White paper

Tested without compromise

Ensuring quality in Axis cameras

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AXIS COMMUNICATIONS

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Introduction

Axis products are designed for reliability. During the development phase, Axis products spend more than one year in a test environment. They are tested for their ability to withstand mechanical wear and tear, water and humidity, vandalism, extreme temperatures, vibration, and more. They are certified against external standards, but Axis testing also goes beyond the required quality approvals.

This document summarizes how the quality of Axis products is ensured by way of thorough and exhaustive testing.

Figure 1: Various types of Axis network cameras.

1. Axis quality: real-life experiences

It is easy to find active Axis installations that are ten years old or more. This is an indication of the high quality of Axis products, but even more convincing are the many case stories that corroborate the products' reliability and durability. Here are just a few examples:

'The earliest completed part, which has been operating for three years now, has maintained its original reliability and quality. It is very impressive.'
Mr. Li Zongda, Network Management Engineer of the School of Continuing Education, Taipei, Taiwan.

'Our blind testing revealed that Axis cameras have a less than a 1% failure rate, compared to cameras from other vendors which generally had a failure rate of between 4% and 5%.'
Ryan Calvert, Chemist Warehouse IT operations manager, Australia.

'Only IP technology offers the reliability required, along with the possibility of integrating and expanding the system with new networking devices at any time and with ease, without interrupting continuous operation. The ability to connect the installations of several buildings using Internet, allowed remote operation from our central room.'
Colonel Abdul Rahman Bin Saad Althiab, Director of Security and Protection, King Fahd Security College, Riyadh, Kingdom of Saudi Arabia.

'In a very short time and at a nominal cost we were able to equip the new cable cars with a video surveillance system which has proved from the outset to be extremely efficient and reliable. Thanks to Axis and its partner Itel di Locatelli, we are able to offer our guests safety and tranquility when traveling for work and pleasure.'
Karin Tscholl, Cable Car Merano 2000, Merano, Italy.

'Before, we had a completely decentralized system that needed frequent maintenance. Now, we have a solution with a monitoring center, cameras that work perfectly, and results that enhance not only our surveillance capacity, but also our store operations. Our Distribution Center manager tells me repeatedly that we've achieved more during the first six months with Axis than we did over six years with the previous solution.'
Jesaias Arruda, Head of Support Division, Bemol, Manaus, Brazil.

'When selecting cameras, the client tested multiple models from several manufacturers. The key selection criteria were camera reliability and image quality. As a result, the client decided on Axis products, which did the best job of solving the set tasks and meeting the company's needs, in terms of both camera product range and camera quality.'
Alexander Denezhko, Fort Dialogue, Bashkiria, Russian Federation.

2. High-quality design and components

The quality work at Axis starts during the design phase. The right sensor and components are chosen to ensure passive cooling. It conducts heat away from the sensor, resulting in less visible noise and better image resolution, without the use of any fans or other sensitive moving parts. Furthermore, circuit boards are always enclosed in a casing for protection against physical and weather damage and electrostatic discharge. Cables and connectors included in the cameras are shielded to withstand electrical surges and induction from surrounding power cables.

Not only details affect quality – the combination of details in the product as a whole is equally important. Consider the camera lens as an example: many vendors sell security cameras without a lens, leaving it to the customer to try to find the most suitable one. Today the market offers an abundance of lenses and cameras with a wide variety of resolutions and image enhancement technologies, which makes it quite a challenge to match the right camera with the right lens. Axis cameras, on the other hand, are always sold together with a lens which is optimized to the sensor and chassis of the camera by means of Axis proprietary system of active alignment.

3. Impact resistance tests

Many security cameras are placed in environments where they are subjected to various kinds of impact. The most obvious example is vandalism and other physical attacks on the camera, but it can also be branches and debris blowing at the camera on a windy day, or birds or animals resting or climbing on the camera. Another example is the human factor: even an experienced installer can occasionally drop a camera on the ground.

Impact-proof tests are performed according to European standard (EN) and International Electrotechnical Commission (IEC) standard EN/IEC 62262. The IK rating of the standard specifies to what extent an enclosure protects its contents from external impact. The tests are used to demonstrate an acceptable level of robustness when assessing the safety of a product and are primarily intended for testing electrotechnical items. Since the IK test is designed to test the protection of the inner parts of a product, it is more correct to call it a robustness test instead of an impact-proof test. According to EN/IEC 62262, IK10 tests should be performed as follows: 'Each exposed surface of the product should be hit five times, evenly distributed over the surface. In no case shall more than three impacts be applied in the surroundings (area) of the same point of the product'.

Axis quality testing goes beyond the standard, defining a higher level of protection. According to Axis criteria every exposed surface should be hit five times, with a total of up to 30 hits from different planes. A standard IEC probe, with a mass of between 0.25 kg (0.55 lb) and 10 kg (22 lb), is selected for use according to the IK rating. Axis products are tested using the vertical hammer method and, according to Axis criteria, the impact points are selected among the weakest points of the camera. This test, which by Axis is referred to as IK10+, is an important distinction, since the standard itself does not define that the product needs to be tested at its weakest points. It is quite possible for a manufacturer to choose the strongest points of the camera when testing for IK10, leading to a successful test result, but possibly to a less robust product.

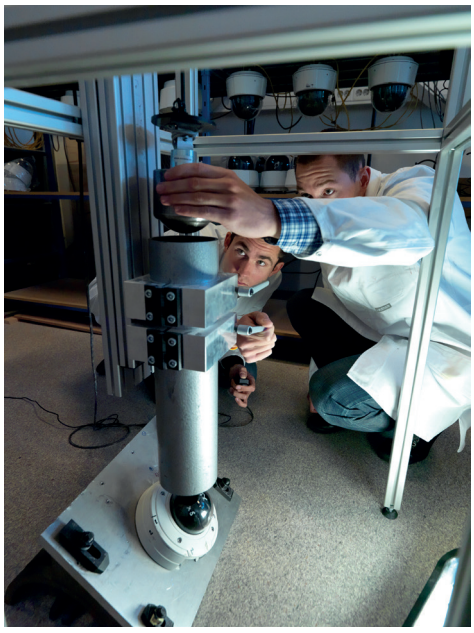

Figure 2: Impact-proof test of a camera.

After the test, the camera should still meet the stated IP rating, meaning that the camera retains its water and dust resistance even after being severely impacted from many angles (see Section 4, Ingress protection tests, for more information on IP tests). There should not be any permanent deviations inside the enclosure that affect the function of the product, nor should any internal components have failed or deteriorated. Again, this is an important aspect, since standard tests such as IK and IP do not demand that they should be applied in combination. A manufacturer can test their product for IK and IP separately and in this way meet the requirements. However, in a real-life situation, the product that has been subjected to impact, such as vandalism, could then lose its water resistance and cease to function during the next rainfall.

Axis cameras are designed based on lessons learned from previous tests, coupled with the latest technology. Impact testing is performed on prototypes to ensure supplier quality control and structural integrity. A high-speed camera is often used during prototype testing to analyze dome deformation and behavior.

4. Ingress protection tests (IP tests)

The elements can have a powerful effect on camera operability. Water can penetrate cameras that are exposed to rain, which can impair the way they function. In severe cases, cameras exposed to water can fail and expose the public to potential electrical hazards. Cameras mounted at construction sites, mining operations, transportation systems and similar environments are subjected to high levels of dust and particles in the air. The dust can impair image quality or render a camera inoperable. Axis cameras are tested for both dust and water resistance.

Regarding the ingress protection of a product, Axis uses the IEC/EN 60529 standard that specifies IP-classification (IPXY) where 'X' is a number between 0 and 6, and 'Y' is a number between 0 and 8. The first digit indicates the degree of protection against the intrusion of solid objects, such as dust, and the second one against water. IP tests should be performed both before and after the impact test.

For IP66, the IP class of most Axis outdoor cameras, the procedure consists of two tests. During the first one, the camera is placed in a dust chamber and subjected to extremely high levels of fine grain talc, at an underpressure of 20 mbar (15 mmHg, 0.29 psi), for a period of 2 hours. The dust level is high enough to present a severe health risk to anyone exposed to it for a prolonged period of time. It is a good indicator of the housing integrity of a camera and the quality of its sealing gaskets.

During the next test, the camera is exposed to a high pressure water stream with a flow rate of 100 l/ minute (26 gallons/minute) onto the camera from 2.5-3 m (8ft 2 in-9ft 10in) away. Following the test, the camera is opened and inspected for water ingress with special attention paid to its sealing gaskets. Its functionality is also thoroughly checked.

Figure 3: Left: Water-proof test of a camera, right: Dust lab.

5. Vibration tests

A camera can be subjected to vibrations from many sources. A camera sitting by a server room, a camera in a factory, or a camera mounted on a vehicle or shipped to a customer can undergo regular vibrations. Over time, vibration can cause a change in key camera functionalities, such as focus or mechanical properties. The ability to keep focus under low level vibrations is critical for the image quality of any camera. Excessive vibration can also wear down screws and other components, leading to permanent damage and camera failure.

Axis cameras undergo three types of vibration tests: vibration robustness tests, vibration performance, and shipment tests. Robustness tests check how a product works after being subjected to vibration and shock, and performance tests check image stability during vibrations. Shipment tests evaluate whether a product will function properly after transport.

5.1 Robustness test

Axis robustness tests determine that the product and its materials are robust, to ensure better protection against vandalism or accidents.

Most products are tested for vibration according to IEC 60068-2-6 and shock according to IEC 60068-2-27. The total number of oscillations in the vibration test, for a typical outdoor product, exceeds 1 million. In the shock test for a typical outdoor product, the camera is subjected to 600 shocks at 15 G. Following the tests, the camera is closely examined for loose screws, mechanical defects, material failure and other key mechanical properties.
The complete camera is always tested, not just its parts, in order to ensure that the camera can still deliver a perfect image after each test. After the camera has been subjected to the robustness test, there should not be any permanent defocusing or functional problems. The camera should always be able to refocus through its software and hardware.

5.2 Performance test

In order to ascertain good image stability during vibrations, Axis has developed far-reaching tests, going beyond the standards to gauge the performance of a camera during operation, such as the image stability of a PTZ camera undergoing low level vibrations.

5.3 Shipment tests

Shipment tests are performed to ensure that a camera will arrive fully functioning at the customer's site. The vibrations of the camera inside the box are measured. As the size of cameras and lenses increases, such tests are more and more important.

Shipment tests are run on packages to determine the integrity of the packaging and its ability to protect the product. A camera, in its packaging, is placed on a platform. It is then subjected to a random vibration profile that replicates a bouncing truck on a poor-quality road. A typical test simulates thousands of miles travelled by road and air.

Figure 4: Equipment used for the shipment test.

The purpose of the experimental test development is to measure qualities not defined in standards and that are of special interest to a project. Experiments have been developed to test the stability of an image undergoing vibrations, to test the accuracy of a camera when restored to default values, and to check at what level a PTZ camera will fail during shock vibrations. A test has even been developed to determine how smooth the pan of a new camera is compared to an old one.

6. Abrasion tests

Abrasion tests, according to the ISO 11998 standard, are performed in a lab to check whether the surfaces protecting the lens, such as polycarbonate windows or domes, are resistant to abrasive materials.

The samples are scrubbed with an abrasive cleaning pad and soap water with a predetermined pressure against the tested surface. Each sample is subjected to 100 cycles. After the test, the product should still function properly, with maintained image quality. It should also be esthetically pleasing.

7. Climate tests

Security cameras are used all over the world in indoor as well as outdoor environments. They are exposed to enormous variations in temperature – from the searing heat of the Middle East to the icy cold of Alaska. In addition, cameras are often mounted on top of poles or buildings, exposing them to extreme wind and sunlight. Consequently, temperature resistance is a critical aspect of any security camera.

High or low temperatures can cause components to fail or freeze. Prolonged exposure to even moderately high temperatures reduces the lifespan of equipment. Humidity can cause component damage, but can also cause condensation on the inside of the camera dome in warmer temperatures, and frost in cooler ones.

Ensuring that Axis cameras work reliably in extreme climate conditions is a critical issue during design and production. Datasheets specify a maximum and minimum operating temperature, as well as a startup temperature. To make sure that all products fulfill the defined values, extensive climate testing is performed, both in labs and at live sites. Long-term tests, where cameras are subjected to extreme temperature and climate conditions, are performed in Sweden, United Arab Emirates and Russian Federation.

7.1 Lab tests (low and high temperature tests)

Temperature tests in labs are performed in climate chambers, where all types of temperatures and climates can be simulated. Tests are made with an interval margin of ±15 °C (±27 °F) at either end of the operational temperature range. The humidity range spans from 0 to 100%.

Figure 5: Temperature test in a climate chamber.

Components as well as complete products are tested. All components have a margin of at least 5 °C (9 °F) to product specifications. Image quality tests are made in different temperatures to ensure image quality across the entire operating temperature range. In addition, condensation performance tests are made to ensure that fog does not build up in front of the lens inside the dome in high humidity environments.

Low temperature test
Axis cameras are guaranteed to start at the camera startup temperature stated in the datasheets, and the cold condition temperature is the most critical one. However, the minimum operating temperature can be lower than the startup temperature once the camera has started.

High temperature test
Axis cameras are designed to keep the noise level at a minimum to guarantee the required image quality. The design is highly focused on heat dissipation. Even in low light conditions, Axis cameras keep down the visible noise, thanks to their passive sensor cooling system.

7.2 Live sites

In addition to extensive lab tests, Axis products undergo live site tests for observation of long-term effects in real environments. The results give reliable data about condensation, corrosion, and mechanical and cosmetic defects of the tested products. Climate data, from a weather station mounted next to the products, is saved and analyses are conducted on all environmental parameters that the products are subjected to. The cameras are monitored round-the-clock for more than five years (44,000 hours).

Live site tests are performed in varying locations and climate zones all over the world: Lund in Sweden, Novosibirsk in Russian Federation, and Dubai in United Arab Emirates. The table below indicates the temperature and humidity ranges for the test locations, both during summer and winter.

Live site	Temp. summer	Humidity summer [%RH]	Temp. winter	Humidity winter [%RH]
Novosibirsk	10 °C to 35 °C (50 °F to 95 °F)	25 to 95	-40 °C to 0 °C (-40 °F to 32 °F)	60 to 95
Dubai	25 °C to 50 °C (77 °F to 122 °F)	15 to 90	15 °C to 25 °C (59 °F to 77 °F)	45 to 65
Lund	12 °C to 32 °C (54 °F to 90 °F)	25 to 100	-15 °C to 5 °C (5 °F to 41 °F)	70 to 100

Figure 6: Axis test camera installed on site in Novosibirsk.

Figure 7: Axis test camera installed on site in Dubai.

8. Reliability of the firmware

For a product to be reliable, the firmware must be dependable at all times. A camera used for surveillance is expected to have high uptime and availability. When the user needs video, there should be no delay or interruption. After installation, the user should be able to 'forget' their camera since it is working, and it will keep on working.

When it comes to testing firmware reliability, there is not the same level of acknowledged international standards as there is for hardware. Since there is not any explicit standard for reliability, Axis invests a lot of research in developing reliability testing, both internally, at Axis research and development department, but also together with universities and in co-operation with Swedish companies in other industries. Axis does not only follow best practices, but advances them or invents them when needed.

At Axis, two types of reliability tests are performed – load testing and stress testing. Load testing verifies that the camera can operate with the expected performance, even when being used to its limit. The camera is put under heavy load, including multiple video streams, starting and stopping streams, handling events, running analytics, and so on, for an extended period of time. Stress testing verifies that the camera can handle unexpected and extreme loads, for example due to network problems, a glitch in the system or even a network attack. The camera should be able to handle such problems and continue to operate.

A large team of test engineers with hundreds of computers and servers with different types of operating systems and a network infrastructure of over 1,000 Ethernet ports are testing all combinations of setups on all Axis products for at least 10 weeks before release. Besides ensuring that all new Axis cameras and encoders are fully compatible with Axis video management systems, it also covers compatibility testing with a number of market-leading video management systems from Axis Application Development Partner (ADP) program. Before a new firmware is released, tests are performed to ensure that it is working with internal and external applications. The firmware is tested for function, performance, stability and system compatibility in several thousand test cases.

9. Quality tests during production

A product must be completely and fully operational with all its intended capabilities at launch, and always with complete documentation for partners and end customers. To maintain quality assurance, all Axis products are tested thoroughly during production, and materials are carefully selected.

9.1 Production

A manufacturer working for Axis must apply quality control at all stages of the production process. The quality assurance covers components, tools, management, the selection and training of staff, and also the finished products, the packaging of the products, and so on. The finished product must conform to the product design specifications in all aspects.

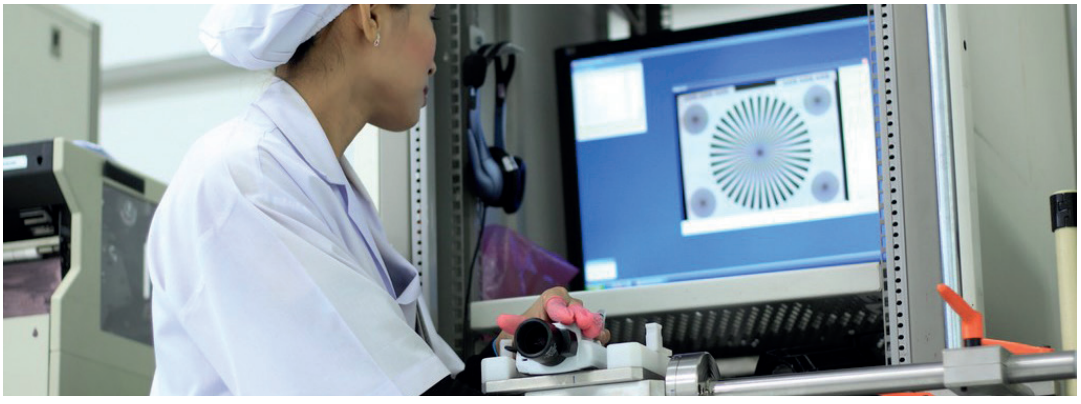

Figure 8: A trained operator performing some of the tests.

At all Axis manufacturing sites, quality control starts as components arrive. Individual components are checked and measured. Most components, including all critical components, such as image sensors, lenses, product specific chipsets and all mechanics, are sourced by Axis to maintain quality assurance throughout the supply chain. Generic components are sourced by Axis contracted manufacturers. Once the components have been checked, electronics are surface mounted using state-of-the-art manufacturing methods. To ensure that no error goes undetected, automated and manual testing, including optical, visual and x-ray inspection, are used. PCB assemblies are tested electrically before being approved for the next step, which is box build in a classified clean room. A proprietary system of active alignment is used to perfectly align the sensor and lens. Once the box build is completed, a battery of functional tests is performed. Every single camera is tested. Some testing is automated, but every camera is also approved by a trained operator.

In the following step, every single camera passes through one of Axis Configuration and Logistics Centers (CLC), located in various places around the world. As the products arrive, quality control procedures start. When a customer puts an order, the cameras are picked, configured and once again subjected to a number of tests, similar to the ones they were subjected to during manufacturing, before they are packed. A dedicated tester is responsible for each camera.

9.2 Materials

The material used for Axis camera windows and domes is polycarbonate (PC). It is chosen over the more commonly used polymethyl methacrylate (PMMA), which is used in, for example, fish tanks and rear lamps of vehicles. PMMA is more fragile, whereas PC has excellent impact resistance and very good optical properties. The PC grades used in Axis products are of the highest quality from the top industry material suppliers. It is used in places where impacts and collisions are common, such as police shields, ice hockey rinks and jet fighter canopies. In an Axis product, a window made of plastic will normally only get marks when being hit, but it will not crack or shatter, thanks to its PC material.

PC is more difficult to manufacture which makes the price approximately 2–3 times higher than for PMMA. The PC material used in Axis camera windows and domes are all UV-stabilized to increase the service life. For non-transparent covers, PC alloys and other materials are used to enhance the ultraviolet (UV) resistance even further.

Axis products are made from materials with very low and compatible thermal expansion coefficients to minimize focus variations due to temperature variations. Minimizing the effect of temperature on the size of lenses, lens holders and sensor holders, thus avoiding movement of the lens, means that the high image quality is always maintained.

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About Axis Communications

Axis offers intelligent security solutions that enable a smarter, safer world. As the market leader in network video, Axis is driving the industry by continually launching innovative network products based on an open platform - delivering high value to customers through a global partner network. Axis has long-term relationships with partners and provides them with knowledge and ground-breaking network products in existing and new markets.

Axis has more than 2,700 dedicated employees in more than 50 countries around the world, supported by a global network of over 90,000 partners. Founded in 1984, Axis is a Sweden-based company listed on NASDAQ Stockholm under the ticker AXIS.

For more information about Axis, please visit our website www.axis.com.

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