INTERNATIONAL MARITIME ORGANIZATION

E

SUB-COMMITTEE ON HUMAN ELEMENT, TRAINING AND WATCHKEEPING
2nd session
Agenda item 3

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VALIDATION OF MODEL TRAINING COURSES

Model Course – Advanced Training for Liquefied Gas Tanker Cargo Operations

Note by the Secretariat

SUMMARY

Executive summary:	This document provides the draft of a revised model course on Advanced Training for Liquefied Gas Tanker Cargo Operations
Strategic direction:	5.2
High-level action:	5.2.2
Planned output:	5.2.2.5
Action to be taken:	Paragraph 3
Related documents:	STW 40/14 and HTW 1/3/6

1 Attached in the annex is a revised draft model course on Advanced Training for Liquefied Gas Cargo Operations.

2 As instructed by the Sub-Committee at its first session, this model course was referred to the correspondence group for further revision, to reflect closely the requirements of the 2010 Manila Amendments.

Action requested of the Sub-Committee

3 The Sub-Committee is invited to consider the above information and take action, as appropriate.

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IMO WORLD MARITIME DAY 2014 CONVENTIONS EFFECTIVE IMPLEMENTATION

ANNEX

DRAFT IMO MODEL COURSE ON ADVANCED TRAINING FOR LIQUEFIED GAS TANKER CARGO OPERATIONS

MODEL COURSE 1.05

ADVANCED TRAINING FOR LIQUEFIED GAS TANKER CARGO OPERATIONS

ACKNOWLEDGEMENTS

This course for Advanced Training for Liquefied Gas Tanker Cargo operations is based on material developed by Anglo Eastern Maritime Training Centre, Mumbai for IMO.

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Contents

		Page
Introduction		4
Part A	**Course Framework**	8
Part B	**Course Outline**	29
Part C	**Detailed Teaching Syllabus**	40
Part D	**Instructor's Manual**	146
	• Appendix-1 (Appended Diagram)	264
	• Appendix-2 (Exercises)	375
	• Case Study-1	400
	• Case Study-2	402
Part E	**Evaluation**	403

Introduction

■ Purpose of the model courses

The purpose of the IMO model courses is to assist maritime training institutes and their teaching staff in organizing and introducing new training courses, or in enhancing, updating or supplementing existing training material where the quality and effectiveness of the training courses may thereby be improved. The purpose is also to enhance the capabilities of shipboard personnel who sail on specialized carriers such as liquefied gas tankers. It is not the intention of the course to compartmentalize the trainee's way of thinking in terms of tanker operation. The idea is to make him/her aware of the specialization of operations specific to a liquefied gas tanker and, sensitize him/her towards the responsibilities that s/he will face on such a vessel.

It is not the intention of the model course programme to present instructors with a rigid "teaching package" which they are expected to "follow blindly". Nor is it the intention to substitute audio-visual or "programmed" material for the instructor's presence. Rather, this document should be used as a guide with the course duration given as indicative of the expected time required to cover the required outcomes. The parties may modify this course to suit their respective training schemes.

As in all training endeavors, the knowledge, skills and dedication of the instructors are the key components in the transfer of knowledge and skills to those being trained through IMO model course material.

Because educational systems and the cultural backgrounds of trainees in maritime subjects vary considerably from country to country, the model course material has been designed to identify the basic entry requirements and trainee target group for each course in universally applicable terms, and to specify clearly the technical content and levels of knowledge and skills necessary to meet the technical intent of IMO conventions and related recommendations.

This course is for Masters, chief engineer officers, chief mates, second engineer officers and any person with immediate responsibility for loading, discharging , care in transit, handling of cargo, tank cleaning or other cargo related operations on liquefied gas tankers. By successfully doing this course, the aforementioned shipboard personnel will fulfill the mandatory minimum requirements of Regulation V/1-2 paragraph 3 of STCW 1978, as amended. The coverage of the model course is wide in scope and includes liquefied gas tanker safety, fire safety measures and systems, prevention and control of pollution, operational practice and obligations under applicable laws and regulations, thereby covering all the training necessary. In addition the course covers the managerial aspects on board including a section on risk assessment and safety management as well as contingency planning in line with the ISM Code.

In order to keep the training programme up to date in future, it is essential that users provide feedback. New information will provide better training in safety at sea and protection of the marine environment. Information, comments and suggestions should be sent to the Head of the STCW and Human Element Section at IMO, London.

■ Use of the model course

The instructor should review the course plan and detailed syllabus, taking into account the information provided under the entry standards specified in the course framework. The actual level of knowledge and skills and the prior technical education of the trainees should be kept in mind during the review, and any areas within the detailed syllabus which may cause difficulties because of differences between the actual trainee entry level and that assumed by the course designers should be identified. To compensate for such differences, the instructor is expected to delete from the course, or to reduce the emphasis on, items dealing with knowledge or skills already attained by the trainees. S/he should also identify any academic knowledge, skills or technical training which they may not have acquired.

The instructor, using his/her professional judgment, can analyze the detailed syllabus and the academic knowledge required to allow training in the technical area to proceed. The instructor can then design the appropriate pre-entry course or alternatively, insert the elements of academic knowledge required to support the technical training elements concerned at appropriate points within the course.

This course is designed to satisfy the requirements of the STCW convention including the 2010 Manila amendments and builds upon the knowledge and skills already included in the IMO Model course 1.04 – "Basic training for liquefied gas tanker cargo operations". The instructor notes and diagrams in the basic course may also be utilised in the preparation of presentation material for the advanced training in liquefied gas tanker operations course.

Within the course plan the course designers have indicated assessment of the time which should be allotted to each area of learning. However, it must be appreciated that these allocations are arbitrary and assume that the trainees have fully met all entry requirements of the course. The instructor should therefore review these assessments and may need to reallocate the time required to achieve each specific learning objective or training outcome.

■ Aims

This course provides training to candidates to be duly qualified under Section A – V/1-2 of the STCW code with specific duties and responsibilities related to cargo or cargo equipment on liquefied gas tankers. It comprises a basic training programme appropriate to their duties, including basic training for liquefied gas tanker safety, fire safety measures, pollution prevention, operational practice and obligations under applicable law and regulations. The course covers the competence requirements as given in the table A-V/1-2-1 of the STCW Code adopted by the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, as amended in 2010.

Any of this training may be given on board or ashore. It could be either by practical instruction on board or in a suitable shore-based installation.

This course comprises of advanced level training for liquefied gas tanker cargo operations.

The course involves:

1. Knowledge of liquefied gas tanker design, systems, and equipment.
2. Knowledge of pump theory and characteristics, including types of cargo pumps and their safe operation
3. Knowledge of the effect of bulk liquid cargoes on trim and stability and structural integrity
4. Proficiency in tanker safety culture and implementation of safety management requirements
5. Proficiency to apply safe preparations, procedures and checklists for all cargo operations
6. Proficiency to perform cargo measurements and calculations,
7. Proficiency to manage and supervise personnel with cargo related responsibilities
8. Knowledge and understanding of basic chemistry and physics and the relevant definitions related to the safe carriage of liquefied gases in bulk in ships.
9. Understanding the information contained in a Material Safety Data Sheet (MSDS)
10. Knowledge and understanding of the hazards and control measures associated with liquefied gas tanker cargo operations.
11. Proficiency to calibrate and use monitoring and gas-detection systems, instruments and equipment
12. Knowledge and understanding of dangers of non-compliance with relevant rules/regulations
13. Knowledge and understanding of safe working practices, including risk assessment and personal shipboard safety relevant to liquefied gas tankers.
14. Knowledge and understanding of liquefied gas tanker emergency procedures.
15. Actions to be taken following collision, grounding or spillage and envelopment of the ship in toxic or flammable vapour
16. Knowledge of medical first-aid procedures and antidotes on board liquefied gas tankers, with reference to the Medical First Aid Guide for Use in Accidents involving Dangerous Goods (MFAG)
17. Understanding of procedures to prevent pollution of the environment
18. Knowledge and understanding of relevant provisions of the International Convention for the Prevention of Pollution from Ships (MARPOL) and other relevant IMO instruments, industry guidelines and port regulations as commonly applied
19. Proficiency in the use of the IBC and IGC Codes and related documents

Instructors should emphasize in their teaching, the hazards involved in the operations on liquefied gas tankers. They should explain, in as much detail as is necessary to ensure these operations are undertaken safely, the systems, equipment and constructional features that exist to control those hazards.

The idea is to help the trainees develop a proactive attitude on how to develop a safety culture and act accordingly.

■ Lesson plans

The detailed syllabus contains specific references to the textbooks or teaching material proposed to be used in the course. Where no adjustment has been found necessary in the acquisition of knowledge and proficiency of the detailed syllabus, the lesson plans may simply consist of the detailed syllabus with keywords or other reminders added to assist the instructor in making his/her presentation of the material.

■ Presentation

The presentation of concepts and methodologies must be repeated in various ways by assessing and evaluating the trainee's performance and achievements until the instructor is satisfied that the trainee has attained the required proficiency under each specific learning objective or training objective. The syllabus is laid out in the form of acquiring knowledge, understanding and proficiency format and each objective specifies that the trainee must know or be able to do as the learning or training outcome. Holistically, these objectives aim to meet the knowledge, understanding and proficiency specified in the appropriate tables of the STCW Code.

■ Implementation

For the course, to run smoothly and to be effective, considerable attention must be paid to the availability and use of:

- Properly qualified instructors
- Support staff
- Rooms and other spaces
- Equipments
- Textbooks, technical papers, and
- Other reference material

Thorough preparation on part of the instructor is the key to successful implementation of the course. IMO has produced a booklet entitled "Guidance on the Implementation of IMO Model Courses", which deals with this aspect in greater detail and which is appended to this model course.

In certain cases, the requirements for some or all of the training in a subject are covered by another IMO model course. In these cases, the specific part of the STCW Code which applies is given and the user is referred to the other model course.

Part A: Course Framework

■ Scope

This course provides training for Masters, chief engineer officers, chief mates, second engineer officers and any person with immediate responsibility for loading, unloading, care in transit, handling of cargo, tank cleaning or other cargo related operations on liquefied gas tankers. It comprises an advanced training programme appropriate to their duties on liquefied gas tankers for their ability to imbibe a safety culture to perform and monitor all cargo operations, familiarity with properties of liquefied gas cargoes, take precautions to prevent hazards, apply health and safety precautions, respond to emergencies fire safety measures, take precautions to prevent pollution of the environment, and monitor and control compliance with legislative requirements. The course takes full account of Regulation A-V/1-2 para 3 of the STCW Code adopted by the International Convention on Standards of Training, Certification and Watch keeping for Seafarers as amended.

This training may be given on board or ashore. It can be supplemented by practical training on board or wherever possible on simulators in training institutions or in a suitable shore-based installation.

■ Objective

The objective of this course is to meet the training requirements Regulation A-V/1-2 para 2.2 of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, as amended, those successfully completing the Advanced training in liquefied gas tanker cargo operations course should therefore be able to safely perform their duties for loading, unloading and care in transit or handling of cargo on liquefied gas tankers. They will make a safer and more effective contribution to the operation and control of the cargo on liquefied gas tanker, which will improve the ship safety and provide greater protection to the environment in particular.

■ Entry standards

This course is open to any person with immediate responsibility for loading, unloading, care in transit, handling of cargo, tank cleaning or other cargo related operations on liquefied gas tankers. It comprises of seafarers who have qualified in accordance with Regulation V/1-2 para 4 of the International Convention on Standards of Training, Certification and Watch keeping for Seafarers, as amended.

■ Course certificate

All who are qualified in "Advanced training for liquefied gas tanker cargo operations" programme in accordance with Regulation V/1-2 paragraph 3 shall be issued with a course completion certificate.

■ Course intake limitations

It is recommended that the number of trainees should not exceed 20 and practical training should be undertaken in small groups of not more than eight. The teacher to trainee ratio would therefore be 1:20 for classroom teaching and 1:8 for practical instruction.

■ Staff requirements

The instructor shall have appropriate training in instructional techniques and training methods (STCW Code, Section A-I/6, para 7). It is recommended that all training and instruction is given by qualified personnel experienced in the handling and characteristics of liquefied gas cargoes and the safety procedures involved. Staff may be recruited among management level deck and engineer officers of liquefied gas tankers, and / or fleet superintendents as appropriate.

■ Teaching facilities and equipment

Ordinary classroom facilities and an overhead projector are sufficient for most of the Course. However, dedicated CBT modules to be run on an ordinary PC as well as exercises on an operational, hands-on liquid cargo handling simulator, will greatly enhance the quality and result of the course. In such cases, a sufficient number of PCs for use by one or two trainees will be required. In addition, a video player will be required if using videos in the teaching program.

The following equipment should be available:

1. Resuscitator
2. Breathing apparatus
3. Portable oxygen meter
4. Portable combustible-gas detector
5. Portable tankscope / Multi point flammable gas (infra- red gas analyzer)
6. Portable toxic-gas detector and chemical absorption tubes
7. Portable multigas – detector
8. Personal multigas – detector
9. Tank evacuation equipment.

■ Use of Simulators

The revised STCW Convention sets standards regarding the performance and use of simulators for mandatory training, assessment or demonstration of competence. The general performance standards for simulators used in training and for simulators used in assessment of competence are given in Section A-I/12. Simulator based training and assessment is not a mandatory requirement for this "Advanced training for liquefied gas tanker cargo operations" course. However, it is widely recognized that well-designed lessons and exercises can improve the effectiveness of training.

■ Fixed Dry Chemical Powder Fire-Fighting System

To enable the trainees to undergo practical exercises and fire-fighting using fixed DCP systems, a fire-fighting mock-up will be needed to conduct realistic drills of extinguishing a LPG / LNG fire by activating the fixed extinguishing system and using the correct techniques in simulated shipboard conditions to extinguish the fire. A typical fixed DCP fire-fighting installation for carrying out such training is provided in Annex 2.

■ Design

The core technical and academic knowledge, understanding and proficiency are set out in Table A-V/1-2-1 of the STCW as amended in 2010, adopted by IMO as part of the 2010 STCW Convention
To show consistency and adherence to STCW 2010, as given in table A-V/1-2-1, a mapping is provided below for easy reference from STCW's competences and training outcomes to the topics covered in this Model course.

Mapping - Topics in this course with STCW table A-V/1-2-2

Mapping - Topics in this course with STCW table A-V/1-2-2

STCW 2010 Table A-V/1-2-2				IMO Model course 1.05		
S. No	**Competence**	**Knowledge, Understanding and Proficiency**		**S. No**	**Topic**	**Sub-topic**
1	*Ability to safely perform and monitor all cargo operations*	**1.0 Knowledge of liquefied gas tanker design, systems, and equipment, including:** 1.1 Types of liquefied gas tankers and cargo tanks construction 1.2 General arrangement and construction 1.3 Cargo containment systems, including materials of construction and insulation 1.4 Cargo-handling equipment And instrumentation, including: 1.4.1 Cargo pumps and pumping arrangements 1.4.2 Cargo pipelines and Valves		**1**	**Knowledge of liquefied gas tanker design, systems, and equipment**	1.1 Types of liquefied gas tankers and cargo tanks Construction 1.2 General arrangement and construction 1.3 Cargo containment systems, including materials of construction and insulation 1.4 Cargo-handling equipment and instrumentation, 1.4.1 Cargo pumps and pumping arrangements 1.4.2 Cargo pipelines and valves

STCW 2010 Table A-V/1-2-2				IMO Model course 1.05		
S. No	**Competence**	**Knowledge, Understanding and Proficiency**		**S. No**	**Topic**	**Sub-topic**
		1.4.3 Expansion devices 1.4.4 Flame screens 1.4.5 Temperature monitoring Systems 1.4.6 Cargo tank level-gauging systems 1.4.7 Tank pressure monitoring and control system 1.5 Cargo temperature maintenance system 1.6 Tank atmosphere control Systems (inert gas, nitrogen), including storage, generation and distribution systems 1.7 Cofferdam heating systems 1.8 Gas-detecting systems 1.9 Ballast system 1.10 Boil-off systems 1.11 Re-liquefaction systems 1.12 Cargo Emergency Shut				1.4.3 Expansion devices 1.4.4 Flame screens 1.4.5 Temperature monitoring Systems 1.4.6 Cargo tank Level-gauging systems 1.4.7 Tank pressure monitoring and control system 1.5 Cargo temperature maintenance system 1.6 Tank atmosphere control Systems (inert gas, nitrogen), including storage, generation and distribution systems 1.7 Cofferdam heating systems

STCW 2010 Table A-V/1-2-2				IMO Model course 1.05		
S. No	**Competence**	**Knowledge, Understanding and Proficiency**		**S. No**	**Topic**	**Sub-topic**
		Down system (ESD) 1.13 Custody transfer system				1.8 Gas-detecting systems 1.9 Ballast system 1.10 Boil-off systems 1.11 Re-liquefaction systems 1.12 Cargo Emergency Shut Down system (ESD) 1.13 Custody transfer system
		2.0 Knowledge of pump theory and characteristics, including types of cargo pumps and their safe operation		**2**	**Knowledge of pump theory and characteristics, including types of cargo pumps and their safe operation**	
					[DB1]	
		3.0 Knowledge of the effect of bulk liquid cargoes on trim and stability and structural integrity		**3**	**Knowledge of the effect of bulk liquid cargoes on trim and stability and structural integrity**	
		4.0 Proficiency in tanker safety culture and implementation of safety management requirements		**4**	**Proficiency in tanker safety culture and implementation of safety management requirements**	

STCW 2010 Table A-V/1-2-2				IMO Model course 1.05		
S. No	**Competence**	**Knowledge, Understanding and Proficiency**		**S. No**	**Topic**	**Sub-topic**
		5.0 Proficiency to apply safe preparations, procedures and checklists for all cargo operations, including: 5.1 post docking and loading: 5.1.1 tank inspection 5.1.2 inerting (Oxygen reduction, Dew point reduction) 5.1.3 gassing-up 5.1.4 cooling down 5.1.5 loading 5.1.6 deballasting 5.1.7 sampling, including closed-loop sampling 5.2 sea passage: 5.2.1 cooling down 5.2.2 pressure maintenance 5.2.3 boil-off 5.2.4 inhibiting 5.3 unloading: 5.3.1 unloading 5.3.2 ballasting 5.3.3 stripping and cleaning systems 5.3.4 systems to make the		**5**	**Proficiency to apply safe preparations, procedures and checklists for all cargo operations**	5.1 Post docking and loading: 5.1.1 Tank inspection 5.1.2 Inerting (Oxygen reduction, Dew point reduction) 5.1.3 Gassing-up 5.1.4 Cooling down 5.1.5 Loading 5.1.6 Deballasting 5.1.7 Sampling, including closed-loop sampling 5.2 Sea passage: 5.2.1 Cooling down 5.2.2 Pressure maintenance 5.2.3 Boil-off 5.2.4 Inhibiting 5.3 Unloading: 5.3.1 Unloading 5.3.2 Ballasting 5.3.3 Stripping and cleaning systems 5.3.4 Systems to make the tank liquid-free 5.4 Pre-docking preparation:

STCW 2010 Table A-V/1-2-2				IMO Model course 1.05		
S. No	**Competence**	**Knowledge, Understanding and Proficiency**		**S. No**	**Topic**	**Sub-topic**
		tank liquid-free 5.4 pre-docking preparation: 5.4.1 warm-up 5.4.2 inerting 5.4.3 gas-freeing 5.5 ship-to-ship transfer				5.4.1 Warm-up 5.4.2 Inerting 5.4.3 Gas-freeing 5.5 Ship-to-ship transfer
		6.0 Proficiency to perform cargo measurements and calculations, including: 6.1 liquid phase 6.2 gas phase 6.3 On Board Quantity (OBQ) 6.4 Remain On Board (ROB) 6.5 boil-off cargo calculations		**6**	**Proficiency to perform cargo Measurements and calculations**	6.1 Liquid phase 6.2 Gas phase 6.3 On Board Quantity (OBQ) 6.4 Remain On Board (ROB) 6.5 Boil-off cargo calculations
		7.0 Proficiency to manage and supervise personnel with cargo related responsibilities		**7**	**Proficiency to manage and Supervise personnel with cargo related responsibilities**	

STCW 2010 Table A-V/1-2-2				IMO Model course 1.05		
S. No	**Competence**	**Knowledge, Understanding and Proficiency**		**S. No**	**Topic**	**Sub-topic**
2	*Familiarity with physical and chemical properties of liquefied gas cargoes*	**8.0 Knowledge and understanding of basic chemistry and physics and the relevant definitions related to the safe carriage of liquefied gases in bulk in ships, including:** 11.1 The chemical structure of gases 11.2 The properties and characteristics of liquefied gases (including CO2) and their vapours, including: 8.2.1 Simple gas laws 8.2.2 States of matter 8.2.3 Liquid and vapour densities 8.2.4 Diffusion and mixing of gases 8.2.5 Compression of gases 8.2.6 Re-liquefaction and refrigeration of gases		**8**	**Knowledge and understanding of basic chemistry and physics and the relevant definitions related to the safe carriage of liquefied gases in bulk in ships**	8.1 The chemical structure of gases 8.2 The properties and characteristics of liquefied gases (including CO2) and their vapours, including: 8.2.1 Simple gas laws 8.2.2 States of matter 8.2.3 Liquid and vapour densities 8.2.4 Diffusion and mixing of gases 8.2.5 Compression of gases 8.2.6 Re-liquefaction and refrigeration of gases 8.2.7 Critical temperature of gases and pressure

STCW 2010 Table A-V/1-2-2				IMO Model course 1.05		
S. No	**Competence**	**Knowledge, Understanding and Proficiency**		**S. No**	**Topic**	**Sub-topic**
		8.2.7 Critical temperature of gases and pressure 8.2.8 Flashpoint, upper and lower explosive limits, auto-ignition temperature 8.2.9 Compatibility, reactivity and positive segregation of gases 8.2.10 Polymerization 8.2.11 Saturated vapour pressure/reference temperature 8.2.12 Dew point and bubble point 8.2.13 Lubrication of compressors 8.2.14 Hydrate formation 11.3 The properties of single liquids				8.2.8 Flashpoint, upper and lower explosive limits, auto-ignition temperature 8.2.9 Compatibility, reactivity and positive segregation of gases 8.2.10 Polymerization 8.2.11 Saturated vapour pressure/reference temperature 8.2.12 Dew point and bubble point 8.2.13 Lubrication of compressors 8.2.14 Hydrate formation 8.3 The properties of single

STCW 2010 Table A-V/1-2-2				IMO Model course 1.05		
S. No	**Competence**	**Knowledge, Understanding and Proficiency**		**S. No**	**Topic**	**Sub-topic**
		11.4 The nature and properties of solutions 11.5 Thermodynamic units 11.6 Basic thermodynamic laws and diagrams 11.7 Properties of materials 11.8 Effect of low temperature-brittle fracture				liquids 8.4 The nature and properties of solutions 8.5 Thermodynamic units 8.6 Basic thermodynamic laws and diagrams 8.7 Properties of materials 8.8 Effect of low temperature brittle fracture
		9.0 Understanding the information contained in a Safety Data Sheet (SDS)		**9**	**Understanding the information Contained in a Safety Data Sheet (SDS)**	
3	*Take precautions to prevent hazards*	**10.0 Knowledge and understanding of the hazards and control measures associated with**		**10**	**Knowledge and understanding of the hazards and control**	10.1 Flammability 10.2 Explosion 10.3 Toxicity 10.4 Reactivity

STCW 2010 Table A-V/1-2-2				IMO Model course 1.05		
S. No	**Competence**	**Knowledge, Understanding and Proficiency**		**S. No**	**Topic**	**Sub-topic**
		liquefied gas tanker cargo operations, including: 12.1 Flammability 12.2 Explosion 12.3 Toxicity 12.4 Reactivity 12.5 Corrosivity 12.6 Health hazards 12.7 Inert gas composition 12.8 Electrostatic hazards 12.9 Polymerizing cargoes			**measures associated with liquefied gas tanker cargo operations.**	10.5 Corrosivity 10.6 Health hazards 10.7 Inert gas composition 10.8 Electrostatic hazards 10.9 Polymerizing cargoes
		11.0 Proficiency to calibrate and use monitoring and gas-detection systems, instruments and equipment		**11**	**Proficiency to calibrate and use monitoring and gas-detection systems, instruments and equipment**	
		12.0 Knowledge and understanding of dangers of non-compliance with relevant rules/regulations		**12**	**Knowledge and understanding of dangers of non-compliance with relevant rules/regulations**	

STCW 2010 Table A-V/1-2-2				IMO Model course 1.05		
S. No	**Competence**	**Knowledge, Understanding and Proficiency**		**S. No**	**Topic**	**Sub-topic**
4	*Apply occupational health and safety precautions*	**13.0 Knowledge and understanding of safe working practices, including risk assessment and personal shipboard safety relevant to liquefied gas tankers, including:** 13.1 Precautions to be taken when entering enclosed spaces (such as compressor rooms), including correct use of different types of breathing apparatus. 13.2 Precautions to be taken before and during repairs and maintenance work including work affecting pumping, piping, electrical and control systems 13.3 Precautions for hot and cold work 13.4 Precautions for electrical safety 13.5 Use of appropriate		**13**	**Knowledge and understanding of safe working practices, including risk assessment and personal shipboard safety relevant to liquefied gas tankers**	: 13.1 Precautions to be taken when entering enclosed spaces (such as compressor rooms) including correct use of different types of breathing apparatus 13.2 Precautions to be taken before and during repairs and maintenance work affecting pumping, piping, electrical and control systems 13.3 Precautions for hot and cold work 13.4 Precautions for electrical safety 13.5 Use of appropriate Personal Protective Equipment.(PPE) 13.6 Precautions for cold burn and frostbite 13.7 Proper use of personal toxicity monitoring

STCW 2010 Table A-V/1-2-2				IMO Model course 1.05		
S. No	**Competence**	**Knowledge, Understanding and Proficiency**		**S. No**	**Topic**	**Sub-topic**
		Personal Protective Equipment.(PPE) 13.6 Precautions for cold burn and frostbite 13.7 Proper use of personal toxicity monitoring equipment				equipment
5	*Respond to emergencies*	**14.0 Knowledge and understanding of liquefied gas tanker emergency procedures, including:** 14.1 Ship emergency response plans 14.2 Cargo operations emergency shutdown procedures 14.3 Emergency cargo valve operations 14.4 Actions to be taken in the event of failure of systems or services essential to cargo operations 14.5 Fire fighting on liquefied gas tankers 14.6 Jettisoning of cargo		**14**	**Knowledge and understanding of liquefied gas tanker emergency procedures.**	14.1 Ship emergency response plan 14.2 Cargo operations emergency shutdown procedure 14.3 Emergency cargo valve operations 14.4 Actions to be taken in the event of failure of systems or services essential to cargo operations 14.5 Fire fighting on liquefied gas tankers 14.6 Jettisoning of cargo 14.7 Enclosed space rescue

STCW 2010 Table A-V/1-2-2				IMO Model course 1.05		
S. No	**Competence**	**Knowledge, Understanding and Proficiency**		**S. No**	**Topic**	**Sub-topic**
		14.7 Enclosed space Rescue				
		15.0 Actions to be taken following collision, grounding or spillage and envelopment of the ship in toxic or flammable vapour		**15**	**Actions to be taken following collision, grounding or spillage and envelopment of the ship in toxic or flammable vapour**	
		16.0 Knowledge of medical first-aid procedures and antidotes on board liquefied gas tankers, with reference to the Medical First Aid Guide for Use in Accidents involving Dangerous Goods (MFAG)		**16**	**Knowledge of medical first-aid procedures and antidotes on board liquefied gas tankers, with reference to the Medical First Aid Guide for Use in Accidents involving Dangerous Goods (MFAG)**	
6	*Take precautions to prevent pollution of the environment*	**17.0 Understanding of procedures to prevent pollution of the environment**		**17**	**Understanding of procedures to prevent pollution of the**	

STCW 2010 Table A-V/1-2-2				IMO Model course 1.05		
S. No	**Competence**	**Knowledge, Understanding and Proficiency**		**S. No**	**Topic**	**Sub-topic**
					environment	
7	*Monitor and control compliance with legislative requirements*	**18.0 Knowledge and understanding of relevant provisions of the International Convention for the Prevention of Pollution from Ships (MARPOL) and other relevant IMO instruments, industry guidelines and port regulations as commonly applied**		**18**	**Knowledge and understanding of the relevant provisions of the International Convention for the Prevention of Pollution from Ships (MARPOL) and other relevant IMO instruments, industry guidelines and port regulations as commonly applied**	
		19.0 Proficiency in the use of the IBC and IGC Codes and related documents		**19**	**Proficiency in the use of the IBC and IGC Codes and related documents**	

■ Teaching Aids (A)

Note: - Other equivalent teaching aids may be used as deemed fit by the instructor.

A1 Instructor's Manual (Part D of this course)
A2 Resuscitator
A3 Breathing apparatus
A4 Portable oxygen meter
A5 Portable combustible-gas detector
A6 Portable tankscope / Multi point flammable gas (infra- red gas analyzer)
A7 Portable toxic-gas detector and chemical absorption tubes
A8 Portable multigas – detector
A9 Personal multigas – detector
A10 Tank evacuation equipment.
A11 Overhead projector for power point presentations
A12 Liquefied gas Tanker Cargo and Ballast Water Handling Simulator
A13 White board
A14 Video player

■ IMO references (R)

R1 SOLAS 1974, International Convention for the Safety of Life at Sea, 1974 (SOLAS 1974) Consolidated Edition 2009, (IMO-II0E)
R2 STCW 78 as amended, including 2010 Manila amendments, International Convention on Standards of Training, Certification and Watch keeping for Seafarers,
R3 MARPOL as amended, International Convention for the Prevention of Pollution from Ships, 1973/1978 (MARPOL as amended) Consolidated Edition 2011
R4 IG Systems, Inert Gas Systems (IMO-860E)
R5 Medical First aid guide for use in accidents involving dangerous good (MFAG)
R6 ISM Code, International Safety Management Code (ISM Code) (IMO-117E
R7 International Code for Fire Safety Systems, 2007 Edition, including Supplement 2012

■ Textbooks (T)

Note: - Other textbooks may be used as deemed fit by the instructor.

T1 Safety in Liquefied gas Tankers, International Chamber of Shipping, Safety in Liquefied gas Tankers. (International Chamber of Shipping, Carthusian Court, 12 Carthusian Street, London, ECIM 6EZ, U.K.)

■ Bibliography (B)

B1 International Safety Guide for Liquefied gas Tankers and Terminals. 5th ed. [London, Witherby and Co. Ltd. (32/36 Aylesbury Street, London, EC1 R OET, U.K),1996] (ISBN 1-85609-081-7)

B2 Safe Liquefied Gas Tanker operations, 2011 edition
Capt. K.S.D Mistree and Mr. B K Sharma. - MARINEX Publications. A-3, Silver Queen, Soonawala Agyari marg, Mumbai 445470, India. e-mail: marinez1@hotmail.com Tel: 91 22 24465470

B3 Ship to Ship Transfer Guide (Liquefied Gas), International Chamber of Shipping/Liquefied gas Companies International Marine Forum, Ship to Ship Transfer Guide (Liquefied Gas), 4th ed. (London, Witherby and Co. Ltd., 2005) (ISBN 1-85609-097-3)

B4 Drager-Tube Handbook, Drager-Tube Handbook 11th ed. (Drager Sicherheitstechnik GmbH, Revalstrasse 1, D-23560 Lubeck, Germany, 1998) (ISBN 3-926762-06-3)

B5 Measures to Prevent Accidental Pollution, INTERTANKO, Measures to Prevent Accidental Pollution, 1990

B6 Code of Safe Working Practices, PO Box 29, Norwich, NR3 1GNTelephone orders/General enquiries:0870 600 5522 Fax orders: 0870 600 5533E-mail: customer.services@tso.co.uk Textphone 0870 240 3701

B7 Tanker Management Self-Assessment, Witherby Publications, 32/36 Aylesbury street London. www.witherbys.com ISBN 10: 1905331231 ISBN 13: 9781905331239

B8 Tanker Safety Training (Liquefied Gas) Specialized Level, Witherbys Publishing, Seamanship International I32/36 Aylesbury street London. www.witherbys.com, ISBN-10:1856093417

B9 LPG Shipping Suggested Competency Standards, SIGTTO, Witherbys Seamanship International, Jan 2008 edition (www.witherbys.com)

B10 LNG Shipping Suggested Competency Standards, SIGTTO, Witherbys Seamanship International, 2nd edition, Dec 2008 (www.witherbys.com)

■ Videos - DVDs, CD ROMs, CBT's (VG)

Note: - Other equivalent videos, CD-ROMs, CBT's may be used as deemed fit by the instructor.

For Liquefied gas Tankers VG(x)

VG1 Portable gas detection equipment calibration procedures
Available from: KARCO Website:http://www.karco.in
E-mail ID: karco@karcoservices.com
Contact Person: Capt. Pravesh Diwan
Telephone: 91-22-67101229

VG2 Tanker safety depends on you
Available from: NATIONAL AUDIO VISUAL CENTER
National Technical Information Service
5301 Shawnee Rd, Alexandria
VA 22312
E-mail: orders@ntis.gov

VG3 Operation and maintenance of inert gas systems

VG4 The ship/shore interface

VG5 Tanker practices series

- cargo - part 4 Code No: 504

VG6 Permit to work Code No: 621
VG7 Entry into enclosed spaces (edition 2) Code No: 682
VG8 Personal safety on tankers (edition 2), Code No: 970
VG9 Cargo fire fighting on Liquefied Gas Carriers (Catalogue code 254)
VG10 Vapour emission control Code No: 1118
VG11 Liquefied Gas Fire Hazard Management - Edition 2
Available from: Videotel Marine International
84 Newman Street, London W1T 3EU, UK
Tel: +44(0) 20 72991800
Fax: +44(0) 207299 1818
E-mail: mail@videotelmail.com
URL: www.videotel.co.uk
VG12 Static electricity on board tankers - DVD
Available From: KARCO Website:http://www.karco.in
E-mail ID: karco@karcoservices.com
Contact Person: Capt. Pravesh Diwan
Telephone: 91-22-67101229
VG13 Low temperature insulation on gas carriers (CBT#0099)
VG14 Gas measurement (CBT#0048)
VG15 Gas Tanker Training system, Advanced (CBT#0168)
Available from:

Seagull AS
Gamleveien 36
P.O. Box 1062
N-3194 Horten, Norway
Phone: +47 33 03 09 10
Fax: +47 33 04 62 79
Email: seagull@sgull.com

Part B: Course Outline

■ Lectures

As far as possible lectures should be presented within a familiar context and should make use of practical examples. They should be well illustrated with diagrams, photographs, charts where appropriate, and be related to the matter learned during seagoing time.

An effective manner of presentation is to develop a technique of giving information and then reinforcing it. For example, first tell the trainees briefly what you are going to present to them; then cover the topic in detail; and, finally, summarize what you have told them.

Course Outline

The tables that follow list the competencies and areas of knowledge, understanding and proficiency, together with the estimated total hours required for lectures and practical exercises. Teaching staff should note that timings are suggestions only and should be adapted to suit individual groups of trainees depending on their experience, ability, equipment and staff available for training.

COURSE OUTLINE

	Knowledge, understanding and proficiency	Total hours for lectures	Total hours for practical's
	COMPETENCE 1 - Ability to safely perform and monitor all cargo operations		
1	**Knowledge of liquefied gas tanker design, systems, and equipment**		
	1.1 types of liquefied gas tankers[DB2] and cargo tanks construction	1.0	
	1.2 general arrangement and construction(*)	0.5	1
	1.3 cargo containment systems, including materials of construction and insulation	3	
	1.4 cargo-handling equipment and instrumentation		
	1.4.1 cargo pumps and pumping arrangements	1	0.5
	1.4.2 cargo pipelines and valves(*)		1
	1.4.3 expansion devices	0.5	
	1.4.4 flame screens		
	1.4.5 temperature monitoring systems		
	1.4.6 cargo tank level-gauging systems		
	1.4.7 tank pressure monitoring and control systems	0.25	
	1.5 cargo temperature maintenance system	0.25	
	1.6 tank atmosphere control systems (inert gas, nitrogen), including storage, generation and distribution systems	0.5	
	1.7 cofferdam heating systems	0.5	
	1.8 gas-detecting systems	0.5	
	1.9 ballast system		0.5
	1.10 boil-off systems	0.5	
	1.11 re-liquefaction systems	2	
	1.12 cargo Emergency Shut Down system (ESD)	0.5	
	1.13 custody transfer system	0.5	
2	**Knowledge of pump theory and characteristics, including types of cargo pumps and their safe operation**	3.0	
3	**Knowledge of the effect of bulk liquid cargoes on trim and stability and structural**	1.0	0.5

	Knowledge, understanding and proficiency	Total hours for lectures	Total hours for practical's
	integrity		
4	**Proficiency in tanker safety culture and implementation of safety management requirements**	1.5	
5	**Proficiency to apply safe preparations, procedures and checklists for all cargo operations**		
	5.1 post docking and loading:		
	5.1.1 tank inspection	0.5	
	5.1.2 inerting (Oxygen reduction, dew point reduction) (*)	0.5	0.5
	5.1.3 gassing-up(*)	0.5	0.5
	5.1.4 cooling down(*)	0.5	
	5.1.5 loading(*)	0.5	1
	5.1.6 deballasting(*)	0.5	0.5
	5.1.7 sampling, including closed-loop sampling	0.5	
	5.2 sea passage:		
	5.2.1 cooling down(*)	0.5	0.5
	5.2.2 pressure maintenance(*)	0.5	0.5
	5.2.3 boil-off	0.25	0.5
	5.2.4 inhibiting	0.25	
	5.3 unloading:		
	5.3.1 unloading(*)	1.0	1.0
	5.3.2 ballasting(*)	0.5	0.5
	5.3.3 stripping and cleaning systems	0.5	
	5.3.4 systems to make the tank liquid-free(*)	0.5	0.5
	5.4 pre-docking preparation:		
	5.4.1 warm-up(*)	0.5	0.5
	5.4.2 inerting	0.5	
	5.4.3 gas-freeing(*)	0.5	0.5
	5.5 ship-to-ship transfer	0.5	
6	**Proficiency to perform cargo measurements and calculations**		
	6.1 liquid phase (#)(**)	0.5	1
	6.2 gas phase (#)(**)	0.5	1
	6.3 On Board Quantity (OBQ)(#)(**)	0.25	0.25
	6.4 Remain On Board (ROB) (#)(**)	0.25	0.25
	6.5 boil-off cargo calculations (#)(**)	0.25	0.25
7	**Proficiency to manage and supervise personnel with cargo related responsibilities**	0.5	

	Knowledge, understanding and proficiency	Total hours for lectures	Total hours for practical's
	Competence 2 Familiarity with physical and chemical properties of liquefied gas cargoes		
8	**Knowledge and understanding of basic chemistry and physics and the relevant definitions related to the safe carriage of liquefied gases in bulk in ships**		
8.1	the chemical structure of gases	0.25	
8.2	the properties and characteristics of liquefied gases (including CO2) and their vapours, including:		
8.2.1	simple gas laws	0.5	1
8.2.2	states of matter		
8.2.3	liquid and vapour densities		
8.2.4	diffusion and mixing of gases	0.5	
8.2.5	compression of gases		
8.2.6	re-liquefaction and refrigeration of gases		
8.2.7	critical temperature of gases and pressure		
8.2.8	flashpoint, upper and lower explosive limits, auto-ignition temperature		
8.2.9	compatibility, reactivity and positive segregation of gases		
8.2.10	polymerization	0.25	
8.2.11	saturated vapour pressure/reference temperature		
8.2.12	dew point and bubble point		
8.2.13	lubrication of compressors		
8.2.14	hydrate formation		
8.3	the properties of single liquids		
8.4	the nature and properties of solutions	0.5	
8.5	thermodynamic units		
8.6	basic thermodynamic laws and diagrams		
8.7	properties of materials		
8.8	effect of low temperature – brittle fracture		
9	**Understanding the information contained in a Safety Data Sheet (SDS) (*)**	0.5	0.5

	Knowledge, understanding and proficiency	Total hours for lectures	Total hours for practical's
	Competency 3 Take precautions to prevent hazards		
10	**Knowledge and understanding of the hazards and control measures associated with liquefied gas tanker cargo operations**		
10.1	flammability	1	
10.2	explosion		
10.3	toxicity	0.5	
10.4	reactivity		
10.5	corrosivity		
10.6	health hazards	0.5	
10.7	inert gas composition	0.5	
10.8	electrostatic hazards		
10.9	polymerizing cargoes		
11	**Proficiency to calibrate and use monitoring and gas-detection systems, instruments and equipment**(#)(**)		0.5
12	**Knowledge and understanding of dangers of non-compliance with relevant rules/regulations**	0.5	
	Competency 4 Apply occupational health and safety precautions		
13	**Knowledge and understanding of safe working practices, including risk assessment and personal shipboard safety relevant to liquefied gas tankers**		
13.1	precautions to be taken when entering enclosed spaces (such as compressor rooms), including the correct use of different types of breathing apparatus(#)(**)	0.5	0.5
13.2	precautions to be taken before and during repair and maintenance work, including work affecting pumping, piping, electrical and control systems	0.25	
13.3	precautions for hot and cold work	0.25	
13.4	precautions for electrical safety	0.25	
13.5	use of appropriate Personal Protective Equipment (PPE)	0.5	
13.6	precautions for cold burn and frostbite	0.25	
13.7	proper use of personal toxicity monitoring equipment	0.5	

	Knowledge, understanding and proficiency		Total hours for lectures	Total hours for practical's
	Competency 5 Respond to emergencies			
14	**Knowledge and understanding of liquefied gas tanker emergency procedures**			
	14.1	ship emergency response plans	0.5	
	14.2	cargo operations emergency shutdown procedure	0.5	
	14.3	emergency cargo valve operations		
	14.4	actions to be taken in the event of failure of systems or services essential to cargo operations		
	14.5	fire-fighting on liquefied gas tankers #	0.5	
	14.6	jettisoning of cargo	0.25	
	14.7	enclosed space rescue	0.25	
15	**Actions to be taken following collision, grounding or spillage and envelopment of the ship in toxic or flammable vapour**		0.5	
16	**Knowledge of medical first-aid procedures and antidotes on board liquefied gas tankers, with reference to the Medical First Aid Guide for Use in Accidents involving Dangerous Goods (MFAG)**		1.5	
	Competence 6 Take precautions to prevent pollution of the environment			
17	**Understanding of procedures to prevent pollution of the environment**		0.5	
	Competence 7 Monitor and control compliance with legislative requirements			
18	**Knowledge and understanding of relevant provisions of the International Convention for the Prevention of Pollution from Ships (MARPOL) and other relevant IMO instruments, industry guidelines and port regulations as commonly applied**		0.25	
19	**Proficiency in the use of the IBC and IGC Codes and related documents**		0.5	

	Knowledge, understanding and proficiency	Total hours for lectures	Total hours for practical's
20	**Case Studies**	1.25	
21	**Test and Discussion**	1.0	
	Subtotals	**44.25**	**15.75**
	Total for the course	**60**	

Notes

It is suggested that relevant topics which are marked with an Asterisk (*) may be taught on a simulator.

It is suggested that relevant topics which are marked with a Hash (#) may be conducted separately in any facility which can conduct practical exercises and instruction under approved and truly realistic training conditions (e.g., simulated shipboard conditions).

It is suggested that relevant topics which are marked with a double Asterisk (**) may be demonstrated practically, conduct exercises or relevant videos to be shown for same.

Teaching staff should note that the hours for lectures and exercises are suggestions only as regards sequence and length of time allocated to each objective. These factors may be adapted by lecturers to suit individual groups of trainees depending on their experience, ability, equipment and staff available for teaching.

Part B: Course Timetable

Teaching staff should note that timetables are suggestions only as regards to sequence and length of time allocated to each objective. Lecturers to adapt these factors to suit the needs of individual group of trainees depending upon their experience, ability and on the equipment and staff available for training: Below is a suggested time table so arranged to let the topics flow in the correct sequence of learning.

Day 1	1.0 Knowledge of liquefied gas tanker design, systems, and equipment 1.1 types of liquefied gas tankers and cargo tanks construction 1.2 general arrangement and construction*	1.2 general arrangement and construction 1.4.3 expansion devices 1.4.4 flame screens 1.4.5 temperature monitoring systems 1.4.6 cargo tank level-gauging systems	1.3 cargo containment systems, including materials of construction and insulation[DB3]	
Day 2	1.4 cargo-handling equipment and instrumentation 1.4.1 cargo pumps and pumping arrangements	1.4.2 cargo pipelines and valves* 1.4.7 tank pressure monitoring and control systems 1.5 cargo temperature maintenance system	1.6 tank atmosphere control systems (inert gas, nitrogen), including storage, generation and distribution systems 1.12 cargo Emergency Shut Down system (ESD) 1.13 custody transfer system	1.8 gas-detecting systems 1.9 ballast system* 11. Proficiency to calibrate and use monitoring and gas-detection systems, instruments and equipment(#)(**)
Day 3	1.11 re-liquefaction systems	1.10 boil-off systems 1.7 cofferdam heating systems	8.1 The chemical structure of gases 8.2.1 simple gas laws 8.2.2 states of matter 8.2.3 liquid and vapour densities	8.4 the nature and properties of solutions 8.5 thermodynamic units 8.6 basic thermodynamic laws and diagrams 8.7 properties of materials

			8.2.4 diffusion and mixing of gases 8.2.5 compression of gases 8.2.6 re-liquefaction and refrigeration of gases 8.2.7 critical temperature of gases and pressure 8.2.8 flashpoint, upper and lower explosive limits, auto-ignition temperature 8.2.9 compatibility, reactivity and positive segregation of gases 8.2.10 polymerization 8.2.11 saturated vapour pressure/reference temperature 8.2.12 dew point and bubble point 8.2.13 lubrication of compressors 8.2.14 hydrate formation 8.3 the properties of single liquids	8.8 effect of low temperature – brittle fracture
Day 4	10.1 flammability 10.2 explosion 10.3 toxicity 10.4 reactivity 10.5 corrosivity	10.6 health hazards 10.7 inert gas composition 10.8 electrostatic hazards 10.9 polymerizing cargoes 9. Understanding the information contained in a Safety Data Sheet (SDS)	13.1 precautions to be taken when entering enclosed spaces (such as compressor rooms), including the correct use of different types of breathing apparatus	13.2 precautions to be taken before and during repair and maintenance work, including work affecting pumping, piping, electrical and control systems 13.3 precautions for hot and cold work

				13.4 precautions for electrical safety 13.5 use of appropriate Personal Protective Equipment (PPE) 13 .6 precautions for cold burn and frostbite
Day 5	4. Proficiency in tanker safety culture and implementation of safety management requirements	7. Proficiency to manage and supervise personnel with cargo related responsibilities 13.7 proper use of personal toxicity monitoring equipment 19. Proficiency in the use of the IBC and IGC Codes and related documents	2 Knowledge of pump theory and characteristics, including types of cargo pumps and their safe operation	
Day 6	3.0 Knowledge of the effect of bulk liquid cargoes on trim and stability and structural integrity	5.1 post docking and loading: 5.1.1 tank inspection 5.1.2 inerting (Oxygen reduction, dew point reduction)*	5.1.3 gassing-up 5.1.4 cooling down	5.1.5 loading
Day 7	5.1.6 deballasting 5.1.7 sampling, including closed-loop sampling	5.2.1 cooling down 5.2.2 pressure maintenance	5.2.3 boil-off 5.2.4 inhibiting	5.3.1 unloading
Day 8	5.3.2 ballasting	5.3.3 stripping and cleaning systems 5.3.4 systems to make the tank liquid-free	5.4.1 warm-up 5.4.2 inerting	5.4.3 gas-freeing 5.5 ship-to-ship transfer

Day 9	6. Proficiency to perform cargo measurements and calculations 6.1 liquid phase	6.2 gas phase	6.3 On Board Quantity (OBQ) 6.4 Remain On Board (ROB) 6.5 boil-off cargo calculations	16 Knowledge of medical first-aid procedures and antidotes on board liquefied gas tankers, with reference to the Medical First Aid Guide for Use in Accidents involving Dangerous Goods (MFAG)
Day 10	14.1 ship emergency response plans 14.2 cargo operations emergency shutdown procedure 14.3 emergency cargo valve operations 14.4 actions to be taken in the event of failure of systems or services essential to cargo operations 14.5 fire-fighting on liquefied gas tankers	14.6 jettisoning of cargo 14.7 enclosed space rescue 15. Actions to be taken following collision, grounding or spillage and envelopment of the ship in toxic or flammable vapour 17. Understanding of procedures to prevent pollution of the environment	18. Knowledge and understanding of relevant provisions of the International Convention for the Prevention of Pollution from Ships (MARPOL) and other relevant IMO instruments, industry guidelines and port regulations as commonly applied 20.0 Case Studies	12. Knowledge and understanding of dangers of non-compliance with relevant rules/regulations

Part C: Detailed Teaching Syllabus

COMPETENCE 1	**Ability to safely perform and monitor all cargo operations**
TOPIC 1	**KNOWLEDGE OF LIQUEFIED GAS TANKER DESIGN, SYSTEMS, AND EQUIPMENT**

TRAINING OUTCOMES:

Demonstrates a knowledge and understanding of:

1. **Liquefied gas tanker design, systems, and equipment**
   - 1.1 types of liquefied gas tankers and cargo tanks construction
     - 1.1.1: IMO Gas Code
     - 1.1.2: ship types
   - 1.2 general arrangement and construction
     - 1.2.1: cargo area segregation
     - 1.2.2: gas dangerous zones
   - 1.3 cargo containment systems, including materials of construction and insulation
     - 1.3.1: types
     - 1.3.2: design criteria
     - 1.3.3: location
   - 1.4 cargo-handling equipment and instrumentation
     - 1.4.1: cargo pumps
     - 1.4.2: cargo pipelines and valves
     - 1.4.3: expansion devices
     - 1.4.4: flame screens
     - 1.4.5: temperature monitoring
     - 1.4.6: cargo tank level gauging systems
     - 1.4.7 tank pressure monitoring and control systems
   - 1.5 cargo temperature maintenance system
     - 1.5.1: control methods
     - 1.5.2: vapor handling
   - 1.6 tank atmosphere control systems (inert gas, nitrogen), including storage, generation and distribution systems
     - 1.6.1: inert gas composition
     - 1.6.2: inert gas generators
   - 1.7 cofferdam heating systems
     - 1.7.1: arrangements
     - 1.7.2: glycol heaters
   - 1.8 gas-detecting systems
     - 1.8.1: spaces monitored

	1.8.2: arrangements
1.9	ballast system
	1.9.1: arrangements
	1.9.2: operation
1.10	boil-off systems
	1.10.1: arrangements
1.11	re-liquefaction systems
	1.11.1: LPG liquefaction systems
	1.11.2: LNG liquefaction systems
1.12	cargo Emergency Shut Down system (ESD)
	1.12.1: operation
	1.12.2 types
1.13	custody transfer system
	1.13.1 function
	1.13.2 purpose

TOPIC 2	**KNOWLEDGE OF PUMP THEORY AND CHARACTERISTICS, INCLUDING TYPES OF CARGO PUMPS AND THEIR SAFE OPERATION**
2.	**Pump theory and characteristics, including types of cargo pumps and their safe operation**
	2.1: centrifugal pumps
	2.1.1: characteristics
	2.1.2: limitations
	2.2: performance
	2.2.1: pump curves
	2.2.2: cavitation
	2.3: operation
	2.3.1: operating conditions
	2.3.2: control & protection
	2.3.3: handling & maintenance

TOPIC 3	**KNOWLEDGE OF THE EFFECT OF BULK LIQUID CARGOES ON TRIM AND STABILITY AND STRUCTURAL INTEGRITY**
3.	**Effect of bulk liquid cargoes on trim and stability and structural integrity**
	3.1: stability and free surface
	3.2: damage stability
	3.3: operations

TOPIC 4	**PROFICIENCY IN TANKER SAFETY CULTURE AND IMPLEMENTATION OF SAFETY MANAGEMENT REQUIREMENTS**
4.	**Tanker safety culture and implementation of safety management requirements**
	4.1: ISM code

4.1.1: purpose
4.1.2: reporting
4.1.3: continuous improvement
4.2: TMSA
4.2.1: purpose
4.2.2: elements

TOPIC 5 PROFICIENCY TO APPLY SAFE PREPARATIONS, PROCEDURES AND CHECKLISTS FOR ALL CARGO OPERATIONS

5. **Safe preparations, procedures and checklists for all cargo operations**
5.1 post docking and loading:
5.1.1 tank inspection
5.1.2: inerting
5.1.3: gassing up
5.1.4:cooling down
5.1.5: loading
5.1.6: deballasting
5.1.7: sampling
5.2 sea passage:
5.2.1: cooling down
5.2.2: pressure maintenance
5.2.3: boiloff
5.2.4: inhibiting
5.3 unloading:
5.3.1: unloading
5.3.2: ballasting
5.3.3: stripping
5.3.4: making tanks liquid free
5.4 pre-docking preparation:
5.4.1: warm up
5.4.2: inerting
5.4.3: gas freeing
5.5 ship-to-ship transfer

6

6.1 liquid phase
6.1.1: definitions
6.1.2: filling limits
6.2 gas phase
6.2.1: equations of state
6.2.2: calculations
6.3 On Board Quantity (OBQ)

6.4 Remaining On Board (ROB)

6.5 boil-off cargo calculations
6.5.1: purpose
6.5.2: procedures

7 Supervision of personnel with cargo related [GEE4]
Responsibilities
7.1: rest hours
7.2: responsibilities

Required performance:

Note that students must be familiar with the content of the basic knowledge of liquefied gas tankers, cargo operation, and understanding of tanker safety culture and safety management from IMO Model Course 1.04. It may be necessary for some students to refresh their knowledge of this content before undertaking this management level content.

TOPIC 1	KNOWLEDGE OF LIQUEFIED GAS TANKER DESIGN, SYSTEMS, AND EQUIPMENT

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
1.0	**Knowledge of liquefied gas tanker design, systems, and equipment** **NOTE: The following knowledge in 1.1 and 1.2 is not required under Table A-V/1-2-2 of the STCW Code. However it is recommended that the trainee has basic knowledge of the following in 1.1 and 1.2:**			
1.1	**Types of liquefied gas tankers and cargo tanks construction (see NOTE)**	**R1,R2,**	**T1,B1,B2,**	**A1,A11, A13,VG15**
1.1.1	Explains why the IMO Gas Carrier Codes establish an international standard for the design, construction and equipment of gas tankers to minimize the risk to the ship, to its crew and to the environment			
1.1.2	Explains why that chapter 19 has a summary of the minimum requirements, with a list of all gas cargoes which can be carried on liquefied gas tankers			
1.1.3	Explains why a product listed in chapter 19 and marked with an asterisk is also covered by the Bulk Chemicals code			
1.1.4	Explains why that chapter 19 lists:			
1.1.4.1	All products covered by the International Gas Carrier Code			
1.1.4.2	The products' UN numbers, which are intended for information only			
1.1.4.3	The minimum ship type requirement			
1.1.4.4	Cargoes requiring an independent tank of type C			
1.1.4.5	Cargoes requiring special environmental control			
1.1.4.6	Vapour-detection requirement			
1.1.4.7	Types of gauging required			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
1.1.4.8	Special requirements as per chapter 14 and 17 additional to the general requirements of the IMO Gas Carrier Codes			
1.2	**General arrangement and construction (see NOTE)**	**R1,R2,**	**T1,B1,B2,B8**	**A1,A11,A13**
1.2.1	Explains why the cargo area has to be segregated from other parts of the ship and other gas-safe spaces			
1.2.2	Explains why that cargo handling systems must be completely separate from accommodation spaces, machinery spaces			
1.2.3	Describes gas-dangerous spaces as:			
1.2.3.1	Spaces in the cargo area which are not arranged or equipped in an approved manner to ensure that their atmosphere is at all times maintained in a gas-safe condition			
1.2.3.2	Enclosed spaces outside the cargo area through which any piping containing liquid or gaseous products passes, or within which such piping terminates, unless approved arrangements are installed to prevent any escape of product vapour into the atmosphere of those spaces			
1.2.3.3	Cargo-containment systems with cargo piping and hold spaces			
1.2.3.4	Spaces separated from a hold space by a single gas-tight steel boundary where cargo is carried in a cargo-containment system requiring a secondary barrier			
1.2.3.5	Cargo pump-rooms and cargo compressor rooms			
1.2.4	Describes gas-dangerous zones as:			
1.2.4.1	A zone on the open deck, or a semi-enclosed space on the open deck, within 3 metres of any cargo tank outlet, gas or vapour outlet, cargo pipe flange or cargo valve or of entrances and ventilation openings to cargo pump -rooms and cargo compressor rooms			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
1.2.4.2	The open deck over cargo areas and 3 metres forward and aft of the cargo areas on the open deck up to a height of 2.4 metres above the weather deck			
1.2.4.3	Zones within 2.4 metres of the outer surface of a cargo- containment system where such surface is exposed to the weather			
1.2.4.4	Enclosed or semi-enclosed spaces in which pipes containing products are located. A space which contains approved gas-detection equipment or a space in which boil-off gas is utilized as fuel and which has been approved by the Administration is not considered a gas-dangerous space in this context			
1.2.4.5	A compartment for cargo hoses			
1.2.4.6	Enclosed or semi-enclosed spaces having a direct opening into any gas-dangerous space or zone			
1.2.5	Explains why that a gas-safe space is a space other than a gas-dangerous space			
1.2.6	Explains why that air intakes for accommodation, service and machinery spaces and control stations have to be at a minimum distance from ventilation outlets of gas-dangerous spaces			
1.2.7	Explains why that access to accommodation or engine-room has to be at a minimum distance of 3 metres from the forward boundary division of accommodation			
1.2.8	Explains why that windows and side scuttles facing the cargo area and on the sides of the deck-houses within a distance of 3 metres should be of the fixed (non-opening) type			
1.2.9	Explains why wheelhouse windows and doors may be located within a distance of 3 metres from the forward boundary division so long as they are so designed that a rapid and efficient gas- and vapour-tightening of the wheelhouse can be ensured			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
1.2.10	Explains why all air intakes and openings into accommodation spaces, service spaces and control stations should be fitted with closing devices			
1.2.11	Explains why access from a gas-dangerous zone on the open weather deck to a gas-safe space has to be via an airlock			
1.2.12	Explains why the ventilation of the airlock should be of the positive-pressure type			
1.2.13	Explains why the airlock doors should be self - closing and without any arrangements by which they could be held open			
1.2.14	Explains why an audible and visual alarm system should be provided which will give a warning on both sides of the airlock if more than one door is moved from the closed position			
1.2.15	Explains why gas-safe spaces within the cargo area should be fitted with a mechanical ventilation system of the positive -pressure type			
1.2.16	Explains why, when this overpressure is lost, all electrical equipment not certified as electrically safe should be de--energized			
1.2.17	Explains why all cargo compressor rooms, pump-rooms and control rooms considered to be gas-dangerous spaces should be fitted with mechanical ventilation system of the negative-pressure type			
1.2.18	Explains why electrical motors driving fans should be placed outside the ventilation ducts			
1.2.19	State that ventilation fans should be of non-sparking construction and that spare parts should be carried for each type of fan on board			
1.2.20	Explains why protection screens of not more than 13 mm square mesh should be fitted in outside openings of ventilation ducts			
1.2.21	Explains why the use of segregation, separation and airlocks is fundamental to the safety of the gas tanker			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
1.3	**Cargo containment systems, including materials of construction and insulation**	**R1,R2,**	**T1,B1,B2,B8**	**A1,A11, A13, A14, VG13**
1.3.1	Lists the five main categories of cargo-containment systems as: • Integral tanks • Membrane tanks • Semi-membrane tanks • Independent tanks • Internal insulation tanks			
1.3.2	Explains why the following parameters must be taken into consideration when designing and constructing a cargo containment system: • Thermal stress, expansion and contraction • Stress caused by the vapour pressure and the weight of liquid • Stress caused by sloshing • Type and thickness of tank material • Types and thickness of insulation material • Method of tank support • Location of tank • Cargo limitation			
1.3.3	Explains the above parameters in relation to the following cargo-containment systems: - • Integral tanks • Gaz transport membrane tanks • Technigaz membrane tanks • Independent tanks of type A (LPG)			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
	• Independent tanks of type A (Conch) • Independent tanks of type B (Kvaerner-Moss/Moss Rosenberg) • Independent tanks of type C • Internal insulation tanks			
1.3.4	Explains location of tanks for each ship type			
1.3.5	Explains assumed standard damage with respect to 1G, 2G, 2PG, 3G Standard of damage			
1.4	**Cargo – handling equipment and instrumentation**	**R1,R2,**	**T1,B1,B2,B8**	**A1,A11,A12, A13**
1.4.1	Cargo pumps and pumping arrangements	**R1,R2,**	**T1,B1,B2,B8**	**A1,A11,A13**
1.4.1.1	States that the main cargo pumps fitted aboard liquefied gas tankers are of the centrifugal type			
1.4.1.2	Describes the different types of pumps used on liquefied gas tankers.			
1.4.1.3	Explains deck mounted pumps on Liquefied Gas tankers			
1.4.1.4	Describes the construction of a deep well pump			
1.4.1.5	Describes the construction of a submerged pump			
1.4.1.6	Describes additional arrangements for alternative unloading			
1.4.1.7	Describes spray pump on LNG tankers			
1.4.1.8	Explains purpose of spray pumps			
1.4.1.9	Describes the operational requirements with respect to limitation on number of starts and required liquid level for spray pump operations			
1.4.2	Cargo pipelines and valves	**R1,R2,**	**T1,B1,B2,B8**	**A1,A11,A13**
1.4.2.1	Describe general liquid and vapour piping requirements			
1.4.2.2	Describes the commonly found fixed piping arrangements in a cargo tank			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
1.4.2.3	Describes generally a cargo piping arrangement			
1.4.2.4	Explains why spool-pieces are used in cargo pipelines: • To ensure segregation of incompatible cargoes • To ensure complete separation from other systems • To connect separated systems			
1.4.2.5	Describes cargo-separation arrangements			
1.4.2.6	Explains why a remotely operated shutoff valve should be provided at each liquid and vapour crossover			
1.4.2.7	Explains why in the case of cargo tanks with a MARVS of not greater than 0.7 bar, all liquid and vapour connections (with the exception of safety relief valves and liquid level gauging devices) should be equipped with a manually operated stop valve or may be remotely operated but capable of manual closure.			
1.4.2.8	Explains why in the case of cargo tanks with a MARVS exceeding 0.7 bar, all liquid and vapour connections (with the exception of safety relief valves and liquid level gauging devices) should be equipped with a manually and remotely operated emergency shutoff valve			
1.4.2.9	Explains why on activating an emergency shutdown system remotely operated crossover valves close. Other remotely operated valves, cargo pumps and compressors may stop automatically depending on the ships design.			
1.4.2.10	Explains why commonly used valve types on gas tankers are: • Ball valves • Globe valves • Gate valves • Butterfly valves			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
1.4.2.11	Describes generally the design of these valves			
1.4.2.12	Explains why strainers are commonly installed in the cargo piping system to protect the cargo-handling plant and equipment from damage by foreign objects			
1.4.2.13	Explains why there are two different types of cargo hoses - the composite construction - the stainless- steel construction			
1.4.2.14	Explains safe use of portable cargo hoses and precautions to be taken			
1.4.3	Expansion devices	**R1,R2,**	**T1,B1,B2,**	**A1,A11,A13**
1.4.3.1	Explains why the design and fitting of cargo pipelines allow for thermal expansion and contraction. This is best achieved by the fitting of expansion loops or by using the natural geometry of the pipe-work, In a few specific cases, expansion bellows may be fitted and, where this is planned, corrosion resistant materials should be used.			
1.4.3.2	Explains why where expansion bellows are fitted in vapour lines, it should be ensured that their pressure rating at least meets the liquid pipeline design criteria. The use of bellows in liquid lines is not recommended.			
1.4.4	Flame screens	**R1,R2,**	**T1,B1,B2,**	**A1,A11,A13**
1.4.4.1	Defines flame screen (gauze screen) as a portable or fitted device incorporating one or more corrosion resistant wire woven fabrics of very small mesh used for preventing sparks from entering a tank or vent opening, or for a short period of time preventing the passage of flame, yet permitting the passage of gas (not to be confused with Flame Arrester).			
1.4.4.2	Explains why flame screens have very small holes which are easily blocked, and should be cleaned regularly.			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
1.4.5	Temperature monitoring systems	**R1,R2,**	**T1,B1,B2,B8**	**A1,A11,A13**
1.4.5.1	Explains why temperature sensors are fitted so that the temperatures of both the cargo and the structure around the cargo system can be monitored			
1.4.5.2	Explains why it is important to be able to monitor temperatures in the cargo system during cool-down and warm-up operations to ensure that unsafe thermal stresses are avoided.			
1.4.5.3	Lists the instruments used on liquefied gas tankers for temperature monitoring as: • Liquid-vapour Thermometers • Liquid-filled Thermometers • Bi-metallic thermometers • Thermocouples • Resistance Thermometers			
1.4.5.4	Explains why the following precautions should be observed with all temperature indicating devices: • The thermometers used should be suitable for the complete range of temperatures expected (e.g. metals may become brittle or liquids freeze at low temperatures) • The sensor should make good thermal contact with the material whose temperature is to be measured • If readings do not change when expected, the instrument should be checked • Thermometers, especially those with capillary tubes, are easily damaged: they should be handled with care and protected from			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
	mechanical damage and extremes of temperature beyond their scales, otherwise they may become inaccurate • When a thermometer is removed from its working location, care should be taken to avoid loosening or removing its pocket, especially if the system is pressurized • when a thermometer is fitted in a working location, care should be taken that it does not touch bottom of the pocket when screwed in as this could cause damage: if the bulb is slack in the pocket a material with high thermal conductivity (e.g. a suitable lubricating oil) can be used to ensure accurate readings • Electrical connections should be clean, tight and correct: care should be taken to see that intrinsically safe leads are not cross-connected with ordinary power sources. • Every temperature sensor must be calibrated as per safety management systems of the organization.			
1.4.6	Cargo tank level – gauging systems	**R1,R2,**	**T1,B1,B2,**	**A1,A11,A13**
1.4.6.1	Lists common types of closed gauging systems for liquefied gas tankers as: .a Float type; .b Capacitances type; .c Radar type			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
1.4.6.2	Describes the operating principle of the most common level gauges			
1.4.6.3	Explains the correct handling procedures when using float gauges			
1.4.6.4	Defines restricted gauging system as a system employing a device which penetrates the tank and which, permits a small quantity of cargo vapour or liquid to be released to the atmosphere. When not in use the device is completely closed			
1.4.6.5	Defines closed gauging system as a system in which the contents of a tank can be measured by means of a (closed ullaging) device which penetrates the tank, but which is part of a closed system preventing the release of tank contents. Examples are float-type systems, electronic probe, magnetic probe and bubbler tubes			
1.4.7	Tank pressure monitoring and control systems	**R1,R2,**	**T1,B1,B2,B8**	**A1,A11, A13**
1.4.7.1	Explains why liquefied gas tankers require the pressure monitoring including the cargo tanks, pumps and compressor discharge lines, liquid and vapour crossover lines			
1.4.7.2	Explains why pressure switches and alarms are fitted to various systems to protect equipment and personnel.			
1.4.7.3	Explains why Vapour relief valves are fitted on the tank domes; these relieve to vent stacks whose height and safe distances from accommodation spaces etc. are specified in the IMO Codes.			
1.4.7.4	Explains why each cargo tank exceeding 20m^3 should be fitted with at least 2 pressure relief valves of the same capacity.			
1.4.7.5	Explains why in the case of cargo tanks permitted to have more than one relief setting, the changing of the set pressure should be carried out under the supervision of the master in accordance			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
	with the procedures approve by the administration. This is to be recorded in the log book.			
1.4.7.6	Explains why the pressure relief valves for tanks are generally pilot valve operated. In this manner, accurate operation is assured at the low pressures prevailing inside the tank.			
1.4.7.7	Explains why LNG carriers are usually installed with a gas burning system, to maintain tank pressures below the set pressure of the relief valve.			
1.4.7.8	Explains why Inter barrier spaces should be provided with pressure relief devices.			
1.4.7.9	Explains why in addition to the cargo tank and hold or inter-barrier space relief valves, all pipelines that may be isolated in liquid filled condition should be provided with relief valves.			
1.4.7.10	Explains why arrangement for safely relieving pressure in the lines to the cargo tanks will vary from ship to ship.			
1.4.7.11	Explains why re-liquefaction systems are used to control cargo temperatures			
1.5	**Cargo temperature maintenance system**	**R1,R2,**	**T1,B1,B2,B8**	**A1,A11,A13**
1.5.1	Explains why it is necessary to control vapour boil-off			
1.5.2	Lists the methods of controlling vapour pressure and temperature in the cargo tanks as: • Leading the cargo boil-off to the boiler, gas turbine or main engine, to be used as fuel • Leading the cargo boil-off to the re-liquefaction plant, where the vapour is liquefied • Cooling the liquid cargo in a heat exchanger or by cooling the shell of the cargo tank			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
1.5.3	Explains why cargo boil-off may only be vented, depending on local regulations			
1.5.4	Describes a system for handling LNG boil off vapour			
1.6	**Tank atmosphere control systems (inert gas, nitrogen), including storage, generation and distribution systems**	**R1,R2,**	**T1,B1,B2,B8**	**A1,A11,A13**
1.6.1.	Explains 'inert gas' with the IMO requirements concerning inerting and the production of inert gas on board gas tankers.			
1.6.2	Describes different methods of producing inert gas			
1.6.3	Explains why the composition of inert gas produced by an inert gas generator is: - approximately 84% nitrogen - approximately 0.5% oxygen - approximately 15% carbon dioxide - approximately 0.5% carbon monoxide, oxides of nitrogen and sulphur dioxide			
1.6.4	Describes an inert gas generator and a Nitrogen Generator system			
1.6.5	Describes the different factors which influence the content of inert gas from an inert gas generator and that from a Nitrogen Generator			
1.6.6	Describes the limitations of using inert gas produced by an inert gas generator			
1.6.7	Explains why nitrogen from a nitrogen generator is used for LNG cargo tanks and inter barrier/annular spaces and IG may be used for hold spaces.			
1.6.8	Describes Dew point meter.			
1.7	**Cofferdam heating systems**	**R1,R2,**	**T1,B1,B2,B8**	**A1,A11,A13**
1.7.1	Defines principles of operation of the cofferdam heating system			
1.7.2	Describes valve arrangements and supply pipeline arrangements			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
1.7.3	Explains why circulating pumps are used to maintain a positive pressure inside the cofferdams.			
1.7.4	Explains glycol heaters			
1.7.5	With the help of a diagram demonstrates: - Use of supply and return valve - Temperature control - Alarm settings and resulting actions			
1.8	**Gas- detecting systems**	**R1,R2,**	**T1,B1,B2,**	**A1,A11,A13**
1.8.1	Explains why Fixed Flammable Gas Detection System is to be installed to detect flammable gases (cargoes) leaked to cargo control rooms), void spaces , pump /compressor /motor rooms, air locks and other spaces in or adjacent to cargo area.			
1.8.2	Explains why the spaces monitored are determined in accordance with the requirements of SOLAS, IBC Code and IGC Code as well as those its flag administration, owner and operator.			
1.8.3	Lists IGC requirements concerning the fixed gas-detection system			
1.8.4	Explains why Indication/Alarm Units and Gas Detection Unit are contained in a common panel and placed in cargo control room.			
1.8.5	Explains why in the spaces to be monitored; for a typical detector, only suction nozzles may be fitted and it is extended with piping and connected to gas detector via selective valves in a panel in cargo control room.			
1.8.6	Explains why all the applicable spaces are regularly monitored with sequential control.			
1.9	**Ballast system**	**R1,R2,**	**T1,B1,B2,**	**A1,A11,A13**
1.9.1	Explains why where cargo tanks do not require a secondary barrier, the hold spaces should be provided with a special			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
	arrangement not connected with machinery spaces			
1.9.2	Explains why ballast spaces may be connected to pumps in the engine room. Duct keels, may be connected to pumps in the engine rooms, provided the connections are led directly to the pumps and the discharge from the pumps should lead directly overboard with no valves or manifolds in either line which could connect the line from the duct keel to lines serving gas safe spaces.			
1.9.3	Explains why pump vents are not to be open to the engine room.			
1.9.4	Explains a ballast line and valve setup for a typical ballasting operation.			
1.9.5	Describes the use of ballast pumps and eductors.			
1.9.6	Explains that ballast operations are carried out to maintain safe trim and stability of gas ships during cargo operations.			
1.9.7	Describes ballast tanks mud flushing systems and its operations.			
1.10	**Boil – off systems**	**R1,R2,**	**T1,B1,B2,B8**	**A1,A11,A13**
1.10.1	Explains boil-off and why it is necessary to control vapour boil-off on LNG carriers.			
1.10.2	Lists the methods of controlling vapour pressure in the cargo tanks as: - Leading the cargo boil-off to the ship's boiler, gas turbine or main engine, to be used as fuel. - Leading the cargo boil-off to the ship's re-liquefaction plant for condensing and returning liquid back to the cargo tanks.			
1.11	**Re-liquefaction systems**	**R1,R2,**	**T1,B1,B2,B8**	**A1,A11,A13**
1.11.1	Explains why there are various types of re-liquefaction systems.			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
1.11.2	Describes a single-stage direct re-liquefaction system for an LPG carrier along with the stages in the cycle on a Mollier diagram			
1.11.3	Explains the limitations of a single-stage direct system			
1.11.4	Describes the two-stage direct system and explain the stages in the cycle on a Mollier diagram.			
1.11.5	Explains the limitations of a two- stage direct system			
1.11.6	Describes a cascade system and the stages in the cycle on Mollier diagrams			
1.11.7	Describes different types of indirect systems			
1.11.8	Explains the limitations of indirect systems			
1.11.9	Describes with the aid of a diagram, a typical LNG BOG re-liquefaction plant.			
1.11.10	Explains why glycol heating / cooling system is used for vaporizing any cargo liquid from the compressor crankcase and cooling critical parts of the compressor.			
1.12	**Cargo emergency shutdown system (ESD)**	**R1,R2,**	**T1,B1,B2,**	**A1,A11,A13**
1.12.1	Explains the principles of operations of an ESD system			
1.12.2	Explains methods of connection between ship and shore and differing requirements for each type for: - Electrical connection - Pneumatic connection - Optical connection			
1.12.3	Discuss pre cargo commencement test connection procedures			
1.12.4	Discuss operating parameters that will activate ESD			
1.12.5	Discuss effect of ESD operations			
1.12.6	Explains ESD system closure time and any effect this may have on the maximum loading rate			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
1.13	**Custody transfer system**	**R1,R2,**	**T1,B1,B2,**	**A1,A11,A13**
1.13.1	States most LNG vessels are fitted with a "custody transfer system". This is an integrated system of cargo instrumentation that allows cargoes to be bought and sold by heat value in BTU (British Thermal Units) or Kilocalorie.			
1.13.2	Explains why in order to determine the amount of energy transferred, accurate volume, density and composition measurements must be made by the system and the information returned to a data logger and computer for recording and calculation			
1.13.3	Explains why custody transfer calculations are carried out on board LPG carriers for weight in air.			
1.13.4	Explains why the equipment used for custody transfer are calibrated and sealed. The seals are not to be tampered with.			
2.0	**Knowledge of pump theory and characteristics, including types of cargo pumps and their safe operation.**[GEE5]	**R1,R2,**	**T1,B1,B2,B9, B10**	**A1,A11,A13, A14, VG15**
2.1	Explains why the main cargo pumps fitted aboard liquefied gas tankers are of the centrifugal type			
2.2	Describes the operating principle of a centrifugal pump			
2.3	Lists drawbacks of using a centrifugal pump as - the main difficulty of constructing a pump with a high differential pressure per stage high efficiency within a limited field - normally not being self-priming backflow through the pump when it is stopped -difficulty of pumping high-TVP liquids resulting in cavitations.			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
2.4	Explains how actual drawbacks of a centrifugal pump are overcome			
2.5	Explains why normally every cargo pump is supplied with graphs describing: - The pump's performance - The pump's efficiency - The pump's power consumption - The pump's NPSH (Net Positive Suction Head)			
2.6	Explains why this graph is based on a shop test			
2.7	Explains "Total head"			
2.8	Explains the benefits of showing the pump's capacity as a function of the total head			
2.9	Explains "design point"			
2.10	Explains "NPSH"			
2.11	Explains "cavitation"			
2.12	Explains the above-mentioned curves in the graph and their relationship			
2.13	Explains how the following factors influence the pump's suction condition - the pump's NPSH - the pressure in the cargo-tank - the liquid level - the cargo's vapour pressure			
2.14	Describe the effect of cavitation			
2.15	Explains why an inducer improves the pump's suction condition			
2.16	explains the effects of running two or more pumps in parallel			
2.17	Explains how a combined pump characteristic is constructed when running pumps in series at the same suction and discharge condition			
2.18	Explains why at normal back-pressure the cargo pumps are run in parallel			
2.19	States at high back-pressure the cargo pumps are run in series with booster pumps			
2.20	Explains why the actual discharge rate depends on:			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
	- the pressure in the shore tank - the static back-pressure - the dynamic back-pressure			
2.21	Explains "static back-pressure"			
2.22	Explains "dynamic back-pressure"			
2.23	Explains the factors influencing dynamic back-pressure			
2.24	Derives the discharge rate of the pump, using a Q -H curve and a system head curve			
2.25	Describes methods of automatic control and protection of cargo pumps			
2.26	Describes correct and safe handling of submersible and deepwell pumps			
2.27	Describes correct operations of spray pumps			
2.28	Describes correct and safe handling of a booster pump			
TOPIC 3	**KNOWLEDGE OF the effect of bulk liquid cargoes on trim and stability and structural integrity**			
3.0	**Knowledge of the effect of bulk liquid cargoes on trim and stability and structural integrity**	**R1,R2,R3, R6**	**B1,B2,B6,B7**	**A1,A11,A13, A14,VG15**
3.1	Explains why the distribution of cargo and ballast should at no time create excessive stress on the ship's hull			
3.2	Explains generally the effect of free surfaces in cargo tanks and ballast tanks			
3.3	Explains measures to ensure adequate stability of the vessel as: - Correct use of valves in the centre line bulkhead - Correct distribution of water and bunkers - Correct distribution of ballast			
3.4	Explains why as part of the statutory requirements, gas tankers are provided with stability data, including worked examples showing cargo loaded in a variety of ways.			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
3.5	Explains why as part of the requirements Gas tankers must be provided with damaged stability calculations			
3.6	Explains why the damage stability calculations must be such that, in specified damaged conditions, the tanker will meet certain survival requirements.			
3.7	Explains progressive flooding			
3.8	Explains standard damage conditions			
3.9	Explains with the aid of a diagram maximum extent of longitudinal damage.			
3.10	Explains maximum extent of transverse damage			
3.11	Explains maximum extent of vertical damage			
3.12	Explains damage stability requirements with the aid of a GZ curve - Shows position of equilibrium - Shows angle of vanishing stability. - Shows maximum GZ requirements. - Shows area under the curve.			
3.13	Explains why on gas tankers where stress considerations may be critical, hourly checks should include, the observation and recording of the shear forces, bending moments, draught and trim and any other relevant stability requirements particular to the tanker.			
3.14	Explains why this trim and stability information should be checked against the required loading plan to confirm that all safe limits are adhered to and that the loading sequence can be followed, or amended, as necessary. Any discrepancies should be reported immediately to the Responsible Person.			
[GEE6]				
4.0	**Proficiency in tanker safety culture and implementation of safety management requirements**	**R1,R2,R3, R6, R7**	**B1,B2,B6,B7**	**A1,A11,A13, A14, VG2, VG8,VG15**
4.1	Explains why the management and operation of vessels within a culture of			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
	safety and environmental excellence was formalized with the introduction of the International Safety Management (ISM) Code.			
4.2	Explains why this code requires vessel operators to implement a safety management system that will help them to achieve incident-free operations.			
4.3	Explains why there is a clear distinction between the standards of those vessel operators that embrace the spirit of the ISM code and those that aim to fulfill only its minimum requirements.			
4.4	Explains why OCIMF's Tanker Management and Self-Assessment (TMSA) programme was introduced in 2004 as a tool to help vessel operators assess, measure and improve their management systems.			
4.5	Explains why the programme encourages vessel operators to assess their safety management systems against listed key performance indicators and provides best practice guidance.			
4.6	Explains why it is an effective way to minimize the possibility of problems reoccurring.			
4.7	Explains why it creates opportunities and optimizes performance in crucial areas such as safety and environmental excellence.			
4.8	Explains why tanker safety management is the approach in implementing the ISM code, COSWP, TMSA and the FSS codes through the consistent application of improved processes and procedures in an organization through their Safety management system manuals in letter and spirit.			
4.9	Explains why one of the elements of the ISM code relates to: - Reports and Analysis of Non-conformities, accidents and Hazardous Occurrences - Maintenance - Documentation			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
	- Company Verification, Review and Evaluation			
4.9.1	Explains why potential non-compliance with cargo related procedures is promptly identified and rectified			
4.10	Identifies the chapters of the COSWP that deal with the hazards related to carriage of liquefied gas in bulk			
4.11	Lists the elements of the TMSA as: •1A, 1B; Management, Leadership and Accountability •2A; Recruitment and Management of shore-based personnel •3A,3B; Recruitment and Management of Ship's personnel •4A, 4B; Reliability and Maintenance Standards •5A; Navigational Safety •6A, 6B; Cargo, Ballast and Mooring Operations •7A, 7B; Management of Change •8A, Incident Investigation and Analysis •9A, 9B; Safety Management •10A, 10B; Environmental Management •11A, 11B; Emergency Preparedness and Contingency Planning •12A, 12B; Measurement, Analysis and Improvement [GEE7]			
5.0	**Proficiency to apply safe preparations, procedures and checklists for all cargo operations**			
5.1	Post docking and loading:			
5.1.1	Tank inspection	**R1,R2,R3, R6**	**B1,B2,B6,B7**	**A1,A11,A13, A14, VG2,VG15**
5.1.1.1	Explains why it may be necessary in some ports to have a visual inspection of cargo tanks			
5.1.1.2	Explains why if there is a requirement to enter the tanks we can sweep and clean up dust and check that there is no foreign substances on the tank top.			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
5.1.1.3	Explains why all bolts and nuts on the pump and cargo tank lines must be checked for tightness.			
5.1.1.4	Explains why it is required to ensure that the pump and its fittings are in the correct position.			
5.1.1.5	Explains why man entry can only be made when tanks are gas free.			
5.1.1.6	States all precautions for enclosed space entry must be taken prior to tank entry. Explains why			
5.1.2	Inerting (oxygen reduction, dew point reduction)	**R1,R2,R3, R4,R6**	**B1,B2,B4,B6, B7**	**A1,A11,A12, A13,A14, VG3,VG15**
5.1.2.1	Explains why during dry-docking or inspection hold spaces contain a certain amount of moist air. These must be dried before any continuation of service, mainly to avoid the formation of corrosive agents			
5.1.2.2	Explains why this formation can occur if the moist air is allowed to combine with sulphur and nitrogen oxides, which may be contained in the inert gas			
5.1.2.3	Explains why during a dry-docking or inspection, cargo tanks that have been opened and contain humid air must be dried. Mainly this is to avoid the formation of ice when they are cooled			
5.1.2.4	Explains why the operation (performed either from shore or at sea), will take approximately 20 hours to reduce the dew point to less than -25°C.			
5.1.2.5	Explains why during the time that the inert gas plant is in operation for the drying and subsequent inerting of the cargo tanks, to bring down the percentage of oxygen to requisite levels required for the next cargo, the inert gas is also used to dry and inert all other vapour pipe-work to below -45°C (to requisite levels required for the next cargo). Before the introduction of gas cargo or the associated vapour, any pipe-work not purged with inert gas must be purged with N2.			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
5.1.2.6	Explains why displacement method or dilution methods are used for exchange gases in a cargo tank			
5.1.2.7	Explains why the order of displacement inlet and outlet points may be carried out by use of the lighter gas on top heavier below in an ascending order of ammonia, nitrogen, air, inert gas (flue-gas) and LPG.			
5.1.2.8	Explains why LNG does not cater to this principle and has to be monitored by density at actual temperatures. At -100°C LNG has the density of air.			
5.1.2.9	Explains why Inerting by displacement relies on stratification caused by differences in the vapour density between the gas entering the tanks and the gas already in.			
5.1.2.10	Explains why dilution can be achieved by pressurizing the tank.			
5.1.3	Gassing – up	**R1,R2,R3, R4,R6**	**B1,B2,B4,B6, B7**	**A1, A11, A12, A13, A14, VG15**
5.1.3.1	Explains why after lay-up or dry-dock, the cargo tanks are filled with inert gas or nitrogen If the purging has been done with inert gas, the cargo tanks will have to be purged with cargo vapour and cooled when the vessel arrives at the loading terminal.			
5.1.3.2	Explains why unlike Nitrogen, inert gas contains approximately 15% carbon dioxide (CO_2 which will freeze at around -56°C and produces a white powder which can block valves, filters and nozzles.)			
5.1.3.3	Explains why during purging, the inert gas in the cargo tanks is replaced with warm cargo vapour. This action removes any freezable gases, such as carbon dioxide, and completes the drying of the tanks. This is known as gassing up or purge drying.			
5.1.3.4	Explains why for gassing up, cargo vapour is introduced into the tank and the tank atmosphere is purged out to shore or vented out.			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
5.1.4	Cooling down	**R1,R2,R3, R4,R6**	**B1,B2,B4,B6, B7**	**A1, A11, A12, A13, A14, VG15**
5.1.4.1	Explains why cool-down is when liquid is introduced into the cargo tanks to reduce the cargo tank temperature gradually so that thermal stresses are minimized and pressure increase is controlled. The lower the cargo carriage temperature is, the more important the cool-down procedure becomes			
5.1.4.2	Explains the purpose and procedure of the cooling-down operation			
5.1.4.3	Explains why the rates at which the cargo tanks can be cooled without creating undue thermal stresses will depend on the design and materials of the containment system.			
5.1.4.4	Explains why cool-down should continue until liquid begins to form in the bottom of the cargo tank, which will be determined from the temperature and / or level gauge readings.			
5.1.5	Loading	**R1,R2,R3, R4,R6**	**B1,B2,B4,B6, B7**	**A1, A11, A12, A13, A14, VG4, VG15**
5.1.5.1	Pre loading - check the following before arrival: - Condition and setting of the cargo tank relief valves - Remotely operated valves - Re-liquefaction plant, maximum number of plants running to reduce tank pressures before loading - Gas detection systems - Alarms and other cargo controls - ESD system - Any cargo manifold reducers that are fitted prior to arrival.			
5.1.5.2	Explains why the terminal should provide all necessary cargo information, including			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
	inhibitor certificates if inhibited cargoes such as VCM or butadiene are to be loaded			
5.1.5.3	Explains why if two or more cargoes are carried simultaneously they are segregated from each other to avoid contamination and chemical reaction			
5.1.5.4	Explains why if it is needed, to avoid contamination, segregation can be achieved by removal of spool pieces.			
5.1.5.5	Explains why cargoes chemically reactive with each other will have to be totally separated in both the liquid and vapour phases			
5.1.5.6	State that this cargo separation is to be obtained by means of removable spool-pieces or pipe sections			
5.1.5.7	Explains why separate re-liquefaction systems are to be used when mutually reactive cargoes are carried			
5.1.5.8	Explains why the Gas Carrier Codes provide special requirements for the safe handling and transport of certain cargoes carried on gas tankers			
5.1.5.9	Lists general preparations for loading as: - inspection of tanks, lines and pumps - inspection of gaskets in cargo system - tightening tests of flanges, connections and tank hatches - a function test of emergency shutdown systems - a function test of fixed gas-measuring equipment - function test of instruments for measuring pressure, temperature and liquid level - line-up inspection - controlling the ship's stability - verifying that agreement for the cargo transfer procedure has been reached with the responsible terminal representative			
5.1.5.10	Explains why when loading cargoes with a temperature which could result in high			

	Knowledge, Understanding and Proficiency	IMO Reference	Text books Bibliography	Teaching aid
	tank pressures, the cargo loading time depends on one, or a combination, of the following factors: - the capacity of the ship's re-liquefaction plant - the capacity of the ship's cargo compressors - the capacity of the terminal's cargo compressors / blowers - the capacity of the terminal's re-liquefaction plant			
5.1.5.11	Lists information to be made available by the terminal in the case of loading and/or discharging			
5.1.5.12	Lists information to be made available by the vessel in the case of loading and/or discharging			
5.1.5.13	Explains why the responsibility for correct and safe operations in port is divided between the master, port captain and terminal manager			
5.1.5.14	States the master should ensure proper liaison between ship and terminal			
5.1.5.15	Explains why, prior to any loading or discharging operation, a pre-cargo-transfer meeting should be held between the responsible personnel from the ship and the terminal			
5.1.5.16	Lists generally the subjects to be discussed during pre-cargo transfer meeting			
5.1.5.17	Explains why a ship/shore safety checklist should be completed jointly by the responsible persons on board and from the terminal			
5.1.5.18	Describes generally the checklist and explains the reasons for and the relevancy of the items to check			
5.1.5.19	Lists the safety precautions and procedures for personnel on watch prior to and during cargo-transfer operations			
5.1.5.20	Explains loading with vapour return and without vapour return to shore.			
5.1.6	Deballasting	**R1,R2,R3, R4,R6**	**B1,B2,B4,B6, B7**	**A1, A11, A12, A13,**

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
				A14, VG15
5.1.6.1	Explains why during loading the ship should at all times be stable and in good trim to allow for an emergency departure if necessary			
5.1.6.2	Explains why some liquefied gas tankers will have to undertake ballasting or deballasting during cargo operations to maintain an adequately stable condition			
5.1.6.3	Explains why the necessity of deballasting operations depends on ship design, cargo quantity, port conditions and ballast tanks location			
5.1.6.4	Explains why the distribution of cargo and ballast should at no time create excessive stress on the ship's hull			
5.1.6.5	Explains why the effect of free surfaces in cargo tanks and ballast tanks to be closely monitored and controlled as per the stowage plan for cargo operations.			
5.1.7	Sampling, including closed – loop sampling	**R1,R2,R3, R6**	**B1,B2,B4,B6, B7**	**A1, A11, A13, A14, VG15**
5.1.7.1	Explains why sampling of liquefied gases onboard ships is usually conducted by drawing a sample of cargo from the fitted sampling points into a sample cylinder			
5.1.7.2	Explains why the sample cylinders are usually double ended stainless steel cylinders of 500 ml capacity, rated to about 120 bar			
5.1.7.3	Explains why to obtain a representative sample the product should be available at a pressure of about 3.5 barg			
5.1.7.4	Explains why for complying it is normal practice to start the cargo pumps and circulate the product back to the tank via the filling line. A valve on the circuit can be partially closed to create the required pressure.			
5.1.7.5	Explains why the cylinder sample is held vertically and purged by opening the sampling point valve with the cylinder valve (nearest to the cargo line) fully			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
	open. The purging rate can be controlled at all times by operating the cylinder valve at the opposite side of the cylinder.			
5.1.7.6	Explains why the cylinder should be filled and emptied at least twice to clean and cool the cylinder. Fill the cylinder as rapidly as pressure permits and maintain a through purge for 60 seconds.			
5.1.7.7	Explains why the valve at the opposite side of the cylinder is closed, followed by the rapid closure of the sample point valve and the connected valve of the cylinder.			
5.1.7.8	Explains why with the cylinder held vertically, the bottom valve should be opened and approximately 20% of the cylinder content released.			
5.1.7.9	Explains closed loop and open loop sampling			
5.2	**Sea passage :**			
5.2.1	Cooling down	**R1,R2,R3, R6**	**B1,B2,B4,B6, B7**	**A1, A11, A12, A13, A14, VG15**
5.2.1.1	Explains why on loaded passage primary concern is with the use of the re-liquefaction plant to maintain or reduce the cargo temperature.			
5.2.1.2	Explains why although most re-liquefaction plants have a suction knock-out drum, there is always a danger that large slugs of liquid are carried over into the compressor in heavy weather, so it may be prudent not to run the compressors in such conditions.			
5.2.1.3	Explains why incondensables will have to be vented-off to minimise compressor discharge pressures and temperatures			
5.2.1.4	Explains why to prevent polymerisation of some cargoes (Butadiene / VCM etc.), compressor discharge temperatures should be limited to that required for each cargo.			
5.2.1.5	Explains why when the condensate return from the re-liquefaction plant is routed to			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
	the top sprays, in calm weather conditions, the small vapour space in the tank combined with the absence of any liquid suction in the tank can cause a cold and dense layer of liquid to form at the surface.			
5.2.1.6	Explains why full re-liquefaction plant capacity should be run on each tank independently and in sequence			
5.2.1.7	Explains why the condensate return from the cargo condenser should be returned through a bottom connection to ensure circulation of the tank contents, so preventing any risk of in-tank rollover of different liquid densities			
5.2.1.8	Explains why during a sea passage where the cargo tanks contain LNG, the naturally-generated boil-off from the tanks is burned in the ship's boilers. The operation is started on deck and controlled by the ship's engineers in the CCR and ECR. If the boil-off cannot be used for gas burning purposes, or if the volume is too great for the boilers to handle, then excess vapour as a last resort may be vented into the air through the No.1 vent mast			
5.2.1.9	Lists the LNGC sea passage entries to be made as: - Daily Cargo Log. - Daily LD (Low density) Compressor Log. - Inner Hull Inspection (IHI) Record. - Monitor inner-hull and insulation space temperatures, as appropriate. - Daily trend monitoring of Average Liquid Temperature (for delivery). - Daily Fuel Oil Equivalent (usually calculated as part of the Voyage Abstract). - Alarm Test Register (on-going from an established register or Planned Maintenance system). - Weather Report (sea state, barometric pressure, etc. all have an effect regarding cargo condition considerations).			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
5.2.2	Pressure maintenance	**R1,R2,R3, R4,R6**	**B1,B2,B4,B6, B7**	**A1, A11, A12, A13, A14, VG15**
5.2.2.1	Explains why on LPG Carrier after the cargo has cooled the re-liquefaction plant capacity can be reduced to a level that balances the heat flow through the tank insulation to maintain cargo tank pressure rise.			
5.2.2.2	Explains why on LNG tankers to control the flow of gas through the LD compressors, adjust the inlet guide vane position. When gas-burning is initiated, - Select the normal boil-off in the boiler combustion control. - Select the maximum / minimum allowed tank pressures. - Select the tank pressure at which the main steam dump operates.			
5.2.2.3	Explains why if the normal boil-off control value has been correctly adjusted, the tank pressures will remain within the selected values. Should the selected normal boil off value be too large, tank pressure will slowly reduce until it reaches the minimum value selected. If the tank pressure value continues to fall below the minimum value selected, the control system will reduce the normal boil-off value until the tank pressure has increased again above the selected value			
5.2.3	Boil – off	**R1,R2,R3, R6**	**B1,B2,B4,B6, B7,B8**	**A1, A11, A12, A13, A14, VG15**
5.2.3.1	Explains why on LNG vessels, if during a loaded passage, additional fuel gas from the cargo tanks is required to be burned in the ship's boilers over and above current natural generation, it can be made available by forced vaporization, using a dedicated forcing vapouriser.			
5.2.3.2	Explains why this operation, called Forced Boil-Off, can be used to			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
	complement gas burning for up to 100% of the boiler's fuel requirement.			
5.2.3.3	Explains why the normal gas burning arrangement is maintained and the forcing vapouriser is brought into operation. This uses a single stripping/spray pump in conjunction with the LNG forcing vapouriser.			
5.2.3.4	Explains why the excess flow from the pump is returned to the same tank through the stripping header pressure control valves			
5.2.4	Inhibiting	**R1,R2,R3, R6**	**B1,B2,B4,B6, B7**	**A1, A11, A13, A14, VG15**
5.2.4.1	Explains why the terminal should provide all necessary cargo information, including inhibitor certificates if inhibited cargoes such as VCM or butadiene are to be loaded.			
5.2.4.2	Explains why cargoes that are required to be inhibited are identified in column I in chapter 19 of the IGC code			
5.2.4.3	Explains why the IMO Codes require cargoes which may self-react either to be carried under an inert gas blanket, or to be inhibited before shipment. In the latter case a certificate must be given to the ship,stating: (1) The quantity and name of the inhibitor added; (2) The date it was added and how long it is expected to remain effective; (3) The action to be taken should the voyage exceed the effective lifetime of the inhibitor; (4) Any temperature limitations affecting the inhibitor			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
5.3	**Unloading**			
5.3.1	Unloading	**R1,R2,R3, R6**	**B1,B2,B4,B6, B7,B8**	**A1,A11, A12,A13.A14, VG5, VG15**
5.3.1.1	Explains why a gas tanker may be unloaded in different ways depending on the type of containment, the cargo and the condition of the terminal			
5.3.1.2	Explains the relevance and lists methods of unloading, such as: - pressure discharge - pressure and booster-pump discharge - centrifugal cargo-pump refrigerated discharge - centrifugal cargo-pump and booster-pump discharge			
5.3.1.3	Explains cargo unloading without vapour return			
5.3.1.4	Explains cargo unloading with vapour return			
5.3.1.5	Explains cargo unloading with heating			
5.3.1.6	States the necessity of starting unloading carefully and slowly to avoid thermal stresses in cargo piping on board and ashore			
5.3.1.7	Explains why overpressure should be maintained in cargo tanks during discharging			
5.3.1.8	Lists ways of maintaining overpressure if it tends to fall during discharging			
5.3.1.9	States general preparations for unloading are to carry out: - function tests of pumps and valves - function tests of instruments for measuring pressure, temperature and cargo level - a function test of fixed gas-measuring equipment - cargo calculation and sampling - line-up inspection for discharging - checking for leakages in cargo system - controlling pressure during discharging			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
	- controlling the ship's stability - verifying that agreement for the cargo transfer procedure has been reached with the responsible terminal representative - ascertaining that all safety regulations are complied with			
5.3.2	Ballasting	**R1,R2,R3, R6**	**B1,B2,B4,B6, B7**	**A1, A11, A13, A14, VG15**
5.3.2.1	Explains why during unloading operations the ship should at all times be stable and in good trim to allow for an emergency departure if necessary			
5.3.2.2	Explains why some liquefied gas tankers will have to undertake ballasting during cargo operations to maintain an adequately stable condition			
5.3.2.3	Explains why the necessity of ballast operations depends on ship design, cargo quantity, port conditions and ballast tanks			
5.3.2.4	Explains why the distribution of cargo and ballast should at no time create excessive stress on the ship's hull			
5.3.2.5	Explains why the effect of free surfaces in cargo tanks and ballast tanks to be closely monitored and controlled as per the stowage plan for cargo operations.			
5.3.2.6	States measures to ensure adequate stability of the vessel as: - correct use of valves in the centre-line bulkhead - correct distribution of water and bunkers - correct distribution of ballast			
5.3.3	Stripping and cleaning systems	**R1,R2,R3, R6**	**B1,B2,B4,B6, B7**	**A1, A11, A12, A13, A14, VG15**
5.3.3.1	Explains why to achieve maximum drainage of liquid during unloading, the following procedure should be followed:			
5.3.3.1.1	Explains why careful trimming or listing of the ship can, depending on the design of a tank, assist drainage of liquid.			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
5.3.3.1.2	Explains why if pumps are used for unloading, the pump discharge valve should be throttled towards completion of unloading to maintain suction to minimum liquid level. Manufacturers' instructions should be consulted as to the liquid level at which throttling should be started and the pump pressure that has to be maintained during later stages of pumping to obtain maximum, stripping.			
5.3.3.1.3	Explains why each pump should be kept under continuous control during stripping to obtain the best results without pumps running dry.			
5.3.4	Systems and procedures to make the tank liquid-free	**R1,R2,R3, R6**	**B1,B2,B4,B6, B7**	**A1, A11, A12, A13, A14, VG15**
5.3.4.1	Explains why even with proper operation of cargo pumps, some liquid will remain in the tanks at termination of pumping. • In the case of ships whose cargo tanks can accept overpressure, further stripping of liquid may be achieved by increasing tank pressure sufficiently to press out the liquid through the piping system ashore. • Alternatively, all stripping may be collected in one of the tanks for subsequent unloading ashore. • The use of cargo compressors, taking suction from other tanks, will ensure that all tanks and associated piping systems are left liquid-free. • Proper stripping of tanks should be checked by the bottom sampling line or temperature sensors.			
5.3.4.2	Explains why in the case of ships with cargo tanks designed for pressures only slightly above atmospheric (fully refrigerated ships), stripping by pressure alone is not possible. • On such ships (and on ships with			

Knowledge, Understanding and Proficiency	IMO Reference	Text books Bibliography	Teaching aid
pressure tanks, if pressure stripping is not successful) the remaining liquid should be boiled off by introducing hot vapour from the cargo compressors to the bottom of the tanks, through puddle heat coils (if fitted). • During such operations the tank pressure must be closely observed, to avoid exceeding the relief valve set pressure. • When pressure has increased to a safe level below the relief valve pressure, the cycle is reversed by starting compressor suction from the tank, reliquefying the vapour in the condenser, and discharging the condensate to shore or retaining on board in a deck pressure vessel. • Alternatively, if the ship is at sea the vapour may be vented instead of being reliquefied.			
5.3.4.3 Explains why some ships are fitted with heating coils in the tank bottom to evaporate liquid residues. The heating medium is hot cargo vapour for internal coils or may be thermal heating oil for coils fitted externally to the tank. Vapour circulating coils should be purged either with inert gas or with vapour from the subsequent cargo if it is compatible with the previous cargo. Similar precautions should be taken with cargo compressors.			
5.3.4.4 Explains why liquid is removed from the piping system and equipment by blowing through with vapour. Hot gas from the compressors passed through the liquid lines will provide heat to evaporate liquid not removed by pressure displacement.			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
	In cold weather and in insulated pipelines, liquid butane, butadiene etc. may evaporate very slowly even at atmospheric pressure.			
5.3.4.5	Explains why for change of cargo, the removal of all traces of ammonia by ventilation alone is a lengthy process.			
5.3.4.6	Explains why remaining traces of ammonia may be removed by water washing or water sweeping. Ammonia is extremely soluble (one volume of water dissolves up to 1000 volumes of ammonia vapour), and the introduction of water into tanks containing high concentrations of ammonia may immediately cause dangerous vacuum conditions unless unrestricted access of air is provided.			
5.3.4.7	Explains why ship's inert gas containing CO_2 should never be used for purging after ammonia cargoes as carbamates will be formed which may block the cargo pipe lines			
5.4	**Pre – docking preparation:**			
5.4.1	Warm – up	**R1,R2,R3, R6**	**B1,B2,B4,B6, B7,B8**	**A1, A11, A12, A13, A14, VG15**
5.4.1.1	Explains the purpose and procedure of vaporizing cargo residue and warming up the tank shell			
5.4.2	Inerting	**R1,R2,R3, R4,R6**	**B1,B2,B4,B6, B7,B8**	**A1, A11, A13, A14, VG15**
5.4.2.1	Explains why vapour from the last cargo in the system are displaced by inert gas from the ship's inert gas generator, or by pure nitrogen from shore. If the ship's inert gas is used, the cargo piping system from the tank should be opened to the vent before the inert gas supply is			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
	connected as an additional precaution against the possible backflow of flammable vapour to the generator.			
5.4.2.2	Explains the basic methods of inerting as: - inerting by displacement - inerting by dilution - inerting by vacuum / pressure			
5.4.3	Gas freeing	**R1,R2,R3, R6**	**B1,B2,B4,B6, B7,B8**	**A1, A11, A12, A13**
5.4.3.1	Explains the purpose and procedure of gas-freeing			
5.4.3.2	Describes with the aid of a flammability diagram the gas-freeing operation and states when the tank is safe with regard to: - flammability hazards - health hazards			
5.5	Ship – to ship transfer (STS)	**R1,R2,R3, R4,R6**	**B1,B2,B3,B4, B6,B7**	**A1, A11, A13**
5.5.1	Explains why STS operation can be performed while ships are at anchor or underway.			
5.5.2	Explains why checklists as per STS transfer guide (liquefied gases) must be complied with			
5.5.3	Explains why proper STS equipment to be present on both the vessels and they should be in good condition.			
5.5.4	Explains why proper attention must be paid to the difference in freeboard and listing of both the vessel while transferring liquefied gases.			
5.5.5	Explains why a proper communication channel needs to be established between the ships.			
5.5.6	Explains why firefighting and spill equipment to be present and crew to be well trained to use them in emergency.			
	[GEE8]			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
6.0	**Proficiency to perform cargo measurements and calculations**			
6.1	Liquid phase	**R2,R6**	**B2,B9,B10**	**A1, A11, A13, A14, VG15**
6.1.1	Defines 'sounding' and 'ullage' as: Ullage is the depth of the space above the liquid in the tank. Sounding is the depth of the space below the liquid in a tank.			
6.1.2	Explains why the IMO Gas Carrier Codes stipulate rigid requirements for the maximum filling of cargo tanks			
6.1.3	Explains reasons for tank filling requirements.			
6.1.4	Defines the formula for calculating the maximum allowable filling limit of a cargo tank			
6.1.5	Explains why a list or diagram indicating the maximum allowable tank filling limit for each tank and for each product which may be carried should be kept on board			
6.1.6	Explains the influence on the filling limit of the cargo tank as per IGC code			
6.1.7	Calculates the maximum allowable filling volume of cargo tanks, given the tank volume, the setting of the safety relief valve, the type of cargo, the loading temperature and pressure-temperature data for the cargo			
6.1.8	Lists units used under the International System of Units (S.I.) and defines: - volume - density - mass			
6.1.9	Defines 'specific gravity'			
6.1.10	Defines 'litre weight'			
6.1.11	Discusses 'weight in air' and 'weight in vacuum'			
6.1.12	Explains why when calculating quantities of liquid gas cargo the procedure includes use of ASTM tables, volume reduction factors			
6.1.13	Calculates the liquid phase			

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
6.2	Gas phase	**R2,R6**	**B2, B9,B10**	**A1, A11, A13, A14, VG15**
6.2.1	Explains equation of state			
6.2.2	Discusses density at $0^{O}C$			
6.2.3	Explains molecular weight and its use in obtaining density at $0^{O}C$			
6.2.4	Explains volume at $0^{o}C$			
6.2.5	Calculates mass of the vapour phase			
6.2.6	Calculates the total cargo quantities in metric tons, given the following factors: - type of cargo and its liquid and vapour temperature - gauge reading of sounding, ship's trim and using: - cargo tank pressures - data sheet for the cargo and trimming tables of vessel.			
6.2.7	Converts mass to "weight in air"			
6.3	On board quantity (OBQ)	**R2,R6**	**B1,B2, B9,B10**	**A1, A11, A13, A14, VG15**
6.3.1	Explains why the liquid and vapour retained on board prior commencement of loading the same cargo for keeping the tanks cooled is called On Board Quantity			
6.3.2	Explains why this quantity is accounted for during cargo calculations to establish the quantity loaded.			
6.4	Remain on board (ROB)	**R2,R6**	**B1,B2, B9,B10**	**A1, A11, A13, A14, VG15**
6.4.1	Explains why the liquid and vapour remaining after unloading is retained on board and used to keep the tanks cold for the next cargo.			
6.4.2	Explains why this quantity is accounted for during cargo calculations to establish the quantity unloaded.			
6.5	Boil – off cargo calculations	**R2,R6**	**B2,B8, B9,B10**	**A1, A11, A13, A14, VG15**

Knowledge, Understanding and Proficiency		IMO Reference	Text books Bibliography	Teaching aid
6.5.1	Explains why on some LNG vessels the boil off is used for propulsion and subsequently conditioning the cargo			
6.5.2	Explains why the quantity consumed needs to be quantified.			
6.5.3	Explains why LNG Calculation are specific to charter parties			
6.5.4	States "mass" is calculated from liquid volume and density at tank condition. - Total CV of LNG discharged = (V x d x CV/kg) – CV of volume remaining on board. - V = volume prior discharged – volume after discharged. - Qr = quantity of vol. ROB is found by PV = mRT where R = 2.87. - Therefore m = PV / RT and Qr = m (CV / kg)			
6.5.5	Explains why on most LNG vessels the calculations are done and recorded by the approved Custody transfer systems. [GEE9]			
7.0	**Proficiency to manage and supervise personnel with cargo related responsibilities**	**R2,R3,R6**	**B1,B2,B6,B7, B9,B10**	**A1,A11,A13, A14,VG5, VG15**
7.1	Explains why ILO lays down the requirements for rest hours for all officers and crew including the Master.			
7.2	Explains why Master and Chief Engineer must plan the work in an optimal manner, in order to ensure that crew is sufficiently rested.			
7.3	Explains why It is the duty of the Company and the Master to ensure that requirements of rest hours are complied with.			
7.4	Explains why the responsible cargo officer on watch shall supervise and direct the cargo operations ensuring that the stresses and stability of the vessel are always within limits. He shall keep Master fully informed with all aspects of cargo care.			
7.5	Explains why the responsible officer shall be responsible for ensuring and maintaining:			

Knowledge, Understanding and Proficiency	IMO Reference	Text books Bibliography	Teaching aid
- suitability of cargo containment prior loading. - cargo is loaded, as per stowage plan. - cargo is cared for during passage with respect to monitoring its parameters, ventilation, cooling, heating etc., as required. - cargo is unloaded safely as per plan. Issuing relevant standing / night orders. - records for cargo and ballast operations are maintained as per company procedures. - records of cargo parameters, soundings of ballast tank and other spaces are maintained as per company procedures. - prior loading of any hazardous cargo, same is discussed with Master			
7.6 Explains why the nominated seaman for operating pumps shall be responsible for: - Obtaining work schedule and orders from the chief officer. - Undertaking tasks and working alongside other deck or engine crew as per instructions received from the responsible officer. - Carrying out the work assigned to him in a safe and efficient manner.			
7.7 Explains why the duty hand and seaman on cargo watches shall carry out the work as assigned to him by the responsible officer of the watch.			

COMPETENCE 2	**Familiarity with physical and chemical properties of liquefied gas cargoes**

TOPIC 8	**KNOWLEDGE AND UNDERSTANDING OF BASIC CHEMISTRY AND PHYSICS AND THE RELEVANT DEFINITIONS RELATED TO THE SAFE CARRIAGE OF LIQUEFIED GASES IN BULK IN SHIPS**

TRAINING OUTCOMES:

Demonstrates a knowledge and understanding of:

8 Basic chemistry and physics and the relevant definitions related to the safe carriage of liquefied gases in bulk in ships

8.1 the chemical structure of gases

8.2 the properties and characteristics of liquefied gases (including CO2) and their vapours, including:
- 8.2.1: simple gas laws
- 8.2.2: states of matter
- 8.2.3: liquid and vapour densities
- 8.2.4: diffusion and mixing of gases
- 8.2.5: compression of gases
- 8.2.6: dew point and bubble point
- 8.2.7: critical temperature of gases and pressure
- 8.2.8: flashpoint and upper and lower explosive limits, auto-ignition temperature
- 8.2.9: compatibility, reactivity and positive segregation of gases
- 8.2.10: polymerization
- 8.2.11: saturated vapour pressure/reference temperature
- 8.2.12: lubrication of compressors
- 8.2.13: hydrate formation

8.3 the properties of single liquids
- 8.3.1: evaporation
- 8.3.2: vapour pressure
- 8.3.3: liquid and vapor densities

8.4 the nature and properties of solutions
- 8.4.1: density of gas solutions
- 8.4.2: vapour pressure of gas solutions

8.5 thermodynamic units

8.6 basic thermodynamic laws and diagrams
- 8.6.1: first and second law
- 8.6.2: gas laws

TOPIC 8 **KNOWLEDGE AND UNDERSTANDING OF BASIC CHEMISTRY AND PHYSICS AND THE RELEVANT DEFINITIONS RELATED TO THE SAFE CARRIAGE OF LIQUEFIED GASES IN BULK IN SHIPS**

8.7 properties of materials
8.8 effect of low temperature – brittle fracture

TOPIC 9 **INFORMATION CONTAINED IN A SAFETY DATA SHEET (SDS)**

9 Information contained in a Safety Data Sheet (SDS)

Required Performance

Note that students must be familiar with the content of the basic knowledge of hazards associated with tanker operations from IMO Model Course 1.04. It may be necessary for some students to refresh their knowledge of this content before undertaking this management level content.

TOPIC 8	KNOWLEDGE AND UNDERSTANDING OF BASIC CHEMISTRY AND PHYSICS AND THE RELEVANT DEFINITIONS RELATED TO THE SAFE CARRIAGE OF LIQUEFIED GASES IN BULK IN SHIPS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
8.0	**Knowledge and understanding of basic chemistry and physics and the relevant definitions related to the safe carriage of liquefied gases in bulk in ships** **NOTE: The following knowledge IN 8.1.1 to 8.1.3 is not required under Table A-V/1-2-2 of the STCW Code. However it is recommended that the trainee has basic knowledge of the following content in 8.1.1 to 8.1.3:**			
8.1	The chemical structure of gases	**R1,R2**	**T1,B2**	**A1,A11, A13,A14, VG11, VG15**
8.1.1	States that most liquefied gas cargoes are hydrocarbons			
8.1.2	Explains why a hydrocarbon molecule is characterized by the presence of carbon and hydrogen atoms in various arrangements			
8.1.3	Explains why hydrocarbons with up to four carbon atoms in Weir molecules are gaseous at ambient temperature and pressure			
8.1.4	States the hydrocarbons with 5 to 20 carbon atoms are liquids at ambient conditions			
8.1.5	Explains why hydrocarbons with more than 20 carbon atoms in their molecules are solids at ambient conditions			
8.1.6	Explains a saturated hydrocarbon molecule with the aid of a molecular structure diagram			
8.1.7	Lists typical liquefied gas cargoes that are saturated hydrocarbons			

TOPIC 8	KNOWLEDGE AND UNDERSTANDING OF BASIC CHEMISTRY AND PHYSICS AND THE RELEVANT DEFINITIONS RELATED TO THE SAFE CARRIAGE OF LIQUEFIED GASES IN BULK IN SHIPS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
8.1.8	Explains an unsaturated hydrocarbon molecule with the aid of a molecular structure diagram			
8.1.9	Lists typical liquefied gas cargoes that are unsaturated hydrocarbons			
8.1.10	Explains why the third group of liquefied gas cargoes is the chemical gases			
8.1.11	Explains why chemical gases are characterized by the molecular structure			
8.1.12	Explains a typical chemical gas molecule with the aid of a molecular structure diagram			
8.1.13	Lists typical liquefied gas cargoes that are chemical gases e.g. Ammonia, VCM			
8.1.14	Explains why saturated hydrocarbons, e.g. methane, ethane, propane and butane, are colorless and odorless			
8.2	The properties and characteristics of liquefied gases (including CO2) and their vapours	**R1,R2,**	**T1,B2**	**A1,A11, A13, A14, VG15**
8.2.1	Simple gas laws	**R1,R2,**	**T1,B2**	**A1, A11, A13**
8.2.1.1	Defines 'absolute temperature' as the fundamental temperatures scale with its zero at absolute zero and expressed either in Kelvin or degrees Rankin. One Kelvin (Since Kelvin scale is starting from absolute zero, temperature in Kelvin Scale is written as 't' Kelvin, without any superscript of '°' indicating degrees) is equal to one Celsius or one centigrade degree and one Rankine degree is equal to one Fahrenheit degree. To convert Celsius to Kelvin adds 273. To convert Fahrenheit to Rankine adds 460.			

TOPIC 8	KNOWLEDGE AND UNDERSTANDING OF BASIC CHEMISTRY AND PHYSICS AND THE RELEVANT DEFINITIONS RELATED TO THE SAFE CARRIAGE OF LIQUEFIED GASES IN BULK IN SHIPS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
8.2.1.2	Defines 'absolute pressure' as sum of atmospheric pressure and gauge pressure.			
8.2.1.3	Defines 'enthalpy' as a thermodynamic function of a system, equivalent to the sum of the internal energy of the system plus the product of its volume multiplied by the pressure exerted on it by its surroundings.			
8.2.1.4	Converts S.I. units to other common units using chart provided in Part D			
8.2.1.5	Explains why Dalton's law of partial pressures is the pressure exerted by a mixture of gases is equal to the sum of the separate pressures which each gas would exert if it alone had occupied the whole volume.			
8.2.1.6	Explains why Joule's second law says the internal energy of an ideal gas is independent of its volume and pressure, depending only on its temperature			
8.2.1.7	Explains Avogadro's number			
8.2.2	States of matter	**R1,R2,**	**T1,B2**	**A1, A11, A13**
8.2.2.1	Describes the three states of aggregation			
8.2.2.2	Explains the relationship between pressure and boiling point			
8.2.2.3	Explains the critical point of a gas			
8.2.2.4	Explains the relationship between temperature and enthalpy for the various states of aggregation			
8.2.2.5	Defines latent heat of vaporization as amount of heat required to convert a unit mass of a liquid at its boiling point into vapor without an increase in temperature			

TOPIC 8	KNOWLEDGE AND UNDERSTANDING OF BASIC CHEMISTRY AND PHYSICS AND THE RELEVANT DEFINITIONS RELATED TO THE SAFE CARRIAGE OF LIQUEFIED GASES IN BULK IN SHIPS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
8.2.2.6	Explains the different curves and lines of a Mollier diagram			
8.2.3	Liquid and vapour densities	**R1,R2,**	**T1,B2**	**A1, A11, A13**
8.2.3.1	Explains density of liquids			
8.2.3.2	Explains density of gases			
8.2.3.3	Explains density of vapours			
8.2.3.4	Explains variations of density with temperature			
8.2.3.5	Explains vapour pressures			
8.2.3.6	Explains variations of vapour pressure with temperature			
8.2.3.7	Demonstrates, with the aid of pressure-temperature-density diagram, appended in Part D for a common liquefied gas cargo, the relationship between vapour pressure, temperature and the densities of liquid and vapour			
8.2.4	Diffusion and mixing of gases	**R1,R2,**	**T1,B2**	**A1,A11, A13**
8.2.4.1	Describes diffusion and mixing of gases			
8.2.4.2	Describes solubility of gases in liquids			
8.2.4.3	Describes miscibility between liquids and the effects of temperature on miscibility			
8.2.4.4	Explains the variation in dew points and the effects of low temperatures			
8.2.4.5	Describes the phenomenon of "roll-over"			
8.2.4.6	Explains why LPG cargoes may be mixtures of different liquefied petroleum gases			
8.2.4.7	Explains why such cargoes are refer to as "LPG-mixtures"			
8.2.4.8	Explains why the mixing may be done in shore tanks or in ship's tanks			

TOPIC 8	KNOWLEDGE AND UNDERSTANDING OF BASIC CHEMISTRY AND PHYSICS AND THE RELEVANT DEFINITIONS RELATED TO THE SAFE CARRIAGE OF LIQUEFIED GASES IN BULK IN SHIPS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
8.2.5	Compression of gases	**R1,R2,**	**T1,B2**	**A1,A11, A13**
8.2.5.1	Explains why Internal energy is that thermodynamic energy which is attributed to the physical state of the gases.			
8.2.5.2	Explains why it includes sensible heat, latent heat, kinetic energy and potential energy			
8.2.5.3	Explains why the term PV represents the energy available within the system due to its pressure and volume.			
8.2.5.4	Explains why it is the change of enthalpy which is important in thermodynamic analysis of compression of gases in the re-liquefaction cycle.			
8.2.5.5	Explains why a change in enthalpy expresses the total energy change in a gas as it passes through any thermodynamic process. It is a particularly useful concept for the analysis of heat and work energy changes in cyclic processes involving compression, expansion, evaporation or condensation such as are encountered in the liquefaction of boil-off vapours.			
8.2.6	Re-liquefaction and refrigeration of gases	**R1,R2,**	**T1,B2**	**A1,A11, A13**
8.2.6.1	Explains why when heat is added to or removed from a substance during a reversible process, the heat involved divided by the temperature of substance is called entropy			
8.2.6.2	Explains why only changes in entropy occur during re-liquefaction.			

TOPIC 8	KNOWLEDGE AND UNDERSTANDING OF BASIC CHEMISTRY AND PHYSICS AND THE RELEVANT DEFINITIONS RELATED TO THE SAFE CARRIAGE OF LIQUEFIED GASES IN BULK IN SHIPS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
8.2.6.3	Explains why the entropy is evaluated by dividing the process into small steps, such that the temperature be considered constant, and summing, the result			
8.2.6.4	Explains why the importance of the First Law of Thermodynamics to re-liquefaction systems is that the sum of the heat and work put into the boil off must be equal to the heat rejected to the sea to maintain cargo temperatures and pressures. The work done by the compressor in compressing the gas can be taken as the addition of an equivalent amount of heat.			
8.2.7	Critical temperature and pressure of gases	**R1,R2,**	**T1,B2**	**A1,A11, A13**
8.2.7.1	Defines Critical Temperature as the temperature above which a gas cannot be liquefied whatever may be the pressure applied.			
8.2.7.2	Defines Critical Pressure as the pressure of a saturated vapour at the critical temperature, i.e. the pressure required to cause liquefaction at that temperature.			
8.2.7.3	Explains why apart from ethylene and LNG, all gas cargoes are below their critical pressures at ambient temperatures			
8.2.7.4	Explains why most gases can therefore be liquefied by pressure and carried at ambient temperatures.			
8.2.7.5	Explains why for ethylene and LNG the critical temperatures and pressures are too high			
8.2.8	Flashpoint, upper and lower explosive limits, auto-ignition temperature	**R1,R2,**	**T1,B2**	**A1,A11, A13**

TOPIC 8	KNOWLEDGE AND UNDERSTANDING OF BASIC CHEMISTRY AND PHYSICS AND THE RELEVANT DEFINITIONS RELATED TO THE SAFE CARRIAGE OF LIQUEFIED GASES IN BULK IN SHIPS			
	Knowledge, Understanding and Proficiency	**IMO Reference**	**Text books Bibliography**	**Teaching aid**
8.2.8.1	Defines the flash point of a liquid as the lowest temperature at which that liquid will evolve sufficient vapour to form a flammable mixture with air.			
8.2.8.2	Defines lower explosive limits as the minimum concentration of flammable vapour to oxygen or to air capable of combustion			
8.2.8.3	Defines upper explosive limits as the maximum concentration of flammable vapour to oxygen or to air capable of combustion			
8.2.8.4	Defines auto ignition temperature as that temperature at which a substance would ignite without the introduction of a source of ignition			
8.2.9	Compatibility, reactivity and positive segregation of gases	**R1,R2,**	**T1,B2**	**A1,A11, A13**
8.2.9.1	Explains why when common pipeline systems are provided for various cargo-related operations, contamination will occur when different grades of cargo are carried simultaneously			
8.2.9.2	Explains why if segregation is needed to avoid cargo contamination, shippers' instructions and regulatory requirements must be observed.			
8.2.9.3	Explains why if a common piping system has to be used for different cargoes, great care should be taken to ensure complete drainage and drying of the piping system before purging with new cargo			
8.2.9.4	Explains why wherever possible, separate re-liquefaction systems should be used for each cargo			

TOPIC 8	KNOWLEDGE AND UNDERSTANDING OF BASIC CHEMISTRY AND PHYSICS AND THE RELEVANT DEFINITIONS RELATED TO THE SAFE CARRIAGE OF LIQUEFIED GASES IN BULK IN SHIPS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
8.2.9.5	Explains why if there is a danger of chemical reaction, it is necessary to use completely segregated systems, known as positive segregation, at all times, utilizing removable spool pieces or pipe sections.			
8.2.9.6	Explains why some substances may require totally independent piping and venting systems			
8.2.9.7	Explains why special treatment of certain cargoes is specified in the relevant IMO Gas Carrier Code.			
8.2.9.8	Explains why If there is any doubt about the reactivity or compatibility of two cargoes, in consultation with the data sheets for each cargo and a cargo compatibility chart, the cargoes should be treated as incompatible and positive segregation provided.			
8.2.10	Polymerization	**R1,R2,**	**T1,B2**	**A1,A11, A13**
8.2.10.1	Defines polymerization as the phenomenon whereby the molecules of a particular compound can be made to link together into a larger unit containing anything from two to thousands of molecules, the new unit being called a polymer.			
8.2.10.2	Explains why a compound may thereby change from a free flowing liquid to a viscous one or even a solid. A great deal of heat may be evolved when this occurs.			
8.2.10.3	Explains why polymerization may occur spontaneously with no outside influence, or it may occur if the compound is heated, or if a catalyst or impurity is added.			
8.2.10.4	Explains why polymerization may prove to be dangerous and may warrant jettisoning of cargo as a last measure to safety.			

TOPIC 8	KNOWLEDGE AND UNDERSTANDING OF BASIC CHEMISTRY AND PHYSICS AND THE RELEVANT DEFINITIONS RELATED TO THE SAFE CARRIAGE OF LIQUEFIED GASES IN BULK IN SHIPS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
8.2.11	Saturated vapour pressure / reference temperature	**R1,R2,**	**T1,B2**	**A1,A11, A13**
8.2.11.1	Defines saturated vapour pressure as the pressure at which a vapour is in equilibrium with its liquid at a specified temperature.			
8.2.11.2	Explains why the sub-cooled temperature should not fall below the temperature assigned to the tank. To ensure that this does not occur tank bottom temperatures should be closely observed.			
8.2.11.3	Explains why reference temperatures means the temperature corresponding to the vapour pressure of the cargo at the set relief valve pressure when no pressure/temperature control is provided or the temperature of the cargo at the termination of loading, in transit or at unloading whichever is greatest when a pressure/temperature control is provided.			
8.2.11.4	Explains why if this reference temperature would result in cargo tanks becoming liquid full at any stage of the voyage an additional pressure relieving system should be fitted in accordance with the IGC code.			
8.2.12	Dew point and bubble point	**R1,R2,**	**T1,B2**	**A1,A11, A13**
8.2.12.1	Defines the dew point of a vapour mixture at a given pressure as the temperature at which the vapour begins to condense as the temperature decreases			

TOPIC 8	KNOWLEDGE AND UNDERSTANDING OF BASIC CHEMISTRY AND PHYSICS AND THE RELEVANT DEFINITIONS RELATED TO THE SAFE CARRIAGE OF LIQUEFIED GASES IN BULK IN SHIPS			
	Knowledge, Understanding and Proficiency	**IMO Reference**	**Text books Bibliography**	**Teaching aid**
8.2.12.2	Defines the bubble point of liquid mixture at a given pressure as that temperature at which the liquid will begin to boil on rising temperature.			
8.2.12.3	Explains why for a liquid mixture in equilibrium with its vapour, the bubble point and the dew point are at different temperatures.			
8.2.12.4	Explains equilibrium curves for propane/butane mixtures at atmospheric pressure.			
8.2.13	Lubrication of compressors	**R1,R2,**	**T1,B2**	**A1,A11, A13**
8.2.13.1	Explains why the lubricating oil must be compatible with the cargo being handled and must be changed, if necessary after use with certain cargos (e.g. Ammonia, butadiene, vinyl chloride)			
8.2.13.2	Explains why the compressors prescribed lubricants and coolants should be used according to the equipment manuals.			
8.2.14	Hydrate formation	**R1,R2,**	**T1,B2**	**A1,A11, A13**
8.2.14.1	Explains why the dew point inside the tank and hold spaces of a liquefied gas tanker is to be lowered and controlled to avoid hydrate and carbonate formation.			
8.2.14.2	Explains why some hydrocarbon products react with water to form 'hydrates'. The presence of water can be due to: - condensed moisture in the inert gas (the IG dew point is too high) - water content of the hydrocarbon product, particularly propane in the cargo piping system.			

TOPIC 8	KNOWLEDGE AND UNDERSTANDING OF BASIC CHEMISTRY AND PHYSICS AND THE RELEVANT DEFINITIONS RELATED TO THE SAFE CARRIAGE OF LIQUEFIED GASES IN BULK IN SHIPS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
8.2.14.3	Explains why hydrates are white crystalline solids that are not soluble in water and can only be washed out by a very fine molecular alcohol known as methyl alcohol			
8.3	The properties of single liquids	**R1,R2,**	**T1,B2**	**A1,A11, A13, A14, VG15**
8.3.1	Explains evaporation			
8.3.2	Explains vapour pressure.			
8.3.3	Explains liquid and vapour densities			
8.4	The nature and properties of solutions	**R1,R2,**	**T1,B2**	**A1,A11, A13, A14, VG15**
8.4.1	Explains density of gas solution			
8.4.2	Explains vapour pressure of gas solutions			
8.5	Thermodynamic units	**R1,R2,**	**T1,B2**	**A1,A11, A13, A14, VG15**
8.5.1	Explains why that any physical quantity can be characterized by dimensions. The arbitrary magnitudes assigned to the dimensions are called units.			
8.5.2	Explains why there are two types of dimensions, *primary* or *fundamental* and *secondary* or *derived* dimensions. Primary dimensions are: mass, ***m;*** length, ***L;*** time, ***t;*** temperature, ***T*** Secondary dimensions are the ones that can be derived from primary dimensions such as: velocity (m/s^2), pressure ($Pa = kg/m^2$).			
8.6	Basic Thermodynamic laws and diagrams	**R1,R2,**	**T1,B2**	**A1,A11, A13, A14, VG15**

TOPIC 8	KNOWLEDGE AND UNDERSTANDING OF BASIC CHEMISTRY AND PHYSICS AND THE RELEVANT DEFINITIONS RELATED TO THE SAFE CARRIAGE OF LIQUEFIED GASES IN BULK IN SHIPS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
8.6.1	Explains the first and second laws of thermodynamics			
8.6.2	Explains the gas laws and states their limitation in practical use			
8.6.3	Defines the general gas equation and states its limitation in practical use			
8.7	Properties of materials	**R1,R2,**	**T1,B2**	**A1,A11, A13, A14, VG15**
8.7.1	Explains why material of the ships structure and cargo tanks undergoes changes due to the properties of the cargoes carried.			
8.7.2	Lists physical properties as low temperature, vapour pressure and density			
8.7.3	Lists chemical properties as corrosivity and reactivity			
8.7.4	Explains why types materials used and designs of containment systems is dependent upon the coefficient of thermal expansion, compatibility with cargo, ductility, strength and toughness of the material.			
8.8	Effect of low temperature brittle fracture	**R1,R2,**	**T1,B2**	**A1,A11, A13, A14, VG15**
8.8.1	Explains why Liquefied gas spilled onto constructional steel such as ships' decks not designed for low temperatures may cool this steel to temperatures where it becomes brittle.			
8.8.2	Explains why stress already within the steel together with that resulting from differential contraction may cause fracture of the steel In the cooled areas.			

TOPIC 8	KNOWLEDGE AND UNDERSTANDING OF BASIC CHEMISTRY AND PHYSICS AND THE RELEVANT DEFINITIONS RELATED TO THE SAFE CARRIAGE OF LIQUEFIED GASES IN BULK IN SHIPS			
	Knowledge, Understanding and Proficiency	**IMO Reference**	**Text books Bibliography**	**Teaching aid**
8.8.3	Explains why the resultant fractures are generally fine and unlikely to propagate beyond the cooled areas.			
8.8.4	Explains why as a protection against such spillage on ships carrying the particularly cold liquids (LNG and ethylene), the area around the manifold is usually sheathed in wood and all liquefied gas tankers are provided with a special steel or wooden or equivalent drip tray under the manifold connection. Special steel is used for all areas of hull and deck likely to come into contact with low temperature cargo.			
9.0	**Understanding** [GEE10] **the information contained in a Safety data sheet (SDS)**	**R1,R2,R6**	**T1,B1,B2,B5, B6**	**A1,A11, A13, A14, VG15**
9.1	Explains why the carriage of liquefied gases in bulk poses health and environmental hazards			
9.2	Explains why the MFAG gives detailed information about signs and symptoms, first aid and the administering of antidotes			[GEE11]
9.3	Describes all sections of the SDS using a safety data sheet.			

COMPETENCE 3 Take precautions to prevent Hazards

TRAINING OUTCOMES:

Demonstrates a knowledge and understanding of:

TOPIC 10 KNOWLEDGE AND UNDERSTANDING OF THE HAZARDS AND CONTROL MEASURES ASSOCIATED WITH LIQUEFIED GAS TANKER CARGO OPERATIONS

10 Hazards and control measures associated with liquefied gas tanker cargo operations

10.1 flammability
10.2 explosion
10.3 toxicity
10.4 reactivity
10.5 corrosivity
10.6 health hazards
10.7 inert gas composition
10.8 electrostatic hazards
10.9 polymerizing cargoes

11 Calibration[GEE12] and use of monitoring and gas-detection systems, instruments and equipment

11.1 use
11.2 calibration

12 Dangers[GEE13] of non-compliance with relevant rules/regulations

12.1 environmental damage
12.2 safety of crew
12.3 legal penalties

Required Performance

Note that students must be familiar with the content of the basic knowledge of hazards associated with tanker operations from IMO Model Course 1.04. It may be necessary for some students to refresh their knowledge of this content before undertaking this management level content.

TOPIC 10	KNOWLEDGE AND UNDERSTANDING OF THE HAZARDS AND CONTROL MEASURES ASSOCIATED WITH LIQUEFIED GAS TANKER CARGO OPERATIONS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
10.0	**Knowledge and understanding of the hazards and control measures associated with liquefied gas tanker cargo operations**			
10.1	Flammability	**R2,R7**	**T1,B1,B2,B6**	**A1,A11, A13, A14, VG15**
10.1.1	Explains why most liquefied gas cargoes are flammable			
10.1.2	Explains why it is not liquids, but the vapours emitted from them, that burn			
10.1.3	Explains why liquefied gas cargoes are carried at or close to their boiling point and give off vapours readily			
10.1.4	Explains why flammable vapours can ignite and will burn when mixed in certain proportions with air			
10.1.5	Explains why certain cargo vapours can burn, if ignited, without being mixed with air			
10.1.6	Explains why combustion is a chemical reaction, and describes the process of burning of hydrocarbons			
10.1.7	Explains why the flammable range will be different for different cargoes			
10.1.8	Explains the effect of increasing and decreasing the proportion of oxygen on the flammable limits			
10.2	Explosion	**R2,R7**	**T1,B1,B2,B6**	**A1,A11, A13, A14, VG15**
10.2.1	Explains why fire and explosion data for each liquefied gas cargo is given in the ICS Cargo Data Sheets			
10.2.2	Explains stoichiometric point			

TOPIC 10	KNOWLEDGE AND UNDERSTANDING OF THE HAZARDS AND CONTROL MEASURES ASSOCIATED WITH LIQUEFIED GAS TANKER CARGO OPERATIONS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
10.2.3	Describes effects of an explosion occurring above and below the stoichiometric point			
10.2.4	Explains the occurrence of primary and secondary explosions			
10.3	Toxicity	**R2**	**T1,B1,B2,B6**	**A1,A11, A13, A14, VG15**
10.3.1	Defines toxicity as the ability to harm, damage and destroy living cells.			
10.3.2	Defines Threshold Limit Value (TLV) as Concentration of gases in air to which it is believed personnel may be exposed up to 8 hours per day or 40 hours per week throughout their working life without adverse effects.			
10.3.3	Explains why the basic TLV is a Time Weighted Average (TWA) and may be supplemented by TLV STEL (Short Term Exposure Limit) or TLV-C (Concentration that should not be exceeded during any part of the working exposure).			
10.4	Reactivity	**R2**	**T1,B1,B2,B6**	**A1,A11, A13, A14, VG15**
10.4.1	Explains why a liquefied gas cargo may react in a number of ways, such as: - With itself - With air - With water - With another cargo - With other materials			
10.4.2	Explains self-reaction and lists gas cargoes that may self-- react			
10.4.3	States precautions against self-reaction include monitoring and reporting of any undue rise in temperatures.			

TOPIC 10	KNOWLEDGE AND UNDERSTANDING OF THE HAZARDS AND CONTROL MEASURES ASSOCIATED WITH LIQUEFIED GAS TANKER CARGO OPERATIONS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
10.4.4	States precautions against reaction with air are to keep cargo tanks inerted with nitrogen.			
10.4.5	States butadiene is a highly reactive petrochemical gas intermediate			
10.4.6	States Ammonia is also toxic and highly reactive. It can form explosive compounds with mercury, chlorine, iodine, bromine, calcium, silver oxide and silver hypochlorite. Ammonia vapour is extremely soluble in water and will be absorbed rapidly and exothermically to produce a strongly alkaline solution of ammonium hydroxide			
10.4.7	States precautions against mixing of incompatible cargoes include using separate lines and also separate re-liquefaction plants.			
10.4.8	Explains why some gas cargoes may react with materials and substances such as: - Tank material - gaskets - cargo hoses - inert gas - Cargo compressor oils - cargo pump seal oils			
10.5	Corrosivity	**R2**	**T1,B1,B2,B6**	**A1,A11, A13, A14, VG15**
10.5.1	Explains why some cargoes and inhibitors may be corrosive; hence materials used in cargo systems must be resistant to such effects.			
10.5.2	Explains why corrosive liquids can also attack human tissues, therefore appropriate protective clothing should be worn.			
10.6	Health hazards	**R2**	**T1,B1,B2,B6**	**A1,A11, A13, A14, VG15**

TOPIC 10	KNOWLEDGE AND UNDERSTANDING OF THE HAZARDS AND CONTROL MEASURES ASSOCIATED WITH LIQUEFIED GAS TANKER CARGO OPERATIONS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
10.6.1	Explains why the health hazards of liquefied gases are their toxicity, oxygen deficiency and low temperatures			
10.6.2	Describes modes by which liquefied gas cargoes and their vapours may be toxic			
10.6.3	Describes toxic properties of inhibitors			
10.6.4	Describes toxic properties of inert gas			
10.6.5	Describes how combustion of cargo products or construction ` materials may produce toxic products			
10.6.6	Defines acute and chronic effects of toxicity, systemic poisons and irritants			
10.6.7	Lists and describes the criteria by which toxicity is measured and expressed			
10.6.8	Explains asphyxia and its symptoms			
10.6.9	Explains anesthesia and its symptom			
10.6.10	Explains frost-bite and its symptoms			
10.6.11	Explains chemical burns and lists cargoes caustic to human skin			
10.7	Inert gas composition	**R2**	**T1,B1,B2,B6**	**A1,A11, A13, A14, VG15**
10.7.1	Explains why the presence of toxic gases such as sulphur dioxide, carbon monoxide and oxides of nitrogen can be ascertained only by measurement; however, provided that the hydrocarbon gas content of an inerted tank exceeds 2 per cent by volume before gas-freeing is started, the dilution of the toxic components of flue gas during the subsequent gas freeing can be correlated with the readings of an			

TOPIC 10	KNOWLEDGE AND UNDERSTANDING OF THE HAZARDS AND CONTROL MEASURES ASSOCIATED WITH LIQUEFIED GAS TANKER CARGO OPERATIONS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	approved combustible gas indicator or equivalent			
10.7.2	Explains why by ventilating the compartment, if a reading of 1 per cent of the lower flammable limit or less is obtained in conjunction with an oxygen reading of 21 per cent by volume, the toxic trace gases will be diluted to concentrations at which it will be safe to enter; alternatively, and irrespective of initial hydrocarbon gas content, ventilation should continue until a steady oxygen reading of 21 per cent by volume is obtained.			
10.8	Electrostatic hazards	**R2**	**T1,B1,B2,B6**	**A1,A11, A13, A14, VG12, VG15**
10.8.1	Explains why static electricity can arise when liquids or gases are pumped at high velocity.			
10.8.2	Explains why non- conducting liquids (static accumulators), emulsions, carbon dioxide and steam are common sources of static electricity.			
10.8.3	Explains why static generation increases with velocity of flow.			
10.8.4	Explains why electrical sparks may occur when making or breaking cargo connections between ship and shore if the cargo connection hose or hard arm provides an electrical path between ship and jetty structures.			
10.8.5	Explains the use of an insulation flange used in connection of ships manifold to shore connection.			

TOPIC 10	KNOWLEDGE AND UNDERSTANDING OF THE HAZARDS AND CONTROL MEASURES ASSOCIATED WITH LIQUEFIED GAS TANKER CARGO OPERATIONS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
10.9	Polymerizing cargoes	**R2**	**T1,B1,B2,B6**	**A1,A11, A13, A14, VG15**
10.9.1	Explains why a compound may change from a free flowing liquid to a viscous one or even a solid and a great deal of heat may be evolved when this occurs.			
10.9.2	Explains why polymerization may, under some circumstances, be dangerous.			
10.9.3	States polymerization may necessitate jettisoning of cargo in an extreme case to prevent the gas tanker from breaking up			
11.0	Proficiency[GEE14] to calibrate and use monitoring and gas-detection systems, instruments and equipment	**R1,R2,R6**	**B1,B2,B6**	**A1,A4,A5, A6,A7,A8, A9, A11,A13, A14, VG14, VG15**
11.1	Explains why gas detection equipment and instrumentation requirements are laid down in the IGC code.			
11.2	Lists IMO requirements concerning the fixed gas-detection system			
11.3	Describes, by means of a drawing, the function of a fixed gas-detection system			
11.4	Describes, by means of a drawing, the procedure to calibrate a fixed gas detector			
11.5	State that the monitoring of atmosphere in gas dangerous and gas safe zones must be carried out regularly and sequentially.			
11.6	Explains why safety system of a tanker must be checked and calibrated as per safety management systems requirements.[GEE15]			

TOPIC 10	KNOWLEDGE AND UNDERSTANDING OF THE HAZARDS AND CONTROL MEASURES ASSOCIATED WITH LIQUEFIED GAS TANKER CARGO OPERATIONS			
	Knowledge, Understanding and Proficiency	**IMO Reference**	**Text books Bibliography**	**Teaching aid**
11.7	State that the pressure in any tank segregated from the main venting system should be carefully monitored to ensure that individual tank venting arrangements are adequate to prevent formation of vacuum or a build-up of pressure.			
11.8	Explains why ships will require the means to enable closed monitoring of tank contents, by a fixed gauging system			
11.9	State that exposure levels in all work locations should be monitored by using suitable instrumentation for detecting and measuring the concentration of the gas.			
11.10	State that Personnel should always carry personal monitors when working in enclosed spaces, gauging, sampling, entering a pump-room, connecting and disconnecting loading lines, cleaning filters, draining to open containments and mopping up spills as H2S concentrations may exceed the TLV-TWA.			
11.11	Explains why measurement of all gases in air must be checked to ensure concentrations are below 1% LFL. (Lower Flammable Limit)			
11.12	Explains why the measurement of all gas must be taken as a percentage by volume of the total atmosphere being measured.			
11.13	State that modern flammable gas monitors (Explosimeters) have a pellistor as the sensing element. Pellistors rely on the presence of oxygen (minimum 11% by volume) to operate efficiently and for this reason flammable gas monitors should not be used for measuring hydrocarbon gas in atmospheres without oxygen.			

TOPIC 10	KNOWLEDGE AND UNDERSTANDING OF THE HAZARDS AND CONTROL MEASURES ASSOCIATED WITH LIQUEFIED GAS TANKER CARGO OPERATIONS			
	Knowledge, Understanding and Proficiency	**IMO Reference**	**Text books Bibliography**	**Teaching aid**
11.14	Performs measurement of oxygen concentrations			
11.15	Explains calibration and test procedures of gas measuring instruments			
11.16	Explains why multi gas instruments are commonly used on board most liquefied gas tankers			
11.17	Explains why the multi-gas instruments may be supplied as compact units fitted with an alarm function for personal protective use during tank entry.			
11.18	Explains why the personal multi gas detectors are capable of continuously measuring the content of the atmosphere by diffusion. They usually employ up to four electrochemical sensors and should automatically provide an audible and visual alarm when the atmosphere becomes unsafe, thereby giving the wearer adequate warning of unsafe conditions.			
11.19	Explains why disposable personal gas monitors are also used			
11.20	Explains why cargo tank oxygen levels should be monitored so that any necessary precautionary measures can be taken prior to the commencement of unloading.			
11.21	Explains why throughout the unloading of cargo, particularly when the boiler load is low or fluctuating, the oxygen content of the inert gas supply must be carefully monitored.			
11.22	Explains why individual Tank Pressure Monitoring and Alarm Systems must be checked regularly.			
11.23	Explains why residual water in the inert gas may freeze in the inert gas main. Operators should be aware of			

TOPIC 10	KNOWLEDGE AND UNDERSTANDING OF THE HAZARDS AND CONTROL MEASURES ASSOCIATED WITH LIQUEFIED GAS TANKER CARGO OPERATIONS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	this and should therefore operate the system to minimize residual water and closely monitor the system's operation.			
11.24	Explains why a close monitoring of vapour line pressures on inerted ships and limiting loading rates on non-inerted ships throughout the loading period during unloading operations is to be carried out.			
11.25	Explains why hold space, cofferdams, void and ballast spaces located within the cargo tank block should be routinely monitored to check that no leakage has occurred from adjacent tanks. Monitoring should include regular atmosphere checks for cargo vapour content and regular sounding/ullaging of the empty spaces			
12.0	**Knowledge[GEE16] and understanding of dangers of non-compliance with relevant rules / regulations**	**R1,R2,R3, R6,R7**	**B1,B2,B3, B5,B6,B7**	**A1,A11, A13, A14, VG15**
12.1	Explains that some gas cargoes like VCM and ammonia cause damage to the marine environment as a result of blanketing, ingestion by sea organisms and the deterioration of amenities			
12.2	Explains greenhouse gases			
12.3	Explains the meaning of toxic load			
12.4	Explains why it is when the toxic load of an area, is exceeded after an incident that causes harm to the marine environment			
12.5	Explains why some gases specially chemical gases can interfere with other[GEE17] legitimate uses of the sea			

TOPIC 10	KNOWLEDGE AND UNDERSTANDING OF THE HAZARDS AND CONTROL MEASURES ASSOCIATED WITH LIQUEFIED GAS TANKER CARGO OPERATIONS			
	Knowledge, Understanding and Proficiency	**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	(water inlets, fish farming, fishing industry and coastal tourism)			
12.6	Explains why those who persist in operating their vessels in contravention to the IMO's body of environmental regulations have direct repercussions on the safety of vessels, the well-being of crews and on the environment in addition to criminal proceedings, heavy fines and imprisonment.			
12.7	Explains why most ships and ship-owner / operators actively seek to comply with environmental regulations.			
12.8	Explains why compliance with international environmental rules still leaves something to be desired.			

COMPETENCE 4	**Apply occupational health and safety precautions**

TOPIC 13	**KNOWLEDGE AND UNDERSTANDING OF SAFE WORKING PRACTICES, INCLUDING RISK ASSESSMENT AND PERSONAL SHIPBOARD SAFETY RELEVANT TO LIQUEFIED GAS TANKERS**

TRAINING OUTCOMES:

Demonstrates a knowledge and understanding of:

13 Safe working practices, including risk assessment and personal shipboard safety relevant to liquefied gas tankers

13.1 precautions to be taken when entering enclosed spaces (such as compressor rooms), including the correct use of different types of breathing apparatus

13.2 precautions to be taken before and during repair and maintenance work, including work affecting pumping, piping, electrical and control systems

13.3 precautions for hot and cold work

13.4 precautions for electrical safety

13.5 use of appropriate Personal Protective Equipment (PPE)

13.6 precautions for cold burn and frostbite

13.7 proper use of personal toxicity monitoring equipment

Required Performance

Note that students must be familiar with the content of the basic knowledge of safe working practices and procedures in accordance with legislation and industry guidelines and personal shipboard safety relevant to liquefied gas tankers from IMO Model Course 1.04. It may be necessary for some students to refresh their knowledge of this content before undertaking this management level content.

TOPIC 13	KNOWLEDGE AND UNDERSTANDING OF SAFE WORKING PRACTICES, INCLUDING RISK ASSESSMENT AND PERSONAL SHIPBOARD SAFETY RELEVANT TO LIQUEFIED GAS TANKERS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
13.0	**Knowledge and understanding of safe working practices, including risk assessment and personal shipboard safety relevant to liquefied gas tankers**			
13.1	**Precautions to be taken when entering enclosed spaces (such as compressor rooms), including the correct use of different types of breathing apparatus**	**R1,R2,R3, R5,R6,R7**	**T1,B1,B2, B4,B6,B8**	**VG7,A1,A2, A3,A4,A5, A6,A7,A8, A9,A10, A11, A13,A14, VG15**
13.1.1	Explains that the ship's SMS requires special procedures to be followed if entering an enclosed space			
13.1.2	Lists the likely sources of leakage of gases as: pipeline flanges, valves, tank seals, manifold connections.			
13.1.3	Explains measures to minimize toxicity and other hazards			
13.1.4	Explains why adequate ventilation should permit the removal of hydrocarbon vapours from the bottom of the enclosed spaces.			
13.1.5	Explains why all precautions for entering compressor-rooms or any cargo spaces / enclosed spaces are to be taken, these include ventilation, noise, lights, gas monitoring, personal gas monitor and permits.			
13.1.6	Explains why the lifeline and harness should be rigged ready for immediate use, and that approved breathing apparatus			

TOPIC 13	KNOWLEDGE AND UNDERSTANDING OF SAFE WORKING PRACTICES, INCLUDING RISK ASSESSMENT AND PERSONAL SHIPBOARD SAFETY RELEVANT TO LIQUEFIED GAS TANKERS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	and resuscitation equipment should be available in an accessible location before entry is made into any enclosed spaces.			
13.1.7	Explains that only positive type SCBA and airline breathing apparatus equipment are recommended for use in enclosed spaces.			
13.1.8	Explains why no one should enter an enclosed space unless their entry is sanctioned by a responsible officer			
13.1.9	Lists the safeguards to be taken for entering a cofferdam, double bottom or other enclosed space			
13.1.10	Explains why toxic gas must be suspected to be present in spaces into which gases may have leaked			
13.2	**Precautions to be taken before and during repair and maintenance work, including work affecting pumping, piping, electrical and control systems**	**R1,R2,R3, R5,R6,R7**	**T1,B1,B2, B4,B6,B8**	**VG6,A1,A2, A3,A4,A5, A6,A7,A8, A9,A10, A11, A13,A14, VG15**
13.2.1	Explains why work planning meetings should be held prior to the commencement of any work, and on each subsequent work day.			
13.2.2	Explains why the prime function of these meetings is to ensure that all personnel involved are aware of the daily schedule, the interrelation between			

TOPIC 13	KNOWLEDGE AND UNDERSTANDING OF SAFE WORKING PRACTICES, INCLUDING RISK ASSESSMENT AND PERSONAL SHIPBOARD SAFETY RELEVANT TO LIQUEFIED GAS TANKERS			
	Knowledge, Understanding and Proficiency	**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	contractors, particular areas of concern and special precautions to be taken			
13.2.3	Describes permit to work system			
13.2.4	Explains why issue of permit does not by itself make the work safe			
13.2.5	Explains why permits should be issued for the relevant repair work jobs, including any repairs being carried out by ship's staff. In particular, permits should be Issued for: - Enclosed space entry. - Cold work - Hot Work. - Electrical isolation - Working aloft - Working on containers and systems under pressure - Working over side - Other hazardous tasks.			
13.2.6	Explains why copies of all permits should be posted as may be necessary. Copies should also be retained by the person in charge of the operation.			
13.2.7	Explains why if any repairs are to be carried out concurrent with cargo handling operations, specific permission should be granted by the terminal operators.			
13.2.8	Explains why whenever practicable, a drill should be held prior to commencing repair work. Subsequent drills should be arranged when the repairs are to be carried out over an extended period.			
13.2.9	Explains why a dedicated safety officer should be appointed by			

TOPIC 13	KNOWLEDGE AND UNDERSTANDING OF SAFE WORKING PRACTICES, INCLUDING RISK ASSESSMENT AND PERSONAL SHIPBOARD SAFETY RELEVANT TO LIQUEFIED GAS TANKERS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	the Master to coordinate the permit and certification processes associated with the repair period.			
13.3	**Precautions for hot and cold work**	**R1,R2,R3, R5,R6,R7**	**T1,B1,B2, B4,B6,B8**	**A1, A11, A13,A14, VG15**
13.3.1	Explains why hot work is to be controlled and governed strictly by vessel's SMS procedure			
13.3.2	Explains why hot work should be prohibited within or on the boundaries of cargo tanks, ballast tanks, slop tanks, bunker tanks, pump rooms and forward cofferdams, including the deck and ship's shell plating, except when special preparations have been made prior to entering the berth or facility and the necessary special conditions have been met.			
13.3.3	Explains why "designated space" in engine room (ER) for carrying out hot work are stated and that it should be assessed for risks and the conditions under which hot work could be carried out in such space.			
13.3.4	Explains why first preference should be given for carrying out hot work in the designated space in ER			
13.3.5	Explains why all hot work outside designated space must be covered by permit to work system			
13.3.6	Explains why fire-main should be continuously pressurized, either			

TOPIC 13	KNOWLEDGE AND UNDERSTANDING OF SAFE WORKING PRACTICES, INCLUDING RISK ASSESSMENT AND PERSONAL SHIPBOARD SAFETY RELEVANT TO LIQUEFIED GAS TANKERS			
	Knowledge, Understanding and Proficiency	**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	by ship's pumps or from a shore supply when carrying out hot work.			
13.3.7	Explains why all areas where hot work is being carried out should be monitored by fire patrols at all times.			
13.3.8	Explains why use of electrical welding equipment should be controlled and correct grounding cables should be used. Welding current should not be returned to the welding machine via the ship's hull.			
13.3.9	Explains why hot work should not be carried out within 30 metres of any non-gas free spaces unless specific permission has been received from the controlling authority.			
13.3.10	Explains why notices should be posted to indicate the current state of any tank or void space, e.g. stating whether it is either gas free and suitable for hot work, or only safe for entry			
13.3.11	Explains why where hot work on pipelines and valves needs to be carried out with the equipment in place, the item requiring hhot work must be disconnected by cold work, and the remaining pipework blanked off.			
13.3.12	Explains why hot and cold work should only be permitted under conditions of strict control. This can best be achieved by the use of work permits which make use of a checklist approach			

TOPIC 13	KNOWLEDGE AND UNDERSTANDING OF SAFE WORKING PRACTICES, INCLUDING RISK ASSESSMENT AND PERSONAL SHIPBOARD SAFETY RELEVANT TO LIQUEFIED GAS TANKERS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
13.4	**Precautions for electrical safety**	**R1,R2,R3, R5,R6,R7**	**T1,B1,B2, B4,B6, B8**	**A1,A11, A13,A14, VG15**
13.4.1	Explains why the design of explosion-proof or intrinsically safe electrical equipment may be compromised by incorrect maintenance procedures.			
13.4.2	Explains why strict compliance with the manufacturer's instructions is required in order to ensure that such equipment remains in a safe condition.			
13.4.3	Explains why maintenance of explosion-proof and intrinsically safe equipment should only be carried out by personnel qualified to undertake such work.			
13.4.4	Explains why non-intrinsically safe electrical equipment must not be taken into an enclosed space that is liable to experience hydrocarbon vapour re-contamination.			
13.5	**Use of appropriate Personal Protective Equipment (PPE)**	**R1,R2,R3, R5,R6,R7**	**T1,B1,B2, B4,B6,B8**	**A1,A11, A13,A14, VG15**
13.5.1	Explains why protective clothing and equipment should be worn by all personnel engaged in operations on board and ashore.			
13.5.2	Explains why as a minimum it is recommended that at all times this should comprise of a boiler suit (or similar clothing providing full cover), safety shoes, safety glasses and a safety helmet as appropriate.			
13.5.3	Explains why storage places for PPE, including breathing apparatus, should be protected			

TOPIC 13	KNOWLEDGE AND UNDERSTANDING OF SAFE WORKING PRACTICES, INCLUDING RISK ASSESSMENT AND PERSONAL SHIPBOARD SAFETY RELEVANT TO LIQUEFIED GAS TANKERS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	from the weather and should be clearly marked.			
13.5.4	Explains why personnel should utilise the equipment and clothing whenever the situation requires.			
13.5.5	Explains why personnel who are likely to be required to use breathing apparatus should be trained in its safe use.			
13.6	**Precautions for cold burn and frostbite**	**R1,R2,R3, R5,R6,R7**	**T1,B1,B2, B4,B6,B8**	**A1, A11, A13,A14, VG15**
13.6.1	Explains why contact of the skin with cryogenic liquids (or even cold gas) can cause severe cryogenic burns. The tissue damage that results is similar to that caused by frost bite or thermal burns. While the cold itself can reduce the feeling of pain, the subsequent thawing of tissue can cause intense pain.			
13.6.2	Explains why contact with non-insulated parts or equipment or vessels containing cryogenic liquids can produce similar damage. Unprotected parts of the skin may stick to low-temperature surfaces and flesh may be torn upon removal.			
13.6.3	Explains why inhalation of cold vapour can cause damage to the lungs and may trigger an asthma attack in susceptible individuals.			
13.6.4	Explains why adequate PPE and gas suits must be worn when working in the vicinity of equipment or areas susceptible to low temperatures			

TOPIC 13	KNOWLEDGE AND UNDERSTANDING OF SAFE WORKING PRACTICES, INCLUDING RISK ASSESSMENT AND PERSONAL SHIPBOARD SAFETY RELEVANT TO LIQUEFIED GAS TANKERS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
13.7	**Proper use of personal toxicity monitoring equipment**	**R1,R2,R3, R5,R6,R7**	**T1,B1,B2, B4,B6,B8**	**A1,A11, A13,A14, VG15**
13.7.1	Explains why the atmosphere in a cargo tank or enclosed space may be dangerous due to flammability, toxicity and/or lack of oxygen			
13.7.2	Explains why toxic gas and oxygen deficiency detectors are commonly used throughout the workplace to warn of potentially harmful exposure to personnel and of dangerous gas leaks.			
13.7.3	Explains why an occupational exposure level (OEL), e.g. Workplace Exposure Limit (WEL) , should be the starting point for setting alarm levels for a particular individual gas or gas mixture, assuming one exists			
13.7.4	Explains why toxic gas monitors have somewhat different roles relating to their use as leak detectors and personal monitors respectively			
13.7.5	Explains why toxic gas detector instruments include tubes or meters.			
13.7.6	Explains why each tube contains a very sensitive reagent system that produces accurate readings when the technical characteristic of the gas detector pump precisely match the reaction kinetics of the reagent system in the tube.			
13.7.7	States precautions when using the tubes include a pump, delivering the correct volume must also pull the sample through the tube at the proper rate.			

TOPIC 13	KNOWLEDGE AND UNDERSTANDING OF SAFE WORKING PRACTICES, INCLUDING RISK ASSESSMENT AND PERSONAL SHIPBOARD SAFETY RELEVANT TO LIQUEFIED GAS TANKERS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
13.7.8	Explains why detector tubes be used with a matching pump from the same manufacturer.			
13.7.9	Explains why The scale on the tube allows the user to evaluate the concentration of the hazardous substance directly after the measurement			
13.7.10	Explains why the number of gases/vapours that can be detected is also far higher than other detection instruments with direct display.			
13.7.11	Explains why there are various types of tubes available and reading the information on the manufacturer's information sheet is of paramount importance.			

COMPETENCE 5 Respond to emergencies

TRAINING OUTCOMES:

Demonstrates a knowledge and understanding of:

TOPIC 14 KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES

14 Liquefied gas tanker emergency procedures

14.1 ship emergency response plans
14.2 cargo operations emergency shutdown procedure
14.3 emergency cargo valve operations
14.4 actions to be taken in the event of failure of systems or services essential to cargo operations
14.5 fire-fighting on liquefied gas tankers #
14.6 jettisoning of cargo
14.7 enclosed space rescue

15 Actions[GEE18] to be taken following collision, grounding or spillage a envelopment of the ship in toxic or flammable vapour

15.1 initial response
15.2 procedures
15.3 collisions
15.4 grounding
15.5 vapour release
15.6 reporting

16 Knowledge[GEE19] of medical first-aid procedures and antidotes on board liquefied gas tankers, with reference to the Medical First Aid Guide for Use in Accidents involving Dangerous Goods (MFAG)

16.1 symptoms
16.2 treatments

Required Performance

Note that students must be familiar with the content of the basic knowledge of emergency procedures including emergency shutdown from IMO Model Course 1.04. It may be necessary for some students to refresh their knowledge of this content before undertaking this management level content.

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Proficiency	**Understanding and**	**IMO Reference**	**Text books Bibliography**	**Teaching aid**
14.0	**Knowledge and understanding of liquefied gas tanker emergency procedures, including :**			
14.1	**Ship emergency response plans**	**R1,R2,R3, R5,R6**	**T1,B1,B2, B5,B6**	**A1,A11, A13,A14, VG15**
14.1.1	Explains why an emergency can occur at any time and in any situation. Effective action is only possible if pre-planned and practical procedures have been developed and are frequently exercised. The Contingency Plan provides guidelines and instructions that assist in making an efficient response to emergency situations onboard ships.			
14.1.2	Explains why these plans should be used actively during emergency drills. The objective of an emergency plan is to make the best use of the resources available. This will be the shipboard personnel whilst the ship is at sea but may include resources from shore when the ship is in harbour or passing through coastal waters.			
14.1.3	Explains why the plans should be directed at achieving the following aims: - rescue and treatment of casualties - safeguarding others - minimizing damage to property and the environment - bringing the incident under control.			

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Proficiency	**Understanding and**	**IMO Reference**	**Text books Bibliography**	**Teaching aid**
14.1.4	Explains why the plans should include advice on the following: - fire - collision - grounding - cargo spillage/leak - personnel casualty			
14.1.5	Explains why contingency plans require a huge volume of reporting and regulatory response.			
14.2	**Cargo operations emergency shutdown procedure**	**R1,R2,R3, R5,R6**	**T1,B1,B2, B5,B6**	**A1,A11, A13,A14, VG15**
14.2.1	Explains why the Emergency Shut Down (ESD) system is a requirement of the IMO Code for the carriage of liquefied gases in bulk and is a recommendation of SIGTTO.			
14.2.2	Explains why all members of the ship's company must be aware of locations and the methods of activating and testing the ESD system specific to their vessel.			
14.2.3	Explains why the ESD system is a quick acting system, which may be activated automatically or manually. It should close all manifold valves, some deck valves and shut down all cargo machinery.			
14.2.4	Explains why on most liquefied gas tankers ESD will be initiated by one of the following: - Manual activation by personnel using the ESD pushbuttons - Loss of ship's power			

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	- Shore activation of their ESD system - Fusible links around each tank domes, manifold and compressor house in case of fire - Cargo tank Very High level alarm - Low tank pressure - Hold/cargo tank differential pressure - Low cargo valves hydraulic pressure - Low control air pressure - Fire extinguisher system released			
14.2.5	Explains why the initiation of ESD will typically lead to the following: - All ESD manifold loading valves will close - The gas compressors will trip - The main unloading and spray pumps will trip - All shore pumps will trip (if linked) - Master gas valve to engine room will close (LNG ships) - Inert gas generator will trip			
14.2.6	Explains why automatic shut down for fire is initiated by fusible plugs which are generally located at each tank dome, manifold platform, and in the cargo compressor and electric motor rooms. ESD1 may also be initiated automatically under conditions such as the following: - Loss of ship's power.			

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	- Vapour header pressure falls below pre-set limit. - Individual tank pressure falls below pre-set limit. - Extreme liquid level in any cargo tank. - Low cargo valve hydraulic pressure.			
14.2.7	Explains why ESD2 is normally initiated by the terminal and will result in all the actions as for ESD1, plus the initiation of a dry break of the shore arm from the ship. ESD2 may be initiated manually, for example, in the event of a terminal emergency, or automatically, for example, if the ship moves outside the movement envelope of the chicksans.			
14.2.8	Explains why LNG vessels must always conduct pre-arrival ESD system tests 48 hours before arrival at any load or unloading port. Additionally in the event of an extended voyage, the ESD system should again be tested at intervals of not more than 30 days from the previous test.			
14.2.9	Explains why these tests must include, but not be limited to: - Cargo ESD system test, including all push buttons and trips (These may be tested in rotation). - All cargo and ballast valves operated. - Manifold valve timings checked. - Check the operating parameters of nitrogen generators and barrier			

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Proficiency	**Understanding and**	**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	space pressures (where applicable). - Barrier space water detection (where applicable). - Mast riser nitrogen snuffers. - Ship/Shore interface connection operations.			
14.2.10	Explains why prior to loading / unloading operations in port, ESD testing is carried out on LPG vessels as part of the pre transfer ship shore check-list.			
14.3	**Emergency cargo valve operations**	**R1,R2,R3, R5,R6**	**T1,B1,B2, B5,B6**	**A1,A11,A12 A13,A14, VG15**
14.3.1	Explains why to avoid pressure surges, valves at the downstream end of a pipeline system should not be closed against the flow of liquid, except in an emergency			
14.3.2	Explains why the incorrect operation of pumps and valves can produce pressure surges in a pipeline system.			
14.3.3	Explains why where the risk of pressure surges exists, information should be exchanged and written agreement reached between the tanker and the terminal concerning the control of flow rates, the rate of valve closure, and pump speeds.			
14.3.4	Explains why this should include the closure period of remotely controlled and automatic shutdown valves. The agreement should be included in the operational plan.			

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
14.3.5	Explains why emergency shutdown valves in liquid piping should fully close under all service conditions within 30 sec of actuation. Information about the closing time of the valves and their operating characteristics should be available on board and the closing time should be verifiable and reproducible. Such valves should close smoothly			
14.3.6	Explains why in the interests of avoiding surge pressures, both ship and shore must confirm closure times are adequate to prevent either side causing a surge pressure to build up in the other's piping system			
14.3.7	Explains why in case of a breakdown of a valve operating system portable hydraulic pumps are generally provided for local operations of valves			
14.4	**Actions to be taken in the event of failure of systems or services essential to cargo operations**	**R1,R2,R3, R5,R6**	**T1,B1,B2, B5,B6**	**A1,A11, A13,A14, VG15**
14.4.1	Describes action to be taken in the event of a failure of anti-surge system			
14.4.2	Describes action to be taken in the event of a failure of Capacitance Level Gauge (Transonic)			
14.4.3	Describes action to be taken in the event of a failure of ESD system			

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
14.4.4	Describes action to be taken in the event of a failure of Gas Detection System			
14.4.5	Describes action to be taken in the event of a failure of High Duty Compressor			
14.4.6	Describes action to be taken in the event of a failure of Hydraulic System			
14.4.7	Describes action to be taken in the event of a failure of Cargo Valves			
14.4.8	Describes action to be taken in the event of a failure of Safety Valves in Cargo Tank			
14.4.9	Describes action to be taken in the event of a failure of Water Curtain system			
14.4.10	Describes action to be taken in the event of a failure of Pumps failure in a Moss cargo tank			
14.4.11	Describes action to be taken in the event of a failure of Pumps failure in a MEMBRANE cargo tank			
14.5	**Fire fighting on liquefied gas tankers**	**R1,R2,R3, R5,R6,R7**	**T1,B1,B2, B5,B6**	**VG11,A1, A11,A13, A14,VG15**
14.5.1	Lists the elements of fire and explains the fire triangle			
14.5.2	Explains the principles of fire prevention			
14.5.3	Lists ignition sources and ways of excluding them			
14.5.4	Explains why ignition can occur when an ignition source with a temperature at or above the auto-ignition temperature of a cargo is introduced to the vapour phase of the cargo			

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
14.5.5	States sources of emission of flammable cargo vapour are: leaks from pumps, flanges, relief valves, etc.			
14.5.6	Explains why most ignition sources on board have a higher temperature than the auto-ignition temperature for most liquefied gas cargoes			
14.5.7	States temperatures of such common ignition sources as: - The flame of a match (1, 1oo) - Electrical sparks (1,100'c) - The light of a burning cigarette (300-800°c)			
14.5.8	Explains why the auto-ignition temperature of most cargoes on gas tankers varies from 165°C for acetaldehyde to 630`C for methyl chloride			
14.5.9	Describes methods of controlling a fire on a liquefied gas tanker: - With DCP - Cooling down with water spray - Nitrogen snuffers			
14.5.10	Explains why to control a liquefied gas fire it is essential to cut off the source of fuel			
14.5.11	Explains why if the fuel source cannot be isolated, it is safer to let the gas fire burn, while cooling the surrounding areas with water			
14.5.12	Explains the phenomenon of BLEVE			
14.5.13	Explains why liquefied gas tankers are fitted with a fixed water-spray system for cooling, fire prevention and crew protection			

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
14.5.14	Explains why the water-spray system covers tank domes, deck tanks, manifolds, deck housing and superstructures facing the cargo area			
14.5.15	Explains why liquefied gas tankers are fitted with a fixed dry-powder extinguishing system covering the deck area			
14.5.16	Explains why liquefied gas tankers are fitted with a fixed extinguishing system for "total flooding" of cargo compressor rooms and control rooms in the cargo area			
14.5.17	Explains why extinguishing agents for total flooding systems are normally either a halon or carbon dioxide			
14.5.18	Explains why liquefied gas tankers are fitted with an inert gas plant for fire prevention in cargo tanks, void spaces and other cargo- related spaces			
14.5.19	Describes water as a fire-fighting agent and Explains why: - Is readily available - Should never be applied onto a burning pool of liquefied gas - Should never be applied onto a burning pool of liquefied gas - It can be used in spray form to produce a water shield for the protection of fire-fighters when they are approaching a liquefied gas fire to cut off the supply of fuel to the fire			

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
14.5.20	Explains why dry chemical powder as a firefighting agent: - Has good smothering effect on flames - Has an inhibiting effect on flames - Can be used in electrical plants and is not toxic - Has a low cooling effect - Should not be used in electronic instruments, control panels			
14.5.21	Explains why carbon dioxide as a fire-fighting agent : - Is an excellent smothering agent - Can be used on fires in electrical equipment and instruments - Should not be injected into explosive atmospheres as it may generate static electricity - Personnel must have left the space into which carbon dioxide is to be injected			
14.5.22	Explains why all fire-fighting appliances should always be kept in good order and ready for use			
14.5.23	Explains why, prior to commencing cargo transfer, the ship's fire-fighting equipment should be made ready, and the international shore connection should be at hand it should not be directed towards electrical equipment			
14.5.24	Explains the importance of fire-prevention procedures and with regard to: - Flame screen			

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Proficiency	**Understanding and**	**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	- Bonding - Electrical storms - Auto-ignition - Spontaneous combustion			
14.6	**Jettisoning of cargo**	**R1,R2,R3, R6**	**T1,B1,B2, B5,B6**	**A1, A11, A13,A14, VG15**
14.6.1	Explains why a major leak may be impossible to control. In that case the two main options available are either abandonment or the jettisoning of the cargo			
14.6.2	Explains why if vessel is along-side and a major leak occurs the following shall be carried out: • Sound general alarm • Stop cargo operation. Activate ESDS • Disconnect loading arms. Activate PERC • Leave jetty • As safety measure - Inert hold space where leakage (Cargo Tank rupture) has been detected until the O2% is reduced to 2%. Continue blowing inert gas to hold space in order to keep temperature as low as possible. Remember to open the hold space vent in order to avoid overpressure in the hold space • Transfer cargo to other tanks in order to empty the tank. Considering stability and stress factors			

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	Consider - jettisoning. Remember two cargo pumps are required in order to have proper pressure • Consider - external assistance • Prepare fire-fighting equipment • Consider- abandonment. Prepare life-rafts, lifeboats			
14.7	**Enclosed space rescue**	**R1,R2, R6**	**T1,B1,B2, B5,B6**	**A1,A2, A3, A4, A5,A6, A7,A8, A9,A10 A11,A13, A14,VG15**
14.7.1	Explains why a responsible member of the crew outside an enclosed space who notices something wrong within, or any other person who sees or suspects a casualty within an enclosed space should first raise an Alarm. On no account should the person(s) attempt to enter it before additional help has arrived, and no one should enter any space or attempt to rescue, without wearing a breathing apparatus set.			
14.7.2	Explains why on hearing an alarm, the Master or responsible officer should muster a Rescue Team comprising at least 2 persons and a third person in charge who should remain outside the space to exercise control.			

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
14.7.3	Explains why the following minimum items should be assembled at site : - 2 x self-contained breathing apparatus - EEBD - resuscitator - lifelines (to be used unless impracticable) - rescue harness / neil - robertson stretcher, with rope			
14.7.4	Explains why the rescuers entering the enclosed space must wear a SCBA and carry an EEBD and Rescue Harness for use of casualty. They should be in continuous communication with the rescue supervisor who in turn should apprise the Master of the events.			
14.7.5	Explains why personnel should be allocated to relieve or back-up the rescue team. Support team should arrange back up equipment outside space like spare SCBA bottles, ropes, first aid equipment, and possibly hoisting equipment to aid in lifting the casualty.			
14.7.6	Explains why a stretcher if available is necessary to evacuate any casualty with suspected neck or spinal injuries, after fastening him			
14.7.7	Explains why In other cases, a rescue harness may be used. If necessary, the EEBD is to be used to supply the casualty with fresh air			
14.7.8	Explains why in case the casualty requires artificial			

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	respiration, then the resuscitator must be used.			
14.7.9	Explains why resuscitation must always be given after the casualty has been brought out in fresh air.			
15.0	**Actions to be taken following collision, grounding or spillage and envelopment of the ship in toxic or flammable vapour** [GEE20]	**R1,R2,R3, R6,R7**	**T1,B1,B2, B5**	**A1,A11, A13,A14, VG15**
15.1	Initial Response: Explains why if an emergency occurs the immediate action must be to: - raise the alarm - provide information to the command centre as to the location and nature of the emergency - shut down all cargo operations and close valves - remove all craft from alongside			
15.2	Procedures: Explains why in case of collision, grounding or spillage following standard procedures are to be followed: - Initial Actions - Follow-Up Actions - Evidence Collection - Emergency Reporting			
15.3	Collisions: Explains standard initial and follow-up actions to be taken subsequent to a collision			
15.4	Grounding: Explains standard initial and follow-up actions to be taken subsequent to a grounding			
15.5	Vapour Release: Explains			

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Proficiency	**Understanding and**	**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	standard initial and follow-up actions to be taken subsequent to a spillage and envelopment of the ship in toxic or flammable vapour			
15.6	Reporting: Explains the importance of evidence collecting and emergency reporting requirements.			
16.0	**Knowledge**[GEE21] **of medical first – aid procedures and antidotes on board liquefied gas tankers, with reference to the Medical first aid guide for use in accidents involving dangerous goods (MFAG)**	**R1,R2,R5, R6**	**B1,B2, B6**	**A1,A11, A13, A14, VG15**
16.1	Symptoms: Explains why the MFAG gives detailed information about signs and symptoms, first aid and the administering First Aid for Chemical Burns and Frostbites			
16.2.1	Treatments: Explains why medical treatment for exposure to hydrocarbon gas first involves the removal of the casualty to an area free of hydrocarbon or other harmful gas area. Where necessary it may also involve artificial respiration, external cardiac massage and the administration of oxygen.			
16.2.2	Explains why advice on first aid procedures is available from the material's data sheets and in the Medical First Aid Guide (MFAG) published by IMO. Antidotes for products carried must be provided on board.			

TOPIC 14	KNOWLEDGE AND UNDERSTANDING OF LIQUEFIED GAS TANKER EMERGENCY PROCEDURES			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
16.2.3	Describes treatment for asphyxia and inhalation of toxic fumes			
16.2.4	Describes procedures to check if patient is breathing and immediate actions if not breathing			
16.2.5	Describes procedures to use oxygen resuscitators			
16.2.6	Explains methods of resuscitation for conscious and unconscious stages			
16.2.7	Explains why the MFAG gives detailed information about administration of antidotes, first aid for toxic or poisonous gases carried on board			
16.2.8	Describes actions to take in accidents involving dangerous goods using the Medical first aid guide (MFAG)			
16.2.9	Describes procedures to transfer patients to hospitals.			

COMPETENCE 6 **Take precautions to prevent pollution of the environment**

TOPIC 17 **UNDERSTANDING OF PROCEDURES TO PREVENT POLLUTION OF THE ATMOSPHERE AND THE ENVIRONMENT**

TRAINING OUTCOMES:

Demonstrates a knowledge and understanding to:

17 Prevent pollution of the environment.

17.1 responsibilities
17.2 oil pollution
17.3 ballast water management

Required Performance

Note that students must be familiar with the content of the basic knowledge of the effects of pollution on human and marine life and shipboard procedures to prevent pollution from IMO Model Course 1.04. It may be necessary for some students to refresh their knowledge of this content before undertaking this management level content.

TOPIC 17	UNDERSTANDING OF PROCEDURES TO PREVENT POLLUTION OF THE ATMOSPHERE AND THE ENVIRONMENT			
Knowledge, Proficiency	**Understanding and**	**IMO Reference**	**Text books Bibliography**	**Teaching aid**
17.0	**Understanding of procedures to prevent pollution of the atmosphere and the environment**	**R1,R2, R3**	**T1,B1,B2, B5**	**VG10, A1,A11, A13,A14, VG15**
17.1	Responsibilities: Explains why it is the responsibility of the master or those in charge of transfer operations involving cargo or bunkers to know the applicable pollution prevention regulations and to ensure that they are not violated.			
17.2	Oil Pollution: Explains why exercises should be held to train personnel in accordance with the Shipboard Oil Pollution Emergency Response Plan, and recorded.			
17.3	Ballast Water Management: Explains why there is a danger of violating ballast water management requirements if ballast taken in port is discharged in another port. It may be necessary to exchange or treat the water prior discharging Some terminals may have specific requirements in this respect, and the master should ensure that they are observed.			
17.4	Explains why the discharge overboard of ammonia washings may be prohibited in certain areas, and care should therefore be taken. The requirements for the control of pollution in Annex II of the MARPOL Convention should be observed.			

COMPETENCE 7	Monitor and control, compliance with legislative requirements

TOPIC 18	KNOWLEDGE AND UNDERSTANDING OF RELEVANT PROVISIONS OF THE INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS (MARPOL) AND OTHER RELEVANT IMO INSTRUMENTS, INDUSTRY GUIDELINES AND PORT REGULATIONS AS COMMONLY APPLIED

TRAINING OUTCOMES:

Demonstrates a knowledge and understanding of:

18 Relevant provisions of the International Convention for the Prevention of Pollution from Ships (MARPOL) and other relevant IMO instruments, industry guidelines and port regulations as commonly applied

18.1 International Conventions
18.2 industry guidelines
18.3 local regulations

TOPIC 19	USE OF THE IBC AND IGC CODES AND RELATED DOCUMENTS

19 Use of the IBC and IGC Codes and related documents

19.1 IGC Code
19.2 IBC Code

TOPIC 18	PROVISIONS OF MARPOL, IMO INSTRUMENTS, INDUSTRY GUIDELINES AND PORT REGULATIONS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
18.0	**Knowledge and understanding of relevant provisions of the international convention for the prevention of pollution from ships (MARPOL) and other relevant IMO instruments, industry guidelines and port regulations as commonly applied**	**R1,R2,R3**	**T1,B1, B2,B5**	**A1,A11, A12,A13, A14,VG15**
18.1	International Conventions			
18.1.1	Explains why most international regulations on marine pollution come from the 1973 International Convention for the Prevention of Pollution from Ships (MARPOL), which was updated in 1978. MARPOL was developed by the International Maritime Organization (IMO) and is aimed at preventing and minimizing pollution from ships - both accidental and from routine operations.			
18.1.2	Explains why Annex I of MARPOL regulate oil pollution from all ships (including gas tankers):			
18.1.3	Explains why all discharges of oil are prohibited unless certain criteria are satisfied			
18.1.4	Lists the criteria for permissible discharge under Annex I for Machinery space - Bilge waste: oily water from the bilges - Sludge: waste residue from the filtration of fuel oil - Ship must be en route - Oily mixture must have been processed through the oil filtering equipment - Oil content of the mixture does not exceed 15 parts per million (ppm)			

TOPIC 18	PROVISIONS OF MARPOL, IMO INSTRUMENTS, INDUSTRY GUIDELINES AND PORT REGULATIONS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	- Oily mixture is not mixed with cargo residues (see later)			
18.1.5	Explains why an international standard for the safe management and operation of ships and for pollution prevention requires an ISM system to be implemented and audited.			
18.2	Industry Guidelines			
18.2.1	Explains why the International Safety Guide for Gas Tankers and Terminals provides guidance on, and examples of, certain aspects of tanker and terminal operations and how they may be managed.			
18.2.2	Explains why SIGTTO identifies safety and environmental issues facing gas tanker, marine operations, and develops and publish recommendations that are accepted as the gas tanker industries Standards.			
18.2.3	Explains why other IMO relevant instruments for preventing pollution from liquefied gas tankers verified for compliance by certificates listed below includes but is not limited to: - International Anti-fouling System Certificate - International Air Pollution Prevention Certificate - International Energy Efficiency Certificate - Ozone-depleting Substances Record Book - Fuel Oil Changeover Procedure and Logbook (record of fuel changeover) - Manufacturer's Operating Manual for Incinerators - Bunker Delivery Note and Representative Sample			

TOPIC 18	PROVISIONS OF MARPOL, IMO INSTRUMENTS, INDUSTRY GUIDELINES AND PORT REGULATIONS			
	Knowledge, Understanding and Proficiency	**IMO Reference**	**Text books Bibliography**	**Teaching aid**
	- Ship Energy Efficiency Management Plan (SEEMP) - Technical File for control of No_x emissions - Record Book of Engine Parameters - Noise Survey Report - Certificate of insurance or other financial security in respect of civil liability for bunker oil pollution damage - Certificate attesting that insurance or other financial security - Certificate of insurance or other financial security in respect of civil liability for oil pollution damage - Cargo Information - International Pollution Prevention Certificate for the Carriage of Noxious Liquid Substances in Bulk (NLS Certificate) - Procedures and Arrangements Manual (P and A Manual) - Shipboard Marine Pollution Emergency Plan for Noxious Liquid Substances - Certificate of Fitness for the Carriage of Liquefied Gases in Bulk - International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk			
18.3	Local Regulations: Explains why compliance with all international, national, and local regulations as amended is an integral part of safe gas tanker cargo operations.			

TOPIC 18	PROVISIONS OF MARPOL, IMO INSTRUMENTS, INDUSTRY GUIDELINES AND PORT REGULATIONS			
Knowledge, Understanding and Proficiency		**IMO Reference**	**Text books Bibliography**	**Teaching aid**
TOPIC 19	**USE OF THE IBC AND IGC CODES AND RELATED[GEE22] DOCUMENTS**			
19.0	**Proficiency in the use of the IBC and IGC Codes and related documents.**	**R2,R8,R9**	**T1,B1,B2, B5,B7**	**A1,A11, A12,A13, A14,VG15**
19.1	Identifies chapter 14 to 19 of the IGC code and explains the relevance of all the columns stated therein in chapter 19.			
19.2	Explains the relevance of Chapter 17 of the IBC code.			

Part D: Instructor's Manual

■ Introduction

This manual reflects the views of the course designer on methodology and organization considered relevant and important in the light of his experience as an instructor. Although the guidance given here would be of value initially, the course instructors are advised to work out their own methods and ideas, refining and developing it further found constructive and discarding ideas and methods which are not found effective.

The course Instructors should also bear in mind that preparation and planning constitute a major contribution to effective presentation of the course.

The instructor's manual provides guidance on the material that is to be presented during the course. The course material reflects the mandatory minimum requirements for the training and qualifications of Masters, Chief Engineer Officers, chief mates , second engineer officers and any person with immediate responsibility for loading, unloading and care during transit and handling, or other cargo related operations on Liquefied Gas tankers as specified in Regulation V/1-2 paragraph 3 of the International Convention on Standards of Training, Certification and Watch keeping for Seafarers 1978, as amended.

The competences stipulated in the STCW 2010 table A-V/1-2-2 have been broadly divided into the following topics and are reflecting how the trainers should design and conduct their course. This is for guidance only.

To show consistency and adherence to STCW 2010, as given in STCW Code Chapter V, Table A-V/1-2-2, a mapping is provided for easy reference in Part A of this Model course from STCW's competences and training outcomes to the topics covered in this IMO Model course

1. Knowledge of liquefied gas tanker design, systems, and equipment,
2. Knowledge of pump theory and characteristics, including types of cargo pumps and their safe operation
3. Knowledge of the effect of bulk liquid cargoes on trim and stability and structural integrity
4. Proficiency in tanker safety culture and implementation of safety management requirements
5. Proficiency to apply safe preparations, procedures and checklists for all cargo operations
6. Proficiency to perform cargo measurements and calculations
7. Proficiency to manage and supervise personnel with cargo related responsibilities
8. Knowledge and understanding of basic chemistry and physics and the relevant definitions related to the safe carriage of liquefied gases in bulk in ships
9. Understanding the information contained in a Safety Data Sheet (SDS)
10. Knowledge and understanding of the hazards and control measures associated with liquefied gas tanker cargo operations

11. Proficiency to calibrate and use monitoring and gas-detection systems, instruments and equipment
12. Knowledge and understanding of dangers of non-compliance with relevant rules/regulations
13. Knowledge and understanding of safe working practices, including risk assessment and personal shipboard safety relevant to liquefied gas tankers
14. Knowledge and understanding of liquefied gas tanker emergency procedures
15. Actions to be taken following collision, grounding or spillage and envelopment of the ship in toxic or flammable vapour
16. Knowledge of medical first-aid procedures and antidotes on board liquefied gas tankers, with reference to the Medical First Aid Guide for Use in Accidents involving Dangerous Goods (MFAG)
17. Understanding of procedures to prevent pollution of the environment
18. Knowledge and understanding of relevant provisions of the International Convention for the Prevention of Pollution from Ships (MARPOL) and other relevant IMO instruments, industry guidelines and port regulations as commonly applied
19. Proficiency in the use of the IBC and IGC Codes and related documents

The texts used as references throughout the course are mentioned in Part A, Course framework are; Teaching Aids (A), IMO Reference Books (R), Text books (T), Bibliography (B) and Videos/ CBT's (VG)

The course outline, timetable and lesson plan provide guidance on the time allocations for the course material, but the instructor is free to make adjustments as deemed necessary. The detailed teaching syllabus must be studied carefully. Lesson plans or lecture notes compiled where appropriate.
It will be necessary to prepare material for use with overhead projectors or for distribution to trainees as handouts. Some sketches and diagrams having the same General learning or specific learning objective numbers given in Part C and Part D respectively as is required to be used by the instructor are provided at the end of the guidance notes. These will provide examples of the kind of material, which is useful in supporting the presentation of the course.

Throughout the course it is important to stress that, aboard ships rules and regulations must be strictly observed and all precautions taken to maximize safety and minimize harmful effects to the environment.

Topics marked with an asterisk (*) could be taught better using a simulator as used in the Model Course: LPG Tanker Cargo and Ballast Handling 2007 Edition T135E which provides detailed training programme for Liquefied gas Tanker operations using specially created cargo handling exercises. Separate exercises have also been included in this model course with a brief on how to conduct table top exercises if simulators are unavailable.

■ Guidance Notes

TOPIC 1 BASIC KNOWLEDGE OF DESIGN AND CHARACTERISTICS

1.0 Knowledge of liquefied gas tanker design, systems, and equipment

1.1 Types of gas tankers

Gas carriers range in capacity from the small pressurised tankers of between 500 and 6,000 m3 for shipment of propane, butane and the chemical gases at ambient temperature up to the fully insulated or refrigerated seagoing tankers of over 100,000 m3 capacity for the transport of LNG and LPG. Between those two distinct types is a third tanker type – semi pressurised gas carrier. The design of these ships are subject to the IMO Gas Code (IGC)

Gas carriers are divided into two main groups:

- Liquefied Petroleum Gas (LPG) Carriers, which are designed to carry mainly butane, propane, butadiene, propylene, vinyl chloride monomer (VCM) and are able to carry anhydrous ammonia.

  Liquefied Natural Gas (LNG) Carriers, which are designed to carry liquefied natural gas (which is mostly methane).

1.2 General arrangement and construction

These very flexible tankers are able to carry many cargoes in a fully refrigerated condition at atmospheric pressure or at temperatures corresponding to carriage pressure of between five and nine bar. The movement of liquefied gases by waterways is now a mature industry, served by a fleet of many tankers, a network of export and import terminals and a wealth of knowledge and experience on the part of various people involved.

Gas carriers have certain features common with other tankers used for the carriage of bulk liquids such as oil and chemical tankers. This includes the segregation of the cargo area from accommodation and machinery spaces and the use of special electrical equipment in gas dangerous zones.

A feature almost unique to the gas carrier is that the cargo is kept under positive pressure to prevent air entering the cargo system. This means that only cargo liquid and cargo vapour are present in the cargo tank and flammable atmospheres cannot develop.

Furthermore all gas carriers utilize closed cargo systems when loading or discharging, with no venting of vapour being allowed to the atmosphere.

In the LNG trade, provision is always made for the use of a vapour return line between tanker and shore to pass vapour displaced by the cargo transfer. In the LPG trade this is not always the case as, under normal circumstances during loading, re-liquefaction is used to retain vapour on board. By these means cargo release to the atmosphere is virtually eliminated and the risk of vapour ignition is minimised.

1.3 Cargo containment systems, including materials of construction and insulation

1.3.1 Lists the five main categories of cargo-containment systems as:

- integral tanks
- membrane tanks
- semi-membrane tanks
- independent tanks
- internal insulation tanks

1.3.2 Explains the above parameters in relation to the following cargo-containment systems: -

- Gaz Transport membrane tanks
- Technigaz membrane tanks
- independent tanks of type A (LPG)
- independent tanks of type A (Conch)
- independent tanks of type B (Kvaerner-Moss/Moss Rosenberg)
- independent tanks of type C
- internal insulation tanks
  - type 1
  - type2

Cargo containment systems in liquefied gas tankers

A cargo containment system is the total arrangement for containing cargo including, where fitted:

(1) A primary barrier (the cargo tank)
(2) Secondary barrier (if fitted)
(3) Associated thermal insulation,
(4) Any intervening spaces, and
(5) Adjacent structure, if necessary, for the support of these elements

For cargoes carried at temperatures between –10 degree C and -55 degree C, the ship's hull may act as the secondary barrier and in such cases it may be a boundary of the hold space.

The basic cargo tank types utilized on board liquefied gas tankers are in accordance with the list below:

- Independent Type 'A': Some other types such as:
- Independent Type 'B': Internal insulation Type '1'
- Independent Type 'C': Internal insulation Type '2'
- Membrane: Integral

Independent Tanks

Independent tanks are completely self-supporting and do not form part of the ship's hull structure. Moreover, they do not contribute to the hull strength of a ship. As defined in the IGC Code, and depending mainly on the design pressure, there are three different types of independent tanks for liquefied gas tankers: these are known as Type 'A', 'B' and 'C'.

Type 'A' Tanks

Type 'A' tanks are constructed primarily of flat surfaces. The maximum allowable tank design pressure in the vapour space of for this type of system is 0.7 barg; this means cargoes must be carried in a fully refrigerated condition at or near atmospheric pressure (normally below 0.25 barg).

This type of tank as found on a fully refrigerated LPG carrier. This is a self-supporting prismatic tank which requires conventional internal stiffening. In this example the tanks is surrounded by a skin of foam insulation. Where perlite insulation is used, it would be found filling the whole of the hold space.

The material used for Type 'A' tanks is not crack propagation resistant. Therefore, in order to ensure safety, in the unlikely event of cargo tank leakage, a secondary containment system is required. This secondary containment system is known as a secondary barrier and is a feature of all ships with Type 'A' tanks capable of carrying cargoes below -10 degree C.

For a fully refrigerated LPG carrier (which will not carry cargoes below –55 degree C) the secondary barrier must be a complete barrier capable of containing the whole tank volume at a defined angle of heel and may form part of the ship's full, as shown in the figure.

In general, it is this design approach which is adopted. By this means appropriate parts of the ship's hull are constructed of special steel capable of withstanding low temperatures. The alternative is to build a separate secondary barrier around each cargo tank.

The IGC Code stipulates that a secondary barrier must be able to contain tank leakage for a period of 15 days.

On such ships, the space between the cargo tank (sometimes referred to as the primary barrier) and the secondary barrier is known as the hold space. When flammable cargoes are being carried, these spaces must be filled with inert gas to

prevent a flammable atmosphere being created in the event of primary barrier leakage.

Type 'B' Tanks

Type 'B' tanks can be constructed of flat surfaces or they may be of the spherical type. This type of containment system is the subject of much more detailed stress analysis compared to Type 'A' systems. These controls must include an investigation of fatigue life and a crack propagation analysis. The most common arrangement of Type 'B' tank is a spherical tank. This tank is of the Kvaerner Moss design.

Because of the enhanced design factors, a Type 'B' tank requires only a partial secondary barrier in the form of a drip tray. The Type 'B' spherical tank is almost exclusively applied to LNG ships; seldom featuring in the LPG trade. A type 'B' tank, however, need not be spherical.

There are Type 'B' tanks of prismatic shape in LNG service. The prismatic Type 'B' tank has the benefit of maximizing ship-deck. Where the prismatic shape is used, the maximum design vapour space pressure is, as for Type 'A' tanks, limited to 0.7 barg.

Type 'C' Tanks

Type 'C' tanks are normally spherical or cylindrical pressure vessels having design pressures higher than 2 barg. The cylindrical vessels may be vertically or horizontally mounted. This type of containment system is always used for semi-pressurized and fully pressurized liquefied gas tankers.

In the case of the semi-pressurized ships it can also be used for fully refrigerated carriage, provided appropriate low temperature steels are used in tank construction. Type 'C' tanks are designed and built to conventional pressure vessel codes and, as a result, can be subjected to accurate stress analysis. Furthermore, design stresses are kept low. Accordingly, no secondary barrier is required for Type 'C' tanks and the hold space can be filled with either inert gas or dry air.

In the case of a typical fully pressurized ship (where the cargo is carried at ambient temperature), the tanks may be designed for a maximum working pressure of about 18 barg. For a semi-pressurized ship the cargo tanks and associated equipment are designed for a working pressure of approximately 5 to 7 barg and a vacuum of 0.5 barg. Typically, the tank steels for the semi-pressurized ships are capable of withstanding carriage temperatures of -48 degree C for LPG or -104 degree C for ethylene. (Of course, an ethylene carrier may also be used to transport LPG.)

Type 'C' tanks as fitted in a typical fully pressurized liquefied gas tanker. With such an arrangement there is comparatively poor utilization of the hull volume; however, this can be improved by using intersecting pressure vessels or bi-lobe type tanks which may be designed with a taper at the forward end of the ship. This is a common arrangement in semi-pressurized ships.

Membrane Tanks (membrane – 0.7 to 1.5 mm thick)

The concept of the membrane containment system is based on a very thin primary barrier (membrane – 0.7 to 1.5 mm thick) which is supported through the insulation. Such tanks are not self-supporting like the independent tanks. An inner hull forms the load bearing structure. Membrane containment systems must always be provided with a secondary barrier to ensure the integrity of the total system in the event of primary barrier leakage.

The membrane is designed in such a way that thermal expansion or contraction is compensated without over-stressing the membrane itself. There are two principal types of membrane system in common use – both named after the companies who developed them and both designed primarily for the carriage of LNG. These two companies have now combined into one.

Semi-Membrane Tanks

The semi-membrane concept is a variation of membrane tank system. The primary barrier is much thicker than in the membrane system, having flat sides and large roundish corners. The tank is self-supporting when empty but not in the loaded condition. In this condition the liquid (hydrostatic) and vapour pressures acting on the primary barrier are transmitted through the insulation to the inner hull as is the case with the membrane system. The corners and edges are designed to accommodate expansion and contraction.

Although semi-membrane tanks were originally developed for the carriage of LNG, no commercial-size LNG carrier has yet been built to this design. The system has, however, been adopted for use in LPG ships and several Japanese-built fully refrigerated LPG carriers have been delivered to this design.

Integral Tanks

Integral tanks form a structural part of the ship's hull and are influenced by the same loads which stress the hull structure. Integral tanks are not normally allowed for the carriage of liquefied gas if the cargo temperature is below -10 degree C. Certain tanks on a limited number of Japanese-built LPG carriers are of the integral type for the dedicated carriage of full refrigerated butane.

Internal Insulation Tanks

Internally insulated cargo tanks are similar to integral tanks. They utilize insulation materials to contain the cargo. The insulation is fixed inside ship's inner hull or to an independent load-bearing surface. The non-self-supporting system obviates the need for an independent tank and permits the carriage of fully refrigerated cargoes at carriage temperatures as low as -55 degree C.

Internal insulation systems have been incorporated in a very limited number of fully refrigerated LPG carriers but, to date, the concept has not proved satisfactory in service.

1.3.3 Explains location of tanks for each ship type

Liquefied Gas tankers are classed in three types based on hazard potential:
i) type 1G, designed to carry the most hazardous cargoes
ii) type 2G and 2PG, designed to carry cargoes having a lesser degree of hazard
iii) type 3G, designed to carry cargoes of the least hazardous nature.

Please use the diagrams provided in Part D 1.3.4 regarding the maximum extent of damage and standard damage conditions.

1.3.3(a) Explains assumed standard damage with respect to 1G, 2G, 2PG, 3G standard of damage.

Diagrams 1.3.5 are self-explanatory**.**

1.4 Cargo – handling equipment and instrumentation

1.4.1 Cargo pumps and pumping arrangements

1.4.1(a) Describes the different types of pumps used on liquefied gas tankers

Liquefied gas tankers are typically fitted with a deepwell or a submerged, electric, centrifugal cargo pumps. The motor windings are cooled by the pumped liquefied cargo which also serves to lubricate and cool the pump and motor bearings. As the cargo serves as both lubricant and coolant, it is critically important that the pumps are never allowed to run dry, even for short periods.

In addition to main cargo pumps, each tank will also be served by an emergency pump for LPG carriers or in the case of an LNG tanker a spray pump. This pump is of limited capacity, typically around 50m^3/hr, and will be used for the following:

.1 To cool down the liquid header prior to discharging.
.2 To cool the cargo tank during a ballast voyage prior to arrival at the loading terminal by discharging LNG to the spray nozzles in the tanks.
.3 In exceptional circumstances, to pump LNG from the tanks to the vapourisers when forced vaporization of LNG to the boilers is required.
.4 To enable the tanks to be stripped as dry as possible for reasons such as tank entry.

Hold or Inter barrier space pumps

These may be submerged pumps or they may be eductors working on the venture principle: as the latter have no moving parts this type requires the least maintenance. Their purpose is to pump out the cargo liquid that has leaked from a cargo tank or water has collected in hold or inter -barrier spaces from cargo or ballast tanks.

Motor driven pumps should be checked frequently for freedom of rotation; condensation may collect in bearings etc., unless the atmosphere in the space is kept dry.

1.4.1(b) Explains deck mounted pumps on liquefied gas tankers.

Deck mounted pumps

These are normally horizontally mounted motor driven centrifugal pumps used where cargo tank should be sufficiently pressurised to provide an adequate liquid suction head.

They may be used as main pumps, booster pumps, heater supply pumps, deck storage tank supply pumps etc.

Particular attention is drawn to the following points:

a. the pump should be primed and, if necessary, cooled down before starting and the cargo tank should be sufficiently pressurized to provide an adequate liquid suction head;
b. if a pressurizing circuit is used the consumption should be logged to ensure that levels are maintained and efficient sealing is achieved; seals should be kept in good condition;
c. motor — pump alignment should be correct to prevent coupling damage; all clearances and tolerances specified by the manufacturer should be observed;
d. after pumps have been replaced, pipe-work should be adjusted to prevent misalignment and to avoid stressing the assembly; likewise sliding feet adjacent should be kept free and carefully lubricated;
e. gas — tight bulkhead seals should be carefully maintained, if fitted.

1.4.1(c) Describes the construction of a deep well pump.

Deepwell pumps

These are single or multi-stage centrifugal pumps with deck mounted motors driving impellers near the tank bottom. The motor may be electric or hydraulic. The impeller casing is supported by the discharge tube which is flange - connected to the tank dome. The drive shaft runs inside the discharge tube and is lubricated by the cargo.

Particular attention is drawn to the following points:

a. before starting pumps care should be taken to ensure they are free, if possible by turning manually;
b. pumps should be started with discharge valves shut or slightly open (according to manufacturers' instructions) to reduce pressure surge and motor current;
c. if protection equipment is not operational or not fitted, care should be taken to ensure that pumps are not allowed to cavitate as lubrication would be lost and damage could occur,

d. flame — proof electric motors may only be drip-proof and it may be necessary to fit waterproof covers when not in use;

1.4.1(d) Describes the construction of a submerged pump

Fixed submerged pumps

These are fixed vertical combined pump and electrical motor assemblies mounted on a seating in the bottom of the tank Power is supplied through or stainless steel sheathed cables which terminate in a junction box at the tank dome. Motors are normally fitted with low liquid level shut down devices to prevent the danger of them running dry in cargo vapor. For ammonia duty the cable and the motor are sheathed or "canned" in stainless steel to prevent the ammonia reaching copper; this sheath is very thin and great care has to be taken to avoid damage e.g. never kink cables, avoid cavitation etc.

1.4.1(e) Describes additional arrangements for alternative unloading.

Instruments failure during unloading operations - Recommended actions by liquefied gas tankers

An emergency can occur at any time and in any situation. Effective action is only possible if pre-planned and practical procedures have been developed and are frequently exercised.

Cargo Pumps Failure

If one cargo pump fails it is possible to maintain the discharge with one pump in one tank. A problem arises when both cargo pumps in a cargo tank fail.

Additional emergency pumps are fitted on most LNG carriers to facilitate unloading. These have to be rigged separately through a special arrangement. Cargo operating manuals need to be consulted to rig and operate these emergency cargo pumps.

1.4.1(f) Describes spray pump on LNG tankers

Cargo and spray pumps

In addition to main cargo pumps, each tank will also be served by a spray pump. This pump is of limited capacity, typically around 50m3/hr, and will be used for the following:

.1 To cool down the liquid header prior to discharging.
.2 To cool the cargo tank during a ballast voyage prior to arrival at the loading terminal by discharging LNG to the spray nozzles in the tanks.
.3 In exceptional circumstances, to pump LNG from the tanks to the vapourisers when forced vaporisation of LNG to the boilers is required.
.4 To enable the tanks to be stripped as dry as possible for reasons such as tank entry.

In the case of total cargo pump failure, provision is made for Moss ships to discharge under pressure.

On LNG vessels where cargo pumps are 440V supply, insulation test are to be carried out before arrival in both the loading port and unloading ports. Also during insulation test, air temperature and humidity must be recorded.

Reference should be made to on board documentation for procedures for starting, stopping and operating cargo and spray pumps, together with the specific arrangements for rigging emergency cargo pumps.

1.4.1(g) Explains purpose of spray pumps

The spray pump is used for either pumping out liquid LNG to be used as fuel via a vaporizer, or for cooling down cargo tanks. It can also be used for "stripping" out the last of the cargo in unloading operations. The trainer depending upon the time available to him may expand each operation; if a simulator is available the uses of the spray pumps may be demonstrated.

1.4.1(h) Describes the operational requirements with respect to limitation on number of starts and required liquid level for spray pump operations

Give a brief on starting processes of different types of pumps then emphasize that after informing the E/R, When the cool down procedure is complete, some designs of vessel use the spray pump to prime the discharge columns on the first start main cargo pump(s). This avoids a pressure surge in the lines. To accommodate this, the columns can be vented through appropriate vent valves start the pumps with the approved time interval between each start and as agreed at the pre-unloading meeting.

This is normally ten minutes for the second pump and five minutes thereafter. Each pump is started in the approved manner. Remain aware of the mechanical damage that flow disruption or repeated starts can cause.

When all the pumps are running, inform the E/R and adjust the discharge valves to give either the maximum flow rate permitted by the terminal, the maximum allowable continuous running amps for the pumps or a stipulation regarding E/R generating capacity, whichever is the prevailing parameter.

For stripping with spray pumps Tank levels should be reduced to the point where the main cargo pumps trip on low current.

Using the stripping/spray pumps, remove the last of the cargo until they also trip on low current (procedure referred to as Tank Stripping / Line Drainage). Note: the quantity remaining onboard must still be gaugable for commercial reasons regarding measurement of cargo out-turn.

1.4.2 Cargo pipelines and valves

1.4.2. Describe general liquid and vapour piping requirements

Cargo Pipelines

Liquefied gas tankers are fitted with liquid and vapour manifolds. These are connected to liquid and vapour headers — or pipelines — with branches leading into each cargo tank. The liquid loading line is led through the tank dome to the bottom of each cargo tank; the vapour connection is taken from the top of each cargo tank. On semi-pressurised and fully refrigerated LPG tankers a vapour connection is taken from the vapour header to the cargo compressor room where re-liquefaction of the boil-off takes place. After re-liquefaction the cargo is piped, via a condensate return line, to each cargo tank.
Cargo pipelines are not allowed beneath deck level on liquefied gas tankers; therefore, all pipe connections to tanks must be taken through the cargo tank domes which penetrate the main deck. Vapour relief valves are also fitted on the tank domes; these are piped, via a vent header, to the vent riser. The vent risers are fitted at a safe height and safe distances from accommodation spaces and other such gas-safe zones as specified in the applicable Gas Codes. Provision must be made in the design and fitting of cargo pipelines to allow for thermal expansion and contraction. This is best achieved by the fitting of expansion loops or by using the natural geometry of the pipework, as appropriate. In a few specific cases, expansion bellows may be fitted and, where this is planned, corrosion resistant materials should be used. Where expansion bellows are fitted in vapour lines, it should be ensured that their pressure rating at least meets the liquid pipeline design criteria. The use of bellows in liquid lines is not recommended. Furthermore, expansion bellows are often subject to a considerable amount of wear and tear while a tanker is in service in particular, sea-water corrosion must be carefully avoided otherwise pin hole leaks are liable to develop".

1.4.2(a) Describes the commonly found fixed piping arrangements in a cargo tank

At each tank, there is a manifold which connects to the loading and discharge lines from the tank to allow for the loading and unloading of cargo. This manifold connects to the cargo pump discharge lines, the loading line and the spray line.

1.4.2(b) Describes generally a cargo piping arrangement

Liquefied gas tankers are normally with midships liquid and vapour manifold crossovers connected in turn to liquid and vapour headers with connections to each cargo tank. The liquid loading line is led the bottom of each cargo tank; the vapour connection is taken from the top of each cargo tank. On semi-refrigerated and fully refrigerated LPG ships a vapour connection is taken to the cargo compressor room for re-liquefaction of the boil-off whence returned, via a condensate return line, cargo tank. In the case of LNG ships the boil-off vapours may be fed direct to the ship's boilers or diesel propulsion plant via a compressor and heater, for use as main propulsion fuel or in the case of newer tonnage may be liquefied and returned as condensate to the cargo tanks.

No cargo pipework is allowed beneath deck level on gas, carriers; therefore, all pipework connections to tanks beneath deck level must be taken through the cargo tank domes which penetrate the deck. Vapour relief valves are also fitted on the tank domes; these relieve to vent stacks whose height and safe distances from accommodation spaces etc. are specified in the IMO Codes.

Provision must be made in the design and fitting of cargo pipework systems to accommodate thermal expansion and contraction. This can be done either using expansion be bellows and fabricated expansion loops or, whose appropriate, by using the natural geometry of the pipework installation Where expansion bellows are used in a pipework section, it is important not to interfere with any pipework supports once the ship has entered service, since they form an integral part of the expansion arrangements. Similarly when replacing parts such as bolts, restraining rods etc., great care must be taken to ensure that the new parts are of the correct material for the service. Removal spool pieces are used in pipelines to interconnect sections of line for special operational reasons such as using the inert gas plant or ensuring segregation of incompatible cargoes.

1.4.2(c) Describes generally the design of these valves.

The types of isolation valve normally found on gas tankers are ball, globe, gate or butterfly valves. These valves are usually fitted with pneumatic or, occasionally hydraulic actuators. Ball valves for LNG and Ethylene service are provided with some means of internal pressure relief; usually, a hole is drilled between the ball cavity and downstream side of the valve. Valves must be of the fire safe type.

Strainers are normally provided at the manifold connections for Loading /discharging. It is important not to bypass these strainers and to ensure they are frequently checked and cleaned. The strainers are installed to protect cargo-handling plant and equipment from damage by foreign objects. Many strainers are designed for one-way flow only. The IMO Codes require at least two pressure relief valves of equal capacity to be fitted to any cargo tank of greater than 20-m3 capacity. Below this capacity one is sufficient. The types of valves normally fitted are either spring-loaded or pilot-operated relief valves.

1.4.2(d) Explains safe use of portable cargo hoses and precautions to be taken.

Liquid and vapour hoses used for cargo transfer should be compatible with the cargo and suitable for the cargo temperature.

The hose should be stenciled or otherwise marked with its specified maximum working pressure and, if used in other than ambient temperature services, its maximum or minimum service temperature or both. The specified maximum working pressure should not be less than 10 bar gauge.

Flexible hoses are suspended from suitable equipment, are not subjected to excessive bending and are not putting excessive strain on the manifold (especially when the manifold is extended by unsupported reducing pieces)

If cargo hoses are carried on the ship the following precautions should be observed:

- Hoses should be checked to ensure that they are suitable, in terms of chemical compatibility, temperature and pressure ratings etc. for the cargo to be carried. The hose details should be checked (see Appendix 13) and the condition of the hose inspected. Hoses should be tested at least every six months and the test results recorded: the tests should be at ambient temperature and up to the working pressure. The IGC Code, Section 5.7 should be referred to.
- Gaskets should be checked for suitability.
- The hose should be supported correctly at all times, especially during use, when tidal and draught variations should be taken into account.
- Pipeline flanges should be cleaned before connecting.
- Nuts and bolts should be of the correct size and material, and damaged bolts should not be used. A bolt should be fitted in every hole and tightened correctly.
- Hose bonding or insulation should be checked.
- Hoses should be drained, purged and depressurized before disconnection. Hoses not purged of cargo vapour should not be stored in enclosed spaces.
- Hose ends should be blanked before storage.

1.4.3 Expansion devices

Expansion bellows may be used to accommodate thermal contraction and expansion in a number of applications

a. In pipe-work systems to accommodate lateral and axial movement;
b. In heat exchangers a bellows may be put in the shell to accommodate tube expansion and contraction, or there may be bellows in both the shell and tube sides;
c. In bulkhead seals for sealing pipes or drive shafts;
d. In valve spindle seats instead of the traditional gland seal to provide a more leak-proof assembly;
e. In automatic controls to accommodate movement without loss of pressure, for example in pneumatic control equipment.

If used properly, bellows pieces are very durable, but they are vulnerable to misuse and for this reason expansion loops and offsets may be used instead. If bellows are intended to be fitted, the design will take careful account of pressure, temperature, diameters, pipe layout and movements. All associated parts such as anchor-points, supports etc., are vital to safe operation within design limits.

The following precautions should be observed:

f. Bellows should never be subjected to unnecessary shocks such as pressure surge;
g. Every effort should be made to protect bellows from internal and external damage: personnel should not stand on or mishandle bellows units;
h. For low temperature service, a flexible sleeve may be fitted to protect the unit from excessive ice build-up: such sleeves should not be permanently removed;

i. The design efficiency of anchor-points, supports, guides or constraints should be maintained: their operation should never be impaired, for example by incomplete re-assembly, change of position, misalignment of pipe-work, or any other action which would place stress on the unit for which it was not designed;
j. Bellows should be inspected regularly for cracks, corrosion, cleanliness etc.;
k. Before replacement units are installed, it should be determined whether pre-compression or extension is necessary;
l. When bellows are stored they should be properly protected against over-extension, compression, misalignment and mechanical damage;
m. When pressure tests are carried out, bellows should be prevented from extending beyond design limits in order to avoid damage or possible bellows failure;
n. Temporary tie-bars or constraints should be removed before cargo service and replaced with normal constraints.

1.4.4 Flame screens

A portable or fixed device incorporating one or more corrosion resistant wire meshes used for preventing sparks from entering an open deck hole, or for a short period of time preventing the passage of flame into the deck hole, yet permitting passage of gas from the deck hole.

1.4.5 Temperature monitoring systems

Remote and local temperature and pressure sensors and gauges Each cargo tank should be provided with at least two devices for indicating cargo temperatures, one placed at the bottom of the cargo tank and the second near the top of the tank below the highest allowable liquid level. The temperature indicating devices should be marked to show the lowest temperature for which the cargo tank has been approved by the administration.

1.4.6 Cargo tank level – gauging systems

1.4.6(a) Lists common types of closed gauging systems for liquefied gas tankers

The common types of closed gauging systems for liquefied gas tankers are:

a) float type;
b) capacitances type;
c) radar type

1.4.6(b) Describes the operating principle of the most common level gauges.

All gauging systems used are specifically designed for the low temperatures experienced on LNG carriers.

Various systems may be fitted to a vessel dependent upon the owner's specifications and cargo containment system. There will generally be at least two independent

gauging systems fitted to each tank, in addition to low, high and high-high level alarms

CAPACITANCE TYPE GAUGES – these gauges operate using the variation of electrical capacitance between two probes when a liquid level changes. A coaxial sensor is installed within a tank, and is constructed of a number of individual segments, depending upon the height of the tank. As the liquid level in the tank changes, the capacitance varies.

FLOAT ACTUATED GAUGES – these employ a float connected by an invar tape or other material suitable for the temperature and suitable for the gas cargo carried for gas tankers to a tensator spring. This spring acts as a counter balance system, maintaining a constant tape tension at the float. This ensures that the float maintains the same level of immersion irrespective of the amount and weight of the tape paid out. The accuracy of this system is dependent upon tank construction and on the operating conditions, however the accuracy should remain within 1 cm.

RADAR TYPE GAUGES – these gauges operate by generating and transmitting radar waves from a generating device mounted externally on the tank. As the speed of the radar waves is known, if the time needed by the signal to reach the cargo liquid level, bounce back and be picked up by the antenna, can be measured accurately, the cargo ullage can be calculated.

All cargo measuring systems in use are highly accurate, and form part of the Custody Transfer System, which is checked and verified by an independent organization during vessel dry docking periods. A certificate of accuracy for the system will be issued.

Generally if any ship repairs are carried out on any gauging system, it will be necessary for the gauge to be re-calibrated and a new certificate issued.

The vessel will carry out and record comparison / calibration checks of the various gauging systems in use during each cargo operation, to enable the early detection of any problems with any of the systems. Where the completion of these tests reveals any significant errors the Company is to be advised immediately with a request for attention.

1.4.6(c) Explains the correct handling procedures when using float gauges

The float must be lifted from the liquid level when not in use; if left down, the fluctuation in level at sea will damage the tape-tensioning device. Float gauges cannot normally register a liquid level of less than four inches in depth.

The float is attached by a tape to an indicating drive, which can be connected by a drive mechanism for remote read-out. Particular attention is drawn to the following:

a. Floats should be stowed manually when at sea except briefly during measurement of tank contents; of the float is left "down" at sea, it will almost certainly be damaged.

b. Remote and local readings should be compared frequently to determine discrepancies; corrections should be applied to readings to allow for tape expansion or contraction and ship trim and heel; correction tables are normally provided.
c. Tapes should be adjusted to ensure free vertical movement; if frayed. they should be replaced. Particular care is necessary with rewind mechanisms which are carefully balanced; if obstructed the gauge readings will be inaccurate.
d. If tapes are renewed, or when reassembling, allowance should be made for the level at which the float begins to lift; this depends on the cargo density because this determines instructions should be consulted.
e. All parts should be securely locked in position; special care is necessary with tape-to- float and tape-to-reel attachments.

1.4.7 Tank pressure monitoring and control systems.

Every pressure sensor must be calibrated as per safety management systems of the organization.

The vapour space of each cargo tank should be provided with a pressure gauge which should incorporate an indicator in the cargo control position. As required by IMO, each cargo tank is fitted with two pressure/vacuum relief valves. In addition, on LNG membrane ships, the primary and secondary insulation spaces around each tank are protected by two pressure relief valves. On LNG Type B spherical tanks, ship's hold spaces around each tank are similarly protected.

1.5 Cargo temperature maintenance system

1.5.1. Explains why it is necessary to control vapour boil-off.

It is necessary here to mention LPG and LNG cargo operate differently with differing requirements and equipment to maintain boil off pressures. When loading LPG without a vapour return line, the vapour which is displaced by the incoming liquid must be liquefied by the re-liquefaction plant; the capacity required for this plus the heat loss through the insulation, may leave little or no capacity for cooling of the cargo during loading. Ship's tank pressures must be regularly observed and on no account should relief valves be allowed to lift loading rates should be reduced and if necessary stopped when difficulties are experienced in maintaining acceptable tank pressures. Ship's tank pressure rise in the early stages of loading can also be controlled to a certain extent by taking some liquid into the cargo tank via the top sprays, if fitted, so condensing part of the cargo vapour.

The boil-off vapour from LNG is lighter than air at vapour temperatures above -110°C or higher depending on LNG composition. Therefore when vapour is vented to the atmosphere, the vapour will tend to rise above the vent outlet and will be rapidly dispersed. When cold vapour is mixed with ambient air, the vapour-air mixture will appear as a readily visible white cloud due to the condensation of the

moisture in the air. It is normally safe to assume that the flammable range of vapour-air mixture does not extend significantly beyond the perimeter of the white cloud.

1.5.2 Describes a system for handling LNG boil off vapour

There is a LNG re-liquefaction system on some LNG vessels, however many LNG carriers use the cargo boil off vapors for their propulsion.

A typical cargo cycle (BOG Cycle) consists of the following equipment:

- one BOG Pre-heater,
- two BOG compressors(duty and standby),
- one Plate-fin heat exchanger (part of the Cold box),
- one LBOG Phase separator (part of the Cold box),
- two LNG Transfer pumps.

BOG generated in cargo tanks at temperature of about -100ºC is sent via special gas header to the pre--cooler where gas is cooled to the temperature –120ºC. Pre cooled BOG is compressed in a two- -stage, integrally-geared centrifugal compressor to approximately 450 kPa(a). Compressed BOG enters a plate-fin heat exchanger where is cooled and condensed against the cold nitrogen stream. The Plate-fin cryogenic heat exchanger and the separator are assembled into one enclosed unit called the Cold box. Reliquefied BOG at temperature –159ºC is collected in a separator to remove non-condensable gases, if present. The pressure in the separator forces the liquefied gas back to the cargo tanks. Non-condensable gases are transferred for burning to the GCU (Gas Combustion Unit), or for venting to the vent mast."

The Nitrogen Cycle consists of the following equipment:

- Two N2 Compander's,
- Nitrogen water coolers,
- Cold box,
- N_2 Inventory system:
    - nitrogen reservoir,
    - two nitrogen booster compressors,
    - nitrogen drier unit,
    - two control valves make-up and spill.

The Compander is the basic refrigeration device in nitrogen cycle. The N2 Compander is a three-stage integrally geared centrifugal compressor with one expander stage. The refrigeration capacity is produced by nitrogen compression-expansion cycle. Nitrogen gas at a pressure 1320 kPa(a) (nitrogen pressure in a low pressure part of the refrigeration loop) is compressed to 5310 kPa(a) in compander's three stage centrifugal compressor. During the compression, the nitrogen is cooled to 41ºC by two water intercoolers and one water after cooler. The high pressure nitrogen is led to the "warm" section at the top of the cold box, where the nitrogen is cooled in plate-fin heat exchanger to –110ºC by the cold nitrogen from low pressure refrigeration loop. Pre cooled high pressure nitrogen is forced to the expander. In the expander high pressure nitrogen expands down to the pressure about 1320 kPa(a)

and reaches temperature at 162.5°C and then it is routed to the heat exchanger "cold" section at the bottom of the cold box. The cold nitrogen absorbs heat from the BOG and warm high pressure nitro-gen. The nitrogen flows through from bottom of the cryogenic heat exchanger to the top before it is returned to the suction side of the compander's three-stage compressor.

Refrigeration capacity control (N2 inventory system). The refrigeration capacity of nitrogen loop has to be adapted to the varied quantity of the BOG generated in cargo tanks. In order to keep the compander's compressors as close as possible to design conditions (to maximize the cycle efficiency), the load is mainly controlled by circulating nitrogen mass flow rate. The relationship between the mass flow and nitrogen loop refrigeration capacity is assumed to be linear. In connection with this that cooling capacity depends on mass flow through the N2 refrigeration loop, the capacity control is realized by increasing or decreasing nitrogen quantity in cycle. The operating concept consists in optimizing the shifting of nitrogen between N2 reservoir and N2 cycle / loop in order to minimize venting of dry and clean nitrogen from closed loop. The cooling capacity control system (called N2 inventory system) comprises the following basic devices:

- nitrogen reservoir,
- nitrogen booster compressors,
- nitrogen drier unit,
- two control valves make-up and spill.

When the cooling capacity needs to be increased (the first stage compressor suction pressure has to be increased), nitrogen is transferred from N2 reservoir via make-up control vale to low pressure part of refrigeration loop. When the cooling capacity needs to be decreased (the first stage compressor suction has to be decreased), nitrogen is transferred from high pressure part of refrigeration loop via spill control valve to the N2 reservoir. Because the mass flow rate of the compander is a direct function of the pressure at compander's compressor suction, this pressure signal is used for cooling capacity control by N2 inventory system.

1.6 Tank atmosphere control systems (inert gas, nitrogen), including storage, generation and distribution systems

1.6.1 Explains 'inert gases with the IMO requirements concerning inerting and the production of inert gas on board gas tankers.

Inerting cargo tanks and pipe work systems is undertaken primarily to ensure a non-flammable condition in the subsequent gassing up with the vapour of the cargo to be loaded. For this purpose a reduction in the oxygen concentration to 5% by volume is generally judged to be adequate, although lower values are usually obtainable and preferred.

For some of the more active chemical gases, VCM or butadiene, oxygen levels as low as 0.1% may be required to avoid chemical reaction with the incoming gassing-up vapour. This level will be difficult to achieve using shipboard inert gas plant.

1.6.2 Describes different methods of producing inert gas.

Inert gas, dry air and Nitrogen generator

Many LNG vessels are equipped with an inert gas generator which may also be used to produce dry air. The inert gas and/or dry air is used for the inerting and gas freeing of cargo tanks, cargo pipes and void spaces when required prior to and after a refit or inspection period.

Inert gas is used on liquefied gas tankers to inert cargo tanks and hold spaces. Production onboard generally uses one of two methods:

•Inert gas is produced by removing oxygen from the air through physical absorption
•Inert gas is produced by combustion of gas oil. (This is the most widely used system).

1.6.2(a) Describes an inert gas generator and a nitrogen generator system.

Inert Gas Generators: Inert gas produced by the combustion of low sulphur gas-oil produces a low oxygen content gas that is further purified and treated to provide an inert gas of acceptable purity. The quality of the inert gas produced will vary widely, depending on the conditions under which the generator is operated.

The system comprises of three main components:

1. Combustion chamber with scrubber and cooler

The burner is designed to ensure proper combustion with a minimum of excess air, while the combustion chamber itself is water jacketed without a brick lining. After combustion, the gas enters the washing /cooling section (i.e. the demister/R22 cooler) at a temperature of about 800°C and is cooled and scrubbed by spraying with seawater. The gas leaves at approximately 5°C above seawater temperature and is essentially free of the sulphur dioxide that forms during the combustion of any sulphur present in the fuel. Combustion type generators must be located outside the cargo area and connections to the cargo system are temporary, normally via spool pieces. When the inert gas plant is not being used, temporary connections must be disconnected and blanked-off.

The main advantages of the combustion type generator as a source of inert gas are:

• The cost of the inert gas produced is much less than the purchase of pure nitrogen

• The inert gas plant is available when necessary.

The disadvantage of this system is the quality of produced gas. Even under good operating conditions, the inert gas supplied is unsuitable for use with many of the chemical gases.

A typical output from an inert gas generator would be as follows:

Component	% by Volume
Nitrogen	85 – 86
Carbon Dioxide	14 - 15
Carbon Monoxide	0.1 -0.3
Oxygen	0.1 - 0.5
Hydrogen	0.2
Sulphur Dioxide	20ppm
Oxides of Nitrogen	0-5 ppm
Other Dew point	- 50°C to -55°C
Ash and soot	traces

Nitrogen Generators Nitrogen is generated onboard using a system called pressure swing absorption. The process is based on the use of an absorbent carbon bed, which acts as a molecular sieve, absorbing oxygen and leaving nitrogen as the unabsorbed product.

On exhaustion, the carbon beds are regenerated in a valve-operated sequential system, venting an oxygen rich waste. This type of system produces nitrogen gas of high purity, with less than 1 % oxygen. The system is normally operated in conjunction with a buffer nitrogen storage system. Nitrogen is not commercially viable as an inert gas for purging cargo tanks, but is used in a number of areas on LNG Carriers such as:

- Inerting the hold and annular space

- Inerting the jacket around the pipe that carries the LNG 'boil-off gas to the engine room.

2. Refrigerated drier (normally cooled by a Freon gas)

In the refrigerated drier the inert gas is cooled to approximately 4°C, resulting in condensation of most of the water vapour present in the gas. Figure 5.37 shows the saturated water vapour content of inert gas as a function of temperature, the water vapour content of inert gas being much less at 4°C than at 25°C.

3. Absorption drier

The absorption drier consists of two vessels that are filled with activated alumina. One vessel is on drying duty while the other vessel is re¬-generated. The cycle time takes about 6 hours. Drying in the absorption drier reduces the atmospheric pressure dew point of the inert gas to -40°C or below.

1.6.2(b) Describes the limitations of using inert gas produced by an inert gas generator and nitrogen generator.
Where the Inert gas generated by burning fossil fuel will have increased % of Carbon dioxide which may not be suitable for Cargo, it will be acceptable to inert hold spaces as the quantity required is reasonable.

The nitrogen produced by a nitrogen generator will not cope up to the demands of the tank containment systems and hence can be used only as a topping up arrangement.

The normal procedures therefore is limited to the use of nitrogen from shore for In tank use to protect the cargo and the annular space around the tanks in case of spherical tanks in the LNG transportation and the use of inert gas from the IGG system for hold spaces where adequate quantities are available.

1.6.2(c) Describes dew point meter.

Portable dew-point meters use the Advanced Ceramic Moisture Sensor. The operation of this sensor depends on the dielectric property of water molecules absorbing onto an active porous insulating layer sandwiched between two layers of conductive material deposited on a ceramic substrate.

Water has a very high dielectric compared to the dielectric of the active layer and the background of the carrier gas so it can be detected easily. The active layer is very thin – less than one micron and the porous top conductor that allows water molecules to penetrate into the active layer is less than 0.1 micron thick. This allows the sensor to respond very rapidly to changes in the moisture surrounding it both when moisture decreases (drying) and increases in the sensor environment.

1.7 Cofferdam heating systems

1.7.1 Defines principles of operation of the cofferdam heating system.

As cargo tanks are cooled the temperature of the surrounding cargo tanks drops, leading to a drop in pressure. When the pressure drop is excessive as in LNG carriers where the temperature drop is to -163°C, a cofferdam adjacent to the cargo tanks will need to be heated to maintain a positive pressure.

The main and stand-by heating coils are served by main and stand-by steam heaters.

A typical system comprises of:

- 2 x glycol water centrifugal circulating pumps rated at 30m3/h x 30 MTH.
- 2 x steam heaters rated at 223,476kcal/h with high and low steam demand regulating valves.
- 1 glycol expansion tank of 1000litre.
- 1 glycol reserve tank of 4500 litre.
- 1 glycol mixing tank of 200litre.
- 1 pneumatic operated expansion tank topping up pump rated at 2.0m3/h x 10 MTH.

There are two (2) steam heaters to heat the glycol water with service steam at 0.8MPa. The steam flow is controlled by manipulating the steam flow control valve in accordance with the measured outlet temperature. Also, the inlet temperature to

the cofferdam and liquid dome is controlled by manipulating a 3-way temperature control valve.

1.7.2 Explains glycol heaters

The glycol water heating system is typically located in the electric motor room. The system heats glycol water which is pumped around the cofferdam system to maintain the temperature inside those spaces, when loaded, at approximately +5°C.

1.8 Gas- detecting systems

1.8.1 Lists IGC requirements concerning the fixed gas-detection system

Gas detection equipment acceptable to the Administration and suitable for the gases to be carried should be provided in accordance with column "f" of the IGC code.

In every installation, the positions of fixed sampling heads should be determined with due regard to the density of the vapours of the products intended to be carried and the dilution resulting from compartment purging or ventilation.
Pipe runs from sampling heads should not be led through gas-safe spaces except as permitted Audible and visual alarms from the gas detection equipment, if required by this section, should be located on the bridge, in the cargo control position, and at the gas detector readout location. Gas detection equipment may be located in the cargo control station, on the bridge or at other suitable locations. When located in a gas-safe space the following conditions should be met:

(a) gas-sampling lines should have shut-off valves or an equivalent arrangement to prevent cross-communication with gas-dangerous spaces; and

(b) exhaust gas from the detector should be discharged to the atmosphere in a safe location. Gas detection equipment should be so designed that it may readily be tested. Testing and calibration should be carried out at regular intervals.

Suitable equipment and span gas for this purpose should be carried on board. Where practicable, permanent connections for such equipment should be fitted.

A permanently installed system of gas detection and audible and visual alarms should be provided for:
(a) Cargo pump rooms;
(b) Cargo compressor rooms;
(c) Motor rooms for cargo handling machinery;
(d) Cargo control rooms unless designated as gas-safe;
(e) Other enclosed spaces in the cargo area where vapour may accumulate

including hold spaces and inter barrier spaces for independent tanks other than type C;

(f) Ventilation hoods and gas ducts where required by Chapter XVI; and
(g) Air-locks

1.8.2 Explains the arrangements of gas detection systems

The gas detection equipment should be capable of sampling and analyzing from each sampling head location sequentially at intervals not exceeding 30 minutes, except that in the case of gas detection for the ventilation hoods and gas ducts sampling should be continuous. Common sampling lines to the detection equipment should not be fitted.

In the case of products which are toxic or toxic and flammable, the Administration may authorize the use of portable equipment, except when column "h" of IGC code, for toxic detection as an alternative to a permanently installed system, if used before entry of the spaces listed in IGC code by personnel and thereafter at 30 minute intervals whilst occupied by them.

For the spaces listed in chapter 13 of the code, alarms should be activated for flammable products when the vapour concentration reaches 30 per cent of the lower flammable limit.

In the case of flammable products, where cargo containment systems other than independent tanks are used, hold spaces and/or inter-barrier spaces should be provided with a permanently installed system of gas detection capable of measuring gas concentrations of 0 to 100 per cent by volume.

The detection equipment, equipped with audible and visual alarms, should be capable of sampling and detecting from each sampling head sequentially at intervals not exceeding 30 minutes. Alarms should be activated when the vapour concentration reaches the equivalent of 30 per cent of the lower flammable limit in air or such other limit as may be approved by the Administration in the light of particular cargo containment arrangements. Common sampling lines to the detection equipment should not be fitted.

In the case of toxic gases, hold spaces and/or inter-barrier spaces should be provided with a permanently installed piping system for obtaining gas samples from the spaces. Gas from these spaces should be sampled and analysed from each sampling head location by means of fixed or portable equipment at intervals not exceeding 4 hours and in any event before personnel enter the space and at 30 minute intervals whilst they remain therein.

Every ship should be provided with at least two sets of portable gas detection equipment acceptable to the Administration and suitable for the products to be carried. A suitable instrument for the measurement of oxygen levels in inert atmospheres should be provided.

1.9 Ballast system

1.9.1 Explains the ballast line and valve setup for deballasting operations

To be explained on a simulator or using the plan of ballast system of a liquefied gas tanker.

1.9.1(a) Describes the use of ballast pumps and eductors.

The ballast pump and eductors are used for ballasting and deballasting operations. The capacity of the ballast pump is such that the ballast operations can cope up with the rate of cargo operations.

Ballast pump are usually of centrifugal type.

Eductors are used for finally draining the tank.

1.9.2 Explains that ballast operations are carried out to maintain safe trim and stability of gas ships during cargo operations.

At all times during unloading, loading and ballasting operations the ship should have adequate stability and suitable trim to allow for departure at short notice in the event of an emergency. While berthed at terminal the ship's boilers, main engines, steering machinery, mooring equipment and other essential equipment should be kept ready to permit the ship to move from the berth at short notice, and in accordance with the terminal regulations.

1.9.2(a) Describes ballast tanks mud flushing systems and its operations.

An automatic back flushing system having an arrangement to reverse the flow of water to remove particles larger than 50 microns during ballasting operations is used in some liquefied gas tankers.

On completion of flushing and draining the tanks, it should be ensured that the tank water supply and tank suctions are closed before shutting off the drive water to avoid water going back to the tank. Shut down the eductor system.

Depending on the stress and stability, it may be possible to discharge more than one pair of ballast tanks before refilling them with clean ballast.

1.10 Boil – off systems

1.10.1 Explains boil-off and why it is necessary to control vapour boil-off on LNG carriers.

On LNG Carriers, cargo boil-off is taken to the engine room using the Low Duty (LD) compressors. This is burned as fuel gas in the ship's boilers. Vessels that are designed for LNG carriage use steam turbine driven axial flow compressors to handle the vapours produced during cool down, loading and loaded passage. A Low Duty (LD) compressor usually handles the boil-off vapours produced during loaded passage, with High Duty (HD) compressors handling the vapours that are produced during loading. The LD compressor takes boil-off vapour and uses a steam-heated vapour heater to warm it for supply to the engine room. Automatic surge controls are fitted to the compressors to protect against damage from flow reversal and subsequent surging. The surge control system ensures that minimum flow is maintained above a set value that depends on the compression ratio.

On most LNG carriers the boil off is used for propulsion which keeps the cargo tank pressures under control and works as a refrigeration system.

1.11 Re-liquefaction systems

1.11.1. Describes a single-stage direct re-liquefaction system for an LPG carrier along with the stages in the cycle on a Mollier diagram.

Single Stage Direct

In a single stage compression re-liquefaction cycle, as shown in Figure in Part D, the boil-off vapours from the cargo tank are drawn-off by the compressor and then compressed. This increases the pressure and temperature of the vapour, allowing it to be condensed against sea water in the condenser. The condensed liquid is then flashed back to the tank via a float expansion valve or a level control. The liquid/vapour mixture returned to the cargo tank is normally distributed by a spray rail to maximise the cooling effect within the tank.

This cycle is also suitable where suction pressures are relatively high, as is the case in the semi-refrigerated carriage of LPG.

The Mollier diagram is the European version of the Anglo-American Psychometric chart. They are identical in content but not in appearance. Mollier diagrams show the heat quantities contained in, and the conditions of, a liquefied gas (or refrigerant) at different temperatures.

The main dark line as shown depicts the saturated liquid line to the left of the apex and the saturated vapour line is shown on the right. Where they meet is called critical point 'k'.

The shape shown on the diagram from point 'a' is an example of the pressure and enthalpy changes that occur in a simple shipboard refrigeration plant.

- At 'a' the vapour is drawn from the tanks and compressed until point 'b'
- from 'b' to 'c', the vapour has heat removed from it by the condenser where it condenses to a liquid
- Where 'c' is to the left of the 'saturated liquid line' it indicates that the liquid is sub-cooled. The liquid is then passed across an expansion valve and returned to the ship's tanks
- 'cd' is always vertical and indicates the level of humidity in the returned condensate.

The total refrigeration effect of a compression cycle is the difference in enthalpy of the 'vapour' drawn by the compressor at 'a' and the condensate returned at 'd', measured in kJ/kg.

1.11.1(a) Explains the limitations for a single-stage direct system

For ships in service in products which readily form dangerous peroxides, re-condensed cargo is not allowed to form stagnant pockets of uninhibited liquid. This may be achieved either by:

a. using the indirect system described in IGC code with the condenser inside the cargo tank, or
b. using the direct system or combined system described in IGC code and
c. respectively or the indirect system described in IGC code with the condenser outside the cargo tank, and designing the condensate system to avoid any places in which liquid could collect and be retained. Where this is impossible inhibited liquid should be added upstream of such a place."

1.11.1(b) Describes the two-stage direct system and explain the stages in the cycle on a Mollier diagram.

TWO STAGE DIRECT CYCLE:

The vapours from the first stage discharge are taken to an intercooler where superheat is removed. The cooling medium is cargo liquid 'flashed down' to intercooler pressure from sea water-cooled condenser/receiver. The remaining parts of the cycle are similar to the single-stage cycle. This system can be used for semi- and fully refrigerated LPG ships. A simplified flow sheet showing a two stage direct cycle is shown in Fig. 1.11.

1.11.1(c) Explains the limitations of a two- stage direct system

If the compressor discharge to suction pressure ratio in a single stage system exceeds about 6:1 the efficiency of machine is reduced and two stage compression with cooling between the stages is therefore sometimes necessary to limit compressor discharge temperatures which increase significantly with increasing compression ratio.

1.11.1(d) Describes a cascade system and the stages in the cycle on Mollier diagrams.

CASCADE DIRECT CYCLE
The cascade system uses a refrigerant such as R22 condense cargo vapours; a simplified flow sheet is shown in Fig. The single stage compression of cargo vapour is identical to the single stage direct cycle, but the cargo condenser is cooled using R22 instead of sea water. The cargo, in condensing evaporates the liquid R22 and the R22 vapours are taken through a conventional R22 closed refrigeration cycle condensing against sea water-hence the term cascade. The cascade cycle is used for refrigerated cargoes and plant capacities are not so affected by sea water temperature changes as are other re-liquefaction cycles

1.11.1(e) Describes different types of indirect systems

INDIRECT SYSTEMS

Indirect cooling is used for cargoes which cannot be compressed for chemical reasons. The boil off passes from tank under own pressure to a condenser which cools and liquefies it. The condensate then returns to the tank under its own pressure or by pump. It is also possible to arrange condensation by cooling coils in the vapour dome or welded to the tank exterior.

1.11.1(f) Explains the limitations of indirect systems

The cycle has to use a very cold refrigerant in the condenser for efficiency; the common refrigerant is hydrogen, helium and propane. The refrigerant works in a cycle; in cascade with the cargo cycle.

This cycle is relatively uncommon as it requires, for efficiency, a very cold refrigerant and large surface.

1.11.2 Describes with the aid of a diagram, a typical LNG BOG re-liquefaction plant.

"A TYPICAL BOG Re-liquefaction system"

In this type of re-liquefaction system for a LNG carrier, the forcing of the BOG from cargo tanks to the cold box in the cryogenic temperature conditions is re-placed for the forcing in under ambient temperature conditions. The pre-heater instead of the pre cooler is installed before BOG compressor. The two-stage centrifugal cryogenic compressor is replaced for three-stage centrifugal compressor working under ambient temperature. During compression the BOG cooling is applied.

The lay-out of the typical system is presented on the figure 1.11 in Part D.

- The Cargo Cycle (BOG Cycle) consists the following equipment:
- One BOG Pre-heater,
- Two BOG Compressors,
- One Plate-fin heat exchanger (part of the Cold box),
- One LBOG Phase separator (part of the Cold box),
- Two LNG Transfer pumps.

To enable stable temperatures at the inlet into the BOG compressor, at level well above cryogenic conditions, a pre-heater is installed upstream of the BOG compressor. BOG generated in cargo tanks at temperature –100°C is sent via special gas header to the pre-heater where gas is warmed to the temperature approximately 37°C and then it is led to the three stage integrally-geared centrifugal BOG compressor. BOG is compressed to the pressure 800 kPa and pre-cooled to temperature 41°C by two water intercoolers and one water after-cooler. BOG compressor forces gas to the plate-fin heat ex-changer where it is liquefied and sent to the separator. The gas temperature on the outlet from the heat exchanger is controlled by temperature control valve. The separator pressure forces liquefied gas back to the cargo tanks.

The Nitrogen cycle consists of the following equipment:

- Two N2 compander's,
- Nitrogen water coolers,
- Cold box,
- N_2 Inventory system:
  - nitrogen reservoir,
  - two nitrogen booster compressors,
  - nitrogen drier unit,
  - two control valves make-up and spill.

At design 100% capacity, the compander's three-stage centrifugal compressor compress 90 000 kg/h nitrogen from 1000 kPa to 4200 kPa. During the 3-stage compression, the gas is cooled to approximately 41°C using water cooled gas coolers in between each stage. The compressed nitrogen is divided in two streams. One of them is transferred to the top of cold box where is pre-cooled to –50°C. The second one as a heating stream is forced via temperature control valve to the pre-heater of BOG. From pre-heater the second stream of the nitrogen is send to the common line with the first one and then nitrogen enters to the second stage of the cold box where is finally cooled to temperature –110°C. The cold high-pressure nitrogen is routed to the expander where it is expanded down to 1000 kPa and it reaches temperature –162°C. During the expansion approximately 1000 kW of power is generated. This is added to the gearbox and thus reducing the motor power. From the expander cold nitrogen is sent to "cold" section of the heat exchanger in the cold box. The nitrogen flowing through heat ex-changer absorbs heat from the BOG. The low pressure nitrogen leaves the top of the cold box at a pressure of 960 kPa and a temperature of 39.5^{o}C. From the upper part of cold box the low pressure nitrogen returns to the suction of the first stage compander's compressor completing the closed N2 refrigeration loop.

1.12 Cargo emergency shutdown system (ESD)

1.12.1 Explains the principles of operations of an ESD system

Ship shore link
Linked ship/shore emergency shutdown systems have been recommended by SIGGTO since the early days of LNG transportation. The ship and terminal emergency systems are linked via a ship-shore umbilical that carries ESD, telecommunications and data signals.

1.12.2 Explains methods of connection between ship and shore and differing requirements for each type for:

- **Electrical connection**
- **Pneumatic connection**
- **Optical connection**

Electrical connection: Miyaki Denki Electric Link Connector

These connectors are manufactured by Miyaki Denki, Kameoka, Japan. In 2003, the connectors were redesigned to achieve ATEX Compliant CENELEC Eex 'd' certification and the current designation is 21-EC-PT. The receptacle incorporates a switch to prevent plug insertion or removal with the receptacle 'live'. Any new projects adopting the system should follow the pin arrangement shown the table, which is compatible with the terminals in Korea and Qatar where use of the system has survived. Under this standard, only two connectors are necessary – one for ESD-1, one for telephones.

It is recommended by SIGTTO that existing terminals using this link, should arrange for passing ESD-1 signals in both directions (not just in the shore → ship direction) so that the appropriate valves close on the shore side. Appended diagrams in part "D" are self-explanatory for methods of connections.

Pneumatic connection:

In the majority of terminals, pneumatic links are only now provided as a backup in the event of failure of the main optical fibre or electrical link. A typical system is shown in a figure appended in Part D Operating pressures vary between two and seven bar, the air being supplied from shore at some installations and from the ship at others. The normal set point should be about 80% of the supply pressure to ensure rapid tripping; commonly used is 2.7 barg supply pressure and 2.4 barg tripping pressure. Appended diagrams in part "D" are self-explanatory for methods of connections

Optical connection: Optic Link Connector

The standard configuration of the optical fibre ink is as shown in the tables. The diagram shows the allocation of fibres for the connector. A test plug is usually provided that has internal loops to return the ship-to-shore signals back to the relevant receiver. It is used in conjunction with the test button to prove the circuits, including the cables to each shipside or jetty connector. The test plug must not be left permanently connected. Appended diagrams in part "D" are self-explanatory for methods of connections.

Electrical connection Electric Ship/Shore Link Systems

The first intrinsically-safe electric ship/shore link was installed at the LNG stern loading berth at Lumut, Brunei, in 1972. This unique system provided both ESD-1 and ESD-2 as well as telephone signals. It was later replaced by a fibre-optic link when the original berth was replaced by a conventional loading berth.

Pneumatic connection: Pneumatic ESD Link System

The earliest ship/shore links used in LNG projects were simple pneumatic umbilical links, an air hose coupled directly into the ship's air security system. Such systems are inherently slow in operation, suffer from problems caused by dirt or moisture and it is difficult, if not impossible, to achieve accurate and repeatable timing. The designer must be aware that the diameter of the pipework and dump valve can significantly influence the closing time.

These drawbacks have led to the development of electronic ESD systems with fibre optic or various intrinsically-safe electric systems providing the ship/shore link.

However, despite its disadvantages, having a pneumatic link is better than having no ESD link at all.
Optical connection

The first optical fiber link system was developed by Sumitomo in association with Furukawa, and came into commercial use at Japanese LNG terminals in time for the start-up of the Australian North West Shelf project in 1989. A compatible system was later developed by SeaTechnik, initially to supply markets outside Japan.

The system uses a 6-core fiber-optic cable; two used for an ESD-1 signal in each direction; two cores used with a multiplexer to provide four data channels; two cores spare. One of the data channels is normally reserved for mooring load monitoring and the other three for telephones.

Compatible fiber-optic systems are used in Japan, Korea, Malaysia, Indonesia, Australia, India, Middle East, Africa, UK and the US. Until 2009, about 90% of all LNG carriers and 65% of all LNG terminals had links based on this system. Details are provided in Appendix I.

1.12.2(a) Discuss pre cargo commencement test connection procedures.

The IGC Code requires that cargo emergency shutdown and alarms systems involved in cargo transfer should be tested and checked before cargo handling operations begin.

The aim of this testing is to establish that the ESD valves will be closed automatically on ESD initiation within the required 30 seconds. It is not usually necessary to check each and every input to the system before every cargo transfer. It is, however, recommended that all inputs and outputs are tested over time to an appropriate schedule. The testing should not itself compromise the integrity of the system.

Certain designs of ESD valves do not have a positive connection between the actuator and the valve and it is possible for the valve to remain open while the actuator is in the 'shut' position. If valves of this type are fitted it is essential that a test procedure is developed to ensure that the valve provides a positive shut-off.
It is recognised that it is not practical to test certain sensors while the ship is in service. However, loops should be checked by appropriate simulation methods, such as disconnecting the sensor and observing that an ESD is initiated by the open circuit condition. The system should be fully reinstated after any such checks. On systems where the high level alarm is combined with a float level gauge, it may be possible to lift the float switch by manually raising the level gauge.

It is not uncommon for fibre-optic links to suffer from signal attenuation problems as a result of small impurities/particles such as salt etc. getting lodged in the connectors, resulting in an unreliable link. As part of the routine testing prior to arrival, the cleaning of these connectors as per manufacturer's guidelines should be considered 'best practice'.

Fibre-optic systems are usually provided with a dummy plug, or simulator, to enable testing of the optical circuits before arrival. Similarly, a test plug is provided with the SIGTTO link for pre-arrival testing of the hazardous area side of the electrical circuit. This procedure should be carried for both the ship and shore equipment.
Pre-arrival checks should include physical inspection of the ship/shore electric or fiber-optic cables and/or pneumatic hoses."

1.12.2(b) Discuss operating parameters that will activate ESD.

"The control system for all required emergency shutdown valves should be so arranged that all such valves may be operated by single controls situated in at least two remote locations on the ship. One of these locations should be the control position required by cargo control room or locations stated by the IGC code.

- The control system should also be provided with fusible elements designed to melt at temperatures between 98ºC and 104ºC, which will cause the emergency shutdown valves to close in the event of fire. Locations for such fusible elements should include the tank domes and loading stations.
- Emergency shutdown valves should be of the fail-closed (closed on loss of power) type and be capable of local manual closing operation.
- Emergency shutdown valves in liquid piping should fully close under all service conditions within 30 seconds of actuation. Information about the closing time of the valves and their operating characteristics should be available on board and the closing time should be verifiable and reproducible. Such valves should close smoothly."

1.12.2(c) Discuss effect of ESD operations

Equipment to be stopped by the ESD system

- Cargo pumps and compressors should be arranged to shutdown automatically if the emergency shutdown valves are closed by the emergency shutdown system required"

If the ESD valves described above are activated, the flow of cargo must also be stopped by tripping all cargo pumps and compressors in operation. During cargo transfer in port this means the ESD valves close and any cargo pumps or compressors are also stopped if they are transferring cargo between ship and shore or within the ship (e.g. re-liquefaction).

At sea, ESD activation again closes the ESD valves and stops the internal flow of cargo within the ship (e.g. re-liquefaction, cargo re-heating, cargo mixing etc.).

Note: for some 'low pressure' ships, the only valves aboard that close on ESD are at the manifolds, so the only result of activating an ESD at sea may be that the cargo pumps and compressors stop because the manifold valves are closed already. The reference to 'cargo pumps' includes all pumps that transfer liquid cargo, including 'primary pumps' (for example, deepwell pumps and submerged pumps), 'spray pumps', 'booster pumps', etc. Likewise the reference to (cargo) 'compressors' includes all machines transferring cargo vapour," equipment (heaters, compressors,

filters, etc.) for making up the gas for its use as fuel and related storage tanks should be located in the cargo area in accordance with IGC code

- If the equipment is in an enclosed space, the space should be ventilated according to the Code and be equipped with a fire-extinguishing system and with a gas detection system, as applicable.
- The compressors should be capable of being remotely stopped from a position which is always and easily accessible, and also from the engine-room.
- In addition, the compressors should be capable of automatically stopping when the suction pressure reaches a certain value depending on the set pressure of the vacuum relief valves of the cargo tanks. The automatic shutdown device of the compressors should have a manual resetting.
- Volumetric compressors should be fitted with pressure relief valves discharging into the suction line of the compressor. The size of the pressure relief valves should be determined in such a way that, with the delivery valve kept closed, the maximum pressure does not exceed by more than 10% the maximum working pressure.

1.12.2(d) Explains ESD system closure time and any effect this may have on the maximum loading rate.

The closing time of the valve referred to in the IGC code (i.e. time from shutdown signal to complete valve closure) should not be greater than: 3600 × U ÷ LR [secs], where U = ullage volume at operating signal level [m^3] LR = maximum loading rate agreed between ship and shore facility [m^3/h]

The loading rate should be adjusted to limit surge pressure on valve closure to an acceptable level taking into account the loading hose or arm, the ship and the shore piping systems where relevant. This time will prevent excessive surge pressure and prevent damage to valves, piping and equipment. It will also prevent pollution."

1.13 Custody transfer system

1.13.1 Explains the function of a custody transfer system

(1) The CTM is a system which allows the quantity of cargo on board at any time to be accurately calculated and therefore provide a means by which the amount of cargo that is transferred either internally or between the ships and shore to be accurately quantified. Such a system can be used on LNG carriers because the cargo is always same whereas on other type of vessels such as oil or LPG, large differences can occur between the cargoes carried on each voyage."

(2) There are two primary types of measuring system used currently on LNG carriers:

i) Based on capacitance measuring system
ii) Based on radar gauging system

(3) The verification and accuracy check of custody transfer measurement system is conducted at each dry dock.

1.13.2 Explains the function of a custody transfer system

Most LNG vessels are fitted with a "custody transfer system". This is an integrated system of cargo instrumentation that allows cargoes to be bought and sold by heat value in BTU (British Thermal Units) or Kilo/cal. To determine the amount of energy transferred, accurate volume, density and composition measurements must be made by the system and the information returned to a data logger and computer for recording and calculation.

2.0 Knowledge of pump theory and characteristics, including types of cargo pumps and their safe operation.

2.1 Explains centrifugal pumps

2.1.1 Describes the operating principle of a centrifugal pump

An impeller, which is inside a casing, physically moves the liquid by means of a throwing movement which is similar to the expelling of water from the bicycle tire when cycling in wet weather. The liquid is sucked into the casing via a discharge valve. The pump provides a continuous flow of liquid and it is powered by a motor, on the tank dome. Liquefied gas tankers pumps will have a long shaft with the bearings cooled by the cargo itself. Centrifugal pumps move large volumes of liquid at a relatively low pressure and consequently are generally used as main cargo pumps

2.1.2 Explains how actual drawbacks of a centrifugal pump are overcome

Cavitation is a problem condition which may develop while a centrifugal pump is operating. This occurs when a liquid boils inside the pump due to insufficient suction head pressure. Low suction head causes a pressure below that of vaporisation of the liquid, at the eye of the impeller.

The resultant gas which forms causes the formation and collapse of 'bubbles' within the liquid. This, because gases cannot be pumped together with the liquid, causes violent fluctuations of pressure within the pump casing and is seen on the discharge gauge. These sudden changes in pressure cause vibrations which can result in serious damage to the pump and, cause pumping inefficiency.
To overcome cavitation:

- Increase suction pressure if possible.
- Decrease liquid temperature if possible.
- Throttle back on the discharge valve to decrease flow-rate.
- Vent gases off the pump casing

2.2 Explains performance of centrifugal pumps

2.2.1 Explains pump curves

2.2.1(a) Explains "Total head"

The total head of a pump is the difference between the pump suction and discharge pressures - expressed in terms of metres or feet head:

2.2.1(b) Explains the benefits of showing the pump's capacity as a function of the total head

The term "suction head" is normally used when the pump's suction supply is above the pump's centerline, and the suction pressure therefore is greater than the atmospheric pressure. The suction head is the static head on the pump suction line above the pump centerline minus the loss of energy within the pump and its suction pipe, expressed in head. The pumps capacity is defined as the quantity of liquid which is discharged from the pump in a given time. Capacity is expressed in 'm3/hr mlc.', 'gal/min', etc. The capacity of a pump is governed by the 'Head', the 'Speed' and the 'Size' of the pump. Capacity of a centrifugal pump is independent of the cargo density

2.2.1(c) Explains "design point"

"Design Point or BEP (best efficiency point)

BEP (best efficiency point) is located somewhere between 80% and 85% of the shut off or maximum head. To maximize the life of the pump you should operate the pump as close to the BEP as you can

2.2.1(d) Explains "NPSH"

The difference between the maximum theoretical suction lift and the pumps permissible suction lift is the pump's net positive suction head above the liquid vapour pressure, abbreviated as NPSH. It is important to state the difference between available NPSH and required NPSH.

2.2.1(e) Explains the above-mentioned curves in the graph and their relationship

"The Q-H curve shows that the maximum head is about 130 metres liquid column (mlc), where the output is of course zero. On the curve is shown the so-called design point, at a head of 100 mlc, giving an output of 115 m3/h; this point represents the most economical working condition of the pump. The curve of efficiency also shows this, giving a maximum efficiency of 51 %.

At the bottom is a curve for NPSH (Net Positive Suction Head). The curve refers to the suction side of the pump and can best be explained as the absolute pressure on the suction side that is necessary to keep the pump full of liquid if the vapour pressure of the liquid were zero. To keep the pump working correctly, the pressure

on the suction side has to be greater than NPSH + VP to keep the pump from cavitating. Note that the greater the discharge rate, the greater the NPSH
In the case of a variable speed pump:

- Head varies as the square of the speed.
- Capacity varies directly as the speed.

Power varies as the cube of the speed since it is a function of head and capacity

2.2.1(f) Explains how the following factors influence the pump's suction condition

- **the pump's NPSH**
- **the pressure in the cargo-tank**
- **the liquid level**
- **the cargo's vapour pressure**

P+H+h>NPSH+LF+TVP NORMAL PUMPING
P+H+h=NPSH+LF+TVP CAVITATION BEGINS
P+H+h<NPSH+LF+TVP PUMPING STOPS

P= cargo tank Pressure
h=Trim
H= Height of liquid
LF= line frictional losses

- the pump's NPSH- Increasing or decreasing the pumps revolutions will correspondingly alter the Net positive Suction head.

- the pressure in the cargo-tank-. If the pressure in the tank is more that the discharge side pressure, the suction head increases correspondingly the flow rate will increase,

- the liquid level -

IF THE LIQUID LEVEL IS ABOVE THE PUMP CENTRELINE, THE SUCTION HEAD IS POSITIVE.

IF BELOW THE CENTRELINE, THE SUCTION HEAD IS NEGATIVE.

During stripping, the practical approach is to increase the level, by a trim change to increase the suction head

- the cargo's vapour pressure- Appreciation of NPSH when pumping liquefied gas is important because the liquid pumped is always at its boiling point. If level reduces the suction side may start cavitating earlier because of the high true vapour pressure of the cargo.

2.2.1(g) Explains the effects of running two or more pumps in parallel

Some types of centrifugal pumps are not fitted with a non-return valve. If running two or more pumps in parallel if their characteristics are not exactly the same or if the pumps are running at different speeds, the higher flow rate will create a back

pressure on the lower flow rate pump which will result in the back flow of cargo and result in filling up that tank.

Three pumps are connected in parallel
Sometimes when three pumps run in parallel, the third pump may not make any difference.
You will see that the third pump (C) is intersecting the system curve at just about the same point as the second pump (B).
All of this means that the capacity of three pumps running will not be greater than that of two pumps

2.2.1(h) Explains how a combined pump characteristic is constructed when running pumps in series at the same suction and discharge condition

When pumps are run in series, the individual characteristic curves can be combined to give the appropriate curve for the series configuration. Figure in Part D shows how this can be done using, in this example, two pumps in series. This time, for each quantity of flow rate, the appropriate head developed by the pump is doubled to give the head developed by two pumps in series.

2.2.2 Describe the effect of cavitation

Cavitation is a problem condition which may develop while a centrifugal pump is operating. This occurs when a liquid boils inside the pump due to insufficient suction head pressure. Low suction head causes a pressure below that of vaporisation of the liquid, at the eye of the impeller. If cavitation is allowed to occur with a deepwell pump, not only will it damage the pump impeller but also the shaft bearings will be starved of cargo for lubrication, causing bearing damage.

2.3 Describe the operation of centrifugal pumps

2.3.1 Explains "static back-pressure"

The static or pressure heads remain constant in most systems. It is the friction head that varies with the pump's capacity.

2.3.1(a) Explains "dynamic back-pressure"

The higher the flow, the more friction or head loss will be in these components. Friction loss varies by approximately the square of the resistance. Twice as much flow produces almost four times the friction losses

2.3.1(b) Explains the factors influencing dynamic back-pressure

The factors influencing dynamic back-pressure in a ship to shore pumping system are:
(a) Back pressure from starting another pump in parallel leading to a back pressure to the previously started pumping
(b) Starting a booster pump
(c) Shore tank change

(d) A Valve operation
(e) Leakage

2.3.1(c) Derives the discharge rate of the pump, using a Q -H curve and a system head curve

Using figure 2(j) as per appendix 1

This shows the capacity of the pump as a function of the head developed by the pump. Capacity is given in terms of volumetric flow rate (Q = quantity), normally stated in m^3/hr (Q). Head (H) developed by the pump is stated as `metres liquid column' (abbreviated to mlc). Adopting the parameters of volumetric flow rate and Head means that the capacity/head curve is the same for any fluid, whether it is LPG, NH VCM etc.

Taking the capacity curve shown in Figure 2(j), this pump will deliver 100 m^3/ hr with a head of 115 mlc across the pump.

To convert this head into a differential pressure reading in bars, the specific gravity of the fluid being pumped must be known. For example, at a differential head of 115 mlc for this pump, the differential pressure across the pump, pumping ammonia at minus 33°C (SG approx. 0.68), would be approximately 8 kg/cm^2. (i.e. [115x0.68]/10)

2.3.1(d) Describes correct operations of spray pumps

Spray pump is of limited capacity, typically around 50m^3/hr, and will be used for the following:

a) To cool down the liquid header prior to discharging.
b) To cool the cargo tank during a ballast voyage prior to arrival at the loading terminal by discharging LNG to the spray nozzles in the tanks.
c) In exceptional circumstances, to pump LNG from the tanks to the vapourisers when forced vaporization of LNG to the boilers is required.
d) To enable the tanks to be stripped as dry as possible for reasons such as tank entry.
e) In the case of total cargo pump failure, provision is made for Moss ships to discharge under pressure. If the ship has to warm-up tanks for technical reasons, the stripping/spray pumps will be used to unload the remaining cargo on completion of the bulk discharge with the main cargo pumps

2.3.1(e) Describes correct and safe operation of a booster pump

Booster pumps are centrifugal pumps and will be of the following types:

- Vertical in-line pumps, deck mounted in the appropriate unloading line and driven by an "increased safety" electric motor

- Horizontal pumps installed in deck or in the cargo compressor room, driven through a gastight bulkhead by an electric motor installed in the electric motor room.

Booster pumps are used to discharge the ship in the following circumstances:

- Where there is a high back pressure from the shore, such as when discharging into pressurised tanks ashore
- When using the cargo heater.

Booster pumps should be circulated with cargo from the main cargo pumps and should not be started until there is sufficient cargo liquid to prevent cavitation.
Positive suction pressure needs to be always maintained.
At completion of discharge the booster pump must always be stopped before the pump drawing from the tank.

Booster pump seals should be properly charged with oil and pressurised with Nitrogen to prevent leakage.

2.3.2 Describes methods of automatic control and protection of cargo pumps

For the safety of gas tankers, and to protect the cargo pumps, the pump is provided with cut outs such as low current trip (low or no suction) and over current trip (excess flow) An ammeter is provided for monitoring the current.

The power consumption is proportional to density and flow. If the flow is reduced, caused by cavitations or an empty tank, the power consumption is reduced. This is detected by a contact ammeter which gives a signal to the pump's main circuit switch, at which the pump stops.

Pumping system may also be equipped with— a differential pressure gauge and/or flow switch.
The differential pressure gauge stops the pump when the differential pressure between the cargo tank and discharge pressure reaches the set point. The flow switch (if provided) can also stop the pump in "no flow" conditions.

2.3.3 Describes correct and safe handling of submersible and deepwell pumps

For submersible pumps the following precautions should be observed;

a. Cables should be checked for insulation resistance before the pump is started;

b. Heaters should be used when tanks are gas-freed to prevent condensation; in some cases heat is provided by applying low voltage to two of the three supply phases and care is necessary to prevent all three being connected, especially if interlocks are not fitted, otherwise the pump will rotate at high speed with no lubrication;

c. When reassembling pumps the discharge piping should be prevented from imposing stresses on the pump casing, fixing devices and cables should be carefully locked in position

d. Bearings are lubricated by the cargo and lubricating passages should be kept clear; filters (whether integral or separate) should be cleaned regularly;

e. Cable connections at the pump should be assembled using new compression washers and pressure or vacuum tested if possible; they are designed to prevent ammonia attacking copper conductors;

f. Stainless steel sheathed cables should be checked for external defects (e.g. cracks, chafing) and should not be kinked; sharp bends should be avoided (see manufacturers' instructions) before the tank is closed down the pump should be turned by hand to ensure freedom of rotation.

Deepwell pumps

Deepwell pumps should be rotated by hand to ensure they are free before start-up and methanol dosing undertaken after obtaining permission from charterers and only where necessary. Particular attention is drawn to the following points:

(a) Before starting pumps care should be taken to ensure they are free, if possible by turning manually;
(b) Pumps should be started with discharge valves shut or slightly open (according to manufacturers' instructions) to reduce pressure surge and motor current;
(c) If protection equipment is not operational or not fitted, care should be taken to ensure that pumps are not allowed to cavitate as lubrication would be lost and damage could occur,
(d) Flame — proof electric motors may only be drip-proof and it may be necessary to fit waterproof covers when not in use;
(e) Heaters if fitted should be used to maintain insulation resistance when the pump is not in service;
(f) Thrust bearings are susceptible to indentation (or "brine ling") when stopped and subject to shipboard vibration because of the heavy weight they have to support: when not in use the pump shaft should be rotated at frequent intervals to vary the bearing surfaces,
(g) If permissible and necessary an antifreeze should be injected before LPG duty to prevent freezing of any water collected in bearings, shaft sleeves, impellers etc.; freezing could cause pumps to seize and motors to burn out;
(h) When pumps have been overhauled care should be taken to ensure that sufficient clearance has been left between the bell mouth and the tank bottom to provide adequate cargo flow and to prevent mechanical interference when cooled down; end — steady devices should be correctly positioned to prevent movement from tensional reaction and all fittings in the tank should be locked in position (e.g. with split pins, wires, lock washers),
(i) Shaft intermediate bearings are lubricated by the cargo and passages in the bearing housing should be kept clear;

(j) Liquid seals at the upper end of the pump discharge tube should be kept in good condition to prevent cargo leakage and leakage of the pressurize liquid into the cargo;
(k) Great care should be taken to ensure that local start stop switches are properly maintained.

3. Knowledge of the effect of bulk liquid cargoes on trim and stability and structural integrity

3.1 Explains generally the effect of free surfaces in cargo tanks and ballast tanks

During loading and discharging operations the ship should at all times be stable and in good trim to allow for an emergency departing if necessary.

Some liquefied gas tankers have to undertake ballasting and deballasting during cargo operations to maintain an adequately stable condition.

The necessity of ballast operations depends upon the ship's design, cargo quantity, port conditions and ballast tanks.

The distribution of cargo and ballast should at no time create excessive stress on the ship's hull.

When a vessel with a partly full tank inclines, the liquid in the tank would move towards the lower side, thereby increasing the inclination. Because the vessel behaves as if her metacentric height has been reduced it can be said that a partly filled tank causes virtual loss of metacentric height. This is called Free Surface effect.

On board a liquefied gas tanker it is essential to ensure that partly filled ballast tanks are minimised as far as possible, so as to avoid the loss of meta-centric height due to free surface effect Measurement to ensure adequate stability of the vessel are

- correct use of centerline bulkhead valves
- correct water and bunker distribution
- correct ballast distribution

3.1(a) Explains measures to ensure adequate stability of the vessel as:

- **Correct use of valves in the centre line bulkhead**
- **Correct distribution of water and bunkers**
- **Correct distribution of ballast**

Correct use of valves in the centre line bulkhead-The vessels listing may be reduced if the centerline bulkhead valves are left open to manage an equal balance of loading on port and starboard sides, correspondingly if a list has been observed due to operational reasons, the list can be controlled by shutting down the bulkhead valves when independent sides need to be loaded/unloaded.

Correct distribution of water and bunkers: To ensure an adequate trim and list condition will depend on the distribution of the bunker and fresh water tanks location, this can be adjusted by transfer/consumption needs.

Correct distribution of ballast- Being independent ballast water tanks, they need to be filled/discharged dependent on the residual stability and the free surface effect of that vessels loaded condition. It needs to be monitored and operations correspondingly planned and executed.
In every condition of loading and discharging the vessels stability will be closely monitored at all times and the vessel has to be in sea going condition of stability in all the stages of Loading or unloading.

The worst situation is with all ballast tanks and cargo tanks partly filled – a situation that could easily be had during loading and discharging.

"U" shaped ballast tanks have large free surface effect when the level is below DB level.

3.2 Explains damage stability and progressive flooding

"Progressive flooding is the flooding of compartments situated outside of the assumed extent of damage. Progressive flooding may extend to compartments, other than those assumed flooded, through down flooding points (i.e. unprotected and Weathertight openings), pipes, ducts, tunnels, etc.

The flooding of compartment(s) due to progressive flooding occurring in a predictable and sequential manner through a down flooding point which is submerged below the damage waterline may be permitted provided all intermediate stages and the final stage of flooding meet the required stability criteria.

Minor progressive flooding through the pipes situated within the assumed extent of damage may be permitted by the Administration, provided the pipes penetrating a watertight subdivision have a total cross-sectional area of not more than 710 mm2 between any two watertight compartments.

If the opening (unprotected or fitted with a Weathertight means of closure) connects two spaces, this opening should not be taken into account if the two connected spaces are flooded or none of these spaces are flooded. If the opening is connected to the outside, it should not be taken into account only if the connected compartment is flooded."

3.2(a) Explains standard damage conditions

Assumed maximum extent of damage:

(a) ***Side damage:***

(i) Longitudinal extent:	$\frac{1}{3}L^{\frac{2}{3}}$ or 14.5 m whichever is less.
(ii) Transverse extent: (inboard from the ship's side at right angles to the centre line at the level of the summer load line)	$\frac{B}{5}$ or 11.5 m whichever is less.
(iii) Vertical extent:	from the base line upwards without limit.

(b) ***Bottom damage:***

	For 0.3L from the forward perpendicular of the ship	Any other part of the ship.
(i) Longitudinal extent:	$\frac{1}{3}L^{\frac{2}{3}}$ or 14.5 m whichever is less.	$\frac{L}{10}$ or 5 m whichever is less.
(ii) Transverse extent:	$\frac{B}{6}$ or 10.0 m whichever is less.	$\frac{B}{6}$ or 5 m whichever is less.
(iii) Vertical extent:	$\frac{B}{15}$ or 2 m whichever is less, measured from the moulded line of the shell at the centre line.	$\frac{B}{15}$ or 2 m whichever is less, measured from the moulded line of the shell at the centre line.

3.2(b) Explains with the aid of a diagram maximum extent of longitudinal damage.

Please refer to the appended diagram in Part D

3.2(c) Explains maximum extent of transverse damage

The transverse extent of damage should be measured to the longitudinal bulkhead when membrane or semi-membrane tanks are used, otherwise to the side of the cargo tanks. (For internal insulation tanks the extent of damage should be measured to the supporting tank plating.

Tanks may protrude into the area of bottom damage provided that such wells are as small as practicable and the penetration does not exceed 25 per cent of double Bottom height or 350 mm whichever is less.

Cargo tanks should be located at the following minimum distances inboard:

(a) Type IG ships: from the side shell plating not less than the transverse extent of damage specified in IGC code and from the moulded line of the bottom shell plating at centre line not less than the vertical extent of damage specified in 2.3.2(b)(iii) and nowhere less than 760 mm from the shell plating.

(b) Types IIG/IIPG and IMG ships: from the moulded line of the bottom shell plating at centre line not less than the vertical extent of damage specified in the IGC code and nowhere less than 760 mm from the shell plating.

3.2(d) Explains maximum extent of vertical damage.

For the purpose of tank location, the vertical extent of damage should be measured to the inner bottom when membrane or semi-membrane tanks are used, otherwise to the bottom of the cargo tanks.

3.3 Explains the effect on trim and stability on cargo operations

To meet the ship's stability requirements, cargo loading and discharge must be conducted in the sequence detailed in the loading plan prepared for the voyage. Periodic checks must be performed during cargo transfer operations to confirm that the actual operation complies with the loading plan

4. Proficiency in tanker safety culture and implementation of safety management requirements

4.1 Describes the ISM Code

For the shipping industry, it is in the professionalism of seafarers that the safety culture must take root.

That culture is more than merely avoiding accidents or even reducing the number of accidents, although these are likely to be the most apparent measures of success. In terms of shipboard operations, it is to do the right thing at the right time in response to normal and emergency situations. The quality and effectiveness of that training will play a significant part in determining the attitude and performance - the professionalism - the seafarer will subsequently demonstrate in his, or her, work. And the attitude adopted will, in turn, be shaped to a large degree by the 'culture' of the shipping company.

The key to achieving that safety culture is in:

- recognizing that accidents on liquefied gas tankers are preventable through following correct procedures and established best practice;

- constantly thinking safety; and
- seeking continuous improvement.

It is relatively unusual for new types of accidents to occur on board liquefied gas tankers and many of those that continue to occur are due to unsafe acts by seafarers. These errors, or more often violations of good practice or established rules, can be readily avoided. Those who make them are often well aware of the errors of their ways. They may have taken short-cuts they should not have taken. Most will have received training aimed at preventing them but, through a culture that is tolerant to the 'calculated risk', they still occur.

The challenge for trainers and training, and managers ashore and afloat, is how to minimise these unsafe acts, how to instill not only the skills but also the attitudes necessary to ensure safety objectives are met. The aim should be to inspire seafarers towards firm and effective self-regulation and to encourage personal ownership of established best practice. Internationally recognised safety principles and the safeguards of best industry practice have to become an integral part of individuals' own standards.

This is in addition to the requirements of regulations which have now formed an integral part of a tanker operator's professional duty. We have today a requirement of the ISM code and the MLC convention which adds up to help install safety being a practice starting from the TOP management to sow the seeds of the safety culture within its organization."

4.2 Describes the TMSA

OCIMF has established a Tanker Management Self-Assessment (TMSA) program to evaluate the management systems of LNG ship managers. The charterers of LNG carriers may conduct audits to confirm the level of compliance with the TMSA Key Performance Indictors (KPI).

5. Proficiency to apply safe preparations, procedures and checklists for all cargo operations

The trainer should impress the importance that all cargo related operations are carried out strictly in compliance with checklists and procedures prescribed by terminals, administrations and vessel's safety management systems.

5.1 Post docking and loading:

5.1.1 Tank inspection

Prior man entry is made for tank inspection tanks are to be gas free and oxygen content to be 21%.

During inspection all tanks to be checked for tank cleanliness, any foreign objects, after dry-docking or any other repairs carried out must be removed. All pipelines

connections to be as per requirements with / without spool pieces , Pumps fitted securely, Pump sump clear, guides for float gauges (if used) in place etc.

5.1.2 Inerting (oxygen reduction, dew point reduction)

Inerting of the cargo system

Inerting of the cargo tanks and pipe work system is undertaken primarily to ensure a non- flammable condition in the subsequent gassing up with the vapour of the cargo to be loaded. For this purpose, a reduction in O2 concentration to five percent by volume is generally judged adequate although lower values are usually obtainable and preferred. For some of the more reactive chemical gases, however, such as VCM or butadiene, O2 levels as low as 0.1 per cent may be required to avoid chemical reaction with the incoming gassing-up vapour. Such low O2 levels can usually only be provided by a nitrogen inerting system.

There are two procedures which can be used for inerting cargo tanks: displacement or dilution.

Inerting by displacement
This relies on stratification in the cargo tank as a result of the difference in vapour densities between the gas entering the tanks and the gas already in the tank. The heavier gas is introduced beneath the lighter gas, and at a low velocity to minimize turbulence if perfect stratification could be achieved with no mixing at the interface then one tank volume of the incoming inert gas would completely displace the air. In practice some mixing does occur and it will be necessary to use more than one tank volume of inert gas. This may vary from 1½ to 4 times the tank volume, depending upon relative densities and tank and piping configurations. There is little density difference between air and inert gas; inert gas from a combustion generator is slightly heavier than air while nitrogen is slightly lighter. These small density differences make inerting by displacement alone very difficult to achieve and usually the process becomes partly displacement, partly dilution. Combustion generated inert gas is usually introduced through the liquid loading line with the air/inert gas being exhausted through the vapour line and into the vent header. Figure shows schematically the inerting of a cargo tank by the displacement method.

Theoretically, displacement is the most economic method but is only practical if the entry of inert gas is diffused and mixing with the initial contents can be largely avoided. If tank geometries and piping entries lend themselves to the displacement method, the practicability of the method will be improved by inerting more than one tank at a time in parallel. The sharing of the inert gas generator output between tanks will reduce gas inlet speeds and reduce the degree of mixing of tank contents. At the same time, the total inert gas flow resistance. Tanks being incited in parallel should be particularly carefully monitored to ensure a reasonably equal sharing of the inert gas flow.

Inerting by dilution

In the dilution method the incoming gas mixes with the gas already in the tank. The dilution method can be carried out in several different ways.

Dilution by repeated pressurization

In the case of Type C pressure vessel tanks, the dilution can be achieved by a process of repeated pressurization of the tank with inert gas using a cargo compressor and followed by release of the compressed contents to atmosphere. Each repetition will bring the tank contents nearer and nearer to the O2 concentration level of the injected inert gas. Thus, to bring the tank contents to a level of five percent O2 within a reasonable number of repetitions, an inert gas quality better than five per cent O2 is required. Quicker results will be achieved by more numerous repetitions each at lower pressurization levels than by fewer repetitions using the higher pressurization levels of which the tank and compressor may be capable.

5.1.3 Gassing – up

The purpose and procedure of the purging (or "gassing up") operation

Neither nitrogen nor CO2 the main constituents for inert gas, can be condensed by LPG ship's re-liquefaction plant because at cargo temperatures they are above their critical temperatures. Purging the inert gas out of the cargo tank with vapour of the cargo to be loaded is necessary so that the re-liquefaction plant can operate continuously and efficiently. Similarly, on change of cargo without any intervening inerting, it may be necessary to purge out the vapour of the previous cargo with vapour of the cargo to be loaded. The basic principles discussed previously in respect of inerting apply equally to purging. In purging, however, there is generally a greater density difference between the purging vapour and the inert gas or vapour to be purged than in the case of inerting from air.

Purging at sea using liquid from deck storage tanks

This method is normally available only to the larger fully, or semi-refrigerated vessel which is equipped with deck storage tanks. in this case, either vapour or liquid can be taken into the cargo tanks.

Liquid can be taken directly from deck storage through the tank sprays (with the exception of ammonia) at a carefully controlled rate to avoid cold liquid impinging on warm tank surfaces.

In this case mixing tends to predominate and the mixed cargo/inert gas mixture can be taken into other tanks or vented up the vent riser.

Alternatively, liquid from the deck storage tanks can be vaporized in the cargo vaporizer and the vapour introduced gradually into the top or bottom of the cargo tank, depending on its density, to displace the existing inert gas or vapour to other tanks or to the vent riser.

Only when the concentration of cargo vapour in the tanks has reached approximately 90 percent, or other such figure specified by the plant manufacturer, should the re-liquefaction plant be started and cool down of the system begin.

Purging alongside

The "gassing operation may also be undertaken using cargo supplied from shore. At certain terminals facilities exist to allow the operation to be carried out alongside but these tend to be the exception as venting of hydrocarbon vapours alongside may present a hazard and is the prohibited by most terminals and port authorities.
Thus, before a vessel arrives alongside with tanks incited, the following points must be considered.

1 Is venting allowed alongside? If so, what is permissible?
2 Is a vapour return facility available?
3 Is liquid or is vapour provided for purging?
4. Will only one tank be purged and cooled down initially from the shore? How much liquid must be taken on board to purge and cool down the remaining tanks?

Before commencing purging operations alongside, the terminal will normally require sampling the tank atmosphere to check that the oxygen is less than five per cent for LPG cargoes (some terminals require as low as two per cent) or the much lower concentrations required for chemical gases such as VCM.

Where venting to atmosphere is permitted, a vapour return facility must be provided and used throughout the purging operation. Either the ship's cargo compressors or a jetty vapour blower can be used to handle the efflux. Some terminals, while prohibiting the venting of cargo vapours, permit the efflux to atmosphere of inert gas. Thus, if a displacement method of purging is used, the need for the vapour return flow to shore may be postponed until cargo vapours are detected in the most vented efflux. This point may be considerably postponed if tanks are purged in series.

Where a terminal supplies a cargo liquid for purging, it should be taken aboard at a carefully controlled rate and passed through the ship's vaporizer or allowed to vaporize in the tank(s). If the supply is of vapour, this can be introduced into the tank(s) at the top or bottom depending on the vapour density. Figures respectively show schematically typical purging operations using liquid from shore and vapour from shore.

Where a vessel arrives alongside with its tanks containing a cargo vapour which requires to be replaced with the vapour of a different cargo to be loaded, then the terminal will normally provide a vapour return line. The vapours taken ashore will be flared until the desired vapour quality is achieved, at which point cool down can begin.
If no facilities (return line etc.) are available for the ship to purge alongside, it is common practice for the ship to prepare one cargo tank and to take sufficient liquid on board so that the vessel can leave the berth, purge and cool down the remaining cargo tanks using this liquid and then return ready for loading.

5.1.4 Cooling down

5.1.4(a) Explains the purpose and procedure of the cooling-down operation

The purpose and procedure of the cooling down operation

Before loading a refrigerated cargo, the tanks must be adequately cooled down in order to minimize thermal stresses and excessive tank pressures during loading. Cool down consists of introducing cargo liquid into a tank at a low ad carefully controlled rate. The lower the cargo carriage temperature, the more important the cool down procedure becomes. The rates at which cargo tanks can be cooled without creating undue thermal stresses depend on the design of the containment system and are typically 10^0C per hour. Reference should always be made to the ship operating manual to determine maximum allowable cool down rates.

The procedure is for cargo liquid from shore or from deck storage to be gradually introduced into the tanks either through spray lines, if fitted for this purpose, or via the cargo loading lines. The vapours produced by the rapid evaporation of this liquid may be taken ashore or handled in the ship's re-liquefaction plant. Additional liquid 'is introduced at a controlled rate depending upon the tank pressures and temperatures resulting. If the vapour is being handled in the ship's re-liquefaction plant, difficulties may be experienced with the "incondensable" remaining from the inert gas. A close watch should be kept on compressor' discharge temperatures incondensable gases vented from the top of the re-liquefaction condenser as required.

As the cargo containment system cools down the thermal contraction of the tank and drop in temperature around it, together tend to cause a pressure drop in the void spaces. Normally pressure control system supplying air or inert gas will maintain these pressures but a watch should be kept on them as the cool down proceeds.

Cool down should continue until liquid begins to form in the bottom of the cargo tanks. This can be seen from the temperature sensors. At this stage, in the case of cool down of cargo tanks for fully refrigerated ammonia for example, the pool of liquid formed will be at approximately - 34°C while the top of the tank may still be at about l4°C, i.e. a temperature gradient of approximately 20°C on cool down. The actual temperature gradient depends on the size of the cargo tanks, position of sprays, etc.

Many of the difficulties that occur during the cool down operation result from inadequate purging of inert gas or from inadequate drying. In this later case, ice or hydrates may form and ice-up valves, pump shafts, etc. Methanol can be added as antifreeze provided the cargo is not put off quality specification or the addition will not damage the insulation of a submerged cargo pump.

Once the cargo tanks have been cooled down, cargo pipework and equipment not already cooled can be cooled down.

5.1.5 Loading

5.1.5(a) Lists information to be made available by the vessel in the case of loading and/or discharging

Many terminals have specific questionnaires which must be answered by every liquefied gas tanker prior arrival.

Pre-arrival information to terminal generally includes arrival particulars including draft, displacement, ETA etc.

Vessel's particulars

Details of cargo handling capacity

Manifold details including type, size, configuration (liquid/ vapour), number, distance between center
Products to be handled at each manifold

Maximum draft/ freeboard expected while alongside

Any limitations

5.1.5(b) Lists generally the subjects to be discussed pre-cargo transfer meeting

(1) Quantity and grade of each last five cargo (quantity & grade) loaded onboard on the last five previous voyages.

(2) Density, temperature and other relevant conditions, including the reference temperature which determines the filling limits;
(3) A plan of the distribution, quantities, ullages, lines and pumps to be used;
(4) Transfer rates and maximum allowable pressures;
(5) Valve check list
(6) Critical stages of the operation;
(7) Notice of rate change;
(8) Stability and stress information;
(9) Drafts and trims;
(10) Emergency stop procedures;
(11) Action to be taken in the event of a spill;
(12) Flammability and toxicity with references to cargo data sheets;
(13) Ballast operations;
(14) Protective equipment requirements;
(15) Hazards of the particular cargoes.
(16) And, as required, requirements for:
(17) Cargo pollution category;
(18) Cooling requirements including rates of cool-down;
(19) Use of the cargo heater or vaporizer;
(20) Heel requirements after unloading;
(21) Under keel clearance limitations;

(22) Bunkering; and
(23) Special precautions required for the particular operation.

5.1.5(c) Describes generally the checklist and explains the reasons for and the relevancy of the items to check

Discuss the Ship /Shore Safety Check List, by its questions and requirements for exchange of written agreements for certain procedures, is a minimum basis for the essential considerations which should be included in such a mutual examination.

Some of the check list questions are directed to considerations for which the ship has prime responsibility; others apply to both ship and terminal. It is not suggested that every item should be the subject of personal checking by both representatives conducting the examination.

All items lying within the responsibility of the tanker should be personally checked by the tanker's representative and similarly all items of the terminal's responsibility personally checked by the terminal representative. In carrying out their full responsibilities however, both representatives, by questioning the other, by sighting of records and, where felt appropriate, by joint visual inspection should assure themselves that the standards of safety on both sides of the operation are fully acceptable.

The joint declaration should not be signed until such mutual assurance is achieved. Thus all applicable questions should result in an affirmative mark in the boxes provided. If a difference of opinion arises on the adequacy of any arrangements made or conditions found, the operation should not be started until measures taken are jointly accepted.

A negative answer to the questions coded 'P' does not necessarily mean that the intended operation cannot be carried out. In such cases, however, permission to proceed should be obtained from the Port Authority.

Items coded 'R' should be rechecked at intervals not exceeding that agreed in the declaration.

Where an item is agreed to be not applicable to the ship, to the terminal or to the operation envisaged, a note to that effect should be entered in the 'Remarks' column.

5.1.5(d) Lists the safety precautions and procedures for personnel on watch prior to and during cargo-transfer operations

During loading, cargo is transferred from shore through the appropriate midships or stern manifolds, and led into the cargo tanks via the filling lines, which usually terminate close to the tank bottoms. If the tank has not been cooled down it is normal to by-pass some of the incoming liquid through the tank sprays, if fitted, to reduce the temperature gradient from tank top to bottom, and to even out the rate of boil-off. The loading rate is determined by the rate of change of the tank pressure.

As the liquid level in the tank rises, the tank pressure is increased by:

- Vapour pressure of the 'warm' cargo;
- Vapour displaced by the incoming liquid (It's not the displacement of vapour which creates tank pressure rising but the decrease of volume allowed for vapour.);
- Vapour generated by heat transfer through the tank walls to the liquid; and
- Vapour generated by heat transfer from the ship and shore pipelines and the shore pumps.

On fully or semi-pressurised ships the vapour pressure increase during loading can be reduced by spray loading, provided the cargo temperature will give a saturation pressure safely below the relief valve set pressure. With fully or semi-pressurised tanks, the boil-off and displaced vapour is either returned to shore or condensed by the ship's re-liquefaction plant. Venting during loading must be avoided. In the case of LNG the boil-off cannot normally be condensed and the ship will be dependent on full vapour return to shore.

The responsible officer should ensure that the following precautions are observed

- In the event of an emergency, the emergency shutdown procedures should be implemented.
- A fixed gas detection equipment should be operated throughout all loading operations.
- During the early stages of loading, the incoming liquid may be relatively warm and generate quantities of vapour in excess of capacity of the re-liquefaction plant or vapour return line. The tank pressure should be regularly observed during loading and the loading rate reduced in good time before approaching safety valve set pressures.

If reducing the loading rate does not reduce the pressure rise, loading should cease immediately, and the terminal should be notified to enable proper steps to be taken in the event of hazard lo the adjacent shore areas.

If venting occurs it will cause self-refrigeration, thus reducing the cargo temperature and pressure.

Filling of the cargo tanks may cause a significant loss of pressure in the hold or inter-barrier spaces, depending upon the cargo system design. This should be continuously monitored and pressure maintained by the addition of supplementary inert gas, dry air or dry nitrogen.

5.1.5(e) Explains Loading with vapour return and without vapour return to shore.

Prior to arrival alongside, the vessel's loading lines on a refrigerated Gas carrier should be cooled down by refrigeration. Usually the vessel will have reduced her ballast to the extent that safe handling of the vessel will admit.

At sea, to avoid damage, the tank liquid level-indicating floats are raised and secured at the top of the tank. Also, certain pressure gauges in exposed positions, notably on the vapour and liquid cargo manifold are shipped and stowed away. On arrival alongside the loading berth, these pressure gauges are shipped in position, and the

liquid level-indicating floats lowered from their sea position. The normal safety valve springs are supplemented (if dual setting is provided) by stronger harbour springs which increase the MARVS. The re-liquefaction system is usually kept running and the tank pressures should be low (about 0.02 bar). After the loading lines have been connected and after the tank readings agreed with the shipper's representative, loading may commence.

If the tank temperatures are on high side due to insufficient liquid on board, the tanks, although pre-cooled as far as possible, may need further cooling. This is done by opening the cross connection between the liquid loading line and the condensate line, and receiving product very slowly through the spray lines. The liquid, as it is sprayed into the tanks, will evaporate, use up latent heat and so cool the tank, but at the same time, due to the increase of vapour present in the tank, the vapour pressure will rise.

If a shore vapour return line is provided, the excess pressure may be relieved by returning the vapour ashore Otherwise, it may be relieved by refrigeration, but due to the high pressure set up in the condensate line resuming from the restricting effect of the spray outlets, "spraying in" has to be suspended because the condenser pressure ~~is~~ may be insufficient to send the condensate back to the tank against the high loading pressure. (Sometimes the liquid can be sprayed into one tank and the condensate sent back to another tank).

When the presence of liquid is well established at the bottom of the tank and the tank is cold, loading proper may commence by opening the liquid loading valves and increasing the loading rate.

Whilst loading, although the tanks are cold, the compression of the vapour trapped in the space above the rising liquid level will lead to an increase of vapour pressure. This pressure can be relieved by refrigeration, which is usually better than returning the vapour ashore, because the returned vapour often goes to a flare and is wasted. There may, however, be some good reason, such as the presence of incondensable or impurities, which override this consideration.

During loading, the vessel has to be de-ballasted. Care should be taken to keep the vessel upright at all times, which means keeping the cargo even and the ballast even because the sounding pipes are near the ship's center line, if the vessel develops a list, the ballast water will run towards the sounding pipe on the "high side" and away from the sounding pipe on the "low side" This may mislead the officer on watch to assume that there is more ballast on the "high side" than there is on the "low side" when, in fact, the opposite is the case, and he may look for other factors (usually bunkers) to account for the list The cargo is similarly affected .

If the vessel does develop a list during the course of loading, the best way to correct it is to bring the vessel upright with the cargo, adjust the ballast, keeping the vessel upright all the time, and level off the cargo.
The maximum safe loading rate varies from ship to ship and also if the loading is with or without vapour return to shore. If shore does not take the ships vapour return the loading rate will be reduced to the ships compressor capacity.

During loading, a regular check on all cargo and ballast tank soundings must be kept. It is particularly important to keep a check on any cargo tank that has already been filled to ensure that, due to some leaky valve or any other reason, no more liquid enters the tank and so over it.

5.1.5(f) Explains closed and open loop sampling

Ships' cargo tanks are normally fitted with several sample connections so that samples may be taken at several different levels. 'Top', 'middle' and 'bottom' samples are common, and these are of great assistance when checking vapour displacement operations, such as inerting or 'gassing up' for example. The lower connections can also be used to take liquid samples if there is a suitable pressure in the cargo tanks. This is not possible with fully refrigerated cargoes, where it is necessary to take samples using the cargo pump, usually recirculating product back to the same tank. Liquid sampling connections should be fitted with two valves to ensure isolation should one be blocked by ice or hydrates, etc., and terminate in a standard connection. During sampling, venting to atmosphere should always be minimised, although it is recognised that a small, controlled amount of cargo vapour may be released during purging of sample points and when creating ullage in sample containers. Any such purging, venting or ullaging of sample containers must be carried out in a safe location, taking into account the properties of the product, wind and weather conditions, and proximity of sources of ignition and ventilation intakes, etc. Taking Samples of Liquefied Gas Cargoes If the sample system has only an inlet connection to the sample container, it will always be necessary to vent small quantities of cargo to atmosphere. This is known as an 'open loop' system. If a second connection is provided so that product can be returned to the cargo tanks, this arrangement is known as a 'closed loop' system and, if used with a sample container with inlet and outlet connections, minimizes the amount of product vented to atmosphere. If the main hazard from the product to be sampled is its flammability, open sampling may be used provided that due care is taken to reduce the amount of product release to an absolute minimum. However, if the cargo has toxic risks, e.g. VCM or butadiene, then SIGTTO recommends the use of 'closed loop' sampling to avoid release of the material to atmosphere. The return path of this closed loop should also be fitted with double shut-off valves. These return valve(s) should be operated full open or closed and should not be used for throttling/flow control during the sampling process.

5.2 Sea Passage

5.2.1 Cooling Down

A small quantity of cargo, known as *heel,* is frequently retained after discharge to maintain the cargo tanks at reduced temperature during the ballast passage. With an LNG cargo, a quantity of approximately 2,000 m^3 is retained upon departure from the discharge port. The actual quantity will depend upon the length of the ballast voyage, the containment system design and fuel policy. During the ballast passage the heel is sprayed in the cargo tanks using installed spray pumps to maintain the tanks in a condition suitable for loading.

With LPG cargoes, the liquid remaining in cargo tanks is normally sufficient to provide the necessary cooling during the ballast voyage, using the reliquefaction plant on an intermittent basis, returning the condensate to the tanks. If the ship will be loading an incompatible cargo, none of the previous cargo should be retained in the cargo tanks. Any small amount of remaining cargo can be retained in pressure vessel deck tanks to avoid contamination of the next cargo.

5.2.2 Pressure Maintenance

Refrigerated and semi-refrigerated gas carriers must maintain control of the cargo temperature and cargo tank pressure. This can be accomplished through reliquefaction or in the case of LNG ships using the boil-off for propulsion.

LPG ships and certain LNG ships are fitted with reliquefaction plants which are used to condense the boil-off. These reliquefaction plants may be used to cool the cargo to meet receiving terminal requirements; however, such cooling can take a considerable period of time. In rough weather entrained liquid can carry over to the compressor suction causing mechanical damage. Under these circumstances, it is preferable not to run the compressors when the ship is rolling heavily. Normally, the condensed vapor is returned through to top spray lines which can quickly reduce the tank pressure without cooling a bulk of the liquid. To achieve bulk cooling, the condensate should be returned to the bottom of each tank separately. If the reliquefaction plant is being run on more than one tank simultaneously, care must be taken to control the condensate return flow to prevent overfilling of one tank. During these operations, incondensable gases must be vented as necessary to minimize compressor discharge pressures and temperatures.

During the loaded passage, the reliquefaction plant can operated continuously or intermittently as needed to maintain the cargo temperature. It may be necessary to operate the reliquefaction plant continuously to meet the cargo conditions required by the receiving terminal.

Before starting the reliquefaction plant, the compressor oil must be compatible with the cargo to be handled and glycol/cooling water system ready for operation. Compressors must be operated in accordance with manufacturer's recommendations and the compressor discharge and suction valves opened slowly to minimize the chance of carryover. Operating conditions should be monitored when is service. Compressors should be stopped in accordance with the manufacturer's recommendations. Generally the compressor is stopped first before closing the suction and discharge valves. The glycol/cooling water system should be left running to provide crankcase heating or the lubricating oil heater left on.

5.2.3 Boil-off

Many LNG ships use the boil-off as fuel for propulsion as a means of controlling cargo tank pressure. LNG boil-off rates will vary based upon ambient conditions and sea states. It is important to monitor the tank and inter-barrier pressures to prevent lifting of the tank relief valves and to prevent the tank pressures from falling below atmospheric pressure. Boil-off rates for LNG carriers on the loaded voyage are typically 0.1% to 0.15% per day. LNG compressors generally use gaseous nitrogen

for shaft seals and an adequate supply must be available. Receiving terminals often require a maximum cargo tank pressure upon arrival which is achieved through a planned use of the boil-off.

5.2.4 Inhibiting

Certain LPG cargos are subject to self-reaction known as polymerization which can be prevented or reduced by adding a suitable inhibitor to the cargo. In general, cargoes which may self-react are inhibited before shipment. There are no inhibitors available for certain cargoes that can self-react and these have to be carried under an inert gas blanket.

The inhibitor may not boil off with the cargo and it is possible for reliquefaction systems to contain uninhibited cargo, therefore, the system should be drained or purged with an inhibited cargo when shut down. Many inhibitors are much more soluble in water than in the cargo, and care should be taken to exclude water from the system; otherwise the concentration of the inhibitor in the cargo could be considerably reduced. If the ship is anchored in still conditions, the inhibited cargo should be circulated daily to ensure a uniform concentration of inhibitor.
Certain cargoes even though inhibited may be protected by inert gas. Care should be taken to ensure that a positive pressure of inert gas is maintained at all times and that the oxygen concentration comply with the shipper's instructions. For butadiene cargo, the compressor discharge temperature must not exceed 600C. A cargo required to be inhibited should not be loaded until a certificate giving following details is provided by manufacturer:

- **Name and amount of inhibitor added.**
- **Date inhibitor was added and the normally expected duration of its effectiveness.**
- **Any temperature limitations affecting the inhibitor.**

Ensure that the expiry date of the inhibitor is appropriate for the contemplated voyage. Typically, the inhibitor should not expire within six months of loading the cargo. In case of difficulties, do not hesitate to seek clarification.

5.3 Unloading

5.3.1 Explains the relevance and lists the methods of unloading, such as:

- **pressure discharge**
- **pressure and booster-pump discharge**
- **centrifugal cargo-pump refrigerated discharge**
- **centrifugal cargo-pump and booster-pump discharge**

A liquefied gas tanker may be unloaded in different ways depending on ship type, cargo and terminal condition.

Methods of unloading

When the vessel arrives at the reception terminal, cargo tank pressures and temperatures should preferably be at values appropriate to the terminal requirements to allow maximum unloading rates to be achieved. Before the unloading operation

begins, the pre-operational ship/shore procedures should be carried out along similar lines to the loading operation previously outlined, i.e. ship/shore information exchange, ship/shore safety checklist, etc.

The method of discharging the vessel will depend on the type of ship, cargo specification and terminal storage. Three basic methods may be used:
Vapour pressure.
Centrifugal cargo pumps with or without a booster pump in series.
Centrifugal cargo pumps through a cargo heater and a booster pump.

General discharging preparation consists of:

• Function test of pumps and valves
• Function test of instruments for pressure.
• Temperature and cargo level measurements.
• Function test of fixed gas measuring equipment.
• Cargo calculation and sampling.
• Line-up inspection for discharging.
• Checks for leakage in cargo system.
• Pressure Control during discharging.
• Stability control
    - Verify that agreement for cargo transfer procedure has been reached with the responsible terminal representative.
    - Ascertain that all safety regulations are complied with.

Unloading by vapour pressure using either a share vapour supply or using a vaporizer and compressor on board is only possible where Type C tanks are fitted; it is an inefficient and slow method of discharge and is restricted to small vessels of this type. Basically the vapour pressure above the liquid is increased and the liquid transferred ashore by this increased pressure. An alternative method is to pressurize, the cargo into a small deck tank from which it is pump ashore.

Discharging by centrifugal cargo pumps either alone or in series with booster pumps is the method adopted by most ships and an understanding of the centrifugal pump characteristic in essential in the interests of efficient cargo unloading.

Increasing the flow rate increases the back pressure which varies approximately as the square of the flow rate giving the shape of curve shown. Where the system characteristic and the pump characteristic intersect is the flow rate and head at which the pump will operate.

Consider now the situation where pumps are run in parallel as would be the normal case for gas tanker unloading. It can be observed how little the flow rate increases by running 3 or 4 pumps. At the same time, if 4 pumps are operated in parallel considerably greater energy is imparted to the cargo which is dissipated as heat in the liquid and results in a temperature increases; this increase in liquid temperature in turn results in an increase of flash gas produced when the liquid discharges into shore storage and which must be handled by the shore compressors. If the shore compressors are unable to handle this additional flash gas, the terminal will require a reduction in flow rate to avoid lifting the shore relief valves.

The net effect of running unnecessary numbers of pumps, therefore, can be to decrease rather than increase the unloading rate. Observing pressure gauges at the manifold will give a good indication of whether or not it is worthwhile running say 4 pumps or 6 pumps Cargo rate is controlled by adjusting the pump discharge valve or recirculating the cargo. Manifold valves should not be used for throttling.

For booster discharge, it also may be desirable to throttle a cargo pump discharge when used in conjunction with a booster pump in order to reduce the pressure in the booster module. Any additional control of flow, however, should be affected by throttling of the booster pump discharge or the main pump recirculation or by a combination of the two. Control of flow solely by throttling the main pump discharge may cause loss of booster pump suction.

5.3.1(a) Explains cargo unloading without vapour return

During the unloading, due to the level of liquid in the tanks falling, the vapour spaces become enlarged. If the rate of evaporation of the product within the tank does not keep pace with the rate of unloading, the pressure in the tanks, which is bound to fall anyway, may come close to creating a slight vacuum. In this case, the pressure can be restored by using the ship's vaporizer. When it is particularly important to discharge the maximum quantity possible (e.g., if the tanks have to be gas-freed subsequent to discharge) the tanks should have the pressure restored prior to draining. The slight degree of under saturation due to a fall in the tank pressure will cause the cargo pumps to gas-up sooner than would be the case if the pressure were restored.

Where vapours produced internally are insufficient to balance the liquid removal rate, it is necessary to add vapour to the tank if discharge is to continue at a constant rate. This vapour may either be provided from shore via a vapour return line or it may be produced on board by using the cargo vaporizer. Liquid is normally taken from the discharge line and diverted through the vaporizer. Vapour return may also be required by some receiving terminals where the receiving rate would otherwise be limited by the capacity of their re-liquefaction plant. Figure shows unloading without the vapour return facility.

Where cargo is being transferred from a refrigerated ship into pressurized storage, it will almost certainly be necessary to warm the cargo on unloading: this means running the cargo booster pumps and cargo heater in series with the main cargo pump. To operate the booster pump and heater, it is necessary to first establish sea water flow through the heater. Thereafter the pump and heater may be slowly cooled down, prior to operation by carefully bleeding in liquid from the main cargo pump unloading. Once cooled down, the discharge valve can be opened until the desired outlet temperature is reached. It is important to ensure that the main cargo pumps maintain adequate suction to the booster pump at all times.

Cargo heating always entails a risk of freezing of the heater circulating water. As well as checking the cargo outlet temperature and the booster pump suction during operation, attention should be paid to the sea water inlet and outlet temperatures

and pressure. The sea water outlet temperature must not be allowed to fall below the manufacturer's recommended limit.

Towards the end of unloading, when the liquid level in the tanks gets low, shutting in the pump discharge valve must slow the pumping rate, so maintaining the backpressure. In this way, the tanks can usually be pumped down to a level of about 20 centimeters. The liquid and vapour remaining after unloading is retained on board and used to keep the tanks cold for the next cargo."

5.3.1(b) Explains cargo unloading with vapour return

During the unloading, due to the level of liquid in the tanks falling, the vapour spaces become enlarged. If shore returns the vapours as their tanks get filled there will be no need for any further action for the ship till stripping levels have reached.

However if receiving vapour from shore there is a serious danger of ship's tank atmosphere being contaminated by those from shore tanks. Charterers usually insist on receiving an analysis certificate of shore tank atmosphere and an indemnity to protect the ship.

5.3.1(c) Explains cargo unloading with heating

Cargo heating always carries with it the risk of freezing the heater circulating water. When checking the cargo outlet temperature and the booster pump suction during operation, attention is to be paid to the sea water inlet and outlet temperatures and pressure.

A minimum sea water temperature of above +10 degree C is normally required to provide satisfactory cargo heating.

In the case of a lower temperature, it may be possible to achieve satisfactory heating by slowing the rate of unloading, but under these circumstances great care will be required if freezing of water in the heater tubes is to be prevented.

The heat exchanger is protected by a temperature switch which stops the flow of cargo if the sea water drops below about +5 degree C.

Water for the heater may be supplied by the condenser cooling water system. The main danger with cargo heating is water freezing in the heat exchanger tubes. This can be prevented by maintaining a high rate of sea water flow through the tubes.

The minimum discharge temperature of the cargo is set by the transmitter controller and limiting valve. Control of the cargo temperature above the minimum temperature is made by controlling the flow through the heater by pass line.

Usually for cargoes with an inlet temperature at the heater warmer than -15 degree C, the sea water temperature must not be less than +5 degree C; for cargoes with a temperature colder than -15 degree C the sea water temperature is not to be less than +10 degree C.

On completion of cargo heating, the heater is to be drained back to a cargo tank. When it is confirmed that all liquid has totally evaporated the flow of seawater can be stopped.

A flow switch is provided which trips the booster and main cargo pumps in case low flow is detected. Great care needs to be taken as vessel becomes light and the suction pressure drops at SW pump used for supplying the heater.

5.3.1(d) Lists ways of maintaining overpressure if it tends to fall during discharging

- Required pressures within the cargo tanks can be maintained by:
- Using spray pumps and spraying cargo
- Using Compressor and bypassing the condenser
- Using Vapourisers and heaters

5.3.2 Explains requirements for ballasting

Simultaneously with cargo discharging, ballast tanks are filled with seawater to maintain a constant draft and trim.

5.3.3 Explains the requirements for stripping

Except where heel is retained to keep the tanks cold on the ballast voyage, the cargo tanks levels are reduced to a minimum. Upon completion of discharge, cargo pump discharge valves are throttled to reduce the NPSH required. Upon completion of discharge, liquid is drained from the deck piping.

5.4 Pre – docking preparation:

5.4.1 Explains the purpose and procedure of vaporizing cargo residue and warming up the tank shell

Tank warming is required to prevent condensation when air is introduced later in the operations.

Tank warm up is part of the gas freeing operations carried out prior to dry-docking or when preparing tanks for inspection purposes.

The tanks are warmed by circulating heated Gas Cargo / LNG cargo vapour. The vapour is re-circulated using the HD compressors and heated using the vapour heater.

Or in the case of an LPG vessel using the LPG Compressor and by passing the condenser and sending the sparged gases to the cargo tanks.

Initially the hot vapour is introduced through the filling lines to the bottom of the cargo tank to facilitate the evaporation of any liquid remaining in the tank. In a second step, when the temperatures have a tendency to stabilize, hot vapour is introduced through the top of the tank via the vapour line.

When at sea, excess vapour generated during the warm up operation is vented to atmosphere or burned in the boilers. When alongside this may be returned to shore.

Initially the tank temperatures will rise slowly as evaporation of the cargo proceeds, accompanied by high vapour generation and venting. On completion of evaporation, tank temperatures will rise rapidly and the rate of venting will fall.

The warming should continue until the vapour temperature within the tank is between +5° C and +10° C.

It is important that tank temperature is above the dew point of the Inert Gas to be introduced. Failure to ensure this will result in water condensing on the tank side on introduction of the Inert Gas.

5.4.2 Explains the basic methods of inerting

It is important for the instructor to first explain the need to bring the HC content below 2 percent then further explain that Displacement method relies on stratification in the cargo tank as a result of the difference in vapour densities between the gas entering the tanks and the gas already in the tank. The heavier gas is introduced beneath the lighter gas, and at a low velocity to minimize turbulence. If perfect stratification could be achieved with no mixing at the interface then one tank volume of the incoming inert gas would completely displace the air. In practice some mixing does occur and it will be necessary to use more than one tank volume of inert gas. This may vary from 1½ to 4 times the tank volume, depending upon relative densities and tank and piping configurations. There is little density difference between air and inert gas; inert gas from a combustion generator is slightly heavier than air while nitrogen is slightly lighter. These small density differences make inerting by displacement alone very difficult to achieve and usually the process becomes partly displacement, partly dilution. Combustion generated inert gas is usually introduced through the liquid loading line with the air/inert gas being exhausted through the vapour line and into the vent header. Figure shows schematically the inerting of a cargo tank by the displacement method. The symbols used in this and the cargo handling schematic diagrams which follow are identified in the flammability diagram.

Theoretically, displacement is the most economic method but is only practical if the entry of inert gas is diffused and mixing with the initial contents can be largely avoided. If tank geometries and piping entries lend themselves to the displacement method, the practicability of the method will be improved by inerting more than one tank at a time in parallel. The sharing of the inert gas generator output between tanks will reduce gas inlet speeds and reduce the degree of mixing of tank contents. At the same time, the total inert gas flow resistance. Tanks being incited in parallel should be particularly carefully monitored to ensure a reasonably equal sharing of the inert gas flow.

By Dilution method: In the dilution method the incoming gas mixes with the gas already in the tank. The dilution method can be carried out in several different ways.

Dilution by repeated pressurization

In the case of Type C pressure vessel tanks, the dilution can be achieved by a process of repeated pressurization of the tank with inert gas using a cargo compressor and followed by release of the compressed contents to atmosphere. Each repetition will bring the tank contents nearer and nearer to the O2 concentration level of the injected inert gas. Thus, to bring the tank contents to a level of five percent O2 within a reasonable number of repetitions, an inert gas quality better than five per cent O2 is required. Quicker results will be achieved by more numerous repetitions each at lower pressurization levels than by fewer repetitions using the higher pressurization levels of which the tank and compressor may be capable.

Inerting by vacuum/pressure method: Type C tanks are usually capable of operating under considerable vacuum and, depending on tank design; vacuum breaking valves are set to permit vacuums in the range from 30 per cent up to 70 percent vacuum. Inciting by successive dilutions may be carried out by repeatedly drawing a vacuum on the tank by the cargo compressor and then breaking the vacuum using inert gas. If, for instance, a 50 per cent vacuum can be drawn then on each vacuum cycle half the O2 content of the tank will be withdrawn. Some of the withdrawn O2will, of course, be replaced by the O2 content of the subsequent vacuum breaking inert gas but, if the quality of the inert gas is good, this method is probably the most economical in the use of minimum inert gas quantity in order to achieve the desired inerting level in the tank. The overall time taken, however, may be longer than with the pressurization method because of the reduction in capacity of the compressor on vacuum and the limitation of the rate of vacuum breaking to the output capacity of the inert gas generator.

5.4.3 Explains the purpose and procedure of gas freeing

After the inerting operation, comes an operation in which air is injected into tanks until after the content of each gases reaches the following criteria so that man can enter inside tanks.

i) Flammable Gas: Less than 1 % LEL
ii) CO_2: Less than 50% OEL
iii) CO: Less than 50% OEL
iv) O_2: 21 Vol %

With the inert gas system in dry air mode, the cargo tanks are purged with dry air until a reading 21% O2 by volume is reached. The dry air is introduced to the cargo tanks via vapour header. The inert gas/dry air mixture is exhausted from the bottom of the tank via filing line and liquid header.

The operation is complete when all tanks have 21% Oxygen value, a Methane content of <0.2% by volume (or whatever is required by the Local Authority) and a dew point below –40 C. Before entry, test for traces of noxious gases (Carbon

Dioxide <0.5% by volume and Carbon Monoxide <50ppm) which may have been constituents of the Inert Gas. In addition, take appropriate precaution as given in the Tanker Safety Guide and other relevant publications.

5.4.3(a) Describes with the aid of a flammability diagram the gas-freeing operation and states when the tank is safe with regard to:

- flammability hazards
- health hazards

The relationship between composition and flammability of mixtures of cargo vapour, air and inert gas is given in the form of a flammability diagram. The purpose of these diagrams is to enable procedures to be developed for avoiding flammable mixtures in the cargo system at all times.

When inert gas or nitrogen is added to a mixture of air and flammable vapour the result is to raise the lower flammable limit concentration and to decrease the upper flammable limit concentration. These effects are illustrated in Figure in Part D, which should be regarded only as a guide to the principals involved.
Every point on the diagram represents a mixture of air, flammable vapour and inert gas, specified in terms of its flammable vapour and oxygen content. Air and flammable vapour mixtures without inert gas lie on the line AB, the slope of which reflects the reduction in oxygen content as the flammable vapour content increases (i.e.. at 50% air and 50% cargo vapour, oxygen is 10M'% of tank atmosphere). Points to the left of the line AB represent mixtures in which the oxygen content is further reduced by the addition of inert gas.

The lower and upper flammability limits for mixtures of flammable vapour and air are represented by the points C and D. As the inert gas content increases so the flammable limits change, as indicated by the lines CE and DE, which finally converge at the point E. Only those mixtures represented by points in the shaded area within the loop CED are capable of burning.

It is evident from Figure appended in Part D that as inert gas is added to flammable vapour and air mixtures the flammable range decreases until the oxygen content reaches a level at which no mixture can burn.

On such a diagram, changes in the composition of the tank atmosphere are represented by movements along straight lines. When adding air the line is directed towards point A, at which only pure air is left in the tank. When adding inert gas the line is directed towards a point on the x-axis corresponding to the oxygen content of the inert gas, at which only inert gas is left in the tank (and in the case of nitrogen will be 0%). These lines are shown on Figure Al.la for an inerted mixture with concentrations corresponding to point F. When such an inerted mixture is diluted by air its composition moves along the line FA and therefore enters the shaded area of flammable mixtures.

Figure 5.4 in Part D, shows that a point G can be established from which a line GA will separate all mixtures (above and to the right, including point F) which will pass through a flammable condition as they are mixed with air during a gas-freeing

operation, from those mixtures which will not become flammable on dilution with air (those below and to the left of line GA, including point H). The line GA is called a line of critical dilution. Note that it is possible to move from mixtures such as at point F to one such as at point H by dilution with additional inert gas. Likewise there is a line of critical dilution when inerting a cargo vapour atmosphere or purging a tank with cargo vapour, and this line is JB; mixtures above and to the right of the line JB go through a flammable condition, mixtures below and to the left of the line JB do not. It can be seen that an initial oxygen content of less than J% will ensure that no flammable mixtures are formed when purging with cargo vapour, and an initial cargo vapour content of less than G% will prevent the formation of flammable mixtures when gas-freeing with air. In practice a safety factor of 2 is adopted to account for less than perfect mixing, equipment error etc. Therefore, the cargo vapour concentration in the cargo system after inerting should not exceed (G/2) % before gas-freeing begins and the oxygen concentration should be below (J/2) % after inerting before purging with cargo vapour. Although a safety factor of 2 is adopted, every effort should be made to ensure that the inerting and purging operations are carried out properly using correct equipment and procedures, and accurately calibrated gas detection equipment.

The diagrams attached to relevant data sheets indicate the limits of flammability of the product in mixtures of air and nitrogen. They also show the lines of critical dilution.

5.5 Ship – to ship transfer

If cargo is to be transferred from one ship to another, the relevant precautions in the ICS/OCIFM publication "Ship to Ship Transfer Guide (Liquefied Gases)" should be closely observed.

Before starting transfer operations the two masters involved should agree on every aspect of the transfer procedure and appoint a person in overall charge. Transfer operations between liquefied gas tankers should be carried out in accordance with the requirements of the receiving vessel.

In all cases, however, each master remains fully responsible for the safety of his own ship, its crew and cargo, and must not permit safety to be prejudiced by the actions of the other master concerned.

Transfer operations should only be carried out in favourable weather conditions and should not begin until the master or responsible officer of each vessel is satisfied that the situation is safe. Safety Checklists as prescribed in the STS guide should be used prior to commencing each operation~~s~~ and, in the event of subsequent stoppages, a further check should be made before resuming operations.

During operations the maximum transfer rate must be consistent with the receiving vessel's re-liquefaction capacity. Alternatively, a vapour return hose connection should be made to the discharging vessel.

6.0 Proficiency to perform cargo measurements and calculations

6.1 Liquid phase

6.1.1 Explains the definitions used for liquid phase of gases

6.1.1(a) Lists units used under the International System of Units (S.I.) and defines:

- **volume**
- **density**
- **mass**

MASS - Measures the amount of matter out of which a body is composed. (SI: kg)

VOLUME - Measures the space occupied by a body. (SI: m3)
Examples: Cube, sphere, cylinder

DENSITY – The mass per unit volume of a substance at specified conditions of temperature and pressure. (SI: kg/m3)

The S. I. Units are an internationally accepted coherent system of units modified in the system consisting of basic units of length (meter), mass (kilogram), time (second), electric current (ampere), thermodynamic temperature (Kelvin), luminous intensity (candela) and amount of substance (mole).

The units for volume are cubic metres (m^3), density is kilograms per cubic metres (kg/m3), mass are kilograms

Other commonly used units for cargo quantity calculations are API gravity, barrel and long ton.

API gravity (at 60 F) = (141.5/ relative density 60/60 F) - 131.5
1 m^3 = 6.28981 barrels
1 long ton = 1.01605 metric ton

6.1.1(b) Defines 'specific gravity (S. G.)

Specific Gravity (S. G.) as the ratio of the weight of a volume of a substance at a given temperature to the weight of an equal volume of fresh water at the same temperature.

Temperature will affect volume and the temperature of comparison must therefore be stated, e.g.

SG 60/60°F — Substance and water at 60°F
SG 15/4°C - Substance at 15°C and water at 4°C

6.1.1(c) Defines 'litre weight'

Weight in air of 1 litre of substance at a given temperature

Approximate vacuum factors are:

Litre weight 1.0 - 1.00108
Litre weight 0.9 - 1.00122
Litre weight 0.8 - 1.00139
Litre weight 0.7 - 1.00161

6.1.1(d) Discuss 'weight in air' and 'weight in vacuum'

When everyday commodities are sold by weight (potatoes, cement, etc.) it is, of course, by their weight-in-air 'weighing', as the term is universally understood is the balancing of the force of gravity acting on commodity against the force of gravity acting on a known mass (typically "brass weight"). Since gravity acts on both sides of the balance, the strength of gravity and the location of the weighing are irrelevant and weighing is basically the balancing of mass against mass. If the weighing was carried out in a total vacuum the balance would be precisely mass against mass and hence the term "weight is synonymous with mass. If, however the weighing takes place in air, as is the normal situation, both the known mass and the commodity are subject to a buoyancy force due to the air which their respective volume are displacing.
If the known balancing weights and the commodity being weighed were of the same density (density = mass / Volume) then their volumes would be same, the buoyancy of each would be the same and again the result would be a balancing of mass against mass. The density of the commodity, however, is generally different from that of balancing weights and, depending on the difference In densities, there is an imbalance in the buoyancy forces on the two sides of the balancing arm The weighing, therefore will result in a commodity weight a little different from the mass of the known weights To simplify matters the known weights are always manufactured to provide the equivalent of their accredited mass at a standard density of 8000 kg/m3 This standard density of balancing weights is incorporated in the international definition of weight-in-air and thus the amount by which the weight-in-air of a commodity differs from the mass depends only upon the density of the commodity weighed. (correction to density of 1.1 kg/m3 is applicable for saturated hydrocarbon gas cargoes).

6.1.1(e) Calculates the liquid phase

Method for Calculating Cargo for saturated Hydrocarbons (Propane, Butane)
1. Obtain the following readings on board:
   A: Trim (and List if applicable)
   B: Tank sounding/Ullage
   D: Temperature of Liquid
   E: Temperature of Vapour
   F: Tank Pressure
   G: Tank Volume - Full

2. Obtain the following information from shore
   P: Density of product at 15°C

3. Obtain the corrections to "B":
   CW: Tape shrinkage (enter with correction tables provided with vapour temp.)
   CP: Float buoyancy correction (enter correction tables provided with liquid density* at observed liquid temperature)
   CT: Trim correction (enters with Trim and Dips and obtains correction)
   CL: List correction (enters with List and Dips and obtains correction)
   Density is obtained from Table 53 (ASTM IP Table or by multiplying the density at 115°C by the VRF obtained at value M.

4. Correct observed Dips "B" (Ullage/Soundings) B + Cow + Cp + CT + CL = C (Corrected Dip)
   Note: Corrections are to be applied algebraically Thus obtain C - corrected sounding.

5. Obtain Liquid Volume from tables for the tank volume at various dips.
   H = uncorrected liquid volume.

6. Obtain correction for tank shrinkage factor from tables, for liquid, by entering with liquid temperature.
   K = Shrinkage factor of Tank (liquid phase).

7. Apply K to H (i.e. H x K). The value of volume thus obtained is the corrected liquid volume.
   L = Corrected liquid volume.

8. Enter Table 54 of ASTM-IP with observed temperature of liquid and density at 15°C to obtain.
   M = Volume reduction factor.

9. Volume at 15°C = L x M = N

10. N x P = Volume X Density = Mass (weight in Vacuum).
    This obtains Q

6.1.2 Explains reasons for tank filling requirements

Filling Limits

The IMO Gas Carrier Code stipulates rigid requirements for the maximum filling limits of cargo tanks to prevent them from becoming "Liquid full" at any stage when loaded. Additionally, however, the Codes permits an alternative solution which obviates any cargo shut out on loading beyond that of normal operational considerations of cargo temperature change. This alternative solution requires the provision of an additional pressure relieving system with relief valves set to open at the maximum operational vapour pressure of the cargo. The system is prevented from operating under normal conditions and is brought into operation only by the

melting of fusible elements suitably located to detect fire surrounding conditions. Few, if any, semi-pressurised ships have been provided with this system."

6.1.2(a) Defines the formula for calculating the maximum allowable filling limit of a cargo tank.

The maximum volume to which a cargo tank should be loaded is determined by the following formula;
V1 = O.98 V x dR/ dL
Where,
V1 = Maximum volume to which the tank may be loaded
V = Volume of the tank
dR = relative density of the cargo at reference temperature.
dL = relative density of the cargo at loading temperature and pressure.

Reference temperature is taken as the temperature corresponding to set pressure of the relief valves, on pressurized ships. On semi-pressurised ships and refrigerated ships, it is the maximum temperature the cargo will reach over the whole cycle of loading, transportation and unloading. Even so, the filling limit must be such that if the temperature control fails or surrounding fire occurs, the tank will not become liquid full before the relief valve opens."

6.1.2(b) Calculates the maximum allowable filling volume of cargo tanks, given the tank volume, the setting of the safety relief valve, the type of cargo, the loading temperature and pressure-temperature data for the cargo

The influence on the filling limit of the cargo tank can be explained by the following calculated examples:

Case 1:
Fully pressurised vessel loading propane at 20°C
Relief valve set at 16 barg.

V1 = 0.98V x dR/dL
Reference temperature + 49°C (corresponding to SVP of 16+1= 17 bar of propane)
Density of liquid propane at 49°C = 0.452 kg/m^3
Loading temperature + 20°C
Density of Liquid propane at 20°C = 0.502 kg/m^3
V1 = 0.98V x0.452/ 0.502
V1 = 0.882
Thus the tank can be filled upto 88.2% of its volume.

Case 2:
Semi- refrigerated vessel loading propane at 42°C
Relief valves set at 5 barg. No additional pressure relieving facility fitted.

Here, since no additional pressure relief is fitted in accordance with the IMO Codes, the reference temperature must be taken as the temperature corresponding to vapour pressure at set pressure of relief valves, i.e.

a temperature corresponding to an SVP 5 + 1 = 6 bar.
Reference temperature = + 8°C
Density of liquid propane at 8°C = 0.519 kg/m^3
Loading temperature -42°C
Density of liquid propane at -42°C = 0.582 kg/m^3
V1 = 0.98 X 0.519/ 0.582
Thus the tank can be filled to 87.4 per cent.

A list or a diagram indicating the maximum allowable filling limits for each tank and for each product which may be carried should be kept on board.

From the above example, it is clearly shown that the safety valve settings influence on the cargo tank filling limits. A lower pressure setting will entail more quantities to be loaded.

6.2 Gas phase

6.2.1 Explains equation of state

THE GENERAL GAS EQUATION is derived by combining the gas laws and is stated as -
(P1.V1)/ T1= (P2.V2)/ T2

Or PV = nRT
where P is the absolute pressure of the gas, V is the volume of the gas, n is the amount of substance of gas (measured in moles), T is the absolute temperature of the gas and R is the ideal, or universal, gas constant.

Gases may be compressed or expanded in two theoretical ways: isothermally, where the change is at constant temperature, or adiabatically where the change is without loss or gain of heat. The pressure/volume relationship between isothermal and adiabatic compressions and expansions are shown in fig.

Compression results in a production of sensible heat (temperature) and expansion in a reduction. In the case of adiabatic changes, (A), it is assumed that no heat enters or leaves the system during change. The more rapid the change the more closely is this assumption achieved. In isothermal change (B), the temperature of gas remains constant, it being assumed that heat enters or leaves the system as required. This would require a very slow change. Under practical (real) conditions neither isothermal nor adiabatic change is possible, and the real situation lies somewhere between these two extremes (C).

6.2.1(a) Explains molecular weight and its use in obtaining density at 0°C

Molar Volume
The volume occupied by one molecular mass in grammes (g mole) under specific conditions. For an ideal gas at standard temperature and pressure it is 0.0224 m mole. (22.4 litres/g.mole)

Mole

This mass that is numerically equal to the molecular mass. It is most frequently expressed as the gram molecular mass (g mole) but may also be expressed in other mass units, i.e. kg mole: At the same pressure and temperature the volume of one mole is the same for all perfect gases. It is practical to assume that petroleum gases are "perfect" gases.

The amount of a substance, in any convenient system of weight measurement, that corresponds to the numerical value of the molecular weight of the substance (e.g. for propane, molecular weight of 44. 1 , a gram-mole weighs 44. 1 grams; a pound-mole weighs 44. 1 pounds; Density of any gas at 0°C= Molecular weight of that gas /22.414"

6.2.1(b) Explains Volume at 0°C

Volume at 0°C= {[Corrected Volume x [273/ (273+ Vapour temp)] x (1.033+Vap Pr.)}/ 1.033

6.2.2 Explains calculations used in vapour phase of gases

6.2.2(a) Calculates mass of the vapour phase
Please see calculations sheet appended in Part D

- Obtain vapour volume

  Vapour Volume = G - H = R.
- Obtain correction for shrinkage factor from tables for vapour, by entering with vapour temperature.

S = Shrinkage factor of tank (Vapour phase)

- . Obtain corrected vapour volume T, thus

T = R x S

- Convert corrected vapour volume at observed temperature and pressure to vapour volume at 0°C and 1 .033 kp/ cm^2 (1.013 bar) absolute pressure,

  Using gas law, (P1V1)/ T1 = (P2V2)/T2

  Obtain U
- Calculate Density of Vapour at 0°C

  Density of Vapour V = Mol. Wt. / 22.414 kg/m^3

- Calculate Mass of Vapour

  Volume x Density = Mass

  U X V = W

- .Total mass X is obtained

  X = Q + W

- Total weight in air Y, can then be calculated as

  Y = [X (P— 1.1)]/ P

6.3 On Board Quantity (OBQ)

For commercial purposes, it is necessary to calculate the quantity of cargo onboard a gas carrier upon completion of loading or prior to discharge. This is known as the On Board Quantity (OBQ). These custody transfer calculations are performed using a standardized procedure. There may be a preprinted calculation sheet for a manual calculation or a mutually accepted software applications.

6.2.3(a) Calculates the total cargo quantities in metric tons, given the following factors:

- **type of cargo and its liquid and vapour temperature**
- **gauge reading of sounding, ship's trim and using:**
  - **cargo tank pressures**
  - **data sheet for the cargo and trimming tables of vessel.**

6.2.3(b) Converts mass to "weight in air"

Calculation sheets in Appendix I provide an example of the process.

6.4 Remaining On Board (ROB)

In some refrigerated trades, a small quantity of cargo on board after discharge is retained as "heel". This product is used to maintain the tanks at a reduced temperature during the ballast voyage but this procedure only applies when the same grade of cargo is to be loaded. In general the quantity retained onboard as heel depends upon:

a) Commercial agreements
b) Type of gas carrier
c) Duration of the ballast voyage
d) Next loading terminal requirements
e) Next cargo grade

In the case of a large LNG carrier, 2000 to 3000 m^3 of liquid may be retained on departure from the discharge port. The mass of this heel must be determined using a custody transfer calculation to determine the quantity Remaining On Board (ROB). This ROB must be deducted from the OBQ to determine the quantity of cargo discharged.

6.5 Boil – off cargo calculations

Boil-off rate can be estimated on the basis of observations of a typical boil-off rate on previously built vessels. In the case of spherical tanks with a diameter of 36 m and the ambient air temperature of 32°C, intensity of the heat flux penetrating the insulation is estimated at about 20 W/m^2. This results in daily loss of about 0.12 % of total quantity of loaded cargo during the laden voyage.

7.0 Supervision of personnel with cargo related responsibilities

The responsibilities of officers and crew assigned to gas carriers are defined in the Company's Safety Management System. The requirements for rest hours are defined in the STCW.

TOPIC 2: BASIC CHEMISTRY AND PHYSICS

8.0 Knowledge and understanding of basic chemistry and physics and the relevant definitions related to the safe carriage of liquefied gases in bulk in ships

8.1 The chemical structure of gases

Explains a saturated hydrocarbon molecule with the aid of a molecular structure diagram

Saturated hydrocarbons are molecules made entirely of single carbon-carbon bonds; they cannot incorporate additional atoms into their structure, thus they are said to be saturated. These molecules are stable and not very reactive.
8.1.7 Lists typical liquefied gas cargoes that are saturated hydrocarbons

"# Carbons	Name	Molecular Formula	Structural Formula
1	Methane	CH4	CH4
2	Ethane	C2H6	CH3CH3
3	Propane	C3H8	CH3CH2CH3
4	Butane	C4H10	CH3CH2CH2CH3
5	Pentane	C5H12	CH3CH2CH2CH2CH3

8.1(a) Explains an unsaturated hydrocarbon molecule with the aid of a molecular structure diagram

Unsaturated hydrocarbons are molecules that contain at least one double or triple carbon-carbon bond within their structure. These molecules are highly reactive, and thus can incorporate other atoms into their structure

8.1(b) Lists typical liquefied gas cargoes that are unsaturated hydrocarbons

Alkenes and Alkynes, CnH2n and Ethene, C2H4, are examples of an unsaturated hydrocarbon

8.1(c) Explains a typical chemical gas molecule with the aid of a molecular structure diagram

Ethane (saturated) Ethene (Unsaturated) Ethyne (Unsaturated)

8.2 The properties and characteristics of liquefied gases (including CO2) and their vapours

8.2.1 Simple gas laws

8.2.1(a) Explains why Dalton's law of partial pressures is the pressure exerted by a mixture of gases is equal to the sum of the separate pressures which each gas would exert if it alone had occupied the whole volume.

Dalton's Law of Partial Pressures
The pressure exerted by a mixture of gases is equal to the sum of the separate pressures which each gas would exert if it alone had occupied the whole volume.

8.2.1(b) Explains why Joule's second law says the internal energy of an ideal gas is independent of its volume and pressure, depending only on its temperature.

Joule's second law explains why the internal energy of an ideal gas is independent of its volume and pressure, depending only on its temperature

8.2.1(c) Explains Avogadro's number.

$6.022\ 141\ 99 \times 10^{23}$

This large number is approximately equal to the number of protons in a gram of pure protons. It is customary to introduce the term 'gram molecule' into explanations of the importance of this number:

a gram molecule is a mole of the molecules:
y grams of a molecule whose relative molecular mass is y, will contain 6.022 x 1023 molecules.

8.2.2 States of matter

The states of matter or forms of matter differ in several properties because of differences in the motions and forces of the molecules (or atoms, ions, or elementary particles) of which they are composed. The states of matter are also known as phases of matter or states of aggregation. There are three commonly recognized states of matter: solid, liquid, and gas. The molecules of a solid are limited to vibration about a fixed position. This restriction gives a solid both a definite volume and a definite shape. As energy in the form of heat is added to a solid, its molecules begin to vibrate more rapidly until they break out of their fixed positions and the solid becomes a liquid. The change from solid to liquid is called melting and occurs at a definite temperature, the melting point. The molecules of a liquid are free to move throughout the liquid but are held from escaping from the liquid by intermolecular forces (see adhesion and cohesion). This gives a liquid a definite volume but no definite shape. As more heat is added to the liquid, some molecules gain enough energy to break away completely from the liquid and escape into the surrounding space (see evaporation). Finally a temperature is reached at which molecules

throughout the liquid are becoming energetic enough to escape and bubbles of vapor form and rise to the surface. The change of the liquid to a vapor, or gas, in this manner is called boiling and occurs at the boiling point. The molecules of a gas are free to move in every possible way; a gas has neither a definite shape nor a definite volume but expands to fill any container in which it is placed. In addition to these three states of matter, scientists also distinguish three additional states—plasma and the Bose-Einstein and the fermionic condensates.

8.2.3 Liquid and vapour densities

8.2.3(a) Explains density of liquids

Liquid density is a term used to describe the mass per unit volume. Different liquids have different density, which is why you'll sometimes see when two liquids are mixed, one will float on top of the other

8.2.3(b) Explains density of gases

There are two ways to look at density of gases: (1) the small scale action of individual air molecules or (2) the large scale action of a large number of molecules. Starting with the small scale action, from the kinetic theory of gases, a gas is composed of a large number of molecules that are very small relative to the distance between molecules. The molecules are in constant, random motion and frequently collide with each other and with the walls of a container. Because the molecules are in motion, a gas will expand to fill the container. Since density is defined to be the mass divided by the volume, density depends directly on the size of the container in which a fixed mass of gas is confined.

8.2.3(c) Explains density of vapours

Vapour density is the density of a vapour in relation to that of hydrogen. It may be defined as mass of a certain volume of a substance divided by mass of same volume of hydrogen.
vapour density = mass of n molecules of gas / mass of n molecules of hydrogen
Therefore:
vapour density = molar mass of gas / molar mass of H2

8.2.3(d) Explains variations of density with temperature

The density of a substance varies with temperature and pressure. This variation is typically small for solids and liquids but much greater for gases. Increasing the pressure on an object decreases the volume of the object and thus increases its density. Increasing the temperature of a substance (with a few exceptions) decreases its density by increasing its volume. In most materials, heating the bottom of a fluid results in convection of the heat from the bottom to the top due to the decrease in the density of the heated fluid. This causes it to rise relative to more dense unheated material

8.2.3(e) Explains vapour pressures

Vapor pressure is the pressure exerted by the molecules of a vapor on the solid or liquid phase with which it is in equilibrium.

8.2.3(f) Explains variations of vapour pressure with temperature

At pressures lower than the vapor pressure, more atoms or molecules of the liquid or solid vaporize and escape from the liquid or solid than are absorbed from the vapor, resulting in boil off. At the vapor pressure the exchange is equal and there is no boil off. At saturated vapour pressures, more molecules or atoms of the vapour changes its state to liquid.

8.2.4 Diffusion and mixing of gases

8.2.4(a) Describes diffusion and mixing of gases

All gases and vapours can mix with each other. They are then said to be in solution with each other. This form of mixing is called diffusion. The molecular movement in a gas is quite accidental and disorderly and this enables diffusion to take place. A gas molecule will, in the process of time, move everywhere within the volume available. Molecules of different gases will spread evenly throughout a volume.

8.2.4(b) Describes solubility of gases in liquids

Gases can dissolve in liquids. It can be said that the liquid absorbs the gas. This phenomenon is called absorption. If no chemical process follows absorption the absorbed amount of gas will be proportional to the pressure above the liquid. The solubility of different gases in the same liquid at the same pressure will be different.
The presence of small amounts of very volatile component in the "MIX" can add significantly to the vapour pressure.

8.2.4(c) Describes miscibility between liquids and the effects of temperature on miscibility

The solubility will vary with temperature, because the components of the liquid mixture are in solution with each other, a low boiling component Ethane, (say) can remain in 'the liquid phase at temperatures well above the boiling point of the pure component.

8.2.4(d) Explains the variation in dew points and the effects of low temperatures

A pure liquid will commence to boil at a fixed temperature depending upon the pressure above it and will continue to boil only at that temperature, providing the pressure is kept constant. On cooling superheated vapour at that same pressure, the vapour will become saturated at the same fixed temperature and will condense to liquid at that temperature. However, because of the differing volatilities of its

components, a mixture of liquefied gases will behave differently. The bubble point of liquid mixture at a given pressure is defined as that temperature at which the liquid will begin to boil on rising temperature. The dew point of a vapour mixture at a given pressure is defined as the temperature at which the vapour begins to condense as the temperature decreases. For a liquid mixture in equilibrium with its vapour, the bubble point and the dew point are at different temperatures.

8.2.4(e) Describes the phenomenon of "roll-over"

A particular danger associated with cargo density is one known as rollover. Rollover is a spontaneous rapid mixing process which occurs in large tanks as a result of a density inversion, stratification develops when the liquid layer adjacent to a liquid surface becomes more dense than the layers beneath, due to boil-off of lighter fractions from the cargo. This obviously unstable situation relieves itself with a sudden mixing, which the name "rollover" aptly describes Rollover can then result in boil-off rates several times greater than normal, causing very rapid over-pressurisation of the tanks, with the resultant lifting of relief valves, and the venting to atmosphere of considerable quantities of vapours. Rollover can occur if similar or compatible cargoes of different densities are put in the same tank. For example, if tank pressure is maintained by boil-off re-liquefaction, the condensate return may be of slightly different temperature (and hence density) from the bulk liquid, and likewise if condensate from two or more cargoes is returned to one tank. In such circumstances, rollover may be prevented by returning condensate that is less dense thank the bulk liquid to the top of the tank, and condensate that is denser to the bottom of the tank.

Rollover may also occur when two part cargoes are loaded into the same tank (e.g. propane and butane). In this case there will be a large boil-off (up to 3% of the total liquid volume) due to the temperature difference between the two. For this reason, the practice is considered unsafe unless a thorough thermodynamic analysis of the process is undertaken, and the loading takes place under strictly controlled conditions.

8.2.5 Compression of gases

8.2.5(a) .Explains the relationship between pressure and boiling point

Every liquid (and solid for that matter) has a vapor pressure at the boiling point, the vapor pressure = atmospheric pressure at temperatures below the boiling point, the vapor pressure is dependent upon the temperature. The molecules in the liquid have energy to escape the surface of the liquid and become a gas molecule. As the temperature closes in on the boiling point, more molecules will have the energy to escape the surface of the liquid.

Boiling point changes with change of pressure, lower the pressure lower will be the boiling point of the liquid.

8.2.5(b) Explains the critical point of a gas

The term "critical point" is sometimes used to specifically denote the vapour–liquid critical point of a material, above which distinct liquid and gas phases do not exist. As shown in the diagram in Part D, this is the point at which the phase boundary between liquid and gas terminates. In water, the critical point occurs at around 647 K (374 °C; 705 °F) and 22.064 MPa.

8.2.5(c) Explains the relationship between temperature and enthalpy for the various states of aggregation

"When heat is added to a condensed-phase substance, its temperature increases until a phase change temperature is reached. With further addition of heat, the temperature remains constant while the phase transition takes place. The amount of substance that transforms is a function of the amount of heat added. After the transition is complete, adding more heat increases the temperature. In other words, the enthalpy of a substance changes isothermally as it undergoes a physical change. The enthalpy change resulting from a phase transition is designated ΔH. There are four types of enthalpy changes resulting from a phase transition:

- Enthalpy of transformation. This applies to the transformations from one solid phase to another, such as the transformation from α-Fe (bcc ferrite) to -Fe (fcc austenite). The transformation is designated ΔHtr.
- Enthalpy of fusion or melting. This applies to the transition of a solid to a liquid and is designated ΔHm.
- Enthalpy of vaporization. This applies to the transition of a liquid to a vapor and is designated ΔHv.
- Enthalpy of sublimation. This applies to the transition of a solid to a vapor and is designated ΔHs.

The heats of phase transitions are called latent heats (for example, latent heat of fusion).

8.2.5(d) Explains the different curves and lines of a Mollier diagram

Enthalpies are normally tabulated for saturation conditions; however, for other conditions the tables would be large and impractical. For this reason, diagrams are used in which enthalpy is plotted on the x-axis and absolute pressures on the y-axis. These diagrams are called Mollier diagrams or pressure-enthalpy diagrams. The absolute pressure is normally plotted on a logarithmic scale.

Figure in Part D shows part of a Mollier diagram for propane. The curved line running from the bottom left up to the right is called the saturated liquid line. The line then turns downwards and the darker shade is called the saturated vapour line. The area enclosed by the saturated liquid line and the saturated vapour line indicates mixtures of liquid and gas. The area to the left of the saturated liquid line indicates sub-cooled liquid and the area to the right of the saturated vapour line indicates superheated vapour where the General Gas Equation PV = mRT applies. The horizontal distance between the saturated liquid line and saturated vapour line denotes latent heat, i.e. the difference in enthalpy between the saturated liquid and saturated vapour. As can be seen, the latent heat decreases when the pressure increases until it is zero at the critical point. The diagonal curved lines indicating m3/kg denote specific volume, which is the volume of a substance per unit weight.

The broken lines running through one temperature are lines of constant temperature in °C.

The thin dark lines run through points of constant entropy and are given in kilojoules/kilogram/ °C (kj/kg/ °C). Lines of constant entropy indicate the increase in heat content when the gas is compressed, and such lines show adiabatic compression. Actual compression differs from this curve due to various losses.

The dark-and-light thick lines in the area between the saturated liquid line and the saturated vapour line run through points having the same dryness fraction (X). The dryness fraction denotes the ratio between gas and liquid, i.e. X = 0.4 means that 40% of the substance is gaseous and 60% is liquid.

8.2.6Dew point and bubble point

8.2.6(a) Explains equilibrium curves for propane/butane mixtures at atmospheric pressure.

The two curves of given in figure in Part D are the bubble points and dew points respectively of the mixture over the whole range from pure propane (zero of the less volatile component) to pure (100 per cent of the less volatile component). It will be noted that at the two extremes, pure material, the bubble points and 'dew points become coincident. Interpreting the diagram, it can be seen that a liquid mixture of composition A will start to boil at its bubble point of -32.50C but can only completely vaporize in equilibrium with its vapour provided the temperature rises to -10°C.

Similarly a vapour mixture of composition B will start to condense at its dew point of -3°C but can only condense completely with a fall in temperature to -25°C.

A further use of such diagram is the estimation of the differing proportions of the components to be found in the liquid mixture and in its equilibrium vapour mixture. Taking again the liquid of composition A we will assume that it is carried fully refrigerated at its initial bubble point of -32.5C. At this temperature, the vapour composition which will be in equilibrium with the liquid is given by C.

8.2.7 Critical temperature of gases and pressure

The critical temperature of a gas is the temperature above which it cannot be liquefied no matter how great a pressure is applied. The critical pressure of a gas is the pressure required to compress the gas to a liquid state at the critical temperature.

8.2.8 Flash point and upper and lower explosive limits, auto-ignition temperature

The flash point of a liquid is the lowest temperature at which the liquid will produce sufficient vapour to form a flammable mixture in air. The flammable range is the upper and lower portions of vapour to air to support combustion. The auto-ignition temperature is the temperature a vapour must be heated to ignite spontaneously.

8.2.9 Compatibility, reactivity and positive segregation of gases

Some chemical gases may react in chemical reactions if accidently mixed. Material Data Sheets and manufacturer's information provides information on compatibility and tank cleaning requirements. Incompatible cargoes must be physically isolated to prevent mixing

8.2.10 Polymerization

Polymerization occurs when a single monomer reacts with another molecule to produce a long chain polymer. This may occur spontaneously or in the presence of a catalyst generating a significant amount of heat. Polymerization can be prevented or delayed by adding a suitable inhibitor to the cargo.

8.2.11 Saturated vapour pressure/reference temperature

The pressure exerted by a saturated vapor at a particular temperature is the saturated vapour pressure for that substance. A saturated vapour is a vapour in equilibrium with its liquid. When a liquid boils, the vapour pressure is equal to the pressure of the liquid. By varying the pressure above a liquid, the liquid boils at varying temperatures.

8.2.12 Lubrication of compressors

Hydrocarbon gases can dissolve in lubricating oil which can result in inadequate lubrication of compressors. In addition, liquefied gases have poor cooling properties and can cause heat build-up in bearings if mixed with lubricating oil. This is particularly true in older compressors which may not be of an oil-free type. Consequently, lubricating oil must be compatible with the cargo and changed if necessary.

8.2.13 Hydrate formation

Hydrates can form in LPG in the presence of free water. LPG hydrates are white crystalline solids which may block filter and valves or damage pumps. Hydrate inhibitors such as methanol may be used with the permission of the shipper.

8.3 The properties of single liquids

8.3.1 Explains evaporation

The evaporation is termed as the transition of molecules from a liquid to a vapor state; the molecules on a surface are usually the first to undergo a phase change.

The average energy of the particles in a liquid is governed by the temperature. The higher the temperature, the higher is the average energy. But within that average, some particles have energies higher than the average, and others have energies lower than the average. Some of the more energetic particles on the surface of the liquid can be moving fast enough to escape from the attractive forces holding the liquid together. They evaporate.

8.3.2 Explains vapour pressure

If two barometer tubes say A and B are immersed in a Mercury reservoir. The space above the Mercury in both the tubes is in vacuum. If water is introduced into B, then water being lighter than Mercury rises to the top and evaporates. The level of the Mercury in tube B falls in proportion to the vapour pressure of the water vapour above the Mercury. The water vapour in B is unsaturated vapour pressure.

Now if more water is introduced into tube B until a stage is reached when no more water evaporates into the space, it can be said the space is saturated with water vapour. The pressure exerted by the water vapour is now called the saturated vapour pressure and the difference in level between tubes A and B represents it.

Unsaturated Vapour and Saturated Vapour pressure

Vapour in the space above a liquid is not static since liquid molecules are constantly leaving the surface of the liquid to enter the vapour phase and vapour molecules are returning to the liquid phase. The space is said to be unsaturated with vapour at a particular temperature if the space can accept more vapour from the liquid at that temperature. A saturated vapour at any temperature is a vapour in equilibrium with Liquid at that temperature.

8.3.3 Explains liquid and vapour densities

The density of a liquid is defined as the mass per unit volume and is commonly measured in kilograms per cubic decimeter (kg/dm3). Alternatively, liquid densities may be quoted in kg/litre or in kg./m3.

The change of density of a liquefied gas in equilibrium with its vapour as temperature varies is shown in the graph appended in Part D. The liquid density decreases markedly with increasing temperature. This is due to the comparatively large coefficient of volume expansion of a liquefied gas.

The liquefied relative density of a liquefied gas is the ratio of its density relative to the density of water at their atmospheric boiling points.

All liquefied gases with the exception of chlorine, have a liquid relative density less than one. This means that in the event of spillage into water these liquids will float prior to evaporation.

Vapor density
Weight of a unit volume of gas or vapor compared to (divided by) the weight of an equal volume of air (or, sometimes, hydrogen). Substances lighter than air (such as acetylene, methane, oxygen) are said to have vapor densities less than 1.0 and substances heavier than air (such as butane, chlorine, ethane) are said to have vapor densities higher than 1.0. Whereas all gases and vapors mix with air, the lighter substances tend to rise and dissipate, and the heavier substances tend to concentrate in low places along floors, sewers, trenches and may create fire and health hazards

8.4 The nature and properties of solutions

8.4.1 Explains density of gas solution

The density of a solution is the sum of mass concentrations of the components of that solution. The density of a solution of gases will be different from the density of the individual components.

If the percentage by volume of components of a gas solution is known, it is possible to perform a variety of calculation using the following relationship to arrive at the relative density of the solution.

Molecular mass of gas in solution M1V1/100

Where

i) M1 - components molecular mass
V1 = percentage by volume of components.

ii) Percentage by mass
Percentage by mass of component = M1V1/Mmix
Where Mmix = molecular mass of gas mixture.

iii) Relative Vapour Density
Relative vapour density of a gas mixture
(at 0°C and 1 bar) = Mmix/Ma
Where Ma = Molecular mass of air

8.4.2. Explains Vapour Pressure of Gas Solutions

Dalton's Law explains why the total pressure of a mixture of different gases in a closed container if the sum of the pressure each gas would exert if it occupied the space alone at the temperature the mixture. The pressure which each component exerts is called its partial pressure and the pressure exerted upon the walls of the enclosing space or at any point within the space is the sum of the partial pressures of the components. Based on this law, a calculation can be done to determine the SVP of a "Mix" cargo. Once the SVP of the "Mix" is obtained at two separate temperatures, this information can be plotted on a graph of Vapour Pressure against Temperature to derive data such as boiling point of the "Mix" and SVP at carriage Temperature.

8.5 Thermodynamic units

There are two types of thermodynamic units; fundamental or derived.

8.6 Basic Thermodynamic laws and diagrams

8.6.1. Explains the first and second laws of thermodynamics

The First Law of Thermodynamics

This explains why the heat lost from source is equal to the total of heat gained and work done on the bodies receiving the heat. This law introduces the equivalence of heat and work as forms of energy.

The importance of the First Law to re-liquefaction systems is that the sum of the heat and work put into the boil off must be equal to the heat rejected to the sea to maintain cargo temperatures and pressures. The work done by the compressor in compressing the gas can be taken as the addition of an equivalent amount of heat.

The second Law of Thermodynamics

This stated that heat always flows from a hot body to a cooler one and is of fundamental significance to liquefied gas carriage. It explains why heat will not transfer up the gradient of temperature of its own accord. This does not mean that heat cannot be made to transfer up the gradient of temperature. It can, but in order to facilitate the transfer, external energy is required.

If the temperature of the sea or air is above cargo temperature heat will flow into the cargo until the temperatures are equal. One purpose of the cargo tank insulation is to reduce the amount of heat that leaks into the cargo"

8.6.2 Explains the gas laws and states their limitation in practical use

8.6.2(a) Defines the general gas equation and states its limitation in practical use

THE GAS LAWS

There are many laws which describe the behavior of gases. A gas which obeys them exactly is called a perfect gas Typical cargo gas obey these laws quite closely.

(i) BOYLE'S LAW explains why at constant temperature, the volume of a given mass of gas varies inversely to its absolute pressure. If, in a process, a perfect gas at constant temperature changes from initial pressure and volume P1 and V1 to final pressure and volume P2 and V2, then by Boyle's Law and

(ii) CHARLE'S LAW explains why the volume of a given mass of gas at constant pressure varies in proportion to its absolute temperature. If the initial and final volumes of gas are V1 and V2 and initial and final temperature are T1 and T2 we get:

(iii) THE GENERAL GAS EQUATION is derived by combining the above laws and is stated as -
$(P1.V1)/ T1= (P2.V2)/ T2$
Or
$PV=nRT$

Even at ordinary temperatures and pressures, real gases can deviate slightly from the ideal value. The effect is much greater under more extreme conditions,
The non-ideal behavior gets worse at lower temperatures.
The non-ideal behavior gets worse at higher pressures.

8.7 Properties of materials

The materials used in the construction of gas carriers have various chemical and mechanical properties which impact the design of the hull, containment system and cargo handling systems

8.8 Effects of low temperature – brittle fracture

The accidental release of a liquefied gas on the hull structures not designed for cryogenic temperatures will convert the metal to a brittle state and crack.

9.0 Safety Data Sheets (SDS)

The health risks and environmental hazards of liquefied gases are described in their SDS.

TOPIC 3 HAZARDS AND CONTROL MEASURES

10.0 Knowledge and understanding of the hazards and control measures associated with liquefied gas tanker cargo operations

10.1 Explains the effect of increasing and decreasing the proportion of oxygen on the flammable limits

Using a flammability diagram appended in Part D show when the initial condition in the tank is with more oxygen the flammable range is more, correspondingly when the oxygen percentage reduces the flammable range reduces.

10.2 Explosion

10.2(a) Explains stoichiometric point

Stoichiometric point: It is defined by the stoichiometric concentration of fuel in pure oxygen for the complete combustion of the fuel (all carbon in the fuel is converted to carbon dioxide).

10.2(b) Describes effects of an explosion occurring above and below the stoichiometric point

If an explosion occurs anywhere above the stoichiometric point the entire fuel will not be consumed If an explosion were to occur below the stoichiometric point on the flammability diagram, it would be a low level explosion as the hydrocarbon quantity is less. An explosion on the stoichiometric point is a powerful explosion consuming most of the fuel and oxygen inside the tank.

10.2(c) Explains the occurrence of primary and secondary explosions

If an explosion occurs anywhere above the stoichiometric point the entire fuel will not be consumed and there is bound to be a secondary explosion inside the tank if air enters the tank after a first explosion. If an explosion were to occur below the

stoichiometric point on the flammability diagram, it would be a low level explosion as the hydrocarbon quantity is less and unless more hydrocarbons enter the tank from some other source there will only be a single explosion.

10.3 Toxicity

Chemical gases can be toxic causing damage to living tissue. Threshold Limit Values (TLV) have been established and are found in the Safety Data Sheets (SDS)

10.3(a) Lists and describes the criteria by which toxicity is measured and expressed

The assessment of toxicity involves two factors Concentration of substance and Period of exposure

The definition of toxicity based on concentration is quantitative. LC is the lethal concentration, stated in milligrams of poison per kilogram body weight, for fifty percent of the test population after continuous exposure for forty-eight hours. This definition does not indicate the carcinogenic and immunosuppressive effects of the substance. The definition of toxicity based on time element defines acute and chronic toxicity. Acute toxin causes injury following a single exposure to the substances or a short term exposure to the substance for a period not exceeding ninety six hours. Chronic toxin causes injury following daily administrative or continuous exposure for at least ninety days. It should be noted that all values of toxicity are based on studies conducted on laboratory animals and organisms.

Threshold limit value (TLV)

TLV refers to the air borne concentration of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect. Because of the wide variations in individual susceptibility, however, a small percentage of workers may experience discomfort from the substances at concentrations at or below the TLV; a smaller percentage may be affected more seriously by aggravation of pre-condition or by the development of occupational illness. TLV is usually stated in parts per million (ppm). Those limits are intended for use in work environments, as guidelines. It must be kept in mind that these limits are not fine lines between safe and dangerous concentrations nor are they a relative index of toxicity.

a) Threshold limit value_— Time weighted average (TLV-TWA)
   is the time weighted average concentration for a normal 8-hour workday and a forty hour work week, to which all workers may be repeatedly exposed, day after day, without adverse effect.
b) Threshold limit value — Short term exposure limit (TLV — STEL)
   the concentration to which workers can be exposed continuously for a short period of time without suffering from irritation, chronic or irreversible tissue damage, narcosis of a sufficient degree to increase the likelihood of accidental injury, impair self-rescue or materially reduce work efficiency, and provided that the daily TLV - TWA is note exceeded. It is not a separate independent exposure limit but it supplements the TWA limit wherever there are recognized

acute effects from a substance whose toxic effects are primarily of a chronic nature. STELs are recommended only where toxic effects have been reported from high short term exposures in either humans or animals.
A STEL is defined as a fifteen minute TWA exposure which should not be exceeded at any time during a workday even if the eight hour TWA is within the TLV-TWA. Exposures above the UV-TWA up to the STEL should not be longer than fifteen minutes and should not occur more than four times per day. There should be at least sixty minutes between each successive exposure in this range. An averaging period more than sixty minutes may be recommended when this is warranted by observed biological effects. .

c) Threshold limit value — Ceiling (UV-C) - is the concentration that should not be exceeded during any part of the working exposure.

10.3(b) Explains asphyxia and its symptoms

Asphyxia
The human body requires air with its normal content of 21 percent of oxygen for breathing, although an atmosphere with somewhat reduced percentage of 19% is breathable.

Where entry into a compartment with insufficient oxygen is absolutely necessary, personnel must be protected by a breathing apparatus and company's SMS procedures strictly followed

10.3(c) Explains anesthesia and its symptom

Anesthesia: In layman's terms this means loss of consciousness. A person inhaling certain vapours (e.g. ethylene oxide) may lose consciousness because of their effects upon the nervous system. The unconsciousness person may react to sensory stimuli but can only be roused with great difficulty. The symptoms of anesthesia are as follows: The patient looks though he is asleep, but does not awaken when rousing stimuli is applied. The muscles usually feel flabby, but on certain occasions they may feel tense. The pulse may be either rapid or slow, but in serious cases it will be weak or irregular. Breathing may be normal but it is often slow and shallow. If pupils do not react to light, it is a sign of deep coma. Body temperature may become low if the patient has been unconscious for several hours.

10.3(d) Describes how combustion of cargo products or construction ` materials may produce toxic products

It is important to bear in mind the toxicity of fumes/smoke given off when certain products used in accommodation and electrical fittings burn, and it is therefore necessary to protect fire-fighters by the use of breathing apparatus.

The following table gives examples of the toxic products given off by the combustion of materials commonly found in ship's accommodation.

Burning material and Toxic Products

- Any combustible material (all contain carbon): CO and CO2
- Polyurethane: Nitrogen oxides

• Wool, silk, plastics containing nitrogen: Hydrogen cyanide
• Cellulose, plastics, rayon: Formic and acetic acid
• Wood, paper: Acrolein (tear gas)
• Rubber: Sulphur dioxide
• PVC fire retardant plastics: Halogen acids and phosgene
• Melamine, nylon, urea formaldehyde plastics: Ammonia
• Phenol formaldehyde, (Bakelite): Aldehydes
• Polystyrene: Gasoline
• Polyurethane foam: Iso-cyanates

10.3(e) Defines acute and chronic effects of toxicity, systemic poisons and irritants

Toxicity based on time element defines acute and chronic toxicity. Acute toxin causes injury following a single exposure to the substances or a short term exposure to the substance for a period not exceeding ninety six hours. Chronic toxin causes injury following daily administrative or continuous exposure for at least ninety days. It should be noted that all values of toxicity are based on studies conducted on laboratory animals and organisms.
Systemic poisons and irritants create dysfunctions of the nervous, circulatory, digestive systems

10.4 Reactivity

10.4(a) Explains self-reaction and lists gas cargoes that may self- react

The Globally Harmonized System (GHS) defines self-reactive substances and mixtures as follows: self-reactive substances and mixtures are thermally unstable liquid or solid substances or mixtures liable to undergo strongly exothermic decomposition even without the participation of oxygen (air).Self-reactive chemicals and mixtures are found as gases, liquids, and solids. These chemicals may be pure products, diluted in other materials to make them more stable or inhibited to delay reactivity. Examples of chemicals that may be self-reactive include, but are not limited to those with weak and/or strained bonds.

10.5 Corrosivity

Some gases such as ammonia are corrosive to specific materials. The design of ships carrying these corrosive cargos must be approved for these gases. Special requirements are listed in Chapter 17 of the IGC Code.

10.6 Health hazards

10.6(a) Describes modes by which liquefied gas cargoes and their vapours may be toxic

Some cargoes are toxic and can cause a temporary or permanent health hazard, such as irritation, tissue damage or impairment of faculties. Such hazards may result from skin or open-wound contact, inhalation or ingestion.

Contact with cargo liquid or vapour should be avoided. Protective clothing should be worn as necessary and breathing apparatus should be worn if there is a danger of inhaling toxic vapour. The toxic gas detection equipment provided should be used as necessary and should be properly maintained.

10.6(b) Describes toxic properties of inhibitors

Some inhibiter used in Gas cargo may be toxic, precaution when handling this inhibited cargo or the inhibitor itself must be taken

10.6(c) Explains frost-bite and its symptoms

Liquefied gases and their vapours may be at very low temperature when compared with human body temperature. Skin contact with such liquids or vapors can lead to frostbite (cold burns).
The symptoms of frostbite are:

- The skin initially reddens and then whitens.
- The affected area is usually painless.
- The affected area feels hard to touch.
- Patient suffers from confusion/agitation/fainting.
- If the affected area is not treated soon, death of tissue (gangrene) may occur

10.6(d) Explains chemical burns and lists cargoes caustic to human skin

Chemical burns can be caused by; ammonia, chlorine, ethylene oxide and propylene oxide and certain other chemical gases. The symptoms are similar to heat burns, excepting that the product may be absorbed through the skin causing toxic side-effects. Chemical burns can seriously damage the eyes.

Symptoms: A burning pain with redness of the skin; an irritating rash; blistering or loss of skin; toxic poisoning (see later). Be sure you know where eye-baths and showers are located.

Chemical burns treatment:

- remove patient from source of contamination- including clothing
- attend first to the eyes and skin
- wash the eyes thoroughly for a minimum of fifteen minutes with large amounts of fresh water
- wash the skin thoroughly for a minimum of fifteen minutes with large amounts of fresh water
- seek urgent medical/first-aid attention

10.7 Inert gas composition

The main hazard associated with inert gas is its low oxygen content. However, inert gas produced by combustion, either in a steam raising boiler or in a separate inert gas generator (flue gas), will contain trace amounts of various toxic gases that may

increase the hazard to personnel exposed to it. Precautions necessary to protect personnel against the toxic components of inert gas during tank entry must be taken.

However, these precautions do not include requirements for the direct measurement of the concentration of the trace constituents of flue gas. This is because gas freeing the atmosphere of a cargo tank from a hydrocarbon gas concentration of about 2% by volume to 1% LFL, and until a steady 21% by volume oxygen reading is obtained, is sufficient to dilute these toxic constituents to below their TLV-TWA.

However the oil and gas industry strongly recommends measurement of toxic gases also and before man entry should be less than 50% OEL.

10.8 Electrostatic hazards

Static electricity can cause sparks capable of igniting flammable gas mixtures. An electrostatic charge can accumulate where conductors are insulated from each other. The cargo systems on gas carriers are bonded to the ship's hull to prevent this charge build up. Hoses are bonded to their flanges by a metal reinforcement, thus providing a continuous path to the manifold and hull. Proper maintenance of grounding arrangements is essential. The ship and shore should be electrically isolated using an insulating flange or length of non-conducting hose. In some cases, terminals may require the connection of a grounding cable to the ship prior to the start of cargo transfer. This procedure has fallen out of favor as the ship and cargo system is already grounded through the hull and the required diameter of the grounding cable is excessive as a result of the small difference in electrical potential. If a bonding cable is demanded, its connection should be well clear of the manifold. Only after the cable is connected, can a suitable switch on the jetty be closed to electrically connect the ship and shore.

10.9 Polymerizing cargoes

The polymerization process can be rapid and generate significant heat. During polymerization, the cargo becomes viscous making it un-pumpable. Inhibitors used to prevent polymerization can be toxic and if improperly added can cause the cargo to go off specification.

11 Explains theuse monitoring and gas-detection systems, instruments and equipment

11.1 Describes the uses of gas detection systems

There are two types of gas detection system commonly used on board LNG carriers, a sampling system and a gas detection system incorporating remote heads.

The sampling system draws gas samples from each monitored location into a central analyser located in a 'safe' area. Typically, samples will be drawn from cargo areas in a pre-programmed sampling sequence and will be passed through an infrared analyser. The system alarms if pre-set limits are exceeded.

Remote detector heads may also be used to monitor gas concentrations. The signal from flameproof infrared gas detectors will be passed to a central control unit having visual and audible alarm functions.

11.2 Describes, by means of a drawing, the procedure to calibrate a fixed gas detector

1. Gas Detector Bump Test

Before you use your instrument, it is important that you know that the sensor and alarms will function properly. The only way that you can be sure of this is to expose your instrument to a known concentration of gas and verify that it responds correctly. A bump test prior to each day's use assures you that your gas detector will save your life if you are in danger.

2. Gas Detector Calibration

Conditions such as temperature, humidity, age and gas exposure will all affect the output of the sensor. Calibrating the instrument compensates for these factors and guarantees that your readings are accurate. The highest accuracy is obtained by calibrating the gas detector on a regular schedule. Do this at least on a monthly basis. A minimum set of calibration gas bottles, spare sensors, and all spare parts required for Portable Gas Detectors Maintenance & Calibration should be always kept onboard in order to be always able to replace any deficient spare part on gas detectors or to be able to calibrate these detectors. It is also a good practice to have all these detectors in double in order that if one is unusable, there is a spare available. A vessel crew cannot perform any cargo tank inspection, enclosed space entry, deck cargo watch if no gas detector is available.

3. Review Data

Almost all gas detectors in use today provide some form of data logging. Information stored in your gas detector can provide keen insight into potential problems that may be hiding in your work environment. You may find cases of alarms with no reports or find conditions where gas concentrations exist just below the alarm thresholds of the instruments. Most data reviews take place only after an accident occurs. A weekly review of data gives you the opportunity to find potential danger points and correct them before tragedy strikes.

The instrument is set up in the factory to be calibrated using a specific hydrocarbon gas/air mixture. The hydrocarbon gas that should be used for calibration and testing should be indicated on a label fixed to the instrument. The accuracy of measurement equipment should be in accordance with the manufacturer's stated standards. Equipment should, on initial supply, have a calibration certificate, traceable where possible to internationally recognised standards. Thereafter, procedures for management of the calibration certification process should form part of the on board Safety Management System. These procedures may include on board calibration in line with the manufacturer's guidelines and/or equipment being periodically landed to a recognized testing facility for calibration, either on a timed basis, or during the

tanker's refit, or when the accuracy of the equipment is considered to be outside the manufacturer's stated accuracy.

Calibration certificates, showing the instrument's serial number, the calibration date and the calibration gas or the method of calibration used, together with reference to applicable standards, should be provided for retention on board.

Instruments are typically calibrated using a calibration gas consistent with the use of the instrument, such as propane or butane. The calibration gas used should be marked on the instrument

The use of an inappropriate gas for calibration could result in erroneous readings during operation, even though the instrument appears to be operating correctly.
Instruments should only be dismantled by persons who are qualified and certified to carry out such work.

Operational Testing and Inspection

Gas measuring instruments should be tested in accordance with the manufacturers' instructions before the commencement of operations requiring their use. Such tests are designed only to ensure that the instrument is working properly. They should not be confused with calibration (see Section 8.2.6 above).

Instruments should only be used if the tests indicate that the instrument is giving accurate readings and that alarms, if fitted, are operating at the pre-determined set points. Physical checks should include (if applicable):

• Hand pump.
• Extension tubes.
• Tightness of connections.
• Batteries.
• Housing and case.

Instruments not passing these operational tests should be re-calibrated before they are returned to operational use. If this is not possible, they should be removed from service and clearly labelled to denote that they are not to be used.

11.2(a) Performs Measurement of Oxygen Concentrations

A typical indicator draws the sample through a teflon membrane into a potassium chloride solution and activates a chemical cell. When the switch is closed current flows round the circuit and deflects the ammeter needle. The more oxygen absorbed by the solution the greater the current and needle deflection indicating the percentage oxygen in the sample.

11.2(b) Explains Calibration and Test Procedures of gas measuring instruments

The instructors to emphasize here that manufacturer's instructions must always be referred to and followed as procedure may vary from instrument to instrument.

Modern instruments can be electronically calibrated on supplying calibration gas. All fixed and portable oxygen analysers and gas measuring instruments should be tested and checked as required by the Company and/or manufacturer's instructions and should be operating correctly.

The in-line oxygen analyser/recorder and sufficient portable oxygen analysers should be working properly.

The calibration certificate should show that its validity is as required by the ship's SMS.

The basic electric circuit (Wheatstone Bridge) of the combustible gas indicator is shown in figure in Part D. Sample gas to be measured is aspirated over the specially treated sensor filament which is heated by the bridge current. Although the gas sample may be below the lower flammable limit, it will burn catalytically on the filament surface. In so doing it will raise the temperature of the filament and thereby increase its electrical resistance and so unbalance the bridge. The resultant imbalance current is shown on the meter and is related to the hydrocarbon content of the sample gas.

Perform the Voltage check and the Zero error checks, fit the required flow meter/ gas bag to release the test gas at rated flows as per manuals, measure the deflections and correct the span as per span gas % in the gas.

12.0 Knowledge and understanding of dangers of non-compliance with relevant rules / regulations

It is important that the Instructors expand more on this– mainly importance of complying with all rules and regulations. And explains to the trainees that these are made for our and environment's safety.

12.1 Explains the environmental damage that some gas cargoes like VCM and Ammonia causes to the marine environment as a result of blanketing, ingestion by sea organisms and the deterioration of amenities

The discharge overboard of VCM and ammonia washings may be prohibited in certain areas, and care should therefore be taken. The requirements of the control of pollution in Annex II of the MARPOL Convention should be observed. If discharged overboard, ammonia-contaminated washings should not be allowed to enter the ship's seawater intakes because ammonia is corrosive to copper-based alloys in the seawater system.

12.1(a) Explains greenhouse gases

Gases that trap heat in the atmosphere are called greenhouse gases. Human activities are contributing to climate change, primarily by releasing billions of tons of carbon dioxide (CO2), Methane (CH4), and other heat-trapping gases, known as greenhouse gases, into the atmosphere every year.

The global average temperature increased by more than 1.3°F over the last century. The average temperature in the Arctic rose by almost twice as much. The buildup of greenhouse gases in our atmosphere and the warming of the planet are responsible for other changes, such as:

- Changing precipitation patterns
- Increases in ocean temperatures, sea level, and acidity
- Melting of glaciers and sea"

12.2 Explains the health risks presented by liquefied gas cargoes

One objective of the IGC Code is to minimize the release of liquefied gas cargoes. Long term exposure to some cargoes can have a damaging effect on the crew. The use of the personnel protective equipment required by Chapter 14 of the IGC Code is intended to prevent these effects and should be used as appropriate.

12.2(a) Explains the meaning of toxic load

The toxicity expressed by a given substance in the air is influenced by two factors, the concentration in the air (c) and the duration of exposure (t). A functional relationship between c and t can be developed, such that the end product of this relationship is a constant:

$f(c,t) = constant$

This constant is known as the Toxic Load. In HSE, the Toxic Load relating to the Specified Level of Toxicity (SLOT) is known as the SLOT Dangerous Toxic Load or SLOT DTL. For a number of gases the relationship between c and t is simple.

This involves single exposure mortality data (usually LC50 tests over a known duration) designed to identify exposure conditions that produce mortality in 50% of a group of animals.
For the purpose of Risk Assessment, it is required to provide estimates of the extent (i.e. hazard ranges and widths) and severity (i.e. how many people are affected, including the numbers of fatalities) of the consequences of each identified major accident hazard. For an evenly distributed population, the number of fatalities resulting from a toxic release may be approximated by estimating the number of people inside the concentration contour leading to an LD50 dose."

12.3 Explains the legal consequences of non-compliance with MARPOL 7/78

Port State control authorities strictly enforce international pollution conventions. Violations can result in fines to the ship and imprisonment of the crew.

TOPIC 4: SAFE WORKING PRACTICES, INCLUDING RISK ASSESSMENT AND PERSONNEL SHIPBOARD SAFETY

13.0 Knowledge and understanding of safe working practices, including risk assessment and personal shipboard safety relevant to liquefied gas tankers

13.1 Precautions to be taken when entering enclosed spaces (such as compressor rooms), including the correct use of different types of breathing apparatus

Many of the casualties that have occurred in enclosed spaces on ships have resulted from people entering an enclosed space without proper supervision or adherence to agreed procedures.

The rapid rescue of personnel who have collapsed in an enclosed space presents particular risk. It is a human reaction to go to the aid of a colleague in difficulties, but far too many additional and unnecessary casualties have occurred from impulsive and ill-prepared rescue attempts.

It is the responsibility of the Company to establish procedures for safe entry of personnel into enclosed spaces. The process of requesting, raising, issuing and documenting permits to enter into an enclosed space should be controlled by procedures in the ship's Safety Management System (SMS). It is the Master's responsibility to ensure that the established procedures for entry into an enclosed space are implemented.

The Master and Responsible Officer are responsible for determining whether entry into an enclosed space may be permitted. It is the duty of the Responsible Officer to ensure:
- That the space is ventilated.
- That the atmosphere in the compartment is tested and found satisfactory.
- That safeguards are in place to protect personnel from the hazards that are identified.

That appropriate means for controlling entry are in place.

Personnel carrying out work in an enclosed space are responsible for following the procedures and for using the safety equipment specified.
Prior to entry into an enclosed space, a risk assessment should be completed to identify the potential hazards and to determine the safeguards to be adopted. The resulting safe working practice should be documented and approved by the Responsible Officer before being countersigned by the Master, who confirms that the practice is safe and in compliance with the ship's Safety management System. The permit, or other enabling document, should be sighted and completed by the person entering the space, prior to entry.

The controls required for safe entry vary with the task being performed and the potential hazards identified during the risk assessment. However, in most cases, an Entry Permit System will provide a convenient and effective means of ensuring and documenting that essential precautions have been taken and, where necessary, that

physical safeguards have been put in place. The adoption of an Entry Permit System, which may include the use of a check-list, is therefore recommended. Permission to continue work should only be given for a period sufficient to complete the task. Under no circumstances should the period exceed one day.

For entry purposes, steady readings of all the following should be obtained:

- 21% oxygen by volume by oxygen content meter*;
- not more than 1% of lower flammable limit (LFL) on a suitably sensitive combustible gas indicator, where the preliminary assessment has determined that there is potential for flammable gases or vapours; and
- not more than 50% of the occupational exposure limit (OEL) of any toxic vapours and gases.

Entry into a space that is not gas free or does not contain 21% Oxygen shall only be permitted in cases of an emergency or for unavoidable operational requirements.
Ships operators must be contacted and consent obtained after proper Risk assessment.

The number of persons entering the tanks shall be kept to a minimum required, but will normally be at least two, each wearing the appropriate PPE.

A stand by team and additional appropriate PPE equipped with the required rescue equipment shall be available outside the enclosed space in which entry has been made.

If entry is absolutely required without the tanks being gas free, or with the presence of gas in a tank for operational requirement following shall be completed prior to undertaking such an operation:

- Risk assessment and hazard identification.
- Plan for work including briefing the concerned personnel on the required precautions, proper techniques, PPE requirement and training.
- Emergency response plan shall be prepared in advance and approved by the Master.
- Suitable breathing apparatus, protective clothing and other equipment required for such entry shall be used by the persons entering the tank.

(Only persons suitably trained and capable of dealing with any unexpected event that may be encountered in the tank shall be sent for such an entry after making the supporting team stand by on the scene to assist the personnel in an unlikely event of an incident.).

13.1(a) Explains measures to minimize toxicity and other hazards

Before allowing access to the space, the Responsible Officer should ensure that:
- Appropriate atmosphere checks have been carried out.
- Piping, inert gas and ventilation systems have been isolated.
- Effective ventilation will be maintained continuously while the enclosed space is occupied.

- Fixed lighting, such as air-turbo lights, are ready for extended entry periods.
- Approved self-contained, positive pressure breathing apparatus and resuscitation equipment is ready for use at the entrance to the space.
- A rescue harness, complete with lifeline, is ready for immediate use at the entrance to the space.
- A fully charged approved safety torch is ready for immediate use at the entrance to the space.
- A responsible member of the crew is in constant attendance outside the enclosed space, in the immediate vicinity of the entrance and in direct contact with the Responsible Officer.
- All persons involved in the operation should be trained in the actions to be taken in the event of an emergency.
- Lines of communications have been clearly established and are understood by all concerned.
- Names and times of entry will be recorded and monitored by personnel outside the space.
- The personnel undertaking the task should ensure that such safeguards are put into effect prior to entering the space.
- Self-Contained Breathing Apparatus (SCBA).
  This consists of a portable supply of compressed air contained in a cylinder or cylinders attached to a carrying frame and harness worn by the user. Air is provided to the user through a face mask, which can be adjusted to give an airtight fit. A pressure gauge indicates the pressure in the cylinder and an audible alarm sounds when the supply is running low.
  Only positive pressure type sets are recommended for use in enclosed spaces because, as their name implies, these maintain a positive pressure within the face mask at all times.
- Air line breathing apparatus enables compressed air equipment to be used for longer periods than would be possible using self-contained equipment.

Formal procedures should be in place to control enclosed space entry. The procedure used should be based on a risk assessment, and should ensure that risk mitigation measures are followed and that entries into the space are recorded.

A communications system should provide links between the enclosed space, navigation bridge, engine room and cargo control room.

Arrangements should be established to enable effective communication to be maintained at all times between personnel within the space and those outside. Regular communication checks should be made a pre-agreed intervals and failure to respond should be a cause to raise the alarm.

VHF/UHF communication should not be used as a primary communication method where it is known that reception may not be reliable or practicable due to noise. Where communication by VHF/UHF is difficult, it is recommended that a standby person is positioned outside the enclosed space and that a visual and remote communication procedure if possible is put in place."

13.1(b) Explains the SCBA and Airline Breathing apparatus equipments and only positive type SCBA sets are recommended for use in enclosed spaces

"Breathing apparatus should be used as necessary by personnel engaged in cargo operation involving toxic cargoes, by fire fighters, and when entering as unsafe space. Tanks or compartments which are not gas-free, which are deficient in oxygen, or which contain smoke should not be entered unless absolutely necessary and then positive type of Self-contained breathing apparatus should he worn. The equipment may be self-contained, or supplied with fresh air via an extensive line through a filter of suitable capacity either from air bottles on deck, or a bellows or blower with its open end in clean air.

Breathing apparatus should always be used in accordance with manufacturer's instructions, and should be inspected before and after use of any damage or corrosion. Before the face mask as fitted, air should be blown through the lines briefly to clear any dust or dirt Care should be taken to ensure a gas-tight seal is obtained when the masks is fitted - this may be difficult if the wearer has a beard when the leakage can be up to 10%. If air bottles are used, care should be taken to ensure that these are full and that full spare bottles are available.

Breathing apparatus restricts the wearer's movements in enclosed spaces; if a SCBA is used, it may be difficult to pass through small openings. A lifeline should be fitted whenever possible 'when breathing apparatus is worn, and it is necessary to leave a space by the route taken on entry to avoid tangling the line; the same applied to air-line equipment. The precautions should be observed whenever such equipment is used in enclosed spaces.

All types of breathing apparatus should be examined and tested by a responsible officer at monthly intervals, and annually by an expert. Defects should be remedied promptly and a record kept of repairs. Air bottles should be refilled as soon as possible after use.
Breathing apparatus should be stowed fully assembled in a place where it is readily accessible to provide for emergencies in different parts of the ship.

Practical demonstration and training in the use of breathing apparatus should be carried out to give personnel experience in its use.

13.1(c) Lists the safeguards to be taken for entering a cofferdam, double bottom or other enclosed space

Cargo tanks, cargo piping and cargo equipment will contain cargo vapour unless they have been gas-freed or inert gas unless they have been ventilated.
Other parts of the cargo system may contain inert gas. Care should be taken to ensure that oxygen levels in the space are safe before personnel enter without breathing apparatus.

Cargo equipment may contain cargo vapour or inert gas. It is important to ensure that such equipment has been adequately ventilated before it is opened up for maintenance.

When ventilating membrane cargo systems, care should be taken to ensure that manufacturers' instructions on differential pressures are observed, otherwise damage may occur.

No cofferdam, ballast tank, peak tank, fuel or lubricating oil tank, fresh water tank, duct keel, void space, access trunk, or any other enclosed space should be entered unless the precautions are strictly observed and permits issued.

Cargo Pump or Compressor Rooms, Motor Rooms and Air Locks

The following precautions are additional to those stated above:

Ventilation fans should be run continuously for at least 10 minutes before cargo operations begin, and throughout their duration. Fans should also be run continuously when leakage of vapour or liquid into the space is suspected.

Safety interlocks are provided to ensure that no machinery can be started until the ventilation system has been operating for at least 10 minutes, long enough to have dispersed any toxic or flammable vapour that may have collected in cargo pump rooms or compressor rooms, and to build up sufficient pressure in motor rooms and air locks. Loss of ventilation pressure can cause shutdown of equipment.

Regular inspections should be undertaken of inlet and outlet grilles to ensure that they have not become obstructed

13.2 Precautions to be taken before and during repair and maintenance work, including work affecting pumping, piping, electrical and control systems

After inerting the system to a safe cargo vapour concentration (see data sheets), it may be necessary to ventilate the system with air to provide safe access for inspection or repairs. Venting with air should be continued until an oxygen content of 21% by volume is obtained. Samples should be taken at various levels, and sampling repeated sometime after the first acceptable readings are obtained, to allow possible pockets of inert gas to mix with the air, and the consequent reduction in oxygen content to be detected before tanks are entered.

When a tank and associated pipelines have been certified gas-free maintenance work may take place Work planning meetings should be held to ensure that operations and maintenance tasks are correctly planned and managed with the aim of completing all tasks safely and efficiently. These meetings may include discussion of:
- Risk assessments.
- Work permits.
- Isolation and tagging requirements.
- The need for safety briefings, tool box talks and correct procedures.

The format and frequency of work planning meetings should be in accordance with the requirements of the company's SMS, and will be determined by the ship's activities.

The instructor should mention here that using lock out/tag out when working on pipelines and other equipment should be done in compliance with the operator's safety management systems.

It may be appropriate to have two levels of meetings – one on a management level and one that addresses the practical issues associated with carrying out specific tasks A hazardous task is defined as a task, other than Hot Work, which presents a hazard to the ship, terminal or personnel, the performance of which needs to be controlled by a risk assessment process, such as a Permit to Work system.

Hot work Permits are required to be made in compliance to company SMS procedures where safe and hazardous areas have been classified. Restrictions if any are to be strictly complied with.

It follows that, for each hazardous task, a work permit or controlled procedure should be developed and approved.

The procedure, approval and record of compliance should be retained within the SMS records. Hazardous tasks should only be carried out alongside a terminal with prior agreement of the Terminal Representative.

Examples of such tasks are:
- Enclosed space entry.
- Tank inspections.
- Diving operations.

On LNG ships using cargo boil-off as fuel, the ventilation equipment in the gas supply system should be running before gas is allowed to pass to the machinery space. All detection equipment in the supply system and machinery space should be working before gas supply begins.

If a gas leak is detected, the gas supply should be stopped until the leak has been repaired.

13.2(a) Describes permit to work system

Permit to Work systems are widely used throughout the shipping industry. The permit is essentially a document which describes the work to be done and the precautions to be taken in doing it, and which sets out all the necessary safety procedures and equipment.

For operations in hazardous and dangerous areas, permits should normally be used for tasks such as:
- Hot Work.
- Work on electrical equipment.
- Diving operations.
- Heavy lifts.

The permit should specify clearly the particular item of equipment or area involved, the extent of work permitted, the conditions to be met and the precautions to be

taken and the time and duration of validity. The latter should not normally exceed a working day. At least two copies of the permit should be made, one for the issuer and one for the person at the work site.

The layout of the permit should include a check-list to provide both the issuer and the user with a methodical procedure to check that it is safe for work to begin and to stipulate all the necessary conditions. If any of the conditions cannot be met, the permit should not be issued until remedial measures have been taken.

It is advisable to have distinctive Permit to Work systems for different hazards. The number of permits required will vary with the complexity of the planned activity. Care must be taken not to issue a permit for subsequent work that negates the safety conditions of an earlier permit.

For example, a permit should not be issued to break a flange adjacent to an area where a Hot Work permit is in force.

Before issuing a permit, the responsible officer must be satisfied that the conditions at the site, or of the equipment to be worked on, are safe for the work to be performed, taking due account of the presence of any ships that will be alongside while the work is being carried out.

While companies will develop their own procedures for managing all aspects of operations and tasks undertaken, many operators choose to incorporate a Permit to Work system into their SMS in order to manage hazardous tasks.

A Permit to Work system is a formal written system that is used to control certain types of work. It delivers a risk based approach to safety management and requires personnel to undertake and record risk assessments in the development of a safe system of work.

Guidance for establishing a Permit to Work system is contained in a number of publications issued by industry organizations and various international safety bodies.

Precautions for cold work and hot work procedures given in the safety guide (LGC) must be followed.

13.3 Precautions for hot and cold work

The implications of hot work and safety measures necessary will be governed by local regulations when such work is to be undertaken in port.

Hot work should not be permitted unless the immediate vicinity and adjacent compartments are certified gas-free. Hot work includes welding, burning, brazing, chipping, caulking and the use of gas torches to heat impellers, rotors etc. as an aid to other work.

Adequate ventilation should always be provided, and special care taken when hot work is to be undertaken near combustible materials, which should either, be protected against heat or removed. Materials such as polyurethane used for tank

insulation produce toxic and asphyxiating vapour if they catch fire. Hot work should not be carried out near such materials unless a qualified fireman is in attendance and suitable fire-fighting and escape apparatus is immediately available.

All equipment which is to be opened up for repair or maintenance should be checked internally for the presence of flammable or toxic vapours or inert gas, and should be purged if necessary before work proceeds.

Before hot work is undertaken, it should be recognised that stress relief may be necessary on completion of work before some materials can be used for their intended duty.

The frequency of atmosphere monitoring must be established. Atmospheres should be re-tested at regular intervals and after each break in work periods. Checks should be made for flammable vapours or liquids, toxic gases or inert gas from non-gas free spaces.

Welding and other equipment to be used should be carefully inspected before each occasion of use to ensure that it is in good condition. Where required it must be correctly earthed. Special attention must be paid to electric-arc equipment to ensure that:

- Electrical supply connections are made in a gas-free space;
- Existing supply wiring is adequate to carry the electrical current demanded without overloading and consequent heating;
- Flexible electric cables laid across the deck have sound insulation; and
- The cable route to the worksite is the safest possible, only passing over gas-free or inerted spaces

Only under exceptional circumstances should any hot work, or cold work involving the use of power tools, be undertaken either on board or within the vicinity of the ship whilst alongside. In the unlikely event that such work must be carried out the most stringent safety precautions and procedures should be drawn up and rigidly adhered to. Under these, and similar, circumstances a Permit to Work system, agreed between the ship, the terminal and, where necessary, relevant port authorities, should be established The Permit should cover a limited period and the terms and conditions for which it was issued should be rigidly enforced.

13.4 Precautions for electrical safety

Electrical instruments used for essential purposes in hazardous areas should be of flameproof and intrinsically safe design. The use of wandering electric power leads should not be permitted.

Electrical sparks may occur when making or breaking cargo connections between ship and shore if the cargo connection hose or hard arm provides an electrically path between ship and jetty structures. A bonding cable / insulating flange is used as a precaution against this hazard. The instructor should state here that bonding cable although may be required by some terminals, is strongly discouraged as its improper use may create an additional hazard in itself.

Electrical current flows through this path due to differences in the electrolytic. Many sources of ignition are eliminated by the ship's design and care should be taken to ensure that design features are not impaired in anyway Other sources of ignition have to be excluded by correct operational practices

Static electricity can arise when liquids or gases are pumped at high velocity. Non-conducting liquids (static accumulators), emulsions, carbon dioxide and steam are common sources of static electricity. In general terms, static generation increases with the velocity of flow. The removal of clothing in hazardous areas, particularly in dry atmosphere conditions can also give rise to static discharge Helicopters are also efficient static generators, the risk being greatest in dry atmospheric conditions. Immediately before approaching any ship for winching or landing, it is generally recommended that the helicopter should drop at earthing cable into the sea to dissipate any static charge it advance.

13.5 Use of appropriate Personal Protective Equipment

Appropriate protective clothing should be worn to protect individuals involved in cargo operations. Gloves should be worn when handling cold equipment or valves. Face shields should be worn where there is a danger of liquid release such as when dismantling cargo equipment or flanges. Respiratory protection is required during cargo operations involving toxic or asphyxiating gases. It should be noted that cargo vapour can be absorbed into working clothing in sufficient quantities to create a hazard near an open flame.

13.6 Precautions for cold burn and frostbite

Contact with cryogenic liquids can cause freezing of tissue. Treatment should be started as soon as possible. To rewarm the victim, remove cold wet clothing and constricting items and warm the affected area in warm water at about 42^0C. Never use dry heat. Thawing may take from 15 to 60 minutes and should be continued until the pale blue color of the skin turns to pink or red. Avoid bending joints or massaging of the flesh. After re-warming, gently cleanse the affected area with soap and water and apply a sterile dressing.

13.7 Proper use of personal toxicity monitoring equipment

Toxicity gas detectors usually operate on the principle of absorption of the toxic gas in a chemical tube which results in a colour change. Immediately prior to use, the ends are broken and inserted into a bellows unit and a sample aspirated through it. The reaction between the gas being sampled and chemical contained in the tube causes a colour change. Usually readings are taken from the length of the stain against the indicator scale on the tube. The tubes have a shelf life and their accuracy may be affected by the presence of other gases which are noted in the instructions provided with tubes. When using this type of instrument, it is important to aspirate the bulb properly to obtain a full sample. Electronic monitoring equipment may also be available which should be calibrated and used in accordance with the manufacturer's instructions.

TOPIC 5: EMERGENCY PROCEDURES

14. Knowledge and understanding of liquefied gas tanker emergency procedures

14.1 Ship emergency response plans

Effective emergency response requires an emergency organization around which procedures may be developed. This emergency response organization generally consists of the following:

a) Emergency Command Center
b) Emergency Party
c) Back-up Emergency Party
d) Engineers Group

Incident plans should then be developed to address a variety a scenarios and drills conducted to exercise the plan.

14.2 Emergency cargo valve operation

In event of a serious incident associated with cargo transfer it is essential to stop the cargo flow. This is accomplished using the Emergency Shutdown System (ESD) installed on both the ship and terminal. In many cases there is a link between the ship and shore ESD systems so that they are operated in a coordinated fashion. These systems are generally tested before arrival and in the case of linked systems before the start of cargo transfer. To ensure proper operation of the ESD system, communications between the ship and terminal is essential during cargo transfer; however, the ship's officers should not hesitate in activating the ESD if there is an emergency and communication with the terminal cannot be established.

14.3 Emergency cargo valve operations

The activation of the ESD can cause pressure surges in the ship and terminal piping systems. To avoid these pressure surges, the closure time of the ESD manifold valves can be adjusted. Information on the closure time should be exchanged with the terminal to set the proper closure time.

Hard arms for liquefied gases are normally fitted with an over-travel alarm system. Once the motions of the ship approaches the operating envelop for the terminal hard arms an ESD may be activated. In some cases, the hard arms are fitted with and Emergency Release System (ERS) which will automatically disconnect the arm with an insignificant amount of spillage should the operating limits of the hard arms be exceeded.

14.4 Actions to be taken in the event of failure of systems or services essential to cargo operations

14.4(a) Describes action to be taken in the event of a failure of Anti-surge system

Where valves are fitted and used, the cargo handling rate should be so adjusted that a pressure surge evolving from the automatic closure of any such valve does not exceed the safe working pressure of either the ship or shore pipeline system.

Alternatively, means may be fitted to relieve the pressure surge created, such as recirculation systems and buffer tanks.

A written agreement should be made between the ship and shore supervisor indicating whether the cargo handling rate will be adjusted or alternative systems will be used; the safe cargo handling rate should be noted in this agreement.

14.4(b) Describes action to be taken in the event of a failure of Capacitance Level Gauge (Transonic)

A typical liquefied gas carrier may have capacitance level gauge (Transonic) where the following may be considered:

Note 1: In this scenario, the High level alarm is disabled and possibly the Very High level alarm will not function (even if it has independent sensor).

Note 2: In this scenario, the trips for cargo/stripping pumps will not work as they should.

Monitor the level readings in tank(s) closely, particularly in the first stages of the unloading operations Monitor the Whessoe tape level reading closely, particularly when tanks are coming to the end Prepare Whessoe readings for commencement of ramping down and final level.

The Instructor may state here that the Gas carrier could have completely independent level alarms along with capacitance gauge. The cargo pump trips could also be independent.

14.4(c) Describes action to be taken in the event of a failure of ESD system

Try to disable ESD (normally optical) and go with the back-up (pneumatic) if available. (LPG carriers may have only one ESD whereas most LNG carriers do have a back-up ESD) If both ESD fails, stop cargo operations Try to detect the problem and solve it. Do not resume loading operations until ESD is functioning.

14.4(d) Describes action to be taken in the event of a failure of Gas Detection System

Most terminals allow cargo work if proper Risk Assessment is taken and portable instruments used at fixed pre-determined intervals.

Some LNG terminals require to Stop cargo operations, Resolve the problem, then Restart cargo operations.

14.4(e) Describes action to be taken in the event of a failure of High Duty Compressor

Advise Terminal both HD compressors failed.
Reduce Loading rate as vapour return will be by free flow. Watch the pressure in cargo tanks closely in order to adjust loading rate if required.
If pressure cannot be controlled by reducing loading rate, stop loading operations.

14.4(f) Describes action to be taken in the event of a failure of Hydraulic System.

Stop cargo operations.
Advise the Terminal as to the nature of the problem.
Try to repair hydraulic system. Check hydraulic oil tank level if loss is noticed check for leaks. Check filter.
Resume loading when problem has been solved.

14.4(g) Describes action to be taken in the event of a failure of Cargo Valves

Stop cargo operations.
Advise the Terminal as to the nature of the problem.
Try to repair hydraulic system. Check hydraulic oil tank level if loss is noticed check for leaks. Check filter.
Resume loading when problem has been solved.
The Instructor may state that depending on circumstances often operations could be carried out after Risk Assessments and use of portable emergency pump.

14.4(h) Describes action to be taken in the event of a failure of Safety Valves in Cargo Tank

Stop cargo operations.
Advise Terminal.
Immediate action should be to reduce tank pressure to minimum.
Evaluate reason for failure. If Pilot valve suspected to be failing, replace pilot valve.
If safety valve has to be overhauled or replaced, consider - leaving the terminal and after repair job has been completed returning to the terminal.
Consider - gas free the tank to carry out the repair.

14.4(i) Describes action to be taken in the event of a failure of Water Curtain system.

The water curtain is used during both Loading and Unloading operations - it is essential for safe operation. Stop cargo operations.
Restore the water curtain.
In consultation with the terminal Consider - connecting a shore line to one end of the pipe curtain as the quantity of spray water required is higher than what a fire pump may be able to deliver.

Restart cargo operations.

14.4(j) Describes action to be taken in the event of a failure of Pumps failure in a Moss cargo tank

If one cargo pump fails it is possible to maintain the unloading with one pump in one tank. A problem arises when both cargo pumps in a cargo tank fail.

Consider - Emergency Unloading. Refer to the vessel's Cargo Handling Manual for further information on 'Pressure Discharge/Liquid Transfer'.

In the case of both cargo pumps failing in a Moss cargo tank, the unloading will be carried out by pressuring the tank containing the failed pumps and forcing the liquid into one or more of the other cargo tanks. Manufacturer's recommendation regarding the arrangement for the tank relief valves has to be referred to. If liquid were transferred to two tanks instead of one tank, then the time to both transfer the liquid to the tanks at sea and the time to discharge the liquid to the terminal once the ship returns would be greatly reduced. Reducing the vapour pressure in the receiving tanks will further increase the transfer rate.

Because of the long time required to pressurize the tank and transfer the liquid, the vessel will normally have to depart the terminal and make the transfer at sea.

One of the ships spray pumps and the LNG vaporiser will be used to create the pressure which is required for discharge.

This procedure is an emergency procedure and as such all relevant ships manuals should be studied prior to commencement of the operation and the ships superintendent kept informed at all times.

14.4(k) Describes action to be taken in the event of a failure of Pumps failure in a MEMBRANE cargo tank

In the event of both main cargo pumps failing in a single tank, then the emergency cargo pump must be used. The procedure for this will be found in the ships specific cargo manual. The ships superintendent must be kept informed at all times when this procedure is necessitated.

14.5 Fire-fighting on liquefied gas tankers

14.5(a) Lists the elements of fire and explains the fire triangle

ELEMENTS OF FIRE

Fire requires a combination of fuel, oxygen, and a source of ignition. It is the vapour given off by a substance, whether solid or liquid, which burns when ignited. Before there can be ignition, sufficient vapour must be produced to form a flammable mixture. Liquids with lower flash point give off sufficient vapour at ambient temperatures but those with higher flash points only form the necessary amount of

vapour when heated. Once the vapour mixture is ignited, the temperature of a substance increases, causing more vapour formation, which sustains the fire.

14.5(b) Explains the principles of fire prevention

The principle method of protection against fire and explosion on liquefied gas tankers and jetties is achieved through operational procedures which control atmospheres and avoid liquid spills or leakages and vapour released to atmosphere Added protection is essential, though more difficult to achieve, by means of controlling sources of ignition A source of ignition is an ever hazard because of the possibility of human error and because its occurrence is usually unexpected.

14.5(c) Lists ignition sources and ways of excluding them

Smoking is perhaps the most common source of ignition to be found in hazardous areas and, to minimize this, smoking activities and utilities such as ashtrays, should always be restricted to pre-defined and approved locations. Considerable care must be taken to enforce these regulations during cargo handling operations at the jetty, particularly when visitors are present who may not appreciate the nature of the cargo being handled.

Hot and cold work should only be permitted under conditions of strict control. This can best be achieved by the use of work permits which make use of a checklist approach. Atmosphere in areas which could become hazardous should be continuously monitored during hot and cold work operations, preferably with instruments which are capable of alarming automatically on the detection of flammable vapour.

The use of "safety" tools in hazardous areas often creates a false sense of security. Constructed from soft copper alloys, these tools are often referred to as "non-sparking" but, it should be appreciated that fragments of steel can easily become imbedded in the heads of this tool.

14.5(d) Explains the phenomenon of BLEVE.

The boiling liquid expanding vapour explosion (BLEVE) is a phenomenon associated with the sudden and catastrophic failure of the pressurized containment of flammable liquids in the presence of a surrounding fire. Such incidents have occurred with damaged rail tank car or road tank vehicle pressure vessels subject to intense heat from surrounding fire. This heat has increased the internal pressure and, particularly at that part of the vessel not wetted by liquid product, the vessel's structure is weakened to the point of failure The sudden release of the vessel's contents to atmosphere and the immediate ignition of the resultant rapidly expanding vapour cloud have produced destructive overpressures and heat radiation.

14.5(e) Explains the importance of fire-prevention procedures with regard to:

- **Flame screen**
- **Bonding**
- **Electrical storms**
- **Auto-ignition**
- **Spontaneous combustion**

Flame Screens: A portable or fixed device incorporating one or more corrosion resistant wire meshes used for preventing sparks from entering an open deck hole, or for a short period of time preventing the passage of Flame into the deck hole, yet permitting passage of gas from the deck hole.

Bonding (Electrical): The connecting together of electrically conducting metal parts to ensure electrical continuity. Static electricity can arise when liquids or gases are pumped at high velocity. Non- conducting liquids (static accumulators), emulsions, carbon dioxide and steam are common sources of static electricity. In general terms, static generation increases with the velocity of flow. The removal of clothing in hazardous areas, particularly in dry atmosphere conditions can also give rise to static discharge Helicopters are also efficient static generators, the risk being greatest in dry atmospheric conditions. Immediately before approaching any ship for winching or landing, it is generally recommended that the helicopter should drop at earthing cable into the sea to dissipate any static charge it advance. Bonding and Earthing are the precautions to be taken to safeguard against Static electricity.

Electrical storms: Cargo operations or the venting of flammable cargo vapours should be stopped during electrical storms in the immediate vicinity of the ship.

Auto-ignition temperature: Ignition can occur when an ignition source with a temperature at or above the auto-ignition temperature of a cargo is introduced to the vapour phase of the cargo.

Sources of flammable cargo vapour emission are leaks from pumps, from relief valves etc. Most ignition sources on board have a higher temperature than the auto ignition temperature for most liquefied gas cargoes. The temperatures of such common ignition sources are:

The flame of a match (741°C)
Electrical sparks (1100°C)
The light of a burning cigarette (300° - 800°C)
The auto ignition temperature of most cargoes on gas tankers varies from 165°c for acetaldehyde to 630°c for methyl chloride

Spontaneous combustion: The ignition of material brought about by a heat producing (exothermic) chemical reaction within the material itself without exposure to an external source of ignition.

14.6 Jettison of cargo

If a cargo tank develops a serious defect at sea resulting in leakage through the primary and secondary barriers, the cargo should be transferred to an unaffected tank containing compatible cargo with sufficient ullage available. Remain cargo that cannot be transferred needs to be discharged through a ship to ship (STS) transfer if possible or as a last resort jettisoned.

If the cargo is to be jettisoned, a stern line should be used if available. If ship has no stern discharge installed, a properly supported extension pipe from the midship manifold can be used. The emergency discharge pipe should be angled downward

and fitted with a reducer to increase the discharge velocity. Seawater spray and fire hoses should be used to protect the hull steel from contact with the low temperature liquid. If possible, the ship' heading should be such that the direction of discharge is downwind to ensure that the ship is not enveloped with a vapor cloud. Ventilation should be secured to extent possible and warnings broadcast to other ships in the vicinity.

14.7 Enclosed space rescue

It should be assumed that personnel noted to be unconscious or disoriented in an enclosed space are suffering from a lack of oxygen or exposure to a toxic gas. The immediate response is to raise an alarm and attempt to ventilate the space. Under no circumstances should persons enter the space or attempt a rescue without a breathing apparatus. Rescuers with proper equipment should remove the victim from the enclosed space as quickly as possible while maintaining communication with a supervisor outside. A resuscitator should be used to revive the victim.

15.0 Actions to be taken following collision, grounding or spillage and envelopment of the ship in toxic or flammable vapour

15.1 Initial response

In the event of a casualty, the following steps should be taken:
Sounding the general alarm and fire alarm,
Assembling the emergency party,
Issuing protective clothing and gas masks if necessary,
Preparing implementing initial fire-fighting,
Mustering the crew and searching if any are missing,
Alerting all departments to dangers,
Closing all water-tight doors and ventilation,

15.2 Procedures

Emergency response should be in accordance with pre-established emergency response plans. Once implemented, the initial goal is to establish communications and report conditions the condition to the proper parties. As the situation develops evidence as to the cause of the casualty should be collected for use in the accident investigation.

15.3 Explains standard initial and follow-up actions to be taken subsequent to a collision

If required, launching boats for survivors, mounting large scale fire-fighting attack if Necessary, assessing hull damage and stability, assessing effect on cargo system, any other necessary action.
Reporting and communication as per company's SMS.

On an LNG Vessel, the event can only be described in a hypothetical context, as no such situation has actually occurred.

1. In the loaded condition with failure of the primary and secondary membranes, liquid cargo will pass through the primary, secondary barriers, inner hull and the ruptured ballast tank and out to the sea. As the membrane containment system is supported by the inner hull steel structure, failure of the inner hull due to the collision damage and embrittlement would lead to collapse of the membrane containment system in the damaged area. This would lead to a further major increase of the outflow of LNG.

2. Ignition may not take place within the vessel due to the over-rich concentration of vapours. In such cases, the attempted separation of the vessel from a colliding vessel or other structure should not be attempted, if circumstances permit, in order to avoid the risk of creating an ignition source during separation. This should be followed despite the colliding vessel probably encountering hull structure failure from both the collision damage and the embrittlement from the outflow of LNG.

3. The vaporization of the spillage will initially form a heavy white vapour cloud and this is likely to quickly envelope the deck and accommodation areas. Hence it is essential that all potential sources of ignition are isolated and the decks cleared of all personnel.

4. If separation has taken place from the colliding vessel or obstruction and there is no gas concentration in the propulsion machinery space, attempts should be made to man oeuvre in such a way as to place the vessel clear of the vapour cloud. This may involve steaming the vessel astern.

5. As far as possible, the damaged tank and barriers should be isolated from other tanks and barriers. This will prevent both back flow of boil-off vapour from undamaged tanks to the ruptured tank and, at later stage, the possible admixture of air and cargo vapour in the whole cargo system.

6. Flooding the ballast tanks adjacent to the damaged tank with sea water, where possible, will reduce the effect of embrittlement on the adjoining bulkheads and prevent gas vapour from entering undamaged tanks.

7. The operation of water sprays and curtains will reduce the possibility of vapour cloud ignition on deck, assuming the deluge and fire main systems are still intact.

8. If ignition does occur, the resulting fire may be such that the dry powder capacity onboard could be exhausted or, if the fire is extinguished, reserves have been run so low that any re-ignition could not be contained. Therefore, thought should be given to the desirability of allowing the fire to burn in a controlled manner.

9. Before attempting to fight large fires, due consideration should be given to the possible options:
   i) Allowing a fire to continue to burn thus running the risk of the fire spreading and greater damage being caused.

ii) Extinguishing the fire and running the risk of damage to life and property if unignited vapour is allowed to drift under light wind conditions to areas of high ignition risk.

10. Where cargo is jettisoned, personnel should be aware of the Rapid Phase Transition (RPT) phenomenon. When LNG, particularly if the LNG is aged, is spilled on to water, a violent interaction can occur. This is the result of rapid vaporization of the LNG, superheated by contact with water.

11. A very careful check should be maintained on all intact cargo tanks, barriers and adjacent compartments."

12. Once the situation has been stabilised and the stability of the vessel is secured, consideration can be given to the problem of what to do with the remaining cargo in the damaged tank.

Factors will include:

i) Damage to the vessel and quantity of remaining cargo.
ii) The operational status of the propulsion machinery, cargo containment system and cargo transfer system.
iii) The location of the vessel.
iv) If the cargo containment system is intact, the possibility of ship to ship transfer may be considered.

15.4 Explains standard initial and follow-up actions to be taken subsequent to a grounding

Sounding the general alarm; maneuvering to refloat; closing all water-tight doors; assessing hull damage and stability; assessing effect on cargo system; determining shoal depth and composition and direction of deep water; follow-up action if required calling a barge to lighten; if required jettisoning cargo; if stuck fast and pounding; clearing boats for launching; record keeping; communications; and any other necessary action.

15.5 Explains standard initial and follow-up actions to be taken subsequent to a spillage and envelopment of the ship in toxic or flammable vapour

The following action should be taken immediately

- All cargo operations should be stopped, all valves in the liquid line should be closed both on the ship and shore as necessary, the alarm should be given, all accommodation access doors should be shut and all ventilation (except closed—circuit systems) shut down.
- Everywhere smoking and naked lights should be prohibited on the ship, and electrical switches used as little as possible.
- Appropriate fire-fighting equipment and breathing apparatus should be assembled for immediate use. The emergency parties should wear breathing apparatus and protective clothing.

- If liquid spillage occurs, fire hoses or water sprays should be played along the deck to disperse the liquid overboard and to maintain steel temperatures so that brittle fracture is avoided; water sprays from hoses can also be used to deflect a gas cloud.

Boiling of LPG/LNG is rapid, due to the large temperature difference between the product and water.

- Gases continuously spreads over an indefinitely large area, it results in a magnification of its rates of evaporation until vaporization is complete.
- No coherent ice layer forms on the water.
- Under particular circumstances, with a Methane concentration below 40%, flameless explosions are possible when the LNG strikes the water. It results from an interfacial phenomenon in which LNG becomes locally superheated at a maximum limit until a rapid boiling occurs. However, commercial LNG is far richer in Methane than 40% and would require lengthy storage before ageing to that concentration.
- The flammable cloud of LNG and air may extend for large distances downwind (only Methane when warmer than 100 degree C is lighter than air) because of the absence of topographic features, which normally promote turbulent mixing.

15.6 Explains the importance of evidence collecting and emergency reporting requirements

When the ship is involved in an incident which results in the discharge or probable discharge of pollutants (Cargo or bunker fuel) , the Master is obliged under the terms of MARPOL to report details of the incident, without delay, to the nearest Coastal State by means of the fastest telecommunication channels available.

The intent of these requirements are to ensure that Coastal States are informed, without delay, of any incident giving rise to oil pollution, or threat of oil pollution, of the marine environment, as well as of assistance and salvage measures, so that appropriate action may be taken.

Without interfering with ship owners' liability, some coastal states consider that it is their responsibility to define techniques and means to be taken against an oil pollution incident and approve such operations which might cause further pollution, i.e. lightening. States are in general entitled to do so under the International Convention relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969.

Ships' Masters have an important role in the collection of evidence that will help the insurance agencies evaluate the damage and establish liability.

Evidence should be collected, recorded and preserved. Memories fade. It is therefore imperative to make notes on how the incident occurred as soon as possible after the event.
The basic rules to remember in case of any accident or incident on board your ship are:

- Keep your owner and manager informed;

- Notify the local P and I correspondent;
- Investigate the accident or incident as soon as practical;
- Collect and retain any evidence or documentation relating to the accident;
- Ask witnesses to write down what happened, and keep detailed records of all relevant facts;
- Take photographs wherever possible.

It is important here for the instructor to emphasize that we need to report other serious incidents also – collision, grounding, fire etc.

16. Knowledge of medical first – aid procedures and antidotes on board liquefied gas tankers, with reference to the Medical first aid guide for use in accidents involving dangerous goods (MFAG)

16.1 Explain that the MFAG gives detailed information about signs and symptoms, first aid and the administering First Aid for chemical burns and Frostbites

16.1(a) Frostbite

Liquefied gases and their vapours may be at very low temperature when compared with human body temperature. Skin contact with such liquids or vapors can lead to frostbite (cold burns). The symptoms of frostbite are:

The skin initially reddens and then whitens.
The affected area is usually painless.
The affected area feels hard to touch.
Patient suffers from confusion/agitation/fainting
If the affected area is not treated soon, death of tissue (gangrene) may occur.

16.1(b) Chemical burns

Some of the liquefied gases will cause chemical bums due to their corrosive action on human skin and tissue. Ammonia Chlorine, Ethylene oxide, Propylene oxide, can cause chemical burns.

The first aid procedures for accidents involving cargo are given in the data sheets in Part D
If cargo liquid should enter the eye, the correct treatment for most cargoes is to flood the eye with clean water and to continue washing for at least 15 minutes. If cargo liquid comes into contact with the skin, the affected area should be washed and any contaminated clothing removed. If frostbite has occurred it should be treated by immersing the affected part in warm water.

If any personnel experience the symptoms of vapour exposure they should leave the area and advise other personnel in the vicinity. The possibility of similar symptoms in others should be constantly borne in mind. Emergency treatment, correct for most cargoes, is to remove the victim to fresh air and, if breathing is weak or irregular or has stopped, provide resuscitation.

16.2 Describes treatment for asphyxia and inhalation of toxic fumes.

16.2(a) Treatment of Asphyxia

If toxic fumes are the cause of asphyxia, the person must be removed into clean air. In all cases of asphyxia, the essential aim of treatment is to increase the amount of oxygen in the blood. Check if the victim is breathing or not

1. By Looking - For chest movements
2. Listening - For breath sounds if possible
3. Feeling - For warm air coming out of nose or mouth. Look for 10 seconds. If no breathing is present, proceed to artificial breaths.

Artificial Breathing

There are two ways of giving artificial resuscitation.

1. Mouth to Mouth
2. Mouth to Nose

1. MOUTH TO MOUTH
It is the easier of the two because it allows for comfortable sealing of Rescuer and victim's mouth.
Step 1: Keep the airway open
Step 2: Pinch the nostrils.
Step 3: Take a FULL breath (in adults only), and make a tight seal around victim's mouth. Blow for about 2 seconds.

Do not forget to watch for chest rise and stop if it's too much. Take your head away from victim's mouth to prevent taking victim's breath into you. Repeat until you have given 2 adequate breaths.

2. MOUTH TO NOSE
Step 1: Keep the airway open.
Step 2: Close the mouth of the victim.
Step 3: Cover the victim's nose with your mouth.
Step 4. Blow and watch for chest rise.
Step 5: Take your head away.
This is preferred in cases when the victim's mouth contains
• Blood
• Vomit
• Poison

What can go wrong?
Air can go into the stomach instead of lungs, which is dangerous because when stomach gets filled with air it can suddenly release the air back along with its contents usually food which can get into the lungs.

This can be prevented by SELLICK'S MANOUVRE. Use 2 fingers to press downwards on the 'C' shaped cartilage on the neck.

Circulation
Look for neck pulse and check for 10 Sec. If not felt go ahead with external cardiac compressions.

OR
If the victim is unconscious and not breathing go ahead with external cardiac compression.

16.2(b) Describes procedures to check if patient is breathing and immediate actions if not breathing

If respiration and heartbeat have stopped, emergency resuscitation methods (mouth-to-mouth breathing and external cardiac massage) must be used. Once respiration and heartbeat have started (or if still present), the person requires further intensive care treatment in hospital.

The instructor must also state here that liquefied gas tankers are provided with oxygen resuscitators that must be used.

16.2(c) Describes procedures to use Oxygen resuscitators

Patients who are unable to breathe on their own will require positive pressure to move oxygen in to their lungs for gaseous exchange to take place. Systems for delivering this vary in complexity starting with a basic pocket mask adjunct which can be used by a basically trained first aider to manually deliver artificial respiration with supplemental oxygen delivered through a port in the mask.

Gas tankers are provided with Oxygen resuscitators that may use a bag-valve-mask (BVM) or Ambu bag, which is a malleable bag attached to a face mask (or invasive airway such as an endotracheal tube or laryngeal mask airway), usually with a reservoir bag attached, which is manually manipulated by the responsible officer to push oxygen (or air) in to the lungs. Automated versions of the BVM system, known as a resuscitator can also deliver measured and timed doses of oxygen direct to patient through a facemask or airway.

Instructions of the equipment must be read in advance and knowledge of its use exercised.

16.2(d) Explains methods of resuscitation for conscious and unconscious stages

Vital Signs - Monitor
• Respiratory Rate
• Pulse Rate
• Blood Glucose Levels (Correct hypoglycemia with Glucagon / Hypo stop if required)
• Oxygen Saturations
• Temperature

Treat any obvious injuries e.g. bleeding, fractures (support and immobilize)

Continue to Observe:

• Airway
• Respirations
• Circulation
• Bleeding

Note: Even though the patient may appear unresponsive it doesn't mean they can't hear you. Keep talking to the patient as hearing is the last sense lost.
"

16.2(e) Describes actions to take in accidents involving dangerous goods using the Medical first aid guide (MFAG)

If there is no evidence of chemical bums, check the Medical First Aid Guide for Use in Accidents involving "Dangerous Goods" to see whether the chemical can be absorbed through intact skin, causing general symptoms of poisoning. If possibility exists, keep patient under observation for 24 hours or longer.

16.2(f) Describes procedures to transfer patients to hospitals.

In the event of an emergency aboard the vessel, wherein time may be of vital essence to save the injured person, helicopter operation becomes inevitable. Proper preparation on board the vessel for the rescue operation will help facilitate the rescue effort and save precious time. On contacting for Radio Medical Advice, the call will be transferred to a Doctor. He will make an assessment of the seriousness of the situation and if required, he will advise the Search and Rescue (SAR) authority on the best method of evacuation and, should helicopter evacuation be thought desirable, the SAR authority will make the necessary arrangements and will keep in touch with the vessel.

Ensure a Tag in attached to the outgoing patient stating his name, address in his home town, Name of the ship, History of medication, Type of illness, Name of the agent and if allergic to any medication.

Any other information thought necessary for assistance to medical and immigration authorities.

TOPIC 6 PROCEDURES TO PREVENT POLLUTION OF THE ATMOSPHERE AND THE ENVIRONMENT

17. Understanding of procedures to prevent pollution of the atmosphere and the environment

17.1 Responsibilities

The Master has the responsibility of ensuring that the ship complies with all local and international pollution regulations. The SMS provided by the Company should detail the policies and procedures necessary for the Master to carry out this duty. Master therefore is required to implement these procedures through his instructions to the ship's crew and to confirm that these requirements are being met.

17.2 Oil pollution

Annex I of MARPOL governs the discharge of oil. Under this convention, gas carriers are required to have a current Shipboard Oil Spill Response Plan. The discharge of ammonia washings is regulated by Annex II of MARPOL

17.3 Ballast water management

The 2004 International Convention for the Control and Management of Ships' Ballast Water and Sediments regulates the discharge of ballast water to prevent introduction of invasive species. Under this convention, ballast water exchange is required and ballast water treatment will be introduced.

TOPIC 7 RELEVANT PROVISIONS OF THE INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS (MARPOL) AND OTHER RELEVANT IMO INSTRUMENT, INDUSTRY GUIEDLINES AND PORT REGULATIONS AS COMMONLY APPLIED

18. Knowledge and understanding of relevant provisions of the international convention for the prevention of pollution from ships (MARPOL) and other relevant IMO instruments, industry guidelines and port regulations as commonly applied

18.1 International Conventions

Shipping activities and the international maritime forum are of international concern and, therefore, shipping matters to the IMO.

IMO has drawn up conventions which affect ships.
Conventions directly affecting ships and shipping activities are the SOLAS 1974, MARPOL and the STCW 1978 Convention, as amended.

In MARPOL, a new chapter 4 on energy efficiency has been added to annex VI regulations on air pollution. It requires an Energy Efficiency Design Index (EEDI) to be stated for new vessels and a ship energy efficiency management plan to be maintained on all vessels. The EEDI is an indicator of the fuel efficiency of a ship, measured in grammes of CO_2 emissions per deadweight tonne per nautical mile: the lower the figure, the better the fuel efficiency. The ship energy efficiency management plan aims to improve the efficiency of a vessel by introducing various management methods such as improved voyage planning to increase fuel efficiency.

Compliance of a liquefied gas tanker with requirements of IGC code is shown in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk (COF) which mentions the products the ship can carry, ambient temperature for which the ship is designed, material used for tank construction and the minimum temperature etc.

18.2 Industry guidelines

The Society of Gas Tanker and Terminal Operators (SIGTTO) and the International Chamber of Shipping (ICS) publish best practice guidelines for the design and operation of gas carriers.

18.3 Local regulations

Coastal states are obligated to accept a gas carrier's Certificate of Fitness for the Carriage of Liquefied Gases in Bulk as meeting the requirements of the IGC Code. In addition they may have additional design or operational requirements that a gas carrier must meet while operating in their ports. Such requirements are generally of an operational nature but may include requirements for specific equipment or certifications. Compliance is generally checked as part of Port State Control inspections.

19. Proficiency in the use of the IBC and IGC Codes and related documents.

19.1 IGC Code

In order to provide an international standard for the safe carnage of liquefied gases (and certain other substances) in bulk by ships, IMO has developed the Gas Carrier Codes

Gas Carrier Codes

International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)
Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (GC Code) and
Code for Existing Ships Carrying Liquefied Gases in Bulk

The year of construction of a gas tanker determines which Code the ship must comply with. The Codes recommend suitable design criteria, construction standards and other safety measures for ships transporting liquefied gases and certain other substances in bulk

These cargoes are also listed in chapter 19 of the IGC Codes, as shown herein.
CHAPTER 19 (IGC CODE) SUMMARY OF MINIMUM REQUIREMENTS

Explanatory notes to the summary of minimum requirements.
UN Numbers- the UN numbers as listed in the table of chapter 19 are intended for information only

Vapour detection required (column f)

F- Flammable vapour detection
T- Toxic vapour detection.
O- Oxygen analyzer.

F + T-Flammable and toxic vapour detection

Gauging — types permitted (column g)
I - Indirect or closed, as described in 13.2.2.1 and .2
C- Indirect, or closed, as described in 13.2.2.1, .2 and .3
R- Indirect, closed or restricted, as described in 13.2.2.1, .2, .3 and .4
Refrigerant gases- Non-toxic and non-flammable gases such as
Dichlorodifluoromethane (1028)
Dichioromonofluoromethane (1029)
Dichiorotetrafluoroethane (1958)
Monochiorodifluoromethane (1018)

Monochiorotetrafluoroethane (1021)

Monochiorodifluoromethane (1022)

Unless otherwise specified, gas mixtures less than 5% total acetylene may be transported with no further requirements than those provided for the major components.

Liquefied gas tankers may have to comply with the Gas Carrier Codes, either through their national laws or through laws of the port States.

The instructor must state here that each Chapter of the code is important and it is recommended that it should be taken up in brief – especially chapters 14 to 19.

19.2 IBC Code

A ship which is constructed for carriage of both liquefied gases and chemicals in bulk must comply with the requirements of both the gas Carrier Code and the Bulk Chemicals Code. Certain gases are identified in Chapter 19 of the IGC Code which are also covered by Chapter 17 of the IBC Code

Appendix 1

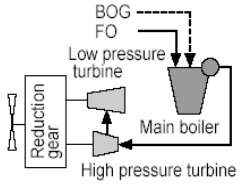
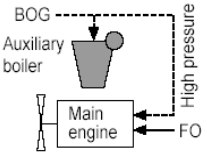
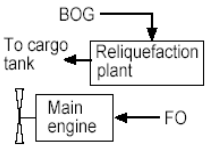
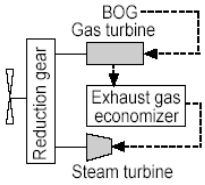
APPENDED DIAGRAMS

Diagrams for use by the Instructor
Print off as handouts
or use for OHP transparencies
if suitably enlarged

NOTE: The numbering of the figure appended herein is that of the General Learning Objectives (GLO)

e.g. Figure no: 2 (A to G) represents GLO 2.0 Knowledge of pump theory and characteristics, including the types of Cargo Pumps and their safe operations and should be used with their respective Specific learning Objectives (SLO) included in Part "C" and Part "D" respectively.

Diagrams from the Basic course (IMO 1.04) may also be used.

Propulsion plant		Steam turbine engine	Dual fuel diesel engine	Diesel engine with reliquefaction plant	Gas combined cycle
Plant configuration					
Advantages		•Most LNG ships adopt and reliability is high •100% of BOG can be fired during voyage	•Fuel efficiency is better •BOG can be used as fuel	•Fuel efficiency is better •The cargo part and engine part can be separated	•Fuel cost is better compared with that of the steam turbine engine
Disadvantages		•Fuel efficiency is low	•Exclusive BOG burning is impossible •BOG can not be fired at a low output	•Heavy fuel oil consumption is high •Electric power for driving reliquefaction plant is required	•High quality fuel oil is required •Dual fuel burning is impossible
Economy	Initial investment	100	105	105	104
	Fuel efficiency (fuel)	100 (BOG + HFO)	67 (BOG + HFO)	65 (HFO)	79 (BOG or Gas Oil)
Discharge gases	CO_2	100 (87)	66	77	73
	NOx	4 (3)	100	99	10
	SOx	67 (0)	43	100	0

(Note) Numerals in parentheses are those in the case of BOG exclusive combustion

Fig 1.0 (a) LNG tanker various propulsion systems

Drive	Steam Turbine		Gas Engine Dual Fuel Engine	Diesel + Reliquefaction	Gas Turbine
	Conventional	EcoBOT			
H/D Compressor	YES	YES	YES	YES	YES
L/D Compressor, single stage	Var. speed	Fixed Speed			
L/D Compressor, 2-stage			YES	YES	
L/D Compressor, 4 stage					YES
EcoRel				YES	
BO/WU Heaters	YES (2)	YES (2)	YES (2)		YES (2)
H/D Gas Heater	Altern. (1)	Altern. (1)	Altern. (1)	YES (1)	Altern. (1)
L/D Heater	Altern. (1)	Altern. (1)	Altern. (1)		Altern. (1)
LNG Vaporizer	YES	YES	YES	YES	YES
Forcing Vaporizer	YES	YES	YES		YES
Mist Separator	YES		(YES)		(YES)

Fig 1.0 (b) Cargo Equipment requirements with differing propulsion systems.

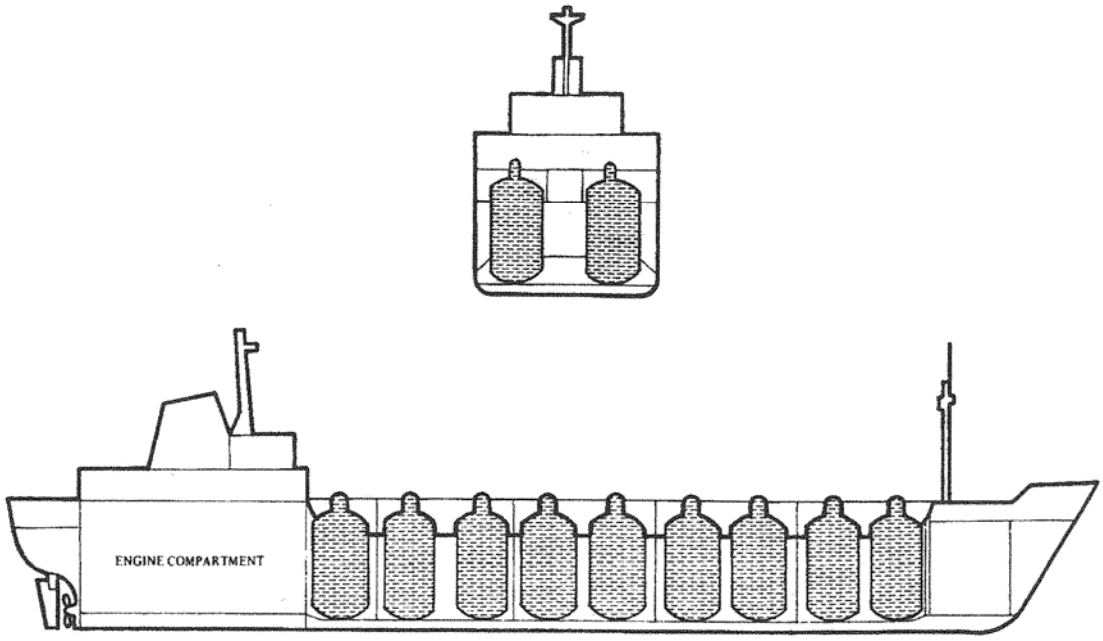
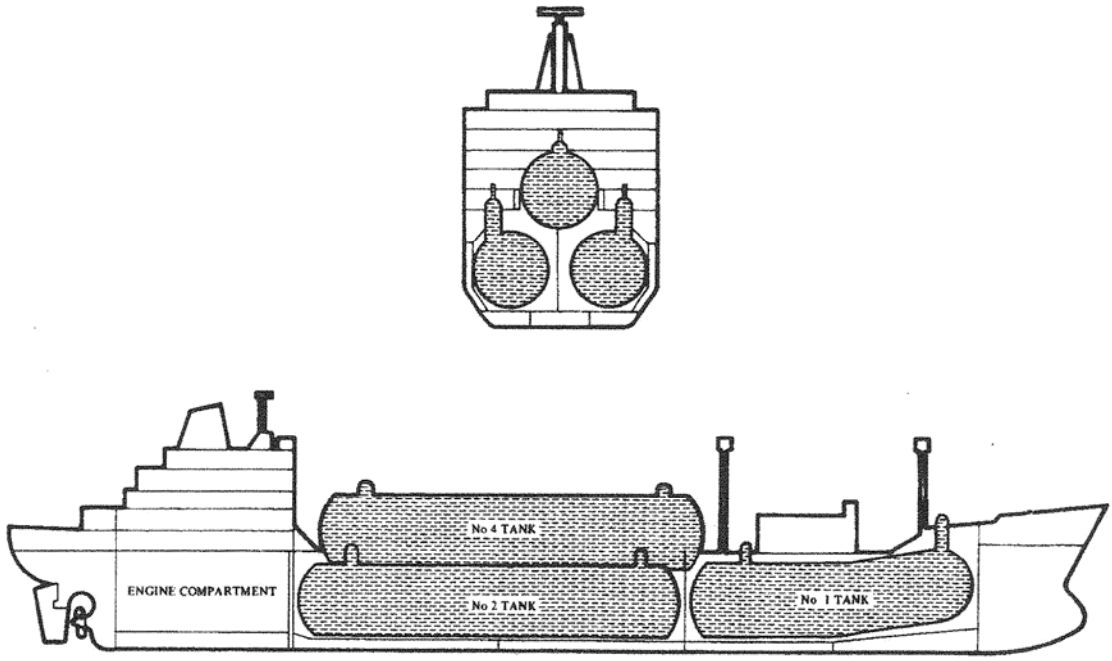


Fig 1.1 (a) A fully pressurized LPG carrier



A semi-pressurized/fully refrigerated LPG/NH_3 carrier

Fig 1.1 (b) Gas carriers (1)

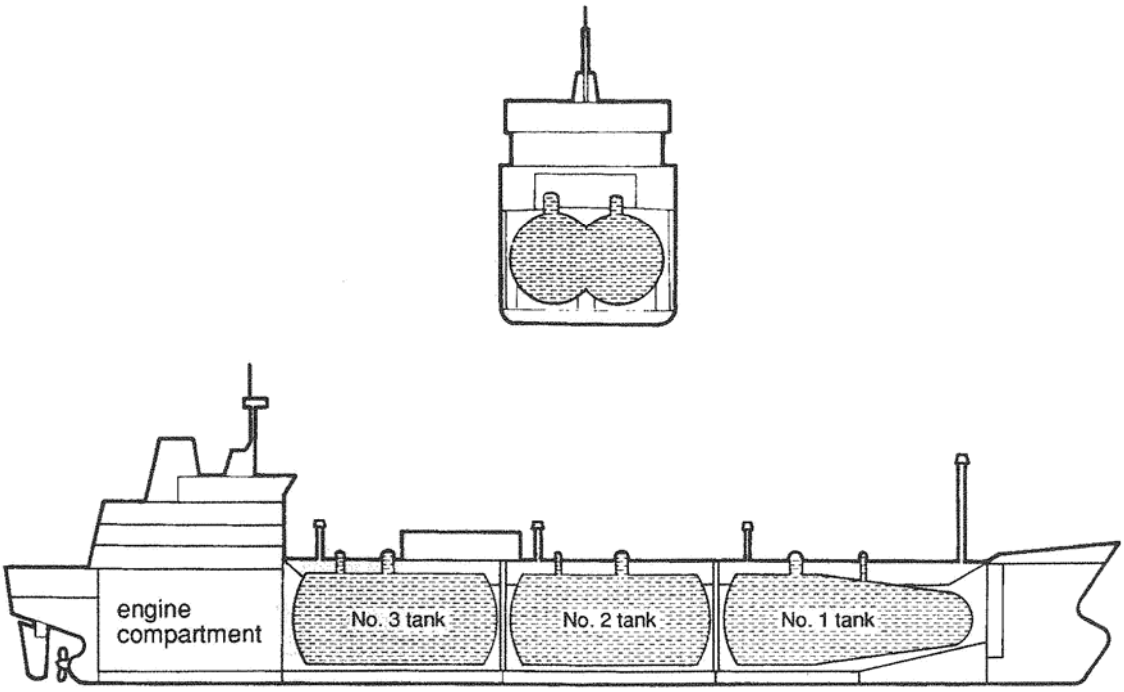
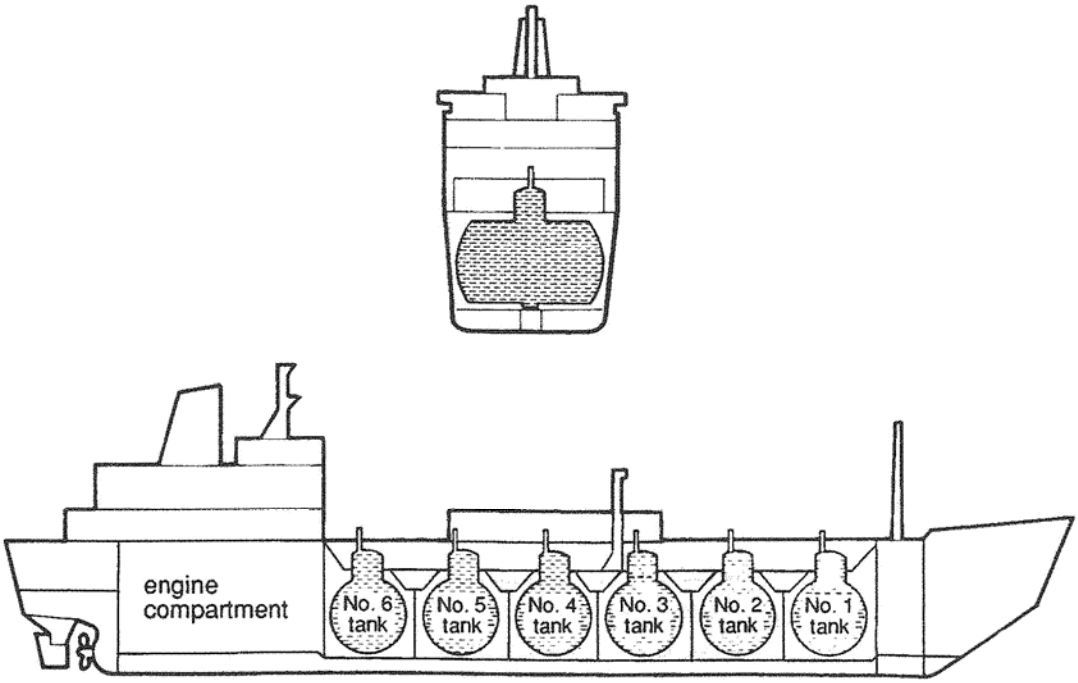


Fig 1.1 (c) A semi-pressurized refrigerated LPG/NH_3 carrier



A semi-pressurized/fully refrigerated LPG/ethylene carrier

Fig 1.1 (d) Gas carriers (2)

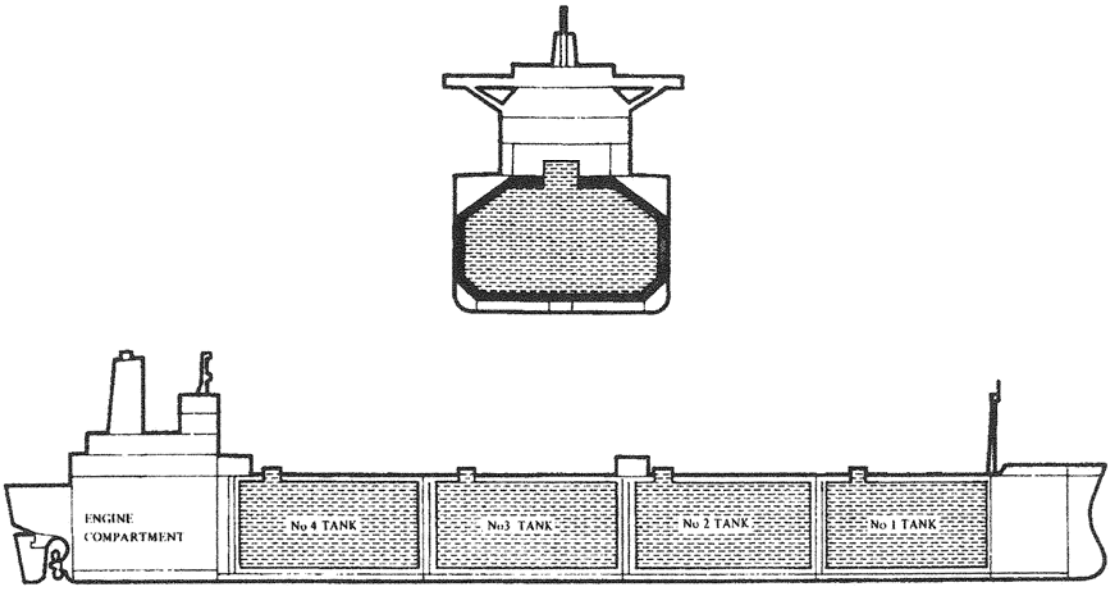


Fig 1.1 (e) A fully refrigerated LPG carrier

Appendix

MODEL FORM OF CERTIFICATE OF FITNESS FOR
THE CARRIAGE OF LIQUEFIED GASES IN BULK

The existing Model Form of Certificate should be replaced by the following:

"CERTIFICATE OF FITNESS FOR THE
CARRIAGE OF LIQUEFIED GASES IN BULK

(Official seal)

Issued under the provisions of the

IMO CODE FOR THE CONSTRUCTION AND EQUIPMENT
OF SHIPS CARRYING LIQUEFIED GASES IN BULK

(resolution A.328(IX) as amended by resolution MSC....(60))

under the authority of the Government of

.....
(full designation of country)

by .....
(full designation of the competent person or organization
authorized under the provisions of the Code)

Particulars of ship[1/]

Name of ship .....

Distinctive number or letters .....

Port of registry .....

Cargo capacity (m^3) .....

Ship type (Code paragraph 2.5) .....

IMO Number[2/] .....

Date on which keel was laid or ship was at a
similar stage of construction or, (in the case of a
converted ship) date on which conversion to a gas
carrier was commenced .....

The ship also complies fully with the following amendments to the Code:

.....

.....

This ship is exempted from compliance with the following provisions of the Code:

.....

.....

THIS IS TO CERTIFY:

1 That the above mentioned ship is:[3/]

.1 a ship as defined in 1.2.2 of the Code;

.2 a ship as defined in 1.2.3 of the Code.

2 .1 That the ship has been surveyed in accordance with the provisions of section 1.6 of the Code;

.2 that the survey showed that the structure, equipment, fittings, arrangements and materials of the ship and the conditions thereof are in all respects satisfactory and that the ship complies with the relevant provisions of the Code.

3 That the following design criteria have been used:

.1 ambient air temperature.....°C

.2 ambient water temperature.....°C

.3

Tank type and number	Stress factors				Materials	MARVS
	A	B	C	D		
Cargo piping						

NB: Tank numbers referred to in this list are identified on attachment 2, signed and dated tank plan.

.4 Mechanical properties of the cargo tank material were determined at ..... °C

4 That the ship is suitable for the carriage in bulk of the following products, provided that all relevant operational provisions of the Code are observed.

Products	Conditions of carriage (tank numbers, etc.)
Continued on attachment 1, additional signed and dated sheets. Tank numbers referred to in this list are identified on attachment 2, signed and dated tank plan.	

5 That in accordance with 1.5/2.7[3/], the provisions of the Code are modified in respect of the ship in the following manner:

6 That the ship must be loaded:

.1 in accordance with the loading conditions provided in the approved loading manual, stamped and dated ..... and signed by a responsible officer of the Administration, or of an organization recognized by the Administration;[3/]

.2 in accordance with the loading limitations appended to this Certificate.[3/]

Where it is required to load the ship other than in accordance with the above instruction, then the necessary calculations to justify the proposed loading conditions should be communicated to the certifying Administration who may authorize in writing the adoption of the proposed loading condition.[4/]

This Certificate is valid until .....[5/]
subject to surveys in accordance with 1.6 of the Code.

Issued at .....
(Place of issue of Certificate)

....
(Date of issue) (Signature of duly authorized official issuing the Certificate)

Fig. 1.2 Example of a Gas carrier's Certificate of Fitness

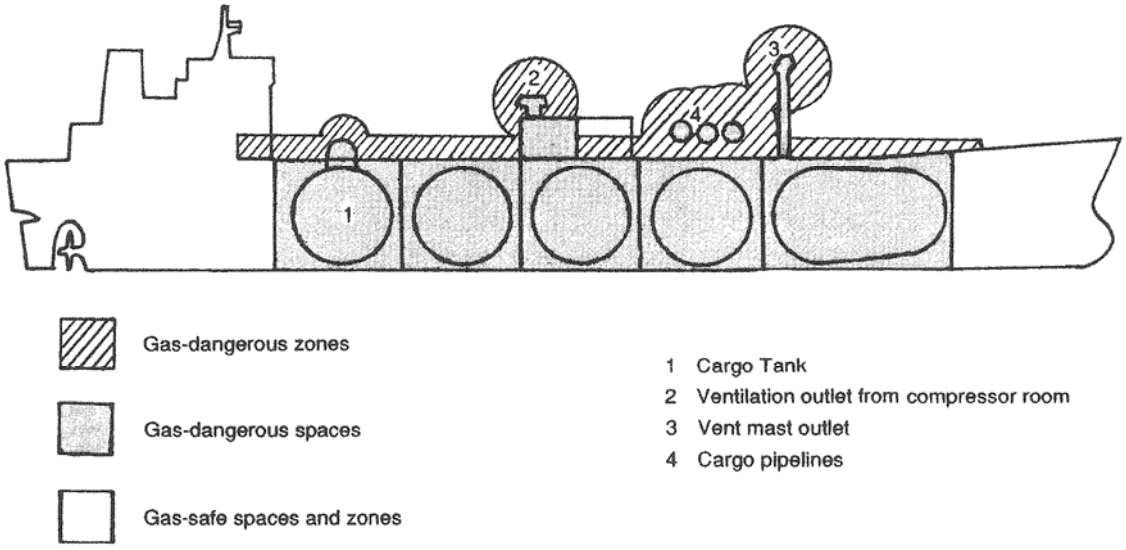


Fig 1.2.4 Gas-dangerous spaces and zones

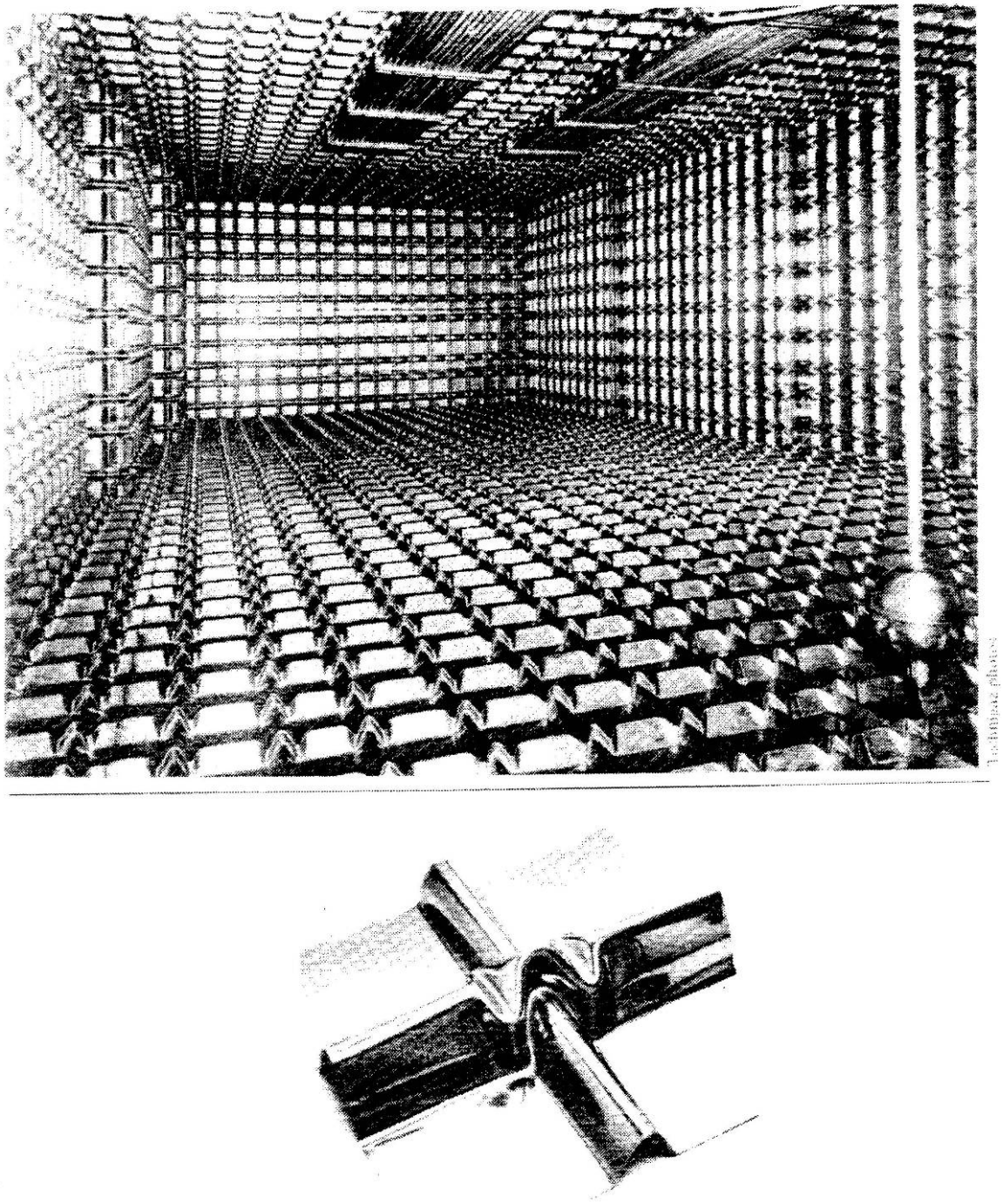


Figure 1.3 (a) A Technigaz membrane tank internal

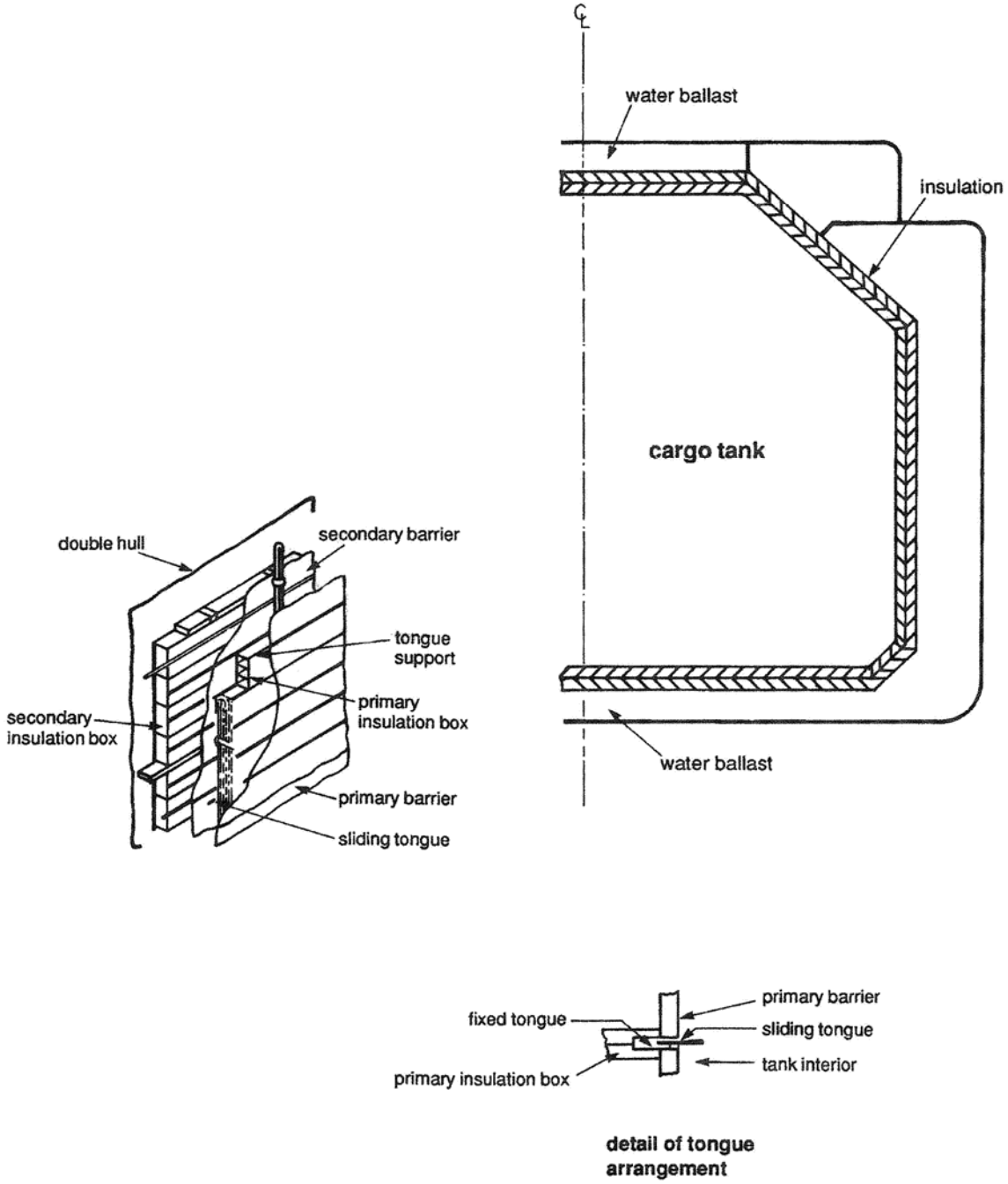
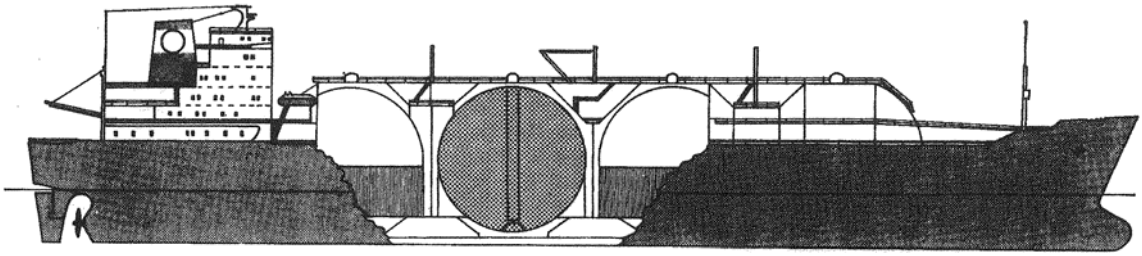
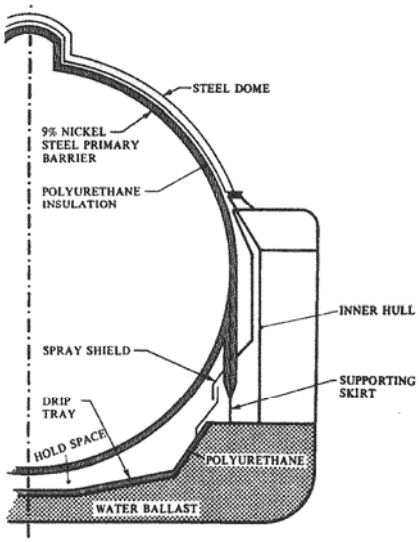


Fig 1.3 (b) A Gaz transport membrane tank



LNG/ethylene/LPG tanker



Independent self-supporting spherical tank (type B)

Fig 1.3 (c) A LNG carrier

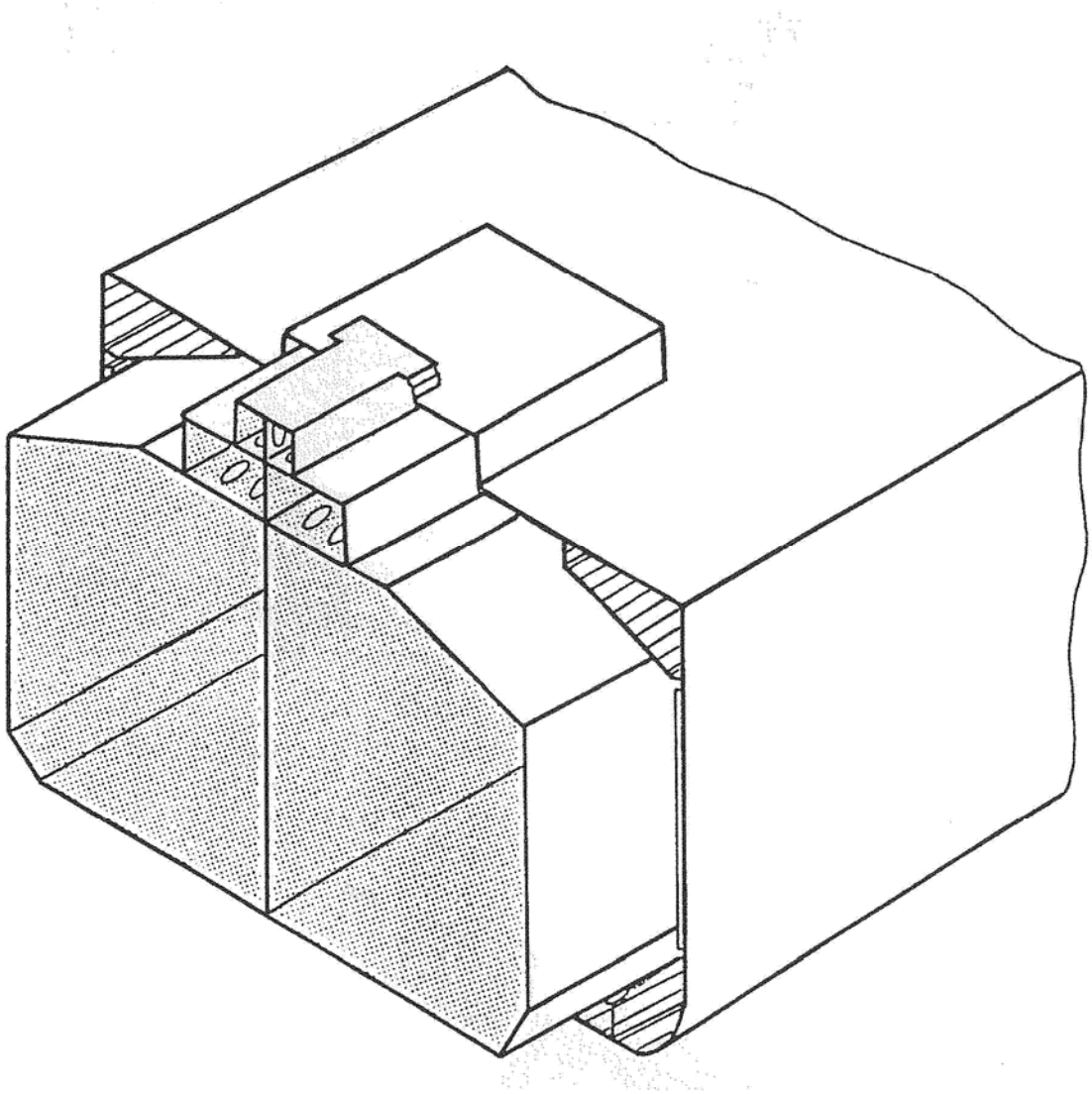


Fig 1.3 (d) An independent tank of type a (for LPG)

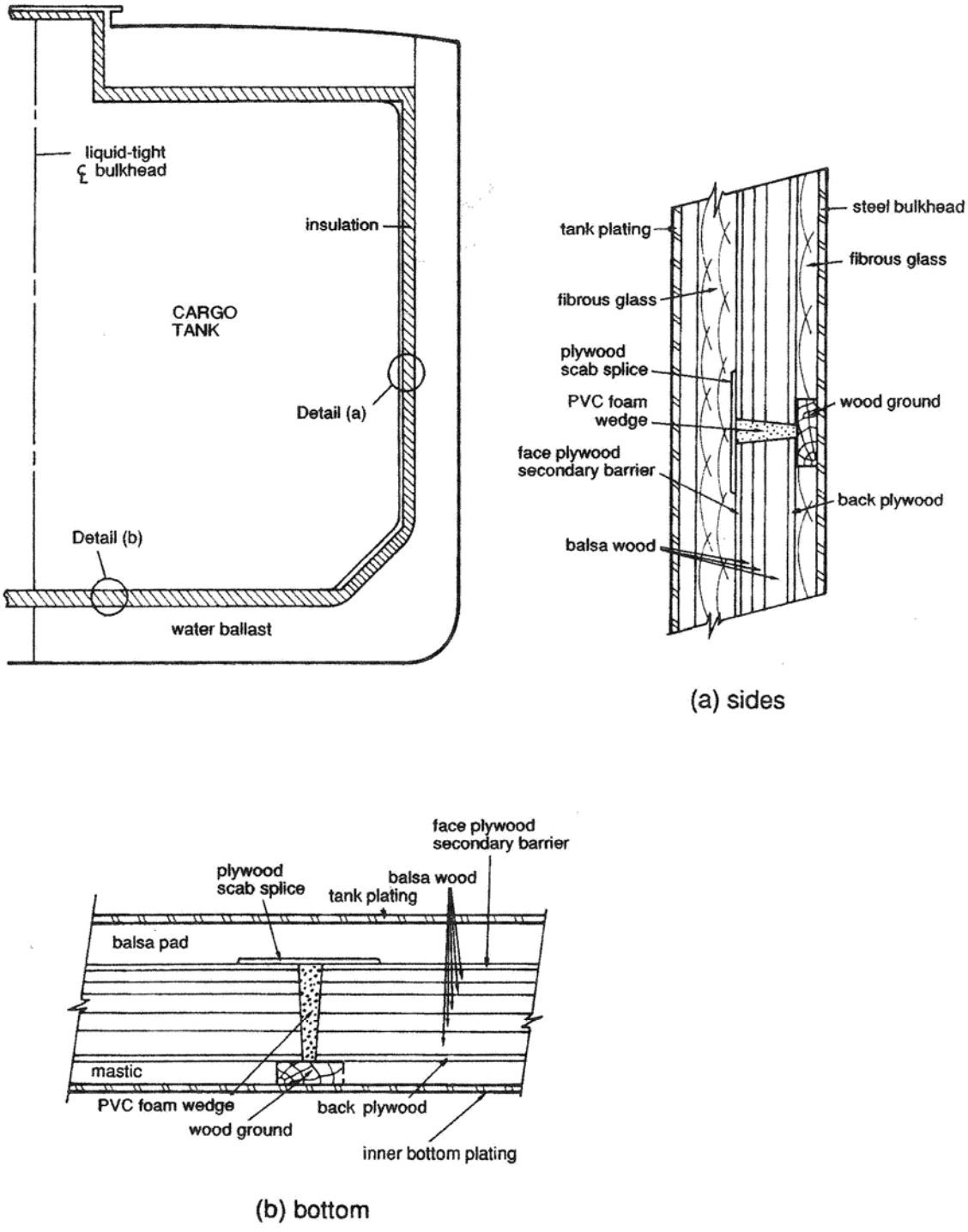


Fig 1.3 (e) An independent tank of type A (coach design)

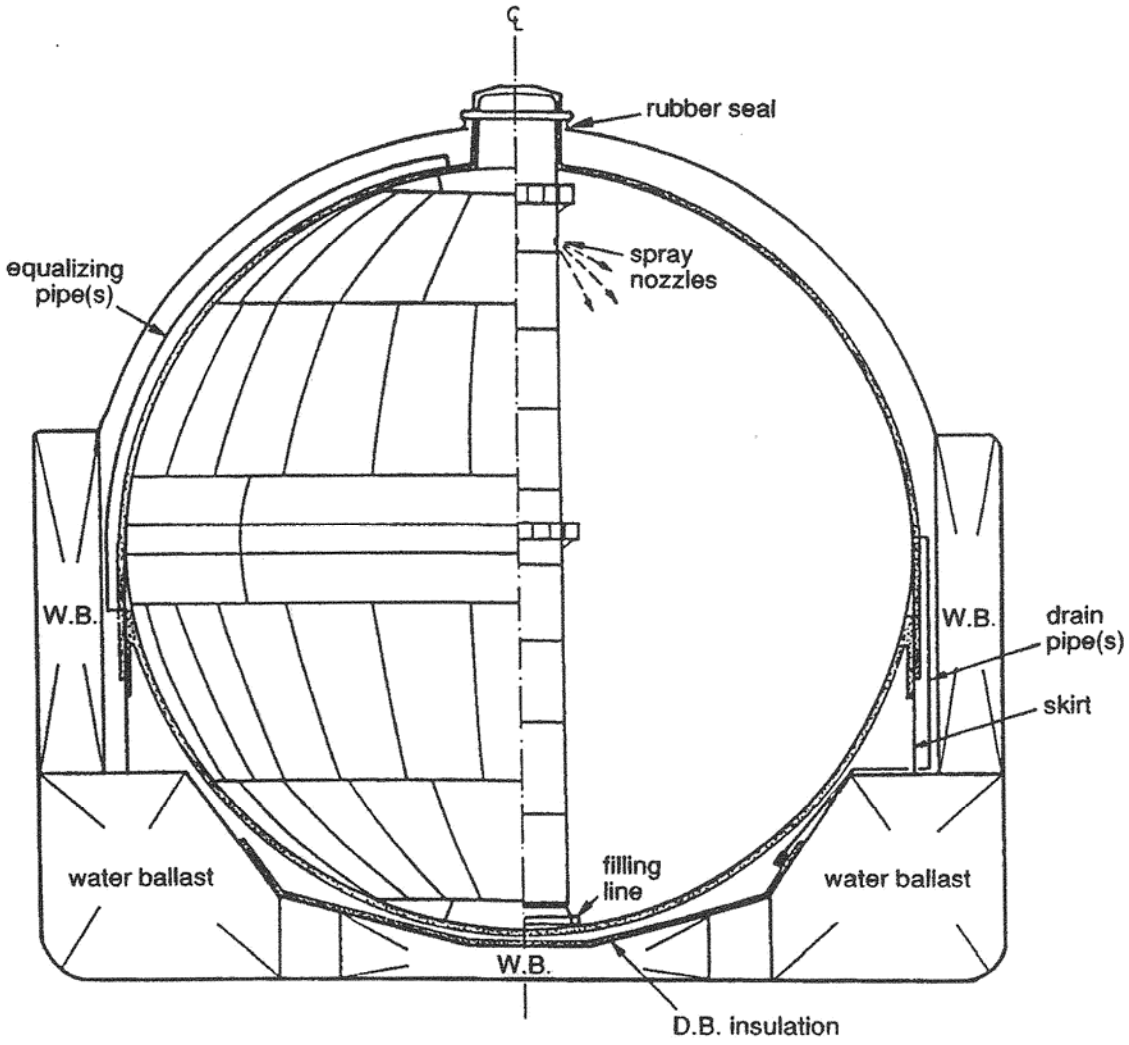


Fig 1.3 (f) An independent tank of type B

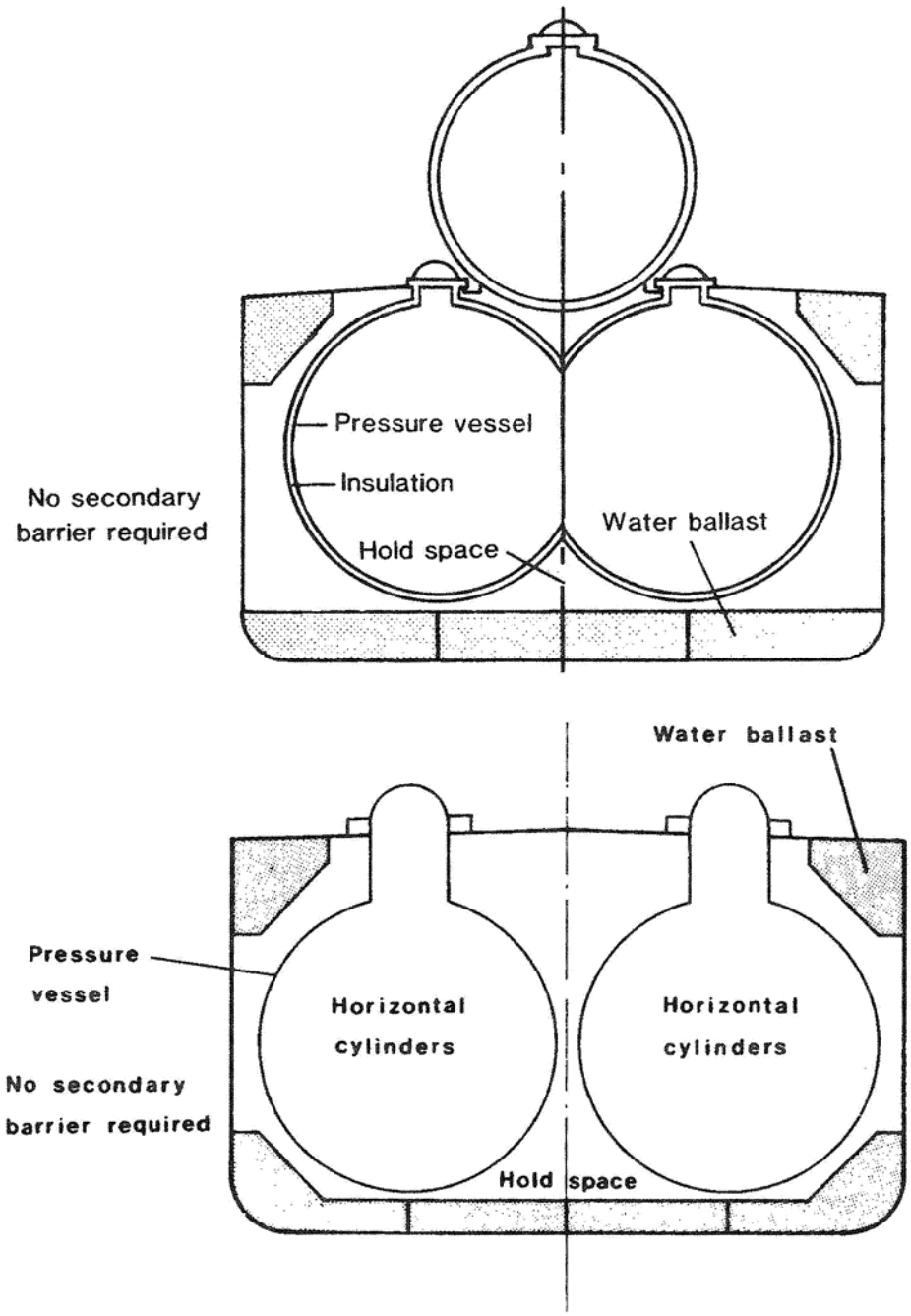


Fig 1.3 (g) Examples of independent tanks of type C

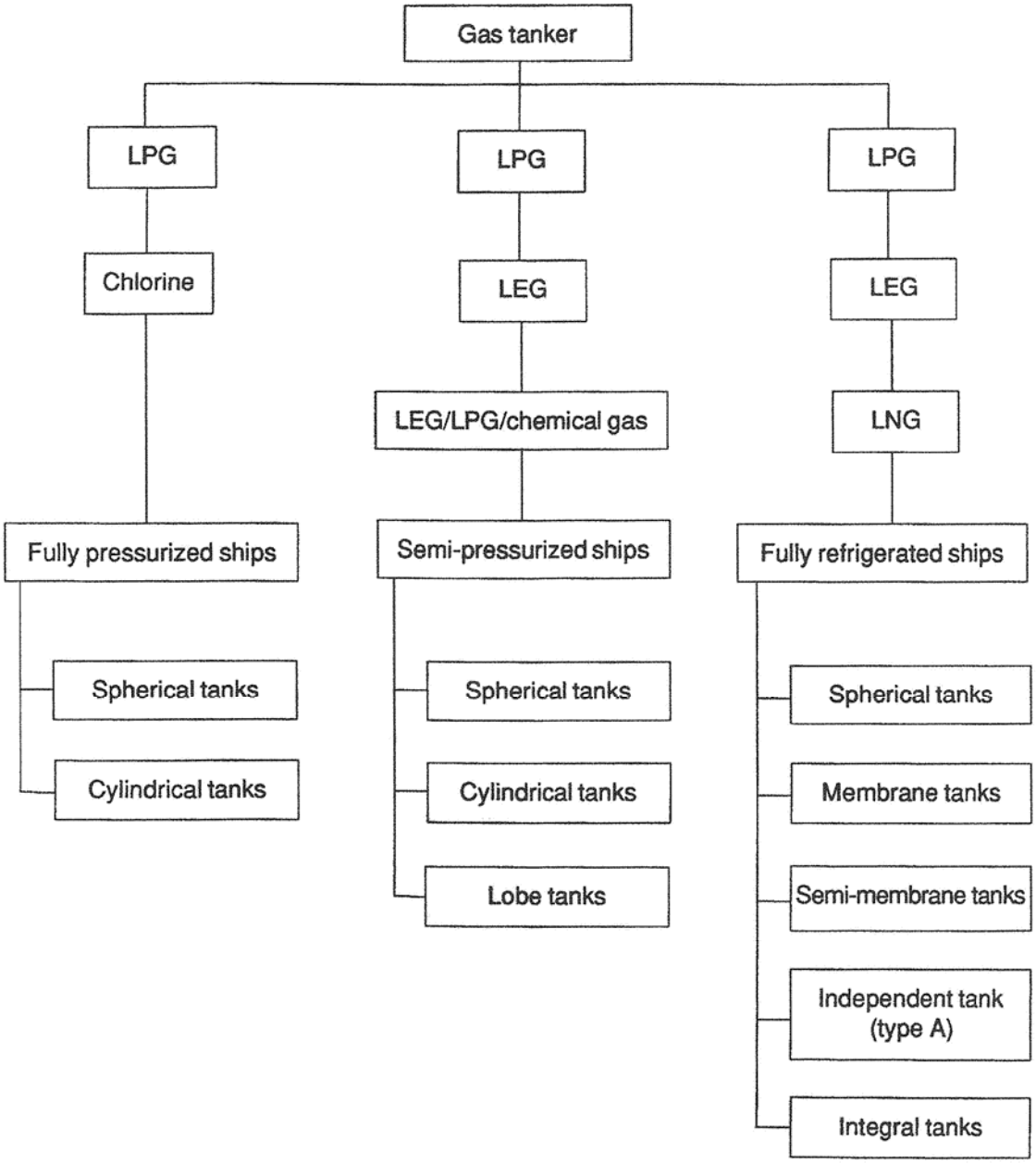


Fig 1.3 (h) Block diagram describing gas tanker types and the relationship between the cargo carried, carriage condition and the cargo – containment system normally used.

Cargo temperature at atmospheric pressure	–10 °C and above	Between –10 °C and –55 °C	Below –55 °C
	No secondary barrier required	Hull may act as the secondary barrier	Separate secondary barrier, where required
Basic tank type			
Integral		*Tank type not normally allowed*	
Membrane		Complete secondary barrier	
Semi-membrane		Complete secondary barrier	
Independent			
Type A		Complete secondary barrier	
Type B		Partial secondary barrier	
Type C		No secondary barrier required	
Internal insulation			
Type 1		Complete secondary barrier	
Type 2		Complete secondary barrier is incorporated	

Fig 1.3 (i) Secondary barrier requirements

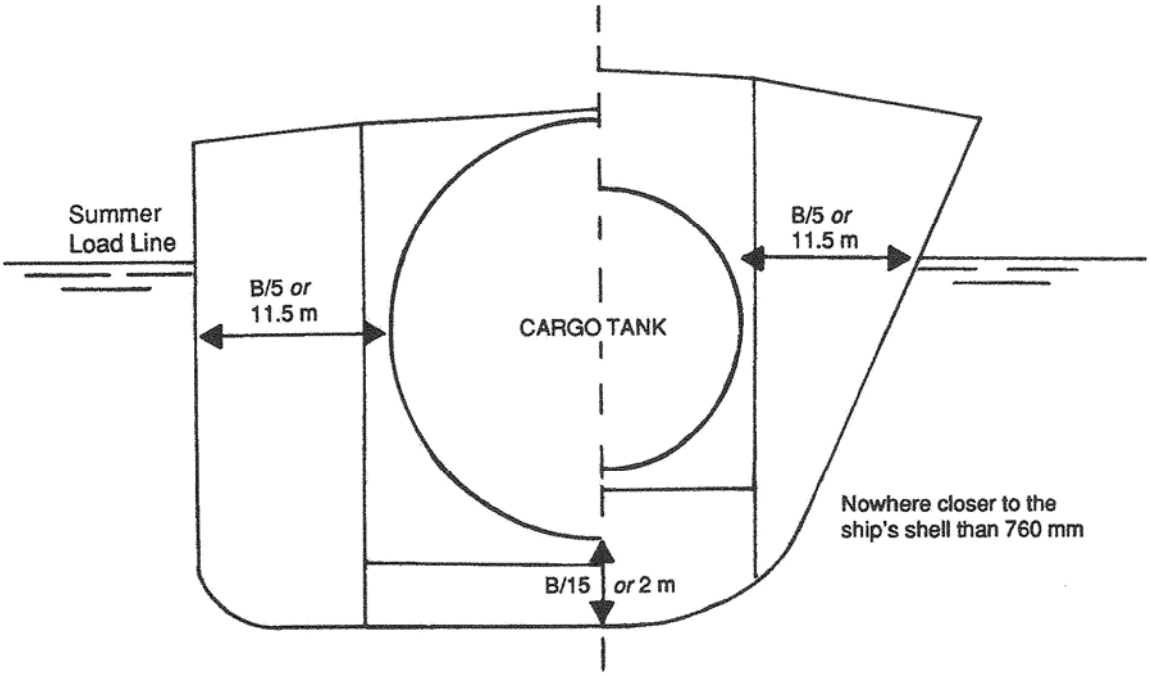


Fig 1.3 (j) Location of cargo tanks in a ship of type 1G

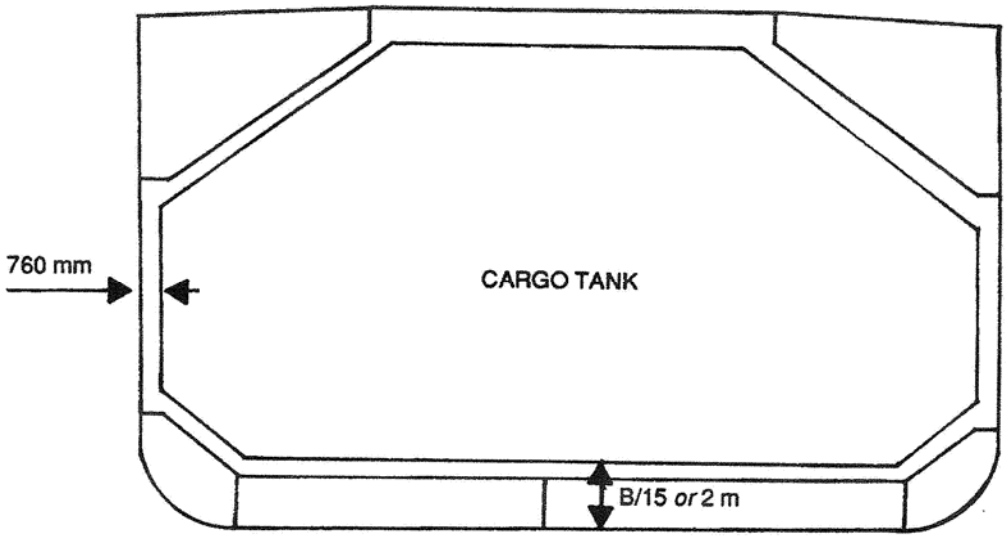


Fig 1.3.4 (a) Location of cargo tanks in ship of types 2G, 2PG and 3G

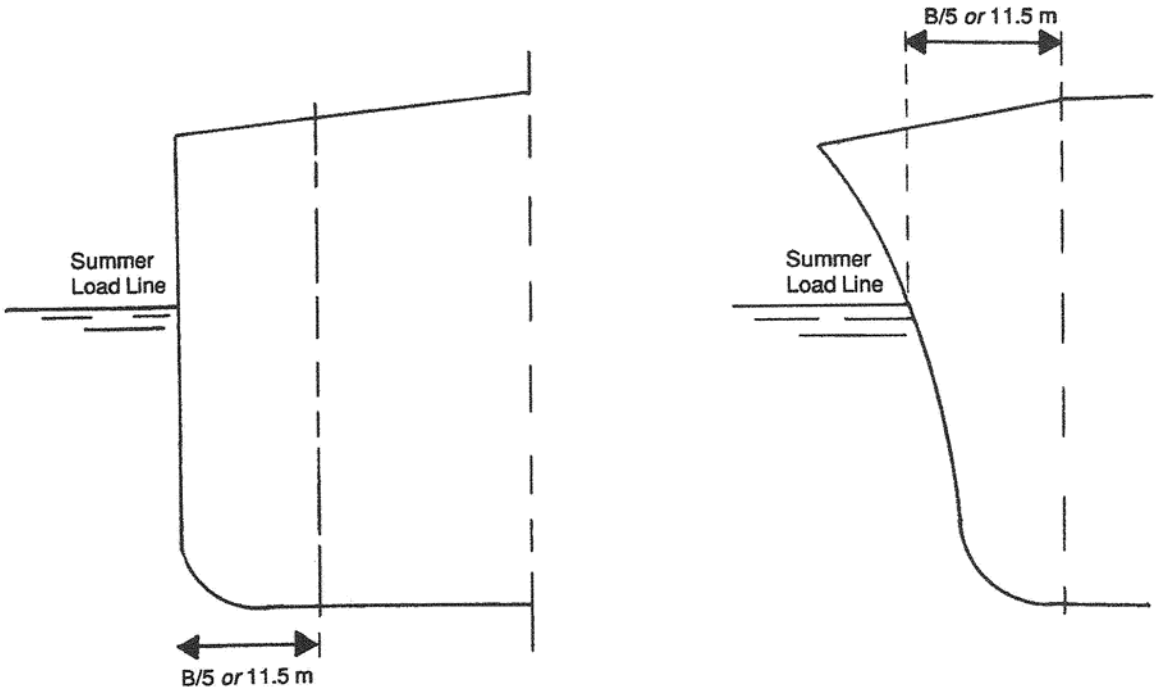
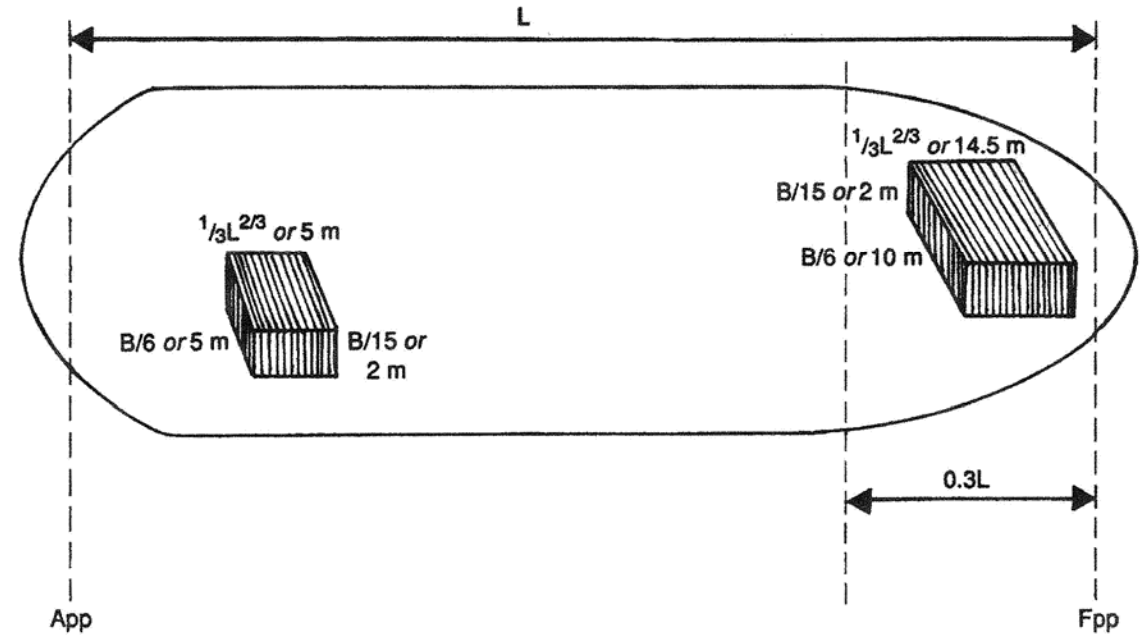


Fig.1.3.4 (b) Location of Tank maximum extent of side damage



"L" and "B" are as defined in
Reg. 3 of the Load Line Convention

Fig 1.3.5 (a) Assumed maximum extent of bottom damage

Ships should be capable of surviving defined damage with the flooding assumptions to the extent determined by the ship's type according to the following standards:

1G	Sustain damage anywhere in its length	
2G	Sustain damage anywhere in its length except involving either of the bulkheads bounding a machinery space located aft	Sustain damage anywhere in its length
2PG	Sustain damage anywhere in its length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage	
3G	Sustain damage anywhere in its length except involving transverse bulheads spaced further apart than the longitudinal extent of damage and except damage involving machinery space located aft	Sustain damage anywhere in its length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage

150 m or more in length

125 m or more in length

Fig 1.3.5 (b) Standard of damage

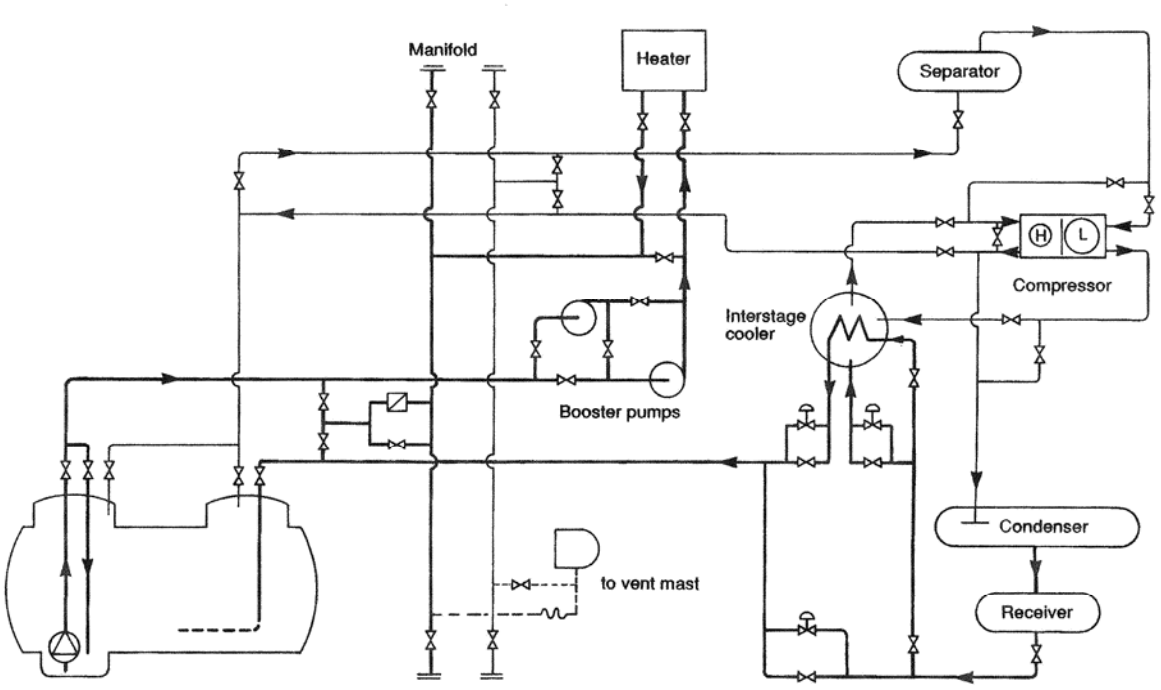


Fig 1.4 (a) Complete cargo handling arrangement for a single tank

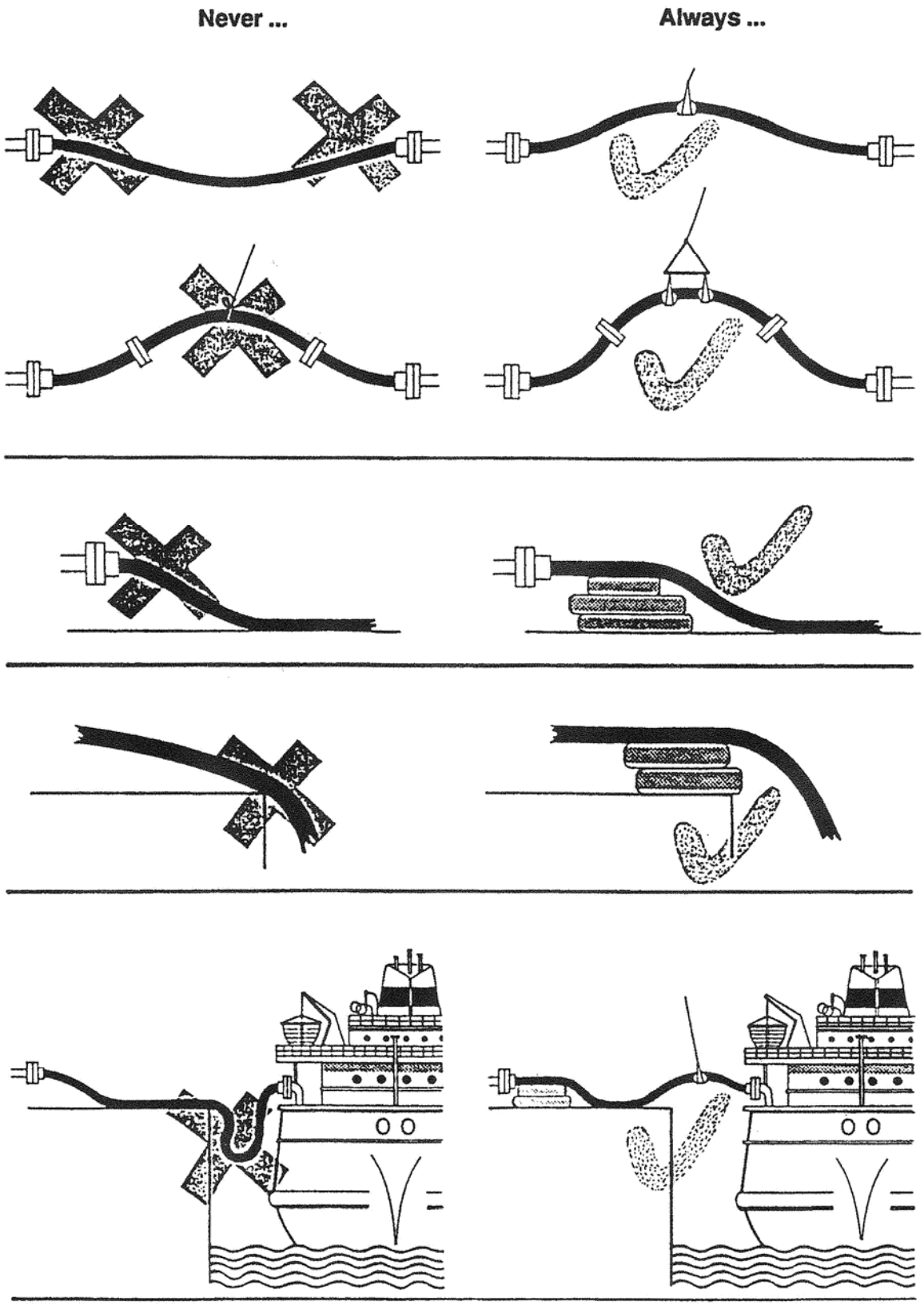


Fig 1.4 (b) Handling a cargo hose

LIQUEFIED GAS — CARGO HOSE FORM

SHIP :

HOSE IDENTIFICATION :

1. MAXIMUM WORKING PRESSURE ..... (This should be stencilled or marked on hose)

2. MAXIMUM & MINIMUM WORKING TEMPERATURES ..... (These should be stencilled or marked on hose)

3. SUITABLE FOR CARGOES OF : ..... (This should be stencilled or marked on hose)

4. TEST PRESSURE & PROCEDURE : ..... (Note method of pressurisation, method of inspection (e.g. measurement of extension, visual inspection for leaks) and any precautions required.)

5.

TESTED (Date)	AT PRESSURE	APPROVED
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....
.....	.....	.....

Fig 1.4 (c) Liquefied gas – cargo hose form

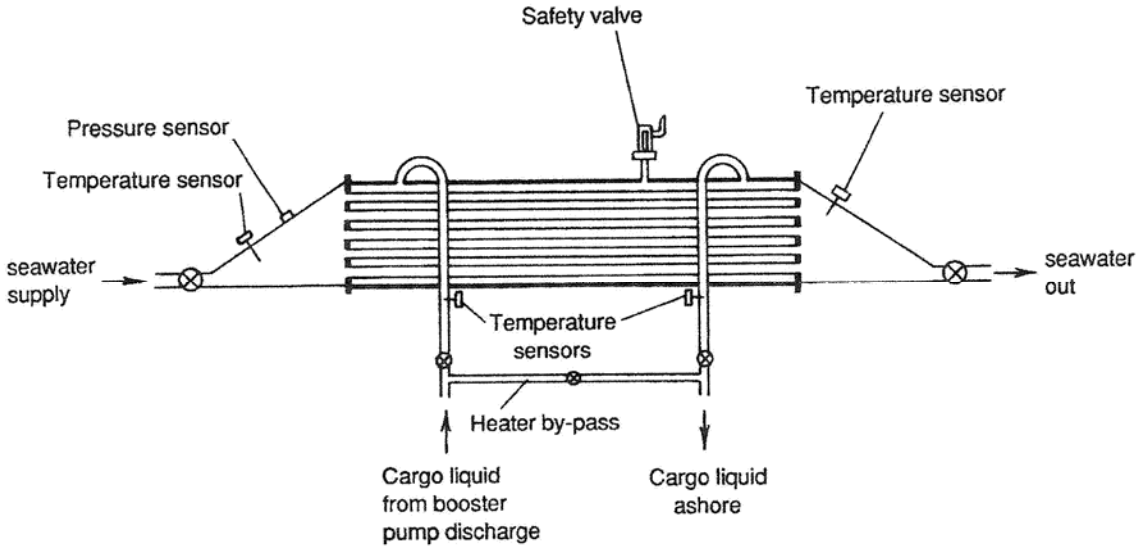


Fig 1.4 (d) A cargo heater

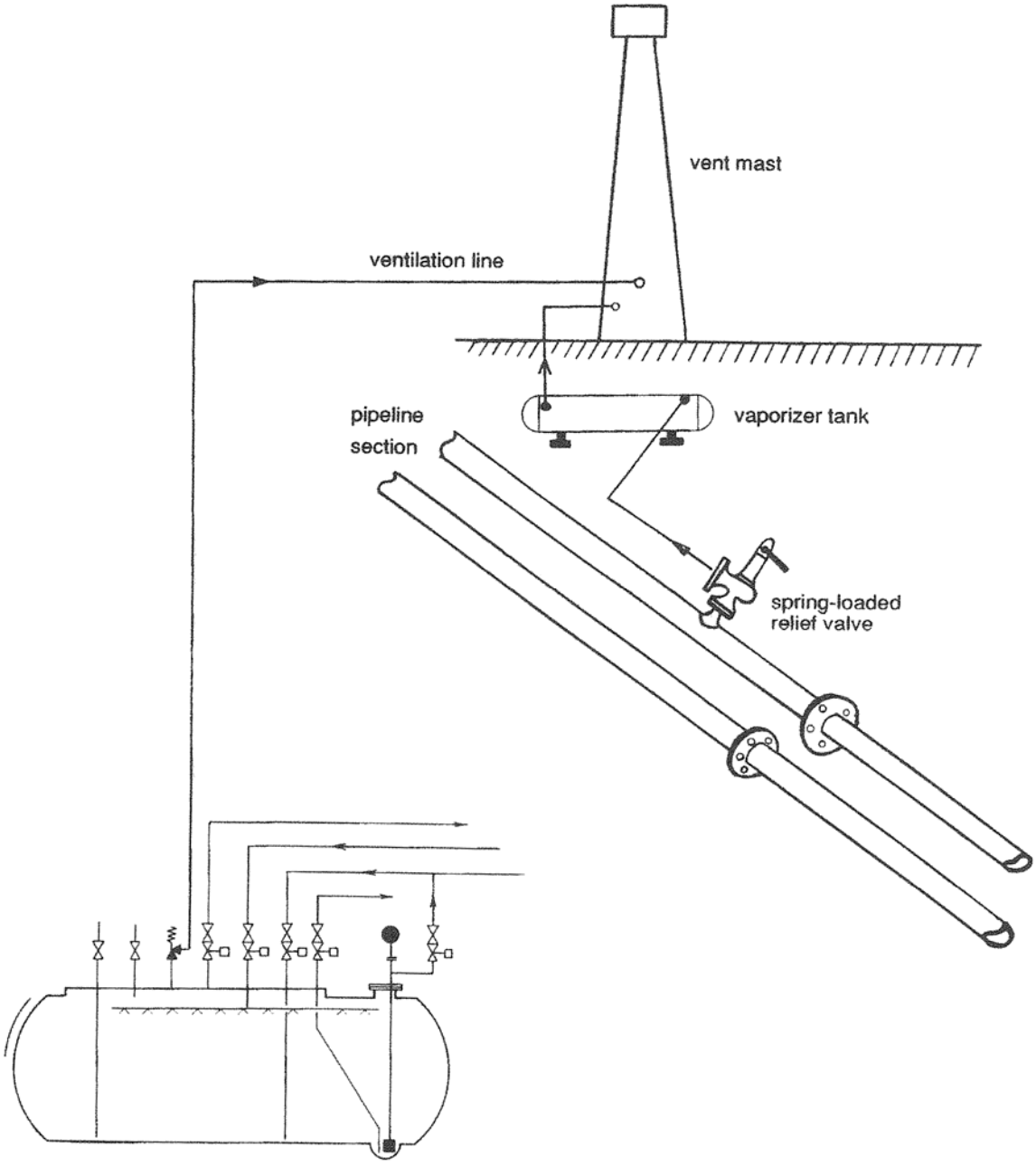


Fig 1.4 (e) Schematic diagram of a pressure – relief system

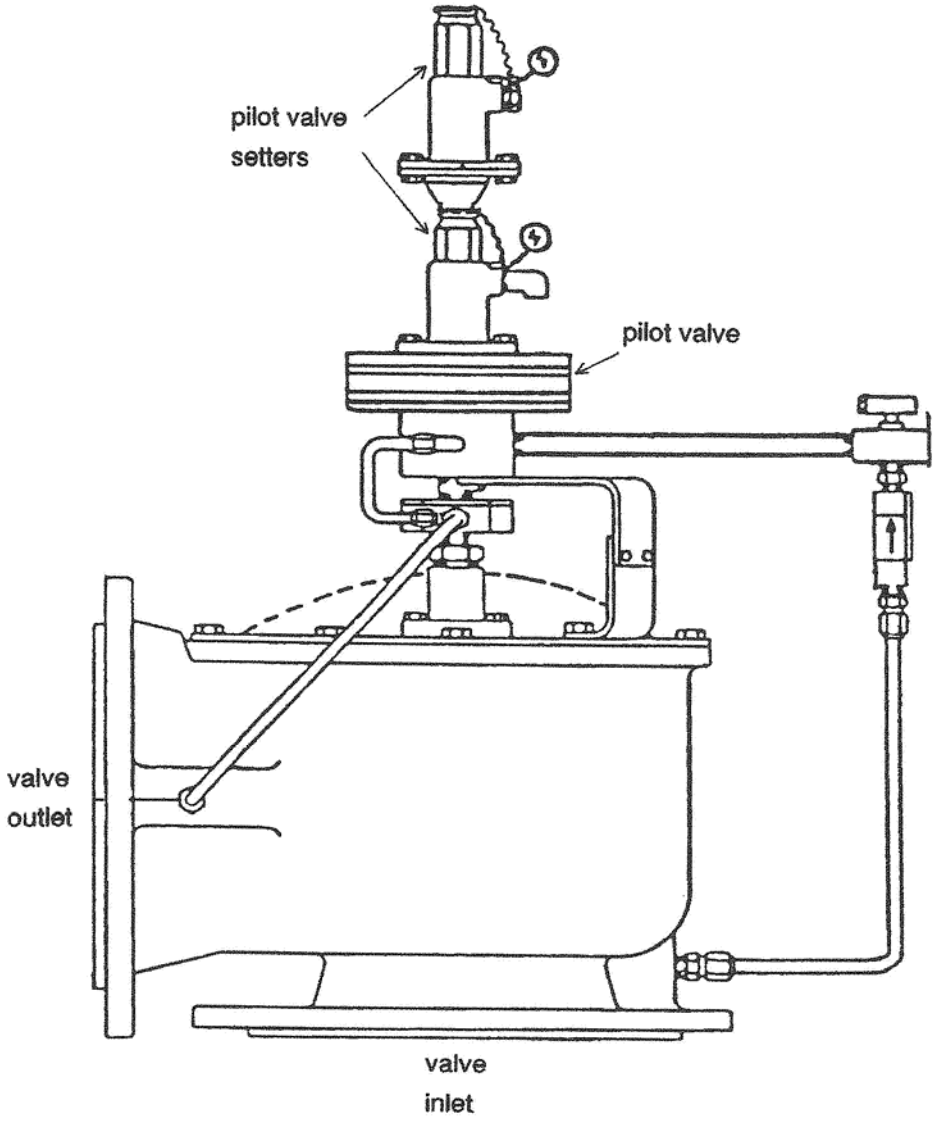


Fig 1.4 (f) A cargo tank safety relief valve

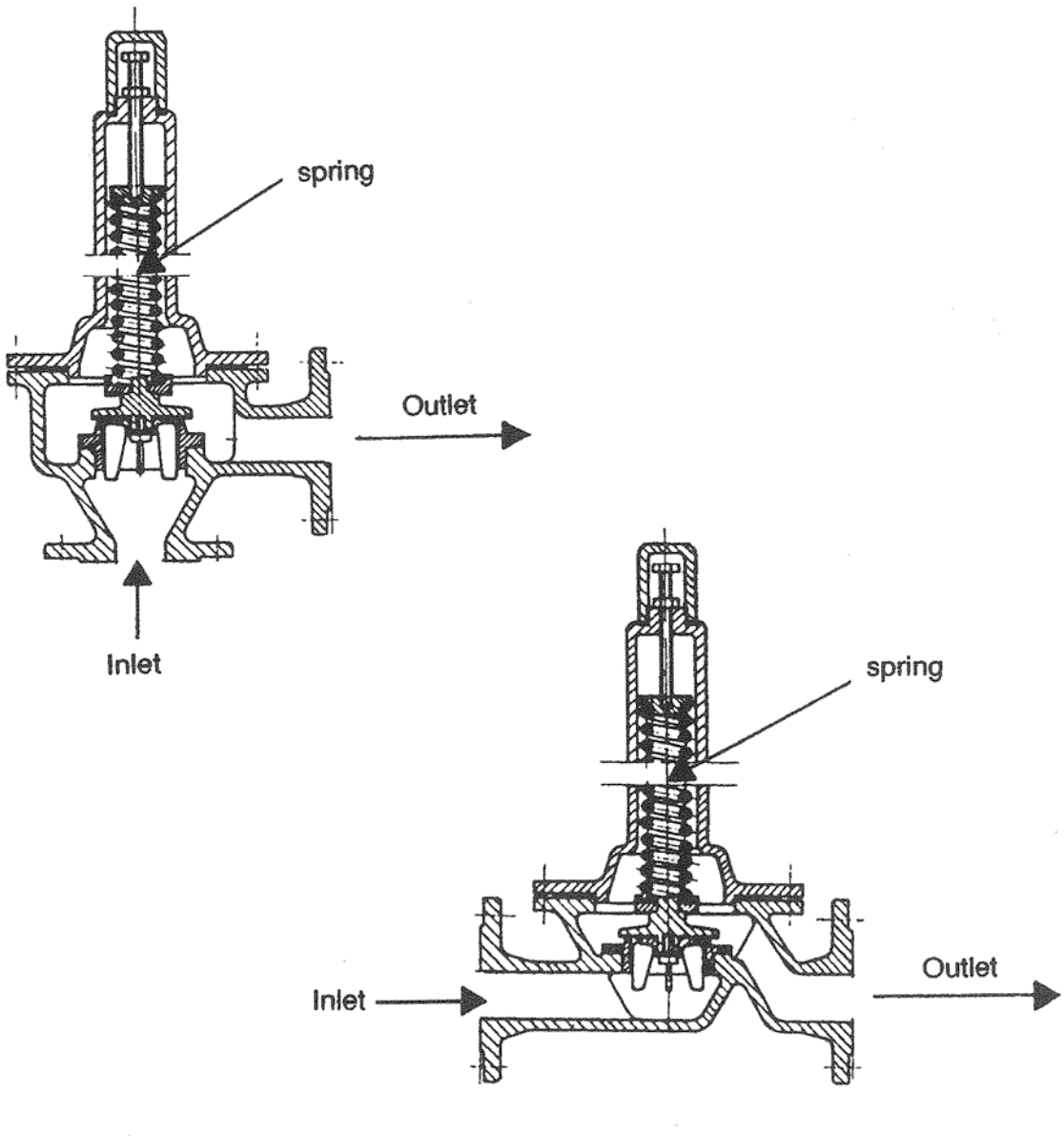


Fig 1.4 (g) Spring – loaded relief valves

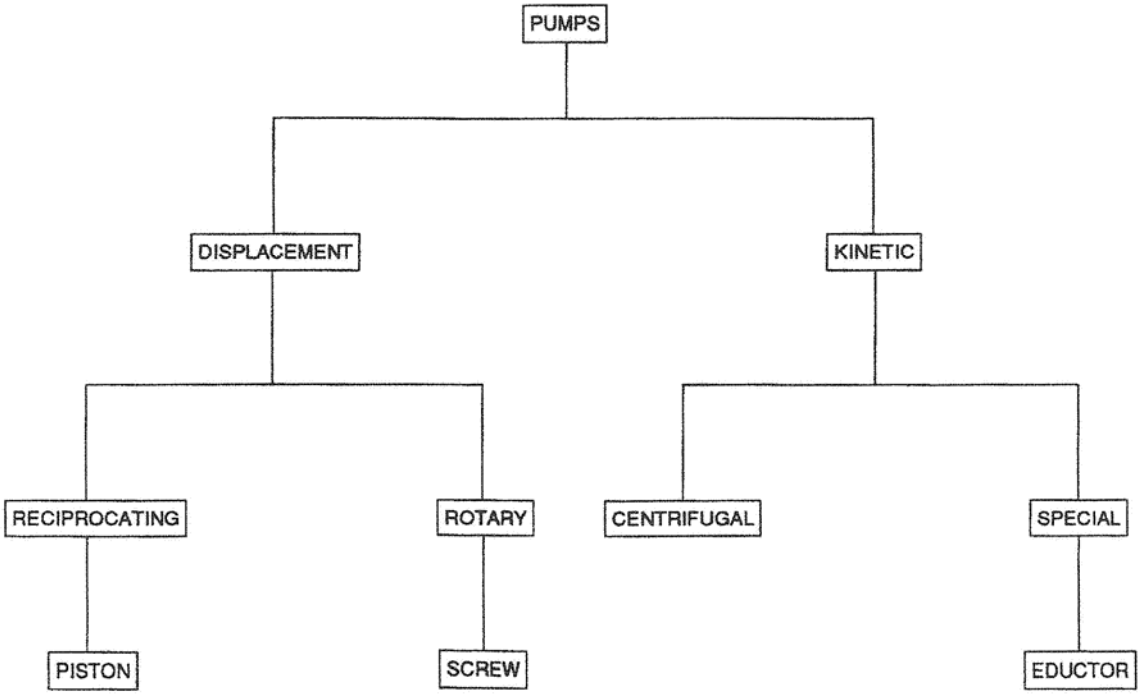


Fig 1.4.1 Pump types

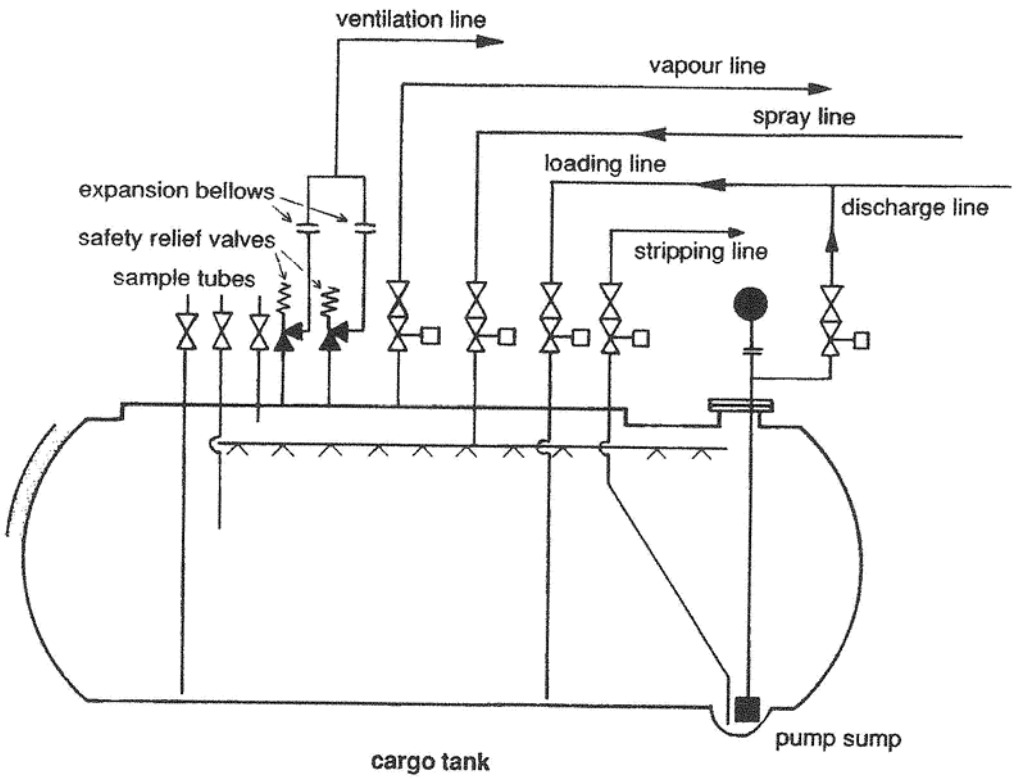


Fig 1.4.2 (a) Arrangement of the pipes and valves of a cargo tank

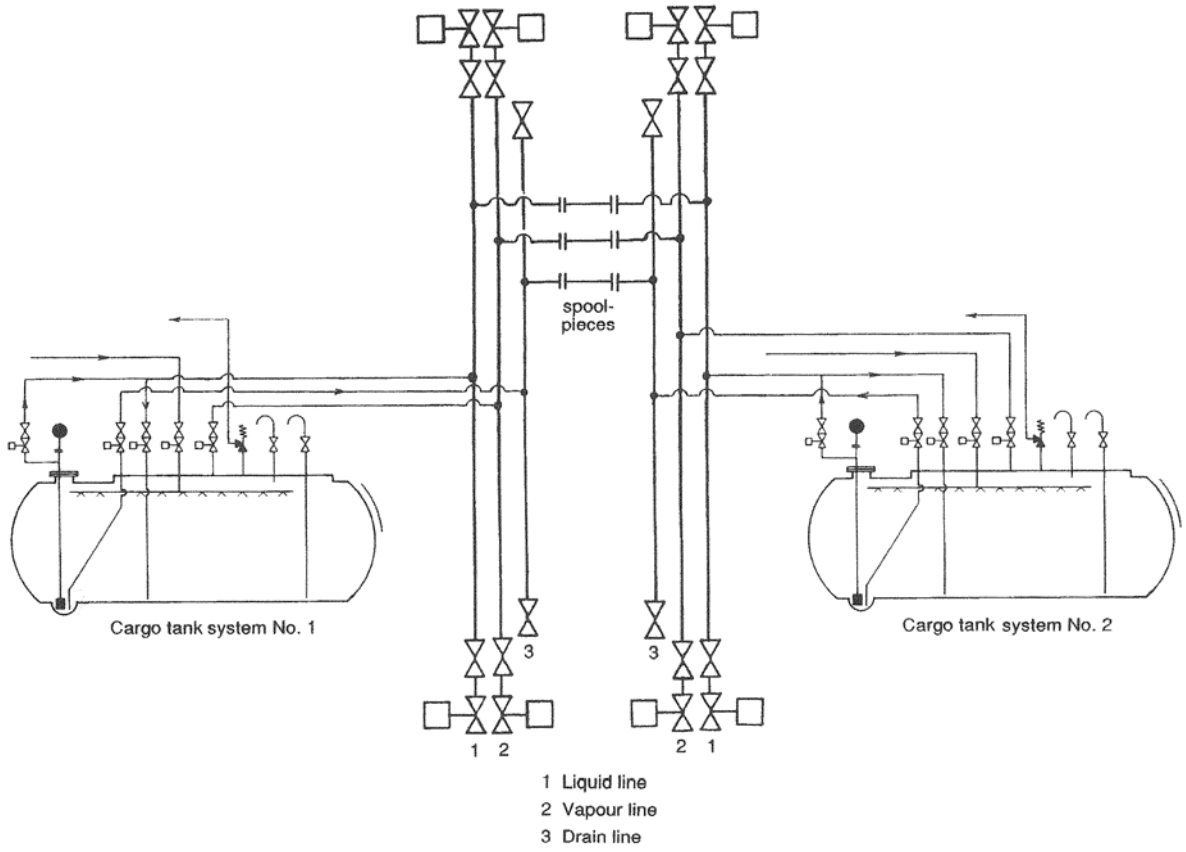


Fig 1.4.2 (b) Simplified diagram of the arrangement of cargo piping

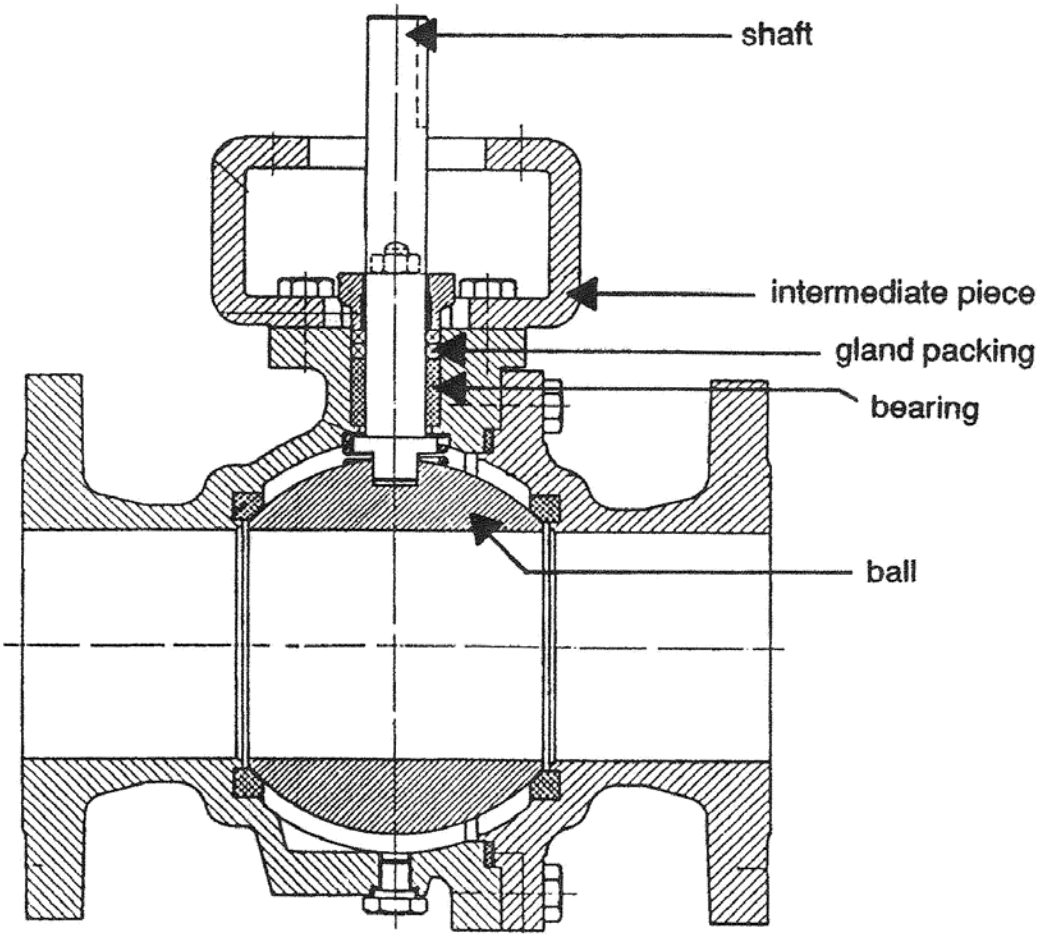


Fig 1.4.2 (c) Example of a ball valve

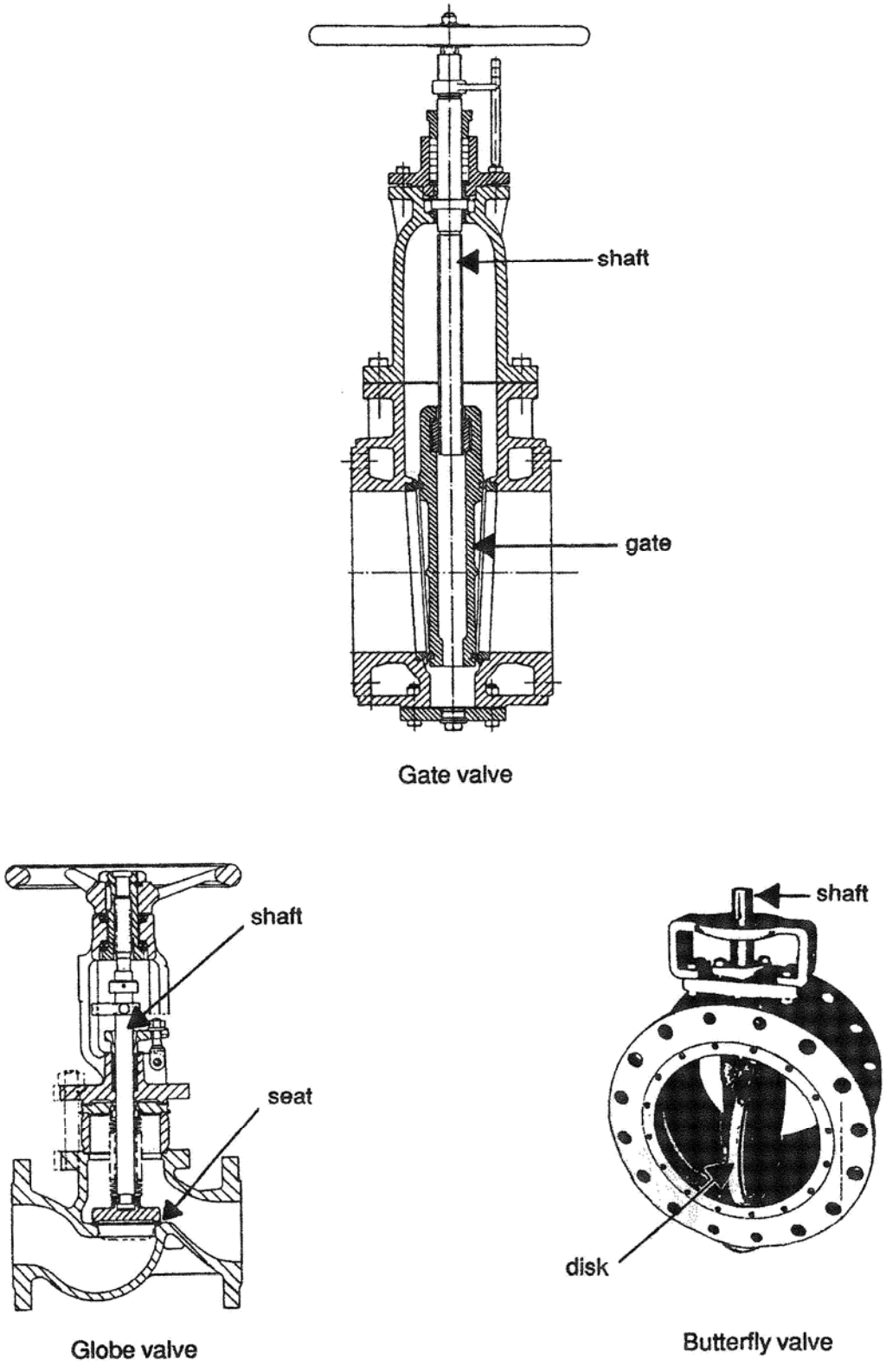


Fig 1.4.2 (d) Examples of gate, globe and butterfly valves

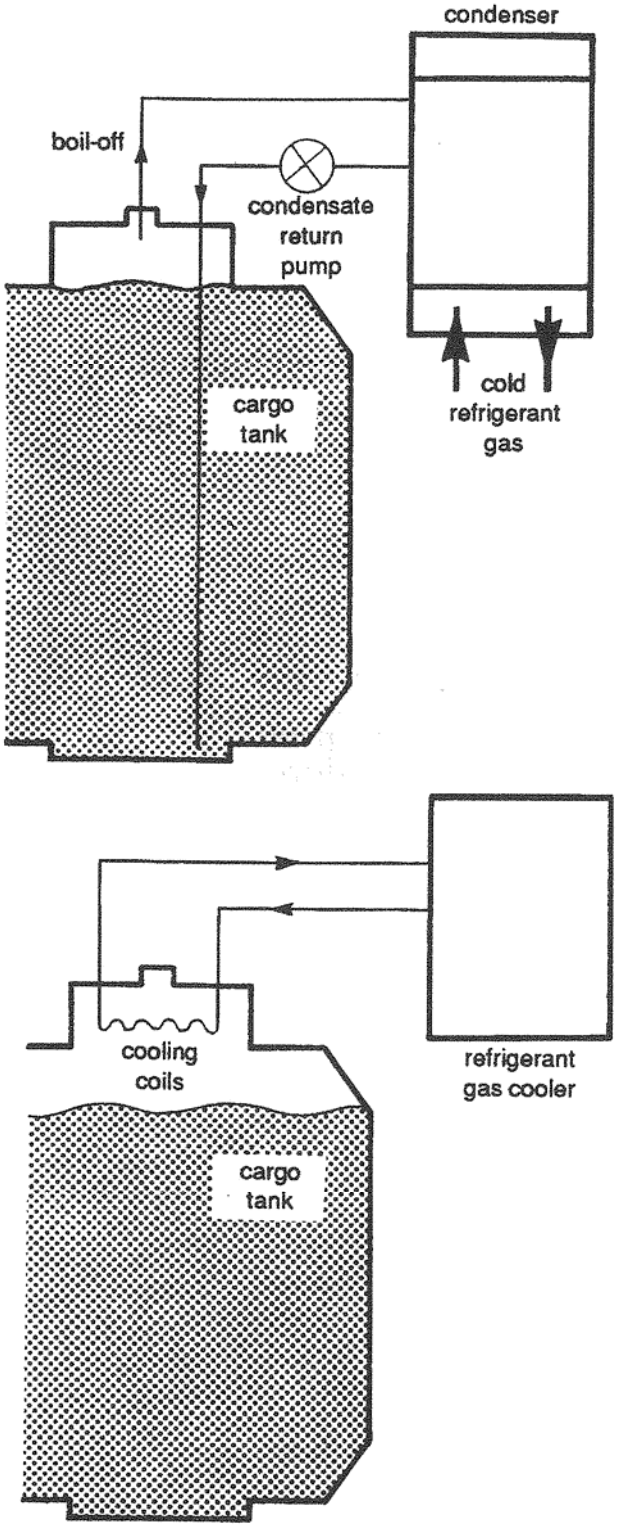


Fig 1.5.2 Examples of indirect cooling cycles

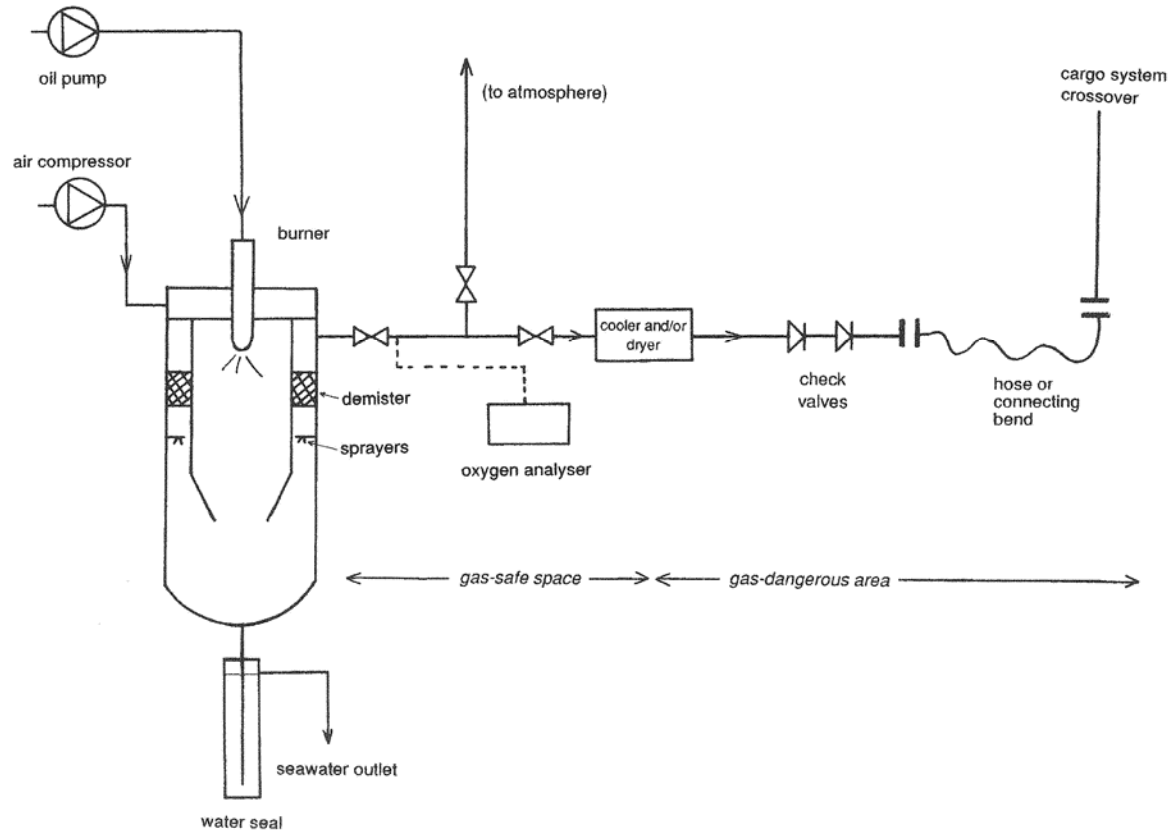


Fig 1.6 (a) Schematic diagram of an inert gas generators system

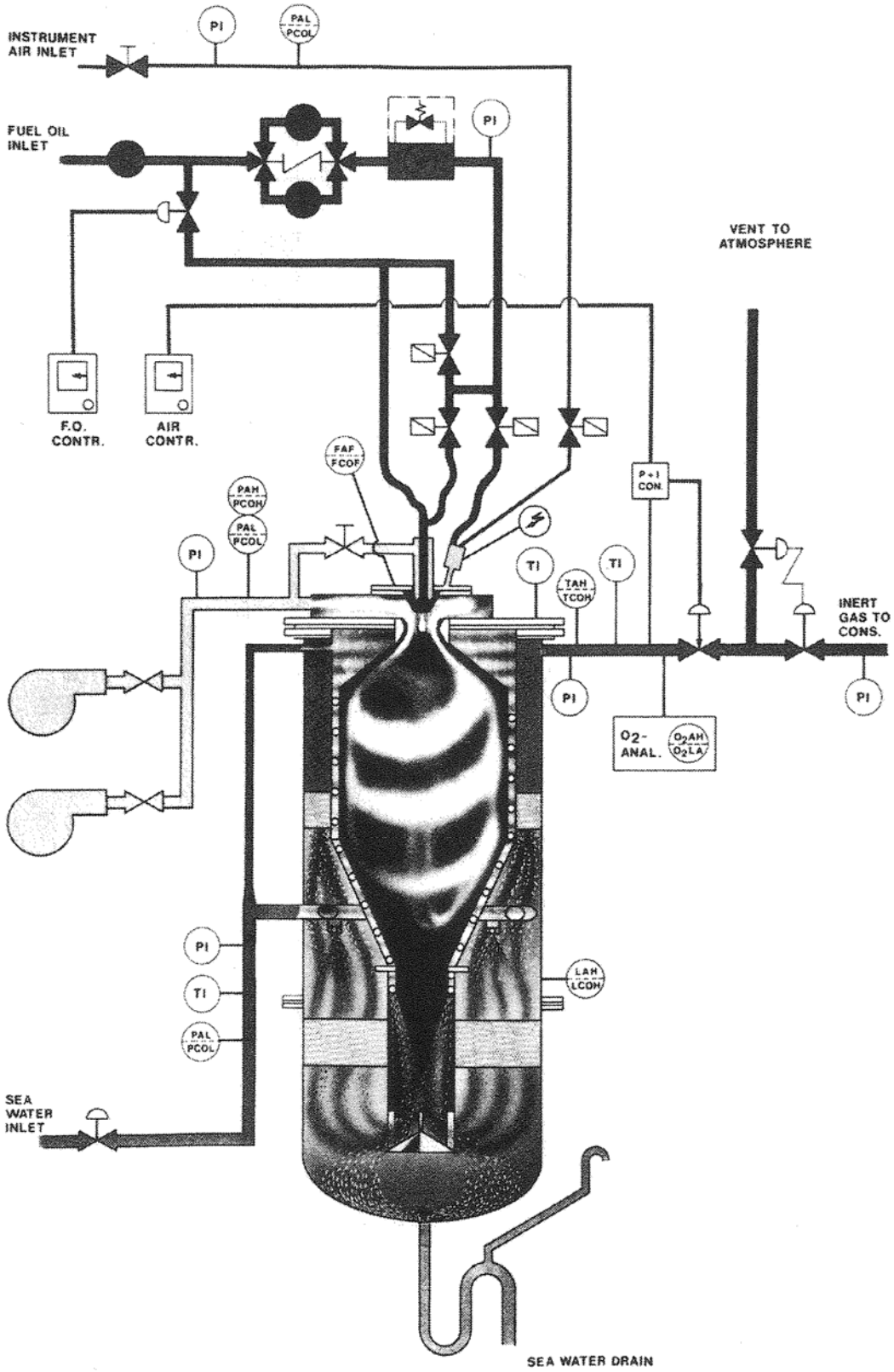


Fig 1.6 (b) An inert gas generator

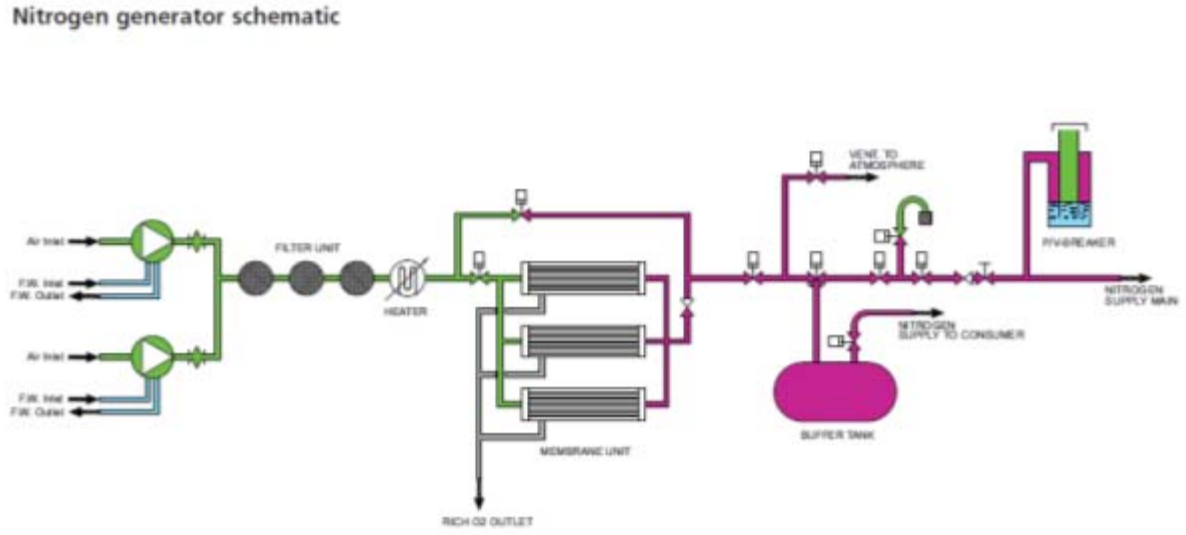


Fig 1.6 (c) Nitrogen generator system of an LNG Tanker

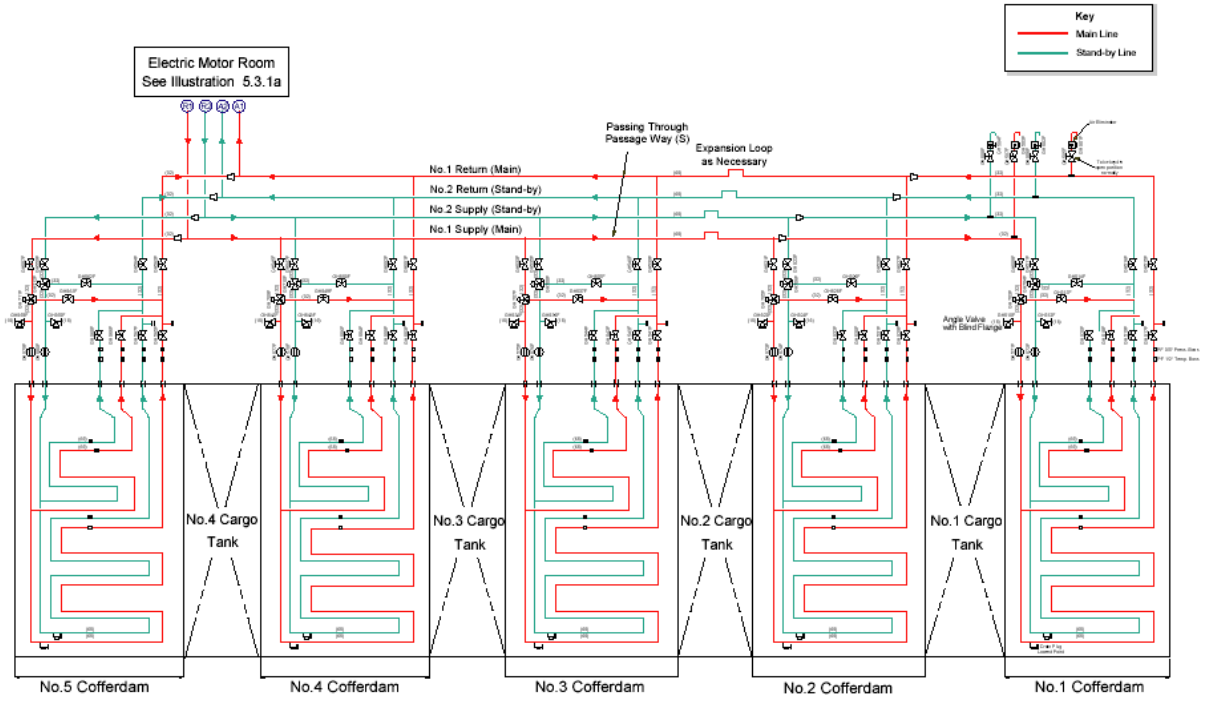


Fig 1.7.4 Glycol heating arrangements for cofferdams of an LNG tanker

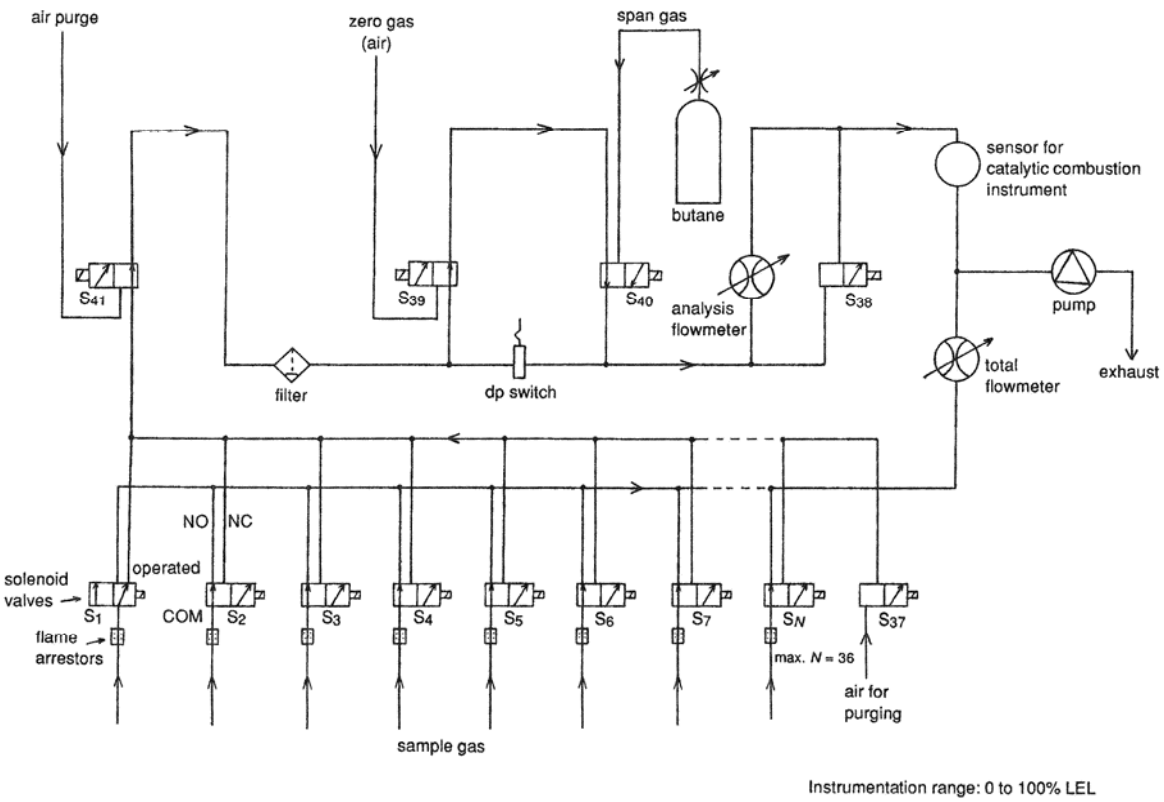


Fig 1.8 flow diagram of a fixed gas – detecting system

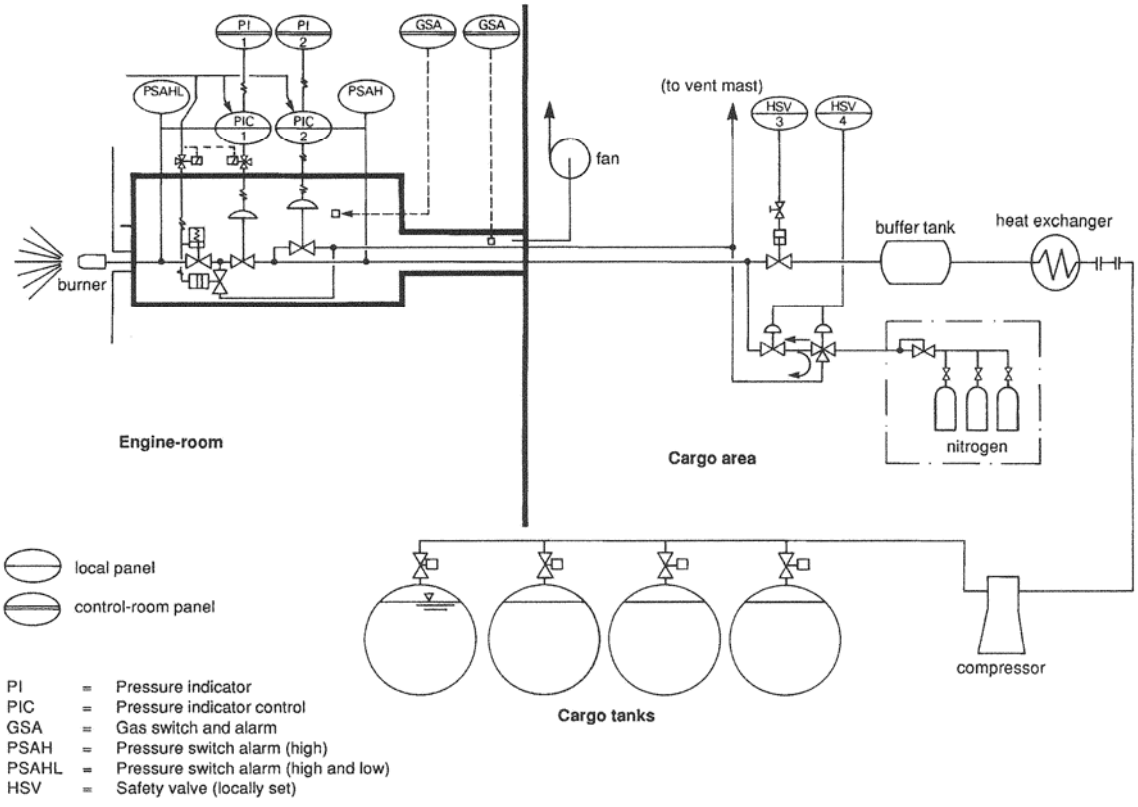


Fig 1.10(a) Schematic diagram of handling of LNG boil – off

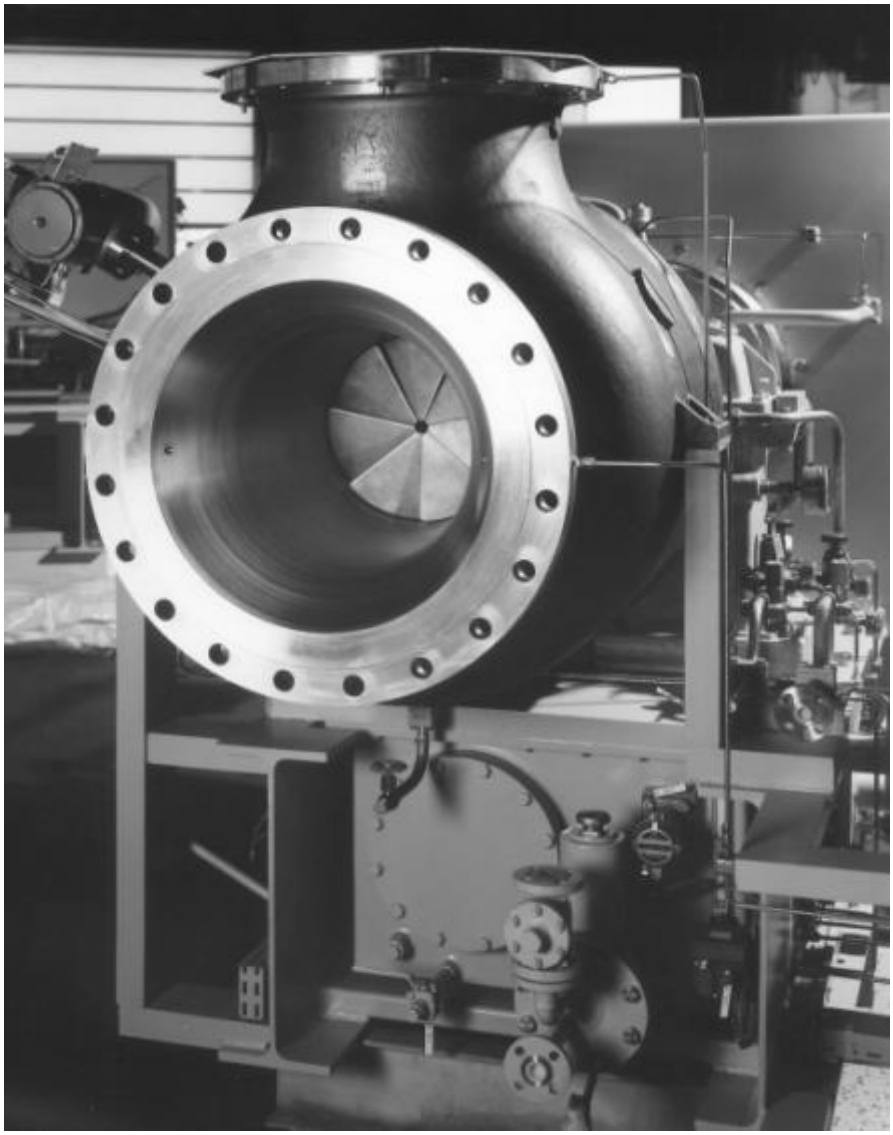


Figure 1.10 (b): LNG HD Compressor

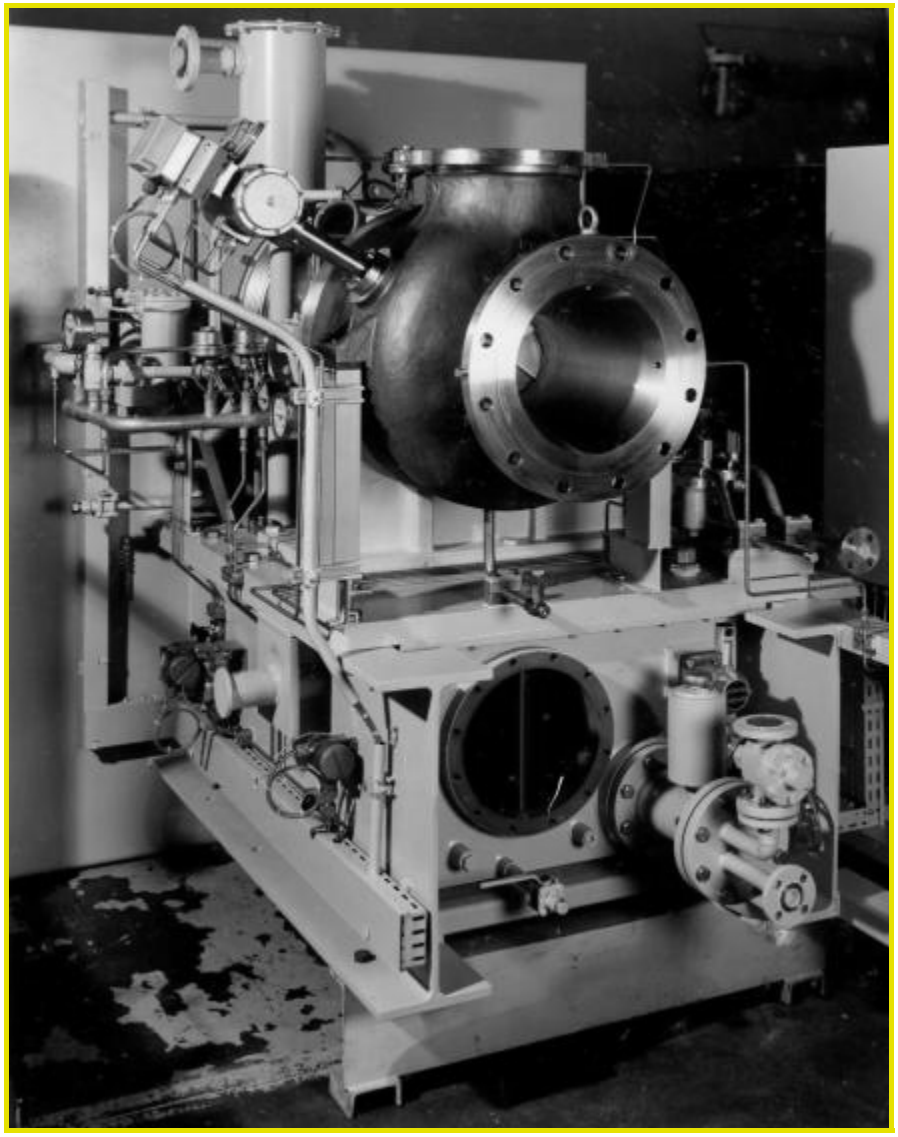


Figure 1.10(c) LNG LD Compressor

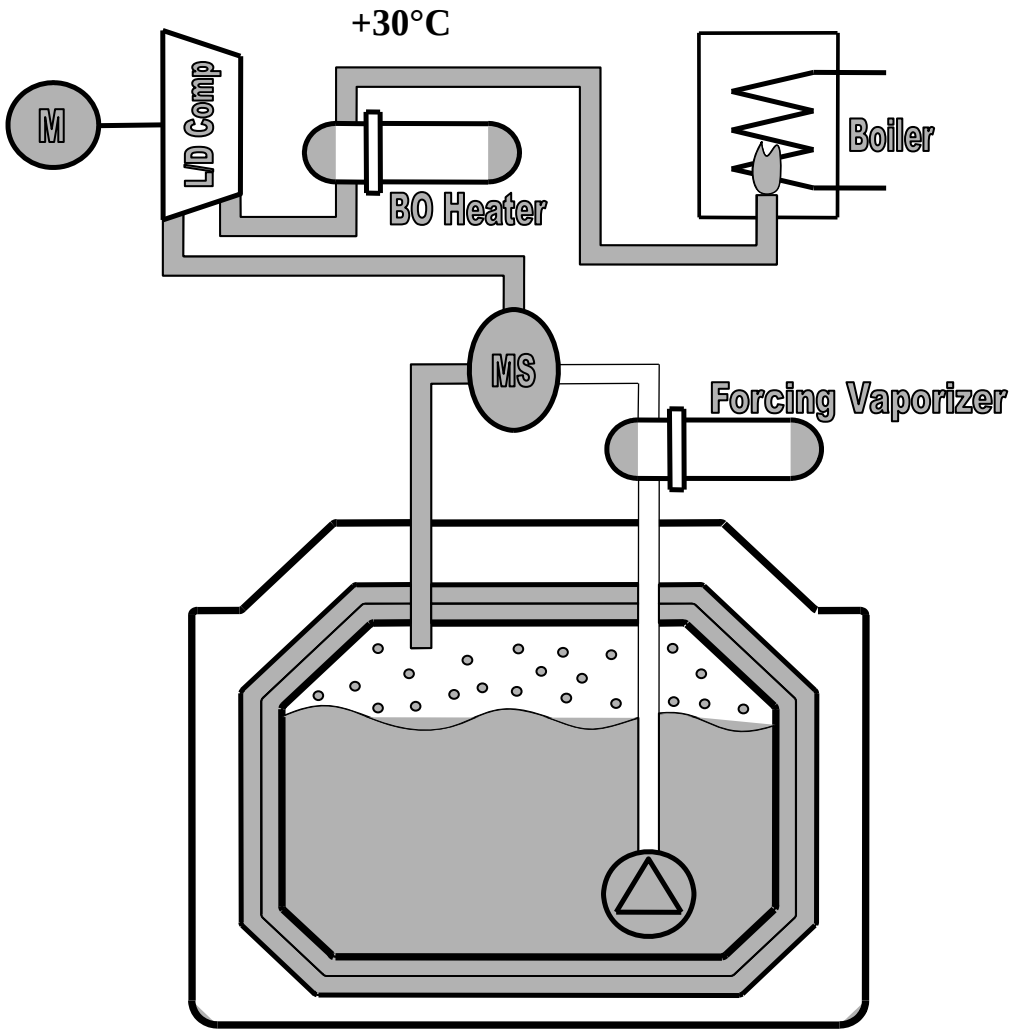


Fig 1.10 (d) Loaded Voyage: BOG is compressed by the LD compressor and heated to 20/30°C before it is sent to the engine room as fuel gas for the steam boilers.

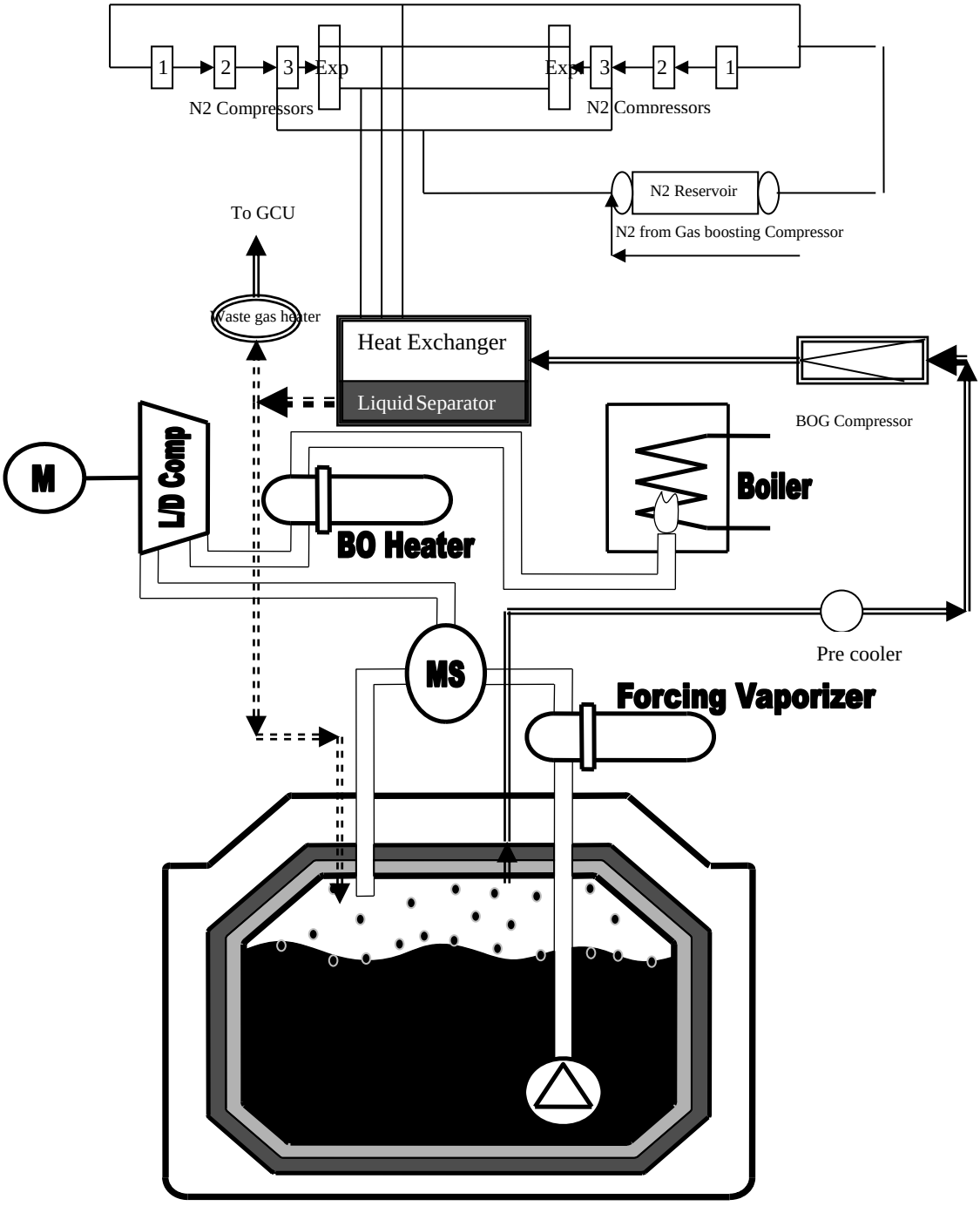


Figure 1.11 (a) Showing a Re-liquefaction Plant on board an LNGC along with a BOG gas burning unit for propulsion system

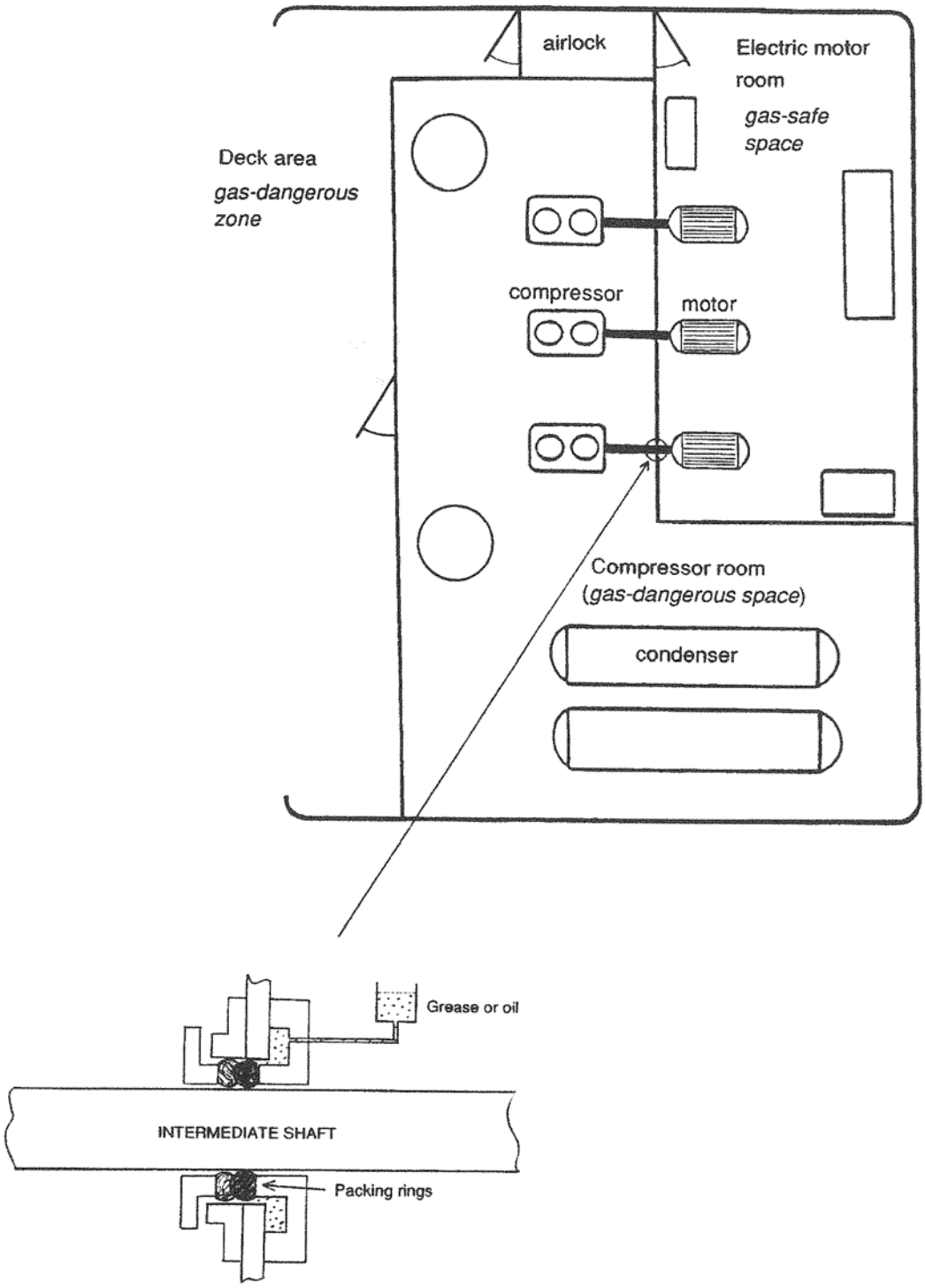


Fig 1.11 (b) Arrangement of a deck-house and an example of a gas-tight arrangement around an intermediate shaft

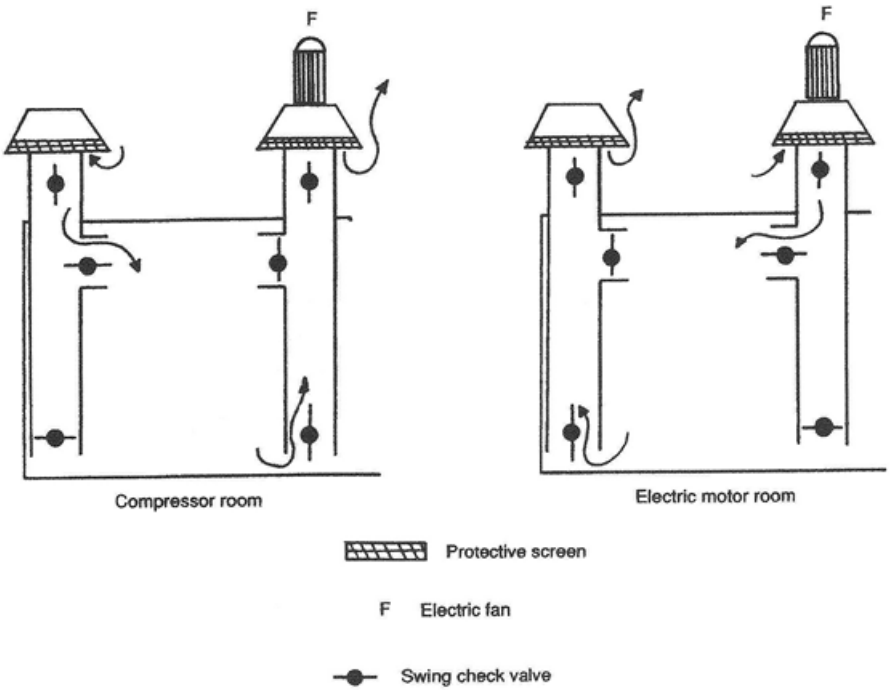


Fig 1.11 (c) Ventilation arrangement of a deck - house

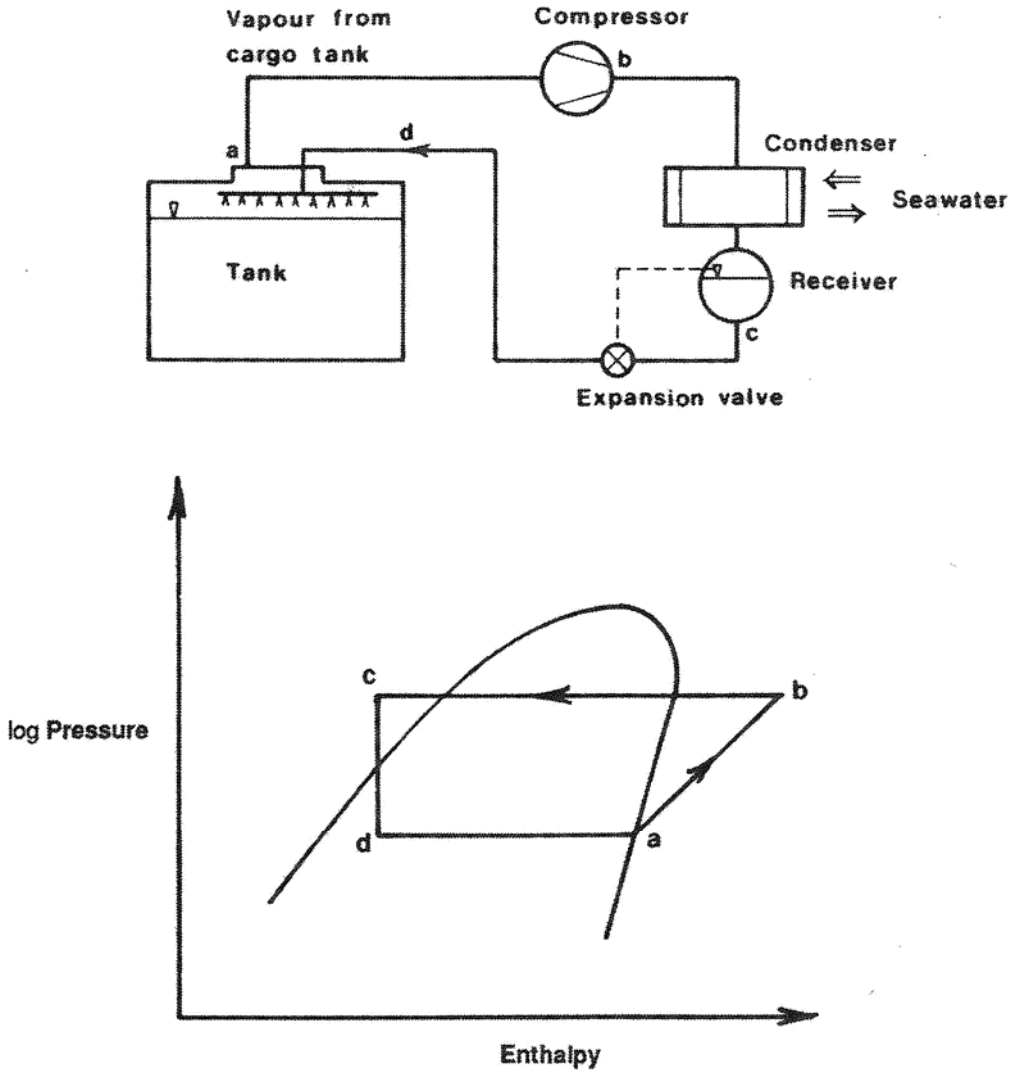


Fig 1.11 (d) Single – stage direct re-liquefaction cycle and a mollier diagram for the cycle

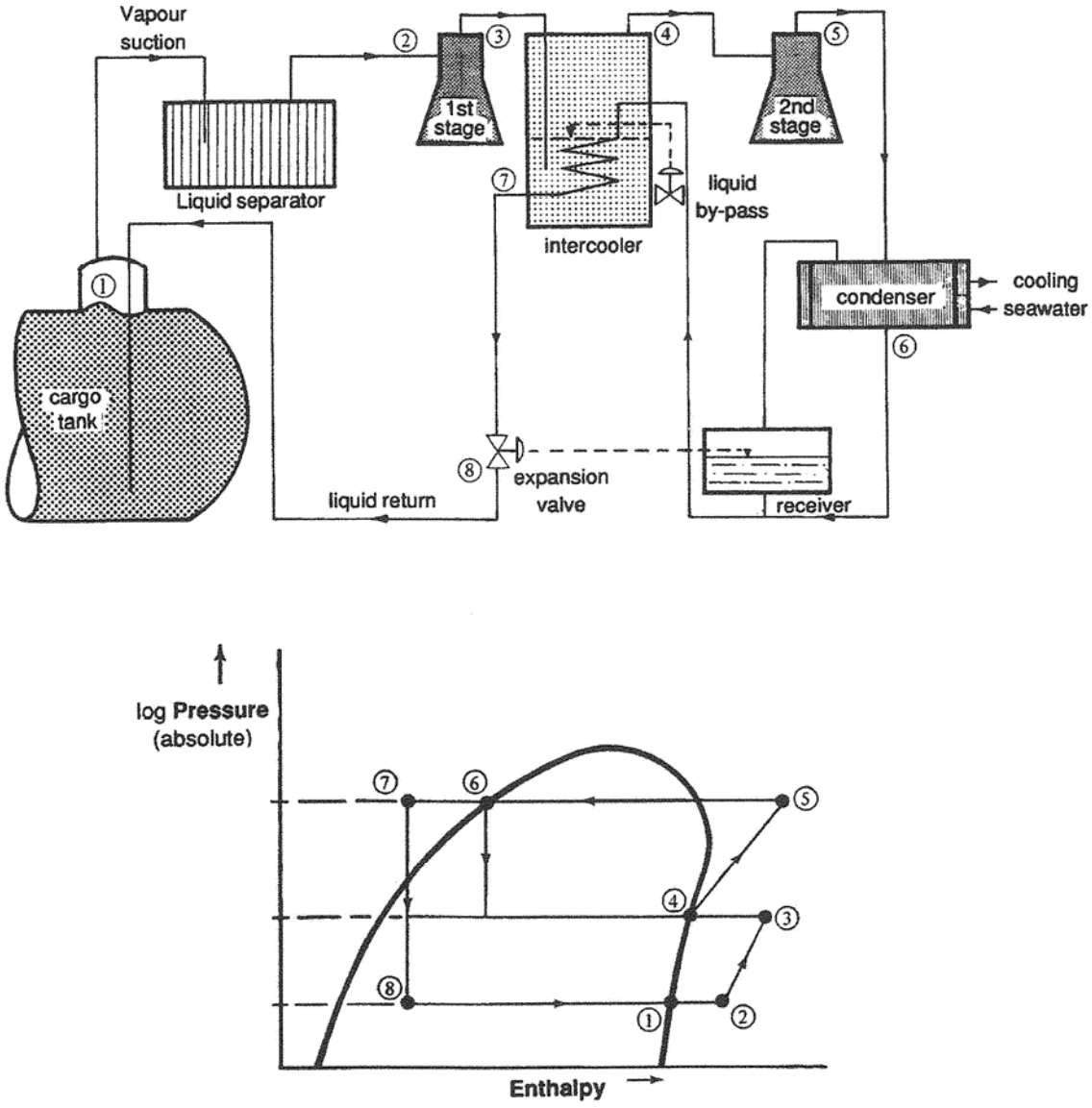


Fig 1.11 (e) Two – stage direct re-liquefaction cycle with interstage cooling and a mollier diagram for the cycle

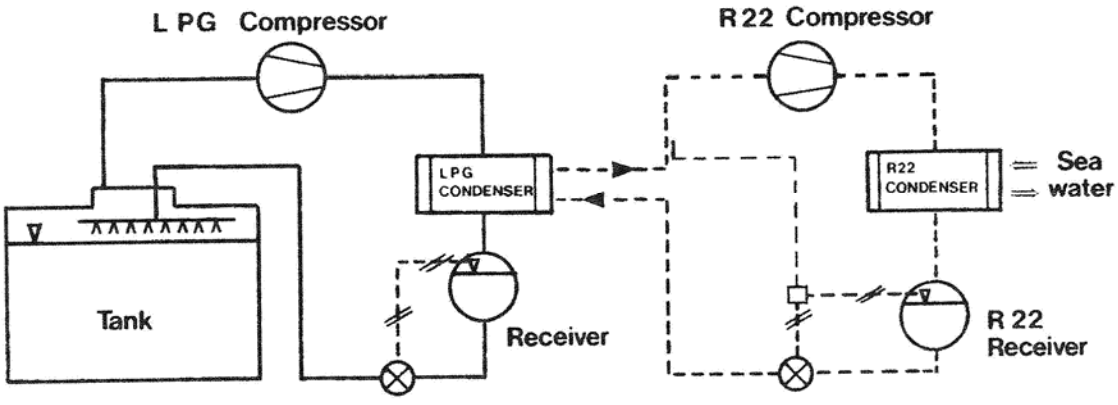


Fig 1.11 (f) A simplified cascade re-liquefaction cycle

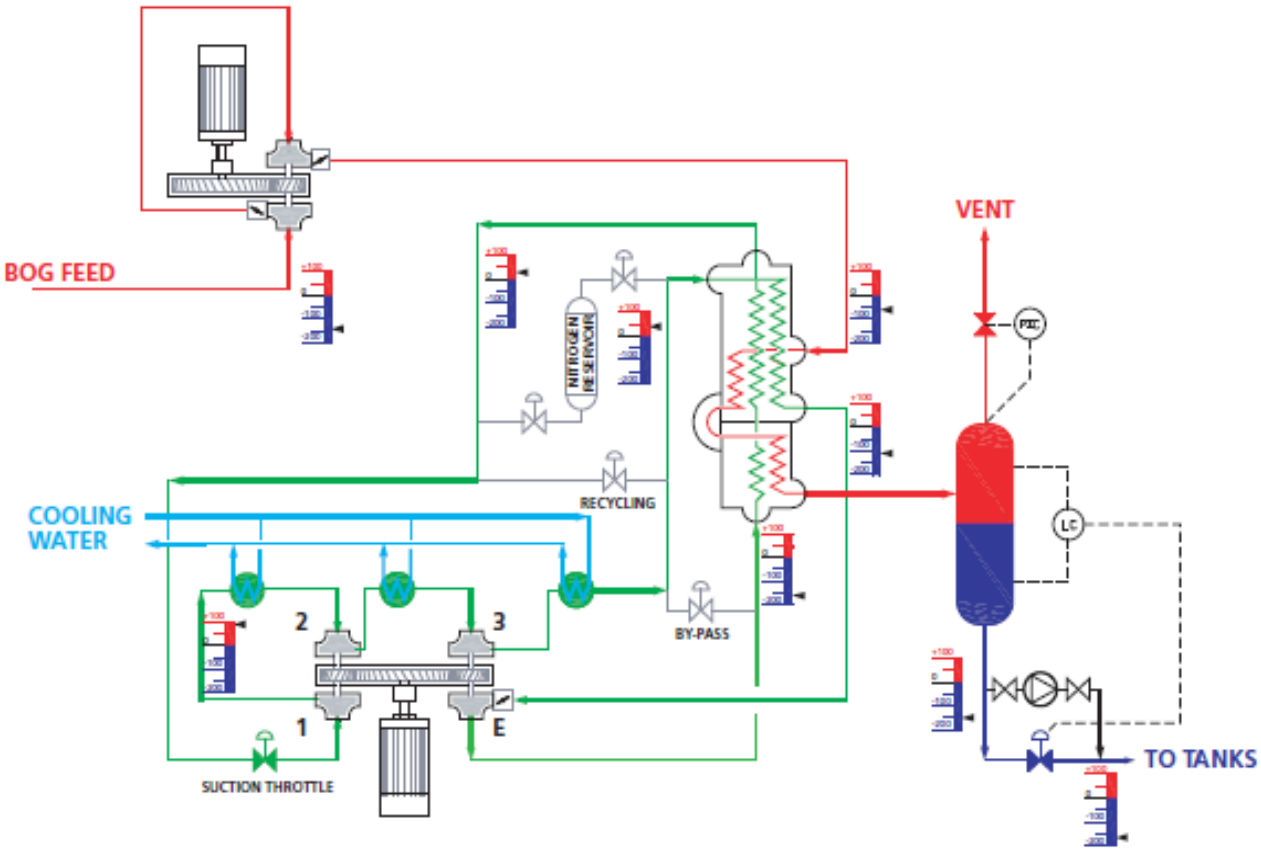
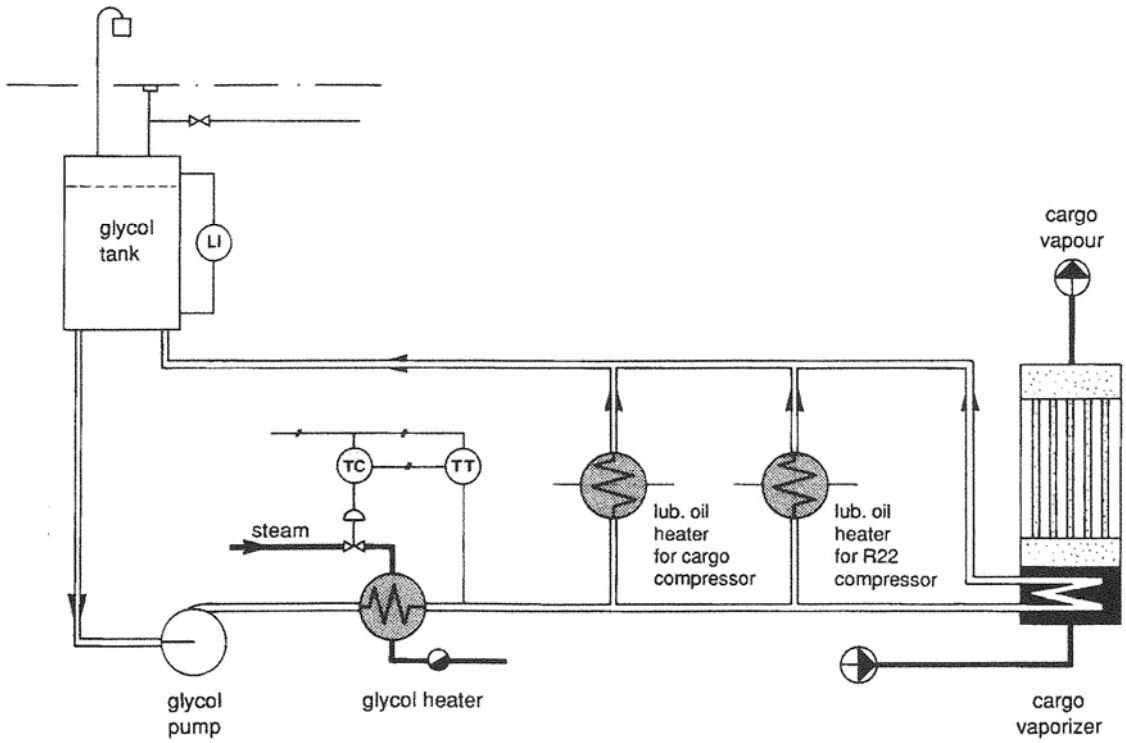


Fig 1.11 (g) A typical LNG Re-liquefaction Plant



LI = level indicator
TT = Temperature transmitter
TC = temperature control

Fig 1.11.10 example of a glycol heating system

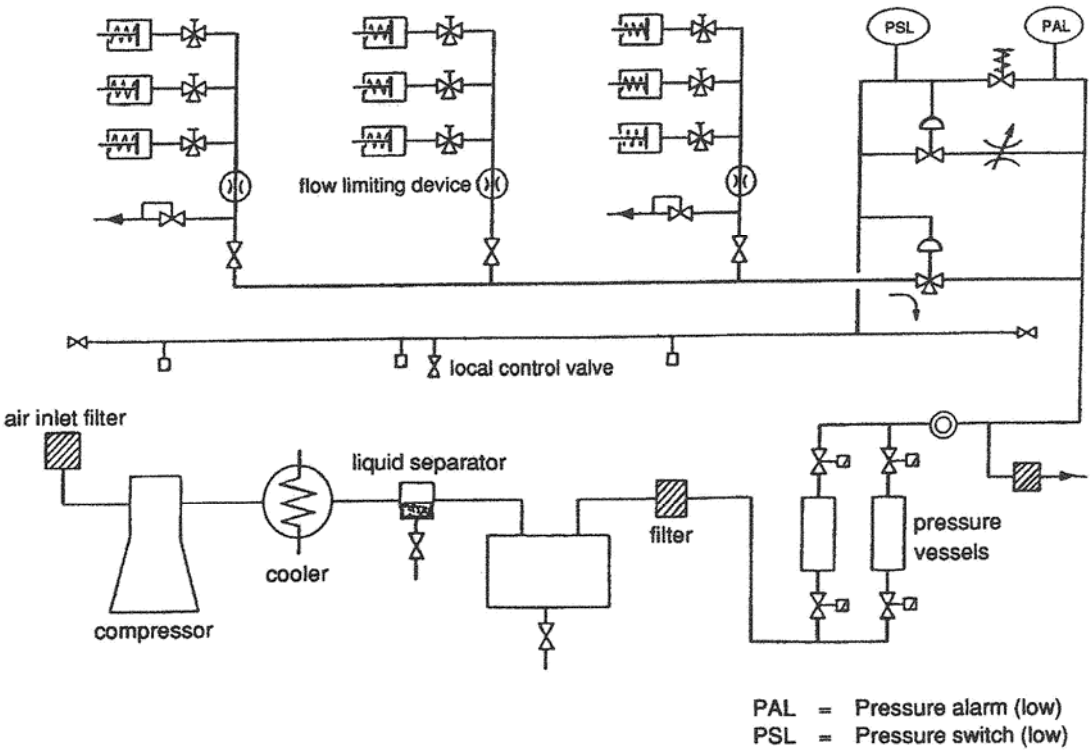


Fig 1.12 (a) A pneumatic emergency shutdown system

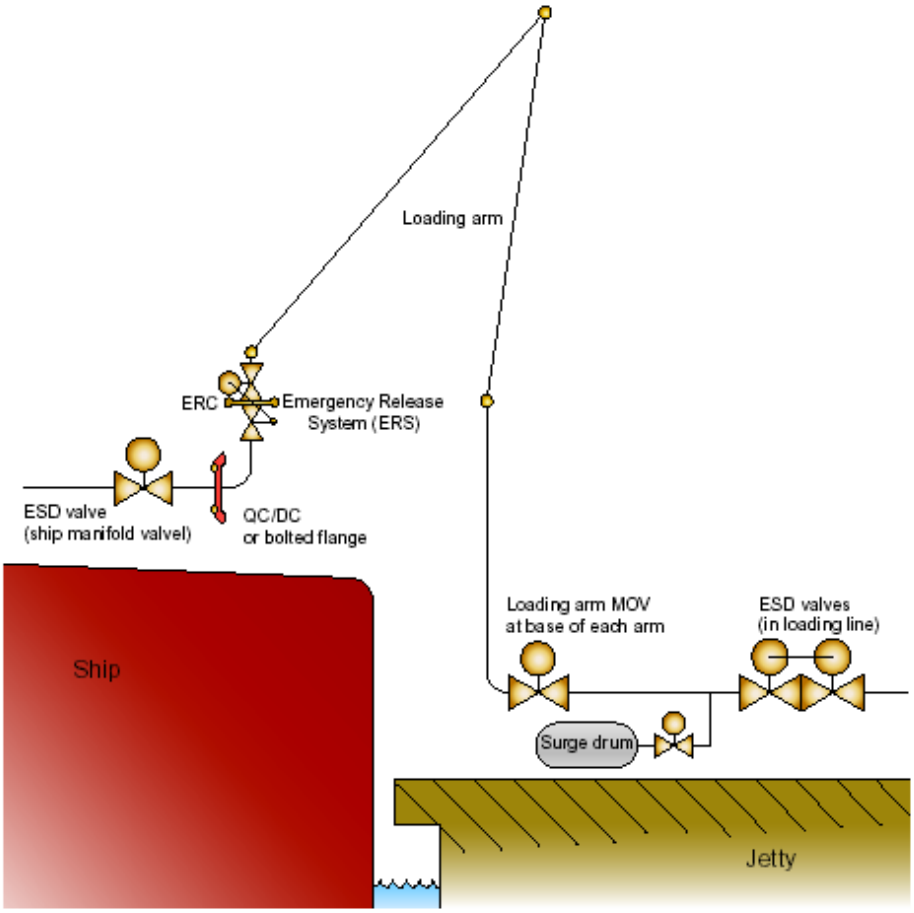


Fig 1.12 (b) Emergency shutdown system

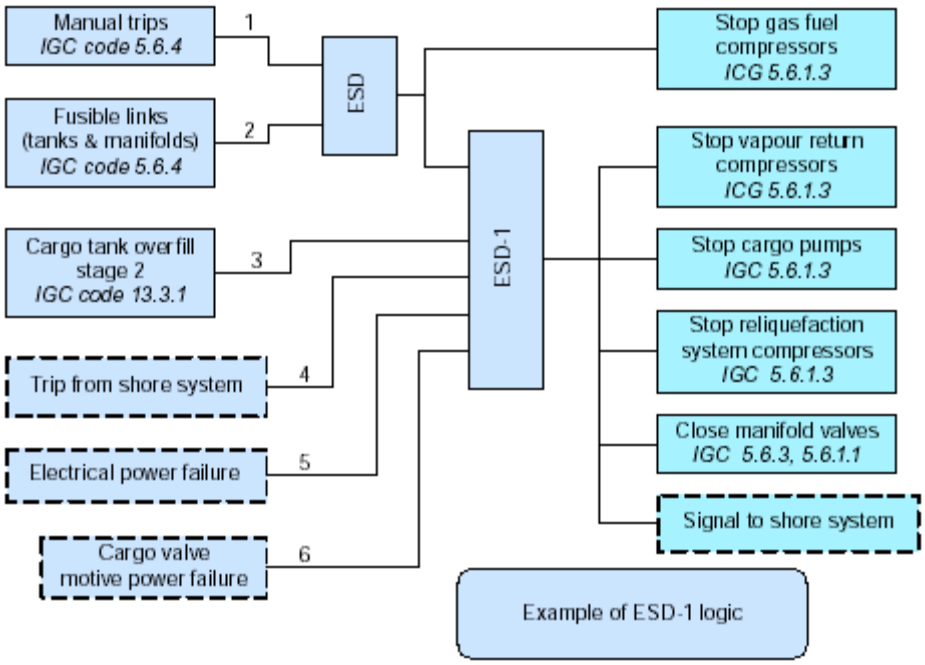


Fig 1.12 (c) ESD system of an LNG Tanker

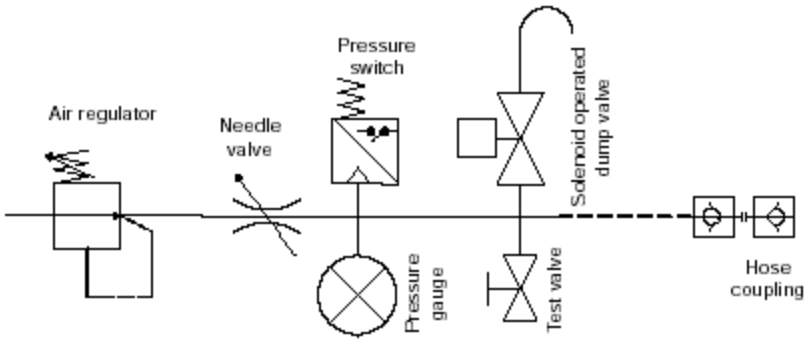


Fig 1.12 (d) Pneumatic ESD Link

Core	Direction	Signal	
1	→	4-channel multiplex data	ship to shore
2	←		shore to ship
3	→	ESD-1 volt free contact	ship to shore
4	←		shore to ship
5	→	Spare/digital SSL	ship to shore
6	←	Spare/digital SSL	shore to ship

CH1	MLM modem signal 1200 baud
CH2	Hotline telephone – Iwatsu TS3 format only supported
CH3	Terminal public telephone audio signal
CH4	Terminal PABX (internal) telephone audio signal

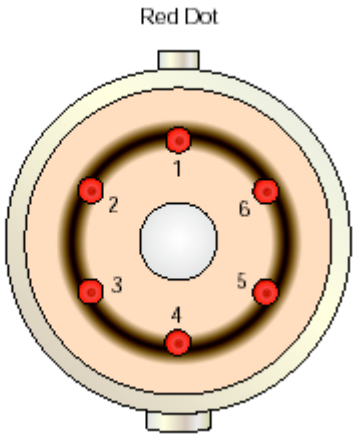
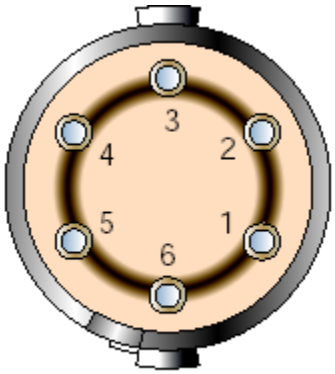


Fig 1.12 (e) ESD Fibre Optic Link Connector



ESD-1 Connection	Pin	Telephone Connection
ESD-1 ship → shore	1	InterPhone or Hotline Telephone
	2	
ESD-1 shore → ship	3	PABX Telephone
	4	
	5	Public Telephone
	6	

Fig 1.12 (f) Miyaki Electrical ESD Link Connector

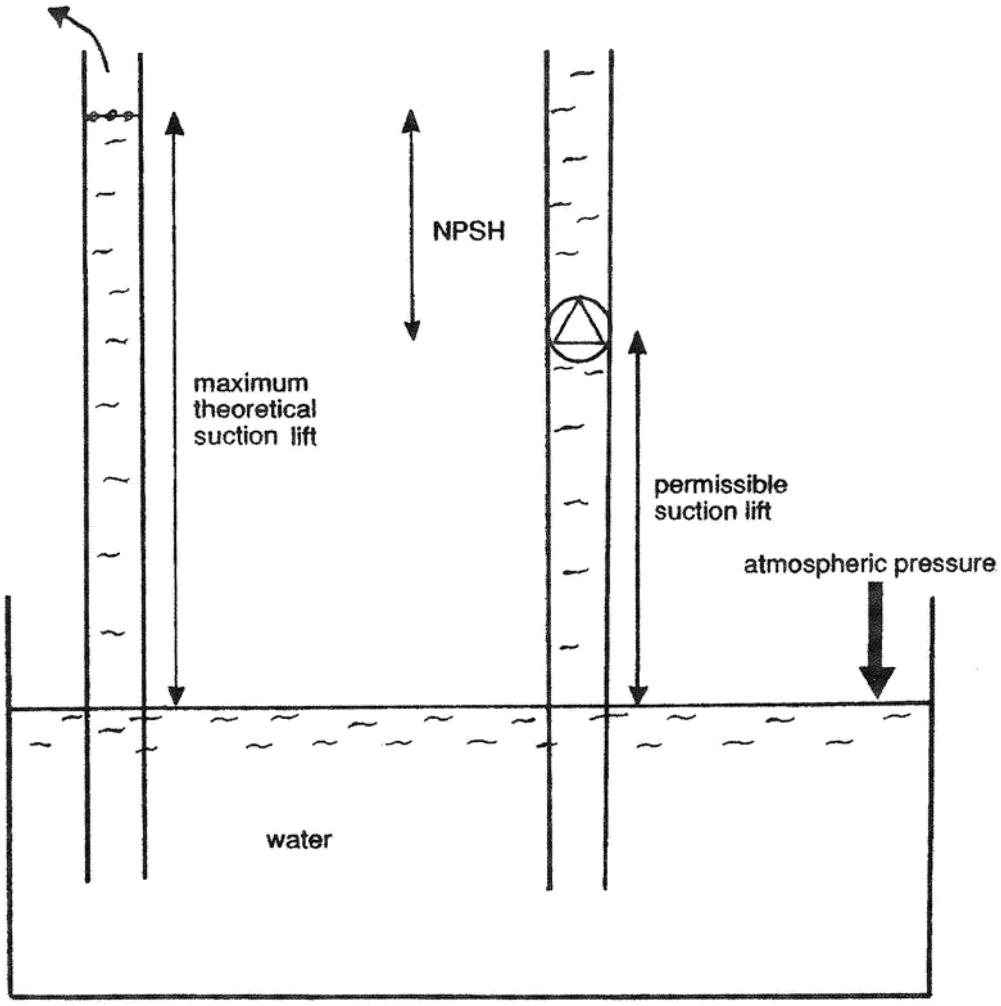


Fig 2.0 (a) Suction lift

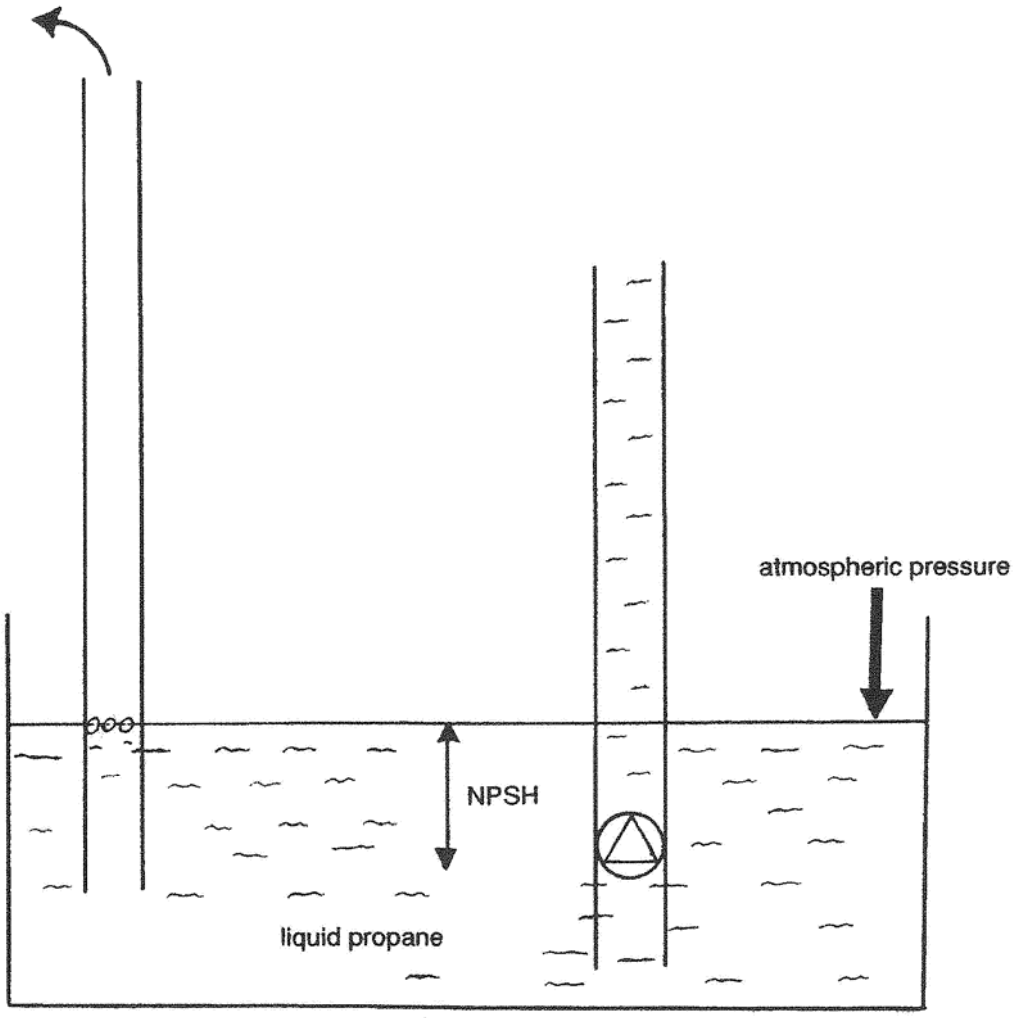


Fig 2.0 (b) Required suction head

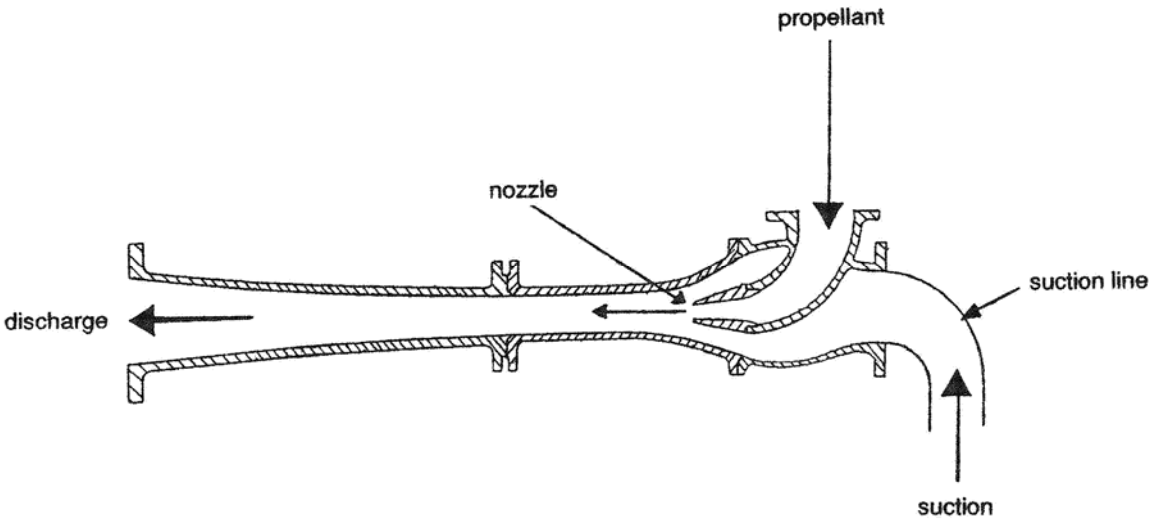


Fig 2.0 (c) The eductor

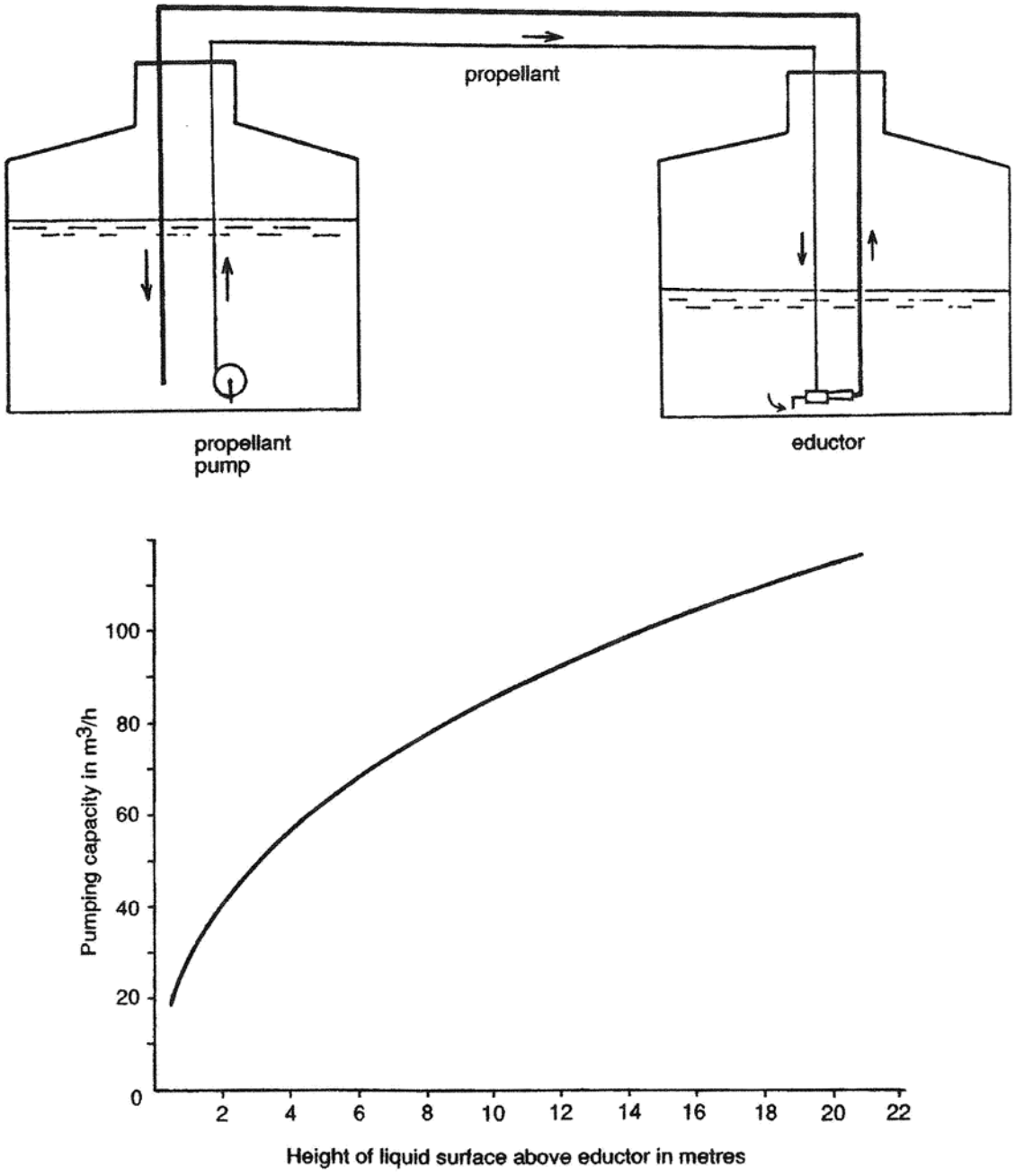
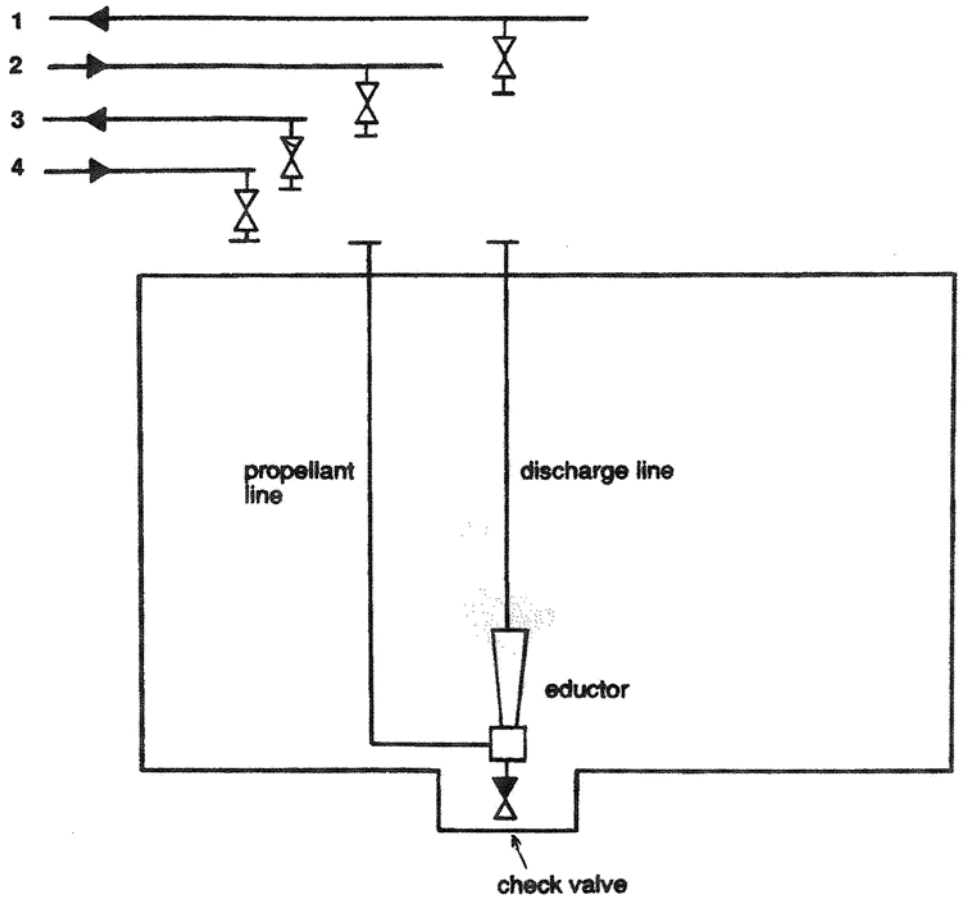


Fig 2.0 (d) The arrangement of an eductor



1 and **2** cargo liquid lines

3 overboard line

4 from main fire pump or emergency fire pump

Disconnectable pipes are used at the cargo side and flexible hoses are used at the water side

Fig 2.0 (e) Hold – space bilge system

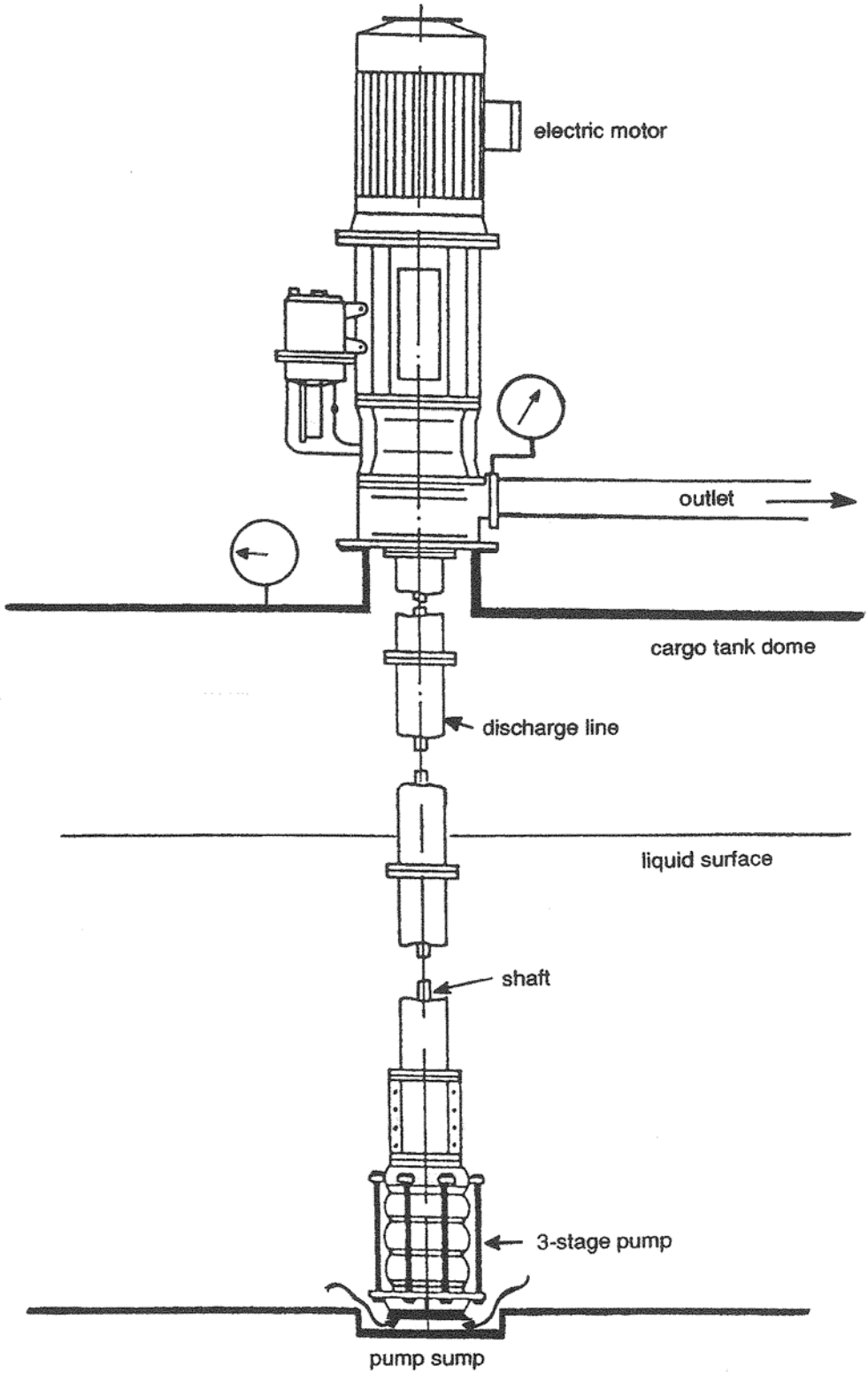


Fig 2.0 (f) Deepwell pump (1)

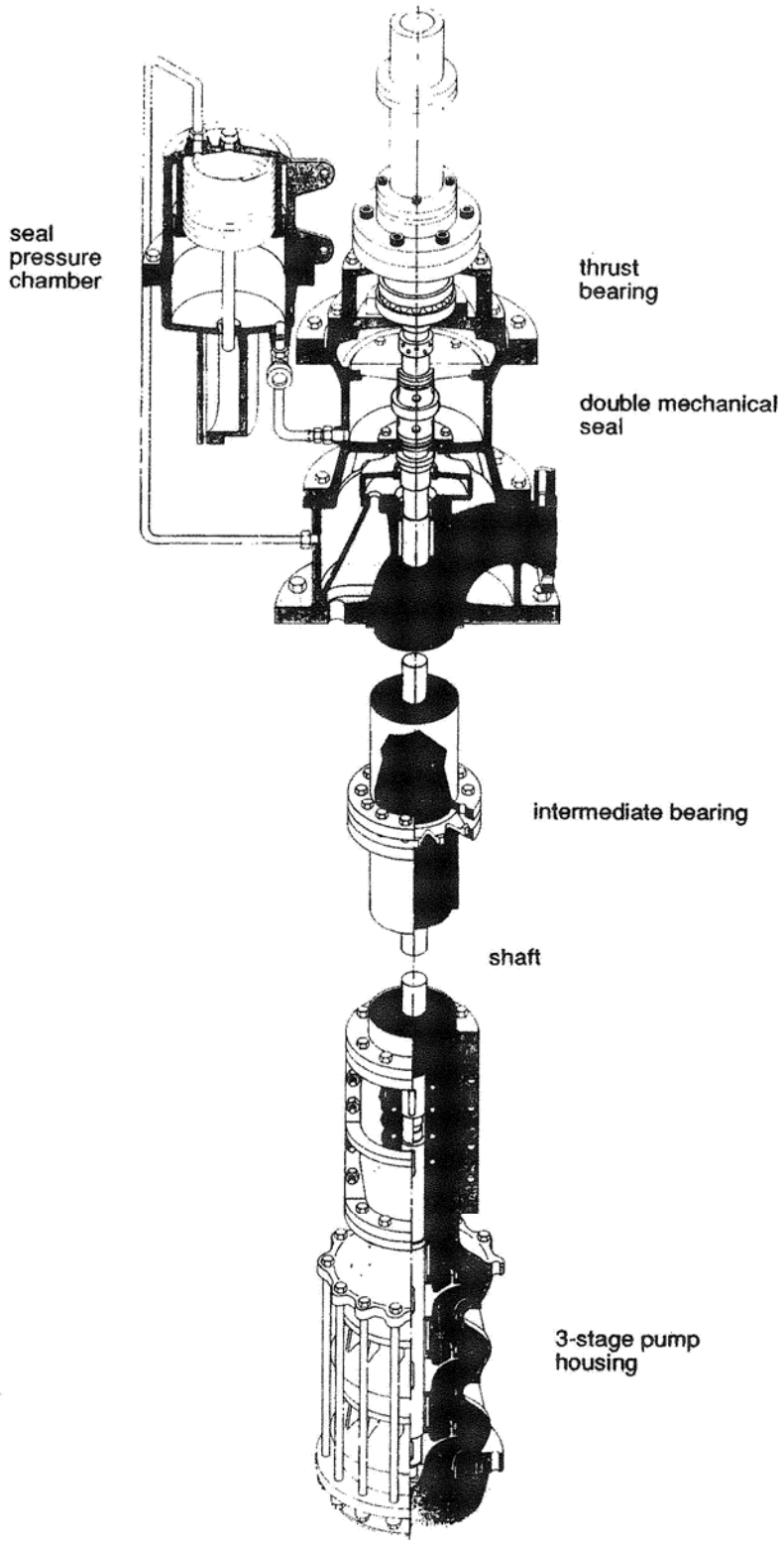


Fig 2.0 (g) Deepwell pump (2)

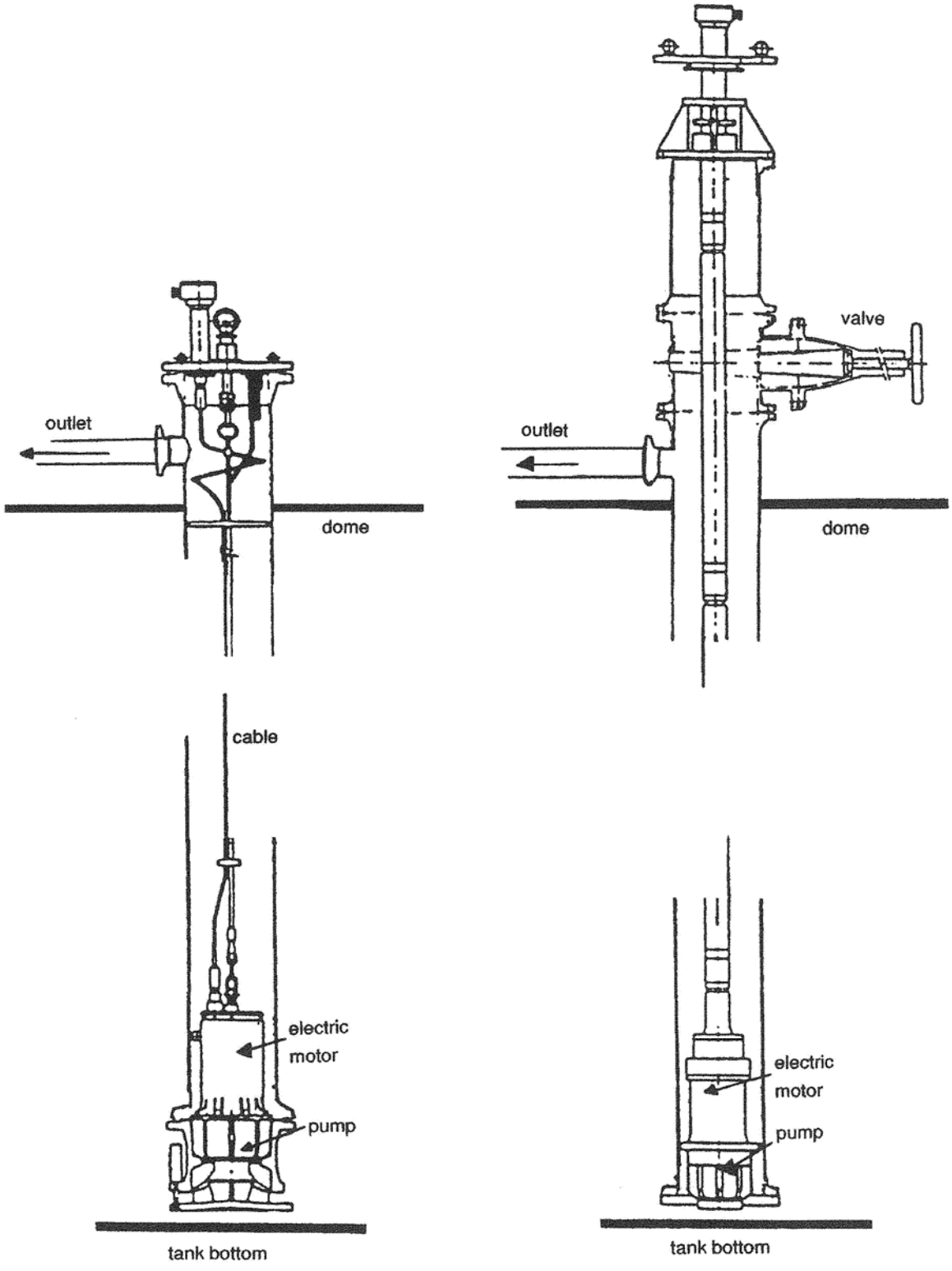
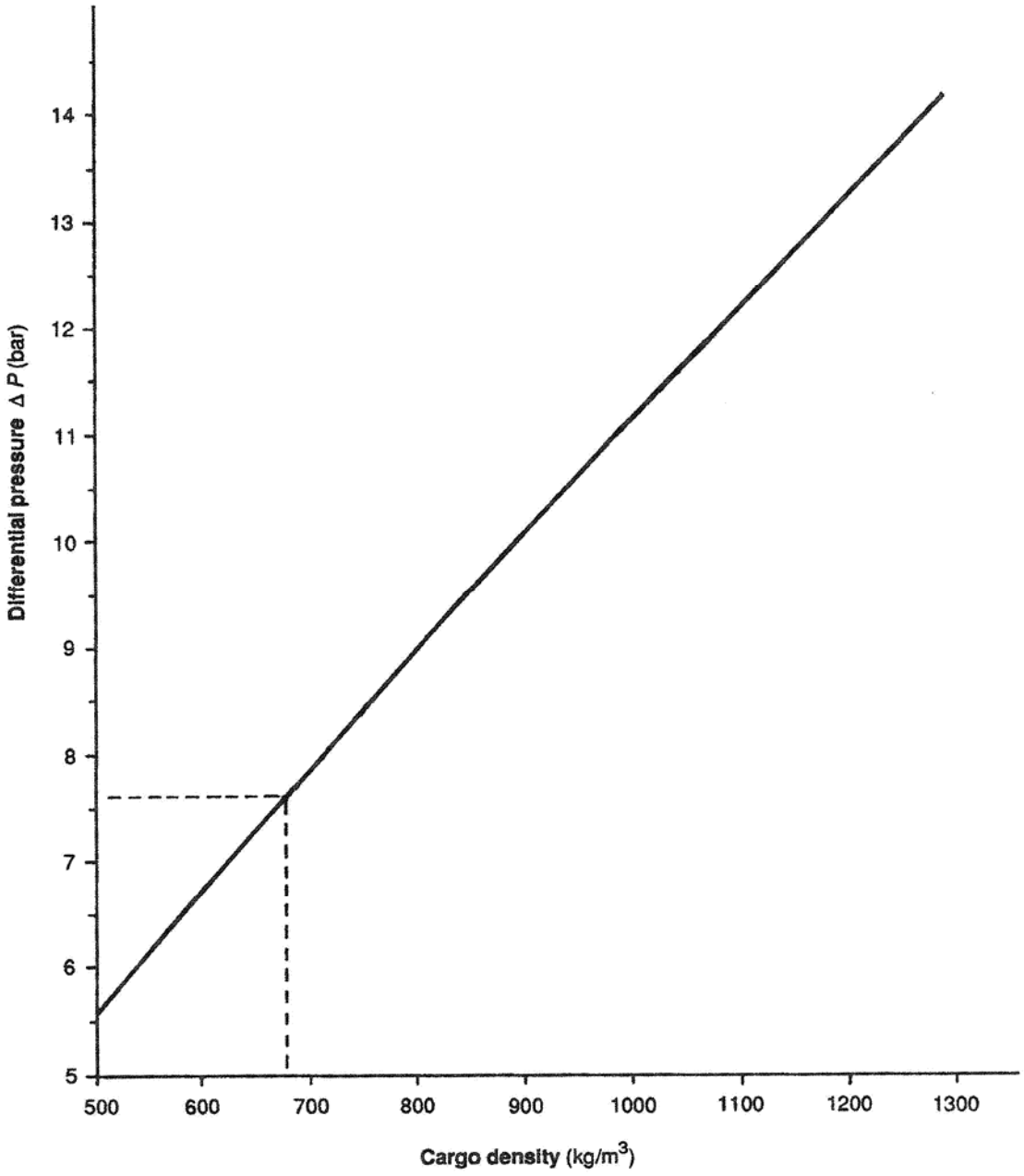


Fig 2.0 (h) Examples of electrical submerged pumps



Example:

Cargo: ammonia

Temperature: –30 °C
Pressure: 0.2 bar gauge
Density: 678 kg/m^3
Setting: ΔP = 7.6 bar

Fig 2.0 (i) Differential pressure – Density relationship

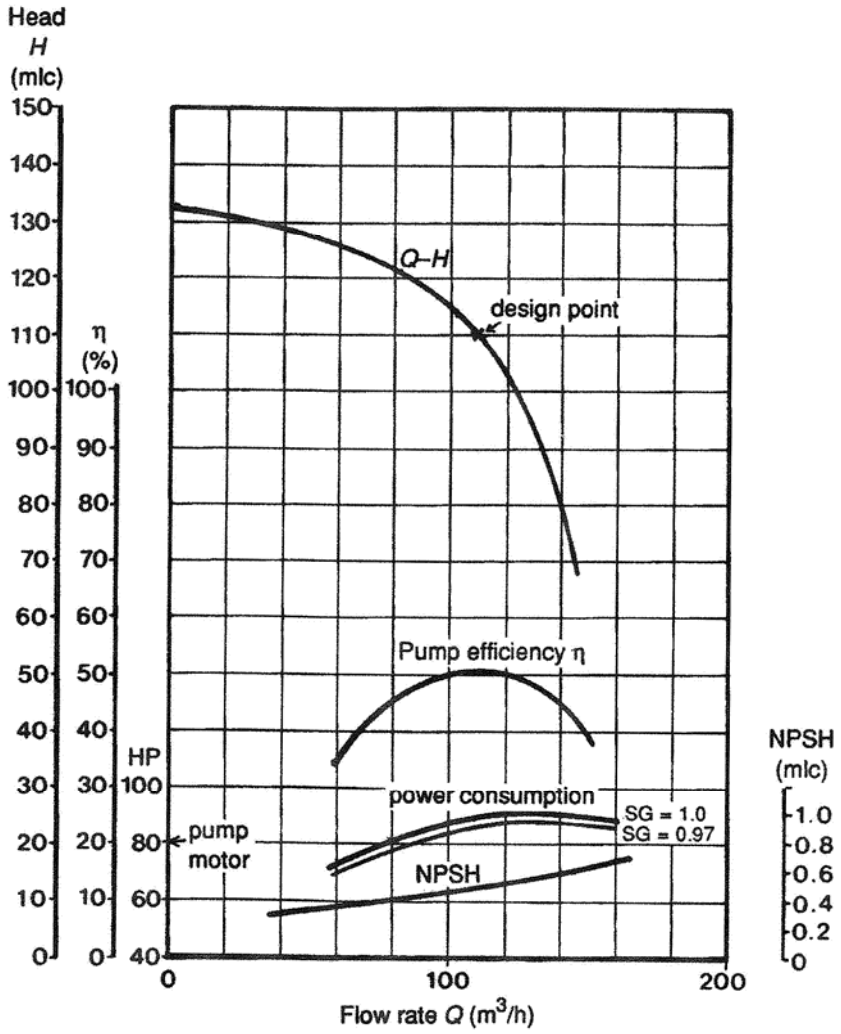


Fig 2.0 (j) Pump performance curves for a typical Deepwell pump

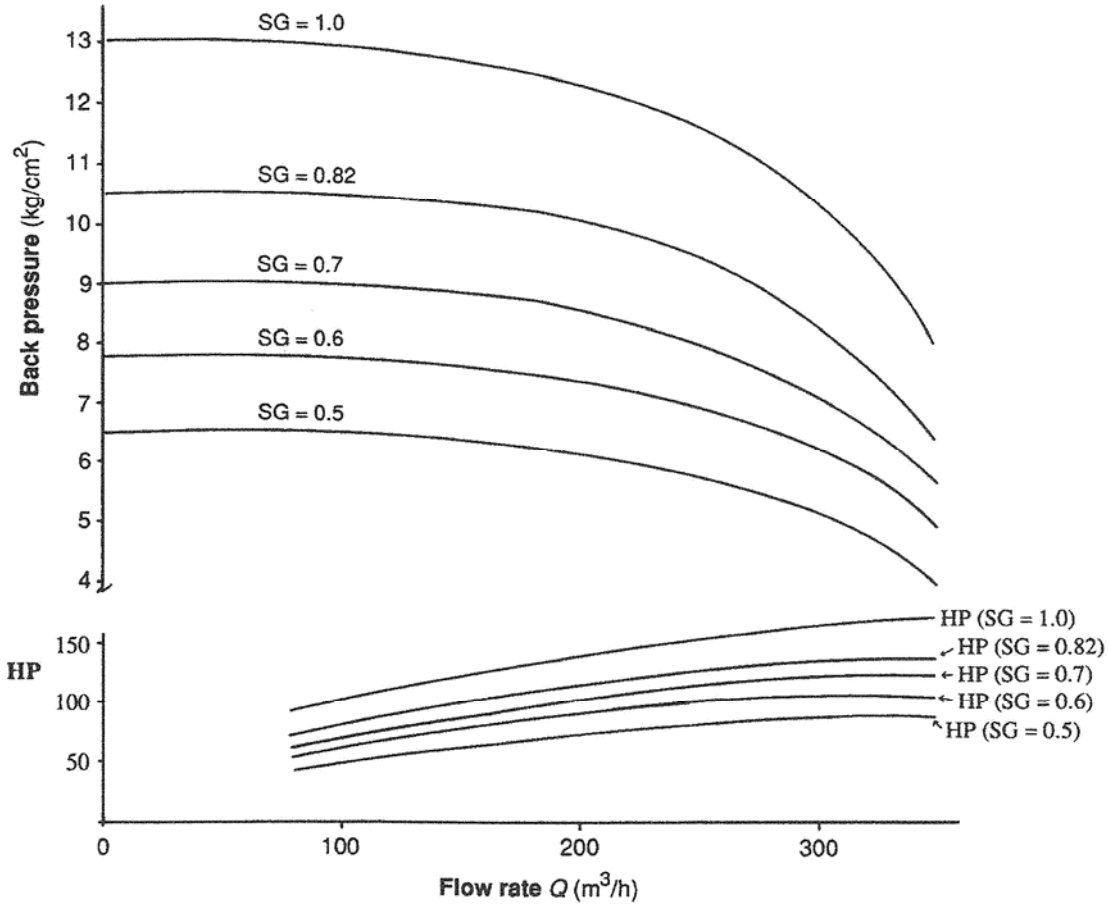


Fig 2.0 (k) Pump characteristics for different specific gravities of pumped liquids.

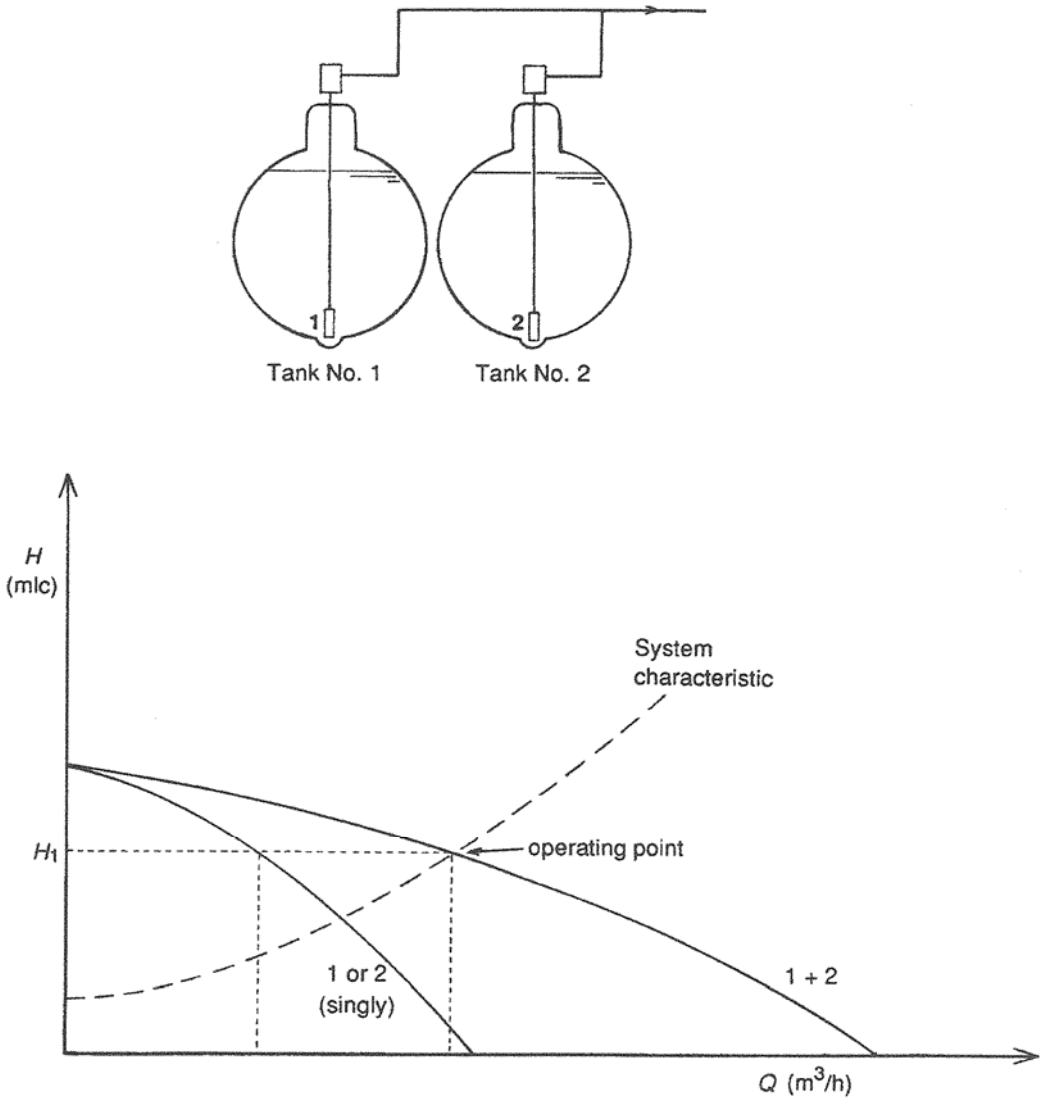


Fig 2.0 (l) The system characteristic of pumps working in parallel

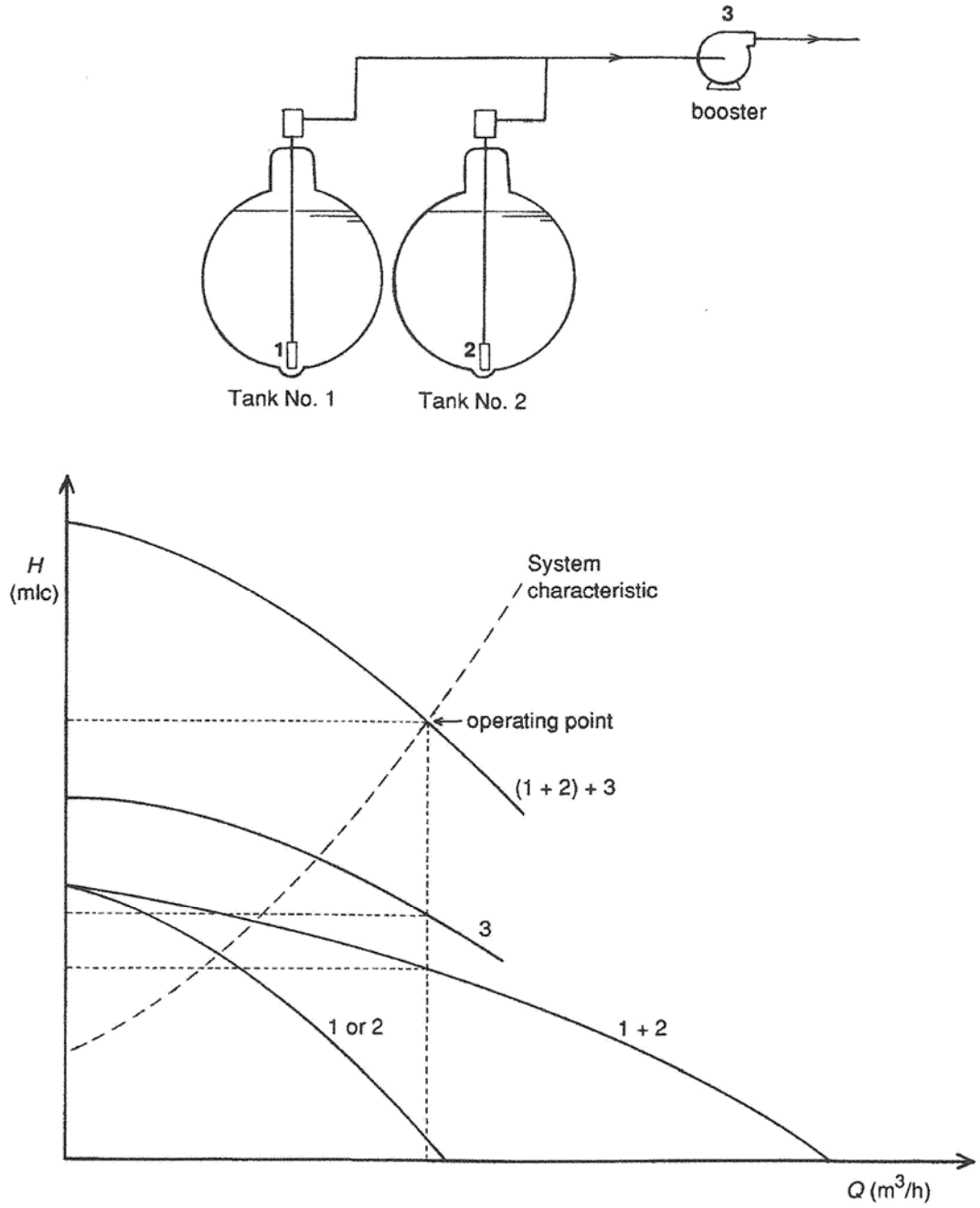


Fig 2.0 (m) The system characteristic of parallel pumps working in series with a booster pump

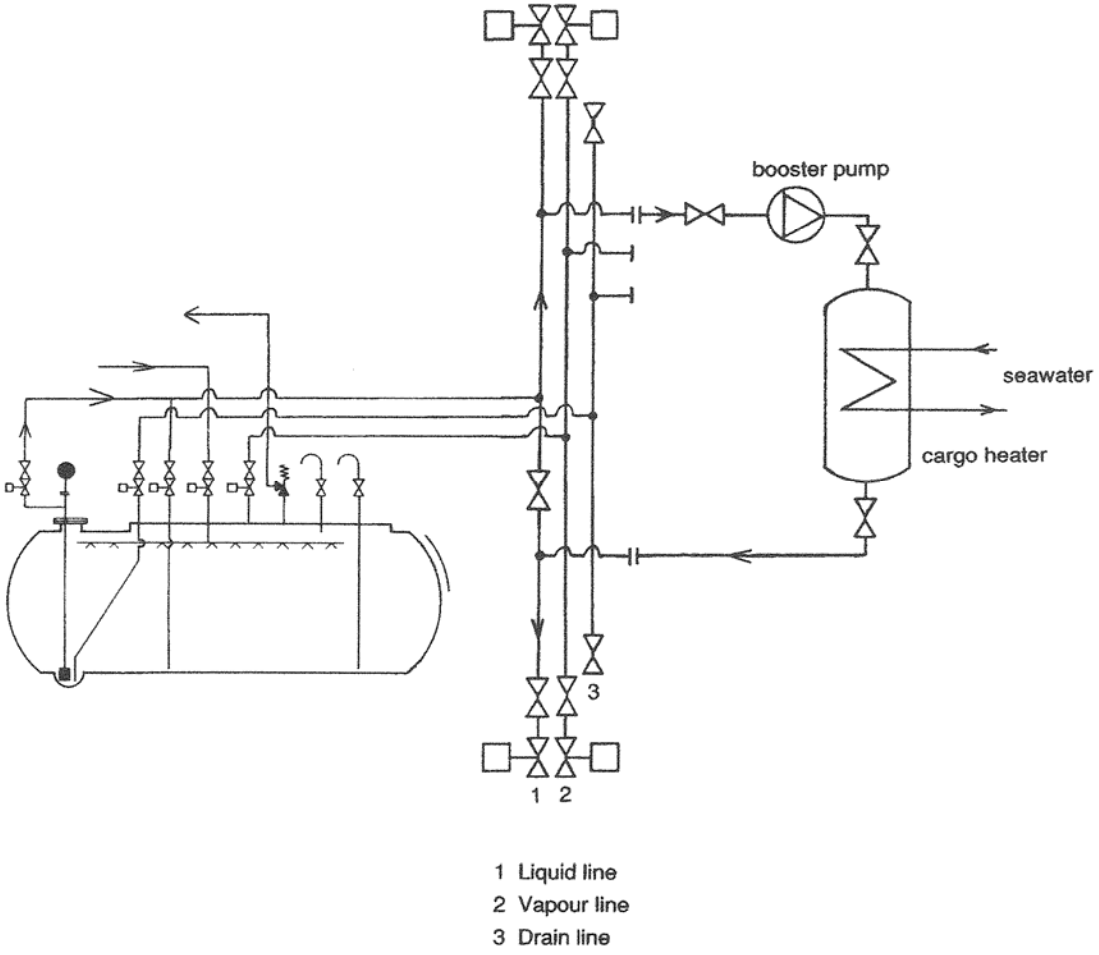


Fig 2.28 Schematic diagram of a cargo heater and booster pump arrangement

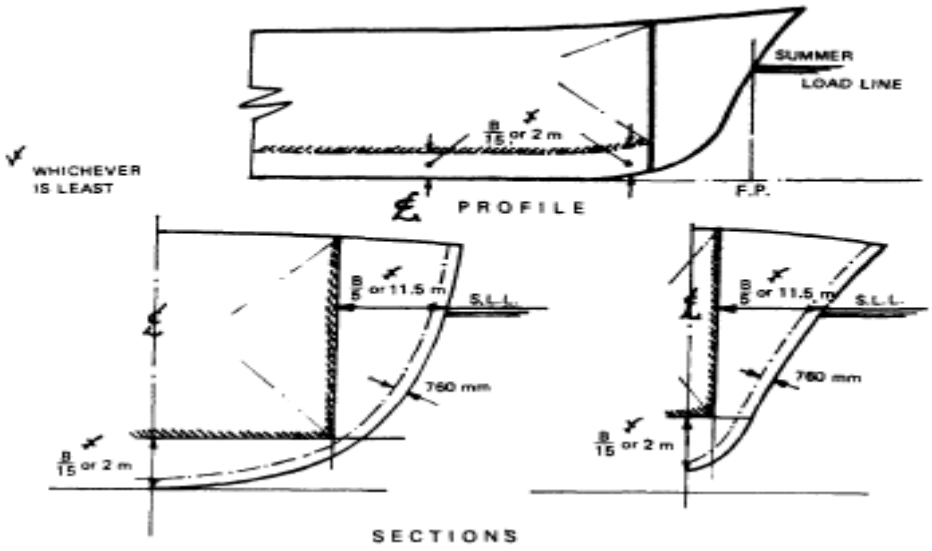


Fig 3.9 Tank Location requirements

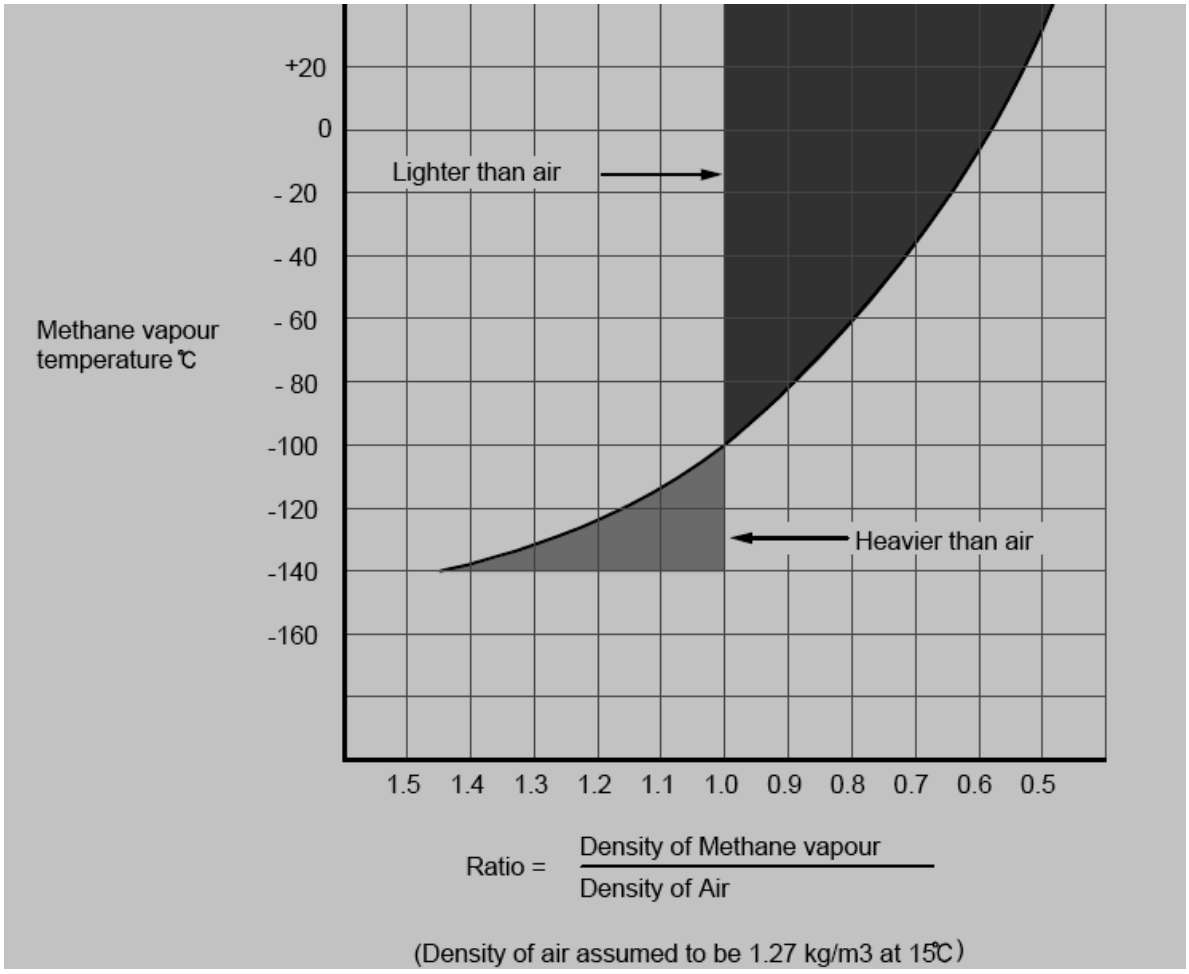


Fig 5.1.2 (a) showing density of air and methane vapour

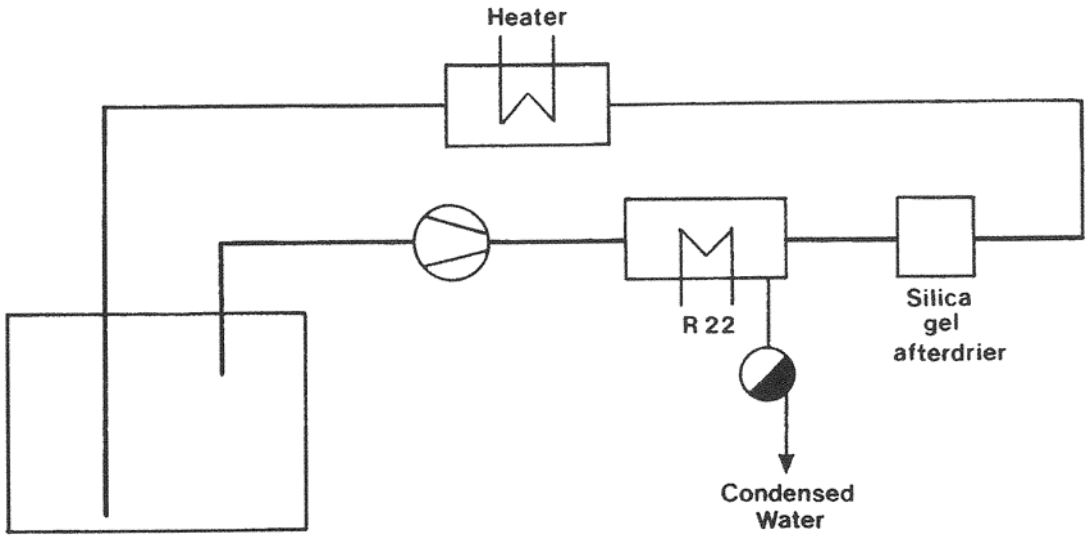


Fig 5.1.2 (b) Air-drying operation

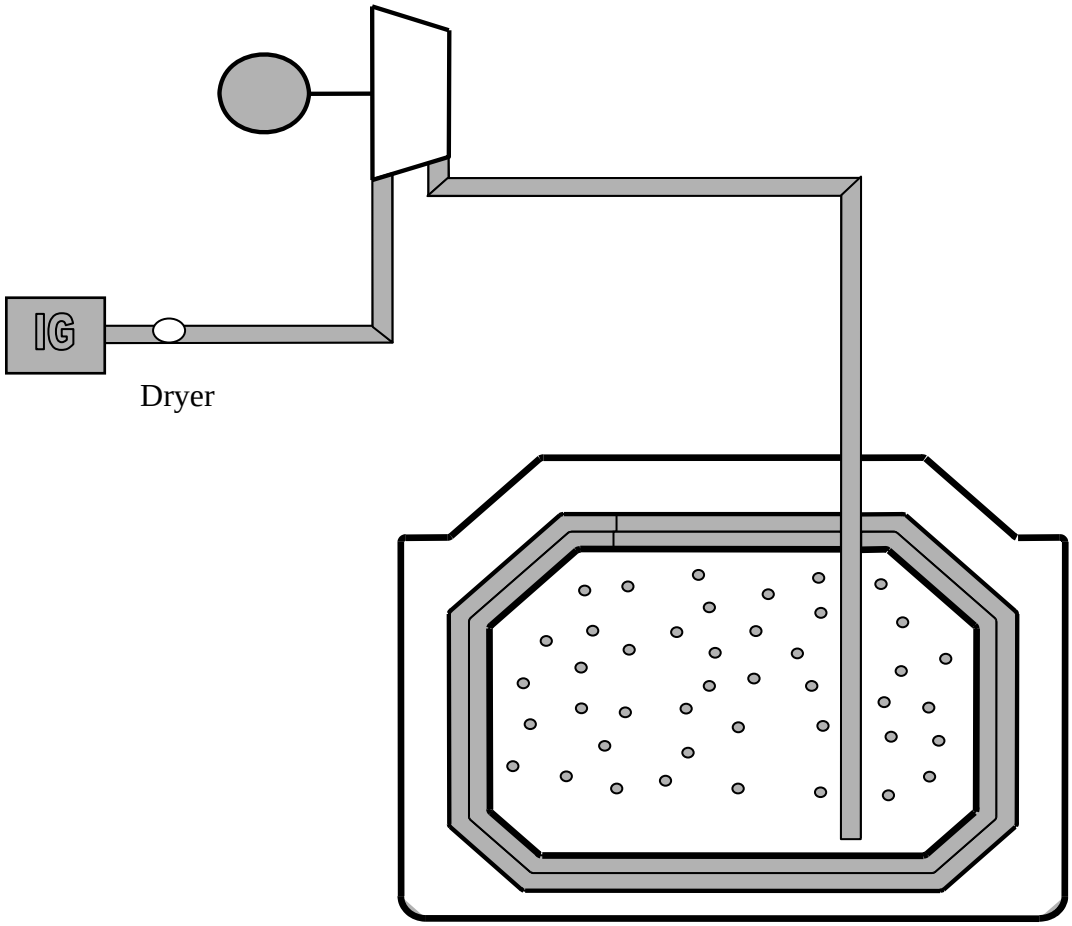


Figure 5.1.2 (c) Drying and Inerting

To reduce the humidity content of the air in the tanks and associated systems in order to prevent ice crystals from forming during cooling Switch to Inert gas when tank atmosphere dew point [-20°C]

To reduce the oxygen content in tanks and associated transfer system to a sufficiently low level in order to eliminate any fired hazard when the spaces are filled with cargo gas Final dew point of the air produced:-45°C

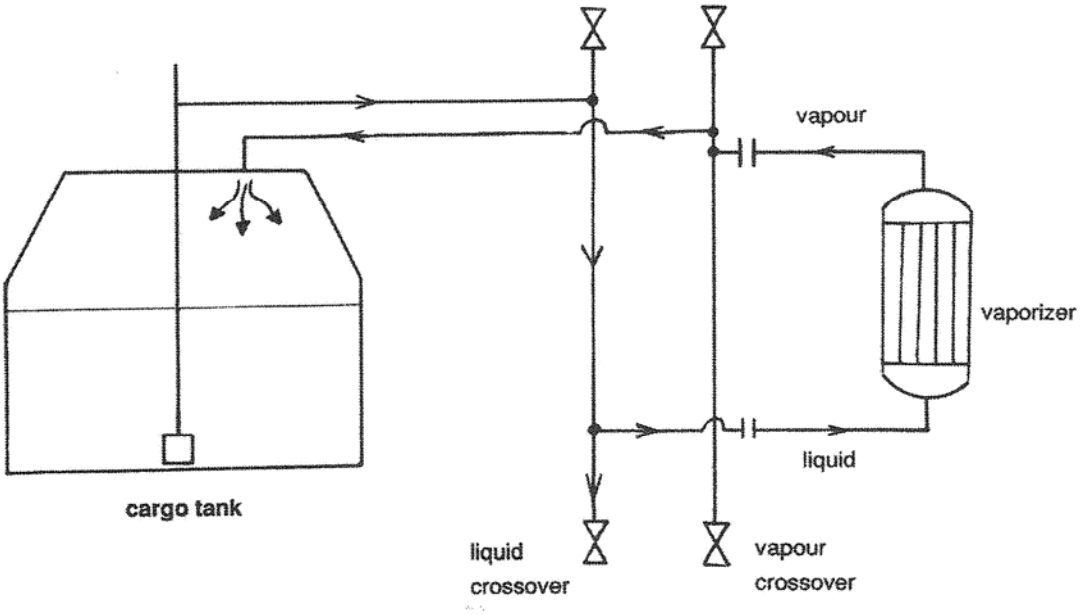


Fig 5.1.3 (a) Schematic diagram of a vaporizer arrangement

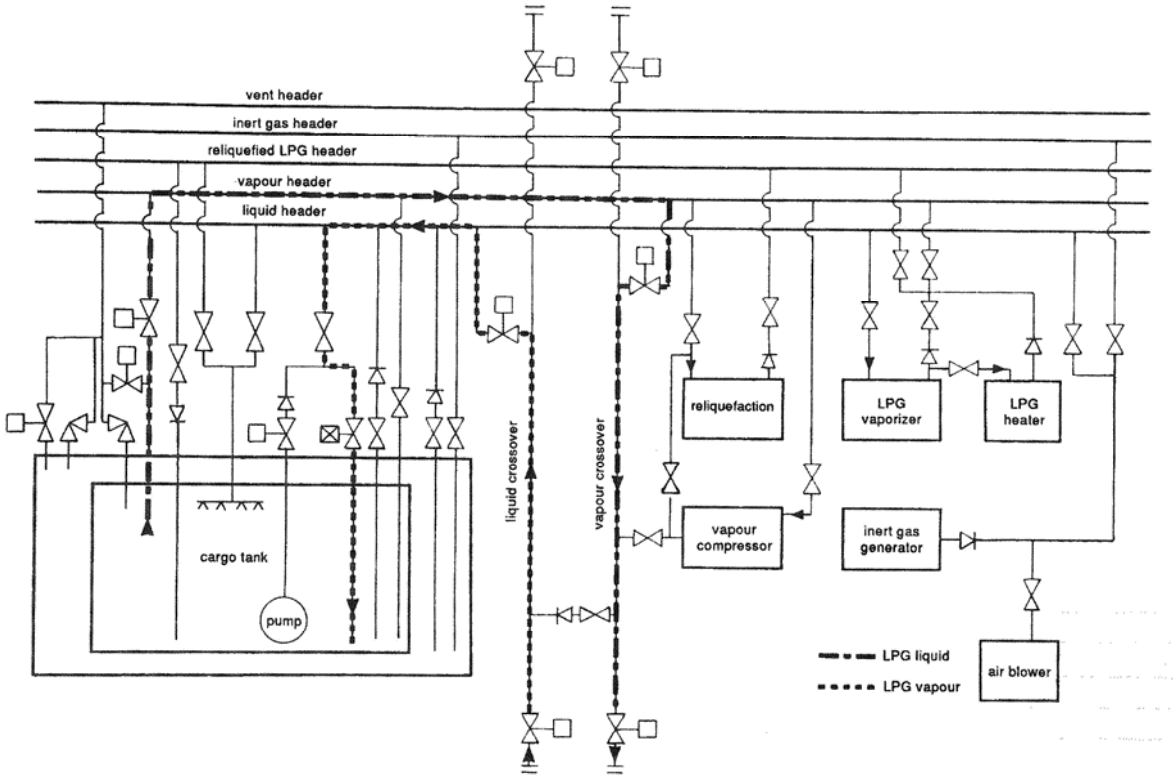


Fig 5.1.3 (b) Purging of a cargo tank, using vapour from shore

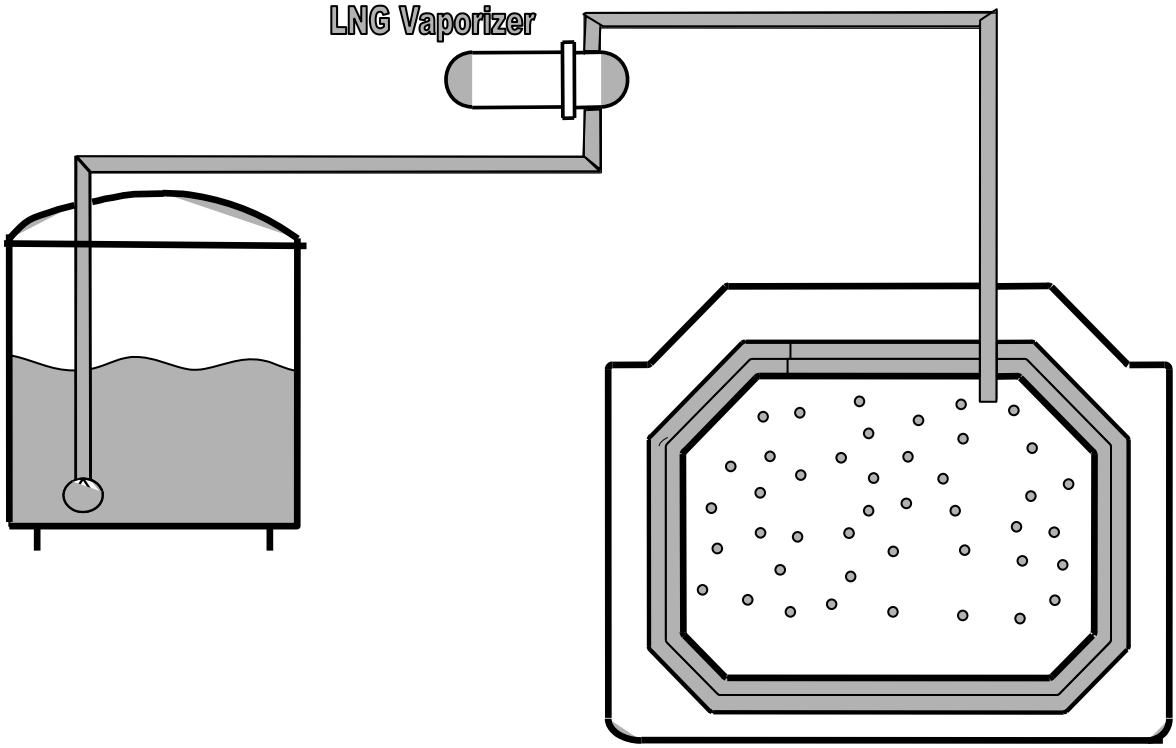


Figure 5.1.3 (c) Gassing up Operations to replace IG with Methane gas

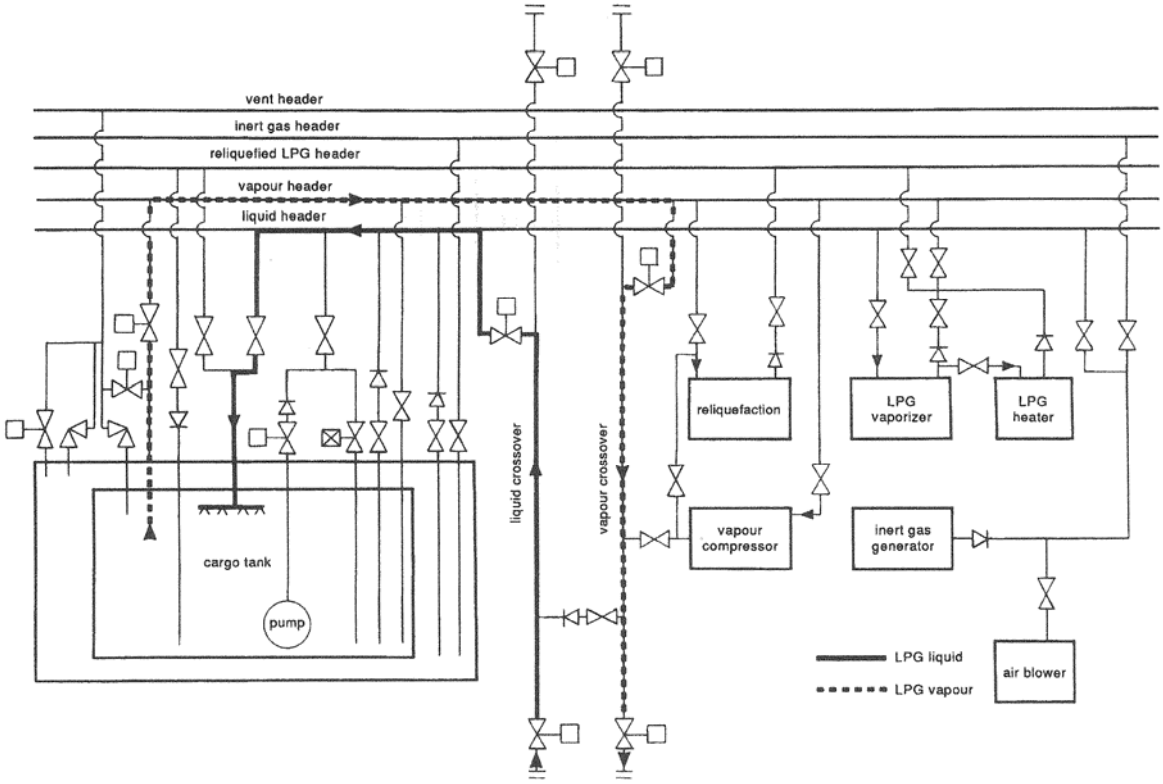
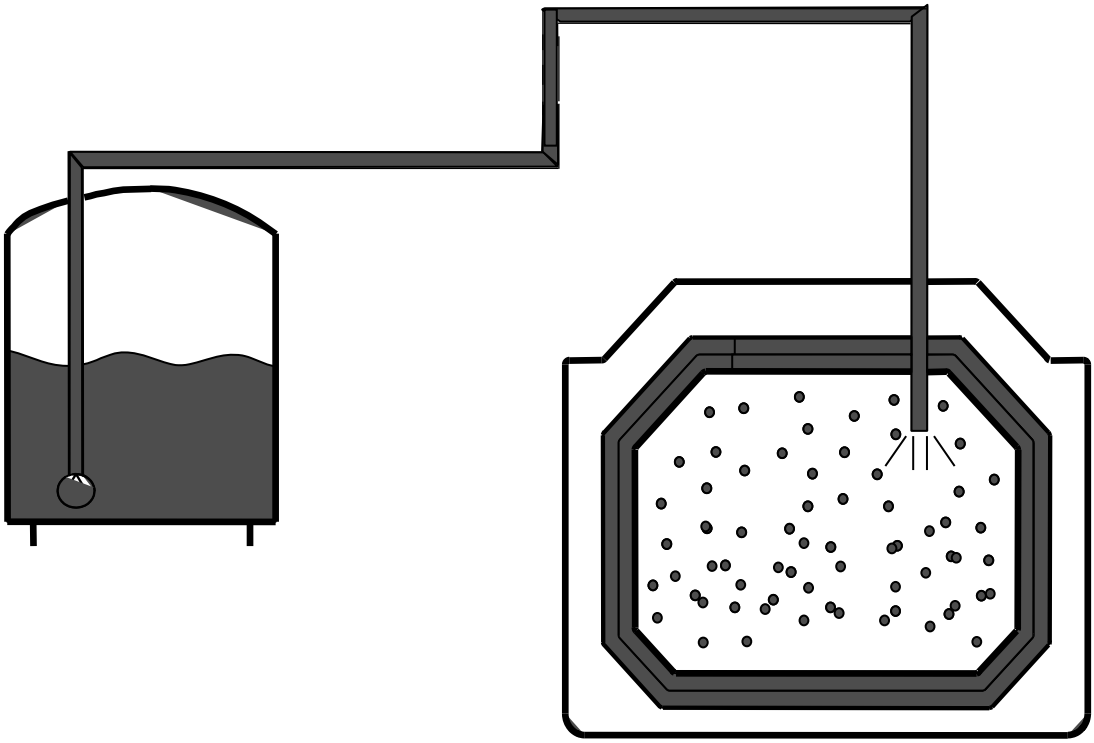


Fig 5.1.4(a) Cooling down of a cargo tank, using liquid from shore and vapour return



Tanks technique	Membrane tanks	Spherical Tanks
Duration (h) : **Stripping – heating** **Inerting** **Gassing** **Cooling-down**	**48** **30** **12 to 20**	**130** **30** **12** **40 to 60**
Quantity of LNG required for tanks cooling down (m3)	**750**	**2300**

Figure 5.1.4 (b) Cooling down and its Requirements of a 130000m3 LNG carrier

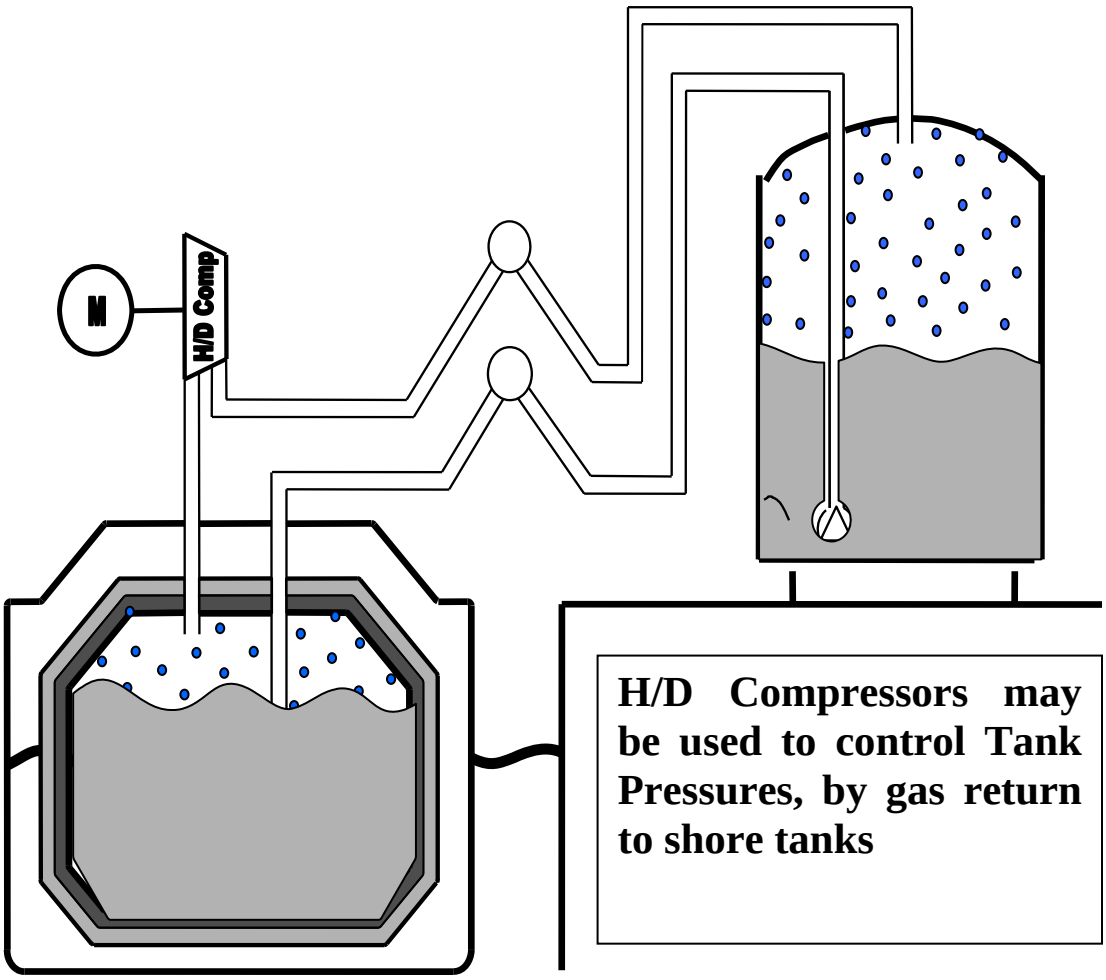


Fig. 5.1.5(a) Shows Loading with HD Compressors

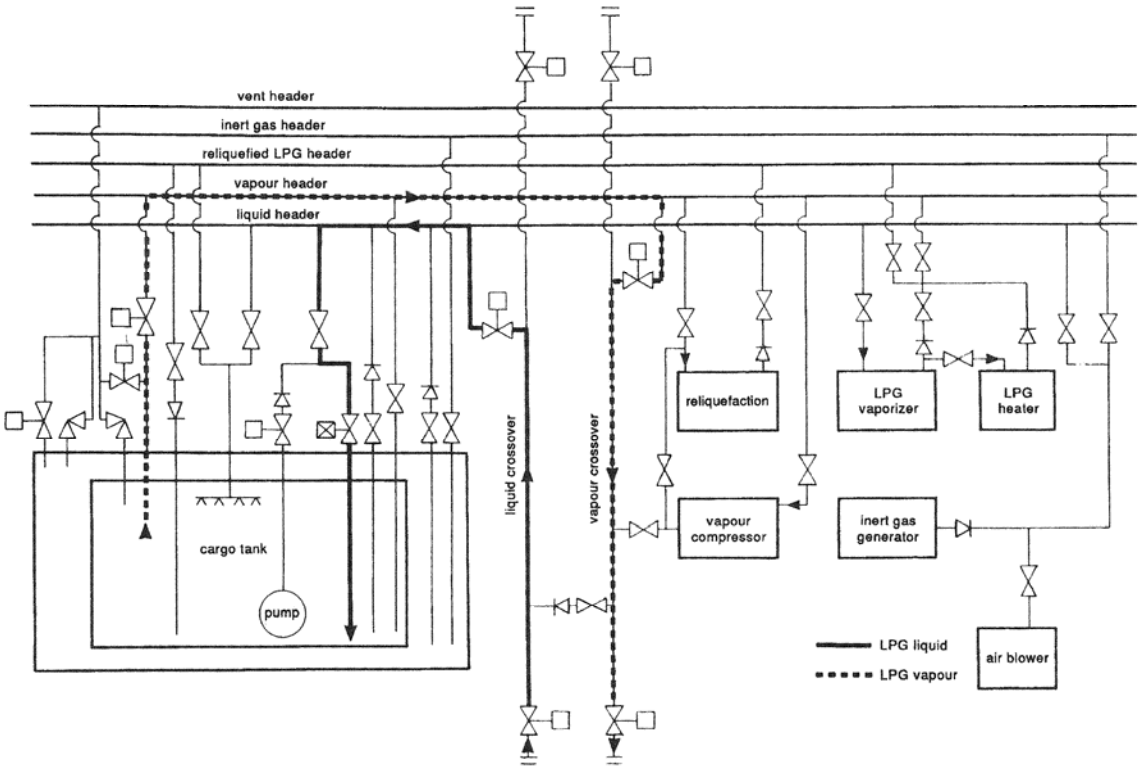


Fig 5.1.5 (b) Loading, with vapour return

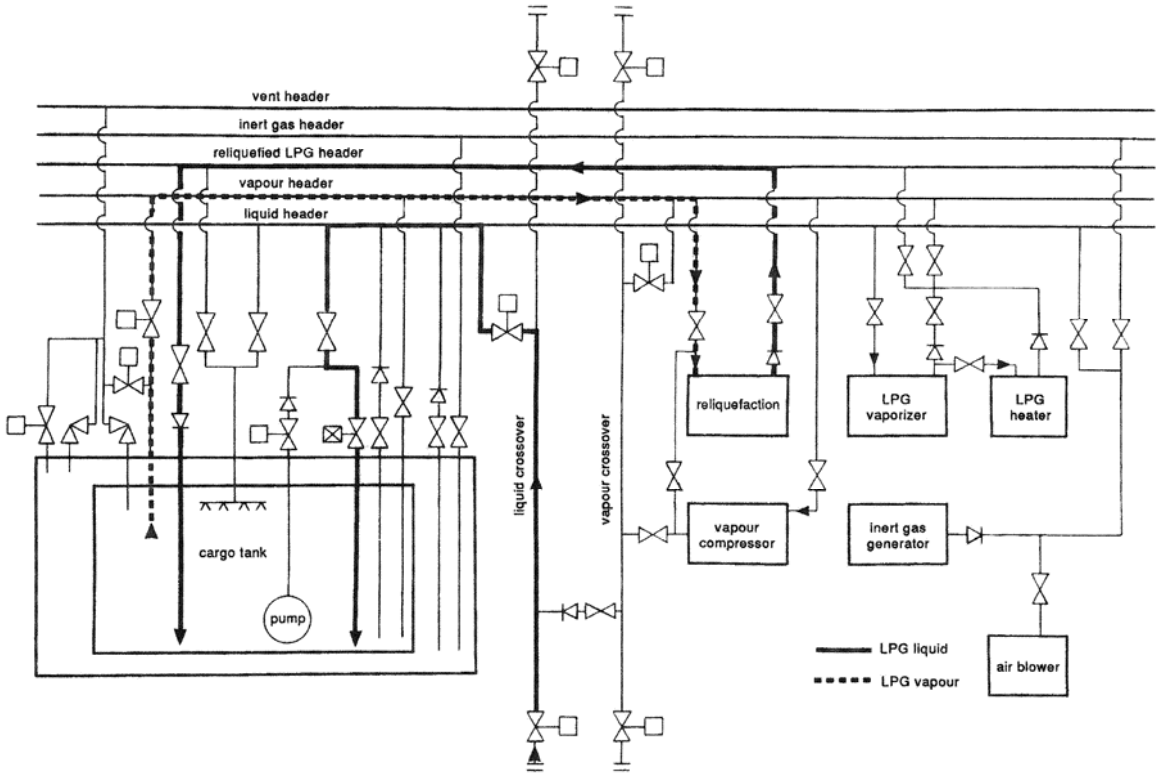


Fig 5.1.5 (c) Loading, without vapour return

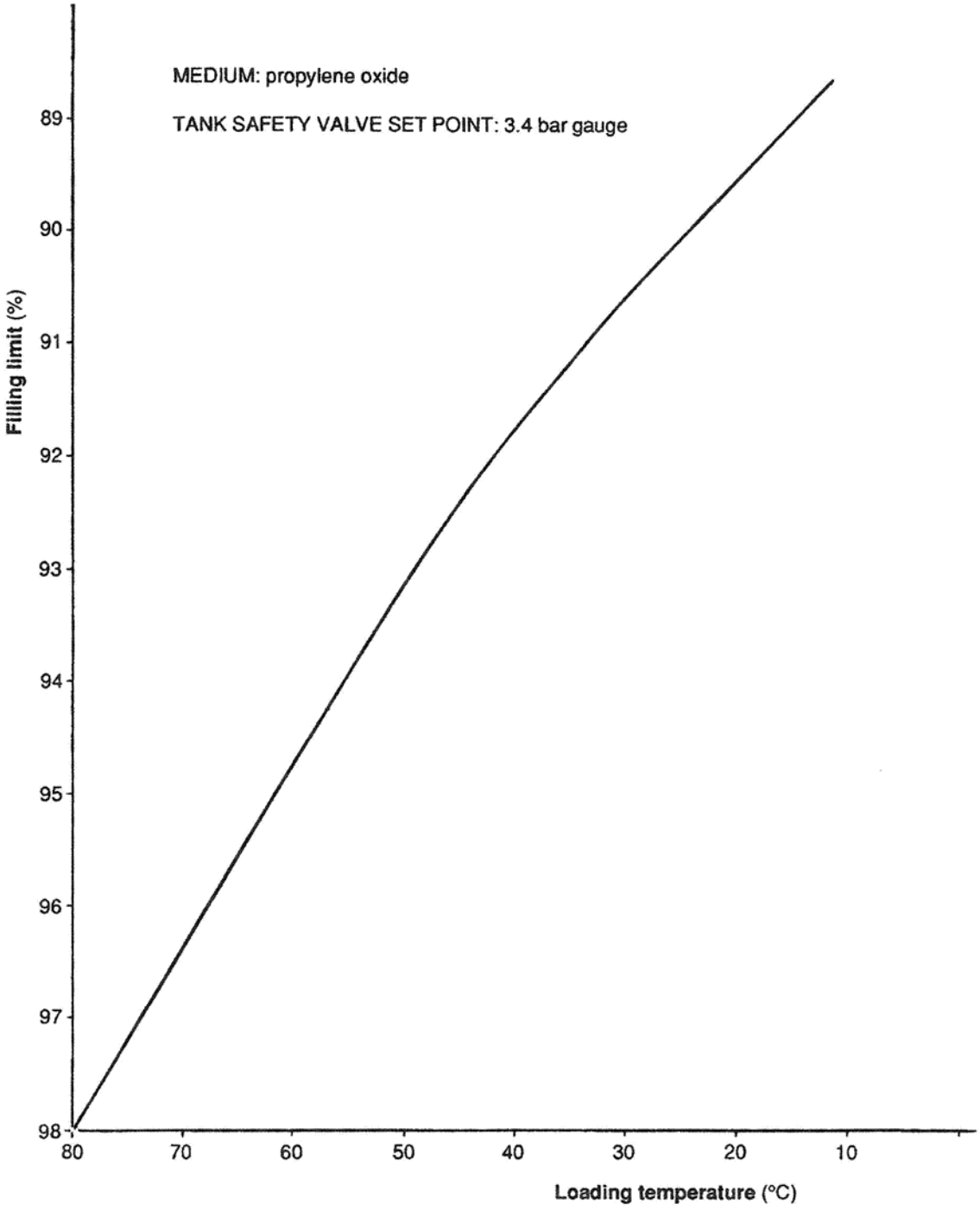


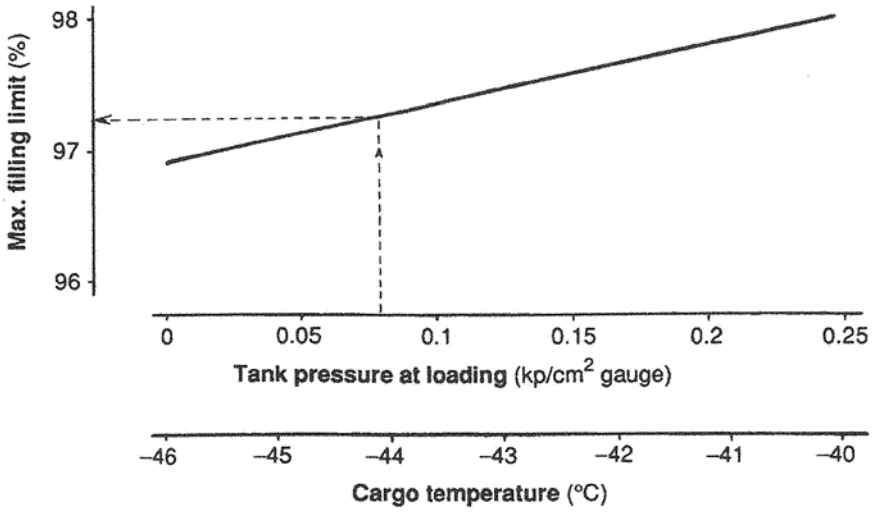
Fig 5.1.5 (d) Diagram showing the maximum filling limit for propylene oxide (semi – pressurized vessel)

Cargo: PROPANE
with 2.5 mole % ethane
in liquid phase

Max. filling limit $x = \frac{d_R}{d_L} \times 98\%$

d_R = density of cargo at relief pressure and temperature
d_L = density of cargo at loading pressure and temperature

Relief pressure: 0.25 kp/cm^2 gauge



Example:

Loading pressure = 0.08 kp/cm^2 gauge
Loading temperature = –44 °C
Maximum filling limit: 97.25%

Fig 5.1.5 (e) Diagram showing the maximum filling limit for propane (fully refrigerated vessel)

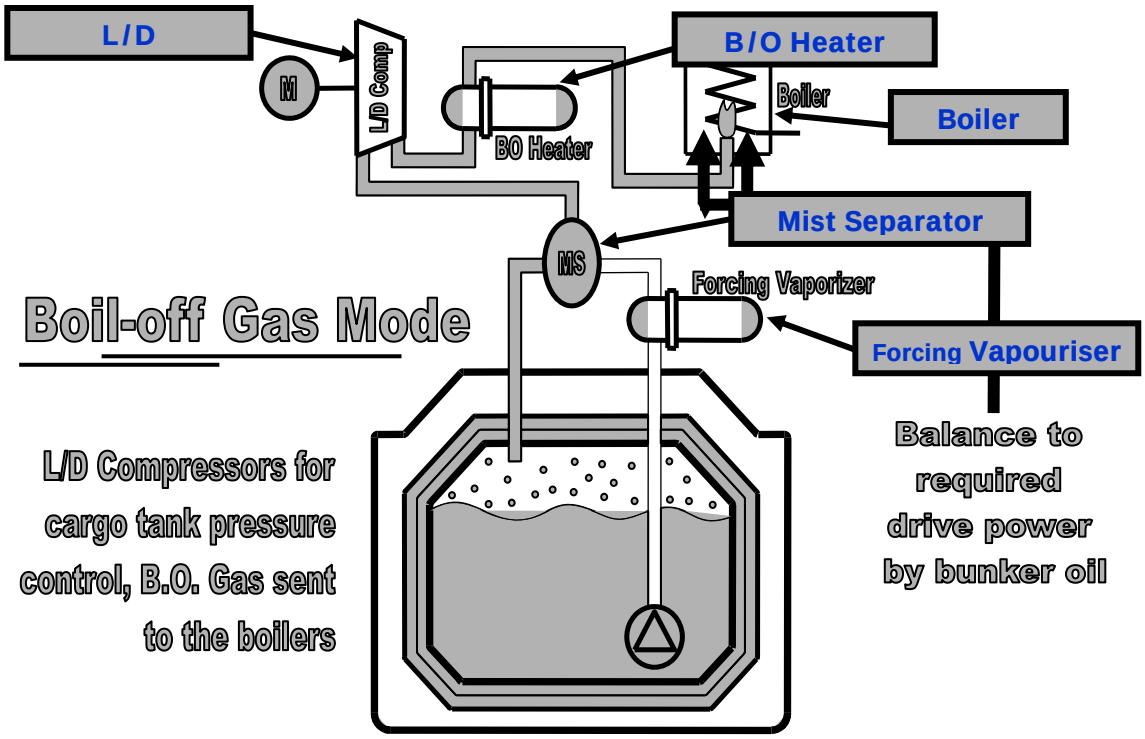


Figure 5.2 LNGC Loaded passage in conventional BOG mode

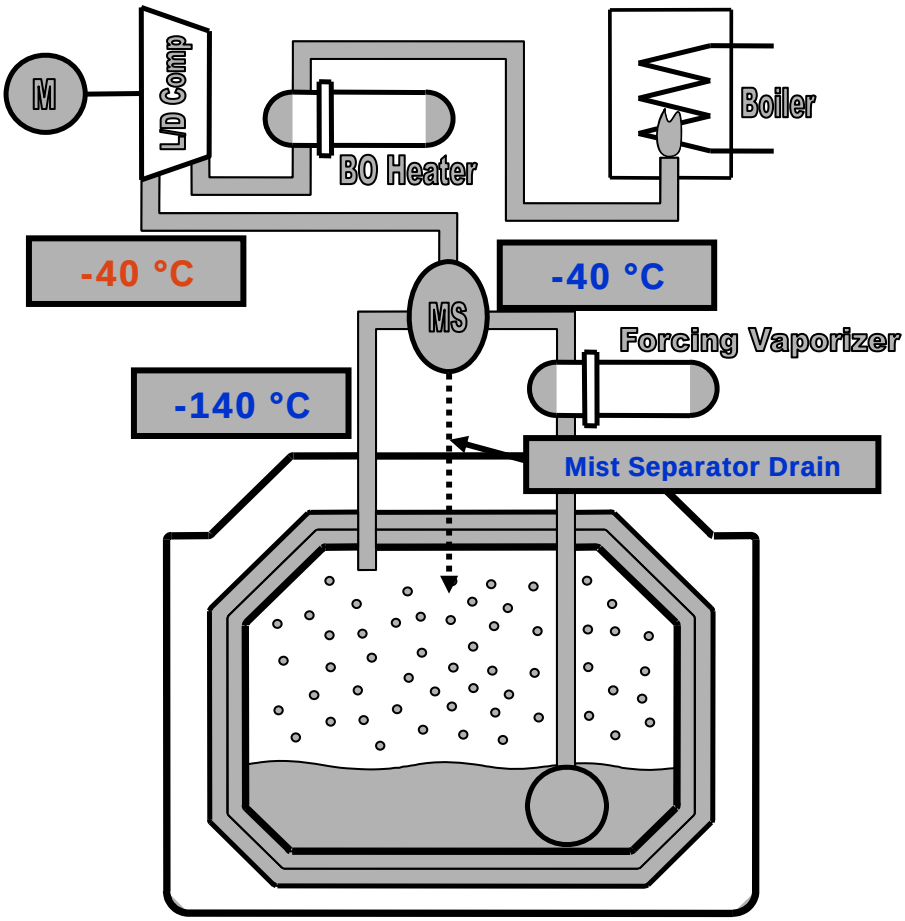


Figure 5.2 Forcing Gas to LD Compressor in Ballast passage

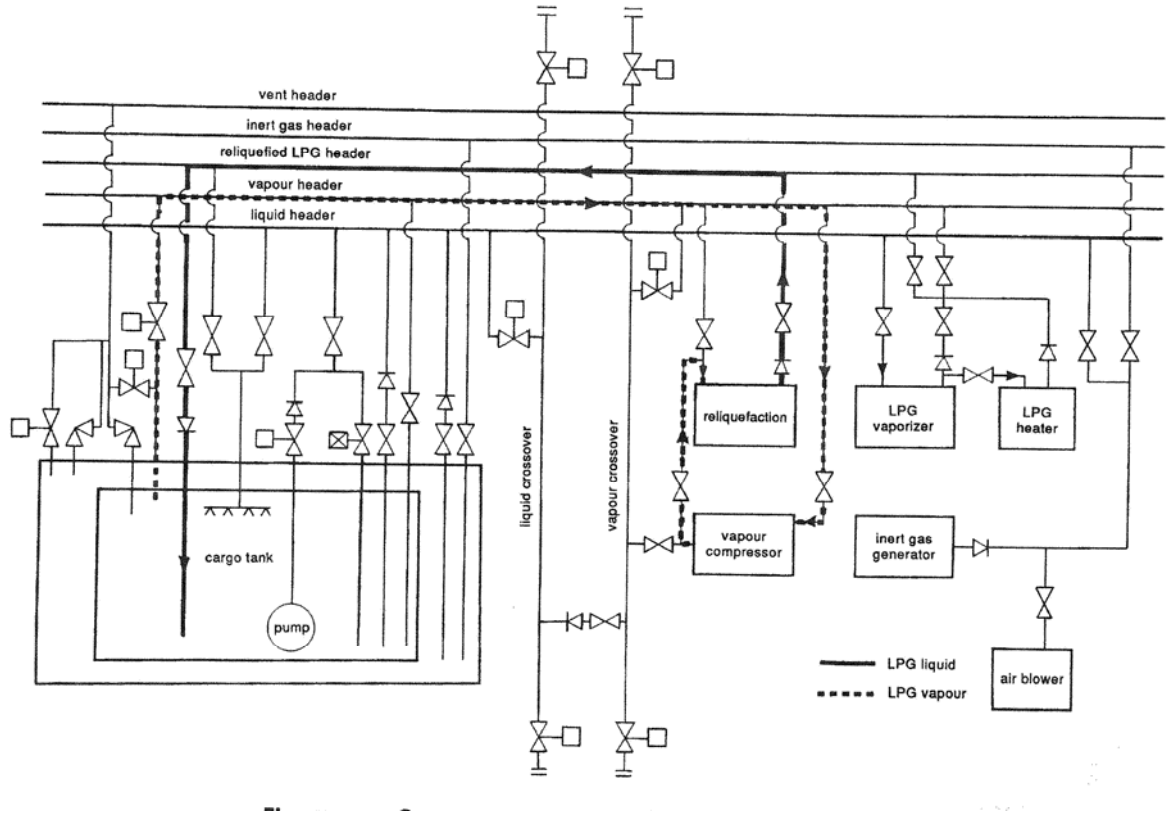
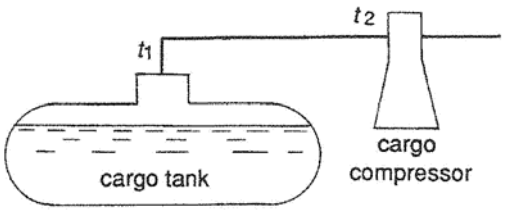


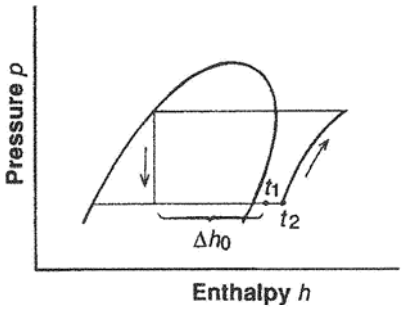
Fig 5.2 (a) Cargo conditioning during loaded passage

PROPANE (C_3H_8) with 2.5 mole % ethane in liquid phase

R22 compressor 50/100% capacity

Cargo compressor 100% capacity





Refrigerating effect:

$Q_0 = m_s \Delta h_0$
where m_s is the suction mass

Example:

Given: Suction pressure of the cargo compressor: 2.1 kp/cm^2 gauge
Seawater temperature: 20 °C

Found: Refrigerating effect = 450, 000 kcal/h
Power consumption of cargo compressor
Power consumption of R22 compressor } Total 320 kW

Fig 5.2 (b) Refrigerating effect and power consumption per cascade unit (1)

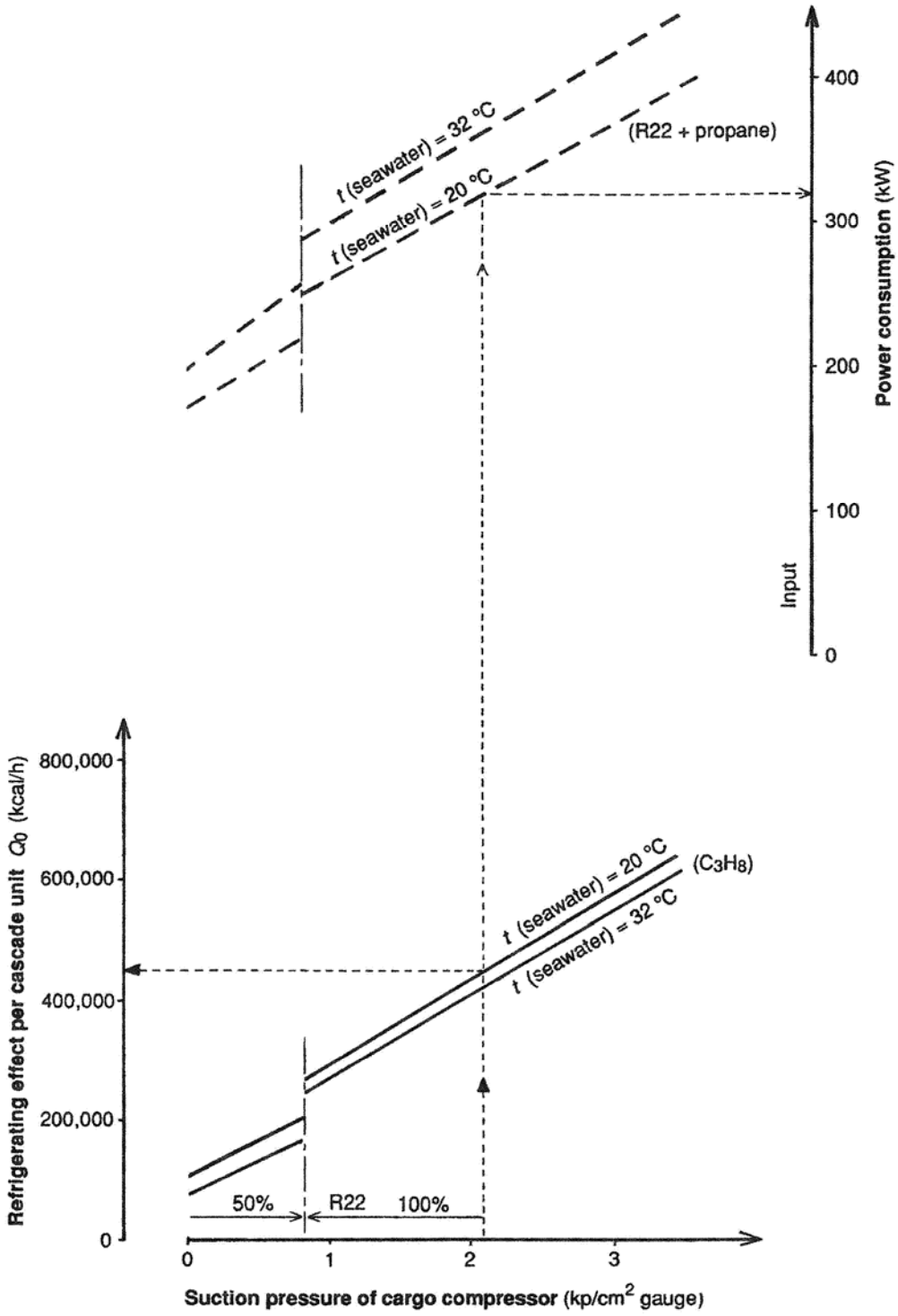
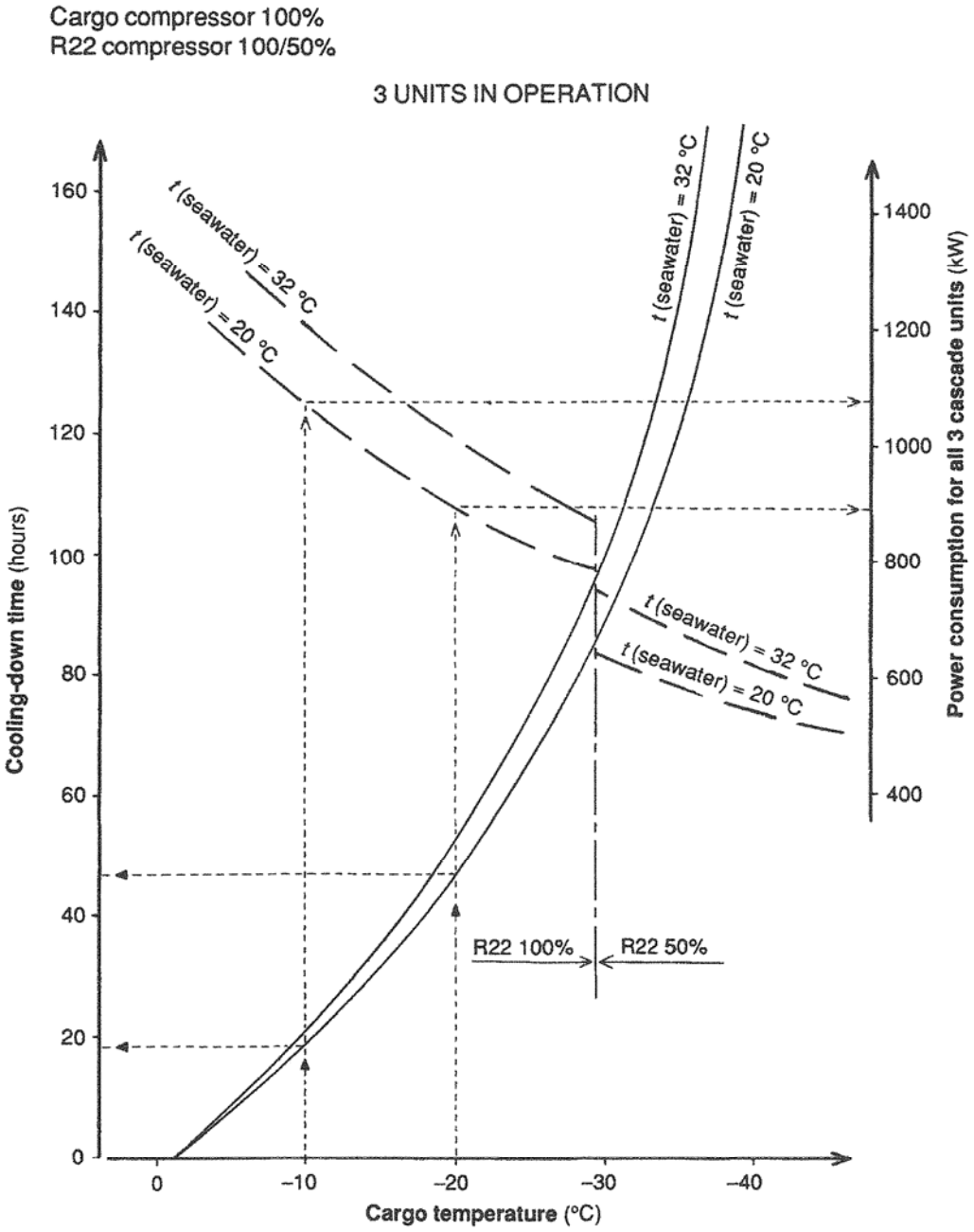


Fig 5.2 (c) Refrigerating effect and power consumption per cascade unit (2)



Example: Given Cargo to be cooled from –10 °C to –20 °C
Seawater temperature [*t* (seawater)]: 20 °C

Found Time required for cooling = 46 – 18 = 28 hours
Power consumption of cascade units:
cargo temperature is –10 °C = 1060 kW
cargo temperature is –20 °C = 890 kW

Fig 5.2 (d) A diagram showing the cooling-down time for propane

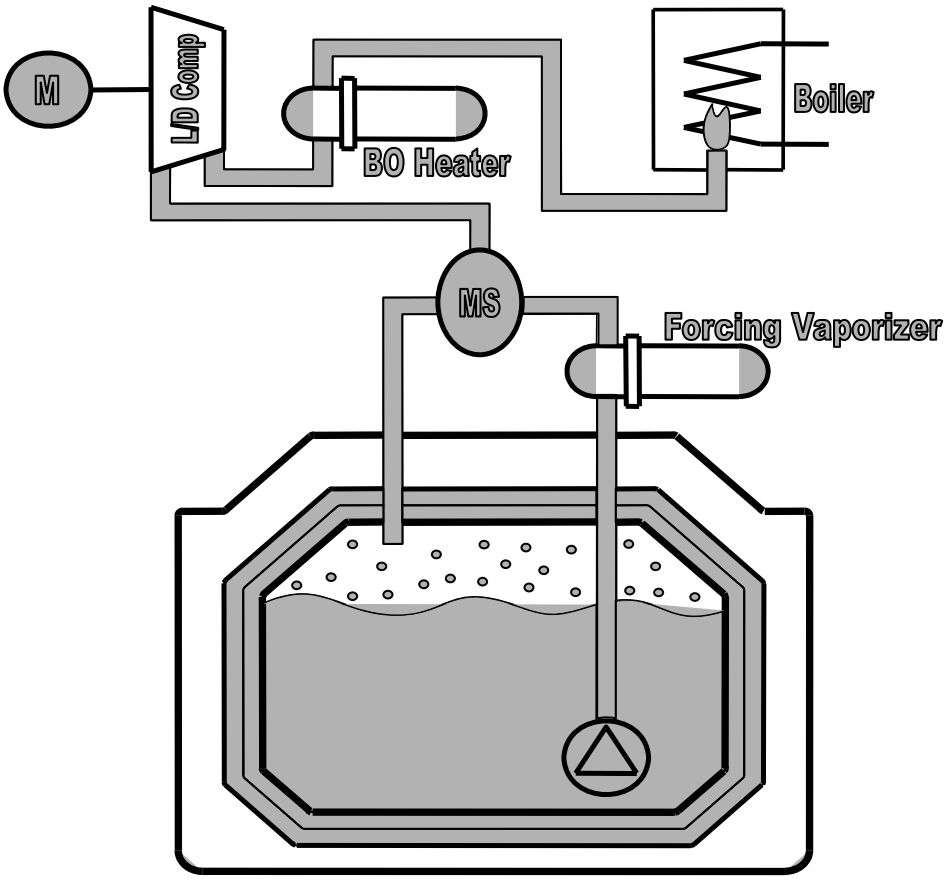


Figure 5.2.3 : Ballast Voyage: If fuel gas demand > natural boil-off, then use forcing vaporiser to create <u>additional</u> vapour

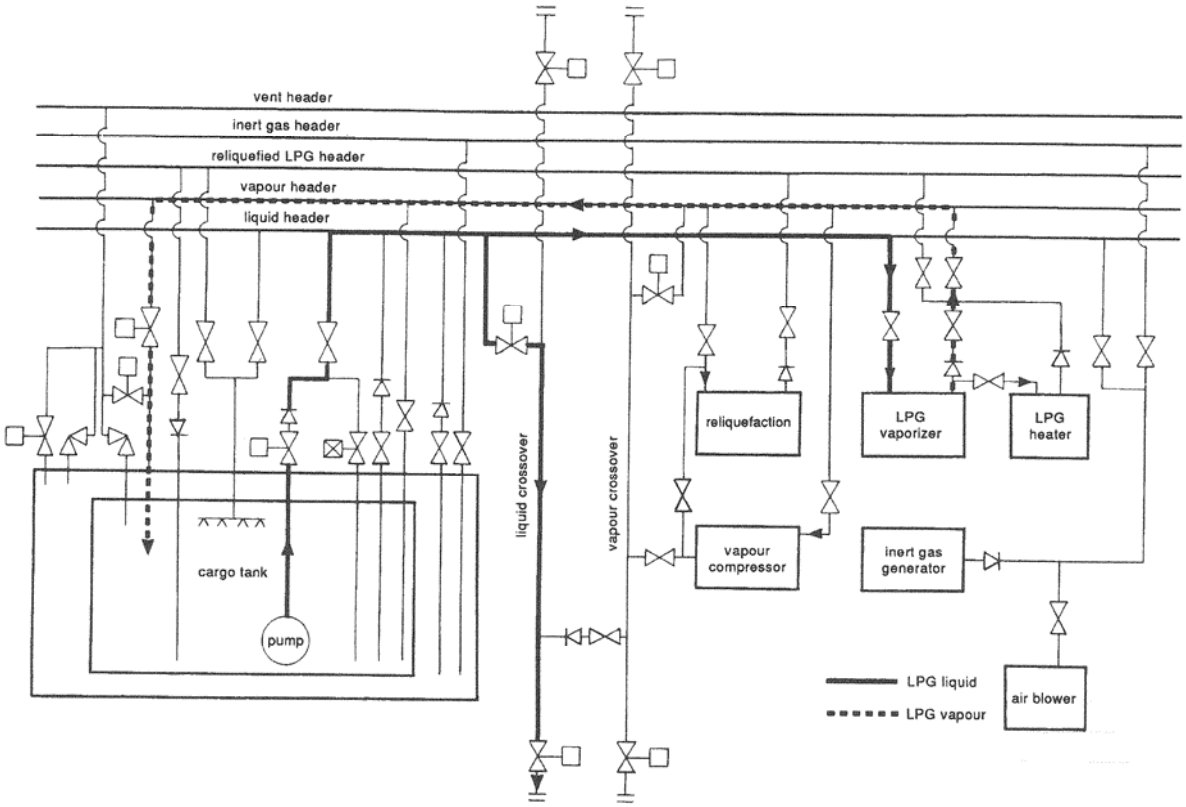


Fig 5.3 (a) Cargo unloading, without vapour return

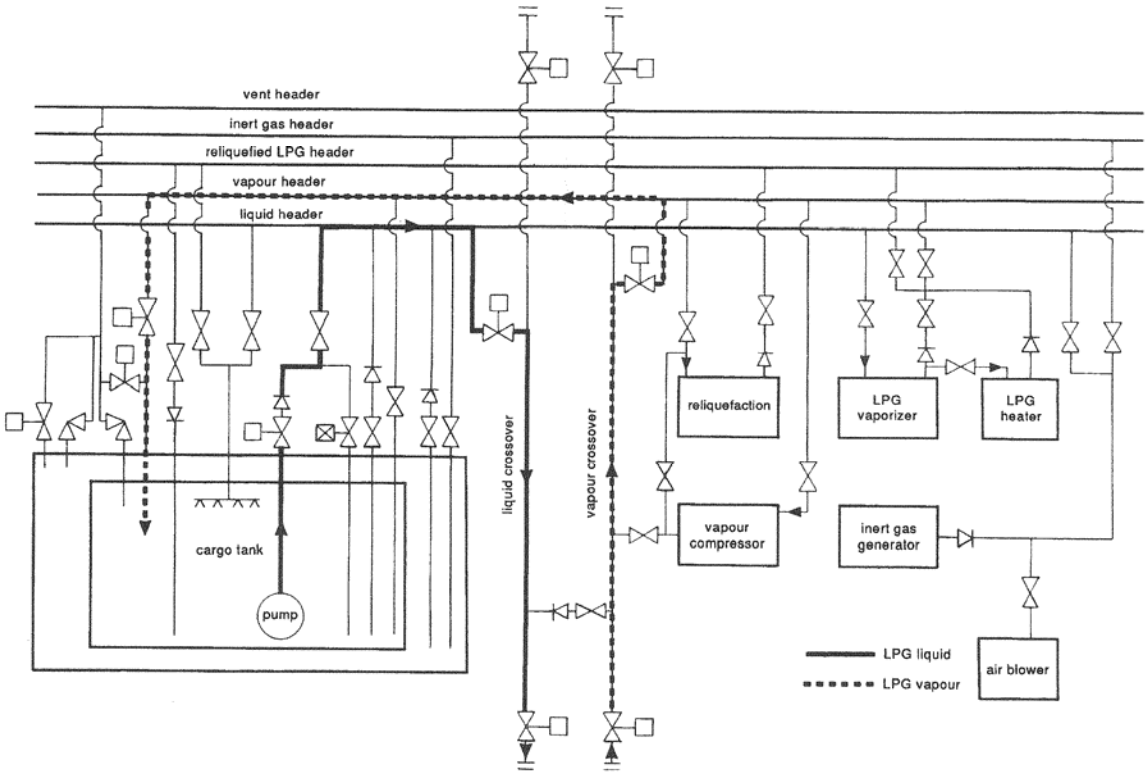


Fig 5.3 (b) Cargo unloading, with vapour return

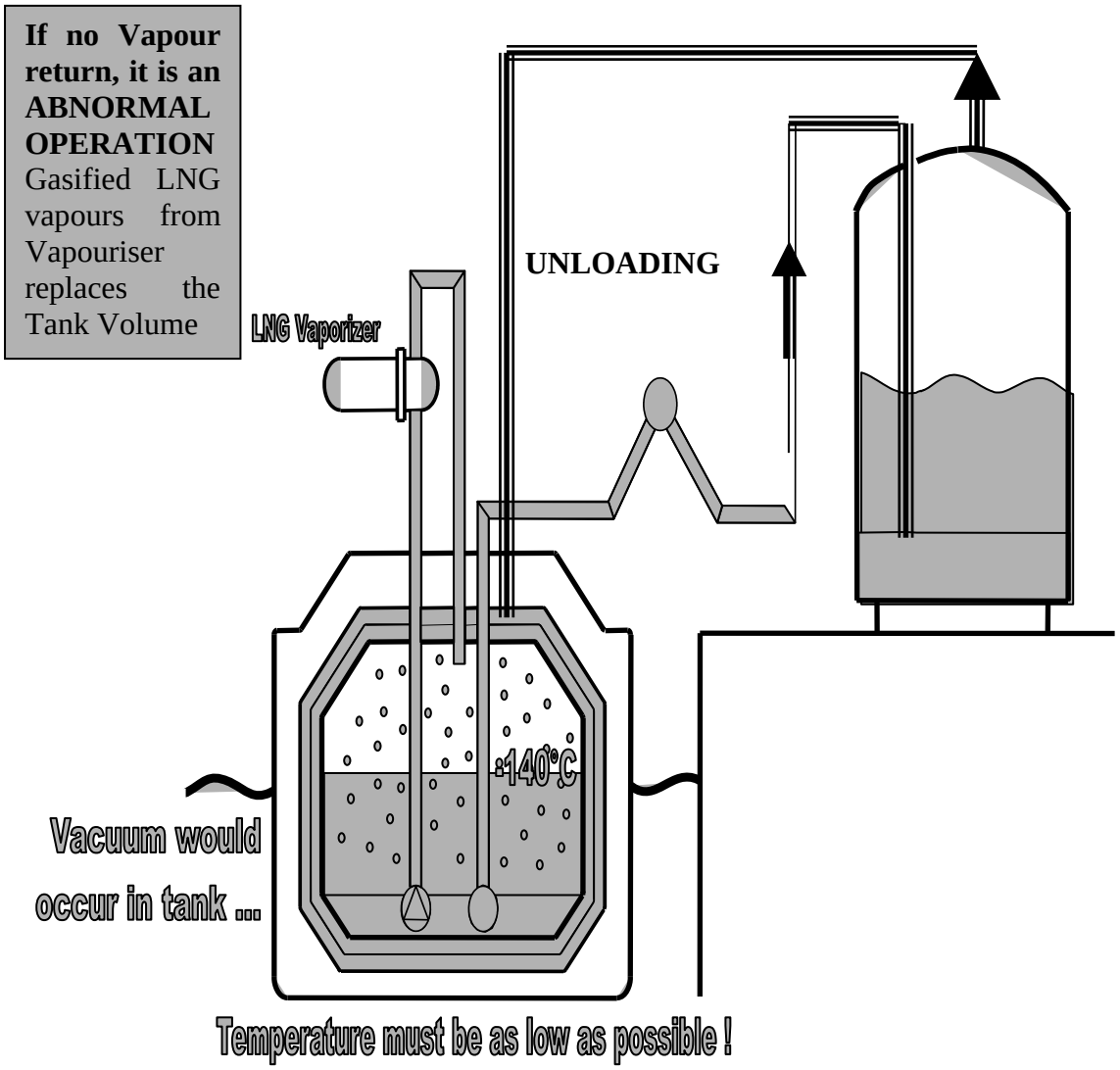


Fig. 5.3.1(a) Unloading with/without vapour Return from shore

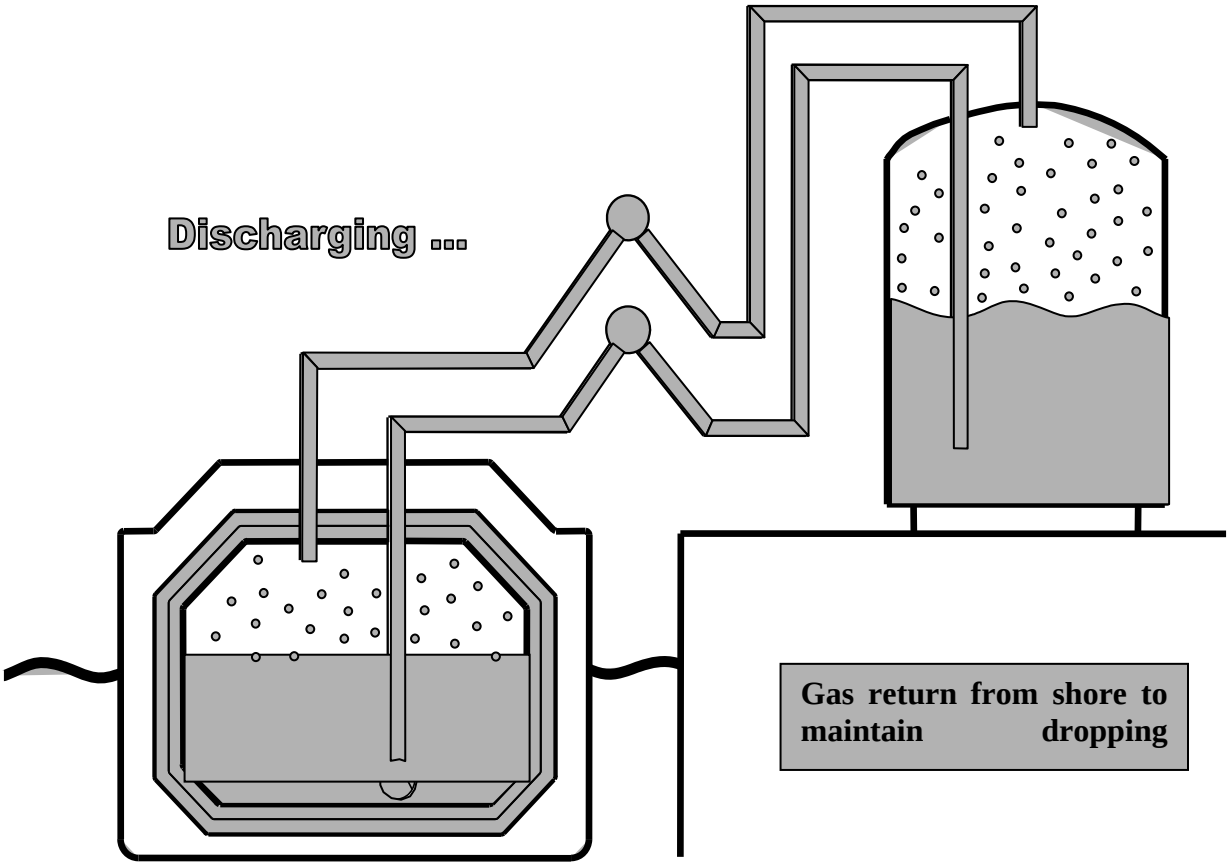


Fig. 5.3.1(b) shows unloading operations with Gas return from shore

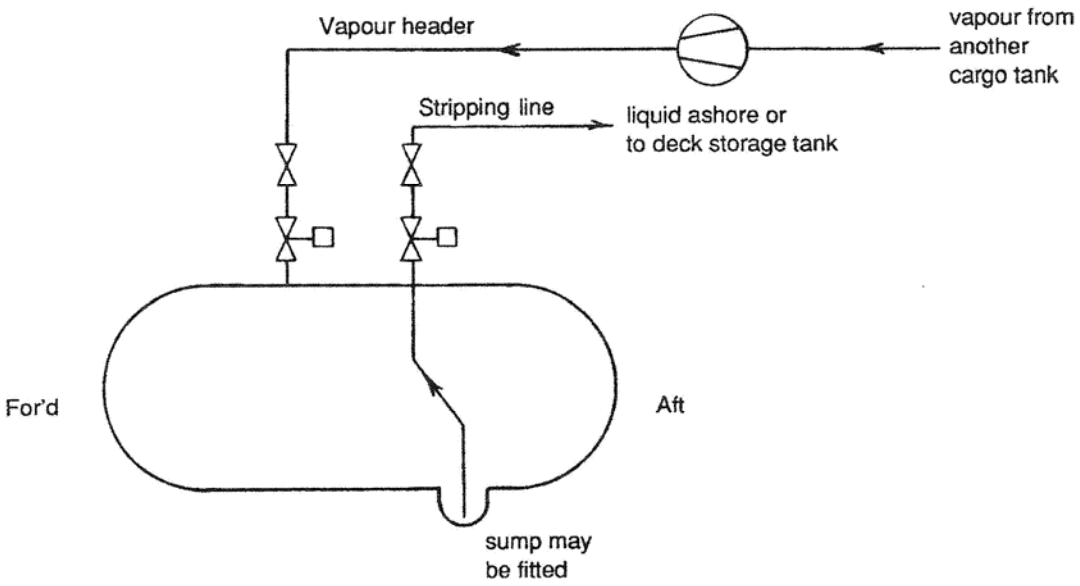


Fig 5.3.3 Removal of residual cargo liquid by pressurization

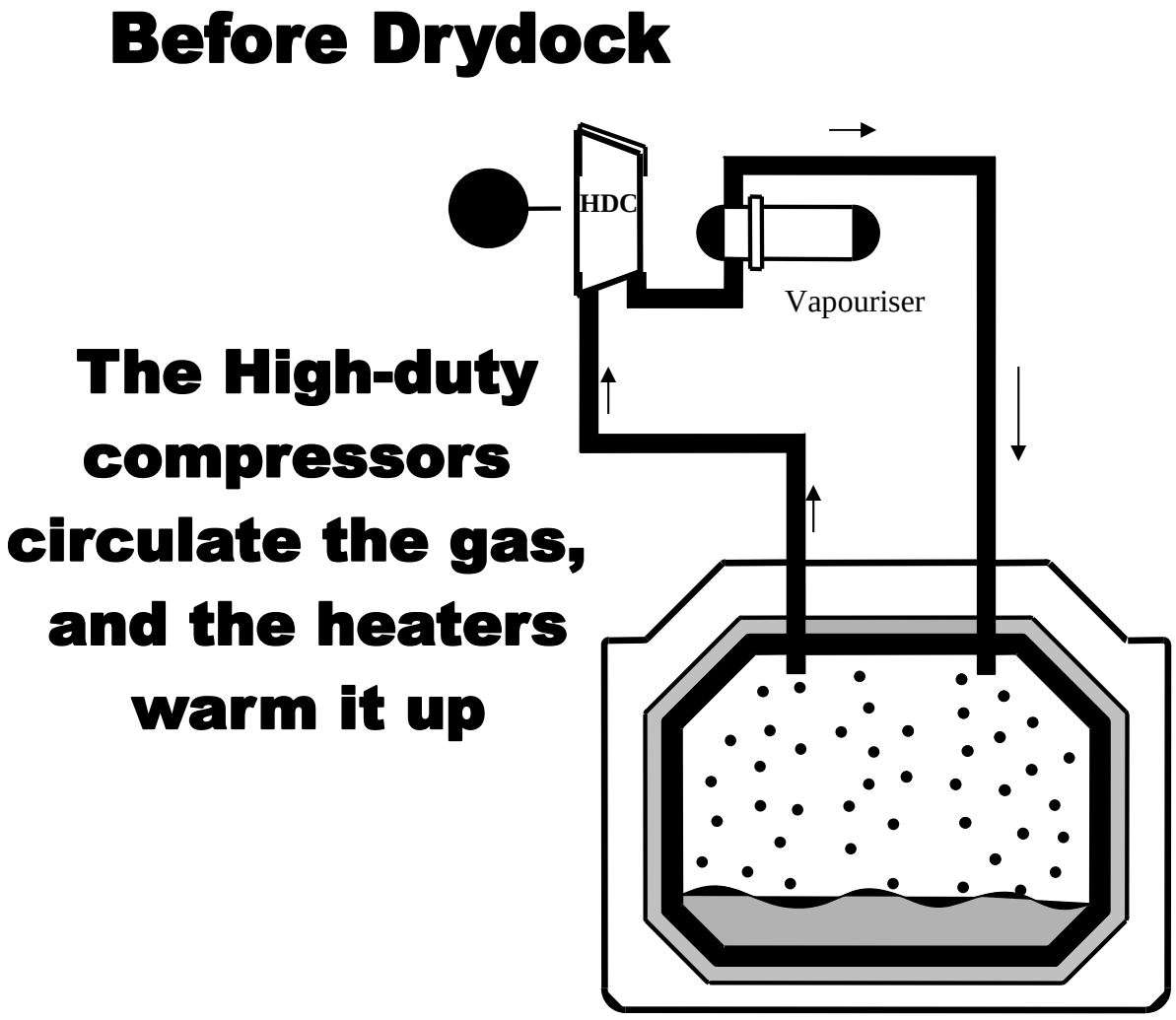


Fig. 5.4.1 (a) Warming up with LNG gas prior Dry docking

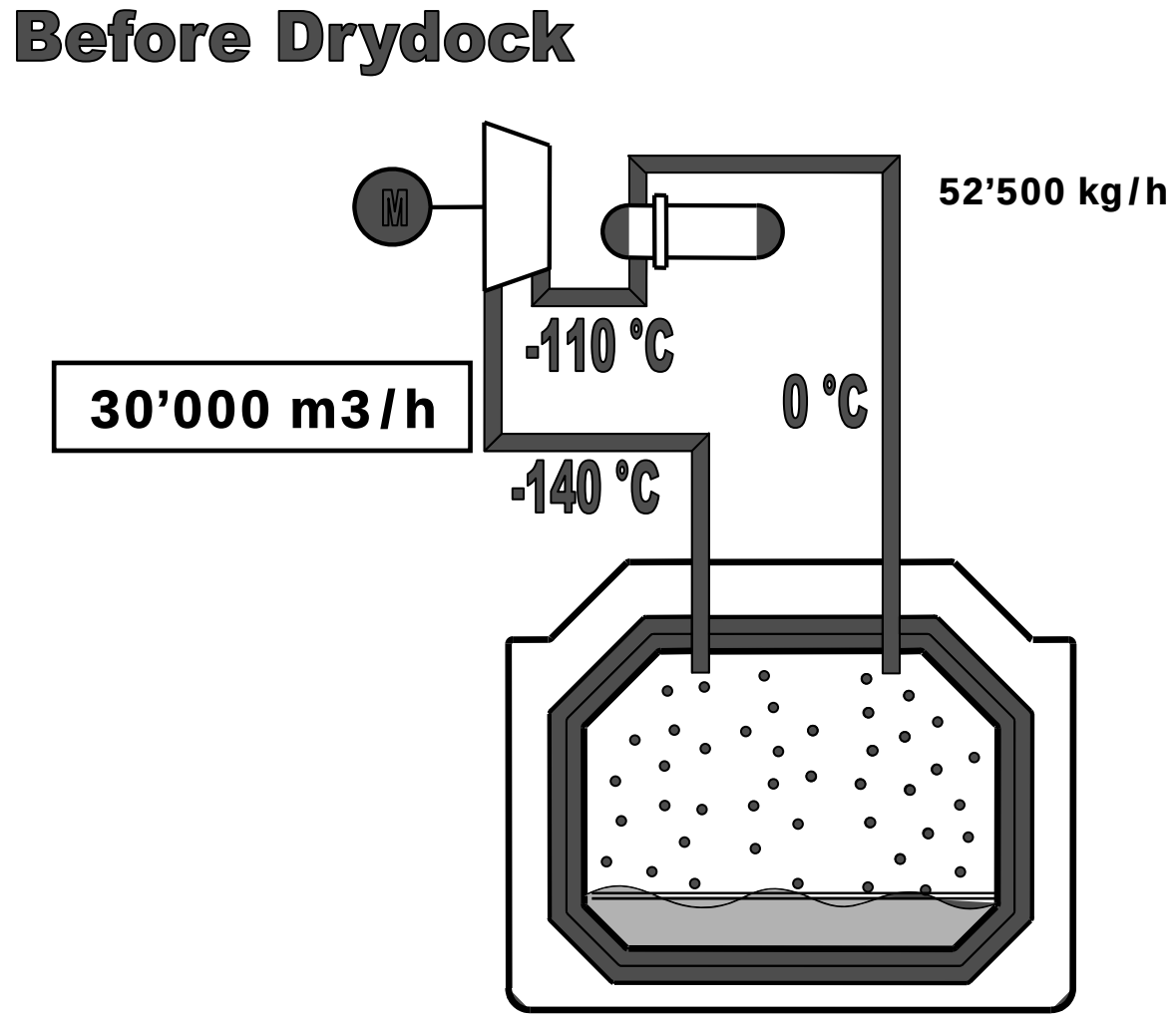


Fig. 5.4.1(b) H/D Compressors Circulates the LNG Cargo and the Heaters warm it up

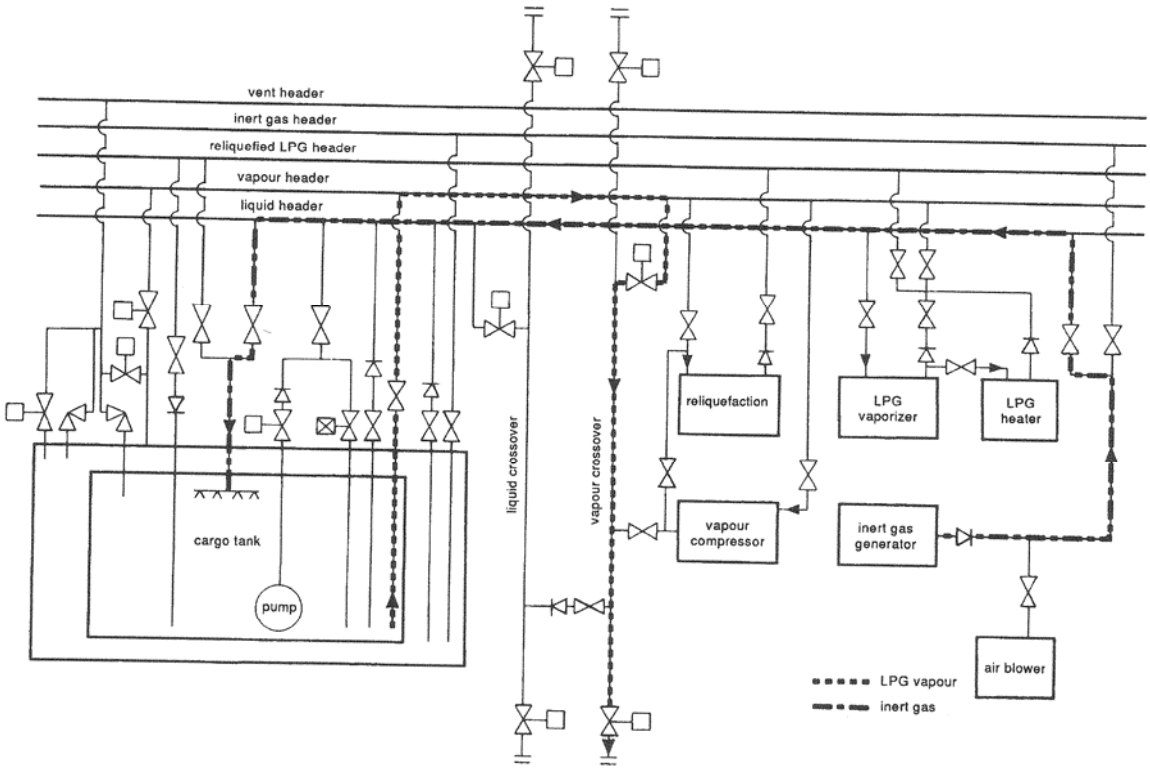


Fig 5.4.2 (a) Inerting of a cargo tank

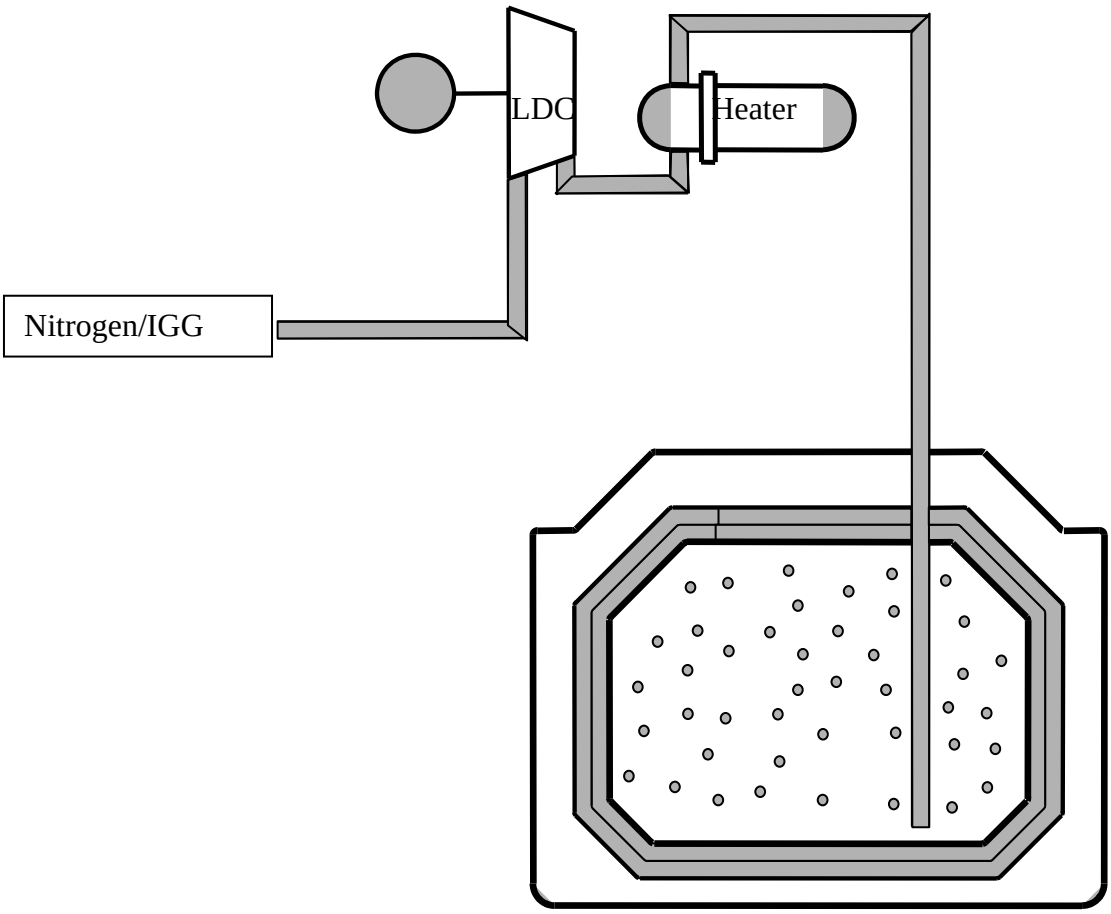


Fig. 5.4.2(b) shows Inerting prior Dry docking

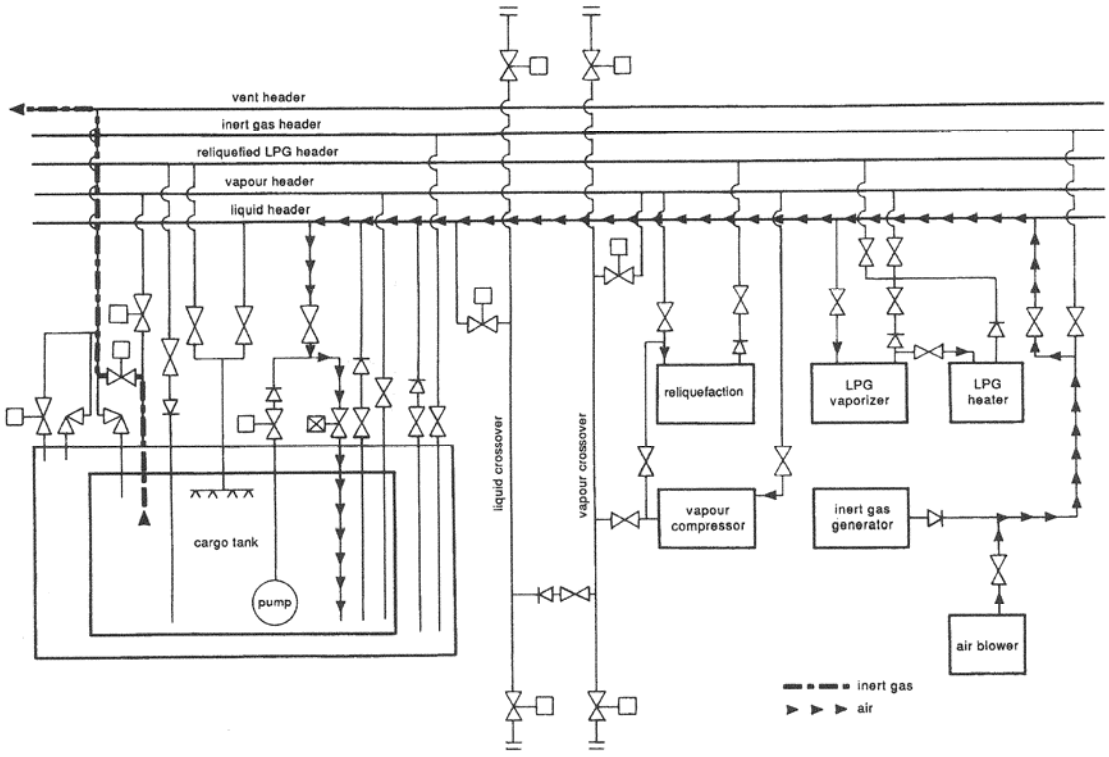


Fig 5.4.3 (a) Aerating (venting) of a cargo tank

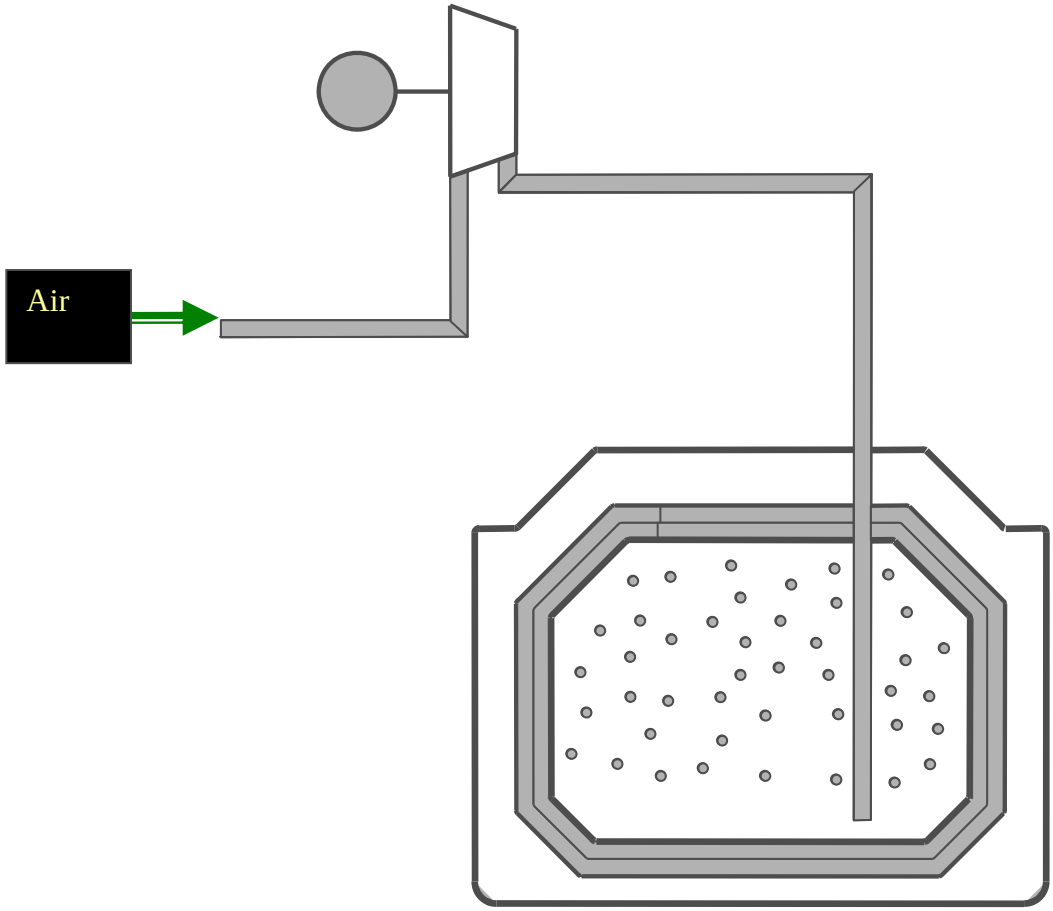


Fig. 5.4.3(b) Shows: Aerating Prior Man entry

			BEFORE	AFTER
ATrim			0	6
B Sounding			7.01	0.09
C Corr. Sounding			7.02	0.1
D Temp. of liquid	°C		. -10	-15
E Temp. of vapour	°C		0	-5
F Tank pressure	kp/cm^3		2.4	2.2
G Full tank volume	m^3		1243.17	1243.17
•Hliquid vol	m^3		1233.1	1.2
K Shrinkage factor			0.999017	0.99889
L COrr. Liquid volume H*K	m^3		1231.89	1.2
• M Vol. red. Fact. (tab. 54)			1.069	1.086
NVolumeatl5°C	L*M m^3		1316.89	1.29
P Density (15°C)	t/ m^3		0.508	0.508
Q Liquid mass	N*P t		668.98	65
R Vapour Volume	G-H m^3		10.07	1241 97
S Shrinkage factor			0.99928	0.999141
T Corr. Vap. Vol.	R*S m^3		10.06	1240.91
U Volume at 0°C, 1 atm.	m^3		33.44	3956.16
V density of vap.=Mol wt / 22.414	kg/m^3		1.9674	• 1.9674
W mass of vapour	U*V kg		66	7783
Xtotal mass (Weight in vacuo)	Q+W		669.046	8.441
Y Total Wt in air	X*(P-.0011)/P		667.597	8.423

Fig 6.0 (a) Showing Sample Cargo Calculations

CARGO CALCULATION SHEET (GAS)
LOADING/DISCHARGING

	GRADE: _____		BEFORE	AFTER
Readings	*A* Trim			
	B Sounding			
	C Corrected sounding			
	D Temperature of liquid	°C		
	E Temperature of vapour	°C		
	F Tank pressure			
	G Full tank volume	m^3		
Liquid	*H* Liquid volume	m^3		
	K Shrinkage factor			
	L Corrected liquid volume (*H* × *K*)	m^3		
	M Volume reduction factor (see table 54B)*			
	N Volume at 15 °C (*L* × *M*)	m^3		
	P Density (at 15 °C)	kg/m^3		
	Q Liquid mass (*N* × *P*)	kg		
Vapour	*R* Vapour volume (*G* − *H*)	m^3		
	S Shrinkage factor			
	T Corrected vapour volume (*R* × *X*)	m^3		
	U Volume at 0 °C, 1 atm.**	m^3		
	V Density of vapour $\left(\frac{\text{Mol. wt}}{22.414}\right)$	kg/m^3		
	W Mass of vapour (*U* × *V*)	kg		
Total	*X* Total mass (Weight in vacuo) (*Q* + *W*)			
	Y Total weight in air $\left(\frac{X \times (P - 1.1)}{P}\right)$			

TOTAL LOADED/DISCHARGED in vacuo t. _____
or in air t. _____

Notes:

* *M*: Table 54B of *Petroleum Measurement Tables* is only applicable to saturated hydrocarbons, e.g. propane and butane

** $U = T \times \frac{(F + 1 \text{ atm.})}{1 \text{ atm.}} \times \frac{273}{273 + E}$ (1 atm. = 1.033 kp/cm² = 1.013 bar)

Fig 6.0 (b) A cargo calculation sheet (gas)

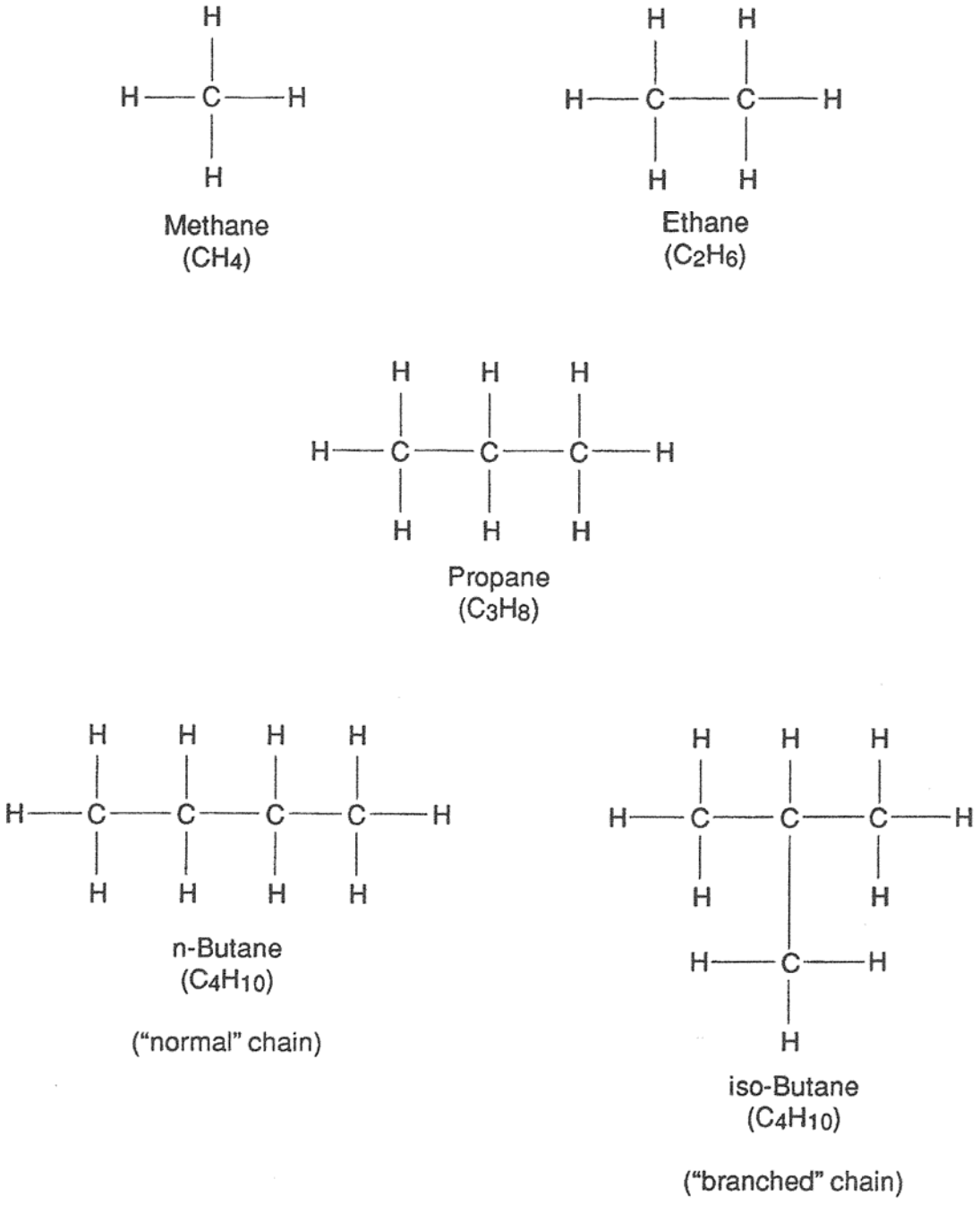


Fig 8.1 (a) Molecular structures of some saturated hydrocarbons

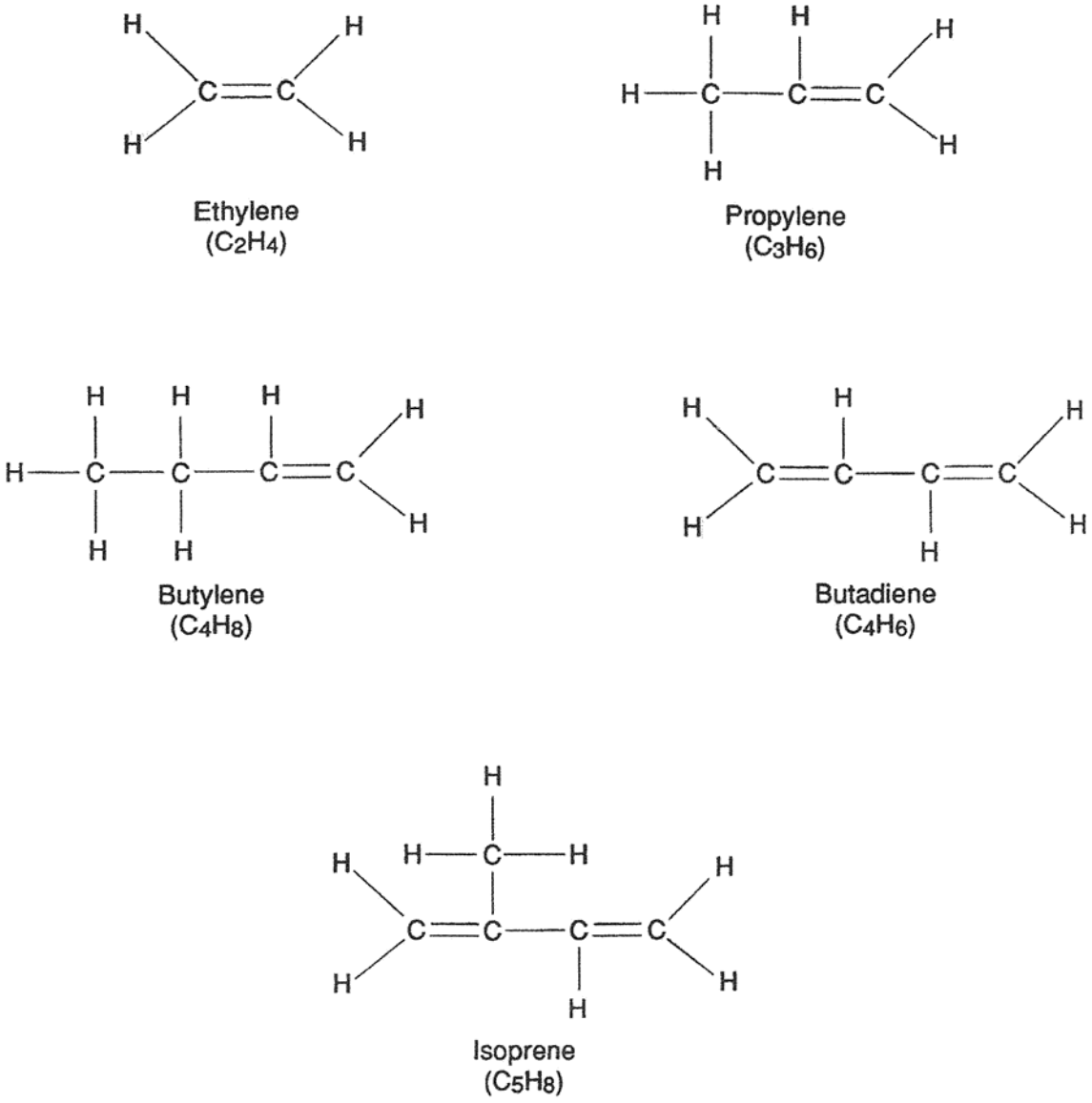
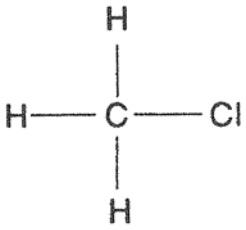
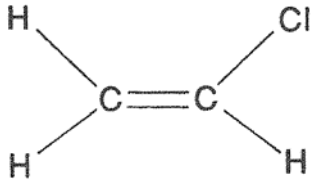


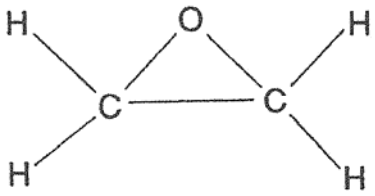
Fig 8.1 (b) Molecular structures of some unsaturated hydrocarbons



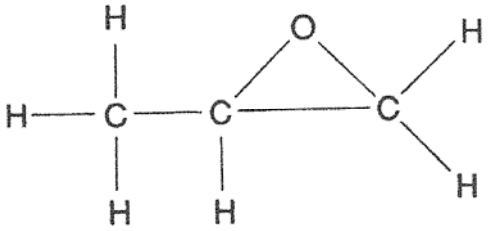
Methyl chloride
(CH_3Cl)



Vinyl chloride monomer (VCM)
(CH_2CHCl)



Ethylene oxide
(C_2H_4O)



Propylene oxide
(C_3H_6O)

Fig 8.1 (c) Molecular structures of some chemical gases

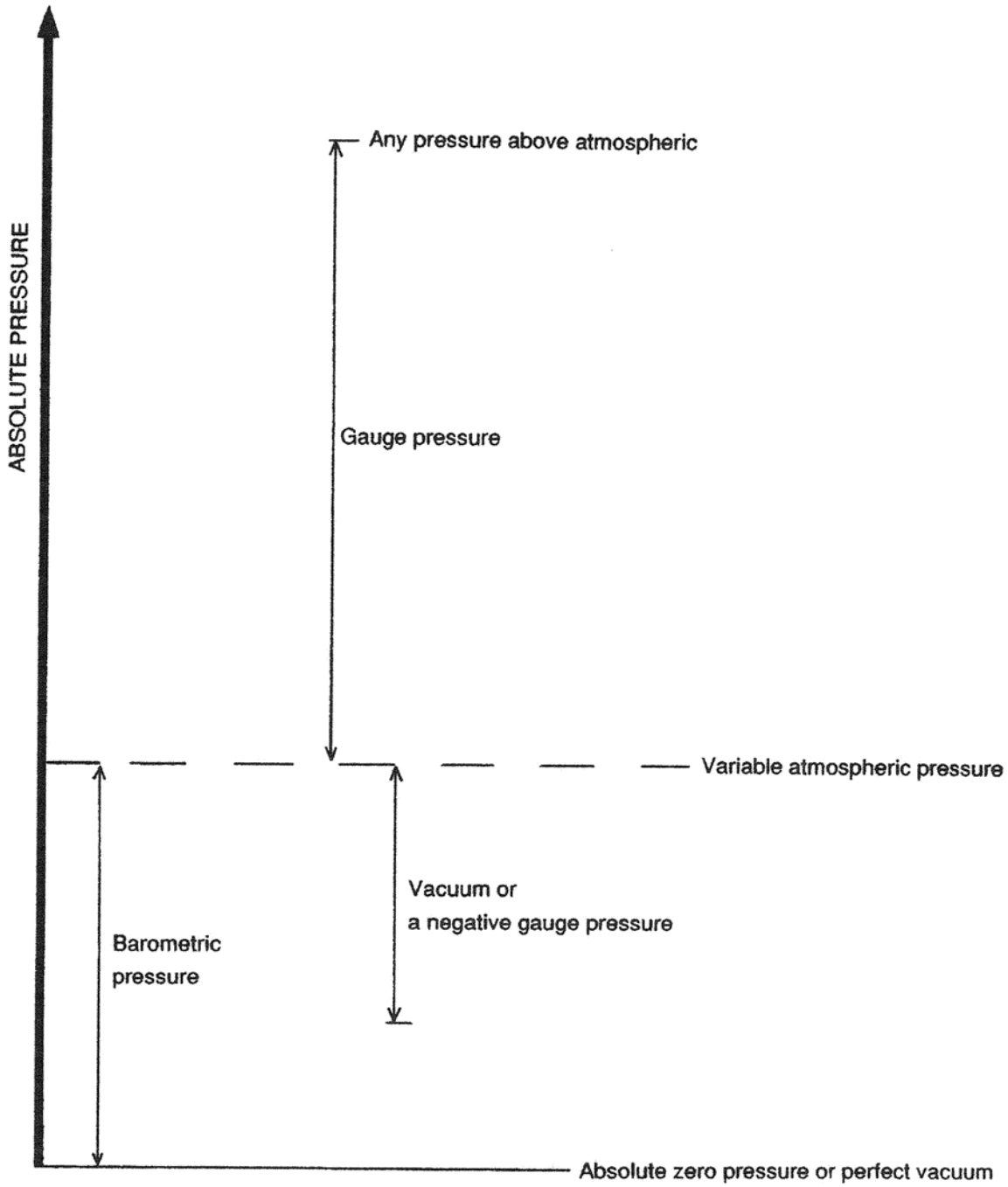


Fig 8.2 (a) Illustration of different pressures

LIQUEFIED GAS — INHIBITOR INFORMATION FORM

To be completed before loading an inhibited cargo

SHIP..... DATE.....

PORT & BERTH..... TIME .....

1. CORRECT TECHNICAL NAME OF CARGO.....

2. CORRECT TECHNICAL NAME OF INHIBITOR .....

3. AMOUNT OF INHIBITOR ADDED.....

4. DATE ADDED.....

5. EXPECTED LIFETIME OF INHIBITOR.....

6. ANY TEMPERATURE LIMITATIONS AFFECTING INHIBITOR.....

7. ACTION TO BE TAKEN IF VOYAGE EXCEEDS EFFECTIVE LIFETIME OF INHIBITOR .....

IF ABOVE INFORMATION NOT SUPPLIED, CARGO SHOULD BE REFUSED (IMCO Codes 18.1.2)

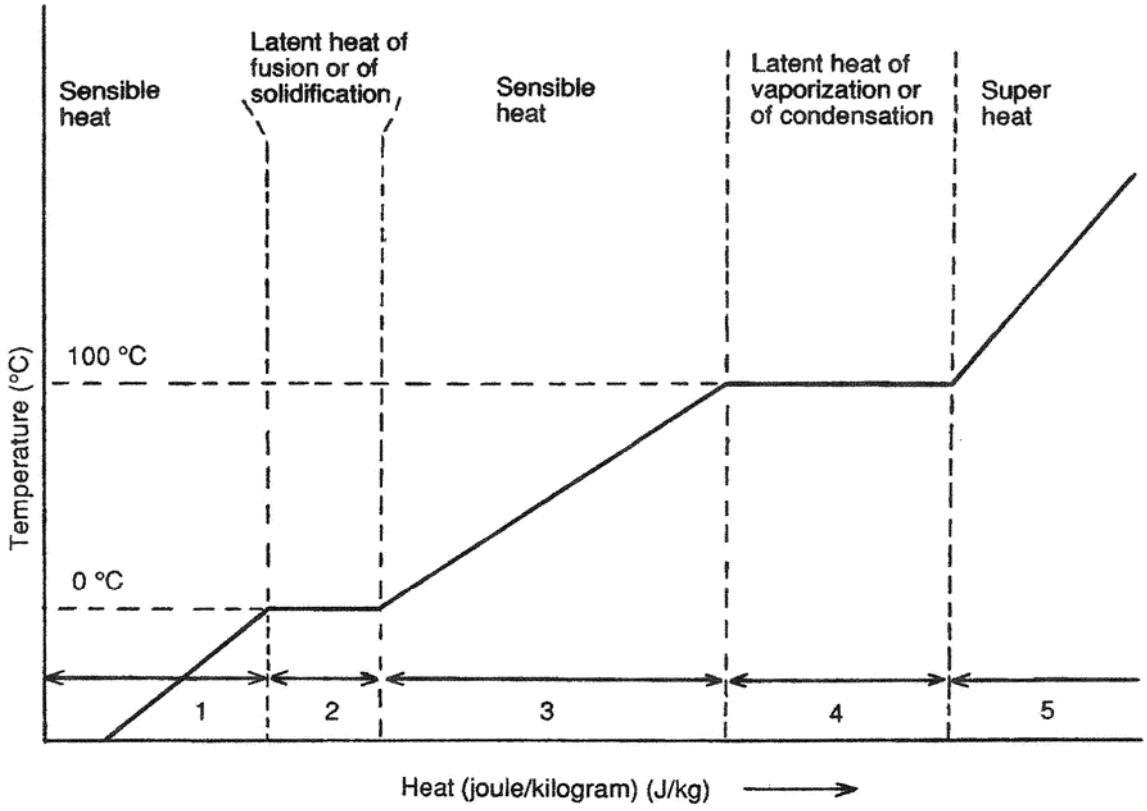
FOR SHIP..... FOR SHORE.....
(Signed) (Signed)

Fig 8.2 (b) Liquefied gas – inhibitor information form

		bar	At. (kp/cm^2)	Atm.	p.s.i.	mmHg	Wg (mmH_2O)	Pa
1 bar	=	1	1.020	0.9869	14.50	750.1	10 197	100 000
1 At. (kp/cm^2)	=	0.9807	1	0.9678	14.22	735.6	10 000	98 067
1 Atm. (760 mmHg)	=	1.0133	1.033	1	14.70	760	10 333	101 325
1 p.s.i. (lb/in^2)	=	0.068 95	0.070 31	0.068 05	1	51.71	703.1	6 895
1 mmHg (Torr)	=	0.001 333	0.001 360	0.001 316	0.019 34	1	13.60	133.3
1 mm water column (Wg)	=	0.9807×10^{-4}	1×10^{-4}	0.9678×10^{-4}	0.001 422	0.073 56	1	9.807

Tbe basal unit in the S.I. system is the pascal (Pa) = 1 N/m^2 = 10^{-5} bar
1 kp/cm^2 (1 At.) is called a 'technical atmosphere', while 1 Atm. (760 mmHg) is called a 'physical atmosphere'
mmHg = millimetre of mercury column

Fig. 8.2 (c) Pressure units

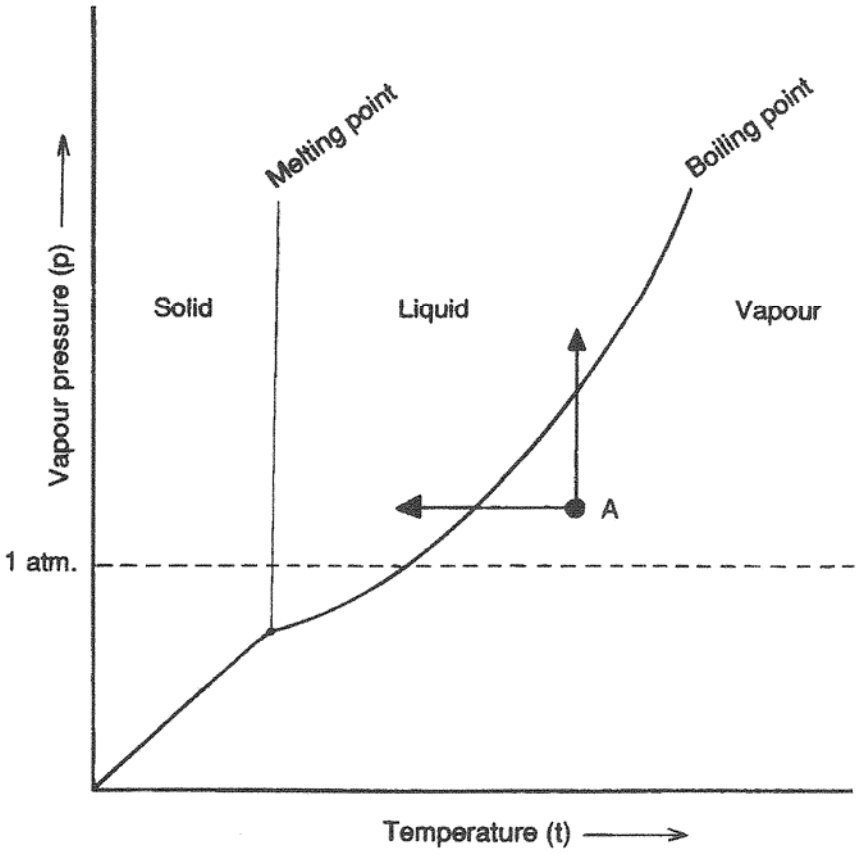


1 Ice
2 Ice + water
3 Water
4 Water + steam
5 Steam

Illustration of the behaviour of water when heated.

In the reverse process, water vapour (steam) can be liquefied and subsequently solidified by removal of heat.

Fig 8.2 (d) States of aggregation (temperature/heat)



.... a gas (A) can be liquefied by removal of heat and/or pressurizing ....

Fig 8.2 (e) States of aggregation (pressure/temperature)

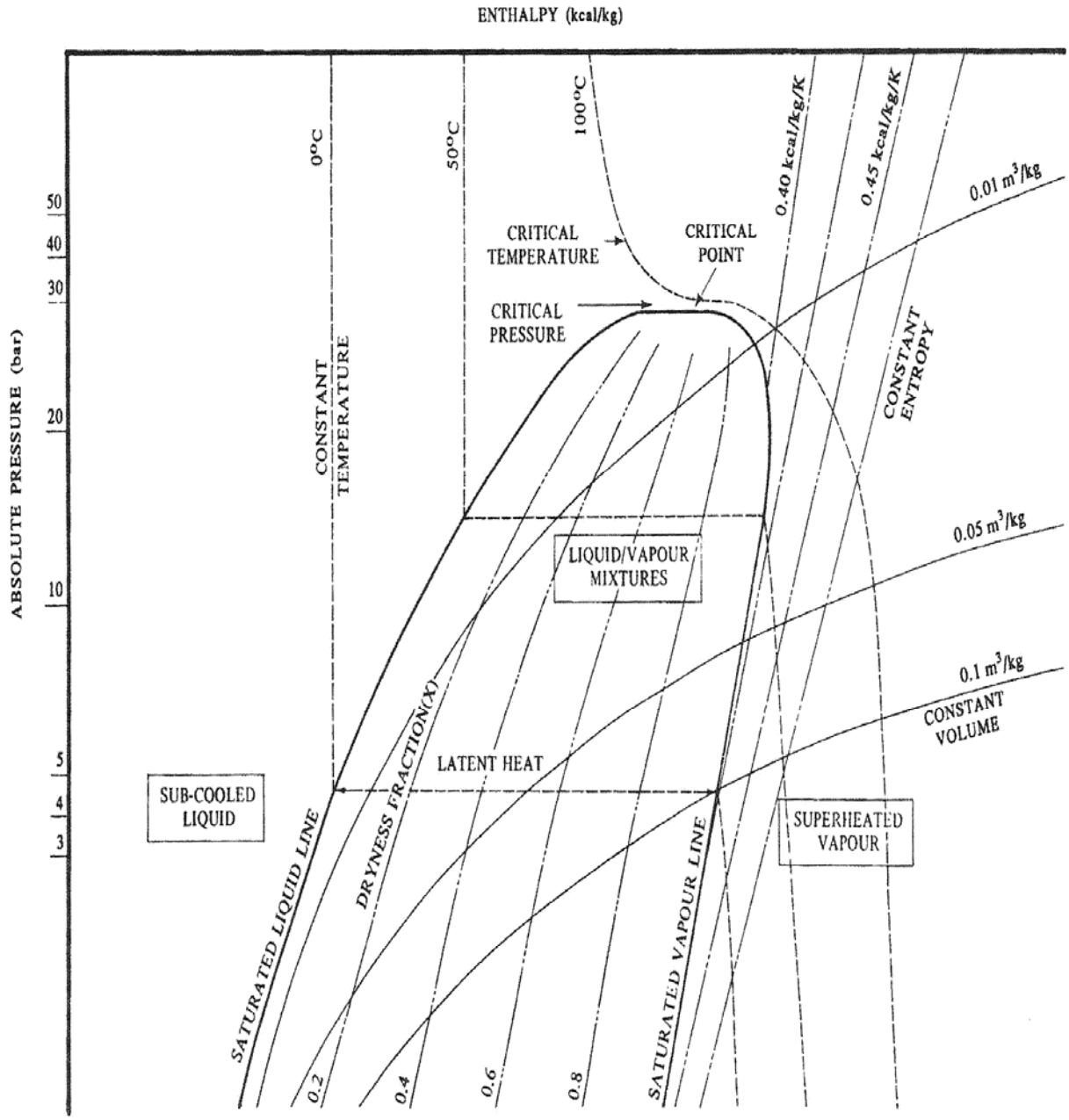


Fig 8.2 (f) A schematic mollier diagram

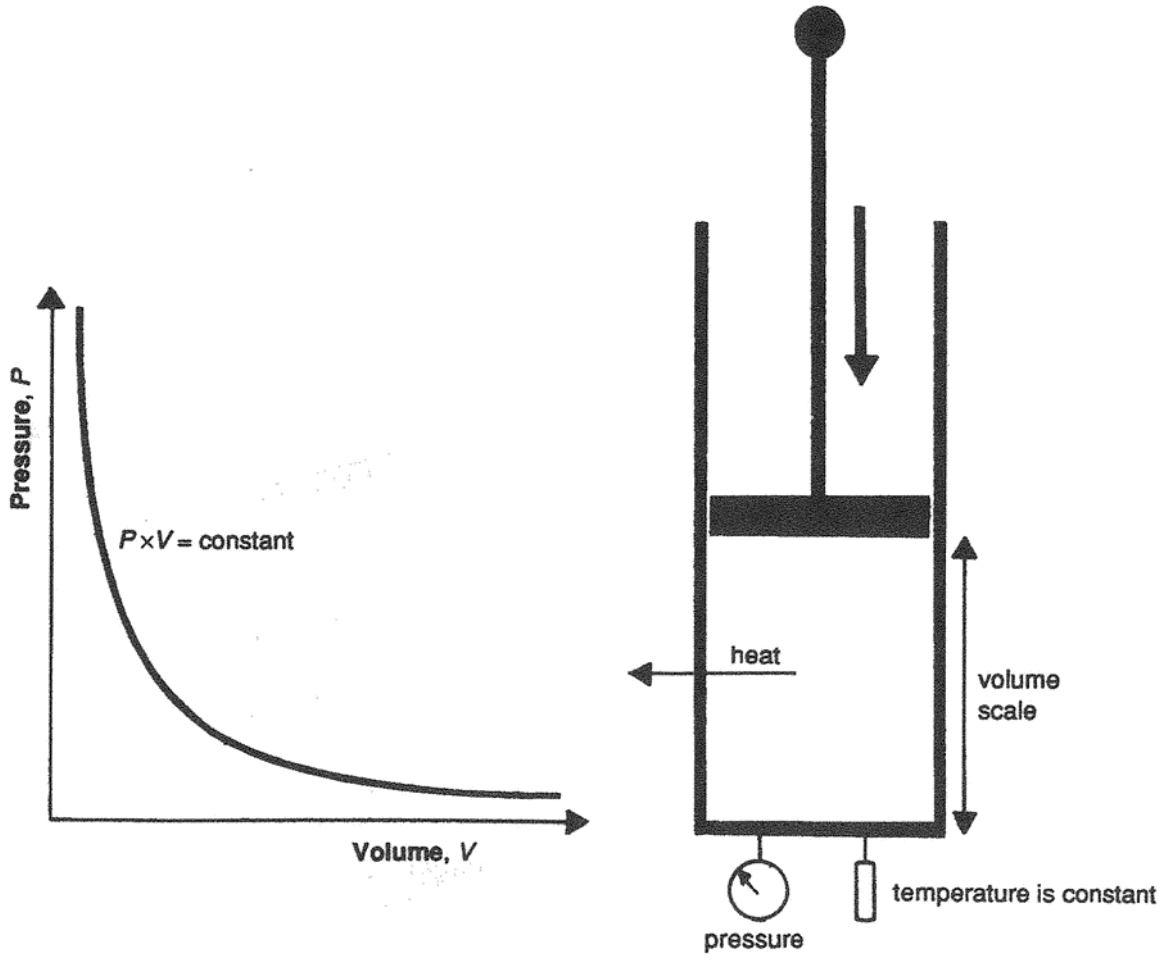


Fig 8.2 (g) Illustration of Boyle's law for ideal gases

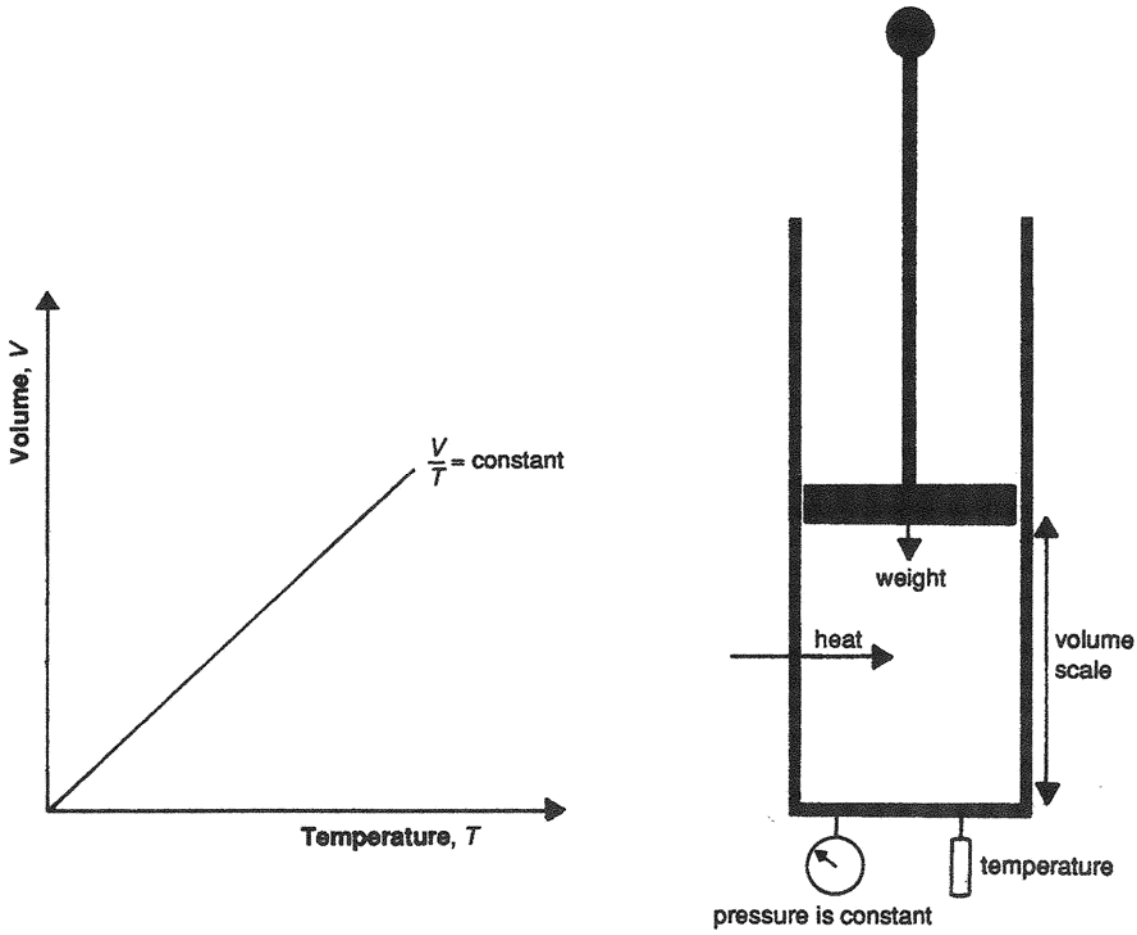
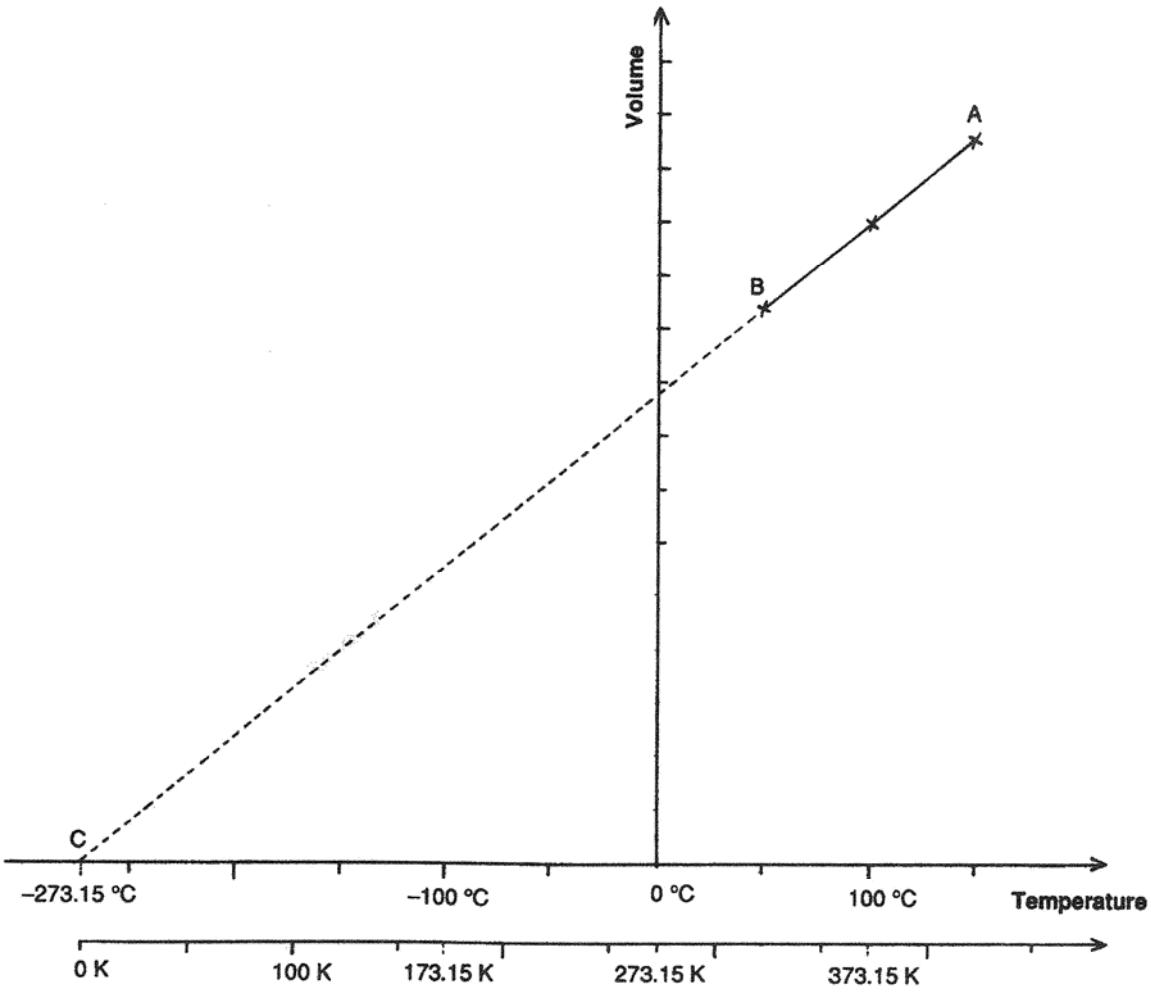


Fig 8.2 (h) Illustration of Charles' law for ideal gases



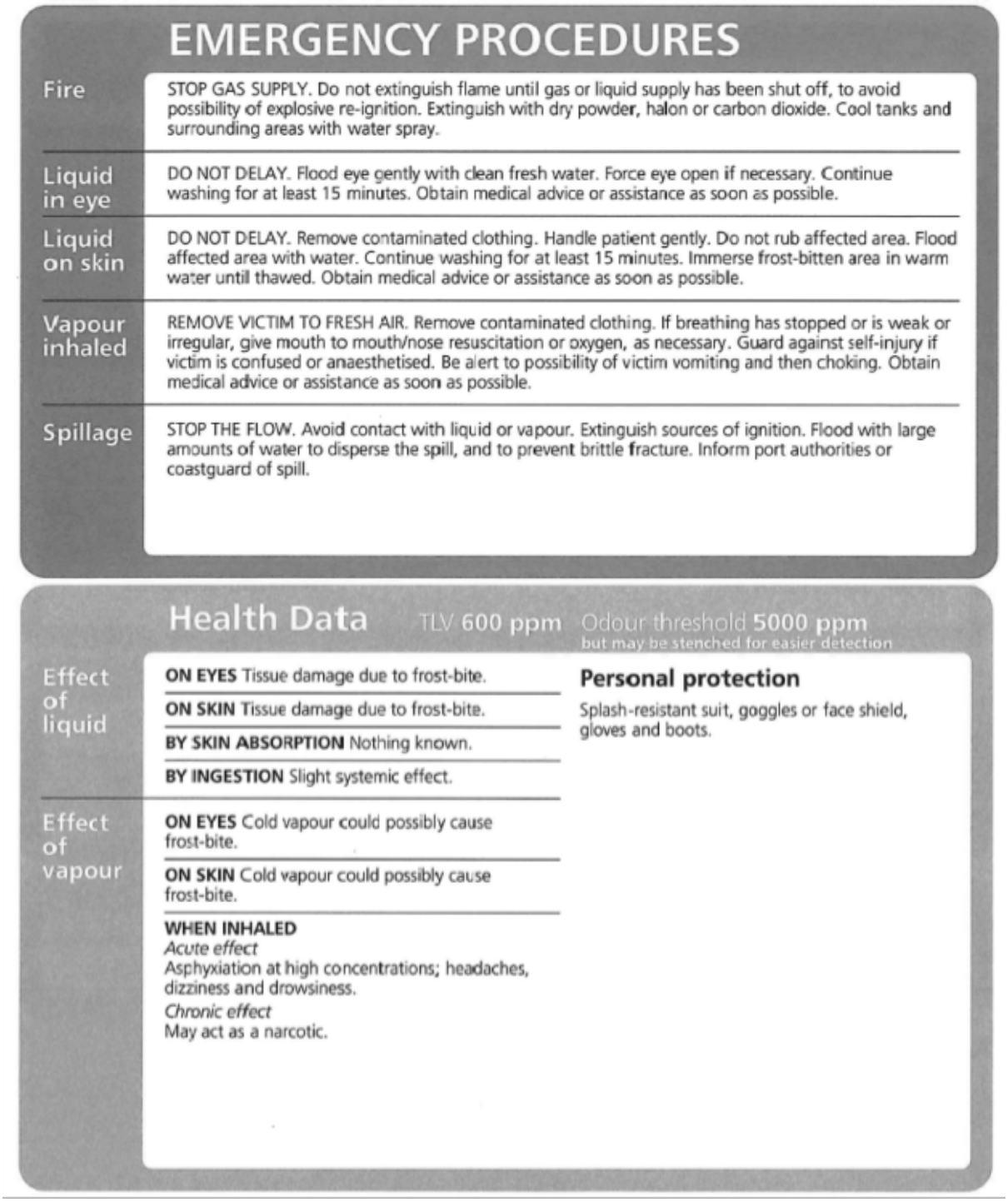
The line between A and B is the result of a real experiment.
The line between B and C is an expected continuation of the line AB.
The point C is the intersection of the expected line and the temperature scale in degrees Celsius.
Start the absolute temperature scale at this point.

Fig 8.2 (i) Illustration of "absolute temperature" resulting from an experiment based on work by Charles

THERMAL QUANTITIES

Quantity	Dimensions	Derived Units
Enthalpy	ML^2T^{-2}	joule
Entropy	$ML^2T^{-2}\theta^{-1}$	joule/K°
Gas Constant	$L^2T^{-2}\theta^{-1}$	joule/kgm- K°
Internal Energy	ML^2T^{-2}	joule
Specific Heat	$L^2T^{-2}\theta^{-1}$	joule/kgm-K°
Temperature	θ	K°
Thermal Conductivity	$MLT^{-3}\theta^{-1}$	watt/meter- K°
Thermal Diffusivity	L^2T^{-1}	meter^2/sec
Heat Transfer Coefficient	$MT^{-3}\theta^{-1}$	watt/meter^2- K°

Fig 8.2 (J) Thermodynamic units



EMERGENCY PROCEDURES

Fire	STOP GAS SUPPLY. Do not extinguish flame until gas or liquid supply has been shut off, to avoid possibility of explosive re-ignition. Extinguish with dry powder, halon or carbon dioxide. Cool tanks and surrounding areas with water spray.
Liquid in eye	DO NOT DELAY. Flood eye gently with clean fresh water. Force eye open if necessary. Continue washing for at least 15 minutes. Obtain medical advice or assistance as soon as possible.
Liquid on skin	DO NOT DELAY. Remove contaminated clothing. Handle patient gently. Do not rub affected area. Flood affected area with water. Continue washing for at least 15 minutes. Immerse frost-bitten area in warm water until thawed. Obtain medical advice or assistance as soon as possible.
Vapour inhaled	REMOVE VICTIM TO FRESH AIR. Remove contaminated clothing. If breathing has stopped or is weak or irregular, give mouth to mouth/nose resuscitation or oxygen, as necessary. Guard against self-injury if victim is confused or anaesthetised. Be alert to possibility of victim vomiting and then choking. Obtain medical advice or assistance as soon as possible.
Spillage	STOP THE FLOW. Avoid contact with liquid or vapour. Extinguish sources of ignition. Flood with large amounts of water to disperse the spill, and to prevent brittle fracture. Inform port authorities or coastguard of spill.

Health Data

TLV **600 ppm** Odour threshold **5000 ppm**
but may be stenched for easier detection

Effect of liquid	**ON EYES** Tissue damage due to frost-bite. **ON SKIN** Tissue damage due to frost-bite. **BY SKIN ABSORPTION** Nothing known. **BY INGESTION** Slight systemic effect.
Effect of vapour	**ON EYES** Cold vapour could possibly cause frost-bite. **ON SKIN** Cold vapour could possibly cause frost-bite. **WHEN INHALED** *Acute effect* Asphyxiation at high concentrations; headaches, dizziness and drowsiness. *Chronic effect* May act as a narcotic.

Personal protection

Splash-resistant suit, goggles or face shield, gloves and boots.

Fig 9.0 (a) ICS cargo data sheet for methane

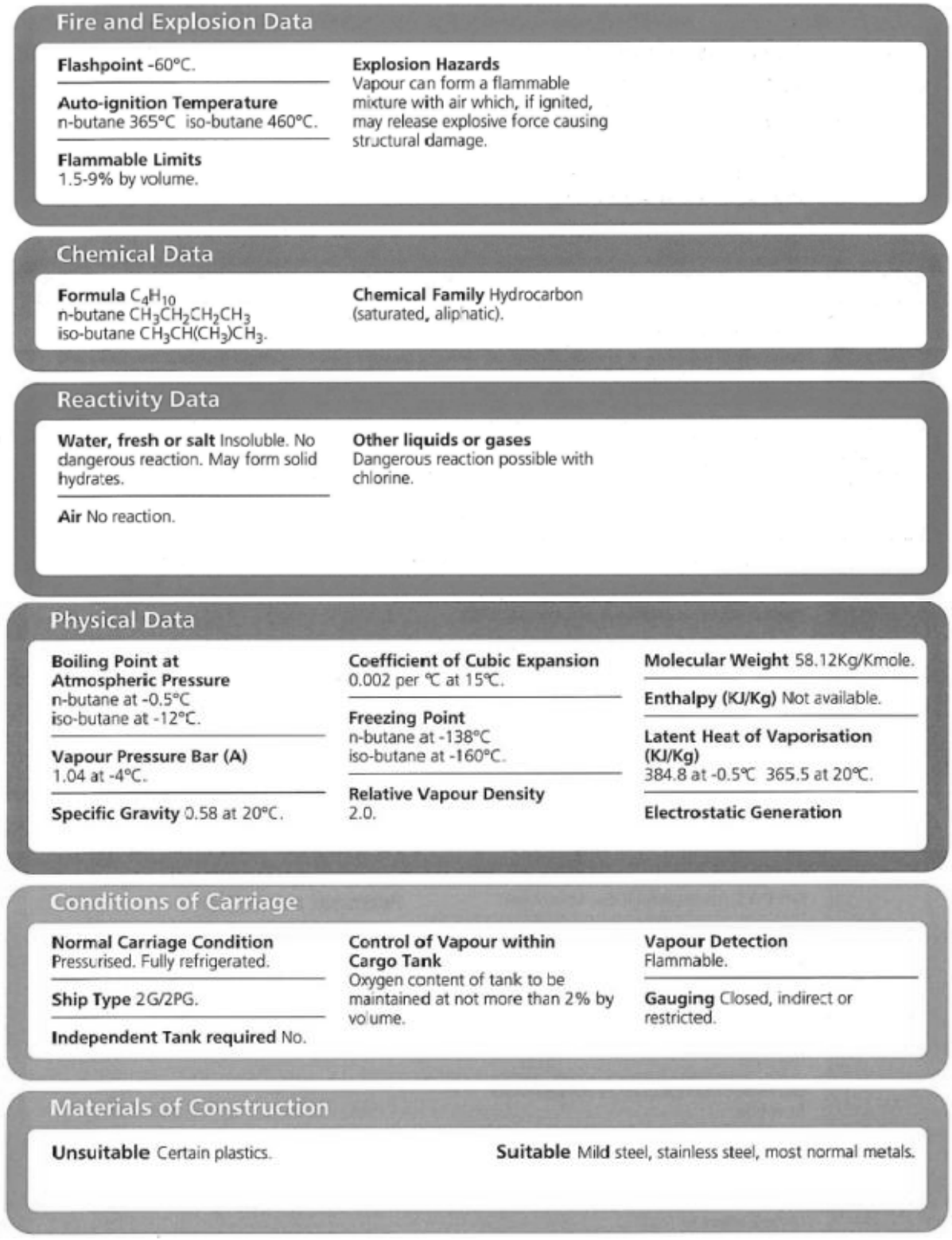


Fig 9.0 (b) ICS cargo data sheet for methane

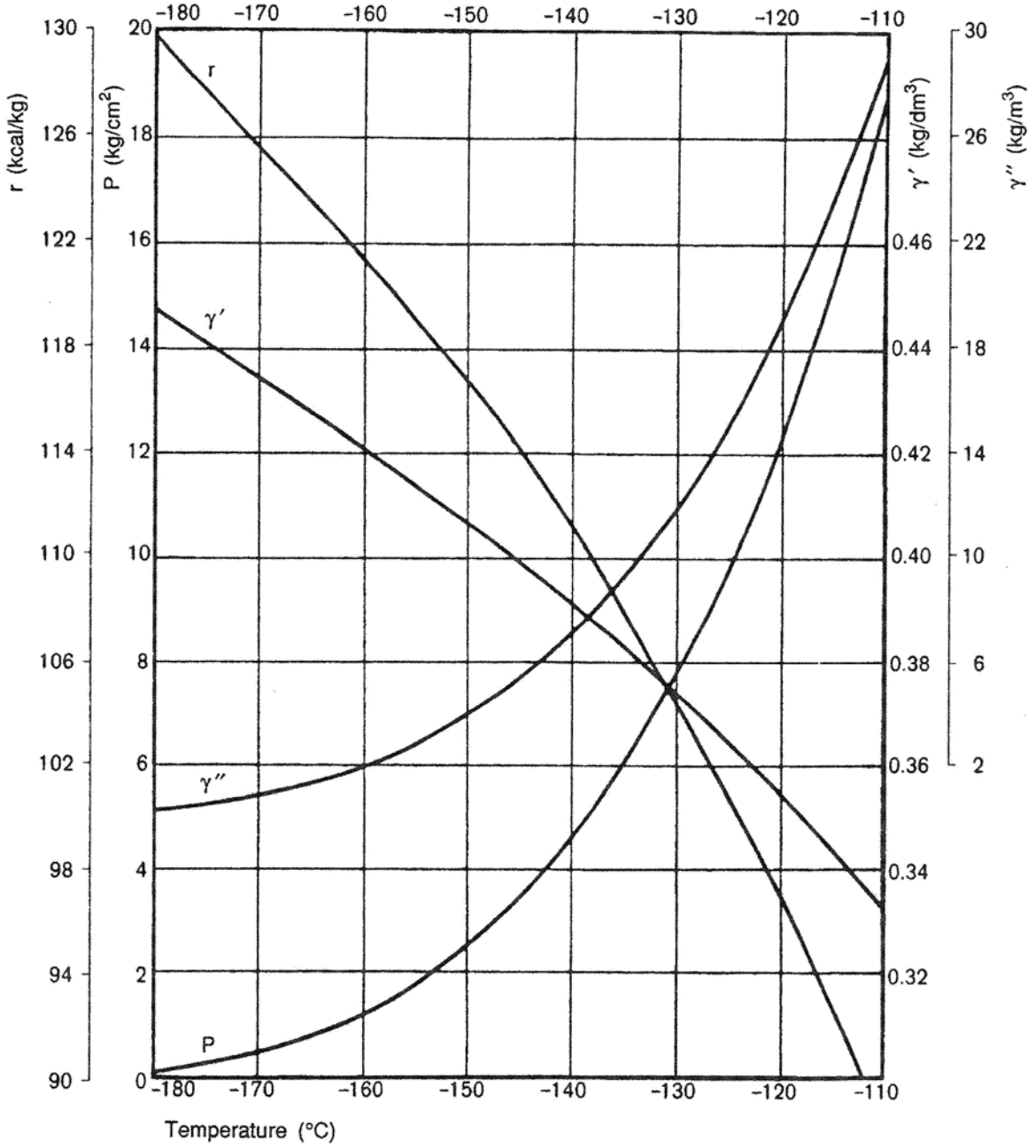


Fig 9.0 (c) ICS cargo data sheet for methane

	Flammable	Toxic	Polymerizable
Methane	✓		
Ethane	✓		
Propane	✓		
Butane	✓		
Ethylene	✓		
Propylene	✓		
Butylene	✓		
Butadiene/isoprene	✓		✓
Ammonia	✓	✓	
VCM	✓	✓	✓
Ethylene oxide	✓	✓	✓
Propylene oxide	✓	✓	
Chlorine (dry)		✓	

Fig 10 Hazards of liquefied gases

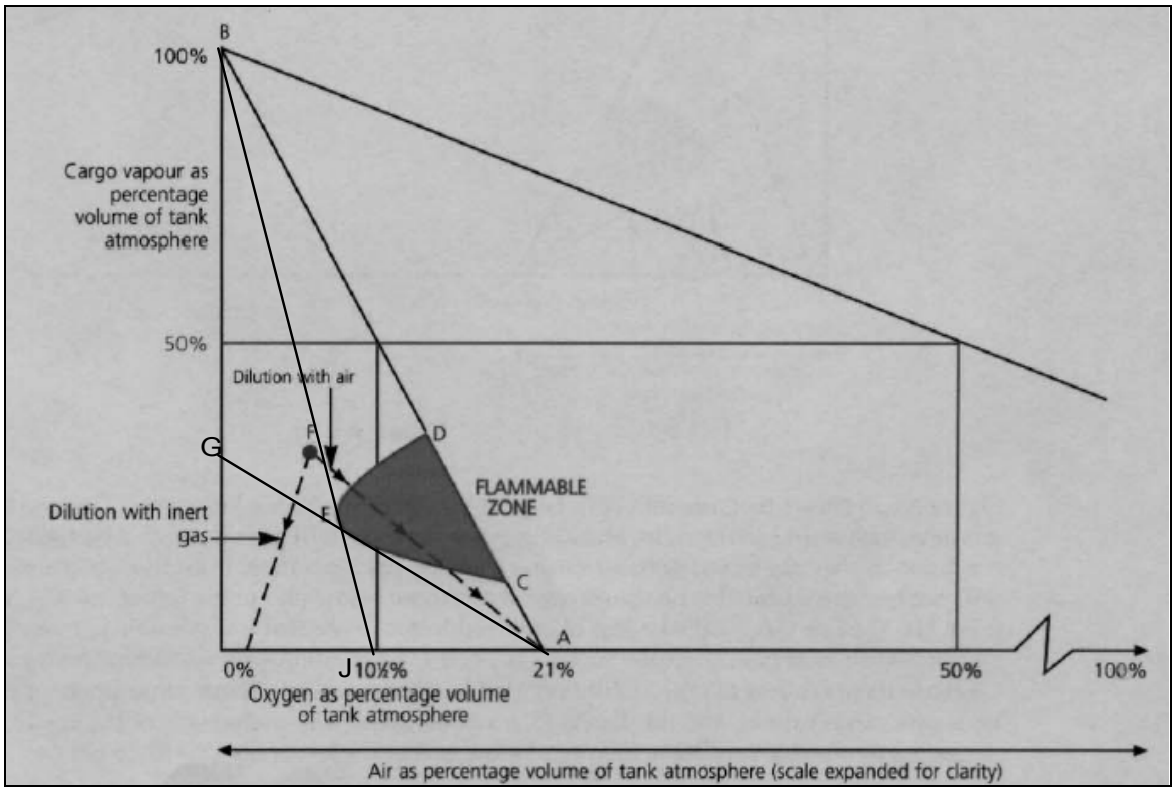


Fig 10.1 (a) Flammability diagram explaining dilution with IG

Liquefied gas	Flashpoint (°C)	Flammable range (% by volume in air)	Auto-ignition temperature (°C)
Methane	–175	5.3–14	595
Ethane	–125	3.1–12.5	510
Propane	–105	2.1–9.5	468
n-Butane	–60	1.8–8.5	365
i-Butane	–76	1.8–8.5	500
Ethylene	–150	3–32	453
Propylene	–180	2–11.1	458
α-Butylene (butene-1)	–80	1.6–9.3	440
β-Butylene (butene-2)	–72	1.8–8.8	465
Butadiene	–60	2–12.6	418
Isoprene	–50	1–9.7	220
VCM	–78	4–33	472
Ethylene oxide	–18	3–100	429
Propylene oxide	–37	2.8–37	465
Ammonia	–57	16–25	615
Chlorine		Non-flammable	

Fig 10.1 (b) Flammability data for some liquefied gases

Reactive with \ Gas	Methane	Ethane	Propane	Butane	Ethylene	Propylene	Butylene	Butadiene /isoprene	Ammonia	VCM	Ethylene oxide	Propylene oxide	Chlorine (dry)
Magnesium								✓			✓	✓	
Mercury								✓	✓		✓	✓	✓
Zinc									✓				✓
Copper								✓	✓		✓	✓	
Aluminium								✓	✓	✓	✓	✓	✓
Mild steel	✓				✓								
Stainless steel											✓		
Iron											✓	✓	
PTFE									✓				
PVC									✓				
Polythene	✓	✓	✓	✓			✓						
Ethanol													✓
Methanol													✓

Note: Reference should be made to the data sheets in Appendix 1 to the ICS *Tanker Safety Guide (Liquefied Gas)* for details of chemical reactivity.

✓ = reactive

Fig 10.4 (a) Reactivity diagram for some liquefied gases

	Methane	Ethane	Propane	Butane	Ethylene	Propylene	Butylene	Butadiene /isoprene	Ammonia	VCM	Ethylene oxide	Propylene oxide	Chlorine (dry)	Water vapour	Oxygen	Carbon dioxide	Air
Methane													✖				
Ethane													✖				
Propane													✖				
Butane													✖				
Ethylene													✖				
Propylene													✖				
Butylene													✖				
Butadiene/isoprene													✖	✖	✖		✖
Ammonia											✖	✖	✖	✖		✖	
Vinyl chloride monomer (VCM)													✖		✖		✖
Ethylene oxide									✖						✖		✖
Propylene oxide									✖								
Chlorine (dry)	✖	✖	✖	✖	✖	✖	✖	✖	✖	✖				✖			
Water vapour								✖	✖				✖				
Oxygen								✖		✖	✖						
Carbon dioxide									✖								
Air								✖		✖	✖						

Note: Reference should be made to the Data Sheets in Appendix 1 to the ICS *Tanker Safety Guide (Liquefied Gas)*

✖ = incompatible

Fig 10.4 (b) Compatibility diagrams for some liquefied gases

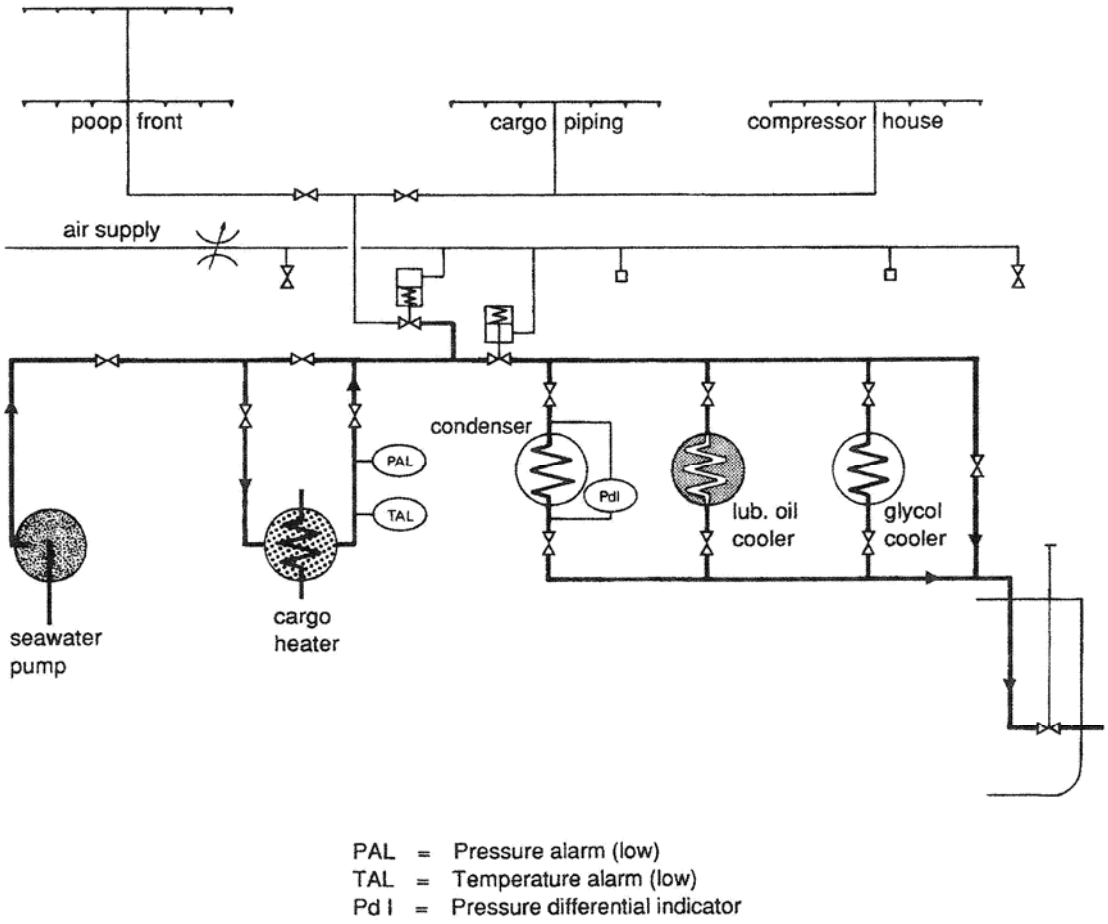


Fig 15.0 A fixed water-spray and cargo machinery cooling system

a *Product name*	b *UN number*	c *Ship type*	d *Independent tank type C required*	e *Control of vapour space within cargo tanks*	f *Vapour detection*	g *Gauging*	h *Special requirements*
Acetaldehyde	1089	2G/ 2PG	–	Inert	F + T	C	14.4.3, 14.4.4, 17.4.1, 17.6.1
Ammonia, anhydrous	1005	2G/ 2PG	–	–	T	C	14.4.2, 14.4.3, 14.4.4, 17.2.1, 17.13
Butadiene	1010	2G/ 2PG	–	–	F	R	17.2.2, 17.4.2, 17.4.3, 17.6, 17.8
Butane	1011	2G/ 2PG	–	–	F	R	
Butane-propane mixtures	1011/ 1978	2G/ 2PG	–	–	F	R	
Butylenes	1012	2G/ 2PG	–	–	F	R	
Chlorine	1017	1G	Yes	Dry	T	I	14.4, 17.3.2, 17.4.1, 17.5, 17.7, 17.9, 17.14
Diethyl ether*	1155	2G/ 2PG	–	Inert	F + T	C	14.4.2, 14.4.3, 17.2.6, 17.3.1, 17.6 1, 17.10, 17.11, 17.15
Dimethylamine	1032	2G/ 2PG	–	–	F + T	C	14.4.2, 14.4.3, 14.4.4, 17.2.1
Ethane	1961	2G	–	–	F	R	
Ethyl chloride	1037	2G/ 2PG	–	–	F + T	R	
Ethylene	1038	2G	–	–	F	R	
Ethylene oxide	1040	1G	Yes	Inert	F + T	C	14.4.2, 14.4.3, 14.4.4, 14.4.6, 17.2.2, 17.3.2, 17.4.1, 17.5, 17.6.1, 17.16
Ethylene oxide-propylene oxide mixtures with ethylene oxide content of not more than 30% by weight	2983	2G/ 2PG	–	Inert	F + T	C	14.4.3, 17.3.1, 17.4.1, 17.6.1, 17.10, 17.11, 17.20
Isoprene*	1218	2G/ 2PG	–	–	F	R	14.4.3, 17.8. 17.10, 17.12
Isopropylamine*	1221	2G/ 2PG	–	–	F + T	C	14.4.2, 14.4.3, 17.2.4, 17.10, 17.11 17.12, 17.17
Methane (LNG)	1972	2G	–	–	F	C	
Methyl acetylene-propadiene mixtures	1060	2G/ 2PG	–	–	F	R	17.18
Methyl bromide	1062	1G	Yes	–	F + T	C	14.4, 17.2.3, 17.3.2, 17.4.1, 17.5, 17.9
Methyl chloride	1063	2G/ 2PG	–	–	F + T	C	17.2.3
Monoethylamine*	1036	2G/ 2PG	–	–	F + T	C	14.4.2, 14.4.3, 14.4.4, 17.2.1, 17.3.1, 17.10, 17.11, 17.12, 17.17
Nitrogen	2040	3G	–	–	O	C	17.19
Propane	1978	2G/ 2PG	–	–	F	R	

* This cargo is covered also by the IBC Code.

Fig 19.0 (a) (IGC Code) – Summary of minimum requirements

a *Product name*	b *UN number*	c *Ship type*	d *Independent tank type C required*	e *Control of vapour space within cargo tanks*	f *Vapour detection*	g *Gauging*	h *Special requirements*
Propylene	1077	2G/ 2PG	–	–	F	R	
Propylene oxide*	1280	2G/ 2PG	–	Inert	F + T	C	14.4.3, 17.3.1, 17.4.1, 17.6.1, 17.10, 17.11, 17.20
Refrigerant gases (see notes)	–	3G	–	–	–	R	
Sulphur dioxide	1079	1G	Yes	Dry	T	C	14.4, 17.3.2, 17.4.1, 17.5, 17.7, 17.9
Vinyl chloride	1086	2G/ 2PG	–	–	F + T	C	14.4.2, 14.4.3, 17.2.2, 17.2.3, 17.3.1, 17.6, 17.21
Vinyl ethyl ether*	1302	2G/ 2PG	–	Inert	F + T	C	14.4.2, 14.4.3, 17.2.2, 17.3.1, 17.6.1, 17.8, 17.10, 17.11, 17.15
Vinylidene chloride*	1303	2G/ 2PG	–	Inert	F + T	R	14.4.2, 14.4.3, 17.2.5, 17.6.1, 17.8, 17.10, 17.11

* This cargo is covered also by the IBC Code.

Explanatory notes to the summary of minimum requirements

UN Numbers			The UN numbers as listed in the table of chapter 19 are intended for information only.
Vapour detection required (column f)	F	–	Flammable vapour detection
	T	–	Toxic vapour detection
	O	–	Oxygen analyser
	F + T	–	Flammable and toxic vapour detection
Gauging – types permitted (column g)	I	–	Indirect or closed, as described in 13.2.2.1 and .2
	C	–	Indirect, or closed, as described in 13.2.2.1, .2 and .3
	R	–	Indirect, closed or restricted, as described in 13.2.2.1, .2, .3 and .4
Refrigerant gases			Non-toxic and non-flammable gases such as:
			dichlorodifluoromethane (1028)
			dichloromonofluoromethane (1029)
			dichlorotetrafluoroethane (1958)
			monochlorodifluoromethane (1018)
			monochlorotetrafluoroethane (1021)
			monochlorotrifluoromethane (1022)

Unless otherwise specified, gas mixtures containing less than 5% total acetylenes may be transported with no further requirements than those provided for the major components.

Fig 19.0 (b) (IGC Code) – Summary of minimum requirements (contd.)

Product name	UN number	Ship type	Independent tank type C required	Control of vapour space within cargo tanks	Vapour detection	Gauging	Special requirements
No specific chapter	*No specific chapter*	Chapter 2 Ship survival capability and location of cargo tanks	*No specific chapter*	Chapter 9, Environmental control	Chapter 13, Instrumentation	Chapter 13, Instrumentation	Chapter 14, Personnel protection Chapter 17, Special requirements

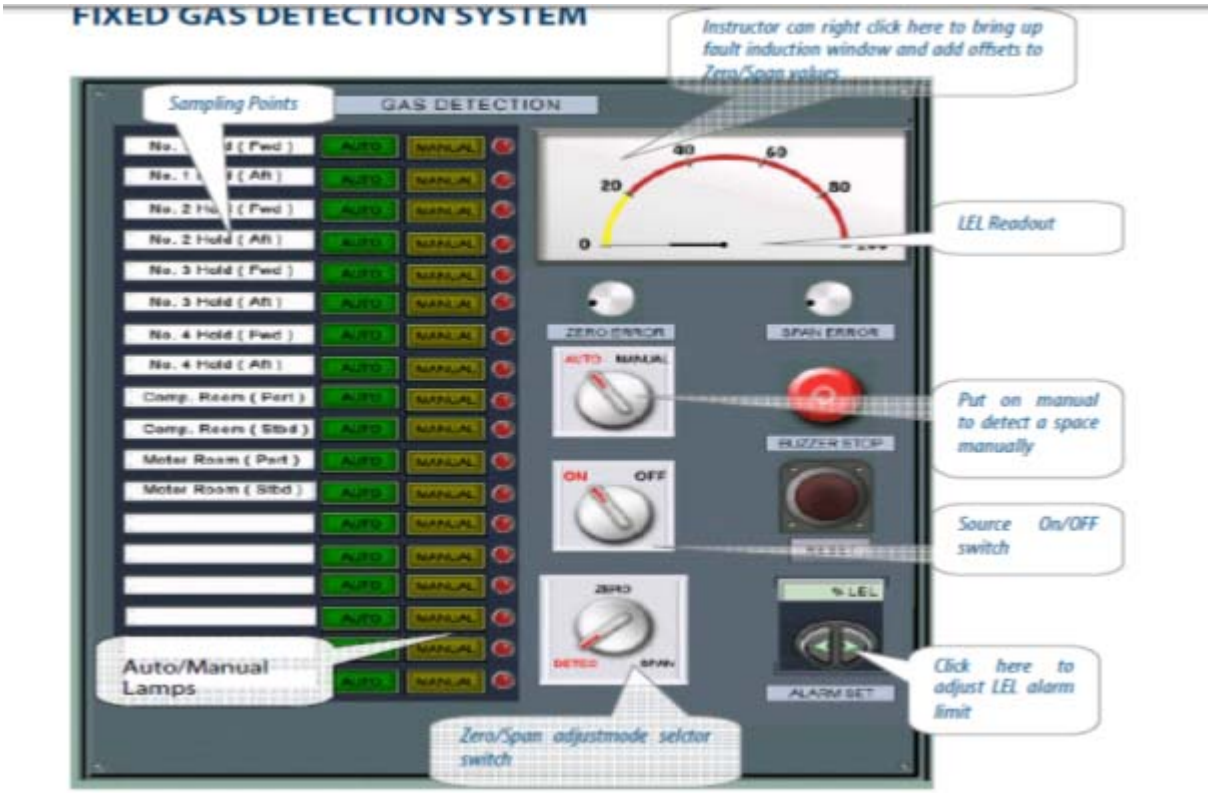
Fig 19.0 (c) Columns in chapter 19 of IGC code related to chapters in the code

APPENDIX 2

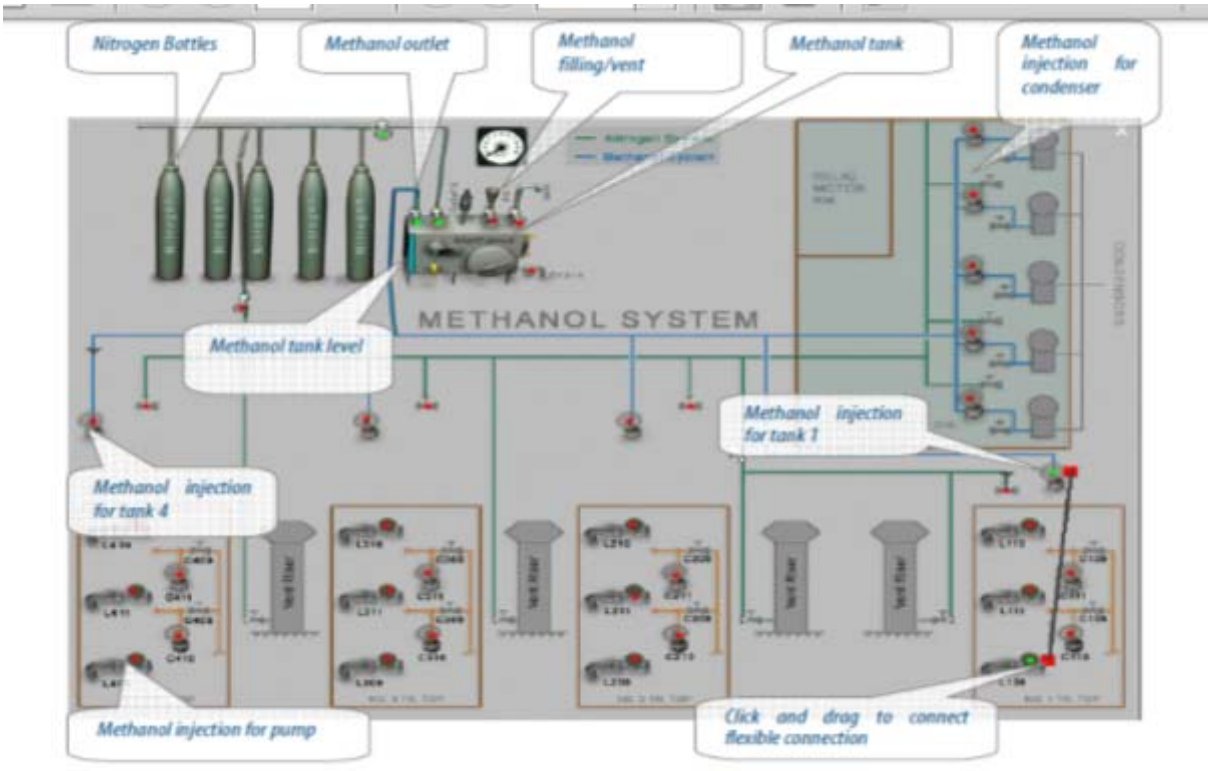
EXERCISES

(INCLUDING LPG and LNG SIMULATOR SCREEN SHOTS)

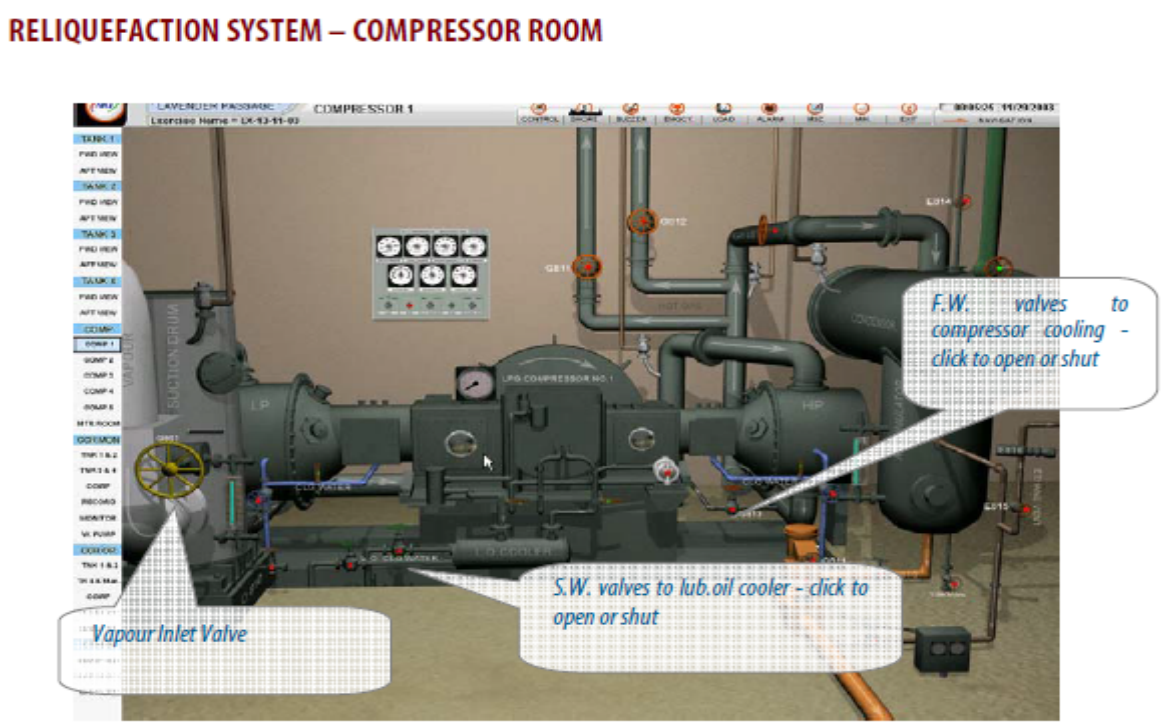
The exercises below are to be carried out on a simulator or table top. For tabletop exercises the candidates should be provided with PC loaded with a liquefied gas tanker's loadicator software and hard copies of same ship's capacity, filling limits, cargo pipeline layout, pumping, ballasting, ventilation, re-liquefaction plans and calibration tables of ballast and cargo tanks.



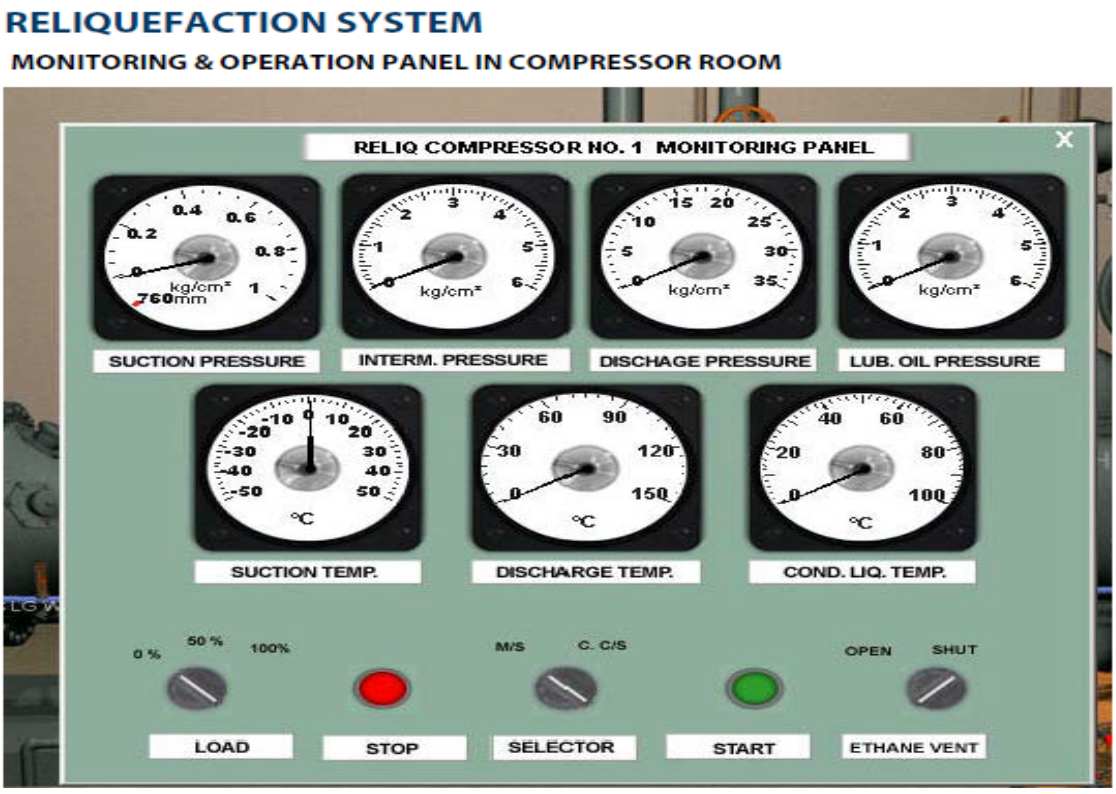
Simulator screen shot of a Gas Detection system



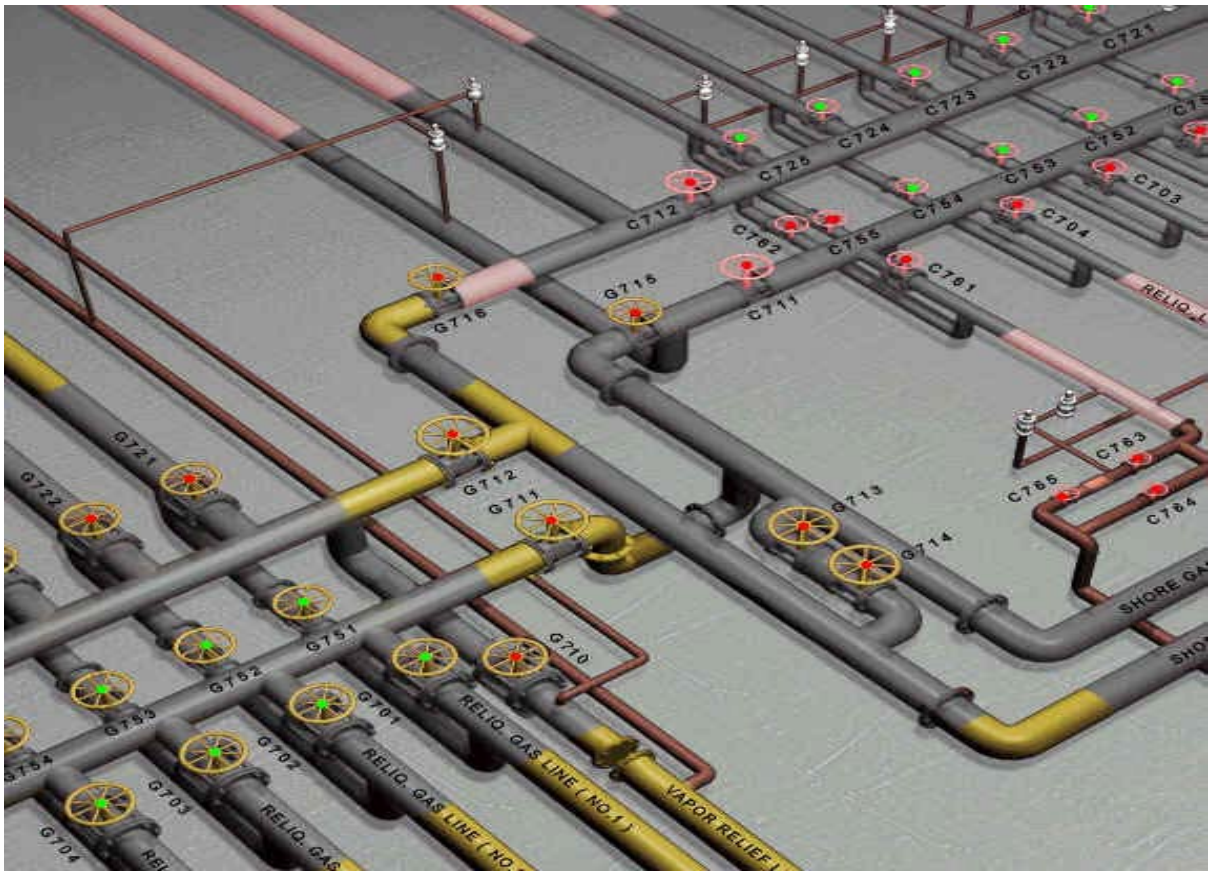
Simulator screen shot of a methanol injection system



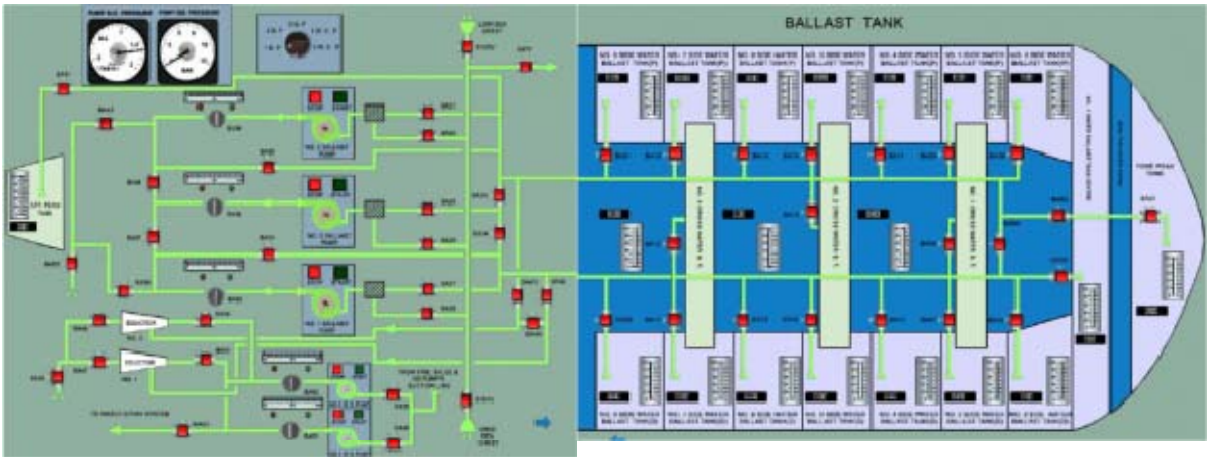
Simulator screen shot of a compressor room



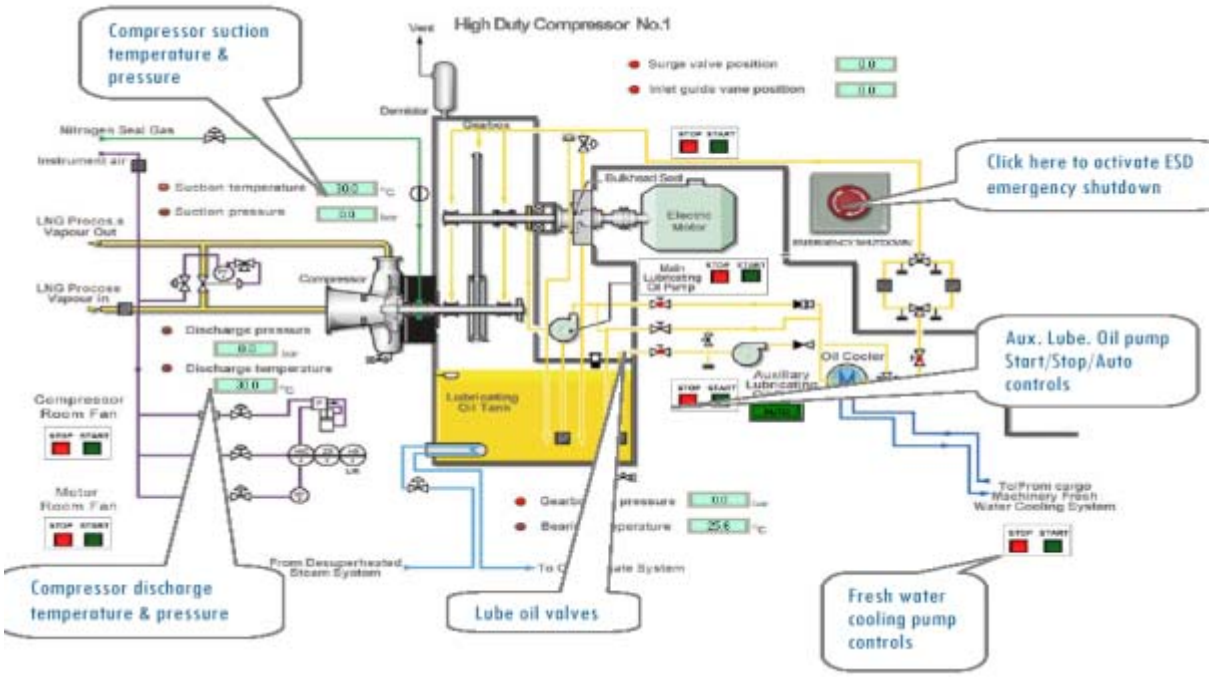
Simulator screen shot of Re-liquefaction monitoring panel



Screen shot of an LPG simulators Re-liquefaction and vapour headers

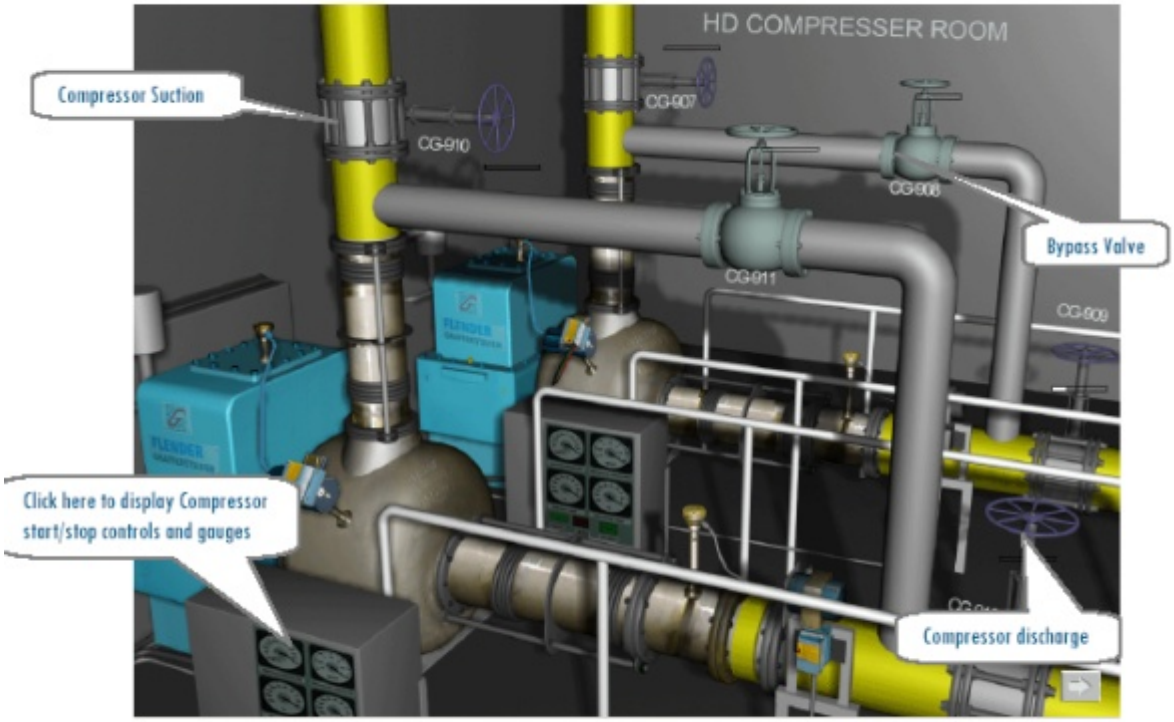


Screen shot of a simulators ballasting system

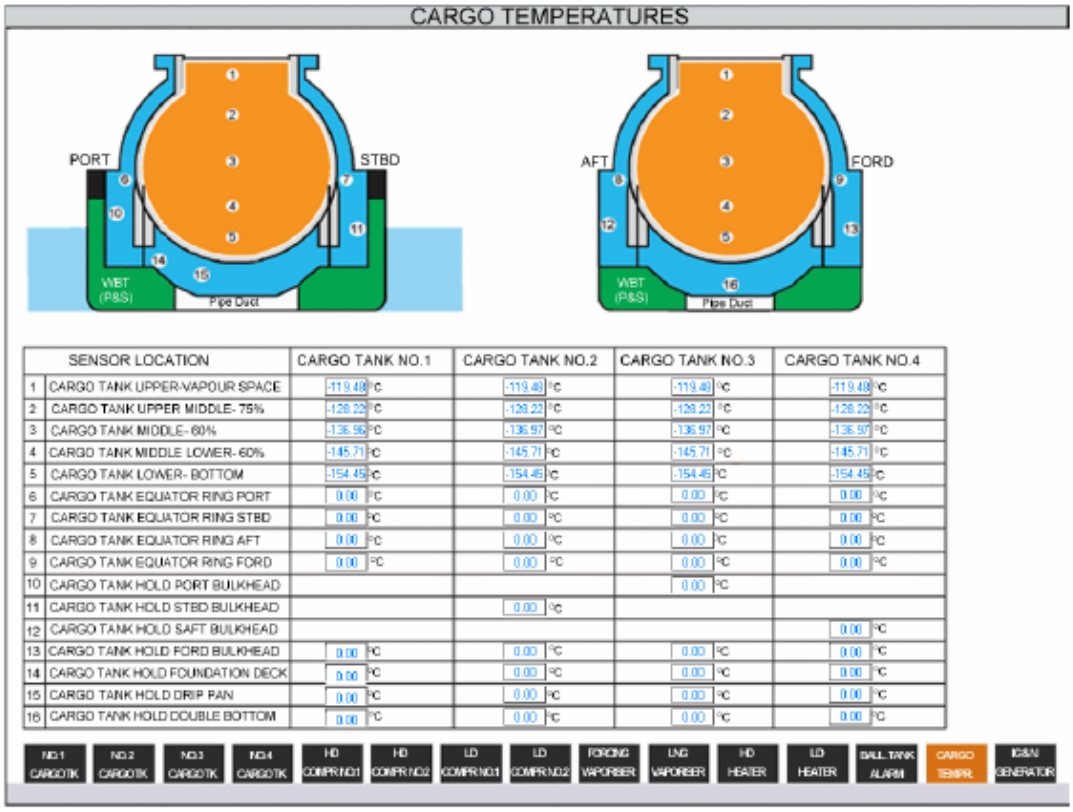


Screen shot of an LNG Tanker DCS HD Compressor panel

3.4 COMPRESSOR PANEL



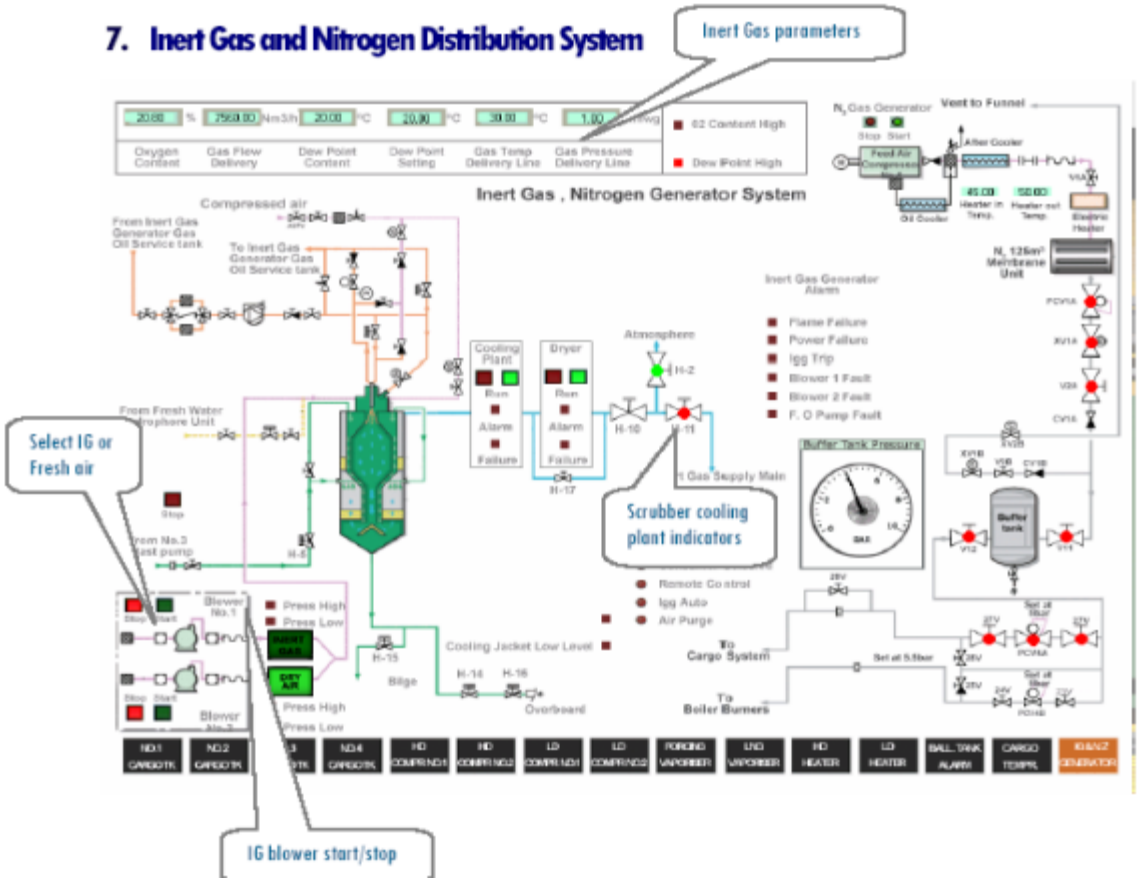
HD Compressor Room



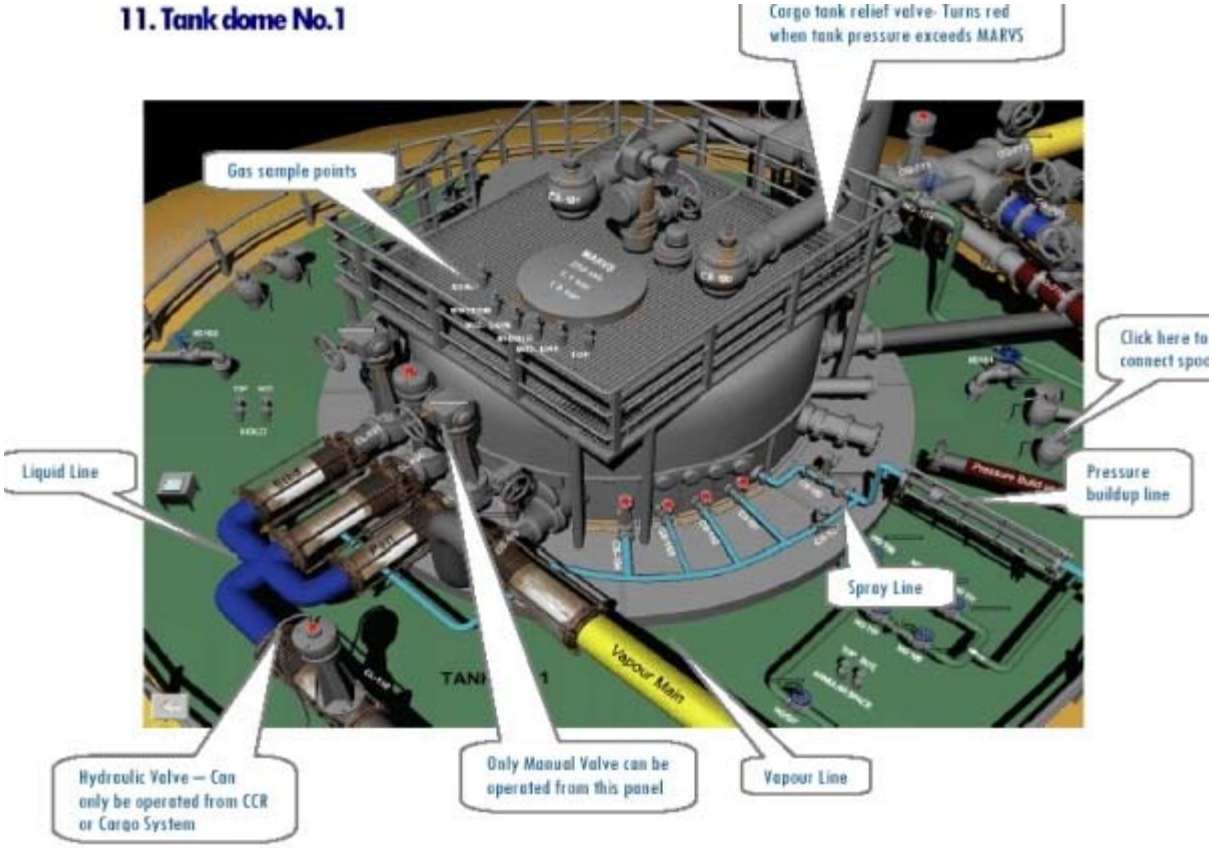
	SENSOR LOCATION	CARGO TANK NO.1	CARGO TANK NO.2	CARGO TANK NO.3	CARGO TANK NO.4
1	CARGO TANK UPPER-VAPOUR SPACE	-119.48 °C	-119.48 °C	-119.48 °C	-119.48 °C
2	CARGO TANK UPPER MIDDLE- 75%	-128.22 °C	-128.22 °C	-128.22 °C	-128.22 °C
3	CARGO TANK MIDDLE- 60%	-136.56 °C	-136.97 °C	-136.97 °C	-136.97 °C
4	CARGO TANK MIDDLE LOWER- 60%	-145.71 °C	-145.71 °C	-145.71 °C	-145.71 °C
5	CARGO TANK LOWER- BOTTOM	-154.45 °C	-154.45 °C	-154.45 °C	-154.45 °C
6	CARGO TANK EQUATOR RING PORT	0.00 °C	0.00 °C	0.00 °C	0.00 °C
7	CARGO TANK EQUATOR RING STBD	0.00 °C	0.00 °C	0.00 °C	0.00 °C
8	CARGO TANK EQUATOR RING AFT	0.00 °C	0.00 °C	0.00 °C	0.00 °C
9	CARGO TANK EQUATOR RING FORD	0.00 °C	0.00 °C	0.00 °C	0.00 °C
10	CARGO TANK HOLD PORT BULKHEAD			0.00 °C	
11	CARGO TANK HOLD STBD BULKHEAD		0.00 °C		
12	CARGO TANK HOLD SAFT BULKHEAD				0.00 °C
13	CARGO TANK HOLD FORD BULKHEAD	0.00 °C	0.00 °C	0.00 °C	0.00 °C
14	CARGO TANK HOLD FOUNDATION DECK	0.00 °C	0.00 °C	0.00 °C	0.00 °C
15	CARGO TANK HOLD DRIP PAN	0.00 °C	0.00 °C	0.00 °C	0.00 °C
16	CARGO TANK HOLD DOUBLE BOTTOM	0.00 °C	0.00 °C	0.00 °C	0.00 °C

NO.1 CARGOTK | NO.2 CARGOTK | NO.3 CARGOTK | NO.4 CARGOTK | HD COMPR NO.1 | HD COMPR NO.2 | LD COMPR NO.1 | LD COMPR NO.2 | FORCING VAPORISER | LNG VAPORISER | HD HEATER | LD HEATER | BALLTANK ALARM | CARGO TEMPR. | IG&N GENERATOR

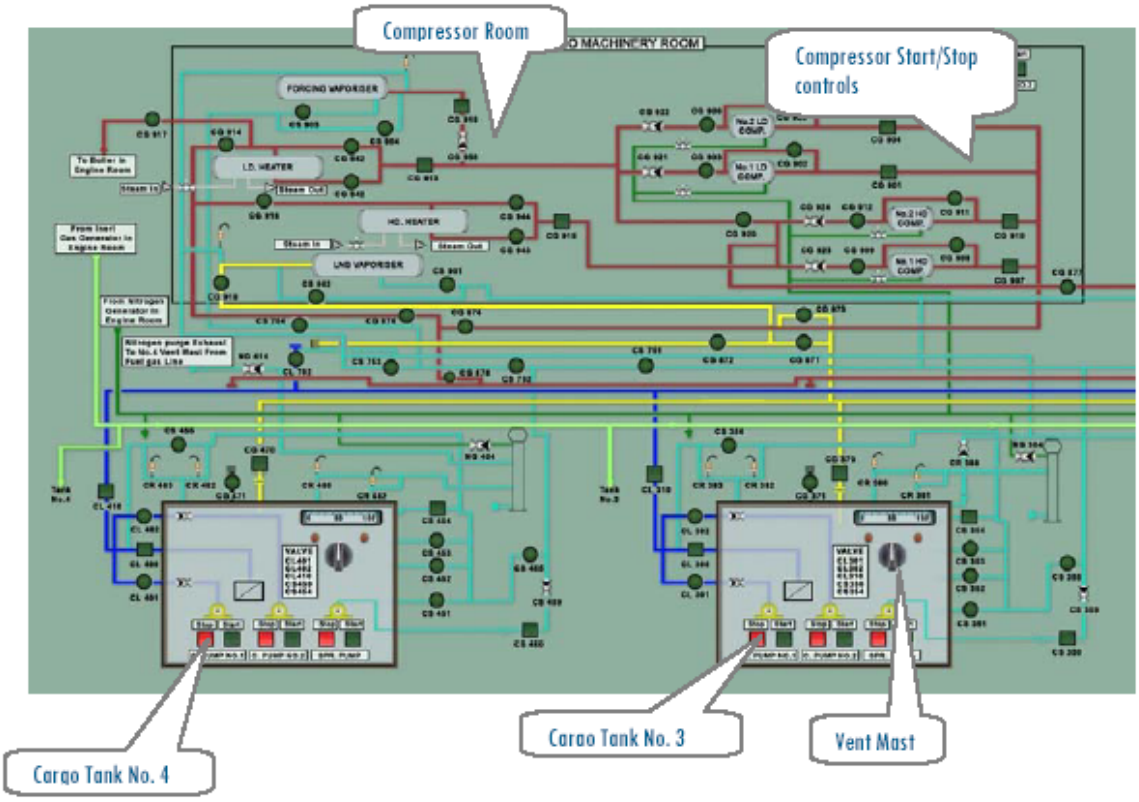
Screenshot of a DCS temperature monitoring panel



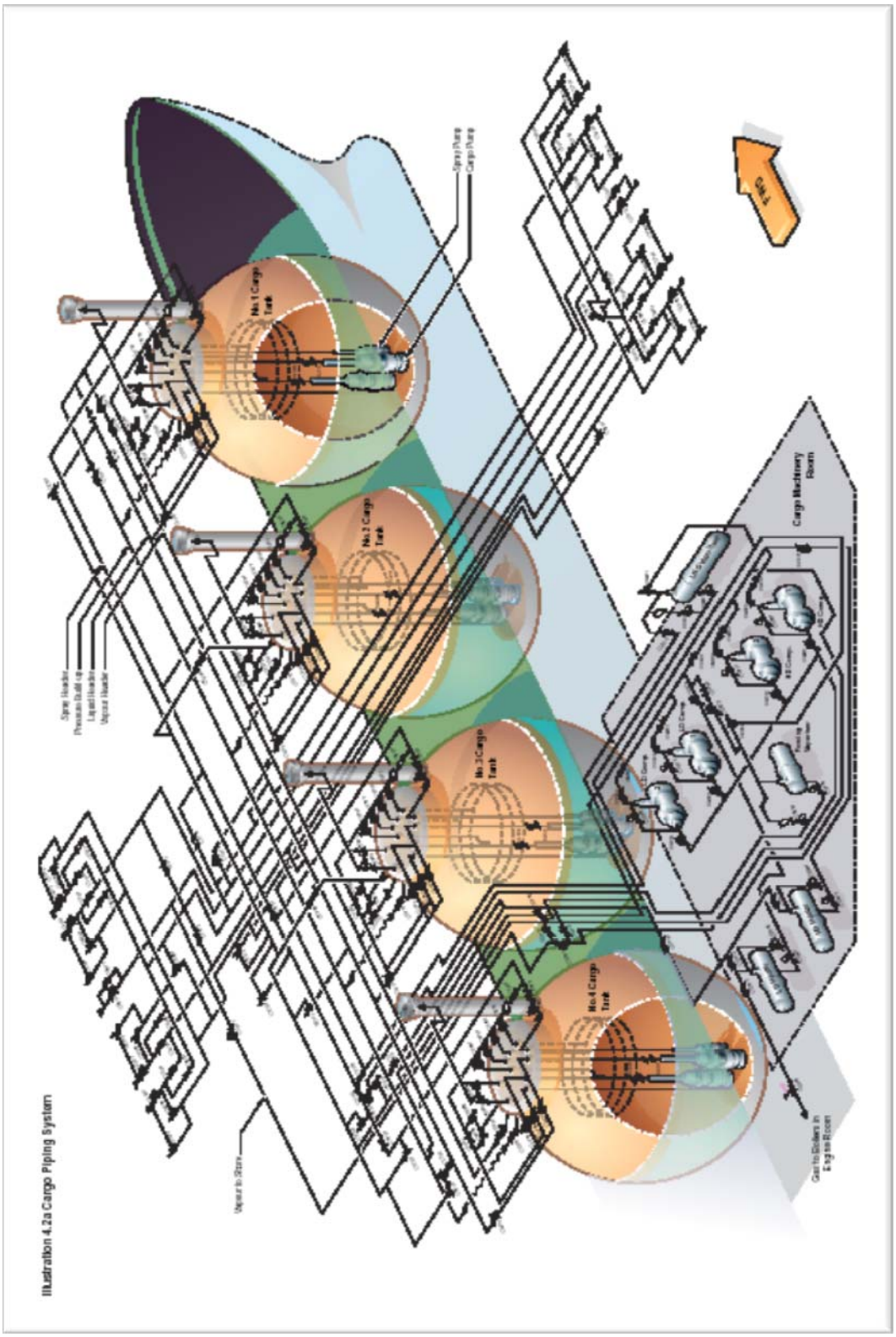
Screen shot of an LNG Tanker DCS IG and Nitrogen system



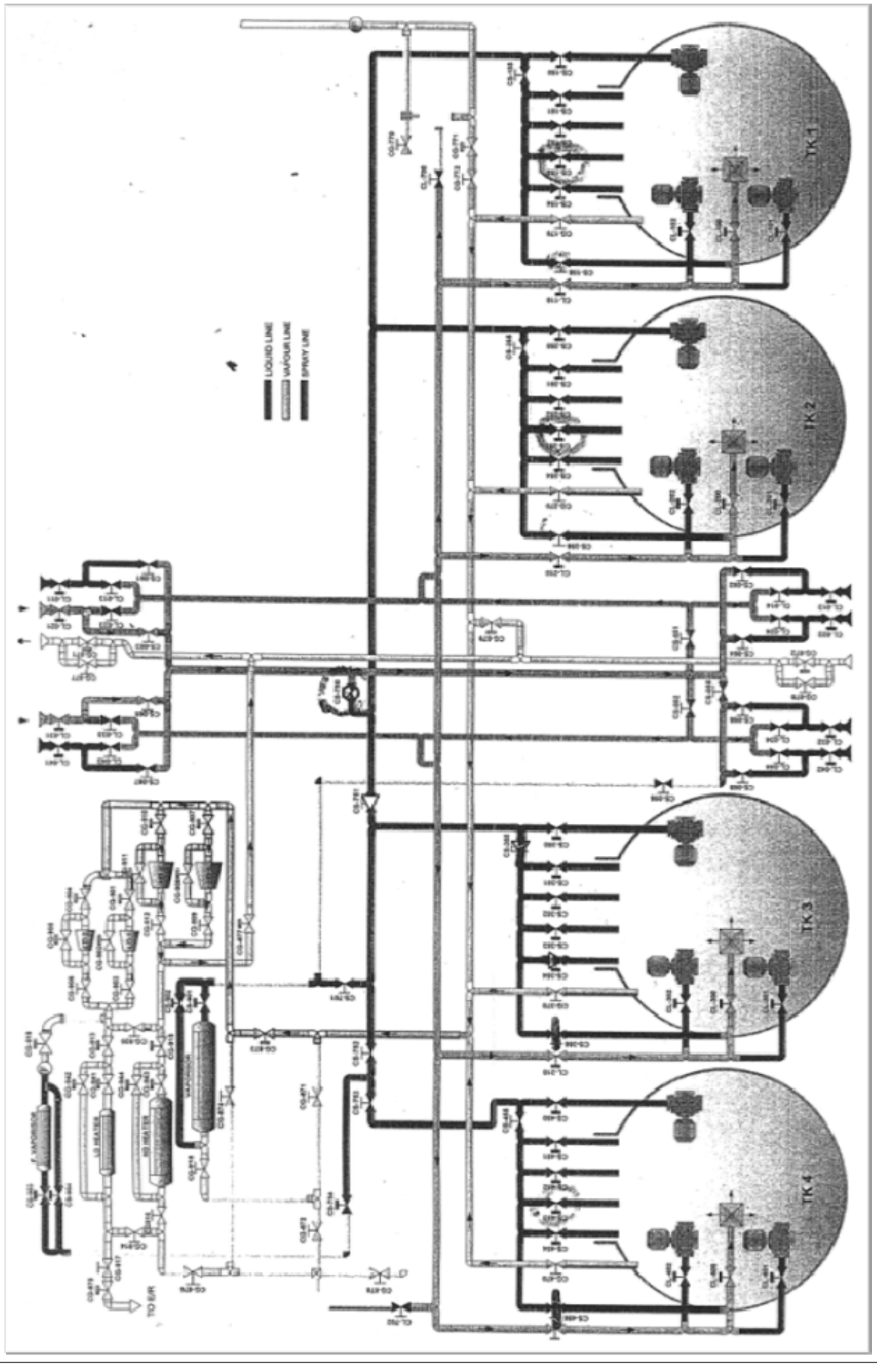
Screen shot of an LNG Tanker Tank Dome



Screen shots of an LNG tanker simulator Cargo tanks and compressor room


No.1 Cargo Tank
No.2 Cargo Tank
No.3 Cargo Tank
No.4 Cargo Tank
Cargo Machinery Room
Vapour Dome
Illustration 4.2a Cargo Piping System

EXERCISE NO. 1: LOADING



Preparing the Stowage Plan

Objectives:

Set up a loading plan from available cargo data sheet.

Give the trainees an overall view of cargo calculations involved in liquefied gas tanker and operations resulting from a certain loading plan.

Proper operation of off-line loadmaster.

Use of cargo and ballast tank calibration table.

Prerequisites:

Simulator familiarization completed.

Theoretical knowledge of hydrostatic data, stability, stress, draft and displacement calculations.

Simulator Condition:

Cargo tanks empty;

Ballast tanks full;

Off-line loadmaster operational.

Training materials:

Mimic diagrams of cargo barograph;

tank survey;

loadmaster shear force;

loadmaster bending moment;

loadmaster deflection;

loadmaster stability;

bunkers/water barographs;

General arrangement and capacity plan of simulated vessel;

Cargo calculation flowchart and list.

Briefing:

Trainees to appreciate the cargo calculations to be done.

Off-line loadmaster is to be used for required planning and calculations.

Cargo details to be loaded are explained.

Initial condition of the vessel to be explained.

Cargo planning should take all elements of draft, trim, stress, and stability into account.

Student action:

From details of cargo a loading sequence to be set up regarding space and weight available.

Trim, stress and stability to be calculated taking into account the effect of free surface.

Total amount of cargo to be loaded to be calculated up to certain tank filling levels.

Instructor action:

By means of tank capacity plans, calculate the total amount of cargo to be loaded.

Check that trainees set up a proper cargo plan.

By means of hydrostatic data trim, list, heel and stability are to be calculated.

The exercise is mainly to check the preparation of the loading plan and is not meant to actually perform the loading of the cargo.

Debriefing:

Make sure trainees have overall understanding of all elements involved by means of questions and answers.

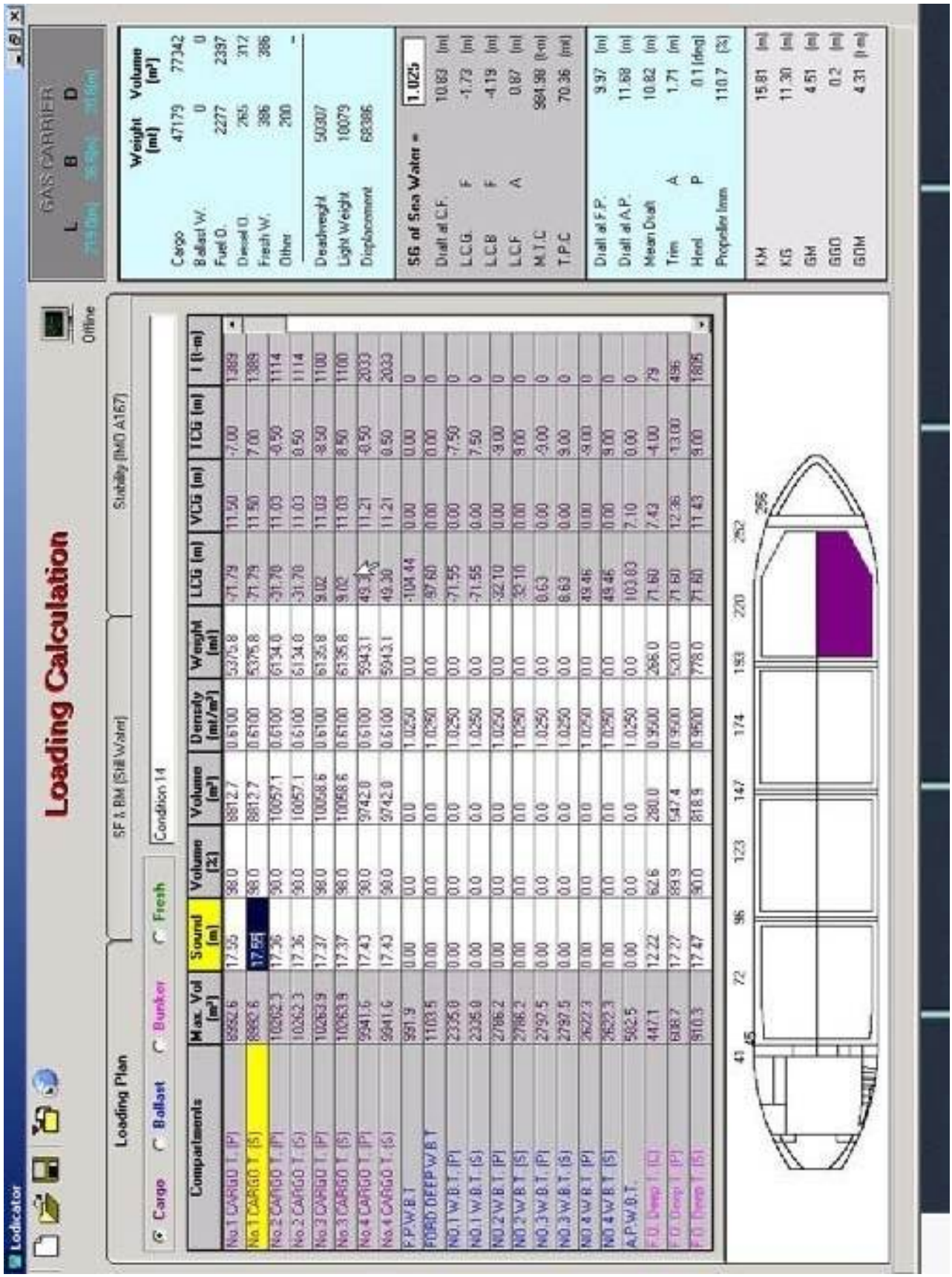
Discuss difficulties in planning and calculations.

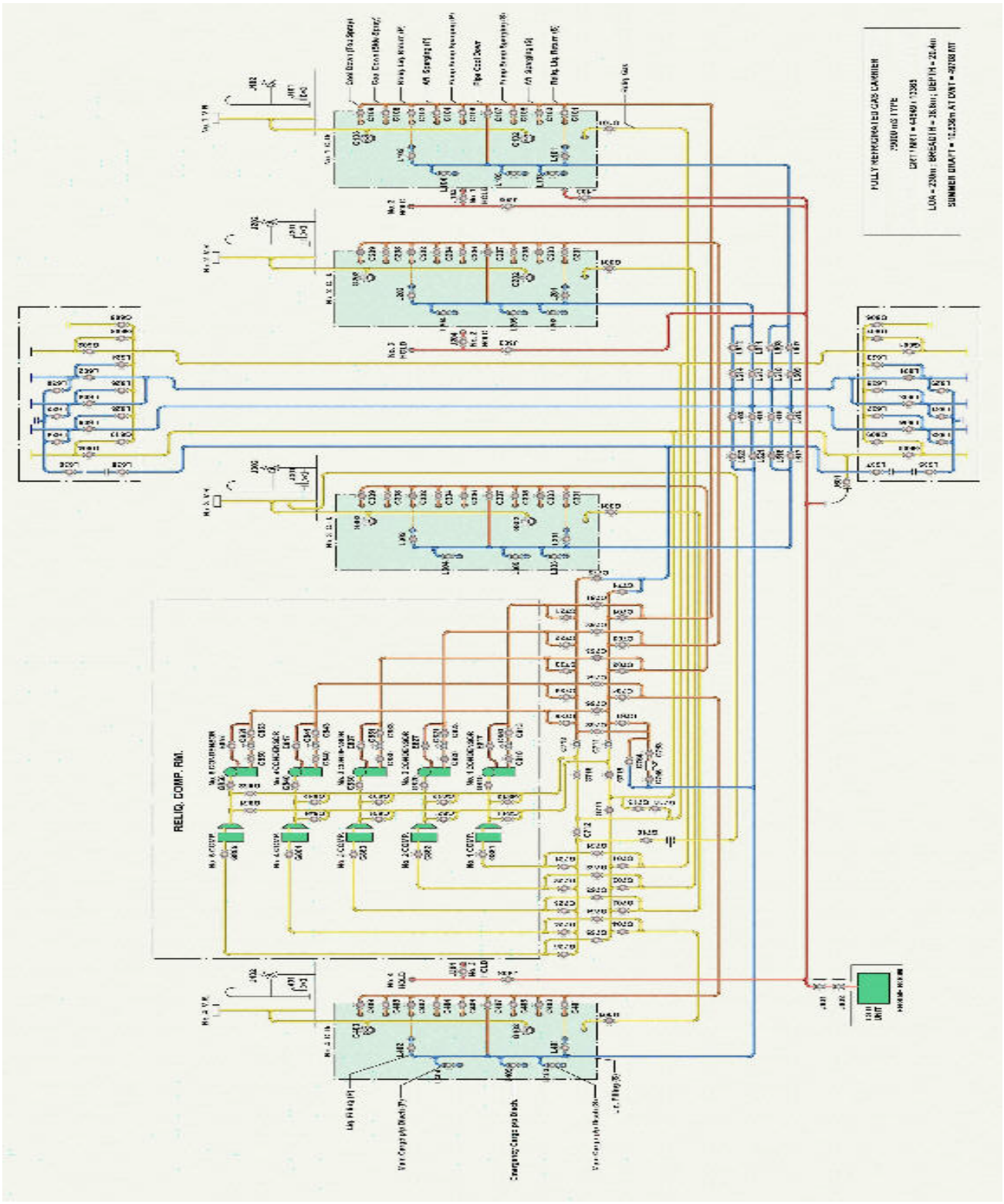
Compare loading sequences, total cargo to be loaded and trim, draft and stress.

Evaluation:

By means of mimic diagrams in loadmaster, check values reached for trim, draft, stress, stability and total cargo to be loaded.

Table top Exercise: Using the loadicator software and the plans provided candidates to make a stowage plan for loading to full capacity with single grade fully refrigerated LPG cargo. Cargo details to be provided.


Loadicator
Loading Calculation
Offline
GAS CARRIER
L
B
D
Loading Plan
Cargo
Ballast
Bunker
Fresh
SF & BM (Still Water)
Condition 14
Suitably (IMO A167)
Compartments
Max. Vol (m³)
Sound (m)
Volume (%)
Volume (m³)
Density (mt/m³)
Weight (mt)
LCG (m)
VCG (m)
TCG (m)
I (t-m)
No.1 CARGO T. (P)
No.1 CARGO T. (S)
No.2 CARGO T. (P)
No.2 CARGO T. (S)
No.3 CARGO T. (P)
No.3 CARGO T. (S)
No.4 CARGO T. (P)
No.4 CARGO T. (S)
F.P.W.B.T.
FORE DEEP W.B.T.
NO.1 W.B.T. (P)
NO.1 W.B.T. (S)
NO.2 W.B.T. (P)
NO.2 W.B.T. (S)
NO.3 W.B.T. (P)
NO.3 W.B.T. (S)
NO.4 W.B.T. (P)
NO.4 W.B.T. (S)
A.P.W.B.T.
F.O. Deep T. (C)
F.O. Deep T. (P)
F.O. Deep T. (S)
Weight (mt)
Volume (m³)
Cargo
Ballast W.
Fuel O.
Diesel O.
Fresh W.
Other
Deadweight
Light Weight
Displacement
SG of Sea Water =
1.025
Draft at C.F.
L.C.G.
L.C.B
L.C.F
M.T.C
T.P.C
Draft at F.P.
Draft at A.P.
Mean Draft
Trim
Heel
Propeller Imm
KM
KG
GM
GGO
GOM


RELIQ. COMP. RM.

EXERCISE NO. 2: LOADING FULL CARGO WITHOUT VAPOUR RETURN

Objectives:

By loading full cargo into the vessel, appreciating efficient cargo planning, deballasting sequence, stability and stress criteria and maximum allowable draft and trim.
By loading liquefied gas, the tanks will be cooled and consequently loaded in preparation for full loading of cargo.
The trainees will learn to use and practice working with gas data sheet.
The trainees will realize that the tanks have to be cooled, vapour line connected to shore before loading commences.
Understanding the principles, operations and safety precautions, involved with full loading of cargo and deballasting.

Prerequisites:

Simulator familiarization completed.

The trainees shall have adequate knowledge of:

- the procedures for loading cargo and operation of compressors;
- ballast lines and compressors;
- loading zones, stability, shear forces and bending moments;
- the Gas Carrier Code;

Emergency shutdown procedures

Table top Exercise: Using the loadicator software and the plans provided candidates to make a loading plan for a ship with single grade fully refrigerated LPG cargo to capacity without vapour return. Cargo details and terminal's maximum loading rate etc. to be provided. Candidates to make bar chart based on 4 hourly progress of loading/deballasting showing expected stability and stability conditions.

EXERCISE NO. 3: UNLOADING

Objectives:

By means of this exercise the relationship between the various sub-systems is to be appreciated and the overall understanding of simultaneously unloading, stripping and ballasting to be demonstrated.
When unloading cargo from the vessel, appreciate the efficient cargo planning, stripping procedure, ballasting sequence, stability and stress criteria and maximum allowable draft and trim.
The trainees to learn to use and practice working with gas data sheet.
The trainees to realize the quantity of the vapour return during unloading needs to be controlled on the shore to maintain the tank pressure within an allowable range.
The trainees to realize that the pipelines have to be cooled with one pump running and liquid in recirculation before unloading commences.
Understanding the principles, operations and safety precautions, involved with unloading of cargo and ballasting.

Prerequisites:

Simulator familiarization completed.
The trainees need to be familiar with:

- procedures for unloading cargo
- stripping procedure
- ballast lines and procedure for deballasting
- Gas Carrier Code

Emergency shutdown procedures.

Training materials:

Mimic diagram of cargo tanks, ballast tanks, liquid, vapour and spray lines;
Pumping system;
OHP sheets of the mimic diagrams of cargo deck lines,
Ballast lines, cargo tanks and ballast tanks;
General plan "LPG/ Ethylene Carrier" and other particulars;
Displacement scales.

Simulator Condition:

Cargo tanks loaded with liquefied petroleum gas;
Ballast tanks empty;
Assume the ship is at the unloading berth;
Shore connection for liquid line to unload LPG cargo from all tanks;
Shore connection for vapour line to receive LPG vapour to maintain tank pressure;
One pump running; circulating cargo by keeping liquid fill valve open;

Vessel pipelines are cooled-down.

Briefing:

The trainees should be convinced of the complexity of the exercise, which should be built up step by step;
Unloading should be started slowly by closing liquid fill valve;
Stress, trim and heel to be monitored;
Unloading and ballasting according to pre-prepared plan;
Trainees should be informed that all pipelines are cooled and ready for unloading;
Ballasting to commence more or less simultaneously with unloading;
Ballasting to be completed by the time stripping of cargo tank starts;
A certain amount of liquid cargo (heel) shall be left for cooling the cargo tanks during ballast voyage;
If necessary, residual liquid should be removed by running deep well pump;
Shear forces and bending moments to be kept within limits. Preliminary check can be done by off-line Load Master;
While unloading, vapour shall be returned from shore or generated by feeding LPG liquid to the ship's vaporiser to maintain the tank pressure within an allowable range.
While unloading at a faster rate, care must be taken because the tank pressure may drop.

Student action:

The trainees will start by preparing an unloading and ballasting plan, keeping stress, trim and heel within the acceptable limits.
Bulk unloading and, ballasting will take place simultaneously.
Stripping operation will continue until all tanks left with certain amount of liquid for cooling;
Ballasting according to IMO requirements;
Trainees can perform preliminary stress check with the Load Master;
Trim and stability to be calculated taking into account the effect of free surface
Connection of shore manifold to ship's line to be made and unloading to commence by running pumps, simultaneously ballasting in keeping with the stress limitations.
During unloading: liquid levels, tank temperature, tank pressure as well as shear forces and bending moments to be monitored;
The trainees will have to prepare the gas pipeline route from the cargo tanks to liquid manifold and vapour from shore to cargo tank;
The low pressure, which is thus created can be compensated returning cargo vapour from shore base or by feeding LPG liquid to the ship's vaporiser;
The unloading is continuous until liquid level is reached to minimum. At this point stripping commences;
Continuous monitoring of flow of liquefied gas and number of pumps in use;

The temperatures and pressure of cargo tank and hold (void) spaces are measured periodically.

Instructor action:

The instructor should ascertain that the choice of unloading order taking into consideration stresses, trim, stability and heel;
Check preliminary stress calculations;
Check tanks unloaded/ballasted in planned sequence in order to keep stresses within limits;
Check tank levels during unloading and stripping;
If the exercise of unloading all tanks takes too long in real time, a start can be made and then continued in fast time until the next stage where stripping of tanks is undertaken.
The instructor will check if the correct route is set up for the unloading. Tank pressure should then be monitored periodically;
The instructor will check that the tanks are unloaded and left with certain amount of liquid (heel) for cooling during ballast voyage;
The instructor will check that the ballast tanks are ballasted properly;
Depending on the facilities provided for the vessel, the reduction of the pressure in the tank during the bulk unloading should be handled carefully in order to prevent activation of vacuum relieving system.

Debriefing:

Trainees should understand possibilities and limitations of a full cargo being unloaded and ballast being loaded.
Check which order tanks have been handled and in which order ballast has been loaded;
Check how much ballast has been loaded in order to create suitable draft, trim and heel;
Trainees should understand that maximum unloading rate depend on number of pumps in use and distance of shore tank etc.;
Stress and stability to be monitored;
Final draft, heel, tank soundings, tank temperatures, tank pressures, quantity of liquid left in the tank will have to be checked;
At the debriefing, attention should be paid to the sequence of the procedures and actions taken from initial unloading to stripping of cargo tanks;
The purpose and results of the various actions taken in the whole operation should be discussed with the trainees;
The session should be conducted in a positive manner to create the right atmosphere for learning from individual actions and those of others.

Evaluation:

By means of observation of final condition assessing if trainees have, by efficient stripping and ballasting in accordance to the plan, maintained pressures within the permitted ranges and that all values of cargo level, temperature, pressure, volume, trim, list, shear force and bending moment are within the determined limits;
Time needed to complete operations will be a measure of efficient conduct of operations;
In alarm log, check that cargo tank low-pressure alarm has not been activated.

Table top Exercise: Using the loadicator software and the plans provided candidates to make unloading plan for ship carrying full load of single grade fully refrigerated LPG cargo to capacity without vapour return. Cargo details and terminal's maximum receiving rate etc. to be provided. Candidates to make bar chart based on 4 hourly progress of unloading/ballasting showing expected stability and stress conditions including draft**.**

EXERCISE 4: LOADING AN LNG TANKER

Item/Matter	Reference/ Requirement	Remarks (if any)
Objective	To provide experience and practical knowledge (via using simulator) the: • requirements and methods for Loading Cargo Tanks (including correct ship/shore line up of cargo (LNG liquid) supply and exhaust valves, pipelines, Deballasting, Cofferdam Heating, etc.) and to • monitor the operation and relevant parameters from take-off values to end.	Loading Operation shall also be linked to Insulation Spaces, Ballast (Stability), Shore Interface, etc. • The use of the HD compressor to heat the vapour returned to shore to be kept ready and highlighted. • Secondary float level gauge to be keep on standby. • On steam propulsion - Maintain slow propeller rotation throughout. • Electrical turning gear may be used. • Explain Auto blasting • Failure may cause propeller to move faster and vessel may move. Link to recent known incident/accident relevant to the operation (if available/known)
Prerequisite	The underpinning knowledge about an LNG Tanker's typical cargo tanks Loading line setup and shore interface, etc.	**Refer Part D fig. 5.1.5 loading with vapour return line using HD Compressors.**
Training Materials	Pre-Exercise lecture on, an LNG Tanker's : • Loading Operation • Critical relationship between Loading and Deballasting Operation • Loading Operation and Shore interface • Loading and Deballasting – Good Practices • Loading and Deballasting – Normal problems • Appropriate checklist(s)	Any other available materials, circulars, etc. can also be highlighted and/or used.

Item/Matter	Reference/ Requirement	Remarks (if any)
Simulator Condition	Loading Exercise mode.	
Briefing	Completed Cooling down and ready for subsequent operation • Appropriate checklist(s) • The operation is considered to be completed when each tank are at 98.5% full by volume.	• LNG liquid is supplied from the terminal to the liquid manifold where it passes to the liquid header and then fed to cargo tanks. • 2 HD compressors in parallel can reduce tank pressure to a recommended 12mbarg. • Commence de-ballasting as per cargo / ballast plan. • Moorings / weather/ ship shore interphase to be followed • 98% is recommended however 98.5% is industry practice if backed by Flag state to allow for fuel consultation high level is at 99%.
Student Action	After the explanations (discussion) the trainees are to: • Note the initial cargo tanks status/condition • To set up the lines • To start up the relevant equipment • To carry out the Loading Operations • To note the changes in the cargo tank atmosphere/level, etc. as the operation progress • Fill up Task List accordingly Note – Final cargo tanks level	The Task List to be used as the operation guide. • Remember to stop HD compressor • Commence preparing LD compressor for gas burning. • At topping up level keep line drain quantity balance and ask terminal to slop loading.
Instructor Action	Set the exercise and closely monitor the procedure followed by the student. Insert faults	Insert faults (various types) only when normal operation well established and under control by a particular trainee

Item/Matter	Reference/ Requirement	Remarks (if any)
Debriefing	After each exercise has been carried out, time allocated for "open discussion" of the exercise and "fault management" (fault introduced and corrective action(s) taken during the exercise). Any deviation from safe / desired methods/procedures used should be focused upon and discussed. Highlight area for improvement	Time to be spent depends upon the trainees' performance.
Evaluation	Continuously evaluate each trainee's performance and response as the exercise progress. Collect completed task checklist from all trainees.	
Table Top Exercise	The exercise may be performed by the use of line diagrams provided, the student will trace out the loading condition from the manifold to the cargo tanks, the HD compressors will be lined up for use when vapour has to be returned, The instructor should monitor the progress of the students and change the tank conditions for the students to take ongoing actions.	If Simulators are unavailable

EXERCISE 5: BALLAST PASSAGE OF AN LNG TANKER

Item/Matter	Reference/ Requirement	Remarks (if any)
Operation	**Ballast Passage**	
Duration	**1.0 hr**	
Objective	To provide experience and practical knowledge (via using simulator) the: • requirements and methods for Ballast Passage Cargo and Cargo Tanks Temperature Management principles	Ballast passage to be linked to Gas Burning, Adjusting Ballast, Control Venting, etc. Link to recent known incident/accident relevant to the operation (if available/known)
Prerequisite	The underpinning knowledge about an LNG Tanker's typical Ballast Passage Cargo Management principles.	Refer to fig. No. 8E for lining up requirements in the ballast passage using the forcing vapouriser to produce the requisite amount of fuel for the ME Propulsion. • Preloading checks • Maximum use of LNG boil off to conserve bunkers • Maintain tank pressure for membrane tanks to more than 70 mbarg at all times to prevent membrane fatigue.
Training Materials	Pre-Exercise lecture on, an LNG Tanker's: • Ballast Passage Cargo Management principles. • Ballast passage - Gas Burning • Ballast passage - Adjusting Ballast • Ballast passage Tank cool-down • Appropriate checklist(s)	Any other available materials, circulars, etc. can also be highlighted and/or used.
Simulator Condition	Ballast Passage mode.	

Item/Matter	Reference/ Requirement	Remarks (if any)
Briefing	Completed Loaded passage and ready for subsequent operation • Ballast Passage Appropriate checklist(s) • The operation is considered to be completed when trainee have carried out minimum three (3) activities: 1. Commence sending Gas (BOG) to Engine Room 2. Adjust Ballast (Trim) 3. Commence Controlled Venting	Focus shall be on safety precautions adopted during Ballast Passage Operations
Student Action	After the explanations (discussion) the trainees are to: • Note the initial cargo tanks status/condition • To set up the lines • To start up the relevant equipment To carry out the following Operations: 1. Commence sending Gas (BOG) to Engine Room 2. Adjust Ballast (Trim) 3. Commence Tank cool-down • To note the changes in relevant parameters etc. as the operation progress • Fill up Task List accordingly.	The Task List to be used as the operation guide.
Instructor Action	Set the exercise and closely monitor the procedure followed by the student. Insert faults.	Insert faults (various types) only when normal operation well established and under control by a particular trainee.
Debriefing	After each exercise has been carried out, time allocated for "open discussion" of the exercise and "fault management" (fault introduced and corrective action(s) taken during the exercise).	Time to be spent depends upon the trainees performance.

Item/Matter	Reference/ Requirement	Remarks (if any)
	Any deviation from safe / desired methods/procedures used should be focused upon and discussed. Highlight area for improvement.	
Evaluation	Continuously evaluate each trainee's performance and response as the exercise progress. Collect completed task checklist from all trainees.	

Table Top Exercise: The student traces the lineup of the BOG from the Cargo tanks to the LDC and to the Machinery space for burning, if pressures fall, then the spray pumps are to be started and the liquid is drawn into the Vapourizer through the spray line and returned to the tanks through the pressure build up line.

CASE STUDY – 1

Overfilling of Cargo Tanks

During the loading of a semi—pressurized LPG vessel of approximately 5000 cbm, a spill occurred due to a cargo tank being over-filled under the following circumstances:

The vessel was lying head up at a river jetty with a 3 knot ebb current, wind blowing from bow to stern.

The loading at the time of the incident was in the charge of the Chief Officer and the rate during the previous hour had indicated that the tank would be in the fully loaded condition in some 2.5 hours.

This particular vessel was fitted with a gas blower which produces a flash cooling effect in the cargo tank by transferring large volumes of gas to the shore.

It was stated by the Chief Officer that he heard a sound from the blower, and while going to investigate it, there was an eruption of liquid from the vent stack.

The action by the Officer was to stop the blower, close the filling valve to the tank in question and advise verbally the jetty operator.

The emergency shutdown button was not pushed because of the automatic closing of the vapour line with a corresponding surge in tank pressure.

During this period, liquid gas erupted from the vent stack with large drops and collected on the vessel's main deck. The fire fighting hoses, at the ready during loading or unloading operations, was used to flush the liquid gas overboard and cause more rapid evaporation.

It was noted that although the liquid had ceased to come out of the vent stack the tank safety valve did not re-seat and a dense cloud of vapour was being exhausted.

A full scale emergency procedure was initiated and a sea water hose was directed on the safety valve in order to impart heat and hopefully free the seized spindle.

In view of the density of the gas around the vessel, a decision was made by the Master to close down the auxiliary generating plant, i.e. shut down the entire ships machinery.

The crew, with the exception of senior officers, was sent ashore. After a period of between one to two hours the valves re-seated.

The jetty supervisor, after consultation with the Harbour Authority, had closed the river to all traffic, and the adjacent traffic lanes were also closed.

Following exhaustive checks using portable explosion meters the Auxiliary plant was restarted and the vessel completed the loading operation by using the gas blower to effect rapid reduction in tank pressures by transferring vapours to shore.

Points for Discussion

a) What would be your action in the event of you having been the Chief Officer?

b) Do you agree with the Master's action of shutting down the complete ships machinery? Give reasons.

c) The ship was in a foreign port, communications were difficult due to language problems. What would you recommend should be done to overcome the problem?

d) Ship personnel have no control over shore pumps or loading Rate, i.e. rapid 'increase in rate would nullify the Chief Officer's estimate as to the completion of cargo. Should we use an ESD or an umbilical cord system?

e) Make general comments on the incident covering the role of jetty personnel and relationship between ship and shore.

CASE STUDY – 2

Tank Overfill and Mast Fire

A ship was loading propane in calm conditions at a sheltered jetty. The final tank was topping-off but, due to lack of attention from the OOW, it overfilled. This caused the relief valve to lift and liquid to be vented from the mast riser.

The liquid that escaped from the mast riser was rapidly vaporizing and when it flowed over the ship's side it was ignited by the engine of a boat moored alongside.

The escaping LPG vapour was drawn into the air inlet of a petrol or diesel engine and resulted in the engine over-speeding. In this instance, the engine increased speed before finally disintegrating. The vapour was ignited and flashed back to the mast riser.

The mast riser was fitted with a flame screen that prevented the flames returning to the tanks. Until the relief valve sat, fire continued to rage at the top of the mast riser as it was being fed with vapour from the cargo tanks.

Points for Discussion

Discuss your actions if you were the responsible officer on deck.

Part E: Evaluation

The effectiveness of any evaluation depends to a great extent on the precision of the description of what is to be evaluated. The detailed teaching syllabus is thus designed, to assist the Instructors, with descriptive verbs, mostly taken from the widely used Bloom's taxonomy.

Evaluation/Assessment is a way of finding out if learning has taken place. It enables the assessor (Instructor), to ascertain if the learner has gained the required skills and knowledge needed at a given point towards a course or qualification.

The purpose of evaluation/assessment is to:

To assist student learning.
To identify students' strengths and weaknesses.
To assess the effectiveness of a particular instructional strategy.
To assess and improve the effectiveness of curriculum programs.
To assess and improve teaching effectiveness.

The different types of evaluation/assessment can be classified as:

Initial / Diagnostic assessment

This should take place before the trainee commences a course/qualification to ensure they are on the right path. Diagnostic assessment is an evaluation of a trainee's skills, knowledge, strength and areas for development. This can be carried out during an individual or group setting by the use of relevant tests.

Formative assessment

Is an integral part of the teaching/learning process and is hence is a "Continuous" assessment. It provides information on trainee's progress and may also be used to encourage and motivate them.

Purpose of formative assessment

To provide feedback to students.
To motivate students.
To diagnose students' strengths and weaknesses.
To help students to develop self-awareness.

Summative assessment

It is designed to measure trainee's achievement against defined objectives and targets. It may take the form of an exam or an assignment and takes place at the end of a course.

Purpose of summative assessment
To pass or fail a trainee
To grade a trainee
Evaluation for Quality assurance

Evaluation can also be required for quality assurance purposes

Purpose of assessment with respect to quality assurance
To provide feedback to Instructors on trainee's learning.
To evaluate a module's strengths and weaknesses.
To improve teaching.

Assessment Planning

Assessment planning should be specific, measurable, achievable, realistic and time-bound (SMART).

Some methods of assessment that could be used depending upon the course / qualification are as follows and should all be adapted to suit individual needs.
Observation (In Oral examination, Simulation exercises, Practical demonstration);
Questions (written or oral);
Tests;
Assignments, activities, projects, tasks and/or case studies
Simulations (also refer to section A-I/12 of the STCW code 2010);
CBT;

Validity

The evaluation methods must be based on clearly defined objectives, and it must truly represent what is meant to be assessed, for example only the relevant criteria and the syllabus or course guide. There must be a reasonable balance between the subject topics involved and also in the testing of trainees' KNOWLEDGE, UNDERSTANDING AND PROFICIENCY of the concepts.

Reliability

Assessment should also be reliable (if the assessment was done again with a similar group/learner, would you receive similar results). We may have to deliver the same subject to different group of learners at different times. If other assessors are also assessing the same course / qualification as us, we need to ensure we are all making the same decisions.

To be reliable an evaluation procedure should produce reasonably consistent results no matter which set of papers or version of the test is used.

If the Instructors are going to assess their own trainees, they need to know what they are to assess and then decide how to do this. The what will come from the standards/learning outcomes of the course/qualification they are delivering. The how may already be decided for them if it is an assignments, tests or examinations.

The instructors need to consider the best way to assess the skills, knowledge and attitudes of our learners, whether this will be formative and/or summative and how the assessment will be valid and reliable.

All work assessed should be valid, authentic, current, sufficient and reliable; this is often known as VACSR – "valid assessments create standard results".
Valid – the work is relevant to the standards/criteria being assessed:
Authentic – the work has been produced solely by the learner;
Current – the work is still relevant at the time of assessment;
Sufficient – the work covers all the standards/criteria:
Reliable – the work is consistent across all learners, over time and at the required level.

It is important to note that no single methods can satisfactorily measure knowledge and skill over the entire spectrum of matters to be tested for the assessment of competence.

Care should therefore be taken to select the method most appropriate to the particular aspect of competence to be tested, bearing in mind the need to frame questions which relate as realistically as possible to the requirements of the officer's job at sea.

STCW Code as amended

The training and assessment of seafarers, as required under the Convention, are administered, supervised and monitored in accordance with the provisions of section A-I/6 of the STCW Code as amended.

Column 3 - Methods for demonstrating competence and Column 4 - Criteria for evaluating competence in Table A-V/1-2-2 (Specification of minimum standard of competence in basic training for Liquefied gas tanker cargo operations) of STCW Code as amended, sets out the methods and criteria for evaluation.

Instructors should refer to this table when designing the assessment.

Instructors should also refer to the guidance as given in Part B-V/1-2 of STCW code, as given below;

Evaluation of competence

The arrangements for evaluating competence should be designed to take account of different methods of assessment which can provide different types of evidence about candidates' competence, e.g.:
direct observation of work activities (including seagoing service);
skills/proficiency/competency tests;
projects and assignments;
evidence from previous experience; and
written, oral and computer-based questioning techniques.

18. One or more of the first four methods listed should almost invariably be used to provide evidence of ability, in addition to appropriate questioning techniques to provide evidence of supporting knowledge and understanding.

Assessment is also covered in detail in another IMO Model Course, however to assist and aid the Instructors, some extracts from the Model course is used to explain in depth.

Multiple choice questions

Marking or scoring is easier if multiple-choice test items are used, but in some cases difficulties may arise in creating plausible distracters.

Detailed sampling allows immediate identification of errors of principle and those of a clerical nature. It must be emphasized that this holds true, in general, only if the test item is based on a single step in the overall calculation. Multiple-choice items involving more than one step may, in some cases, have to be resorted to in order to allow the creation of a sufficient number of plausible distracters, but care must be exercised to ensure that distracters are not plausible for more than one reason if the nature of the error made (and hence the distracter chosen) is to affect the scoring of the test item.

Compiling tests

Whilst each examining authority establishes its own rules, the length of time which can be devoted to assessing the competence of candidates for certificates of competency is limited by practical, economic and sociological restraints. Therefore a prime objective of those responsible for the organization and administration of the examination system is to find the most efficient, effective and economical method of assessing the competency of candidates. An examination system should effectively test the breadth of a candidate's knowledge of the subject areas pertinent to the tasks he is expected to undertake. It is not possible to examine candidates fully in all areas, so in effect the examination samples a candidate's knowledge by covering as wide a scope as is possible within the time constraints and testing his depth of knowledge in selected areas.

The examination as a whole should assess each candidates comprehension of principles, concepts and methodology; his ability to apply principles, concepts and methodology; his ability to organize facts, ideas and arguments and his abilities and skills in carrying out those tasks he will be called upon to perform in the duties he is to be certificated to undertake.

All evaluation and testing techniques have their advantages and disadvantages. An examining authority should carefully analyse precisely what it should be testing and can test. A careful selection of test and evaluation methods should then be made to ensure that the best of the variety of techniques available today is used. Each test shall be that best suited to the learning outcome or ability to be tested.

Quality of test items

No matter which type of test is used, it is essential that all questions or test items used should be as brief as possible, since the time taken to read the questions themselves lengthens the examination. Questions must also be clear and complete. To ensure this, it is necessary that they be reviewed by a person other than the originator. No

extraneous information should be incorporated into questions; such inclusions can waste the time of the knowledgeable candidates and tend to be regarded as 'trick questions'. In all cases, the questions should be checked to ensure that they measure an objective which is essential to, the job concerned.

TEST PAPER – 1

TOTAL MARKS : 100
PASSING MARKS : 50%
DURATION : 30 Min (All questions carry 4 marks each)

Test Paper

Q1: What happens when the "Emergency Shut Down –System" is activated?

a. **All ESD valves close**
b. **All Cargo compressors stop**
c. **All Cargo pumps stop**
d. **All of the above**

Q2: Which extinguishing agent is the main one that is used on liquefied gas tankers?

e. **Dry Chemical Powder**
f. **Water**
g. **CO2**
h. **Foam**

Q3: What is the main content of LNG?

i. **Propane**
j. **Butane**
k. **Methane**
l. **Ethane**

Q4: What is the purpose of running cargo pumps in parallel?

m. **To increase pressure**
n. **To increase flow**
o. **To increase NPSH**
p. **To decrease NPSH**

Q5: What is the maximum allowed oxygen content in Inert gas as per IMO IGC code?

q. **7 % by volume**
r. **10 %**
s. **No requirements**
t. **5 %**

Q6: Centrifugal pumps are started with the:

u. Suction valve shut
v. Discharge valve open
w. Drain valve open
x. Discharge v/v shut

Q10: Mention three types of instruments that are used in cargo tanks.

y. ----------
z. ----------
aa. ----------

Q14: Which statement is correct?

bb. Pressure is directly proportional to temperature
cc. Pressure is inversely proportional to temperature
dd. They are not related

Q16: Which statement is correct?

ee. Pressure is directly proportional to volume
ff. Pressure is inversely proportional to volume
gg. They are not related

Q17: Gas concentration in inert gas condition is checked by:

hh. Explosimeter
ii. Dragger Tubes
jj. Tank Scope

Q18: Which statement is false?

kk. Ammonia is lighter than LPG
ll. LNG is heavier than LPG
mm. Nitrogen is lighter than LPG
nn. None of the above

Q19: The primary function of a cargo compressor on pressurized LPG ships is:

oo. For re-liquefaction
pp. For compressing gas in cargo tanks
qq. Transferring cargo vapours

Q20: The cargo compressor room blowers should be on:

rr. Supply mode
ss. Exhaust mode
tt. Does not matter

Q21: What is the meaning of purging?

uu. Blow air in cargo tank
vv. Liquid free the tank with hot gas
ww. To change vapour phase with cargo

Q22: The motor room fan should always run on:

xx. Extraction/positive mode
yy. Supply/positive mode
zz. c) Neutral/negative mode

Q23: The mixture of glycol is used cargo compressors as cooling medium because:

a. It is non-reactive with cargo
aaa. It has a high heat transfer ratio
bbb. It has an anti-freezing property

Q24: Gauging cargo tanks with slip tubes is considered as:

a. Open method
b. Closed method
c. Restricted gauging

Q25: Write down all Personnel Protective Equipment you will use while working during Cargo Operations:

