

WHITE PAPER

Battery health in body worn cameras

August 2026

Summary

Lithium-ion batteries in Axis body worn cameras are consumable components that degrade with time and usage. When the battery's capacity diminishes, the maximum operating time between full charges decreases as well.

Calendar aging, degradation caused by the side reactions that occur within a battery over time, is inevitable. However, by following battery health guidelines when you use, charge, and store your battery, you can extend the life of your battery.

Battery degradation depends on several factors:

- **Temperature** — extreme heat can accelerate the battery's chemical reactions while extreme cold can slow them down, both phenomena causing temporary or permanent capacity loss.
- **Charge state** — storing batteries in fully charged or depleted states induces non-recoverable capacity loss.
- **Total number of charge cycles** — with each charge cycle, the battery's capacity diminishes slightly. The battery's total number of equivalent complete charge cycles (when 100% of a battery's capacity is discharged and then replenished) is, therefore, an indicator of the battery's current health status.
- **User behavior** — heavy use and high-rate discharges can increase the number of charge cycles and lead to increased impedance, both of which shorten battery life. Different camera profiles (such as resolution settings) and usage behavior (such as user interaction) consume different amounts of battery power.

Axis body worn cameras come with several features especially designed to protect the battery, such as temperature-dependent adaptive charging and auto shutdown at low capacity and extreme temperatures. AXIS Body Worn Manager also has a predefined camera profile that maximizes the camera's operating time between charges.

The battery in your Axis body worn camera is designed to provide at least 80% of its original capacity after 500 full charge cycles, as long as battery health guidelines are followed. The battery must then be replaced after 500 full charge cycles when swelling and battery degradation accelerate.

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1 Introduction

This white paper provides information about the battery used in Axis body worn cameras. We discuss the key factors affecting battery health, as well as the camera's battery friendly features that help protect the battery. The paper also highlights what you, as a user, can do to extend battery life and operation time.

2 The battery in Axis body worn cameras

Axis body worn cameras use rechargeable lithium-ion batteries for their power supply. This type of battery is widely used in mobile phones, laptop computers, and other electronic devices because it provides high energy density, long life, and short charging times compared with other types of batteries.

Like all other rechargeable batteries, lithium-ion batteries are consumable components that inevitably degrade with time and usage. As a result of degradation, the battery's capacity diminishes and its internal resistance increases, which means shorter operating time between charges.

3 Factors that affect battery health

Battery manufacturers provide statistics on the rate of battery degradation in a lab environment. In a real environment, however, degradation can deviate substantially, as it's strongly affected by environmental conditions and the use of features that impact the camera's power consumption.

3.1 Temperature

Temperature has a significant impact on lithium-ion batteries because their functioning relies on chemical reactions. Heat accelerates chemical reactions, thereby hastening permanent capacity loss. It can happen, for instance, when a camera is left on the dashboard of a car in the sun. Coldness slows down or even stops these reactions, causing temporary capacity loss. Therefore, operating the camera in very cold weather leads to shorter operating time. Charging below 0 °C (32 °F) can result in severe, irreversible capacity loss and safety issues.

Storing a body worn camera at ambient temperatures above or below the specified temperature ranges causes irreversible damage to the battery. When you monitor the temperature of your device, it is important to remember that the battery temperature is higher than the ambient temperature you observe.

Table 3.1 Accepted battery temperature ranges for AXIS W102 Body Worn Camera. For other cameras, check their datasheets.

		Lower limit	Higher limit
Operating temperature		-20 °C (-4 °F).	55 °C (131 °F).
Ambient charging temperature		0 °C (32 °F).	40 °C (104 °F). If the battery temperature is above 45 °C (113 °F) at charging, the battery is only charged up to 70% of full capacity. This is to protect the battery. If the temperature is between 40 and 60 °C, the battery can be charged at a lower current.
Storage temperature	< 3 months	-20 °C (-4 °F).	45 °C (113 °F).
	> 3 months	23 °C (73 °F).	27 °C (81 °F).

To keep track of possible abnormal battery degradation, any camera usage at non-recommended temperatures is automatically registered in the body worn system report. Such information is also helpful for Axis support to determine whether a malfunctioning battery is covered by Axis warranty.

3.2 Charge state

Storing batteries in fully charged or depleted states will induce non-recoverable capacity loss.

When the battery is fully charged, the highly active chemical reaction speeds up battery degradation. Therefore, a camera that sits in a docking station or is connected to a USB-C charger for an extended period of time will suffer unnecessary capacity loss.

The battery self-discharges over time even when not in use. When a camera is stored with a very low charge state for more than three months, the battery can get over-discharged and damaged. A camera should also be used at least once a year so that the battery is discharged and charged again the normal way.

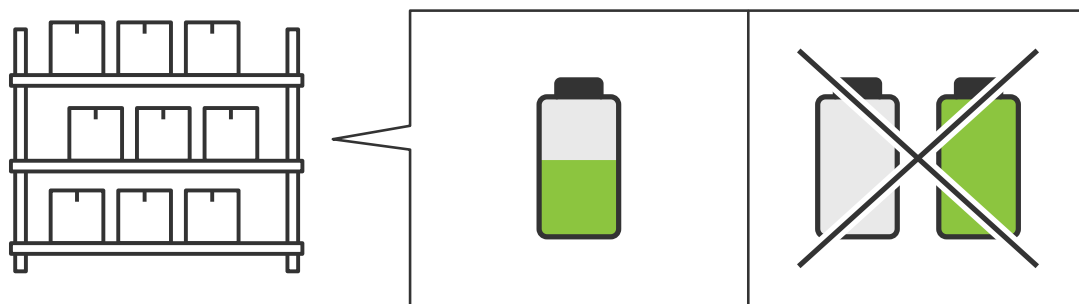


Figure 3.1 Long term storage of the camera should optimally be done at a medium battery charge state. The camera should neither be allowed to fully discharge, nor sit fully charged in its docking station for an extended period of time.

3.3 Total number of charge cycles

With each complete charge cycle, the capacity of a lithium-ion battery diminishes slightly. For this reason, the total number of charge cycles that a battery has undergone is an important indicator of the battery's current health status. You can find your battery's total number of charge cycles in your body worn system.

A charge cycle is completed when 100% of a battery's capacity is discharged and then replenished. Depending on how much the camera is used each day, it can take several days before a charge cycle is completed. For example, assume that a camera is configured so that the battery lasts for 15 hours when fully charged. If the user's work shift is 10 hours, one charge cycle is considered complete after 1.5 workday.

The lithium-ion battery inside an Axis body worn camera is designed to provide at least 80% of its capacity for 500 full charge cycles. In the above example, this accounts for roughly 750 workdays (about 3 years).

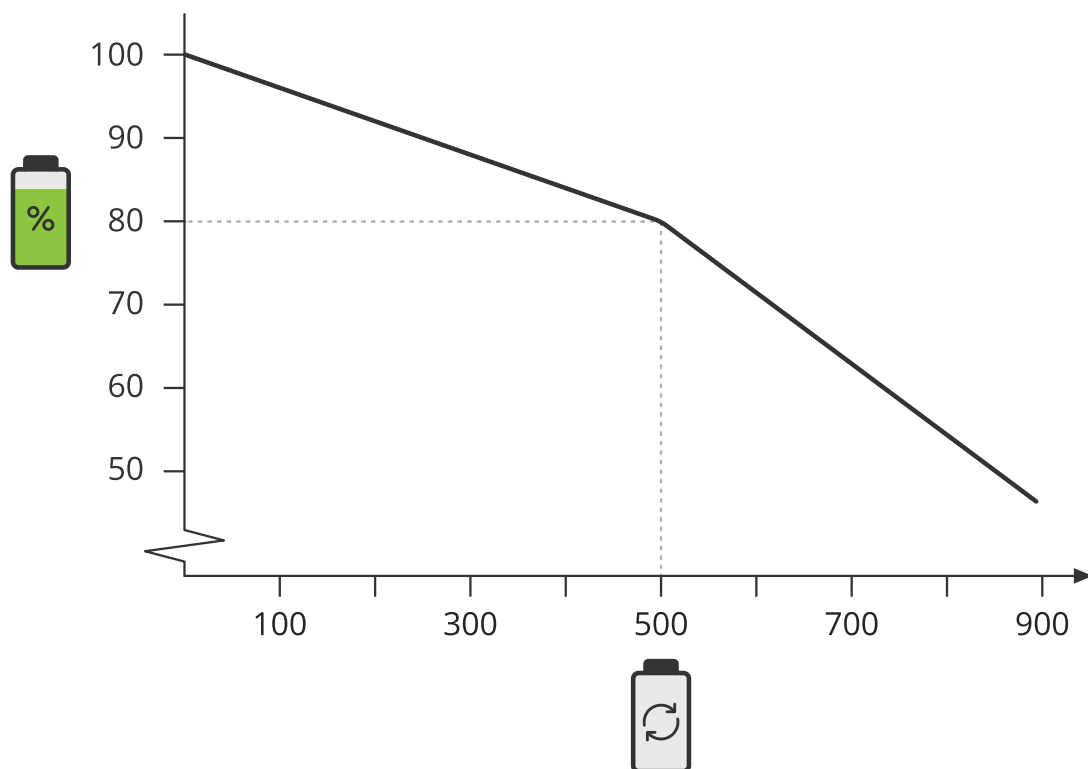


Figure 3.2 Typical lithium-ion battery degradation, depicting battery capacity over charge cycles. After approximately 500 charge cycles, the battery has at least 80% of full capacity but degradation is accelerating.

After 500 charge cycles, the degradation of lithium-ion batteries typically accelerates. Therefore, batteries must be replaced after 500 charge cycles.

3.4 User behavior

How much a battery is used every day has a direct impact on its rate of degradation. Heavy use and high-rate discharges can increase the number of charge cycles and lead to increased impedance, which shortens battery life.

Under similar environment conditions and in the same period of time, two users with different camera profiles and usage rates might not consume the same amount of battery power. The table below exemplifies this difference.

Table 3.2 Different camera usage results in different operating times.

	User 1 (customized camera profile)	User 2 (camera profile optimized for operating time)
Live stream	Sometimes on	Off
Location data	On	Off
Unholster detection	Off	Off
AXIS Body Worn Assistant	Sometimes on	Off
Fall detection	On	Off

LED display	Active user interaction, mix of high and normal intensity	No user interaction, normal intensity
Battery life	Standard	Extended

Over time, this difference will compound the number of charge cycles each user needs, leading User 1 to require a new battery far sooner than User 2.

4 Battery friendly design

Axis body worn solutions comes with several features for extended battery life:

- **Adaptive charging**
The adaptive charging function adjusts the maximum charging current and voltage based on the battery temperature, so that the camera is charged as fast as possible without damaging the battery. Temperature data is read from the temperature sensor on the battery control module every few seconds. This means that the charging time varies with the ambient temperature. For example, at normal room temperature, a battery may be fully charged after about 3.5 hours of charging in a docking station or about 4.0 hours of charging with a USB-C cable.
- **Auto shutdown at extreme temperature**
If the camera's internal temperature is too high or too low, the camera will automatically shut down to protect the battery. This could happen, for example, when the camera is left in a vehicle.
- **Auto shut down at low charge state**
To avoid becoming over-discharged during storage, the camera will shut down when the charge state is close to 0%.
- **Charge limit in high temperatures**
To protect the battery, a charge limit of 70% is applied when charging takes place in ambient temperatures above 45 °C (113 °F).
- **Charge limit before being assigned to a system**
To comply with international regulations and avoid unnecessary capacity loss due to high charge state during storage and shipping, we apply a charge limit of 30% when our cameras are shipped. We also apply a storage charge limit of 60% before our cameras are added to a body worn system via AXIS Body Worn Manager.
- **Camera profile for optimized operation time**
AXIS Body Worn Manager has a predefined camera profile, *Optimized for Operation Time*, which can be used directly or as a reference. Applying this profile, or using the same settings as the profile, maximizes the camera's operating time. The settings include, for example, using 720p resolution, using no location data, and keeping the front recording indicator off.
- **Dynamic LED control**
LEDs on the camera consume a considerable amount of power. For power saving, the LED intensity is adjusted dynamically according to the surrounding lighting conditions. The brighter the surrounding lighting, the higher the LED intensity, and vice versa.
- **Smart Charge mode in select models**
To prevent lifespan degradation and swelling, the camera will lower its maximum charge limit if it detects prolonged docking. If the camera is mostly docked over a three-week period, it will enter the Basic Smart Charge mode and stop charging at 85%. If it's mostly docked over a two-month period, the camera will enter a Strict Smart Charge mode and stop charging at 55%. To exit the Smart Charge mode, you must drop the camera's battery level below 30% and then fully recharge the battery.

5 Battery health guidelines

Although Axis makes a lot of efforts to optimize your battery's performance, battery life is ultimately in your hands. By following battery health guidelines (which are based on the factors outlined in this document) when using, charging, and storing your camera, you can make the battery last longer.

You can find specific health guidelines for your battery in your camera's user manual. The same guidelines are followed by Axis during production, configuration, and transportation of body worn cameras. For example, all units in Axis configuration and logistics centers (CLCs) are charged every three months.

6 Battery replacement and Axis warranty

The battery in Axis body worn cameras is designed to provide at least 80% of its original capacity after 500 full charge cycles. You can find information about your battery's current number of completed charge cycles in the body worn system. You must replace the battery after 500 full charge cycles to maintain your camera's functionality and prevent harmful battery swelling.

Axis body worn cameras are covered by Axis 3-year limited hardware warranty. This means that manufacturing defects in the battery are covered in the same way as manufacturing defects in the camera's other components. Battery degradation is excluded from the warranty because it is considered *normal wear and tear or deterioration*.

About Axis Communications

Axis enables a smarter and safer world by improving security, safety, operational efficiency, and business intelligence. As a network technology company and industry leader, Axis offers video surveillance, access control, intercoms, and audio solutions. These are enhanced by intelligent analytics applications and supported by high-quality training.

Axis has around 5,000 dedicated employees in over 50 countries and collaborates with technology and system integration partners worldwide to deliver customer solutions. Axis was founded in 1984, and the headquarters are in Lund, Sweden.