

WHITE PAPER

Battery health in body worn cameras

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Summary

As all other rechargeable batteries, the 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 chargings decreases.

Battery degradation is inevitable but varies depending on several factors:

- **Temperature** – coldness can slow down or stop the battery's chemical reactions while heat can accelerate them, both phenomena causing temporary or permanent capacity loss.
- **Charge level** – chemical reactions inside the battery are also driven by voltage, which is directly linked to charge levels. Storing batteries in fully charged or depleted state can induce non-recoverable capacity loss.
- **Total number of charge cycles** – with each complete charge cycle (when 100% of a battery's capacity is discharged) the battery capacity diminishes slightly. The total number of charge cycles that a battery has undergone is, thus, an indicator of the battery's current health status.
- **User behavior** – heavy use requires an increased number of charge cycles and thus shortens battery life. Different camera profiles (such as resolution settings) and usage behavior (such as heavy user interaction) consume different amounts of battery power.

Axis body worn cameras come with several features especially designed to protect the battery, for example, adaptive charging depending on temperature and auto shutdown at low charge level. AXIS Body Worn Manager also has a predefined camera profile that maximizes the camera's operating time between chargings.

The battery is designed to provide at least 80% of its original capacity after 500 full charge cycles, as long as battery health guidelines are followed. Axis recommends you replace the battery after 500 cycles.

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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 as power supplies. This type of battery is widely used in mobile phones, laptop computers, and other electronic devices because it provides high capacity, long life, and short charging time at low weight, compared with other types of batteries.

As 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, which means shorter operating time between chargings.

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, strongly affected by:

- environmental conditions, for example, operating temperature.
- how the camera is operated.

3.1 Temperature

Temperature has a significant impact on lithium-ion batteries because their functioning relies on chemical reactions.

Coldness can slow down or even stop these reactions, causing temporary or permanent capacity loss. Therefore, operating the camera in very cold weather leads to shorter operating time. Charging below 0 °C (32 °F) could result in severe, irreversible capacity loss.

Heat can accelerate chemical reactions, thereby hasten temporary and permanent capacity loss. It could happen, for instance, when a camera is left on the dashboard of a car in the sun.

Using, charging, or just storing a body worn camera at ambient temperatures above or below the specified temperature ranges may cause irreversible damage to the battery.

Table 3.1 Accepted temperature ranges for Axis body worn cameras.

		Lower limit	Higher limit	Optimal performance
Operating temperature		-20 °C (-4 °F)	55 °C (131 °F)	
Charging temperature		0 °C (32 °F)	40 °C (104 °F)	
Storage temperature	< 3 months	-20 °C (-4 °F)	45 °C (113 °F)	25 °C (77 °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 level

Chemical reactions inside the battery are also driven by voltage, which is directly linked to charge levels. Storing batteries in fully charged or depleted state can induce non-recoverable capacity loss.

When the battery is fully charged, the highly active chemical reaction can speed 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 could 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 level for more than three months, the battery can get over-discharged and thereby permanently damaged. A camera should also be used at least once a year so that the battery is discharged and charged again the normal way. This helps activate the battery and restore its energy.

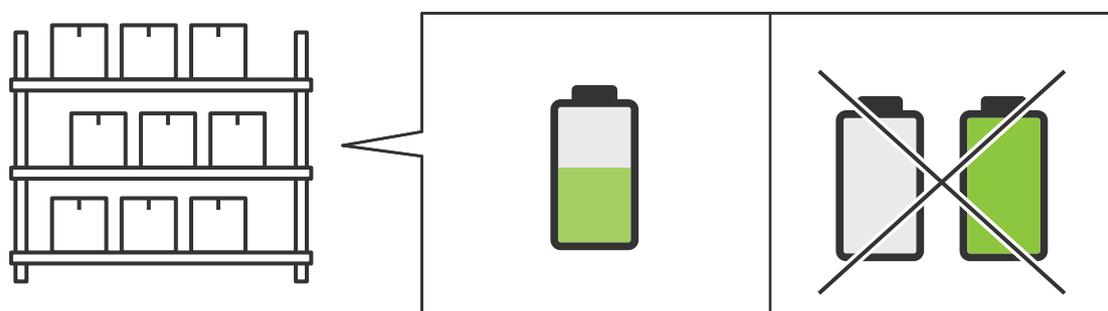


Figure 1. Long term storage of the camera should optimally be done at a medium battery charge level. The camera should neither be allowed to fully discharge, nor sit fully charged in its docking station for an extended period of time.

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. The number can be found in the body worn system report.

A charge cycle is completed when 100% of a battery's capacity is discharged. Depending on how much the camera is used every day, it could take several days before a charge cycle is completed.

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.

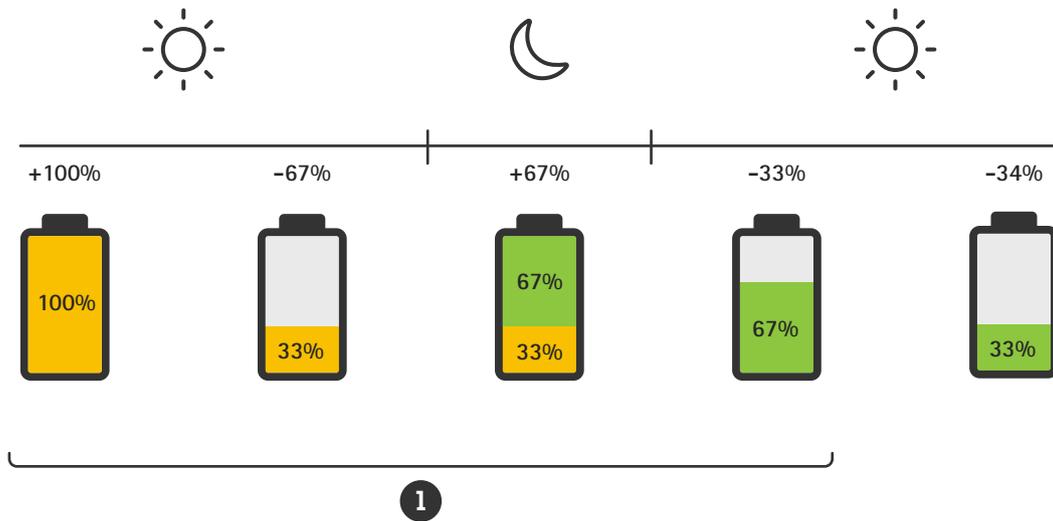


Figure 2. One charge cycle (1) is complete when 100% of the capacity has been discharged. This is when the battery would have been completely discharged, had it not already been recharged.

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).

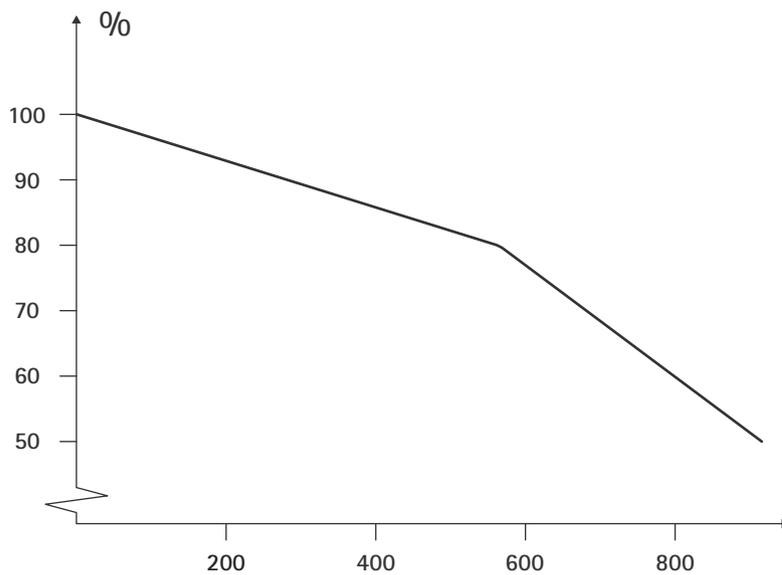


Figure 3. Typical lithium-ion battery degradation. After 500 charge cycles, the battery has at least 80% of full capacity but degradation is starting to accelerate and battery should be replaced.

After 500 charge cycles, the degradation of lithium-ion batteries typically accelerates. Axis therefore recommends a battery change after 500 charge cycles.

3.4 Camera usage

How much the battery is used every day has a direct impact on the rate of degradation. Heavy use requires an increased number of charge cycles and thus shortens battery life.

Under similar environment conditions and in the same period of time, two users with different camera profiles and usage behavior might not consume the same amount of battery power. The table below exemplifies this difference. Assuming both users record two hours per day at 25 °C and use the prebuffer option, the difference in maximum operating time is two hours.

Table 3.2 Different camera usage results in different operating time.

	User 1 (camera profile: optimized for operating time)	User 2 (camera profile: customized)
Video stream	720p @ 30 fps, H.264	1080p @ 30 fps, H.264
Location data	Off	Off
Unholster detection	Off	Off
AXIS Body Worn Assistant	Off	Sometimes on
Fall detection	Off	On
LED display	No user interaction, normal intensity	Active user interaction, mix of high and normal intensity
Resulting, remaining operating time (new battery, 25 °C, pre-buffer on, record 2 h)	17 h	15 h

4 Battery friendly design

Axis body worn solution 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 protection board every few seconds. This means that the charging time varies with the ambient temperature. At normal room temperature, the battery is fully charged after about 3.5 hours of charging in a docking station or about four hours of charging with a USB-C cable.
- **Auto shutdown at high temperature**
If the camera's internal temperature is too high, the camera will automatically shut down to protect the battery. This could typically happen when the camera is left in a vehicle.
- **Auto shut down at low charge level**
To avoid becoming over-discharged during storage, the camera will shut down when the charge level is close to 0%.

- Charge limit when not in use
To avoid unnecessary capacity loss due to high charge level during storage, a charge limit of 60% is applied to the camera when it does not belong to a body worn system. This is when the camera has not yet been added to, and after it has been removed from, 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.

5 Battery health guidelines

Although Axis makes a lot of efforts to optimize the battery's performance, battery life is ultimately in the user's hands. By following battery health guidelines (which are based on the factors outlined in this document) when using, charging, and storing the cameras, you can make the batteries last longer. The guidelines can be found in the 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. The body worn system report can be used to check the current number of charge cycles. Axis recommends you replace the battery after 500 cycles.

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 creating solutions for improving security and business performance. As a network technology company and industry leader, Axis offers solutions in video surveillance, access control, intercom, and audio systems. They are enhanced by intelligent analytics applications and supported by high-quality training.

Axis has around 4,000 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