Fixed Dome Camera with Improved Impact Resistance

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1. Introduction

There is an increasing demand for surveillance camera systems to enhance security for the 2020 Tokyo Olympic and Paralympic Games.

Surveillance cameras are installed at various places for specific purposes. However, those installed within reach, such as on low ceilings and walls, may be vandalized such as by hitting with an umbrella. To prevent such destruction, surveillance cameras that can resist impact are needed.

To meet such demands, Mitsubishi Electric Corporation has developed fixed dome cameras with improved impact resistance.

2. Fixed Dome Cameras with Impact Resistance

2.1 Specifications

Figure 1 shows the appearance of a fixed dome camera with impact resistance, and Table 1 lists the specifications.

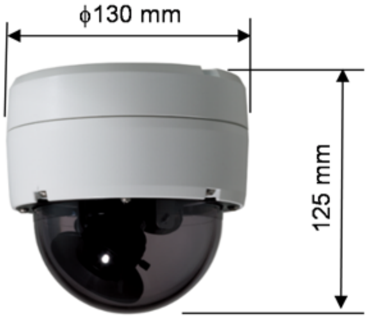

Fig. 1 Fixed dome camera with impact resistance

Table 1 Specifications

No.	Item	Specification
1	Image sensor	1/3 CMOS
2	Effective pixel count	Approx. 1,310 thousand pixels
3	Picture size	SXVGA, VGA, QVGA
4	Dynamic range function	Provided
5	Electronic sensitization	16 times max.
6	Automatic electronic sensitization function	Automatic and manual switching
7	Digital sensitization	8 times max.
8	Lowest written illuminance	With a smoked dome Normal time: 0.50 lux 0.04 lux (Electronic sensitization: 16 times) With a clear dome Normal time: 0.250 lux 0.016 lux (Electronic sensitization: 16 times)
9	Impact resistance	50 J (conforming to JIS C 60068-2-75)
10	Service temperature and humidity	−10 to 50°C, 80% RH or less (no condensation)
11	Outside dimensions	Approx. ϕ130 × 125 (H) (mm)
12	Mass	<900 g

CMOS:	Complementary Metal Oxide Semiconductor
VGA:	Video Graphics Array
SXVGA:	Super eXtended VGA
QVGA:	Quarter VGA
RH:	Relative Humidity

2.2 Advantages

Fixed dome cameras with impact resistance have the following advantages.

(1) Higher impact resistance to prevent breakage

Impact resistance of 50 J was achieved in a hammer test (JIS C 60068-2-75).

(2) Good resolution

The resolution of the dome cover is 2 million pixels.

(3) Reduced stray light

Deterioration of image quality due to light entering from outside of the angle of view is reduced.

3. Development Details

3.1 Issues and solutions

Figure 2 shows the development flow, issues, and solutions.

3.2 Impact resistance specifications and testing standards

3.2.1 Impact resistance specifications

In the fixed dome camera market, the impact resistance specifications are broadly divided into impact

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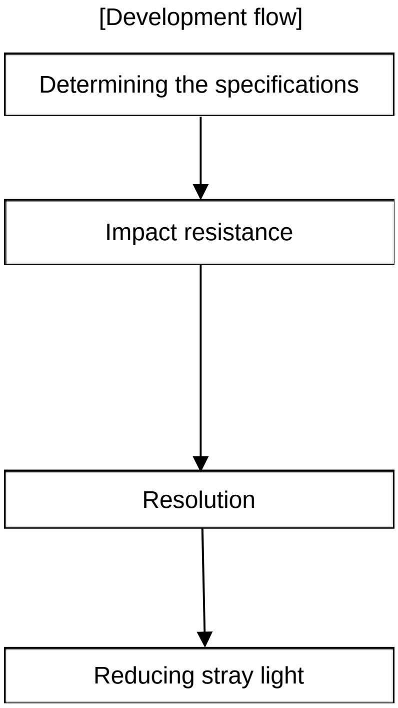


Issue:
- Determining the highest impact resistance specification in the industry.

Solution:
- Researched the market trend of fixed dome cameras.

Issues:
- Securing the strength of cases with the required resistance (determining the material of the cases).
- Determining the thickness of the dome cover such that when an impact is applied, the cover will not touch the lens.

Solutions:
- Designed the strength of the cases through shock analysis.
- Designed the thickness and clearance through preliminary testing and shock analysis.

Issue:
- Determining the tolerable thickness of the dome cover.

Solution:
- Clarified the correlation between the thickness and modulation transfer function (MTF) when a dome cover is installed through optical analysis.

Issue:
- Understanding the directions of incoming light beams and their intensity that cause a stray light phenomenon.

Solution:
- Calculated the light intensity through optical path analysis and designed a structure to suppress stray light.

Fig. 2 Development flow, issues and solutions

energy of 20 J according to IEC62262 for Europe and America and impact energy of 50 J based on JIS C 60068-2-75 for the Japanese market.

We set the impact energy of our dome cameras at 50 J, which is the highest level in the industry, based on JIS C 60068-2-75.

3.2.2 Testing standards

An impact resistance of 50 J means that the impact energy value obtained in accordance with the hammer testing standards is 50 J (at maximum). In the hammer test, as shown in Fig. 3, a 10-kg hammer is used to hit a sample three times from 0.5 m high using a pendulum.

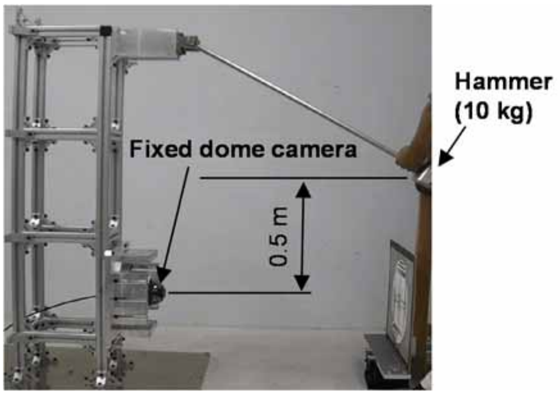


Fig. 3 State of hammer test

3.3 Development details

Figure 4 illustrates the configuration of a fixed dome camera. The camera unit and lens unit (inner parts) are secured with cases and protected with a transparent dome cover. For the fixed dome cameras with impact resistance developed this time, existing types of camera and lens units were used and new types of cases and dome cover were developed. An impact from outside of the product is absorbed by the cases and dome cover. Furthermore, a rubber blackout hood with shock absorbing structure is provided near the lens. In this way, the structure has achieved the impact resistance of 50 J.

With this design, we have succeeded in commercializing fixed dome cameras that satisfy the

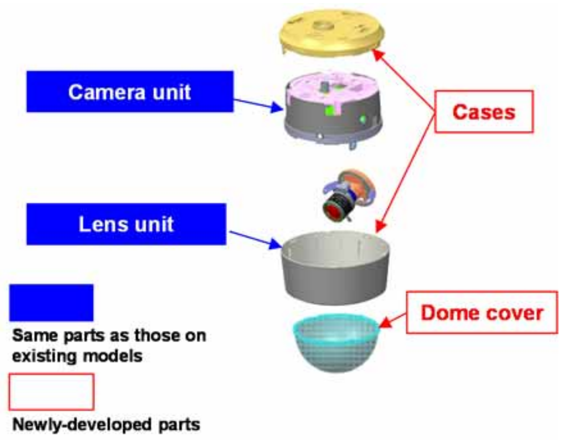


Fig. 4 Configuration of fixed dome camera

impact resistance of 50 J while providing the necessary optical performance.

3.3.1 Thickness of dome covers to secure impact resistance(2)(3)(4)

(1) Change to the material of cases

Since an impact applied to a dome cover is transmitted to the cases, the cases must have enough strength. Therefore, the material of the cases was changed from the resin used in conventional products to die-cast aluminum.

(2) Design of the impact resistance of dome covers

The lens unit inside a dome camera is protected by a hemispherical dome cover. If an impact is applied to the dome cover, it may momentarily deform, and if it touches the lens unit, the lens unit may break. To avoid this problem, the thickness of the dome cover and the clearance between the cover and lens unit should be sufficient such that even if the cover deforms, the impact will not be directly transmitted to the lens unit. Generally, the thicker the dome cover, the smaller its deformation when an impact is applied. However, there is a limit on the thickness as shown in Section 3.3.2 below and so it needs to be optimized. The deformation of a dome cover when an impact is applied was calculated through shock analysis and a preliminary test was carried out to understand the variation and obtain a factor to correct for errors in the analytic values. The value was then used to improve the design accuracy.

The obtained correction factor was used to carry out shock analysis shown in Fig. 5 with the curvature radius and thickness of the dome cover as main parameters. In the analysis, the necessary thickness (A mm or more) of the dome cover was calculated such that it will not come into contact with the lens when it momentarily deforms in relation to the clearance between the lens and cover.

3.3.2 Thickness of dome cover to secure the resolution

The thicker a dome cover, the larger the optical path difference due to refraction. Therefore, a thicker cover affects the focusing performance of the lens and reduces the resolution. To check that sufficient resolution could be secured, optical analysis was performed with the curvature radius and thickness of the dome cover as main parameters to determine the thickness. Figure 6 illustrates the optical analysis model. Light beams incident into the dome cover from infinity are condensed by the lens and the CMOS calculates the defocus amount when they are received. MTF is obtained as an indicator for the resolution. Figure 7 shows the correlation between the MTF and the thickness of the dome cover obtained from the optical analysis results. Based on these results, the required thickness (B mm or less) of the cover that satisfies the standard MTF value was obtained. Since the thickness of A mm or more obtained in Section 3.3.1(2) is required to secure the impact resistance, the thickness of the cover should be between A mm and B mm. The risk is lower for thinner dome covers considering the formability (such as sink marks poor appearance) and material strength (brittleness). Therefore, the thickness of A mm that would satisfy both impact resistance and resolution was selected.

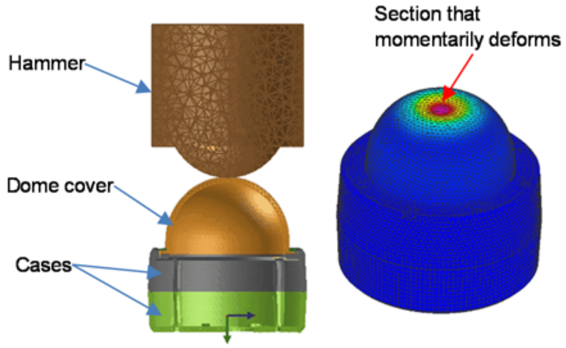


Fig. 5 Results of shock analysis

3.3.3 Reduction of stray light phenomenon

The larger the clearance between the lens unit and dome cover, the more the stray light phenomenon occurs, which deteriorates the image quality. To reduce such

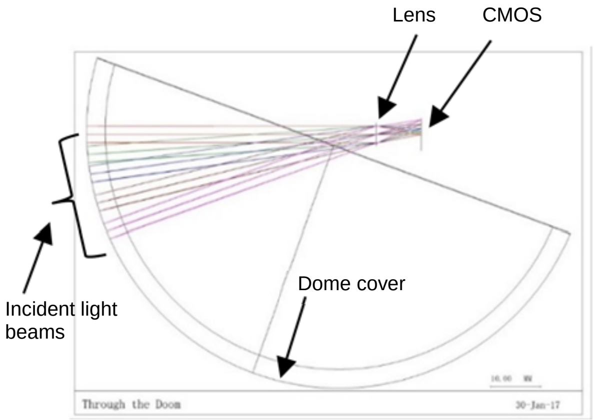


Fig. 6 Optical analysis model

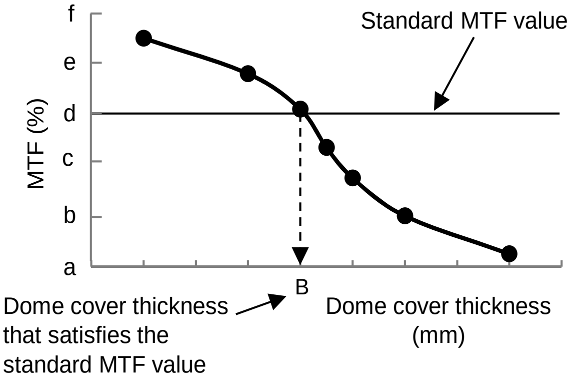


Fig. 7 Results of optical analysis

deterioration, optical path analysis was performed to identify the ray paths that would cause stray light. A blackout hood to shield light is provided to reduce stray light, while the rubber blackout hood with shock-absorbing structure increases the impact resistance.

(1) Stray light phenomenon

The stray light phenomenon is unnecessary light scattering that occurs inside the body tube of optical equipment. For surveillance cameras, it means that light beams from outside of the angle of view of the lens are unnecessarily reflected in the lens and refracted, and enter the images. As a result, they appear in images as objects that do not exist in the angle of view. Figure 8 shows an example of the stray light phenomenon. The figure shows that fluorescent light beams entering from the rear of the lens, etc. are reflected in the dome cover and other parts and appear in the image as flares.

(2) Optical path analysis

To reduce the stray light phenomenon described in (1), when developing our fixed dome camera this time, we performed optical path analysis to calculate and understand the paths of light beams passing through the lens and their intensity. Figure 9 shows the results of the analysis. The stray light phenomenon occurs (1) when a light beam from the rear of the lens is reflected inside the dome cover and enters the lens, and (2) when a light beam from the side of the lens is reflected in the edge of the lens and inside the dome cover and enters the lens.

(3) Structure for suppressing stray light

The optical path analysis results in (2) show that the stray light phenomenon occurs due to light beams coming from the two paths shown in Fig. 9. Therefore, a hood to shield light was added to reduce the stray light. Figure 10(c) shows the images taken before and after installing the hood. On the image before installation, the lens is reflected in the dome cover, while on the image after installation, such reflection is reduced.

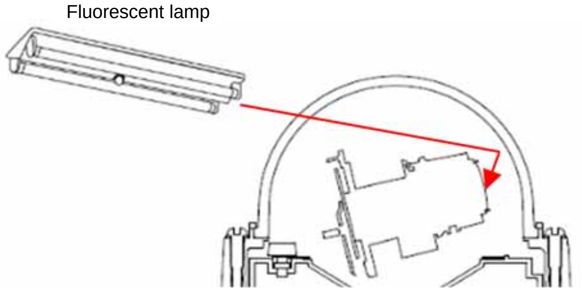
3.3.4 Shock-absorbing structure

As described previously, to reduce the stray light phenomenon, a blackout hood was installed near the lens, but as a result of this structure, an impact to the dome cover tended to be transmitted to the lens. To prevent this, the following two modifications were made to the blackout hood to absorb external impacts (Fig. 11).

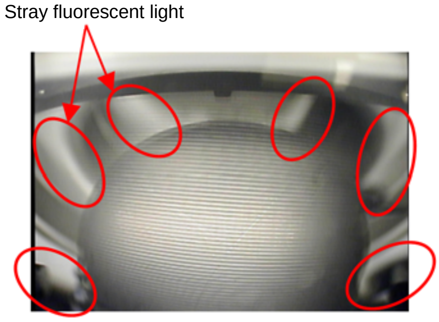
(1) The blackout hood is made of rubber material.
(2) A constriction structure is provided at the base of the blackout hood to serve as the starting point of deformation.

4. Conclusion

The fixed dome cameras with impact resistance (models: NC-6710 and NC-8610) developed this time offer higher impact resistance to prevent damage while enabling use of the coaxial and LAN cable networks of existing surveillance camera systems. We will continue to increase the product types and support the development of social infrastructure to help create a safe and secure society.

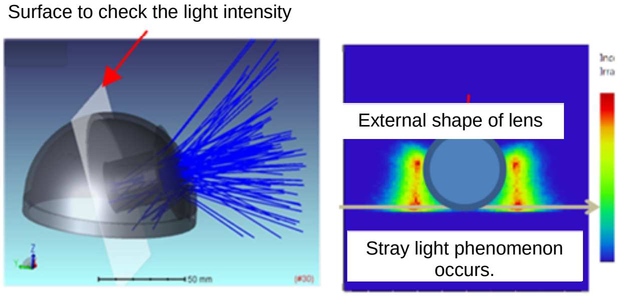


(a) Entry path of light

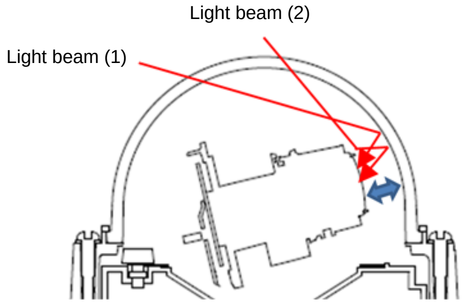


(b) Stray light phenomenon

Fig. 8 Path of light entering the lens and occurrence of stray light phenomenon

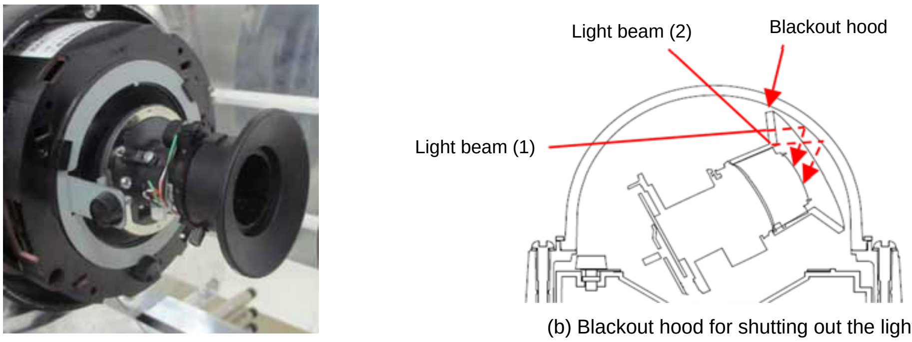


(a) Entry path of light beams (b) Light intensity distribution



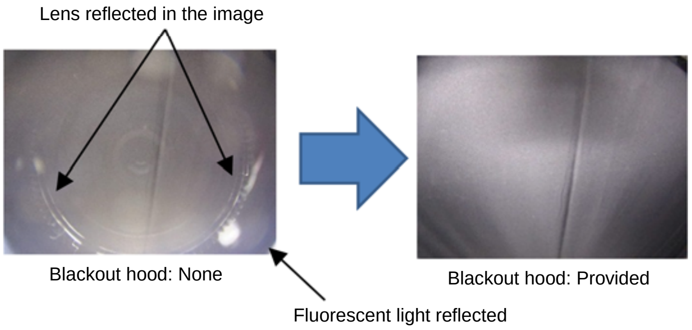
(c) Entry path of light beams

Fig. 9 Results of optical path analysis



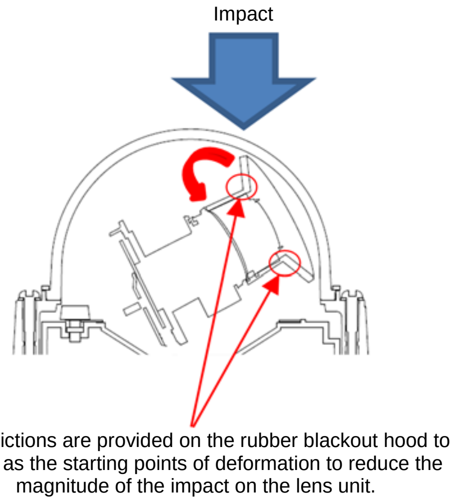
(a) Blackout hood

(b) Blackout hood for shutting out the light

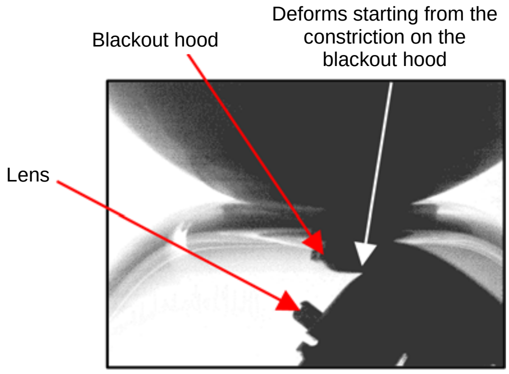


(c) Improvement

Fig. 10 Structure for suppressing stray light and improvement effect



Constrictions are provided on the rubber blackout hood to serve as the starting points of deformation to reduce the magnitude of the impact on the lens unit.



Deformation of hood under impact

Fig. 11 Shock-absorbing structure

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