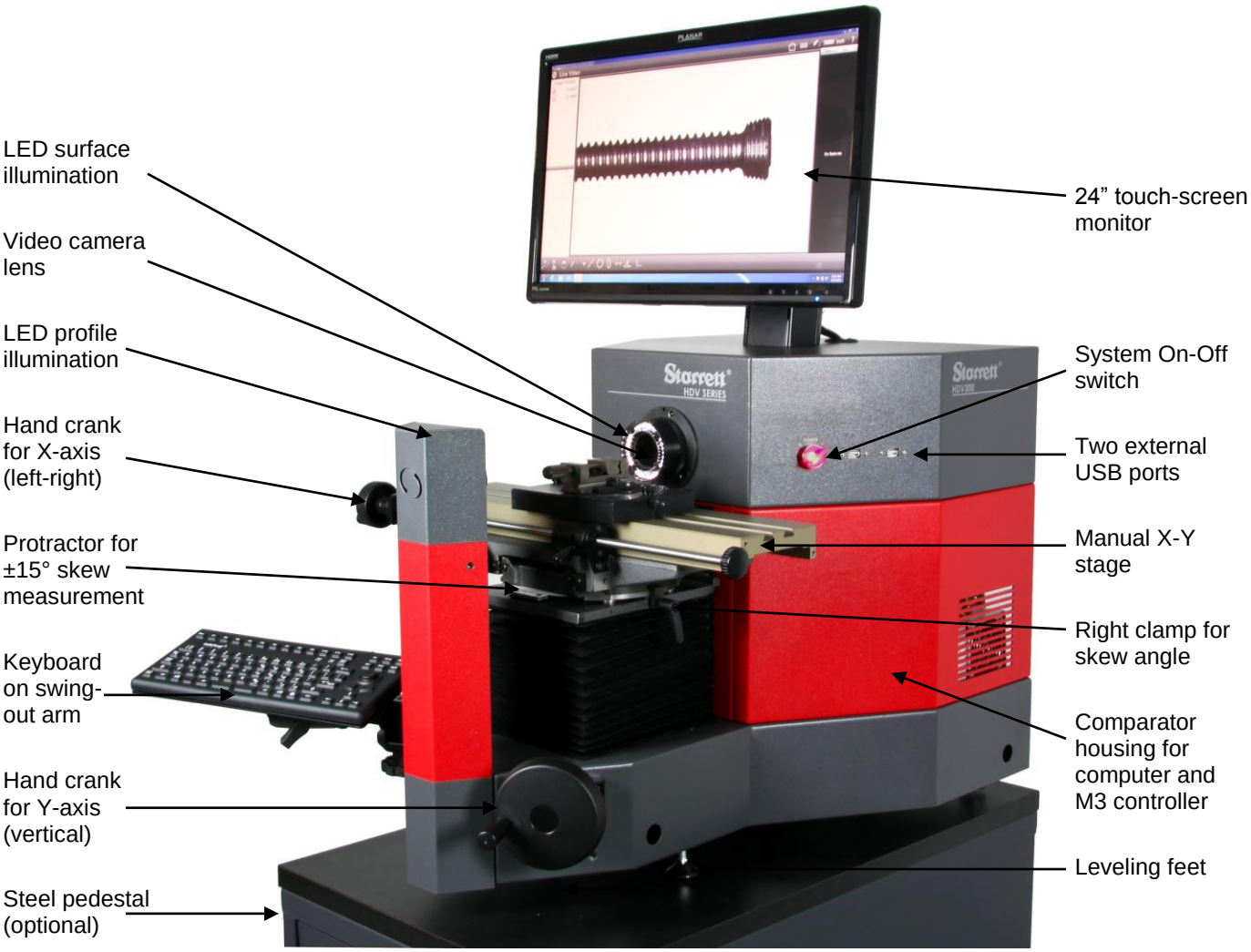


Figure 1. System component overview, manual system

3.2 Manual Position and Focus Controls

Precision X-axis positioning is by rotating a knurled hand wheel with a hand crank, as shown in Figures 1 and 2. The stage can be disengaged from the shaft of the hand wheel by raising the lever of a latch block around the shaft, thereby allowing the stage to be pushed directly by hand for coarse X-axis positioning. The stage is reengaged to the shaft by lowering the lever of the latch block.

Y-axis positioning is via the large hand crank at the base of the unit, as shown in Figures 1 and 2. Rotate clockwise to raise the stage, counterclockwise to lower the stage.

The stage can be rotated by ±15° around a vertical axis to provide skew adjustment for parts that are not perfectly aligned with the stage. The skew angle can be read to a precision of 10’ by means of a Vernier scale. To release the stage for skew adjustment, first release the locking levers at the right and left of the rotation mechanism that supports the stage. Turn the levers

counterclockwise to release the stage, then clockwise to lock down the stage once you have set the desired skew angle.

Focus adjustment over 2” (50 mm) is achieved by moving the stage horizontally toward or away from the camera optics. This adjustment uses a hand wheel with a hand crank at the front of the stage, as shown in Figure 2. Rotate clockwise to decrease the distance to the optics, counter-clockwise to increase the distance.

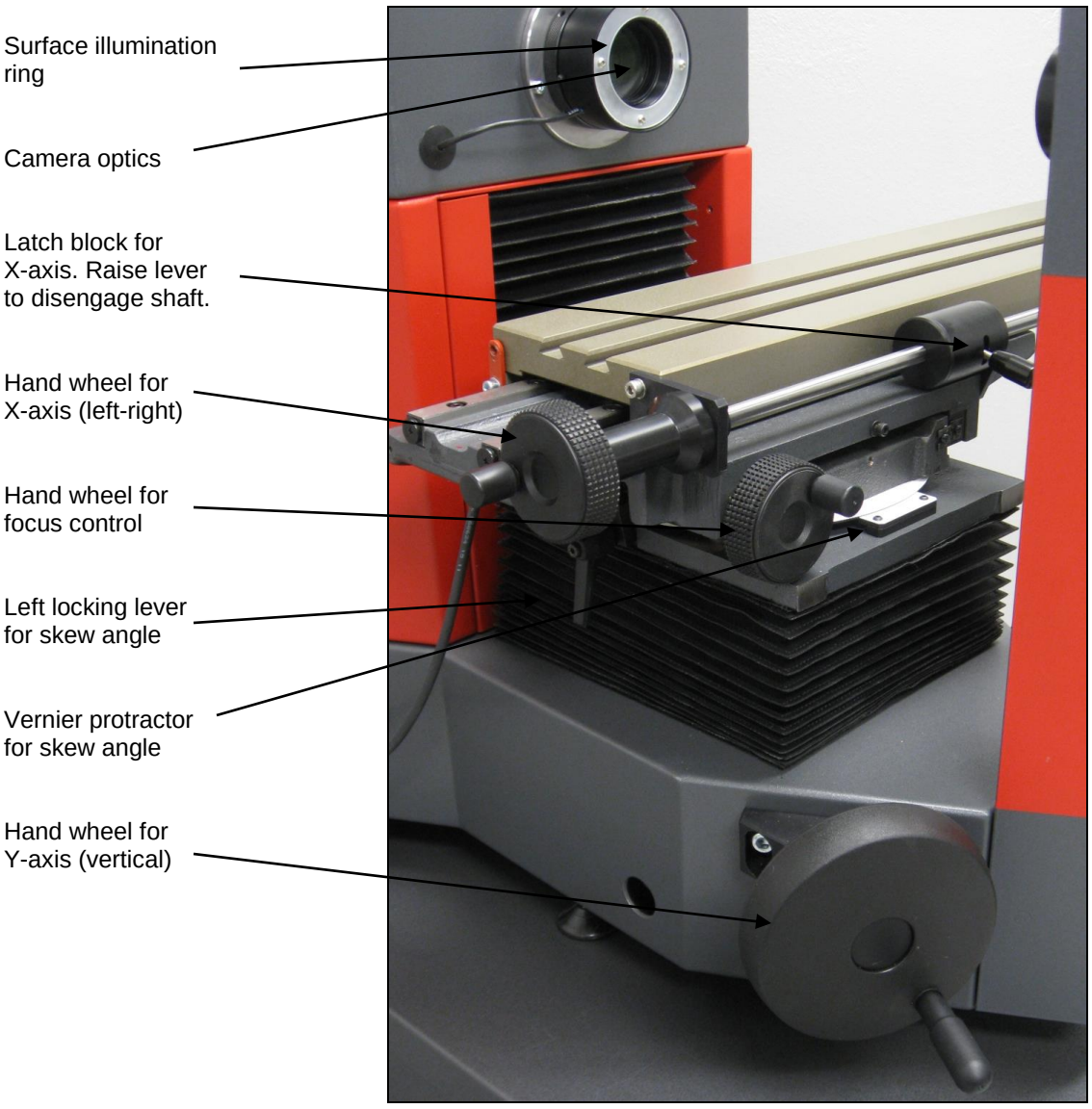


Figure 2. Stage adjustments

3.3 CNC System Components

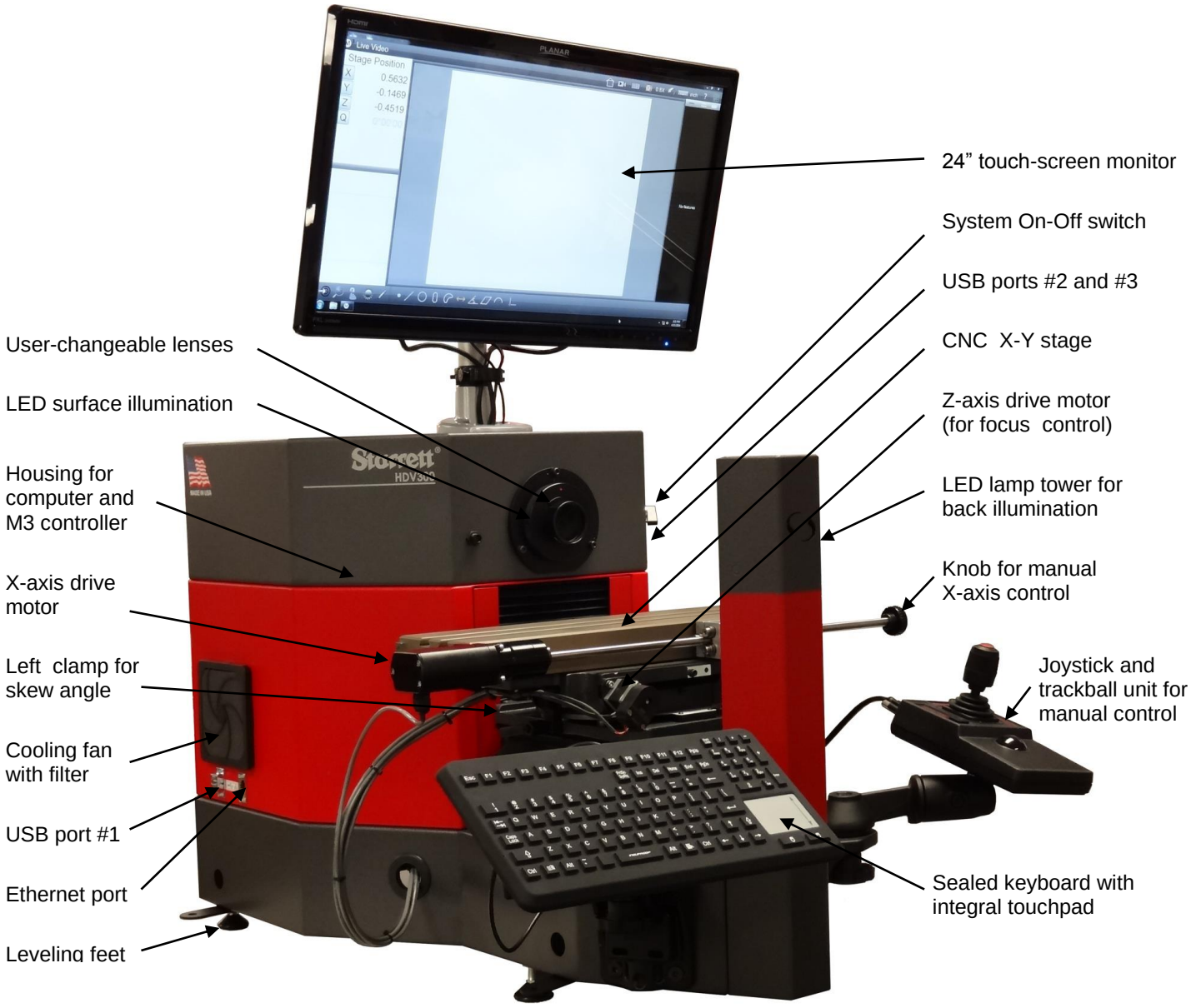


Figure 3. System component overview, CNC system

3.4 Manual Position and Illumination Controls in CNC System

The CNC version of the HDV300 and HDV400 allows fully automatic operation under program control for illumination, for right-left position of the stage (X-axis), for up-down position of the stage (Y-axis), and for in-out position of the stage (Z-axis, used for focus adjustment). The systems also allow manual operation for setup, for quick individual measurements, and for short runs. With the exception of one knob for X-axis fine adjustment, such manuals controls are also via the system’s computer, but are driven by direct operator inputs, not by previously written programs.

- **Illumination control** of front and back illumination can be via sliders on the computer screen. Move the sliders directly with your finger.

- **Position control of the stage** in the X, Y and Z axes can be via the joystick and trackball unit as illustrated below.
- **X-position control** can also be via a knob at the end of the X drive shaft. First press the red emergency stop switch at the back of the joystick and trackball unit, which removes power from all servo-motors. Do not attempt to turn the knob while the X-axis motor is under power.

Knob to manually rotate X-axis drive shaft. First press E-Stop button at back of joystick unit.

Button to toggle between slow and fast control. Applies to X, Y and Z axes.

Rotate joystick to move stage in and out (for Z-axis focus control).

Move joystick from right to left to move stage from right to left (for X-axis control).

Move joystick from front to back to move stage up or down (for Y-axis control).

Z Toggle button. Press to toggle between trackball control X-Y axes or Z-axis,

Axis Lock button. Press to toggle between axis lock, where only one axis can be moved at a time, and no axis lock.

Trackball for X-Y or Z fine control, as selected by Z Toggle button.

Figure 4. Manual controls of CNC system

3.5 Keyboard Adjustment

The system keyboard is secured magnetically to a tray, which is held by a ball joint at the end of a pivoting swing-out arm, as shown in Figure 5. Adjustment of the ball joint and pivot angle sets the keyboard angle and position.

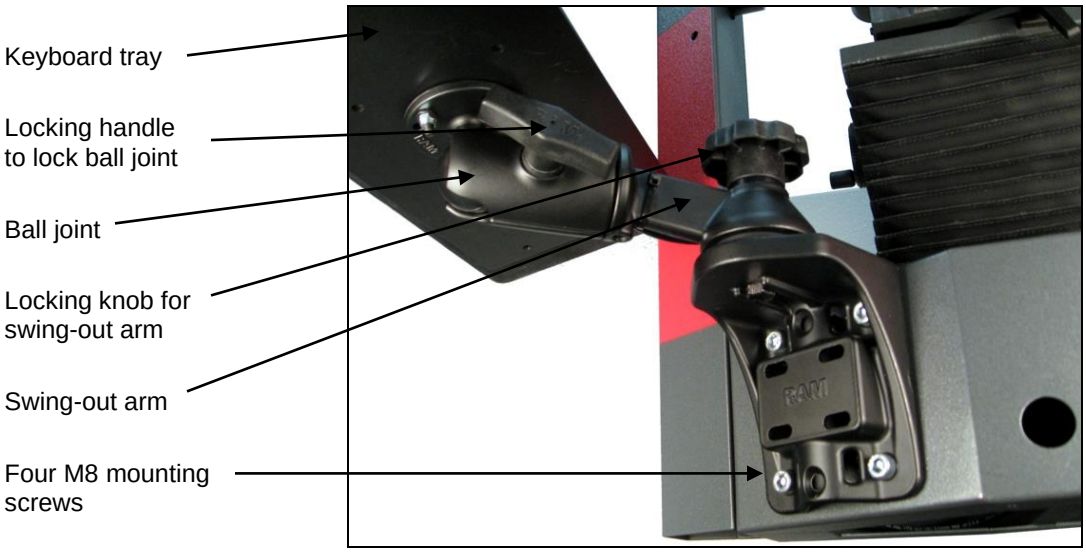


Figure 5. Attachment and adjustment of keyboard.

3.6 Keyboard Usage

While most software control by the operator will be via the system's 24" touch-screen monitor, use of the keyboard is required for specific tasks, such as entering file names and paths. The keyboard is sealed for use in harsh environments. The keyboard includes a touchpad which provides the same functions as moving the mouse, and two adjacent buttons which provide the same functions as the left and right mouse buttons.

Figure 6. Sealed keyboard.

3.7 Changing Lenses

Figure 7. Lens change-out.

Lens assemblies from 0.3X to 4.0X are designed and factory-adjusted for quick change-out with no need for user adjustment. The CCD camera is mounted to the housing and is not attached to the lens assembly. It is not hurt by ambient light; however, it is vulnerable to dust settling on the CCD sensor. To avoid dust problems, the CCD sensor should be protected at all times with a lens assembly in place, except when changing lenses.

To remove a lens assembly, first gently pull off the surface illumination ring and place it on the stage, a shown in Figure 7. Then grab the lens assembly by its knurled outer ring and turn it counterclockwise until you feel that the bayonet fitting has disengaged. The lens assembly can then be pulled out.

To install a lens assembly, reverse the process. Insert the lens assembly and turn it clockwise until you feel that the bayonet fitting has engaged. Then slip the illumination ring back on.

Cautions	• Do not leave the camera unprotected by a lens assembly to minimize dust settling on the CCD sensor surface. • Do not touch optical surfaces, since oil from your hands can permanently damage optical coatings. • Place unused lens assemblies in a polyethylene Ziploc bag for dirt protection. • Store unused lens assemblies in a safe place, since they are breakable and expensive.

3.8 Lighting Control

HDV300 and HDV400 system provide long-life LED lighting for surface and profile illumination. Lighting levels are adjusted via the system's M3 software by sliding graphical controls on the touch-screen.

3.9 Environmental Considerations

HDV300 and HDV400 systems are factory calibrated under the standard laboratory environmental conditions shown below:

Specification	Calibration Requirement
Ambient Temperature	20°C ± 0.5°C (68°F ± 1°F)
Humidity	40-60% RH
Temperature rate of change	0.5°C (1°F) per hour

HDV systems can be safely operated under the following environmental conditions:

Environmental Condition	Operational Requirement
Ambient Temperature	20°C ± 3°C (68°F ± 5°F)
Humidity	< 90% RH

If the system is to be operated under environmental conditions that are substantially different from those shown above, the system should be recalibrated under the expected conditions. Users should also consider the material characteristics of the parts under inspection, in particular coefficients of thermal expansion. Numerical compensation may be required when measuring parts under conditions different from those controlling the stated dimensional specifications for these parts.

Before performing critical parts measurements, allow the system to warm up and temperature stabilize for 30 minutes.

3.10 Safety Considerations

General Safety 	Starrett vision metrology systems are designed for safety and proper ergonomics during normal use. Exercise caution when lifting, handling or moving the system to maintain equipment calibration and measurement performance. Consult Starrett if you have any question regarding transporting, using, or maintaining this system. Follow standard safety protocols for electrical and mechanical equipment in addition to all guidelines outlined in this manual. Failure to exercise proper safety practices may result personal injury and equipment damage.
Electrical Safety 	Follow the guidelines below to avoid potentially hazardous electrical conditions, which could result in electrical shock and equipment damage. • Use only properly grounded 3-prong polarized 120 Vac power receptacles in North America, or appropriate safety-rated receptacles outside of North America. • Disconnect all power sources prior to moving or working on the equipment. • Keep component air vents clear, clean and free from dust and debris to provide proper circulation to electrical components and to avoid overheating. • Keep all liquids away from the system. • Ensure that the ground is clean, dry and free from debris at all times. • Do not operate the equipment in excessively humid conditions (> 90% relative humidity). • Do not operate the equipment in an explosive environment, such as around volatile or flammable solvents. • Do not open the housing except to make computer connections or to change the fan. • Do operate system with the housing open.
	Disconnect power, or do not plug in the power cord, if hazardous conditions exist such as: • Damaged or frayed power cord. • Damaged or improperly grounded power receptacle. • Equipment exposed to excessive moisture or liquid spills. • Impact or damage to the equipment. Have the system inspected by authorized personnel before operating. • Ongoing repair service by a technician
Mechanical Safety 	**CAUTION:** The metrology stage has moving components and pinch points. Do not place hands and mechanical items near pinch points. Failure to observe this warning could result in personal injury and equipment damage.

3.11 Equipment On/Off Control

HDV300 and HDV400 systems have an On/Off rotary selector switch on the right side of the housing, and a rocker switch in the back just above the 115/230V power connector (as required by for CE certification). During normal operation, the toggle switch at the back should always be in the On position, and the rotary switch should be used to apply and remove power.

Figure 8: On/Off power switch

Turn the rotary power switch clockwise to the position marked "**|**" to apply power. The system's built-in PC will self-boot and come up in Windows. Launch the MetLogix M3 software by clicking on the M3 icon.

Before removing power, first close all computer files and applications, then shut down the computer using the Windows "Shut down" button. Otherwise computer files could be corrupted by the sudden loss of power. After the computer has been properly shut down, turn the rotary power switch counterclockwise to the position marked "**O**".

	**Turn-Off Sequence:** Before removing power, first shut down the computer in software. This will ensure that all files are properly closed.

3.12 Fuse Replacement

The toggle switch at the back is part of a power entry module, which includes an EMI/RFI filter and a holder for two fuses. If power is properly applied to the system but the electronics are not energized, the problem could be due to a blown use. To check and replace fuses, follow these steps:

1) Unplug the power cable from the power entry module.
2) Pry open the cover above the power switch by inserting a small flat-blade screwdriver from the top.
3) Pry out the red fuse holder module by using the small flat-blade screwdriver from the side.
4) Check the existing fuses for electrical continuity.
5) Replace any blown fuse with a fresh fuse of the same size. The recommended fuse rating is 5A, 250 Vac for 115V or 230V AC power.
6) Press in the red fuse holder.
7) Press in the cover above the power switch.
8) Plug in the power cable.

	**Hazardous Voltages:** If work is to be done inside of the metrology unit or on the power entry module, always first unplug the 115V or 230V power cable to remove dangerous line voltages.

4. INSTALLATION

Starrett Kinemetric vision metrology systems and optical comparator systems are normally installed by a factory-trained installer who also provides operator training. The information below covers basic hardware installation in the event that such an installer is not available.

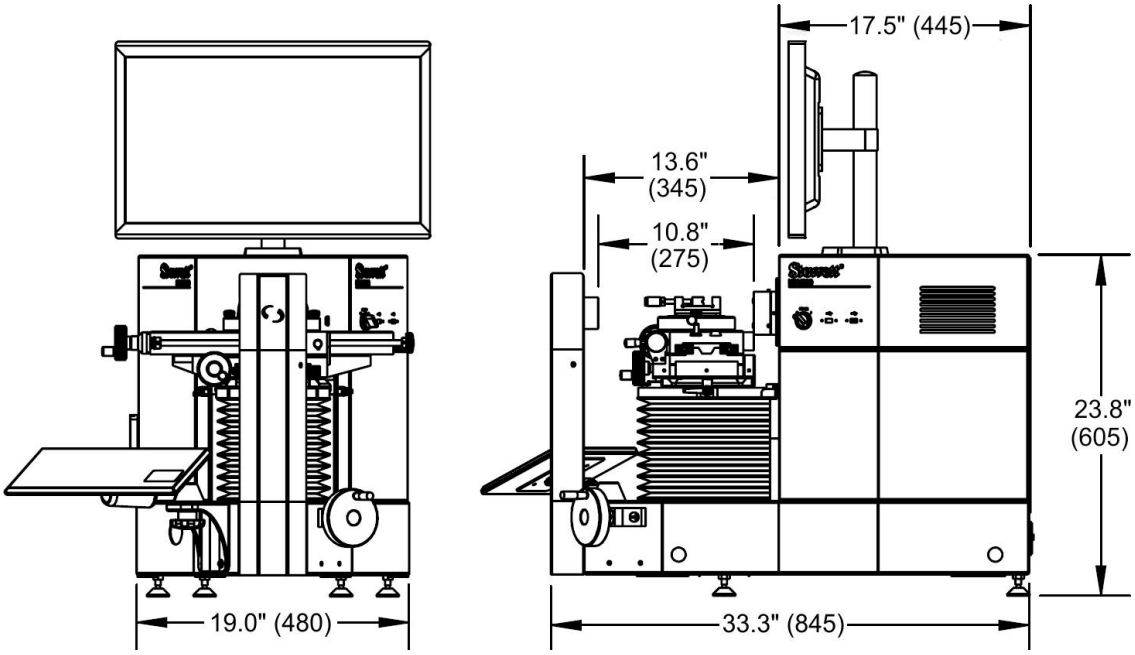


Figure 9. Dimensioned outline drawing, manual system

4.1 Required Tools and Equipment

The following items are required to uncrate and install HDV300 or HDV400 metrology systems:

1. Forklift or pallet cart (to move shipping crate inside building),
2. Battery powered drill with Phillips bit (to remove top and sides of shipping crate),
3. Two crescent wrenches (to remove screws which attach shipping tabs to the crate, also to adjust the height of feet of the cabinet stand and metrology unit).
4. Two 5 ft (1.2 m) long pipes, 3/4" (20 mm) diameter (to create temporary lifting handles).
5. Bubble level (to level pedestal and main unit).

4.2 Moving the Equipment

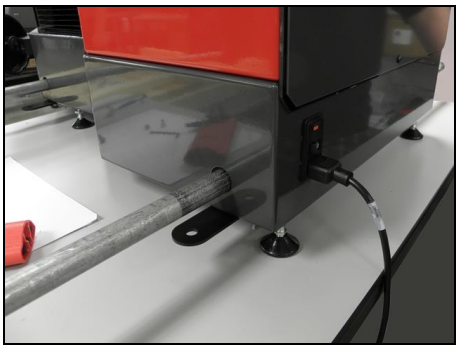
The HDV system or HDV system and cabinet stand are shipped in a single wooden shipping crate, which is designed to be moved by a forklift or a pallet cart. Use a forklift or pallet cart to move the crate within the building to the final location where the system will be installed. Exercise care in handling the unopened shipping crate, as excessive force or a drop may damage its contents.

4.3 Uncrating the Equipment

1. Use a reversing battery powered drill with a Phillips bit to remove all wood screws from the top of the crate, then lift off the top. Remove all wood screws from the side panels of the crate, then remove the panels. This will expose the HDV300 and cabinet stand (if ordered) on the pallet base of the crate.

2. Lift the cabinet stand (if ordered) off the pallet base. Use at least two people, since the cabinet stand weighs 150 lbs (70 kg). The cabinet may contain items that further increase this weight, so remove these items first. Bend your knees when lifting heavy items, not your back.

3. The metrology unit is secured to the wooden pallet by four mounting tabs and bolts. Use a crescent wrench to loosen the nut of each bolt, then remove the nuts. This will allows the metrology units to be lifted off. Later you will be able to use a 5 mm Allen wrench to loosen the mounting tabs and rotate them by 90º so that they no longer protrude.



4. To lift the metrology unit, insert two 5-foot (1.2 m) long sections of 3/4" (20 mm) plumbing pipe through the mounting holes provided for that purpose at the front and back of the base, as illustrated. Four people can then each lift a section of pipe and carry the metrology unit, which weights over 200 lbs (90 kg).

4.4 Leveling the Cabinet Stand and Metrology Unit

Locate the cabinet stand so that it has a clearance of at least 1 foot (30 cm) on the sides and in the back for installation and maintenance. The cabinet should be leveled before the metrology unit is placed on top, and the weight on each the four feet of the cabinet should be made about equal to avoid deformation of the cabinet under load.

To level the cabinet, place a bubble on the top surface in the right-to-left and front-to-back directions. Adjust the height of the feet until the top surface is horizontal. To adjust the height of each foot, first turn the lock-nut counterclockwise to its lowest position. Then use a crescent wrench to rotate the bolt clockwise to achieve the desired corner height. Assess the force required to rotate each foot to ensure that each foot bears about the same weight. When done, rotate the lock-nut clockwise to prevent the bolt from further rotation.

Repeat the process with the metrology unit after it has been placed on the cabinet stand. Again ensure that unit is level and that each foot bears about the same weight.

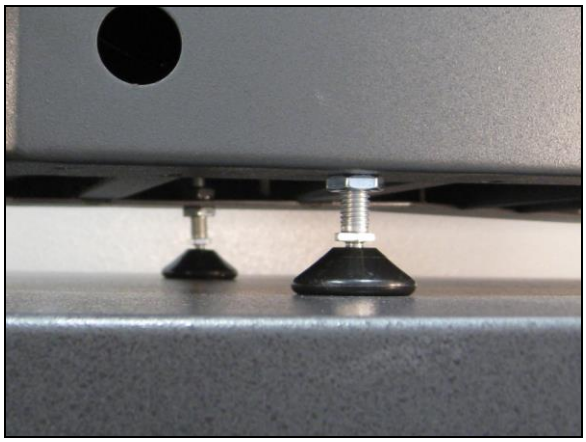


Figure 10. Two leveling feet.

4.5 Retainer Removal

Models HDV300 and HDV400 use two steel stage locks to prevent motion of the stage during shipment. Remove these retainers once the equipment has been placed in its final position. Also remove any tape and packing materials that may have been added to protect the equipment during shipment.

Figure 11. Removable shipping tab

4.6 Electrical Connection

Models HDV300 and HDV400 are shipped by Starrett fully assembled, electrically interconnected, and ready to run following the removal of retainers and packing materials. Simply plug in the system and turn on the system's two power switches (in the back and on the side).

Starrett vision metrology systems and optical comparators are factory set for 115V or 230V AC power, depending on the destination country. Contact Starrett if you ever need to move a system to a country with different AC power.

	**WARNING:** Make sure that the power plug to which the system is connected is a properly rated and grounded receptacle. Do not energize the power cable until the entire system has been properly set up per these instructions.

4.7 On-site Functional Test, Calibration and Training

All Starrett vision metrology systems and optical comparators are calibrated at the factory prior to shipment; however, it is possible that components may have moved during shipment. A complete functional test and calibration are recommended following physical installation.

Professional system installation is normally provided by Starrett for all new vision metrology systems and optical comparators sold in North America. Installation includes equipment setup, on-site calibration and on-site operator training. While professional installation is a separately-quoted line item, it is highly recommended and is purchased by most users.

As part of its setup services, Starrett oversees the equipment's in-plant transportation to its permanent location and uncrating. Starrett then performs the physical setup and electrical connection, followed by a completed functional checkout. This typically takes 1/2 day for a manual system. The system is then allowed to temperature stabilize overnight.

On-site calibration normally takes place on the day following setup. Calibration uses NIST-traceable glass grids and gage blocks. Calibration typically takes 1/2 day for a manual system like the HDV300.

On-site basic operator training is provided following calibration. This typically takes 1/2 day for a manual system like the HDV300 or HDV400. Many customers choose to augment basic CNC training with 1 or 2 days of specialized hands-on training, where new operators program actual parts of the type on which they will be working. Training is with the new equipment and is limited to 1 to 3 people, so that these can all get hands-on time. Starrett's objective is to create power users, who can then train other users when needed.

Installation services in North America (USA, Canada and Mexico) are provided by professional installers and service technicians operating out of the Laguna Hills, CA, headquarters of Starrett Kinemetric and its regional sales offices. Outside of North America, installation services are provided by Starrett subsidiaries in Brazil (for South America), Scotland (for Europe and Africa), China (for Mainland China), and Singapore (for Southeast Asia and Australia).

5. MEASUREMENT STRATEGY

HDV300 and HDV400 systems can be operated with any of 7 telecentric fixed-focus lenses with magnification from 0.14X to 4.0X and with 6.5:1 zoom optics with continuously adjustable magnification from 0.7X to 4.5X. Here magnification is the image size at the camera CCD detector divided by the object size. Since the CCD size is fixed (namely 9.93 x 8.70 mm), each magnification has a corresponding field of view (FOV), which is the CCD size divided by magnification. The higher the magnification, the higher the resolution but the smaller the field of view.

The 6 telecentric optics with magnifications from 0.3X to 4.0X and the 6.5:1 zoom optics are mounted via a bayonet fitting and can be changed by the user in seconds. Note that the centering of the optical axis of different optics may vary by a small amount, so that all measurements on the same part need to be taken with the same optics. The larger 0.14X telecentric optics are not bayonet mounted, but are part of a dedicated machine.

In addition to magnification, focus and lighting, factors that affect resolution and accuracy include keeping the optics clean, using the full calibration and shape correction algorithms available with M3 software (Tech Bulletin 080713), and having a well stabilized system free from vibration.

5.1 Telecentric Lens Measurement Strategy

Select telecentric optics to perform high accuracy, high throughput FOV measurements. In general, select the largest lens whose field of view encompasses the entire part. The 0.14X lens accommodates parts up to 2.47” x 1.86” (63 x 47 mm). If the entire part cannot fit into the FOV, no problem. Simply move the stage by up to 12" (300 mm) with the HDV300 or up to 16” (400 mm) with the HDV400, and the M3 software will seamlessly integrate FOV measurements with encoder readings from stage motion.

5.2 Zoom Optics Measurement Strategy

The 6.5:1 zoom optics allows magnification to be continuously adjusted from 0.7X to 4.5X. While the zoom optics can provide the same FOV as the four higher magnification telecentric lenses, they do not offer the same low optical distortion that is required for accurate FOV measurements.

Select zoom optics to measure large parts which would not fit into a single FOV, also for smaller parts where extremely high magnification is required. The lowest magnification range accommodates parts up to 0.44" x 0.37" (11.2 x 9.4 mm) in the FOV. To measure large parts, locate the edge of interest at minimum magnification, then take the actual measurement at maximum magnification using the system's crosshairs. The zoom optics’ parcentricity feature will ensure that a feature will remain at the optical center of the video image throughout the magnification range.

5.3 Lighting Strategy

Once the image has been properly focused and magnification has been set, adjust front lighting and back lighting using the on-screen sliders provided by M3 software. You may also utilize room lighting, or shield the system from room lighting, as appropriate.

Correct lighting is paramount to accurate measurement with any video-based measurement system. A clear image with lighting toward the low side is recommended. Lighting that is too low will result in a dark, low-contrast image with indiscernible features. Lighting that is too bright may result in a washed-out image and in hot spots (blooms) that distort features.

When adjusting lighting, start with light that is lower than desired, then increase lighting while viewing the image on the computer monitor. Maintain constant lighting for consistent results. Do not to change light levels between points used to measure the same geometrical feature.

Depending on the part characteristics and the feature being measured, the right combination of lighting from the available sources may aid in bringing out a particular feature. Take time to experiment by balancing the available light sources.

- **Zoom optics** come with a dedicated 64 mm (2.5”) diameter LED ring light for front illumination and a 50 mm (2”) diameter LED back light for silhouette illumination. The back light is built into

the column at the front of the instrument and is collimated so that the emitted rays are parallel to the optical axis of the imaging lens. If glare develops on edges of convoluted, reflective parts, install a furnished aperture into the back light. This aperture limits the diameter of the illuminating lens.

- **Telecentric lenses from 0.3X to 4.0X** use the same 50 mm (2”) diameter LED back light as the zoom optics, except that a neutral density filter is installed to reduce intensity. This is because telecentric lenses have greater light gathering capability. If there is a problem with glare, the same aperture as for the zoom optics can be installed for telecentric lenses with magnification greater than 0.8X. A polarizer is built into the ring light. The resulting polarizing ring light can be rotated in its mount to reduce the effects of room lights or reflections from convoluted parts. A dot on the edge of the polarizer normally points up to reduce the effects of room lights.

- **The 0.14X telecentric lens** uses a dedicated 100 mm (4”) diameter collimated LED back light. A polarizer in a separate mount fits over the lens and can be rotated to reduce glare when necessary. A built-in LED coaxial illuminator is used for front lighting.

Alignment of the back light is required for optimal performance of telecentric lenses, as the emitted light must be parallel to the optical axis of the lenses. While alignment has been done at the factory, alignment may need to be repeated following shipment and installation at the user site. To initiate realignment, first remove the cover of the column that holds the back light. Find the three sets of push-pull screws that rotate the mount that holds the back light. These are located along the diameter of the back light on both the front and back sides of the mount. While carefully watching illumination of the screen, first loosen then tighten the push-pull screws until the mount is aligned to provide even illumination over the full field of view. When that condition is achieved, lock the three sets of screws.

5.4 M3 Software Operation

M3 software operation is outside of the scope this hardware-oriented user manual. Please refer to the separate MetLogix M3 software manual.

6. SYSTEM MAINTENANCE

HDV300 and HDV400 benchtop horizontal digital video comparators have been designed for years of superior service. Periodic maintenance outlined in this section should be performed to maintain the system in peak operating condition.

- Perform a daily inspection to ensure that the system is operating correctly and that proper safety guidelines are being followed.
- Periodically verify basic optical performance.
- Periodically perform cleaning and lubrication.
- Replace the fan filter, lenses and fuses when needed.
- Schedule regular factory-authorized calibration and maintenance service to preserve proper function and accuracy.

6.1 Daily Inspections

On a daily basis, inspect your system for general safety and basic functionality:

- Verify that the work area is clean, dry and free of debris. Remove any debris or loose items from around the system and metrology stage.
- Verify that the electrical power cord is plugged into a grounded power source and is unobstructed.
- Verify that temperature and humidity are within recommended ranges.
- Allow the system to warm up to normal operating temperature before performing critical parts measurements.

6.2 Weekly or Monthly Maintenance

On a weekly or monthly basis (based on experience), do the following:

- Inspect the fan filter. If dirty, wash or replace the filter.
- Inspect the system for cleanliness. If dirty, follow cleaning instructions stated under "Cleaning."
- Verify that the stage control mechanisms move freely. Lubricate as needed or every 6 months, as stated later under "Lubrication."
- Check the system for calibration against a chrome-on-glass standard.

6.3 Fan Filter Maintenance, Standard Fan

In the standard HDV300/400 configuration, the side or back of the housing includes a 4-3/4" (120 mm fan, which sucks in ambient air through a filter and maintains a slightly positive pressure inside the housing. While the system is running, the air that comes in contact with the electronics has passed through this filter.

Inspect the fan filter for cleanliness at least monthly. If found dirty, it can be washed in hot water or be replaced. To inspect the filter, pry off the fan bezel with a flat-blade screwdriver and remove the filter, which is held by the bezel. To reinstall the filter, reseat it in the bezel and press the bezel back in place.

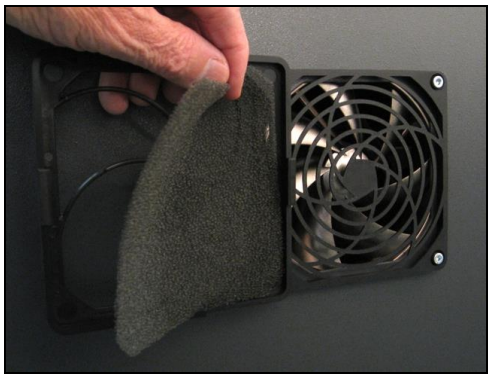


Figure 12. Standard fan filter.

Fan filters and the fan itself are user-replaceable items. They are readily available from electronics distributors and in computer stores. When purchasing a new fan, ensure that the voltage is 24V, as marked on the old fan.

6.4 Maintenance, Inline Clean Air Kit

Figure 13. Inline Clean Air Kit Exterior

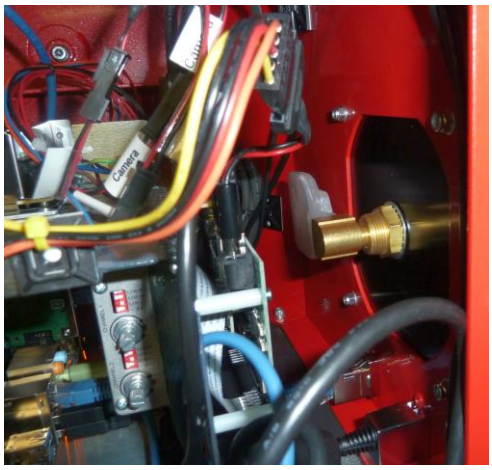


Figure 15. Inline Clean Air Kit Interior

With the Inline Clean Air Kit, the fan on the side of the HDV300/400 is replaced with a panel and fittings to allow the use of pressurized air to keep the internals of the machine clean. Pressure between 8 and 15 psi has been found to be effective at sufficiently pressurizing the housing to prevent the ingress of dust, particulates, oil vapors, and similar such as found in machine shop environments.

Air entering the machine must be clean and dry. It is recommended that air coming from the compressor be passed through a filter and dryer. The filter/moisture collector provided with the kit is designed as a failsafe to prevent damage to the machine should the method to filter and clean the air from the compressor fail.

DO NOT RELY ON THE SUPPLIED FILTER AS THE SOLE MEANS OF CLEANING THE AIR FOR THE MACHINE.

Regularly check the openings of the machine to ensure that the housing is pressurized. If air is not felt escaping from openings, increase the pressure going to the machine.

Though testing has shown between 8 and 15 psi sufficiently pressurized the housing, differences in equipment and conditions may require more than 15 psi to pressurize the housing to an adequate level.

Excessive air pressure is not necessary.

Periodically check the filter for contaminants and appearance of filter element.

Figure 16. Inline Clean Air Kit filter

If moisture is present, drain the filter by removing the black plug at the bottom of the inline filter as shown in *Figure 16.*

Should the filter element appear damaged in any way replace it immediately.

6.5 Zoom Optics Alignment Verification

The system's zoom optics (if ordered) should be verified regularly to ensure accurate measurement. Parfocality, parcentricity and squareness verifications are straightforward and may be performed as often as desired. Focus is adjusted as needed by changing the distance between the lens and the surface being viewed.

NOTE: Optical alignment verification may be performed by any qualified operator. However, optical alignment correction should only be performed by an authorized technician. Report any observed alignment discrepancies and contact the factory or your local Starrett representative to schedule authorized service.

Zoom Optics Parfocality & Focus

Parfocality is the condition in which the video image will remain in focus as the magnification is adjusted from highest to lowest. Starrett zoom optics are designed to maintain parfocality throughout their magnification range.

To check parfocality, always reference a flat, sharp edge. Do not select a rough or sloping feature. The MAG checker provided with the system is an ideal part to check parfocality.

Steps to check parfocality:

1. Place the MAG checker or other suitable inspection part on the stage and secure properly.
2. Backlight the image as necessary. Set light levels as needed to avoid blooming.
3. At low magnification, select a flat, sharp edge in the center of the field of view (FOV).
4. Select highest magnification, and carefully refocus the image by physically changing the viewing distance.
5. While observing the feature, slowly adjust the magnification lower. Verify that the feature remains focused as the magnification is lowered.
6. Report any observed discrepancy. If the error is verified, contact your Starrett representative for authorized service.

Zoom Optics Parcentricity

Parcentricity describes the condition wherein a feature will remain at the optical center of the video image throughout the magnification range. Like parfocality, parcentricity requires that the feature be first located at highest magnification.

Steps to check parcentricity:

1. Place the MAG checker or other suitable inspection part on the stage and secure properly.
2. Select the crosshair image tool in M3 software and place it at its defined center position. The crosshair is to remain at this position during the parcentricity test.
3. Zoom to low magnification, and adjust the stage position so that the crosshair is centered on the X-Y axis of the calibration standard (or another suitable feature if the standard is not used).
4. Change to high magnification and refocus the image.
5. Adjust the stage position as needed to recenter the crosshair on the feature.
6. While observing the feature, slowly adjust the magnification lower. Verify that the feature remains at the center of the crosshair as the magnification is lowered.
7. Report any observed discrepancy. If the error is verified, contact your Starrett representative for authorized service.

Zoom Optics Squareness

Squareness refers to the alignment of the camera relative to the motion of the metrology stage. If the camera is misaligned (out of square), an image will appear to drift diagonally across the video image as the stage position is moved along one axis.

Steps to check squareness:

1. Place the MAG checker or other suitable inspection part on the stage and secure properly.
2. Select the crosshair image tool in software and verify that it is at its defined center position. Please refer to the M3 software manual for details.
3. At low mag, select a point-like feature such as a corner or the standard's X-Y origin. Using the stage, position it to the center of the crosshair.
4. Zoom to high magnification, then refocus and recenter the point as needed.
5. While observing the feature, slowly move the stage X axis ONLY. (Do not move the stage Y axis.) Verify that the point remains aligned on the X axis of the crosshair as the feature is moved to the left and right within the field of view
6. Report any observed discrepancy. If the error is verified, contact your Starrett representative for authorized service.

6.6 Calibration Verification

Calibration should be verified periodically depending on user requirements and systems usage, and should be at least monthly. Calibration should also be verified after the system has been serviced or moved. A chrome-on-glass calibration verification standard artifact, P/N 300LSTD, is available from Starrett or its authorized distributors. This standard has a length of 300 mm and major calibration fiducials spaced every 30 mm.

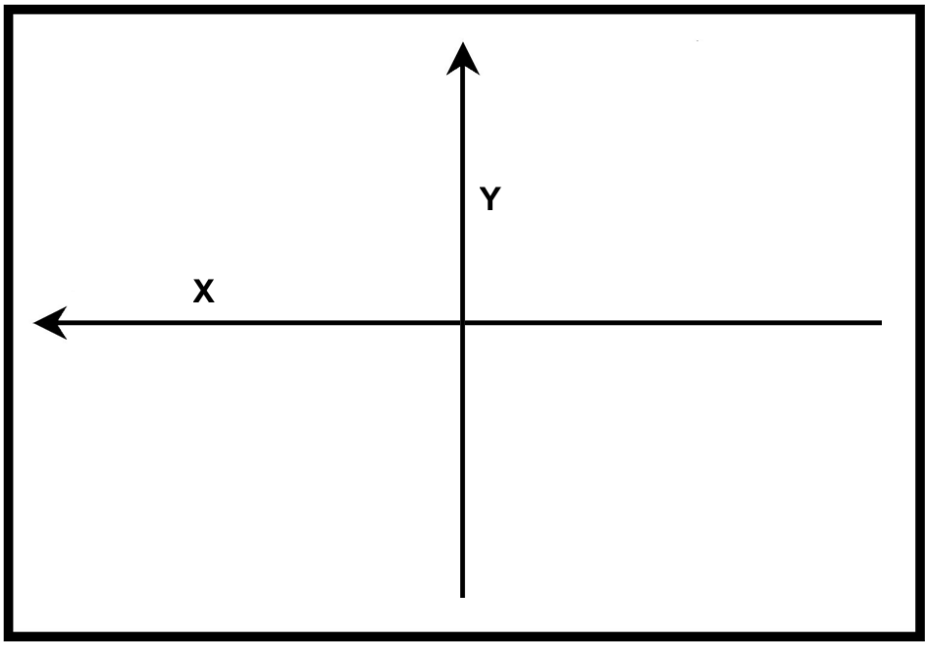


Figure 17. X and Y calibration axes

Steps to validate calibration:

1. Place the calibrated verification along the X axis. Secure the standard to the stage with a holder (available from Starrett).
2. Skew the center of the two end circles of the calibration standard. Refer to the M3 software manual for proper alignment procedure.

3. Using the HDV system, measure the position of fiducials spaced every 30 mm. For each fiducial, take the average of multiple readings for improved accuracy.
4. Calculate the absolute measurement error for each fiducial by subtracting the calibrated position of the fiducial from the above average readings, then
5. Verify that the calculated absolute X measurement errors are within the HDV system accuracy specification, which is E1 = 3.0 µm + 1 µm x L/(33 mm).
6. Repeat for the Y axis.
7. Enter the absolute X and Y errors on an X-Y Axes Accuracy Validation Results Plot, as shown below. In this plot, the straight line defined by blue diamonds ◆ is the maximum error specified by 3.0 µm + 1 µm x L/(33 mm). The green squares ■ are the absolute X errors. The red triangles ▲ are the Y errors. The HDV system is within the factory calibration spec if all X and Y errors fall below the straight line.

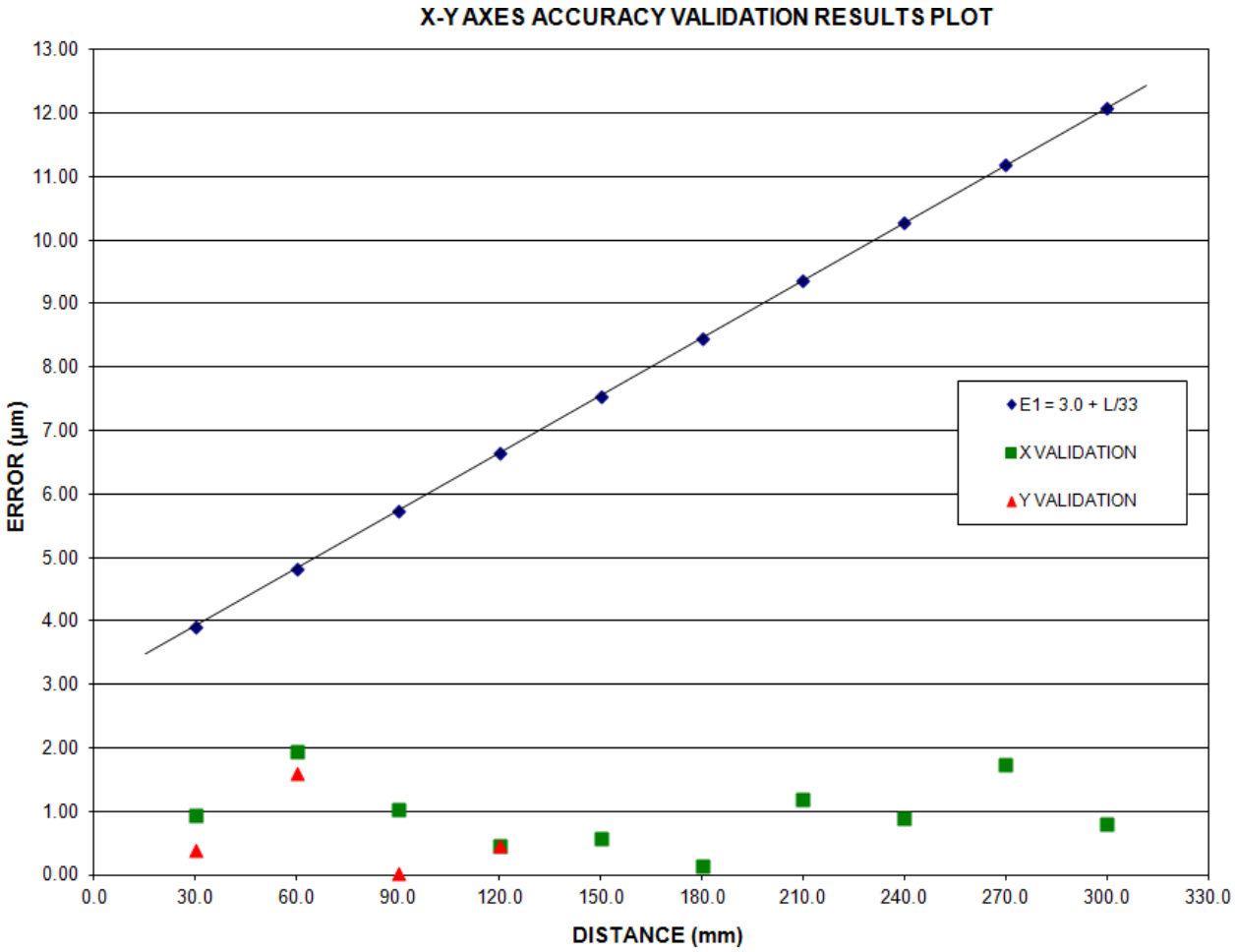


Figure 18. Sample Accuracy Validation Results Plot

6.7 Cleaning

To the degree possible, the system should be kept in a clean environment, away from dirt, dust, oil and debris which could affect system performance or degrade the system's mechanical and electronic parts. If a clean environment is not available, the machine should be kept as clean and protected as is possible. In harsh environments, preventive maintenance and factory service should be scheduled more frequently to keep the system in top working order.

WARNING: Never pour fluid on the system when cleaning. Do not over-wet cleaning cloth. Excessive moisture can seep into mechanical or electrical parts, damage the equipment and possibly cause an electrical short circuit and physical injury. As a precaution, unplug the system before cleaning. Always unplug the system before using any flammable cleaning fluid.

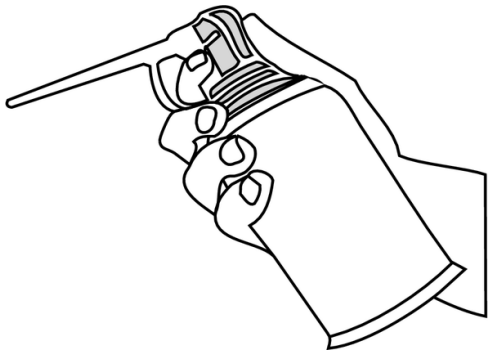
Cleaning External Surfaces

Wipe down with a clean, lint-free cloth moistened (not wet) with plain water or Simple Green®. Never wipe down with acetone or other harsh solvents, which may damage painted or plastic surfaces. Isopropyl alcohol may be used to clean surface contaminants where Simple Green proves ineffective.

Cleaning Optics

WARNING: Do not touch lens surfaces with your fingertips, since the resulting fingerprints will destroy optical coatings over time. Only clean optical surfaces with proper cleaning supplies, and then only when necessary.

If a lens is covered with loose dust, first try blowing off this dust using a can of optical grade (oil-free) canned compressed air. Be careful not to shake the lens, or propellant may blow onto the lens. As alternative, use a lens brush to gently wipe off the dust.



Optical compressed air

If the lens is soiled with greasy deposits which cannot be blown or brushed off, use an alcohol-based commercial lens cleaner and a lens tissue or a lens cloth. These items are available from camera stores. Apply the lens cleaner generously to dissolve the grease, then blot off the lens cleaner and dissolved grease using minimum motion. Avoid rubbing the lens, since hard particles from the deposit or the lens cloth could scratch the optical coatings.

If the greasy deposits do not come off with the lens cleaner, use a stronger solvent such as reagent-grade acetone as a last resort. Gently wipe the lens surface while moving the lens cloth to always present a clean surface to the lens. Wipe in a circular manner moving from the center of the lens toward the outer edge. Do not reuse the lens cloth to avoid redepositing contaminants.

Cleaning Mechanical Parts

To ensure a long, trouble-free service life, wipe down the system regularly to remove any dust or dirt from the system. Most critical components are covered and require no user service. Should the stage mechanics require service, please contact your Starrett representative.

6.8 Lubrication

Every 6 months, lead-screws may be lubricated with a small amount of Tri-Flow®. Apply to each screw and traverse the stage or column through the entire range of travel several times to distribute the lubricant. Use a clean soft cloth or paper towel to wipe up any excess.

NOTE: Use only approved lubricants, as inappropriate lubricants can damage system components. Approved lubricants may be obtained by contacting Starrett or an authorized Starrett representative.

7. GLOSSARY

The following terms may have additional meanings. The definitions that follow are in the context of the HDV300 and HDV400 benchtop horizontal digital video comparators.

Accuracy The maximum error that the system will produce when measuring a true standard.

Aperture An optical element which limits the diameter of the optical bundle that can pass through a specific plane.

Axis A direction which allows movement and along which dimensions can be measured. In the HDV300, the X-axis is horizontal from left to right, and the Y axis is vertical from bottom to top.

Blooming A condition where the parts of the video image are distorted by oversaturated bright regions, making objects appear larger than they really are.

CCD Charge Coupled Device. The solid-state image sensing element of the HDV300 video camera.

Distortion Optical image distortion at the CCD sensor across the maximum field of view. Expressed in percent for the dimensional error along one axis divided by the true dimension.

DXF A computer aided design (CAD) data file format developed by Autodesk, Inc. and now also used by other companies for the export and import of CAD data.

Focus The condition which provides the sharpest image. Achieved by optimizing the distance between the object and imaging optics.

FOV Field of View. The region of the metrology stage being viewed by the camera and displayed on the video monitor.

FOV Measurement A video measurement performed in a single field of view without moving the stage or camera.

Illumination, Front Lighting applied to the object from the same side as the camera so that surface features can be viewed on the video monitor.

Illumination, Back Lighting applied from the back of the object so as to create a silhouette when the object is viewed by the camera.

Pixel A picture element. Term used to describe the individual light detectors of the CCD sensor in the camera and also the individual light emitters of an LCD video monitor.

Mag Shorthand for magnification.

Magnification, Lens In a vision metrology system, the image size in the CCD plane divided by the corresponding object size (0.14X to 4X for HDV300 telecentric lenses). In an optical comparator, the image size on the projection screen divided by the corresponding object size (typically 10X to 100X).

Magnification, Image Image size on the video monitor divided by the corresponding object size. Same as lens magnification in a properly adjusted optical comparator.

Parcentricity The condition where a feature remain at the optical center of the video image throughout the magnification range of zoom optics.

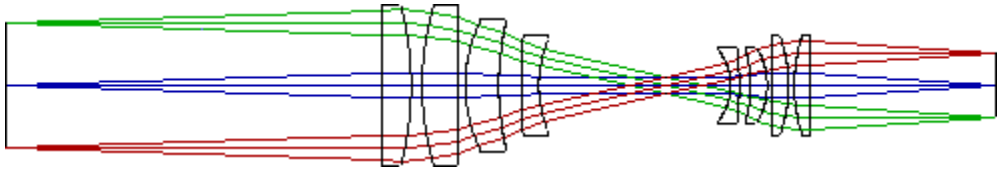
Parfocality The condition where the video image remains in focus as the magnification is adjusted from highest to lowest with zoom optics.

Repeatability The three-sigma variation of multiple readings on the same object that is positioned at multiple locations across the field of view.

Resolution The least significant digit to which a physical quantity can be read. High resolution does not imply high accuracy.

Squareness The alignment of the camera relative to the motion of the metrology stage. If the camera is misaligned (out of square), the image will drift diagonally as the stage position is moved along one axis.

Telecentric A lens property where the light from the object stays parallel to the optical axis across the entire field of view, thereby eliminating optical distortion. This can only happen if the entrance aperture of the lens is larger than the field of view, requiring a large and expensive lens.



Object Telecentric lens CCD detector

Zoom Optics Optics which can change magnification based on a user selection. Zoom control can be manual or motorized, depending on the metrology system.