TEXT
Engine-room Resource Management (ERM)

The Maritime Human Resource Institute, Japan
&
Dr. David GATFIELD
Warsash Maritime Academy, the United Kingdom

Acknowledgement

The Maritime Human Resource Institute, Japan conducts various activities to dedicate to the maritime society and to assist in the seafarers' administrative issues. The requirements concerning BRM/ERM have been introduced into the competence tables as mandatory requirements for navigation and engineer officers by the comprehensive review of the STCW Convention and the Code adopted in 2010. Training methods and roles of requirements for BRM can be considered to be already established, however those for ERM can be said to be expected. The institute therefore decided to produce an educational visual aid which contains briefings on ERM, its requirements and case examples. The institute organized the ERM expert committee consisted of members from the maritime education institutions, maritime bodies concerned and shipping industries to address this issue and consideration for producing the visual aid was implemented by the committee. It was our honor that Doctor David Gatfield, a professor of Warsash Maritime Academy who contributed to development of the requirements for ERM in the comprehensive review of STCW Convention and the Code, kindly participated in producing it as the coproducer.

We hereby acknowledge the members of the ERM expert committee for their contribution and the cooperation for shootings extended by all the personnel on board Musashi Maru, a Ro-Ro ship of MOL Ferry Corporation Limited and Seiun Maru, a Training Ship of National Institute for Sea Training, Independent Administrative Institution, Japan in producing this DVD.

Musashi Maru, Ro-Ro Ship
MOL Ferry Co., Ltd.

Seiun Maru, Training Ship
National Institute for Sea Training

Planning & Produce: The Maritime Human Resource Institute, Japan

Kaiji center building, 4-5 Kojimachi
Chiyoda-ku, Tokyo Japan

Coproducer: Doctor David Gatfield
Warsash Maritime Academy
Southampton Solent University
Newtown Road, Warsash, Southampton
SO31 9ZL The United Kingdom

TEXT

1. Preface

In June 2010, the proposed amendment to the STCW Convention and the Code was adopted at the diplomatic conference convened in Manila. This amendment includes many amendments to the Convention to meet the contemporary technologies and to eliminate ambiguity of the provisions. And as one of the amendments, a requirement of knowledge on Engine-room resource management (ERM) has been newly introduced into the competence table for engineer officers at the operational level. This requirement, as a knowledge, understanding and proficiency for competence "Maintain a safe engineering watch", requires engineer officers to acquire the knowledge of ERM and to practice ERM. In practicing ERM, it's vital to develop consciousness based on its concept and comprehension of the components constructing ERM. Furthermore, since ERM cannot be practiced if it is only understood by specialized personnel, it is essential for all personnel to share common perceptions about its necessity, understanding ERM equally and appropriately. From this aspect, it is also necessary for the engineer officers at the management level to review ERM at this time as it becomes a mandatory requirement, taking into account that the competence of "Use leadership and managerial skills" as an essential element of ERM has been introduced into the competence table of the function of "Controlling the operation of the ship and care for person on board" at the management level.

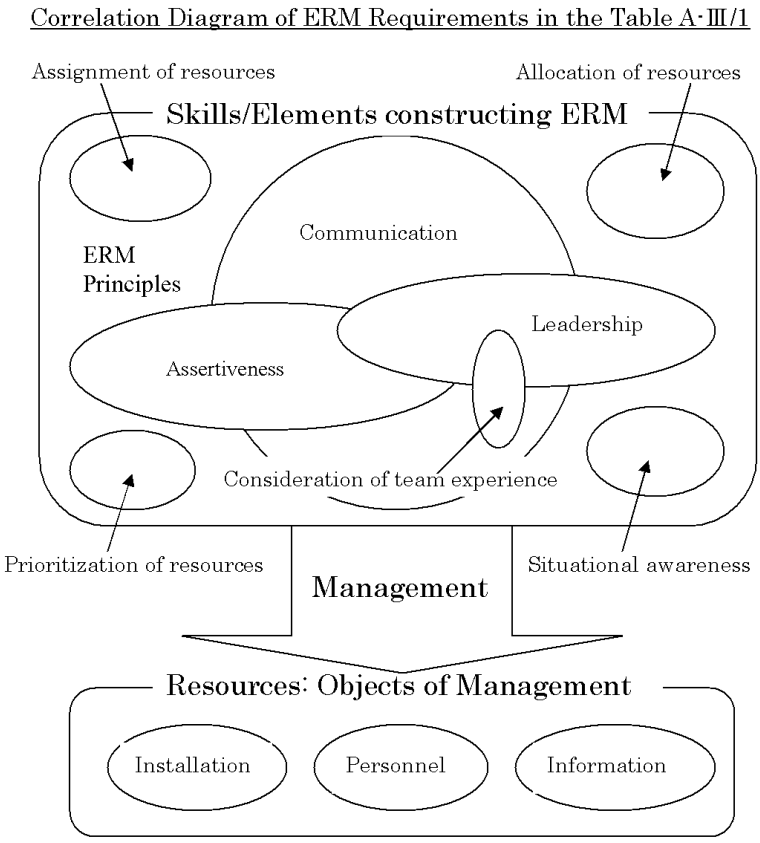
This DVD was produced in terms of this point of view as a visual aid to allow people to learn what ERM is and what its components are through actual operational scenes of a ship, introducing the requirements for ERM. The components of ERM are not based on a new idea or imagination, but it can be said to be previously-existing human elements. Consequently, anyone can practice ERM by understanding its purpose and necessity of the components without having specialized technical skills, but by adopting the human elements as non-technical skills such as leadership, communication, situational awareness and others.

2. ERM and Resources

2.1 ERM

ERM is an approach to achieve a ship's safe navigation by appropriately managing the resources of personnel, equipment and information in the machinery space and by effectively utilizing them. So, allocation, assignment and prioritization of resources, effective communication, assertiveness, leadership, situational awareness, consideration of team experience and knowledge of ERM principles are stipulated in the amended competence table as essential requirements in practicing ERM. In addition, management of resources includes personnel management, equipment management and information management and personnel management means that personnel are appropriately arranged based on their qualifications, their experience and their certifications. Equipment management is to manage the operation and maintenance of machinery, and running and maintenance records. Information management is to manage records of information, sharing of information and appropriate understanding and response to information. It's said that full practice of ERM is essential to ensure the ship's safe navigation especially in such a situation of entering/leaving ports where operational condition is continuously changing.

A correlation diagram that presents skills/elements constructing ERM based on the amended competence table A-Ⅲ/1 is shown below. The diagram says that communication is the most essential competence in practicing ERM and the communication can be a fundamental competence supporting leadership and assertiveness and also a shared common competence, and also there is the common competence between leadership and assertiveness. Consideration of team experience is also supported by communication and shares common competence with leadership. Three requirements regarding resources and situational awareness can be said to be independent skills/elements sharing no common competence with communication. The inside the framed rectangle means ERM principles. ERM principles are fundamental elements included in ERM and are the principles regarding personnel arrangement, how personnel arrangement should be, personnel's capability required and a code of conduct. Particularly, by the amendments, ERM principles for carrying out watches are described in Part 3 (Watchkeeping principles in general) of STCW Code A-Ⅷ/2 (Watchkeeping arrangements and principles to be observed) as shown in the paragraph 8 (ERM principles after the amendments in 2010).



2.2 Resources

There are personnel, equipment and information as resources. Personnel in resources are a human resource to be allocated for safe navigation and are required to have competency to manage and utilize other personnel as well as appropriate qualification for performing tasks. In addition, the personnel are required to be well versed in the functions of equipment upon his/her position, to have the capability to utilize information from the equipment and to confirm the functions are being demonstrated. Equipment should be set up and run as required to meet all of the requirements for the safe operation of the ship and all of the equipment required should be fully functional. Information comes from many sources: external to the ship, personnel, running and maintenance records, drawings, instruction manuals and equipment. There are two types of information from the equipment: the information such as alarms and operation data that automatically comes from equipment, like a monitoring system, and the information such as leaking, running sounds and vibrations detected by personnel using their five senses. All information must be appropriately understood, shared and utilized for the safe navigation of the ship.

2.3 Utilization of information

2.3.1 Entering/Leaving port

Personnel stationed when entering/leaving a port can maintain their motivation and the effective operation of machinery with an excellent teamwork by sharing information relating to their ship's consequences from the bridge and information the team members have. Particularly, the information from the bridge enables the engine room personnel, for whom it is difficult to know the navigational situation of the ship, to take proactive actions resulting in growing assuredness and swiftness of the machinery operation, preventing faulty operation.

Furthermore, it enables the personnel to be incentivized by their awareness of being one of the ship's operators. With regard to the information that the team members have, that is information detected by machinery operation and machinery rounds, the engine room personnel should try to share insignificant concerns and notes that they have.

2.3.2 Engineering watch

When operating and maintaining engine room machinery, it is essential for personnel in charge of an engineering watch to try to find any sign of malfunctions that is information from the machinery by personnel using their five senses through engine room rounds. In fact, there are many cases that the information about running sounds, leaks, vibrations and the like detected through such machinery rounds, can be utilized to prevent incidents. In addition to that, the personnel need to undertake the watch, understanding operation procedures, functions, features and operation data of the machinery by obtaining information from manuals, piping diagrams, status boards and others as well as the information taken over from the previous watch engineer officer.

2.3.3 Operation and maintenance

Personnel assigned to manage specific installations need to perform duties such as operation, maintenance and management of spare parts, making operation and maintenance plans by obtaining thorough information concerned in operation and maintenance through thoroughly reading instruction books. Furthermore, the personnel need to provide their successors with sufficient and appropriate information by leaving detailed records of operation, maintenance and consumption of spare parts.

3. Requirements of ERM

3.1 Allocation and assignment

Allocation and assignment of resources can be said that they are requirements relating to human resources. It indicates that personnel being assigned tasks upon his/her position should appropriately be allocated in order to maintain safe navigation.

Particularly, when entering or leaving ports, establishment of adequate command system and effective machinery operation system are necessary to ensure the safe navigation and appropriate allocation of personnel is essential for this purpose. In allocating personnel, allocation of experienced personnel depending on the situation and training of inexperienced personnel should be taken into account based on the idea that matches the right person to the right place at the right time in the machinery space.

3.2 Prioritization

Prioritization is usually set up in operating/handling machinery. But, when personnel carry out the assignment in various situations, they need to work on the tasks giving consideration and decision-making to prioritization in some cases. In such a case, personnel need to make a prioritization, taking into account its safeness, urgency and adequacy.

3.3 Communication

Communication is an information exchange necessary for maintaining safe navigation. In this information exchange, there are forms of order, response, provision of information and report according to the scenes of ship' s operation, and effective communication means that this information exchange is being fully carried out. Before each communication the rank, personality and awareness of personnel should be reflected upon to determine how much information exchange is necessary. Effective communication could be blocked if these human factors are not properly considered. Furthermore, it can be said that a lack of communication is largely caused by the attitude of both sides. Therefore, personnel need to try to ensure there is enough information

exchange, with a recognition of the importance of effective communication and of sharing information. Besides which personnel should be mindful of the following communication issues that are considered to be inappropriate:

3.3.1 “I had no report”; the idea that I could not receive the expected report due to a negligence of the person who should report it.

3.3.2 “No one is aware of it”; the idea that unawareness of information/situation that I was already aware of, must be caused by a lack of ability of the person who should be aware of it.

3.3.3 “I have not heard of it” or ”No one lets me know it”; the idea that the delay of information to be preferentially informed must be caused by the person who should be distributing it not understanding the meaning of prompt distribution of information.

3.3.4 “It has already been realized”; you are obsessed with an idea that has already been realized without the information being reported or provided.

3.3.5 “I didn’t say it since I was not asked”; the idea that I don’t need to advise people the information I have unless I am specifically asked of it.

3.4 Assertiveness

Assertiveness generally means a human element that enables personnel to sincerely and equally communicate with others without violating the right of others. It is often necessary for personnel to be assertive within the workplace. That is to say, having made a judgment necessary for maintaining safe navigation, personnel have to assert their judgment without any hesitation, notwithstanding their position and hierarchical relationship within the workplace. Especially, in an emergency case or after in-depth consideration, the person responsible at the station has to clearly assert his/her decision with uncompromising stance, avoiding unclear assertiveness. It may at times be necessary to ask a senior officer to explain the appropriateness of a decision they have made, or even to alert a superior officer if you consider that they have made an inappropriate decision. Assertiveness is a behavior that meets the element of “notify any doubt” in BRM/ERM principles and is therefore an inherent element of BRM/ERM.

3.5 Leadership

Leadership is an essential human element necessary for practicing ERM. Leadership is a skill necessary to achieve joint tasks and requires situational awareness and the competence to lead, understanding how to influence and motivate other personnel.

3.6 Situational awareness

Situational awareness is a competence available to act proactively in various situations and to precisely determine the existence of risks, the possibility of environmental pollution, illegal situations and the likelihood of incidents. It is essential to have a complete awareness of the situation so that necessary measures and actions can be taken proactively, in order to prevent the occurrence of incidents and environmental pollution.

3.7 Consideration of team experience

Consideration of team experience means taking into account the experience of all members of the team in order to achieve safe navigation and watchkeeping. It may be the case that even a new joiner may have certain experience and skills that could be useful to the team leader in a certain situation. It is therefore necessary that the team leaders understands the background and experience of all members of their team.

4. Scenario text

Ship : 10,000 gross ton class Ro-Ro ship propelled by diesel engine
Character : Deck department- - - Captain, Third officer, Watch officer, Quarter master
Engine department- - -Chief engineer
First engineer (issuing instructions to personnel in engine room)
Second engineer (handling main engine/equipment in control room)
Third engineer (handling machinery in engine room as leader of the station)
No.1 oiler, oiler (Mr. Sato) assistant oiler (Mr. Yamamoto)
Stations when entering/leaving port : Bridge (W/H) : Captain, Third officer, Quarter master
Control room (C/R): Chief engineer, First engineer,
Second engineer
Engine room (E/R): Third engineer, No. 1 oiler, Oiler, Assistant oiler

	Narration/Dialogue	Remarks
1	**(The amendments to the STCW Convention)** The International Maritime Organization (IMO) has newly introduced requirements for Engine-room Resource Management ERM into the competence of marine engineer officers under the 2010 Manila amendments. This DVD was produced to allow people to learn what ERM is, what ERM principles are and what should be understood. **(Mandate of ERM)** Recent analyses of marine casualties indicated that many of the fundamental elements of Bridge Resource Management (BRM) and Engine-room Resource Management (ERM) were not being practiced. In addition, it was also clearly evident that a lack of communication was a prominent factor in marine casualties. In this context, IMO reached a conclusion that it was imperative to include the non-technical skills such as BRM and ERM in the STCW Code as requirements for deck and engineer officers in order to prevent maritime incidents. **(ERM)** ERM is an approach to achieve safe navigation by appropriately managing the resources of personnel, equipment and information in the machinery space and by effectively utilizing them. Namely, management of resources includes personnel management, equipment management and information management. **(ERM requirements)** ERM requirements are stipulated in the competence table A-Ⅲ/1 as shown on the display as requirements for the competence “Maintain a safe engineering watch” at the operational level. That is “Knowledge of ERM principles including these 5 requirements” as “Knowledge, understanding and proficiency” **(ERM principles)**	1: Introduction and clarification of ERM

1	ERM principles are fundamental elements in ERM and particularly, regarding necessary ERM principles to maintain a watch, nine principles such as proper arrangements of personnel, consideration of qualification limit and appropriate communication are stipulated in Section A of chapter Ⅷ of the STCW Code providing how to arrange personnel, personnel competency required, a code of conduct and others. **(Resource)** Now, let's briefly explain constituent elements of ERM based on the provisions. First, with regard to resources, personnel means human resources allocated for safe navigation and are required to have competency to manage and utilize other personnel as well as appropriate qualification in performing tasks. In addition, personnel are required to be well versed in the functions of equipment and to have capability to utilize information from the equipment and to confirm the functions are being demonstrated. Equipment as resource means all installations to maintain safe navigation and they should be fully functional. Information resource means information comes from external, personnel, running and maintenance records, drawings, instruction manuals and equipment. There are two types of information from the equipment, which are the information that automatically comes from equipment like a monitoring system and the information detected by personnel using their five senses. **(Allocation and assignment)** Allocation and assignment of resources says that appropriate personnel should be allocated properly and in particular, it becomes more important when entering or leaving ports due to the need to establish an adequate command system and to handle propulsion machinery more accurately. **(Prioritization)** Personnel are required to prioritize various duties considering their judgments on safety, urgency and adequacy in accordance with situations. **(Communication)** Communication is an information exchange necessary for maintaining safe navigation. In this information exchange, there are forms of order, response, provision of information and report according to the operational aspects, and effective communication means that this information exchange is being fully carried out. Before each communication the rank, personality and awareness of personnel could be reflected upon to determine how much information exchange is necessary and it can be said that a lack of communication is largely caused by the attitude of both sides. Personnel therefore should be mindful of the following communication issues.	

1	・ “I had no report”; the idea that I could not receive the expected report due to a negligence of the person who should report it. ・ “No one is aware of it”; the idea that unawareness of information/situation that I was already aware of, must be caused by a lack of ability of the person who should be aware of it. ・ “I have not heard of it”; the idea that the delay of imformation to be preferentially informed must be caused by the person who should be distributing it not understanding the meaning of prompt distribution of imformation. ・ “It has already been realized”; you are obsessed with an idea that has already been realized without the information being reported or provided. ・ “I didn’t say it since I was not asked”; the idea that I don’t need to advise people of the information I have unless I am specifically asked of it. **(Assertiveness)** It is often necessary for personnel to be assertive within the workplace for maintaining safe navigation without any hesitation, notwithstanding their position and hierarchical relationship. Furthermore, junior personnel sometimes have to be assertive in asking for clarification of decisions made by their superiors if the reasons for those decisions are not clear, and if he/she considers that these decisions might adversely affect the safe navigation. Assertiveness is a behavior that meets the element of “notify any doubt” in BRM/ERM principles and is therefore an inherent element of BRM/ERM. **(Leadership)** Leadership is an essential human element in practicing ERM and requires an ability to lead, understanding influence to other personnel and how to motivate them. **(Situational awareness)** Situational awareness is an ability to assess accurately the existence of risks, the possibility of environmental pollution, illegal situations and the likelihood of incidents in various situations. **(Consideration of team experience)** Consideration of team experience is to take experiences of all members of the team including junior personnel into account and to utilize the experiences in order to achieve safe navigation and watchkeeping. **(Preparation for entering port)** Now, let’s watch the scene of a ship entering a port. This ship is a 10,000 gross ton class Ro-Ro ship. When entering and leaving port, main engine maneuvering is carried out from the control room and a direct telephone line is used for communication between the bridge and the control room in addition to the engine telegraph. In order to ensure sharing information, an engine room command communication system is used for communication between the engine control room and the engine room so that personnel in the	

1	engine room can listen to information issued from the control room through loudspeakers and personnel in the engine control room can listen to information issued from the engine room through a speaker. The second engineer who was checking the unmanned machinery in the control room received a phone call from the bridge saying that there was 25 miles left to the pilot station. The second engineer immediately reported the information from the bridge to the chief engineer and having received the chief engineer's instruction, he informed the first engineer, the third engineer and the engine crew members who should be standing by. After that, the second engineer changed the control mode from unmanned to manned and the control position of the main engine from the bridge to the control room and began preparations for entering the port, starting reduction of main engine speed.	
2	Control room Direct phone rings (1) W/H (3/O) →C/R (2/E) : 15 miles left to the pilot station. (2) C/R (2/E)→W/H (3/O) : All right, 15 miles left to the pilot station. (3) C/R (1/E) →E/R : 15 miles to the pilot station, Number 2 generator is about to be started from control room, report the running condition. (4) E/R (3/E) →C/R : All right, 15 miles to the pilot station, Number 2 generator is about to be started from control room. (5) E/R (3/E) → Yamamoto : Let's go. (6) C/R (2/E) : I'm starting Number 2 generator. D/G room, checking Number 2 generator (7) E/R (3/E): Exhaust gas temperature of Number 1 cylinder is rising a bit faster, it would be settled down in a short while. Control room (8) W/H (3/O) →C/R (2/E) : I am putting steering motors into parallel running. (9) C/R (2/E)→W/H (3/O) : All right, beginning parallel running of steering motors. (10) C/R (1/E)→E/R : Steering motors are now running in parallel, report the running condition.	2: From state of navigation to stand-by engine Preparation for entering port Preparations for stand-by engine vary according to the systems and dimensions of the propulsion plant, however generally speaking, the following preparations are necessary. ① Reducing engine speed until harbor full speed. (Change fuel oil if necessary) ② stopping auxiliaries Fresh water generator Exhaust gas economizer ③ Starting auxiliaries Parallel running of steering motors Parallel running of main air compressors Parallel running of generators Auxiliary boiler Preparation for thruster Checking of generator right after start Right after starting generator, running parameters such as LO pressure and revolution speed and existence of abnormal noise, abnormal vibration, water leak, oil leak and gas leak should be checked.

2	(11) E/R (3/E)→C/R : All right, steering motors are now running in parallel. Number 2 generator seems to be OK. Engine room (12) E/R (3/E)→E/R (No. 1 Oiler) : Ah!, Number one, do me a favor? Check the steering gear please. (13) E/R (No. 1 Oiler) →E/R (3/E） : O.K , I will. Control room (14) C/R (1/E)→E/R : All right, Number 2 generator is in good order. I am starting parallel running of Number 1 and 2 generators. (15) C/R (2/E) : I am putting Number 1 and 2 generators into parallel running. (16) C/R (1/E)→E/R : Parallel running of Number 1 and 2 generators started. (17) E/R (3/E)→C/R : All right, beginning parallel running of Number 1 and 2 generators. (18) C/R (1/E)→E/R : Start Number 2 main air compressor and start parallel running of main air compressors. (19) E/R (3/E)→C/R : Yes, certainly, I will start parallel running of main air compressors. Engine room (20) E/R (3/E) →E/R (Oiler Mr. Sato) : Start Number 2 main air compressor and start parallel running please, and make sure you operate the magnetic drain valves just in case. (21) E/R (Mr. Sato) →E/R (3/E) : Yes, I will. Parallel running of main air compressors (22) E/R (No. 1 Oiler)→E/R (3/E) : Third engineer, there was no problem with the parallel running of the steering motors. (23) E/R (3/E) →E/R (No.1 Oiler) : All right, Thank you. (24) E/R (3/E) →C/R :There was no problem with the parallel running of steering motors. (25) C/R (1/E)→E/R : All right, there was no problem with the parallel running of steering motors.	Exhaust gas temperature of generator Exhaust gas shows variations in temperature right after starting generator and the temperatures of all the cylinders outlet would become stable at almost same temperature as generator begins load running on the condition that injection pressure of each fuel injection valve is properly arranged and atomizing condition of each fuel injection valve is in good order. Parallel running of generators Although one generator usually supplies power necessary to maintain navigation, when leaving/entering port, two generators are put into parallel running to prepare for use of thruster and ensuring power. Parallel running of main air compressors During stand-by engine, main engine would be stopped and started several times and starting main engine needs a large amount of compressed air. Therefore, main air compressors are put into parallel running to prepare for starting main engine prior to stand-by engine. Usually, main air compressors are started and stopped automatically by pressure switch of main air reservoir. Drain valve of main air compressor When starting, drain valve of

2	(26) C/R (2/E) →W/H (3/O) : There was no problem with the parallel running of steering motors. (27) W/H (3/O) →C/R (2/E) : Yes, Thank you for the report. (28) E/R (Oiler Sato)→E/R (3/E) : Third engineer, I have started the parallel running of main air compressors and they are in good order. (29) E/R (3/E)→E/R (Oiler Sato) : All right, thank you (30) E/R (3/E) →C/R : The parallel running of main air compressors has been started in good order, Sir. (31) C/R (1/E)→E/R : All right, the parallel running of main air compressors has been started in good order. Alarm sounds (32) C/R (1/E)→E/R : It's exhaust gas high temperature alarm of Number 1 cylinder on Number 2 generator. Engine room, check the generator and report the situation. Generator room, Checking work on No.2 Generator (33) C/R (C/E) : It seems not to be a sensor problem. The fuel injection valve must be faulty. The temperature seems to soar just after the load running was started. I wonder why there was no sign of this at the time of starting. (34) C/R (1/E) : Nothing was reported like that. I will ask him if there was any sign of it later. (35) E/R (3/E)→C/R : The temperature of Number 1 cylinder was 350 and 50 degrees higher than any other cylinder. No problem found other than that, Sir. Control room (36) C/R (1/E) : All right. (37) C/R (1/E)→C/R(C/E) : Chief engineer, let's start Number 3 generator immediately for parallel running of Number 1 and 3 generator. (38) C/R (C/E) : Yes, Go ahead (39) C/R (1/E)→E/R : I am starting Number 3 generator, report running condition. I will disconnect Number 2 generator to make single running of Number 1 generator.	main air compressor usually opens to discharge drain and closes automatically after a lapse of several tens of seconds. Exhaust gas high temperature alarm of generator Exhaust gas high temperature alarm of generator is absolute high temperature and deviation high temperature and this case indicates the latter, which means that only temperature of No. 1 cylinder is the highest among all the exhaust gas temperatures. If the running of this generator had been continued, the temperature would reach to the absolute high temperature. Sensor problem Sensor problem means that sensor detecting exhaust gas temperature is abnormal and actual temperature is not abnormal. Temperature sensor problem occurs in case that disconnection and short circuit of signal lines rather than sensor element gets worse. In some cases, sensor problem alarm and temperature alarm occur simultaneously. Judgment of fuel valve

2	(40) E/R (3/E) →C/R ：All right, Number 3 generator is about to be started and Number 2 generator is being disconnected. (41) C/R (2/E): I am starting Number 3 generator. Generator room, Checking No.3 Generator (42) W/H (3/O)→C/R (2/E) ：5 miles left to the pilot station. (43) C/R (2/E)→W/H (3/O) ：All right, 5 miles to the pilot station. (44) C/R (1/E)→E/R ：5 miles to the pilot station. (45) E/R (3/E)→C/R ：All right, 5 miles to the pilot station. All looks good with Number 3 generator. (46) C/R (1/E)→E/R ：All right, all looks good with Number 3 generator. After putting Number 1 and 3 generators into parallel running, I will switch on the bow thruster and deck machinery. (47) E/R (3/E)→C/R ：All right, starting parallel running of Number 1 and 3 generators and switch on the bow thruster and deck machinery. (48) C/R (2/E)：Speed reduction of the main engine completed. (49) C/R (C/E)：O.K (50) C/R (2/E)：I will inform the bridge. (51) C/R (1/E) →E/R ：We have about one hour left to approach the berth. Stop Number 2 generator at the engine side and replace fuel injection valve of Number 1 cylinder. (52) E/R (3/E)→C/R ：I think stand-by engine will come soon and so I would like to avoid the work of replacing the fuel injection valve during the stand-by period. Two persons will be unavailable for stand-by and if something urgent happens, it will be more difficult to address the situation. Besides, if we started working on Number 2 generator now it would be unavailable for use in an emergency. (53) C/R (C/E)：First engineer, we should respect their decision and we would be better to avoid any additional work during stand-by, so we have enough personnel available for any other urgent situations. (54) C/R (1/E)：Yes, I understood. (55) C/R (1/E)→E/R ：Engine room, stop Number 2 generator at the engine side as usual and make it stand-by condition. (56) E/R (3/E) →C/R ：Understood, I will stop Number 2 generator and prepare for stand-by.	Judgment that the fuel injection valve got worse was made over No.1 cylinder exhaust gas high temperature alarm of No.2 generator. It is an adequate judgment as most likely cause. A bad fuel injection valve results in bad atomizing of fuel oil and abnormal combustion appears in the cylinder, consequently exhaust gas temperature rises. Stop generator and preparation

2	(57) E/R (3/E) →E/R (Assis. Oiler Yamamoto) : Mr. Yamamoto, go and check the temperature, please. (58) E/R (Assis. Oiler Yamamoto) →E/R (3/E) : O.K, I will. Bridge (59) W/H (Capt): Reduction of main engine speed seemed to be completed. Was there a report of preparations for stand-by engine? There are only 3 miles to the pilot station. (60) W/H (3/O) : Not yet, sir, I guess that is coming soon. Control room (61) C/R (C/E): The exhaust gas temperature of main engine has dropped below 200. The damper of the exhaust gas economizer is still open. Who was aware of that? (62) C/R (2/E) : I wasn't. (63) C/R (1/E): Sorry, I missed it. I'll close it now. (64) C/R (1/E) →E/R : Closing the damper of exhaust gas economizer. (65) E/R (3/E) →C/R : All right. The damper of exhaust gas economizer is about to be closed. (66) E/R (Yamamoto) →E/R (3/E) : The exhaust gas temperature has dropped. (67) E/R (3/E) →E/R (Yamamoto) : I see, thank you. (68) E/R (3/E) →C/R : I will stop No 2 generator as the exhaust gas temperature has dropped. (69) C/R (1/E) →E/R : All right, stop No 2 generator. Bridge (70) W/H (Capt): There has been no report of preparation for stand-by engine. Did something happen? I guess they missed it. (71) W/H (3/O): I will ask the control room. (72) W/H (3/O) →C/R (2/E) : We will soon be 3 miles from the pilot station. Is stand-by engine possible? (73) C/R (2/E) →W/H (3/O) : Certainly, I missed the report for trouble of Number 2 generator. Stand-by engine is now available. I have already switched on the bow thruster and the deck machinery. (74) W/H (3/O) →C/R (2/E) : Thank you for that, I will report it to the Captain. (75) W/H (3/O) : Captain, stand-by engine is now available. Electric power for the bow thruster and deck machinery is already	for stand-by In case of this ship, generator is started remotely from the engine control room and stopped manually at the engine side. In a ship which has automated generator system, stop of generator at the engine side is done to prepare for next start after carrying out air running to blow away remained gas in the cylinders. In addition, in order to make generator state of stand-by, it is necessary to meet the conditions such as closing all indicator valves, lining up staring air and disengaging turning gear. Exhaust gas economizer Exhaust gas economizer is a heat exchanger to heat boiler water by main engine exhaust gas. During cold condition and low load running of main engine, damper of exhaust gas economizer is closed to stop influx of exhaust gas into the economizer and to avoid the surface of heating tubes from being cooled down and corroded in many cases. A pump to circulate boiler water between auxiliary boiler and exhaust gas economize is called boiler water circulating pump. Engine telegraph Engine telegraph is communication equipment for main engine maneuvering order without fail and placed in navigation bridge, engine control room and engine room. When maneuvering main engine is in the engine control room or the engine room, if indicating position of engine telegraph in the control room or the engine room does not meet the indicating position of engine telegraph in the bridge, telegraph gong will continue to ring until they meet each other. Engine telegraph in the bridge is also the maneuvering lever for

2	available. (76) W/H (Capt) : All right, Stand-by engine. <u>Sub-telegraph rings</u> (77) W/H (3/O): Stand-by engine. Control room (78) C/R (2/E): Chief engineer, stand-by engine is requested. (79) C/R (C/E): O.K. (80) C/R (2/E): Yes, I will respond. (81) C/R (1/E) →E/R : Stand-by engine, Stand-by engine. Bridge (82) W/H (3/O): Stand-by engine, Sir. (83) W/H (Capt): Slow down engine.	main engine and having met the lever position to the requested speed position, revolution speed requested can be automatically ensured. The following shows engine telegraph positions. Stop Dead Slow Ahead/Astern Slow Ahead/Astern Half Ahead/Astern Full Ahead/Astern Nav. Full Furthermore, in addition to engine telegraph, sub-telegraph is installed to communicate the following orders. Stand by Engine Finish with Engine Full Away
3	**(Personnel arrangement for entering port)** Now, let's review the scene of entering port in terms of engine-room resource management. First of all, regarding personnel arrangement, personnel were allocated in the engine control room and the engine room and it can be said this was satisfactory considering roles of each person. In addition, it is important that the third engineer was likely standing at the position where he could quickly contact the control room. **(Communication)** Regarding the communication, there were three lessons. The third engineer was aware of the rapid rising of the exhaust gas temperature of No. 1 cylinder when No. 2 generator was started, but he didn't report it to the control room. This means that the information detected by five senses from equipment was not shared. If it had been shared, personnel in the control room could have paid attention to the temperature and could have addressed the situation before the alarm sounded. It is necessary to communicate to the team leader anything that was felt to be wrong. The chief engineer said impatiently that the damper of exhaust gas economizer had not been closed. This behavior is like a rebuke and is likely to inhibit further communication. In this case, the chief engineer should have only said to close the damper as a member of the team.	3 : Narrative interpretation on the events from state of navigation to stand-by engine

3	The second engineer tried to inform the bridge of completion of preparation for stand-by engine when he completed reduction of main engine revolution, however, he forgot to do this, being absorbed in the order to the engine room issued by the first engineer. There was a question from the bridge for the delay of notifying completion of preparation for stand-by engine. If there had been no question, embarkation of the pilot could be obstructed. When any doubt exists about a situation, it is essential to make an inquiry in order to clarify the situation, regardless of the rank of the person you are asking. **(Assertiveness)** The third engineer asserted his judgment as the leader of the station against the order to replace the fuel injection valve of Number 2 generator during stand-by engine. This means "assertiveness" and meeting "notify any doubt" in the ERM principles. The decision to make retaining the engine on stand-by the top priority was correct in terms of situational awareness and prioritization. Now, let's continue to watch the scene of entering the port.	
4	Telegraph gong sounds Slow ahead engine→Half ahead engine (1) C/R (2/E) : Half ahead engine. (2) C/R (1/E) : Half ahead engine. (3) W/H (3/O) →C/R (2/E) : Pilot embarked. 5 miles left to the berth. (4) C/R (2/E) →W/H (3/O) : All right, pilot on board, 5 miles left to the berth. (5) C/R (1/E) →E/R : Pilot got on board. 5 miles left to the berth. Engine room (6) E/R (3/E) →E/R(No. 1 Oiler, Oiler, Assistant oiler) : (To Mr. Sato) When they begin to use the bow thruster, please go to generators and pay attention to the running condition. I will watch main engine from near the maneuvering lever. Number one oiler, please watch and check around cylinder head of main engine. Before approaching the berth, let's change the sea chest to the high suction. During the stay in port, periodical maintenance is scheduled to No.1 LO purifier, so let's stop it soon so that we can open the bowl assembly smoothly when we get alongside. (7) No. 1 Oiler →E/R (3/E, Oiler, Assistant oiler) : Wouldn't it be better to decide whether or not we should change sea chest after we make sure the depth of water at the berth? This	4：From embarkation of a pilot to berthing. (stand-by engine was ordered and became once slow ahead engine and half ahead engine was ordered after embarkation of the pilot) Instruction of the third engineer The third engineer gave instructions to ratings, explaining the anticipated situation. This indicates the third engineer's leadership and situational awareness. Sea chest There are usually two or three sea chests (Primary suction of sea water) to take in cooling sea water for machinery and one is located at high position of the hull under

4	time, I think, if possible, it would be better to change sea chest after berthing. Because, in the past, having changed over the sea chest after a rough passage, air went into cooling sea water line and the pressure in the line went down, almost shutting down generators with a blackout. As we had two-days of rough passage, there is a possibility that air remains in high sea chest. Apart from this, you would be better to make sure if cleaning of the sea strainer is necessary. (8) E/R (3/E) →E/R(No. 1 Oiler, Oiler, Assistant oiler) : I didn't know that such trouble happened. O.K. I will ask first engineer for instruction. Telegraph gong sounds Half ahead engine→Full ahead engine (9) C/R (2/E) : Full ahead engine. (10) C/R (1/E) →E/R : Full ahead engine. (11) E/R(3/E) →C/R : First engineer, I thought I should change over the sea chest before berthing as usual, but as we had two-days of rough passage, if possible I would like to change sea chest after berthing making sure of the depth of water at the berth. Please give me instruction. Then, as periodical maintenance of Number 1 LO purifier is scheduled during stay in the port, I would like to stop it in a short while so that it is ready for maintenance. Please tell me what you would like me to do. Control room (12) C/R (1/E) →E/R : All right, regarding sea chest, I will instruct you after confirming the depth of water at the berth. You can stop Number 1 LO purifier accordingly. (13) E/R (3/E) →C/R : All right, I will stop Number 1 LO purifier accordingly. (14) C/R (1/E) →C/R (2/E) : Second engineer, ask the bridge about the depth of water at the berth. (15) C/R (2/E) →C/R (1/E) : Yes. (16) C/R (2/E) →W/H (3/O) : Please advise the water depth at the berth. (17) W/H (3/O) →C/R (2/E) : A depth of 9 meters is anticipated. (18) C/R (2/E) →W/H (3/O) : 9 meters is anticipated. (19) C/R (2/E) →C/R (C/E, 1/E) : 9 meters is anticipated.	water and the other is located at the bottom of the hull. It is common to use the bottom sea chest under the navigation and to use high position sea chest in port where depth of the sea is low. In addition, sea water from the sea chest goes through suction valve and goes into strainer to remove clogging contents like a trash and sea weed in the sea water. Some ships have no such a strainer. Periodical maintenance of LO purifier Periodical maintenance of LO purifier is commonly to overhaul a bowl assembly removing sludge from separating discs and renewing packing at a certain interval. The third engineer thought that he could do it in a short period of time since he removed the bowl assembly from the shaft and put it in washing oil in preparation of overhaul

4	(20) C/R (1/E) →C/R (C/E) : Chief, the depth of water at the berth is 9 meters and it's a bit risky to use low sea chest until nearby the berth, isn't it? (21) C/R (C/E) →C/R (1/E) : I've been to this port in the past and it would be O.K since an under keel clearance of 1-2 meters can be assured considering the tide level and the bottom of water is firm mud. It would be better to changeover the sea chest and clean the sea strainer after berthing. (22) C/R (1/E) →C/R (C/E) : Yes, I understand. (23) C/R (1/E) →E/R : The depth of water anticipated is 9 meters at the berth. Changing over the sea chest and cleaning the sea strainer are to be done after berthing. (24) E/R(3/E) →C/R : All right, Changing over the sea chest and cleaning the sea strainer are to be done after berthing. Telegraph gong sounds Full ahead engine→Half ahead engine (25) C/R (2/E) : Half ahead engine. (26) C/R (1/E) →E/R : Half ahead engine. Bridge (27) W/H (Speaker): Made fast the tug aft. (28) W/H (3/O) →Forward station and Aft station : All right, made fast the tug aft. (29) W/H (3/O) →C/R (2/E) : 1,000 meters to the berth. Made fast the tug aft. (30) C/R (2/E) →W/H (3/O) : All right, 1,000 meters to the berth. Made fast the tug aft. Control room (31) C/R (1/E) →E/R : 1,000 meters to the berth. Made fast the tug aft. (32) C/R (C/E) →C/R (1/E) : First engineer, do you have any maintenance work planned for the main engine in this port? (33)C/R (1/E) →C/R (C/E) : Number 1 and 3 cylinder fuel injection valves are planned to be replaced. Other than this, I have planned to renew the motor bearing of Number 1 main cooling sea water pump. (34) C/R (C/E) →C/R (1/E) : Well, Cargo watch, replacing fuel valves of main engine, replacing fuel valve of Number 2 generator and so on. Good work planning is	Replacement of main engine fuel injection valve Main engine fuel injection valve is usually replaced according to the period of working time recommended by manufacturer, but it is accordingly replaced when judgment was made as combustion state got worse and flaw of combustion was found in equipment like such a combustion analyzer.

4	necessary. Then, let's me see how should we do trial run of main engine after replacing fuel injection valves? I guess we don't need to take the time as we are only replacing four fuel injection valves and it would be O.K to make sure of the condition during a trial run of main engine before departure. And I will inform Captain about the replacement of the fuel injection valves on the main engine. (35) C/R (1/E) →C/R(C/E) : Yes, certainly. (36) E/R (3/E) →C/R : First engineer, automatic combustion equipment of auxiliary boiler is still OFF. I will switch it to start. (37) C/R(1/E) →E/R : Switch on immediately and start heating circulation of fuel oil. Starting automatic combustion equipment of auxiliary boiler (38) E/R (Oiler Sato): Boiler, O.K. (39) E/R (3/E) →C/R : Automatic combustion equipment on. Heating circulation started (40) C/R (1/E) →E/R : All right. (41) C/R (C/E) →C/R (1/E, 2/E) : The third engineer must be aware of it, as the steam pressure of boiler seemed to be going down. I didn't realize it, since the monitor does not scan the state of the power switch while it's out of service and I didn't look at the steam pressure. Does the third engineer completely look around the machinery? (42) C/R(1/E) →C/R (C/E) : Yes, he does. The third engineer is not very experienced, but he looks around machinery and makes full use of his five senses and informs me of anything he finds. (43)C/R (C/E） →C/R (1/E, 2/E) : So the third engineer fully understands his roles and assignments and demonstrates leadership at his station. Telegraph gong rings Half ahead engine→Slow ahead engine (44) C/R (2/E) : Slow ahead engine. (45) C/R (1/E) →E/R : Slow ahead engine. (46) W/H (3/O) →C/R (2/E) : 300 meters to the berth. (47) C/R (2/E) →W/H (3/O) : All right, 300 meters to the berth. (48) C/R (1/E) →E/R : 300 meters to the berth. Telegraph gong rings	Auxiliary boiler automatic combustion equipment Some automatic combustion equipment of auxiliary boiler on board diesel ship is stopped during under way since steam pressure is maintained by exhaust gas economizer. In this case, it was necessary to restart the equipment as entering port.

4	Slow ahead engine→ Stop engine (49) C/R (2/E) : Stop engine. (50) C/R (1/E) →E/R : Stop engine. Starting to use the bow thruster. Bridge (51) W/H (Pilot): Slow astern engine. Control room Telegraph gong rings Stop engine →Slow astern engine (52) C/R (2/E) : Slow astern engine. Bridge (53) W/H (3/O): Slow astern engine, sir. Control room (54) C/R (1/E) →E/R : Slow astern engine. (55) W/H (3/O)→C/R (2/E) : Made fast the headlines. (56) C/R (2/E) →W/H (3/O) : Made fast the headlines. (57) C/R(1/E) →E/R : Made fast the headlines. Telegraph gong rings Slow astern engine →Stop engine (58) C/R (2/E) : Stop engine. (59) C/R (1/E) →E/R : Stop engine. Telegraph gong rings Finish with engine (60) C/R (2/E) : Finished with engine (61) C/R(1/E) →E/R : Finished with engine. Take readings of tank levels and flow meters. (62) W/H(3/O) →C/R (2/E) : Finished using bow thruster and steering gear. (63) C/R (2/E) →W/H (3/O) : All right, Finished using bow thruster and steering gear. (64) C/R(1/E) →E/R : Finished using bow thruster and steering gears. Switched them off. (65) C/R (1/E) →E/R : Now, let's work on to put main machinery into port condition.	Taking readings of flow meters and tank levels It is necessary to take readings of fuel oil flow meter and tank levels in order to calculate consumption of fuel oil, boiler water and lubricating oil. Usually, changing time from state of navigation to state of berthing is the time when finish with engine was ordered.

5 5	The scene from embarkation of the pilot to berthing has been shown. **(Leadership)** Firstly, let's focus on the third engineer's leadership. Although the third engineer is not very experienced, he appropriately issued his instructions as the leader of the station looking ahead based on precise situational awareness. It can be said that the third engineer's leadership and situational awareness were demonstrated. **(Consideration of team experience)** Regarding the changeover of the sea chest, Number one oiler contributed to the safe navigation of the ship by advising the third engineer of his experience. This means that consideration of team experience was demonstrated in terms of ERM. **(Communication)** Regarding the replacement of main engine fuel injection valves, it was important that the Chief Engineer communicated this to the Captain from the aspect of maintaining an exchange of appropriate information. This was a matter relating to main engine and included communication that the main engine temporarily becomes unable to start even though the ship is in port, and that trial run of the main engine before departure is to double up as a test run after replacing the fuel injection valves. **(Sharing information)** As the ship approached the berth, information relating to movement of the ship was informed and engine orders were continuously commanded. All the information was shared by all personnel in the control room and the engine room. This enabled the personnel in charge to operate the machinery safely and effectively, increasing their situational awareness about the movement of the ship. Furthermore, sharing information can build teamwork, raises motivation and maintains a sense of heightened awareness. Now, please watch the scene of the meeting before the maintenance work starts.	5：Narrative interpretation on the scene from embarkation of the pilot to berthing.
6	Meeting before maintenance work (1) 1/E: Now today's jobs are to replace Number 1 and 3 cylinder fuel injection valves on the main engine, replace Number 1clyinder fuel injection valve on Number 2 generator, renew motor bearings on Number 1 main cooling sea water pump, change over the sea chest from low to high and clean the sea strainer, and maintain a cargo watch, anything else?	6：Meeting before maintenance works

6	(2) 3/E: I have periodical maintenance of Number 1 LO purifier. (3) 1/E: How many hours do you need to do that? (4) 3/E: As I have already opened bowl assembly while it was hot to make it easy to clean up, I guess about two hours to complete. (5) C/E: Third engineer, regarding the fuel valve of Number 2 generator, was there any sign of high temperature? Although I looked at monitor display, I thought there was no problem at the time of start and I was checking other points. I therefore, was not aware of it. (6) 3/E: It was a little higher than the others soon after starting. But I thought such a difference was acceptable. (7) 1/E: But, you should have informed us of anything you found, even if it was only slightly different from normal. If you had reported it, we would pay more careful attention to it and we might possibly have addressed the situation before the alarm sounded. (8) C/E: That's right. However, you said that replacing the fuel valve should not be done during stand-by engine. That was great. It was nice that you questioned us when you felt that something we asked you to do was not the right thing to do in the situation. (9) 3/E: Thanks, I will try to tell you about anything I find that is slightly abnormal from now on. (10) No. 1 Oiler: Third engineer, it seems to be easy to change over the sea chest and to inspect and clean the sea strainer, but you had better do it very carefully, because only opening the lid of the strainer can cause unexpected problems. The other day, they tried to open the lid of a strainer and this lid was instantly blown off soon after they removed the securing dogs, consequently a large amount of sea water came into the engine room. Of course, they had confirmed that there was no water pressure by opening the air vent valve, but it was found later that the air vent valve was clogged with rubbish and rust, besides which the sea water suction valve was being held slightly open with sea grass. Therefore, at least, when you open the lid of strainer, you should confirm that there is no pressure inside the strainer after just loosening the securing dogs and only then should you remove the securing dogs. (11) 3/E : O.K. Understood. (12)1/E : That's right, now, how should we distribute the work tasks? Mr. Sato and I will take the main engine, second engineer and Mr. Yamamoto take Number 2 generator and third engineer and Number one take the sea chest and sea strainer. Third engineer, you work on Number 1 LO purifier after that. Second engineer, you should confirm condition of Number 2 generator with load running after replacing the fuel injection valve. I guess you can complete it in hour so you should work on renewing the motor bearings of Number 1 main cooling sea water pump after the generator. Regarding the cargo watch, I will talk to the deck department about that as we will have to prioritize maintenance work, if there is	

6	something wrong with cargo watch, let me know. Is there anything else to talk over? (13) C/E: Now, today's work will be carried out at several places and please do communicate with each other, if you have a problem. Then, if you have done something unusual and made any adjustment concerning your work, needless to say you should let everyone know, you should write it on the status board as well as leave a note in the work record book. Third engineer, you work on the periodical maintenance of LO the purifier and don't forget to follow the procedures including isolating the appropriate valves. There was a case with a certain ship while undocking, when there was an incident that let to fuel oil blowing off from the safety valve of fuel oil heater when they started the FO booster pump. As all personnel were closely involved, they only looked into the safety valve and pressure regulating valve and it was hard to find that the cause was the return valve was closed. Aside from this, the problem was that no one knew how that valve which was usually not closed had come to be closed. And also, on another ship, one engineer tried to adjust a diaphragm type pressure regulating valve for steam pressure by hand and broke the diaphragm plate not being aware of existence of the stopper bolt. This happened because he was not aware of how the stopper bolt worked. Although his unawareness of the stopper bolt was questionable, the most serious problem was that the information about how the stopper bolt worked was not shared. Sharing of information is essential not only to stand-by engine but also to maintenance works. Keep it in mind. (14) 1/E: Yes, Certainly, let's begin.	
7	**(Toolbox meeting)** Having a meeting before maintenance work begins has become routine in recent years. This is because, it can be thought that the meeting, called a toolbox meeting, has become important due to the strengthening of legal restrictions on safety and the enhancement of safety awareness, although a meeting at which all members of the engine department attended was seldom held until these toolbox meetings became routine. Furthermore, there was a background that there had been a lack of communication caused by the fact that the engine room team is comprised of seafarers from many different nationalities and cultures. The toolbox meeting has as its aim to carry out the maintenance work more safely and without failures, through maintaining an exchange of appropriate communications. **(Sharing information)** The Chief Engineer explained that sharing information in the ERM	7：Narrative interpretation on the meeting before maintenance work.

7	principles was important not only for operating ship but also maintenance work pointing to two incidents that actually happened as examples. This is an effect of the meeting too and it goes without saying that the sharing information is built upon an effective communication. Everyone should understand this. From now on, let's continue to watch. Next scene is trial run of main engine.	
8	Control room (1) C/R (1/E) →E/R : We will have the main engine trial run shortly. Engine room station, let me know if you are ready for it. (2) E/R (3/E) →C/R : Engine room station is ready for the trial run. (3) C/R (1/E) →E/R : All right, ready for the trail run. (4) C/R(2/E) →C/R(C/E, 1/E) : I will ask the bridge. (5) C/R(2/E) →W/H(3/O) : We have main engine trial run shortly, let me know if you are ready for it. (6) W/H(3/O) →C/R(2/E) : All stations on deck are ready for main engine trial run. (7) C/R(2/E) →W/H(3/O) : All right, deck department is ready for the trial run. (8) C/R(1/E) →C/R(C/E) : Chief Engineer, all stations are ready. Can we proceed? I'll go to the engine side to check the replaced fuel injection valves. (9) C/R(C/E) →C/R(1/E) : O.K. Go ahead. Second engineer, as we have replaced Number 1 and 3 cylinder fuel injection valves, make the trial a little longer than usual. (10) C/R(2/E) →C/R(C/E) : Yes, sir. I will inform the bridge. (11) C/R(2/E) →W/H(3/O) : From now, we are starting main engine trial run. As we have replaced fuel injection valves, we will make it a little longer than usual. (12) W/H(3/O) →C/R(2/E) : All right. Bridge (13) W/H (3/O): Captain, the main engine trial run is now starting. As fuel injection valves were replaced, we will make the trial a little longer than usual. (14) W/H (Capt) : All right, Third officer, inform each station on deck that trial run will be a little longer than usual.	8：Main engine trial run The members of deck department need to be stationed to take necessary measures such as loosening of mooring lines, paying attention to the sea around the stern part of the hull and others because the hull moves a little with a rotation of the propeller during the main engine trial run. Checking of main engine fuel injection valve During main engine trial run after replacing fuel injection valve, it is necessary to make sure if there are oil leak, gas leak and flame of combustion by opening the indicator valve, and to confirm sound of injection over the replaced injection valve. For this reason, it takes a little longer time than usual.

8	(15) W/H (3/O) : Yes, sir. (16) W/H (3/O)→Each station on deck : The main engine trial will begin soon. Having replaced fuel injection valves in this port, the trial run will be a little longer than usual. Each station, do you copy? (17) W/H (Speaker): This is forward station, we copy. This is aft station, we copy.	
9	**(Sharing information when conducting main engine trail run)** When conducting main engine trial run, the deck station was informed that the engine trial would be longer than usual. Although this seems to be only a simple communication, it is a very important sharing of information. Next, let's watch the scene of approaching the harbor limit, leaving the port after main engine trail run.	9： Narrative interpretation on main engine trial run.
10	Control room (1) W/H (3/O) →C/R (2/E) : We have 1 mile left to the harbor limit. Finished using bow thruster and deck machinery. (2) C/R (2/E) →W/H (3/O) : All right, 1 mile to the harbor limit. Finished using bow thruster and deck machinery. (3) C/R (1/E) →E/R : 1 mile to the harbor limit. Finished using bow thruster and deck machinery. Both now switched off. (4) E/R (3/E)→C/R : All right, 1 mile to the harbor limit. Finished using bow thruster and deck machinery. And no problem found with the replaced bearing of Number 1 main cooling sea water pump and running condition of Number 1 LO purifier is in good order. (5) C/R (1/E) →E/R : All right, but too early to make a judgment on the running condition, since only 15 minutes has passed after changing the pump to Number 1. Pay attention continuously to the bearings. (6) E/R (3/E) →C/R : Yes, Certainly. (7) C/R (C/E) →C/R (1/E) : First engineer, we cannot find anything about the running sound of the bearings and the vibration of LO purifier on the monitor. Having done the maintenance works, the third engineer reported it. That was good of him. (8) C/R (1/E) →C/R (C/E) : Yes, I think so. Telegraph gong rings	10：From harbor limit to state of navigation. Main cooling sea water pump/ motor bearing Pump/motor bearing is a ball bearing and pump/motor axle rotates approximately at 2,000 min^{-1}. If the fitting condition is in something wrong, it will generate abnormal heat/vibration. Therefore, after renewing ball bearing, careful check is necessary. Running condition of LO purifier LO purifier is a centrifugal separator and it rotates approximately at 7,000 min^{-1}. Therefore, when starting purifier after maintenance, careful attention is necessary to make sure if there is no abnormal vibration caused by unbalance force of bowl assembly. Excess vibration likely results in serious

10	Slow ahead engine→Half ahead engine (9) C/R (2/E): Half ahead engine. (10) C/R (1/E) →E/R : Half ahead engine, opening the damper of exhaust gas economizer. (11) E/R (3/E) →C/R : All right, the damper of exhaust gas economizer is opening. (12) E/R (Oiler Sato) →3/E : (Sign) Damper, O.K. (13) E/R (3/E) →Sato : (Sign) All right (14) E/R (3/E) →C/R : I have confirmed the damper opened and that the bypass was closed. (15) C/R (1/E) →E/R : All right. (16) C/R (C/E) →C/R (1/E) : As far as I can monitor, the fuel injection valves of the main engine are good. (17) C/R (1/E) →C/R (C/E) : Yes, Number one would report to us if something was wrong as he is watching the valves. I'll ask him in any case. (18) C/R (1/E) →E/R : Report if something's wrong like an oil or gas leak from Number 1 and 3 cylinder fuel valves on the main engine. (19) E/R (No. 1 Oiler)→E/R(3/E) : (Sign) No problem (20) E/R(3/E) → E/R (No. 1 Oiler) : (Sign) All right (21) E/R (3/E) →C/R : No oil leak, gas leak or any other problem found. (22) C/R (1/E) →E/R : All right. Telegraph gong rings : Half ahead engine →Full ahead engine (23) C/R (2/E) : Full ahead engine (24) C/R (1/E) →E/R : Full ahead engine (25) E/R (3/E) →C/R : First engineer, is it okay to start the ejector pump in preparation for starting the fresh water generator? (26) C/R (1/E) →E/R : All right, start the ejector pump. (27) E/R (3/E) →C/R : Thank you, I will.	accident.

10	(28) E/R (3/E) →E/R (Oiler Mr. Sato) : Mr. Sato, Let's start the pump. (29) E/R (Oiler Mr. Sato) →E/R ((3/E) : All right. Starting ejector pump by Oiler Sato & checking SW Pump by 3/E (30) E/R (Oiler Mr. Sato) →E/R ((3/E) : Third engineer, I have started the ejector pump. (31) E/R (3/E) →C/R : Started ejector pump. In addition, no problem found with the motor bearing condition of Number 1 main cooling sea water pump. (32) C/R (1/E) →E/R : All right, stop automatic combustion equipment of auxiliary boiler. (33) E/R (3/E) →C/R : All right, I will stop the combustion equipment. Stopping automatic combustion equipment (34) W/H (W/O)→C/R(2/E) : Full Away engine will soon be ordered. Put steering motors to single running. (35) C/R (2/E)→W/H (W/O) : All right, Full Away engine will be soon. Steering motors to single running. (36) C/R (1/E) →E/R : Full Away engine will be soon. Steering motors to single running. Telegraph gong rings : Full ahead engine →Full Away engine (37) C/R (2/E): Full Away engine. (38) C/R (1/E) →E/R : Full Away engine (39) C/R (2/E): I am making Number 1 generator single running. (40) C/R (1/E) →E/R : Put main air compressors into single running. Number 1 generator is now single running. Stop Number 2 generator at the engine side, looking at the exhaust gas temperatures. (41) E/R(3/E) →C/R : All right, main air compressor is single running, I will stop Number 2 generator accordingly. Stopped the combustion equipment of auxiliary boiler. (42) C/R (1/E) →E/R : All right, the auxiliary boiler stopped. Main air compressor single running	Ejector pump In case of generating fresh water by vacuum evaporation of sea water, vacuum inside fresh water generator is established by ejector pump

10	(43) E/R (3/E) →C/R : I put main air compressors into Number 1 single running. (44) C/R (1/E) →E/R : All right, Number 1 main air compressor is single running. Generator room, preparation for stand-by (45) E/R (3/E) →C/R : I stopped Number 2 generator and completed the preparation for stand-by. (46) C/R (1/E) →C/R (C/E) : Chief engineer, can we start usual watch shift? (47) C/R (C/E) →C/R (1/E) : O.K. (48) C/R (1/E) →E/R : All right, engine room station, Number 2 generator is about to be set to first stand-by. (49) C/R (2/E): I am setting Number 2 generator to first stand-by. (50) C/R (1/E) →E/R : Subsequent procedures will be done by the watch personnel. Today we have manned watch shift. Dismissed. 3/E and Oiler Sato entered the control room (51) C/R (3/E): No problem with the machinery. (52) C/R (C/E) →C/R (1/E, 2/E) : As 15 knots is planned for this voyage, we should set revolution speed to 130 revolutions per minute and blade angle to 20 degree. (53) C/R (1/E) →C/R (C/E) : Yes, sir. Third engineer, takes over. (54) C/R (3/E) →C/R (1/E) : I will have a good look around while increasing the engine speed. (55) C/R (C/E) →C/R (Sato) : Are you OK? Thanks for takeover. Third engineer looks around engine room (56) E/R (3/E) : There is a little accumulation of fuel oil in the fuel oil leakage pan. 3/E→C/E（Telephone） Telephone rings (57) C/E's room (C/E)→C/R (3/E) : Yes, Chief Engineer. (58) C/R (3/E) →C/E's room (C/E)	

10	: This is third engineer. I found accumulation of fuel oil in the fuel oil leakage pan of Number 3 cylinder on the main engine. So far, there's been no oil leak like this, so it's probably from its high pressure fuel pipes. (59) C/E's room (C/E)→C/R (3/E) : The fitting of the high pressure fuel pipes was likely not good since it is unlikely that the high pressure fuel pipe is broken. Make sure that there is no oil leak falling on the surface of an exhaust gas pipe or any other high temperature surface such as a cylinder head. There was an incident where leaking oil fell on the exhaust manifold resulting in an engine room fire. (60) C/R (3/E) →C/E's room (C/E) : When I looked around, there was no oil leak like that. (61) C/E's room (C/E)→C/R (3/E) : O.K. So, I will come to the control room and you can confirm whether the leak is from fore or aft. I will communicate to first engineer and you communicate to the bridge telling them the situation and that there is a possibility that we may need to stop the main engine. (62) C/R (3/E) →C/E's room (C/E) : Yes, understood. (63) C/R (3/E) →W/H (W/O) : This is the third engineer on duty. I have found an oil leak from the fuel injection valves on the main engine. I will confirm from which valve the oil leak is coming. So we may need to stop the main engine according to the circumstances. (64) W/H (W/O)→C/R (3/E) : All right. I will report it to Captain. (65) C/R(3/E) →C/R (Oiler, Mr. Sato) : First, I will make sure whether the leak is from fore or aft of Number 3 cylinder. I think I can determine where the leak is coming from looking at the oil pan carefully. Mr. Sato you stay here in the control room as someone may call us. (66) C/R (Oiler, Mr. Sato)→C/R (3/Ｅ) : O.K. Probably, you can see a marking by looking at the surface of each pipe. Engine room (Number 3 cylinder oil leak pan) (67) E/R (3/E)：It must be the aft high pressure fuel pipe. (68) C/R (3/E) →C/R (C/E, 1/E) : It's the aft side high pressure pipe. I found oil drops from the pipe. (69) C/R (C/E) →C/R (1/E, 3/E) : As engine load rises, oil leak will increase. It will be better to stop the main engine rather than cutting the fuel oil to Number 3 cylinder. (70) C/R (1/E) →C/R (C/E, 3/E) ; Yes, I think so too. It's not too late to stop the main engine soon.	Fuel oil high pressure pipe Fuel oil high pressure pipe is a pipe connecting fuel injection valve and fuel injection pump. As injection pressure is very high, heavy wall pipe is used for the high pressure pipe. In addition, oil leak from the pipe is so dangerous that the high pressure pipe becomes a double pipe wearing a casing pipe. For this reason, if oil leak happens in case that the high pressure pipe broke or fitting of the pipe was wrong, the leaked oil will be collected in the leaked oil tank after going through the hollow portion of the high pressure pipe and pipeline leading to the tank.

10	Maybe, it would be O.K, if we remove the pipe and refit it to Number 3 cylinder. (71) C/R (C/E) →C/R (1/E, 3/E) : Then, let's do that. I will talk to Captain. (72) C/R (C/E) →W/H (Capt) : This is Chief Engineer. Can I speak to Captain? (73) W/H (W/O) →C/R (C/E) : Please hold the line for a moment. (74) W/H (Capt)→C/R (C/E) : Yes, speaking. (75) C/R (C/E) →W/H (Capt) : There is oil leak from the aft high pressure fuel pipe of Number 3 cylinder on the main engine. It is only a small leak at the moment, but it will likely increase from now on. I would like to stop the main engine and refit the high pressure pipe. Is that possible? (76) W/H (Capt)→C/R (C/E) : We are now in the fairway, so we will go another 1 mile, leaving the route and make for a temporary anchorage. How many hours will it take to complete the work? (77) C/R (C/E) →W/H (Capt) : About half an hour after stopping the main engine. (78) W/H (Capt)→C/R (C/E) : All right. I will alter the course now.	Main engine running by cutting fuel oil to a certain cylinder Continuous running of diesel engine by cutting fuel oil to a certain cylinder is one of emergency operations and it is carried out in case of that stopping main engine is inappropriate or that they cannot stop engine when repair is necessary.
11	**(Importance of machinery rounds)** You have watched the scene of getting to Full Away on passage from the situation approaching the harbor limit after having left the port. Full Away engine was ordered and the ship was at Full Away on passage, but the ship was temporarily anchored after going ahead 1 mile due to the oil leak from the fuel oil high pressure pipe of the replaced fuel oil injection valve. The oil leak was found by the third engineer while on engine room rounds. The leaked oil goes to the leaked oil tank from the oil pan and an alarm will sound when the leaked oil level rises to a certain level. However, the ship must be under way at Full Away speed when the alarm sounds, therefore it took a longer time to stop the main engine. In the engine room there is a lot of information from the machinery that we cannot get from the monitoring systems in the control room. It is very important to find the information and to address a situation before an alarm sounds. For this reason, you can easily understand that engine room rounds are essential. **(Communication)** Now, the third engineer turned his attention to the renewed motor bearings of Number 1 main cooling sea water pump and the LO purifier on which periodical maintenance had been done. Regarding the running condition of the bearings, the first engineer stated that only 15 minutes running was too short to judge if it was running	11 : Narrative interpretation on the scene from the harbor limit to the state of navigation.

	okay, responding to the third engineer's report. It would have been better if he had justified his report, thereby sharing information and maintaining effective communication.	
11	**(Prioritization)** In addition, the third engineer decided to start the ejector pump for the fresh water generator early in preparation for sea passage. He made this decision because he knew that it took a long time to establish a vacuum inside the fresh water generator. This decision represents his proper prioritization. **(Utilization of information)** Next, regarding the phone call from the third engineer reporting oil leak, the Chief Engineer made sure that there was no oil leak on the exhaust pipes and around the cylinder heads of the main engine, making reference to a previous incident of oil leaking onto a hot surface that led to an engine room fire. It is very convincing and effective that the Chief Engineer explains things by using his experiential knowledge and information to foster the skills of correct prioritization of resources and maintaining situational awareness within his team members. **(The incident of engine room fire)** So let's explain the incident which the Chief Engineer used as an example. It was caused by oil leaking from around a nipple of a fuel oil pipe that was broken because of vibration. The oil fell onto the surface of a hot exhaust pipe and started a fire, which then spread throughout the engine room. In this case, two issues were pointed out as problem areas. One was that although the watch engineer found the oil leak around the crankcase of the main engine, he didn't inform the Chief Engineer of it immediately and the other was that although the Chief Engineer was informed of the oil leak by the watch officer on the bridge, he didn't issue appropriate instructions such as stopping the FO booster pump, thinking that the watch engineer was familiar with handling the main engine. **(Communication with bridge)** The scene you had watched so far was slightly different from actual situations, but the exchanges of information between the bridge and the control room were considered to be the minimum extent of communication when practicing ERM. The information was transmitted to the engine room and all the personnel could become fully aware of the ship's situation. Such information enables all personnel in the engine room to work as a team when in operating machinery and to maintain their motivation.	

11	**(Maintaining safe navigation)** Now, everyone should understand that safe navigation cannot be achieved only by the technical skills necessary to operate and maintain machinery. In order to ensure the safe navigation of the ship, it is necessary for all personnel to utilize in collaboration their technical skills and non-technical skills represented by communication. It can be also said that ERM is the competence necessary to collaborate and to utilize technical and non technical skills. We hope that the lessons learned through this DVD will contribute to your safe navigation. END	

5. Background of the amendment to the STCW Convention

International Maritime Organization (IMO) resolved the necessity of amending the STCW Convention and the Code at STW 37 held in January, 2006 and embarked on the actual work to amend the Convention at STW 38 held in January, 2007. Since then, STW meeting was held five times including two intercessional meetings to discuss the issue and finalized the draft amendment to the Convention at STW 41 held in January, 2010. This draft amendment was adopted at the diplomatic conference held in Manila in June, 2010. As the result, this amendment is entered into force in January, 2012 and five years later from 2012, the amendment is fully implemented in January, 2017.

6. Background and process of making ERM mandatory

In June, 2006, IMO-Flag State Implementation Committee analyzed the outcome of investigation of the causes into seventy five casualties and identified that;

6.1 a high number of casualties were attributed to poor bridge resource management (BRM) practices, and stressed that;

6.2 the importance of BRM training and that the need to adopt BRM principles in the work place scenario was imperative.

Singapore invited MSC to instruct STW Sub-Committee to consider the issue of making key elements of BRM training mandatory. MSC agreed to refer Singapore's proposal to the STW Sub-Committee for detailed consideration. STW 38 held in January, 2007 considered the proposals concerned and agreed that there was a need to develop the key elements of BRM/ERM as mandatory requirements. Based on the agreement, Singapore, Japan and others submitted specified proposals to include BRM/ERM as mandatory requirements and through the discussion, the Sub-Committee agreed that;

6.3 BRM/ERM should be introduced as a requirement for the competence "Maintain a safe navigational (engineering) watch", but not as a new competence.

6.3 BRM and ERM should be considered to be the same in the level of requirement and to be arranged in a same manner.

6.4 BRM/ERM should be introduced only into the operational level.

6.5 Communication, leadership and situational awareness should be taken into account in developing the requirements.

In this context, the drafting group was organized at the first intercessional working group held in September, 2008 and a consolidating draft including these agreements was developed and it was approved as the

draft amendment by the STW Sub-Committee.

On the other hand, the United States proposed moving section B-VIII/2, part 3-1, paragraphs 4 and 5 (bridge resource management principles) to section A-VIII/2, part 3, expressing a view point that weakness in bridge management had been cited as a major cause for marine casualties worldwide and that BRM instruction would provide officers with the skills, such as teamwork, teambuilding, communication, leadership, decision-making and resource management. This proposal was agreed with ERM principles to be moved as well. After that, Australia, Japan, Singapore, the United States and IMarEST submitted a proposal to move the BRM/ERM principles to section A, integrating BRM and ERM principles. This proposal was approved and adopted as a draft amendment to the Convention at the STW 40 held in January, 2009.

7. The competence table of ERM in the amendment to STCW Convention, 2010.

(Extract from the competence Table A-Ⅲ/1 in ChapterⅢ(Engine Department) of the STCW Code)

Table A-III/1

Specification of minimum standard of competence for officers in charge of an engineering watch in a manned engine-room or designated duty engineers in a periodically unmanned engine-room

Function: Marine engineering at the operational level

Column 1	**Column 2**	**Column 3**	**Column 4**
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating Competence**	**Criteria for evaluating competence**
Maintain a safe engineering watch	*Engine-room resource management* Knowledge of engine-room resource management principles, including: .1 allocation, assignment, and prioritization of resources .2 effective communication .3 assertiveness and leadership .4 obtaining and maintaining situational awareness .5 consideration of team experience	Assessment of evidence obtained from one or more of the following: .1 approved training .2 approved in-service experience .3 approved simulator Training	Resources are allocated and assigned as needed in correct priority to perform necessary tasks Communication is clearly and unambiguously given and received Questionable decisions and/or actions result in appropriate challenge and response Effective leadership behaviors are identified Team member(s) share accurate understanding of current and predicted engine-room and associated systems state, and of external environment

7.1 Column 3 of the competence table (Methods for demonstrating competence)

In column 3 “Methods for demonstrating competence” of the competence table, the followings are stipulated;

.1.1 approved training

.1.2 approved in-service experience

.1.3 approved simulator training

With regard to the method of “approved in-service experience”, it was debatable for the idea that ERM training during in-service experience was unrealistic since ERM training cannot be available unless in a group of more than several persons. However, it has remained in the column for the possibility of setting up the situation for ERM training in a group of more than several persons.

Regarding the method of “approved simulator training, it is imperative to establish training objectives, and a training program to meet these objectives and methods of evaluation. The requirements for ERM are non-technical skills and as such personality, culture and even personal consciousness often affect the practice of ERM. Careful consideration needs to be given when developing training programme to ensure that all of the competencies required for effective ERM can be demonstrated.

7.2 Column 4 of the competence table (Criteria for evaluating competence)

With regard to “Resources are allocated and assigned as needed” as a criteria for evaluating competence, it can be considered that general arrangement appropriate has been established, however a diversity of personnel arrangement upon sort of ships should be reflected in developing the criteria. Regarding “Communication”, “Questionable decision and/or actions” and “Effective leadership”, developing objective criteria is often difficult and also an evaluator’s subjective view is often reflected in the criteria. Therefore, it is appropriate to set up criteria that at least meet the standards required, taking into account these factors.

Then, regarding “Accurate understanding of current and predicted engine-room and associated systems state, and of external environment”, quantitative and qualitative criteria on training programme should be developed.

8. ERM principles after the amendment in 2010

ERM principles were introduced into Chapter Ⅷ of section B in the STCW Code as a recommended guideline in 2006. This guideline was almost the same as BRM principles that were introduced in 1995 and BRM and ERM principles were integrated into nine principles as mandatory requirements as follows.

Section A-Ⅷ/2 of the STCW Code

PART 3 . WATCHKEEPING PRINCIPLES IN GENERAL

8 Watches shall be carried out based on the following bridge and engine-room resource management principles:

.1 proper arrangements for watchkeeping personnel shall be ensured in accordance with the situations;

.2 any limitation in qualifications or fitness of individuals shall be taken into account when deploying watchkeeping personnel;

.3 understanding of watchkeeping personnel regarding their individual roles, responsibility and team roles shall be established;

.4 the master, chief engineer officer and officer in charge of watch duties shall maintain a proper watch, making the most effective use of the resources available such as information, installations/equipment and other personnel;

.5 watchkeeping personnel shall understand functions and operation of installations/equipment, and be familiar with handling them;

.6 watchkeeping personnel shall understand information and how to respond to information from each station/installation/equipment;

.7 information from the stations/installations/equipment shall be appropriately shared by all the watchkeeping personnel;

.8 watchkeeping personnel shall maintain an exchange of appropriate communication in any situation; and

.9 watchkeeping personnel shall notify the master/chief engineer officer/officer in charge of watch duties without any hesitation when in any doubt as to what action to take in the interest of safety.

The following shows purports of nine BRM/ERM principles

BRM/ERM principles to maintain watchkeeping

1. Ensuring proper arrangements of personnel
2. Consideration of any limitation in qualification or fitness
3. Understanding of roles, responsibility and team roles

4. Utilizing information, equipment and personnel
5. Understanding of functions and operation of equipment
6. Understanding information and how to respond to information
7. Sharing information
8. Maintaining an exchange of appropriate communication
9. Notifying any doubt

(Reference: ERM principles before the amendment)

Section B-Ⅷ/2

Engine-room resource management

8-1 Companies should issue guidance on proper engine-room procedures and promote the use of check lists appropriate to each ship, taking into account national and international guidance.

8-2 Companies should also issue guidance to chief engineers and officers in charge of the engineering watch, manned or unmanned, on each ship concerning the need for continuously reassessing how engineering watch resources are being allocated and used based on engine-room resource management principles such as the following:

.1 a sufficient number of qualified individuals should be on watch to ensure all duties can be performed effectively;

.2 all members of the engineering watch should be appropriately qualified and fit to perform their duties efficiently and effectively or the officer in charge of the engineering watch should take into account any limitation in qualifications or fitness of the individuals available when making engineering and operational decisions;

.3 duties should be clearly and unambiguously assigned to specific individuals, who should confirm that they understand their responsibilities;

.4 tasks should be performed in a clear order of priority;

.5 no member of the engineering watch should be assigned more duties or more difficult tasks than can be performed effectively;

.6 individuals should be assigned at all times to locations at which they can most efficiently and effectively perform their duties, and individuals should be reassigned to other locations as circumstances may require;

.7 members of the engineering watch should not be assigned to different tasks or locations until the officer in charge of the engineering watch is certain that adjustments can be accomplished efficiently and effectively;

.8 instruments and equipment considered necessary for effective performance of duties should be readily available to appropriate members of the engineering watch;

.9 communications among members of the engineering watch and between members of the engineering and navigational watches should be clear, immediate, reliable and relevant to the business at hand;

.10 non-essential activity and distractions should be avoided, suppressed or removed;

.11 all engine-room equipment should be operating properly and, if not, the officer in charge of the engineering watch should take into account any malfunction or inoperable equipment due to maintenance, which may exist when making operational decisions;

.12 all essential information should be collected, processed and interpreted and made conveniently available to all for the performance of their duties;

.13 non-essential materials should not be placed so as to hinder engine-room operations;

.14 members of the engineering watch should at all times be prepared to respond efficiently and effectively to changes in circumstances;

.15 clear and effective data monitoring to identify possible areas of concern in equipment or systems should be ensured so as to prevent breakdowns/accidents/incidents; and

.16 effective methods of cross-checking information, data and indications should be developed to obviate the need for total reliance on any specific type of equipment, system or component.