



2026

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Guidance for  
Photovoltaic Systems Onboard  
Ships

## APPLICATION OF "GUIDANCE FOR PHOTOVOLTAIC SYSTEMS ONBOARD SHIPS"

1. Unless expressly specified otherwise, the requirements in the Guidance apply to photovoltaic systems onboard ships for which contracts for construction are signed or for which the application for Classification Survey is submitted to the Society on or after 1 September 2025.

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# CHAPTER 1 GENERAL

## Section 1 General

### 101. Background

1. As part of efforts to combat climate change and achieve carbon neutrality, the installation of photovoltaic modules on ships has been steadily increasing.
2. Photovoltaic cells generate electricity through photoelectric conversion without emitting exhaust gases. These systems can operate in both grid-connected configurations and stand-alone systems onboard ships.
3. Photovoltaic modules are generally installed on exposed decks with high solar irradiance conditions. Standards are required to support their reliable application as onboard power sources.

### 102. Purpose

1. This guidance outlines installation methods to ensure the safety and reliability of photovoltaic systems installed onboard ships.
2. It also provides type approval criteria for photovoltaic systems and their components to validate their intended functionality.

### 103. Application

1. This guidance applies to photovoltaic systems with a rated capacity of 2 kW or more when installed on ships.
2. It is applicable to non-concentrating photovoltaic modules and does not apply to concentrating photovoltaic modules.

### 104. Definitions

Unless otherwise defined in this Guidance, terminology shall follow the definitions provided in the **Rules for the Classification of Steel Ships**.

1. **Photovoltaic power:** The direct conversion of sunlight directly into electrical energy via the photovoltaic effect.
2. **Photovoltaic cell:** A semiconductor element used in photovoltaic generation.
3. **Photovoltaic module:** A structured assembly of photovoltaic cells interconnected in series and/or parallel, designed to withstand long-term exposure to environmental conditions and mechanical stress.
4. **Photovoltaic string:** An electrical assembly composed of photovoltaic modules connected in series.
5. **Photovoltaic array:** A mechanical and electrical assembly comprising multiple photovoltaic modules or strings, including structures supports, that converts solar energy into DC electricity and supplies it.
6. **Photovoltaic system:** An assembly of components that converts solar energy into electricity and supplies electrical power.
7. **Support structure:** In photovoltaic equipment, a support structure (also referred to as “racking”) is a structural component used to physically support one or more modules and to position them in a fixed or sun-tracking orientation.
8. **Junction box:** An enclosure where circuits are electrically connected and that includes protective devices, designed to be sealed or otherwise protected from environmental exposure.
9. **Blocking diode:** A diode connected in series with a module or array to prevent reverse current flow.
10. **Bypass diode:** A diode connected across one or more modules to allow current to bypass shaded or faulty cells, thereby preventing hot spot damage caused by reverse voltage bias.

11. **Energy storage system:** A system composed of an energy storage device, power conversion equipment (if necessary), control units, and auxiliary components. It supplies or absorbs electrical energy at the necessary voltage and power levels, can respond to variations in load power.
12. **Hot spot:** A localized area of intense heating within a photovoltaic module, occurring when the operating current exceeds the short-circuit current of a shaded or defective cell (or group of cells,) forcing them into reverse bias. This condition causes the affected cells to dissipate energy as heat, potentially leading to overheating. The resulting voltage stress or damage may create a localized shunt path, allowing a significant portion of the module current to flow through it.
13. **Short-circuit current:** The current produced by a photovoltaic cell or module when its terminals are short-circuited, measured under specified irradiance and temperature conditions.

#### 105. Class notations

1. Ships that comply with the requirements specified in this Guidance will be assigned the additional installations notation **SolarPV**.

#### 106. Equivalency

1. The equivalence of alternative and novel features which deviate from or are not directly applicable to the Guidance is to be in accordance with **Pt 1, Ch 1, 105.** of **Rules for the Classification of Steel Ships**.

## Section 2 Drawings and Data for Approval and Onboard Retention

### 201. General

1. In addition to the drawings and data required in accordance with **Pt 6, Ch 1** of the **Rules for the Classification of Steel Ships**, the drawings and data specified in **202.** shall be submitted to the Society for approval, as applicable.

### 202. Drawings and data for approval

#### 1. Drawings and data to be submitted by the shipyard

- (1) Wiring diagram of power system
- (2) Wiring diagram of control system
- (3) General arrangement of photovoltaic systems
- (4) Operation manual
  - (A) Description of the Power Management System (PMS) for the photovoltaic systems, including its location and arrangement plan, as applicable
- (5) Control strategy for interconnection with other generating sources, as applicable
- (6) Drawings and data related to computer-based systems in accordance with **Pt 6, Ch 2, Sec 4** of the **Rules for the Classification of Steel Ships**, as applicable
- (7) Drawings and data related to computer-based systems, in accordance with **Pt 6, Ch 2, Sec 4** of the **Rules for the Classification of Steel Ships**, as applicable
- (8) Short circuit calculation
  - (A) Maximum calculated short-circuit current values at the main switchboards and downstream distribution boards
  - (B) Rated breaking and making capacities of protective devices
- (9) Wiring diagram of the fire detection and alarm system, if independent from vessel's marine systems
- (10) List of alarms and shutdowns as required by the manufacturer
- (11) List of all photovoltaic system installed in the hazardous areas, as applicable
- (12) Structural load analysis report and design loads applied in the structural design of the support structure
- (13) Detailed drawings of the foundation and support structures for the photovoltaic system
- (14) Nondestructive testing (NDT) records for critical welds of steel support structures, where applicable
- (15) Procedure for temporary removal of photovoltaic array(s), as applicable
- (16) Test procedure and reporting after installation
- (17) Control consoles and/or control panels for photovoltaic systems
- (18) Documentation of the photovoltaic system in accordance with clause 4 of IEC 62446-1

### 203. Drawings and data to be retained onboard

1. Procedure for temporary removal of photovoltaic array(s), as applicable
2. Maintenance manual
3. Photovoltaic system documentation in accordance with clause 4 of IEC 62446-1 and clause 4 of IEC 62446-2, shall be retained onboard and include the following:
  - (1) Performance benchmark data
  - (2) Records, including test results ↓

## CHAPTER 2 TESTS FOR PHOTOVOLTAIC SYSTEMS

### Section 1 General

#### 101. General

1. Manufacturing, testing, inspection, and associated data shall comply with the specifications and recognized standards required by this Guidance.
2. For aspects of manufacturing, testing, and inspection of photovoltaic systems not specified in this section, the applicable requirements of Pt 6, the **Rules for the Classification of Steel Ships**, shall apply.

### Section 2 Type Approval for Photovoltaic Systems

#### 201. Type approval for photovoltaic systems

1. The photovoltaic system and its components shall, in principle, be type-approved in accordance with the criteria specified in **Table 1** and the procedure for type approval shall follow the **Guidance for Approval of Manufacturing Process and Type Approval, etc.** However, alternative test methods may be applied if deemed equivalent by the Society
2. The type approval certificate shall be submitted to the Society and retained onboard for verification by Surveyors.

**Table 1 Type approval criteria for photovoltaic systems**

No.	Components	Test standards
1	Photovoltaic Modules	IEC 61215 series IEC 61730 series IEC 61701 <sup>(1)</sup>
2	Bypass Diodes and Blocking Diodes (if applicable)	IEC 61701 <sup>(1)</sup>
3	Power Converters	IEC 62109 series <sup>(1)(2)</sup>
4	Junction Boxes	IEC 62790 <sup>(1)</sup>
5	All Components <sup>(4)</sup>	IEC 60068-2-6 Test kb <sup>(3)</sup>
(Notes)		
(1) Salt mist test shall be carried out in accordance with IEC 61701 or Test Kb of IEC 60068-2-52.		
(2) IEC 62109-1 provides general testing requirements for power converters used in the photovoltaic system. IEC 62109-2 and IEC 62109-3 are to be referenced for alternative or additional testing requirements applicable to the power converters technology used in the photovoltaic system. In addition, when power converters are connected to main source of electrical power of 50 kVA or more, they shall be type-approved in accordance with <b>Ch. 3, Sec. 3</b> of the <b>Guidance for Approval of Manufacturing Process and Type Approval, etc.</b>		
(3) All components of the photovoltaic system shall be tested in accordance with IEC 60068-2-6 Test Fc (Vibration Test). The acceptance criteria shall follow Item 8 of <b>Table 3.23.1</b> in <b>Ch.3, Sec.23</b> of the <b>Guidance for Type Approval of Manufacturing Process and Type Approval, etc.</b>		
(4) It is considered as module-integrated equipment as defined in IEC 62109-3:2020 (see IEC62109-3:2020, clause 1)		

## Section 3 Commissioning Test

### 301. General

1. The test procedure shall be submitted to the Society for approval.
2. A visual inspection shall be carried out for the components of the photovoltaic system.
3. A ship equipped with a photovoltaic system shall be tested in accordance with **302**, in addition to the standard onboard test requirements. The Society may require additional or modified test items and requirements, if deemed necessary.

### 302. Tests after installation

1. Commissioning tests for photovoltaic arrays shall follow the procedures specified in IEC 62446-1:2016, 5.3.4 and shall include the following:
  - (1) 6.1: Continuity of protective earthing and equipotential bonding conductors
  - (2) 6.2: Polarity test
  - (3) 6.3: Test of photovoltaic string junction boxes
  - (4) 6.4: Measurement of open-circuit voltage of photovoltaic string
  - (5) 6.5: Measurement of current of photovoltaic string
  - (6) 6.6: Functional test
  - (7) 6.7: Insulation resistance test of the photovoltaic array
2. **Interface verification test**
  - (1) Verify the interface between the photovoltaic system and the energy storage system.
  - (2) Verify the interface between the energy storage system and the energy management system.
3. **Test of alarms and safety devices**
  - (1) Test the operation of alarms and automatic shutdown devices, including overcurrent protection.
4. **Functional verification of associated systems**
  - (1) Verify the functionality of systems associated with the photovoltaic system.
5. **Synchronization test**
  - (1) Perform a synchronization test when the photovoltaic system is connected to the main power source.
  - (2) Verify whether the output of the connected energy storage system remains synchronized with the main source of electrical power, even when the photovoltaic system is generating less than its rated output or is not generating power.
  - (3) Verify whether an alternative power source automatically supplies power to the main switchboard when the output of the connected energy storage system decreases. ⚡

## CHAPTER 3 SYSTEMS AND EQUIPMENT

### Section 1 General

#### 101. General

1. A separate power source shall be provided considering periods of no sunlight when the photovoltaic system is connected to the main power source.
2. The photovoltaic system shall be type-approved or comply with national standards, recognized international standards, or other standards deemed equivalent.
3. All materials used in the photovoltaic system and its support structure shall be designed and approved for use in marine and offshore environments.
4. Electrical equipment not specified in this Chapter shall comply with the applicable requirements of **Pt 6** of the **Rules for the Classification of Steel Ships**.

#### 102. Materials

1. Components and associated materials used in photovoltaic systems shall be flame retardant and moisture resistant.
2. Materials shall be corrosion-resistant or treated with corrosion-resistant coatings appropriate for the installation location and environmental conditions.
3. Conductive materials shall be copper, copper alloys, stainless steel, or other materials that provide equivalent or superior electrical, thermal, and mechanical safety performance.

#### 103. Construction

1. All components shall be safely constructed to withstand deformation, loosening, and other forms of mechanical damage.
2. Parts that may come into contact with personnel, or require regular maintenance and inspection, shall be free from sharp projections or edges.
3. Connections within the photovoltaic system shall be constructed to prevent loosening under environmental operating conditions.
4. Components of the system intended for replacement or disassembly shall be designed to allow for safe and convenient handling.
5. Dual-rated equipment with voltage or frequency conversion functions shall allow the converted voltage and frequency to be readily identified. However, equipment with automatic conversion functionality is exempted.
6. Electrical components and accessories shall be rated for voltages or power levels equal to or exceeding the maximum values expected during service.
7. In general, the design of the photovoltaic system shall optimize the orientation and curvature of photovoltaic modules.

#### 104. Arrangement and location of area

1. The support structure shall be permanently secured to the hull by welding or equivalent means, and the underlying hull structure shall be properly reinforced. However, the photovoltaic array, excluding the support structure, may be removed in accordance with the temporary removal procedure.

#### 105. Protective devices

1. Electrical installations shall be adequately protected against all overcurrent conditions, including

short-circuits.

## Section 2 System Design

### 201. General

#### 1. General

- (1) The output voltage and frequency of the photovoltaic system shall remain within the limits specified in **Pt 6, Ch 1, 201. 5. (3)** of the **Rules for the Classification of Steel Ships**.
- (2) Harmonic distortion of the photovoltaic system shall comply with **Pt 6, Ch 1, 201. 8** of the **Rules for the Classification of Steel Ships**.
- (3) Additional requirements for DC distribution systems shall comply with the **Guidance for DC Distribution Systems**.

#### 2. System design

- (1) The photovoltaic system shall be designed in accordance with the requirements and considerations of IEC 62548.
- (2) A single failure in the photovoltaic system shall not adversely affect other onboard systems.
- (3) The photovoltaic system shall be capable of interrupting abnormal current flow and shall be equipped with effective protective devices.

### 202. Construction and design

1. Photovoltaic modules and arrays are generally configured as shown in **Figure 1**; however, configurations may vary depending on the manufacturer's design.

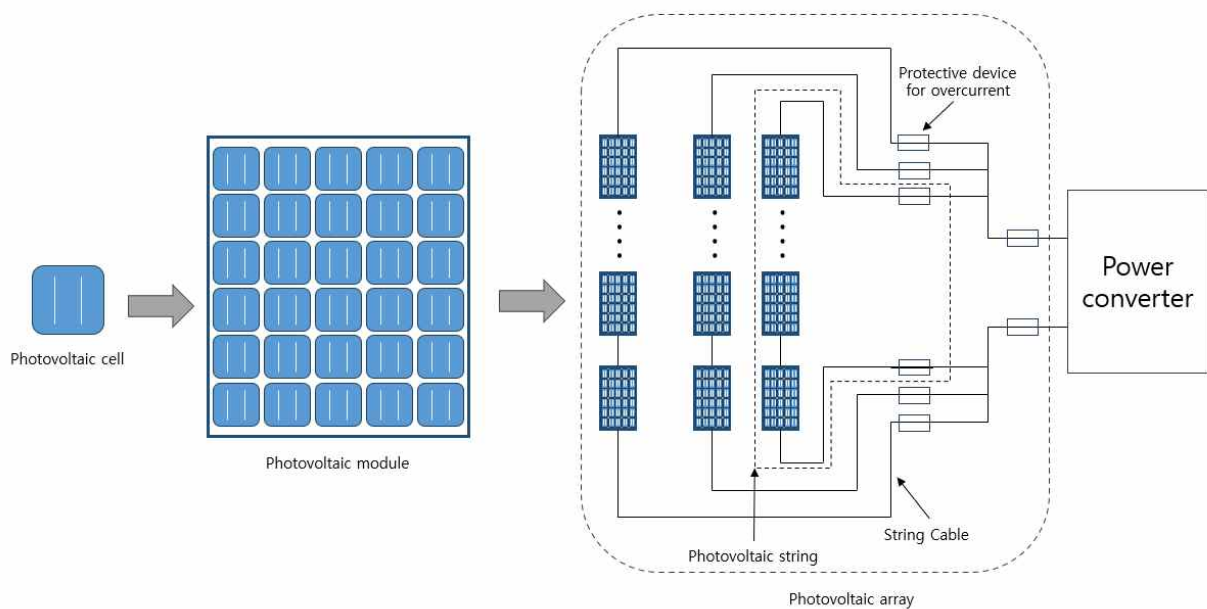


Figure 1 Configuration of photovoltaic modules and arrays

#### 2. Degree of protection

- (1) The photovoltaic system shall have a degree of protection suitable for its intended installation location.
- (2) Components of the photovoltaic system installed on exposed decks shall have a minimum degree of protection of IP56.

### 203. Integration with energy storage system

1. In general, the output of photovoltaic arrays fluctuates with environmental conditions and rated power is achieved only under limited conditions. Therefore, the photovoltaic system shall be integrated with an energy storage device to stabilize, store, and distribute the generated power to the ship's power system.
2. Systems used for battery charging shall comply with 5.1.7 and 6.5.6 of IEC 62548:2016.

3. Energy storage systems and power converters shall be designed and constructed in accordance with **Pt 6, Ch 1, Sec 12** or **Sec 13** of the **Rules for the Classification of Steel Ships**, as applicable.
4. Where lithium-ion batteries are used as the energy storage device, the relevant requirements of the **Guidance for Battery Systems on Board Ships** shall be complied with.

## 204. Control, monitoring and safety system

### 1. General

- (1) The control, monitoring and safety systems of the photovoltaic system shall comply with the basic requirements specified in **Pt 6, Ch 2** of **Rules for the Classification of Steel Ships**.
- (2) For control, monitoring, and safety systems not specifically addressed in this section, appropriate arrangements may be accepted as deemed appropriate by the Society.
- (3) Adequate fire protection equipment shall be provided in the vicinity of the photovoltaic system.

### 2. Control and monitoring system

- (1) Performance monitoring of the photovoltaic system shall comply with IEC 61724, and control and monitoring parameters shall be measured in accordance with the relevant requirements of the IEC 60904 series.
- (2) If a dedicated subsystem is provided for the control and monitoring of the photovoltaic system, it shall interface with the higher-level control and monitoring system.
- (3) The following parameters related to the photovoltaic system shall be monitored in real time. The listed items may be added to or modified depending on the type and capacity of photovoltaic system.
  - (A) Output power
  - (B) Current and voltage
  - (C) Solar irradiance on the tilted and horizontal plane
  - (D) Module temperature
  - (E) Ambient temperature and wind speed
  - (F) Energy production
- (4) The module temperature in item (3) (D) shall be measured using one or more temperature sensors installed on the rear surface of a representative module within the photovoltaic array.

### 3. Safety system

- (1) A monitoring device shall be provided to detect the normal and abnormal operating conditions of the photovoltaic system.
- (2) Protective devices shall be installed to prevent faults in the photovoltaic system from adversely affecting the ship's electrical systems.
- (3) An emergency stop device shall be located in an accessible area. The emergency stop circuit shall be independent of the control, monitoring, and alarm systems.

## 205. Electrical protection system

### 1. General

- (1) Protection requirements for photovoltaic arrays shall comply with clause 6 of IEC 62548:2016 and include the following:
  - (A) 6.1.2 – Disconnection of photovoltaic arrays from the main AC power output circuit
  - (B) 6.2 – Protection against electric shock
  - (C) 6.3 – Protection against thermal effects
  - (D) 6.4 – Protection against the effects of insulation faults
  - (E) 6.5 – Protection against overcurrent
  - (F) 6.6 – Protection against the effects of lightning and overvoltage

### 2. Disconnection

- (1) The operation and maintenance manual for the photovoltaic system shall include procedures for both normal and emergency disconnection, including the electrical isolation of system components.
- (2) The photovoltaic system shall comply with 13.2 and 13.3 of IEC 62446-2 regarding safety and isolation procedures.

### 3. Shading and hot spot prevention

- (1) The design and installation of the photovoltaic system shall minimize the risk of partial or full shading and the formation of hot spots. The photovoltaic array shall be cleaned regularly to prevent shading and hot spots caused by salt deposits or foreign materials, in accordance with the system's operation and maintenance procedures.
- (2) For further details on systems incorporating bypass or blocking diodes, refer to **306**.

## Section 3 Electrical and Associated Installations

### 301. General

1. The photovoltaic system shall comply with the requirements specified in clause 7 of IEC 62548.
2. All equipment in the photovoltaic system shall be clearly labeled and marked in accordance with clause 10 of IEC 62548.

### 302. Temperature rating

1. According to IEC 62548:2016, 7.3.7.2, photovoltaic modules frequently operate at temperatures approximately 40°C above ambient. Components in contact with or located near the modules shall be rated accordingly. Insulating materials shall be selected in accordance with **Pt 6, Ch 1** of the **Rules for the Classification of Steel Ships**.
2. The photovoltaic system shall be designed in accordance with **Pt 6, Ch 1, 201. 6** of the **Rules for the Classification of Steel Ships**, considering the ambient temperature conditions on the open decks.
3. In accordance with IEC 62548:2016, 5.1.9, modules and associated components shall be equipped with appropriate ventilation and cooling (or heating) to ensure operation within the rated automatic temperature range and maintain optimal performance.
4. In accordance with IEC 62548:2016, 7.2, the maximum voltage and the voltage correction factors for the photovoltaic array shall be calculated based on the lowest expected operating temperature.

### 303. Cables

1. Cables used in the photovoltaic system shall be designed and installed in accordance with the following requirements:
  - (1) **Pt 6, Ch 1, Sec 5** of the **Rules for the Classification of Steel Ships**
  - (2) IEC 62548:2016, 7.3.7

### 304. Power converters

1. Power conversion equipment for the photovoltaic system shall be designed and installed in accordance with the following requirements:
  - (1) **Pt 6, Ch 1, 1201** of the **Rules for the Classification of Steel Ships** (as applicable)
  - (2) IEC 62109 series

### 305. Junction boxes

1. Junction boxes for photovoltaic modules shall be designed and installed in accordance with the following requirements:
  - (1) **Pt 6, Ch 1, 511.3** and **511.4** of the **Rules for the Classification of Steel Ships**
  - (2) IEC 62790 series

### 306. Bypass diodes and blocking diodes

1. Bypass diodes may be used in the photovoltaic system to prevent reverse voltage bias and hot spots, and blocking diodes may be used to prevent reverse current.
2. Bypass diodes and blocking diodes shall comply with the following requirements:
  - (1) Bypass diodes: IEC 62548:2016, 7.3.2.1 and 7.3.11
  - (2) Blocking diodes: IEC 62548:2016, 7.3.12

### 307. Support structure

1. Support structures or mounting methods (e.g. adhesives, bolts, ties, or other means) for photovoltaic modules shall be designed in accordance with IEC 62548:2016, 5.2, taking into account wind effects, operational modes, and loading conditions.

2. Inspection records for critical welds in support structures constructed of steel shall be included in the non-destructive testing (NDT) drawings.

## Section 4 Installation

### 401. General

1. The photovoltaic system shall comply with the applicable requirements of **Pt 6, the Rules for the Classification of Steel Ships** and those specified in this Guidance.
2. The hull structure shall possess adequate strength and rigidity to support the maximum anticipated loads from the photovoltaic system. The deck load imposed by the installed photovoltaic system shall not exceed the deck's rated load-bearing capacity. If the load exceeds the allowable limit, the hull structure shall be assessed in accordance with the **Guidance for Direct Strength Assessment in Appendix 3-2 of Pt 3, the Rules**.
3. The installation location and arrangement of the photovoltaic system shall be designed to minimize the potential for full or partial shading of the array and to reduce potential hazards associated with reflected light, including glare and reflection from the photovoltaic modules.
4. For photovoltaic arrays intended for temporary removal, the support structures or mounting methods shall facilitate safe removal, storage, and reinstallation by crew members. For additional details, refer to **sec 403**.

### 402. Installation in hazardous area

1. As a general principle, the photovoltaic system shall not be installed in hazardous areas.
2. If installation in a hazardous area is unavoidable, the electrical equipment shall comply with the requirements of **Pt 6, Ch 1, Sec 9** of the **Rules for the Classification of Steel Ships**.

### 403. Physical protection of installation

1. Photovoltaic arrays shall be installed in locations protected from physical impacts or damage and shall not interfere with the normal operation of the ship.
2. It is recommended that photovoltaic arrays be designed for temporary removal under conditions where physical damage may occur, such as during extreme weather or cargo handling operations.
3. For photovoltaic arrays designed for temporary removal, a documented procedure for safe electrical and physical disconnection, storage, and reinstallation shall be submitted for review and retained onboard. The procedure submitted for approval shall include verification steps to the satisfaction of the attending Surveyor.

### 404. Access and crew protection

1. Electrical equipment shall be arranged in locations that are accessible and suitable for inspection or adjustment, and shall comply with IEC 62548:2016, 7.3.3.2.
2. Photovoltaic modules installed in areas subject where personnel may walk over them shall be designed to withstand pedestrian impact. Fall prevention measures, such as anti-slip coating or temporary guardrails, shall be provided.

### 405. Navigation safety

1. The photovoltaic system shall be designed to eliminate or minimize potential hazards caused by sunlight reflection, including glint and glare from the photovoltaic modules.
2. The system shall be installed so that it does not obstruct visibility from the navigation bridge, in accordance with **Pt 9, Ch 5** of the **Rules for the Classification of Steel Ships**. ⚓

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