GUIDANCE NOTES

GD13-2017

China Classification Society

Guide for Safety and Reliability Assessment for Shipboard Software

For approval

CCS Management Department for Vessel Products

June 2017

Contents

1 Scope and description

1.1 This Guide is a guide for the safety and reliability assessment for the software of shipboard computer systems (hereinafter referred to as the computer systems, including the programmable electronic systems), which specifies the technical requirements for the safety and reliability in the development, testing, authentication, production and maintenance for the software of shipboard computer systems, and also specifies a number of requirements for the hardware of the corresponding software; these requirements shall be used together with the technical requirements for the products. This Guide is applied to the computer system installed on the classified ships, and the system provides control, alarm, monitoring, safety or internal communication functions including the programmable electronic systems, which meet the classification requirements. This Guide does not apply to loaders and radiocommunication equipment and navigation equipment that have specific performance standards of the International Maritime Organization.

1.2 This Guide mainly focuses on the lifecycle of software development with some processes in the integral safety lifecycle adopted. The V model is adopted as the development model for the software in this Guide. And the evolution of relevant models is not contained in this Guide.

1.3 Given the direct application of small simple computer systems and the application of some functions in complex systems, this Guide defines the small low complexity computer system and gives a simplified assessment method in Appendix2.

1.4 When this Guide is applied, the documentation referred in this Guide can be prepared according to the internal document management system of the shakeholders while the content of the documentation shall conform to the relevant content referred to in this Guide.

1.5 Additional markings

1.5.1 The following additional markings can be granted based on different system classifications (see Article 4.1 for the classification) for the computer systems with system lifecycle established, whose system and hardware are certificated according to the Rules for classification of sea-going steel ships and other requirements and meet all the technical requirements for software specified in this Guide:

(1) SLC1 for Category I system;

(2) SLC 2 for Category II system;

(1) SLC 3 for Category III system.

1.6Threeappendixes are attached to this Guide, which are:

1.6.1Appendix1, the verification form of testing and inspection for on-site ship surveyor to assess the safety and reliability of the software in the shipboard computer system.

1.6.2Appendix2,theassessment method for small low complexity computer system.

1.6.3 Appendix3, the technical proposal for the design and realization stages of the computer system.

2 Normative references

2.1 The following references are necessary to the application of this Guide. For the dated reference documents, only the referred versions are applicable while for those not dated, the latest versions shall be applicable.

Reference documents **Table 2.1**

1.		*Rules for the Classification of Sea-going Steel Ships* (2015) issued by China Classification Society and its modification notifications
2.		Article 55, Chapter II-1, International convention for the safety of life at sea
3.	GD22-2015	Guidelines for type approval test of electric and electronic products issued by China Classification Society
4.	IACS UR E22	Application and utilization of programmable electronic system on ships
5.	IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems
6.	IEC 61511	The application of function safety and safety instrument system in process industry
7.	IEC 60092-504	Electrical equipment for ships - Part 504: Album Control and measuring instruments
8.	IEC 60812	System reliability analysis technology - Analysis for the impact of failure modes
9.	IEC 61025	Analysis for fault trees
10.	IEEE 730	Software quality assurance program
11.	ISO 9001	Quality management system requirements
12.	ISO/IEC 90003	Software engineering - computer software ISO9001: 2008 application guide
13.	ISO/IEC 12207	System and software engineering Software lifecycle process
14.	ISO/IEC 15288	System and software engineering Software lifecycle process
15.	ISO 17894	Ship and maritime technology Computer application Development and general use principles of programmable electronic systems on the sea
16.	ISO/IEC 25000	System and software engineering Quality requirements and evaluation (SQuaRE) SQuaRE guidelines of systems and software
17.	ISO/IEC 25041	System and software engineering quality requirements and evaluation (SQuaRE) of systems and software Evaluation guidelines for developers, assignees and independent evaluators

3 Terms and abbreviations

3.1 Terms

3.1.1 software

Intellectual creation comprising the programs, procedures, data, rules and any associated documentation pertaining to the operation of a data processing system.

3.1.2 computer system

Consisting of hardware, software and I/O units based on computer technology.

Note: The term contains the microelectronic device based on one or more than one CPUs and relevant memories.

3.1.3 system

A group of interacting elements based on the design, which may include the interacting hardware, software and personnel, etc.

3.1.4Subsystem

A model element with the semantics of package (other model elements may be included) and class (behaviors may be included) . The behavior of the subsystem is supplied by the classes contained in it or other subsystems. One or multiple interfaces are realized in the subsystem, which define the behavior that can be executed by the subsystem.

3.1.5 Module

A function set of programs, discrete components and packaged programs or a group of merged discrete components.

3.1.6 Software module

Construct that consists of specifications and/or data descriptions and can also interact with other such constructs.

3.1.7 Safety function

Function to be implemented by a computer system, other technical safety-related system or external risk reduction facilities to achieve or maintain a safe state for the EUC, in respect of specific hazardous event.

3.1.8 Equipment under control (EUC)

Equipment, machinery, apparatuses and/or plants used for manufacturing, processing, transportation or other activities

3.1.9 Small low complexity computer system

A computer system, in which the failure modes of each individual component are well-defined; and the behavior of the system under fault conditions can be completely determined.

Note: Behavior of the system under fault conditions may be determined by analytical and/or test methods.

3.1.10 Dynamic testing

Executing software and/or operating hardware in a controlled and systematic way, so as to demonstrate the presence of the required behavior and the absence of unwanted behavior.

3.1.11 Quality plan

Documents of quality control measures, resources and activity sequence specified for specific software products and projects, which are a series of documents describing the relevant quality standards and stating how to meet the corresponding standards.

3.1.12 System lifecycle

Necessary activities involved in the implementation of the system, occurring during a period of time that starts at the concept phase of a project and finishes when all the computer systems and their related items are no longer available for use.

3.1.13 Software lifecycle

Activities occurring during a period of time that starts when software is conceived and ends when the software is permanently decommissioned.

Note: A software lifecycle typically includes requirement phase, development phase, test phase, integration phase, installation phase and modification phase etc.

3.1.14 Software Configuration Management, SCM

A technology for modification identification, organization and control, applying to the whole software operation.

3.1.15 Programmable device

The physical unit with software shall be installed.

3.1.16 Vessel

The vessel and offshore device equipped with computer systems shall be installed.

3.1.17 Stakeholders

Stakeholders refer to the persons or organizations that can affect, be affected, or perceive to be affected by decision-makings or activities.

3.1.18 Owner

The owner signs a contract with the system integrator and/or the supplier providing the hardware and software system according to specifications. During the construction period, the owner may be the builder party of the vessel (builder or shipyard). After the vessel is delivered, the owner may be the vessel operating company.

3.1.19 System integrator

The system integrator is responsible for integrating the systems and products provided by the supplier into a complete system that specifies the requirements. The system integrator may also be responsible for the system integration of the vessel. The shipyard shall act as a system integrator unless there is another organization that specializes in contracting or is assigned to assume this responsibility. If more than one team complete the system integration at any time, it is necessary that a team is responsible for the overall system integration and the coordination of integration activities. If different system integrators are responsible for particular stages in multiple integration phases, it is necessary that a team is responsible for identifying and coordinating all phases of the integration.

3.1.20 Supplier

The supplier is a system component or a software contractor or a subcontractor under the coordination of the system integrator or shipyard. The supplier provides the system integrator with programmable devices, subsystems or systems. The supplier shall provide descriptions of the software's functions to certify the applicable international and national standards in compliance with the requirements of the shipowner and the applicable requirements of this section.

3.2 Abbreviations

3.2.1 ISO: International Organization for Standardization, 国际标准化组织。

3.2.2 IEC：International Electrotechnical Commission。

3.2.2 IEC: International Electrotechnical Commission,。

3.2.3 IEEE: Institute of Electrical and Electronics Engineers。

3.2.4 FMEA: Failure Mode and Effects Analysis,。

3.2.5 FMECA: Failure Mode, Effects and Criticality Analysis。

3.2.6 FAT: Factory Acceptance Test。

3.2.7 PE: Programmable Electronic。

4 Categorization of computer systems

4.1 The computer system is divided into the categories as shown in Table 4.1 based on the impact of system functions..

Categorization of computer systems **Table 4.1**

Category	Effects	Typical system functionality
I	Those systems, failure of which will not lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment.	- Monitoring and daily management functions
II	Those systems, failure of which could eventually lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment.	- Monitoring and alarm functions - Control functions which are necessary to maintain the ship in its normal operational and habitable conditions
III	Those systems, failure of which could immediately lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment.	- Control functions for maintaining the vessel's propulsion and steering - Safety functions of the vessel

4.2 Some examples of the categorization of computer systems are described in Table 4.2 for reference. The examples are not exhaustive and the system should be accurately classified according to the risk assessment of all operational conditions.

Examples of system categories **Table 4.2**

System category	Example
II	(1) Liquid-cargo-handling control system; (2) Relevant control of the bilge water detection and bilge pump; (3) Fuel handling system; (4) Remote control system of ballast water valve; (5) Stable and floating control systems, such as anti-pitching fin control system; (6) Alarm and monitoring of propulsion system.
III	(1) Vessel propulsion system that generates and controls mechanical thrust to move the vessel (not including equipment used only in operating conditions, such as bow thruster); (2) Steering control system; (3) Vessel power plant system (including power management system); (4) Vessel safety system, including fire detection and fire fighting, water inflow detection and drainage, internal communication system related to evacuation and vessel system related to life-saving equipment operations; (5) Dynamic positioning system with additional marks of DP2 and DP3; (6) Drilling system.

4.3 Objects

4.3.1 Typical hierarchical structure and relationships of computer systems are shown in Figure 4.1.

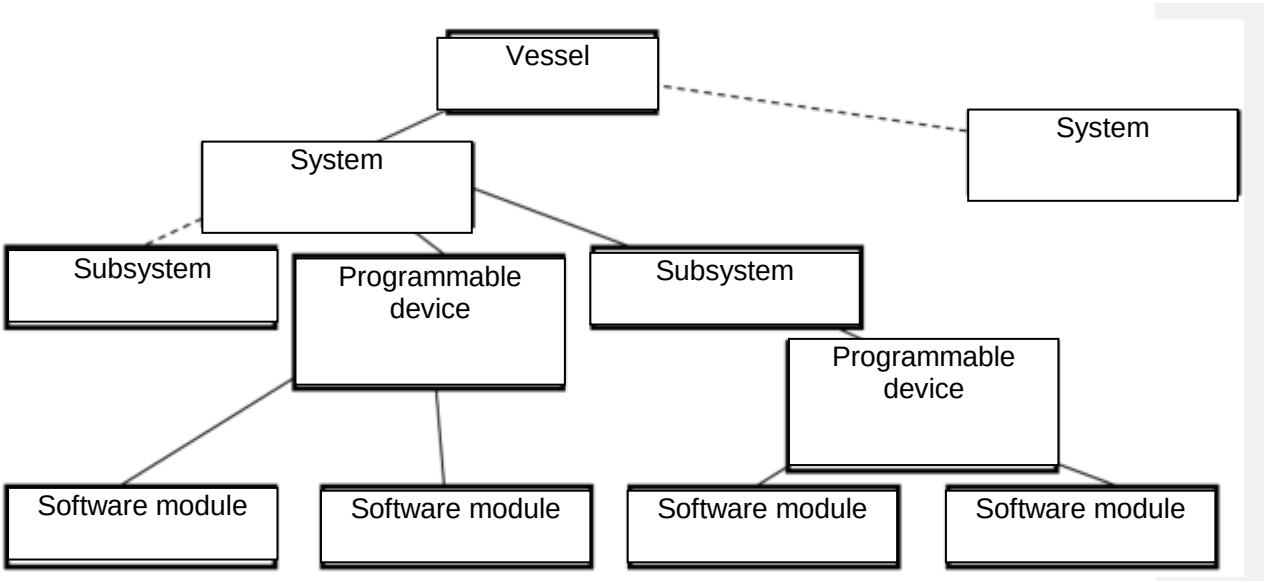


Figure 4.1 Computer System Hierarchy Diagram

5 Quality system requirements

5.1 Quality assurance system

5.1.1 It shall be demonstrated that the system integrator and the supplier have certain product quality assurance ability and quality management level and that a management system ensuring that the product meets the rules issued by China Classification Society and relevant conventions has been established by the system integrator and the supplier via the quality assurance system.

5.1.2 The system integrator and supplier shall establish and implement ISO9001 or equivalent standard quality management system and hold valid certificates. The system integrator and supplier shall take into account the provisions of ISO9001 and ISO90003 when managing the quality system of software preparation, software test and related hardware. The quality system shall include:
(1) Procedures related to liability, system documentation, configuration management and personnel qualification.
(2) Procedures of software and the life-cycle of related hardware, including:
① Institution arrangement of relevant hardware and software procured from the supplier;
② Institution arrangement of software code preparation and verification;
③ Institution arrangement of verification before the onboard system integration is completed.
(3) Quality system approval shall meet at least the following requirements:
① Category II and III computer systems shall have verification procedures at the system, subsystem, and programmable device and module levels so as to verify the software code;
② Category II and III computer systems shall have checkpoints, which can be a document required to be submitted, a test, a technical design review or an expert review;
③ Inform the owner of software modification process and onboard installation process.
(4) A quality plan document shall be formulated to record how the quality management system is applicable to a particular computer system, including at least all the contents described in (1) to (3) mentioned above.

5.2 Software quality plan

5.2.1 The system integrator and the supplier shall make a quality plan for the lifecycle of software development.

5.2.2 The software quality plan shall regulate the software activities in the whole lifecycle and define relevant procedures, responsibilities and systematic documents. IEEE 730 can be referred to when making the quality plan.

5.2.3 For software of Category II and III system, safety function requirements shall be included in the quality plan, whose specific assurance method shall be designed to verify and affirm whether the safety function requirements are met.

5.2.4 Configuration management shall be developed for the shipboard computer system during the lifecycle of software development. See Article 5.6 for details.

5.3 Quality control in production

5.3.1 The product quality shall be ensured by means of practicable quality assurance measures, plans and organization.

5.3.2 The system integrator and the supplier shall have documents of product quality control which shall describe the producing process flow accurately and also describe the quality control requirements for each process flow with words, diagrams and table; and it shall contain specific control objects, standards and methods, inspection methods and all the supporting documents ensuring the implementation of quality assurance measures in the production. The supporting documents for passing the "test and simulation" are required for products with functions related to safety.

5.4 Final test report

5.4.1 The system integrator shall make final tests for the products and submit the report. The final test report shall be a report prepared according to the tests of the finished products and the test results.

5.5 Software traceability

5.5.1 Requirements for software traceability: the modification of programming content and data as well as the version change shall be marked and documented according to the procedures. It shall be ensured that the forming process of software quality can be traceable when required. The procedures for the modification of programming content and data as well as the version change shall be defined in the software configuration management, version statements and other quality assurance documents (in particular, inform the owner of software modifications and onboard installation process). And the modifications and changes shall be determined in the documents.

5.5.2 The mentioned documents shall be kept for at least one year from the end of the lifecycle of software development. The system integrator shall have solid evidence to prove that the software has retired indeed.

5.6 Configuration management

5.6.1 Configuration management is used to ensure the consistency of deliverable items in several developments when some deliverable items are changed. In general, it consists of hardware and software configuration management.

5.6.2 Requirements:

(1) Administrative and technical controls shall be applied during the lifecycle of software development to manage software changes and ensure that all the provisions for software safety are always met.

(2) It shall be ensured that all the necessary operations are executed to state that all the required software demands are obtained.

(3) The unique and accurate identification for all the configuration items that are necessary to maintain the integrity of the computer system shall be maintained. The configuration items include the following at least: safety analysis and requirements, software rules and design documentation, software source code modules, testing plan and results applied to the software components and packages of the computer system, and all the tools and development environments for the creation, testing or implementation of the software of computer system.

(4) Change control procedure shall be applied to avoid unlicensed modifications and the modification requests shall be documented; the effect of modification shall be suggested in the analysis to approve or reject the request; the details and authorization for all the approved modification shall be documented; the composition of all the software baselines(including the reconstruction of early baseline).

(5) The information for configuration status, release status, judgment and passing of all the modifications and the details of modification shall be documented for approval.

(6) The software release shall be officially documented. The main software backup and all the relevant documents shall be kept within the development lifecycle of the released software for maintenance and modification.

6 System lifecycle

6.1 Division of system lifecycle

6.1.1 The system lifecycle is divided into 5 stages, which respectively are concept, requirement, implementation, verification and running. Each stage is divided according to its different scopes of purposes, with a relationship and requirements in following table and figure.

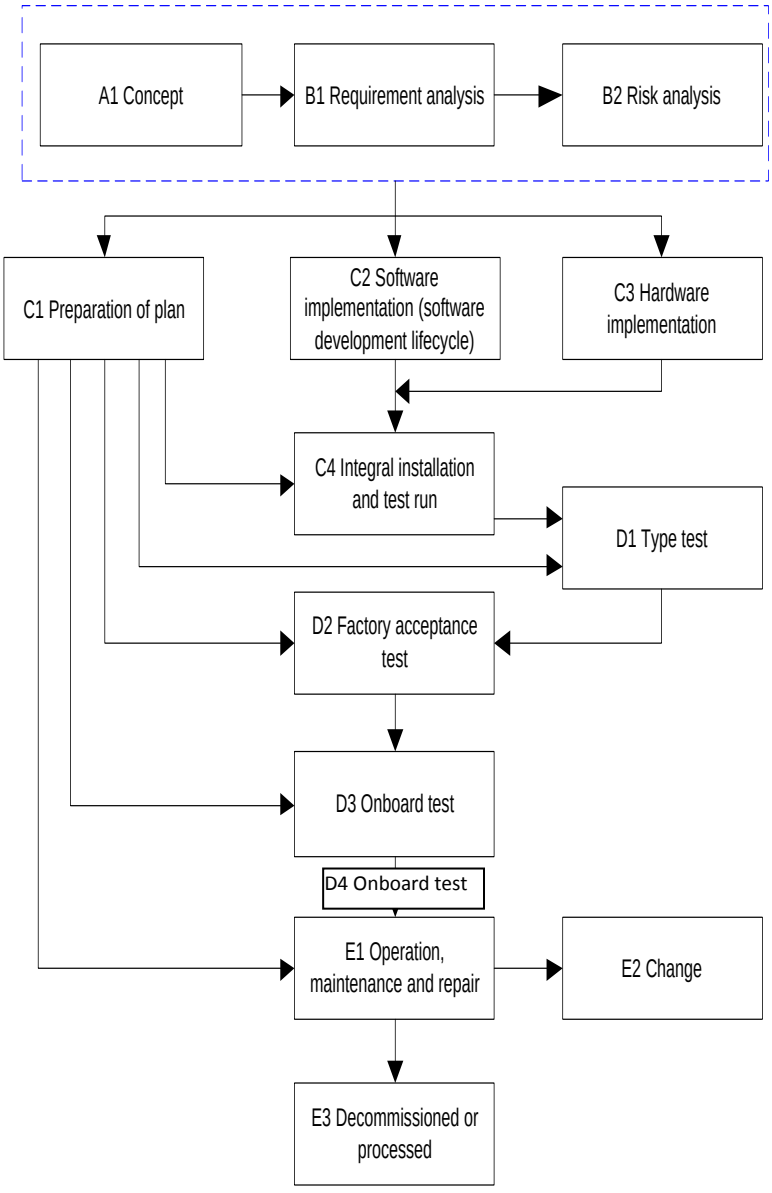


Fig. 6.1.1 System Lifecycle

Overview of System Lifecycle **Table 6.1.1**

System Lifecycle Stage		Purpose	Requirement	Input	Output
Box Number of Fig. 6.1.1	Title				
A Concept					
A1	Concept	Improve the understanding of controlled equipment and its environment (actual and legal) to meet the needs of the implementation of its lifecycle activities.	Ensure full understanding on controlled equipment and required control function and actual environment; determine the possible source of danger; obtain relevant information on determining danger; get the existing safety regulations; take into account the danger produced by interaction between adjacent controlled equipment; and keep the above required information and results in documentation.	All information necessary to meet all such requirements	Information obtained from concept to overall scope
B Requirement					
B1	Requirement analysis	All works required for describing the purpose, scope, definitions, and function of new system when creating or modifying the computer system. These include: determine the computer system boundary; stipulate the scope of risk analysis		Information obtained from concept to overall scope	Requirements and specifications of computer system
B2	Risk analysis (only for functions related to safety)	Prove that the system enters a fail-safe condition in case of a single fault and the	See Article 6.3.1.	Requirements and specifications of computer system	Requirements and specifications of functions related to

		system in service would not loss or drop to the performance standard unacceptable of CCS in order to ensure the safety and reliability of computer system.			safety (including information and records distributed according to safety requirements)
C Implementation					
C1	Preparation of plan.	Prove the computer system meets the requirements of installation, operation and maintenance by prescribed and technical procedures.	Develop a plan of installation, operation and maintenance of computer system, to ensure to keep the safety of required functions in operation and maintenance. Prepare the FAT test and onboard test programs that function tests related to safety are included.	Requirements and specifications of computer system; Requirements and specifications of functions related to safety.	Plan for software quality; installation, operation and maintenance plans for computer system; type test program; FAT test program; simulation test program before the final integration; and onboard test program; onboard integrated test program.
C2	Software implementation	Establish the computer system software conforming to requirements and specifications of computer system and of functions related to safety.	See Chapter 7 for software development lifecycle in details.	Requirements and specifications of computer system	Verification of each computer system that conforms to the requirements and specifications. See Chapter 7 for software development lifecycle in details.
C3	Hardware implementation	Establish the computer system hardware that conforms to requirements and specifications of computer system and of functions related to safety.	See Article 6.3.2 and 6.4	Requirements and specifications of computer system.	Verification of each computer system that conforms to the requirements and specifications.

C4	Integral installation and test run	Install the computer system; Give a test run for computer system;		Installation, operation and maintenance plans for computer system	Computer system installed; computer system after a full test run;
D Acceptance					
D1	Type test	Confirm the computer system conforms to requirements and specifications of computer system (including functions related to safety); Confirm the system confirms to GD22-2015.	Category II and III systems shall be performed an environmental test according to GD22-2015, Category I system can be performed an environmental test referring to GD22-2015. For others, see also Article 6.5 and 6.7	Requirements and specifications of computer system; requirements and specification of functions related to safety; type test program.	Confirm the verification of computer system conform to requirements of functions related to safety. Type test report.
D2	Factory acceptance test	Make a computer system test in factory	FAT report shall include: ① tools and equipment used; ② FAT activity record; ③ Differences and disposal of actual and expected results. Analyze and assess the differences between expected and actual results to ensure whether to continue the test or put forward a change request.	Requirements and specifications of computer system; FAT test program.	FAT test report.
D3	Simulation test before the final integration		See Article 6.3.3 and 6.6.	Software function description; software list and version number installed for the system; software maintenance and user manual; list of interfaces between systems and other systems of ships; list of data transmission	Test report.

				standards.	
D4	Onboard test	Perform the onboard test to verify the system execution ability as scheduled after the interconnection between all systems, including full system test and integration test.	Verify the normal implementation of functions by the full system test under the condition of actual hardware parts and final application software. Verify the normal implementation of functions by the integration system in case of all systems in integration. For others, See Article 6.6.	Requirements and specifications of computer system; onboard test program.	Onboard test report.
E Running					
E1	Operation, maintenance and repair	Operate, maintain and repair the computer system for keeping the functional safety as required.	See Article 6.2.	Installation, operation and maintenance plans for computer system	Functions that continue to meet the requirements from the computer system; Documents of operation, repair and maintenance for computer system in time-ordered.
E2	Change	Ensure the computer system under control at and after the stage of change.	Verify the change returning the suitable stage of lifecycle. Keep records in documentation. Record modifications by the shakeholders. Provide the subsequent significant modifications on software and hardware of	Requirements and specifications of computer system Plan for software quality Test program at corresponding stage	Realization of functional safety required by computer system at and after the stage of the change; Documents of operation, repair and maintenance for computer system in time-ordered.

			systems II and III to CCS for approval. Notify the approved modification and change scheme in advance and analyze relevant effects, meanwhile get an approval on modification from CCS. Give change verification on the software modified to prove that meets the computer system requirements. Note: major modifications refer to modifications impacting safe traffic and/or safety of ships. For others, see Article 6.3.4 and 6.3.6.		
E3	Decommissioning or processing	Ensure the functional safety of computer system adapts to cases of being and after being decommissioned or processed.	Analyze effects and make a plan including the system shutdown and removal before the decommissioning or processing. Indicate disposal and process of sensitive information in the computer system operating instruction.	Request for decommissioning or processing based on functional safety management procedures.	

6.1.2 The documentation mentioned in this Guide can be prepared based on the shakeholders' internal document management system when using this Guide; however, its content shall comply with the related content mentioned in this Guide.

6.1.3 The content needed to be supplemented for system lifecycle in the above table will be separately listed below.

6.1.4 See Chapter 7 for software development lifecycle in details.

6.2 Software safety at maintenance stage

6.2.1 Purpose

It needs to meet the software safety requirements at maintenance stage.

6.2.2 Requirements

(1) The modification of the program and data, and changes of the version shall be recorded and submitted to our society for approval.

(2) To guarantee that the specifications of corresponding departments responsible for the software development Lifecycle (SDLC) are qualified to support their activities, the following is specially required:

①trainings on fault diagnosis and repairing and system testing are provided to the staff;

②trainings are provided to operating personnel;

③periodical retraining is provided to the staff.

(3) All trainings, experience and qualification of those personnel who are related to any activity concerning SDLC shall be documented.

(4) Analysis on risks (or potential risks) shall be conducted and specifications of suggestion on minimizing those risks shall be put forward.

(5) As for specifications applied to analysis on operation and maintenance of performance, it is especially required:

①that procedures used to identify system failures which will affect the function safety shall contain specifications used to test repeated failure for daily maintenance;

②that the requirement rate and the failure rate in operation and maintenance shall be estimated to make sure whether they are consistent with those presumed in system design.

(6) Procedures used for modification of safety-related systems shall be launched.

(7) Approval procedures and competent departments are required for the modification.

(8) Procedures shall maintain the accuracy of information on potential risks and safety-related systems.

(9) In the SDLC, configuration management of the computer particularly requires :

①specifications used to realize configuration control;

②specifications used for unique identification on all elements of a configuration management item (hardware and software);

③procedures used to prevent unauthorized entries from entering service.

(10) Training terms on suitable occasions and emergency service are required.

(11) The operators shall establish programs for receiving, recording, solving and tracking problems and modifying requests. The problems shall be dealt with as per troubleshooting programs. System operation plans shall be established and maintained, including identification of the configuration items, operation procedures and predicted maintenance. Transfer and retire of software shall be included in the plans.

(12) All new updates, releases or modifications of the system and (or) components version shall be tested by the operators. In addition, the components used for release shall meet specified standards. Integration testing shall be included if the interface of the released components has been modified.

(13) Configuration audit shall be performed regularly to verify the integrity of operation configuration.

6.2.3Input

(1) Operating instruction of computer systems

(2) Software quality plans

(3) Risk analysis and prevention procedures

(4) Training terms on suitable occasions and emergency services

6.2.4 Output

Records of modification of programs and data and change of version.

6.3 Requirements for software and supporting hardware

6.3.1 Risk analysis

The system risk assessment is to determine the system risk of the entire life-cycle by identifying and assessing the hazard of each function of the system. The *Risk Management and Risk Assessment Technology* (IEC / ISO31010) shall be adopted to determine the method of risk assessment. The system classification shall be verified by the results of the risk assessment. Risk assessment reports of Category II and III systems shall be submitted to CCS. As needed by CCS, it may also require Category I system to submit a risk assessment report. The risk assessment report is generally submitted by the system integrator or supplier, including data obtained from other suppliers. It may be necessary to obtain the consent of CCS and the system supplier based on the corrected system category of risk assessment. When the risk of the computer system is obvious, the risk assessment is allowed to exempt submission, but the system integrator or supplier shall submit supporting documents to explain the reasons for exemption. The certification documents shall include known risks, the current computer system and the equivalence of the operating environment of the initial computer system used to determine the risk, and the existing controlling measures applicable to use in the current environment.

6.3.2 Hardware implementation

"Relevant hardware description" shall include at least the following drawings:

(1) System specifications shall include a detailed description of the hardware configuration, system function description and system self-test description;

(2) Hardware and external equipment configuration block diagrams shall be marked with the internal connection of system main units / modules and the interface with other systems;

(3) System wiring diagram;

(4) Technical specification details of hardware and external equipment.

6.3.3 Integration test before onboard installation

Prior to the onboard integration, an inter-system integration test shall be done between the system, subsystem and software module. The purpose is to check the correct execution of the software functions, the normal interaction and functional execution of the software and its controlled hardware, and the normal response of the software system in case of failure. The failure shall be simulated as truly as possible to prove proper system fault detection and system response. The failure analysis results of any requirement shall be able to be detected. A simulation test (The simulation test means that the equipment under control is partially or completely replaced by simulation tools when testing the control system, or the communication network and lines are replaced by simulation tools.) can verify functional and fault tests. For Category II and III systems, the following requirements shall be met:

(1) The processes of functional test and fault test shall be submitted to CCS. CCS may require to make FMEA analysis to support the fault test process;

(2) The factory acceptance test shall be witnessed by the ship surveyor of CCS on site, including functional test and fault test;

(3) The following documents shall be submitted:

① Software function description;

② Software list and version number of the system installation;

③ Software maintenance and user manual;

④ List of interfaces between the systems and other systems of the vessel;

⑤ List of data transmission standard;

⑥ Other documents that CCS may require to submit, including FMEA analysis or similar documents that prove adequate fault test applications.

6.3.4 The owner shall designate the system integrator who meets the requirements of Article 5.1 and 5.2 as the responsible party for the software change and inform CCS. The software modifications that have been considered and accepted at the initial recognition may be considered as limited lifecycle steps. Analysis records and test reports affecting software modifications shall be submitted to CCS for future reference. The owner shall be responsible for managing the traceability of the modifications and can update the software registration forms with the system integrator to complete the modified records. The software registration forms shall include the system software lists and the version number required in Clause 6.3.3 of this section and the security scan results described in Clause 6.3.6 of this section.

6.3.5 The Owner shall ensure that necessary procedures for software and hardware alteration management are stored on board and that any software modifications/upgrades are carried out according to the procedure. Alterations of all computer systems during the operation phase shall be recorded and traceable.

6.3.6 The owner, system integrator and supplier shall take security strategies in quality system and procedure. The software can not be modified unless authorized. Whether physical or remote control systems, physical and logical security measures shall be taken to prevent unauthorized or unintentional modifications. All ship-mounted workpieces, software codes, executable programs and physical media shall be scanned for viruses and malware before installation. The scanned results shall be recorded and saved in the software registration forms.

6.4 Requirements for Category II and III systems data link

6.4.1 The failure status of data link shall be clarified in the risk assessment analysis. A single fault in the data link hardware shall be automatically processed to restore the normal operation of the system. The characteristics of the data link shall prevent the system from overloading under any operating conditions. The data link shall have a self-test function to detect its own link failure and the communication failure of the nodes connected to the link. An alarm shall be sent out when a fault occurs.

6.4.2 The following requirements shall be met when the computer system adopts the wireless data link. Category III system shall not adopt the wireless data link unless specifically considered by CCS:

(1) An approved international wireless communication system agreement shall be applied and the following requirements shall be met:

① Information integrity: prevent, inspect, diagnose and correct the failure so that the received information (compared with the sent information) shall not be destroyed or altered;

② Configuration and equipment verification: only the connection with the equipment included in the system design shall be allowed;

③ Information encryption: confidential and/or key data content shall be protected;

④ Security management: the network assets shall be protected to prevent illegal access to network assets.

(2) The internal wireless system inside the vessel shall meet the requirements for the radio frequency and power levels by International Telecommunication Union and the competent authorities of Flag State. The system operation shall take into account the provisions of the RF transmission aspects of ports and local regulations. The wireless data communication link shall be prohibited due to frequency and power limitations.

(3) The wireless data communication equipment shall be tested during mooring and navigational tests, which testifies that RF transmission will not cause the failures of itself and any other equipment due to electromagnetic interference under the anticipated operating conditions.

6.5 The approval for programmable device of Category II and III systems. The system integrator or supplier shall complete the approval of the integrated programmable device within the system. The approval of the programmable device can be completed by adopting a single piece of inspection or as a component of type approval after the documents referred to in Article 5.1, 5.2 and 6.3 of this Guide are approved and the tests required are witnessed by the CCS ship surveyor (see Table 6.1.1-D1). The approval documents shall describe the compatibility of the programmable device in ship applications and the necessity of onboard tests during the ship integration, identifying that the system components as approved programmable device.

6.6 Final integration and onboard test. Before the installation, a simulation test shall be performed to check the safe interconnection between other computer systems and functions which can not be tested in the above steps. Category II and III systems shall submit a final integration and onboard test report to CCS and the onboard test shall be witnessed by the CCS ship surveyor. Under the final use environment of the computer system and the completion of connection with other interlinked systems, the following shall be verified:

(1) Design function;

(2) Safety response caused by internal failure or the equipment failure of external system;
(3) And the safe interconnection between other systems on the vessel.
6.7 If the subsystem and programmable device can not determine the integration conditions in the vessel system, CCS may approve its limited application under limited use. In order to achieve the approval, the requirements of Article 5.1 and 5.2 of this Guide may be required to be met. The CCS may also require other necessary drawings, detailed information, test reports and inspections related to the supplier's declaration criteria. Subsystem and programmable device may be granted with limited approval upon the completion of the required inspections and tests.

7 Softwaredevelopment Lifecycle

7.1 Quality plans of SDLC shall be made by the system integrator and the supplier. Administrative and technical means shall be applied for control in software Lifecycle so as to manage the software changes and guarantee satisfaction in software safety-related aspects and to prove that the system integrator and the supplier possess valid quality control programs satisfactory to all stages of SDLC.

7.2 Software quality plans shall include the following contents:

7.2.1 The SDLC shall meet the requirements specified in Article 5.2.

7.2.2 In the SDLC, configuration management of the shipboard computer system particularly requires:

(1) formal configuration control nodes to be executed in particular phases;

(2) procedures used for unique identification on all components of some items (hardware and software);

(3) procedures used to prevent unauthorized entries from entering service.

7.2.3 See the figure and table below for division of SDLC relations among divisions.

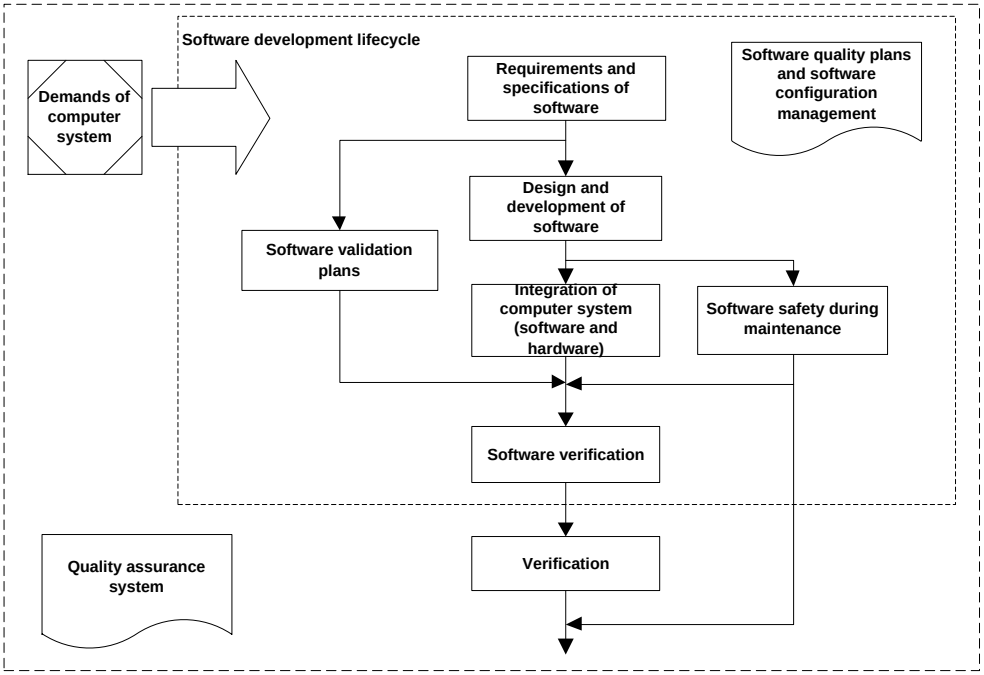


Fig.7.2.3-1 Software Development Lifecycle

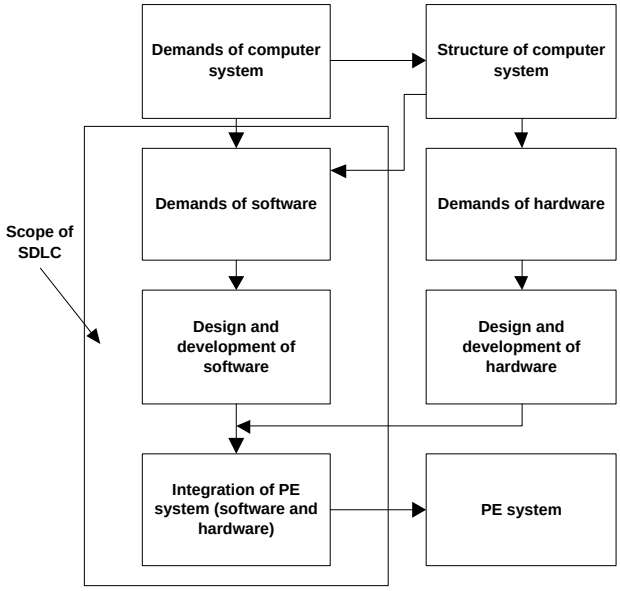


Fig. 7.2.3-2 Scope and External Relations of SDLC

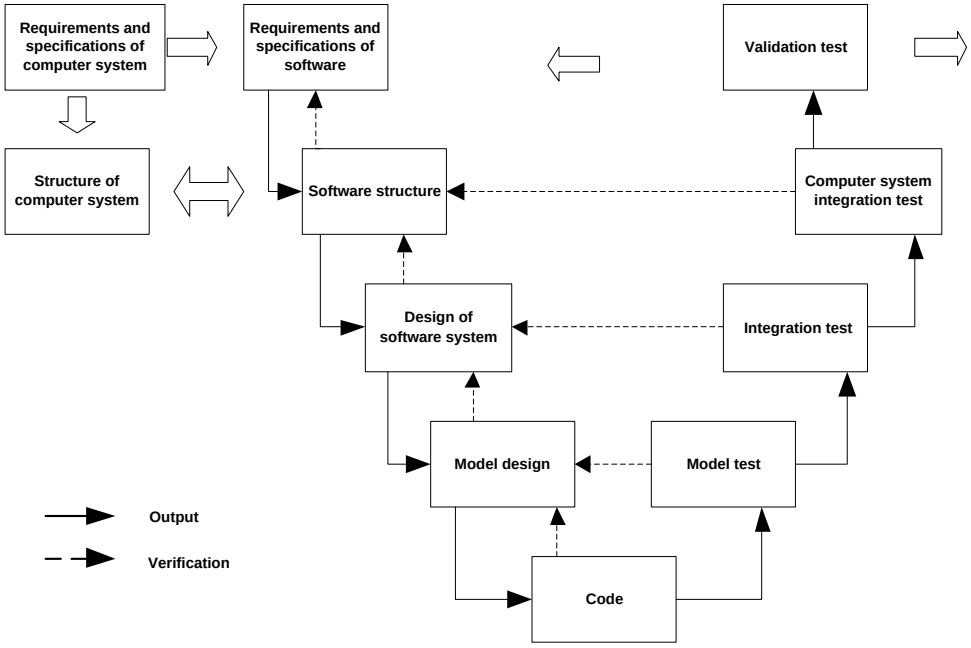


Fig. 7.2.3-3 SDLC Model (Model V)

Note: In addition to Model V, other SDLC models approved by our Society are accepted in the manual.

7.3Requirements and Specifications of Software

7.3.1 Objectives

(1) To specify requirements and specifications of software as per the requirements of system functions;

(2) To specify the requirements of software safety function for any computer system to achieve some safety functions;

(3) To specify the requirements of each computer system for software integration.

7.3.2 Requirements

(1) The information presented in Article 7.3.1 shall be reviewed by software developers for comprehensive provisions of requirements. The following factors shall be particularly taken into consideration:

①safety functions;

②system configuration or composition;

③hardware requirements;

④software requirements;

⑤capacity and response time performance;

⑥interface of equipment and operators

(2) The specification of software safety within required categories or levels shall be expressed and structured in such a way that they are:

①clear, precise, unambiguous, verifiable, testable, maintainable and feasible;

②traceable to provisions of safety requirements of computer system;

③ presented avoiding unclear terms and descriptions or incomprehensible terms and descriptions for the document users in any phase of the SDLC.

(3) If no special definitions concerning computer system safety is provided, all EUC-related operation modes shall be specified in the special requirements of software safety.

(4) Any safety-related or corresponding constraints between software and hardware shall be specified and documented in the requirements and specification of software.

(5) Within the scope of hardware design specifications of computer system, the following shall be taken into consideration for the requirements and specification of software:

①self-monitoring of software;

②monitoring of programmable electronic hardware, sensors and actuators;

③periodical tests on safety functions in the operation of system;

④tests on safety functions by EUC when operable.

(6) Clear distinction between non-safety and safety functions of computer system shall be presented in the requirements and specifications of software.

(7) Security attributes of products rather than that of engineering project shall be presented in the requirements and specifications of software.

7.3.3 Input

Requirements and specifications of computer system

7.3.4 Output

Requirements and specifications of software

7.4 Software validation plans

7.4.1 Objectives

Software validation plans are prepared as per the requirements and specifications of software.

7.4.2 Preparation Requirements

(1) Followings shall be taken into consideration in software validation plans:

①details during validation.

②details of personnel who execute the validation.

③identification of EUC operation-related models shall include:

— preparation for application, including setting and adjustment;

— stable status of launching, teaching, automation, manual operation, semi-automation and operation.

— reset, power-off and maintenance;

— reasonable foreseeable abnormal conditions.

④identification of each EUC operation-related models shall be validated before trial operation.

⑤confirmed technology routes (e.g. analysis methods, statistical tests, etc.)

⑥measures and procedures used to confirm each function which meets the requirements of software functions.

⑦special references for the requirements and specifications of software.

⑧environment necessary to validation activities (e.g. adjustment tools and equipment are needed in testing).

⑨pass/failure criteria.

⑩records of evaluation validation, especially this Guidelines and procedures for failure evaluation.

(2) Technology strategies for software validation shall include:

①either or both of manual and automatic technology;

②either or both of dynamic and static technology;

③either or both of analysis and statistic technology.

(3) Pass/ failure criteria for software validation shall include:

① required input signal and its order and value;

② expected output signal and its order and value;

③other acceptable criteria, such as memory usage, timing and allowable deviation of value.

7.4.3Input

Requirements and specifications of software

7.4.4 Output

Software validation plans.

7.5 Design and development of Software

The design and development of software in the SDLC shall be described in this part.

7.5.1 Requirements for the software structure and coding language

(1) Objectives

① Software structure:

Software structure is established to meet requirements for software safety of different system levels.

The review and evaluation shall be performed for requirements for software of hardware in the computer system, including the impact on EUC safety due to the mutual effect of hardware and software.

② Requirements of coding language:

During the appropriate integration tools are selected in accordance with the required system levels, including language and compilers.

(2) Requirements of software structure

Software structure refers to the major components of software and subsystems, including how they realize the inner connection and how they achieve required attributes, especially the safety integrity. The major components include operation systems, database, large-equipment input/output subsystems, communication subsystems, applications, programming and diagnostic tools, etc.

The proposed design of software structure will be established by software suppliers and (or) developers. The design of software structure shall be presented in detail, which will include:

① Integration technology and measures selected and conformed to meet software requirements and specifications based on systems at different levels during the required software development Lifecycle. These technology and measures include software design strategies for fault allowable deviation (consistent with hardware) and fault prevention, redundancy and diversity (when applicable).

② According to the division of components/ subsystems, following information shall be provided for each part:

— whether they are new, existing or patented;

— whether they have been verified; and, if they have, their verification criteria;

— whether each component/ subsystem is safety-related;

③The mutual effect and evaluation of all software/hardware are confirmed and their importance is defined.

④ Structure which indicate clear definition or restrict clear definition are presented with symbols.

⑤ Design features used to maintain the safety integrity of all data are selected. Such data may include large-equipment input/output data, communication data, operation interface data, maintenance data and inner database data.

⑥ Proper integration test of software architecture are specified to ensure that the software architecture can meet the software safety requirements of specified system level.

(3) Requirements of supporting tools and programming language

① In the event that users adopting limited variable language during application programming with a low safety integrity, required tools and programming language may be confined as standard PLC language, editors and loaders. The responsibility of its compliance is mainly undertaken by the suppliers.

②It is required to limit the subsets of PLC language in systems with higher level, verify and validate the tools such as code analyzers, emulators, etc. Under these circumstances, the responsibility is jointly-undertaken by the suppliers and the users.

③Even in systems with lower level, total-variable languages are widely used for embedded application tools. The responsibility of its compliance is mainly undertaken by the developers. The PCL suppliers who use total-variable languages to provide users with low-variable languages for application programming are included.

④ According to the natural characteristics of software development, it is required to ensure that responsibility specified in following (a) ~ (d) requirements are undertaken by the suppliers and the users in separate or joint manner. The division of liabilities shall be documented during the preparation of the security technology.

(a) A set of appropriate integration tools shall be selected as per required system levels, including languages, compilers, configuration management tools and automatic testing tools during application. The availability of suitable developing tools for corresponding service in the whole Lifecycle of the computer system shall be taken into consideration (not those tools used during the initial phase of system developing).

Within the requirements of safety integrity levels, the selection of programming languages shall meet following requirements:

Translators/ compliers with validation certificates based on national or international standards are provided, or the evaluation for the suitability of its objectives is established;

The characteristics are completely and clearly defined or confined;

The selection shall be in accordance with characteristics of application;

Characteristics which contribute to detecting program errors are included;

Characteristics which match the design methods are supported.

(b) When it is failed to meet ①, reasons for another alternative language shall be recorded in the specification of software structure designs, which shall present the suitability of language objectives in detail and any additional measure about language drawbacks.

(c) The coding standards shall

be reviewed by the evaluating party to make sure whether they are suitable for application intentions;

be used for development of all safety software.

(d) Programming habits shall be specified in coding standards, which describe characteristics of non-safety languages (such as undefined language characteristics and unstructured designs) and provide procedures of source code documents. Source code documents shall at least include following information:

legal entities (such as companies, authors, etc.);

description;

input and output;

configuration management history.

(4) Input

① Requirements and specifications of software

② Designs of hardware structure in computer systems

(5) Output

① Specification for software structure design

② Development tools and coding standards

③ Selection of development tools

④ Specification for test of software structure integration

⑤ Specification for test of computer system integration

7.5.2 Detailed design and development

(1) Objectives

To design software to meet requirements of different system levels, which can be analyzed, verified and modified in a safe manner.

Designs for software structure and individual software modules are included in the detailed designs and development.

(2) Requirements

① Detailed design refers to software structure designs— the major components in the structure are divided in software modules, designs of single software modules and coding systems (such as basic software installed in each hardware unit and communication software and applications installed at network nodes).

②The detailed design and development of software are required to offer logic language for the formation of each piece of software and provide detailed design documents for the definition of the inner structure and interface of the interface of components, including the testing on each component.

③The development of software shall possess modularization, testability and safe modification.

④As for each major component/ subsystem in the specification of software structure designs, the further optimization of designs shall be divided as per software modules. Each specified software modules shall be provided with applicable designs and tests for each one.

⑤ Specification for designs of software systems and single modules are required.

⑥The description documents shall include:

(a) description of basic software installed in each hardware unit;

(b) description of communication software installed at network nodes;

(c) description of applications (not the program list)

(d) tools used for system setting and equipment configuration;

(e) description of mutual restrictions and dependence between special functions, performance, modules and other parts.

Description of applications shall include:

(a) information on system modules (which must be in operation to maintain functions), including the dependency on other systems;

(b) details for each module which achieve enough levels to understand its functions;

(c) relations among software modules (which must be executed to maintain all functions)

(d) data flow and control flow among software modules;

(e) configuration of software which includes priority strategies;

(f) switch-over mechanism of the redundancy system (if any);

(g) self-monitoring of software (e.g. verification of watch-dog and data range of application driven);

(h) verification tests and external equipment diagnostic tests (e.g. sensor and terminal element);

(i) measures taken for unexpected process variables, such as exceeded sensor value, open circuit inspection, short circuit inspection.

(3) Input

① Specification for software structure design

⑤Supporting tools and coding standards

(4) Output

① Specification for software system designs

② Description of software system integration tests

③ Specification for software module designs

④ Specification for software module tests

7.5.3 Code implementation

(1) Objectives

To prepare single software module and design and implement the software with appropriate tool set (including language and compiler) in the whole lifecycle of software verification, validation, evaluation and modification.

(2) Requirements

Source code shall:

①be readable, understandable and testable;

②meet the requirements for software module design;

③meet the requirements for coding standards;

④meet relevant requirements in safety plans.

The code of each piece of software shall be reviewed to check whether the code compiling and its records meet the description of detailed design documents.

(3) Input

① Design specification for software module

②Support tools and coding standards

(4) Output

① List of source codes

② Code review record

7.5.4 Software module testing

(1) Objectives

Software module testing is a kind of verification activity. It is the combination of code review and software module test to provide evidence that a software module meets its relevant requirements, i.e. verified.

(2) Requirements

①Each software module shall be tested as per the regulations in software design.

The tests indicate that each software module performs its intended function and does not perform unintended functions.

② Records of software module tests shall be documented. The contents of documentation of records of software module tests of ships' service equipment of categories II and III include but not limited to software module test plan, software module test case, software module test record, test record analysis report, problem report ticket of software module test and summary report of test.

③ Specification for correction measures of test failures shall be stipulated.

④The sytem ingegrator and the supplier shall perform overall module test for the logic and requirements of software module using the testing method.

⑤For systems of categories II and III, the sytem ingegrator and the supplier shall verify each software module as per software module test specification, which is formulated in the design stage of software system.

⑥The sytem ingegrator and the supplier can perform module test with white-box testing and design test cases as per such methods as boundary value analysis, error guessing, equivalence class or input classification. The above methods can be selected as per the safety level requirements of software and characteristics of programmable equipment.

(3) Input

① Specification for software module testing

② List of source codes

③ Code review record

(4) Output

① Records of software module testing

② Verification and testing of software module

7.5.5 Software integration test

(1) Objectives

Software integration test is the integration from software component to software unit and the objective is to collect software component step by step, check the integration with preliminary and detailed design, provide evidence that all software modules, assemblies and subsystems interact correctly to perform their intended functions rather than unintended functions.

(2) Requirements

① Software integration tests shall be correctly specified in design and development stage.

② Software integration tests generally include: software subsystem test and software system test.

③The following contents shall be specified for software integration test:

(a) Classification of software managing integration;

(b) Test cases and test data

(c) Types of tests to be performed

(d) Test environment, tools, configurations and programs;

(e) Test completion criteria shall be determined; and

(f) Scale of correction action for test failure.

④ Software integration tests shall be performed as per the requirements for software integration tests. These tests shall indicate that all software modules and software assemblies/subsystems act correctly to perform their intended functions rather than unintended functions.

⑤ Records of software integration tests shall be documented and indicate whether the test results meet the objectives and test criteria. In case of a failure, the reason for the failure shall be recorded.

⑥In software integration process, an impact analysis shall be carried out for any modification or change of the software to determine the impact on the software modules and re-verification and re-design activities needed.

(3) Additional requirements for software subsystem tests:

① It is suggested to perform subsystem tests with black-box testing and design black-box testing cases by such methods as dynamic test, equivalence class and input classification, including boundary value analysis. The above methods can be selected as per the safety level of software and characteristics of ship's service programmable equipment.

②For systems of categories II and III, subsystem tests shall be performed and test results shall be analyzed to verify whether software modules are correctly integrated. It shall be validated that the test results can be traced to the criteria established based on test traceability in test plan documentation.

(4) Additional requirements for software system tests:

①It shall be ensured that subsystems meet the requirements of categories II and III stated above.

② System test activities shall be carried out as specified in software-related system test plans of ship's service programmable equipment.

③The following properties shall be considered in system tests:

-Integrity for validation of relevant software design specification;

-Correctness for validation of relevant software design specification (successfully completed);

-Repeatability;

-Precisely defined validation configuration.

④For system tests of systems of categories II and III, protection function against modification shall be verified:

(a) Prevent users from modifying programs;

(b) Prevent users from modifying operation parameters of programs.

⑤For system tests of systems of categories II and III, the function that safe failure of system will occur under single fault condition shall be verified.

⑥ System tests shall be carried out by black-box testing, whose test cases shall be designed by such methods as equivalence class and process simulation. The above methods can be selected as per the safety level requirements and requirements for characteristics of programmable equipment.

⑦ In case of discrepancy between expected results and actual results, analysis and evaluation shall be made to determine whether to continue the test or issue a change request. If a change request is issued, then the progress shall return to early phase of development lifecycle. These decisions shall all serve as the validation results and documentation of system tests.

(5) Input

Test specification for software system integration (software subsystem/system tests)

(6) Output

① Records of software system integration tests

② Verification and testing software systems

7.6 Computer system integration (hardware and software)

7.6.1 Objectives

(1) To integrate software on target computer system hardware.

(2) To integrate software and hardware on the computer system to ensure its compatibility and meet the expected requirements.

7.6.2 Requirements for integration tests

(1) Integration tests shall be specified in the design and development stage to ensure the compatibilities of hardware and software in computer systems.

(2) The following shall be specified for integration tests of computer systems (hardware and software):

① System splitting by integration level;

② Test cases and test data;

③ Types of tests to be performed;

④ Test environment, including tools, support software and configuration description;

⑤ Criteria for determining test completion.

(3) During integration tests required for computer systems (hardware and software), activities performed by developers as per their own intentions shall be distinguished from activities performed from the standpoint of users.

(4) Integration tests required for computer systems (software and hardware) shall be distinguished in the following activities:

① Inclusion of software systems into target programmable electronic hardware;

② Computer system integration, i.e. adding sensors and actuators;

③ Full integration of EUC and computer systems.

(5) Software shall be integrated as per the integration tests required for programmable electronics (hardware and software) and safety-related programmable electronic hardware.

(6) During integration tests of safety-related programmable electronics (hardware and software), an impact analysis shall be carried out for any modification or change performed on integration system to determine the impacts on all software modules and re-verification activities needed.

(7) Test cases and their results shall be recorded for subsequent analysis.

(8) Integration tests of safety-related programmable electronics (hardware and software) shall be documented and it shall be indicated whether the test results meet the test objectives and test criteria. In case of a failure, the reason for the failure shall be recorded. Impact analyses shall be carried out for any modification or change of software to determine the impacts on all software assemblies/models and re-verification and re-design activities needed.

(9) For systems of category II and III, the sytem ingegrator and the supplier shall reserve and submit supporting documents for integration tests, which shall include testing plan and testing report. For systems of category III and II, CCS shall witness the integration tests.

7.6.3 Requirements for fault simulation tests

(1) The sytem ingegrator and the supplier shall formulate specification for system fault simulation tests as per system design specification. Fault simulation shall be carried out as real as possible to prove that it has appropriate system fault detection and system response. Any necessary fault analysis record shall be observed.

(2) Specification for fault simulation tests includes:

① Name of faulted assemblies or elements;

② Type of fault;

③ Insertion of fault mode;

④Required system response (output record).

(3) Test cases of fault simulation and their expectation results shall be documented. The document shall indicate the test results and whether the test results meet the test objectives and test criteria. In case of a failure result, the reason for the failure shall be documented.

7.6.4Input

(1) Specification for integration test of software architectures

(2) Specification for computer system tests (including specification for fault simulation tests)

(3) Computer system hardware

7.6.5 Output

(1) Records of integration tests of software architectures

(2) Records of integration tests of computer systems

(3) Verification and testing computer system

7.7 Change management

7.7.1 Objectives

To provide software-related information and specification to keep the safety of computer systems in operation and modification stage

7.7.2 Requirements

(1) Whether the system integrator and the supplier inform the modified and changed plans of the approved system in advance and carry out the analysis of the impact, with the modification reported to CCS.

(2) The sytem ingegrator and the supplier shall record modifications. Subsequent major modifications of software of systems of category III shall be submitted to CCS for approval.

(3) Approved modification and change schemes shall be notified in advance and impact analysis shall be carried out, and the modification shall be approved by CCS.

(4) Change validation shall be carried out for modified software to the satisfaction of CCS.

Note: Major modifications refer to modifications impacting safe operation and/or safety of ships.

7.7.3Input

All input and output documents listed in 6.1~6.2

7.7.4 Output

Software operation and modification procedure

7.8 Software verification

7.8.1 Objective

To reach the required software system level, test and evaluate outputs of development lifecycle phase of given software to ensure the correctness and consistency of outputs and standards provided upon input of the phase.

7.8.2 Requirements

(1) Synchronization plan shall be prepared for software verification and development, and information shall be documented for each phase of software development lifecycle.

(2) The verification plan shall refer to the criteria, techniques and tools to be used in the verification activities, and the following shall be indicated:

① Evaluation of safety integrity requirements;

② Selection and documentation of verification strategies, activities and techniques;

③ Selection and use of verification tools (testing tools, professional testing software, input/output simulators etc.);

④ Evaluation of verification records;

⑤ Correction actions adopted.

(3) Software verification shall be carried out as per the plan.

(4) Documented evidence proving the phase verified have been completed in all aspects.

(5) After each verification, the verification documentation shall include:

① Identification of verified items;

② Identification of information of corresponding verification;

③ Nonconformance (e.g. software module, data architecture and algorithm that is not frequently used).

(6) All information required for the correct implementation of phase N+1 in stage N of software development lifecycle shall be available and verified. Outputs of phase N include:

① Specification, design specification or codes of phase N shall fully meet the following requirements:

-Functionality;

-Requirements for safety integrity, performance and preparation of other safety plans;

-Readable by the development team;

-Testability for further verification;

-Safe modification allowing further improvement.

② Designs specifying and describing phase N

Validation plans and/or tests specified in phase N fully meet the requirements.

③ Check incompatibility between:

-Tests specified in phase N and tests specified in phase N-1;

-Outputs of phase N.

(7) The following verification activities shall be carried out in phases of software development lifecycle:

① Verification of software requirements (see 7.8.2 (8));

② Verification of software architecture (see 7.8.2 (9));

③ Verification of software system design (see 7.8.2 (10));

④ Verification of software module design (see 7.8.2 (11));

⑤ Verification of codes (see 7.8.2 (12));

⑥ Data verification (see 7.8.2 (13));

⑦ Software module test (see 7.5.4);

⑧ Software integration test (see 7.5.5);

⑨ Computer system integration test (see 7.5.6);

⑩Additional requirements for the data links of Category II and III systems (see 6.4).

(8) Verification of software requirements: once the software requirements are specified, the verification shall consider the following items before next phase, software design and development:

① Consider whether the specified software requirements have fully met the requirements on function, safety integrity, performance and other safety validation planning requirements specified by computer system.

② Consider whether the software safety validation plan has fully met the specified software safety requirements.

③ Check incompatibility between:

-Specified software requirements and specified computer system safety requirements;

-Specified software requirements and software validation plan.

(9) Verification of software architecture: after establishing software architecture design, the verification shall:

①Consider whether the software architecture design has fully met the specified software safety requirements.

②Consider whether the tests specified by software architecture integration fully meet the requirements of design specification for software architecture.

③ Consider whether the properties of each main component/subsystem fully meet the following requirements:

-Required flexibility of safety performance;

-Testability for further verification;

-Readable by development and verification team;

-Safe modification allowing further improvement.

④ Check the following incompatibilities among:

-Description of software architecture design and specified software safety requirements;

-Description of software architecture design and specified software architecture integration tests;

-Specified tests for software architecture integration and software safety validation plan.

(10) Verification of software system design: after specifying software system design, the verification shall:

① Consider whether the specified software system design has fully met the requirements of software architecture design.

② Consider whether the specified tests for software system integration have fully met the requirements for specified software system design.

③ Consider whether the properties of each main component specified in software system design can fully meet the following requirements:

-Required flexibility of safety performance;

-Testability for further verification;

-Readable by development and verification team;

-Safe modification allowing further improvement.

④ Check incompatibility among:

-Specified software system design and description of software architecture design;

-Design specification for software system and tests specified for software system integration;

-Tests specified for software system integration and tests specified for architecture integration.

(11) Verification of software module design: after specifying each software module design, the verification shall:

① Consider whether the specified software module design has fully met the requirements specified for software system design.

② Consider whether the tests specified for each software module fully meet the requirements specified for software module design.

③ Consider whether the properties of each software module fully meet the following requirements:

-Required flexibility of safety performance;

-Testability for further verification;

-Readable by development and verification team;

-Safe modification allowing further improvement.

④ Check incompatibility among:

-Specified software module design and specified software system design;

-(For each software module) specified software module design and specified software module testing;

-Specified software module test and specified integration test of software system.

(12) Code verification: source code shall be verified by static method to ensure the conformance between the specified design of software module, required coding standards and safety planning requirements.

Note: In early phase of software safety lifecycle, the verification is static (e.g. check, review, formal proof etc.).Code verification includes such techniques as software inspection and walk-through. It combines the records of code verification and software module testing to ensure each software module meets relevant specifications. After then, the main verification method is forward testing.

(13) Data verification

①The following shall be verified for data architecture specified in the design:

-Integrity;

-Consistency;

-Protection against change or damage;

-Consistency of functional requirements of data driven system.

②The following shall be verified for application data:

-Consistency with data architecture;

-Integrity;

-Compatibility with base system software (e.g. implementing sequence, operation time etc.);

-Correction of data value.

③All modified parameters shall be verified to prevent:

-invalid or undefined initial values;

-wrong, inconsistent or unreasonable values;

-Unauthorized change;

-Data damage.

④All large equipment interface and relevant software (i.e. sensors, actuators and offline interfaces) shall be verified to:

-be used for detection of failure of expected interface;

-be used for error tolerance for failure of expected interface.

⑤For all communication interfaces and relevant software, the sufficiency of the following events shall be verified:

-Failure detection;

-Error prevention;

-Data validation.

7.8.3 Input

Applicable verification plan (based on stages)

7.8.4 Output

Applicable verification report (based on stages)

8 Test and verification

8.1 Test and verification shall be performed to the computer system as required by Table 8.2, and specific requirements for software are proposed in this section.

8.2 Test and verification shall be performed to the assessment of small low complexity computer system as required by Appendix2 in this Guide.

Test and verification **Table 8.2**

S/N	Requirements	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided
1	Quality plan	X	X		Ⓐ	Ⓐ	Ⓐ	Software quality plan
2	Risk assessment report		X			Ⓐ	Ⓐ	Risk assessment report
3	Function description for software modules and description for related hardware	X (if necessary)	X			Ⓘ	Ⓘ	① Specification of computer system requirements ② Instruction for the hardware of computer system ③ Specification of software requirements ④ Design specification of software structure ⑤ Test specification of software structure integration ⑥ Test specification of computer system integration ⑦ Development tools and coding standards ⑧ Selection for development tools ⑨ Design specification of software system ⑩Test specification of software system integration ⑪Design specification of software modules ⑫Test specification of software modules
4.1	Verification evidence for software codes	X (if necessary)	X			Ⓘ	Ⓘ	Code review report

S/N	Requirements	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided
4.2	The functional test basis of the components of Category II and III systems on the software module, subsystem and system level	X	X			①	①	① Test specification of software module ② Test records of software module ③ Test specification of software system ④ Test records of software system ⑤ Test records of software structure integration ⑥ Test records of computer system integration
4.3	The process of functional test and fault test, including FMEA or similar analysis that CCS may require		X			Ⓐ	Ⓐ	① Risk assessment report ② Fault test records of computer system
5.1	Factory acceptance tests, including functional test and fault test	X	X			Ⓦ	Ⓦ	FAT report
5.2	Simulation test process before the final integration		X			Ⓐ	Ⓐ	Test specification of computer system integration
5.3	Simulation test before the final integration		X			Ⓦ	Ⓦ	Test records of computer system integration
6.1	Onboard test process (including wireless network test)		X			Ⓐ	Ⓐ	Onboard test report
6.2	Onboard integration test (including wireless network test)		X			Ⓦ	Ⓦ	Onboard test report

S/N	Requirements	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided
7	- Software list and version number of system installation - Software function description - Software maintenance and user manual - List of interfaces between the systems and other systems of the vessel		X			①	①	① Software list and version number of system installation ② software function description ③ software maintenance and user manual ④ List of interfaces between the systems and other systems of the vessel
8	Updated software registration form		X	X		①	①	Updated software registration form
9	Programs and documents related to security strategies					①	①	Programs and documents related to security strategies
10	The hardware report shall follow the requirements of CCS *Guidelines for Type Approval Test of Electric and Electuonic Products*.	X	X		Ⓐ	Ⓐ	Ⓐ	Type test report for computer system

Note 1: The symbols used in the table and their meanings are as follows:

Ⓐ Submit CCS for approval　　Ⓘ Submit CCS for future reference　　Ⓦ Require CCS ship surveyor for witness

Note 2: The level of the witness shall be determined in accordance with the following requirements. If the design or arrangement inconsistent with the intended requirements is adopted, an engineering analysis which is in accordance with the relevant international (see Article 55 of Chapter II-1 of the SOLAS Convention.) or domestic standards shall be submitted to the CCS and be recognized.

Appendix1 Verification of tests and inspections

Applicant name: _____ Work control number: _____

Product name:_____Product model: _____

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
1	Quality plan		X	X		Ⓐ	Ⓐ	Ⓐ		
	Software quality plan	5.1 5.2							Software quality plan	
a	Are there clear standard and guidance documents to define the products?									
b	Does all stakeholders (eg, developers, project leaders, etc.) review the products?									
c	Has the acceptance criteria for the products been established?									
d	Have the products clearly defined the target and scope of application?									
e	Whether which software content that has been covered by the software quality assurance program is clarified or not?									
f	Are the intended use of the software specified?									
g	Whether which part that has been covered by the software quality assurance plan during the software development life-cycle is described or not?									
h	Are available references included?									
i	Is a summary of the project management structure included?									
j	Has the files for the development, verification, validation, use and maintenance of the software been detailed?									
k	Are the files listed and described?									
l	Are the files that need to be evaluated by software quality plans already listed?									
m	Are the standards, practices and quality requirements used are identified (eg, IEC, ISO, IEEE, etc.)?									
n	Whether how to monitor and ensure the compliance of process and products is described or not (eg, traceability, reports and trends)?									
o	Is the role of software management plans in software verification and validation identified and described?									
p	Are the methods and programs for reporting, tracking and									

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
	resolving problems are described?									
q	Whether which tools and techniques are used to support software assurance activities are described or not (eg, inspection lists, plans and report templates and databases for traceability)?									
r	Is the ensurement that the supplier's control can meet customers' requirements through internal and external supervision discussed (eg, inspection, evaluation/review and monthly status report)?									
s	Dose the software design and development ensure that it can meet specific design and development requirements to prevent and respond to potential failure conditions?									
t	Inform the owner whether the process of software modification and installation on board is clear.									
	Traceability of software	5.1 5.5 5.6 6.3.4							①Software quality plan ②Records of procedure, data modification and version alteration	
a	Whether to identify and document programming content, data modification and version alteration in accordance with the procedure.									
b	Whether the software configuration management, software version introduction and other quality assurance documents are formulated.									
c	Whether the process that the programming content, data modification and version alteration must comply with is explicit, and ensure to record these modifications or alterations in the document.									
d	Inform the owner whether the process of software modification and installation on board is clear.									
e	The owner shall designate the system integrator as the responsible party for the software alteration and inform CCS.									
f	The software modifications that have been considered and accepted at the initial recognition may be considered as limited lifecycle steps.									
g	Analysis records and test reports affecting software modifications shall be submitted to CCS for future reference.									

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
h	The owner shall be responsible for managing the traceability of the modifications and can update the software registration forms with the system integrator to complete the modified records.									
	Security Strategy	6.3.6								
a	The owner, system integrator and supplier shall adopt a security strategy in the quality system and procedure.									
b	The software can not be modified unless authorized. Whether physical or remote control systems, physical and logical security measures shall be taken to prevent unauthorized or unintentional modifications.									
c	All ship-mounted workpieces, software codes, executable programs and physical media shall be scanned for viruses and malware before installation.									
d	The scanned results shall be recorded and saved in the software registration forms.									
2	Risk assessment report	表 -B2 6.2 6.3		X			Ⓐ	Ⓐ	Risk assessment report	
	Risk assessment report									
a	Risk assessment report is submitted by the system integrator or supplier, including the data obtained from other suppliers.									
b	It may be necessary to obtain the consent of CCS and the system supplier based on the corrected system category of risk assessment.									
c	When the risk of the computer system is obvious, the risk assessment is allowed to exempt submission, but the system integrator or supplier shall submit supporting documents to explain the reasons for exemption. The certification documents shall include known risks, the current computer system and the equivalence of the operating environment of the initial computer system used to determine the risk, and the existing controlling measures applicable to use in the current environment. Where the articles d and e are not applicable.									
d	Whether the appropriate method is adopted, such as fault tree analysis, risk analysis, FMEA or FMECA analysis; (when article c comes into force, this article is not applicable)									
e	Whether the acceptable performance standard of single fault, that the system enters fault-safe status and that the									

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
	operating system can not be lost or degraded not to meet the regulations of classification society shall be testified by fault analysis. (When article c comes into force, this article is not applicable)									
	Category II and III systems data link requirements									
a	The status of data link failure shall be clearly defined in risk assessment analysis.									
3	Function description for software modules and description for related hardware		X (if necessary)	X			①	①	① Specification of computer system requirements ② Instruction for the hardware of computer system ③ Specification of software requirements ④ Design specification of software structure ⑤ Test specification of software structure integration ⑥ Test specification of computer system integration ⑦ Development tools and coding standards ⑧ Selection	

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
									for development tools ⑨ Design specification of software system ⑩Specification of software integration test ⑪Specification of software module design ⑫Specification of software module test	
	Description of software									
a	Is the software requirement specification formulated according to system functional requirements?	7.3								
b	Whether the requirement of software security function is specified for each computer system that needs to realize a certain security function	7.3								
c	Whether the requirement of software integration is specified for each computer system	7.3								
d	Whether the description of software structure design includes: in the required development life-circle of software, select and determine the integration technology that meets the software requirement specification according to systems at different levels.	7.5.1								
e	Whether the technologies and measures that software requires to standardize include: fault allowed tolerance (consistent with hardware) and fault-avoidance software design strategies, (when it is applicable) redundancy and diversity.	7.5.1								
f	Whether the description of software structure design includes: determine the importance of the interactions, evaluation and refinement of all software/hardware.	7.5.1								
g	Whether the description of software structure design includes: determine the appropriate software structure integration test to ensure that the software structure meets the software security requirements of the specified system	7.5.1								

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
	level.									
h	Is the standard and naming scheme explicit?	7.5.1								
i	Whether the specifications of software system design and single module design will be provided	7.5.2								
j	Whether the software system design and single module design specifications illustrate the mutual constraints and dependencies among function, performance, modules and other parts	7.5.2								
k	Whether the software system design and single module design specifications illustrate software self-monitoring (e.g., including application-driven watchdog and data scope verification)	7.5.2								
l	Whether the software system design and single module design specifications require verification test and external equipmentdiagnostic test (such as sensors and terminal components)	7.5.2								
m	Whether the software system design and the single module design specifications take measures on bad process variables such as sensor values beyond the range, open circuits and short circuits of detection	7.5.2								
	Hardware description	图 -C3 6.3.2								
a	Whether includes: system specification, including detailed description of hardware configuration, system function description and system self-inspection description;									
b	Whether includes: the configuration block diagram of hardware and external device, and the internal connection of the main unit/module of the system and the interface of other systems shall be marked;									
c	Whether includes: system wiring diagram;									
d	Whether includes: technical specification details of hardware and external equipment.									
4.1	Verification evidence for software codes		X (if necessary)	X			Ⓘ	Ⓘ	Code review report	
a	Whether the software developer reviews the software code, checks the coding and whether its result conforms to the description of the detailed design document.	7.5.3								
b	Whether the software developer certifies the coding and whether the coding obtained conforms to the records of the	7.5.3								

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
	detailed design documentation.									
4.2	The functional test basis of the components of Category II and III systems on the software module, subsystem and system level		X	X			Ⓘ	Ⓘ		
	Testing of module								① Test specification of software module ② Test records of software module	
a	Whether the record of the software module test is documented.	7.5.4								
b	Whether the contents recorded in documentation of software module test records for Category II and III vessel equipment include software module test plan, software module test trial case, software module test record, test record analysis report, software module test problem report and test summary report.	7.5.4								
c	After each module design is specified, please verify: consider whether the specified module design meets the system design of the specified software.	7.8.2（11）								
d	After each module design is specified, please verify: consider whether the specified test of each module fully meets the requirements of the specified software module.	7.8.2（11）								
e	After each module design is specified, consider whether the properties of each module meets: ①The flexibility of the required safety performance; ②The testability of further verification; ③The development and verification can be readable for groups; ④ Further security modification is allowed.	7.8.2（11）								
f	After each module design is specified, check the incompatibility among the following three points: ①Specified software module design and specified software system design; ②Specified software module design and specified software module test (for each software module); ③ Specified software module test and specified software system integration test.	7.8.2（11）								
	Subsystem test								①Specification	

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
									of software system test ②Test records of software system	
a	Whether the software system integration test indicates all software modules and software components/subsystems are working correctly to perform their intended functions without performing unintended functions	7.5.5								
b	Whether the record of software system integration test is documented, and illustrate whether the test record meets the purpose and criterion. If the failure occurs, record the cause of failure.	7.5.5								
c	During the software integration process, whether the impact analysis on any modification or alteration of software will be conducted to determine the impact on all software modules, the required reinspection and redesign activities.	7.5.5								
d	System test								①Specification of software system test ②Test records of software system	
e	Whether the software system integration test indicates all software modules and software components/subsystems are working correctly to perform their intended functions without performing unintended functions	7.5.5								
f	Whether the record of software system integration test is documented, and illustrate whether the test record meets the purpose and criterion. If the failure occurs, record the cause of failure.	7.5.5								
g	During the software integration process, whether the impact analysis on any modification or alteration of software will be conducted to determine the impact on all software modules, the required reinspection and redesign activities.	7.5.5								
h	Whether the software system test verifies the protection function of anti-modification	7.5.5								
i	Whether the system test of Category II and III systems verifies the system safely fails in case of the single fault	7.5.5								
	Integration testing								①Specification of software	

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
									structure integration test ②Test records of software structure integration ③Specification of computer system integration test ④Test records of computer system integration	
a	After the software structure design is completed, please verify: consider whether the description of software structure design meets the software safety requirements.	7.8.2(9)								
b	After the software structure design is completed, please verify: consider whether the specified test of software integration fully meets the requirements of specifications of software structure design.	7.8.2(9)								
c	After the software structure design is completed, consider whether the properties of each main component/subsystem meets: ①The flexibility of the required safety performance; ②The testability of further verification; ③The development and verification can be readable for groups; ④ Further security modification is allowed.	7.8.2(9)								
d	After the software structure design is completed, check the following incompatibilities: ①The description of software structure design and the specified software security requirements; ②The description of software structure design and the specified software structure integration test; ③The software structure integration test and software security verification plan.	7.8.2(9)								
e	Whether the computer system integration test specifies: ①Split the system according to the integration level; ②Test trial cases and test data; ③Types of test performance; ④Test environment including tools, support software and configuration descriptions; ⑤The criteria for determining test completion.	7.6.2								
f	When the computer system integration test is being	7.6.2								

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
	conducted, whether the activities performed by the developers on their own intentions and the activities performed from the user's standpoint shall be distinguished									
g	During the programmable electronics (hardware and software) integration test related to safety, whether the impact analysis on any modification or alteration of software will be conducted to determine the impact on all software modules and the required reinspection.	7.6.2								
h	Whether the programmable electronics (hardware and software) integration test related to safety is documented, and illustrates whether the test result meets the purpose and the criterion of the test. If the failure occurs, record the cause of failure. The impact analysis on any modification or alteration of software shall be conducted to determine the impact on all software modules, the required reinspection and redesign activities.	7.6.2								
i	For Category II and III systems, whether the system integrator and supplier maintain and submit the certification documents of integration tests according to demand, including test plan and test report.	7.6.2								
j	For Category II and III systems, whether the China Classification Society has witnessed the integration test.	7.6.2								
	Category II and III systems data link requirements	6.4.1								
a	A single fault in the data link hardware shall be automatically processed to restore the normal operation of the system.									
b	The characteristics of the data link shall prevent the system from overloading under any operating conditions.									
c	The data link shall have a self-test function to detect its own link failure and the communication failure of the nodes connected to the link.									
d	An alarm shall be sent out when a fault occurs.									
	The supplementary requirements for the computer system that adopts the wireless data link	6.4.2								
a	Category III system shall not adopt the wireless data link unless specifically considered by CCS									
b	An accepted international wireless communication system protocol shall be adopted									
c	Information integrity: prevent, inspect, diagnose and correct the failure so that the received information (compared with the sent information) shall not be destroyed or altered;									
d	Configuration and device verification: only the connection									

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
	with the device included in the system design shall be allowed;									
e	Information encryption: confidential and/or key data content shall be protected;									
f	Security management: the network assets shall be protected to prevent illegal access to network assets.									
g	The internal wireless system inside the vessel shall meet the requirements for the radio frequency and power levels by International Telecommunication Union and the competent authorities of Flag State.									
h	The system operation shall take into account the provisions of the RF transmission aspects of ports and local regulations. The wireless data communication link shall be prohibited due to frequency and power limitations.									
i	The wireless data communication device shall be tested during mooring and navigational tests, which testifies that RF transmission will not cause the failures of itself and any other device due to electromagnetic interference under the anticipated operating conditions.									
	Modified test								①Software quality plan ②Records of procedure, data modification and version alteration ③Software operation and modification regulation ④Software modification impact analysis record ⑤ Test report	
a	Whether the system integrator and supplier shall record the modification.	7.7								
b	Whether the system integrator and supplier are informed of	7.7								

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
	the modification and alteration plans of the approved system in advance, and the impact analysis shall be conducted and the alteration shall be reported to the Classification Society.									
c	Whether the system integrator and supplier shall submit the subsequent significant modifications of Category III system software to the Classification Society for approval.	7.7								
d	According to the record of impact analysis, whether the appropriate phase of the software development life-cycle has been returned and verified accordingly.	7.8								
4.3	The process of functional test and fault test, including FMEA or similar analysis that CCS may require			X			Ⓐ	Ⓐ	① Risk assessment report ② Fault test records of computer system	
a	Whether the appropriate method is adopted, such as fault tree analysis, risk analysis, FMEA or FMECA analysis;	6.2								
b	Whether the acceptable performance standard of single fault, that the system enters fault-safe status and that the operating system can not be lost or degraded not to meet the regulations of classification society shall be testified by fault analysis	6.2								
c	Whether the failure simulation test specification includes the following contents: ①Names of failure components or the components; ②Type of failure; ③Mode of insert fault ; ④Required system response (output record).	7.6.3								
d	Whether the expected record of the software module test case is documented. Illustrates the record of fault simulation and whether it meets the purpose and the criterion of the test. If failure record occurs, whether the failure cause is documented.	7.6.3								
e	During the programmable electronics (hardware and software) integration test related to safety, whether the impact analysis on any modification or alteration of software will be conducted to determine the impact on all software modules and the required reinspection.	7.6.2								
f	Whether the programmable electronics (hardware and software) integration test related to safety is documented,	7.6.2								

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
	and illustrates whether the test result meets the purpose and the criterion of the test. If the failure occurs, record the cause of failure. The impact analysis on any modification or alteration of software shall be conducted to determine the impact on all software modules, the required reinspection and redesign activities.									
5.1	Factory acceptance tests, including functional test and fault test	表 -D2	X	X			Ⓦ	Ⓦ	FAT report	
a	Whether the FAT process is recorded in chronological order to trace the order of the FAT activities									
b	Whether the tool and equipment used and the relevant calibration data are recorded									
c	Whether there is a difference between the expected record and the actual record. When there is a difference between the expected record and the actual record, analysis and assessment should be conducted to determine follow-up testing or alteration request. If the alteration request is made, whether to return to the earlier development life-cycle stage or not.									
5.2	Simulation test process before the final integration			X			Ⓐ	Ⓐ	Test specification of computer system integration	
a	Whether the computer system integration test specifies: ①Split the system according to the integration level; ②Test trial cases and test data; ③Types of test performance; ④Test environment including tools, support software and configuration descriptions; ⑤The criteria for determining test completion.	7.6.2								
b	When the computer system integration test is being conducted, whether the activities performed by the developers on their own intentions and the activities performed from the user's standpoint shall be distinguished	7.6.2								
5.3	Simulation test before the final integration			X			Ⓦ	Ⓦ	Test records of computer system integration	

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
a	Verify that all the functions can be implemented normally under the system integration condition.	表 -D3								
b	Verify that the function can be implemented normally under the condition of the actual hardware components and the final application.	表 -D3								
c	During the programmable electronics (hardware and software) integration test related to safety, whether the impact analysis on any modification or alteration of software will be conducted to determine the impact on all software modules and the required reinspection.	7.6.2								
d	Whether the programmable electronics (hardware and software) integration test related to safety is documented, and illustrates whether the test result meets the purpose and the criterion of the test. If the failure occurs, record the cause of failure. The impact analysis on any modification or alteration of software shall be conducted to determine the impact on all software modules, the required reinspection and redesign activities.	7.6.2								
e	For Category II and III systems, whether the system integrator and supplier maintain and submit the certification documents of integration tests according to demand, including test plan and test report.	7.6.2								
f	For Category II and III systems, whether the China Classification Society has witnessed the integration test.	7.6.2								
6.1	Onboard test process (including wireless network test)	表 –C1 表 –D4 6.6		X			Ⓐ	Ⓐ	Onboard test program	
a	Test program shall include the design function verification									
b	Test program shall include security response verification caused by internal fault or external system equipment fault									
c	Test program shall include verification of safe interconnection with other systems on vessels									
6.2	Onboard integration test (including wireless network test)			X			Ⓦ	Ⓦ	Onboard test report	
a	Verify that all the functions can be implemented normally under the system integration condition.	表 -D3								
b	Verify that the function can be implemented normally under the condition of the actual hardware components and the	表 -D3								

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
	final application.									
c	Whether generates reports according to the finished product test and test results	5.4								
d	Does the final test report contain a general assessment of the software being tested?	5.4								
e	Will the differences between the test environment and the operating environment, and the assessment of the impact of the difference on the test results be provided?	5.4								
f	Whether the test result summary includes "all the results comply with the expectations", "the problems occurred" (if applicable) and, "the deviations from requirements" (if applicable).	5.4								
g	The wireless data communication device shall be tested during mooring and navigational tests, which testifies that RF transmission will not cause the failures of itself and any other device due to electromagnetic interference under the anticipated operating conditions.	6.4								
7	- Software list and version number of system installation - Software function description - Software maintenance and user manual - List of interfaces between the systems and other systems of the vessel	6.3.3		X			①	①	① Software list and version number of system installation ② software function description ③ software maintenance and user manual ④ List of interfaces between the systems and other systems of the vessel	
8	Updated software registration form	6.3.3		X	X		①	①	Updated software registration form	

S/N	Requirements	Reference items	Supplier	System integrator	Owner	Category I system	Category II system	Category III system	Documents to be provided	Whether they are satisfied or not
a	Whether includes software list and version number of the system installation									
b	Whether includes the safe scan results of "all ship-mounted workpieces, software codes, executable programs and physical media shall be scanned for viruses and malware before installation".									
9	Programs and documents related to security strategies	6.3.6					Ⓘ	Ⓘ	Programs and documents related to security strategies	
a	The owner, system integrator and supplier shall adopt a security strategy in the quality system and procedure.									
b	The software can not be modified unless authorized. Whether physical or remote control systems, physical and logical security measures shall be taken to prevent unauthorized or unintentional modifications.									
c	All ship-mounted workpieces, software codes, executable programs and physical media shall be scanned for viruses and malware before installation.									
d	The scanned results shall be recorded and saved in the software registration forms.									
10	The hardware report shall follow the requirements of CCS *Guidelines for Type Approval Test of Electric and Electuonic Products*.		X	X		Ⓐ	Ⓐ	Ⓐ	Type test report for computer system	
	The type test report shall follow the requirements of CCS *Guidelines for Type Approval Test of Electric and Electuonic Products*									

Note 1: The symbols used in the table and their meanings are as follows:
ⒶSubmit CCS for approval ⒾSubmit CCS for future reference ⓌRequire CCS ship surveyor for witness
Note 2: the 囡 in the table refers to "Table 6.1.1".

Ship surveyor: Date: _____Authorized group leader: _____ __Date: __

For principal of the executable recognized unit sector review: _____Date: _____

Appendix2 Evaluation of small low complexity computer systems

1Objectives

1.1Single case evaluation method is adopted for small low complexity computer systems so as to reasonably and effectively simplify the evaluation method of software.

2 Requirements

2.1 Document

2.1.1 Software description shall be based on internal document management system of the system integrator and the supplier and merge with the document provided by clause 2.1 in table 8.2, and the content includes:

(1) System function description, including description of the software module function and description of associated programmable device hardware, list of interfaces between the system and other systems of the ship, list of data transmission standards, mutual restrictions and dependencies between special functions, performance, modules and other parts;

(2) Software design description, including software function description, software maintenance and user manual, especially the configuration of software which includes priority strategy;

(3) Software version and version number of system installation ;

(4) Failure mode analysis;

(5) The switch-over mechanism of redundancy system (if any);

(6) System test, integration test and failure simulation testing method.

2.2 Test

(1) For newly designed software, failure mode analysis of the software shall be checked, and the software shall be tested using the confirmed testing method provided by the system integrator and the supplier.

(2) Functional test evidence and integrated test evidence of software modules, subsystems and system-level programmable device.

(3) For products produced before software reuse and modification, regression testing shall be carried out.

Note 1:Software reuse means using various knowledge of existing software to develop new software to cut the cost of the development and maintenance of software. Software reuse is an important technique to improve the productivity and quality of software. Software reuse mainly refers to code reuse, but not specifically program. Software reuse also includes all relevant aspects, such as domain knowledge, development experience, design decisions, system architecture, demands, design, documents and etc.

Note 2:Regression testing means retest of software after modification of the software to make sure that no new mistakes have been brought in or caused the other codes to generate mistakes.

3 Input

3.1 Requirements and specifications of computer system

4 Output

4.1 Software description

4.2 Hardware description

4.3 Test report

Appendix3Technical recommendations for the design and implementation stages of computer system

1 General requirements

1.1 The design of relevant system of computer system safety (including overall structure of hardware and software, sensors, actuators, embedded software, application software and etc., see the following figure) shall conform to all the following requirements from1.1.1 to 1.1.2.

1.1.1 Hardware safety integrity requirements include:

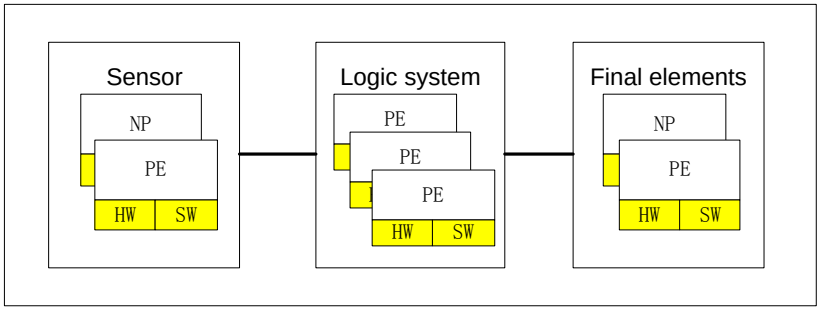
(1) structural constraints of hardware safety integrity; and

(2) requirements of probability of dangerous random hardware failure.

1.1.2 Requirements of system safety integrity include：

(1) requirements of avoidance of failure and system failure control; or

(2) evidence of equipment being verified through operation.



Programmable electronic structure		
PE Hardware structure	PE Software structure	
	PE Embedded software	PE Application software
Specific characteristics of PE hardware in general and at operation: Such as: --Diagnostic test; --Redundancy processor; --Dual I/O card	Such as: --Communication driver; --Failure processing; --Executable software	Such as: --Input/output function; --Derivative function (for example: sensor inspection when embedded software service is not provided)

PE： Programmable electronics, NP: Non-programmable devices, HW: Hardware, SW: Software.

Figure Appendix3-1.1.2Relationship between PE hardware and software structure

1.2 When safety function and non-safety function are executed at the same time, unless safety function and non-safety function are proved to be fully independent (that is to say, the failure of non-safety function will not cause the dangerous failure of safety function), the hardware and software of computer system shall be considered safety-related. Wherever practicable, safety function and non-safety function shall be divided.

1.3 The requirements of hardware and software shall be determined by the safety integrity level of safety function that has the highest safety integrity level, unless it can be proven that the implementation of safety function of different safety integrity level is totally independent.

1.4 When requiring independence among safety functions (see 1.2 and 1.3), the following items shall be documented during design.

1.4.1 Methods to obtain independence;

1.4.2Verification of the rationality of methods.

2. Techniques and measures of hardware safety integrity: failure control in operation

Appendix3Table 2-1~Table 2-6 provide recommendations of safety integrity techniques and measures

I/O unit and interface (external communication) Appendix3Table 2-1

Diagnostic techniques/measures	See IEC61508-7	Maximum diagnostic coverage that can be obtained after consideration	Notes
Detection failure with on-line monitoring	A1.1	Low (low demand mode) Medium(high demand mode or continuous mode)	Diagnostic coverage relying on failure detection
Test pattern	A6.1	High	
Code protection	A6.2	High	
Multi-channel parallel output	A6.3	High	Only effective if the dataflow changes during the diagnostic test interval
Monitored outputs	A6.4	High	Only effective if the dataflow changes during the diagnostic test interval

Data paths (internal communication) **Appendix3 Table 2-2**

Diagnostic techniques/measures	See IEC61508-7	Maximum diagnostic coverage that can be obtained after consideration	Notes
One-bit hardware redundancy	A7.1	Low	
Multi-bit hardware redundancy	A7.2	Medium	
Complete hardware redundancy	A7.3	High	
Inspection with test pattern	A7.4	High	Only effective on transient failures
Transmission redundancy	A7.5	High	
Information redundancy	A7.6	High	

Power supply **Appendix3 Table 2-3**

Diagnostic techniques/measures	See IEC61508-7	Maximum diagnostic coverage that can be obtained after consideration	Notes
Over-voltage protection with safety shut-off or switching to stand-by power unit	A8.1	Low	Techniques in the table shall be adopted, other techniques are also recommended
Voltage control with safety shut-off or switching to stand-by power unit (secondary)	A8.2	High	
Power cut with safety shut-off or switching to stand-by power unit	A8.3	High	Techniques in the table shall be adopted, other techniques are also recommended
Idle current principle	A1.5	Low	Only effective when power is cut

Program sequence(watch-dog) **Appendix3Table 2-4**

Diagnostic techniques/measures	See IEC61508-7	Maximum diagnostic coverage that can be obtained after consideration	Notes
Watch-dog with separate time base but without time-window	A9.1	Low	
Watch-dog with separate time base and time-window	A9.2	Medium	
Logic monitoring of program sequence	A9.3	Medium	Relying on the quality of monitoring
Combination of temporal and logical monitoring of program sequences	A9.4	High	
Temporal monitoring with on-line check	A9.5	Medium	

Sensor **Appendix3Table2-5**

Diagnostic techniques/measures	See IEC61508-7	Maximum diagnostic coverage that can be obtained after consideration	Notes
Detection failure with on-line monitoring	A1.1	Low (low demand mode) Medium(high demand mode or continuous mode)	Diagnostic coverage relying on failure detection
Reactive current principle	A1.5	Low	Only effective on E/E/PE safety-related system that need no continuous control or maintain EUC safety status
Simulation signal monitoring	A2.7	Low	
Test pattern	A6.1	High	
Input comparison/voting	A6.5	High	Only effective if the dataflow changes during the diagnostic test interval
Reference to sensor	A12.1	High	Diagnostic coverage relying on failure detection
Switches that are reliably switched on.	A12.2	High	

Final elements (actuator) **Appendix3Table 2-6**

Diagnostic techniques/measures	See IEC61508-7	Maximum diagnostic coverage that can be obtained after consideration	Notes
Detection failure with on-line monitoring	A1.1	Low (low demand mode) Medium(high demand mode or continuous mode)	Diagnostic coverage relying on failure detection
Relay contact monitoring	A1.2	High	
Reactive current principle	A1.5	Low	Only effective on E/E/PE safety-related system that need no continuous control or maintain EUC safety status
Test pattern	A6.1	High	
Monitoring	A13.1	High	Diagnostic coverage relying on failure detection
Cross-monitoring of multiple actuators	A13.2	High	

3 Recommendations on techniques and measure for system integrity

3.1Appendix3Table 3.1-1, Appendix3Table 3.1-2 provide recommendations concerning techniques and measures for system safety integrity

3.1.1 Control failure caused by the design of hardware and software;

3.1.2 Control failure caused by environmental stress and influence;

3.1.3 Failure of control operation process.

Techniques and measures for controlling system failure caused by hardware design **Appendix3Table 3.1-1**

	Techniques and measures	See IEC61508-7	I	II	III
1	Program sequence monitoring	A.9	Highly recommended (HR) Low	HR Low	HR Medium
2	Detection failure with on-line monitoring	A1.1	R Low	R Low	R Medium
3	Test with redundancy hardware	A2.1	R Low	R Low	R Medium
4	Standard test of access port and boundary-scan structure	A2.1	R Low	R Low	R Medium
5	Code protection	A6.2	R Low	R Low	R Medium
6	Multi-hardware	B1.4	- Low	- Low	R Medium
Note: At least one technique of 2~6 shall be adopted.					

Techniques and measures for controlling system failures caused by environmental stress orinfluence **Appendix3Table 3.1-2**

	Techniques and measures	See IEC61508-7	I	II	III
1	Measures to prevent voltage breakdown, voltage fluctuation, over-voltage, low-voltage	A8	Must be adopted	Must be adopted	Must be adopted
2	Power wire and information wire shall be separated (note 1)	A11.1	Must be adopted	Must be adopted	Must be adopted
3	Improve anti-interference performance	A11.3	Must be adopted	Must be adopted	Must be adopted
4	Measures against physical environment (temperature, humidity, vibration and etc.)	A14	Must be adopted	Must be adopted	Must be adopted
5	Program sequence monitoring	A9	HR Low	HR Low	HR Medium
6	Measures against the rising of temperature	A10	HR Low	HR Low	HR Medium
7	Space division of multiple lines	A11.2	HR Low	HR Low	HR Medium
8	failure with on-line monitoring check (note 2)	A1.1	R Low	R Low	R Medium
9	Test with redundancy hardware	A2.1	R Low	R Low	R Medium
10	Code protection	A6.2	R Low	R Low	R Medium
11	Anti-synthetic signal transmission	A11.4	R Low	R Low	R Medium
12	Multi-hardware(Note 3)	B1.4	- Low	- Low	- Medium
13	Software structure	7.4.3 of GB/T20438.3	See table A.2 of GB/T20438.3		

Note: At least 1 technique of 8~13 shall be adopted.

Note 1: If optical media is adopted for information transmission, then there is no need to separate power wire and information wire. There is no need to power components of the system separately and separate the low power cables designed for the transmission of information to/ from these components.

Note 2: For a safety -related system operating in low demand mode (for example: emergency system shutdown), diagnostic coverage rate of failure detection by on-line monitoring is usually low or void.

Note 3:If confirmed or proved by experience of broad application: to meet target failure measure, hardware has fully got rid of design failure and strong enough to prevent common cause failures, then multi-hardware is not needed.