

GUIDANCE NOTES

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China Classification Society

**GUIDELINES FOR SURVEYS OF MONITORING
SYSTEMS FOR STRUCTURES AND EQUIPMENT OF
MOBILE UNITS AND OFFSHORE INSTALLATIONS**

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CHAPTER 1 GENERAL

Section 1 GENERAL PROVISIONS

1.1.1 Purposes

1.1.1.1 China Classification Society (CCS) established the *Guidelines for Surveys of Monitoring Systems for Structures and Equipment of Mobile Units and Offshore Installations* (hereinafter referred to as the Guidelines), which aims to provide basis for the design, manufacturing, installation and surveys of the monitoring systems for structures and equipment of mobile units and offshore installations (hereinafter referred to as the monitoring systems), and to meet the technical requirements of the monitoring systems, diagnosis of equipment failures and digital twin systems.

1.1.2 Scope of Application

1.1.2.1 The Guidelines apply to the structure monitoring systems and equipment monitoring systems, which are collectively called as the monitoring systems (including remote monitoring and diagnosis).

1.1.2.2 Structure monitoring systems mainly monitor the parameters, such as structure motions, local stress or force borne, global stress or force borne as well as corresponding environmental conditions.

1.1.2.3 Equipment monitoring systems mainly monitor the state of equipment and systems.

Section 2 RULES AND STANDARDS

1.2.1 General requirements

1.2.1.1 The design, manufacturing and installation of the monitoring systems shall meet the requirements of relevant regulations of competent authorities of the local sea areas as well as the national, industrial and classification societies' rules and standards. Generally, the following rules and standards shall be referred to (for undated references, their latest version applies to the Guidelines):

- | | | |
|------|----------------|---|
| (1) | IMO A.830 (19) | <i>Code on Alarms and Indicators</i> |
| (2) | IEC60092-504 | <i>Electrical installations in ships-part 504: Special features-Control and Instrumentation</i> |
| (3) | CCS | <i>Rules for Classification of Mobile Offshore Units (2023)</i> |
| (4) | CCS | <i>Rules for Offshore Oil and Gas Process System (2020)</i> |
| (5) | CCS | <i>Rules for Classification of Offshore Floating Installation (2023)</i> |
| (6) | CCS | <i>Rules for Classification of Sea-going Steel Ships (2021)</i> |
| (7) | CCS | <i>Rules for Construction and Surveys of Fixed Units in Shallow Sea (2004)</i> |
| (8) | CCS | <i>Rules for Classification and Construction of Fixed Offshore Units (2012)</i> |
| (9) | CCS | <i>Guidelines for Certification of Subsea Production System (2016)</i> |
| (10) | CCS | <i>Guidelines for Type Approval Test of Electric and Electronic Products (2006)</i> |
| (11) | CCS | <i>Guidelines for Quality Assessment of Ship Data (2021)</i> |
| (12) | CCS | <i>Rules for Materials and Welding and its Notification of Modification (2021)</i> |
| (13) | CCS | <i>Rules for Surveys of Marine Products (2018)</i> |
| (14) | CCS | <i>Guidelines for Safety and Reliability Assessment for Shipboard Software (2015)</i> |

CHAPTER 2 SURVEY AND CERTIFICATION

Section 1 GENERAL PROVISIONS

2.1.1 General requirements

2.1.1.1 After CCS completes surveys and certification of the monitoring systems, equipment and its arrangement, algorithms for assessment, versions of monitoring software and other aspects based on the Guidelines, if there is any substantial change, the applicant shall inform CCS in time, and apply for re-surveys.

2.1.1.2 In order to ensure the smooth operation and timely surveys of the monitoring systems, the applicant shall provide necessary conditions for surveys, including relevant safety measures for surveys.

Section 2 CATEGORIES OF SURVEYS OF MONITORING SYSTEMS

2.2.1 General requirements

2.2.1.1 The monitoring systems shall be surveyed to confirm their compliance with the requirements of the Guidelines.

2.2.1.2 The design, manufacturing, test and surveys of the monitoring systems involved in the Guidelines can be conducted according to the standards accepted by CCS, if there is not any specific technical requirement.

2.2.1.3 After the monitoring systems are surveyed and certified, relevant certificates and/or other documents of certification for surveys shall be issued to the applicant.

2.2.2 Product certificate

2.2.2.1 The survey of monitoring system products shall be conducted according to the Guidelines, which generally include surveys for classed products and surveys for product verification. Product surveys are conducted to confirm the products meet the requirements of the rules for classification or requirements of the applicant.

2.2.2.2 The survey process of product certificates generally includes product design drawings review, product surveys and test, as well as issuance of product certificates.

2.2.2.3 The surveys of the products proposed to be used in classed units shall conform to the provisions in CCS's *Rules for Classification of Mobile Offshore Units*, *Rules for Classification of Offshore Floating Installation*, *Rules for Classification of Sea-Going Steel Ships* and *Rules for Materials and Welding*, in addition to the provisions in the Guidelines.

2.2.3 Class notation

2.2.3.1 After the surveys of classed products, the owner of the classed mobile units or classed offshore installations can submit applications to CCS for the following class notations:

- (1) Class notation of structure monitoring: HMS (X).
- (2) Class notation of equipment monitoring: EMS (X).

2.2.3.2 The sensors used to monitor the structural stress of important parts shall be installed in structure monitoring systems, and the sensors/components for monitoring other parameters can also be selected. The letters in parentheses of the class notation for structures are representative letters for the selected sensors/components, and multiple letters shall be separated by commas. The sensors/components listed in Table 2.2.3.2 can be selected.

Representative letters of optional sensors/components **Table 2.2.3.2**

Letters	Description
Gn	Sensor(s) for monitoring the global deformation of the hull
Dn	Sensor(s) for monitoring the local deformation of the structure
On	Sensor(s) for monitoring the output of the propulsion shaft
An	Sensor(s) for monitoring axial acceleration
Mn	Device(s) used to monitor rigid motion of the structure (with 6 degree of freedom)
Pn	Sensor(s) for monitoring the instantaneous pressure of sea water on structures (slamming)
Sn	Sensor(s) for monitoring liquid pressure in tanks (sloshing)
Tn	Sensor(s) for monitoring temperature
Bn	Device(s) for monitoring waves
Wn	Sensor(s) of wind speed and wind direction
Nn	Sensor(s) for external navigation information
Cn	Connecting with the loading computer online; the loading computer shall be upgraded continuously based on loading state

Note: n refers to the quantity of the sensors or devices

2.2.3.3 The letters in parentheses of the class notation for equipment monitoring systems are representative letters for the selected sensors/components, and each group of letters shall be separated by commas. The sensors/components listed in Table 2.2.3.3 can be selected.

Representative letters of selected sensors/components **Table 2.2.3.3**

Letter	Description
Dn	Sensor(s) for monitoring the local deformation of the equipment
Qn	Sensor(s) for monitoring torque
An	Sensor(s) for monitoring acceleration
Mn	Device(s) used to monitor rigid motion of the structure (with 6 degree of freedom)
Vn	Sensor(s) for monitoring vibration/pulse signals
Tn	Sensor(s) for monitoring temperature
Rn	Sensor(s) for monitoring rotation speed
Pn	Sensor(s) for monitoring pressure
Ln	Sensor(s) for monitoring liquid levels
Fn	Sensor(s) for monitoring frequency
Sn	Sensor(s) for monitoring stress

Note: n refers to the quantity of the sensors or devices

2.2.3.4 With the approval and agreement of the Headquarters of CCS, the Surveyor at the site shall complete the surveys of monitoring systems and issue the corresponding survey reports according to the relevant survey requirements in the Guidelines, after which the Headquarters of CCS shall assign the corresponding class notation and provide the mark in the classification certificate of the mobile unit or offshore installation.

2.2.4 Documents of compliance

2.2.4.1 According to the applications or contract/agreement of the owner or designer or builder, for the monitoring systems used on non-CCS-classed mobile units or offshore installations, the Surveyor, after completing the survey and test of product verification, can issue the documents of compliance or survey certificates for marine products. Any survey-related documents issued only reflect the status at the time when the survey is carried out.

Section 3 DESIGN REVIEW

2.3.1 General provisions

2.3.1.1 Before commencement, the applicant shall submit the drawings and documents specified in this section (including the requirements of commissioning procedures for important equipment) to CCS for review. If necessary, CCS can require expanding the scope of drawings and documents

submitted for review:

2.3.1.2 The manufacturing and installation processes of monitoring systems shall be submitted to the organization implementing surveys of CCS for review.

2.3.1.3 If there is any substantial modification or supplement of approved drawings and documents, the applicant shall submit the modified or supplemented parts for review.

2.3.1.4 Before the manufacturing and installation of monitoring systems, the applicant shall submit the written applications for surveys to CCS.

2.3.2 Plans and documents to be submitted¹

2.3.2.1 The documents and data that shall be submitted for review and approval shall include but not be limited to:

- (1) Technical specifications of monitoring systems (software and hardware);
- (2) Lists of certificates and certification materials of equipment in the monitoring system;
- (3) The block diagram of configuration of hardware and external equipment (block diagrams of system functions);
- (4) Diagrams and layouts of power systems for monitoring systems (including remote monitoring systems, if any);
- (5) Layouts of sensors (including information about various sensors);
- (6) Outlines and reports of testing outlines of sensors;
- (7) Setting and calibration reports of sensors and systems;
- (8) Reports of installation processes for monitoring systems and equipment;
- (9) Instructions of software design (including algorithms, models, data quality and network security);
- (10) System wiring diagram;
- (11) Specifications of user interfaces;
- (12) Diagrams of power systems;
- (13) Reports of software testing and evaluation;
- (14) Outlines of joint commissioning and testing of systems;
- (15) Reports of joint commissioning of systems;

2.3.2.2 The following documents shall be submitted for review:

- (1) Operation manuals of monitoring systems;
- (2) Equipment selection/product specifications of monitoring systems.

2.3.3 Documents maintained on installations

2.3.3.1 Instruction manuals shall be maintained on installations, which shall include at least:

- (1) Operation instructions of equipment and software;
- (2) Instructions for setting and calibration of sensors and systems;
- (3) Instructions for fault identification;
- (4) Instructions of operation for repair;
- (5) Instructions for system maintenance and function testing (indicating the testing methods of components and systems as well as the contents observed in testing);
- (6) Interpretation and description of monitoring results for systems.

2.3.3.2 The logs on maintenance and calibration of monitoring systems (including remote monitoring systems, if any) shall be maintained on installations.

Section 4 SURVEYS OF EQUIPMENT OF MONITORING SYSTEM

2.4.1 General provisions

2.4.1.1 The product surveys of equipment in the monitoring systems shall be applied for in

¹ The documents submitted by the manufacturer above shall cover the general requirements for surveys, and these requirements shall be selected for different products based on specific product characteristics.

accordance with relevant rules and guidelines to obtain corresponding product certificates.

2.4.2 Lists of certificates of components in the monitoring system

2.4.2.1 For the details of the requirements of product certification for classed mobile units and offshore installations (MU&OI), see CCS's *Rules for Classification of Mobile Offshore Units* and CHAPTER 3, PART ONE, *Rules for Classification of Offshore Floating Installation*.

2.4.2.2 For the requirements for the product certification of non-classed MU&OI, see the certification requirements in CCS's *Rules for Classification of Mobile Offshore Units*, *Rules for Classification of Offshore Floating Installation*, and *Rules for Offshore Oil and Gas Process System*.

Section 5 SURVEYS OF INSTALLATION AND COMMISSIONING OF MONITORING SYSTEMS

2.5.1 General provisions

2.5.1.1 The equipment with certificates shall be installed in accordance with relevant requirements.

2.5.1.2 The applicant shall submit test outlines to CCS for review and approval, and survey the commissioning of monitoring systems in accordance with the technical requirements of approved test outlines.

2.5.2 Surveys of system installation and commissioning

2.5.2.1 Surveys at the site of system installation:

(1) Check the product certificates and quality certificates of components of monitoring systems;
(2) Check to ensure the arrangement of sensors is consistent with the approved plans;
(3) Check to ensure the package of sensors is consistent with the approved plans;
(4) In the survey of equipment welding and installation of monitoring systems or fixtures for sensors, the surveys of installation and welding of the system shall be fulfilled according to CCS's *Rules for Materials and Welding* (if applicable);

(5) The laying of cables of monitoring systems shall meet the requirements of fire resistance, explosion proofing and electromagnetic compatibility. Crossing watertight bulkheads or fire rated bulkheads shall meet the technical requirements of integrity of bulkheads.

(6) Survey the installation of other associated equipment of monitoring systems;

(7) Conduct functional testing after installing the equipment of monitoring systems, and survey the connectivity of single sensors or equipment;

(8) Check to confirm the grounding of monitoring systems;

(9) Check to confirm the software version and functions of the monitoring system are consistent with the approval certificate.

2.5.2.2 Functional test after installation of monitoring systems:

(1) Verify to determine whether the initial readings, accuracy and other parameters of sensors and the system meet design requirements;

(2) Determine whether the results of joint commissioning of monitoring systems meet design requirements;

(3) Determine whether the functions and performance of monitoring systems meet design requirements;

(4) Test the functions in normal operation and emergency operation of monitoring systems.

2.5.2.3 After the Surveyor on site completes the surveys of monitoring systems and issues the corresponding survey reports according to the relevant survey requirements in the Guidelines, the Headquarters of CCS shall assign the corresponding class notation for classification and provide the mark in the classification certificate of the mobile unit or offshore installation.

2.5.2.4 For the monitoring systems used on non-CCS-classed mobile units or offshore installations, the Surveyor, after completing the survey of the systems, can issue the documents of

compliance.

Section 6 IN-SERVICE SURVEYS OF MONITORING SYSTEMS

2.6.1 Surveys for class notations

2.6.1.1 Annual survey:

(1) Check the maintenance and calibration logs of monitoring systems, including the records of software upgrading and maintenance to verify that the equipment has been in normal daily maintenance status since the last survey and can ensure effective operation of monitoring systems;

(2) When the parts and components for which certification is required, certificates for relevant components shall be provided, and there shall be records of commissioning and functional testing for relevant items;

(3) Check various sensors, the equipment for data acquisition, transmission control and data processing and their protection facilities. Verify to confirm the monitoring system is in normal operation by referring to monitoring data and operation records. For inaccessible sensors, the history data acquired by sensors shall be checked to confirm that they can ensure the normal operation of the system;

(4) Confirm whether there is any unapproved change in monitoring systems and equipment;

(5) The survey period of the class notation shall be consistent with the survey period of the installation, and the period of annual surveys should be consistent with the statutory survey periods of the unit or installation.

2.6.1.2 Intermediate survey: the survey contents shall be consistent with the requirements in 2.6.1.1 “Annual survey”.

2.6.1.3 Renewal survey: the survey contents shall be consistent with the requirements of 2.6.1.1 “Annual Survey”, and the requirements of service life of sensor systems or the owner’s specifications can also be referred to for different monitoring systems.

2.6.2 Surveys for documents of compliance

2.6.2.1 If the owner applies for an annual survey of the monitoring systems with documents of compliance, the contents shall be consistent with the requirements in 2.6.1.1.

2.6.2.2 The annual survey period of the monitoring system should be consistent with the survey period of the installation, and the period of annual surveys should be consistent with the statutory survey periods of the unit or installation.

CHAPTER 3 DESIGN OF MONITORING SYSTEM

Section 1 GENERAL PROVISIONS

3.1.1 General requirements

3.1.1.1 All components in the system shall be replaceable and easy to maintain.

3.1.1.2 The electrical equipment installed in hazardous areas shall meet the requirements of PART FIVE of CCS's *Rules for Classification of Mobile Offshore Units*, and PART SIX of CCS's *Rules for Classification of Offshore Floating Installation* as well as the relevant regulations of governmental authorities.

3.1.1.3 The displays of all equipment located in bridge houses/central control rooms shall not disturb the night shifts of watch-keepers.

3.1.1.4 Monitoring systems shall have the functions of processing and indication, and shall be able to provide relevant information to installation operators.

3.1.1.5 The computers used for the system shall be capable of implementing required tasks, such as processing sensors' signals, indicating required information on screens, giving alarm and storing data.

3.1.1.6 The monitoring system shall have the function of automatic switching to standby power supply in case of loss of main power supplies. It shall be able to fulfill data storage and system monitoring under the standby power supply, so as to ensure the integrity of data.

3.1.1.7 If there is any failure in the communication system, the monitoring system shall be capable of automatic identification and prompts.

3.1.1.8 The monitoring system shall meet the technical requirements of the following monitoring environments:

(1) Requirement of environmental temperature: the temperature applicable for the monitoring system shall be consistent with the requirement of the temperature of structures and equipment of the installation to be monitored.

(2) Inclination and swinging: both inclination and swinging shall meet the technical requirements of electrical equipment in PART FIVE of CCS's *Rules for Classification of Offshore Floating Installation* and PART FOUR of CCS's *Rules for Classification of Mobile Offshore Units*;

(3) Vibration and impact: the general conditions for vibration that are specified in 2.7 of CCS GD01-2006 shall be met;

(4) Moisture air: 95% of relative humidity at +55°C;

(5) The sensors of monitoring systems that are used underwater shall meet the technical requirements of water pressure, corrosion prevention and communications.

3.1.1.9 For the equipment of environmental monitoring systems, the technical requirements of PART FOUR and PART EIGHT of CCS's *Rules for Classification of Sea-Going Steel Ships* shall be referred to.

3.1.1.10 The system shall give at least following visual or audible alarm:

(1) Failure of power supplies;

(2) Failure of sensors;

(3) The data monitored by the sensor exceed the alarm threshold of the system.

3.1.1.11 The procedures and data in the data recording system shall not be damaged or lost due to interruption of power supply.

3.1.1.12 The user application interfaces (such as those for indication, keys and alarm) shall be installed in the bridge house/central control room.

3.1.1.13 Appropriate data storage devices shall be used to store time-series data and statistical information.

3.1.1.14 The system shall have the minimum data storage capacity and functions.

3.1.1.15 For monitoring systems, the data thresholds of configuration calibration devices and

sensors and the cut-off frequency of filters shall be selected, and different statistical calculation methods shall be selected for different sensors.

3.1.1.16 The system shall be equipped with output ports, and be provided with relevant information interfaces and be kept with certain confidentiality levels.

3.1.1.17 In case of any failure, the monitoring system can (manually or automatically) switch to the local control or safe operation mode of the installation, or can be shut down in a safe manner, which will not affect the safety of the installation or other systems.

3.1.1.18 Installation of the monitoring system shall not cause the reduction of reliability of the structure or equipment of the installation.

3.1.1.19 The monitoring system shall meet the requirements of electromagnetic compatibility for mobile units or offshore installations.

3.1.1.20 The crossing of cables of the monitoring system through the watertight bulkhead or fire rated bulkhead shall meet the relevant technical requirements.

3.1.1.21 The watertightness, explosion-proof performance and protection grades of the monitoring system shall meet the requirements of the relevant regulations and specifications.

3.1.1.22 For the monitoring system added for the mobile units or offshore installations in operation, if the power load is larger than 100 kW, the calculations of all power loads shall be submitted again.

3.1.1.23 All monitoring systems need independent feed circuits and shall be at least equipped with short-circuit protection.

3.1.1.24 Wired, wireless and other modes can be adopted for data transmission, which shall not interfere and affect other systems.

3.1.1.25 The sensor of the monitoring system shall be calibrated regularly, and the calibration period shall not be longer than the survey period of the sensor equipment or the period of the annual survey for the system.

3.1.2 Structure monitoring system

3.1.2.1 In the computer procedures, the structure monitoring system shall inverse the structural characteristic physical quantity obtained by the strain meter to the non-distribution locations, so as to enable the readings of the instruments loaded to be used in setting and surveys of the system.

3.1.2.2 The initial setting of the strain meter of the structure monitoring system shall be the stress calculated under an agreed condition for hydrostatic loading. The calculation stress shall be compatible with the output of the loading computer and the calculation conducted using the loading manual.

3.1.2.3 The strain meter of the structure monitoring system shall not be initially set when there is dynamic stress, so as to avoid significant errors.

3.1.2.4 The initial setting of the strain meter for the structure monitoring system shall be conducted under the conditions of small effects on temperature and absence of any large gradient.

3.1.2.5 If the stress difference calculated using the strain meter for the structure monitoring system exceeds 5% or 10 N/mm² (whichever is larger) of the set value, the conditions for hydrostatic loading shall be established again.

3.1.2.6 The structure monitoring system can be used to acquire and monitor the data including the structural stress, environmental conditions and operation parameters of MU&OI. When the change of these data approaches the pre-warning threshold, the system will give alarm.

3.1.2.7 The sensors of weights and center of gravity shall acquire and monitor the data of the structure or equipment to be measured. Different algorithms shall be designed for different structures and equipment, meeting the technical requirements for monitoring the structure and equipment.

3.1.2.8 If loading computers are provided for MU&OI, the hydrostatic shear force and bending moment can be submitted together to the structure monitoring system. These data can be imported manually, read from magnetic disks or transmitted through other data chains.

3.1.2.9 For MU&OI structure monitoring, the effects of the zero drift of the sensor in the monitoring system and structural creep shall be considered.

3.1.3 Equipment monitoring system

3.1.3.1 The equipment monitoring system shall be used to acquire and monitor the data including the operating parameters of equipment, state parameters of equipment and operation parameters. When the change of these data approaches the pre-warning threshold, the system shall give alarms but shall not conduct any automatic operation (e.g. emergency shutdown and tripping).

3.1.3.2 The equipment monitoring system can utilize the history data from equipment monitoring to determine the operating status of equipment.

3.1.4 Monitoring scope

3.1.4.1 For MU&OI structure monitoring, the corresponding structure monitoring sensors shall be installed, and the arrangement of sensors shall reflect the state of important structures.

3.1.4.2 The monitoring parameters recommended for MU&OI and the corresponding sensors/components are shown in Table 3.1.4.2, while not all sensors are listed in this table.

Monitoring parameters recommended for MU&OI and the corresponding sensors/components

Table 3.1.4.2

Category	No.	Parameter	Ships applicable	Optional sensors/components	Remarks
General monitoring	1	Location, navigation speed/direction	Optional based on actual conditions	Nn	
	2	Output power and rotation speed of thrusters	Optional based on actual conditions	On	
	3	Conditions of waves	Optional based on actual conditions	Bn	
	4	Submersible condition	Submersible type/the column-stabilized type with submersible functions	Sn	Used to monitor the hollowing of the unit at the seabed under the submersible state
	5	Wind conditions	Optional based on actual conditions	Wn	
Location for monitoring of global deformation of the structure	6	Surrounding the external plates of the buoyancy tank at the middle of the lower buoyancy tank, and passing through the longitudinal bulkhead	Semi-submersible	Gn	
	7	Surrounding the middle of the cross tie	Semi-submersible	Gn	
	8	Surrounding the external plates of the column in the middle of the column, as well as passing through the bulkheads vertically	Semi-submersible	Gn	
	9	Surrounding and middle of the bottom deck in the box-type deck structure (or the lattice type deck structure)	Semi-submersible	Gn	
	10	Surrounding the hull on the self-elevating units	Self-elevating	Gn	Monitor the global deformation of the self-elevating unit's spud leg
	11	Hull center on the self-elevating unit	Self-elevating	Gn	Monitor sagging and hogging of the hull on the self-elevating unit
	12	Wellhead area of the fixed unit	Fixed	Gn	Monitor the horizontal displacement at the wellhead on the fixed unit
Location for monitoring of local deformation of the structure	13	At the joint between the column and lower buoyancy tank, or at the main bracket toes at the joint of the column and buoyancy tank	Semi-submersible	Dn	
	14	At the joint of the cross tie and column of the double-lower-buoyancy tank semi-submersible unit	Semi-submersible	Dn	
	15	At the joint of the column and bottom deck	Semi-submersible	Dn	

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CHAPTER 3 DESIGN OF MONITORING SYSTEM

	16	Location of the derrick base	Semi-submersible/self-elevating	Dn	
	17	Connection between the jack room/support and deck	Self-elevating	Dn	
	18	Leg chord	Self-elevating	Dn	
	19	Leg brace	Self-elevating	Dn	
	20	Upper fairlead/lower fairlead of the leg	Self-elevating	Dn	
	21	Connection between the leg and spudcan	Self-elevating	Dn	
	22	Kingpost bottom and bracing members	Fixed	Dn	
	23	Main legs of each vertical face	Fixed	Dn	
	24	Diagonal and horizontal braces of each vertical face	Fixed	Dn	
Locations for monitoring slamming	25	Head sea side of the external plating of the column	Semi-submersible	Pn	
	26	At the joint of the bottom deck and column	Semi-submersible	Pn	
	27	Middle of the bottom deck	Semi-submersible/self-elevating	Pn	
	28	Side plating of the upper hull	Self-elevating	Pn	
	29	Leg wells	Self-elevating	Pn	
	30	Module deck above the splash area	Fixed	Pn	
Locations for monitoring three-way acceleration	31	Center of the helicopter deck	All	Mn	
	32	Crane cab	All	Mn	
	33	Derrick	All	Mn	
	34	Cantilevered beam	Self-elevating	Mn	
	35	Vertical acceleration at the centerline of the stem (0.01 L)	FPSO/drilling ship	An	L refers to the ship length
	36	Transverse acceleration at the 0.4 L amidships	FPSO/drilling ship	An	Monitor the inertial loading on sensitive goods. Sudden changes in response may indicate exceptions, such as flooding in holds or vehicle's deck.
	37	Lateral load at the ship bottom close to the fore perpendicular	FPSO/drilling ship	Pn	
	38	Lateral load at the side	FPSO/drilling ship	Pn	
	39	Loading computer	FPSO/drilling ship	Cn	If the ship has been provided with loading computers, whether on-line connection with the hull monitoring system shall be conducted can be selected.
	40	Structural temperature	FPSO/drilling ship	Tn	
	41	Liquid sloshing response in the liquid tank	FPSO/drilling ship	Sn	
	42	Motion of the ship	FPSO/drilling ship	Mn	
	43	Monitoring of vibration information	Fixed or submersible units	Mn	
44	Connection between the upper hull/deck and column	Semi-submersible	Sn		

	45	Connection between the lower floating unit and column	Semi-submersible	Sn	
	46	Connection between the column and cross tie	Semi-submersible	Sn	
	47	Connection between the upper hull/deck and derrick	Semi-submersible	Sn	
	48	Corners of moon pools, well slots and other big-opening structures	FPSO/semi-submersible/self-elevating	Sn	
	49	Connection between the crane base and support structure	FPSO/semi-submersible/self-elevating/ fixed	Sn	
	50	Connection between the jack room/support and deck	Self-elevating	Sn	
	51	Pipe nodes of the lattice leg	Self-elevating	Sn	
	52	Connection between the leg and spudcan	Self-elevating	Sn	
	53	Lifting/locking device	Self-elevating	Sn	
	54	Total longitudinal stress at L/4 amidships (the port and starboard)	FPSO/drilling ship	Sn	L refers to the ship length
	55	Longitudinal bottom stress close to the middle of the ship (L/2) (the port and starboard)	FPSO/drilling ship	Sn	L refers to the ship length
	56	Jacket nodes	Fixed	Sn	
	57	Nodes of upper modules	Fixed	Sn	
Location for structure monitoring of FPSO	58	Module foundation and its strengthening region	FPSO		
	59	Support structure and adjacent structure of the position mooring region	FPSO		
	60	Connection structure of the main structure of the flare boom/tower	FPSO		
	61	Crude oil export equipment base and its strengthening	FPSO		
	62	Connection region between the helicopter deck and the main structure	FPSO		
	63	Support structure for the distributed mooring system	FPSO		
	64	The riser receiving unit and its structure extending into the main structure	FPSO		
Motion monitoring	65	Monitoring of air gap	Semi-submersible/self-elevating/ fixed	Ln	

3.1.4.3 For the monitoring system with EMS (×) class notation, the different status of the equipment shall be monitored.

3.1.4.4 The parameters recommended to be monitored for different equipment and corresponding optional sensors/components are listed in Table 3.1.4.4 below.

Parameters recommended to be monitored for different equipment and corresponding optional sensors/components

Table 3.1.4.4

No.	Parameter	Optional sensors/components	Remarks
1	Measurement of rotation speed of equipment	Sn	
2	Measurement of equipment pressure	Pn	
3	Measurement of liquid level	Ln	
4	Measurement of flow rate	Fn	
5	Measurement of stress	Sn	

6	Measurement of local deformation of equipment	Dn	
7	Torque sensor	Qn	
8	Vibration sensor	Vn	
9	Acceleration sensor	An	
10	Temperature sensor	Tn	

3.1.4.5 The optional sensors/components for environment monitoring equipment are listed in Table 3.1.4.5 below.

Sensors/components optional for parameters of different environment monitoring Table 3.1.4.5

No.	Parameter	Optional sensors/components	Remarks
1	Current	Vn	
2	Wind speed and wind direction	Wn	
3	Environment and pressure of the unit	Tn-Pn	
4	Waves	Bn	
5	Temperature of sea water	Tn	
6	Sea ice (if applicable)	In	
7	Water level	WDn	
8	Salinity of sea water	Sn	

Section 2 SYSTEM COMPOSITION AND COMPONENTS

3.2.1 System composition

3.2.1.1 A monitoring system is generally composed of a computer system (upper layer), sensors installed (lower layer), a data acquisition device, and signal transmission equipment between devices. Each sensor monitors the corresponding information and sends the information to the computer system through the signal transmission system. The computer system processes, displays, give alarms for and stores the information received.

3.2.2 System components

3.2.2.1 The sensor is a monitoring device that can sense the measured information, converse the sensed information into electrical signals or other required forms of information output based on certain laws, and obtain the relevant parameters of environment, structure and equipment that are required for monitoring systems. The sensor shall be provided with methods and measures for site calibration.

3.2.2.2 The equipment of the signal transmission system refers to the cables used for signal transmission (including optical cables and electrical cables) as well as the wireless transmission and receiving devices. The mobile unit and offshore installation supply power, forming a closed-loop system for power transmission and signal transmission.

3.2.2.3 Data acquisition devices refer to the interrogator, amplifier and other signal receiving and conversing equipment that are used for signal acquisition of various sensors. These devices converse the relevant signals into the forms of readable and processable data.

3.2.2.4 Data processing systems refer to the various systems processing sensor signals, including the computer, network controller, indication unit and analysis software, with the purpose of meeting the requirements of data processing, storage, indication, recording, control, etc.

3.2.2.5 Accessory devices refer to those devices used for equipment fixing, sensor package and other aspects in the monitoring system, including the sensor fixing support, package housing, windlass, cabinet and junction boxes.

3.2.2.6 Other components constituting the monitoring system, for example, power supply, cabinet and control panel.

Section 3 REQUIREMENTS FOR SYSTEM DESIGN

3.3.1 System design

3.3.1.1 During the selection of the sensor or monitoring system, it shall be ensured that the sensor or monitoring system is applicable to the use on MU&OI in the target marine environment. Their type and accuracy shall also be applicable to the use of the signal. Based on the environment of use, the sensor and its components shall have good corrosion resistance and the capability of resisting the attachment of aquatic creatures.

3.3.1.2 If other sensors have been installed on the mobile unit or offshore installation to monitor the parameters to be monitored in the monitoring system, installing an independent sensor for the monitoring system is not required, and the compatibility design shall be conducted for both. Signals and data shall not interfere with each other.

3.3.1.3 The monitoring system shall be designed according to the fail-safe principle, and shall meet the technical requirement of fire resistance and explosion proofing for MU&OI. The intrinsically-safe or flame-proof type system equipment should be selected.

3.3.1.4 The power of the monitoring system shall be supplied by the main power. In case of the loss of the main power, the monitoring system shall be able to switch to the standby power of the system automatically. The storage battery pack can be adopted as the standby power, the capacity of which shall maintain at least 30 min power demand. If the above monitoring system may be adversely affected due to the interruption of the power, the standby power shall be switched to in an uninterrupted mode.

3.3.1.5 After the loss of power, the monitoring system shall have the capability of maintaining data integrity as well as the capability of maintaining the continuous recording and analysis of data after power restoration.

3.3.1.6 If any monitoring system is added to the existing mobile unit or offshore installation, the design can be conducted based on the power supply capability of the existing mobile unit or offshore installation, provided that the requirements of safety for the mobile unit or offshore installation are met.

3.3.1.7 if there is any emergency in the mobile unit or offshore installation, the monitoring system can be interrupted; however, there shall be no safe risks caused to other mobile units or offshore installations.

3.3.1.8 The functions of the monitoring system shall be independent of each other. When there is any failure in one system or multiple systems, the normal operation of other systems shall not be affected.

3.3.1.9 The mode of redundancy design should be adopted for the equipment of the monitoring system, and the monitoring system shall be provided with the reliable mechanism of redundancy conversion.

3.3.1.10 Video monitoring is to use video detection means to monitor, control and record information on targets. Usually, video image information is transmitted to the monitoring system host through video control hosts, wireless and wired transmission systems, and the status of structure and equipment are monitored and warned through video.

3.3.1.11 The monitoring system shall have the functions of maintaining data integrity in special operating conditions, such as typhoon, and shall have enough data storage space (if applicable).

3.3.2 Sensor

3.3.2.1 The effects of temperature changes and marine environment on the measured values of the strain sensor shall be considered.

3.3.2.2 Installing the sensor used to measure the global deformation of the structure shall minimize local deformation.

3.3.2.3 If the sensors of other systems are used in the structure monitoring systems, the connection with these sensors shall not affect the performance of other original systems. The failure of the structure monitoring system shall not affect the performance of other original systems.

3.3.2.4 The appropriate spans and sensitivities of acceleration sensors shall be selected as per the measurement scale, frequency range and testing environment.

3.3.2.5 The rigid motion of the installation shall be measured through integrated sensors, and shall be able to measure the parameters of the six degrees of freedom (3 for translation, and 3 for rotation), translation (acceleration), rolling, pitching and yawing motion angles, etc. The range and error of measurement shall meet the requirements of the preset functions.

3.3.2.6 The measurement range and error of the sea water pressure sensor that is acted on MU&OI shall be selected based on the location of the sensor.

3.3.2.7 The measurement range and error of the sensor for the liquid flowing pressure of the liquid tank (sloshing) shall meet the requirements of the preset function.

3.3.2.8 The measurement range of the structural deformation sensor shall be within the yield deformation range of the relevant materials, and the measurement error shall meet the preset functions. For the installations made of special materials or other types of materials, i.e. the installations built using composite materials, the deformation range shall be given special considerations to by CCS.

3.3.2.9 The measurement range and error of the sensors used for measuring the low-frequency response (e.g. motion and wave loads), slamming responses and sloshing responses shall meet the requirements of preset functions, avoiding the omission of the response frequency peak in the data measured.

3.3.2.10 The data of the sensor shall be acquired by the data processing unit accurately, and the transmission rate of relevant data shall have certain real-time performance. If underwater sensors are used, the real-time performance of data shall meet the requirements of the owner's specifications.

3.3.2.11 The package process of the underwater sensor shall be adapted to the structure of the unit or installation, and shall meet the use requirements in structural sealing, corrosion resistance, service life, maintenance, etc.

3.3.2.12 The information from the sea condition parameters shall be updated and submitted once every 10 min at least.

3.3.2.13 The redundancy design shall be considered for the sensor, and the rate of survival of the sensor should be higher than 80%. The sensor shall be calibrated before initial use, and shall meet the requirements of the owner's specifications.

3.3.3 Signal conditioner

3.3.3.1 The signal conditioner shall match the connected sensor.

3.3.3.2 The signal of the analog sensor shall be subjected to noise reduction processing before data analysis to avoid interference caused by noise signals. The filter shall match the frequency ranges of different sensors.

3.3.4 Circuit design

3.3.4.1 The rated voltage of any cable shall not be lower than the rated voltage of its circuit. The external wiring of electrical cables/optical cables and electrical elements and components shall be of flame-proof types at least, and shall meet the standard requirements of the fire-secure characteristics of electrical cables in IEC60332-11/21.

3.3.4.2 The components easy to repair and replace shall be adopted for the design of circuit connection, and shall meet the technical requirements of fire resistance, corrosion prevention, explosion proofing, etc.

3.3.4.3 The circuit shall be designed to ensure it can be effectively tested, calibrated, maintained and repaired. It can be repaired by replacing the unit or functional cards. In some cases, the simulation operation or test circuit shall be provided to check whether the equipment is operating normally.

3.3.4.4 The circuit shall be designed to have no direct relation with the main electric network of MU&OI. For example, the power supply is designed to be fulfilled through the isolation transformer.

3.3.4.5 The signal strength shall be high enough to overwhelm the effects of the contact corrosion and interference signals. The transmitter and amplifier shall be arranged as close to each other as possible.

3.3.4.6 In order to avoid the external interference with the control and instrument cables, for

selecting and installing cables, the measures including using shielded cables and paired cables, adopting the amplifier with balanced input and laying signal cables separately from other cables.

3.3.4.7 For the circuit design, the interference caused to the nodes when the circuit crosses the structure (e.g. crosses the articulated point and bulkhead) shall be considered, and protection measures shall be implemented.

3.3.4.8 The alarm circuit shall be designed by adopting the mode of closed circuits (i.e. alarm or failure signals shall be sent in case of disconnection) generally. If circuit monitoring is arranged, other circuit design modes can also be adopted.

3.3.4.9 If there is any grounding failure in the alarm (or measurement) circuit, alarms shall be given, unless such failure will not cause adverse effects on normal operation of the system as well as the safety of ships and personnel as designed.

3.3.4.10 The failure of one sensor signal channel (or one module, which can include several channels) shall not affect other alarm channels (modules).

3.3.4.11 The failure of the indicator light (including the short circuit) shall not affect the audible alarm circuit.

3.3.4.12 The accuracy of the signal processing for the monitoring alarm system shall meet the requirements of the accepted standards, for which the manufacturer shall provide provisions.

3.3.4.13 There shall be reliable grounding of the cables in the monitoring system.

3.3.4.14 The optical cables in the monitoring system shall meet the requirements of the signal transmission, and shall be subjected to redundancy design.

3.3.4.15 The connector or penetrator for the electrical cables and optical cables of the monitoring system shall meet the fire-resistance and explosion-proof requirements of the system.

3.3.5 Storage equipment

3.3.5.1 When the storage equipment of the monitoring system is selected, it shall be ensured that the equipment shall be applicable to MU&OI in the target marine environment and have good electromagnetic compatibility.

3.3.5.2 Storage equipment shall have enough space to meet the requirement of the data storage and calculation analysis of the monitoring system.

3.3.5.3 The storage equipment of the monitoring system shall survey the power supply of equipment. If there is any standby power supply, the automatic switching function between main and standby power supplies shall be checked, and tested. After powering off the storage equipment, the integrity of the storage data shall be maintained as far as possible.

3.3.5.4 The storage equipment of the monitoring system shall be provided with the measure of data security protection and the setting of data access permission to guarantee the security of the monitoring system's data.

Section 4 DATA PROCESSING AND STORAGE

3.4.1 General requirements

3.4.1.1 The monitored parameters of MU&OI structure and equipment shall be processed, and monitoring data shall be extracted.

3.4.1.2 The measured signal shall be subjected to data processing according to the given time intervals, and the results of data processing conducted at each time interval shall be stored. The selected time interval shall be set when the software is configured initially.

3.4.1.3 The type of the sensor processing signals shall be defined during the initial configuration of the system. Document retrieval can be conducted for the information about configuration.

3.4.2 Data filtering

3.4.2.1 The software should include the high-pass and low-pass time domain digital filters. The cut-off frequency of the filter shall be able to be configured through software.

3.4.2.2 The filter shall be started up with the startup of the monitoring software. It shall always be

maintained in operation as long as the software is kept running during normal operation. Some signals that are damaged due to the filter construction (stabilization) during startup and filtered shall not be used in the following data analysis.

3.4.2.3 The system shall be able to filter the data of the measured time series of the monitoring system. The time series requiring filtering can be configured through software.

3.4.2.4 The system shall be able to conduct the following filtering processing for measured signals, and should provide 4 different time series.

(1) No filtering (the static values as well as wave-frequency responses and vibration responses shall be maintained);

(2) High-pass filtering (the static values as well as the temperature fluctuation of the low-frequency current shall be deleted, and the wave-frequency responses and vibration responses of signals shall be maintained);

(3) Low-pass filtering (the static values and wave frequency responses shall be maintained);

(4) High-pass filtering (only vibration responses shall be maintained).

3.4.2.5 Software shall be able to indicate each type of the four different time series described in 3.4.2.4.

3.4.2.6 Software shall be able to conduct data analysis based on each type of the four different time series described in 3.4.2.4.

3.4.3 Statistical calculation

3.4.3.1 Software shall be able to conduct statistical calculation based on the time series described in 3.4.1.2 or 3.4.2.5. The sensor selected for the statistical calculation and statistical operation to be conducted shall be configured during the initial setting of software.

3.4.3.2 For the characteristics of sensor signals, the following installation response parameters can be calculated and counted:

(1) Maximum value;

(2) Minimum value;

(3) Average value;

(4) Standard deviation;

(5) Deflection;

(6) Kurtosis;

(7) Average zero-crossing period.

3.4.3.3 For the responses of each installation/equipment, the histograms of all peaks or other expression modes should be established based on time sequences. The amplitude of each response shall be divided into the preset time intervals, and the peaks in each time interval shall be counted. The interval shall be set during software configuration.

3.4.3.4 The histograms or other expression modes of responses of installations/equipment that are described in 3.4.3.3 should be established for the troughs of waves.

3.4.3.5 In the structure monitoring system, for transient phenomena, e.g. effects of liquid (slamming and sloshing), the total energy of each effect shall be calculated.

3.4.3.6 In the structure monitoring system, for transient phenomena, e.g. effects of liquid (slamming and sloshing), the rise time of each effect shall be calculated. The limitations made for calculation shall be configurable.

3.4.3.7 For the statistics of the parameters obtained in 3.4.3.2 to 3.4.3.4, the probability curve that exceeds the specified value within the given time shall be assessed. The given time interval shall be configured through the software.

3.4.3.8 Based on the probability curve, the probability exceeding the preset threshold will be found out. The threshold shall be configured through software.

3.4.4 Prediction of structural fatigue life (when applicable)

3.4.4.1 The fatigue life of the structural member equipped with sensors shall be predicted based on the measured time history.

3.4.4.2 For each strain sensor using the cycle counting, the histogram of stress responses shall be

established.

3.4.5 Structural loads (if applicable) generated by the instantaneous pressure of sea water (slamming)

3.4.5.1 The instantaneous peak values recorded by the sensor shall be counted. The sensor is installed to record the slamming events exceeding the threshold. The counting conducted within the time limit defined in advance shall be used for indication. The threshold and time limits shall be configured through software.

3.4.6 Structural stress

3.4.6.1 The deformation of the mobile unit or offshore installation is generally affected by the deformation caused by the structure temperature differences of the mobile unit or offshore installation. The stress sensor shall have the function of temperature compensation.

3.4.6.2 The structure monitoring system shall be able to obtain the hydrostatic bending moment/torque calculated by the loading computer (if applicable).

3.4.6.3 The structure monitoring system shall provide the following three independent options for each strain sensor for selection, and the statistical analysis and alarm shall be conducted by inputting the information. The option shall be selected during the initial installation of the structure monitoring system.

(1) Measured stress records (including the effects that may be caused due to the difference of the structural temperature of the installation);

(2) The measured stress is subjected to high-pass filtering to eliminate the effect of the low-cycle temperature;

(3) The measured stress shall be subjected to the high-pass filtering to eliminate the effects of the low-cycle temperature. Then, the filtered stress signal shall be added through the offset of deformation. The deformation of each sensor location can be calculated through the loading computer.

3.4.6.4 The structural stress monitoring shall meet the monitoring of the hot spots of structural stress of the installation's main structure, and the stress sensor shall meet the environmental conditions and stress range of the locations of the stress on structure's hot spots.

3.4.6.5 The monitoring of the risers, anchor chain system, upper module and other key hot spot areas on MU&OI shall meet the requirements of the stress monitoring for the monitored hot spot structure.

3.4.7 Monitoring of equipment state

3.4.7.1 The sensors shall be arranged based on the types of equipment failures, the layout of sensors shall be analyzed, and the type and installation mode of the sensors monitoring equipment state shall be specified.

3.4.7.2 The signal transmission mode of the equipment state monitoring shall be specified to meet the modes and requirements of the signal transmission of the installation.

3.4.7.3 The equipment state shall be indicated, and the possible accident status shall be predicted.

3.4.8 Loads generated by the instantaneous pressure of sea water (slamming)

3.4.8.1 For the loads generated by the instantaneous pressure of sea water (slamming), it is recommended to measure the positive stress (strain) on the structure where the loads act. For example, the positive stress on the external shell plating shall be measured.

3.4.8.2 Such load can also be measured through the pressure sensor installed on the external shell plating.

3.4.8.3 The acceleration sensor of the bow area of the ship-type facilities (e.g. FPSO) can be used as the indicator of slamming events.

3.4.9 Loads generated by the liquid flowing (sloshing) in the liquid tank (when applicable)

3.4.9.1 For the loads generated by the liquid motion in the liquid tank (sloshing), it is recommended to measure the stress (strain) on the structure where the loads act.

3.4.9.2 Such load can also be measured through the pressure measured by the pressure sensor installed on the boundary of the compartment.

3.4.10 Structural temperature

3.4.10.1 For the monitoring of structural stress and other aspects, the effects of the temperature of the measurement point shall be considered.

3.4.10.2 For the temperature sensor installed on the support structure of the goods hold (can store the refrigerated or heated goods), its operating temperature range shall cover the goods temperature and the structural temperature of voids at least.

3.4.11 Threshold and alarm

3.4.11.1 For the equipment state monitoring, various failure states of equipment shall be considered thoroughly; the monitoring system shall be used to monitor the physical quantities in various equipment states, analyze the types of equipment failures, specify analysis methods, and store the equipment monitoring data.

3.4.11.2 The design of monitoring software shall allow the input of the minimum and maximum thresholds for each sensor, or the pre-warning threshold shall be set based on the gradients of the limit state of the structure or equipment of the mobile unit or offshore installation.

3.4.11.3 The measured value shall be compared with the threshold given by each sensor. If the monitored value exceeds the pre-warning threshold, the alarm shall be given, and indication shall be provided on the system interface.

3.4.11.4 The cause of alarm shall be written automatically into the alarm logs of electrical equipment; the alarm logs shall not be changed without permission in the system.

3.4.11.5 The system shall provide the function of inquiring the information about history alarms as required.

3.4.11.6 The system shall use different indication colors to distinguish the alarm information of different grades, and the alarm modes of different grades shall be set.

3.4.12 Prediction of trends

3.4.12.1 A predicted trend shall be formed by the 4 h data series of each sensor to conduct trend prediction of the expected responses of each sensor in the next 1 hour at least. The measured values and predicted data shall be used for indication.

3.4.12.2 When the signal of any sensor exceeds 80% of the specified threshold, the expected time for reaching the threshold shall be predicted based on the trend analysis. The measured values and predicted data shall be used for indication.

3.4.13 Data storage

3.4.13.1 The system shall have enough capacity to store one-year statistical data of all sensors and 24 h time series. The system shall be able to store the time series with the transient values exceeding the given threshold.

3.4.13.2 The system shall be able to back up recorded data on equipment. The equipment shall be suitable for reading by personal computers.

3.4.13.3 The data backup document shall include all recorded data, and shall be indicated in appropriate text formats. The document shall include enough information describing its contents clearly.

3.4.13.4 For each time interval, the system shall store the results of all calculations for each recorded parameter. The stored data shall be attached with time tags (dates and time) marking the start of each time interval.

3.4.13.5 The system shall store automatically the time-history data generated at several time intervals of all measured parameters based on the time limit of recording for at least last 4 hours. In case of the time series exceeding such limit, automatic backing up shall be conducted automatically.

3.4.13.6 The system shall be able to store the data specified in 3.4.13.5 permanently. The monitored data for one month should be used as the storage unit of data. Its storage capacity shall be

able to store at least 12 similar time limits permanently.

3.4.13.7 Unless there have been provisions in this section, the data storage of monitoring systems shall meet the relevant requirements of CHAPTER 3 in CCS's *Guidelines for Verification of Digital Systems of Ships and Offshore Installations*.

Section 5 DISPLAY AND MONITORING

3.5.1 Display

3.5.1.1 The monitoring system shall have appropriate screen display.

3.5.1.2 The system's screen shall display the following information at least:

- (1) The location of each sensor, which shall be clear visually;
- (2) The state of each sensor, i.e. whether the sensor is in operation or there is any failure in the sensor;
- (3) Real-time information measured for each sensor;
- (4) The ratio between the signal value and threshold of each sensor;
- (5) The trend of statistical parameters of each sensor, including the state of prediction;
- (6) State of alarms;
- (7) State of the monitored equipment.

3.5.2 Monitoring

3.5.2.1 The requirements about monitoring in the monitoring system shall be implemented based on the requirements of CHAPTER 3 of the Guidelines and Section 2, CHAPTER 6, of CCS's *Guidelines for Verification of Digital Systems of Ships and Offshore Installations*.

3.5.3 Manual input

3.5.3.1 The system shall have the function of manual input.

3.5.3.2 The manual input for the system shall ensure the compliance of data modification.

3.5.3.3 The system shall record the relevant information about manual input operation, including operators, operation time and input information.

Section 6 NETWORK SECURITY

3.6.1 Network security

3.6.1.1 The requirements about network security of monitoring systems shall be implemented in accordance with the requirements of 1.4.1, Section 4, CHAPTER 1, CCS's *Guidelines for Verification of Digital Systems of Ships and Offshore Installations*.

3.6.1.2 The requirements about network management in the monitoring system shall be implemented based on the requirements of Section 4, CHAPTER 2, CCS's *Guidelines for Requirements and Security Assessment of Ship Network Systems*.

3.6.1.3 The network security in the monitoring system shall meet the requirement of confidentiality of production and operation units. The confidentiality grades for the network system shall be set to protect the network system.

Section 7 DATA INTEGRATION

3.7.1 General requirements

3.7.1.1 The requirements about data integration in the monitoring system shall be implemented based on the requirements of CHAPTER 4 "DATA INTEGRATION", CCS's *Guidelines for Verification of Digital Systems of Ships and Offshore Installations*.

Section 8 DIGITAL TWIN SYSTEM

3.8.1 General requirements

3.8.1.1 The requirements about digital twin in the monitoring system shall be implemented in accordance with the requirements of CCS's *Guidelines for Digital Twin Systems of Ships and Offshore Installations*.

CHAPTER 4 SYSTEM MANUFACTURING AND INSTALLATION

Section 1 GENERAL PROVISIONS

4.1.1 General requirements

4.1.1.1 The manufacturing and installation of monitoring systems shall be suitable for the specific applications of MU&OI. The quantity, functions, monitoring items and specific contents of the monitoring systems used for the mobile and classed MU&OI shall meet the relevant requirements of the technical agreement or specifications of the items in the system. The equipment installed on MU&OI shall meet the requirements of relevant regulations such as *Safety Regulations of Offshore Fixed Units*, *Safety Regulations of Floating Production Storage and Offloading (FPSO) Installation* as well as *Technical Regulations for Statutory Survey of Offshore Mobile Units*.

4.1.1.2 The monitoring system shall be designed to be a system that can be manufactured and installed on site of MU&OI. The initial setting of the system shall be conducted based on approved plans (e.g. items of monitoring and alarms and written description, the link of alarm signal delay and alarm limits). After the initial setting has been completed and confirmed by CCS, the system shall have corresponding protection installations to ensure that computers can only be used for the presentation, simulation and alarming of monitoring data, and unauthorized modification shall be avoided.

Section 2 REQUIREMENTS FOR SYSTEM MANUFACTURING TECHNOLOGIES

4.2.1 General requirements

4.2.1.1 The selection of manufacturing materials for the monitoring system shall meet the requirements of 3.1.1 “Structure and environment operating conditions” in the Guidelines.

4.2.1.2 The building and installation of the accessory devices of the monitoring system shall not affect the safety of the main structure, and construction shall be conducted based on the plans approved by CCS.

4.2.1.3 There shall be specific provisions for the connections between the monitoring system and other systems, e.g. the VDR (voyage data recorder) system, control system and safety system. The specific requirements of connections shall meet the requirements of CCS-approved plans of MU&OI.

4.2.2 Testing of components

4.2.2.1 The components in the monitoring system shall be surveyed in accordance with the requirements of certification lists in 2.4.2 of the Guidelines. The reliability of product environment, safety regulations, EMC (electromagnetic compatibility) and other aspects shall meet the relevant test requirements of CCS’s *Guidelines for Type Approval Test of Electric and Electronic Products* (GD22-2015).

4.2.2.2 Test items and requirements

(1) Test of environmental conditions

Conduct based on CCS’s *Guidelines for Type Approval Test of Electric and Electronic Products* (GD22-2015). The applicable environmental category (Table 1.3.2 in GD22-2015) shall be Category B, and the equipment is categorized into the “all equipment used for control, protection, safety, monitoring and alarm and internal communication, computers and other electronic equipment” (Table 1.3.3b in GD22-2015). The performance test can be conducted jointly with the items specified in (2)

below.

(2) Test of electromagnetic compatibility

The EMC test shall be conducted based on the relevant test requirements in Table 3.1.2 “product category: equipment of internal communication and type process” in CHAPTER 3, CCS’s *Guidelines for Type Approval Test of Electric and Electronic Products* (GD22-2015 EMC).

4.2.2.3 Functional test

(1) Arrangement of test

The extracted samples shall constitute an integral system for test. For each type of alarm channels, the method of simulation test shall be arranged. Such method shall be conducted by simulating the state as actual as possible.

(2) Test items, methods and results

They shall be conducted as per the test procedures approved by CCS. Following the provisions in 5.2 and 5.3 in the Guidelines as well as the specific product characteristics, the test procedures shall regulate the test method adopted for verifying each function as well as the determination regulations for test results. The contents of system self-survey, the simulation test of system failure and the transfer test of redundant equipment (if any) shall also be included.

Section 3 SYSTEM INSTALLATION

4.3.1 General requirements

4.3.1.1 The installation mode of the equipment of the monitoring system shall be convenient and rapid installation and dismantling can be conducted.

4.3.1.2 If the monitoring system installed for the installation does not meet the requirements of this chapter, with the consent of CCS, other arrangement with the safety level equivalent to the Guidelines can be adopted.

4.3.1.3 Installing the monitoring system (including sensors) under any condition shall not damage the structure of the installation and not affect the performance of the installation. It shall not cause any potential safety hazard or substitute for the correct determination and responsibility of the personnel on the installation.

4.3.1.4 Installing the monitoring system (including sensors) shall meet the technical requirements of fire resistance, explosion proofing, corrosion prevention and other aspects of MU&OI. The Surveyor shall survey the installation of the monitoring system.

4.3.2 Installation manual

4.3.2.1 Establish risk management programs to identify, describe and assess risk sources and minimize the risk consequences.

4.3.2.1 The contractor shall use the installation manual as the basis for installing the monitoring system, and the installation manual shall include:

- (1) Installation procedures;
- (2) Pre-commissioning procedures;
- (3) Emergency procedures;
- (4) Environmental conditions limits;
- (5) Weather windows for fulfilling operations;
- (6) Quality control;
- (7) Limitation of design and operation;
- (8) Health, safety and environment factors;
- (9) Responsibilities and communication procedures.

4.3.3 Installation of system equipment

4.3.3.1 When welding is adopted to install the equipment in the monitoring system, the welding-related data shall be submitted to CCS for review, the installation shall be conducted as the plan approved by CCS, and the surveys of welding for system installation shall be completed in

accordance with CCS's *Rules for Materials and Welding*.

4.3.3.2 For the sensor locations in the monitoring system, the structural layout of the installation, locations of the measured objects, maintenance and operation modes as well as the requirements of sensor installation channels, maintenance channels and emergency channels and other aspects shall be considered.

4.3.3.3 The sensor shall be protected by means of selecting sites appropriately or arranging breakwaters to avoid wave-caused damages. The monitoring system shall meet the requirements of sealing and water proofing.

4.3.3.4 The motion sensor for motion measurement shall be placed at the place where the sensor base will not be affected by vibration. The accelerometer and motion monitoring equipment shall be installed on the structure with the minimum local structural vibration. If an elastic support is used, it shall be proven that the frequency characteristics will not affect the signals within the scope of the measured frequency.

4.3.3.5 For location of the center of gravity in rigid motion, the requirements of loading conditions shall be referred to.

4.3.3.6 The monitoring system shall be located on the equipment underwater, and the convenience of installation, retrieval and replacement shall be considered.

4.3.3.7 For the arrangement routes of the cable of the monitoring system, the requirements of fire resistance, explosion proofing, penetration, and other aspects shall be considered. During laying, the original flame resistance shall not be damaged. When cables are laid in bundles, the measures restricting flames to spread along the cable shall be adopted. When the cable passes through the bulkhead and deck that require fire resistance, it shall be ensured that the fire-resistance integrity of the deck and bulkhead will not be reduced.

4.3.3.8 The installation of the accessory device of the monitoring system shall meet the technical requirements of water proofing, dust resistance and corrosion prevention. The accessory device shall not interfere with other equipment, and shall not affect the safety and reliability of the main structure.

4.3.3.9 After installing the devices in the monitoring system, standalone commissioning shall be conducted for a single sensor, and the connectivity of equipment shall be surveyed.

4.3.3.10 The Surveyor shall inspect the state and quality after installing the monitoring state, and keep records.

CHAPTER 5 SYSTEM COMMISSIONING AND OPERATION & MAINTENANCE

Section 1 GENERAL PROVISIONS

5.1.1 General requirements

5.1.1.1 The commissioning of the monitoring system shall be conducted based on the standalone commissioning. The items of the standalone system that have been tested shall not be tested again generally.

5.1.1.2 After the installation construction of the monitoring system, pre-commissioning shall be conducted for the whole system, and the procedures for commissioning shall be approved by CCS.

5.1.1.3 The monitoring system shall complete the system commissioning on land or at the wharf if possible. The outlines of the commissioning of the monitoring system after the unit or installation is placed in a proper position shall be approved by CCS.

Section 2 SYSTEM COMMISSIONING

5.2.1 General requirements

5.2.1.1 The commissioning of the monitoring system shall be based on the functional requirements of the system. The outlines of the commissioning for the monitoring system shall be established and submitted to CCS for review. The Surveyor shall verify the system commissioning.

5.2.2 Commissioning outlines

5.2.2.1 The commissioning outlines shall be established, which shall include all operation requirements of the system for fulfilling its functions.

5.2.2.2 The contractor shall use the commissioning outlines as the basis for commissioning of the monitoring system, and the commissioning outlines shall include:

- (1) On/off procedures;
- (2) Functional commissioning procedures;
- (3) Emergency procedures;
- (4) Control of indicators for technical acceptance;
- (5) Limitation of design and operation;
- (6) Responsibilities and communication procedures.

5.2.3 On/off test

5.2.3.1 The on/off test for the monitoring system shall be conducted, the normal on/off or emergency shutdown operation shall be executed, and it shall be ensured that the indicated state of various types of equipment is normal.

5.2.3.2 The shutdown test shall be conducted for some equipment in the system to ensure the independence of equipment and confirm the normal state indication of other equipment.

5.2.3.3 It shall be confirmed that the automatic shutdown (process shutdown) caused by accidents (e.g. high-voltage, high-temperature and flame failures) has been completed and meets the requirements.

5.2.3.4 Test for the local shutdown of the monitoring system and shutdown of the whole monitoring system shall be conducted one by one, and the compliance with design requirements shall be confirmed.

5.2.3.5 Test for the shutdown caused by the fusible plug circuit shall be conducted, and the

compliance with design requirements shall be confirmed.

5.2.3.6 If the shutdown design is graded. During the test, verification shall be conducted in an order of lower-to-higher grades of shutdown.

5.2.4 Functional test

5.2.4.1 The following items shall be inspected and tested during the functional test of the monitoring system:

- (1) Confirm the normal operation of various switches of the monitoring system;
- (2) Confirm the normal indication and normal data transmission of various sensors (the structure, environment and equipment) in the monitoring system;
- (3) Ensure the normal operation of the UPS system in the monitoring system (if applicable);
- (4) Set monitoring parameters of software, conduct whole-process commissioning for the monitoring system, and confirm the function requirements are met;
- (5) Conduct joint commissioning to the central control system and sensor meter to confirm that various indications of the alarm display panel shall be normal;
- (6) Survey the monitoring parameters and software accuracy in the system to ensure the requirements of the owner's specifications shall be met.

Section 3 SYSTEM OPERATION AND MAINTENANCE

5.3.1 General requirements

5.3.1.1 There shall be the requirements of operation and maintenance (O&M) for the monitoring system, which shall constitute an O&M manual. The manual shall be submitted to CCS for review.

5.3.2 Requirement for O&M management manual

5.3.2.1 The manual shall propose requirements of the logs of maintenance and calibration for the monitoring system.

5.3.2.2 The manual shall propose requirements of verification modes for normal operation of the monitoring system.

5.3.2.3 The manual shall propose requirements for the appearance of the sensor and the inspection mode for its protection measures.

5.3.2.4 The manual shall propose requirements for the survey modes of the corrosion of the accessory device and the reliability of the structure.

5.3.2.5 The manual shall propose the basis for determining the correctness of the data of the monitoring system and simple processing methods.

CHAPTER 6 REMOTE MONITORING SYSTEM

Section 1 GENERAL PROVISIONS

6.1.1 General requirements

6.1.1.1 The remote monitoring system refers to the process in which the centralized monitoring system on the unit and installation transmits monitoring data and information to the monitoring center by wireless/wired modes. The monitoring center of the remote monitoring system shall be located at the shore-based terminal or designated offshore control center.

6.1.1.2 The remote monitoring system is mainly applicable to the prevention of exceptions in the state and other aspects of the structure and equipment of MU&OI. The user can obtain the alarm information in time, conduct monitoring through the network and adopt corresponding operation to reduce losses and lost. The corresponding processing shall be conducted to the monitoring system to fulfill the remote monitoring of MU&OI.

6.1.1.3 The remote monitoring system shall be provided with the software interface, hardware interface, communication interface, user interface, etc. Modularized design shall be adopted for various interfaces. There shall be a good operation interface, and certain coordination and smoothness shall be maintained.

6.1.1.4 The remote monitoring system shall be provided with certain levels of access permission.

6.1.1.5 For the unattended or periodically unattended installations, there should be redundant capacity of data transmission in the unit, installation and monitoring center.

6.1.1.6 The data obtained by the remote monitoring station can be the simplified data of the monitoring system on the installation (for example, the data obtained after eliminating inessential data through algorithmic processing), while the purpose and scope of monitoring shall not be affected.

6.1.1.7 For the information indicated in the remote monitoring station, relevant requirements of CHAPTER 3 of the Guidelines can be referred to.

6.1.1.8 The remote monitoring system shall meet the relevant requirements of CHAPTER 1 and CHAPTER 2 of the Guidelines.

6.1.1.9 The remote monitoring system shall calibrate the state of the sensor.

6.1.1.10 The data transmission between the installation and shore base shall meet the technical requirements of CHAPTER 3 of CCS's *Guidelines for Requirements and Security Assessment of Ship Network Systems*.

Section 2 COMPOSITION OF REMOTE MONITORING SYSTEM

6.2.1 General requirements

6.2.1.1 The remote monitoring system shall be composed of the local monitoring unit, data transmission network, and remote monitoring center.

6.2.1.2 The equipment should have extensibility, and shall be able to extend the functions of the structure, environment, image, state and other data acquiring functions.

6.2.1.3 The equipment power supply in the remote monitoring system shall meet the requirements of Section 1, CHAPTER 3, the Guidelines.

6.2.1.4 The hardware equipment shall meet the requirements of CHAPTER 3 of the Guidelines. The software equipment shall meet the requirements of CCS's *Guidelines for Safety and Reliability Assessment for Shipboard Software*.

Section 3 REMOTE TRANSMISSION

6.3.1 General requirements

6.3.1.1 For the remote data transmission, the communication protocol with calibration functions shall be adopted, and the mistransmitted data package shall be corrected in time.

Section 4 REQUIREMENTS OF FUNCTION

6.4.1 Monitoring and alarm

6.4.1.1 For the monitoring of the structure data of the installation, the pre-warning threshold for monitoring shall be set. After thorough analysis of data results, alarm information shall be given if the set threshold is exceeded.

6.4.1.2 For the monitoring of the data about equipment state, the failure in equipment shall be predicted, and alarm shall be given in case of any data exception, providing basis for equipment maintenance.

6.4.2 Data storage

6.4.2.1 The remote monitoring system shall be provided with the database system to store and manage data, and the database system shall have the function of data backup. The content stored in the database shall not be less than the requirements specified in Section 4, CHAPTER 3, the Guidelines.

6.4.2.2 The remote monitoring system shall have the function of statistical analysis of data.

6.4.2.3 The remote monitoring system shall have the functions of maintaining data integrity in special operating conditions, such as typhoon (if applicable).

6.4.3 Shore-based terminal

6.4.3.1 The shore-based terminal shall have the function of remote login to access the remote monitoring center and indicate data.

6.4.3.2 The shore-based terminal shall have the functions of receiving and pushing important alarm information.

6.4.3.3 The shore-based terminal shall send pre-warning and instruction information to the monitored installation or monitoring unit (one-way) based on the results of statistical analysis of data.

Section 5 REMOTE SURVEY

6.5.1 Survey scope

6.5.1.1 Inspect and determine whether the hardware configuration, software configuration and other aspects of the local monitoring system and remote monitoring system meet the requirements of Section 2 of this chapter.

6.5.1.2 Inspect the network status between the monitoring system and the remote monitoring system to ensure there is no packet loss in the communication testing within unit time.

6.5.1.3 Run a simulation to send testing data to the remote monitoring center. The testing data shall not be shorter than the data to be acquired for the project, and it shall be confirmed whether the following requirements are met:

(1) Whether the real-time performance, accuracy and integrity of the data acquired by the local monitoring system and remote monitoring system meet the requirements;

(2) Inspect to ensure the data transmission delay meets the requirements of Section 3, CHAPTER 3, the Guidelines;

(3) Inspect the network security of the remote monitoring system;

(4) Inspect the compatibility between the monitoring software and the network security software to confirm that the functions of the monitoring software do not conflict with the software guaranteeing network security.

(5) Inspect to ensure the monitoring alarm of the remote monitoring system, data storage and analysis, as well as the shore-based terminal, meets the requirements of Section 4 of this CHAPTER.