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**Maintainability design requirements for manned spacecraft
flight products**

载人航天器飞行产品维修性设计要求

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6.1 Maintenance Safety Design Requirements

6.1.1 Safety Design for Manned Spacecraft Maintenance The safety design requirements for the maintenance of manned spacecraft are as follows:

- a) Redundancy design or maintenance work mode design should be carried out to reduce the impact of maintenance on manned spacecraft and reduce safety risks caused by maintenance. risk.
- b) Debris collection and protection designs should be implemented to reduce the amount of debris generated during maintenance or to prevent debris from affecting manned spacecraft.
- c) For power supply connectors, the design should ensure that one end of the socket is energized and the other end of the pin is de-energized.
- d) Electrostatic discharge (ESD) Protection design should be implemented. All electronic products should be reliably grounded, and anti-static wrist straps and grounding points should be designed to prevent static electricity generation during operation. Electrically damaged products.
- e) Ergonomic design should be carried out to reduce safety risks caused by astronaut operations and meet the following requirements. 1) Products under maintenance should be marked in easily observable locations to facilitate astronauts' observation and identification of faulty products from multiple angles in orbit; The logo design shall meet the requirements of Chapter 5 of GB/T 47586-2026. 2) Electrical connectors and pipe joints of products under maintenance should have easily observable markings to reduce misoperation by astronauts due to incorrect identification. The logo design should meet the requirements of Chapter 5 of GB/T 47586-2026. 3) If misoperation could damage the product or manned spacecraft's functionality, the corresponding operating interface should be designed with anti-misoperation features to prevent such errors. The occurrence of misoperation.

6.1.2 Astronaut Maintenance Safety Design The safety design requirements for astronaut maintenance are as follows:

- a) All parts that astronauts will touch should be free of sharp angles and edges, and have good mechanical safety features;
- b) Power supply circuits with a voltage higher than 36V should be able to be disconnected from upstream to ensure no risk of electric shock;
- c) It should be able to monitor the temperature of high-temperature equipment to ensure that astronauts can only carry out maintenance work when the temperature is below 45°C;
- d) Protective measures should be implemented for equipment and moving mechanisms exposed to pollution, electromagnetic radiation, and high temperatures around the maintenance operation area, and protective devices should be installed nearby. Prominent warning signs;
- e) During pipeline operations, leakage of toxic or hazardous working fluids should be minimized to the greatest extent possible, and the safety risks posed by pipeline pressure to astronauts should be reduced as much as possible. risk;
- f) Measures should be provided to secure astronauts during extravehicular activities to prevent them from drifting away during operations.

6.2 Requirements for Maintenance Work Mode Design The design requirements for maintenance work modes are as follows:

6.4 Isolation Design Requirements

6.4.1 Power Supply Isolation Design The power supply isolation design requirements are as follows:

- a) The power supply to the object being repaired should be disconnectable. To minimize the impact of repairs, each product being repaired should ideally use an independent power supply switch. Turn off power to reduce the number of products that are affected by power outages.
- b) If a power supply circuit with a voltage below 36V cannot be disconnected during maintenance, appropriate protective design should be implemented.

6.4.2 Information Isolation Design The information isolation design requirements are as follows:

- a) During maintenance, the product is powered off, but the upstream and downstream electronic devices connected to it are powered on. It should be ensured that the insertion and removal processes do not... It affects upstream and downstream equipment connected to the product;
- b) Hot-swappable information interfaces (such as 1553B bus interfaces, Ethernet interfaces, etc.) should be given priority. For interfaces that do not support hot-swappability... Hot-swappable information interfaces (such as RS-422, LVDS, etc.) should be protected by

protective measures (e.g., protection against power failure of the information interface, protection against damage from upstream and downstream products). Power outages, etc.

c) After the cable connector is disconnected, leaving the connector suspended should not result in the transmission of incorrect commands.

6.4.3 Pipeline isolation design The pipeline isolation design requirements are as follows:

a) When repairing piping systems containing toxic or hazardous liquids, care should be taken to ensure the integrity of the piping during the product's removal from and connection to the piping. The leakage of the working fluid does not exceed the specified limit, and the leaked working fluid is collectable;

b) During maintenance of products with sealed chamber piping systems containing toxic or harmful gases as the internal working fluid, during the process of cutting out and connecting the piping to the product... No working fluid leakage should be ensured;

c) For products with sealed internal piping systems containing air or oxygen as the working fluid, during product maintenance, it is permissible to allow for the removal and connection of piping during the product cutting process. Minor leakage of the working fluid is possible, but the amount of leakage should be kept within the limits of the chamber pressure control capacity.

6.5 Maintenance Layout Design Requirements The maintenance layout design requirements are as follows:

a) The product should meet the requirements of visibility and accessibility during maintenance. When repairing the product, it is advisable to minimize the disassembly and movement of other peripheral equipment. Peripheral equipment;

b) Consumable parts, products with limited lifespan, short replacement cycles, and products with maintenance time constraints should be located in easily accessible areas. A location unobstructed by other products;

7.1 Design Requirements for Auxiliary Facilities

7.1.1 Design of In-cabin Auxiliary Facilities The main auxiliary facilities inside the cabin include fixed foot limiters, rigid handrails, and movable foot limiters, and their design requirements are as follows:

a) For products that are frequently operated, fixed foot limiters and rigid handrails should be designed;

b) For products that are not frequently operated, a movement foot limiter and a corresponding installation interface should be designed, and it should be able to be fixed to rigid handrails, etc. On the rigid structure inside the cabin.

7.1.2 Design Requirements for External Auxiliary Facilities External auxiliary facilities

mainly include external foot limiters, external operating tables or workbenches, and external fixed handrails, and their design requirements are as follows:

- a) Extravehicular support facilities should be compatible with the astronauts' ability to operate while wearing extravehicular spacesuits;
- b) An external foot restraint device should be designed to ensure that the astronaut is stably restrained in the designated position;
- c) An external control panel or workbench should be designed to ensure that equipment used outside the cabin can be secured;
- d) External fixed handrails should be designed to help secure astronauts and support them as they crawl along the cabin walls.

7.2 Design Requirements for Maintenance Tools The design requirements for maintenance tools are as follows:

- a) Standardization and universalization should be implemented, and the types and quantities of maintenance tools should be minimized to cover astronaut maintenance operations;
- b) It should meet ergonomic requirements and pass ergonomic evaluation;
- c) The operating force should be within the range of the astronaut's force characteristics and easy to operate;
- d) Installation, adjustment, and use require only one hand from the astronaut; the handle of the maintenance tool is adaptable to both right and left-hand operation.
- e) The size and shape of the handles of maintenance tools should be easy for astronauts to grip, and the surface of the handles should have anti-slip measures;