Certification report test attachment
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IEC 61508:2023 Parts 1-7

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AOPDDR-3D 3D Safety Sensor Detection Capability Evaluation Report Form

I. Smallest Detectable Object

• Description: The smallest object size that the sensor can reliably detect.

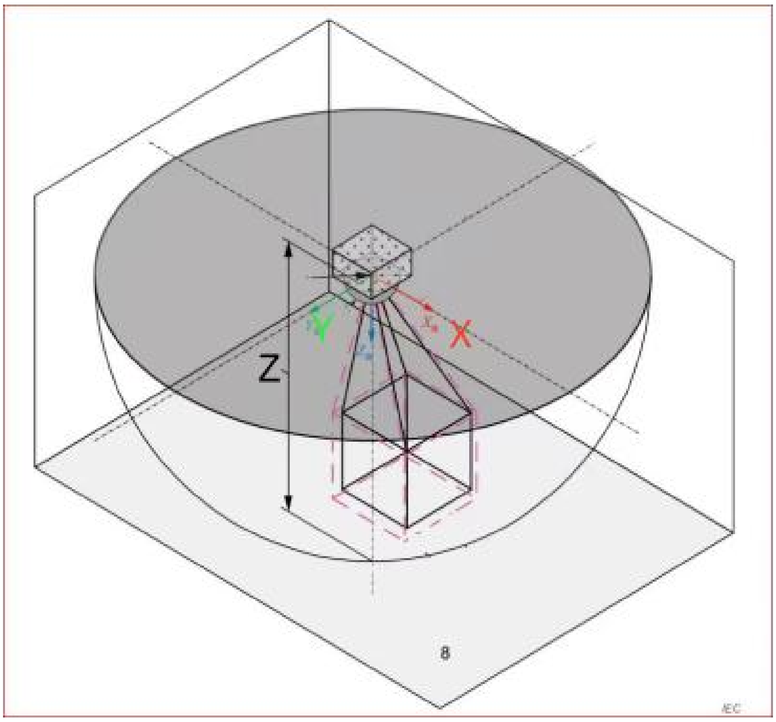
A cylinder with a diameter of ≥ 70mm.

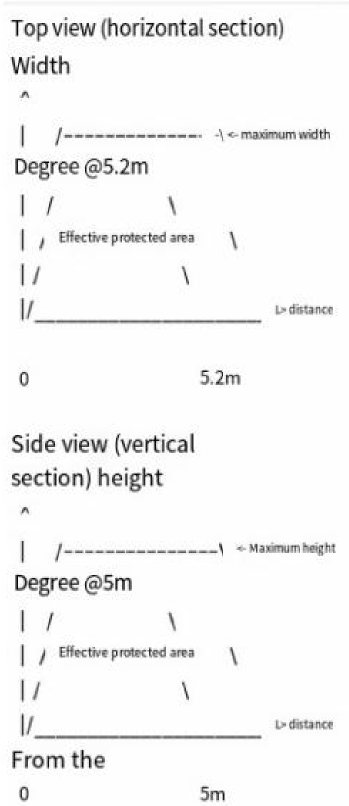
• Test parameters: ⌀50-70 Detect the metal rod, the object to be tested is silver, the Z-axis of the stereoscopic sensor is vertically suspended at a height of 3m, first enter the head 50mm and then enter the detection area 70mm for recording.

• Test results: Intrusion tests can effectively detect object intrusions in both continuous and intermittent tests, and provide prompt feedback.

⌀50-70 Test metal rod (silver)

Ii. Detection Scope/Area





• Description: The three-dimensional protected area that the sensor can effectively cover.

• Parameters: Z5m*X5.2m*Y7.5m

• Length of Y: Max7.5 m

• X-width: Max 5.2m

• Z height: Max5 m

• Test parameters: Standard test object 50-70mm metal cylinder, the color of the tested object is silver, measuring tool tape measure. The stereoscopic sensors are suspended in sequence at a height of 1 to 5 meters directly above and move from the XY direction into the detection area to record data.

• Test data:

Z-axis height	X-axis width	Y-axis length
1m	0.6m	1.5m
2m	1.2m	3m
3m	2.4m	4.5m
4m	3.3m	6m
5m	5.2m	7.5m

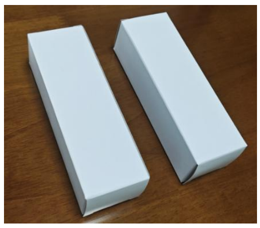
Iii. Resolution

• Explanation: The minimum distance between two adjacent objects that the sensor can distinguish at a given distance.

Example: At X =0.2m, ≤ Y =0.2m.

• Test parameters: Standard test object: 100mm*30mm*45mm paper box. The color of the tested object is white. Measuring tool: caliper. The stereoscopic sensors are suspended in sequence at a height of 1 to 5 meters directly above and move from the XY direction into the detection area to record data.

Test data:

Z-axis height	Z-axis blind zone	Remarks	
1m	30mm	Near scene	
2m	45mm		
3m	60mm	Typical working distance	
4m	80mm	Distant scene	
5m	110mm		

Iv. Response Time

• Explanation: The time required from when an object enters the detection area
• Parameter: ≤100 ms
• Test parameters: The standard test object is a 100mm*30mm*45mm paper box. The color of the tested object is white. The measuring tool is a high-resolution oscilloscope. The stereoscopic sensors are suspended in sequence at
• Test results: All test results are within 100ms, meeting the requirements for testing and certification.

V. Blind Spots

Note: The sensor is unable to detect the near-field area of an object.
• Parameters: The distance from the sensor surface is defined as the blind zone at a height of 100-250mm.
• Test parameters: The standard test object is a 100mm*30mm*45mm paper box. The color of the tested object is white. The measuring tool is a tape measure. The three-dimensional sensors are suspended in sequence at a height of 3 meters directly above and move from the Z direction into the detection area to record
• Test data:

Z-axis height	Z-axis blind zone	Remarks
1m	100mm	Minimum
2m	130mm	
3m	150mm	
4m	200mm	
5m	250mm	Maximum

Vi. Failure Rate (Related to Safety)

Note: The failure rate of the system in terms of safety functions is usually expressed as the probability of failure per hour.

- Parameters: 3.90E-08/2.19E-05
- Safety failure rate (AS) : 2.36E-07 /hr
- Detected dangerous failure rate (ADD) : 2.36E-07 /h
- Undetected Hazardous failure rate (ADU) : 3.90E-08 /h
- Test data: For specific calculation data, please refer to the explanations on the attached page.

Vii. Detection Performance for Different Test Objects

Note: Verify and evaluate the stability of the test using test objects of different colors and surface materials.

- Test object types: 70mm matte metal cylinder, 90mm transparent acrylic cylinder,70mm black foam cylinder, 80mm stainless steel cylinder,70mm white paper box cylinder, manually simulated
- Test data:

Test object category	Specific description	Comparison of minimum detection distances	Response time comparison	Comprehensive evaluation
70mm silver metal cylinder	Reference object	100%	100%	Meet the requirements
90mm transparent acrylic	Transparent object	120%	110%	Generally good
70mm black foam	Highly light-absorbing object	100%	100%	Meet the requirements
80mm stainless steel cylinder	Highly reflective object	100%	100%	Meet the requirements
70mm white paper box cylinder	Light-colored objects	100%	100%	Meet the requirements
Human hand simulation	Irregular object	100%	100%	Meet the requirements

Attached

1. The evaluation is based on the IEC 61508-1-7 standard and IEC 61496:2023 product standard.

One of the core contributions of IEC 61508 is the establishment of the Safety Integrity Level (SIL) concept, which IEC 61496 directly inherits and applies.

- IEC 61508: This standard defines four safety levels (SIL 1 to SIL 4), each specifying quantifiable requirements for hardware safety integrity and system safety integrity (e.g., hazard failure probability, hardware fault margin, diagnostic coverage, etc.).
- IEC 61496: When designing and validating electro-sensitive protection devices, the required SIL level (typically SIL 2 or SIL 3) must be specified. Manufacturers must design, manufacture, and certify their products in accordance with the SIL level requirements outlined in IEC 61508.

IEC 61496 is the safety standard for "electromagnetic sensitive protection equipment", specifically for equipment such as safety light screens, laser scanners, etc. The standard is indeed divided into several parts:

- IEC 61496-1: General Requirements and Test Methods.
- IEC 61496-2: Specific requirements for the use of Active Optical Protection Devices (AOPD), such as safety screens.
- IEC 61496-3: Specific requirements for Active Photoelectric Diffuse Reflective Protection Devices (AOPDDR), which typically refers to the failure rate of 3D security scanners or area sensors that detect objects by analyzing reflected light.
- IEC 61496-4: Specific requirements for vision-based protection equipment (VBPE).
- IEC 61496-5: Specific requirements for diffuse protection using vision-based protective equipment (VBPE).

As the device is AOPDDR-3D (Active Photoelectric Diffuse Reflection Protection-3D), the core reference in the evaluation report is IEC 61496-3.

Conclusion: The reference cited in the evaluation is IEC 61496-3.

2. Data on the evaluation results of AOPDDR-3D's detection capability

- The failure rate is expressed as FIT, with 1 FIT = 1 failure / 10^9 hours. Therefore, 1 FIT = 1E-09 /hr.
- The table shows the FIT values and their total for four fault categories:
  - λ_IO = 35 FIT
  - λ_Y = 70 FIT
  - λ_OO = 367 FIT
  - λ_LI = 39 FIT
- **Total Failure Rate (λ_Total) = 35 + 70 + 367 + 39 = 511 FIT

At the same time, the table gives a key result: Security Failure Score (SFF) = 92.37%.

computational process

Step 1: Calculate the total failure rate (λ _Total)

λ _Total = 511 FIT = 511 × 10^{-9} /hr = **5.11E-07 /hr**

Step 2: Calculate the undetected hazardous failure rate (λ DU)

SFF is defined as the ratio of detected hazardous failures to total failures. Therefore, the proportion of undetected hazardous failures is 1-SFF.

λ DU = λ _Total × (1 - SFF)
λ DU = 5.11E-07 × (1 - 0.9237)
λ DU = 5.11E-07 × 0.0763
λ DU ≈ **3.90E-08 /hr**

Step 3: Calculate the sum of the safety failure rate (λ S) and the detected dangerous failure rate (λ DD)

λ S + λ DD = λ _Total × SFF
λ S + λ DD = 5.11E-07 × 0.9237
λ S + λ DD ≈ **4.72E-07 /hr**

Step 4: Assign λ S and λ DD (based on common design patterns)

The certificate does not directly specify the exact split between λ S and λ DD. However, in security product design, a common design objective is to ensure the security failure rate (λ S) is higher than or equal to the detected hazard failure rate (λ DD), as this means the system is more likely to enter a secure state when failures occur.

If we assume a reasonable condition, λ S ≈ λ DD, we can estimate:

λ S ≈ (λ S + λ DD) / 2 ≈ 4.72E-07 / 2 ≈ 2.36E-07 /hr
λ DD ≈ (λ S + λ DD) / 2 ≈ 4.72E-07 / 2 ≈ 2.36E-07 /hr

Note: This is an estimate based on industry common practice. The exact allocation is determined by the manufacturer's internal design and diagnostic coverage.

What are the evaluation result data regarding the detection capability of AOPDDR-3D?

This is specific technical data that needs to be found in the original assessment report.

When evaluating the detection capability of AOPDDR-3D (3D Security Sensor), the report should include the following key data:

- Minimum detectable object: the smallest object that can be reliably detected (e.g., a cylinder with a diameter of 70mm).
- Detection range/area: the size of the protection area that the sensor can effectively cover (length, width, height).
- Resolution: The minimum distance between two adjacent objects that the sensor can distinguish at a given distance.
- Response time: The time required from the detection of an object to the output of a safety signal.
- Blind area: The area where the sensor cannot detect objects near the surface.
- Failure rate: Safety failure rate
- Detection performance for different test objects: Different test objects with different colors and surface materials (high reflectivity/absorption) may be used for verification.

final result

The failure rate calculated from the certificate data is as follows:

Failure rate category Failure rate (per hour) Notes

The safety failure rate (λS) is approximately 2.36E-07/hr, and the sum of λS and λDD is 4.72E-07/hr. This value is estimated based on $\lambda S \approx \lambda DD$.

The detected dangerous failure rate (λDD) is approximately 2.36E-07/hr, with the sum of λS and λDD being 4.72E-07/hr. This value is estimated based on the assumption that $\lambda S \approx \lambda DD$.

The undetected hazardous failure rate (λDU) is 3.90E-08/hr, calculated as $\lambda\_Total \times (1-SFF)$.

sum up ：

1. Core parameter: The sensor's most critical parameter is λDU = 3.90E-08/hr. This ultra-low undetectable hazard failure rate is the fundamental reason for its ability to build systems with high SIL ratings (with PFDavg reaching 2.19E-05 under 1oo2 architecture).
2. High reliability: More than 92% of the total failure rate is safe or can be detected in time ($\lambda S + \lambda DD$), which reflects its strong built-in diagnostic capability and safety-oriented design.
3. Certificate Verification: The computational results demonstrate that both the SIL 3 capability claimed in the certificate and the published PFDavg value are supported by robust reliability data.

Approver
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