ICS 73.100.01
CCS D 10

Social Organization Standard

T/CAOE 40-2021

Technical guidelines for seafloor polymetallic nodules mining system

海底多金属结核采矿系统技术指南

Issue date: 2021-07-15

Issued by China Association of Oceanic Engineering

Contents

Foreword

China Association of Oceanic Engineering is in charge of this English translation. In case of any doubt about the contents of English translation, the Chinese original shall be considered authoritative.

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This document was proposed by Beijing Pioneer Hi-Tech Development Corporation.

This document was prepared by China Association of Oceanic Engineering.

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Technical guidelines for seafloor polymetallic nodules mining system

1 Scope

This document provides green, economy, reliability, intelligence, and safety technical principles for seafloor polymetallic nodules mining system, as well as factors to be considered, and gives the relevant technical guidelines.

This document is applicable to design, construction, operation and management of seafloor polymetallic nodules mining system and the relevant key components in the "area".

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including amendments) applies.

GB/T 5080.1, *Reliability test—Part 1: Test conditions and statistical test principles*

GB/T 31024.1, *Cooperative intelligent transportation systems—Dedicated short range communications—Part 1: General technical requirement*

GB/T 37472, *General requirements for heave compensation system of submersible mothership*

GB/T 40073, *External pressure strength test procedure for metal pressure hull of submersibles*

ISO 14000, *Environment management systems*

ISO 9001, *Quality management systems—Requirements*

ISO 31000, *Risk management—Guidelines*

API RP 1111, *Design, Construction, Operation, and Maintenance of Offshore Hydrocarbon Pipelines (Limit State Design)*

API RP 16Q, *Design, Selection, Operation, and Maintenance of Marine Drilling Riser Systems*

API RP 17B, *Recommended Practice for Flexible Pipe*

API RP 2RD, *Design of Risers for Floating Production Systems (FPSs) and Tension-Leg Platforms (TLPs)*

API Spec 17J, *Specification for Unbonded Flexible Pipe*

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

3.1

area

the sea-bed and ocean floor and the subsoil thereof, beyond the limits of national jurisdiction

[SOURCE: *United Nations Convention on the Law of the Sea*]

3.2

polymetallic nodules

a type of polymetallic ore existing on the seafloor in the form of nodules, generally rich in manganese, cobalt, nickel, copper and other metal compositions

NOTE Also called manganese nodules or ferromanganese nodules.

3.3

exploitation

recovery of polymetallic nodules and extract minerals from polymetallic nodules for commercial purposes, including the construction and operation of mining, processing and transportation system for the production and sale of minerals.

[SOURCE: *Decision of the Council of the International Seabed Authority relating to amendments to the Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area and related matters*, modified]

3.4

mining system

a system includes seafloor ore collecting system, underwater lifting system (e.g. hydraulic lift system and underwater shuttle lifting system), surface support platform/vessel, transport system, offshore mineral processing system, etc, to collect polymetallic nodules from seafloor and transport nodules to the sea surface, then process and transport nodules to the target port.

3.5

collecting system

an underwater system for collecting polymetallic nodules on the seafloor, including a driving mechanism and a gathering mechanism

3.6

lifting system

all equipment that used to transport polymetallic nodules from the seafloor to the ocean surface, usually refers to hydraulic lift system or underwater shuttle lifting system

3.7

hydraulic lift system

a subsystem consists of pumps and pipes for transporting polymetallic nodules from the near seafloor buffer station to the surface support platform/vessel

3.8

underwater shuttle lifting system

a subsystem with underwater shuttle transports polymetallic nodules from the seafloor to the surface support platform/vessel

3.9

surface support platform/vessel

platforms/vessels support mining, ore loading and unloading, ore storage, central control, power supply or related functions on-site for mining operation

3.10

transport system

ships and associated marine devices transport the seafloor polymetallic nodules from offshore to port

3.11

offshore mineral processing

the process of producing concentrates, intermediate concentrates, or metal products by picking, sorting, washing of ores on the seafloor or/and surface support platform/vessel

3.12

plume

a dispersion of seawater that contains dense sediment particles

[SOURCE: *Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area,* International Seabed Authority Legal and Technical Commission, modified]

3.13

underwater shuttle

an underwater shuttle system that operates between the seafloor and a surface support platform/vessel and has the function of gathering and transporting seafloor polymetallic nodules

3.14

flexible pipe

flexible pipe connecting the seafloor collecting system and the buffer station

3.15

buffer station

a device with the upper end connected with the surface support platform/vessel through a riser, and the lower end connected with the seafloor collecting system through a flexible pipe, and quantitatively and continuously feeds the ore to lifting riser

4 Basic principle

Principles of Green, Economy, Reliability, Intelligence and Safety (GERIS) shall be met in

the entire production process and mining system service life.

5 Green principle

5.1 General requirements

The overall requirements of Green principle for the seafloor polymetallic nodules mining system are as follows.

— Comply with the provisions of the *United Nations Convention on the Law of the Sea*.

— It should select low environmental impact materials and techniques during the mining system life cycle.

— Advanced, reliable and environmental friendly technologies should be approved by International Seabed Authority.

— Energy saving technologies and measures should be adopted in entire production chain include seafloor collecting system, lifting system, surface support platform/vessel, transport system.

— It should meet with ISO 14000 environmental management standards.

— Technologies used to reduce influence of noise, light, magnetism, heat, mechanical disturbance and oil pollution should be selected.

— Environmentally friendly materials and coatings, such as corrosion-resistant, pollution-free, should to be considered.

— Given priority, the energy module should use clean or renewable energy with high energy density, stable output and low frequency replenishment, and should be adopted with technologies and processes to improve energy efficiency.

— It should reduce carbon dioxide emissions and promote the process of carbon neutrality.

5.2 Requirements for underwater ore collecting system

Collecting method should consider with minimum disturbance to the deep-sea sediment, the details are as follows.

— Collecting method should cause limited plume diffusion range, factors considered should include the initial velocity, duration, suspended matter content, near-bottom hydrological conditions, and sediment damage thickness.

— It should choose seafloor non-contact movement and/limited contact collecting

technologies.

— While the contact collecting technology is used, it is advisable to adopt a design that should minimize the contact area and contact pressure between the vehicle and seafloor as possible.

5.3 Lifting system requirements

The lifting system should meet with the following requirements.

— The amount of seawater lifted from the bottom to the sea surface should be reduced to minimize the environmental impact of tail water.

— It should minimize the nodules fragmentation and liquification to reduce the content of fine particles discharged into the tail water.

— Discharge of tail water should be selected with low plume impact method.

— Tail water should be discharged near seafloor, and surface discharge is prohibited.

5.4 Surface support platform/vessel requirements

The surface support platform/vessel should conform to *Articles of the Protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships, 1973* and *Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter*.

5.5 Transport system requirements

The transport system should be zero or pollution-free discharge. There should be no tail water leakage during the transportation process. It is appropriate to achieve zero or pollution-free discharge during the polymetallic nodules temporarily stored on the surface support platform/vessel.

5.6 Offshore mineral processing system requirements

The offshore mineral processing system should meet with the following requirements.

— It is advisable to adopt environmental friendly beneficiation and smelting process, as well as comprehensive utilization technology, it should use clean energy and environmental friendly chemicals, and should use seawater as process water.

— Tailings should be treated to meet with the relevant standard before discharge, and tail water should be zero discharge at surface.

— Set up environmental monitoring points around the discharge locations.

6 Economy principle

6.1 General requirements

Taking the economics benefits and efficient utilization of seafloor polymetallic nodules resources and the protection and preservation of deep-sea environment as constraints, it should improve the mining efficiency and reduce the mining cost in the entire production chain. The details are as follows.

— Improve mining efficiency by improving the collection coverage rate and the collection efficiency of the ore collector, reducing the loss of resources and energy consumption per unit.

— Control the operation mode of the entire circulation process, simplify operation procedures, control the unit mining cost and acquire the commercial benefits.

— The design life of mining system should be complied with mining development period, and cyclic utilization should be considered in system components design to reduce costs.

6.2 Collection rate

The collection rate (C) is determined by collection coverage rate (C_f) and collector collection efficiency (C_x). The collection rate is calculated in accordance with formula (1). Collection coverage rate (C_f) and collector collection efficiency (C_x) should be optimized by mining plan.

$$C = C_x \times C_f \quad \cdots\cdots (1)$$

where

C_f is the collection coverage rate, which is the ratio of the mining coverage area (A_c) to the designated mining area (A_d), shown as formula (2).

C_x is the collection efficiency, which is the ratio of the mining amount per unit area (A_m) to the ore existing amount per unit area (Q_a), shown as formula (3).

$$C_f = \frac{A_c}{A_d} \quad \cdots\cdots (2)$$

$$C_x = \frac{A_m}{Q_a} \quad \cdots\cdots (3)$$

The collection rate of mining system should not be less than 90%. The following measures should be taken to improve the system collection rate.

— Design and optimize ore collection planning by collector position control.

— Ensure the system has accurate positioning and navigation capabilities.

— Improve the moving stability of the seafloor ore collecting devices.

— The collection trajectory should be closely connected, and the overlap coverage of collector collection surface should not exceed 10%.

6.3 Recovery rate

The recovery rate (R) is an important indicator to measure the mining technology level of mining system. It depends on the recovery of polymetallic nodules in the mining area (R_C) and the estimated reserves in the same mining area (R_S). The recovery rate is calculated as the formula (4).

$$R = \frac{R_C}{R_S} \quad (4)$$

where

R_C is the recovery of polymetallic nodules in the mining area, the unit is tonne (t).

R_S is the estimated reserves of polymetallic nodules in the same mining area, the unit is tonne (t).

The recovery rate of seafloor polymetallic nodules should be greater than 85%.

6.4 Energy consumption per unit

The following consumption reduction technologies and measures should be adopted in all mining systems.

— Increase the transport concentration of seafloor polymetallic nodules on the premise of smooth transportation.

— Design the surface support platform/vessel for continuous transport of nodules, shorten the production process, and design the transport vessels and transportation mode according to the simplest transport process.

6.5 Cost of seafloor polymetallic nodules mining system

Mining system cost should be improved by optimizing system design, prolonging the service life, and introducing intelligent management to improve economics benefits; the following measures should be used to reduce the system cost according to the system composition.

— The seafloor ore collecting system should adopt with the following measures:

- use high-efficiency ore collecting method to minimize down time;
- control the collector construction cost;

- collecting plan should be designed in accordance with the collection rate requirements to improve economics benefits.

— The underwater lifting system should adopt an energy-saving and operation efficiency mode, and should choose the economical and high-efficiency hydraulic lift system/ underwater shuttle lifting system.

— The surface support platform/vessel should be designed to transport seafloor polymetallic nodules in a continuous and large-scale way, shorten the transport process on the platform, improve the operational economy of the mining system as much as possible.

— In the design of transport system, transportation ships design and transportation plan should in accordance with the simplest transport procedure.

7 Reliability principle

7.1 General requirements

Mining system should be designed to operate under complex marine environmental conditions continuously and reliably during service life. The system should be complied with ISO 9001, and the design requirements may refer to the provisions of GB 5080.1. Details are as follows.

— The service life of the mining system should not less than 20 years.

— Mining system should be capable to survive in the 100-year environmental condition.

— The steady and reliable working time of the mining system is more than 280 days throughout the year.

— The coupling dynamics of the linkage of the seafloor ore collecting system, the underwater lifting system and surface support platform/vessel should be verified through numerical simulation and model test.

— Underwater vulnerable components should be quick-replaceable.

7.2 Seafloor ore collecting system reliability

Seafloor ore collecting system should ensure the reliability of continuously maneuvering the system along a given route, and should ensure the reliability of system operations in terrain changes, precise detection, ore collection and ore lifting. Measures should be taken as follows.

— Keep sufficient redundancy to ensure ore feeding operation smoothly, continuity and reliability, and keep spares for vulnerable components.