

## APPENDIX 4

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118 The BCSN "FLY ASH" is replaced by "FLY ASH, DRY".

119 The following rows are added in the table:

MATERIAL	GROUP	REFERENCES
DISTILLERS DRIED GRAINS WITH SOLUBLES	C	
FERROUS SULPHATE HEPTAHYDRATE	C	
FLY ASH, WET	A	
GRANULAR FERROUS SULPHATE	C	
LOGS	B	see Wood Products – General schedule
MAGNESIUM SULPHATE FERTILIZERS	C	
PULP WOOD	B	see Wood Products – General schedule
ROUNDWOOD	B	see Wood Products – General schedule
SAW LOGS	B	see Wood Products – General schedule
TIMBER	B	see Wood Products – General schedule
Wood Products – General	B	

120 The words "WOOD PULP PELLETS" and "Pellets, wood pulp" are deleted.

## 第 116/2015 號行政長官公告

## Aviso do Chefe do Executivo n.º 116/2015

中華人民共和國是國際海事組織的成員國及一九七四年十一月一日訂於倫敦的《國際海上人命安全公約》（下稱“公約”）的締約國；

國際海事組織海上安全委員會於一九八三年六月十七日對公約第VII章作出修正，將有關國際散裝運輸液化氣體船舶構造和設備規則的規定作為公約的強制性規定，並透過第MSC.5(48)號決議通過了《國際散裝運輸液化氣體船舶構造和設備規則》（IGC規則）；

中華人民共和國於一九九九年十二月十三日以照會通知聯合國秘書長，經修訂的公約自一九九九年十二月二十日起適用於澳門特別行政區；

基於此，行政長官根據第3/1999號法律《法規的公佈與格式》第六條第一款的規定，命令公佈包含上指規則的第MSC.5(48)號決議的中文及英文文本。

二零一五年七月二十二日發佈。

行政長官 崔世安

Considerando que a República Popular da China é um Estado Membro da Organização Marítima Internacional e um Estado Contratante da Convenção Internacional para a Salvaguarda da Vida Humana no Mar, concluída em Londres em 1 de Novembro de 1974, adiante designada por Convenção;

Considerando igualmente que, em 17 de Junho de 1983, o Comité de Segurança Marítima da Organização Marítima Internacional procedeu a emendas ao capítulo VII da Convenção para tornar as disposições relativas ao Código Internacional para a Construção e Equipamento de Navios que Transportam Gases Liquefeitos a Granel obrigatórias nos termos da Convenção, e que, através da resolução MSC.5(48), adoptou o Código Internacional para a Construção e Equipamento de Navios que Transportam Gases Liquefeitos a Granel (Código IGC);

Considerando ainda que a República Popular da China, por nota datada de 13 de Dezembro de 1999, notificou o Secretário-Geral das Nações Unidas sobre a aplicação da Convenção, tal como emendada, na Região Administrativa Especial de Macau a partir de 20 de Dezembro de 1999;

O Chefe do Executivo manda publicar, nos termos do n.º 1 do artigo 6.º da Lei n.º 3/1999 (Publicação e formulário dos diplomas), a resolução MSC.5(48), que contém o referido Código, nos seus textos em línguas chinesa e inglesa.

Promulgado em 22 de Julho de 2015.

O Chefe do Executivo, *Chui Sai On*.

## 決議 MSC.5 (48)

(1983 年 6 月 17 日通過)

通過《國際散裝運輸液化氣體船舶構造和設備規則》

(IGC 規則)

海上安全委員會，

回顧了決議 A.328 (IX)，在該決議中，大會授權海安會對散裝運輸液化氣體船舶構造和設備規則進行必要的修改，

注意到在決議 MSC.6 (48) 中，大會通過了對 1974 年國際海上人命安全公約 (1974 SOLAS 公約) 第 VII 章的修正案，使國際散裝運輸液化氣體船舶構造和設備規則 (IGC 規則) 根據該公約為法定的規則，

審議了建議的 IGC 規則的文本：

- 1 通過 IGC 規則，該規則的文本為本決議的附件；
- 2 注意到按經決議 MSC.6 (48) 修正的 1974 SOLAS 公約第 VII 章 C 部分，IGC 規則的修正案將根據該公約第八條通過、生效及執行；
- 3 要求秘書長將上述通過了的 IGC 規則的修正條款 (包括第 19 章內規定的新貨品)，通知各有關政府，建議在這些修正條款生效之前，這些新貨品應由符合修正條款規定的液化氣體船裝運；

4 進一步要求秘書長將本決議條款的副本連同 IGC 規則的文本轉發給本組織所有成員國以及不是本組織成員國的所有 1974 SOLAS 公約締約國的政府。

## 秘書處說明

1. 海上安全委員會於 1983 年 6 月在其第四十八屆會議上通過了對 1974 年國際海上人命安全公約（SOLAS）的修正案。公約三十三個締約國的代表出席了該屆會議，所有的修正案文本皆按第八條第二款第（四）項所規定的程序獲得了通過。

2. 該屆會議所通過的修正案包括第 III 章和第 VII 章的新文本，以及第 II-1 章、第 II-2 章和第 IV 章的修正案。

3. 在第 II-1 章、第 II-2 章、第 III 章和第 VII 章中採用了十進位編號制。除通用的海制單位被認為更適宜之處外，公制和英制單位均已被國際標準單位所替代。

4. 相互參照皆以簡明形式給出，例如第 II-2/10.4 條意即第 II-2 章第 10 條之 4。

5. 公約及其修正條款中所有的腳註係指公約所附的有關建議及其他國際上所接受的標準。海上安全委員會指出，這些腳註並不構成公約的一部分，之所以加上腳註，是為了參閱方便。這些腳註可以改動，以反映它們所提及的決議、建議或文件的修改。所提及的將由大會第十三屆常會通過的決議草案，將由大會通過後的決議正式編號所替代。

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國際散裝運輸液化氣體船舶構造和設備規則

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## 序言

1 本規則的目的在於為海上運輸本規則第 19 章所列的散裝液化氣體和某些其他物質提供一個國際標準，在考慮到有關貨品性質的情況下，規定了這類運輸船舶的設計和建造標準以及船上所應裝配的設備，以便使其對船舶、船員及環境所造成的危險減至最少。

2 基本原理是船舶的型式與本規則所包括貨品的危險性有關。每一貨品可以有一個或多個危險特性，包括易燃性、毒性、腐蝕性及反應性。由於貨品在低溫下或壓力條件下運輸還可能引起另外的危險性。

3 嚴重的碰撞或擱淺可能導致貨艙破損，造成貨品不可控制地釋放。此項釋放可能引起貨品的蒸發和擴散，並在某些情況下可能導致船體的脆性斷裂。本規則根據現有的知識和技術要求儘可能減少這種危險性。

4 制訂本規則的過程中，認識到必須以良好的造船和工程原則以及對各種貨品的危險性有徹底的了解為基礎；且進一步認識到液化氣體船舶的設計建造不僅是一門複雜的技術，而且正在迅速發展之中；故本規則不應保持不變；因此，本組織將在考慮到經驗和技術進一步發展的情況下對本規則進行定期的複審。

5 對新貨品及其運輸條件的要求，在國際海事組織海安會通過後，將根據 1974 年國際海上人命安全公約第八條的規定，在適當的修正案生效之前，暫作建議案進行通告。

6 本規則主要涉及船舶設計和設備。為了確保貨品的安全運輸，必須對整個系統進行鑑定。保證貨品安全運輸的其他方面，例如訓練、操作、交通控制和港口裝卸等，本組織正在作或將作更進一步研究。

7 本規則的制訂得到國際船級社協會（IACS）的大力支持，並對 IACS 關於液化氣體船舶統一要求的第 4、5 和 6 章作了充分考慮。

8 本規則第 10 章的制訂得到了國際電工技術委員會（IEC）的大力支持。

9 本規則第 18 章處理了液化氣體運輸船舶的操作問題，它突出了其他章節中屬於操作性質的條款，並提到了液化氣體安全操作的其他重要方面。

10 本規則的編排與海安會在其第四十八屆會議上通過的國際散裝運輸危險化學品船舶構造和設備規則（IBC）相一致。

## 第 1 章 總則

### 1.1 適用範圍

1.1.1 本規則適用於不論噸位大小（包括 500 噸以下）凡散裝運輸溫度在 37.8°C 時蒸氣絕對壓力超過 2.8 bar 的液化氣體和第 19 章所列的其他貨品的船舶。

1.1.2 除非另有明文規定，本規則適用於在 1986 年 7 月 1 日或以後安放龍骨或處於相當階段的船舶；相當階段係指：

- .1 可認為某一具體船舶建造開始；
- .2 該船業已開始的裝配量至少為 50 噸或為所有結構材料估算重量的 1%，以較小者為準。

1.1.3 不論何時建造的船舶，凡在 1986 年 7 月 1 日或以後改建成氣體運輸船舶應該作為氣體運輸船舶，並把改建日期作為建造日期。

1.1.4.1 當液貨艙裝有按本規則要求具有 1G 型船舶的貨品時，位於 2.6.1.1 所屬的保護區域內的液艙不應裝載具有閃點（閉杯閃點試驗）60 °C 或小於 60 °C 的易燃液體，也不應裝載第 19 章所列的易燃貨品。

1.1.4.2 同樣地，當液貨艙裝有按本規則要求具有 2G/2PG 型船舶的貨品時，位於 2.6.1.2 所述的保護區域內的液艙不應裝載上面所述的易燃液體。

1.1.4.3 對液貨艙裝有按本規則要求 1G 或 2G/2PG 型船舶的貨品時，在每一種情況下，上述限制只適用於貨艙縱向範圍以內的保護區域。

1.1.4.4 如果液貨艙裝有按本規則要求具有 1G 或 2G/2PG 型船舶的貨品時，且其數量僅限於供冷卻、循環或作燃料用時，則在這些保護區域內可以裝載上述易燃液體和貨品。

1.1.5 除 1.1.7.1 內要求者外，當船舶擬裝載本規則所包括的貨品或國際散裝運輸危險化學品構造和設備規則 (IBC)(國際海事組織大會授權、根據大會決議 A.490 (XII) 召開的海安會已通過並可能被組織修訂) 所包括的貨品，則該船舶應按所裝運貨品的情況，符合兩個規則的要求。

1.1.6 如果擬裝載的貨品可認為是屬於本規則的範圍但在現有的第 19 章中尚未給出者，則主管機關及有關這類貨品裝載的港口主管機關應根據本規則的原則建立適當的基本裝載條件，並應將這些條件通知本組織。

1.1.7.1 當船舶設計和建造成用來裝載下列貨品時，應該首先滿足本規則的下列要求：

- .1 本規則第 19 章中專門列出的貨品；
- .2 既在本規則又在國際散裝化學品規則中列出的一種或幾種貨品，這些貨品在第 19 章表中“a”欄用(\*)作了標記。

1.1.7.2 若船舶擬專門裝載 1.1.7.1.2 中指明的一種或幾種貨品，應該採用經修正的國際散裝化學品規則的要求。

1.1.8 符合國際氣體運輸規則的船舶應在 1.5 中給出的國際散裝運輸液化氣體適裝證書中註明。如符合本規則的修正案，按情況需要，也應在國際散裝運輸液化氣體適裝證書中註明。

## 1.2 危險性

本規則中所考慮的氣體的危險性包括火災、毒性、腐蝕性、反應性、低溫及低壓。

## 1.3 定義

除另有明文規定外，下列定義適用於本規則。其他的定義則在第4章中給出。

1.3.1 “起居處所”係指用作公共處所、走廊、盥洗室、住室、辦公室、醫務室、電影院、娛樂室、理髮室、沒有炊事用具的配膳室以及類似處所。公共處所係指居住處所中作大廳、餐廳、休息室及類似用途的固定圍蔽處所。

1.3.2 “‘A’級分隔”係指1983年SOLAS修正條款第II-2/3.3條中所定義的分隔。

1.3.3.1 “主管機關”係指船旗國政府。

1.3.3.2 “港口主管機關”係指船舶裝卸貨物港所在國的主管機關。

1.3.4 “沸點”係指貨品呈現蒸氣壓力等於大氣壓力時的溫度。

1.3.5 “寬度（B）”係指船舶的最大寬度，金屬船在船中部量至肋骨型線，其他材料船在船中部量至船體外表面。寬度（B）應以米計。

1.3.6 “貨物區域”係指船上設有貨物圍護系統、貨泵艙和壓縮機艙的區域，並包括上述區域在船舶整個船寬和船長範圍的甲板面積。最後一個貨艙後面或最前一個貨艙前面的隔離艙、壓載艙或空艙（如設有時）不應算作貨物區域。

1.3.7 “貨物圍護系統”係指用來圍護貨物的裝置，包括主屏壁和次屏壁（如設有時）以及附屬的絕熱層和壁間處所，如果需要支持這些構件，還包括鄰接結構。若次屏壁是船體結構的一部分，它可以是貨艙的邊界。

1.3.8 “貨物控制室”係指用來控制貨物裝卸作業並符合 3.4 要求的處所。

1.3.9 “貨物”係指符合本規則的船舶散裝運輸的第 19 章一覽表所列的貨品。

1.3.10 “貨物服務處所”係指貨物區域內面積大於 2m<sup>2</sup> 用作車間、櫥櫃及儲藏室的處所，以及供貨物裝卸設備用的處所。

1.3.11 “液貨艙”係指設計來作為裝載貨物的主要容器的液密殼板，包括不論有無絕熱層或次屏壁（或兩者）的所有這類容器。

1.3.12 “隔離艙”係指兩個相鄰鋼質艙壁或甲板之間的隔離處所。該處所可為空艙或壓載艙。

1.3.13 “控制站”係指設有船舶無線電台、主要導航設備或應急電源的處所，或指火警記錄器或失火控制設備集中的處所，但不包括很可能設置在貨物區域內的失火控制設備。

1.3.14 “易燃貨品”係指第 19 章“f”欄中標有“F”的貨品。

1.3.15 “可燃限度”係指對燃料氧化劑混合物狀態的限制，它在外加一足夠強的着火源後於給定的試驗儀器中正好能形成可燃的條件。

1.3.16 “氣體運輸船”係指建造或改建成用來散裝運輸任何液化氣體或第 19 章表中所列其他貨品的貨船。

## 1.3.17 “氣體危險處所或區域” 係指：

- .1 貨物區域中未裝置或未配備認可的設備以確保其空氣在任何時候均處於氣體安全狀態的處所；
- .2 貨物區域以外含有液體或氣體貨品的任何管路通過（或在其中終止）的圍蔽處所，但安裝了認可型裝置能防止貨品蒸氣逸入該處所內空氣之中的處所除外；
- .3 貨物圍護系統和貨物管系；
  - .4.1 要求裝次屏壁的貨物圍護系統中裝載貨物的貨艙；
  - .4.2 不要求裝次屏壁的貨物圍護系統中裝載貨物的貨艙；
- .5 用單一鋼質氣密邊界與上面.4.1 所述的貨物相分隔的處所；
- .6 貨泵艙和貨物壓縮機艙；
- .7 離液貨艙出口、氣體或蒸氣出口、液貨管法蘭或液貨閥或通到貨泵艙和貨物壓縮機艙的入口或通風口 3m 範圍以內開敞甲板上的區域（或開敞甲板上的半圍蔽處所）；
- .8 貨物區域內上方的開敞甲板、開敞甲板上貨物區域前後 3m 及離露天甲板 2.4m 高度範圍以內的處所；
- .9 離貨物圍護系統外表面（該表面是露天的）2.4m 以內的處所；

- .10 內部設有含貨品管路的圍蔽或半圍蔽處所。但含有符合 13.6.5 要求的氣體監測設備的處所，或利用蒸發氣體作為燃料並符合第 16 章要求的處所，在此不認為是氣體危險處所；
- .11 供貨物軟管用的處所；或
- .12 向任一危險處所或區域直接開口的圍蔽處所或半圍蔽處所。

1.3.18 “氣體安全處所”係指貨物危險區域以外的處所。

1.3.19 “貨艙”係指由船舶結構圍蔽、內部設有貨物圍護系統的處所。

1.3.20 “獨立”係指不以任何方式和其他系統相連接的管路系統或透氣系統，並且沒有任何設施可以用來和其他系統作潛在的連接。

1.3.21 “絕熱處所”係指全部或部分地被絕熱材料填充的處所，它可能是（或不是）屏壁間處所。

1.3.22 “屏壁間處所”係指主屏壁和次屏壁之間的處所，不論是全部還是部分地被絕熱材料或其他材料填充。

1.3.23 “長度（L）”係指從龍骨頂量至最小型深 85% 處水線總長的 96%，或在此水線上由艙柱前緣量至舵杆軸線的長度，取其中較大者。對設計有龍骨傾斜的船舶，量取長度的水線應與設計水線平行。長度（L）應以米計。

1.3.24 “A 類機器處所”係指裝有下列設施的處所以及通往這些處所的圍壁通道：



- .1 主推進用的內燃機；
- .2 作其他用途的合計總輸出功率不小於 373 kW 的內燃機；或
- .3 任何燃油鍋爐或燃油裝置。

1.3.25 “機器處所”係指一切 A 類機器處所和一切其他包括推進機械、鍋爐、燃油裝置、蒸氣機和內燃機、發電機和主要電動機、加油站、冷藏機、減搖裝置、通風機和空氣調節機的處所，以及類似處所；連同通往這些處所的圍壁通道。

1.3.26 “MARVS”係指液貨艙內釋放閥設定的最大許用值。

1.3.27 “燃油裝置”係指準備為燃油鍋爐輸送燃油或準備為內燃機輸送加熱燃油的設備，並包括用於處理壓力超過 1.8 bar 油類的任何油壓泵、過濾器及加熱器。

1.3.28 “組織”係指國際海事組織（IMO）。

1.3.29 “滲透率”係指某一處所假定被水浸佔的容積與該處所總容積之比。

1.3.30.1 “主屏壁”係指貨物圍護系統具有兩層界面時用來裝貨的內層構件。

1.3.30.2 “次屏壁”係指貨物圍護系統中的液密外層構件，用來對液貨通過主屏壁可能產生的泄漏提供暫時的保護並防止船體結構的溫度下降至不安全的程度。次屏壁的型式在第 4 章中有更完整的定義。

1.3.31 “相對密度”係指某一貨品的質量與等體積淡水的質量之比。

1.3.32 “隔離”係指不和另一貨物管系或貨物透氣系統相連接的貨物管系或貨物透氣系統。這種隔離可以通過設計或操作方法予以實現。操作方法不應在液貨艙內使用，它應採用下列型式之一：

- .1 拆去短管或閥門，並且盲斷管端；
- .2 裝設兩個串接的盲通兩用法蘭，並具有檢測的設施。  
此項型式亦可用在類似處所，以及通往這些處所的圍壁通道內。

1.3.33 “服務處所”係指用作廚房、裝有炊事用具的配膳室、廚櫃、郵件及貴重物品室、儲藏室、構成機器處所部分以外的車間以及類似處所，包括通往這些處所的圍壁通道。

1.3.34 “1974 SOLAS 公約”係指 1974 年國際海上人命安全公約。

1.3.35 “SOLAS 1983 修正條款”係指 1983 年 6 月 17 日國際海事組織下屬的海安會第四十八屆會議以決議 MSC.6 (48) 通過的 1974 年 SOLAS 公約的修正條款。

1.3.36 “液艙蓋”係指用來保護突出在露天甲板上使貨物圍護系統免受損傷的結構或用來保證甲板結構連續性和完整性的結構。

1.3.37 “液艙氣室”係指液貨艙向上延伸的部分。如貨物圍護系統在甲板下方，則液艙氣室突出露天甲板或液艙蓋。

1.3.38 “毒性貨品”係指第 19 章表中“f”欄內標有“T”的貨品。

1.3.39 “蒸氣壓力”係指在規定溫度下液體上方飽和蒸氣的平衡壓力，以 bar (絕對值) 計。

1.3.40 “空艙”係指貨物圍護系統外方貨物區域內的圍蔽處所，但不包括貨艙、壓載艙、燃油艙、貨泵艙、壓縮機艙或人員正常使用的任何處所。

#### 1.4 等效

1.4.1 對本規則要求船上所應裝設或配備的專門裝置、材料、設備和器具，及其項目或型式，或要求作出的任何特殊規定，或要求符合的任何程序或佈置，主管機關可允許在該船上裝設或配備任何其他裝置、材料、設備和器具及其項目或型式，或作任何其他的規定、程序或佈置，但須通過試驗或其他方法經主管機關認定這些裝置、材料、設備和器具及其項目或型式，或特定的規定、程序或佈置至少與本規則所要求者具有同等效能。然而，主管機關不准許採用改變本規則規定的特定裝置、材料、設備和器具及其項目或型的操作方法或程序。

1.4.2 當主管機關准許採用的替代裝置、材料，設備和器具及其項目或型式，或規定、程序或佈置時，它應將其細節連同驗證報告提交國際海事組織，以便國際海事組織能將其轉知 1974 年 SOLAS 公約其他締約國政府，供其官員參考。

#### 1.5 檢驗與發證

##### 1.5.1 檢驗程序

1.5.1.1 船舶的檢驗，包括本規則條文的實施及免除的准許，應由主管機關的官員進行。然而，主管機關也可委託指定的驗船師或認可的機構進行。

1.5.1.2 指定驗船師或認可機構去執行檢驗的主管機關至少應對指定的驗船師或認可機構授權進行：

- .1 要求修理船舶；
- .2 在有關國家的港口當局\*的要求下執行檢驗。

主管機關應通知海事組織關於指定驗船師和認可機構的特定職責和權力範圍，並發給締約國政府。

1.5.1.3 當指定的驗船師或認可機構確認船舶或設備的狀態實質上與證書所載情況不符，或船舶不宜作對船舶或船上人員沒有危險的出海航行時，該驗船師或機構應確保能立即採取正確措施並應及時通知主管機關。如果未能採取此類措施，應撤銷有關證書，並立即通知主管機關；同時假使船舶處於另一締約國的港口，也應立即通知有關國家港口當局。

1.5.1.4 在任何情況下，主管機關應保證檢驗的完整性和有效性，並應作出必要的安排以保證滿足這一要求。

#### 1.5.2 檢驗要求

1.5.2.1 液化氣體船舶的結構、設備、附件、裝置和材料（不包括貨船結構安全證書、貨船安全設備證書和貨船安全無線電報證書或貨船安全電話證書已涉及的有關項目）應接受下列檢驗：

- .1 在船舶投入營運之前或第一次頒發國際散裝運輸液化氣體適裝證書之前的初次檢驗。此項檢驗應包括對本規則有關的船舶結構、設備、附件、裝置和材料進行一次全面的檢查，這項檢驗應保證結構、設備、附件、裝置和材料完全符合本規則的可適用的規定。

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\* 國家港口當局的含義和 1974 年 SOLAS 公約及其 1978 年議定書的第 1 章第 19 條相同。

- .2 按主管機關規定的周期（不超過五年）進行定期檢驗。此項檢驗應保證結構、設備、附件、裝置和材料完全符合本規則的可適用的規定。
- .3 在國際散裝運輸液化氣體適裝證書的有效期限內至少有一次中間檢驗。如在證書有效期限內只進行一次這樣的中間檢驗時，則此檢驗不應在該證書有效期限一半日期的 6 個月之前或 6 個月之後進行。中間檢驗應保證安全設備、其他設備及有關的泵和管路系統符合本規則的可適用的規定，並處於良好的工作狀態。這類檢驗應在國際散裝運輸液化氣體適裝證書上簽證。
- .4 在國際散裝運輸液化氣體適裝證書周年之日 3 個月前或後以內進行一次法定年度檢驗。此項檢驗應包括一次全面的檢查以保證結構、設備、附件、裝置和材料在各方面都保持船舶營運時所需要的良好狀態。此項檢驗應在國際散裝運輸液化氣體適裝證書上簽證。
- .5 按 1.5.3.3 規定的要求進行了研究後有要求時，或作了一次重大的修理或更新後，應根據情況進行一次全面的或部分的額外的檢驗。這種檢驗應保證這類修理或更新是有效地進行的，並且這類修理或更新的材料和工藝質量是良好的；還應使船舶適於海上航行而對船舶或船上人員無危險。

### 1.5.3 檢驗後狀態的保持

1.5.3.1 應保持船舶及其設備的狀態使之符合本規則的規定，並保證船舶仍能適於海上航行而對船舶或船上人員無危險。

1.5.3.2 按 1.5.2 規定在任何一次檢驗完成後，未經主管機關的批准，不應該在結構、設備、附件、裝置及材料上有任何變動，但直接替換者除外。

1.5.3.3 如船上發生任何事故或發現任一缺陷，只要它們對船舶的安全性或救生設備（或其他設備）的完整性或有效性有影響時，船長或船東應儘快報告主管機關、負責頒發證書的指定驗船師或認可機構，他們應着手調查研究以決定按 1.5.2.5 要求的檢驗是否必要。若船舶處在另一締約國政府的港口，則船長或船東應立即報告該國家港口當局，指定驗船師或認可機構應核實是否已經作了這樣的報告。

### 1.5.4 證書的頒發

1.5.4.1 對符合本規則有關規定的液化氣體船舶進行了初次檢驗或定期檢驗後應頒發一份國際散裝運輸液化氣體適裝證書，其示範格式在附錄中列出。

1.5.4.2 按本節規定頒發的證書應存放在船上以便隨時進行檢查。

1.5.4.3 船舶按 1.1.5 規定進行設計和建造時，應按本節要求以及國際散裝化學品規則的 1.5 節要求頒發國際適裝證書。

### 1.5.5 由另一國政府簽署或頒發證書

1.5.5.1 應另一國政府的要求，締約國政府可對掛其他國家國旗的船舶進行檢驗，如果認為符合本規則要求，可對其頒發或授權頒發證

書，並根據情況也可按本規則要求對該船的證書簽署或授權簽署。這樣頒發的證書應包含一份聲明，表示該證書的頒發是應船旗國政府的要求而進行的。

#### 1.5.6 證書的期限及有效期

1.5.6.1 國際散裝運輸液化氣體適裝證書頒發的周期由主管機關規定，從初步檢驗或定期檢驗起不應超過 5 年。

1.5.6.2 證書的展期不得超過 5 年。

1.5.6.3 證書應停止生效：

- .1 如在 1.5.2 規定的期限內未進行檢驗；
- .2 當船舶換掛另一國家的國旗時，只有當頒發新證書的政府認為該船完全符合 1.5.3.1 和 1.5.3.2 的要求，才能頒發新證書。當船舶換掛國旗是在兩個締約國政府之間進行時，如在換掛國旗的關係發生之後 12 個月內提出要求，原船旗國政府應儘早向主管機關轉交該船在換掛國旗之前所具有的證書副本，如可行，還應包括有關的檢驗報告副本。

## 第 2 章 船舶抗沉能力\*與液貨艙位置

### 2.1 通則

2.1.1 受本規則約束的船舶應能承受在外力作用下船體遭受假定破損後的正常進水影響。此外，為了保護船舶及周圍環境，若遇諸如和碼頭或拖船相接觸而引起船體較小損傷，液貨艙應加保護防止穿透，並應提供在碰撞或擱淺時免遭破損的措施，此項措施可把液貨艙佈置在舷內離船體外板有一規定最小距離之處。所假定的破損和液艙與船體外板間的距離取決於所裝貨品所具有的危險程度。

2.1.2 受本規則約束的船舶應按下列標準之一設計：

- .1 1G 型船舶係指擬運載第 19 章所列貨品的氣體運輸船，它要求採取最有效的保護措施預防此類貨物的逸泄。
- .2 2G 型船舶係指擬運載第 19 章所列貨品的氣體運輸船，它要求採取有效的保護措施預防此類貨物的逸泄。
- .3 2PG 型船舶係指長度為 150 m 及 150 m 以下擬運載第 19 章所列貨品的氣體運輸船，它要求採取重大保護措施預防這類貨物的逸泄，且貨品裝載在獨立的針對 MARVS 至少為 7 bar 及貨物圍護系統設計溫度為 -55 °C 或以上而設計的 C 型艙（見 4.2.4.4）中。應注意到這類船舶的長度，如超過 150 m 應認為是 2G 型船舶。
- .4 3G 型船舶係指擬運載第 19 章所列貨品的氣體運輸船，它要求採取中等保護措施預防這類貨物的逸泄。

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\* 參見關於散裝化學品規則和氣體運輸船舶規則的抗沉要求統一應用準則。



這就是說，1G 型船舶是用來運載具有最大危險性貨品的氣體運輸船，2G/2PG 以及 3G 型船舶運載貨品的危險程度則逐漸減小。因此，1G 型船舶應能承受最嚴重的破損標準，而其液貨艙應位於舷內離船體外極具有最大規定距離的處所。

2.1.3 個別貨品要求的船型表示在第 19 章表的“c”欄中。

2.1.4 如果擬運載不止一種第 19 章所列的貨品，其破損標準應按最嚴格船型要求的貨品來確定。但對個別液貨艙位置的要求，即係按與擬運載各貨品有關船型的要求。

## 2.2 乾舷和完整穩性

2.2.1 受本規則約束的船舶可按現行的國際載重線公約勘定最小乾舷。然而，勘定乾舷所決定的吃水不應該大於本規則其他條款所允許的最大吃水。

2.2.2 船舶在所有航海條件及裝卸貨物期間的穩性應該達到主管機關認可的標準。

2.2.3 在對裝載狀態計算消耗液體自由液面的影響時，應對每種液體假定：至少一對橫向液艙或一個中心液艙有自由液面，且須考慮進去的液艙（或組合液艙）應該是自由液面影響最大的艙室。在未破損艙室內的自由液面影響應採用主管機關認可的方法計算。

2.2.4 貨物區域內的雙層底處所中一般不應採用固體壓載。然而，如因考慮到穩性，在這些處所中裝設固體壓載成為不可避免時，則其分佈應由需要決定，以保證船底破損引起的衝擊荷重不會直接傳遞到液貨艙結構。

2.2.5 應向船長提供一本裝載和穩性資料手冊，其內容包括典型營運狀態、裝載、卸載以壓載操作的細節，估算其他裝載狀態的規定，以及船舶抗沉能力小結。此外，手冊還應包括能使船長採用安全和適航方式裝載貨物和操作該船的足夠資料。

### 2.3 乾舷甲板以下的舷側排水孔

2.3.1 從乾舷甲板以下處所或從裝有水密門的乾舷甲板上的上層建築和甲板室內通過外板排水閥門的裝設及控制，應符合現行國際載重線公約的有關規定，但是閥門選擇應限於：

- .1 具有主動關閉設備（從乾舷甲板上方操作）的自動止回閥一隻；或
- .2 如從夏季載重水線至排水管舷內端的垂直距離超過 0.01L，無主動關閉設備的自動止回閥二隻，但是舷內閥在營運條件下要始終能接近供檢查。

2.3.2 本節範圍內，“夏季載重水線”和“乾舷甲板”的含義和現行的國際載重水線公約的定義相同。

2.3.3 2.3.1.1 和 2.3.1.2 所述的自動止回閥應為主管機關認可的型式，應能在考慮了 2.9 的抗沉要求所述的下沉、縱傾和橫傾後，完全有效地防止水進入船內。

### 2.4 裝載狀態

破損抗沉能力應根據提交給主管機關的裝載資料針對所有預計的裝載狀態以及吃水和縱傾的變化進行研究。抗沉要求不必適用於船舶

處在壓載狀態\*的情況，但要求留在船上的貨物僅供冷卻、循環或作燃料用。

## 2.5 破損範圍假定

### 2.5.1 假定的最大破損範圍應該是：

#### .1 舷側破損：

.1.1 縱向範圍： $1/3L^{2/3}$  或 14.5 m，取小者。

.1.2 橫向範圍： $B/5$  或 11.5 m，取小者。

從舷側向舷內沿夏季載重水線垂直於縱中剖面方向量取。

.1.3 垂向範圍：向上無限制。

在中心線處自船底外板型線量起。

#### .2 船底破損

距艏垂線  $0.3L$  範圍內。 船舶的其他部分。

#### .2.1 縱向範圍：

$1/3L^{2/3}$  或 14.5m，取小者。  $1/3L^{2/3}$  或 5m，取小者。

\* 在估算壓載狀態時，甲板上的小型獨立清洗艙的貨物不必考慮在內。

### .2.2 橫向範圍：

B/6 或 10m，取小者。

B/6 或 5m，取小者。

### .2.3 垂向範圍：

B/15 或 2m，取小者，在中心線上自船底外板型線量起（見 2.6.3）。

B/15 或 2m，取小者，在中心線上自船底外板型線量起（見 2.6.3）。

### 2.5.2 其他破損：

- .1 如果破損範圍雖小於 2.5.1 所規定的最大值，但卻導致更嚴重情況的任何破損應該加以考慮。
- .2 貨物區域內任何部位的局部舷倒破損，若其範圍為船體外板向舷內擴展到 760mm，則應加以考慮，且當 2.8.1 可適用的部分也要求滿足時，應假定橫艙壁受到破損。

## 2.6 液貨艙佈置

### 2.6.1 液貨艙應佈置在舷內下列距離處：

- .1 1G 型船舶：離船側外板不小於 2.5.1.1.2 規定的橫向破損範圍，在中心線上離船底外板型線不小於 2.5.1.2.3 規定的垂向破損範圍以及任何部位離船體外板不小於 760 mm。
- .2 2G/2PG 和 3G 型船舶：在中心線上離船底外板型線不小於 2.5.1.2.3 規定的垂向破損範圍，以及任何部位離外板不小於 760 mm。

2.6.2 就液貨艙佈置而言，如採用薄膜液艙或半薄膜液艙，船底破損的垂向範圍應量到內底，其他艙量至液貨艙底。採用薄膜液艙或半薄膜液艙時，舷側破損的橫向範圍應量到縱艙壁，其他艙量至液貨艙舷側（見圖 2.1）。對內部絕熱液艙，破損範圍應量至液艙支持板。

2.6.3 除 1G 型船舶外，液貨艙內的吸水井可以突入 2.5.1.2.3 規定的船底垂向破損範圍內，但要求此項井儘可能小，且內底板以下的突出部分不超過雙層底高的 25%或 350mm（取小者）。如果沒有雙層底，船底破損上限以下的突出部分不應超過 350mm。在確定受破損影響的艙室時，按本款設置的吸水井可予忽略。

## 2.7 浸水假定

2.7.1 2.9 的要求應該用計算予以證實，計算中須考慮船舶的設計特徵；破損艙室的佈置、結構外形及所裝內容；液體的分佈、相對密度和自由液面影響；以及所有裝載狀態下的吃水及縱傾。

2.7.2 假定破損處所的滲透率應取下列值：

<u>處所</u>	<u>滲透率</u>
物料貯放處所	0.60
起居處所	0.95
機器處所	0.85
空艙	0.95
供裝消耗液體用	0-0.95*
供其他液體用	0-0.95*

\* 部分裝滿艙室的滲透率應和該艙室所裝載的液體量相一致。

2.7.3 凡遇破損穿透裝有液體艙室的情況，應假定所裝貨物完全從該艙流失，並由海水替代直至最終平衡水線面的液面高度。

2.7.4 如果水密橫艙壁之間的破損假定為 2.8.1.4，.5 和 .6 中所規定的範圍，則橫艙壁之間的距離至少應等於 2.5.1.1.1 規定的縱向破損範圍才認為有效。如果橫艙壁之間的距離小於上述值，則在此破損範圍內的這類艙壁中的一個或多個，在確定浸水艙室時應假定為不存在。再則如果水密艙壁界限是在 2.5 所要求的垂向或水平向穿透範圍內，則任何限制邊艙或雙層底艙的橫艙壁部分應假定為破損。如果橫艙壁上有長度超過 3m 的台階或壁凹位於假定的破損穿透範圍內，則該橫艙壁應假定為破損。在本款範圍內，艙尖艙艙壁形成的台階及艙尖艙艙頂不應作為台階。

2.7.5 船舶的設計應通過有效的佈置使不對稱浸水減至最小。

2.7.6 凡要求採用機械手段的平衡裝置（例如閘或橫通調平管，如裝有時）不應認為可用來減小橫傾角或達到最小剩餘穩性範圍以滿足 2.9.1 的要求，且如採用平衡裝置的話，在所有階段均應保持足夠的剩餘穩性。用大截面導管連通的處所可認為是互通處所。

2.7.7 如果管路、導管、圍井或隧道位於 2.5 規定的假定破損穿透範圍內，其佈置應使在每一破損情況下延續進水不會擴展到假定進水艙室以外的其他艙室。

2.7.8 直接位於舷側破損上方的上層建築，其浮力應不加考慮。然而，破損範圍以外上層建築的不浸水部分可以考慮進去，只要：

- .1 它們用水密分艙和破損處所隔離，且這些完整處所滿足 2.9.1.2.1 的要求；

- .2 這些分隔內的開口能用遠距離控制的水密滑門關閉，且在 2.9.1 要求的最小剩餘穩性範圍內，不加保護的開口不被浸沒；但允許能風雨密關閉的其他開口浸沒。

## 2.8 破損標準

2.8.1 船舶應能按照下列標準，依據 2.7 按船型確定的浸水假定範圍，承受 2.5 所示的破損：

- .1 1G 型船應假定在其長度內任何部位經受破損；
- .2 長度超過 150m 的 2G 型船應假定在其長度內任何部位經受破損；
- .3 長度為 150m 或不足 150m 的 2G 型船應假定在其長度內任何部位經受破損，但不包括作為艙部機艙邊界的艙壁；
- .4 2PG 型船應假定在其長度內任何部位經受破損，但不包括間距超過 2.5.1.1.1 規定的縱向破損範圍的橫向艙壁；
- .5 長度為 125m 或超過 125m 的 3G 型船應假定在其長度內任何部位經受破損，但不包括間距超過 2.5.1.1.1 規定的縱向破損範圍的橫向艙壁；
- .6 長度不足 125m 的 3G 型船應假定在其長度內任何部位經受破損，但不包括間距超過 2.5.1.1.1 規定的縱向破損範圍的橫向艙壁，且不包括位於艙部的機艙破損。但是承受機艙浸水的抗沉能力應由主管機關考慮。

2.8.2 若是小型的且不是一切方面都滿足 2.8.1.3, .4 和 .6 相應要求的 2G/2PG 型船和 3G 型船, 可由主管機關考慮對其作特殊免除, 但要求採取可保持同等安全程度的替代措施。此替代措施的性質應經認可並清楚地加以說明, 並隨時可向港口主管機關提交。任何此項免除應在 1.5.4 所述的國際散裝運輸液化氣體適裝證書中適當地註明。

## 2.9 抗沉要求

受本規則約束的船舶應按 2.8 所提供的破損標準, 在 2.5 規定的假定破損範圍內仍能在穩定條件下抗沉, 並應滿足下列標準:

### 2.9.1 在浸水的任何階段:

- .1 計及下沉、橫傾和縱傾後的水線應該位於可能發生延續浸水的任何開口下緣以下。這類開口應包括空氣管和用風雨密門就艙口蓋關閉的開口, 但不包括用水密人孔蓋關閉的開口、甲板平齊的水密艙口、保持甲板高度完整性的小型水密艙口蓋、遠距離控制的水密滑門以及非開啓型的舷窗;
- .2 不對稱浸水引起的最大橫傾角應不超過  $30^\circ$ ; 及
- .3 浸水中間階段的剩餘穩性應得到主管機關的同意。然而, 無論如何不應比 2.9.2.1 所要求的值小很多。

### 2.9.2 處於浸水後的最終平衡階段:

- .1 復原力臂曲線超過平衡位置應有一個  $20^\circ$  的最小範圍, 且在  $20^\circ$  範圍內至少有一個 0.1m 的最大剩餘復原力臂; 此範圍內該曲線下的面積應不小於 0.0175m 弧度。



在此範圍內不加保護的開口不應浸沒，除非有關處所假定是浸水的。在這個範圍內，2.9.1.1 所列的任一開口和能水密關閉的其他開口可以允許浸沒；

.2 供給應急電源。

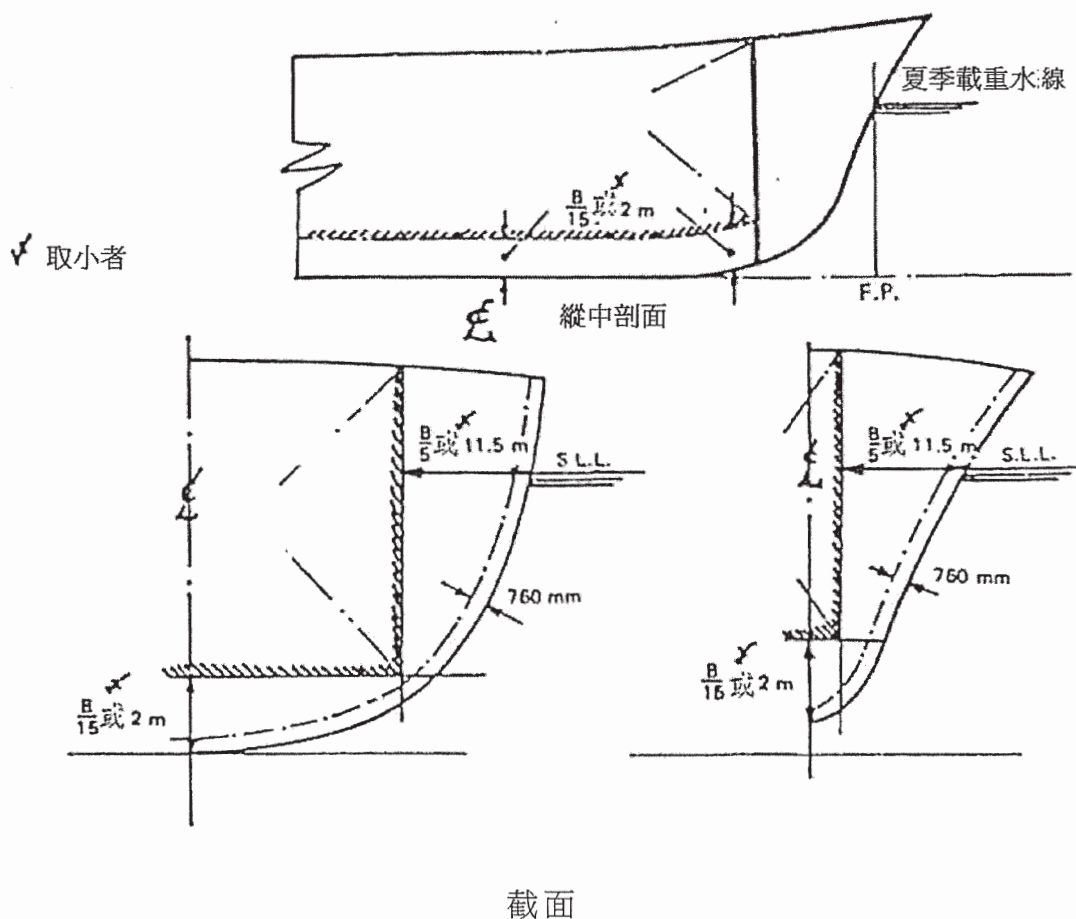


圖 2.1 - 2.6 規定的液艙佈置要求

### 第 3 章 船舶佈置

#### 3.1 貨物區域的分隔

3.1.1 貨艙應與機艙、鍋爐艙、起居處所、服務處所、控制站、錨鏈艙、飲用水和生活用水艙以及儲物艙分隔開。貨艙應位於 A 類機器處所（主管機關認為船舶安全或航行所必需者除外）的前面。

3.1.2 如貨物係裝載在不要求有次屏壁的貨物圍護系統中，貨艙和 3.1.1 所述處所之間，或貨艙和其下面的處所或其舷外一側的處所之間，可以用隔離艙、燃油艙或全焊接結構形成 A-60 級分隔的單層水密艙壁予以隔開。如果相鄰處所中沒有着火源或火災危險，則氣密的 A-0 級分隔亦可同意。

3.1.3 凡貨物裝載在要求有次屏壁的貨物圍護系統中，貨艙和 3.1.1 所述處所之間，或貨艙和其下面或其舷外一側含有着火源或火災危險的處所之間，應該用隔離艙或燃油艙予以隔開。如果相鄰處所中沒有着火源或火災危險，可以用氣密的單層 A-0 級分隔予以隔開。

3.1.4 如貨物裝載在要求有次屏壁的貨物圍護系統中：

- .1 溫度低於 $-10^{\circ}\text{C}$ 者，貨艙應以雙層底同海水相分隔；及
- .2 溫度低於 $-55^{\circ}\text{C}$ 者，船舶也應設有一道形成邊艙的縱艙壁。

3.1.5 可能含有貨物或貨物蒸氣的管路系統應：

- .1 與其他管系相隔離，但為了與貨物淨化、氣體清除或隋化作業有關而需相互連接者除外。在此情況下，應採取預防措施確保貨物或貨物蒸氣不致通過連通管而進入其他管系；

- .2 除第 16 章中規定的以外，上述管路系統不應通過任何起居處所、服務處所或控制站，或通過機器處所（但貨泵艙或貨物壓縮機艙除外）；
- .3 除安裝在豎向圍壁通道或等效裝置內的管路用來通過貨物圍護系統上方的空艙處所，以及除供排水、通風或淨化用的管路可以橫穿隔離艙外，上述管路系統應從開敞甲板直接通至貨物圍護系統；
- .4 除按 3.8 規定的艙艙裝卸裝置、按 3.1.6 的應急貨物拋棄管路系統和按第 16 章的規定以外，上述管路系統應位於開敞甲板上方的貨物區域內；及
- .5 除在航行中不承受內部壓力的橫向接岸管路或應急貨物拋棄管路系統外，上述管路系統應位於 2.6.1 所規定的橫向液艙位置以內。

3.1.6 貨物應急拋棄管路系統應按情況需要符合 3.1.5 要求並可從起居處所、服務處所、控制站或機器處所的后部外面經過，但不應穿過這些處所。如果貨物應急拋棄管路系統是永久性裝設的，則應在貨物區內為管路提供一適當的切斷設施。

3.1.7 應設有裝置以密封露天甲板上貨物圍護系統的開口。

## 3.2 起居、服務及機器處所和控制站

3.2.1 任何起居處所、服務處所或控制站都不應佈置在貨物區域內。起居處所、服務處所或控制站，其面向貨物區域艙壁的位置應避免氣體通過要求設置次屏壁的貨物圍護系統船上的某一破損甲板或艙壁而從貨艙進入這些處所。

3.2.2 為了防止危險蒸氣的侵襲，相當於貨物管系、貨物通風系統及機器處所中從燃氣裝置排出廢氣的位置，應適當考慮起居處所、服務處所、機器處所和控制站的空氣進口及開口。

3.2.3 穿過氣密門或其他型式門的通道不應該從氣體安全處所通到氣體危險處所，但當起居處所位於艙部時通過 3.6.1 所允許的空氣閘通到貨物區前面服務處所的通道除外。

3.2.4 起居處所、服務處所和控制站的進口、空氣進口及開口不應面向貨物區。它們應設置在不面向貨物區的端壁上，或設置在艙室的舷外側（或兩側）上，後者離面向貨物區艙室端的距離至少為船長的 4%（但不少於 3m）。然而，這個距離不必超過 5m。面向貨物區和在上述距離範圍內的艙室兩側上的窗和舷窗應是固定（非開啓）型。駕駛室的窗可以是非固定型的，其門可位於上述範圍內，但它們的設計要確保駕駛室能達到迅速而有效的氣密和蒸氣密。對於專門用來裝載既不燃燒又無毒性的危險貨物，主管機關可准許放寬上述要求。

3.2.5 上層連續甲板以下殼板上的舷窗及第一層上層建築上的舷窗應該是固定（非開啓）型的。

3.2.6 通到起居處所、服務處所和控制站的所有空氣進口及開口應該安裝關閉設備。對於毒性氣體，這些進口及開口應能在處所內部進行操作。

### 3.3 貨泵艙及貨物壓縮機艙

3.3.1.1 除非主管機關另有特別許可，貨泵艙和貨物壓縮機艙應位於露天甲板上方，並在貨物區域內。按照 1983 年修正的 SOLAS 公約第 II-2 章第 58 條的規定，貨物壓縮機艙應作為防火用的貨泵艙。

3.3.1.2 當貨泵艙和貨物壓縮機艙允許設置在最後面貨艙的後端（或最前面貨艙的前端）的露天甲板上方（或下方）時，1.3.6 所定義的貨物區域的限制應擴展到包括貨泵艙和貨物壓縮機艙的整個船寬和船深範圍以及這些處所上方的甲板面積。

3.3.1.3 如貨物區域的限制範圍按 3.3.1.2 擴展，則把貨泵艙和貨物壓縮機艙同起居處所、服務處所、控制站和 A 類機器處所隔開的艙壁位置，應佈置成能避免氣體通過甲板或艙壁的單一破損而進入這些處所。

3.3.2 當貨泵和壓縮機靠通過艙壁或甲板的軸驅動時，在艙壁或甲板處應安裝具有高效潤滑或其他能確保永久性氣密的密封裝置。

3.3.3 貨泵艙或貨物壓縮機艙的佈置應確保能讓穿有保護服或攜帶呼吸器的人員安全無阻地出入，並在受傷時能把昏迷人員救出。所有在貨物裝卸時必需的閥門對穿有保護服的人員來說應該是易於接近的。應配備適當裝置以適當處理貨泵艙和壓縮機艙的排水問題。

#### 3.4 貨物控制室

3.4.1 任一貨物控制室應位於露天甲板上方，並可設在貨物區域內，貨物控制室可以設在起居處所、服務處所或控制站內，但要滿足下列條件：

- .1 貨物控制室是一氣體安全處所；且
- .2.1 如果進口符合 3.2.4 的要求，控制室可以有通到上述處所的通道；

.2.2 如果進口不符合 3.2.4 的要求，控制室不應有通到上述處所的通道，且與這些處所的邊界絕熱應達到“A-60”級完整性。

3.4.2 如果貨物控制室設計成氣體安全處所，其儀錶應儘可能採用非直接讀出系統，且在任何情況下應設計成能防止氣體逃逸至該處所的大氣中。如果氣體探測器是按 13.6.5 安裝的，則其在貨物控制室內的設置應不違反氣體安全處所的要求。

3.4.3 如果裝載可燃貨物船舶的貨物控制室是氣體危險處所，則應排除着火源。應考慮任何電氣設備的安全特性。

### 3.5 進入貨物區域各處所的通道

3.5.1 至少對船體內層結構的一側在任何固定結構或裝置不移去的情況下應能進行目視檢查。如果這一目視檢查只能在內殼的外面一側進行（不論與 3.5.2，4.7.7 或 4.10.16 所要求的檢驗是否聯合進行），內殼不應是燃油艙的邊界壁。

3.5.2 應能對貨艙內絕熱一側進行檢查。如果當液艙處於營運溫度時，絕熱系統的完整性能靠貨艙邊界外側的檢查加以驗證，則不要求檢查貨艙內絕熱一側。

3.5.3 貨艙、空艙、認為有氣體危險的其他處所以及液貨艙的佈置應允許穿著保護服、攜帶呼吸器的人員進入並檢查該處所，並在發生工傷事故時允許把昏迷人員從該處所中救出，還應滿足下列條件：

.1 通道的設置：

.1.1 應直接從開敞甲板通至液貨艙：

- .1.2 應通過水平開口、艙口或人孔，它們的尺寸應足夠能讓攜帶呼吸器的人員無妨礙地上下梯道，並且還應提供一淨開口以便把受傷的人員從處所的底部提升上來，該淨開口的最小尺寸應不小於 600mm x 600mm；及
- .1.3 應通過垂向開口或人孔（供該處所的整個長寬範圍使用），這類開孔的最小淨尺寸應為 600mm X 800mm，離底板的高度不大於 600mm，但設有格柵或其他的立足點除外。
- .2 如果通過這些開口或搬移一個受傷人員的能力可以使主管機關認為滿意，則 3.5.3.1.2 和 .1.3 所述的尺度可以減少。
- .3 3.5.3.1.2 和 .1.3 的要求不適用於 1.3.17.5 所述的處所。這類處所只應設有從開敞露天甲板通達的直接通道或間接通道，不包括圍蔽的氣體安全處所。

3.5.4 從開敞露天甲板到氣體安全處所的通道應設置在高出露天甲板至少 2.4m 的氣體安全區域內，除非該通道採用了按 3.6 規定的空氣閘。

### 3.6 空氣閘

3.6.1 空氣閘只允許設在開敞露天甲板上的氣體危險區域和氣體安全處所之間，空氣閘應有兩扇實質上氣密的鋼門，它們之間的距離至少為 1.5m 但不大於 2.5m。

3.6.2 此類門應是自閉式的，不設任何門背扣裝置。

3.6.3 應給空氣閘兩側配備聲光報警系統，以指示是否有不止一扇門從關閉位置開啓。

3.6.4 在裝載可燃貨品的船上，受空氣閘保護處所內的非認可安全型電氣設備，當該處所發生過壓損耗時應能切斷電路（亦見 10.2.5.4）。供操縱、錨泊和繫泊設備用以及供應急消防泵用的非認可型安全電氣設備，不應該位於受空氣閘保護的處所內。

3.6.5 空氣閘處所應該從某一氣體安全處所進行機械通風，且對開敞露天甲板上的氣體危險區域應保持過壓。

3.6.6 應對空氣閘處所進行貨物蒸氣監督。

3.6.7 按照現行國際載重線公約的要求，門欄的高度應不小於 300mm。

### 3.7 艙底水、壓載和燃油佈置

3.7.1.1 如貨物裝載在不要求設有次屏壁的貨物圍護系統中，貨艙應配備適當的、不與機艙相連接的排水裝置。應有檢測任何泄漏的設施。

3.7.1.2 若有次屏壁，應有適當的排水裝置用來處理通過相鄰船體結構漏進貨艙（或絕熱艙）的污水。吸口不應通到機艙內的泵上。應有檢測此項泄露的設施。

3.7.2 屏壁間處所應設有適合於在液貨艙泄漏或破裂時處理液貨的排泄系統。

3.7.3 若為內層絕熱艙，屏壁間處所和次屏壁與內層船體（或獨立液艙結構）之間的處所不要求設置檢測泄漏的設施和排水裝置，因為這些處所全部充滿了符合 4.9.7.2 要求的絕熱材料。



3.7.4 壓載處所、燃油艙和氣體安全處所可以連接到機艙內的泵上。箱形龍骨可以和機艙內的泵相連接，但其連接管應直接通到泵上。且從泵中排出的水應直接排至舷外，而從箱形龍骨通出的管路和氣體安全處所管路相連接的管路上，不應有任何閥或分配閥箱。泵的出口不應通向機器處所。

### 3.8 艙或艙裝卸裝置

3.8.1 可安裝供艙或艙裝卸貨物用的貨物管系，但應經主管機關的批准和滿足本節要求。

3.8.1.1 通過起居處所、服務處所或控制站的艙或艙裝卸管路不應用來輸送要求 1G 型船的貨品。艙或艙裝卸管路不應用來輸送 1.3.38 規定的毒性貨品，除非獲得了主管機關的特殊認可。

3.8.2 不應允許採用便攜式裝置。

3.8.3 除第 5 章要求外，下列規定適用於貨物管系和有關於的管路設備：

- .1 在貨物區域以外的貨物管系和有關於的管路設備應為全焊接連接。貨物區域外的管路應在開敞甲板上敷設，且在舷內至少 760mm，但橫過船寬的接岸管路除外。此類管路應明顯地加以識別，且在貨物區域內與貨物管系的連接點上應配有截止閥。在此連接點位置上，當不再使用時，應能用一可拆除的短管和盲板法蘭予以隔離。
- .2 此管路應是全焊透對接焊接，且不論其管徑大小和設計溫度多少，應經全部射線探傷。管路上的法蘭接頭只允許設在貨物區域內及設在通岸管接頭處。

- .3 應配有裝置能讓此類管路在使用後洗淨和除氣。當不再使用時，短管應拆去，管端應用盲板法蘭堵住。與清洗用途連在一起的通風管路應設在貨物區域內。

3.8.4 起居處所、服務處所、機器處所和控制站的進口、空氣進口及開口不應面向艙或艙裝卸裝置的通岸接頭處。它們應位於上層建築或甲板室的舷外側，離開的距離至少為船長的 4%，但離面向艙或艙裝卸裝置的貨物通岸管接頭處的艙室端的距離不小於 3m。然而，這個距離不必超過 5m。面向通岸接頭處及上述距離範圍內的上層建築或甲板室兩側的舷窗應該是固定（非開啓）型。此外，在艙或艙裝置使用期間，相應上層建築或甲板室兩側的所有門、舷門及其他開口應保持關閉狀態。如為符合 3.2.4 的小船，且本款要求不可能達到，則主管機關可准許放寬上述要求。

3.8.5 通到離貨物通岸管接頭處 10m 範圍內處所的甲板開口和空氣進口，在艙或艙裝卸裝置使用期間應保持關閉狀態。

3.8.6 離貨物通岸管接頭處 3m 範圍內的電氣設備應該符合第 10 章的要求。

3.8.7 供艙或艙裝卸區域用的消防設備應符合 11.3.1.3 和 11.4.7 的要求。

3.8.8 應提供貨物控制站和通岸管接頭處之間的通信裝置，必要時應為認可的安全型。

## 第 4 章 貨物圍護系統

### 4.1 通則

4.1.1 主管機關應該採取適當步驟確保在實施和應用本章規定\*中的一致性。

4.1.2 除 1.3 中的定義以外，本章給出的定義在整個規則中適用。

### 4.2 定義

#### 4.2.1 整體液艙

4.2.1.1 整體液艙構成船體結構的一部分，並且以相同方式與船體相鄰結構受到同樣載荷的影響。

4.2.1.2 4.2.6 中所定的設計蒸氣壓力  $P_0$  通常不應超過 0.25 bar。如果船體構件尺寸有適當增加， $P_0$  亦可相應增加到某一較大數值，但應小於 0.7 bar。

4.2.1.3 如果貨物沸點不低於  $-10^{\circ}\text{C}$ ，則可用整體液艙來裝載這些貨物。經過主管機關的特殊考慮，也可採用較低溫度。

#### 4.2.2 薄膜液艙

4.2.2.1 薄膜液艙是非自身支持的艙，它由鄰接的船體結構通過絕熱層支持的一層薄膜所組成。薄膜的設計方式應使熱膨脹和其他膨脹（或收縮）得到補償，免受過大的薄膜應力。

4.2.2.2 設計蒸氣壓力  $P_0$  通常不應超過 0.25 bar。如果船體結構尺寸有適當增加，並且對支持的絕熱層強度作了適當考慮， $P_0$  可相應增

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\* 應參考國際船級社協會（IACS）會員社及聯繫會員社所發表的規範，特別是 IACS 的統一要求 NOS.G1 和 G2。

加到某一較高值，但應低於 0.7 bar。

4.2.2.3 薄膜液艙的定義並不排斥這些設計，例如應用非金屬薄膜或用包括或合併在絕熱層中的薄膜。但是這些設計應經主管機關特殊考慮。薄膜厚度，在任何情況下，一般應不超過 10mm。

#### 4.2.3 半薄膜液艙

4.2.3.1 半薄膜液艙是裝載狀態下非自身支持的艙，它包含有一薄層，其中一部分由相鄰船體結構通過絕熱層支持，而且與上述支持部分相連接的這一薄層的圓形部分也應設計成能承受熱膨脹和其他膨脹（或收縮）。

4.2.3.2 設計蒸氣壓力通常不應超過 0.25 bar。然而，如果船體構件有適當增加，並且對支持的絕熱層強度作了適當考慮， $P_0$  可相應增加到某一較高數值，但應低於 0.7 bar。

#### 4.2.4 獨立液艙

4.2.4.1 獨立液艙是自身支持的，它不構成船體結構的一部分，及對船體強度不是主要的。獨立液艙共有三類，分別在 4.2.4.2 至 4.2.4.4 中敘述。

4.2.4.2 A 型獨立液艙，其設計主要應用經典的船舶結構分析程序的承認的標準<sup>\*</sup>，如果這類液艙主要是由平面構成（重力液艙），則其設計蒸氣壓力  $P_0$  應該低於 0.7 bar。

4.2.4.3 B 型獨立液艙，其設計應用模型試驗，精確分析手段和分析方法確定應力大小，疲勞壽命和裂紋擴展特性。如果這類液艙主要由

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\* 第 4、5 和 6 章承認的標準是指主管機關承認的船級社所制訂和保留的標準。

平面構成（重力液艙），則其設計蒸氣壓力  $P_0$  應低於 0.7 bar。

4.2.4.4 C 型獨立液艙（亦稱受壓容器），它是符合受壓容器標準的液艙，其設計蒸氣壓力不小於：

$$P_0 = 2 + AC(P_r)^{1.5} \quad (\text{bar})$$

式中：
$$A = 0.0185 \left( \frac{\sigma_m}{\Delta\sigma_A} \right)^2$$

其中：

$\sigma_m$  = 設計第一類薄膜應力

$\Delta\sigma_A$  = 許用薄膜動應力（全幅，當概率範圍為  $Q = 10^{-8}$  時）

55 N/mm<sup>2</sup>，對鐵素體／馬氏體鋼

25 N/mm<sup>2</sup>，對鋁合金（5083-0）

C = 特徵液艙的尺度，取下列值中的最大值：

$$h ; 0.75b ; \text{ or } 0.45\ell$$

其中：

h = 液艙高度（沿船舶垂向量取）（m）

b = 液艙寬度（沿船舶橫向量取）（m）

$\ell$  = 液艙長度（沿船舶縱向量取）（m）

$P_r$  = 設計溫度下貨物的相對密度（淡水： $P_r = 1$ ）。

但是，主管機關根據液艙的形狀及其支承裝置和連接件，可把滿足本分段標準的液艙歸屬 A 型或 B 型。

#### 4.2.5 內部絕熱液艙

4.2.5.1 內部絕熱液艙為非自身支持，由適合於貨物圍護系統的絕熱材料所組成，受到鄰接的內層船體結構或獨立液艙的支持。絕熱層的內表面與貨物直接接觸。

4.2.5.2 兩類內部絕熱液艙是：

- .1 1 型液艙，係指艙內的絕熱層或絕熱層和一層或多層襯裏組合絕熱層只起到主屏壁的作用。必要時，內層船體或獨立液艙結構應起到次屏壁作用。
- .2 2 型液艙，係指艙內絕熱層或絕熱層和一層或多層襯裏組合絕熱層能同時起到主屏壁和次屏壁的作用，而且這些屏壁可以清楚地識別。

“襯裏”一詞係指一層薄的非自身支持的金屬、非金屬或複合材料構成內層絕熱液艙的一部分，使提高抗斷能力或其他機械性能。襯裏不同於薄膜，因為它不單獨作為液體屏壁。

4.2.5.3 內層絕熱液艙應該採用合適的材料建造，使貨物圍護系統能按 4.4.7 所要求的模型試驗和精確的分析方法進行設計。

4.2.5.4 設計蒸氣壓力  $P_0$  通常不應超過 0.25 bar。如果貨物圍護系統的設計用於較高蒸氣壓力時， $P_0$  值可以提高；但若內層絕熱液艙是由內層船體結構支持，則  $P_0$  不應超過 0.7 bar。假如內層絕熱液艙受到獨立液艙結構的適當支持，則主管機關可以接受大於 0.7 bar 的設計蒸氣壓力。

#### 4.2.6 設計蒸氣壓力

4.2.6.1 設計蒸氣壓力  $P_0$  是液艙頂部的最大表壓力，它在液艙設計中已被使用。

4.2.6.2 對於沒有溫度控制以及貨物壓力只是由環境溫度支配的液貨艙， $P_0$  不應該低於貨物處於溫度 45°C 時的蒸氣表壓力。然而，對於限制航區運行或在限制期限內航行的船舶，主管機關可以接受一個較低的溫度值，且在這種情況下，可以把液艙中的任一絕熱層考慮進去。相反，對於一直運行在較高環境溫度區域的船舶可以要求一個較高的溫度值。

4.2.6.3 包括 4.2.6.2 在內的所有情況下， $P_0$  不應低於釋放閥設定的最大許用值 MARVS。

4.2.6.4 經主管機關特別考慮，並符合 4.2.1 到 4.2.5 對各類液艙所規定的限制條件，在港內條件下，如果動力荷重得到減少，可以允許採用比  $P_0$  高的蒸氣壓力。

#### 4.2.7 設計溫度

供選擇材料用的設計溫度是在液艙內貨物可以載運的最低溫度。應有使主管機關滿意的措施確保液艙或貨物溫度不下降到設計溫度以下。

#### 4.3 設計載荷

##### 4.3.1 一般要求

4.3.1.1 液艙連同其支持構件以及其他附件的設計，應考慮下列載荷的適當組合：

內部壓力

外部壓力

船舶運動引起的動載荷

熱載荷

晃動載荷

船舶撓曲引起的載荷

在支持構件部位的液艙和貨物重量以及相應的反作用力

絕熱層重量

作用在塔架和其他連接附件處的載荷。

這些載荷的範圍應根據液艙的型式加以考慮，並在下列各款中作詳細的說明。

4.3.1.2 應計及 4.10 所述相應於壓力試驗時的載荷。

4.3.1.3 應計及 4.2.6.4 所述在港內條件下蒸氣壓力的增加。

4.3.1.4 液艙的設計應考慮最不利的橫傾從 0°到 30°，並不超過 4.5.1 所規定的許用應力。

#### 4.3.2 內部壓力

4.3.2.1 設計蒸氣壓力  $P_0$  引起的內部壓頭  $h_{eq}$  (bar 表壓) 和 4.3.2.2 所述的液體壓力  $h_{gd}$ ，不包括液體晃動的影響，應按下式計算：

$$h_{eq} = P_0 + (h_{gd})_{max} \text{ (bar)}$$

等效的計算方法也可以採用。



4.3.2.2 內部液體壓力是指由於 4.3.4.1 所述的船舶運動引起貨物重心加速度所產生的壓力。由重力和動加速度聯合作用引起的內部壓頭  $h_{gd}$  應按下式計算：

$$h_{gd} = a_{\beta} z_{\beta} \frac{\rho}{1.02 \times 10^4} (\text{bar})$$

式中：

$a_{\beta}$  = 由重力或動載荷在任意方向  $\beta$  上引起的無因次加速度(相對於重力加速度)(見圖 4.1)。

$z_{\beta}$  = 須決定壓力的點以上的最大液柱高度 (m)，在  $\beta$  方向上量自液艙殼體(見圖 4.2)。不作為液貨艙總體積一部分的艙頂小氣室，在確定  $z_{\beta}$  時可不予考慮。

$\rho$  = 設計溫度下的貨物最大密度 ( $\text{kg/m}^3$ )

應該考慮給出  $h_{gd}$  最大值的 ( $h_{gd}$ )<sub>max</sub> 方向。如需要考慮三個方向的加速度，應採橢球替代圖 4.1 中的橢圓。上述公式僅適用於注滿的液艙。

#### 4.3.3 外部壓力

外部設計壓力載荷，應根據最小內部壓力(最大真空度)和液艙的任何部分可能同時承受的最大外部壓力之間的差值予以確定。

#### 4.3.4 船舶運動引起的動載荷

4.3.4.1 動載荷的確定應計及船舶在其使用壽命期間所經受的船舶運動的長期分佈，包括不規則海況中的縱蕩、橫蕩、垂蕩、橫搖、縱搖和艏搖等的影響(通常取為相當於  $10^8$  次波遇)。由於採取必要的減

速和船艏方向的變化，可以考慮減少動載荷，如果這種考慮是已作為船體強度評定的一個組成部分。

4.3.4.2 為防止塑性變形和屈曲的設計，動載荷應取船舶使用壽命期間（通常取為相當於  $10^{-8}$  的概率範圍）可能遇到的最大載荷。加速度分量的指導公式見 4.12。

4.3.4.3 如要考慮疲勞的設計，動載譜應根據船舶使用壽命期間的長期分佈計算加以確定（通常取為相當於  $10^8$  次波遇）。若採用簡化的動載譜來估算疲勞壽命，則這些動載譜應經主管機關特別考慮。

4.3.4.4 為了裂紋擴展估算的實際應用，可以採用十五天為一期的簡化載荷分佈圖，這類載荷分佈取自圖 4.3。

4.3.4.5 限制航區的船舶可給與特別考慮。

4.3.4.6 作用在液艙上的加速度應在其重心上加以估算，它包括下列分量：

垂向加速度：垂蕩，縱搖及可能還有橫搖引起的運動加速度（垂直於船舶基線）；

橫向加速度：橫蕩，艏搖和橫搖的運動加速度；以及橫搖的重力分量；

縱向加速度：縱蕩和縱傾的運動加速度；以及縱搖的重力分量。

#### 4.3.5 晃動載荷

4.3.5.1 對於擬作部分注滿的液艙，應考慮由於 4.3.4.6 所述任何一種運動引起的重大晃動載荷所造成的危險性。

4.3.5.2 如發現具有重大的晃動誘發載荷的危險性，則應要求做專門的試驗和計算。

#### 4.3.6 熱載荷

4.3.6.1 對擬載運貨物溫度低於-55°C 的液艙，應考慮冷卻期間的瞬時熱載荷。

4.3.6.2 如設計的支持設施以及運行溫度可能引起重大熱應力時，對於這類液艙應考慮固定熱載荷。

#### 4.3.7 支持構件上的載荷

作用在支持構件上的載荷，見 4.6 規定。

### 4.4 結構分析

#### 4.4.1 整體液艙

整體液艙的結構分析應按照承認的標準。液艙界限的結構尺寸，計及 4.3.2 規定的內壓力，至少應滿足深艙的要求，但最終的結構尺寸應不小於這些標準的要求。

#### 4.4.2 薄膜液艙

4.4.2.1 對薄膜液艙，應該考慮所有靜、動載荷的影響，以確定薄膜及相聯的絕熱層對塑性變形和疲勞的適應性。

4.4.2.2 在給出認可以前，通常應對既有主屏壁又有次屏壁，包括角隅和接頭在內的模型進行試驗，以驗證這些結構能承受靜、動和熱載荷引起的組合應變。試驗條件應該代表貨物圍護系統在其使用壽命中可能遇到的最嚴重運行條件。材料試驗應確保時效不妨礙材料發揮它預期的功能。

4.4.2.3 為了進行 4.4.2.2 所述的試驗，應該對船舶和貨物圍護系統的具體運動、加速度和響應作一完整的分析，除非這些數據是從相似船舶中獲得的。

4.4.2.4 應該特別注意薄膜的可能破壞，這些破壞是由於屏壁間的超壓、液貨艙的真空、液貨晃動的影響及船體振動的影響而引起。

4.4.2.5 計及 4.3.2 所述的內部壓力的船體的結構分析，應使主管機關滿意。然而，應特別注意對船體撓曲以及它們與薄膜和相聯的絕熱層的一致性。內層船殼板厚度，在考慮了 4.3.2 所述的內部壓力後，應至少滿足承認的標準對深艙的要求。薄膜、薄膜支持構件材料和絕熱層的許用應力應根據每一具體情況加以確定。

#### 4.4.3 半薄膜液艙

計及 4.3.2 所述內部壓力的結構分析，應按對薄膜液艙或獨立液艙的要求（如適合時）進行。

#### 4.4.4 A 型獨立液艙

4.4.4.1 計及 4.3.2 所述內部壓力的結構分析，應使主管機關滿意。液貨艙板厚，計及 4.3.2 所述內部壓力以及 4.5.2 所要求的腐蝕餘量，應至少滿足承認的標準對深艙的要求。

4.4.4.2 在承認的標準中沒有包括的某些部件諸如在支持構件處的結構，其應力在儘可能考慮 4.3 所述的載荷和支持構件處的船舶撓曲後，應按直接計算法確定。

#### 4.4.5 B 型獨立液艙

對這類液艙適用下列情況：

- .1 動、靜載荷的影響應用來決定結構對下列內容的適應性：

塑性變形

屈曲

疲勞破壞

裂紋擴展。

按照 4.3.4 有限元分析法或類似的方法、斷裂力學分析法或其他相當的分析方法進行統計波浪載荷的分析。

- .2 應採用三維分析法評定船體上的應力程度。這種分析模型應包括帶有支持構件的液貨艙，鍵固系統以及船體的其他適當部分。
- .3 對在不規則波浪上具體船舶的加速度和運動，以及船舶及其液貨艙對這些力和運動的響應，應作一完整的分析。除非這些數據是從相似船舶獲得的。
- .4 屈曲分析應考慮最大的建造公差。
- .5 如主管機關認為有必要，為了確定應力集中系數和結構構件的疲勞壽命，可要求做模型試驗。
- .6 疲勞載荷的積累效應應符合：

$$\sum \frac{n_i}{N_i} + \frac{10^3}{N_j} \leq C_w$$

式中：

$n_i$  = 船舶壽命期間每一應力級上的應力循環次數

$N_i$  = 按照韋勒 (S - N) 曲線，相應應力級達到斷裂時的循環次數

$N_j$  = 加載和卸載的疲勞載荷達到斷裂時的循環次數

$C_w$  = 應小於或等於 0.5；對取用大於 0.5 的值，主管機關可給與特別的考慮，但不應小於 1.0，此種情況均取決於建立韋勒 (S - N) 曲線時所用的試驗方法和數據。

#### 4.4.6 C 型獨立液艙

4.4.6.1 根據內部壓力確定的結構尺寸應該按如下計算：

- .1 承受內壓包括法蘭在內的受壓容器，其受壓部件的厚度和形狀，應按主管機關可接受的標準予以確定。在所有情況下，這些計算按照一般認可的受壓容器設計原理。受壓容器中受壓部件的開口應按主管機關可接受的標準進行加強。
- .2 在上述計算中應考慮 4.3.2 所述的液體設計壓力。
- .3 按 4.10.9 規定進行檢查和無損探傷，在計算中的焊接效率，應按 4.4.6.1.1 規定取 0.95。若考慮了其他因素，例如所使用的材料、接頭型式、焊接程序以及載荷型式等，焊接效率可以增大到 1.0。對於處理受壓容器，主管機關可以接受局部無損探傷，但應不少於 4.10.9.2.2 的規定，這些規定取決於這些因素，例

如採用的材料、設計溫度、製造材料的零韌性轉變溫度、接頭型式和焊接程序等，但此時焊縫效率在任何情況下，應不大於 0.85。對於特殊材料，上述效率應予減小、根據焊接接頭規定的機械性能而定。

#### 4.4.6.2 屈曲標準應如下：

- .1 承受外壓和使受壓縮應力的其他載荷的受壓容器，其厚度和形狀應符合主管機關可接受的標準，在所有情況下，均應按照可接受的一般受壓容器屈曲理論進行這些計算，並應充分考慮到理論和實際屈曲應力值之間的差別；這些差別是由於板邊不對準，以及在規定的弧長（或弦長）範圍內有橢圓度或失圓度等引起。
- .2 用來驗算受壓容器屈曲的計算壓力  $P_e$  應不小於下式給出的值：

$$P_e = P_1 + P_2 + P_3 + P_4 \text{ (bar)}$$

式中：

$P_1$  = 真空釋放閥的設定壓力。對不配備真空釋放閥的容器， $P_1$  應作特別考慮，但一般應取不小於 0.25 bar。

$P_2$  = 容納受壓容器或部分受壓容器的完全封閉處所的壓力釋放閥設定壓力；其他部位  $P_2 = 0$ 。

$P_3$  = 由絕熱層的重量和收縮、殼體重量（包括腐蝕餘量）及受壓容器可能受到的其他載荷等作用在殼體上的壓縮力。這些壓力包括（但不限於）氣室的重量、塔架和管路的重量、部分注滿

條件下貨品的效應以及加速度和船體的撓曲。此外，還應考慮外部壓力或內部壓力或兩者的局部影響。

$P_4$  = 露天甲板上受壓容器或部分受壓容器的水柱引起的外部壓力；其他部位  $P_4 = 0$ 。

4.4.6.3 關於靜、動載荷應該按以下規定進行分析：

- .1 受壓容器的結構尺寸應該按 4.4.6.1 和 .2 的規定。
- .2 在支持構件處及殼體支持連接件處應進行載荷和應力計算。如適用，應採用 4.3 中的載荷。支持構件處的應力應符合主管機關可接受的標準。在特殊情況下，主管機關可要求作疲勞分析。
- .3 如主管機關要求，應特別考慮第二類應力和熱應力。

4.4.6.4 對受壓容器，按 4.4.6.1 計算得到的厚度，或 4.4.6.2 所要求的厚度加上腐蝕餘量（如有時），應看作為最小值，不應有負公差。

4.4.6.5 加工成形後的受壓容器，其殼體和封頭的最小厚度，包括腐蝕裕度，對碳錳鋼和鎳鋼應不小於 5 mm；對奧氏體鋼 3 mm；鋁合金 7 mm。

#### 4.4.7 內層絕熱液艙

4.4.7.1 應考慮所有靜、動載荷的影響以確定液艙對下列因素的適用性：

疲勞破壞

從自由表面和支持表面的裂紋擴展



壓縮、拉伸和剪切強度。

應該採用按 4.3.4 的統計波浪載荷分析法、有限元分析法或其他類似方法，以及斷裂力學分析法或其他等效方法進行分析。

4.4.7.2.1 應該特別注意抗裂和內層船體或獨立液艙結構的撓曲及其絕熱材料的一致性。應進行三維結構分析使主管機關滿意。這個分析是為了評定內層船體或獨立液艙結構（或兩者）的應力級和變形，分析時應考慮到 4.3.2 所述的內部壓力。

如壓載水艙鄰接於構成內層絕熱液艙支持構件的內層船體，則其分析應考慮到壓載水在船舶運動影響下而引起的動載荷。

4.4.7.2.2 內層絕熱液艙和內層船體結構或獨立液艙結構的許用應力及其相關的撓曲，應按每一具體情況予以確定。

4.4.7.2.3 內層船體的板厚或獨立液艙的板厚，在考慮了 4.3.2 所述的內部壓力後，應至少符合承認的標準要求。平面結構液艙至少應符合對深艙的承認的標準要求。

4.4.7.3 船舶、貨物 and 任何壓載對某一具體船舶在不規則波浪上的加速度和運動的響應，應作一完整的分析，並使主管機關滿意，除非這些數據是取自類似船舶的。

4.4.7.4.1 為了確認設計原理，包括結構元件在內的複合模型的原型試驗應在靜、動載荷和熱載荷聯合作用下進行。

4.4.7.4.2 試驗條件應代表貨物圍護系統在船舶使用壽命期間所經受的最嚴重情況，包括熱循環。為此，根據每年 19 個來回航次，至少應考慮 400 次熱循環。如預計每年超過 19 個來回航次，將要求更高

的熱循環次數。這 400 次熱循環可分成 20 個完整循環（貨物溫度達 45°C）及 380 個部分循環（貨物溫度達到壓載狀態航行時預計到達的溫度）。

4.4.7.4.3 模型應能代表實際構造，包括角隅、接頭、泵座、管路貫通件及其他關鍵性區域，並應考慮材料性能、工藝和質量控制方面的任何變化。

4.4.7.4.4 應該進行拉伸和疲勞的聯合試驗，以評定內層船體或獨立液艙結構有穿透性裂紋擴展時絕熱材料的裂紋動態。在這些試驗中，如可行，裂紋區域應經受壓載水的最大靜水壓力。

4.4.7.5 疲勞載荷的影響應按 4.4.5.6 的規定或等效方法予以確定。

4.4.7.6 對於內部絕熱液艙，修補程序應在絕熱材料和內層船體或獨立液艙結構的原型試驗期間制訂出來。

#### 4.5 許用應力和腐蝕餘量

##### 4.5.1 許用應力

4.5.1.1 對於獨立液艙，許用應力通常應是承認的標準對船體結構所給的許用應力。

4.5.1.2 對薄膜液艙，應參考 4.4.2.5 的要求。

4.5.1.3 對主要由平面結構組成的 A 型獨立液艙，其主要構件和次要構件（加強材、強肋骨、縱桁、縱材）的應力，如按經典分析方法計算，對碳錳鋼和鋁合金應不超過  $R_m/2.66$  或  $R_e/1.33$  的較低值，其中的  $R_m$  和  $R_e$  見 4.5.1.7 的定義。然而，如對主要構件進行了詳細計算，4.5.1.8 中的相當應力  $\sigma_e$  可比上述數值增加至主管機關可接受的應

力；計算時應考慮到彎曲、剪切、軸向和扭轉變形以及由於雙層底和液貨艙底的撓曲而引起的船體／液貨艙的相互作用力。

4.5.1.4 對主要由回轉體結構組成的 B 型獨立液艙，其許用應力應不超過。

$$\sigma_m \leq f$$

$$\sigma_L \leq 1.5f$$

$$\sigma_b \leq 1.5F$$

$$\sigma_L + \sigma_b \leq 1.5F$$

$$\sigma_m + \sigma_b \leq 1.5F$$

式中：

$\sigma_m$  = 相當第一類薄膜總應力

$\sigma_L$  = 相當第一類薄膜局部應力

$\sigma_b$  = 相當第一類彎曲應力

$$f = \frac{R_m}{A} \text{ 或 } \frac{R_e}{B}, \text{ 取其小者}$$

$$F = \frac{R_m}{C} \text{ 或 } \frac{R_e}{D}, \text{ 取其小者}$$

$R_m$  和  $R_e$  見 4.5.1.7 的定義。 $\sigma_m$ ， $\sigma_L$  和  $\sigma_b$  見 4.13 應力分類定義。 $A$ ， $B$ ， $C$  和  $D$  值應在國際散裝運輸液化氣體適裝證書上註明，至少應不少於下列最小值：

	鎳鋼和碳錳鋼	奧氏體	鋁合金
A	3	3.5	4
B	2	1.6	1.5
C	3	3	3
D	1.5	1.5	1.5

4.5.1.5 對主要由平面結構組成的 B 型液艙，主管機關可要求滿足額外的或其他應力標準。

4.5.1.6 對 C 型獨立液艙，按 4.4.6.1.1 計算中所採用的最大許用薄膜應力應取下列較小者：

$$\frac{R_m}{A} \text{ 或 } \frac{R_e}{B}$$

式中：

$R_m$  和  $R_e$  見 4.5.1.7 定義。

(A 和 B 值應在 1.5 所提供的國際散裝運輸液化氣體適裝證書中註明，且至少應有 4.5.1.4 表中所給的最小值。

4.5.1.7 下列定義適用於 4.5.1.3，4.5.1.4 和 4.5.1.6：

- .1  $R_e$  = 室溫下屈服應力下限值 ( $N/mm^2$ )。如應力—應變曲線上無明顯的屈服應力，可採用 0.2% 的條件屈服應力。

$R_m$  = 室溫下抗拉強度下限值 ( $N/mm^2$ )。

對鋁合金焊接件，應採用退火狀態下的  $R_e$  和  $R_m$  的相應值。

- .2 上述性解應和材料的機械性能下限值相一致，包括製造狀態的焊接金屬。經主管機關的特殊考慮，可在低溫下提高屈服應力和抗拉強度。定作材料性能依據的溫度應該在 1.5 提供的國際散裝運輸液化氣體證書中註明。

4.5.1.8 相當應力  $\sigma_c$  ( von Mises , Huber ) 應按下式確定 :

$$\sigma_c = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3\tau_{xy}^2}$$

式中 :

$\sigma_y$  = x 方向的總正應力

$\sigma_x$  = y 方向的總正應力

$\tau_{xy}$  = x - y 平面內的總剪應力。

4.5.1.9 當靜應力和動應力進行分別計算，且除非有其他計算方法證明恰當時，則總應力可按下式計算：

$$\sigma_x = \sigma_{x.st} \pm \sqrt{\sum (\sigma_{x.dyn})^2}$$

$$\sigma_y = \sigma_{y.st} \pm \sqrt{\sum (\sigma_{y.dyn})^2}$$

$$\tau_{xy} = \tau_{xy.st} \pm \sqrt{\sum (\tau_{xy.dyn})^2}$$

式中 :

$\sigma_{x.st}$  ,  $\sigma_{y.st}$  和  $\tau_{xy.st}$  = 靜應力

$\sigma_{x.dyn}$  ,  $\sigma_{y.dyn}$  和  $\tau_{xy.dyn}$  = 動應力

都從加速度分量和因撓曲和扭轉引起的船體應變分量中單獨確定。

4.5.1.10 對內層絕熱液艙，應參考 4.4.7.2 的要求。

4.5.1.11 使用第 6 章規定外的材料的許用應力，每種情況均應徵得主管機關的批准。

4.5.1.12 應力可能更會被疲勞分析、裂紋擴展分析和屈曲標準所限制。

#### 4.5.2 腐蝕餘量

4.5.2.1 一般在結構分析的厚度中，不應再有任何腐蝕餘量要求。然而，如果在液貨艙周圍無環境控制，如惰性化，或貨物是帶腐蝕性的，則主管機關可要求加適當的腐蝕餘量。

4.5.2.2 如果受壓容器內所裝貨物是非腐蝕性的及外表面由惰性氣保護，或由具有認可型蒸氣屏適當的絕熱層保護，則受壓容器一般不要求加腐蝕餘量。油漆或其他薄的塗層不能看作是保護層。如果採用了具有認可型抗腐蝕性能的特殊合金，不應要求有任何腐蝕餘量。假如上述條件不滿足，按 4.4.6 算得的結構尺寸應適當增加。

#### 4.6 支持構件

4.6.1 貨物液艙應由船體支持，使在受到靜、動載荷作用下能防止液艙本體的移動，但允許液艙在溫度變化和船體撓曲時可以收縮和膨脹，而不引起船體和液艙的過大應力。

4.6.2 設計具有支持構件的液艙應適應橫傾 30°，不超出 4.5.1 規定的許用應力。

4.6.3 支持構件的設計應考慮由於轉動和移動的影響而可能引起的最大合成加速度。在給定方向上的這個加速度可按圖 4.1 予以確定。

“加速度橢圓”的半軸應按 4.3.4.2 確定。

4.6.4 應設置適當的支持構件以承受作用在液艙上的碰撞力（此力相當於 $\frac{1}{2}$ 液艙和貨物重量的向前衝力，以及 $\frac{1}{4}$ 液艙和貨物重量的向後衝力），使不產生可能危及液艙結構的變形。

4.6.5 4.6.2 和 4.6.4 所述的載荷不需相互組合，也不需和波浪誘發載荷相組合。

4.6.6 對獨立液艙，如適合，也對薄膜液艙或半薄膜液艙，應採取措施用鍵固定液艙，防止 4.6.3 所述的轉動影響。

4.6.7 獨立液艙應設置防浮裝置。此防浮裝置應能承受某一貨艙進水至船舶夏季載重吃水時由一個空液艙引起的向上力，不致產生可能危及船體結構的塑性變形。

#### 4.7 次屏壁

4.7.1 如在大氣壓力下貨物溫度低於 $-10^{\circ}\text{C}$ ，應按 4.7.3 要求設立次屏壁，作為液貨可能從主屏壁泄漏出來的臨時圍護設施。

4.7.2 如在大氣壓力下貨物溫度不低於 $-55^{\circ}\text{C}$ ，則船體結構可作為次屏壁。

在這種情況下：

- .1 船體材料應按 4.9.2 的要求，適合於在大氣壓力下貨物的溫度；及
- .2 該設計應使此溫度不會造成不能接受的船體應力。

4.7.3 與液艙型式有關的次屏壁通常應按下表設置。對於不同於 4.2 所定義的基本液艙型式的液艙，次屏壁要求應根據每一具體情況由主管機關確定。

大氣壓力下的貨物溫度	-10°C 及以上	-10°C 至 -55°C	-55°C 以下
基本液艙型式	不要求次屏壁	船體可作為次屏壁	單獨設立次屏壁（如需要時）
整體 薄膜 半薄膜 獨立液艙 A 型 B 型 C 型 內層絕熱液艙 1 型 2 型		通常不許可的液艙型式 <sup>1</sup> 完整的次屏壁 完整的次屏壁 <sup>2</sup>  完整的次屏壁 部分的次屏壁 不要求次屏壁  完整的次屏壁 結合成一體的次屏壁	

4.7.4 次屏壁的設計應為：

- .1 在考慮了 4.3.4.4 所述的載荷譜後，能容納預計泄漏的液貨達 15 天，但對於有不同要求的特別航程除外；
- .2 按 4.8.2 所指的主屏壁出現泄漏時，應能防止船體結構的溫度下降到不安全的程度；以及
- .3 主屏壁的破壞機理不會引起次屏壁的破壞，反之亦然。

4.7.5 次屏壁應能在船舶橫傾角 30°時完成它的功效。

<sup>1/</sup> 按 4.2.1.3 規定，如允許在大氣壓力下的貨物溫度低於 -10°C，通常應要求完整的次屏壁。

<sup>2/</sup> 如半薄膜液艙在各方面均能適合於 B 型獨立液艙的要求（支持方式除外），主管機關經特別考慮後可同意設立部分的次屏壁。



4.7.6.1 如要求設置部分次屏壁時，其設置範圍應根據主屏壁主要泄漏的初始探測，按 4.3.4.4 所述的載荷譜所造成的破壞範圍內相對應的貨物泄漏量加以確定。可適當計及液體蒸發、泄漏率、泵容量及其他有關因素。在所有情況下，液貨艙處的內底應設有防止液貨的保護設施。

4.7.6.2 次屏壁範圍以外的處所，應設有類似防濺屏障的設施，以使液貨擋回流入主屏壁和次屏壁之間的處所，並使船體結構溫度保持在安全程度上。

4.7.7 應能對次屏壁的有效性作定期檢查，檢查方法可以採用壓力真空試驗、外表檢查或主管機關認為適當的其他方法。所採用的方法應提交主管機關審批。

## 4.8 絕熱

4.8.1 如果運載的貨品溫度在 $-10^{\circ}\text{C}$ 以下，則應設置適當的絕熱層以確保船體溫度不會下降到第 6 章對有關鋼級規定的最小許用工作溫度以下，詳見 4.9，此時的液貨艙處在設計溫度下，其環境溫度空氣為 $5^{\circ}\text{C}$ （海水為 $0^{\circ}\text{C}$ ）。這些條件一般可適用於環球航區。但對運行在限制航區的船舶，主管機關可允許採用較高的環境溫度值。相反，對偶爾或有規律地運行在冬季月份可能遇到較低溫度的緯度區域的船舶，主管機關可規定低的環境溫度。設計中所選用的環境溫度應在 1.5 所述的國際散裝運輸液化氣體適裝證書中註明。

4.8.2 如果要求設置完整的或部分的次屏壁，則應按 4.8.1 的假設進行計算，以校核船體的溫度不會下降到第 6 章對有關鋼級規定的最小許用工作溫度以下，詳見 4.9。完整或部分的次屏壁應假定處於大氣壓力下的貨物溫度。

4.8.3 按 4.8.1 和 4.8.2 要求進行的計算應假定空氣和水是靜止的，除 4.8.4 所允許的以外，加熱的方式均不足以相信。如為 4.8.2 所述的情況，泄漏貨物蒸發產生的冷卻效應在熱傳導分析中應加以考慮。對於連接內外層殼體的構件，確定鋼材級別時可取平均溫度。

4.8.4 在 4.8.1 和 4.8.2 所述的情況中以及對於空氣為 $5^{\circ}\text{C}$ 和海水為 $0^{\circ}\text{C}$ 的這種環境溫度條件，可以採用認可的方法對船體橫向結構材料加熱，以確保這些材料的溫度不下降到最小值的允許值以下。如果規定了較低的環境溫度，亦可以採用認可的方法對船體縱向構件材料加熱，但這些材料如不加熱也能保持適合於空氣為 $5^{\circ}\text{C}$ 和海水為 $0^{\circ}\text{C}$ 的溫度條件。這些加熱方式應滿足下列要求：

- .1 應有足夠的熱量可用來使船體結構溫度在 4.8.1 和 4.8.2 所述的條件下仍能高出最小的許用溫度；
- .2 加熱系統應佈置成當該系統的任一部分失效時，備用加熱可保持不低於 100%理論熱載荷，
- .3 加熱系統應被認為是一個主要的輔助設備；
- .4 加熱系統的設計和構造應使主管機關滿意。

4.8.5 在確定絕熱層厚度時，應適當注意可接受的蒸發量以及船上的再生液化裝置、主推進機械或其他溫度控制系統。

#### 4.9 材料

4.9.1 船體外板和甲板板以及所附連的加強材應符合承認的標準，除非由於低溫貨物的影響在設計條件下的材料設計溫度處在  $-5^{\circ}\text{C}$  以下，此時材料應按表 6.5 的規定，假定周圍海水和空氣的溫度分別為  $0^{\circ}\text{C}$  和  $5^{\circ}\text{C}$ 。在設計條件下，應假定完整的和部分的次屏壁是處於大氣壓力下的貨物溫度狀態，對於沒有設置次屏壁的液艙，應假定主屏壁是處於貨物溫度狀態。

4.9.2 構成次屏壁的船體材料應符合表 6.2 的要求，不構成船體結構一部分但用在次屏壁中的金屬材料應根據情況按表 6.2 或 6.3 的規定（如適用時）。構成次屏壁的絕熱材料應符合 4.9.7 的要求。若次屏壁是由甲板或舷側外板構成，則表 6.2 所要求的材料級別應不同程度地延伸到鄰接的甲板或舷側外板上（如適用時）。

4.9.3 液貨艙結構中採用的材料應按 6.1，6.2 或 6.3 的規定。

4.9.4 非 4.9.1, 4.9.2 和 4.9.3 所述的材料用於建造遵守因貨物而減低溫度以及不構成次屏壁的船舶, 對 4.8 確定的溫度應按表 6.5 的規定。這些包括內底板、縱艙壁板、橫艙壁板、肋板、深桁材、水平桁材以及所有附連的加強構件。

4.9.5 絕熱材料應適合於其相鄰結構可能施加的載荷。

4.9.6 如可行, 由於位置或環境條件的關係, 絕熱材料應有適當的阻火和防火焰傳播的性能, 並應有足夠的保護水汽滲透和防止機械損傷的措施。

4.9.7.1 用作絕熱的材料, 應對下列性能作試驗 (如適用時), 以確保它們適合於預定的用途:

- .1 與貨物的一致性
- .2 在貨物中的可溶性
- .3 貨物的吸收作用
- .4 收縮量
- .5 時效
- .6 孤立氣泡率
- .7 密度
- .8 機械性能
- .9 熱膨脹
- .10 磨耗性

- .11 黏結力
- .12 熱傳導性
- .13 抗振
- .14 阻火和防火焰傳播。

4.9.7.2 除滿足上述要求以外，構成 4.2.5 所述的貨物圍護一部分的絕熱材料，應在模擬時效和熱循環後，對下列性能進行試驗，以確保它們適合於預定的用途：

- .1 黏接（黏附和黏結強度）
- .2 貨物壓力的耐壓能力
- .3 疲勞和裂紋擴展性能
- .4 貨物組成物和其他添加劑與預計在正常工作下要和絕熱層相接觸的一致性
- .5 如適用時，應計及有水和水壓力存在時絕熱性能的影響
- .6 氣體拒吸性。

4.9.7.3 上述性能，如適用時，應在營運中預計出現的最高溫度和最低設計溫度以下 5°C 之間的範圍內進行試驗，但不低於 -196°C。

4.9.8 絕熱材料的加工製造、貯存、裝卸、安裝、質量控制以及有害的露於陽光下的控制，應使主管機關滿意。

4.9.9 當採用粉末或粒狀絕熱材料時，其佈置應能防止振動而使材料壓實，這種設計應結合措施確保材料有足夠的浮力以保持所需的熱傳導性，同時也能防止圍護系統中壓力不適當的增加。

#### 4.10 構造和試驗

4.10.1.1 獨立液艙殼體的所有焊接接頭應為對接焊、全焊透型。對於氣室和殼體的連接，主管機關可以批准採用全焊透 T 型焊接。除氣室上的小貫穿件外，噴嘴焊縫一般也應設計成全焊透焊。

4.10.1.2 C 型獨立液艙的焊接接頭細節應該滿足以下要求：

- .1 受壓容器的所有縱向或周向接頭應為對接、全焊透、雙面 V 型坡口或單面 V 型坡口型。全焊透的對接焊縫應該採用雙面焊或加墊環焊。如果採用墊環，則在焊後墊環應予除去，除非主管機關對很小的處理受壓容器予以專門批准。採用其他的邊緣坡口形式，根據主管機關對電焊認可試驗結果亦可同意。
- .2 受壓容器立體和氣室，以及氣室及其相聯附件之間的連接接頭，其斜坡口應該按主管機關可接受的受壓容器標準進行設計。連接容器的噴嘴、氣室或其他貫通件以及所有連接法蘭至容器或噴嘴的所有焊縫應在容器壁（或噴嘴壁）的全厚度範圍內都是全焊透焊縫，對小直徑噴嘴經主管機關專門批准除外。

4.10.2 工藝質量應使主管機關滿意。除 C 型獨立液艙外，液艙的焊縫的檢查和無損探傷試驗應該按 6.3.7 的要求進行。

4.10.3 對薄膜液艙、質量保證措施、焊接程序考核、設計細節、材料、構造、部件的檢驗和生產試驗應符合在原型試驗程序時制訂的標準。

4.10.4 本節對獨立液艙或薄膜液艙的有關要求亦適用於半薄膜液艙（如適合時）。

4.10.5.1 對內層絕熱液艙，為了保證材料的均勻性，質量控制程序（包括環境控制、應用程序、角隅、貫通件及其他設計細節、材料技術規格、安裝及部件的生產試驗）均應符合進行原型試驗時制訂的標準。

4.10.5.2 質量控制技術規定（包括構造缺陷的最大許用尺度、製造和安裝中的試驗和檢查以及每一階段取樣試驗等）應該使主管機關滿意。

4.10.6 整體液艙應做水壓或空氣壓力試驗，使主管機關滿意。一般這種試驗應儘實際可行使其應力接近設計應力，並使液艙頂的壓力至少相當於 MARVS。

4.10.7 裝有薄膜液艙或半薄膜液艙的船舶，隔離艙和正常情況下裝載液體並鄰接於支持薄膜的船體結構的所有處所，應按承認的標準進行水壓或空氣壓力試驗。此外，支持薄膜的其他貨艙結構應做密性試驗。管隧和正常情況下裝載液體的其他艙室不必做水壓試驗。

4.10.8.1 裝有內層絕熱液艙（其內層船體是支持結構）的船舶，所有內層船體結構在考慮了釋放閥的最大值 MARVS 後，應按承認的標準進行水壓或空氣壓力試驗。

4.10.8.2 裝有內部絕熱液艙（其獨立液艙是支持結構）的船舶，獨立液艙應按 4.10.10.1 規定進行試驗。

4.10.8.3 對於內層絕熱液艙（其內層船體結構或某一獨立液艙結構作次屏壁用），這些結構的密性試驗應該採用使主管機關滿意的工藝進行。

4.10.8.4 這些試驗應在構成內層絕熱艙的材料敷上以前進行。

4.10.9 對 C 型獨立液艙，應進行如下檢查和無損探傷試驗：

- .1 製造和工藝質量——關於製造和工藝質量的公差，例如偏離實際形狀的局部失圓度，焊接接頭的對中以及不同厚度板的削斜，應符合主管機關承認的標準。這些公差還應與 4.4.6.2 所述的屈曲分析相關。
- .2 無損探傷試驗——就焊接接頭的無損探傷試驗的完成和範圍而言，無損探傷試驗的範圍應該是全部或部分按照主管機關可接受的標準，但所作的控制應不少於如下規定：

.2.1 按 4.4.6.1.3 規定進行全部無損探傷試驗：

射線檢查：

對接焊縫 100%，及

表面裂紋檢查：

所有焊縫 10%，

開孔和噴嘴等的加強環 100%。

如主管機關專門許可，可以接受採用部分超聲波檢查替代部分射線檢查。此外，主管機關可要求對開孔和噴嘴周圍的電焊或加強環等進行全部超聲波檢查。

.2.2 按 4.4.6.1.3 規定進行部分無損探傷試驗：



射線檢查：

對接焊縫：全部焊縫交叉接頭，以及至少選取均勻分佈焊縫全長的 10%。

表面裂紋檢查：

開孔和噴嘴等的加強環 100%。

超聲波檢查：

主管機關可根據每一具體情況給與考慮。

4.10.10 對每個獨立液艙應該進行下列水壓或空氣壓力試驗：

- .1 對 A 型獨立液艙，這種試驗應使其應力儘實際可行接近設計應力，並且在液艙頂的壓力至少相當於 MARVS。當進行空氣壓力試驗時，其試驗條件應儘實際可行模擬履艙及其支持構件的實際載荷條件。
- .2 對 B 型獨立液艙，應按 4.10.10.1 對 A 型獨立液艙要求那樣進行試驗。此外，試驗條件下在主要構件中的最大第一類薄膜應力或最大彎曲應力，應不超過材料（製造狀態）在試驗溫度下屈服強度的 90%。為確保滿足這個條件，當計算表明此應力超過材料屈服強度的 75%時，其原型試驗應採用應變儀或其他適當設備加以監視。
- .3 C 型獨立液艙應該進行下列試驗：
  - .3.1 每一受壓容器在製造完成以後，應該做水壓力試驗，試驗時的壓力應使在液艙頂面測得的壓力不小於 1.5

$P_o$ ，但在任何一點所算得的第一類薄膜應力應不超過材料屈服應力的 90%。 $P_o$  的定義見 4.2.6。為了確保滿足此條件，如計算表明這個應力會超過屈服強度的 75%時，原型試驗應在簡單圓筒形和球形受壓容器以外的受壓容器中採用應變儀或其他的適當設備加以監視。

- .3.2 試驗所採用的水溫，應至少比製成材料的零韌性轉變溫度高出 30°C。
- .3.3 每 25mm 厚度，壓力應保持 2 小時，任何情況下不得少於 2 小時。
- .3.4 如貨物受壓容器需要，並經主管機關專門認可，可在 4.10.10.3.1, .2 和 .3 所述的條件下進行空氣壓力試驗。
- .3.5 主管機關根據工作溫度，可對採用較高許用應力液艙的試驗給與特別考慮。但是 4.10.10.3.1 的要求應該完全滿足。
- .3.6 完工和裝配後，每一受壓容器及其有關的附件應該進行適當的密性試驗。
- .3.7 液貨艙以外的受壓容器氣壓試驗應由主管機關針對各種情況予以考慮。這些試驗只有對以下這些容器才允許：這些容器如此設計（或支持）致使它們不能安全地注滿水；或者這些容器不能乾燥，並且在使用中不允許留下試驗介質的痕跡。

4.10.11 所有液艙應進行密性試驗，此試驗可以和 4.10.10 所述的壓力試驗一起進行或單獨進行。

4.10.12 關於次屏壁的檢驗要求應該由主管機關根據每一情況加以確定。

4.10.13 在裝有 B 型獨立液艙的船上，至少應測量一個液艙及其支持構件，以便確認其應力的程度，除非某種尺度船舶的設計和佈置得到了實際規模試驗的經驗。對 C 型獨立液艙，可以根據它們的形狀及其支持構件和附件的佈置，要求作類似的測量。

4.10.14 應驗證貨物圍護系統的全部性能在初始冷卻以及貨物裝卸時是否符合設計參數。用於驗證設計參數的部件和設備的性能記錄應予以保存，並可供主管機關使用。

4.10.15 如果按 4.8.4 規定裝有加熱裝置，則應對其所需的熱量輸出或熱量分配予以試驗。

4.10.16 船體應在第一次滿載航行時對冷點進行檢查。

4.10.17 內層絕熱液艙的絕熱材料應作額外的檢查，以驗證它們在船舶第三次滿載航行後的表面情況是否符合要求。但此類額外檢查應在船舶建成後或內層絕熱液艙經大修後船舶運行的頭 6 個月內進行。

4.10.18 對 C 型獨立液艙，作受壓容器標記所使用的方法應使不致於產生無法接受的局部應力。

#### 4.11 C 型獨立液艙的應力消除

4.11.1 對碳和碳錳鋼制的 C 型獨立液艙，如設計溫度低於 -10°C 以下，應進行焊後熱處理。其他各種情況的焊後熱處理和不使用上述材

料的焊後熱處理應使主管機關滿意。熱處理的溫度和保溫時間應徵得主管機關的同意。

4.11.2 碳鋼或碳錳鋼制的大型受壓容器進行熱處理有困難時，在經主管機關批准並遵守下列條件的情況下，可以用充壓機械法應力消除過程替代熱處理：

- .1 焊接受壓容器的複雜部件，例如帶噴嘴的貯槽或氣室連同其相鄰的殼板，在被焊接到受壓容器的較大部件以前，應進行熱處理。
- .2 板厚應不超過主管機關可接受的標準所規定的值。
- .3 為了確定在機械法應力消除時的最大第一類薄膜應力而進行的詳細分析，應表明此應力非常接近（但不超過）材料屈服應力的 90%。主管機關為了驗證計算結果，可以要求應力消除充壓時作應變測量。
- .4 機械法應力消除程序，應預先提交主管機關審批。

#### 4.12 加速度分量的指導公式

下列公式作為計算加速度分量的指導，此加速度相應於在北大西洋上概率級為  $10^{-8}$  的船舶運動，適用於超過 50m 長的船舶。

##### 4.3.4.6 所述的垂向加速度

$$a_z = \pm a_g \sqrt{1 + \left(5.3 - \frac{45}{L_0}\right)^2 \left(\frac{X}{L_0} + 0.05\right)^2 \left(\frac{0.6}{C_B}\right)^{1.5}}$$

## 4.3.4.6 所述的橫向加速度

$$a_y = \pm a_0 \sqrt{0.6 + 2.5 \left( \frac{X}{L_0} + 0.05 \right)^2 + K \left( 1 + 0.6K \frac{Z}{B} \right)^2}$$

## 4.3.4.6 所述的縱向加速度

$$a_x = \pm a_0 \sqrt{0.06 + A^2 - 0.25A}$$

式中：

$$A = \left( 0.7 - \frac{L_0}{1200} + 5 \frac{Z}{L_0} \right) \left( \frac{0.6}{C_B} \right)$$

而

$L_0$  = 承認的標準規定用來確定結構尺寸的船長 (m)

$C_B$  = 方形系數

$B$  = 船舶最大型寬 (m)

$X$  = 從船中到裝貨液艙重心之間的縱向距離 (m)；船中以前的  $X$  為正值，其後為負值

$Z$  = 從船舶的實際水線到裝貨液貨艙重心之間的垂向距離 (m)；水線以上為正值，水線以下為負值。

$$a_0 = 0.2 \frac{V}{\sqrt{L_0}} + \frac{34 - \frac{600}{L_0}}{L_0} \quad \text{其中 } V \text{ 為服務航速 (節)}$$

$K$  = 一般為 1。對於特殊的裝載情況和船型， $K$  值可按下列公式確定：

$K = 13 \text{ GM/B}$ ，其中  $K \geq 1.0$  和  $\text{GM} =$  靜穩心高度 (m)

$a_x$ ， $a_y$  和  $a_z$  為相應方向上的最大無因次加速度值（即為相對於重力加速度的值），為了便於計算，可認為是分別作用的。 $a_z$  不包括重力分量， $a_y$  包括因橫搖在橫方向上的重力引起的分量， $a_x$  包括因縱搖在縱方向上的重力引起的分量。

#### 4.13 應力分類

為了評定 4.5.1.4 所述的應力，本節將應力進行分類如下：

4.13.1 正應力係指垂直於參考平面的應力分量。

4.13.2 薄膜應力係指正應力分量，它在所考慮的截面厚度範圍內均勻分佈且等於平均值。

4.13.3 彎曲應力係指扣除薄膜應力後，在所考慮的截面厚度範圍內變化的應力。

4.13.4 剪切應力係指作用在參考平面內的應力分量。

4.13.5 第一類應力係指由外加载荷所產生的應力，它是平衡外力和外力矩所需要的。第一類應力的基本特性為它不是自身限制的。明顯超過屈服強度的第一類應力將導致破壞或至少嚴重變形。

4.13.6 第一類總體薄膜應力係指一種第一類薄膜應力，它在結構中的分配不會由於屈服而引起載荷再分配。

4.13.7 在由壓力或其他機械載荷產生的而且與第一類應力或不連續效應有關的薄膜應力，把載荷傳遞到結構的其他部位過程中產生過度的扭曲時，出現第一類局部薄膜應力。這些應力即使具有某些第二類應力的特性，亦應歸入第一類局部應力。如果滿足下列條件，可以認為應力區域是局部的：

$$S_1 \leq 0.5\sqrt{Rt}$$

及

$$S_2 \geq 2.5\sqrt{Rt}$$

式中：

$S_1$  = 在子午線方向上相當應力超過  $1.1f$  的距離

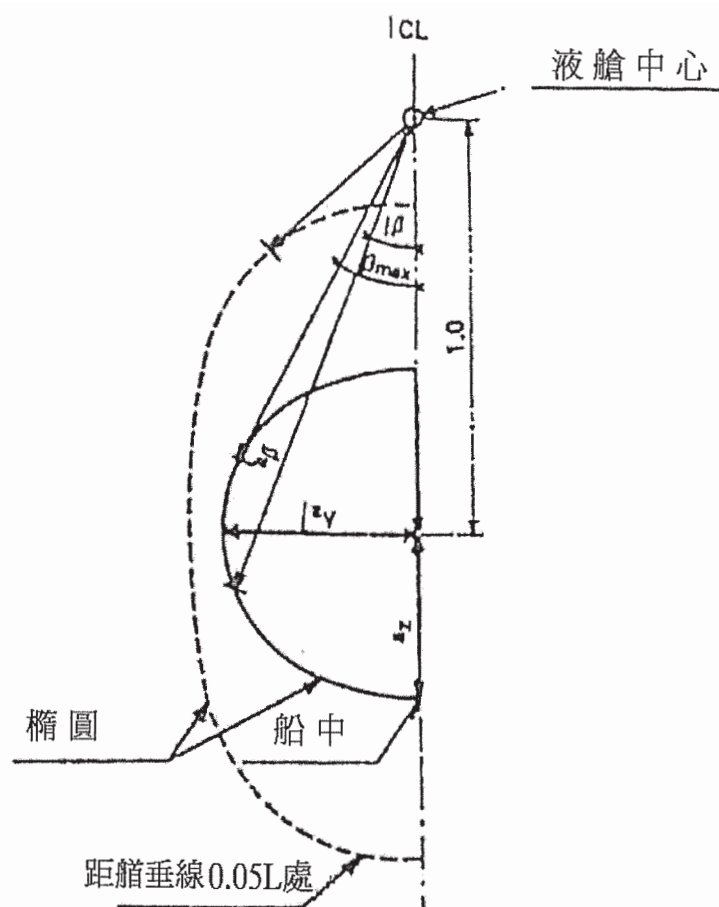
$S_2$  = 在子午線方向上到超過第一類總體薄膜應力極限的另一區域的距離

$R$  = 容器的平均半徑

$t$  = 容器在第一類總體薄膜應力超過極限部位的壁厚

$f$  = 第一類總體薄膜的許用應力。

4.13.8 第二類應力是由鄰近部分的結構或結構自身約束產生的正應力或剪應力。第二類應力的基本特性是，它是自身限制的。局部屈服或較小的扭曲能滿足這類應力產生的條件。



$a_{\beta}$  = 在任意方向  $\beta$  上的合成加速度（靜的和動的）

$a_y$  = 加速度的橫向分量

$a_z$  = 加速度的垂向分量

圖 4.1 - 加速度橢圓



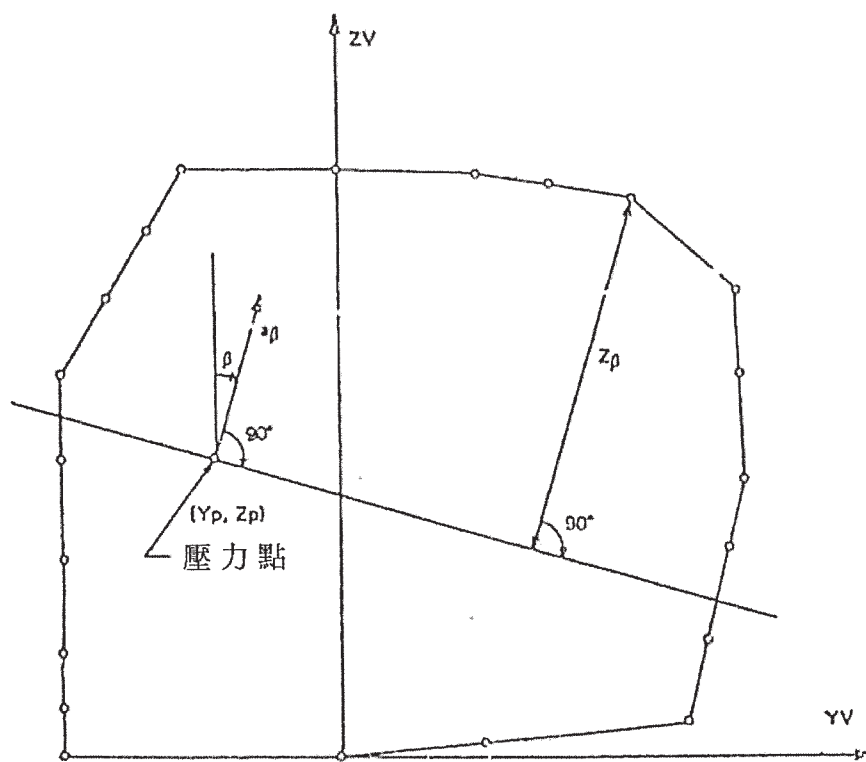
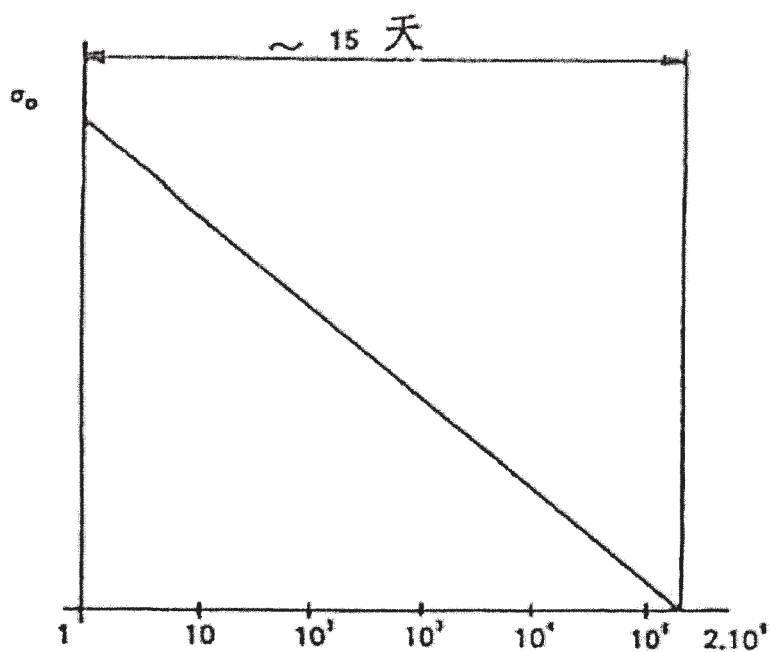


圖 4.2 - 內部壓頭的確定



響應循環次數

$\sigma_0$  = 船舶使用壽命中可能出現的最大應力

響應循環次數比例尺以對數計； $2 \times 10^5$  值作為估算例子。

圖 4.3 - 簡化的載荷分佈

## 第 5 章 處理受壓容器和液體、蒸氣與處理壓力管路系統

### 5.1 通則

5.1.1 主管機關在執行和應用本章的規定中應採取適當步驟確保一致性\*。

5.1.2 如主管機關要求，第 4 章對 C 型獨立液艙的要求亦可適用於處理受壓容器。第 4 章中使用的“受壓容器”一詞包括 C 型獨立液艙和處理受壓容器。

### 5.2 貨物和處理管路

#### 5.2.1 通則

5.2.1.1 本節要求適用於包括蒸氣管系及安全閥透氣管或類似管路在內的貨品和處理管系。不含貨物的儀錶管路可免除這些要求。

5.2.1.2 應採用支管、環形管、彎頭、機械膨脹接頭（例如波紋管、滑動接頭和球狀接頭或類似的適當部件），以保護管路、管系部件和液貨艙免受由於熱膨脹引起的過大應力的影響和船體與液貨艙移動的影響。如管路中採用機械膨脹接頭，應儘量減少其使用數量；如管路位於液貨艙外面，應採用波紋管型。

5.2.1.3 如需要時，低溫管路應與其相鄰的船體結構進行熱隔離，以防船體的溫度降低到船體材料的設計溫度以下。如液體管路需經常拆卸或預計可能有液體泄漏（例如通岸接頭和泵密封等），則應對其下方的船體部分提供保護措施。

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\* 應參考 IACS 會員社和聯繫會員社所發表的規則，特別應參考 IACS 的統一要求 No G3。

5.2.1.4 如液艙或管路採用熱絕緣和船體結構相隔離，則管路和液艙兩者均採取電氣接地措施。所有具有填料的管接頭和軟管接頭應進行電氣聯結。

5.2.1.5 應配備適當裝置以在拆開貨物軟管前卸除壓力，並在脫開貨物軟管之前把液貨從貨物的裝、卸交叉聯箱和貨物軟管放到液貨艙或其他適當位置。

5.2.1.6 在充滿液體條件下可以切斷的所有管路或部件應裝有釋放閥。

5.2.1.7 從貨物管系由釋放閥排出的液貨應回至液貨艙內；或者，如設有能檢測和處理可能流進透氣系統中的任何液貨設備，則也可回至透氣桅。貨泵上的釋放閥的排出應回至泵的吸口。

## 5.2.2 按內壓力確定的尺寸

5.2.2.1 按 5.2.4 所述的條件，管壁厚度應不小於：

$$t = \frac{t_0 + b + c}{1 - \frac{a}{100}} \quad (\text{mm})$$

式中：

$t_0$  = 理論計算厚度

$$t_0 = PD / (20 Ke + P) \quad (\text{mm})$$

其中：

$P$  = 5.2.3 中所述的設計壓力 (bar)

$D$  = 外徑 (mm)

$K = 5.2.4$  中所述的許用應力 ( $N/mm^2$ )

$e =$  效率系數；對無縫鋼管，以及由認可製造廠供應的縱向焊接或螺旋焊接的管子，其焊縫按承認的標準經無損探傷檢查認為等效於無縫鋼管者，則此系數為 1.0；其他情況的效率系數，根據製造方法可由主管機關確定。

$b =$  彎曲減薄值 (mm)。b 值應選取得能使在彎頭中僅由內壓力引起的計算應力不超過許用應力。如未作過此種正確的計算，則 b 值應為：

$$b = \frac{Dt_e}{2.5r} \text{ (mm)}$$

式中：

$r =$  平均彎曲半徑 (mm)

$c =$  腐蝕餘量 (mm)。如預計有腐蝕或侵蝕，則管壁厚度應比其設計要求的值有所增加。增加的量應和預計的管子壽命相一致。

$a =$  厚度製造負公差 (%)。

### 5.2.3 預計壓力

5.2.3.1 5.2.2.1 的  $t_0$  公式中，其設計壓力  $P$  是指此系統在營運中可能承受的最大壓力。

5.2.3.2 對管子、管系和部件應適當地採用下列設計條件中的較大者：

- .1 對可能和釋放閥隔離並可能含有某種液體的蒸氣管系或零部件，應為 45°C 時的飽和蒸氣壓力，如經主管機關同意可以取用較高或較低值 (見 4.2.6.2)；

- .2 對可能和釋放閥隔離並在任何時候只含有蒸氣的管系或部件，應為 45°C 時的過熱蒸氣壓力，如經主管機關同意可以取用較高或較低值（見 4.2.6.2），但都假定系統中飽和蒸氣的初始狀態係處於該系統的工作壓力和工作溫度；
- .3 液貨艙和貨物處理系統釋放閥最大許用設定值 MARVS；
- .4 相關泵或壓縮機的釋放閥開啓壓力；
- .5 貨物管路系統在卸貨或裝貨時的最大總壓頭；
- .6 管路系統上釋放閥的開啓壓力。

5.2.3.3 設計壓力應不小於 10 bar，但對有開口端的管路應小於 5 bar。

#### 5.2.4 許用應力

5.2.4.1 5.2.2.1 公式中需考慮的管子許用應力，應取下列應力的較低值：

$$\frac{R_m}{A} \text{ 或 } \frac{R_e}{B}$$

式中：

$R_m$  = 室溫時，材料抗拉強度下限值（N/mm<sup>2</sup>）

$R_e$  = 室溫時，材料屈服應力下限值（N/mm<sup>2</sup>）。如果應力應變曲線沒有明顯的屈服應力，則取用 0.2%條件屈服應力。

A 和 B 值應在 1.5 規定的國際散裝運輸液化氣體適裝證書上予以註明，A 值至少為 2.7，B 值至少為 1.8。

5.2.4.2 最小壁厚應符合承認的標準。

5.2.4.3 如果機械強度有這種需要，以防止管子的損壞、破損、過度中垂或失穩，而且這些問題是由支持構件、船舶撓度或其他原因參與的累計載荷引起的，則此時的管壁厚度應比 5.2.2 所要求的值有所增加。如果這樣做不現實或會引起過大的局部應力時，這些載荷應予減少，或用其他設計方法加以防止或消除。

5.2.4.4 法蘭、閥件和其他附件，計及 5.2.2 所規定的設計壓力，應為主管機關可接受的標準。用於蒸氣管的波形膨脹接頭，主管機關可以接受較低的設計壓力。

5.2.4.5 對於不符合標準的法蘭，法蘭和螺栓的規格應使主管機關滿意。

#### 5.2.5 應力分析

當設計溫度為  $-110^{\circ}\text{C}$  或更低時，對於管系的每一支路，計及管子的重量[包括加速度載荷（如大時）]、內部壓力、熱收縮、船舶中拱中垂引起的載荷等所產生的所有應力，應向主管機關提交一份完整的應力分析。當溫度高於  $-110^{\circ}\text{C}$  時，主管機關可要求的應力分析內容為諸如管系的設計或剛度、及材料選擇等。在任何情況下，即使沒有提交計算書，但熱應力都應予考慮。這些分析可按主管機關可接受的實施規則進行。

#### 5.2.6 材料

5.2.6.1 管路系統中所用材料的選擇和試驗，計及最低的設計溫度後，應符合第 6 章的要求。但是開口端透氣管的材料質量可允許有所放寬，條件為壓力釋放閥設定值時的貨物溫度為  $-55^{\circ}\text{C}$  或高於  $-55^{\circ}\text{C}$ ，

以及不會出現液貨排至透氣管。在同樣溫度下，對液貨艙內的開口端管路（薄膜艙和半薄膜艙內的排出管和所有管路除外），可允許有類似的放寬。

5.2.6.2 熔點在 925°C 以下的材料不應用於液貨艙外的管子，但與液貨艙連接的短管除外，此時應設置防火絕緣。

### 5.3 管路部件的型式試驗

5.3.1 每一類管路部件應進行型式試驗。

5.3.2.1 擬使用於工作溫度-55°C 以下的各種尺寸和類型的閥件，應在最低設計溫度（或更低）和不低於閥件設計壓力下進行密性試驗。試驗期間應確認閥件的良好操作性能。

5.3.2.2 對擬用在液貨艙外貨物管路上的每種波紋膨脹接頭，如需要時，對擬設置在液貨艙內的波紋膨脹接頭，應進行下列型式試驗：

- .1 不處於壓縮狀態下的波紋接頭類型單件，應經受不小於五倍設計壓力的壓力試驗而不破壞。試驗時間不少於五分鐘。
- .2 帶有所有附件（例如法蘭、牽條、關節件等）的型式膨脹接頭應在製造廠推薦的最大位移條件下經受兩倍設計壓力的壓力試驗而不產生永久變形。主管機關根據所採用的材料，可要求在最低設計溫度下進行這種試驗。
- .3 對完整的膨脹接頭應進行循環試驗（熱運動），它在壓力、溫度、軸向運動、旋轉運動和橫向運動的條件



下應能滿意地承受至少和在實際管運中遇到的一樣多的循環次數。當該試驗與管運溫度下的試驗(至少)一樣嚴重時，在允許的環境溫度下進行試驗。

- .4 對完整的膨脹管接頭應在無內壓力下進行循環疲勞試驗(船舶變形)，通過模擬相當於在一段補償管段中的波紋接頭運動予以完成，要求在不高於 5 周/秒的頻率下其交變次數至少為  $2 \times 10^6$  次。這一試驗只有當由於管路佈置實際上會經受船舶變形載荷時才要求進行。
- .5 如能提供完整的文件並確認膨脹接頭能適應承受預計的工作條件，則主管機關可以免除進行本款所述的試驗。當最大的內部表壓力超過 1.0 bar 時，此類文件應包括足夠的試驗資料以證明所用設計方法的合理性，特別應參考設計方案和試驗結果之間的相互關係。

#### 5.4 管路製造和接合細節

5.4.1 本節要求適合於液貨艙內、外的管子。然而主管機關可接受放鬆對液貨艙內的管路和開口端管路的的要求。

5.4.2 可考慮採用下列管段直接連接(不用法蘭)：

- .1 根部完全焊透的對接焊接頭在各種情況下均可以採用。當設計溫度低於  $-10^{\circ}\text{C}$  時，對接焊應為雙面焊或等效於雙面焊的對接接頭。這可採用在第一道焊道上加墊環、焊接材料嵌補或惰性氣體封底等辦法來達

到。當設計壓力超過 10 bar 及設計溫度為  $-10^{\circ}\text{C}$  或  $-10^{\circ}\text{C}$  以下時，墊環應除去。

- .2 套裝式焊接接頭及其焊接（具有使主管機關滿意的尺寸）只能用在外徑為小於或等於 50 mm 和設計溫度不低於  $-55^{\circ}\text{C}$  有開口端的管路上。
- .3 主管機關能接受的螺紋聯接只能用在外徑為小於或等於 25 mm 的輔助管路或儀錶管路。

5.4.3.1 法蘭接頭中的法蘭應為整體、套裝焊接或插入焊接法蘭。

5.4.3.2 法蘭的型式、製造和試驗應符合主管機關能接受的標準。除開口端的管路外，所有管路應特別遵守下列限制：

- .1 設計溫度低於  $-55^{\circ}\text{C}$ ，只能採用整體法蘭。
- .2 設計溫度低於  $-10^{\circ}\text{C}$ ，公稱尺寸超過 100 mm 的管路不應採用套裝焊接法蘭；公稱尺寸超過 50 mm 的管路不應採用插入焊接法蘭。

5.4.4 上述 5.4.2 和 .3 以外的管路連接，主管機關可針對每一具體情況接受何種型式的管路接頭。

5.4.5 應設置波紋接頭和膨脹接頭以允許管路膨脹：

- .1 如果需要，波紋接頭應防止冰凍。
- .2 除位於液貨艙內者外，不應採用套裝接頭。

5.4.6 焊接、焊後熱處理和無損探傷試驗：

- .1 焊接應按 6.3 要求進行。

- .2 對碳鋼、碳錳鋼和低合金鋼管子的所有對接焊縫，要求進行熱處理。主管機關對壁厚小於 10 mm 的管子，根據有關管系的設計溫度和壓力可免除消除熱應力的要求。
- .3 除在焊接前和焊接期間進行正常控制以及對完工焊縫進行目視檢查以外，為了證明焊接已按本段的要求正確進行，必須要求進行下列試驗：
  - .3.1 對工作溫度低於 $-10^{\circ}\text{C}$ 及內徑大於 75 mm 或壁厚大於 10 mm 的管系，對焊接接頭要求進行 100%的射線檢查。
  - .3.2 對於其他管子的對接焊接頭，主管機關根據其用途、位置和材料，決定是否應進行局部射線檢查或其他無損探傷檢查。一般至少應有 10%的管子對接焊的接頭進行射線檢查。

## 5.5 管路試驗

5.5.1 本節要求適用於液貨艙內、外的管路。但主管機關對液貨艙內的管路和開口端管路可接受放寬這些要求。

5.5.2 所有貨物及處理管路裝配後，應進行至少 1.5 倍設計壓力的水壓試驗。當管系或管系的部件完全製造完畢並已裝配了所有附件後，水壓試驗可在裝船之前進行。在船上焊接的接頭應進行至少為 1.5 倍設計壓力的水壓試驗。如果管路中不允許有水並且管路系統在投入使用之前不能進行乾燥，採用其他試驗流體或試驗方法的建議應提交主管機關審批。

5.5.3 每一貨物管路和處理管路系統在船上組裝以後，應使用空氣、鹵化物或其他適當的介質進行密性試驗，其壓力取決於所採用的泄漏檢測方式。

5.5.4 所有管路系統（包括閥、附件及操作貨物或蒸氣用的設備）應在不晚於第一次裝貨作業的正常工作狀態下進行試驗。

## 5.6 貨物系統閥件要求

5.6.1 每一貨物管路系統和液貨艙應設置如下閥件（如適用時）：

- .1 MARVS 不超過 0.7 bar（表壓）的液貨艙，除安全閥和液面測量裝置以外的所有液體和蒸氣連接接頭，應設有截止閥，其位置儘可能接近液貨艙。這些閥可以遠距離控制，但應能就地手工操作並完全圍蔽。在船上應設有一個或多個應急的遙控截止閥，用來截止船和岸之間的液貨和蒸氣貨物的輸送。這些閥可根據船舶設計要求進行佈置，可以是 5.6.3 所要求的同一閥件，且應滿足 5.6.4 的要求。
- .2 MARVS 超過 0.7 bar（表壓）的液貨艙，除安全閥和液面測量裝置以外的所有液體和蒸氣連接接頭，應設置一手工操作的截止閥和一遙控的應急截止閥。這些閥應儘可能靠近液艙。如管徑不超過 50 mm，釋流閥可用來代替應急的截止閥。假如此閥符合 5.6.4 的要求，並能就地手工操作和對管路提供完全圍蔽，那麼可單獨採用一個閥代替兩個分離閥。

- .3 如果 5.6.1.1 和 .2 要求的應急截止閥是由 5.6.4 要求的應急截止系統關閉，則貨泵和壓縮機應能實現自動關閉。

5.6.2 供儀器或測量裝置用的液貨艙連接接頭不必設置釋流閥或應急截止閥，但這些裝置的結構應能使液艙內貨物外流不超過 1.5 mm 直徑圓孔所通過的流量。

5.6.3 在使用中的每一貨物軟管連接接頭處，應設置一個遙控的應急截止閥。在輸送作業中不使用的連接接頭可用盲板法蘭代替閥。

5.6.4 所有要求應急截止閥的控制系統應佈置得使其所有這些閥件可以位於至少兩個遠離的地方用簡單的控制進行操作，其中的一個位置應是 13.1.3 所要求的控制位置或貨物控制室。控制系統也應設有能在 98°C 和 104°C 之間熔化的易熔元件，可以在失火中使應急關閉閥關閉。這些易熔元件的位置應包括液艙氣室和裝貨站。應急截止閥應為動力故障關閉型，以及能就地進行手動關閉。液貨管路中的應急截止閥，在所有的作業條件下，應能在 30 秒鐘的動作時間內完全關閉，關於這些閥關閉的時間及其操作特性資料，應保存在船上，關閉時間應可核實，並能重現。這些閥的關閉應是平穩的。

5.6.5 釋流閥應在製造廠規定的蒸氣或液體的關閉額定流量下能實現自動關閉。包括附件、閥和由釋流閥保護的輔助設備在內的管路應具有比釋流閥的額定關閉流量較大的容量。釋流閥可以設計成具有不超過 1.0 mm 直徑圓孔面積的旁通，以便使截止閥關閉後的壓力平衡。

## 5.7 船舶的貨物軟管

5.7.1 用於輸送貨物的液體軟管和蒸氣軟管應與貨物具有一致性，且與其貨物溫度相適應。

5.7.2 承受液艙壓力或泵或蒸氣壓縮機排出壓力的軟管應按爆破壓力設計，此壓力應不小於軟管在輸送貨物時所承受最大壓力的 5 倍。

5.7.3 配有端部附件的每一新型軟管，應在不小於 5 倍規定的最大工作壓力下進行原型試驗，原型試驗時的軟管溫度應是擬定的極限工作溫度。供原型試驗用的軟管不應再用作貨物運輸。每一段新製成的軟管，在使用前，應在環境溫度下進行水壓試驗，其試驗壓力值不低於規定工作壓力的 1.5 倍，也不大於爆破壓力的五分之二。軟管上應用模板噴刷或其他方法標記出規定的最大工作壓力，如果不是在環境溫度工作條件下使用，則還應標記出它的最大或最小工作溫度或兩者都標出。規定的最大工作壓力應不小於 10 bar（表壓）。

## 5.8 貨物輸送方法

5.8.1 如果貨物是靠貨泵輸送的，而貨泵在液艙外於營運時不能接近進行修理，則至少應設置兩個獨立的設施把貨物從每一液艙輸出，此種設計應能在一台貨泵或一種輸送設施發生故障時不至於妨礙其他貨泵或另一輸送設施的使用。

5.8.2 靠氣體增壓輸送貨物的過程，應消除在這種輸送過程中釋放閥的開啓。氣體增壓可以作為一種輸送貨物的設施，但液貨艙的安全系數在貨物輸送作業的條件下不會減少。

## 5.9 蒸氣回路連接器

應設置蒸氣回路管子至岸上裝置相連接的接頭。

## 第 6 章 結構材料

### 6.1 通則

6.1.1 主管機關應採取適當的步驟以保證執行和實施本章規定\*的一致性。

6.1.2 本章規定適用於建造液貨艙、貨物處理受壓容器、為貨物裝卸和貨物處理管系、次屏壁及與物品運輸有關的相鄰船體結構所用的板材、型材、管材、鍛件、鑄件和焊接件。對於軋製材料、鍛件和鑄件的要求，見 6.2 和表 6.1 至 6.5 的規定。對於焊接件要求，見 6.3 的規定。

6.1.3 有關的製造、試驗、檢驗以及文件應符合承認的標準的規定和本規則規定的要求。

6.1.4.1 除主管機關另有規定外，驗收試驗應包括 V 型缺口韌性試驗。V 型缺口所規定的要求系為三個全尺寸（10 mm x 10 mm）試樣的最小平均衝擊值和單個試樣的最小單一衝擊值。V 型缺口的尺寸和誤差應根據承認的標準。對小於 5.0 mm 尺寸試樣的試驗和要求應根據公認的標準。小尺寸試樣的最小平均值規定如下：

V 型缺口試 樣尺寸	3 個試樣的最 小平均衝擊值
10 x 10 mm	E
10 x 7.5 mm	$\frac{5}{6}$ E
10 x 5.0 mm	$\frac{2}{3}$ E

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\* 應參考國際船級社協會（IACS）會員社及聯繫會員社所發表的規範，特別是 IACS 的統一要求 No.W1。

式中：E = 表 6.1 至 6.4 所規定的衝擊值 (J)。

3 個試樣中允許有 1 個試樣的值小於規定的平均值，但不得小於規定平均值的 70%。

6.1.4.2 在所有情況下，材料厚度所許可的最大尺寸的卻貝試樣應截取得使其試樣儘可能位於表面和厚度中心之間的中點處，並使缺口長度方向垂直於表面（見圖 6.1）。當一組 3 個 V 型缺口試樣的平均值達不到規定的要求，或者不止一個試樣的值低於所要求的平均值，或者當一個試樣的值低於單個所許可的最低值時，則可從原先取樣的材料上再取 3 個試樣進行附加試驗，同時將所得結果與以往求出的結果組成一個新的平均值。如果這個新的平均值符合要求，而且個別結果低於所要求的值不超過兩個以及單個試樣的結果低於所要求的值不超過一個，則此件或這批材料可以接受。其他型式的韌性試驗，諸如落錘試驗可由主管機關自行決定，此次試驗可作為附加試驗或替代 V 型缺口試驗。

6.1.5 抗拉強度、屈服應力和延伸率應達到主管機關滿意的程度。對於具有有限屈服點的碳錳鋼和其他材料，應考慮限制屈服與拉伸之間的比例。

6.1.6 作為材料驗收，試驗彎曲試驗可不作，但對焊接試驗則要求作彎曲試驗。

6.1.7 具有供選擇化學成分或機械性能的材料可由主管機關認可。

6.1.8 如規定或要求作焊後熱處理，母材性能應在熱處理情況下按照本章適用的表列內容進行確定，而且焊縫性能應在熱處理情況下按照 6.3 的規定確定。如果採用焊後熱處理，試驗要求可由主管機關酌情



修改。

6.1.9 如本章參照 A，B，D，E，AH，DH 和 EH 船體結構用各種鋼級，這些鋼級應根據承認的標準為船體結構用的各種鋼級。

## 6.2 材料要求

結構材料的要求見下表：

表 6.1： 用於設計溫度不低於 0°C 的液貨艙和處理受壓容器所用的板材、管材（無縫和焊接）、型材和鍛件。

表 6.2： 用於設計溫度低於 0°C 至 -55°C 的液貨艙、次屏壁和處理受壓容器所用的板材、型材和鍛件。

表 6.3： 用於設計溫度低於 -55°C 至 -165°C 的液貨艙、次屏壁和處理受壓容器所用的板材、型材和鍛件。

表 6.4： 用於設計溫度低於 0°C 至 -165°C 的液貨艙和處理管系所用的管材（無縫和焊接）、鍛件和鑄件。

表 6.5： 4.9.1 和 4.9.4 所要求的船體結構用板材和型材。

表 6.1

用於設計溫度不低於 0°C 的液貨艙和處理受壓容器所用的板 材、管材（無縫和焊接） <sup>1/</sup> 、型材和鍛件		
<u>化學成分和熱處理</u>		
碳錳鋼，全鎮靜。		
厚度超過 20 mm 的細精粒鋼		
經主管機關同意增加少量的合金元素		
應經主管機關認可的化學成分限度		
正火或淬火和回火 <sup>2/</sup>		
<u>抗拉和韌性（衝擊）試驗的要求</u>		
<u>板材</u>	按件試驗	
<u>型材和鍛材</u>	按批試驗	
<u>拉伸性能</u>	屈限應力下限值不超過 410 N/mm <sup>2</sup> <sup>3/</sup>	
<u>V-缺口試驗</u>		
<u>板材</u>	橫向試樣。最小平均衝擊功（E）27J	
<u>型材和鍛材</u>	縱向試樣。最大平均衝擊功（E）41J	
<u>試驗溫度</u>	厚度 t（mm）	試驗溫度（°C）
	t ≤ 20	0
	20 < t ≤ 40	-20

註：

- 1/ 對於無縫管和附件應當採用正常的施工做法。使用縱向和螺旋焊接管應經主管機關的特別認可。
- 2/ 可以採用控制軋製程序替代正火或淬火和回火，但須經主管機關的特別認可。
- 3/ 對屈服應力下限值超過  $410 \text{ N/mm}^2$  的材料，可提請主管機關予以特別認可。對於這些材料的焊縫硬度和熱影響區域，應予以特別注意。

表 6.2

<p>用於設計溫度低於 0°C 至 -55°C 的液貨艙、次屏壁和處理受壓容器所用的板材、型材和鍛件 <sup>1/</sup></p> <p>最大厚度為 25 mm <sup>2/</sup></p>																													
<p><u>化學成分和熱處理</u></p> <p>碳錳鋼，全鎮靜。鋁處理細晶粒鋼</p> <p>化學成分（爐前分析）</p> <table border="0" style="width: 100%; text-align: center;"> <tr> <td style="width: 16.6%;">C</td> <td style="width: 16.6%;">Mn</td> <td style="width: 16.6%;">Si</td> <td style="width: 16.6%;">S</td> <td style="width: 16.6%;">P</td> <td style="width: 16.6%;"></td> </tr> <tr> <td>0.16%max.<sup>3/</sup></td> <td>0.70-1.60%</td> <td>0.10-0.50%</td> <td>0.035%max.</td> <td>0.035%max.</td> <td></td> </tr> </table> <p>選擇性添加料：合金和晶粒細化元素一般應按照下列要求：</p> <table border="0" style="width: 100%; text-align: center;"> <tr> <td style="width: 16.6%;">Ni</td> <td style="width: 16.6%;">Cr</td> <td style="width: 16.6%;">Mo</td> <td style="width: 16.6%;">Cu</td> <td style="width: 16.6%;">Nb</td> <td style="width: 16.6%;">V</td> </tr> <tr> <td>0.80%max.</td> <td>0.25%max.</td> <td>0.08%max.</td> <td>0.35%max.</td> <td>0.05%max.</td> <td>0.10%max.</td> </tr> </table> <p>正火或淬火和回火 <sup>4/</sup></p>						C	Mn	Si	S	P		0.16%max. <sup>3/</sup>	0.70-1.60%	0.10-0.50%	0.035%max.	0.035%max.		Ni	Cr	Mo	Cu	Nb	V	0.80%max.	0.25%max.	0.08%max.	0.35%max.	0.05%max.	0.10%max.
C	Mn	Si	S	P																									
0.16%max. <sup>3/</sup>	0.70-1.60%	0.10-0.50%	0.035%max.	0.035%max.																									
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0.80%max.	0.25%max.	0.08%max.	0.35%max.	0.05%max.	0.10%max.																								
<p><u>抗拉和韌性（衝擊）試驗要求</u></p> <table border="0" style="width: 100%;"> <tr> <td style="width: 45%;"><u>板材</u></td> <td>按件試驗</td> </tr> <tr> <td><u>型材</u></td> <td>按批試驗</td> </tr> <tr> <td><u>V 型缺口試驗</u></td> <td>試驗溫度比設計溫度低 5°C，或為 -20°C，取其小者。</td> </tr> <tr> <td><u>板材</u></td> <td>橫向試樣。最小平均衝擊功（E）27J</td> </tr> <tr> <td><u>型材和鍛件</u> <sup>1/</sup></td> <td>縱向試樣。最小平均衝擊功（E）41J</td> </tr> </table>						<u>板材</u>	按件試驗	<u>型材</u>	按批試驗	<u>V 型缺口試驗</u>	試驗溫度比設計溫度低 5°C，或為 -20°C，取其小者。	<u>板材</u>	橫向試樣。最小平均衝擊功（E）27J	<u>型材和鍛件</u> <sup>1/</sup>	縱向試樣。最小平均衝擊功（E）41J														
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<u>型材和鍛件</u> <sup>1/</sup>	縱向試樣。最小平均衝擊功（E）41J																												

註：

- <sup>1/</sup> 對鍛件的 V 型缺口和化學要求可由主管機關予以特殊考慮。
- <sup>2/</sup> 對材料厚度超過 25 mm 者，V 型缺口試驗應按下列要求進行：

材料厚度 (mm)	試驗溫度 (°C)
$25 < t \leq 30$	比設計溫度低 10°, 或為 -20°, 取其小者
$30 < t \leq 35$	比設計溫度低 15°, 或為 -20°, 取其小者
$35 < t \leq 40$	比設計溫度低 20°

衝擊功應按照表內所列試樣的適用型式。對材料厚度超過 40 mm 者，V 型缺口值應予以特殊考慮。

用於液艙和液艙部件的材料，如焊接後經熱應力完全消除處理者可在比設計溫度低 5°C 或在 -20°C (取其小者) 時進行試驗。

對經熱應力消除處理的加強構件和其他附件，其試驗溫度應與鄰近液艙的殼體厚度所要求的溫度相同。

- <sup>3/</sup> 經主管機關特別同意，碳含量最大可增加至 0.18%，但設計溫度不得低於 -40°C。
- <sup>4/</sup> 可以採用控制軋製程序替代正火或淬火和回火，但須經主管機關特別認可。

指南：

對厚度超過 25 mm 的材料，試驗溫度為 -60°C 或以下者，可能有必要採用表 6.3 所列的鋼材或經特殊處理的鋼材。

表 6.3

用於設計溫度低於 $-55^{\circ}\text{C}$ 至 $-165^{\circ}\text{C}$ <sup>2/</sup> 的液貨艙、次屏壁和處理受壓容器所用的板材、型材和鍛件 <sup>1/</sup> 最大厚度為 25 mm <sup>3/</sup>		
最小設計溫度 ( $^{\circ}\text{C}$ )	化學成分 <sup>4/</sup> 和熱處理	衝擊試驗溫度 ( $^{\circ}\text{C}$ )
-60	1.5%鎳鋼—正火	-65
-65	2.25%鎳鋼—正火或正火和回火 <sup>5/</sup>	-70
-90	3.5%鎳鋼—正火或正火和回火 <sup>5/</sup>	-95
-105	5%鎳鋼—正火或正火和回火 <sup>5/6/</sup>	-110
-165	9%鎳鋼—二次正火和回火或淬火和回火	-196
-165	奧氏體不銹鋼，諸如型號 304，304L，316，316L，321 和 347 等經溶態處理 <sup>7/</sup>	-196
-165	鋁合金；諸如型號 5083 經退火	無要求
-165	奧氏體鐵—鎳合金（36%鎳）按同意的熱處理	無要求

<u>抗拉和韌性（衝擊）試驗的要求：</u>	
<u>板材</u>	按件試驗
<u>型材和鍛件</u>	按批試驗
<u>V 型缺口試驗</u>	
<u>板材</u>	橫向試樣。最小平均衝擊功（E）27J
<u>型材和鍛件</u>	縱向試樣。最小平均衝擊功（E）41J

註：

- 1/ 對應用至極限範圍的鍛件所要求的衝擊試驗，須經主管機關特別考慮。
- 2/ 對設計溫度低於-165°C 的要求應經主管機關特別同意。
- 3/ 對 1.5% Ni，2.25% Ni，3.5% Ni 和 5% Ni 的材料，如厚度超過 25 mm，衝擊試驗應按下列要求進行：

材料厚度（mm）	試驗溫度（°C）
25 < t ≤ 30	比設計溫度低 10°
30 < t ≤ 35	比設計溫度低 15°
35 < t ≤ 40	比設計溫度低 20°

任何情況下試驗溫度均不可超過上述表列的數值。

衝擊功應按照表內所列試樣的適用型式。對材料厚度超過 40 mm，試樣衝擊功應予以特殊考慮。

對 9%鎳、奧氏體不銹鋼和鋁合金，用厚度超過 25 mm 的材料，可按主管機關的指示辦理。

- 4/ 化學成分極限範圍應經主管機關認可。
- 5/ 經淬火和回火的鋼材如取用較低的最小設計溫度可經主管機關特別同意。
- 6/ 經主管機關特別同意，特別熱處理過的 5%鎳鋼，諸如經三次熱處理的 5%鎳鋼可用在-165°C 的溫度條件，但應在-196°C 下進行衝擊試驗。
- 7/ 經主管機關同意，可以免做衝擊試驗。



表 6.4

用於設計溫度低於 0°C 至 -165°C <sup>3/</sup> 的液貨艙和處理管系所用的管 材（無縫和焊接） <sup>1/</sup> 、鍛件 <sup>2/</sup> ；和鑄件 <sup>2/</sup> 最大厚度為 25 mm			
最小設計 溫度 (°C)	化學成分 <sup>5/</sup> 和熱處理	衝擊試驗	
		試驗溫度 (°C)	最小平均衝 擊功(E) (J)
-55	碳錳鋼，全鎮靜細晶粒，正火 或按同意的方法 <sup>6/</sup>	<sup>4/</sup>	27
-65	2.25%鎳鋼，正火或正火和回 火 <sup>6/</sup>	-70	34
-90	3.5%鎳鋼，正火或正火和回火 <sup>6/</sup>	-95	34
-165	9%鎳鋼 <sup>7/</sup> ，二次正火和回火或 淬火和回火	-196	41
	奧氏體不銹鋼，諸如型號 304，304L，316，316L，321 和 347，經溶態處理 <sup>8/</sup>	-196	41
	鋁合金，諸如 5083 型，退火		無要求
抗拉和韌性（衝擊）試驗要求 按批試驗 衝擊試驗—縱向試樣			

註：

- 1/ 如使用縱向或螺旋焊接的管子，則應經主管機關特別認可。
- 2/ 對於鍛件和鑄件的要求可經主管機關的特別考慮。
- 3/ 對設計溫度低於 $-165^{\circ}\text{C}$ 的要求應經主管機關特別同意。
- 4/ 試驗溫度應比設計溫度低 $5^{\circ}\text{C}$ 或為 $-20^{\circ}\text{C}$ ，取其小者。
- 5/ 化學成分的極限範圍應經主管機關認可。
- 6/ 對淬火和回火的材料可提請主管機關特別同意採用較低的設計溫度。
- 7/ 化學成分不適用於鑄件。
- 8/ 經主管機關同意，衝擊試驗可予免做。

表 6.5

4.9.1 和 4.9.4 所要求的船體結構用板材和型材							
船體結構最低設計溫度 (°C)	根據 6.1.9 規定的各種鋼級的最大厚度 (mm)						
	A	B	D	E	AH	DH	EH
0 及以上 <sup>1/</sup> -5 及以上 <sup>2/</sup>	常例做法						
至 -5	15	25	30	50	25	45	50
至 -10	X	20	25	50	20	40	50
至 -20	X	X	20	50	X	30	50
至 -30	X	X	X	40	X	20	40
低於 -30	按表 6.2 規定 但表 6.2 內及該表腳註 <sup>2/</sup> 中所指的厚度範圍不適用						

註：

“X” 係指不使用的鋼級。

<sup>1/</sup> 係指 4.9.4 範圍內適用。

<sup>2/</sup> 係指 4.9.1 範圍內適用。

### 6.3 焊接和無損探傷檢查

#### 6.3.1 通則

本節要求一般適用於碳、碳錳鋼、鎳合金和不銹鋼，同時作為驗

收其他材料試驗的基礎。主管機關可自行決定對不鏽鋼和鋁合金焊接件免做衝擊試驗以及對其他任何材料可特別要求加做其他試驗。

### 6.3.2 焊接材料

除經主管機關另行同意外，對擬用作焊接液貨艙的焊接材料應根據承認的標準規定。所有焊接材料應要求作溶敷金屬試驗和對接焊縫試驗，主管機關另行同意者除外。抗拉和 V 型缺口衝擊試驗所得的結果應符合承認的標準規定。溶敷金屬的化學成分應作記錄供查驗和認可。

### 6.3.3 液貨艙和處理受壓容器的焊接程序試驗

6.3.3.1 對所有液貨艙和處理受壓容器的對接焊縫，要求作焊接程序試驗，而且其試件應代表：

每種母材

每種焊接材料和每種焊接方法

每種焊接位置。

對板材的對接焊縫，其試件應截取得使軋製方向平行於焊接方向。每一種焊接程序試驗所認可的材料厚度範圍應按照承認的標準規定。射線或超聲波探傷檢查可由製造廠或主管機關選擇決定。擬作填角焊用的焊接材料的焊接程序試驗應按照承認的標準。在這種情況下，應選擇具有滿意衝擊性能的焊接材料。

6.3.3.2 對液貨艙和處理受壓容器所作的下列焊接程序試驗應在每一試件上進行：

.1 十字焊接拉伸試驗。

- .2 橫向彎曲試驗由主管機關自行選擇，可為正彎、反彎或側彎。如果母材和焊接金屬具有不同的強度級，則縱向彎曲試驗可替代橫向彎曲試驗。
- .3 一組 3 個 V 型缺口衝擊試樣，一般在下列位置上截取，如圖 6.1 所示：  
焊縫的中心線  
熔合線 (F.L.)  
距熔合線 1 mm  
距熔合線 3 mm  
距熔合線 5 mm
- .4 主管機關可要求作宏觀斷面、微觀斷面和硬度測定檢驗。

#### 6.3.4 試驗要求

6.3.4.1 拉伸試驗：一般來說，抗拉強度不應低於相應母材規定的最小抗拉強度。如果焊縫金屬的抗拉強度低於母材金屬的抗拉強度，則主管機關可要求橫向焊縫抗拉強度應不低於對焊縫金屬所規定的最小抗拉強度。在每一情況下，裂縫位置應作出報告備查。

6.3.4.2 彎曲試驗：除主管機關另有特殊要求或另經許可者外，彎心直徑為 4 倍試樣厚度的 180°彎曲試驗時不得斷裂。

6.3.4.3 V 型缺口衝擊試驗：卻貝試驗應在對被連接母材所規定的溫度下進行。焊接金屬衝擊試驗結果應表明最小平均衝擊功 (E) 不得低於 27J。小尺寸試樣的焊縫金屬要求和單個衝擊功應根據 6.1.4 規

定。熔合線和熱影響區衝擊試驗的結果應表明最小平均衝擊功符合母材的橫向或縱向要求（視何者適合而定），而且對小尺寸試樣，最小平均衝擊功應按照 6.1.4 規定。如果材料的厚度不可能截取大尺寸試樣或是標準小尺寸試樣，則其試驗程序和驗收標準應根據認可標準的規定。

#### 6.3.5 管路的焊接程序試驗

對管路應進行焊接程序試驗。試驗的具體要求應與 6.3.3 對液貨艙規定的要求相類似。除非主管機關另行同意，試驗要求應根據 6.3.4 的規定。

#### 6.3.6 成品焊接試驗

6.3.6.1 除整體液艙和薄膜液艙外的所有液貨艙和處理受壓容器，一般應對每 50 M 的對接焊縫接頭進行成品焊接試驗並應代表每一焊接位置。對次屏壁應進行如對主屏壁所要求的同樣型式的成品焊接試驗。但經主管機關許可，試驗數量可以減少。除 6.3.6.2，.3 和.4 所規定的試驗以外，對液貨艙或次屏壁的其他試驗可由主管機關自行決定。

6.3.6.2 對 A 型和 B 型獨立液艙和半薄膜液艙的成品試驗應包括下列試驗：

- .1 彎曲試驗，如要求作程序試驗，每 50 m 焊縫應作一組 3 個 V 型缺口試驗。V 型缺口試驗應使缺口交替位於焊縫中心和熱影響區（根據程序試驗考核的結果選定最關鍵的位置）。對於奧氏體不鏽鋼，所有缺口應位於焊縫中心處。

- .2 試驗要求與 6.3.4 所適用的試驗要求相同，但如衝擊試驗不符合衝擊功的要求，經主管機關特別考慮，通過落錘試驗，仍能予以驗收。在此情況下，對每套不合格的卻貝試件，應選兩個試樣作落錘試驗。這兩個試樣應處在與卻貝試驗同樣的溫度下進行落錘試驗得出“不破斷”特性。

6.3.6.3 對 C 型獨立液艙和處理受壓容器，除 6.3.6.1 規定的那些試驗外，尚要求作橫向焊縫拉伸試驗。各種試驗要求見 6.3.4，但對未達到規定衝擊功要求的衝擊試驗只要經主管機關特殊考慮，通過落錘試驗仍可予以接受。在這種情況下，對每套不合格的卻貝試件，應取兩個試樣作落錘試驗，並應處在卻貝試驗同樣的溫度下進行試驗得出“不斷裂”的特性。

6.3.6.4 整體液艙和薄膜液艙的成品試驗應根據承認的標準規定。

#### 6.3.7 無損探傷檢查

6.3.7.1 對 A 型獨立液艙和半薄膜液艙如設計溫度為  $-20^{\circ}\text{C}$  或以下時，以及對 B 型獨立艙不論溫度如何，其液貨艙殼板的所有全焊透對接焊縫應作 100%射線檢查。

6.3.7.1.1 如設計溫度高於  $-20^{\circ}\text{C}$ ，在交叉點處的所有全焊透對接焊縫和至少 10%的其餘液艙結構的全焊透焊縫應作射線檢查。

6.3.7.1.2 在每一情況下，如經主管機關考慮有必要時，其餘的液艙結構焊縫，包括扶強材以及其他配件和連接件的焊縫應採用磁粉或著色進行檢查。

6.3.7.1.3 所有特別焊縫檢查程序和驗收標準應根據承認的標準規定。主管機關可接受經認可的超聲波檢查程序替代射線檢查，但也可要求選擇一定的位置用射線透視作補充檢查。此外，主管機關除可要求採用正常射線檢查外，還可要求採用超聲波探傷檢查。

6.3.7.2 C 型獨立液艙和處理受壓容器的檢查應按 4.10.9 的規定進行。

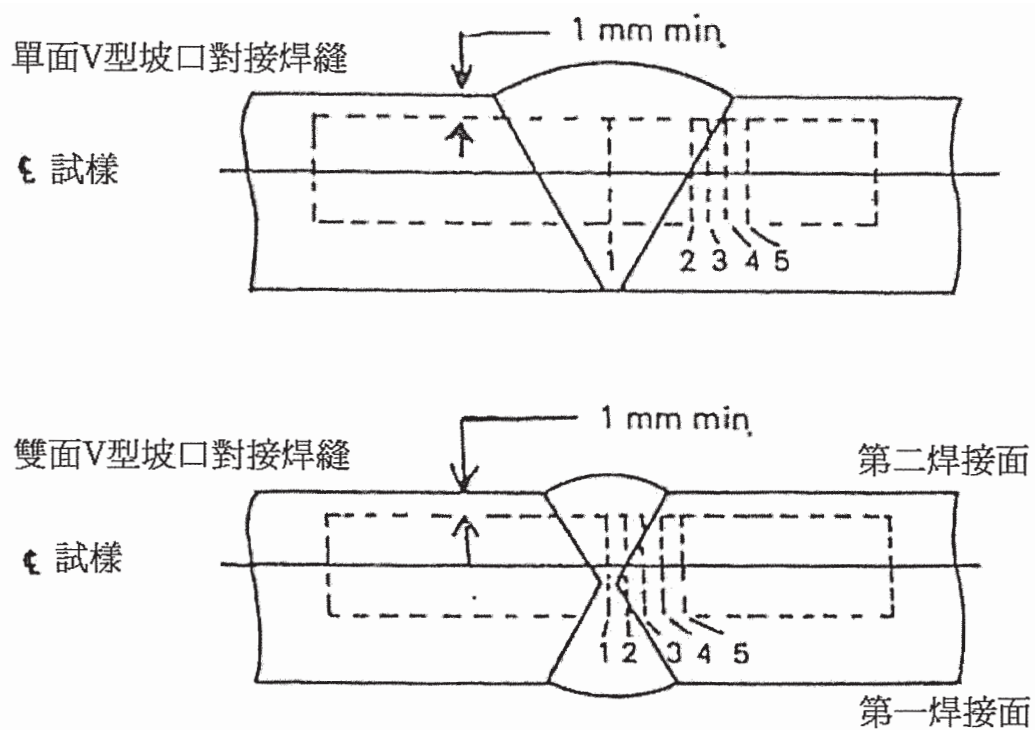
6.3.7.3 對整體和薄膜液，特殊焊縫檢查程序和驗收標準應根據承認的標準規定。

6.3.7.4 內層殼體或支撐內部絕熱液艙的獨立液艙結構的檢查和無損探傷檢查應考慮計及 4.4.7 規定的設計準則。檢查和無損探傷檢查的計劃應使主管機關的滿意。

6.3.7.5 管路的檢查應按照第 5 章的規定。

6.3.7.6 如主管機關認為有必要，主屏壁應作射線檢查。如船體的外殼作為次屏壁的一部分，所有舷側頂外板的對接縫和舷側外板上的所有對接縫的交叉點應作射線檢查。





缺口位置：

1. 位於焊縫中心
2. 位於熔合線上
3. 在 HAZ 位置，距熔合線 1 mm
4. 在 HAZ 位置，距熔合線 3 mm
5. 在 HAZ 位置，距熔合線 5 mm

HAZ = 熱影響區

材料厚度所許可的最大尺寸的卻貝試樣應截取得使試件的中心位置儘可能接近材料厚度表面和中心之間的中點處。在所有情況下，從材料的表面至試樣邊的距離應為 1 mm 或以上。此外對雙面 V 形坡口對接焊縫，試樣尚應在接近於第二個焊接面處截取。

圖 6.1 - 焊接試樣的定向

## 第 7 章 貨物壓力／溫度控制

### 7.1 通則

7.1.1 除非全部貨艙系統設計成能在環境設計溫度上限條件下承受貨物的最大蒸氣表壓力，否則應設有下列一種或一種以上的系統以保持貨艙壓力低於釋放閥設定的最大許用值 MARVS (以下同)。但本節另有規定者除外：

- .1 用機械製冷方式調節液貨艙內壓力的系統；
- .2 遵照第 16 章將蒸發氣體作為燃料供船上使用或供廢熱系統使用的系統。此系統在任何時間都可使用，包括船舶在港或在航行期間，但要設置一種處理過剩能量的裝置，諸如蒸氣排泄系統，並應徵得主管機關的同意；
- .3 使物品加溫和增大壓力的系統，絕熱層或液貨艙設計壓力或兩者均應足以為所涉及的操作時間和溫度提供適當的餘量。在每一情況下，此系統應為主管機關可以接受；
- .4 主管機關可接受的其他系統；
- .5 除上述系統以外，主管機關可允許船舶在海上航行時某些貨物通過排放其蒸氣至大氣壓來予以控制。經港口當局同意，泊港時也可用此方法。

7.1.2 7.1.1 所要求的系統，其結構、安裝和試驗應使主管機關滿意。結構的材料應適合所載運的貨物。對正常營運的船舶，環境溫度的上限應為：

海水 32°C

空氣 45°C

對營運於特別熱或冷的航區的船舶，主管機關應對這些設計溫度作適當增減。

7.1.3 對第 17 章規定的某些很危險性的貨物，不論是否設有處理蒸發氣體的系統，貨物圍護系統應於環境設計溫度上限範圍內能承受貨物的最大蒸氣壓力。

## 7.2 製冷系統

7.2.1 製冷系統應包括一台或多台在環境設計溫度上限的範圍內能保持所要求的貨物壓力／溫度的機組。除非設有另一種能控制貨物壓力／溫度的設施能使主管機關滿意，否則應設有至少能提供相等於所要的最大單個機組容量的一台（或幾台）備用機組。備用機組應包括帶有驅動電動機的壓縮機、控制系統以及任何必需的附件等，以便能獨立於正常工作機組運行。除非用於該機組的正常熱交換器的容量至少能超過最大要求容量的 25%，否則應設有備用熱交換器，但不要求有獨立管路系統。

7.2.2.1 如果同時載運兩種或兩種以上能起危險化學反應的冷凍貨物時，則對製冷系統應予特別考慮，以避免貨物混在一起的可能性。如載運這類貨物，應對每種貨物設置獨立的製冷系統，每一製冷系統應按 7.2.1 規定備有備用機組。但是，如果利用間接或組合系統進行冷卻，而且熱交換器的泄漏不致在任何可以設想的情況下造成貨物的相混，則不必設置單獨使用的製冷機組。

7.2.2.2 如載運兩種或多種在運輸條件下不會相互溶解的冷凍貨物，但它們的蒸氣壓力能在液貨混合情況下相加者，則應對製冷系統特別考慮，以避免貨物相混的可能性。

7.2.3 如果製冷系統要求用冷卻水，則應由專為此而設的泵或泵組提供足夠的冷卻水。這台泵或這些泵至少應具有兩個海水吸入管路，如有可能，應引自左舷和右舷的海水箱。應配備一台具有足夠容量的備用泵，此泵可作其他用途，只要這些用途不妨礙製冷這一項主要工作。

7.2.4 製冷系統可按下列方式之一進行佈置：

- .1 一個直接系統將氣貨壓縮、冷凝和輸回液貨艙。對第 17 章規定的某些貨物不得採用；
- .2 一個間接系統將貨物或氣貨用載冷劑冷卻或冷凝，但不需要壓縮；
- .3 一個組合系統將氣貨壓縮，在貨物／載冷劑熱交換器內冷凝並輸回液貨艙。對第 17 章規定的某些貨物不得使用。

7.2.5 所有製冷劑和載冷劑必須相互相容，並與可能接觸的貨物相容。熱交換可在遠離液貨艙處進行或是通過設置在液貨艙裏面或外邊的冷卻盤管進行。

## 第 8 章 液貨艙的透氣系統

### 8.1 通則

所有液貨艙應設有適合於貨物圍護系統設計和所載運貨物的壓力釋放系統。可能承受超過其設計能力的貨物處所，屏壁間處所以及貨物管路也應設有適當的壓力釋放系統。此系統應與透氣管路系統連接，其設計應使貨物蒸氣積聚在甲板上或進入居住處所、服務處所、控制站和機器處所或可能造成危險的其他處所的可能性減少至最低限度。第 7 章所規定的壓力控制系統應獨立於壓力釋放閥。

### 8.2 壓力釋放系統

8.2.1 容積超過 20 m<sup>3</sup> 的每一液貨艙至少應設置兩隻容量大致相等的壓力釋放閥，其設計和構造應適合於規定的用途。容積未超過 20 m<sup>3</sup> 的液貨艙可設置單個釋放閥。

8.2.2 屏壁間處所應設有使主管機關滿意的壓力釋放裝置。

8.2.3 壓力釋放閥的開啓壓力應不大於在設計液艙中已採用的蒸氣壓力。

8.2.4 壓力釋放閥應連接在甲板以上部分的液貨艙最高部位。工作溫度低於 0°C 的液貨艙上的壓力釋放閥，其佈置應防止在關閉時形成結冰造成閥失靈。承受低環境溫度液貨艙上的壓力釋放閥的構造和佈置應給與適當考慮。

8.2.5 壓力釋放閥應進行原型試驗以保證閥具有所要求的排量。每一閥應經試驗以保證在規定的設定壓力下開啓，開啓壓力的偏差，在 0 至 1.5 bar 時不超過±10%，在 1.5 至 3.0 bar 時不超過±6%，在 3.0 bar 及以上時不超過±3%。壓力釋放閥應由主管機關認可的主管當局進行

校核和鉛封，此項工作應作出記錄（包括閥的調整壓力），保留在船上。

8.2.6 如液貨艙允許有一個以上釋放閥設定值時，可採用下列方法完成：

- .1 安裝兩隻或更多隻經正確調整和鉛封閥以及提供必要時可把不用的閥與液貨艙隔離的設施；或
- .2 安裝釋放閥，其設定值可通過插入預先認可的設定環或替換彈簧或用其他類似設施來變更，不要求作壓力試驗來核實新設定的壓力。所有其他閥的調整應鉛封。

8.2.7 變更 8.2.6 規定的設定壓力應在船長的監督下根據主管機關認可的規程以及船舶操作手冊的規定進行。設定壓力值的變更應記錄在航行日誌內並在貨物控制室（如沒有時）內貼上標記，並在每一釋放閥上標明設定壓力。

8.2.8 在液貨艙和釋放閥之間不應設有為便於維修而設的截止閥或其他隔離設施，除非設有所有下列裝置：

- .1 防止有一個以上壓力釋放閥同時失效的合適裝置；
- .2 能自動和明顯地表明某個釋放閥失效的裝置；
- .3 壓力釋放閥排量應是這樣：如果一隻閥不能工作時，其餘的各閥具有 8.5 所要求的聯合排量。但是，如果船上備有一隻保養良好的備用閥，上述排量可由所有釋放閥來承擔。

8.2.9 裝在液貨艙上的每一壓力釋放閥應與透氣系統相連接，此系統的構造應把排放的氣體引向上方，且其佈置應使水或雪能進入排氣系統的可能性減少至最低限度。透氣管出口的高度應不低於露天甲板以上  $B/3$  或 6 m，取其大者，並高出工作區域和縱向步橋 6 m。

8.2.10 液貨艙壓力釋放閥排氣管出口的佈置離最近的通向居住處所、服務處所和控制站或其他氣體安全處所的空氣吸入口或開口的距離至少等於  $B$  或 25 m，取其小者。對長度小於 90 m 的船舶，經主管機關同意可以取較小者。連接至貨物圍護系統的所有其他排氣管出口的佈置離最近的通向居住處所的服務處所和控制站，或其他氣體安全處所的空氣吸入口或開口的距離至少應為 10 m。

8.2.11 其他各章未涉及的所有其他貨物排氣管出口應按 8.2.9 和 8.2.10 的規定佈置。

8.2.12 如果同時載運的幾種貨物，其相互間能起危險反應，則應對每一種載運的貨物設置單位的壓力釋放系統。

8.2.13 在排氣管路系統中，應設有從易於積聚液體的地方排泄液體的設施。壓力釋放閥和管路的佈置應在任何情況下也不會使液體積聚在壓力釋放閥內或附近。

8.2.14 在排氣管出口處應設置適當的防護網罩，以免異物進入。

8.2.15 所有排氣管路的設計和佈置應確保不因管子的溫度變化或船舶的運動而受到損壞。

8.2.16 按 8.5 規定要求確定排量時，應計及壓力釋放閥排氣管路中的背壓。



8.2.17 壓力釋放閥在液貨艙上的位置應使船舶處於橫傾 15°及 0.015L 縱傾（L 的定義見 1.3.23）的條件下依然保持蒸氣狀態。

### 8.3 用於液位控制的其他壓力釋放系統

8.3.1 如按 15.1.4.2 的要求，應對每一液艙增設一個壓力釋放系統以防止在 8.5 所述播及火災的情況下在系統釋放的任何時間內不使液體滿艙。此壓力釋放系統應包括如下：

- .1 一隻或幾隻釋放閥設定的壓力相當於 15.1.4.2 所規定的溫度時液貨艙的蒸氣表壓力；和
- .2 一個越控裝置，必要時以阻止其正常工作。此裝置應包括易熔元件，設計在 98°C 到 104°C 之間下熔化，且使 8.3.1.1 規定的釋放閥可以作用。易熔元件應特別位於釋放閥的附近。一旦在系統電源發生故障時此系統可以產生作用。該越控裝置應不依賴於船上的任何動力源。

8.3.2 增設的壓力釋放系統的總釋放量在 8.3.1.1 所述的壓力下應不低於下列公式之值：

$$Q' = FG'A^{0.82} \text{ (m}^3\text{/s)}$$

式中：

Q' = 在 273 K 和 1.013 bar 標準狀態下所要求的最小空氣排放率。

$$G^1 = \frac{12.4}{(L + \rho_r^m)D} \sqrt{\frac{Z \cdot T^1}{M}}$$

式中：

$P_r$  = 在釋壓條件下，液態貨品的相對密度

( $P_r = 1.0$ ，淡水)；

$m = -di/d_{pr}$  = 在釋壓條件下，液態熱含的遞減相對於液態密度 (kJ/kg) 的增加。對設定壓力不大於 2.0 bar，可使用表 8.1 所列之值。對於未列入表內的貨品和較高的設定壓力， $m$  值應根據貨品本身的熱動力資料進行計算；

$i$  = 液體的熱含 (kJ/kg)；

$T'$  = 在釋壓狀態，亦即增設的壓力釋放系統設定壓力下，以 K 表示的溫度；

$F$ ， $A$ ， $L$ ， $D$ ， $Z$  和  $M$  見 8.5.2 的定義。

8.3.3 如符合 8.3.1.1 規定而要求改變本節中所設置的釋放閥的設定壓力，則應按照 8.2.6 和 8.2.7 的規定辦理。

8.3.4 8.3.1.1 所述的釋放閥可與 8.2 所述的壓力釋放閥相同，但是設定壓力和釋放量應符合本節要求。

8.3.5 這類壓力釋放閥的排氣可導致 8.2.9 所述的透氣系統。如果安裝單獨的透氣系統，則應按照 8.2.9 至 8.2.15 的要求。

表 8.1—系數 m

貨品	$m = -di/d_{Pr}$ (kJ/kg)
氨	3400
丁二烯	1800
丁烷	2000
丁烯	1900
乙烷	2100
乙烯	1500
甲烷	2300
甲基氯	816
氦	400
丙烷	2000
丙烯	1600
丙烯氧化物	1550
乙烯基氯	900

表內所列之值可適用於設定壓力不大於 2.0 bar。

#### 8.4 真空保護系統

8.4.1 凡設計能承受最大外部壓力差超過 0.25 bar 並能承受在最大卸貨速率下，無蒸氣返回液貨艙而可能達到的最大外部壓力差的液貨艙或採用貨物冷凍系統時，均不需要真空保護系統。

8.4.2 凡設計能承受最大外部壓力差不超過 0.25 bar 的液貨艙，或不能承受在最大的卸貨速率下，無蒸氣返回液貨艙而可能達到的最大外部壓力差的液貨艙或採用貨物冷凍系統，或採用送蒸氣氣體給機械處所，則應設置：

- .1 兩天獨立的壓力開關，用於在充分低於液貨艙最大設計外部壓力差的情況下，用適當方式作順序報警和順序停止從液貨艙抽吸液體貨物或蒸氣以及停止冷凍設備（如設有時）；或
- .2 真空釋放閥，具有至少等於最大單艙卸貨速度的氣流量，調整在足夠低於貨艙最大外部設計壓差的情況下開啓；或
- .3 主管機關可接受的其他真空釋放系統。

8.4.3 遵照第 17 章的要求，真空釋放閥應允許惰性氣體、貨物蒸氣或空氣進入液貨艙，且其佈置應儘量減少水或雪進入液貨艙的可能性。如許可貨物蒸氣進入，則應由貨物蒸氣管路以外的途徑進入。

8.4.4 真空保護系統應能進行試驗，以保證其在規定的壓力下起作用。

#### 8.5 閥的大小

壓力釋放閥對每個液貨艙應具有一個組合釋放量，它應能釋放下列兩者中的大者而液貨艙內壓力的升高不超過 MARVS 值的 20%：

- .1 液貨艙惰化氣體系統的最大能量，如果液貨艙惰化氣體系統的可達到的最大工作壓力超過液貨艙 MARVS 值；或
- .2 播及火災時產生的蒸氣量按下列公式進行計算：

$$Q = FGA^{0.82} \text{ (m}^3\text{/S)}$$

式中：

Q = 在 273 K 和 1.013 bar 標準狀態下，所要求的空氣最小排出率。

F = 不同類型液貨艙的火災播及系數：

F = 1.0 對於甲板上無絕熱層的液貨艙

F = 0.5 對於甲板上方的液貨艙，絕熱層經主管機關認可。（此項認可根據使用認可的防火材料、絕熱層的熱傳導和處於火災情況下的穩定性）；

F = 0.5 對於安裝在貨艙中非絕熱的獨立液貨艙；

F = 0.2 對於在貨艙內的絕熱的獨立液貨艙（或在絕熱貨艙內的非絕熱的獨立液貨艙）；

F = 0.1 對於在惰化貨艙內的絕熱的獨立液貨艙（或在惰化的絕熱貨艙內的非絕熱的獨立液貨艙）；

F = 0.1 對於薄膜和半薄膜液貨艙。

對於部分突出於露天甲板的獨立液貨艙，其火災播及系數應根據甲板上和甲板下的表面面積決定。

G = 氣體系數

$$G = \frac{12.4}{LD} \sqrt{\frac{Z \cdot T}{M}}$$

式中：

T = 在釋放狀態下的溫度 K，即壓力釋放閥設定壓力的 120%。

L = 在釋放狀態下，貨物的氣化熱 (kJ/kg)。

D = 常數，根據比熱 k 決定，見表 8.2；如 k 值不知，則 D 應取 0.606。

常數 D 也可用下列公式算得：

$$D = \sqrt{k \left( \frac{2}{k+1} \right)^{\frac{k+1}{k-1}}}$$

Z = 在釋放狀態下氣體的壓縮性系數；如此系數未知，則取 Z = 1.0。

M = 貨品的分子量。

A = 不同類型液貨艙外表面面積 (m<sup>2</sup>):

對回轉型液貨艙殼體：

A = 外表面面積；

對非回轉型液貨艙殼體：

A = 外表面面積減去底表面的投影面積；

對由一組受壓容器組成的液貨艙：

- 船體結構絕熱：

A = 貨艙的外表面面積減去其投影的面積；

- 液貨艙結構絕熱：

A = 一組受壓容器的外表面面積 (不包括絕熱層) 減去投影底面積，見圖 8.1。

表 8.2 常數 D

k	D	k	D
1.00	0.606	1.52	0.704
1.02	0.611	1.54	0.707
1.04	0.615	1.56	0.710
1.06	0.620	1.58	0.713
1.08	0.624	1.60	0.716
1.10	0.628	1.62	0.719
1.12	0.633	1.64	0.722
1.14	0.637	1.66	0.725
1.16	0.641	1.68	0.728
1.18	0.645	1.70	0.731
1.20	0.649	1.72	0.734
1.22	0.652	1.74	0.736
1.24	0.656	1.76	0.739
1.26	0.660	1.78	0.742
1.28	0.664	1.80	0.745
1.30	0.667	1.82	0.747
1.32	0.671	1.84	0.750
1.34	0.674	1.86	0.752
1.36	0.677	1.88	0.755
1.38	0.681	1.90	0.758
1.40	0.685	1.92	0.760
1.42	0.688	1.94	0.763
1.44	0.691	1.96	0.765
1.46	0.695	1.98	0.767
1.48	0.698	2.00	0.770
1.50	0.701	2.02	0.772
		2.20	0.792

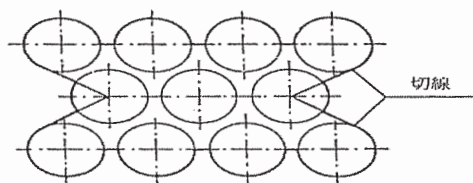


圖 8.1

## 第 9 章 環境控制

### 9.1 液貨艙和貨物管路系統內的環境控制

9.1.1 應裝有一個管路系統，使每個液貨艙能安全清除氣體，且能在氣體清除狀態安全地用貨物氣體掃除空氣。此系統的佈置應使在清除氣體或掃除空氣後留下氣體或空氣死角的可能性減少至最低限度。

9.1.2 為了合適地監測掃除空氣和清除氣體的進程，應對每個液貨艙設置足夠數量的採樣點。氣體採樣連接裝置應在主甲板上裝設閥門並加蓋板。

9.1.3 對可燃氣體，應利用惰化介質作為中間步驟，在清除氣體作業的每個階段減少可燃氣體混合物存在於液貨艙的可能性。此外，此系統應能使液貨艙在灌注液貨或氣貨前，用惰化介質掃除空氣，不允許有可燃混合氣在任何時候存在於液貨艙內。

9.1.4 可能含有貨物的管路系統應能按 9.1.1 和 9.1.3 的規定清除氣體和掃除空氣。

9.1.5 用於這些作業程序的惰性氣體可由岸上或船上供給。

### 9.2 液貨艙內的環境控制（除 C 型獨立液艙以外的貨物保護系統）

9.2.1 供可燃氣體用的附有要求全部設次屏壁的貨物圍護系統的屏壁間處所和貨艙處所，應用適當的乾燥惰性氣體予以惰化，並用船上惰性氣體發生系統進行補充或用船上能充分供應正常消耗至少達 30 天的儲存量來維持惰化。

9.2.2.1 供可燃氣體用的附有要求部分設次屏壁的貨物圍護系統的屏壁間處所和貨艙處所，應用適當的乾燥惰性氣體予以惰化，並用船上



惰性氣體發生系統進行補充或用船上能充分供應正常消耗至少達 30 天的儲存量來維持惰化。

9.2.2.2 或者，遵照第 17 章規定的限制，主管機關可允許對 9.2.2.1 所述的處所用乾燥的空氣充填，但船上應保存一定的惰性氣體儲存量或設有惰性氣體發生系統足以惰化最大的這些處所；同時這些處所的形狀和有關的氣體檢測系統連同惰化設施的能力能迅速地探知液貨艙的任何泄漏，以及能在危險條件形成之前完成惰化作用。應設有能產生足夠數量、適當質量和能滿足預期需要的乾燥空氣設備。

9.2.3 對非可燃性氣體，9.2.1 和 9.2.2.1 所述的處所可用適當的乾燥空氣或惰性氣體來維持。

9.2.4 如屬內層絕熱的液艙，屏壁間處所不要求設有環境控制裝置；位於次屏壁與內層船體之間的處所，以及位於次屏壁與符合 4.9.7.2 規定的全部充填絕熱材料的獨立液艙結構之間的處所，也不要求設有環境控制裝置。

### 9.3 C 型獨立液艙周圍處所的環境控制

冷凍液貨艙周圍處所未設置次屏壁者應灌注合適的乾燥惰性氣體或乾燥的空氣，並用船上惰性氣體發生系統、船上儲存的惰性氣體或合適的乾燥空氣設備提供的乾燥空氣來補充和維持這種狀態。

### 9.4 惰化

9.4.1 惰化係指加進相容氣體製造一個不可燃的環境。這些氣體可裝在儲存容器內或在船上製造或由岸上供給。惰性氣體在化學性質上和操作上，應在所有要惰化處所內可能產生的溫度下，與處所的結構材料和貨物相容。應考慮到氣體的露點。

9.4.2 如儲存惰性氣體還用作滅火，則應裝在獨立的容器內，且不應用於貨物的用途。

9.4.3 當惰性氣體在 0°C 以下儲存時，無論是液態或是氣態，其儲存和供應系統的設計應使在船舶結構上施加的溫度不下降至極限值之下。

9.4.4 應設有適於所載運貨物的裝置，以防止貨物蒸氣倒回至惰性氣體系統中。

9.4.5 此裝置應使每個惰化的處所能予以隔離，並設有必要的控制和釋放閥等，用來控制這些處所的壓力。

## 9.5 船上惰性氣體的生產

9.5.1 遵照第 17 章的特殊要求，此設備應能產生含氧量在任何時候不大於 5%（容積）的惰性氣體。遵照第 17 章的要求，此設備的惰性氣體出口處須設置一能連續顯示含氧讀數的儀錶及一個設定含氧量在 5%（容積）報警的報警器。此外，如惰性氣體採用船上的空氣分餾法制取，此法涉及用於連續施放的液態氮冷劑的儲存，送入儲存器的液化氣體應予監測微量氧以避免為惰化而施放惰性氣體時可能有初先高富氧氣體。

9.5.2 惰性氣體系統應具有與貨物圍護系統相適應的壓力控制和監測裝置。應設有一種主管機關可接受的安裝在貨物區域能防止貨物氣體回流的設施。

9.5.3 安裝惰性氣體發生裝置的處所不應有進入起居處所、服務處所或控制站的直接通道，但可位於機艙處所內。如果這種設備安裝在機器處所或液貨艙區域以外的其他處所，則應按 9.5.2 要求在貨物區域

內的惰性氣體總管上裝有兩個止回閥或等效設施。惰性氣體管路不得通過起居處所、服務處所或控制站。

9.5.4 產生惰性氣體的火焰燃燒設備不得位於貨物區域內，對於採用催化燃燒法的惰性氣體發生裝置的安裝位置可給與特殊考慮。

## 第 10 章 電氣設備

### 10.1 通則

10.1.1 本章規定適用於載運易燃貨品的船舶，並應與 SOLAS 1983 修正條款第 II-1 章的第 D 部分一起實施。

10.1.2 配備的電氣設備應使易燃貨品燃燒和爆炸的危險減少到最低程度。符合本章規定的電氣設備不必當作第 3 章範圍內的着火源來看待。

10.1.3 主管機關應採取適當的措施以保證本章關於電氣設備規定的實施和執行的一致性。\*

10.1.4 當允許存在 10.2 內所列的例外時，電氣設備或電纜，除了在上是必要的以外，不得安裝或敷設在危險處所或危險區域。

10.1.5 如電氣設備按 10.1.4 規定安裝在危險處所或危險區域應使主管機關認為滿意，並經主管機關認可的有關機關核准方可在易燃大氣中操作。

### 10.2 設備的類型

合格安全型設備可以按照下列規定安裝在氣體危險處所和氣體危險區域：

#### 10.2.1 氣體危險處所和區域—通則

本質安全型電氣設備和電纜可安裝和敷設在 1.3.17 所規定的所有氣體危險處所和區域內。

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\* 可參考國際電工委員會出版的建議，特別是出版物 92-502。

### 10.2.2 貨物圍護系統

潛水貨泵電動機及其輸送電纜可以裝設在貨物圍護系統內。應設有裝置以能在低液位時自動關閉電動機。這可用檢測泵排出低壓力、電動機低電流或低液位的方法實現。此種關閉動作應在貨物控制站報警。貨泵電動機應能在除氣操作期間切斷其電源。

### 10.2.3 貨艙和某些其他處所

10.2.3.1 如貨物裝載在要求次屏壁貨物圍護系統內的貨艙中，則此貨艙內可敷設潛水貨泵電動機的輸電電纜。

10.2.3.2 如貨物裝載在不要求次屏壁貨物圍護系統內的貨艙中以及 1.3.17.5 所述的處所中，則此貨艙內可按下列要求裝設：

- .1 路過電纜敷設；
- .2 隔爆型的或通風、充氣型的照明設備。照明系統至少應有兩個分路供電。所有的開關和保護裝置應能中斷所有的電極或相位，並應裝設在氣體安全區域；和
- .3 電測深儀或測程儀以及外加電流陰極保護系統的陽極或電極。這些裝置應安裝在氣密的外殼內；

下列僅可裝設在 1.3.17.5 所述的處所內：

- .4 為貨物或壓載系統閥門操縱所用的防火電動機；並且
- .5 隔爆型通用音響報警指示器。

#### 10.2.4 貨泵艙和貨物壓縮機艙

10.2.4.1 照明設備應具有通風、充氣型外殼或應為隔爆型。照明系統至少應有兩個分路供電。所有的開關和保護裝置應能中斷所有的電極或相位，並應安裝在氣體安全處所內。

10.2.4.2 驅動貨泵或貨物壓縮機的電動機應以氣密艙壁或甲板使之與這些處所隔開。應對被驅動設備及其電動機之間的傳動軸設置彈性聯軸節或其他保持對中的措施，此外，在傳動軸通過氣密艙壁或甲板處，應設有合適的密封裝置。此項電動機及其附屬設備應安裝在符合第 12 章的艙室內。

10.2.4.3 如因操作或結構上的要求而不可能符合 10.2.4.2 所述的規定，可安裝下列合格安全型的電動機：

- .1 具有防爆外殼的增加安全型；和
- .2 通風、充氣型。

10.2.4.4 通用音響報警指示器應具有防爆罩殼。

#### 10.2.5 露天甲板上的區域以及貨艙以外的處所

10.2.5.1 露天甲板上的區域或露天甲板上的非圍閉處所，距任何液貨艙出口、氣體或蒸氣出口、貨物管法蘭、貨物閥門或通向貨泵艙和貨物壓縮機艙的通風口或入口的 3m 範圍內；在貨物區域上方露天甲板的區域內和距露天甲板上貨物區域前後各 3m 以及甲板以上高度達 2.4 m 的範圍內；距貨物圍護系統的露天外表面 2.4m 內的區域，可安裝下列設備：

- .1 合格安全型設備；和

.2 敷設路過電纜。

10.2.5.2 在含有貨品管系的圍閉或半圍閉處所內以及放置貨物軟管的艙室中，可裝設下列設備：

- .1 防爆型或具有通風、充氣型的照明設備。照明系統至少應有兩個分路供電。所有的開關和保護裝置應能中斷所有的極或相位並應裝設在氣體安全處所內；和

.2 敷設路過電纜。

10.2.5.3 對具有直接開口通向任何氣體危險處所或區域的圍閉或半圍閉處所，應安裝符合對開口通往的處所或區域的要求的電氣設備。

10.2.5.4 用空氣閘保護的處所內安裝的電氣設備應為合格安全型，除非其佈置係按 3.6.4 要求的措施可以使其停止通電者。

## 第 11 章 防火和滅火

### 11.1 防火安全要求

11.1.1 不論船舶噸位的大小(包括小於 500 總噸的船舶), SOLAS 1983 年修正條款第 II-2 章對油船的要求應適用於本規則範圍內的船舶, 但:

- .1 第 56 條之 4 不適用;
- .2 第 4 條適用於貨船部分, 第 7 條按其適用於 2,000 總噸及 2,000 總噸以上油船的情況, 均應適用;
- .3 SOLAS 1983 年修正條款第 II-2 章有關油船的條款不適用, 並以本規則的各章、節替代如下:

SOLAS 條文	本規則置換條文
17	11.6
56.1 和 56.2	第 3 章
60、61、62	11.3 和 11.4
63	11.5

11.1.2 除在第 10 和 16 章中另有規定外, 所有着火源應從可能存在可燃性蒸氣的處所內排除。

11.1.3 本節規定與第 3 章一起適用。

11.1.4 為了滅火, 在最後面貨艙的末端或在最前面貨艙的前端處的隔離艙、壓載艙或空艙上方的任何露天甲板區域應包括在貨物區域內。

### 11.2 消防總管設備



11.2.1 凡裝運受本規則約束的貨品的一切船舶，不論噸位大小，應符合 SOLAS 1983 年修正條款第 II-2/4 和 II-2/7 條的要求，但當消防泵和消防總管用作如 11.3.3 所許可的水霧系統的一部分時，所要求的消防泵排量、消防總管和供水管的直徑則不受第 4.2.1 和 4.4.1 條的限制。此外，第 4.4.2 條的要求，在表壓力至少為 5.0 bar 時應得到滿足。

11.2.2 水滅火系統的佈置應至少使兩股水柱能射到貨艙區域內甲板的任何部位和甲板上方的貨物圍護系統和液艙蓋板部分。應佈置必要數目的消火栓以滿足上述要求並符合 SOLAS 1983 年修正條款第 II-2/4.5.1 和 II-2/4.8 條的要求。消防栓所配備的消防水帶的長度不應超過 33m。

11.2.3 應在任何管道交叉處和船艙前部的消防總管或主管上安裝截止閥，並在貨物區甲板上的消防栓之間不大於 40m 的間隔內裝設截止閥，以便隔斷總管的損壞管段。

11.2.4 作滅火用的所有水槍應為認可的兩用型，既可形成水霧也可形成水柱。滅火系統中所有的管子、閥門、水槍以及其他附件應能耐海水腐蝕，為此，可使用鍍鋅管；此外尚應能耐火焰影響。

11.2.5 如船舶機艙無人值班，則應設有裝置使至少有一台消防泵能在駕駛台內或貨物區外其他控制站進行遙控啟動並與消防總管相連接。

### 11.3 水霧系統

11.3.1 在載運可燃性或毒性貨品或載運兩者的船上，應安裝供冷卻、防火和保護船員用的水霧系統，其覆蓋範圍包括：

- .1 露天的液貨艙氣室和液貨艙的任何露天部分；

- .2 甲板上儲存可燃貨品或毒品的露天容器；
- .3 液體和蒸氣貨物的裝卸總管及其控制閥區域，以及主要控制閥所在的任何其他區域以及至少等於防滴盤面積的其他區域；和
- .4 所有面向貨物區的通常有人管理的上層建築和甲板室的限界面、貨物壓縮機艙、貨泵艙、有高度失火危險物品的儲藏室及貨物控制室。未存放有高度失火危險物品或設備的無人管理的艙樓限界面則不要求水霧保護。

11.3.2 此水霧系統應能覆蓋 11.3.1 所提及的所有區域，其均勻分佈的水霧對水平投影面的噴射量至少為每分鐘 10 升/m<sup>2</sup>，對垂直面至少為每分鐘 4 升/m<sup>2</sup>。對水平面或垂直面無明顯區別的結構，水霧系統的排量應取下列二者的較大之值：

- .1 水平投影面乘以每分鐘 10 升/m<sup>2</sup>；或
- .2 實際表面乘以每分鐘 4 升/m<sup>2</sup>。

在垂直面上，保護較低區域的噴嘴間距可以計入預計從高處流下的水量。為了隔斷損壞部分，在噴霧總管上應每隔一段距離安裝截止閥。或者把系統分成可以進行獨立操作的兩個或多個區段，但須將必需的控制器一起安裝在貨物區後部。保護 11.3.1.1 和 .2 所述的任何區域的區段應能覆蓋包括這個區域的整個橫向液艙群。

11.3.3 水霧泵的排量應足以同時向所有區域輸送所需要的水量，或者如系統分成幾個區段時，其佈置和排量應能同時向任一區段和 11.3.1.3 和 .4 所述的表面供水。或者可利用主消防泵作此用途，但是，

其總的排量應增加水霧系統所需要的水量。不論何種情況，在貨物區以外的消防總管和水霧總管之間應設有通過截止閥的連接管。

11.3.4 通常作其他用途的水泵可用來向水霧總管供水，但需經主管機關認可。

11.3.5 水霧系統中所有的管子、閥門、噴嘴以及其他設備應能耐海水的腐蝕，為此，可使用鍍鋅管，此外還應能耐火焰的影響。

#### 11.4 化學乾粉滅火系統

11.4.1 凡擬載運可燃貨品的船舶應安裝固定式化學乾粉滅火系統，以便對貨物區甲板和如適用時對艙部或艙部貨物裝卸區進行滅火。本系統和化學乾粉應適合作滅火用途並使主管機關滿意。

11.4.2 本系統應至少能用兩條手持軟管或組合型乾粉噴射器／手持軟管把乾粉輸送至甲板上方露天貨物區的任何部分，包括甲板上方的貨品管系。本系統應利用專供此種用途的惰性氣體（例如氮）來驅動，且應將惰性氣體儲存在鄰近乾粉容器的受壓容器內。

11.4.3 用於貨物區的這種系統應至少包括兩個獨立自給式化學乾粉裝置，連同配套的控制器、受壓介質固定式管系、乾粉噴射器或手持軟管，對載貨容積小於 1,000 m<sup>3</sup> 的船舶，經主管機關同意允許只安裝一台這種裝置。應設有乾粉噴射器，其佈置應能保護貨物裝卸的集合管區，且能就地或遙控地起動和噴射。如果乾粉噴射器能從單一位置傳送必要的乾粉量至所有要求的區域，則乾粉噴射器不要求能遙控瞄準。所有的手持軟管和乾粉噴射器應能在軟管盤架處或乾粉噴射器處起動。至少應有一條手持軟管或一台乾粉噴射器置於貨物區的後部。

11.4.4 具有兩個或多個乾粉噴射器、手持軟管或其組合型的滅火裝置應在乾粉容器處設有總管並引出獨立的分管，除非設有經主管機關認可的其他合適的裝置能保證正常工作者可以例外。如裝置上附有兩根或多根管子，其佈置應使任何或所有的乾粉噴射器和手持軟管能在額定排量下同時或順序地工作。

11.4.5 乾粉噴射器的排量應不低於 10 kg/s。手持軟管應為不能扭曲的，並應設有一枝能開／關的噴槍，其噴射率不低於 3.5 kg/s。最大的排射率應只需要一個人操作即可。手持軟管的長度應不超過 33 m。如在乾粉容器和手持軟管或乾粉噴射器之間設置固定管，則管子長度應不超過當管子被持續或間斷使用時，能把乾粉維持在流動狀態，同時當系統關閉時，仍能清除乾粉的長度。手持軟管和噴槍應為防風雨型結構或儲存在防風雨的室內或蓋板內，且應易於取用。

11.4.6 每一容器內應儲存足量的化學乾粉以能向每一乾粉裝置所附的全部乾粉噴射器和手持軟管至少提供噴射 45s 所需的乾粉。固定式乾粉噴射器覆蓋範圍應符合下列要求：

固定式乾粉噴射器排量 (kg/s)	10	25	45
最大覆蓋範圍的距離 (m)	10	30	40

應考慮手持軟管噴射的最大覆蓋有效距離須等於軟管本身長度。如被保護區域顯然高出乾粉噴射器或手持軟管盤架，則應予以特別考慮。

11.4.7 對設有艙或艙裝卸設備的船舶應提供附加的化學乾粉裝置，至少具備符合 11.4.1 至 11.4.6 要求的一個乾粉噴射器和一條手持軟管。此種附加裝置的位置應能保護艙或艙裝卸設備。貨物區域前或後的貨物管道區應由手持軟管來保護。

## 11.5 氣體危險圍蔽處所

11.5.1 可能出現可燃液體或蒸氣滲漏而通常要進入的圍蔽處所，例如貨物壓縮機艙或貨泵艙應設有能撲滅這些處所內火災的固定裝置。另外，這一系統或另一個固定式系統應能對發生過火災的處所進行惰化以保證火災不再發生。就設計而言，該處所的邊界應假設為完整無損的。除非慎重考慮到靜電的危險性，否則應避免使用二氧化碳和蒸氣滅火系統。

11.5.2 應提供關閉通達此項處所的通風口和其他開口的裝置，必要時，也應在該處所內提供聲音報警信號，以便在惰化／滅火介質進入該處所前使人員能緊急撤離該處所。

## 11.6 消防人員的裝備

11.6.1 凡載有可燃性貨品的每一船舶應配備如下符合 SOLAS 1983 年修正條款第 II-2/17 條要求的消防人員的裝備：

<u>貨物總容積</u>	<u>裝備的數量（套）</u>
2,000 m <sup>3</sup> 以下	2
2,000 m <sup>3</sup> 至 5,000m <sup>3</sup>	4
5,000 m <sup>3</sup> 以上	5

11.6.2 有關安全設備的附加要求，見第 14 章。

11.6.3 作為消防人員裝備一部分的任何呼吸器應為自給式空氣呼吸器，其容量至少為 1,200 升自由空氣。

## 第 12 章 貨物區內的機械通風

本章要求替代 SOLAS 1983 年修正條款第 II-2/59.3 條。

### 12.1 貨物正常裝卸作業期間要求進入的處所

12.1.1 電動機艙、貨物壓縮機艙、貨泵艙、具有貨物裝卸設備的其他圍閉處所以及進行貨物裝卸操作的類似處所應設置可在處所外部進行控制的機械通風系統。在進入此類艙室並操作設備前，應採取措施使這些處所通風，且應在艙室外面張貼需要進行通風的警告標誌。

12.1.2 機械通風進出口的佈置應確保有足夠的空氣流通於處所之間，以免易燃的或有毒蒸氣的聚集，並保證有一個安全的工作環境，但在任何情況下，通風系統的容量根據處所總容積計算，每小時應不少於 30 次空氣交換；而作為例外，氣體安全貨物控制室可以為每小時換氣 8 次。

12.1.3 通風系統應為固定型的。如為負壓型，可允許從處所的上部或下部抽風，或從上下部同時抽風，這取決於所裝運貨品蒸氣的濃度。

12.1.4 對裝設驅動貨物壓縮機或泵的電動機艙，裝有惰性氣體發生器的機器處所以外的處所，被認為是氣體安全處所的貨物控制室以及在貨物區內的其他氣體安全處所，其通風系統均應為正壓型的。

12.1.5 對貨物壓縮機艙和泵艙以及被認為是氣體危險處所的貨物控制室，其通風系統均應為負壓型。

12.1.6 氣體危險處所的排氣通向管應向上排放，其排放位置應距居住處所、服務處所和控制站以及其他氣體安全處所的通風進口和開口在水平方向至少 10 m。

12.1.7 通風進口的佈置應儘量減少任何通風排氣口排出的危險蒸氣再循環的可能性。

12.1.8 氣體危險處所的通風管應不通過居住處所、服務處所和機器處所或控制站，但第 16 章所允許者可例外。

12.1.9 如擬載運易燃貨品，驅動風機的電動機應置放在通風管外面，風機不應在通風處所或與該處所相聯繫的通風系統中引起蒸氣點火源。用於氣體危險處所的風機和風機管道（僅限於風機處）應為非火花型結構，具體限定如下：

- .1 非金屬材料的葉輪或罩殼，應對消除靜電予以適當注意；
- .2 非鐵材料的葉輪和罩殼；
- .3 奧氏體不鏽鋼葉輪和罩殼；和
- .4 葉梢間隙不小於 13mm 的鐵質葉輪和罩殼。

鋁或鎂合金製造的固定或轉動部件和鐵質的固定或轉動部件的任何組合，不論葉梢間隙是多大，都被認為有產生火花的危險，故不應用在這些處所內。

12.1.10 本章所述船上的每一種風機都應設有備件。

12.1.11 應在通風管的外側開口處設置不超過 13mm 網孔的保護網。

## 12.2 通常不進入的處所

貨艙、屏壁間處所、空艙、隔離艙、裝有貨物管系的處所和可能積聚貨物蒸氣的其他處所應能進行通風以便在必要進入這些

處所時確保有一個安全的環境。如對這些處所未設固定式的通風系統，則應提供認可型移動式機械通風裝置。必要時，根據這些供通風用的處所（例如貨艙和屏壁間處所）佈置的情況，應安裝必要的固定式的管道。風機或鼓風機應遠離人員出入口，且應符合 12.1.9 的規定。



## 第 13 章 測試設備（儀錶、氣體探測）

### 13.1 通則

13.1.1 每個液貨艙應設有指示貨物液面、壓力和溫度的裝置。壓力計和溫度指示器應根據本章所評述的要求安裝在液體和蒸氣管系內，貨物冷藏裝置內以及惰性氣體系統內。

13.1.2 如要求裝設次屏壁，應配備固定式測試設備，以便在主屏壁任一位置的液密失效時或液貨在任一位置與次屏壁接觸時能探測出來。這種測試設備應包含按 13.6 規定的適當的氣體檢測裝置。然而，這種測試設備不要求能定出液貨在主屏壁上漏穿的區域或液貨與次屏壁接觸的範圍。

13.1.3 如果船舶裝卸貨是通過遠距離控制的閥和泵進行的，則與給定的一個液貨艙有關的所有控制器和指示器都應集中在一個控制位置。

13.1.4 測試設備應經試驗，以保證在工作條件下的可靠性，並應定期複校。測試設備的試驗程序和複校間隔時間應經主管機關認可。

### 13.2 液貨艙液位指示器

13.2.1 每一液貨艙應至少設置一個液位測量裝置，它應設計成在壓力低於液貨艙釋放閥設定的最大許用值的情況下溫度在貨物操作溫度範圍內進行動作。如僅設置一個液位儀，則其佈置應使在液貨艙營運的狀態下，仍能進行必要的維修保養工作。

13.2.2 除按第 19 章表中“g”欄對特種貨物的特殊要求外，液貨艙液位儀可為下述類型：

- .1 間接裝置，用秤重或管式流量計測定貨物量；
- .2 密閉裝置，不穿透液貨艙，例如使用放射性同位素或超聲波裝置；
- .3 密閉裝置，穿透液貨艙，但形成密閉系統的一部分並防止貨物逸出，例如浮式系統、電子探頭、磁性探頭和氣泡管式指示器等。如果密閉式測量裝置不直接安裝在液貨艙上，則應在儘可能接近液貨艙處設置一隻關閉閥；和
- .4 限制裝置，例如固定管式和滑動管式液位儀，該儀器穿透液貨艙且在使用時許可少量的貨物蒸氣或液體逸向大氣。當這些裝置不使用時，應保持完全關閉。裝置的設計和安裝應保證在打開該裝置時不致發生危險性的貨物逸出。這種測量裝置的設計應使最大開口的直徑不超過 1.5mm 或取等效面積，除非這種裝置配備一個過流閥。

13.2.3 對具有設計蒸氣壓力不超過 0.7 bar 的液貨艙，主管機關可允許具有適當保護蓋和內部液位表尺，並且位於液位上方的觀測孔可作為測量的輔助手段。

13.2.4 不應裝設玻璃管式液位儀。主管機關可以允許甲板液艙裝設類似安裝在高壓鍋爐上並設有釋流閥的增強型玻璃管式液位儀，但須遵照第 17 章的規定。

### 13.3 溢流控制

13.3.1 除第 13.3.2 的規定以外，每一液貨艙應設置一台獨立於其他液位指示器的高液位報警器，並在動作時會發出聲光報警信號。獨立

於高液位報警器以外的另一液位傳感器應能自動啓動一隻關閉閥，使既能避免裝卸管系中液體壓力過高又能防止液艙充滿液體。5.6.4 所述的應急關閉閥可供此用途。如為此用途使用另一隻閥，應在船上備有 5.6.4 所述的相同的使用說明。在裝貨期間，凡使用這些閥可能造成在裝卸系統內形成一個潛在的突然過壓時，主管機關和港口主管當局可同意使用替代安排，如限制裝貨率等。

13.3.2 如液貨艙屬於下述兩者情況之一時，則不必設置高液位報警器和液貨艙充注自動關閉裝置：

- .1 具有容積不超過 200 m<sup>3</sup> 的受壓液艙；或
- .2 設計成能在進行裝貨操作時承受最大可能的壓力，且此項壓力低於液貨艙釋放閥的開始釋放壓力。

13.3.3 液面報警器的電路（如有時）應能在裝貨之前進行試驗。

#### 13.4 壓力錶

13.4.1 每一液貨艙的蒸氣處所應配備一隻壓力錶，它應與 13.1.3 所要求的貨物控制位置內的指示器相結合。此外，尚應在駕駛台內設置高壓報警器，如要求作真空保護，還應設置低壓報警器。在指示器上應註明最大和最小的許用壓力。在達到設定壓力之前，應發出警報。對設有釋放壓力閥的液貨艙，根據 8.2.6 規定，它們可設定在不只一個壓力值上，並應對每一設定壓力配備高壓報警器。

13.4.2 在每一貨泵排放管路和每個液體和蒸氣貨物總管處應至少配置一隻壓力錶。

13.4.3 應配備現場能讀出的總管壓力錶，以指示出截止閥和通岸連接軟管之間的壓力。

13.4.4 未設與大氣相連開口的貨艙和屏壁間處所應配備壓力錶。

### 13.5 溫度指示儀

13.5.1 每一液貨艙應至少設有兩個儀錶以指示貨物溫度，一個置放在液貨艙底部，另一隻靠近液貨艙的頂部，但低於許可的最高液面。溫度指示儀應有標誌表明經主管機關認可的液貨艙的最低溫度。

13.5.2 如果貨物在溫度低於 $-55^{\circ}\text{C}$ 下於具有次屏壁的貨物圍護系統內裝運，在絕熱層或鄰近貨物圍護系統的船體結構上應配備溫度指示儀。此指示儀應定期顯示讀數，並且如實用時，還應在當溫度接近於船體鋼材適合的最低溫度時發出聲響報警信號。

13.5.3 如貨物在低於 $-55^{\circ}\text{C}$ 的溫度下裝運，液貨艙的邊界如與貨物圍護系統的設計相適應，應配備如下溫度指示儀：

- .1 足夠數目的溫度指示儀使不產生不合要求的溫度差。
- .2 可在一個液艙上設置超過 13.5.3.1 所要求數量的指示儀以核實初始冷卻的過程是否合格。這些指示儀可為暫時的也可為永久性的。當建造成批同型船舶時，第二批和以後各批的船舶不需符合本款的規定。

13.5.4 溫度指示儀的數目和位置應使主管機關滿意。

### 13.6 氣體探測要求

13.6.1 應根據第 19 章表中“f”欄的要求提供主管機關可以接受的並適合於所載運氣體的氣體探測設備。

13.6.2 每台探測裝置在確定固定取樣點的位置時，應適當考慮擬載運貨品的蒸氣密度以及由於艙室清洗或通風所造成的稀釋物。

13.6.3 從取樣點引出的管子不應通過氣體安全處所，除 13.6.5 許可的以外。

13.6.4 凡按本節要求的氣體探測設備的聲光報警器，應設在駕駛台 13.1.3 所要求的貨物控制位置以及氣體探測器讀出位置。

13.6.5 氣體探測設備可安裝在 13.1.3 所要求的貨物控制位置、駕駛台或其他合適的位置。如果此設備安裝在氣體安全處所，應滿足下述條件：

- .1 氣體取樣管應具有關閉閥或等效裝置以防止與氣體危險區相互連通；以及
- .2 從探測器排出的氣體應在安全位置排向大氣。

13.6.6 氣體探測設備應設計成使其易於試驗，並應對其進行定期的試驗和校準。船上應備有為此用途的適當設備和試驗用氣體。如果可能，應為這種設備設置固定式連接器。

13.6.7 應為下述各處所安裝固定氣體探測系統和聲光報警器：

- .1 貨泵艙；
- .2 貨物壓縮機艙；
- .3 貨物裝卸機械用的電動機艙；
- .4 貨物控制室（指定為氣體安全處所者除外）；
- .5 貨物區內可能積聚蒸氣的其他圍蔽處所，包括貨艙和除 C 型以外的獨立液艙的屏壁間處所；

- .6 按第 16 章所要求的通風罩和氣體管道；以及
- .7 空氣閘。

13.6.8 氣體探測設備應能在不超過 30 分鐘時間間隔內依次從每個取樣點抽樣和分析，但對於 13.6.7.6 所述的通風罩和氣體管道內的氣體探測，則應連續抽樣。不應設置通向探測設備的公用取樣管。

13.6.9 如貨品是有毒的或既有毒並易燃的，則除第 19 章表中“h”欄內所列參照 17.9 的以外，主管機關可准予使用可攜式設備替代固定式裝置用作毒氣檢測，但這種設備的使用應在人員進入 13.6.7 所述的處所之前以及人員停留在這些處所期間的每 30 分鐘以內。

13.6.10 對 13.6.7 所述的處所，當蒸氣濃度達到可燃下限的 30% 時，易燃物品的警報器應該觸發。

13.6.11 如屬易燃貨品，當採用貨物圍護系統而不採用獨立液艙時，貨艙和屏壁間處所應設有能測量氣體濃度按容積從 0% 至 100% 的固定裝置氣體探測系統。配有聲光報警的探測設備應能依次從每個取樣點取樣和探測，其間隔時間不超過 30 分鐘。如蒸氣濃度達到相當於在空氣中的可燃下限 30% 或根據特殊貨物圍護系統經主管機關認可的其他限度時，報警器應觸發。不應設置通向探測設備的公用取樣管。

13.6.12 如屬毒性氣體，貨艙和屏壁間處所應設有固定裝置的管系以便從處所中獲取氣體樣品。對這些處所的氣體應採用固定式或可攜式設備在每個樣品點抽樣和分析；其時間間隔應不超過 4 小時，且在任何情況下，至少在人員進入處所之前及人員停留在這些處所期間的每 30 分鐘以內，均應取樣。

13.6.13 每一船舶應至少配備兩套經主管機關認可並適合於所載運貨品的可攜式氣體探測設備。

13.6.14 應安裝一台測量惰性大氣中含氧量的適當儀器。

## 第 14 章 人員保護

### 14.1 保護設備

為了保護從事裝卸操作的船員，應在考慮到貨品特性的情況下，對人員提供包括眼保護在內的適當的保護設備。

### 14.2 安全設備

14.2.1 除 11.6.1 所要求的消防人員的裝備以外，尚應對每一個允許進入充滿氣體處所內工作的人員提供足量的不少於兩整套的安全設備。

14.2.2 一整套的安全設備應包括：

- .1 一套不採用儲存氧的自給式空氣呼吸器，其容量至少為 1,200 升自由空氣；
- .2 保護服、長靴、手套和貼肉的防護目鏡；
- .3 配有腰帶的鋼芯援救繩；及
- .4 防爆燈。

14.2.3 應供應足量的壓縮空氣，包括：

- .1 按 14.2.1 的要求，每一呼吸器配備一套充滿空氣的氣瓶；適用於供應所要求純度的高壓空氣的特種空氣壓縮機；和能對 14.2.1 所要求的呼吸器的足夠多備用呼吸器空氣瓶進行充氣的充氣閥箱；或
- .2 按 14.2.1 所要求的每一呼吸器提供空氣總容量至少為 6,000 升的充滿空氣的備用氣瓶。



14.2.4 作為替代措施，主管機關可接受一種適用於 14.2.1 所要求的呼吸器的具有軟管接頭的低壓空氣管路系統。該系統應提供足量的高壓空氣，通過減壓裝置供應低壓空氣以便能使兩個人在氣體危險處所工作至少 1 小時而不需要動用呼吸器的氣瓶。應備有設施為使適宜於供應所要求純度的高壓空氣的特種空氣壓縮機向固定空氣氣瓶和呼吸器氣瓶再充氣。

14.2.5 14.1 所要求的保護設備和 14.2.1 所要求的安全設備應保存在合適的具有明顯標誌的位於易於到達地點的櫃內。

14.2.6 應由負責工作人員對壓縮空氣設備進行每月至少 1 次的檢查，並將檢查結果記錄在航行日誌內，且此項設備應至少每年由專家檢查和試驗 1 次。

### 14.3 急救設備

14.3.1 應在易於抵達之處放置適合於從甲板以下處所提起一個受傷人員的擔架一副。

14.3.2 應在船上配備醫藥急救設備，包括氧氣復甦設備和所載運貨品的解毒劑（如備有時）。

### 14.4 對各種貨品的人員保護要求

14.4.1 14.4 規定適用於船舶載運第 19 章表中“h”欄所列的貨品。

14.4.2 應為船上每一人員提供適宜於應急逃生之用的呼吸防毒面具和眼保護設備，但需考慮下列情況：

- .1.1 過濾器型呼吸防毒面具，只是在該過濾器適合於船舶核准載運的所有指定貨物的情況下才予接受；

- .1.2 自給式呼吸器通常應至少能持續工作 15 分鐘；
- .2 應急逃生呼吸防毒面具不應作滅火或貨物裝卸用，並應對此作出標誌；
- .3 兩套額外的呼吸防毒面具和眼保護設備應永久性地存放在駕駛台。

14.4.3 應在甲板上的方便之處設有經適當標誌的除污染噴頭和眼沖洗設備，這些設備應在所有環境條件下均可使用。

14.4.4 如船舶載貨容積為 2,000m<sup>3</sup> 及以上時，除按 11.6.1 和 14.2.1 所要求配備的設備以外，尚應配備兩整套安全設備。對本款所要求的每一自給式空氣呼吸器應至少設置三套備用充滿空氣的氣瓶。

14.4.5 為防止人員受到主要貨物釋放的影響，應在居住區域內提供一個安全處所，其設計和設備應徵得主管機關的同意。

14.4.6 對於高度危險的貨品，貨物控制室應只能是氣體安全型的。

## 第 15 章 液貨艙的充裝極限

### 15.1 通則

15.1.1 除 15.1.3 所許可者以外，液貨艙內充裝的液體在基準溫度下不得超過液艙容積的 98%。

15.1.2 液貨艙應裝載的最大容積係按下列公式來確定：

$$V_L = 0.98V \frac{\rho_R}{\rho_L}$$

式中：

$V_L$  = 液貨艙可裝載的最大容積

$V$  = 液艙容積

$\rho_R$  = 在基準溫度下貨物的相對密度

$\rho_L$  = 裝載溫度和裝載壓力下的貨物相對密度。

15.1.3 考慮到液艙的形狀、壓力釋放閥的佈置、液位和溫度測量儀的精度以及壓力釋放閥在設定壓力下與貨物蒸氣壓力相應的溫度和裝載溫度之間的差異，主管機關可允許在基準溫度下的裝載限額大於 15.1.1 和 15.1.2 所規定的 98%，但是仍應保持 8.2.17 中所規定的條件。

15.1.4 僅在本章範圍內，“基準溫度”係指：

- .1 當未配備有第 7 章所述的貨物蒸氣壓力／溫度控制器時，在壓力釋放閥設定的壓力下與貨物蒸氣壓力相應的溫度；

- .2 當配備有第 7 章所述的貨物蒸氣壓力／溫度控制器時，裝貨終止時、運輸期間或卸貨時的溫度，視何者溫度最高而定。如果當貨物於達到 8.2 所要求的釋放閥設定壓力下與貨物蒸氣壓力相應的溫度之前，此種基準溫度將會導致液艙注滿液體的話，則應再安裝 1 隻符合 8.3 要求的壓力釋放閥。

#### 15.2 向船長提供的資料

針對可能載運的每種物品，可能採用的每種裝貨溫度以及可適用的最高基準溫度，每個液貨艙應指明最大許可的充裝極限，並列成表格提供給主管當局予以認可。壓力釋放閥，包括 8.3 所要求的那些閥上業已設定的壓力也應列在表上。此表的副本應由船長負責永久保存在船上。

## 第 16 章 用貨物作燃料

### 16.1 通則

16.1.1 甲烷（液態天然氣）是唯一的貨種，其蒸氣或蒸發出的氣體可供主推進機處所和鍋爐艙內使用，但在這些處所或艙室中只可供鍋爐、惰性氣體發生器和內燃機使用。

16.1.2 本章的規定並不排除這些蒸氣或蒸發出的氣體在其他位置作其他用途使用，諸如貨物再液化和製造惰性氣體，但是這些其他位置和作其他用途需經主管機關特殊考慮。

### 16.2 氣體燃料供應

16.2.1 氣體燃料管不應通過居住處所、服務處所或控制站。氣體燃料管可通過或延伸至另外一些處所，但需滿足下列要求之一：

- .1 氣體燃料管應為氣體燃料儲存在內管中的雙層管系結構。在同心管之間的空間應用惰性氣體增壓使其壓力大於燃料壓力。應安裝適當的報警器以指示管子之間壓力的降低；
- .2 氣體燃料管應安裝在機械抽風式通風管或管道內。在管子或管道內外壁之間的空氣空間應安裝機械通風設備，其功率至少能供每小時換氣 30 次。通風系統的佈置應使壓力維持低於大氣的壓力。鼓風機應置放在通風管或管道外面。通風出口應位於決不會點燃易燃氣體／空氣混合物的地方。通風入口的佈置應不致使氣體或氣體／空氣混合物被吸入到系統中去。當供應管內有氣體時應在作業中始終保持通風。根據

16.2.9 的規定，應設有連續氣體檢測器以示明氣體的泄漏並切斷向機器處所供應氣體燃料。管道鼓風機的佈置應在所要求的空氣流動不能實現和維持的情況下能切斷給機器處所供應氣體燃料。

16.2.2 如發生氣體泄漏，只有在查出泄漏之處並予以修復後才能供應氣體燃料。內容大意如此的說明書應張貼在機器處所顯著的地方。

16.2.3 供氣體燃料管用的雙層壁管系或管道應在按 16.2.4 所要求的通風箱或通風罩處終止。

16.2.4 對法蘭、閘門等和在氣體利用裝置上的氣體燃料管（不圍蔽在雙層壁管路系統或通風管道中）佔用的地方，諸如鍋爐、柴油機、燃氣輪機等應設有通風箱或通風罩。如果這種通風箱或通風罩不是由 16.2.1.2 所規定的、供管道用的抽風機來驅動，則應裝備抽風系統並應按照 16.2.9 的規定設有連續的氣體探測裝置以檢測泄漏並停止向機器處所供應氣體燃料。抽風機的佈置應在抽風不起作用以致不能實現所要求的空氣流動的情況下切斷向機器處所供應氣體燃料。通風箱或通風罩的安裝或架設應能使通風空氣掃過氣體利用裝置且在箱或罩的頂部予以排出。

16.2.5 空氣通風系統所需要的補償空氣和從通風系統排出的空氣應從安全位置進出。

16.2.6 每台氣體利用裝置應配備 1 套 3 個自動閘。其中兩個閘應串接在通向消耗設備的氣體燃料管路上。另一個閘則應安裝在兩個串接閘門之間部分氣體燃料管路的排氣管路上，且應排向開敞大氣的安全處所。這些閘門應佈置成當必需的鼓風失效、鍋爐燃燒器熄火、氣體

燃料供應管壓力不正常或驅動介質控制閥門失效時能導致自動關閉兩個串接氣體燃料閥並自動打開排氣閥。或者，兩個串接閥中的一隻閥的功能與通氣管路上的閥的功能能結合成一隻閥體，其佈置應是：如發生上述情況之一時，能切斷氣體流向氣體利用裝置並打開排氣口。

16.2.7 應在機器處所的外面裝設能在機器處所內予以關閉的氣體燃料主閥。閥的佈置應為當檢測出氣體泄漏或是導管或通風罩發生通風失效或是發生雙層壁氣體燃料管失壓時，閥門能自動關閉。

16.2.8 應採取措施對機器處所內的氣體燃料管系進行惰化和氣體清除。

16.2.9 按照 16.2.1 和 16.2.4 的要求所安裝的氣體探測系統在燃燒下限的 30%時應能報警，並在氣體濃度達到燃燒下限的 60%之前停止向機器處所供應氣體燃料。

16.2.10 氣體燃料系統的所有細節應提交給主管機關認可。

## 第 17 章 特殊要求

### 17.1 通則

凡引用第 19 章表中“h”欄的特殊要求時，適用本章的規定。這些特殊要求是對本規則一般要求的補充。

### 17.2 結構材料

在正常作業時可能與貨物接觸的材料應能抗氣體的腐蝕作用。另外，供液貨艙及附屬的管路、閥門、附件以及其他地方用的下列結構材料不應用於第 19 章表中“h”欄所列的貨品：

- .1 汞、銅與銅基軸承合金及鋅；
- .2 銅、銀、汞、鎂和其他形成乙塊化合物的金屬；
- .3 鋁和鋁基軸承合金；
- .4 銅、銅合金、鋅或鍍鋅鋼；
- .5 鋁或銅或其任一種的合金；
- .6 銅和含銅量大於 1%的銅基軸承合金。

### 17.3 獨立液艙

17.3.1 貨品只應在獨立液艙中載運。

17.3.2 貨品在 C 型獨立液艙中載運，並適用 7.1.3 的規定。液貨艙的設計壓力應考慮任何氣墊壓力或蒸氣排放卸載壓力。

### 17.4 製冷系統

17.4.1 只應採用 7.2.4.2 所述的間接系統。



17.4.2 對於裝運容易發生危險的過氧化物貨品的船舶，再冷凝的貨物不允許形成非抑制液體的滯積囊。這可採取下述任一方法來實現：

- .1 採用 7.2.4.2 所述的液貨艙內部具有冷凝器的間接系統；或
- .2 分別採用 7.2.4.1 所述的直接系統或 7.2.4.3 所述的綜合系統，或是採用 7.2.4.2 所述的液貨艙外部具有冷凝器的間接系統，同時把這種冷凝系統設計成能避免在任何地方積聚和滯留液體。如不可能，則應在這一地點的前段添加抑制性液體。

17.4.3 如果船舶在連續裝運 17.4.2 所規定的貨品當中插入一次壓載航行，則在壓載航行前應除去所有未加抑制的液體。如果在連續裝運這種貨物之間裝運第二種貨物，則在裝載第二種貨物前應徹底地排泄和清洗再液化系統。清洗應使用惰性氣體或（如相容時）第二種貨物的蒸氣進行。應採取實際步驟確保在貨物系統中不積聚聚合物或過氧化物。

## 17.5 甲板貨物管

對直徑超過 75 mm 的貨物管上所有對接焊接頭均要求作 100% 的射線照相檢驗。

## 17.6 排除蒸氣處所的空氣

裝貨前應排除液貨艙及其附屬管中的空氣，然後用下述方法對空氣進行清除：

- .1 引入惰性氣體以保持正壓力。惰性氣體的儲存或生產量應足以滿足正常的操作要求以及釋放閥的泄漏。惰性氣體中的含氧量在任何時候不得超過容積的 0.2%；  
或
- .2 控制貨物的溫度使在所有時間內都保持正壓力。

### 17.7 濕度控制

對於不易燃而可能變成腐蝕性或與水起危險反應的氣體，要求進行溫度控制以確保液貨艙在裝貨前是乾燥的，同時在卸貨期間應引入乾燥空氣或貨物蒸氣以防出現負壓力。在本條範圍內，乾燥空氣係指在大氣壓力下應有 -45°C 或更低的露點。

### 17.8 抑制

應注意確保貨物充分抑制以防止在整個航行期間起聚合作用。船上應持有製造商提供的證書，說明：

- .1 所添加的抑制劑的名稱和數量；
- .2 添加劑加入的日期和正常情況下預計的有效期；
- .3 影響抑制劑的任何溫度限制；
- .4 航行周期超過抑制劑有效期時應採取的措施。

### 17.9 固定安裝的有毒氣體檢測器

17.9.1 氣體取樣管路不應引入或穿過氣體安全處所。如蒸氣濃度達到閥門限值，應觸發 13.6.7 所述的報警器。

17.9.2 不允許使用按 13.6.9 規定的可攜式設備作為替代裝置。

### 17.10 透氣出口處的防火網

如載運本節所述的某種貨物，液貨艙的透氣出口處應配備能易於更換和有效的防火網或認可型的安全罩。在設計防火網和安全罩時，應適當注意這些裝置在惡劣氣候條件下由於貨物蒸氣的凝結或結冰而引起阻塞的可能性。取出防火網後應裝上普通的保護網。

### 17.11 每個液艙最大的許可載貨量

如載運本節所述的貨物時，任何一個液艙的載貨量不應超過 3,000 m<sup>3</sup>。

### 17.12 電動潛水貨泵

在易燃液體裝貨前、運輸中和卸貨期間，配備有電動潛水電動機泵的液貨艙內的蒸氣處所應充惰化氣體至正壓力。

### 17.13 氮

因為高濃度的氮在有限空間內可能會引起燃燒，因此除開敞甲板區域以外，應適用第 10 章對可燃貨品的規定。決不能把液態氮濺入含有空氣的液艙內，因為這樣在艙內會引起靜電荷從而造成着火的危險。當氮在 -20°C 以上溫度載運時（蒸氣壓力為表壓 1.9 bar），為了使應力腐蝕裂縫的危險性減至最低限度，在液態氮引入之前，受壓容器內以及碳錳鋼材料製成的管子內蒸氣空間中的含氧量應減至可能的最低值。在 -33°C 下作業的液艙冷凝系統可能會受到影響，除非它們業經作了熱應力消除。

### 17.14 氮

#### 17.14.1 貨物圍護系統

17.14.1.1 每一液艙載貨的容積應不超過 600 m<sup>3</sup>，而所有液貨艙的載貨的總容積應不超過 1,200 m<sup>3</sup>。

17.14.1.2 液艙的設計蒸氣壓力應不低於表壓 13.5 bar（並參見 7.1.3 和 17.3.2）。

17.14.1.3 液艙突出在上甲板上方的部分應設有保護措施，以防計及全部被火焰包圍時的熱輻射。

17.14.1.4 每一液艙應配備兩隻安全釋放閥。應在液貨艙和安全釋放閥之間安裝適當材料製成的安全片。安全片的裂破壓力應比安全釋放閥的開啓壓力低 1 bar，開啓壓力應設定等於液艙的設計蒸氣壓力，但不低於 13.5 bar（表壓）。安全片與釋放閥之間的處所應通過一個過流閥連接到壓力錶和氣體檢測系統上。應採取措施使這一空間保持在正常作業時達到或接近大氣壓力。

17.14.1.5 壓力釋放閥出口的佈置應能使船上以及周圍環境的危險性減少至最低限度。釋放閥的滲漏應引至吸收裝置，以儘可能降低氣體濃度。釋放閥排放管佈置在船舶的前端在甲板平面向舷外排放，同時應設一用機械聯鎖的、能選擇左、右舷的裝置，以確保有一條排放管總是開着的。

17.14.1.6 主管機關和港口當局可要求氯氣在規定的最大壓力下以冷凍狀態裝運。

## 17.14.2 貨物管系

17.14.2.1 貨物的排卸應利用岸上的壓縮氯蒸氣、乾燥空氣或另一種認可的氣體或全潛泵。液艙內蒸氣處所的壓力在排放期間應不超過 10.5 bar 表壓。主管機關應不允許使用船上配置的貨物排放壓縮機。

17.14.2.2 貨物泵系的設計表壓力應不小於 21 bar 表壓。貨管的內徑應不超過 100 mm。補償管子的熱力運動的方式只同意用管子彎頭。使用法蘭接頭的數目應減至最少，如要使用，法蘭應為槽舌結合的焊接形式。

17.14.2.3 貨物管系的釋放閥應排放至吸收裝置（並參見 8.2.16）。

#### 17.14.3 材料

17.14.3.1 液貨艙和貨物管系應由適用於貨物和 -40°C 溫度的鋼材製成，即使打算採用更高的運輸溫度，也應如此。

17.14.3.2 液貨艙應作熱應力消除。機械性應力消除不允許作為等效方法。

#### 17.14.4 儀錶--安全裝置

17.14.4.1 船舶應設有與貨物管系和貨艙相連接的氯氣吸收裝置。吸收裝置應至少能按合理的吸收率來中和至少為全部貨物容量的 2%。

17.14.4.2 在液貨艙除氣期間，不應將蒸氣排向大氣。

17.14.4.3 應配備能檢測氯濃度（體積含量）至少為 1 ppm 的氣體探測系統。吸氣點應佈置在：

- .1 接近貨物貨艙的底部；
- .2 安全釋放閥的管子內；
- .3 氣體吸收裝置的出口處；
- .4 居住、服務和機器處所及控制站的通風系統的進口處；

- .5 貨物區前端、中部和後端的甲板上（只要求用於貨物裝卸和除氣操作時）。

氣體探測系統應配備聲光報警器，設定點為 5 ppm。

17.14.4.4 每一液貨艙應裝備一個高壓報警器，能在表壓等於 10.5 bar 時發出音響報警信號。

#### 17.14.5 人員保護

除第 14 章所述的要求外，尚應滿足下列要求：

.1 14.4.5 所要求的圍蔽處所應能從開敞甲板和居住處所方便而迅速地進入，且能迅速地作氣密關閉。從甲板和居住艙室的其餘地方進入該圍蔽處所應通過空氣閘。該處所應設計成能容納船上的全部船員並應能提供維持不少於 4 小時的未受污染的空氣源。14.4.3 所要求的消毒淋浴設備之一應設置在該處所靠近空氣閘的部位。

.2 應配備一台壓縮機和必要設備以注滿空氣瓶。

.3 17.14.5.1 所述的處所內應配備一套氧氣理療設備。

#### 17.14.6 液貨艙的充裝極限

17.14.6.1 如擬載運氯氣，則 15.1.4.2 的要求不適用。

17.14.6.2 裝貨後，液貨艙蒸氣處所內氣體中氯容積含量應大於 80%。

#### 17.15 乙醚、乙氧基乙烯

17.15.1 乙醚及乙氧基乙烯貨物只准用深井泵或由液壓操縱的潛水泵排放。這些泵的型式應設計成能避免液壓施加在軸填料蓋上。

17.15.2 如貨物系統是按預計壓力設計的，惰性氣體置換法可用來排放 C 型獨立液艙的貨物。

#### 17.16 環氧乙烷

17.16.1 載運環氧乙烷時，適用 17.20 的要求，同時應滿足本節給出的附加和修改要求。

17.16.2 甲板液艙不應用作載運環氧乙烷。

17.16.3 416 和 442 型不銹鋼以及鑄鐵不應用於環氧乙烷貨物圍護系統和管系。

17.16.4 裝貨前，各液艙應進行徹底而有效的清潔以清除艙內及附屬管路中前次所裝貨物的痕跡，除非剛剛裝過的貨物是環氧乙烷、氧化丙烯或是這些貨品的混合物。用不銹鋼以外的鋼質液艙裝氨時，應特別予以注意。

17.16.5 環氧乙烷只准用深井泵或惰性氣體置換法排放。泵的佈置應符合 17.20.6.3 規定。

17.16.6 環氧乙烷只准以冷凍狀態載運並保持溫度低於 30°C。

17.16.7 壓力釋放閥應設定在表壓不低於 5.5 bar。最大設定壓力應經主管機關專門批准。

17.16.8 17.20.15 所要求的氯氣保護襯墊應能使液貨艙蒸氣處所的氯濃度在任何時候不少於 45%（按容積計）。

17.16.9 在裝貨前及在液貨艙內裝有環氧乙烷的液體或蒸氣的任何時間內，液貨艙應用氯氣惰化。

17.16.10 17.20.17 和 11.3 所要求的水霧系統在火災延至貨物圍護系統的情況下應能自動操作。

17.16.11 應提供一投棄貨物的裝置，以便在不可控制的自身反應時可將環氧乙烷應急排放。

#### 17.17 異丙胺、乙胺

應配備如 1.3.32 所規定的隔離管路系統。

#### 17.18 甲基乙炔—丙二烯混合物

17.18.1 甲基乙炔—丙二烯混合物應適當地進行穩定處理以便運輸。另外，對混合物，在冷凍時應規定其溫度和壓力的上限。

17.18.2 可予接受的、穩定處理後的成分樣例為：

##### .1 成分 1

.1.1 最大的甲基乙炔對丙二烯摩爾比為 3 : 1；

.1.2 摩爾百分濃度為 65 的甲基乙炔和丙二烯的最大化合濃度；

.1.3 摩爾百分濃度為 24 的丙烷、丁烷和異丁烷的最低化合濃度，其中至少 1/3（以摩爾為單位）為丁烷和 1/3 為丙烷；以及

.1.4 摩爾百分濃度為 10 的丙烯和丁烯的最大化合濃度。

##### .2 成分 2

.2.1 摩爾百分濃度為 30 的甲基乙炔和丙二烯的最高化合濃度；



- .2.2 摩爾百分濃度為 20 的甲基乙炔的最高濃度；
- .2.3 摩爾百分濃度為 20 的丙烯的最高濃度；
- .2.4 摩爾百分濃度為 45 的丙烯的最高濃度；
- .2.5 摩爾百分濃度為 2 的丁二烯和丁烯的最高化合濃度；
- .2.6 摩爾百分濃度為 4 的飽和的 C<sub>4</sub> 碳氫化合物的最低濃度；以及
- .2.7 摩爾百分濃度為 25 的丙烷最低濃度。

17.18.3 只要混合物的穩定性經過驗證達到主管機關滿意的程度也可接受其他化合成分。

17.18.4 載運甲基甲乙炔—丙烯混合物的船舶最好具有按 7.2.4.2 規定的直接製冷系統。或者，對未設有直接製冷系統的船舶可使用直接蒸氣壓縮冷凍，但應受到與化合成分有關的壓力和溫度的限制。對於 17.18.2 所給出的成分樣例，應具有下列特點：

- .1 一台蒸氣壓縮機，其在運行期間溫度的升高不應超過 60°C，壓力增加不應高出 17.5 bar 表壓力，同時在繼續運行期間，不允許蒸氣在壓縮機內停滯。
- .2 壓縮機每一級的排放管或往復壓縮機同一級中的每一氣缸引出的排放管應具有：
  - .2.1 兩隻溫度激動的關閉開關，設定在 60°C 或 60°C 以下動作；

- .2.2 一隻壓力激動的關閉開關，設定在 17.5 bar 或 17.5 bar 表壓以下動作；及
- .2.3 一隻安全釋放閥，設定在 18.0 bar 或 18.0 bar 表壓以下釋放。
- .3 17.18.4.2.3 所要求的釋放閥應引至滿足 8.2.9，8.2.10，8.2.13 和 8.2.14 要求的某一桅處排氣，且不應釋放入壓縮機的吸入管內。
- .4 一台報警器，當一高壓開關或高溫開關動作時，該報警器應在貨物控制站和駕駛台內發出警報。

17.18.5 準備裝載甲基乙炔—丙二烯混合物的液艙管系，包括貨物冷凍系統，應與其他液艙的管系和冷凍系統相獨立（如 1.3.20 規定）或隔離（如 1.3.32 規定）。此種隔離適用於所有液體和蒸氣排氣管路及其他諸如公用的惰性氣體供應管這樣的連接接頭。

#### 17.19 氫

結構和附屬設備（諸如絕緣）的材料應能承受高濃度氧的作用，它是由於在貨物部分系統的低溫使氧冷凝和濃縮所造成的。對這些可能發生冷凝情況的區域，其通風應給與特別考慮以避免形成富氧大氣層。

#### 17.20 氧化丙烯和含有按重量計不超過 30 %環氧乙烷的環氧乙烷／氧化丙烯的混合物

17.20.1 根據本節規定所運輸的貨品應為不存在乙炔者。

17.20.2.1 除非液貨艙經適當的清潔，否則這些貨品不應裝運在曾經儲存過已知有催化聚合作用的上述三種貨物之一的液艙內，例如：

- .1 無水氨和氨氣溶液；
- .2 胺及胺溶液；
- .3 氧化物質（例如氯）。

17.20.2.2 裝貨前，各液艙應進行徹底而有效的清潔，以清除艙內附屬管路中過去裝貨物的痕跡，除非剛剛裝過氧化丙烯或環氧乙烷—氧化丙烯混合物。對在不鋼以外的鋼質液艙中裝氨時，應特別予以注意。

17.20.2.3 在所有的情況下，對液艙及其附屬的管路清洗方法的有效性應通過適當的試驗或檢驗方法進行校核，以查明當存在上述貨品時，不致遺留下可能會引起危險情況的酸性或鹼性物質的痕跡。

17.20.2.4 在每次初次裝載上述貨品之前，應進入液艙進行檢查，以確保無污染物、無大量鐵鏽沉澱及明顯的結構缺陷。如這些液貨艙繼續裝運上述貨品，則進行此種檢查的間隔期應不超過兩年。

17.20.2.5 載運上述貨品的液艙應為鋼質或不鏽鋼的結構。

17.20.2.6 裝運過上述貨品的液艙，在對液艙及其附屬的管路用沖洗或吹洗進行徹底的清潔後可用作載運其他貨物。

17.20.3.1 所有的閥、法蘭、配件和輔助設備應為與上述貨品相適用的一種型式，且應為鋼或不鏽鋼或其他為主管機關接受的材料所建造。建造前，所用材料的化學成分應提交給主管機關認可。閥盤或閥盤面、閥基座和閥中其他易磨損的部件應由含鉻量不低於 11% 的不鏽鋼製成。

17.20.3.2 襯墊應由不與上述貨品起反應、不溶於上述貨品、不降低上述貨品的自然溫度且能耐火和具有合適的機械性能的材料製成。面向貨物的表面應為聚四氟乙烯（PTFE）或其惰性達到類似安全程度的材料。含有聚四氟乙烯（PTFE）或類似氟化聚合物作填料的螺旋卷繞的不鏽鋼可以被主管機關所接受。

17.20.3.3 如需使用絕緣和墊料，應為不與上述貨品起反應、不溶於上述貨品或是不降低上述貨品自燃溫度的材料。

17.20.3.4 通常發現，下列材料用作上述貨品圍護系統中的襯墊、墊料、和類似用途時，其效果是不良的，應在主管機關認可以前進行試驗：

- .1 氯丁橡膠或天然橡膠（如與上述貨品接觸時）；
- .2 石棉或用於石棉的黏合劑；
- .3 含有鎂氧化物的材料（例如礦棉）。

17.20.4 裝卸管路應延伸至液艙底或任何集液槽底部 100 mm 的範圍內。

17.20.5.1 貨品的裝卸方式應使液艙不致向大氣排氣。如果液艙裝貨期間，利用岸上回收蒸氣法，則與貨品相連接的貨物圍護系統的蒸氣回收系統應與所有其他圍護系統開分。

17.20.5.2 在卸貨作業時，液貨艙的壓力應保持在 0.07 bar 表壓以上。

17.20.5.3 貨物只可由深井泵、液壓操作的潛水泵或惰性氣體置換法來排卸。每一貨泵的佈置應能確保當泵的排卸管被截止或被阻塞時，此項貨品不會顯著發熱。

17.20.6 載運上述貨品的液艙的透氣系統應與載運其他貨品的液艙透氣系統分開。應設置能對液艙內容進行取樣而不必開啓液艙與大氣相通的設施。

17.20.7 運輸上述貨品所用的貨物軟管應標明“限於運輸氧化烯貨品”。

17.20.8 對上述貨品的貨艙應進行監測。A 和 B 型獨立液艙周圍的貨艙也應惰化並對氧進行監測。這些處所的氧含量應保持在 2% 以下。可攜式取樣設備應是合格的。

17.20.9 拆開通岸管路前，液體和蒸氣管路中的壓力應通過安裝在裝貨集管上的適當的閥進行釋放。從這些管路出來的液體和蒸氣不應排向大氣。

17.20.10 液貨艙應按在貨物裝載、運輸或卸載過程中可能遇到的最大壓力進行設計。

17.20.11 對載運氧化丙烯具有設計蒸氣壓力低於 0.6 bar 的液艙和對載運環氧乙烷氧化丙烯混合物具有設計蒸氣壓力低於 1.2 bar 的液艙，應設有一個冷卻系統，以保持貨物在基準溫度以下。有關基準溫度參閱 15.1.4.1。

17.20.12 壓力釋放閥的設定值應不小於 0.2 bar 表壓，而且對 C 型獨立液艙，如載運氧化丙烯時不大於 7.0 bar 表壓，而載運環氧乙烷—氧化丙烯混合物時，則大於 5.3 bar 表壓。

17.20.13.1 裝載上述貨品的液艙管系應與所有其他液艙（包括空液艙）的管系以及與所有貨物壓縮機全部隔開。如果裝載上述貨品的液艙管系並不按 1.3.20 規定是獨立的話，則所要求管系的分隔應通過拆

去短管、閘門、或其他管段並在這些位置安裝盲板法蘭予以實現。這樣要求的分隔同樣也適用於所有液體和蒸氣管路、液體和蒸氣透氣管路以及任何其他可能的連接接頭（諸如公用的氣體供應管路等）。

17.20.13.2 上述貨品只能按經主管機關認可的貨物裝卸圖運輸。擬定的每一裝貨佈置應在單獨的裝卸圖上表明。貨物裝卸圖上應標明全部貨物管路系統和為滿足上述管路隔離要求安裝盲板法蘭的位置。每一份經認可的貨物裝卸圖的副本應保存在船上。國際散裝運輸液化氣體適裝證書的背簽中應包括認可的貨物裝卸圖。

17.20.13.3 裝載上述貨品前，應從港口當局認可的負責人員處取得證實業已達到所要求的管系分隔的證書並攜帶在船上。在盲板法蘭和管路法蘭之間的每一連接接頭應由負責人員裝上金屬絲並加以鉛封以保證不致由於疏忽而拆去盲板法蘭。

17.20.14 每一液艙的最大許可充裝極限應按可能採用的每一裝貨溫度和適用的最大基準溫度指明在提交給主管機關認可的表格上。此表的副本應由船長永久性地保存在船上。

17.20.15 應在適當的氮氣保護墊下載運貨物。應安裝一氮氣自動補充系統，以防萬一由於環境條件或冷凍系統的誤動作造成貨品溫度下降時液艙壓力不致下降到低於 0.07 bar 表壓以下。在船上應備有足量的氮氣以滿足自動壓力控制的需要。應採用商業純度的氮氣（按容積計 99.9%）作為氣墊。一組通過減壓閥連接到液貨艙的氮氣瓶可以滿足本文提出的“自動”一詞義的含義。

17.20.16 液貨艙蒸氣處所應在裝貨前和裝貨後作試驗，以保證按容積計的含氧量為 2% 或以下。

17.20.17 應設有足夠容量的水霧系統以有效地覆蓋裝貨總管及與貨品裝卸有關的露天甲板管系和液貨艙氣室周圍的區域。管系和噴嘴的佈置應使水霧的均勻分佈率為每分鐘 10 升/m<sup>2</sup>。水霧系統應能既可就地手控操作又可遠距離手控操作，同時其佈置應確保任何溢出的貨物能被沖洗乾淨。另外，若大氣溫度許可時，應在裝卸作業期間，將一條具有壓力的輸水軟管連到水槍以便隨時使用。

#### 17.21 氯乙炔

如添加抑制劑能預防氯乙炔的聚合作用，則 17.8 的規定是適用的。如未曾添加抑制劑或是抑制劑添加量不足，則 17.6 規定所要使用的任何惰性氣體內含氧量應不超過 0.1%。在開始裝貨之前，從液艙和管系內取出的惰性氣體樣品應加以分析。如載運氯乙炔，液艙內始終應保持正壓力，甚至在連續裝運之間的壓載航行時也應如此。

## 第 18 章 操作要求

### 18.1 貨物資料

18.1.1 船上應備有資料且供所有有關方面使用，主要內容為貨物安全運輸提供必要的數據。此類資料應針對每種被運輸的貨品，其具體項目如下：

- .1 一份為貨物安全圍護所必需的物理和化學性能的詳細說明書；
- .2 發生溢出或泄漏事故時需要採取的措施；
- .3 防備人員偶而接觸的防範措施；
- .4 滅火程序和滅火劑；
- .5 貨物運輸、氣體清除、壓載、清洗液艙和交換貨物的程序；
- .6 安全裝卸特種貨物所需的特殊設備；
- .7 內層船殼鋼最低溫度；
- .8 應急措施。

18.1.2 如未提供 17.8 所要求的證書，則應拒絕裝運需作抑制的貨品。

18.1.3 遵照本規則的每條船上應保存有本規則的副本或結合本規則條款的國家規則。

### 18.2 相容性

18.2.1 船長應弄清楚所裝載的每一貨品的數量和特性係在 1.5 所規定的國際散裝運輸液化氣體適裝證書和 2.2.5 所規定的裝載和穩性手



冊所述範圍之內，同時如證書第 3 節有所要求，則船長還應核實這些貨品已列入國際散裝運輸液化氣體適裝證書之中。

18.2.2 如貨物係混裝時，應注意避免可能發生的危險性化學反應。就下述情況而言，這點特別重要：

- .1 同一液艙內連續裝貨之間所要求的液艙清洗程序；以及
- .2 同時載運幾種在混裝時會起化學反應的貨物。只有整個貨物系統包括但並不限於貨物管路、液艙、透氣系統和冷藏系統，按 1.3.32 規定的加以分隔時才許可進行混裝。

### 18.3 人員培訓\*

18.3.1 對貨物操作人員應在操作程序方面進行適當訓練。

18.3.2 所有人員對使用船上備有的保護設備應進行充分訓練並進行與他們的職務相適應的、在緊急情況下採取必要操作程序的基本訓練。

18.3.3 高級船員應進行應急程序的訓練以處理泄漏、溢出或是貨物發生火災的情況，並對其中足夠數量的人員講授和訓練適於所載貨物的主要急救方法。

### 18.4 進入處所

18.4.1 人員不得進入可能有氣體聚集的液貨艙、貨艙、空艙、貨物裝卸處所或其他圍閉處所，除非：

---

\* 參閱 1978 年國際海員培訓、發證及值班標準公約，特別是該公約附則第 V 章第 V/3 條“散裝液化氣體船船長、高級及普通船員培訓及資歷的法定最低要求”，以及 1978 年國際海員培訓與發證會議決議 12 的內容。

- .1 在上述處所大氣中的氣體含量用固定式或可攜式設備確定具有足夠的氧氣而且不存在有毒大氣；或
- .2 人員配帶有呼吸器和其他必需的保護設備，且全部操作是在高級船員嚴密監督下進行的。

18.4.2 人員進入裝有可燃貨品的船上的任一氣體危險處所不得引入任何潛在的着火源，除非業已核准該處所已清除過氣體並一直保持著那種狀況。

18.4.3.1 對內部絕熱液艙，如在其相鄰液艙進行熱工工作，應採取專門的防火措施。為此目的，應考慮絕熱材料吸收氣體的特性和把已吸收的氣體除掉的特性。

18.4.3.2 對內部絕熱液艙，應根據 4.4.7.6 所規定的程序進行修理。

## 18.5 低溫下裝運貨物

18.5.1 如貨物在低溫下裝運時，應注意下列事項：

- .1 與貨物圍護系統相配套的加墊設備的操作方式應能確保溫度不致下降到低於船殼結構材料的設計溫度；
- .2 裝載方式應確保任何液艙、管系或其他附屬設備中不致發生令人不滿意的溫度梯度；以及
- .3 當液艙的溫度逐漸從環境溫度或接近環境溫度向下冷卻時，應嚴格遵守為特定液艙、管系和附屬設備所規定的冷卻程序。

## 18.6 防護設備

應使人員意識到貨物處理過程中可能涉及的危險性，同時在指導其在貨物裝卸過程中小心操作並使用 14.1 所規定的合適防護設備。

## 18.7 系統和控制

在貨物裝卸作業開始前，應試驗和檢驗與貨物運輸有關的貨物應急關閉系統和報警系統。在運輸作業前也應試驗和／或檢驗主要的貨物裝卸控制設備。

## 18.8 貨物運輸作業

18.8.1 在運輸開始前，船上人員與岸上負責設備人員應共同討論包括應急措施在內的貨物運輸作業要求，並在整個運輸作業過程中保持通信聯繫。

18.8.2 13.3.1 所述的閥的關閉時間（即指從激發關閉信號至閥全部關閉為止的時間）應不大於下列公式之值：

$$\frac{3600 U}{LR} \text{ (s)}$$

式中：U = 作業信號液位上方空擋容積（m<sup>3</sup>）

LR = 經商定的船、岸運輸工具之間最大裝貨率（m<sup>3</sup>/h）。

考慮到裝貨軟管或吊臂以及船和岸之間有關的管系系統，裝貨率應調整在當閥關閉時把急衝壓力限定在可以接受的標準上。

## 18.9 附加的操作要求

在本規則下述條文中可查明附加的操作要求：

3.8.4, 3.8.5, 7.1.1.5, 8.2.5, 8.2.7, 9.4.2, 12.1.1, 12.1.10, 13.1.4, 14.2.5, 14.2.6, 14.3.1, 15.1, 15.2, 16.2.2, 17.4.2, 17.6, 17.7, 17.12, 17.13, 17.14, 17.15, 17.16, 17.17, 17.18, 17.20。

## 第 19 章 最低要求一覽表

### 最低要求一覽表的註釋

聯合國編號 第 19 章表內所列的聯合國編號係供參考之用。

蒸氣檢測要求 F— 易燃性蒸氣檢測

( f 欄 ) T— 毒性蒸氣檢測

O— 氧氣分析器

F+T— 易燃和毒性蒸氣檢測

儀錶－許可的類型

( g 欄 ) I— 13.2.2.1 和 .2 所述的間接或封閉型

C— 13.2.2.1, .2 和 .3 所述的間接或封閉型

R— 13.2.2.1, .2, .3 和 .4 所述的間接、封閉或限制型

致冷劑氣體 無毒和不易燃的氣體，諸如：

( 1028 ) 二氯二氟甲烷

( 1029 ) 二氯一氟甲烷

( 1958 ) 二氯四氟乙烷

( 1018 ) 一氯二氟甲烷

( 1021 )            一氯四氟乙烷

( 1022 )            一氯三氟甲烷

除另有明文規定外，氣體混合物中所含的乙炔低於總量的 5% 可予運輸，不再有比對主要組成成分更進一步的要求。

a 貨品名稱	b 聯合國編號	c 包裝種類	d 是否受限制	e 裝載於貨櫃或 裝於固定式設備	f 裝載於	g 裝載	h 特殊要求
乙醛	1089	2G/2PG	-	Inert	F+T	C	14.4.3, 14.4.4, 17.4.1, 17.6.1
氨(無水的)	1005	2G/2PG	-	-	T	C	14.4.2, 14.4.3, 14.4.4, 17.2.1, 17.13
丁二烯	1010	2G/2PG	-	-	F	R	17.2.2, 17.4.2, 17.4.3, 17.6, 17.8
丁烷	1011	2G/2PG	-	-	F	R	
丁烷/丙烷混合物	1011/1978	2G/2PG	-	-	F	R	
丁烯	1012	2G/2PG	-	-	F	R	
氯	1017	1G	Yes	Dry	T	I	14.4, 17.3.2, 17.4.1, 17.5, 17.7, 17.9, 17.14
乙醚*	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
二甲基胺	1032	2G/2PG	-	-	F+T	C	14.4.2, 14.4.3, 14.4.4, 17.2.1
乙烷	1961	2G	-	-	F	R	
氯乙烷	1037	2G/2PG	-	-	F+T	R	
乙烯	1038	2G	-	-	F	R	
環氧乙烷	1040	1G	Yes	Inert	F+T	C	14.4.2, 14.4.3, 14.4.4, 17.2.2, 17.3.2, 17.4.1, 17.4.1

\* 此貨品也包括在 IBC 規則內。

a 貨品名稱	b 海關編目號碼	c 危險程度	d 是否劇毒或極度腐蝕性	e 是否對水生生物有害	f 反應性	g 穩定性	h 特殊要求
環氧乙烷/氧化丙烯混合物，但環氧乙烷的含量按重量計不超過 30%	2983	2G/2PG	-	Inert	F+T	C	17.5, 17.6.1, 17.16 14.4.3, 17.3.1, 17.4.1, 17.6.1, 17.10, 17.11, 17.20
異戊間二烯*	1218	2G/2PG	-	-	F	R	14.4.3, 17.8, 17.10, 17.12
異丙胺	1221	2G/2PG	-	-	F+T	C	14.4.2, 14.4.3, 17.2.4, 17.10, 17.11, 17.12, 17.17
甲烷（液態天然氣）	1972	2G	-	-	F	C	
甲基乙炔-丙二烯混合物	1060	2G/2PG	-	-	F	R	17.18
溴甲烷	1062	1G	Yes	-	F+T	C	14.4, 17.2.3, 17.3.2, 17.4.1, 17.5, 17.9
氯甲烷	1063	2G/2PG	-	-	F+T	C	17.2.3
乙烷*	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,

\* 此貨品也包括在 IBC 規則內。



a	b	c	d	e	f	g	h
貨品名稱	聯合國編號	船舶種類	要求C型獨立艙	液貨艙內蒸氣處所的控制	蒸氣處理	儀器	特殊要求
							17.12, 17.17
氮	2040	3G	-	-	O	C	17.19
丙烷	1978	2G/2PG	-	-	F	R	
丙烯	1077	2G/2PG	-	-	F	R	
氧化丙烯	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
致冷氣體 (見注解)	-	3G	-	-	-	R	
二氧化硫	1079	1G	Yes	Dry	T	C	14.4, 17.3.2, 17.4.1, 17.5, 17.7, 17.9
氯乙烯	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
乙氧基乙烯*	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
亞乙烯基氣*	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

\* 此貨品也包括在 IBC 規則內。

附 錄

國際散裝運輸液化氣體適裝證書的標準格式

國際散裝運輸液化氣體適裝證書

( 公 章 )

根據國際散裝運輸液化

氣體船舶構造和設備規則的規定發證

( 決 議 MSC.5 ( 48 ) )

經 ..... 政府授權，由 .....  
( 國 家 的 正 式 全 名 ) ( 主 管 機 關 授 權 的 組 織 或 人 員 )

發 給 。

船名	船舶編號或呼號	船籍港	貨容量 m <sup>3</sup>	船舶類別 ( 本規則 則 2.1 節 <sup>1/</sup> )

安放龍骨或相應建造階段的日期或如屬改建船舶，則為改建成氣體運輸船的開始日期：

.....

船舶亦完全符合本規則下列修正案的要求：

.....  
.....

船舶免除本規則的下列規定：

.....

.....

-----

本證書應以發證國家的官方語文書寫。如所用語文既非英文又非法文，則應包括英文或法文的譯文。

茲證明：

- 1 .1 此船業已根據本規則 1.5 的規定進行了檢驗；
- .2 檢驗查明船舶的結構、設備、附件、裝置和材料及其狀況在各方面均為合格，且該船符合本規則的有關條款。

2 下列設計參數業已採用：

.1 環境空氣溫度 \_\_\_\_\_ °C <sup>2/</sup>

.2 環境水溫 \_\_\_\_\_ °C <sup>2/</sup>

.3

液艙型式 及艙號	應力系數 <sup>3/</sup>				材料 <sup>3/</sup>	MARVS
	A	B	C	D		
貨物管系						

注意：本表所列液艙編號註明在附頁 2 經簽署並註有日期的液艙圖上。

.4 液貨艙材料的機械性能是在 \_\_\_\_\_ °C <sup>4/</sup>時確定的。

3 該船適於散裝運輸下列貨品，但須符合本規則所有有關操作規定：<sup>5/</sup>

貨 品	運載條件( 艙號等 )
<p>若表內填不上，則續寫在額外經簽署並註有日期的附頁 1 上。本表所列的艙號註明在附頁 2 經簽署並註有日期的液艙圖上。</p>	

4 按照 1.4 / 2.8.2\* 的規定，對該船用下述方式修改了本規則的規定：

5 該船的裝載必須符合：

\* .1 認可的裝貨手冊中所提供的裝載條件，該手冊應由主管機關的負責官員或主管機關承認的機構蓋上印記、記錄日期.....並簽字；

\* .2 本證書所附的裝載限制。

如果要求該船的裝載不按照上述規定，則應向發證的主管機關遞送能論證所建議裝載條件的必要的計算書，該主管機關可以書面授權採用建議的裝載條件。 \*\*

\* 按需要刪去。

\*\* 這段文字如不包括在證書中，則可附於該證書，但應適當加以簽字並蓋上印記。

本證書有效至.....。

19.....年.....月.....日頒發於.....

(發證地點)

.....

(經正式授權核發證書的官員簽字)

(發證單位的公章或鋼印)

填寫完證書時的註釋：

- 1/ “船舶類別”：填入此欄的船型必須與所有有關建議內容相關，例如，填入“2G型”是指完全符合本規則規定的2G型。
- 2/ 第 2.1 和 2.2 段：應填入為符合本規則 4.8.1 規定的經主管機關接受或要求的環境溫度。
- 3/ 第 2.3 段：應填入為符合本規則 4.5.1.4 和 4.5.1.6 規定的經主管機關接受或要求的應力系數和材料。
- 4/ 第 2.4 段：應填入為符合 4.5.1.7 規定的經主管機關接受的溫度。
- 5/ 第 3 段：只有本規則第 19 章所列的貨品或根據本規則 1.1.6 經主管機關評定的貨品才可列在表內。對後一種“新”貨品而言，應註上暫行的特殊要求。

法定年度檢驗的簽署

茲證明在根據國際散裝運輸液化氣體船舶構造和設備規則

1.5.2.1.4 要求的法定年度檢驗中，查明該船符合規則的有關規定。

簽字\_\_\_\_\_

(授權官員簽字)

地點\_\_\_\_\_

日期\_\_\_\_\_

(發證機關的公章或鋼印)

簽字\_\_\_\_\_

(授權官員簽字)

地點\_\_\_\_\_

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(發證機關的公章或鋼印)

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地點\_\_\_\_\_

日期\_\_\_\_\_

(發證機關的公章或鋼印)

註：如果符合 1.5.2.1.3 和 1.5.2.1.4 的有關規定，則期間檢驗可以

替代法定的年度檢驗。

期間檢驗的簽署

茲證明業已按國際散裝運輸液化氣體船舶構造和設備規則  
1.5.2.1.3 進行了期間檢驗，檢驗查明該船符合本規則的有關規定。

簽字\_\_\_\_\_

(授權官員簽字)

地點\_\_\_\_\_

日期\_\_\_\_\_

(發證機關的公章或鋼印)

簽字\_\_\_\_\_

(授權官員簽字)

地點\_\_\_\_\_

日期\_\_\_\_\_

(發證機關的公章或鋼印)



國際散裝運輸液化氣體適裝證書的附頁 1

第 3 節規定的貨品清單續表及運載條件。

貨 品	運載條件 ( 艙號等)

日期 \_\_\_\_\_

( 與證書同 )

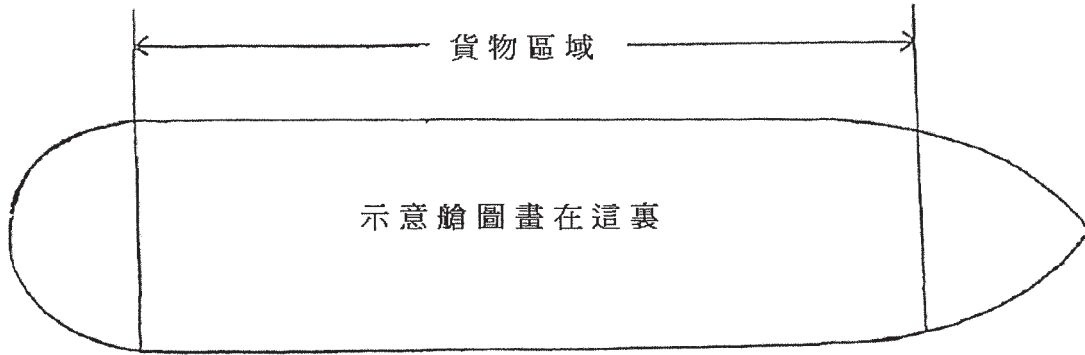
發證官員簽字和 / 或發證當局蓋章

國際散裝運輸液化氣體適裝證書附頁 2

液艙圖 (樣式)

船名： .....

船舶編號或呼號： .....



日期 .....

(與證書同)

發證官員簽字和 / 或發證當局蓋章

RESOLUTION MSC.5(48)

Adopted 17 June 1983

ADOPTION OF THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND  
EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

THE MARITIME SAFETY COMMITTEE,

RECALLING resolution A.328(IX) by which the Assembly authorized the Maritime Safety Committee to amend the Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk as may be necessary,

NOTING resolution MSC.6(48) by which it adopts, inter alia, amendments to chapter VII of the International Convention for the Safety of Life at Sea, 1974 (1974 SOLAS Convention), to make the provisions of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) mandatory under that Convention,

HAVING CONSIDERED the text of the proposed IGC Code:

- 1 ADOPTS THE IGC Code, the text of which is given in the Annex to the present resolution;
- 2 NOTES that under part C of chapter VII of the 1974 SOLAS Convention as amended by resolution MSC.6(48), amendments to the IGC Code shall be adopted, brought into force and take effect in accordance with the provisions of article VIII of that Convention;
- 3 REQUESTS the Secretary-General to circulate to all Governments concerned amendments to the IGC Code adopted as above which comprise the inclusion in chapter 19 of new products, recommending that, pending the entry into force of those amendments, these new products should be carried by gas carriers in compliance with the provisions of the amendments;
- 4 FURTHER REQUESTS the Secretary-General to transmit a copy of the present resolution together with the text of the IGC Code to all Members of the Organization and to all Contracting Governments to the 1974 SOLAS Convention which are not Members of the Organization.

\*\*\*

*Note by the Secretariat*

1. At its forty-eighth session held in June 1983, the Maritime Safety Committee adopted amendments to the International Convention for the Safety of Life at Sea, 1974 (SOLAS). Thirty-three Contracting Governments to the Convention were present at the session and all the texts of the amendments were adopted in accordance with the procedure specified in Article VIII(b)(iv).
2. The amendments adopted at the session consist of complete replacement texts of Chapters III and VII and amendments to Chapters II-1, II-2 and IV.
3. The decimal numbering system has been used in Chapters II-1, II-2, III and VII. Metric and Imperial units have been replaced with those of the *Système International* (SI Units), except where conventionally accepted nautical units were considered more appropriate.
4. Cross references are given in a concise form, e.g. Regulation II-2/10.4 meaning paragraph 4 of Regulation 10 of Chapter II-2.
5. Footnotes given throughout the Convention, as well as amendments thereto, refer to the relevant recommendations annexed to the Convention and other internationally accepted standards. The Maritime Safety Committee has emphasized that these footnotes do not form part of the Convention and are only inserted for ease of reference. The footnotes are to be altered to reflect any changes which may be made to the resolutions, recommendations or documents on which they are based. References to draft resolutions to be considered by the Assembly at its thirteenth regular session are to be replaced by the definitive numbers of the resolutions as adopted by the Assembly.

ANNEXINTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF  
SHIPS CARRYING LIQUEFIED GASES IN BULK

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Preamble

1 The purpose of this Code is to provide an international standard for the safe carriage by sea in bulk of liquefied gases and certain other substances listed in chapter 19 of the Code, by prescribing the design and construction standards of ships involved in such carriage and the equipment they should carry so as to minimize the risk to the ship, to its crew and to the environment, having regard to the nature of the products involved.

2 The basic philosophy is one of ship types related to the hazards of the products covered by the Code. Each of the products may have one or more hazard properties which include flammability, toxicity, corrosivity and reactivity. A further possible hazard may arise due to the products being transported under cryogenic or pressure conditions.

3 Severe collisions or strandings could lead to cargo tank damage and result in uncontrolled release of the product. Such release could result in evaporation and dispersion of the product and, in some cases, could cause brittle fracture of the ship's hull. The requirements in the Code are intended to minimize this risk as far as is practicable, based upon present knowledge and technology.

4 Throughout the development of the Code it was recognized that it must be based upon sound naval architectural and engineering principles and the best understanding available as to the hazards of the various products covered; furthermore that gas carrier design technology is not only a complex technology but is rapidly evolving and that the Code should not remain static. Therefore the Organization will periodically review the Code taking into account both experience and future development.

5 Requirements for new products and their conditions of carriage will be circulated as recommendations, on an interim basis, when adopted by the Maritime Safety Committee of the Organization, prior to the entry into force of the appropriate amendments, under the terms of article VIII of the International Convention for the Safety of Life at Sea, 1974.

6 The Code primarily deals with ship design and equipment. In order to ensure the safe transport of the products the total system must, however, be appraised. Other important facets of the safe transport of the products, such as training, operation, traffic control and handling in port, are being or will be examined further by the Organization.

7 The development of the Code has been greatly assisted by the work of the International Association of Classification Societies (IACS) and full account has been taken of the IACS Unified Requirements for Liquefied Gas Tankers in chapters 4, 5 and 6.

8 The development of chapter 10 has been greatly assisted by the relevant work of the International Electrotechnical Commission (IEC).

9 Chapter 18 of the Code dealing with operation of liquefied gas carriers highlights the regulations in other chapters that are operational in nature and mentions those other important safety features that are peculiar to gas carrier operation.

10 The layout of the Code is in line with the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code) adopted by the Maritime Safety Committee at its forty-eighth session.

## CHAPTER 1 - GENERAL

1.1 Application

1.1.1 The Code applies to ships regardless of their size, including those of less than 500 tons gross tonnage, engaged in carriage of liquefied gases having a vapour pressure exceeding 2.8 bar absolute at a temperature of 37.8°C, and other products as shown in chapter 19, when carried in bulk.

1.1.2 Unless expressly provided otherwise, the Code applies to ships the keels of which are laid or which are at a stage at which:

- .1 construction identifiable with the ship begins; and
- .2 assembly of that ship has commenced comprising at least 50 tonnes or 1% of the estimated mass of all structural material, whichever is less;

on or after 1 July 1986.

1.1.3 A ship, irrespective of the date of construction, which is converted to a gas carrier on or after 1 July 1986 should be treated as a gas carrier constructed on the date on which such conversion commences.

1.1.4.1 When cargo tanks contain products for which the Code requires a type 1G ship, neither flammable liquids having a flashpoint of 60°C (closed cup test) or less nor flammable products listed in chapter 19 should be carried in tanks located within the protective zones described in 2.6.1.1.

1.1.4.2 Similarly, when cargo tanks contain products for which the Code requires a type 2G/2PG ship, the above-mentioned flammable liquids should not be carried in tanks located within the protective zones described in 2.6.1.2.

1.1.4.3 In each case the restriction applies to the protective zones within the longitudinal extent of the hold spaces for the cargo tanks loaded with products for which the Code requires a type 1G or 2G/2PG ship.

1.1.4.4 The above-mentioned flammable liquids and products may be carried within these protective zones when the quantity retained in the cargo tanks of products for which the Code requires a type 1G or 2G/2PG ship is solely used for cooling, circulation or fuelling purposes.

1.1.5 Except as provided in 1.1.7.1, when it is intended to carry products covered by this Code and products covered by the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk adopted by the Maritime Safety Committee under the authority of the Assembly of the Organization conferred by resolution A.490(XII), as may be amended by the Organization (IBC Code), the ship should comply with the requirements of both Codes appropriate to the products carried.

1.1.6 Where it is proposed to carry products which may be considered to come within the scope of the Code but are not at present designated in chapter 19, the Administrations and the port Administrations involved in such carriage should establish preliminary suitable conditions of carriage based on the principles of the Code and notify the Organization of such conditions.

1.1.7.1 The requirements of this Code should take precedence when a ship is designed and constructed for the carriage of the following products:

- .1 those listed exclusively in chapter 19 of this Code; and
- .2 one or more of the products which are listed both in this Code and in the International Bulk Chemical Code. These products are marked with an asterisk (\*) in column 'a' in the table of chapter 19.

1.1.7.2 When a ship is intended exclusively to carry one or more of the products noted in 1.1.7.1.2, the requirements of the International Bulk Chemical Code as amended should apply.

1.1.8 Compliance of the ship with the requirements of the International Gas Carrier Code should be shown in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk provided for in 1.5. Compliance with the amendments to the Code, as appropriate, should also be indicated in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk.

## 1.2 Hazards

Hazards of gases considered in this Code include fire, toxicity, corrosivity, reactivity, low temperature and pressure.

## 1.3 Definitions

Except where expressly provided otherwise, the following definitions apply to the Code. Additional definitions are given in chapter 4.

1.3.1 "Accommodation spaces" are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, barber shops, pantries containing no cooking appliances and similar spaces. Public spaces are those portions of the accommodation which are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

1.3.2 "'A' class divisions" means divisions as defined in regulation II-2/3.3 of the 1983 SOLAS amendments.

1.3.3.1 "Administration" means the Government of the State whose flag the ship is entitled to fly.

1.3.3.2 "Port Administration" means the appropriate authority of the country in the port of which the ship is loading or unloading.

1.3.4 "Boiling point" is the temperature at which a product exhibits a vapour pressure equal to the atmospheric pressure.

1.3.5 "Breadth (B)" means the maximum breadth of the ship, measured amidships to the moulded line of the frame in a ship with a metal shell and to the outer surface of the hull in a ship with a shell of any other material. The breadth (B) should be measured in metres.

1.3.6 "Cargo area" is that part of the ship which contains the cargo containment system and cargo pump and compressor rooms and includes deck areas over the full length and breadth of the part of the ship over the above-mentioned spaces. Where fitted, the cofferdams, ballast or void spaces at the after end of the aftermost hold space or at the forward end of the forwardmost hold space are excluded from the cargo area.

1.3.7 "Cargo containment system" is the arrangement for containment of cargo including, where fitted, a primary and secondary barrier, associated insulation and any intervening spaces, and adjacent structure if necessary for the support of these elements. If the secondary barrier is part of the hull structure it may be a boundary of the hold space.

1.3.8 "Cargo control room" is a space used in the control of cargo handling operations and complying with the requirements of 3.4.

1.3.9 "Cargoes" are products listed in chapter 19 carried in bulk by ships subject to the Code.

1.3.10 "Cargo service spaces" are spaces within the cargo area used for workshops, lockers and store-rooms of more than 2 m<sup>2</sup> in area, used for cargo handling equipment.

1.3.11 "Cargo tank" is the liquid-tight shell designed to be the primary container of the cargo and includes all such containers whether or not associated with insulation or secondary barriers or both.

1.3.12 "Cofferdam" is the isolating space between two adjacent steel bulkheads or decks. This space may be a void space or a ballast space.

1.3.13 "Control stations" are those spaces in which ships' radio or main navigating equipment or the emergency source of power is located or where the fire-recording or fire-control equipment is centralized. This does not include special fire-control equipment which can be most practically located in the cargo area.

1.3.14 "Flammable products" are those identified by an "F" in column "f" in the table of chapter 19.

1.3.15 "Flammability limits" are the conditions defining the state of fuel-oxidant mixture at which application of an adequately strong external ignition source is only just capable of producing flammability in a given test apparatus.

1.3.16 "Gas carrier" is a cargo ship constructed or adapted and used for the carriage in bulk of any liquefied gas or other products listed in the table of chapter 19.

1.3.17 "Gas-dangerous space or zone" is:

- .1 a space in the cargo area which is not arranged or equipped in an approved manner to ensure that its atmosphere is at all times maintained in a gas-safe condition;
- .2 an enclosed space 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 that space;
- .3 a cargo containment system and cargo piping;
- .4.1 a hold space where cargo is carried in a cargo containment system requiring a secondary barrier;

- .4.2 a hold space where cargo is carried in a cargo containment system not requiring a secondary barrier;
  - .5 a space separated from a hold space described in .4.1 by a single gas-tight steel boundary;
  - .6 a cargo pump room and cargo compressor room;
  - .7 a zone on the open deck, or semi-enclosed space on the open deck, within 3 m 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;
  - .8 the open deck over the cargo area and 3 m forward and aft of the cargo area on the open deck up to a height of 2.4 m above the weather deck;
  - .9 a zone within 2.4 m of the outer surface of a cargo containment system where such surface is exposed to the weather;
  - .10 an enclosed or semi-enclosed space in which pipes containing products are located. A space which contains gas detection equipment complying with 13.6.5 and a space utilizing boil-off gas as fuel and complying with chapter 16 are not considered gas-dangerous spaces in this context;
  - .11 a compartment for cargo hoses; or
  - .12 an enclosed or semi-enclosed space having a direct opening into any gas-dangerous space or zone.
- 1.3.18 "Gas-safe space" is a space other than a gas-dangerous space.
- 1.3.19 "Hold space" is the space enclosed by the ship's structure in which a cargo containment system is situated.
- 1.3.20 "Independent" means that a piping or venting system, for example, is in no way connected to another system and there are no provisions available for the potential connection to other systems.



1.3.21 "Insulation space" is the space, which may or may not be an interbarrier space, occupied wholly or in part by insulation.

1.3.22 "Interbarrier space" is the space between a primary and a secondary barrier, whether or not completely or partially occupied by insulation or other material.

1.3.23 "Length (L)" means 96% of the total length on a waterline at 85% of the least moulded depth measured from the top of the keel, or the length from the foreside of the stem to the axis of the rudder stock on that waterline, if that be greater. In ships designed with a rake of keel, the waterline on which this length is measured should be parallel to the designed waterline. The length (L) should be measured in metres.

1.3.24 "Machinery spaces of category A" are those spaces and trunks to such spaces which contain:

- .1 internal combustion machinery used for main propulsion; or
- .2 internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW; or
- .3 any oil-fired boiler or oil fuel unit.

1.3.25 "Machinery spaces" are all machinery spaces of category A and all other spaces containing propelling machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air-conditioning machinery, and similar spaces; and trunks to such spaces.

1.3.26 "MARVS" is the maximum allowable relief valve setting of a cargo tank.

1.3.27 "Oil fuel unit" is the equipment used for the preparation of oil fuel for delivery to an oil-fired boiler, or equipment used for the preparation for delivery of heated oil to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 1.8 bar gauge.

1.3.28 "Organization" is the International Maritime Organization (IMO).

1.3.29 "Permeability" of a space means the ratio of the volume within that space which is assumed to be occupied by water to the total volume of that space.

1.3.30.1 "Primary barrier" is the inner element designed to contain the cargo when the cargo containment system includes two boundaries.

1.3.30.2 "Secondary barrier" is the liquid-resisting outer element of a cargo containment system designed to afford temporary containment of any envisaged leakage of liquid cargo through the primary barrier and to prevent the lowering of the temperature of the ship's structure to an unsafe level. Types of secondary barrier are more fully defined in chapter 4.

1.3.31 "Relative density" is the ratio of the mass of a volume of a product to the mass of an equal volume of fresh water.

1.3.32 "Separate" means that a cargo piping system or cargo vent system, for example, is not connected to another cargo piping or cargo vent system. This separation may be achieved by the use of design or operational methods. Operational methods should not be used within a cargo tank and should consist of one of the following types:

- .1 removing spool pieces or valves and blanking the pipe ends;
- .2 arrangement of two spectacle flanges in series with provisions for detecting leakage into the pipe between the two spectacle flanges.

1.3.33 "Service spaces" are those spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store-rooms, workshops other than those forming part of the machinery spaces and similar spaces and trunks to such spaces.

1.3.34 "1974 SOLAS Convention" means the International Convention for the Safety of Life at Sea, 1974.

1.3.35 "1983 SOLAS amendments" means amendments to the 1974 SOLAS Convention adopted by the Maritime Safety Committee of the Organization at its forty-eighth session on 17 June 1983 by resolution MSC.6(48).

1.3.36 "Tank cover" is the protective structure intended to protect the cargo containment system against damage where it protrudes through the weather deck or to ensure the continuity and integrity of the deck structure.

1.3.37 "Tank dome" is the upward extension of a portion of a cargo tank. In the case of below-deck cargo containment systems the tank dome protrudes through the weather deck or through a tank cover.

1.3.38 "Toxic products" are those identified by a "T" in column "f" in the table of chapter 19.

1.3.39 "Vapour pressure" is the equilibrium pressure of the saturated vapour above the liquid expressed in bars absolute at a specified temperature.

1.3.40 "Void space" is an enclosed space in the cargo area external to a cargo containment system, other than a hold space, ballast space, fuel oil tank, cargo pump or compressor room, or any space in normal use by personnel.

#### 1.4 Equivalents

1.4.1 Where the Code requires that a particular fitting, material, appliance, apparatus, item of equipment or type thereof should be fitted or carried in a ship, or that any particular provision should be made, or any procedure or arrangement should be complied with, the Administration may allow any other fitting, material, appliance, apparatus, item of equipment or type thereof to be fitted or carried, or any other provision, procedure or arrangement to be made in that ship, if it is satisfied by trial thereof or otherwise that such fitting, material, appliance, apparatus, item of equipment or type thereof or that any particular provision, procedure or arrangement is at least as effective as that required by the Code. However, the Administration may not allow operational methods or procedures to be made an alternative to a particular fitting, material, appliance, apparatus, item of equipment, or type thereof which is prescribed by the Code.

1.4.2 When the Administration so allows any fitting, material, appliance, apparatus, item of equipment, or type thereof, or provision, procedure or arrangement to be substituted, it should communicate to the Organization the particulars thereof together with a report on the evidence submitted, so that the Organization may circulate the same to other Contracting Governments to the 1974 SOLAS Convention for the information of their officers.

#### 1.5 Surveys and certification

##### 1.5.1 Survey procedure

1.5.1.1 The survey of ships, so far as regards the enforcement of the provisions of the regulations and the granting of exemptions therefrom, should be carried out by officers of the Administration. The Administration may, however, entrust the surveys either to surveyors nominated for the purpose or to organizations recognized by it.

1.5.1.2 The Administration nominating surveyors or recognizing organizations to conduct surveys should, as a minimum, empower any nominated surveyor or recognized organization to:

- .1 require repairs to a ship; and
- .2 carry out surveys if requested by the port State authority\* concerned.

The Administration should notify the Organization of the specific responsibilities and conditions of the authority delegated to nominated surveyors or recognized organizations for circulation to the Contracting Governments.

1.5.1.3 When a nominated surveyor or recognized organization determines that the condition of the ship or its equipment does not correspond substantially with the particulars of the certificate or is such that the ship is not fit to proceed to sea without danger to the ship, or persons on board, such surveyor or organization should immediately ensure that corrective action is taken and should in due course notify the Administration. If such corrective action is not taken the relevant certificate should be withdrawn and the Administration should be notified immediately; and, if the ship is in a port of another Contracting Government, the port State authority concerned should also be notified immediately.

1.5.1.4 In every case, the Administration should guarantee the completeness and efficiency of the survey, and should undertake to ensure the necessary arrangements to satisfy this obligation.

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\* Port State authority has the meaning as presented in chapter I, regulation 19 of the 1978 Protocol to the 1974 SOLAS Convention.

### 1.5.2 Survey requirements

1.5.2.1 The structure, equipment, fittings, arrangements and material (other than items in respect of which a Cargo Ship Safety Construction Certificate, Cargo Ship Safety Equipment Certificate and Cargo Ship Safety Radiotelegraphy Certificate or Cargo Ship Safety Radiotelephony Certificate is issued) of a gas carrier should be subjected to the following surveys:

- .1 An initial survey before the ship is put in service or before the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk is issued for the first time, which should include a complete examination of its structure, equipment, fittings, arrangements and material in so far as the ship is covered by the Code. This survey should be such as to ensure that the structure, equipment, fittings, arrangements and material fully comply with the applicable provisions of the Code.
- .2 A periodical survey at intervals specified by the Administration, but not exceeding 5 years which should be such as to ensure that the structure, equipment, fittings, arrangements and material comply with the applicable provisions of the Code.
- .3 A minimum of one intermediate survey during the period of validity of the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk. In cases where only one such intermediate survey is carried out in any one certificate validity period, it should be held not before 6 months prior to, nor later than 6 months after, the half-way date of the certificate's period of validity. Intermediate surveys should be such as to ensure that the safety equipment, and other equipment, and associated pump and piping systems comply with the applicable provisions of the Code and are in good working order. Such surveys should be endorsed on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk.

- .4 A mandatory annual survey within 3 months before or after the anniversary date of the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk which should include a general examination to ensure that the structure, equipment, fittings, arrangements and materials remain in all respects satisfactory for the service for which the ship is intended. Such a survey should be endorsed in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk.
- .5 An additional survey, either general or partial according to the circumstances, should be made when required after an investigation prescribed in 1.5.3.3, or whenever any important repairs or renewals are made. Such a survey should ensure that the necessary repairs or renewals have been effectively made, that the material and workmanship of such repairs or renewals are satisfactory; and that the ship is fit to proceed to sea without danger to the ship or persons on board.

1.5.3 Maintenance of conditions after survey

1.5.3.1 The condition of the ship and its equipment should be maintained to conform with the provisions of the Code to ensure that the ship will remain fit to proceed to sea without danger to the ship or persons on board.

1.5.3.2 After any survey of the ship under 1.5.2 has been completed, no change should be made in the structure, equipment, fittings, arrangements and material covered by the survey, without the sanction of the Administration, except by direct replacement.

1.5.3.3 Whenever an accident occurs to a ship or a defect is discovered, either of which affects the safety of the ship or the efficiency or completeness of its life-saving appliances or other equipment, the master or owner of the ship should report at the earliest opportunity to the Administration, the nominated surveyor or recognized organization responsible for issuing the relevant certificate, who should cause investigations to be initiated to determine whether a survey, as required by 1.5.2.5 is necessary. If the ship is in a port of another Contracting Government, the master or owner should also report immediately to the port State authority concerned and the nominated surveyor or recognized organization should ascertain that such a report has been made.

1.5.4 Issue of certificate

1.5.4.1 A certificate called an International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk, the model form of which is set out in the appendix, should be issued after an initial or periodical survey to a gas carrier which complies with the relevant requirements of the Code.

1.5.4.2 The certificate issued under the provisions of this section should be available on board for inspection at all times.

1.5.4.3 When a ship is designed and constructed under the provisions of 1.1.5, International Certificates of Fitness should be issued in accordance with the requirements of this section and with the requirements of section 1.5 of the International Bulk Chemical Code.

1.5.5 Issue or endorsement of certificate by another Government

1.5.5.1 A Contracting Government may, at the request of another Government cause a ship entitled to fly the flag of the other State to be surveyed and, if satisfied that the requirements of the Code are complied with, issue or authorize the issue of the certificate to the ship, and, where appropriate, endorse or authorize the endorsement of the certificate on board the ship in accordance with the Code. Any certificate so issued should contain a statement to the effect that it has been issued at the request of the Government of the State whose flag the ship is entitled to fly.



1.5.6 Duration and validity of the certificate

1.5.6.1 An International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk should be issued for a period specified by the Administration which should not exceed 5 years from the date of the initial survey or the periodical survey.

1.5.6.2 No extension of the 5 year period of the certificate should be permitted.

1.5.6.3 The certificate should cease to be valid:

- .1 if the surveys are not carried out within the period specified by 1.5.2;
- .2 upon transfer of the ship to the flag of another State. A new certificate should only be issued when the Government issuing the new certificate is fully satisfied that the ship is in compliance with the requirements of 1.5.3.1 and 1.5.3.2. Where a transfer occurs between Contracting Governments, the Government of the State whose flag the ship was formerly entitled to fly should, if requested within 12 months after the transfer has taken place, as soon as possible transmit to the Administration copies of the certificates carried by the ship before the transfer and, if available, copies of the relevant survey reports.

## CHAPTER 2 - SHIP SURVIVAL CAPABILITY\* AND LOCATION OF CARGO TANKS

2.1 General

2.1.1 Ships subject to the Code should survive the normal effects of flooding following assumed hull damage caused by some external force. In addition, to safeguard the ship and the environment, the cargo tanks should be protected from penetration in the case of minor damage to the ship resulting, for example, from contact with a jetty or tug, and given a measure of protection from damage in the case of collision or stranding, by locating them at specified minimum distances inboard from the ship's shell plating. Both the damage to be assumed and the proximity of the tanks to the ship's shell should be dependent upon the degree of hazard presented by the product to be carried.

2.1.2 Ships subject to the Code should be designed to one of the following standards:

- .1 A type 1G ship is a gas carrier intended to transport products indicated in chapter 19 which require maximum preventive measures to preclude the escape of such cargo.
- .2 A type 2G ship is a gas carrier intended to transport products indicated in chapter 19 which require significant preventive measures to preclude the escape of such cargo.

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\* Reference is made to the Guidelines for Uniform Application of the Survival Requirements of the Bulk Chemical Code and the Gas Carrier Code.

- .3 A type 2PG ship is a gas carrier of 150 m in length or less intended to transport products indicated in chapter 19 which require significant preventive measures to preclude escape of such cargo, and where the products are carried in independent type C tanks designed (see 4.2.4.4) for a MARVS of at least 7 bar gauge and a cargo containment system design temperature of  $-55^{\circ}\text{C}$  or above. Note that a ship of this description but over 150 m in length is to be considered a type 2G ship.
- .4 A type 3G ship is a gas carrier intended to carry products indicated in chapter 19 which require moderate preventive measures to preclude the escape of such cargo.

Thus a type 1G ship is a gas carrier intended for the transportation of products considered to present the greatest overall hazard and types 2G/2PG and type 3G for products of progressively lesser hazards. Accordingly, a type 1G ship should survive the most severe standard of damage and its cargo tanks should be located at the maximum prescribed distance inboard from the shell plating.

2.1.3 The ship type required for individual products is indicated in column "c" in the table of chapter 19.

2.1.4 If a ship is intended to carry more than one product listed in chapter 19, the standard of damage should correspond to that product having the most stringent ship type requirement. The requirements for the location of individual cargo tanks, however, are those for ship types related to the respective products intended to be carried.

## 2.2 Freeboard and intact stability

2.2.1 Ships subject to the Code may be assigned the minimum freeboard permitted by the International Convention on Load Lines in force. However, the draught associated with the assignment should not be greater than the maximum draught otherwise permitted by this Code.

2.2.2 The stability of the ship in all seagoing conditions and during loading and unloading cargo should be to a standard which is acceptable to the Administration.

2.2.3 When calculating the effect of free surfaces of consumable liquids for loading conditions it should be assumed that, for each type of liquid, at least one transverse pair or a single centre tank has a free surface and the tank or combination of tanks to be taken into account should be those where the effect of free surfaces is the greatest. The free surface effect in undamaged compartments should be calculated by a method acceptable to the Administration.

2.2.4 Solid ballast should not normally be used in double bottom spaces in the cargo area. Where, however, because of stability considerations, the fitting of solid ballast in such spaces becomes unavoidable, then its disposition should be governed by the need to ensure that the impact loads resulting from bottom damage are not directly transmitted to the cargo tank structure.

2.2.5 The master of the ship should be supplied with a Loading and Stability Information booklet. This booklet should contain details of typical service conditions, loading, unloading and ballasting operations, provisions for evaluating other conditions of loading and a summary of the ship's survival capabilities. In addition, the booklet should contain sufficient information to enable the master to load and operate the ship in a safe and seaworthy manner.

### 2.3 Shipside discharges below the freeboard deck

2.3.1 The provision and control of valves fitted to discharges led through the shell from spaces below the freeboard deck or from within the superstructures and deckhouses on the freeboard deck fitted with weathertight doors should comply with the requirements of the relevant regulation of the International Convention on Load Lines in force, except that the choice of valves should be limited to:

- .1 one automatic non-return valve with a positive means of closing from above the freeboard deck; or
- .2 where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0.01L, two automatic non-return valves without positive means of closing, provided that the inboard valve is always accessible for examination under service conditions.

2.3.2 For the purpose of this chapter "summer load waterline" and "freeboard deck", have the meanings defined in the International Convention on Load Lines in force.

2.3.3 The automatic non-return valves referred to in 2.3.1.1 and 2.3.1.2 should be of a type acceptable to the Administration and should be fully effective in preventing admission of water into the ship, taking into account the sinkage, trim and heel in survival requirements in 2.9.

#### 2.4 Conditions of loading

Damage survival capability should be investigated on the basis of loading information submitted to the Administration for all anticipated conditions of loading and variations in draught and trim. The survival requirements need not be applied to the ship when in the ballast condition\*, provided that any cargo retained on board is solely used for cooling, circulation or fuelling purposes.

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\* The cargo content of small independent purge tanks on deck need not be taken into account when assessing the ballast condition.

## 2.5 Damage assumptions

### 2.5.1 The assumed maximum extent of damage should be:

#### .1 Side damage:

.1.1 Longitudinal extent:  $1/3L^{2/3}$  or 14.5 m,  
whichever is less

.1.2 Transverse extent: B/5 or 11.5 m, whichever  
is less  
measured inboard from the  
ship's side at right angles to  
the centreline at the level  
of the summer load line

.1.3 Vertical extent: upwards without limit  
from the moulded line of the  
bottom shell plating at centre-  
line.

#### .2 Bottom damage:

For 0.3L from the forward perpendicular of the ship	Any other part of the ship
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.2.1 Longitudinal extent: $1/3L^{2/3}$ or 14.5 m, whichever is less	$1/3L^{2/3}$ or 5 m, whichever is less
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.2.2 Transverse extent: B/6 or 10 m, whichever is less	B/6 or 5 m, which- ever is less
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.2.3 Vertical extent: B/15 or 2 m, whichever is less measured from the moulded line of the bottom shell plating at centre- line (see 2.6.3).	B/15 or 2 m, which- ever is less measured from the moulded line of the bottom shell plating at centreline (see 2.6.3).
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2.5.2 Other damage:

- .1 If any damage of a lesser extent than the maximum damage specified in 2.5.1 would result in a more severe condition, such damage should be assumed.
- .2 Local side damage anywhere in the cargo area extending inboard 760 mm measured normal to the hull shell should be considered and transverse bulkheads should be assumed damaged when also required by the applicable subparagraphs of 2.8.1.

2.6 Location of cargo tanks

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

- .1 Type 1G ships: from the side shell plating not less than the transverse extent of damage specified in 2.5.1.1.2 and from the moulded line of the bottom shell plating at centreline not less than the vertical extent of damage specified in 2.5.1.2.3 and nowhere less than 760 mm from the shell plating.
- .2 Types 2G/2PG and 3G ships: from the moulded line of the bottom shell plating at centreline not less than the vertical extent of damage specified in 2.5.1.2.3 and nowhere less than 760 mm from the shell plating.

2.6.2 For the purpose of tank location, the vertical extent of bottom damage should be measured to the inner bottom when membrane or semi-membrane tanks are used, otherwise to the bottom of the cargo tanks. The transverse extent of side damage should be measured to the longitudinal bulkhead when membrane or semi-membrane tanks are used, otherwise to the side of the cargo tanks (see figure 2.1). For internal insulation tanks the extent of damage should be measured to the supporting tank plating.

2.6.3 Except for type IG ships, suction wells installed in cargo tanks may protrude into the vertical extent of bottom damage specified in 2.5.1.2.3 provided that such wells are as small as practicable and the protrusion below the inner bottom plating does not exceed 25% of the depth of the double bottom or 350 mm, whichever is less. Where there is no double bottom, the protrusion below the upper limit of bottom damage should not exceed 350 mm. Suction wells installed in accordance with this paragraph may be ignored in determining the compartments affected by damage.

## 2.7 Flooding assumptions

2.7.1 The requirements of 2.9 should be confirmed by calculations which take into consideration the design characteristics of the ship; the arrangements, configuration and contents of the damaged compartments; the distribution, relative densities and the free surface effects of liquids; and the draught and trim for all conditions of loading.

2.7.2 The permeabilities of spaces assumed to be damaged should be as follows:

<u>Spaces</u>	<u>Permeabilities</u>
Appropriated to stores	0.60
Occupied by accommodation	0.95
Occupied by machinery	0.85
Voids	0.95
Intended for consumable liquids	0 to 0.95*
Intended for other liquids	0 to 0.95*

2.7.3 Wherever damage penetrates a tank containing liquids, it should be assumed that the contents are completely lost from that compartment and replaced by salt water up to the level of the final plane of equilibrium.

\* The permeability of partially filled compartments should be consistent with the amount of liquid carried in the compartment.



2.7.4 Where the damage between transverse watertight bulkheads is envisaged as specified in 2.8.1.4, .5, and .6, transverse bulkheads should be spaced at least at a distance equal to the longitudinal extent of damage specified in 2.5.1.1.1 in order to be considered effective. Where transverse bulkheads are spaced at a lesser distance, one or more of these bulkheads within such extent of damage should be assumed as non-existent for the purpose of determining flooded compartments. Further, any portion of a transverse bulkhead bounding side compartments or double bottom compartments should be assumed damaged if the watertight bulkhead boundaries are within the extent of vertical or horizontal penetration required by 2.5. Also, any transverse bulkhead should be assumed damaged if it contains a step or recess of more than 3 m in length located within the extent of penetration of assumed damage. The step formed by the after peak bulkhead and after peak tank top should not be regarded as a step for the purpose of this paragraph.

2.7.5 The ship should be so designed as to keep unsymmetrical flooding to the minimum consistent with efficient arrangements.

2.7.6 Equalization arrangements requiring mechanical aids such as valves or cross-levelling pipes, if fitted, should not be considered for the purpose of reducing an angle of heel or attaining the minimum range of residual stability to meet the requirements of 2.9.1 and sufficient residual stability should be maintained during all stages where equalization is used. Spaces which are linked by ducts of large cross-sectional area may be considered to be common.

2.7.7 If pipes, ducts, trunks or tunnels are situated within the assumed extent of damage penetration, as defined in 2.5, arrangements should be such that progressive flooding cannot thereby extend to compartments other than those assumed to be flooded for each case of damage.

2.7.8 The buoyancy of any superstructure directly above the side damage should be disregarded. The unflooded parts of superstructures beyond the extent of damage, however, may be taken into consideration provided that:

- .1 they are separated from the damaged space by watertight divisions and the requirements of 2.9.1.2.1 in respect of these intact spaces are complied with; and
- .2 openings in such divisions are capable of being closed by remotely operated sliding watertight doors and unprotected openings are not immersed within the minimum range of residual stability required in 2.9.1; however the immersion of any other openings capable of being closed weathertight may be permitted.

## 2.8 Standard of damage

2.8.1 Ships should be capable of surviving the damage indicated in 2.5 with the flooding assumptions in 2.7 to the extent determined by the ship's type according to the following standards:

- .1 A type 1G ship should be assumed to sustain damage anywhere in its length;
- .2 A type 2G ship of more than 150 m in length should be assumed to sustain damage anywhere in its length;
- .3 A type 2G ship of 150 m in length or less should be assumed to sustain damage anywhere in its length except involving either of the bulkheads bounding a machinery space located aft;
- .4 A type 2PG ship should be assumed to sustain damage anywhere in its length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage as specified in 2.5.1.1.1;
- .5 A type 3G ship of 125 m in length or more should be assumed to sustain damage anywhere in its length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage specified in 2.5.1.1.1;

- .6 A type 3G ship less than 125 m in length should be assumed to sustain damage anywhere in its length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage specified in 2.5.1.1.1 and except damage involving the machinery space when located aft. However, the ability to survive the flooding of the machinery space should be considered by the Administration.

2.8.2 In the case of small type 2G/2PG and 3G ships which do not comply in all respects with the appropriate requirements of 2.8.1.3, .4, and .6, special dispensations may only be considered by the Administration provided that alternative measures can be taken which maintain the same degree of safety. The nature of the alternative measures should be approved and clearly stated and be available to the port Administration. Any such dispensation should be duly noted on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk referred to in 1.5.4.

## 2.9 Survival requirements

Ships subject to the Code should be capable of surviving the assumed damage specified in 2.5 to the standard provided in 2.8 in a condition of stable equilibrium and should satisfy the following criteria.

### 2.9.1 In any stage of flooding:

- .1 the waterline, taking into account sinkage, heel and trim, should be below the lower edge of any opening through which progressive flooding or downflooding may take place. Such openings should include air pipes and openings which are closed by means of weathertight doors or hatch covers and may exclude those openings closed by means of watertight manhole covers and watertight flush scuttles, small watertight cargo tank hatch covers which maintain the high integrity of the deck, remotely operated watertight sliding doors, and sidescuttles of the non-opening type;

- .2 the maximum angle of heel due to unsymmetrical flooding should not exceed 30°; and
- .3 the residual stability during intermediate stages of flooding should be to the satisfaction of the Administration. However, it should never be significantly less than that required by 2.9.2.1.

2.9.2 At final equilibrium after flooding:

- .1 the righting lever curve should have a minimum range of 20° beyond the position of equilibrium in association with a maximum residual righting lever of at least 0.1 m within the 20° range; the area under the curve within this range should not be less than 0.0175 m/rad. Unprotected openings should not be immersed within this range unless the space concerned is assumed to be flooded. Within this range, the immersion of any of the openings listed in 2.9.1.1 and other openings capable of being closed weathertight may be permitted; and
- .2 the emergency source of power should be capable of operating.

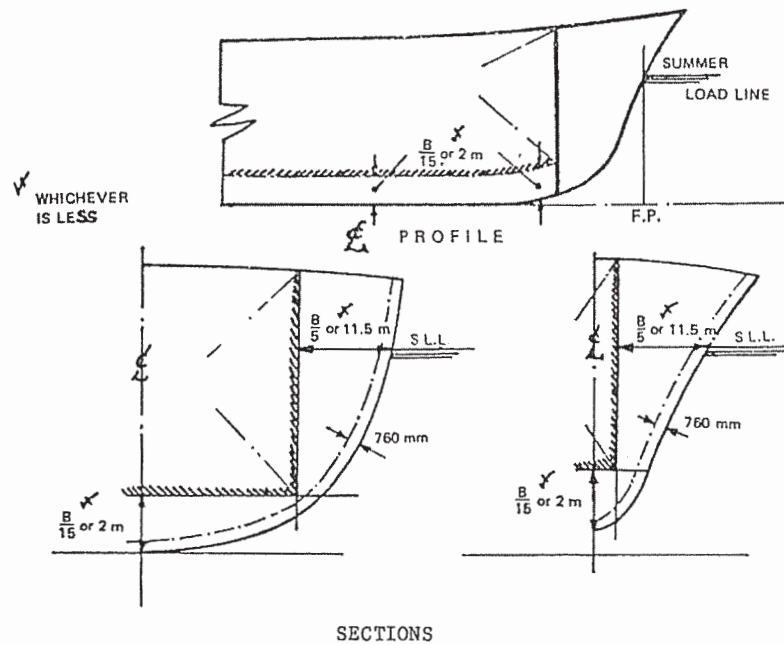


Figure 2.1 - Tank location requirements as set out in 2.6

## CHAPTER 3 - SHIP ARRANGEMENTS

3.1 Segregation of the cargo area

3.1.1 Hold spaces should be segregated from machinery and boiler spaces, accommodation spaces, service spaces and control stations, chain lockers, drinking and domestic water tanks and from stores. Hold spaces should be located forward of machinery spaces of category A, other than those deemed necessary by the Administration for the safety or navigation of the ship.

3.1.2 Where cargo is carried in a cargo containment system not requiring a secondary barrier, segregation of hold spaces from spaces referred to in 3.1.1 or spaces either below or outboard of the hold spaces may be effected by cofferdams, fuel oil tanks or a single gastight bulkhead of all-welded construction forming an A-60 class division. A gastight A-0 class division is satisfactory if there is no source of ignition or fire hazard in the adjoining spaces.

3.1.3 Where cargo is carried in a cargo containment system requiring a secondary barrier, segregation of hold spaces from spaces referred to in 3.1.1 or spaces either below or outboard of the hold spaces which contain a source of ignition or fire hazard should be effected by cofferdams or fuel oil tanks. If there is no source of ignition or fire hazard in the adjoining space, segregation may be by a single A-0 class division which is gastight.

3.1.4 When cargo is carried in a cargo containment system requiring a secondary barrier:

- .1 at temperatures below  $-10^{\circ}\text{C}$ , hold spaces should be segregated from the sea by a double bottom; and
- .2 at temperatures below  $-55^{\circ}\text{C}$ , the ship should also have a longitudinal bulkhead forming side tanks.

3.1.5 Any piping system which may contain cargo or cargo vapour should:

- .1 be segregated from other piping systems, except where inter-connections are required for cargo-related operations such as purging, gas-freeing or inerting. In such cases, precautions should be taken to ensure that cargo or cargo vapour cannot enter such other piping systems through the inter-connections;
- .2 except as provided in chapter 16, not pass through any accommodation space, service space or control station or through a machinery space other than a cargo pump room or cargo compressor space;
- .3 be connected into the cargo containment system directly from the open deck except that pipes installed in a vertical trunkway or equivalent may be used to traverse void spaces above a cargo containment system and except that pipes for drainage, venting or purging may traverse cofferdams;
- .4 except for bow or stern loading and unloading arrangements in accordance with 3.8 and emergency cargo jettisoning piping systems in accordance with 3.1.6, and except in accordance with chapter 16, be located in the cargo area above the open deck; and
- .5 except for thwartship shore connection piping not subject to internal pressure at sea or emergency cargo jettisoning piping systems, be located inboard of the transverse tank location requirements of 2.6.1.

3.1.6 Any emergency cargo jettisoning piping system should comply with 3.1.5 as appropriate and may be led aft externally to accommodation spaces, service spaces or control stations or machinery spaces, but should not pass through them. If an emergency cargo jettisoning piping system is permanently installed a suitable means of isolation from the cargo piping should be provided within the cargo area.

3.1.7 Arrangements should be made for sealing the weather decks in way of openings for cargo containment systems.

### 3.2 Accommodation, service and machinery spaces and control stations

3.2.1 No accommodation space, service space or control station should be located within the cargo area. The bulkhead of accommodation spaces, service spaces or control stations which face the cargo area should be so located as to avoid the entry of gas from the hold space to such spaces through a single failure of a deck or bulkhead on a ship having a containment system requiring a secondary barrier.

3.2.2 In order to guard against the danger of hazardous vapours, due consideration should be given to the location of air intakes and openings into accommodation, service and machinery spaces and control stations in relation to cargo piping, cargo vent systems and machinery space exhausts from gas burning arrangements.

3.2.3 Access through doors, gastight or otherwise, should not be permitted from a gas-safe space to a gas-dangerous space, except for access to service spaces forward of the cargo area through air-locks as permitted by 3.6.1 when accommodation spaces are aft.

3.2.4 Entrances, air inlets and openings to accommodation spaces, service spaces and control stations should not face the cargo area. They should be located on the end bulkhead not facing the cargo area or on the outboard side of the house or on both at a distance of at least 4% of the length of the ship but not less than 3 m from the end of the house facing the cargo area. This distance, however, need not exceed 5 m. Windows and sidescuttles facing the cargo area and on the sides of the houses within the distance mentioned above should be of the fixed (non-opening) type. Wheelhouse windows may be non-fixed and wheelhouse doors may be located within the above limits so long as they are so designed that a rapid and efficient gas and vapour tightening of the wheelhouse can be ensured. For ships dedicated to the carriage of cargoes which have neither flammable nor toxic hazards, the Administration may approve relaxations from the above requirements.

3.2.5 Sidescuttles in the shell below the uppermost continuous deck and in the first tier of the superstructure are to be of the fixed (non-opening) type.

3.2.6 All air intakes and openings into the accommodation spaces, service spaces and control stations should be fitted with closing devices. For toxic gases they are to be operated from inside the space.

### 3.3 Cargo pump rooms and cargo compressor rooms

3.3.1.1 Cargo pump rooms and cargo compressor rooms should be situated above the weather deck and located within the cargo area unless specially approved by the Administration. Cargo compressor rooms should be treated as cargo pump rooms for the purpose of fire protection according to regulation II-2/58 of the 1983 SOLAS amendments.

3.3.1.2 When cargo pump rooms and cargo compressor rooms are permitted to be fitted above or below the weather deck at the after end of the aftermost hold space or at the forward end of the forwardmost hold space, the limits of the cargo area as defined in 1.3.6 should be extended to include the cargo pump rooms and cargo compressor rooms for the full breadth and depth of the ship and deck areas above those spaces.

3.3.1.3 Where the limits of the cargo area are extended by 3.3.1.2, the bulkhead which separates the cargo pump rooms and cargo compressor rooms from accommodation and service spaces, control stations and machinery spaces of category A should be so located as to avoid the entry of gas to these spaces through a single failure of a deck or bulkhead.

3.3.2 Where pumps and compressors are driven by shafting passing through a bulkhead or deck, gastight seals with efficient lubrication or other means of ensuring the permanence of the gas seal should be fitted in way of the bulkhead or deck.



3.3.3 Arrangements of cargo pump rooms and cargo compressor rooms should be such as to ensure safe unrestricted access for personnel wearing protective clothing and breathing apparatus, and in the event of injury to allow unconscious personnel to be removed. All valves necessary for cargo handling should be readily accessible to personnel wearing protective clothing. Suitable arrangements should be made to deal with drainage of pump and compressor rooms.

#### 3.4 Cargo control rooms

3.4.1 Any cargo control room should be above the weather deck and may be located in the cargo area. The cargo control room may be located within the accommodation spaces, service spaces or control stations provided the following conditions are complied with:

- .1 the cargo control room is a gas-safe space; and
- .2.1 if the entrance complies with 3.2.4, the control room may have access to the spaces described above;
- .2.2 if the entrance does not comply with 3.2.4, the control room should have no access to the spaces described above and the boundaries to such spaces should be insulated to 'A-60' class integrity.

3.4.2 If the cargo control room is designed to be a gas-safe space, instrumentation should, as far as possible, be by indirect reading systems and should in any case be designed to prevent any escape of gas into the atmosphere of that space. Location of the gas detector within the cargo control room will not violate the gas-safe space if installed in accordance with 13.6.5.

3.4.3 If the cargo control room for ships carrying flammable cargoes is a gas-dangerous space, sources of ignition should be excluded. Consideration should be paid to the safety characteristics of any electrical installations.

### 3.5 Access to spaces in the cargo area

3.5.1 Visual inspection should be possible of at least one side of the inner hull structure without the removal of any fixed structure or fitting. If such a visual inspection, whether combined with those inspections required in 3.5.2, 4.7.7 or 4.10.16 or not, is only possible at the outer face of the inner hull, the inner hull should not be a fuel-oil tank boundary wall.

3.5.2 Inspection of one side of any insulation in hold spaces should be possible. If the integrity of the insulation system can be verified by inspection of the outside of the hold space boundary when tanks are at service temperature, inspection of one side of the insulation in the hold space need not be required.

3.5.3 Arrangements for hold spaces, void spaces and other spaces that could be considered gas-dangerous and cargo tanks should be such as to allow entry and inspection of any such space by personnel wearing protective clothing and breathing apparatus and in the event of injury to allow unconscious personnel to be removed from the space and should comply with the following:

- .1 Access should be provided:
  - .1.1 to cargo tanks direct from the open deck;
  - .1.2 through horizontal openings, hatches or manholes, the dimensions of which should be sufficient to allow a person wearing a breathing apparatus to ascend or descend any ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the space; the minimum clear opening should be not less than 600 mm by 600 mm; and
  - .1.3 through vertical openings, or manholes providing passage through the length and breadth of the space, the minimum clear opening of which should be not less than 600 mm by 800 mm at a height of not more than 600 mm from the bottom plating unless gratings or other footholds are provided.

.2 the dimensions referred to in 3.5.3.1.2 and .1.3 may be decreased if the ability to traverse such openings or to remove an injured person can be proved to the satisfaction of the Administration.

.3 The requirements of 3.5.3.1.2 and .1.3 do not apply to spaces described in 1.3.17.5. Such spaces should be provided only with direct or indirect access from the open weather deck, not including an enclosed gas-safe space.

3.5.4 Access from the open weather deck to gas-safe spaces should be located in a gas-safe zone at least 2.4 m above the weather deck unless the access is by means of an air-lock in accordance with 3.6.

### 3.6 Air-locks

3.6.1 An air-lock should only be permitted between a gas-dangerous zone on the open weather deck and a gas-safe space and should consist of two steel doors substantially gas-tight spaced at least 1.5 m but not more than 2.5 m apart.

3.6.2 The doors should be self-closing and without any holding back arrangements.

3.6.3 An audible and visual alarm system to give a warning on both sides of the air-lock should be provided to indicate if more than one door is moved from the closed position.

3.6.4 In ships carrying flammable products, electrical equipment which is not of the certified safe type in spaces protected by air-locks should be de-energized upon loss of overpressure in the space (see also 10.2.5.4). Electrical equipment which is not of the certified safe type for manoeuvring, anchoring and mooring equipment as well as the emergency fire pumps should not be located in spaces to be protected by air-locks.

3.6.5 The air-lock space should be mechanically ventilated from a gas-safe space and maintained at an overpressure to the gas-dangerous zone on the open weather deck.

3.6.6 The air-lock space should be monitored for cargo vapour.

3.6.7 Subject to the requirements of the International Convention on Load Lines in force, the door sill should not be less than 300 mm in height.

### 3.7 Bilge, ballast and fuel oil arrangements

3.7.1.1 Where cargo is carried in a cargo containment system not requiring a secondary barrier, hold spaces should be provided with suitable drainage arrangements not connected with the machinery space. Means of detecting any leakage should be provided.

3.7.1.2 Where there is a secondary barrier, suitable drainage arrangements for dealing with any leakage into the hold or insulation spaces through adjacent ship structure should be provided. The suction should not be led to pumps inside the machinery space. Means of detecting such leakage should be provided.

3.7.2 The interbarrier space should be provided with a drainage system suitable for handling liquid cargo in the event of cargo tank leakage or rupture. Such arrangements should provide for the return of leakage to the cargo tanks.

3.7.3 In case of internal insulation tanks, means of detecting leakage and drainage arrangements are not required for interbarrier spaces and spaces between the secondary barrier and the inner hull or independent tank structure which are completely filled by insulation material complying with 4.9.7.2.

3.7.4 Ballast spaces, fuel oil tanks and gas-safe spaces may be connected to pumps in the machinery spaces. Duct keels may be connected to pumps in the machinery spaces, provided the connections are led directly to the pumps and the discharge from the pumps led 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. Pump vents should not be open to machinery spaces.

3.8 Bow or stern loading and unloading arrangements

3.8.1 Subject to the approval of the Administration and to the requirements of this section, cargo piping may be arranged to permit bow or stern loading and unloading.

3.8.1.1 Bow or stern loading and unloading lines which are led past accommodation spaces, service spaces or control stations should not be used for the transfer of products requiring a type IG ship. Bow or stern loading and unloading lines should not be used for the transfer of toxic products as specified in 1.3.38 unless specifically approved by the Administration.

3.8.2 Portable arrangements should not be permitted.

3.8.3 In addition to the requirements of chapter 5 the following provisions apply to cargo piping and related piping equipment:

- .1 Cargo piping and related piping equipment outside the cargo area should have only welded connections. The piping outside the cargo area should run on the open deck and should be at least 760 mm inboard except for thwartships shore connection piping. Such piping should be clearly identified and fitted with a shutoff valve at its connection to the cargo piping system within the cargo area. At this location, it should also be capable of being separated by means of a removable spool piece and blank flanges when not in use.

.2 The piping is to be full penetration butt welded, and fully radiographed regardless of pipe diameter and design temperature. Flange connections in the piping are only permitted within the cargo area and at the shore connection.

.3 Arrangements should be made to allow such piping to be purged and gas-freed after use. When not in use, the spool pieces should be removed and the pipe ends be blank-flanged. The vent pipes connected with the purge should be located in the cargo area.

3.8.4 Entrances, air inlets and openings to accommodation spaces, service spaces, machinery spaces and control stations should not face the cargo shore connection location of bow or stern loading and unloading arrangements. They should be located on the outboard side of the superstructure or deckhouse at a distance of at least 4% of the length of the ship but not less than 3 m from the end of the house facing the cargo shore connection location of the bow or stern loading and unloading arrangements. This distance, however, need not exceed 5 m. Side-scuttles facing the shore connection location and on the sides of the superstructure or deckhouse within the distance mentioned above should be of the fixed (non-opening) type. In addition, during the use of the bow or stern loading and unloading arrangements, all doors, ports and other openings on the corresponding superstructure or deckhouse side should be kept closed. Where, in the case of small ships, compliance with 3.2.4 and this paragraph is not possible, the Administration may approve relaxations from the above requirements.

3.8.5 Deck openings and air inlets to spaces within distances of 10 m from the cargo shore connection location should be kept closed during the use of bow or stern loading or unloading arrangements.

3.8.6 Electrical equipment within a zone of 3 m from the cargo shore connection location should be in accordance with chapter 10.

3.8.7 Fire-fighting arrangements for the bow or stern loading and unloading areas should be in accordance with 11.3.1.3 and 11.4.7.

3.8.8 Means of communication between the cargo control station and the shore connection location should be provided and if necessary certified safe.

## CHAPTER 4 - CARGO CONTAINMENT

4.1 General

4.1.1 Administrations should take appropriate steps to ensure uniformity in the implementation and application of the provisions of this chapter\*.

4.1.2 In addition to the definitions in 1.3, the definitions given in this chapter apply throughout the Code.

4.2 Definitions4.2.1 Integral tanks

4.2.1.1 Integral tanks form a structural part of the ship's hull and are influenced in the same manner and by the same loads which stress the adjacent hull structure.

4.2.1.2 The design vapour pressure  $P_o$  as defined in 4.2.6 should not normally exceed 0.25 bar. If, however, the hull scantlings are increased accordingly,  $P_o$  may be increased to a higher value but less than 0.7 bar.

4.2.1.3 Integral tanks may be used for products provided the boiling point of the cargo is not below  $-10^{\circ}\text{C}$ . A lower temperature may be accepted by the Administration subject to special consideration.

4.2.2 Membrane tanks

4.2.2.1 Membrane tanks are non-self-supporting tanks which consist of a thin layer (membrane) supported through insulation by the adjacent hull structure. The membrane is designed in such a way that thermal and other expansion or contraction is compensated for without undue stressing of the membrane.

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\* Reference is made to the published Rules of members and associate members of the International Association of Classification Societies and in particular to IACS Unified Requirements Nos. G1 and G2.



4.2.2.2 The design vapour pressure  $P_o$  should not normally exceed 0.25 bar. If, however, the hull scantlings are increased accordingly and consideration is given, where appropriate, to the strength of the supporting insulation,  $P_o$  may be increased to a higher value but less than 0.7 bar.

4.2.2.3 The definition of membrane tanks does not exclude designs such as those in which non-metallic membranes are used or in which membranes are included or incorporated in insulation. Such designs require, however, special consideration by the Administration. In any case the thickness of the membranes should normally not exceed 10 mm.

#### 4.2.3 Semi-membrane tanks

4.2.3.1 Semi-membrane tanks are non-self-supporting tanks in the loaded condition and consist of a layer, parts of which are supported through insulation by the adjacent hull structure, whereas the rounded parts of this layer connecting the above-mentioned supported parts are designed also to accommodate the thermal and other expansion or contraction.

4.2.3.2 The design vapour pressure  $P_o$  should not normally exceed 0.25 bar. If, however, the hull scantlings are increased accordingly, and consideration is given, where appropriate, to the strength of the supporting insulation,  $P_o$  may be increased to a higher value but less than 0.7 bar.

#### 4.2.4 Independent tanks

4.2.4.1 Independent tanks are self-supporting; they do not form part of the ship's hull and are not essential to the hull strength. There are three categories of independent tanks referred to in 4.2.4.2 to 4.2.4.4.

4.2.4.2 Type A independent tanks are tanks which are designed primarily using Recognized Standards\* of classical ship-structural analysis procedures. Where such tanks are primarily constructed of plane surfaces

\* Recognized Standards for the purpose of chapters 4, 5 and 6 are standards laid down and maintained by a classification society recognized by the Administration.

(gravity tanks), the design vapour pressure  $P_o$  should be less than 0.7 bar.

4.2.4.3 Type B independent tanks are tanks which are designed using model tests, refined analytical tools and analysis methods to determine stress levels, fatigue life and crack propagation characteristics. Where such tanks are primarily constructed of plane surfaces (gravity tanks) the design vapour pressure  $P_o$  should be less than 0.7 bar.

4.2.4.4 Type C independent tanks (also referred to as pressure vessels) are tanks meeting pressure vessel criteria and having a design vapour pressure not less than:

$$P_o = 2 + AC(\rho_r)^{1.5} \quad (\text{bar})$$

where:

$$A = 0.0185 \left( \frac{\sigma_m}{\Delta \sigma_A} \right)^2$$

with

$\sigma_m$  = design primary membrane stress

$\Delta \sigma_A$  = allowable dynamic membrane stress (double amplitude at probability level  $Q = 10^{-8}$ )  
55 N/mm<sup>2</sup> for ferritic/martensitic steel  
25 N/mm<sup>2</sup> for aluminium alloy (5083-0)

C = a characteristic tank dimension to be taken as the greatest of the following:

h; 0.75b; or 0.45ℓ

with

h = height of tank (dimension in ship's vertical direction) (m)

b = width of tank (dimension in ship's transverse direction) (m)

ℓ = length of tank (dimension in ship's longitudinal direction) (m)

$\rho_r$  = the relative density of the cargo ( $\rho_r = 1$  for fresh water) at the design temperature.

However, the Administration may allocate a tank complying with the criterion of this subparagraph to type A or type B, dependent on the configuration of the tank and the arrangement of its supports and attachments.

#### 4.2.5 Internal insulation tanks

4.2.5.1 Internal insulation tanks are non-self-supporting and consist of thermal insulation materials which contribute to the cargo containment and are supported by the structure of the adjacent inner hull or of an independent tank. The inner surface of the insulation is exposed to the cargo.

4.2.5.2 The two categories of internal insulation tanks are:

- .1 Type 1 tanks which are tanks in which the insulation or a combination of the insulation and one or more liners functions only as the primary barrier. The inner hull or an independent tank structure should function as the secondary barrier when required.
- .2 Type 2 tanks which are tanks in which the insulation or a combination of the insulation and one or more liners functions as both the primary and the secondary barrier and where these barriers are clearly distinguishable.

The term "liner" means a thin, non-self-supporting, metallic, nonmetallic or composite material which forms part of an internal insulation tank in order to enhance its fracture resistance or other mechanical properties. A liner differs from a membrane in that it is not intended to function alone as a liquid barrier.

4.2.5.3 Internal insulation tanks should be of suitable materials enabling the cargo containment system to be designed using model tests and refined analytical methods as required in 4.4.7.

4.2.5.4 The design vapour pressure  $P_o$  should not normally exceed 0.25 bar. If, however, the cargo containment system is designed for a higher vapour pressure,  $P_o$  may be increased to such higher value, but not exceeding 0.7 bar if the internal insulation tanks are supported by the inner hull structure. However, a design vapour pressure of more than 0.7 bar may be accepted by the Administration provided the internal insulation tanks are supported by suitable independent tank structures.

#### 4.2.6 Design vapour pressure

4.2.6.1 The design vapour pressure  $P_o$  is the maximum gauge pressure at the top of the tank which has been used in the design of the tank.

4.2.6.2 For cargo tanks where there is no temperature control and where the pressure of the cargo is dictated only by the ambient temperature,  $P_o$  should not be less than the gauge vapour pressure of the cargo at a temperature of 45°C. However, lesser values of this temperature may be accepted by the Administration for ships operating in restricted areas or on voyages of restricted duration and account may be taken in such cases of any insulation of the tanks. Conversely, higher values of this temperature may be required for ships permanently operating in areas of high ambient temperature.

4.2.6.3 In all cases, including 4.2.6.2,  $P_o$  should not be less than MARVS.

4.2.6.4 Subject to special consideration by the Administration and to the limitations given in 4.2.1 to 4.2.5 for the various tank types, a vapour pressure higher than  $P_o$  may be accepted in harbour conditions, where dynamic loads are reduced.

#### 4.2.7 Design temperature

The design temperature for selection of materials is the minimum temperature at which cargo may be loaded or transported in the cargo tanks. Provision to the satisfaction of the Administration should be made to ensure that the tank or cargo temperature cannot be lowered below the design temperature.

### 4.3 Design loads

#### 4.3.1 General

4.3.1.1 Tanks together with their supports and other fixtures should be designed taking into account proper combinations of the following loads:

internal pressure

external pressure

dynamic loads due to the motions of the ship

thermal loads  
sloshing loads  
loads corresponding to ship deflection  
tank and cargo weight with the corresponding reactions in way  
of supports  
insulation weight  
loads in way of towers and other attachments.

The extent to which these loads should be considered depends on the type of tank, and is more fully detailed in the following paragraphs.

4.3.1.2 Account should be taken of the loads corresponding to the pressure test referred to in 4.10.

4.3.1.3 Account should be taken of an increase of vapour pressure in harbour conditions referred to in 4.2.6.4.

4.3.1.4 The tanks should be designed for the most unfavourable static heel angle within the range  $0^{\circ}$  to  $30^{\circ}$  without exceeding allowable stresses given in 4.5.1.

#### 4.3.2 Internal pressure.

4.3.2.1 The internal pressure head  $h_{eq}$  in bars gauge resulting from the design vapour pressure  $P_o$  and the liquid pressure  $h_{gd}$  defined in 4.3.2.2, but not including effects of liquid sloshing, should be calculated as follows:

$$h_{eq} = P_o + (h_{gd})_{max} \quad (\text{bar})$$

Equivalent calculation procedures may be applied.

4.3.2.2 The internal liquid pressures are those created by the resulting acceleration of the centre of gravity of the cargo due to the motions of the ship referred to in 4.3.4.1. The value of internal pressure head  $h_{gd}$  resulting from combined effects of gravity and dynamic accelerations should be calculated as follows:

$$h_{gd} = a\beta Z\beta \frac{\rho}{1.02 \times 10^4} \quad (\text{bar})$$

where:

$a_{\beta}$  = dimensionless acceleration (i.e. relative to the acceleration of gravity), resulting from gravitational and dynamic loads, in an arbitrary direction  $\beta$  (see figure 4.1).

$Z_{\beta}$  = largest liquid height (m) above the point where the pressure is to be determined measured from the tank shell in the  $\beta$  direction (see figure 4.2). Small tank domes not considered to be part of the accepted total volume of the cargo tank need not be considered when determining  $Z_{\beta}$ .

$\rho$  = maximum cargo density ( $\text{kg/m}^3$ ) at the design temperature.

The direction which gives the maximum value  $(h_{gd})_{\max}$  of  $h_{gd}$  should be considered. Where acceleration in three directions needs to be considered, an ellipsoid should be used instead of the ellipse in figure 4.1. The above formula applies only to full tanks.

#### 4.3.3 External pressure.

External design pressure loads should be based on the difference between the minimum internal pressure (maximum vacuum) and the maximum external pressure to which any portion of the tank may be subjected simultaneously.

#### 4.3.4 Dynamic loads due to ship motions.

4.3.4.1 The determination of dynamic loads should take account of the long-term distribution of ship motions, including the effects of surge, sway, heave, roll, pitch and yaw on irregular seas which the ship will experience during its operating life (normally taken to correspond to  $10^8$  wave encounters). Account may be taken of reduction in dynamic loads due to necessary speed reduction and variation of heading when this consideration has also formed part of the hull strength assessment.

4.3.4.2 For design against plastic deformation and buckling the dynamic loads should be taken as the most probable largest loads the ship will encounter during its operating life (normally taken to correspond to a probability level of  $10^{-8}$ ). Guidance formulae for acceleration components are given in 4.12.

4.3.4.3 When design against fatigue is to be considered, the dynamic spectrum should be determined by long-term distribution calculation based on the operating life of the ship (normally taken to correspond to  $10^8$  wave encounters). If simplified dynamic loading spectra are used for the estimation of the fatigue life, those should be specially considered by the Administration.

4.3.4.4 For practical application of crack propagation estimates, simplified load distribution over a period of 15 days may be used. Such distributions may be obtained as indicated in figure 4.3.

4.3.4.5 Ships for restricted service may be given special consideration.

4.3.4.6 The accelerations acting on tanks are estimated at their centre of gravity and include the following components:

vertical acceleration:	motion accelerations of heave, pitch and, possibly, roll (normal to the ship base);
transverse acceleration:	motion accelerations of sway, yaw and roll; and gravity component of roll;
longitudinal acceleration:	motion accelerations of surge and pitch; and gravity component of pitch.

#### 4.3.5 Sloshing loads.

4.3.5.1 When partial filling is contemplated, the risk of significant loads due to sloshing induced by any of the ship motions referred to in 4.3.4.6 should be considered.

4.3.5.2 When risk of significant sloshing-induced loads is found to be present, special tests and calculations should be required.

#### 4.3.6 Thermal loads.

4.3.6.1 Transient thermal loads during cooling down periods should be considered for tanks intended for cargo temperatures below  $-55^{\circ}\text{C}$ .

4.3.6.2 Stationary thermal loads should be considered for tanks where design supporting arrangement and operating temperature may give rise to significant thermal stresses.

#### 4.3.7 Loads on supports.

The loads on supports are covered by 4.6.

#### 4.4 Structural analyses

##### 4.4.1 Integral tanks.

The structural analysis of integral tanks should be in accordance with Recognized Standards. The tank boundary scantlings should meet at least the requirements for deep tanks taking into account the internal pressure as indicated in 4.3.2, but the resulting scantlings should not be less than normally required by such standards.

##### 4.4.2 Membrane tanks.

4.4.2.1 For membrane tanks, the effects of all static and dynamic loads should be considered to determine the suitability of the membrane and of the associated insulation with respect to plastic deformation and fatigue.

4.4.2.2 Before approval is given, a model of both the primary and secondary barriers, including corners and joints, should normally be tested to verify that they will withstand the expected combined strains due to static, dynamic and thermal loads. Test conditions should represent the most extreme service conditions the cargo containment system will see in its life. Material tests should ensure that ageing is not liable to prevent the materials from carrying out their intended function.

4.4.2.3 For the purpose of the test referred to in 4.4.2.2, a complete analysis of the particular motions, accelerations and response of ships and cargo containment systems should be performed, unless these data are available from similar ships.

4.4.2.4 Special attention should be paid to the possible collapse of the membrane due to an overpressure in the interbarrier space, to a possible vacuum in the cargo tank, to the sloshing effects and to hull vibration effects.



4.4.2.5 A structural analysis of the hull should be to the satisfaction of the Administration, taking into account the internal pressure as indicated in 4.3.2. Special attention, however, should be paid to deflections of the hull and their compatibility with the membrane and associated insulation. Inner hull plating thickness should meet at least the requirements of Recognized Standards for deep tanks taking into account the internal pressure as indicated in 4.3.2. The allowable stress for the membrane, membrane-supporting material and insulation should be determined in each particular case.

4.4.3 Semi-membrane tanks.

A structural analysis should be performed in accordance with the requirements for membrane tanks or independent tanks as appropriate, taking into account the internal pressure as indicated in 4.3.2.

4.4.4 Type A independent tanks.

4.4.4.1 A structural analysis should be performed to the satisfaction of the Administration taking into account the internal pressure as indicated in 4.3.2. The cargo tank plating thickness should meet at least the requirements of Recognized Standards for deep tanks taking into account the internal pressure as indicated in 4.3.2 and any corrosion allowance required by 4.5.2.

4.4.4.2 For parts such as structure in way of supports not otherwise covered by Recognized Standards, stresses should be determined by direct calculations, taking into account the loads referred to in 4.3 as far as applicable, and the ship deflection in way of supports.

4.4.5 Type B independent tanks.

For tanks of this type the following applies:

- .1 The effects of all dynamic and static loads should be used to determine the suitability of the structure with respect to:
  - plastic deformation
  - buckling
  - fatigue failure
  - crack propagation.

Statistical wave load analyses in accordance with 4.3.4, finite element analyses or similar methods and fracture mechanics analyses or an equivalent approach, should be carried out.

- .2 A three-dimensional analysis should be carried out to evaluate the stress levels contributed by the ship's hull. The model for this analysis should include the cargo tank with its supporting and keying system as well as a reasonable part of the hull.
- .3 A complete analysis of the particular ship accelerations and motions in irregular waves and of the response of the ship and its cargo tanks to these forces and motions should be performed unless these data are available from similar ships.
- .4 A buckling analysis should consider the maximum construction tolerances.
- .5 Where deemed necessary by the Administration, model tests may be required to determine stress concentration factors and fatigue life of structural elements.
- .6 The cumulative effect of the fatigue load should comply with:

$$\sum \frac{n_i}{N_i} + \frac{10^3}{N_j} \leq C_w$$

where:

- $n_i$  = number of stress cycles at each stress level during the life of the ship
- $N_i$  = number of cycles to fracture for the respective stress level according to the Wöhler (S-N) curve
- $N_j$  = number of cycles to fracture for the fatigue loads due to loading and unloading
- $C_w$  = should be less than or equal to 0.5, except that the Administration may give special consideration to the use of a value greater than 0.5 but not greater than 1.0, dependent on the test procedure and data used to establish the Wöhler (S-N) curve.

4.4.6 Type C independent tanks

4.4.6.1 Scantlings based on internal pressure should be calculated as follows:

- .1 The thickness and form of pressure-containing parts of pressure vessels under internal pressure, including flanges should be determined according to a standard acceptable to the Administration. These calculations in all cases should be based on generally accepted pressure vessel design theory. Openings in pressure-containing parts of pressure vessels should be reinforced in accordance with a standard acceptable to the Administration.
- .2 The design liquid pressure defined in 4.3.2 should be taken into account in the above calculations.
- .3 The welded joint efficiency factor to be used in the calculation according to 4.4.6.1.1 should be 0.95 when the inspection and the non-destructive testing referred to in 4.10.9 are carried out. This figure may be increased up to 1.0 when account is taken of other considerations, such as the material used, type of joints, welding procedure and type of loading. For process pressure vessels the Administration may accept partial non-destructive examinations, but not less than those of 4.10.9.2.2 depending on such factors as the material used, the design temperature, the nil ductility transition temperature of the material as fabricated, the type of joint and welding procedure, but in this case an efficiency factor of not more than 0.85 should be adopted. For special materials, the above-mentioned factors should be reduced depending on the specified mechanical properties of the welded joint.

4.4.6.2 Buckling criteria should be as follows:

- .1 The thickness and form of pressure vessels subject to external pressure and other loads causing compressive stresses should be to a standard acceptable to the Administration. These calculations in all cases should be based on generally accepted pressure vessel buckling theory and should adequately account for the difference in theoretical and actual buckling stress as a result of plate edge misalignment, ovality and deviation from true circular form over a specified arc or chord length.
- .2 The design external pressure  $P_e$  used for verifying the buckling of the pressure vessels should not be less than that given by:

$$P_e = P_1 + P_2 + P_3 + P_4 \quad (\text{bar})$$

where:

- $P_1$  = setting value of vacuum relief valves. For vessels not fitted with vacuum relief valves  $P_1$  should be specially considered, but should not in general be taken as less than 0.25 bar.
- $P_2$  = the set pressure of the pressure relief valves for completely closed spaces containing pressure vessels or parts of pressure vessels; elsewhere  $P_2 = 0$ .
- $P_3$  = compressive actions in the shell due to the weight and contraction of insulation, weight of shell, including corrosion allowance, and other miscellaneous external pressure loads to which the pressure vessel may be subjected. These include, but are not limited to, weight of domes, weight of towers and piping, effect of product in the partially filled condition, accelerations and hull deflection. In addition the local effect of external or internal pressure or both should be taken into account.
- $P_4$  = external pressure due to head of water for pressure vessels or part of pressure vessels on exposed decks; elsewhere  $P_4 = 0$ .

4.4.6.3 Stress analysis in respect of static and dynamic loads should be performed as follows:

- .1 Pressure vessel scantlings should be determined in accordance with 4.4.6.1 and .2.

.2 Calculations of the loads and stresses in way of the supports and the shell attachment of the support should be made. Loads referred to in 4.3 should be used, as applicable. Stresses in way of the supports should be to a standard acceptable to the Administration. In special cases a fatigue analysis may be required by the Administration.

.3 If required by the Administration, secondary stresses and thermal stresses should be specially considered.

4.4.6.4 For pressure vessels, the thickness calculated according to 4.4.6.1 or the thickness required by 4.4.6.2 plus the corrosion allowance, if any, should be considered as a minimum without any negative tolerance.

4.4.6.5 For pressure vessels, the minimum thickness of shell and heads including corrosion allowance, after forming, should not be less than 5 mm for carbon-manganese steels and nickel steels, 3 mm for austenitic steels or 7 mm for aluminium alloys.

4.4.7 Internal insulation tanks.

4.4.7.1 The effects of all static and dynamic loads should be considered to determine the suitability of the tank with respect to:

fatigue failure  
crack propagation from both free and supported surfaces  
adhesive and cohesive strength  
compressive, tensile and shear strength.

Statistical wave load analysis in accordance with 4.3.4, finite element analysis or similar methods and fracture mechanics analysis or an equivalent approach should be carried out.

4.4.7.2.1 Special attention should be given to crack resistance and to deflections of the inner hull or independent tank structure and their compatibility with the insulation materials. A three-dimensional structural analysis should be carried out to the satisfaction of the Administration. This analysis is to evaluate the stress levels and deformations contributed either by the inner hull or by the independent tank structure or both and should also take into account the internal pressure as indicated in 4.3.2. Where water ballast spaces are adjacent to the inner hull forming the supporting structure of the internal insulation tank, the analysis should take account of the dynamic loads caused by water ballast under the influence of ship motions.

4.4.7.2.2 The allowable stresses and associated deflections for the internal insulation tank and the inner hull structure or independent tank structure should be determined in each particular case.

4.4.7.2.3 Thicknesses of plating of the inner hull or of an independent tank should at least comply with the requirements of Recognized Standards, taking into account the internal pressure as indicated in 4.3.2. Tanks constructed of plane surfaces should at least comply with Recognized Standards for deep tanks.

4.4.7.3 A complete analysis of the response of ship, cargo and any ballast to accelerations and motions in irregular waves of the particular ship should be performed to the satisfaction of the Administration unless such analysis is available for a similar ship.

4.4.7.4.1 In order to confirm the design principles, prototype testing of composite models including structural elements should be carried out under combined effects of static, dynamic and thermal loads.

4.4.7.4.2 Test conditions should represent the most extreme service conditions the cargo containment system will be exposed to during the lifetime of the ship, including thermal cycles. For this purpose, 400 thermal cycles are considered to be a minimum, based upon 19 round voyages per year; where more than 19 round voyages per year are expected, a higher number of thermal cycles will be required. These 400 thermal cycles may be divided into 20 full cycles (cargo temperature to 45°C) and 380 partial cycles (cargo temperature to that temperature expected to be reached in the ballast voyage).

4.4.7.4.3 Models should be representative of the actual construction including corners, joints, pump mounts, piping penetrations and other critical areas, and should take into account variations in any material properties, workmanship and quality control.

4.4.7.4.4 Combined tension and fatigue tests should be carried out to evaluate crack behaviour of the insulation material in the case where a through crack develops in the inner hull or independent tank structure. In these tests, where applicable the crack area should be subjected to the maximum hydrostatic pressure of the ballast water.

4.4.7.5 The effects of fatigue loading should be determined in accordance with 4.4.5.6 or by an equivalent method.

4.4.7.6 For internal insulation tanks, repair procedures should be developed during the prototype testing programme for both the insulation material and the inner hull or the independent tank structure.

#### 4.5 Allowable stresses and corrosion allowances

##### 4.5.1 Allowable stresses

4.5.1.1 For integral tanks, allowable stresses should normally be those given for hull structure in Recognized Standards.

4.5.1.2 For membrane tanks, reference is made to the requirements of 4.4.2.5.

4.5.1.3 For type A independent tanks primarily constructed of plane surfaces, the stresses for primary and secondary members (stiffeners, web frames, stringers, girders) when calculated by classical analysis procedures should not exceed the lower of  $R_m/2.66$  or  $R_e/1.33$  for carbon-manganese steels and aluminium alloys, where  $R_m$  and  $R_e$  are defined in 4.5.1.7. However, if detailed calculations are carried out for the primary members, the equivalent stress  $\sigma_C$  as defined in 4.5.1.8 may be increased over that indicated above to a stress acceptable to the Administration; calculations should take into account the effects of bending, shear, axial and torsional deformation as well as the hull/cargo tank interaction forces due to the deflection of the double bottom and cargo tank bottoms.

4.5.1.4 For type B independent tanks, primarily constructed of bodies of revolution, the allowable stresses should not exceed:

$$\begin{aligned}\sigma_m &\leq f \\ \sigma_L &\leq 1.5 f \\ \sigma_b &\leq 1.5 F \\ \sigma_L + \sigma_b &\leq 1.5 F \\ \sigma_m + \sigma_b &\leq 1.5 F\end{aligned}$$

where

$\sigma_m$  = equivalent primary general membrane stress

$\sigma_L$  = equivalent primary local membrane stress

$\sigma_b$  = equivalent primary bending stress

$f$  = the lesser of  $\frac{R_m}{A}$  or  $\frac{R_e}{B}$

$F$  = the lesser of  $\frac{R_m}{C}$  or  $\frac{R_e}{D}$

with  $R_m$  and  $R_e$  as defined in 4.5.1.7. With regard to the stresses  $\sigma_m$ ,  $\sigma_L$  and  $\sigma_b$  see also the definition of stress categories in 4.13. The values of A, B, C and D should be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk and should have at least the following minimum values:

	Nickel steels and carbon-manganese steels	Austenitic steels	Aluminium alloys
A	3	3.5	4
B	2	1.6	1.5
C	3	3	3
D	1.5	1.5	1.5

4.5.1.5 For type B independent tanks, primarily constructed of plane surfaces, the Administration may require compliance with additional or other stress criteria.



4.5.1.6 For type C independent tanks the maximum allowable membrane stress to be used in calculation according to 4.4.6.1.1 should be the lower of:

$$\frac{R_m}{A} \text{ or } \frac{R_e}{B}$$

where:

$R_m$  and  $R_e$  are as defined in 4.5.1.7.

The values of A and B should be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk provided for in 1.5, and should have at least the minimum values indicated in the table of 4.5.1.4.

4.5.1.7 For the purpose of 4.5.1.3, 4.5.1.4 and 4.5.1.6 the following apply:

- .1  $R_e$  = specified minimum yield stress at room temperature (N/mm<sup>2</sup>). If the stress-strain curve does not show a defined yield stress, the 0.2% proof stress applies.
- $R_m$  = specified minimum tensile strength at room temperature (N/mm<sup>2</sup>).

For welded connections in aluminium alloys the respective values of  $R_e$  or  $R_m$  in annealed conditions should be used.

- .2 The above properties should correspond to the minimum specified mechanical properties of the material, including the weld metal in the as-fabricated condition. Subject to special consideration by the Administration, account may be taken of enhanced yield stress and tensile strength at low temperature. The temperature on which the material properties are based should be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk provided for in 1.5.

4.5.1.8 The equivalent stress  $\sigma_C$  (von Mises, Huber) should be determined by:

$$\sigma_C = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3\tau_{xy}^2}$$

where:

$\sigma_x$  = total normal stress in x-direction  
 $\sigma_y$  = total normal stress in y-direction  
 $\tau_{xy}$  = total shear stress in x-y plane.

4.5.1.9 When the static and dynamic stresses are calculated separately and unless other methods of calculation are justified, the total stresses should be calculated according to:

$$\sigma_x = \sigma_{x.st} \pm \sqrt{\sum (\sigma_{x.dyn})^2}$$

$$\sigma_y = \sigma_{y.st} \pm \sqrt{\sum (\sigma_{y.dyn})^2}$$

$$\tau_{xy} = \tau_{xy.st} \pm \sqrt{\sum (\tau_{xy.dyn})^2}$$

where:

$\sigma_{x.st}$ ,  $\sigma_{y.st}$  and  $\tau_{xy.st}$  = static stresses  
 $\sigma_{x.dyn}$ ,  $\sigma_{y.dyn}$  and  $\tau_{xy.dyn}$  = dynamic stresses  
 all determined separately from acceleration components and hull strain components due to deflection and torsion.

4.5.1.10 For internal insulation tanks, reference is made to the requirement of 4.4.7.2.

4.5.1.11 Allowable stresses for materials other than those covered by chapter 6 should be subject to approval by the Administration in each case.

4.5.1.12 Stresses may be further limited by fatigue analysis, crack propagation analysis and buckling criteria.

#### 4.5.2 Corrosion allowances

4.5.2.1 No corrosion allowance should generally be required in addition to the thickness resulting from the structural analysis. However, where there is no environmental control around the cargo tank, such as inerting, or where the cargo is of a corrosive nature, the Administration may require a suitable corrosion allowance.

4.5.2.2 For pressure vessels no corrosion allowance is generally required if the contents of the pressure vessel are non-corrosive and the external surface is protected by inert atmosphere or by an appropriate insulation with an approved vapour barrier. Paint or other thin coatings should not be credited as protection. Where special alloys are used with acceptable corrosion resistance, no corrosion allowance should be required. If the above conditions are not satisfied, the scantlings calculated according to 4.4.6 should be increased as appropriate.

#### 4.6 Supports

4.6.1 Cargo tanks should be supported by the hull in a manner which will prevent bodily movement of the tank under static and dynamic loads while allowing contraction and expansion of the tank under temperature variations and hull deflections without undue stressing of the tank and of the hull.

4.6.2 The tanks with supports should also be designed for a static angle of heel of  $30^{\circ}$  without exceeding allowable stresses given in 4.5.1.

4.6.3 The supports should be calculated for the most probable largest resulting acceleration, taking into account rotational as well as translational effects. This acceleration in a given direction may be determined as shown in figure 4.1. The half axes of the "acceleration ellipse" should be determined according to 4.3.4.2.

4.6.4 Suitable supports should be provided to withstand a collision force acting on the tank corresponding to one half the weight of the tank and cargo in the forward direction and one quarter the weight of the tank and cargo in the aft direction without deformation likely to endanger the tank structure.

4.6.5 The loads mentioned in 4.6.2 and 4.6.4 need not be combined with each other or with wave-induced loads.

4.6.6 For independent tanks and, where appropriate, for membrane and semi-membrane tanks, provision should be made to key the tanks against the rotational effects referred to in 4.6.3.

4.6.7 Antiflotation arrangements should be provided for independent tanks. The antiflotation arrangements should be suitable to withstand an upward force caused by an empty tank in a hold space flooded to the summer load draught of the ship, without plastic deformation likely to endanger the hull structure.

#### 4.7 Secondary barrier

4.7.1 Where the cargo temperature at atmospheric pressure is below  $-10^{\circ}\text{C}$ , a secondary barrier should be provided when required by 4.7.3 to act as a temporary containment for any envisaged leakage of liquid cargo through the primary barrier.

4.7.2 Where the cargo temperature at atmospheric pressure is not below  $-55^{\circ}\text{C}$ , the hull structure may act as a secondary barrier. In such a case:

- .1 the hull material should be suitable for the cargo temperature at atmospheric pressure as required by 4.9.2; and
- .2 the design should be such that this temperature will not result in unacceptable hull stresses.

4.7.3 Secondary barriers in relation to tank types should normally be provided in accordance with the following table. For tanks which differ from the basic tank types as defined in 4.2 the secondary barrier requirements should be decided by the Administration in each case.

Cargo temperature at atmospheric pressure	-10°C and above	Below -10°C down to -55°C	Below -55°C
Basic tank type	No secondary barrier required	Hull may act as secondary barrier	Separate secondary barrier where required
Integral Membrano		Tank type not normally allowed <sup>1/</sup>	
Semi-membrane		Complete secondary barrier	
Independent		Complete secondary barrier <sup>2/</sup>	
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	

<sup>1/</sup> A complete secondary barrier should normally be required if cargoes with a temperature at atmospheric pressure below -10°C are permitted in accordance with 4.2.1.3.

<sup>2/</sup> In the case of semi-membrane tanks which comply in all respects with the requirements applicable to type B independent tanks, except for the manner of support, the Administration may, after special consideration, accept a partial secondary barrier.

4.7.4 The secondary barrier should be so designed that:

- .1 it is capable of containing any envisaged leakage of liquid cargo for a period of 15 days, unless different requirements apply for particular voyages, taking into account the load spectrum referred to in 4.3.4.4;
- .2 it will prevent lowering of the temperature of the ship structure to an unsafe level in the case of leakage of the primary barrier as indicated in 4.8.2; and
- .3 the mechanism of failure for the primary barrier does not also cause the failure of the secondary barrier and vice versa.

4.7.5 The secondary barrier should fulfil its functions at a static angle of heel of 30°.

4.7.6.1 Where a partial secondary barrier is required, its extent should be determined on the basis of cargo leakage corresponding to the extent of failure resulting from the load spectrum referred to in 4.3.4.4 after the initial detection of a primary leak. Due account may be taken of liquid evaporation, rate of leakage, pumping capacity and other relevant factors. In all cases, however, the inner bottom in way of cargo tanks should be protected against liquid cargo.

4.7.6.2 Clear of the partial secondary barrier, provision such as a spray shield should be made to deflect any liquid cargo down into the space between the primary and secondary barriers and to keep the temperature of the hull structure to a safe level.

4.7.7 The secondary barrier should be capable of being periodically checked for its effectiveness, by means of a pressure/vacuum test, a visual inspection or another suitable method acceptable to the Administration. The method should be submitted to the Administration for approval.

#### 4.8 Insulation

4.8.1 Where a product is carried at a temperature below  $-10^{\circ}\text{C}$  suitable insulation should be provided to ensure that the temperature of the hull structure does not fall below the minimum allowable service temperature given in chapter 6 for the grade of steel concerned, as detailed in 4.9, when the cargo tanks are at their design temperature and the ambient temperatures are  $5^{\circ}\text{C}$  for air and  $0^{\circ}\text{C}$  for seawater. These conditions may generally be used for world-wide service. However, higher values of the ambient temperatures may be accepted by the Administration for ships operated in restricted areas. Conversely, lesser values of the ambient temperatures may be fixed by the Administration for ships trading occasionally or regularly to areas in latitudes where such lower temperatures are expected during the winter months. The ambient temperatures used in the design should be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk as provided for in 1.5.

4.8.2 Where a complete or partial secondary barrier is required, calculations should be made with the assumptions in 4.8.1 to check that the temperature of the hull structure does not fall below the minimum allowable service temperature given in chapter 6 for the grade of steel concerned, as detailed in 4.9. The complete or partial secondary barrier should be assumed to be at the cargo temperature at atmospheric pressure.

4.8.3 Calculations required by 4.8.1 and 4.8.2 should be made assuming still air and still water, and except as permitted by 4.8.4, no credit should be given for means of heating. In the case referred to in 4.8.2, the cooling effect of the rising boil-off vapour from the leaked cargo should be considered in the heat transmission studies. For members connecting inner and outer hulls, the mean temperature may be taken for determining the steel grade.

4.8.4 In all cases referred to in 4.8.1 and 4.8.2 and for ambient temperature conditions of 5°C for air and 0°C for seawater, approved means of heating transverse hull structural material may be used to ensure that the temperatures of this material do not fall below the minimum allowable values. If lower ambient temperatures are specified, approved means of heating may also be used for longitudinal hull structural material, provided this material remains suitable for the temperature conditions of 5°C for air and 0°C for seawater without heating. Such means of heating should comply with the following requirements:

- .1 sufficient heat should be available to maintain the hull structure above the minimum allowable temperature in the conditions referred to in 4.8.1 and 4.8.2;
- .2 the heating system should be so arranged that, in the event of a failure in any part of the system, stand-by heating could be maintained equal to not less than 100% of the theoretical heat load;
- .3 the heating system should be considered as an essential auxiliary; and
- .4 the design and construction of the heating system should be to the satisfaction of the Administration.

4.8.5 In determining the insulation thickness, due regard should be paid to the amount of acceptable boil-off in association with the reliquefaction plant on board, main propulsion machinery or other temperature control system.

#### 4.9 Materials

4.9.1 The shell and deck plating of the ship and all stiffeners attached thereto should be in accordance with Recognized Standards, unless the calculated temperature of the material in the design condition is below  $-5^{\circ}\text{C}$  due to the effect of the low temperature cargo, in which case the material should be in accordance with table 6.5 assuming the ambient sea and air temperature of  $0^{\circ}\text{C}$  and  $5^{\circ}\text{C}$  respectively. In the design condition, the complete or partial secondary barrier should be assumed to be at the cargo temperature at atmospheric pressure and for tanks without secondary barriers, the primary barrier should be assumed to be at the cargo temperature.

4.9.2 Hull material forming the secondary barrier should be in accordance with table 6.2. Metallic materials used in secondary barriers not forming part of the hull structure should be in accordance with table 6.2 or 6.3 as applicable. Insulation materials forming a secondary barrier should comply with the requirements of 4.9.7. Where the secondary barrier is formed by the deck or side shell plating, the material grade required by table 6.2 should be carried into the adjacent deck or side shell plating, where applicable, to a suitable extent.

4.9.3 Materials used in the construction of cargo tanks should be in accordance with table 6.1, 6.2 or 6.3.



4.9.4 Materials other than those referred to in 4.9.1, 4.9.2 and 4.9.3 used in the construction of the ship which are subject to reduced temperature due to the cargo and which do not form part of the secondary barrier should be in accordance with table 6.5 for temperatures as determined by 4.8. This includes inner bottom plating, longitudinal bulkhead plating, transverse bulkhead plating, floors, webs, stringers and all attached stiffening members.

4.9.5 The insulation materials should be suitable for loads which may be imposed on them by the adjacent structure.

4.9.6 Where applicable, due to location or environmental conditions, insulation materials should have suitable properties of resistance to fire and flame spread and should be adequately protected against penetration of water vapour and mechanical damage.

4.9.7.1 Materials used for thermal insulation should be tested for the following properties as applicable, to ensure that they are adequate for the intended service:

- .1 compatibility with the cargo
- .2 solubility in the cargo
- .3 absorption of the cargo
- .4 shrinkage
- .5 ageing
- .6 closed cell content
- .7 density
- .8 mechanical properties
- .9 thermal expansion
- .10 abrasion
- .11 cohesion
- .12 thermal conductivity
- .13 resistance to vibrations
- .14 resistance to fire and flame spread.

4.9.7.2 In addition to meeting the above requirements, insulation materials which form part of the cargo containment as defined in 4.2.5 should be tested for the following properties after simulation of ageing and thermal cycling to ensure that they are adequate for the intended service:

- .1 bonding (adhesive and cohesive strength)
- .2 resistance to cargo pressure
- .3 fatigue and crack propagation properties
- .4 compatibility with cargo constituents and any other agent expected to be in contact with the insulation in normal service
- .5 where applicable the influence of presence of water and water pressure on the insulation properties should be taken into account
- .6 gas de-absorbing.

4.9.7.3 The above properties, where applicable, should be tested for the range between the expected maximum temperature in service and 5°C below the minimum design temperature, but not lower than -196°C.

4.9.8 The procedure for fabrication, storage, handling, erection, quality control and control against harmful exposure to sunlight of insulation materials should be to the satisfaction of the Administration.

4.9.9 Where powder or granulated insulation is used, the arrangements should be such as to prevent compacting of the material due to vibrations. The design should incorporate means to ensure that the material remains sufficiently buoyant to maintain the required thermal conductivity and also prevent any undue increase of pressure on the containment system.

#### 4.10 Construction and testing

4.10.1.1 All welded joints of the shells of independent tanks should be of the butt weld, full penetration type. For dome-to-shell connections, the Administration may approve tee welds of the full penetration type. Except for small penetrations on domes, nozzle welds are also generally to be designed with full penetration.

4.10.1.2 Welding joint details for type C independent tanks should be as follows:

- .1 All longitudinal and circumferential joints of pressure vessels should be of butt welded, full penetration, double vee or single vee type. Full penetration butt welds should be obtained by double welding or by the use of backing rings. If used, backing rings should be removed, unless specifically approved by the Administration for very small process pressure vessels. Other edge preparations may be allowed by the Administration depending on the results of the tests carried out at the approval of the welding procedure.
- .2 The bevel preparation of the joints between the pressure vessel body and domes and between domes and relevant fittings should be designed according to a standard for pressure vessels acceptable to the Administration. All welds connecting nozzles, domes or other penetrations of the vessel and all welds connecting flanges to the vessel or nozzles should be full penetration welds extending through the entire thickness of the vessel wall or nozzle wall, unless specially approved by the Administration for small nozzle diameters.

4.10.2 Workmanship should be to the satisfaction of the Administration. Inspection and non-destructive testing of welds for tanks other than type C independent tanks should be in accordance with the requirements of 6.3.7.

4.10.3 For membrane tanks, quality assurance measures, weld procedure qualification, design details, materials, construction, inspection and production testing of components, should be to standards developed during the prototype testing programme.

4.10.4 For semi-membrane tanks the relevant requirements in this section for independent tanks or for membrane tanks should be applied as appropriate.

4.10.5.1 For internal insulation tanks, in order to ensure uniform quality of the material, quality control procedures including environmental control, application procedure qualification, corners, penetrations and other design details, materials specification, installation and production testing of components should be to standards developed during the prototype test programme.

4.10.5.2 A quality control specification including maximum permissible size of constructional defects, tests and inspections during the fabrication, installation and also sampling tests at each of these stages should be to the satisfaction of the Administration.

4.10.6 Integral tanks should be hydrostatically or hydropneumatically tested to the satisfaction of the Administration. The test in general should be so performed that the stresses approximate, as far as practicable, to the design stresses and that the pressure at the top of the tank corresponds at least to the MARVS.

4.10.7 In ships fitted with membrane or semi-membrane tanks, cofferdams and all spaces which may normally contain liquid and are adjacent to the hull structure supporting the membrane should be hydrostatically or hydropneumatically tested in accordance with Recognized Standards. In addition, any other hold structure supporting the membrane should be tested for tightness. Pipe tunnels and other compartments which do not normally contain liquid need not be hydrostatically tested.

4.10.8.1 In ships fitted with internal insulation tanks where the inner hull is the supporting structure, all inner hull structure should be hydrostatically or hydropneumatically tested in accordance with Recognized Standards, taking into account the MARVS.

4.10.8.2 In ships fitted with internal insulation tanks where independent tanks are the supporting structure, the independent tanks should be tested in accordance with 4.10.10.1.

4.10.8.3 For internal insulation tanks where the inner hull structure or an independent tank structure acts as a secondary barrier, a tightness test of those structures should be carried out using techniques to the satisfaction of the Administration.

4.10.8.4 These tests should be performed before the application of the materials which will form the internal insulation tank.

4.10.9 For type C independent tanks, inspection and non-destructive testing should be as follows:

.1 Manufacture and workmanship - The tolerances relating to manufacture and workmanship such as local out-of-roundness deviations from the true form, welded joints alignment and tapering of plates having different thicknesses, should comply with standards acceptable to the Administration. The tolerances should also be related to the buckling analysis referred to in 4.4.6.2.

.2 Non-destructive testing - As far as completion and extension of non-destructive testing of welded joints are concerned, the extent of non-destructive testing should be total or partial according to standards acceptable to the Administration, but the controls to be carried out should not be less than the following:

.2.1 Total non-destructive testing referred to in 4.4.6.1.3:

Radiography:

butt welds 100% and

Surface crack detection:

all welds 10%;

reinforcement rings around holes, nozzles, etc. 100%.

As an alternative, ultrasonic testing may be accepted as a partial substitute for the radiographic testing, if specially allowed by the Administration. In addition, the Administration may require total ultrasonic testing on welding or reinforcement rings around holes, nozzles, etc.

- .2.2 Partial non-destructive testing referred to in 4.4.6.1.3:
- Radiography:  
butt welds: all welded crossing joints and at least 10% of the full length at selected positions uniformly distributed and
- Surface crack detection:  
reinforcement rings around holes, nozzles, etc. 100%
- Ultrasonic testing:  
as may be required by the Administration in each instance.

4.10.10 Each independent tank should be subjected to a hydrostatic or hydropneumatic test as follows:

- .1 For type A independent tanks, this test should be so performed that the stresses approximate, as far as practicable, to the design stresses and that the pressure at the top of the tank corresponds at least to the MARVS. When a hydropneumatic test is performed, the conditions should simulate, as far as practicable, the actual loading of the tank and of its supports.
- .2 For type B independent tanks, the test should be performed as required in 4.10.10.1 for type A independent tanks. In addition, the maximum primary membrane stress or maximum bending stress in primary members under test conditions should not exceed 90% of the yield strength of the material (as fabricated) at the test temperature. To ensure that this condition is satisfied, when calculations indicate that this stress exceeds 75% of the yield strength, the prototype test should be monitored by the use of strain gauges or other suitable equipment.
- .3 Type C independent tanks should be tested as follows:
- .3.1 Each pressure vessel, when completely manufactured, should be subjected to a hydrostatic test at a pressure measured at the top of the tanks, of not less than  $1.5 P_o$ , but in

no case during the pressure test should the calculated primary membrane stress at any point exceed 90% of the yield stress of the material. The definition of  $P_0$  is given in 4.2.6. To ensure that this condition is satisfied where calculations indicate that this stress will exceed 0.75 times the yield strength, the prototype test should be monitored by the use of strain gauges or other suitable equipment in pressure vessels other than simple cylindrical and spherical pressure vessels.

- .3.2 The temperature of the water used for the test should be at least 30°C above the nil ductility transition temperature of the material as fabricated.
- .3.3 The pressure should be held for 2 h per 25 mm of thickness but in no case less than 2 h.
- .3.4 Where necessary for cargo pressure vessels, and with the specific approval of the Administration, a hydropneumatic test may be carried out under the conditions prescribed in 4.10.10.3.1, .2 and .3.
- .3.5 Special consideration may be given by the Administration to the testing of tanks in which higher allowable stresses are used, depending on service temperature. However, the requirements of 4.10.10.3.1 should be fully complied with.
- .3.6 After completion and assembly, each pressure vessel and its related fittings should be subjected to an adequate tightness test.
- .3.7 Pneumatic testing of pressure vessels other than cargo tanks should be considered on an individual case basis by the Administration. Such testing should be permitted only for those vessels which are so designed or supported that they cannot be safely filled with water, or for those vessels which cannot be dried and are to be used in a service where traces of the testing medium cannot be tolerated.

4.10.11 All tanks should be subjected to a tightness test which may be performed in combination with the pressure test referred to in 4.10.10 or separately.

4.10.12 Requirements with respect to inspection of secondary barriers should be decided by the Administration in each case.

4.10.13 In ships fitted with type B independent tanks, at least one tank and its support should be instrumented to confirm stress levels unless the design and arrangement for the size of ship involved are supported by full-scale experience. Similar instrumentation may be required by the Administration for type C independent tanks dependent on their configuration and on the arrangement of their supports and attachments.

4.10.14 The overall performance of the cargo containment system should be verified for compliance with the design parameters during the initial cool-down, loading and discharging of the cargo. Records of the performance of the components and equipment essential to verify the design parameters should be maintained and be available to the Administration.

4.10.15 Heating arrangements, if fitted in accordance with 4.8.4, should be tested for required heat output and heat distribution.

4.10.16 The hull should be inspected for cold spots following the first loaded voyage.

4.10.17 The insulation materials of internal insulation tanks should be subjected to additional inspection in order to verify their surface conditions after the third loaded voyage of the ship, but not later than the first 6 months of the ship's service after building or a major repair work is undertaken on the internal insulation tanks.



4.10.18 For type C independent tanks, the required marking of the pressure vessel should be achieved by a method which does not cause unacceptable local stress rises.

4.11 Stress relieving for type C independent tanks

4.11.1 For type C independent tanks of carbon and carbon-manganese steel, post-weld heat treatment should be performed after welding if the design temperature is below  $-10^{\circ}\text{C}$ . Post-weld heat treatment in all other cases and for materials other than those mentioned above should be to the satisfaction of the Administration. The soaking temperature and holding time should be to the satisfaction of the Administration.

4.11.2 In the case of large cargo pressure vessels of carbon or carbon-manganese steel for which it is difficult to perform the heat treatment, mechanical stress relieving by pressurizing may be carried out as an alternative to the heat treatment with the approval of the Administration and subject to the following conditions:

- .1 Complicated welded pressure vessel parts such as sumps or domes with nozzles, with adjacent shell plates should be heat treated before they are welded to larger parts of the pressure vessel.
- .2 The plate thicknesses should not exceed those given by a standard acceptable to the Administration.
- .3 The performance of a detailed stress analysis to ascertain that the maximum primary membrane stress during the mechanical stress relieving, closely approaches, but does not exceed, 90% of the yield stress of the material. Strain measurements during the stress relief pressurization may be required by the Administration for verifying the calculations.
- .4 The procedure for mechanical stress relieving should be submitted beforehand to the Administration for approval.

4.12 Guidance formulae for acceleration components

The following formulae are given as guidance for the components of acceleration due to ship's motions corresponding to a probability level of  $10^{-8}$  in the North Atlantic and apply to ships with a length exceeding 50 m.

Vertical acceleration as defined in 4.3.4.6

$$a_z = \pm a_o \sqrt{1 + \left(5.3 - \frac{45}{L_o}\right)^2 \left(\frac{x}{L_o} + 0.05\right)^2 \left(\frac{0.6}{C_B}\right)^{1.5}}$$

Transverse acceleration as defined in 4.3.4.6

$$a_y = \pm a_o \sqrt{0.6 + 2.5 \left(\frac{x}{L_o} + 0.05\right)^2 + K \left(1 + 0.6 K \frac{z}{B}\right)^2}$$

Longitudinal acceleration as defined in 4.3.4.6

$$a_x = \pm a_o \sqrt{0.06 + A^2 - 0.25 A}$$

with:

$$A = \left(0.7 - \frac{L_o}{1200} + \frac{z}{L_o}\right) \left(\frac{0.6}{C_B}\right)$$

where:

- $L_o$  = length of the ship for determination of scantlings as defined in Recognized Standards (m)
- $C_B$  = block coefficient
- $B$  = greatest moulded breadth of the ship (m)
- $x$  = longitudinal distance (m) from amidships to the centre of gravity of the tank with contents;  $x$  is positive forward of amidships, negative aft of amidships
- $z$  = vertical distance (m) from the ship's actual waterline to the centre of gravity of tank with contents;  $z$  is positive above and negative below the waterline.

$$a_o = 0.2 \frac{V}{\sqrt{L_o}} + \frac{34 - \frac{600}{L_o}}{L_o}$$

where:  $V$  = service speed (knots)

$K$  = 1 in general. For particular loading conditions and hull forms, determination of  $K$  according to the formula below may be necessary.

$K$  =  $13GM/B$ , where  $K \geq 1.0$  and  $GM$  = metacentric height (m)

$a_x$ ,  $a_y$  and  $a_z$  = maximum dimensionless accelerations (i.e. relative to the acceleration of gravity) in the respective directions and they are considered as acting separately for calculation purposes.  $a_z$  does not include the component due to the static weight,  $a_y$  includes the component due to the static weight in the transverse direction due to rolling and  $a_x$  includes the component due to the static weight in the longitudinal direction due to pitching.

#### 4.13 Stress categories

For the purpose of stress evaluation referred to in 4.5.1.4, stress categories are defined in this section.

4.13.1 Normal stress is the component of stress normal to the plane of reference.

4.13.2 Membrane stress is the component of normal stress which is uniformly distributed and equal to the average value of the stress across the thickness of the section under consideration.

4.13.3 Bending stress is the variable stress across the thickness of the section under consideration, after the subtraction of the membrane stress.

4.13.4 Shear stress is the component of the stress acting in the plane of reference.

4.13.5 Primary stress is a stress produced by the imposed loading and which is necessary to balance the external forces and moments. The basic characteristic of a primary stress is that it is not self-limiting. Primary stresses which considerably exceed the yield strength will result in failure or at least in gross deformations.

4.13.6 Primary general membrane stress is a primary membrane stress which is so distributed in the structure that no redistribution of load occurs as a result of yielding.

4.13.7 Primary local membrane stress arises where a membrane stress produced by pressure or other mechanical loading and associated with a primary or a discontinuity effect produces excessive distortion in the transfer of loads for other portions of the structure. Such a stress is classified as a primary local membrane stress although it has some characteristics of a secondary stress. A stress region may be considered as local if:

$$S_1 \leq 0.5\sqrt{Rt} \quad \text{and} \\ S_2 \geq 2.5\sqrt{Rt}$$

where:

$S_1$  = distance in the meridional direction over which the equivalent stress exceeds  $1.1 f$

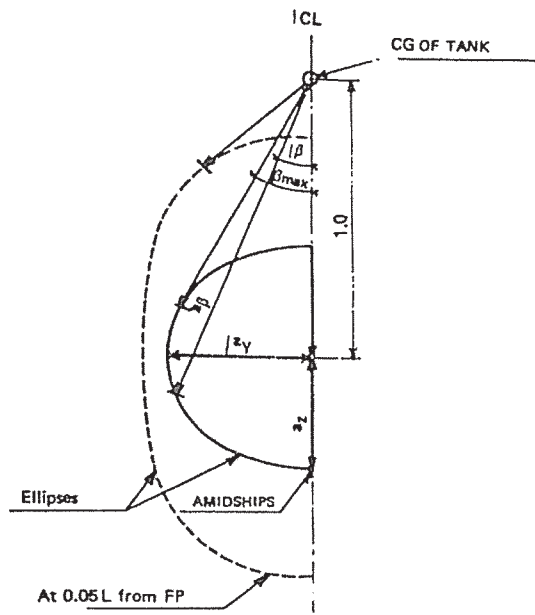
$S_2$  = distance in the meridional direction to another region where the limits for primary general membrane stress are exceeded

$R$  = mean radius of the vessel

$t$  = wall thickness of the vessel at the location where the primary general membrane stress limit is exceeded

$f$  = allowable primary general membrane stress.

4.13.8 Secondary stress is a normal stress or shear stress developed by constraints of adjacent parts or by self-constraint of a structure. The basic characteristic of a secondary stress is that it is self-limiting. Local yielding and minor distortions can satisfy the conditions which cause the stress to occur.



- $a_{\beta}$  = resulting acceleration (static and dynamic) in arbitrary direction  $\beta$
- $a_y$  = transverse component of acceleration
- $a_z$  = vertical component of acceleration

Figure 4.1 – Acceleration ellipse

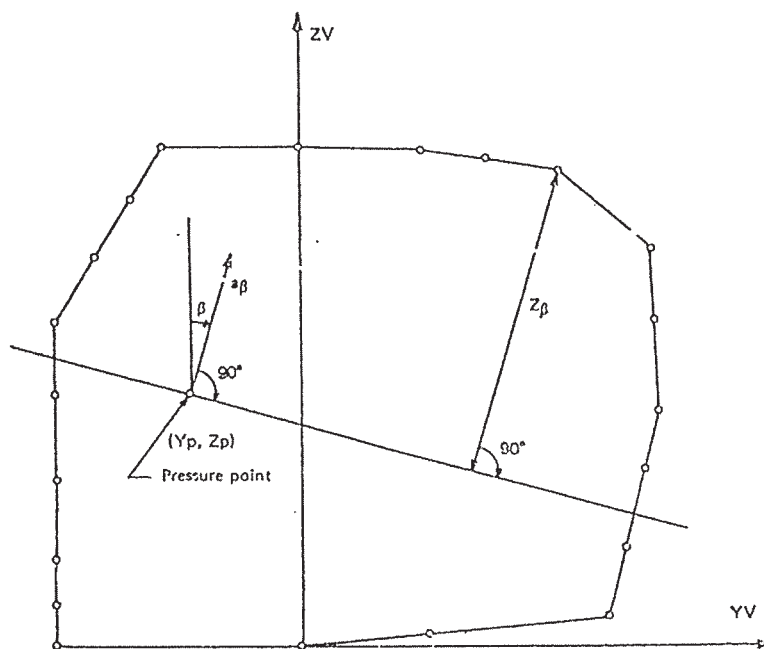
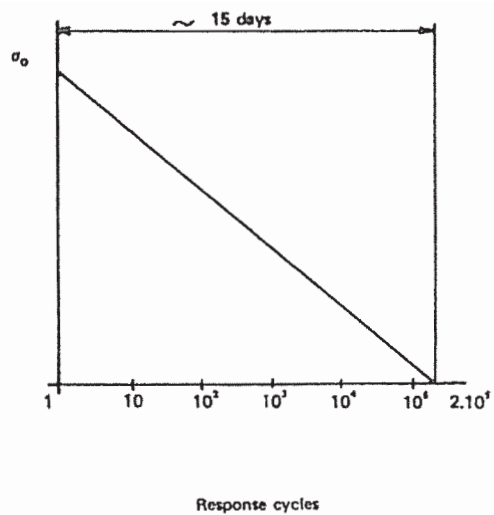


Figure 4.2 - Determination of internal pressure heads



$\sigma_0$  = most probable maximum stress over the life of the ship  
Response cycle scale is logarithmic; the value of  $2 \cdot 10^5$  is given as an example of estimate.

Figure 4.3 - Simplified load distribution

CHAPTER 5 - PROCESS PRESSURE VESSELS AND LIQUID,  
VAPOUR, AND PRESSURE PIPING SYSTEMS

5.1 General

5.1.1 Administrations should take appropriate steps to ensure uniformity in the implementation and application of the provisions of this chapter.\*

5.1.2 The requirements for type C independent tanks in chapter 4 may also apply to process pressure vessels if required by the Administration. If so required the term "pressure vessels" as used in chapter 4 covers both type C independent tanks and process pressure vessels.

5.2 Cargo and process piping

5.2.1 General

5.2.1.1 The requirements of this section apply to product and process piping including vapour piping and vent lines of safety valves or similar piping. Instrument piping not containing cargo is exempt from these requirements.

5.2.1.2 Provision should be made by the use of offsets, loops, bends, mechanical expansion joints such as bellows, slip joints and ball joints or similar suitable means to protect the piping, piping system components and cargo tanks from excessive stresses due to thermal movement and from movements of the tank and hull structure. Where mechanical expansion joints are used in piping they should be held to a minimum and, where located outside cargo tanks, should be of the bellows type.

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\* Reference is made to the published Rules of members and associate members of the International Association of Classification Societies and in particular to IACS Unified Requirement No G3.



5.2.1.3 Low-temperature piping should be thermally isolated from the adjacent hull structure, where necessary, to prevent the temperature of the hull from falling below the design temperature of the hull material. Where liquid piping is dismantled regularly, or where liquid leakage may be anticipated, such as at shore connections and at pump seals, protection for the hull beneath should be provided.

5.2.1.4 Where tanks or piping are separated from the ship's structure by thermal isolation, provision should be made for electrically bonding both the piping and the tanks. All gasketed pipe joints and hose connections should be electrically bonded.

5.2.1.5 Suitable means should be provided to relieve the pressure and remove liquid contents from cargo loading and discharging crossover headers and cargo hoses to the cargo tanks or other suitable location, prior to disconnecting the cargo hoses.

5.2.1.6 All pipelines or components which may be isolated in a liquid full condition should be provided with relief valves.

5.2.1.7 Relief valves discharging liquid cargo from the cargo piping system should discharge into the cargo tanks; alternatively they may discharge to the cargo vent mast if means are provided to detect and dispose of any liquid cargo which may flow into the vent system. Relief valves on cargo pumps should discharge to the pump suction.

#### 5.2.2 Scantlings based on internal pressure

5.2.2.1 Subject to the conditions stated in 5.2.4, the wall thickness of pipes should not be less than:

$$t = \frac{t_o + b + c}{1 - \frac{a}{100}} \quad (\text{mm})$$

where:

$t_o$  = theoretical thickness

$$t_o = PD / (20 K e + P) \quad (\text{mm})$$

with:

P = design pressure (bar) referred to in 5.2.3

D = outside diameter (mm)

K = allowable stress ( $\text{N/mm}^2$ ) referred to in 5.2.4

e = efficiency factor equal 1.0 for seamless pipes and for longitudinally or spirally welded pipes, delivered by approved manufacturers of welded pipes, which are considered equivalent to seamless pipes when non-destructive testing on welds is carried out in accordance with Recognized Standards. In other cases an efficiency factor value depending on the manufacturing process may be determined by the Administration.

b = allowance for bending (mm). The value of b should be chosen so that the calculated stress in the bend, due to internal pressure only, does not exceed the allowable stress. Where such justification is not given, b should be:

$$b = \frac{D t_o}{2.5 r} \quad (\text{mm})$$

with:

r = mean radius of the bend (mm)

c = corrosion allowance (mm). If corrosion or erosion is expected, the wall thickness of the piping should be increased over that required by other design requirements. This allowance should be consistent with the expected life of the piping.

a = negative manufacturing tolerance for thickness (%).

### 5.2.3 Design pressure

5.2.3.1 The design pressure P in the formula for  $t_o$  in 5.2.2.1 is the maximum gauge pressure to which the system may be subjected in service.

5.2.3.2 The greater of the following design conditions should be used for piping, piping system and components as appropriate:

- .1 for vapour piping systems or components which may be separated from their relief valves and which may contain some liquid: the saturated vapour pressure at 45°C, or higher or lower if agreed upon by the Administration (see 4.2.6.2);
- .2 for systems or components which may be separated from their relief valves and which contain only vapour at all times: the superheated vapour pressure at 45°C or higher or lower if agreed upon by the Administration (see 4.2.6.2), assuming an initial condition of saturated vapour in the system at the system operating pressure and temperature; or
- .3 the MARVS of the cargo tanks and cargo processing systems; or
- .4 the pressure setting of the associated pump or compressor discharge relief valve; or
- .5 the maximum total discharge or loading head of the cargo piping system; or
- .6 the relief valve setting on a pipeline system.

5.2.3.3 The design pressure should not be less than 10 bar gauge except for open ended lines where it should be not less than 5 bar gauge.

5.2.4 Permissible stresses

5.2.4.1 For pipes, the permissible stress to be considered in the formula for t in 5.2.2.1 is the lower of the following values:

$$\frac{R_m}{A} \text{ or } \frac{R_e}{B}$$

where:

- $R_m$  = specified minimum tensile strength at room temperature (N/mm<sup>2</sup>)
- $R_e$  = specified minimum yield stress at room temperature (N/mm<sup>2</sup>). If the stress-strain curve does not show a defined yield stress, the 0.2% proof stress applies.

The values of A and B should be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk as provided for in 1.5 and have values of at least A = 2.7 and B = 1.8.

5.2.4.2 The minimum wall thickness should be in accordance with Recognized Standards.

5.2.4.3 Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipes due to superimposed loads from supports, ship deflection or other causes, the wall thickness should be increased over that required by 5.2.2, or, if this is impracticable or would cause excessive local stresses, these loads should be reduced, protected against or eliminated by other design methods.

5.2.4.4 Flanges, valves and other fittings should be to a standard acceptable to the Administration, taking into account the design pressure defined in 5.2.2. For bellows expansion joints used in vapour service, a lower minimum design pressure may be accepted by the Administration.

5.2.4.5 For flanges not complying with a standard, the dimensions of flanges and related bolts should be to the satisfaction of the Administration.

#### 5.2.5 Stress analysis

When the design temperature is  $-110^{\circ}\text{C}$  or lower, a complete stress analysis, taking into account all the stresses due to weight of pipes, including acceleration loads if significant, internal pressure, thermal contraction and loads induced by hog and sag of the ship for each branch of the piping system should be submitted to the Administration. For temperatures of above  $-110^{\circ}\text{C}$ , a stress analysis may be required by the Administration in relation to such matters as the design or stiffness of the piping system and the choice of materials. In any case, consideration should be given to thermal stresses, even though calculations are not submitted. The analysis may be carried out according to a code of practice acceptable to the Administration.

### 5.2.6 Materials

5.2.6.1 The choice and testing of materials used in piping systems should comply with the requirements of chapter 6 taking into account the minimum design temperature. However, some relaxation may be permitted in the quality of material of open ended vent piping, provided the temperature of the cargo at the pressure relief valve setting is  $-55^{\circ}\text{C}$  or greater and provided no liquid discharge to the vent piping can occur. Similar relaxations may be permitted under the same temperature conditions to open ended piping inside cargo tanks, excluding discharge piping and all piping inside membrane and semi-membrane tanks.

5.2.6.2 Materials having a melting point below  $925^{\circ}\text{C}$  should not be used for piping outside the cargo tanks except for short lengths of pipes attached to the cargo tanks, in which case fire-resisting insulation should be provided.

### 5.3 Type tests on piping components

5.3.1 Each type of piping component should be subject to type tests.

5.3.2.1 Each size and type of valve intended to be used at a working temperature below  $-55^{\circ}\text{C}$  should be subjected to a tightness test to the minimum design temperature or lower, and to a pressure not lower than the design pressure of the valve. During the test the satisfactory operation of the valve should be ascertained.

5.3.2.2 The following type tests should be performed on each type of expansion bellows intended for use on cargo piping outside the cargo tank and, where required, on those expansion bellows installed within the cargo tanks:

- .1 A type element of the bellows, not precompressed, should be pressure tested at not less than 5 times the design pressure without bursting. The duration of the test should not be less than 5 min.

- .2 A pressure test should be performed on a type expansion joint complete with all the accessories such as flanges, stays and articulations, at twice the design pressure at the extreme displacement conditions recommended by the manufacturer without permanent deformation. Depending on the materials used, the Administration may require the test to be at the minimum design temperature.
- .3 A cyclic test (thermal movements) should be performed on a complete expansion joint, which is to successfully withstand at least as many cycles, under the conditions of pressure, temperature, axial movement, rotational movement and transverse movement, as it will encounter in actual service. Testing at ambient temperature is permitted, when this testing is at least as severe as testing at the service temperature.
- .4 A cyclic fatigue test (ship deformation) should be performed on a complete expansion joint, without internal pressure, by simulating the bellows movement corresponding to a compensated pipe length, for at least 2,000,000 cycles at a frequency not higher than 5 cycles/s. This test is only required when, due to the piping arrangement, ship deformation loads are actually experienced.
- .5 The Administration may waive performance of the tests referred to in this paragraph provided that complete documentation is supplied to establish the suitability of the expansion joints to withstand the expected working conditions. When the maximum internal pressure exceeds 1.0 bar gauge this documentation is to include sufficient test data to justify the design method used, with particular reference to correlation between calculation and test results.

#### 5.4 Piping fabrication and joining details

5.4.1 The requirements of this section apply to piping inside and outside the cargo tanks. However, the Administration may accept relaxations from these requirements for piping inside cargo tanks and open ended piping.

5.4.2 The following direct connection of pipe lengths, without flanges, may be considered:

- .1 Butt welded joints with complete penetration at the root may be used in all applications. For design temperatures below  $-10^{\circ}\text{C}$ , butt welds should be either double welded or equivalent to a double welded butt joint. This may be accomplished by use of a backing ring, consumable insert or inert gas back-up on the first pass. For design pressures in excess of 10 bar and design temperatures of  $-10^{\circ}\text{C}$  or lower, backing rings should be removed.
- .2 Slip-on welded joints with sleeves and related welding, having dimensions satisfactory to the Administration, should only be used for open ended lines with external diameter of 50 mm or less and design temperatures not lower than  $-55^{\circ}\text{C}$ .
- .3 Screwed couplings acceptable to the Administration should only be used for accessory lines and instrumentation lines with external diameters of 25 mm or less.

5.4.3.1 Flanges in flange connections should be of the welded neck, slip-on or socket welded type.

5.4.3.2 Flanges should comply with standards acceptable to the Administration as to their type, manufacture and test. In particular, for all piping except open ended, the following restrictions apply:

- .1 For design temperatures lower than  $-55^{\circ}\text{C}$ , only welded neck flanges should be used.

- .2 For design temperatures lower than  $-10^{\circ}\text{C}$ , slip-on flanges should not be used in nominal sizes above 100 mm and socket welded flanges should not be used in nominal sizes above 50 mm.

5.4.4 Piping connections, other than those mentioned in 5.4.2 and .3, may be accepted by the Administration in each case.

5.4.5 Bellows and expansion joints should be provided to allow for expansion of piping.

- .1 If necessary, bellows should be protected against icing.
- .2 Slip joints should not be used except within the cargo tanks.

5.4.6 Welding, post-weld heat treatments and non-destructive testing.

- .1 Welding should be carried out in accordance with 6.3.
- .2 Post-weld heat treatments should be required for all butt welds of pipes made with carbon, carbon-manganese and low alloy steels. The Administration may waive the requirement for thermal stress relieving of pipes having wall thickness less than 10 mm in relation to the design temperature and pressure of the piping system concerned.
- .3 In addition to normal controls before and during the welding and to the visual inspection of the finished welds, as necessary for proving that the welding has been carried out correctly and according to the requirements of this paragraph, the following tests should be required:
  - .3.1 100% radiographic inspection of butt welded joints for piping systems with service temperatures lower than  $-10^{\circ}\text{C}$  and with inside diameters of more than 75 mm or wall thicknesses greater than 10 mm.
  - .3.2 For other butt welded joints of pipes, spot radiographic tests or other non-destructive tests should be carried out at the discretion of the Administration depending upon service, position and materials. In general, at least 10% of butt welded joints of pipes should be radiographed.



#### 5.5 Testing of piping

5.5.1 The requirements of this section apply to piping inside and outside the cargo tanks. However, the Administration may accept relaxations from these requirements for piping inside cargo tanks and open ended piping.

5.5.2 After assembly, all cargo and process piping should be subjected to a hydrostatic test to at least 1.5 times the design pressure. When piping systems or parts of systems are completely manufactured and equipped with all fittings, the hydrostatic test may be conducted prior to installation aboard ship. Joints welded on board should be hydrostatically tested to at least 1.5 times the design pressure. Where water cannot be tolerated and the piping cannot be dried prior to putting the system into service, proposals for alternative testing fluids or testing means should be submitted to the Administration for approval.

5.5.3 After assembly on board, each cargo and process piping system should be subjected to a leak test using air, halides, or other suitable medium to a pressure depending on the leak detection method applied.

5.5.4 All piping systems including valves, fittings and associated equipment for handling cargo or vapours should be tested under normal operating conditions not later than at the first loading operation.

#### 5.6 Cargo system valving requirements

5.6.1 Every cargo piping system and cargo tank should be provided with the following valves, as applicable:

- .1 For cargo tanks with a MARVS not exceeding 0.7 bar gauge, all liquid and vapour connections, except safety relief valves and liquid level gauging devices, should have shutoff valves located as close to the tank as practicable. These valves may be remotely controlled but should be capable of local manual operation and provide full closure. One or more remotely controlled emergency shutdown valves should be provided on the ship for shutting down liquid and vapour cargo transfer between ship and shore. Such valves may be arranged to suit the ship's design and may be the same valve as required in 5.6.3 and should comply with the requirements of 5.6.4.
- .2 For cargo tanks with a MARVS exceeding 0.7 bar gauge, all liquid and vapour connections, except safety relief valves and liquid level gauging devices, should be equipped with a manually operated stop valve and a remotely controlled emergency shutdown valve. These valves should be located as close to the tank as practicable. Where the pipe size does not exceed 50 mm in diameter, excess flow valves may be used in lieu of the emergency shutdown valve. A single valve may be substituted for the two separate valves provided the valve complies with the requirements of 5.6.4, is capable of local manual operation and provides full closure of the line.
- .3 Cargo pumps and compressors should be arranged to shutdown automatically if the emergency shutdown valves required by 5.6.1.1 and .2 are closed by the emergency shutdown system required by 5.6.4.

5.6.2 Cargo tank connections for gauging or measuring devices need not be equipped with excess flow or emergency shutdown valves provided that the devices are so constructed that the outward flow of tank contents cannot exceed that passed by a 1.5 mm diameter circular hole.

5.6.3 One remotely operated emergency shutdown valve should be provided at each cargo hose connection in use. Connections not used in transfer operations may be blinded with blank flanges in lieu of valves.

5.6.4 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 13.1.3 or cargo control room. The control system should also be provided with fusible elements designed to melt at temperatures between 98<sup>o</sup>C and 104<sup>o</sup>C 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 s 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.

5.6.5 Excess flow valves should close automatically at the rated closing flow of vapour or liquid as specified by the manufacturer. The piping including fittings, valves, and appurtenances protected by an excess flow valve, should have a greater capacity than the rated closing flow of the excess flow valve. Excess flow valves may be designed with a bypass not exceeding an area of 1.0 mm diameter circular opening to allow equalization of pressure, after an operating shutdown.

#### 5.7 Ship's cargo hoses

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

5.7.2 Hoses subject to tank pressure, or the discharge pressure of pumps or vapour compressors, should be designed for a bursting pressure not less than 5 times the maximum pressure the hose will be subjected to during cargo transfer.

5.7.3 Each new type of cargo hose, complete with end fittings, should be prototype tested to a pressure not less than 5 times its specified maximum working pressure. The hose temperature during this prototype test should be the intended extreme service temperature. Hoses used for prototype testing should not be used for cargo service. Thereafter, before being placed in service, each new length of cargo hose produced should be hydrostatically tested at ambient temperature to a pressure not less than 1.5 times its specified maximum working pressure nor more than two fifths its bursting pressure. The hose should be stencilled 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.

#### 5.8 Cargo transfer methods

5.8.1 Where cargo transfer is by means of cargo pumps not accessible for repair with the tanks in service, at least two separate means should be provided to transfer cargo from each cargo tank and the design should be such that failure of one cargo pump, or means of transfer, will not prevent the cargo transfer by another pump or pumps, or other cargo transfer means.

5.8.2 The procedure for transfer of cargo by gas pressurization should preclude lifting of the relief valves during such transfer. Gas pressurization may be accepted as a means of transfer of cargo for those tanks so designed that the design factor of safety is not reduced under the conditions prevailing during the cargo transfer operation.

5.9 Vapour return connections

Connections for vapour return lines to the shore installations should be provided.

## CHAPTER 6 - MATERIALS OF CONSTRUCTION

6.1 General

6.1.1 Administrations should take appropriate steps to ensure uniformity in the implementation and application of the provisions of this chapter.\*

6.1.2 This chapter gives the requirements for plates, sections, pipes, forgings, castings and weldments used in the construction of cargo tanks, cargo process pressure vessels, cargo and process piping, secondary barriers and contiguous hull structures associated with the transportation of the products. The requirements for rolled materials, forgings and castings are given in 6.2 and tables 6.1 to 6.5. The requirements for weldments are given in 6.3.

6.1.3 The manufacture, testing, inspection and documentation should be in accordance with Recognized Standards and the specific requirements given in this Code.

6.1.4.1 Acceptance tests should include Charpy V-notch toughness tests unless otherwise specified by the Administration. The specified Charpy V-notch requirements are minimum average energy values for three full size (10 mm x 10 mm) specimens and minimum single energy values for individual specimens. Dimensions and tolerances of Charpy V-notch specimens should be in accordance with Recognized Standards. The testing and requirements for specimens smaller than 5.0 mm size should be in accordance with Recognized Standards. Minimum average values for sub-sized specimens should be:

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\* Reference is made to the published Rules of members and associate members of the International Association of Classification Societies and in particular to IACS Unified Requirement No.W1.

Charpy V-notch specimen size	Minimum energy average of three specimens
10 x 10 mm	E
10 x 7.5 mm	5/6 E
10 x 5.0 mm	2/3 E

where: E = the energy values (J) specified in tables 6.1 to 6.4.

Only one individual value may be below the specified average value provided it is not less than 70% of that value.

6.1.4.2 In all cases, the largest size Charpy specimens possible for the material thickness should be machined with the specimens located as near as practicable to a point midway between the surface and the centre of the thickness and the length of the notch perpendicular to the surface (see figure 6.1). If the average value of the three initial Charpy V-notch specimens fails to meet the stated requirements, or the value for more than one specimen is below the required average value, or when the value for one specimen is below the minimum value permitted for a single specimen, three additional specimens from the same material may be tested and the results combined with those previously obtained to form a new average. If this new average complies with the requirements and if no more than two individual results are lower than the required average and no more than one result is lower than the required value for a single specimen, the piece or batch may be accepted. At the discretion of the Administration other types of toughness tests, such as a drop weight test, may be used. This may be in addition to or in lieu of the Charpy V-notch test.

6.1.5 Tensile strength, yield stress and elongation should be to the satisfaction of the Administration. For carbon-manganese steel and other materials with definitive yield points, consideration should be given to the limitation of the yield to tensile ratio.

6.1.6 The bend test may be omitted as a material acceptance test, but is required for weld tests.

6.1.7 Materials with alternative chemical composition or mechanical properties may be accepted by the Administration.

6.1.8 Where post-weld heat treatment is specified or required, the properties of the base material should be determined in the heat treated condition in accordance with the applicable table of this chapter and the weld properties should be determined in the heat treated condition in accordance with 6.3. In cases where a post-weld heat treatment is applied, the test requirements may be modified at the discretion of the Administration.

6.1.9 Where reference is made in this chapter to A, B, D, E, AH, DH and EH hull structural steels, these steel grades are hull structural steels according to Recognized Standards.

## 6.2 Material requirements

The requirements for materials of construction are shown in the tables as follows:

Table 6.1:	Plates, pipes (seamless and welded), sections and forgings for cargo tanks and process pressure vessels for design temperatures not lower than 0°C.
Table 6.2:	Plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures below 0°C and down to -55°C.
Table 6.3:	Plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures below -55°C and down to -165°C.
Table 6.4:	Pipes (seamless and welded), forgings and castings for cargo process piping for design temperatures below 0°C and down to -165°C.
Table 6.5:	Plates and sections for hull structures required by 4.9.1 and 4.9.4.



Table 6.1

PLATES, PIPES (SEAMLESS AND WELDED), <sup>1/</sup> SECTIONS AND FORGINGS FOR CARGO TANKS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES NOT LOWER THAN 0°C		
CHEMICAL COMPOSITION AND HEAT TREATMENT		
CARBON-MANGANESE STEEL	Fully killed	
Fine grain steel where thickness exceeds 20 mm		
Small additions of alloying elements by agreement with the Administration		
Composition limits to be approved by the Administration		
Normalized, or quenched and tempered <sup>2/</sup>		
TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS		
PLATES	Each "piece" to be tested	
SECTIONS AND FORGINGS	Batch test	
TENSILE PROPERTIES	Specified minimum yield stress not to exceed 410 N/mm <sup>2</sup> <sup>3/</sup>	
CHARPY V-NOTCH TEST		
PLATE	Transverse test pieces. Minimum average energy value (E) 27 J	
SECTIONS AND FORGINGS	Longitudinal test pieces. Minimum average energy value (E) 41 J	
TEST TEMPERATURE:	Thickness t (mm)	Test temperature (°C)
	t ≤ 20	0
	20 < t ≤ 40	-20

NOTES

- <sup>1/</sup> For seamless pipes and fittings normal practice applies. The use of longitudinally and spirally welded pipes should be specially approved by the Administration.
- <sup>2/</sup> A controlled rolling procedure may be used as an alternative to normalizing or quenching and tempering, subject to special approval by the Administration.
- <sup>3/</sup> Materials with specified minimum yield stress exceeding 410 N/mm<sup>2</sup> may be specially approved by the Administration. For these materials, particular attention should be given to the hardness of the weld and heat affected zone.

Table 6.2

PLATES, SECTIONS AND FORGINGS <sup>1/</sup> FOR CARGO TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW 0°C AND DOWN TO -55°C					
Maximum thickness 25 mm <sup>2/</sup>					
CHEMICAL COMPOSITION AND HEAT TREATMENT					
CARBON-MANGANESE STEEL Fully killed. Aluminium treated fine grain steel.					
Chemical composition (ladle analysis)					
C	Mn	Si	S	P	
0.16% max. <sup>3/</sup>	0.70-1.60%	0.10-0.50%	0.035% max.	0.035% max.	
Optional additions: Alloys and grain refining elements may be generally in accordance with the following:					
Ni	Cr	Mo	Cu	Nb	V
0.80% max.	0.25% max.	0.08% max.	0.35% max.	0.05% max.	0.10% max.
Normalized or quenched and tempered <sup>4/</sup>					
TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS					
PLATES	Each "piece" to be tested				
SECTIONS	Batch test				
CHARPY V-NOTCH TEST	Test temperatures 5°C below the design temperature or -20°C whichever is lower				
PLATES	Transverse test pieces. Minimum average energy value (E) 27 J				
SECTIONS AND FORGINGS <sup>1/</sup>	Longitudinal test pieces. Minimum average energy value (E) 41 J				

## NOTES

<sup>1/</sup> The Charpy V-notch and chemistry requirements for forgings may be specially considered by the Administration.

<sup>2/</sup> For material thickness of more than 25 mm, Charpy V-notch tests should be conducted as follows:

Material thickness (mm)	Test temperature (°C)
25 < t ≤ 30	10° below design temperature or -20° whichever is lower
30 < t ≤ 35	15° below design temperature or -20° whichever is lower
35 < t ≤ 40	20° below design temperature

The impact energy value should be in accordance with the table for the applicable type of test specimen. For material thickness of more than 40 mm, the Charpy V-notch values should be specially considered.

Materials for tanks and parts of tanks which are completely thermally stress relieved after welding may be tested at a temperature 5°C below design temperature or -20°C whichever is lower.

For thermally stress relieved reinforcements and other fittings, the test temperature should be the same as that required for the adjacent tank-shell thickness.

3/ By special agreement with the Administration, the carbon content may be increased to 0.18 % maximum provided the design temperature is not lower than -40°C.

4/ A controlled rolling procedure may be used as an alternative to normalizing or quenching and tempering, subject to special approval by the Administration.

Guidance:

For materials exceeding 25 mm in thickness for which the test temperature is -60°C or lower, the application of specially treated steels or steels in accordance with table 6.3 may be necessary.

Table 6.3

PLATES, SECTIONS AND FORGINGS <sup>1/</sup> FOR CARGO TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW -55°C AND DOWN TO -165°C <sup>2/</sup>		
Maximum thickness 25mm <sup>3/</sup>		
Minimum design temp.(°C)	Chemical composition <sup>4/</sup> and heat treatment	Impact test temp.(°C)
-60	1.5% nickel steel - normalized	-65
-65	2.25% nickel steel - normalized or normalized and tempered 5/	-70
-90	3.5% nickel steel - normalized or normalized and tempered 5/	-95
-105	5% nickel steel - normalized or normalized and tempered 5/ 6/	-110
-165	9% nickel steel - double normalized and tempered or quenched and tempered	-196
-165	Austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347 solution treated 7/	-196
-165	Aluminium alloys; such as type 5083 annealed	Not required
-165	Austenitic Fe-Ni alloy (36% nickel) Heat treatment as agreed	Not required
TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS		
PLATES	Each "piece" to be tested	
SECTIONS AND FORGINGS	Batch test	
CHARPY V-NOTCH TEST		
PLATES	Transverse test pieces.	Minimum average energy value (E) 27 J
SECTIONS AND FORGINGS	Longitudinal test pieces.	Minimum average energy value (E) 41 J

## NOTES

- <sup>1/</sup> The impact test required for forgings used in critical applications should be subject to special consideration by the Administration.
- <sup>2/</sup> The requirements for design temperatures below -165°C should be specially agreed with the Administration.
- <sup>3/</sup> For materials 1.5% Ni, 2.25% Ni, 3.5% Ni and 5% Ni, with thicknesses greater than 25 mm, the impact tests should be conducted as follows:

Material thickness (mm)	Test temperature (°C)
$25 < t \leq 30$	10° below design temperature
$30 < t \leq 35$	15° below design temperature
$35 < t \leq 40$	20° below design temperature

In no case should the test temperature be above that indicated in the table.

The energy value should be in accordance with the table for the applicable type of test specimen. For material thickness of more than 40 mm, the Charpy V-notch values should be specially considered.

For 9% Ni, austenitic stainless steels and aluminium alloys, thicknesses greater than 25 mm may be used at the discretion of the Administration.

- 4/ The chemical composition limits should be approved by the Administration.
- 5/ A lower minimum design temperature for quenched and tempered steels may be specially agreed with the Administration.
- 6/ A specially heat treated 5% nickel steel, for example triple heat treated 5% nickel steel, may be used down to -165°C upon special agreement with the Administration, provided that the impact tests are carried out at -196°C.
- 7/ The impact test may be omitted subject to agreement with the Administration.

Table 6.4

PIPES (SEAMLESS AND WELDED), <sup>1/</sup> FORGINGS <sup>2/</sup> AND CASTINGS <sup>2/</sup> FOR CARGO AND PROCESS PIPING FOR DESIGN TEMPERATURES BELOW 0°C AND DOWN TO -165°C <sup>3/</sup>			
Maximum thickness 25 mm			
Minimum design temp. (°C)	Chemical composition <sup>5/</sup> and heat treatment	Impact test	
		Test temp. (°C)	Minimum average energy (E) (J)
-55	Carbon-manganese steel. Fully killed fine grain. Normalized or as agreed <sup>6/</sup>	<u>4/</u>	27
-65	2.25% nickel steel. Normalized or normalized and tempered <sup>6/</sup>	-70	34
-90	3.5% nickel steel. Normalized or normalized and tempered <sup>6/</sup>	-95	34
-165	9% nickel steel <sup>7/</sup> . Double normalized and tempered or quenched and tempered	-196	41
	Austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347. Solution treated <sup>8/</sup>	-196	41
	Aluminium alloys, such as type 5083 annealed		Not required
TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS			
Each batch to be tested			
IMPACT TEST - Longitudinal test pieces			

## NOTES

- <sup>1/</sup> The use of longitudinally or spirally welded pipes should be specially approved by the Administration.
- <sup>2/</sup> The requirements for forgings and castings may be subject to special consideration by the Administration.
- <sup>3/</sup> The requirements for design temperatures below -165°C should be specially agreed with the Administration.
- <sup>4/</sup> The test temperature should be 5°C below the design temperature or -20°C whichever is lower.
- <sup>5/</sup> The composition limits should be approved by the Administration.
- <sup>6/</sup> A lower design temperature may be specially agreed with the Administration for quenched and tempered materials.
- <sup>7/</sup> This chemical composition is not suitable for castings.
- <sup>8/</sup> Impact tests may be omitted subject to agreement with the Administration.

Table 6.5

PLATES AND SECTIONS FOR HULL STRUCTURES REQUIRED BY 4.9.1 AND 4.9.4							
Minimum design temperature of hull structure (°C)	Maximum thickness (mm) for steel grades in accordance with 6.1.9						
	A	B	D	E	AH	DH	EH
0 and above <sup>1/</sup> -5 and above <sup>2/</sup>	Normal practice						
down to -5	15	25	30	50	25	45	50
down to -10	x	20	25	50	20	40	50
down to -20	x	x	20	50	x	30	50
down to -30	x	x	x	40	x	20	40
Below -30	In accordance with table 6.2 except that the thickness limitation given in table 6.2 and in footnote <sup>2/</sup> of that table does not apply.						

NOTES

"x" means steel grade not to be used.

<sup>1/</sup> For the purpose of 4.9.4

<sup>2/</sup> For the purpose of 4.9.1

### 6.3 Welding and non-destructive testing

#### 6.3.1 General

The requirements of this section are those generally employed for carbon, carbon-manganese, nickel alloy and stainless steels, and may form the basis for acceptance testing of other material. At the discretion of the Administration, impact testing of stainless steel and aluminium alloy weldments may be omitted and other tests may be specially required for any material.

#### 6.3.2 Welding consumables

Welding consumables intended for welding of cargo tanks should be in accordance with Recognized Standards unless otherwise agreed with the Administration. Deposited weld metal tests and butt weld tests should be required for all welding consumables, unless otherwise specially agreed with the Administration. The results obtained from tensile and Charpy V-notch impact tests should be in accordance with Recognized Standards. The chemical composition of the deposited weld metal should be recorded for information and approval.

#### 6.3.3 Welding procedure tests for cargo tanks and process pressure vessels

6.3.3.1 Welding procedure tests for cargo tanks and process pressure vessels are required for all butt welds and the test assemblies should be representative of:

- each base material
- each type of consumable and welding process
- each welding position.



For butt welds in plates, the test assemblies should be so prepared that the rolling direction is parallel to the direction of welding. The range of thickness qualified by each welding procedure test should be in accordance with Recognized Standards. Radiographic or ultrasonic testing may be performed at the option of the fabricator or the Administration. Procedure tests for consumables intended for fillet welding should be in accordance with Recognized Standards. In such cases consumables should be selected which exhibit satisfactory impact properties.

6.3.3.2 The following welding procedure tests for cargo tanks and process pressure vessels should be made from each test assembly:

- .1 Cross-weld tensile tests.
- .2 Transverse bend tests which may be face, root or side bends at the discretion of the Administration. However, longitudinal bend tests may be required in lieu of transverse bend tests in cases where the base material and weld metal have different strength levels.
- .3 One set of three Charpy V-notch impacts, generally at each of the following locations, as shown in figure 6.1:
  - Centreline of the welds
  - Fusion line (F.L.)
  - 1 mm from the F.L.
  - 3 mm from the F.L.
  - 5 mm from the F.L.
- .4 Macrosection, microsection and hardness survey may also be required by the Administration.

#### 6.3.4 Test requirements

6.3.4.1 Tensile tests: Generally, tensile strength should not be less than the specified minimum tensile strength for the appropriate parent materials. The Administration may also require that the transverse weld tensile strength should not be less than the specified minimum tensile strength for the weld metal, where the weld metal has a lower tensile strength than that of the parent metal. In every case, the position of fracture is to be reported for information.

6.3.4.2 Bend tests: No fracture is acceptable after a 180° bend over a former of a diameter 4 times the thickness of the test pieces, unless otherwise specially required by or agreed with the Administration.

6.3.4.3 Charpy V-notch impact tests: Charpy tests should be conducted at the temperature prescribed for the base material being joined. The results of weld metal impact tests, minimum average energy (E), should be no less than 27 J. The weld metal requirements for subsize specimens and single energy values should be in accordance with 6.1.4. The results of fusion line and heat affected zone impact tests should show a minimum average energy (E) in accordance with the transverse or longitudinal requirements of the base material, whichever is applicable, and for subsize specimens, the minimum average energy (E) should be in accordance with 6.1.4. If the material thickness does not permit machining either full-size or standard subsize specimens, the testing procedure and acceptance standards should be in accordance with Recognized Standards.

6.3.5 Welding procedure tests for piping

Welding procedure tests for piping should be carried out and should be similar to those detailed for cargo tanks in 6.3.3. Unless otherwise specially agreed with the Administration, the test requirements should be in accordance with 6.3.4.

6.3.6 Production weld tests

6.3.6.1 For all cargo tanks and process pressure vessels except integral and membrane tanks, production weld tests should generally be performed for approximately each 50 m of butt weld joints and should be representative of each welding position. For secondary barriers, the same type production tests as required for primary tanks should be performed except that the number of tests may be reduced subject to agreement with the Administration. Tests, other than those specified in 6.3.6.2, .3 and .4, may be required for cargo tanks or secondary barriers at the discretion of the Administration.

6.3.6.2 The production tests for types A and B independent tanks and semi-membrane tanks should include the following tests:

- .1 Bend tests, and where required for procedure tests one set of three Charpy V-notch tests should be made for each 50 m of weld. The Charpy V-notch tests should be made with specimens having the notch alternately located in the centre of the weld and in the heat affected zone (most critical location based on procedure qualification results). For austenitic stainless steel, all notches should be in the centre of the weld.
- .2 The test requirements are the same as the applicable test requirements listed in 6.3.4 except that impact tests that do not meet the prescribed energy requirements may still be accepted, upon special consideration by the Administration, by passing a drop weight test. In such cases, two drop weight specimens should be tested for each set of Charpy specimens that failed and both must show "no break" performance at the temperature at which the Charpy tests were conducted.

6.3.6.3 In addition to those tests listed in 6.3.6.1 for type C independent tanks and process pressure vessels, transverse weld tensile tests are required. The test requirements are listed in 6.3.4 except that impact tests that do not meet the prescribed energy requirements may still be accepted upon special consideration by the Administration, by passing a drop weight test. In such cases, two drop weight specimens should be tested for each set of Charpy specimens that failed, and both must show "no break" performance at the temperature at which the Charpy tests were conducted.

6.3.6.4 Production tests for integral and membrane tanks should be in accordance with Recognized Standards.

#### 6.3.7 Non-destructive testing

6.3.7.1 For type A independent tanks and semi-membrane tanks where the design temperature is  $-20^{\circ}\text{C}$  or less, and for type B independent tanks regardless of temperature, all full penetration butt welds of the shell plating of cargo tanks should be subjected to 100% radiographic inspection.

6.3.7.1.1 Where the design temperature is higher than  $-20^{\circ}\text{C}$ , all full penetration butt welds in way of intersections and at least 10% of the remaining full penetration welds of tank structures should be subjected to radiographic inspection.

6.3.7.1.2 In each case the remaining tank structure including the welding of stiffeners and other fittings and attachments should be examined by magnetic particle or dye penetrant methods as considered necessary by the Administration.

6.3.7.1.3 All test procedures and acceptance standards should be in accordance with Recognized Standards. The Administration may accept an approved ultrasonic test procedure in lieu of radiographic inspection, but may in addition require supplementary inspection by radiography at selected locations. Further, the Administration may require ultrasonic testing in addition to normal radiographic inspection.

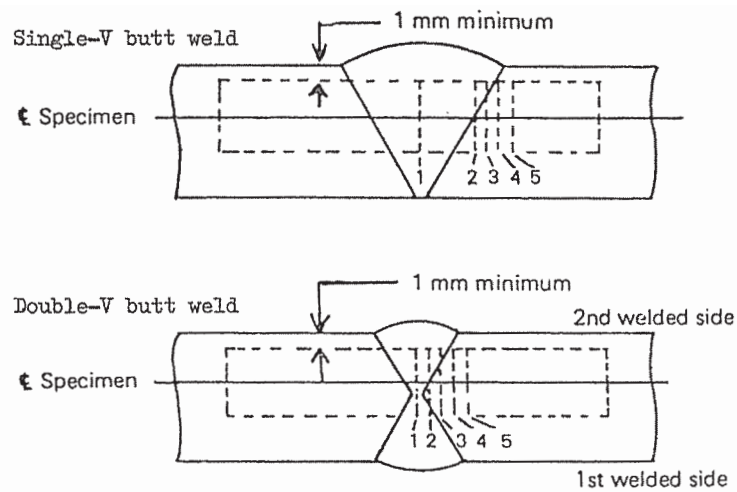
6.3.7.2 Inspection of type C independent tanks and process pressure vessels should be carried out in accordance with 4.10.9.

6.3.7.3 For integral and membrane tanks, special weld inspection procedures and acceptance criteria should be in accordance with Recognized Standards.

6.3.7.4 The inspection and non-destructive testing of the inner hull or the independent tank structures supporting internal insulation tanks should take into account the design criteria given in 4.4.7. The schedule for inspection and non-destructive testing should be to the satisfaction of the Administration.

6.3.7.5 Inspection of piping should be carried out in accordance with the requirements of chapter 5.

6.3.7.6 The secondary barrier should be radiographed as considered necessary by the Administration. Where the outer shell of the hull is part of the secondary barrier, all sheer strake butts and the intersections of all butts and seams in the side shell should be tested by radiography.



Notch location:

- 1 Centre of weld
  - 2 On fusion line
  - 3 In HAZ, 1 mm from fusion line
  - 4 In HAZ, 3 mm from fusion line
  - 5 In HAZ, 5 mm from fusion line
- HAZ = heat affected zone

The largest size Charpy specimens possible for the material thickness should be machined with the centre of the specimens located as near as practicable to a point midway between the surface and the centre of the thickness. In all cases, the distance from the surface of the material to the edge of the specimen should be approximately one mm or greater. In addition for double-V butt welds, specimens should be machined closer to the surface of the second welded side.

Figure 6.1 - Orientation of weld test specimen

## CHAPTER 7 - CARGO PRESSURE/TEMPERATURE CONTROL

7.1 General

7.1.1 Unless the entire cargo system is designed to withstand the full gauge vapour pressure of the cargo under conditions of the upper ambient design temperatures, maintenance of the cargo tank pressure below the MARVS should be provided by one or more of the following means, except as otherwise provided in this section:

- .1 a system which regulates the pressure in the cargo tanks by the use of mechanical refrigeration;
- .2 a system whereby the boil-off vapours are utilized as fuel for shipboard use or waste heat system subject to the provisions of chapter 16. This system may be used at all times, including while in port and while manoeuvring, provided that a means of disposing of excess energy is provided, such as a steam dump system, that is satisfactory to the Administration;
- .3 a system allowing the product to warm up and increase in pressure. The insulation or cargo tank design pressure or both should be adequate to provide for a suitable margin for the operating time and temperatures involved. The system should be acceptable to the Administration in each case;
- .4 other systems acceptable to the Administration;
- .5 in addition to the above means, the Administration may permit certain cargoes to be controlled by venting cargo vapours to the atmosphere at sea. This may also be permitted in port with the permission of the port Administration.

7.1.2 The systems required by 7.1.1 should be constructed, fitted and tested to the satisfaction of the Administration. Materials used in their construction should be suitable for use with the cargoes to be carried. For normal service, the upper ambient design temperature should be:

sea 32°C

air 45°C.

For service in especially hot or cold zones these design temperatures should be increased or reduced, as appropriate, by the Administration.

7.1.3 For certain highly dangerous cargoes specified in chapter 17, the cargo containment system should be capable of withstanding the full vapour pressure of the cargo under conditions of the upper ambient design temperatures irrespective of any system provided for dealing with boil-off gas.

## 7.2 Refrigeration systems

7.2.1 A refrigeration system should consist of one or more units capable of maintaining the required cargo pressure/temperature under conditions of the upper ambient design temperatures. Unless an alternative means of controlling the cargo pressure/temperature is provided to the satisfaction of the Administration, a stand-by unit (or units) affording spare capacity at least equal to the largest required single unit should be provided. A stand-by unit should consist of a compressor with its driving motor, control system and any necessary fittings to permit operation independently of the normal service units. A stand-by heat exchanger should be provided unless the normal heat exchanger for the unit has an excess capacity of at least 25% of the largest required capacity. Separate piping systems are not required.

7.2.2.1 Where two or more refrigerated cargoes which may react chemically in a dangerous manner are carried simultaneously, special consideration should be given to the refrigeration systems to avoid the possibility of mixing cargoes. For the carriage of such cargoes, separate refrigeration systems, each complete with a stand-by unit as specified in 7.2.1, should be provided for each cargo. However, where cooling is provided by an indirect or combined system and leakage in the heat exchangers cannot cause mixing of the cargoes under any envisaged condition, separate refrigeration units need not be fitted.

7.2.2.2 Where two or more refrigerated cargoes are not mutually soluble under the conditions of carriage, so that their vapour pressures would be additive on mixing, special consideration should be given to the refrigeration systems to avoid the possibility of mixing cargoes.

7.2.3 Where cooling water is required in refrigeration systems, an adequate supply should be provided by a pump or pumps used exclusively for this purpose. This pump or these pumps should have at least two sea suction lines, where practicable leading from sea-chests, one port and one starboard. A spare pump of adequate capacity should be provided, which may be a pump used for other services so long as its use for cooling would not interfere with any other essential service.

7.2.4 The refrigeration system may be arranged in one of the following ways:

- .1 a direct system where evaporated cargo is compressed, condensed and returned to cargo tanks. For certain cargoes specified in chapter 17 this system should not be used;
- .2 an indirect system where cargo or evaporated cargo is cooled or condensed by refrigerant without being compressed;
- .3 a combined system where evaporated cargo is compressed and condensed in a cargo/refrigerant heat exchanger and returned to the cargo tanks. For certain cargoes specified in chapter 17 this system should not be used.

7.2.5 All primary and secondary refrigerants must be compatible with each other and with the cargo with which they come into contact. The heat exchange may take place either remotely from the cargo tank or by cooling coils fitted inside or outside the cargo tank.



## CHAPTER 8 - CARGO TANK VENT SYSTEMS

8.1 General

All cargo tanks should be provided with a pressure relief system appropriate to the design of the cargo containment system and the cargo being carried. Hold spaces, interbarrier spaces and cargo piping which may be subject to pressures beyond their design capabilities should also be provided with a suitable pressure relief system. The pressure relief system should be connected to a vent piping system so designed as to minimize the possibility of cargo vapour accumulating on the decks, or entering accommodation spaces, service spaces, control stations and machinery spaces, or other spaces where it may create a dangerous condition. Pressure control systems specified by chapter 7 should be independent of the pressure relief valves.

8.2 Pressure relief systems

8.2.1 Each cargo tank with a volume exceeding  $20 \text{ m}^3$  should be fitted with at least two pressure relief valves of approximately equal capacity, suitably designed and constructed for the prescribed service. For cargo tanks with a volume not exceeding  $20 \text{ m}^3$ , a single relief valve may be fitted.

8.2.2 Interbarrier spaces should be provided with pressure relief devices to the satisfaction of the Administration.

8.2.3 The setting of the pressure relief valves should not be higher than the vapour pressure which has been used in the design of the tank.

8.2.4 Pressure relief valves should be connected to the highest part of the cargo tank above deck level. Pressure relief valves on cargo tanks with a design temperature below  $0^{\circ}\text{C}$  should be arranged to prevent their becoming inoperative due to ice formation when they are closed. Due consideration should be given to the construction and arrangement of pressure relief valves on cargo tanks subject to low ambient temperatures.

8.2.5 Pressure relief valves should be prototype tested to ensure that the valves have the capacity required. Each valve should be tested to ensure that it opens at the prescribed pressure setting with an allowance not exceeding  $\pm 10\%$  for 0 to 1.5 bar,  $\pm 6\%$  for 1.5 to 3.0 bar,  $\pm 3\%$  for 3.0 bar and above. Pressure relief valves should be set and sealed by a competent authority acceptable to the Administration and a record of this action, including the values of set pressure, should be retained aboard the ship.

8.2.6 In the case of cargo tanks permitted to have more than one relief valve setting this may be accomplished by:

- .1 installing two or more properly set and sealed valves and providing means as necessary for isolating the valves not in use from the cargo tank; or
- .2 installing relief valves whose settings may be changed by the insertion of previously approved spacer pieces or alternative springs or by other similar means not requiring pressure testing to verify the new set pressure. All other valve adjustments should be sealed.

8.2.7 The changing of the set pressure under the provisions of 8.2.6 should be carried out under the supervision of the master in accordance with procedures approved by the Administration and specified in the ship's operating manual. Changes in set pressures should be recorded in the ship's log and a sign posted in the cargo control room, if provided, and at each relief valve, stating the set pressure.

8.2.8 Stop valves or other means of blanking off pipes between tanks and pressure relief valves to facilitate maintenance should not be fitted unless all the following arrangements are provided:

- .1 suitable arrangements to prevent more than one pressure relief valve being out of service at the same time;
- .2 a device which automatically and in a clearly visible way indicates which one of the pressure relief valves is out of service; and

.3 pressure relief valve capacities such that if one valve is out of service the remaining valves have the combined relieving capacity required by 8.5. However, this capacity may be provided by the combined capacity of all valves, if a suitably maintained valve is carried on board.

8.2.9 Each pressure relief valve installed on a cargo tank should be connected to a venting system, which should be so constructed that the discharge of gas will be directed upwards and so arranged as to minimize the possibility of water or snow entering the vent system. The height of vent exits should be not less than  $B/3$  or 6 m whichever is greater, above the weather deck and 6 m above the working area and the fore and aft gangway.

8.2.10 Cargo tank pressure relief valve vent exits should be arranged at a distance at least equal to  $B$  or 25 m, whichever is less, from the nearest air intake or opening to accommodation spaces, service spaces and control stations, or other gas-safe spaces. For ships less than 90 m in length, smaller distances may be permitted by the Administration. All other vent exits connected to the cargo containment system should be arranged at a distance of at least 10 m from the nearest air intake or opening to accommodation spaces, service spaces and control stations, or other gas-safe spaces.

8.2.11 All other cargo vent exits not dealt with in other chapters should be arranged in accordance with 8.2.9 and 8.2.10.

8.2.12 If cargoes which react in a hazardous manner with each other are carried simultaneously, a separate pressure relief system should be fitted for each cargo carried.

8.2.13 In the vent piping system, means for draining liquid from places where it may accumulate should be provided. The pressure relief valves and piping should be so arranged that liquid can under no circumstances accumulate in or near the pressure relief valves.

8.2.14 Suitable protection screens should be fitted on vent outlets to prevent the ingress of foreign objects.

8.2.15 All vent piping should be so designed and arranged that it will not be damaged by temperature variations to which it may be exposed, or by the ship's motions.

8.2.16 The back pressure in the vent lines from the pressure relief valves should be taken into account in determining the flow capacity required by 8.5.

8.2.17 Pressure relief valves should be positioned on the cargo tank so that they will remain in the vapour phase under conditions of 15° list and 0.015 L trim, where L is as defined in 1.3.23.

### 8.3 Additional pressure relieving system for liquid level control

8.3.1 Where required by 15.1.4.2, an additional pressure relieving system to prevent the tank from becoming liquid full at any time during relief under the fire exposure conditions referred to in 8.5 should be fitted to each tank. This pressure relieving system should consist of:

- .1 one or more relief valves set at a pressure corresponding to the gauge vapour pressure of the cargo at the reference temperature defined in 15.1.4.2; and

- .2 an override arrangement, whenever necessary, to prevent its normal operation. This arrangement should include fusible elements designed to melt at temperatures between 98°C and 104°C and to cause relief valves specified in 8.3.1.1 to become operable. The fusible elements should be located, in particular, in the vicinity of relief valves. The system should become operable upon loss of system power if provided. The override arrangement should not be dependent on any source of ship's power.

8.3.2 The total relieving capacity of the additional pressure relieving system at the pressure mentioned in 8.3.1.1 should not be less than:

$$Q' = FG' A^{0.82} \quad (\text{m}^3/\text{s})$$

where:

$Q'$  = minimum required rate of discharge of air at standard conditions of 273 K and 1.013 bar.

$$G' = \frac{12.4}{(L + \rho_r m) D} \sqrt{\frac{Z \cdot T'}{M}}$$

with:

$\rho_r$  = relative density of liquid phase of product at relieving conditions ( $\rho_r = 1.0$  for fresh water);

$m$  =  $-di/d\rho_r$  = gradient of decrease of liquid phase enthalpy against increase of liquid phase density (kJ/kg) at relieving conditions. For set pressures not higher than 2.0 bar the values in table 8.1 may be used. For products not listed in the table and for higher set pressures, the value of  $m$  should be calculated on the basis of the thermodynamic data of the product itself;

$i$  = enthalpy of liquid (kJ/kg);

$T'$  = temperature in kelvins (K) at relieving conditions, i.e. at the pressure at which the additional pressure relieving system is set;

$F$ ,  $A$ ,  $L$ ,  $D$ ,  $Z$  and  $M$  are defined in 8.5.2.

8.3.3 Compliance with 8.3.1.1 requires changing of the setting of the relief valves provided for in this section. This should be accomplished in accordance with the provisions of 8.2.6 and 8.2.7.

8.3.4 Relief valves mentioned under 8.3.1.1 above may be the same as the pressure relief valves mentioned in 8.2, provided the setting pressure and the relieving capacity are in compliance with the requirements of this section.

8.3.5 The exhaust of such pressure relief valves may be led to the venting system referred to in 8.2.9. If separate venting arrangements are fitted these should be in accordance with the requirements of 8.2.9 to 8.2.15.

TABLE 8.1 - FACTOR m

Product	$m = -di/d_{Pr}$ (kJ/kg)
Ammonia, anhydrous	3400
Butadiene	1800
Butane	2000
Butylenes	1900
Ethane	2100
Ethylene	1500
Methane	2300
Methyl chloride	816
Nitrogen	400
Propane	2000
Propylene	1600
Propylene oxide	1550
Vinyl chloride	900

The values in this table may be used for set pressures not higher than 2.0 bar.

#### 8.4 Vacuum protection systems

8.4.1 Cargo tanks designed to withstand a maximum external pressure differential exceeding 0.25 bar and capable of withstanding the maximum external pressure differential which can be attained at maximum discharge rates with no vapour return into the cargo tanks, or by operation of a cargo refrigeration system, need no vacuum relief protection.

8.4.2 Cargo tanks designed to withstand a maximum external pressure differential not exceeding 0.25 bar, or tanks which cannot withstand the maximum external pressure differential that can be attained at maximum discharge rates with no vapour return into the cargo tanks, or by operation of a cargo refrigeration system, or by sending boil-off vapour to the machinery spaces, should be fitted with:

- .1 two independent pressure switches to sequentially alarm and subsequently stop all suction of cargo liquid or vapour from the cargo tank, and refrigeration equipment if fitted, by suitable means at a pressure sufficiently below the maximum external designed pressure differential of the cargo tank; or
- .2 vacuum relief valves with a gas flow capacity at least equal to the maximum cargo discharge rate per cargo tank, set to open at a pressure sufficiently below the external design differential pressure of the cargo tank; or
- .3 other vacuum relief systems acceptable to the Administration.

8.4.3 Subject to the requirements of chapter 17, the vacuum relief valves should admit an inert gas, cargo vapour or air to the cargo tank and should be arranged to minimize the possibility of the entrance of water or snow. If cargo vapour is admitted, it should be from a source other than the cargo vapour lines.

8.4.4 The vacuum protection system should be capable of being tested to ensure that it operates at the prescribed pressure.

#### 8.5 Size of valves

Pressure relief valves should have a combined relieving capacity for each cargo tank to discharge the greater of the following with not more than a 20% rise in cargo tank pressure above the MARVS:

- .1 the maximum capacity of the cargo tank inerting system if the maximum attainable working pressure of the cargo tank inerting system exceeds the MARVS of the cargo tanks; or

.2 vapours generated under fire exposure computed using the following formula:

$$Q = FGA^{0.82} \quad (\text{m}^3/\text{s})$$

where:

Q = minimum required rate of discharge of air at standard conditions of 273 K and 1.013 bar.

F = fire exposure factor for different cargo tank types:

F = 1.0 for tanks without insulation located on deck;

F = 0.5 for tanks above the deck when insulation is approved by the Administration. (Approval will be based on the use of an approved fireproofing material, the thermal conductance of insulation, and its stability under fire exposure);

F = 0.5 for uninsulated independent tanks installed in holds;

F = 0.2 for insulated independent tanks in holds (or uninsulated independent tanks in insulated holds);

F = 0.1 for insulated independent tanks in inerted holds (or uninsulated independent tanks in inerted, insulated holds);

F = 0.1 for membrane and semi-membrane tanks.

For independent tanks partly protruding through the open deck, the fire exposure factor should be determined on the basis of the surface areas above and below deck.

G = gas factor

$$G = \frac{12.4}{LD} \sqrt{\frac{Z \cdot T}{M}}$$

with:

T = temperature in kelvins (K) at relieving conditions, i.e. 120% of the pressure at which the pressure relief valve is set.

L = latent heat of the material being vaporized at relieving conditions, in kJ/kg



D = constant based on relation of specific heats k, shown in table 8.2; if k is not known, D = 0.606 should be used. The constant D may also be calculated by the following formula:

$$D = \sqrt{k \left( \frac{2}{k+1} \right)^{\frac{k+1}{k-1}}}$$

Z = compressibility factor of the gas at relieving conditions; if not known, Z = 1.0 should be used.

M = molecular mass of the product

A = external surface area of the tank (m<sup>2</sup>) for different tank types:

for body-of-revolution type tanks:

A = external surface area;

for other than body-of-revolution type tanks:

A = external surface area less the projected bottom surface area;

for tanks consisting of an array of pressure vessel tanks:

- insulation on the ship's structure:

A = external surface area of the hold less its projected area;

- insulation on the tank structure:

A = external surface area of the array of pressure vessels excluding insulation, less the projected bottom area as shown in figure 8.1.

TABLE 8.2 - CONSTANT D

k	D	k	D
1.00	0.606	1.52	0.704
1.02	0.611	1.54	0.707
1.04	0.615	1.56	0.710
1.06	0.620	1.58	0.713
1.08	0.624	1.60	0.716
1.10	0.628	1.62	0.719
1.12	0.633	1.64	0.722
1.14	0.637	1.66	0.725
1.16	0.641	1.68	0.728
1.18	0.645	1.70	0.731
1.20	0.649	1.72	0.734
1.22	0.652	1.74	0.736
1.24	0.656	1.76	0.739
1.26	0.660	1.78	0.742
1.28	0.664	1.80	0.745
1.30	0.667	1.82	0.747
1.32	0.671	1.84	0.750
1.34	0.674	1.86	0.752
1.36	0.677	1.88	0.755
1.38	0.681	1.90	0.758
1.40	0.685	1.92	0.760
1.42	0.688	1.94	0.763
1.44	0.691	1.96	0.765
1.46	0.695	1.98	0.767
1.48	0.698	2.00	0.770
1.50	0.701	2.02	0.772
		2.20	0.792

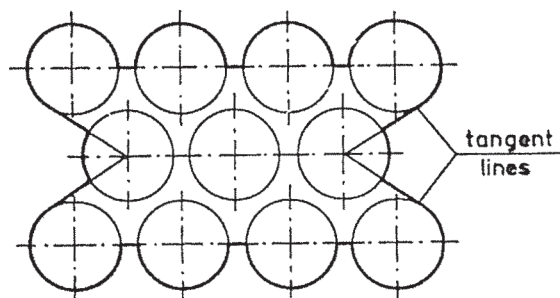


Figure 8.1

CHAPTER 9 - ENVIRONMENTAL CONTROL

9.1 Environmental control within cargo tanks and cargo piping systems

9.1.1 A piping system should be provided to enable each cargo tank to be safely gas-freed, and to be safely purged with cargo gas from a gas-free condition. The system should be arranged to minimize the possibility of pockets of gas or air remaining after gas-freeing or purging.

9.1.2 A sufficient number of gas sampling points should be provided for each cargo tank in order to adequately monitor the progress of purging and gas-freeing. Gas sampling connections should be valved and capped above the main deck.

9.1.3 For flammable gases, the system should be arranged to minimize the possibility of a flammable mixture existing in the cargo tank during any part of the gas-freeing operation by utilizing an inerting medium as an intermediate step. In addition, the system should enable the cargo tank to be purged with an inerting medium prior to filling with cargo vapour or liquid, without permitting a flammable mixture to exist at any time within the cargo tank.

9.1.4 Piping systems which may contain cargo should be capable of being gas-freed and purged as provided in 9.1.1 and 9.1.3.

9.1.5 Inert gas utilized in these procedures may be provided from the shore or from the ship.

9.2 Environmental control within the hold spaces (cargo containment systems other than type C independent tanks)

9.2.1 Interbarrier and hold spaces associated with cargo containment systems for flammable gases requiring full secondary barriers should be inerted with a suitable dry inert gas and kept inerted with make-up gas provided by a shipboard inert gas generation system, or by shipboard storage which should be sufficient for normal consumption for at least 30 days.

9.2.2.1 Interbarrier and hold spaces associated with cargo containment systems for flammable gases requiring partial secondary barriers should be inerted with suitable dry inert gas and kept inerted with make-up gas provided by a shipboard inert gas generation system or by shipboard storage which should be sufficient for normal consumption for at least 30 days.

9.2.2.2 Alternatively, subject to the restrictions specified in chapter 17, the Administration may allow the spaces referred to in 9.2.2.1 to be filled with dry air provided that the ship maintains a stored charge of inert gas or is fitted with an inert gas generation system sufficient to inert the largest of these spaces; and provided that the configuration of the spaces and the relevant vapour detection systems, together with the capability of the inerting arrangements, ensure that any leakage from the cargo tanks will be rapidly detected and inerting effected before a dangerous condition can develop. Equipment for the provision of sufficient dry air of suitable quality to satisfy the expected demand should be provided.

9.2.3 For non-flammable gases, the spaces referred to in 9.2.1 and 9.2.2.1 may be maintained with a suitable dry air or inert atmosphere.

9.2.4 In case of internal insulation tanks, environmental control arrangements are not required for interbarrier spaces and spaces between the secondary barrier and the inner hull or independent tank structures completely filled with insulation materials complying with 4.9.7.2.

9.3 Environmental control of spaces surrounding type C independent tanks

Spaces surrounding refrigerated cargo tanks not having secondary barriers should be filled with suitable dry inert gas or dry air and be maintained in this condition with make-up inert gas provided by a shipboard inert gas generation system, shipboard storage of inert gas, or dry air provided by suitable air drying equipment.

9.4 Inerting

9.4.1 Inerting refers to the process of providing a non-combustible environment by the addition of compatible gases, which may be carried in storage vessels or produced on board the ship or supplied from the shore. The inert gases should be compatible chemically and operationally, at all temperatures likely to occur within the spaces to be inerted, with the materials of construction of the spaces and the cargo. The dew points of the gases should be taken into consideration.

9.4.2 Where inert gas is also stored for fire-fighting purposes, it should be carried in separate containers and should not be used for cargo services.

9.4.3 Where inert gas is stored at temperatures below 0°C, either as a liquid or as a vapour, the storage and supply system should be so designed that the temperature of the ship's structure is not reduced below the limiting values imposed on it.

9.4.4 Arrangements suitable for the cargo carried should be provided to prevent the backflow of cargo vapour into the inert gas system.

9.4.5 The arrangements should be such that each space being inerted can be isolated and the necessary controls and relief valves etc. should be provided for controlling pressure in these spaces.

#### 9.5 Inert gas production on board

9.5.1 The equipment should be capable of producing inert gas with an oxygen content at no time greater than 5% by volume subject to the special requirements of chapter 17. A continuous-reading oxygen content meter should be fitted to the inert gas supply from the equipment and should be fitted with an alarm set at a maximum of 5% oxygen content by volume subject to the requirements of chapter 17. Additionally, where inert gas is made by an on-board process of fractional distillation of air which involves the storage of the cryogenic liquefied nitrogen for subsequent release, the liquefied gas entering the storage vessel should be monitored for traces of oxygen to avoid possible initial high oxygen enrichment of the gas when released for inerting purposes.

9.5.2 An inert gas system should have pressure controls and monitoring arrangements appropriate to the cargo containment system. A means acceptable to the Administration, located in the cargo area, of preventing the backflow of cargo gas should be provided.

9.5.3 Spaces containing inert gas generating plants should have no direct access to accommodation spaces, service spaces or control stations, but may be located in machinery spaces. If such plants are located in machinery spaces or other spaces outside the cargo tank area, two non-return valves, or equivalent devices should be fitted in the inert gas main in the cargo area as required in 9.5.2. Inert gas piping should not pass through accommodation spaces, service spaces or control stations.

9.5.4 Flame burning equipment for generating inert gas should not be located within the cargo area. Special consideration may be given to the location of inert gas generating equipment using the catalytic combustion process.

CHAPTER 10 - ELECTRICAL INSTALLATIONS

10.1 General

10.1.1 The provisions of this chapter are applicable to ships carrying flammable products and should be applied in conjunction with part D of chapter II-1 of the 1983 SOLAS amendments.

10.1.2 Electrical installations should be such as to minimize the risk of fire and explosion from flammable products. Electrical installations complying with this chapter need not be considered as a source of ignition for the purposes of chapter 3.

10.1.3 Administrations should take appropriate steps to ensure uniformity in the implementation and application of the provisions of this chapter in respect of electrical installations.\*

10.1.4 Electrical equipment or wiring should not be installed in gas-dangerous spaces or zones unless essential for operational purposes, when the exceptions listed in 10.2 are permitted.

10.1.5 Where electrical equipment is installed in gas-dangerous spaces or zones as provided in 10.1.4, it should be to the satisfaction of the Administration and approved by the relevant authorities recognized by the Administration for operation in the flammable atmosphere concerned.

10.2 Types of equipment

Certified safe type equipment may be fitted in gas-dangerous spaces and zones in accordance with the following provisions:

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\* Reference is made to the Recommendations published by the International Electrotechnical Commission and in particular to Publication 92-502.

#### 10.2.1 Gas-dangerous spaces and zones, general

Intrinsically safe electrical equipment and wiring may be fitted in all gas-dangerous spaces and zones as defined in 1.3.17.

#### 10.2.2 Cargo containment systems

Submerged cargo pump motors and their supply cables may be fitted in cargo containment systems. Arrangements should be made to automatically shut down the motors in the event of low liquid level. This may be accomplished by sensing low pump discharge pressure, low motor current, or low liquid level. This shutdown should be alarmed at the cargo control station. Cargo pump motors should be capable of being isolated from their electrical supply during gas-freeing operations.

#### 10.2.3 Hold spaces and certain other spaces

10.2.3.1 In hold spaces where cargo is carried in a cargo containment system requiring a secondary barrier, supply cables for submerged cargo pump motors may be installed.

10.2.3.2 In hold spaces where cargo is carried in a cargo containment system not requiring a secondary barrier and in spaces described in 1.3.17.5, the following may be installed:

- .1 through runs of cables;
- .2 lighting fittings with pressurized enclosures or of the flameproof type. The lighting system should be divided between at least two branch circuits. All switches and protective devices should interrupt all poles or phases and be located in a gas-safe space; and
- .3 electrical depth sounding or log devices and impressed current cathodic protection system anodes or electrodes. These devices should be housed in gastight enclosures;

and only in spaces described in 1.3.17.5:

- .4 flameproof motors for valve operation for cargo or ballast systems; and
- .5 flameproof general alarm audible indicators.



10.2.4 Cargo pump and cargo compressor rooms

10.2.4.1 Lighting fittings should have pressurized enclosures or should be of the flameproof type. The lighting system should be divided between at least two branch circuits. All switches and protective devices should interrupt all poles or phases and be located in a gas-safe space.

10.2.4.2 Electric motors for driving cargo pumps or cargo compressors should be separated from these spaces by a gastight bulkhead or deck. Flexible couplings or other means of maintaining alignment should be fitted to the shafts between the driven equipment and its motors and, in addition, suitable glands should be provided where the shafts pass through the gastight bulkhead or deck. Such electric motors and associated equipment should be located in a compartment complying with chapter 12.

10.2.4.3 Where operational or structural requirements are such as to make it impossible to comply with the method described in 10.2.4.2, motors of the following certified safe types may be installed:

- .1 increased safety type with flameproof enclosure; and
- .2 pressurized type.

10.2.4.4 General alarm audible indicators should have flameproof enclosures.

10.2.5 Zones on open decks, spaces other than hold spaces

10.2.5.1 In zones on open decks or non-enclosed spaces on the open deck, within 3 m of any cargo tank outlet, gas or vapour outlet, cargo pipe flange, cargo valves or entrances and ventilation openings to cargo pump rooms and cargo compressor rooms; in zones on the open deck over the cargo area and 3 m forward and aft of the cargo area on the open deck and up to a height of 2.4 m above the deck; in zones within 2.4 m of the outer surface of a cargo containment system where such surface is exposed to the weather the following may be installed:

- .1 certified safe type equipment; and
- .2 through runs of cables.

10.2.5.2 In enclosed or semi-enclosed spaces in which pipes containing cargo products are located and in compartments for cargo hoses the following may be installed:

- .1 lighting fittings with pressurized enclosures, or of the flame-proof type. The lighting system should be divided between at least two branch circuits. All switches and protective devices should interrupt all poles or phases and be located in a gas-safe space; and
- .2 through runs of cables.

10.2.5.3 In enclosed or semi-enclosed spaces having a direct opening into any gas-dangerous space or zone there should be installed electrical installations complying with the requirements for the space or zone to which the opening leads.

10.2.5.4 Electrical equipment within spaces protected by air-locks should be of the certified safe type unless arranged to be de-energized by measures required by 3.6.4.

CHAPTER 11 - FIRE PROTECTION AND FIRE EXTINGUISHMENT

11.1 Fire safety requirements

11.1.1 The requirements for tankers in chapter II-2 of the 1983 SOLAS amendments should apply to ships covered by the Code, irrespective of tonnage including ships of less than 500 tons gross tonnage, except that:

- .1 regulation 56.4 does not apply;
- .2 regulation 4 as applicable to cargo ships and regulation 7 should apply as they would apply to tankers of 2,000 tons gross tonnage and over;
- .3 the following regulations of chapter II-2 of the 1983 SOLAS amendments related to tankers do not apply and are replaced by chapters and sections of the Code as detailed below:

<u>Regulation</u>	<u>Replaced by</u>
17	11.6
56.1 and 56.2	chapter 3
60, 61, 62	11.3 and 11.4
63	11.5

11.1.2 All sources of ignition should be excluded from spaces where flammable vapour may be present except as otherwise provided in chapters 10 and 16.

11.1.3 The provisions of this section apply in conjunction with chapter 3.

11.1.4 For the purposes of fire fighting, any open deck areas above cofferdams, ballast or void spaces at the after end of the aftermost hold space or at the forward end of the forwardmost hold space should be included in the cargo area.

## 11.2 Fire water main equipment

11.2.1 All ships, irrespective of size, carrying products which are subject to this Code should comply with the requirements of regulations II-2/4 and II-2/7 of the 1983 SOLAS amendments, except that the required fire pump capacity and fire main and water service pipe diameter should not be limited by the provisions of regulations 4.2.1 and 4.4.1 when the fire pump and fire main are used as part of the water spray system as permitted by 11.3.3. In addition, the requirements of regulation 4.4.2 should be met at a pressure of at least 5.0 bar gauge.

11.2.2 The arrangements should be such that at least two jets of water can reach any part of the deck in the cargo area and those portions of the cargo containment system and tank covers above the deck. The necessary number of fire hydrants should be located to satisfy the above arrangements and to comply with the requirements of regulations II-2/4.5.1 and II-2/4.8 of the 1983 SOLAS amendments, with hose lengths not exceeding 33 m.

11.2.3 Stop valves should be fitted in any crossover provided and in the fire main or mains at the poop front and at intervals of not more than 40 m between hydrants on the deck in the cargo area for the purpose of isolating damaged sections of the main.

11.2.4 All water nozzles provided for fire-fighting use should be of an approved dual-purpose type capable of producing either a spray or a jet. All pipes, valves, nozzles and other fittings in the fire-fighting systems should be resistant to corrosion by seawater, for which purpose galvanized pipe, for example, may be used, and to the effect of fire.

11.2.5 Where the ship's engine-room is unattended, arrangements should be made to start and connect to the fire main at least one fire pump by remote control from the navigating bridge or other control station outside the cargo area.

### 11.3 Water spray system

11.3.1 On ships carrying flammable or toxic products or both, a water spray system for cooling, fire prevention and crew protection should be installed to cover:

- .1 exposed cargo tank domes and any exposed parts of cargo tanks;
- .2 exposed on-deck storage vessels for flammable or toxic products;
- .3 cargo liquid and vapour discharge and loading manifolds and the area of their control valves and any other areas where essential control valves are situated and which should be at least equal to the area of the drip trays provided; and
- .4 boundaries of superstructures and deckhouses normally manned, cargo compressor rooms, cargo pump rooms, store-rooms containing high fire risk items and cargo control rooms, all facing the cargo area. Boundaries of unmanned forecastle structures not containing high fire risk items or equipment do not require water spray protection.

11.3.2 The system should be capable of covering all areas mentioned in 11.3.1 with a uniformly distributed water spray of at least  $10 \text{ l/m}^2$  per minute for horizontal projected surfaces and  $4 \text{ l/m}^2$  per minute for vertical surfaces. For structures having no clearly defined horizontal or vertical surfaces, the capacity of the water spray system should be the greater of the following:

- .1 projected horizontal surface multiplied by  $10 \text{ l/m}^2$  per minute; or
- .2 actual surface multiplied by  $4 \text{ l/m}^2$  per minute.

On vertical surfaces, spacing of nozzles protecting lower areas may take account of anticipated rundown from higher areas. Stop valves should be fitted at intervals in the spray main for the purpose of isolating damaged sections. Alternatively, the system may be divided into two or more sections which may be operated independently provided the necessary controls are located together, aft of the cargo area. A section protecting any area included in 11.3.1.1 and .2 should cover the whole of the athwartship tank grouping which includes that area.

11.3.3 The capacity of the water spray pumps should be sufficient to deliver the required amount of water to all areas simultaneously or where the system is divided into sections, the arrangements and capacity should be such as to supply water simultaneously to any one section and to the surfaces specified in 11.3.1.3 and .4. Alternatively, the main fire pumps may be used for this service provided that their total capacity is increased by the amount needed for the spray system. In either case, a connection, through a stop valve, should be made between the fire main and water spray main outside the cargo area.

11.3.4 Subject to the approval of the Administration, water pumps normally used for other services may be arranged to supply the water spray main.

11.3.5 All pipes, valves, nozzles and other fittings in the water spray systems should be resistant to corrosion by seawater, for which purpose galvanized pipe, for example, may be used, and to the effect of fire.

#### 11.4 Dry chemical powder fire-extinguishing systems

11.4.1 Ships in which the carriage of flammable products is intended should be fitted with fixed dry chemical powder type extinguishing systems for the purpose of fighting fire on the deck in the cargo area and bow or stern cargo handling areas if applicable. The system and the dry chemical powder should be adequate for this purpose and satisfactory to the Administration.

11.4.2 The system should be capable of delivering powder from at least two hand hose lines or combination monitor/hand hose lines to any part of the above-deck exposed cargo area including above-deck product piping. The system should be activated by an inert gas such as nitrogen, used exclusively for this purpose and stored in pressure vessels adjacent to the powder containers.

11.4.3 The system for use in the cargo area should consist of at least two independent self-contained dry chemical powder units with associated controls, pressurizing medium fixed piping, monitors or hand hose lines. For ships with a cargo capacity of less than 1,000 m<sup>3</sup> only one such unit need be fitted, subject to approval by the Administration. A monitor should be provided and so arranged as to protect the cargo loading and discharge manifold areas and be capable of actuation and discharge locally and remotely. The monitor is not required to be remotely aimed if it can deliver the necessary powder to all required areas of coverage from a single position. All hand hose lines and monitors should be capable of actuation at the hose storage reel or monitor. At least one hand hose line or monitor should be situated at the after end of the cargo area.

11.4.4 A fire-extinguishing unit having two or more monitors, hand hose lines, or combinations thereof, should have independent pipes with a manifold at the powder container, unless a suitable alternative means is provided to ensure proper performance as approved by the Administration. Where two or more pipes are attached to a unit the arrangement should be such that any or all of the monitors and hand hose lines should be capable of simultaneous or sequential operation at their rated capacities.

11.4.5 The capacity of a monitor should be not less than 10 kg/s. Hand hose lines should be non-kinkable and be fitted with a nozzle capable of on/off operation and discharge at a rate not less than 3.5 kg/s. The maximum discharge rate should be such as to allow operation by one man. The length of a hand hose line should not exceed 33 m. Where fixed piping is provided between the powder container and a hand hose line or monitor, the length of piping should not exceed that length which is capable of maintaining the powder in a fluidized state during sustained or intermittent use, and which can be purged of powder when the system is shut down. Hand hose lines and nozzles should be of weather-resistant construction or stored in weather-resistant housing or covers and be readily accessible.

11.4.6 A sufficient quantity of dry chemical powder should be stored in each container to provide a minimum 45 seconds discharge time for all monitors and hand hose lines attached to each powder unit. Coverage from fixed monitors should be in accordance with the following requirements:

Capacity of fixed monitors (kg/s) each 10 25 45

Maximum distance of coverage (m) 10 30 40

Hand hose lines should be considered to have a maximum effective distance of coverage equal to the length of hose. Special consideration should be given where areas to be protected are substantially higher than the monitor or hand hose reel locations.

11.4.7 Ships fitted with bow or stern loading and discharge arrangements should be provided with an additional dry chemical powder unit complete with at least one monitor and one hand hose line complying with the requirements of 11.4.1 to 11.4.6. This additional unit should be located to protect the bow or stern loading and discharge arrangements. The area of the cargo line forward or aft of the cargo area should be protected by hand hose lines.



### 11.5 Gas-dangerous enclosed spaces

11.5.1 Enclosed spaces normally entered where flammable liquid or vapour leakage may occur, such as cargo compressor and pump rooms, should be provided with a fixed installation which is capable of extinguishing a fire within the space. Additionally, this system or another fixed system should be capable of inerting the space following a fire to ensure that the fire does not recur. For purposes of design, the boundaries of the space should be assumed to remain intact. Carbon dioxide and steam smothering systems should be avoided unless due consideration is given to the danger of static electricity.

11.5.2 Provision should be made for closure of ventilation and any other openings into the space and, where necessary, for an audible warning signal to be sounded within the space for the emergency escape of personnel before admission of the inerting/extinguishing medium.

### 11.6 Firemen's outfits

11.6.1 Every ship carrying flammable products should carry firemen's outfits complying with the requirements of regulation II-2/17 of the 1983 SOLAS amendments as follows:

<u>Total cargo capacity</u>	<u>Number of outfits</u>
below 2,000 m <sup>3</sup>	2
between 2,000 m <sup>3</sup> and 5,000 m <sup>3</sup>	4
above 5,000 m <sup>3</sup>	5

11.6.2 Additional requirements for safety equipment are given in chapter 14.

11.6.3 Any breathing apparatus required as part of a fireman's outfit should be a self-contained air-breathing apparatus having a capacity of at least 1,200ℓ of free air.

## CHAPTER 12 - MECHANICAL VENTILATION IN THE CARGO AREA

The requirements of this chapter replace regulation II-2/59.3 of the 1983 SOLAS amendments.

12.1 Spaces required to be entered during normal cargo handling operations

12.1.1 Electric motor rooms, cargo compressor and pump rooms, other enclosed spaces which contain cargo handling equipment and similar spaces in which cargo handling operations are performed should be fitted with mechanical ventilation systems capable of being controlled from outside such spaces. Provision should be made to ventilate such spaces prior to entering the compartment and operating the equipment and a warning notice requiring the use of such ventilation should be placed outside the compartment.

12.1.2 Mechanical ventilation inlets and outlets should be arranged to ensure sufficient air movement through the space to avoid the accumulation of flammable or toxic vapours and to ensure a safe working environment, but in no case should the ventilation system have a capacity of less than 30 changes of air per hour based upon the total volume of the space. As an exception, gas-safe cargo control rooms may have eight changes of air per hour.

12.1.3 Ventilation systems should be fixed and, if of the negative pressure type, permit extraction from either the upper or the lower parts of the spaces, or from both the upper and the lower parts, depending on the density of the vapours of the products carried.

12.1.4 In rooms housing electric motors driving cargo compressors or pumps, spaces except machinery spaces containing inert gas generators, cargo control rooms if considered as gas-safe spaces and other gas-safe spaces within the cargo area, the ventilation should be of the positive pressure type.

12.1.5 In cargo compressor and pump rooms and in cargo control rooms if considered gas-dangerous, the ventilation should be of the negative pressure type.

12.1.6 Ventilation exhaust ducts from gas-dangerous spaces should discharge upwards in locations at least 10 m in the horizontal direction from ventilation intakes and openings to accommodation spaces, service spaces and control stations and other gas-safe spaces.

12.1.7 Ventilation intakes should be so arranged as to minimize the possibility of re-cycling hazardous vapours from any ventilation discharge opening.

12.1.8 Ventilation ducts from gas-dangerous spaces should not be led through accommodation, service and machinery spaces or control stations, except as allowed in chapter 16.

12.1.9 Electric motors driving fans should be placed outside the ventilation ducts if the carriage of flammable products is intended. Ventilation fans should not produce a source of vapour ignition in either the ventilated space or the ventilation system associated with the space. Ventilation fans and fan ducts, in way of fans only, for gas-dangerous spaces should be of nonsparking construction defined as:

- .1 impellers or housing of nonmetallic construction, due regard being paid to the elimination of static electricity;
- .2 impellers and housing of nonferrous materials;
- .3 impellers and housing of austenitic stainless steel; and
- .4 ferrous impellers and housing with not less than 13 mm design tip clearance.

Any combination of an aluminium or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and should not be used in these places.

12.1.10 Spare parts should be carried for each type of fan on board referred to in this chapter.

12.1.11 Protection screens of not more than 13 mm square mesh should be fitted in outside openings of ventilation ducts.

#### 12.2 Spaces not normally entered

Hold spaces, interbarrier spaces, void spaces, cofferdams, spaces containing cargo piping and other spaces where cargo vapours may accumulate, should be capable of being ventilated to ensure a safe environment when entry into the spaces is necessary. Where a permanent ventilation system is not provided for such spaces, approved means of portable mechanical ventilation should be provided. Where necessary owing to the arrangement of spaces, such as hold spaces and interbarrier spaces, essential ducting for such ventilation should be permanently installed. Fans or blowers should be clear of personnel access openings, and should comply with 12.1.9.

CHAPTER 13 - INSTRUMENTATION (GAUGING, GAS DETECTION)

13.1 General

13.1.1 Each cargo tank should be provided with means for indicating level, pressure and temperature of the cargo. Pressure gauges and temperature indicating devices should be installed in the liquid and vapour piping systems, in cargo refrigerating installations and in the inert gas systems as detailed in this chapter.

13.1.2 Where a secondary barrier is required, permanently installed instrumentation should be provided to detect when the primary barrier fails to be liquid-tight at any location or when liquid cargo is in contact with the secondary barrier at any location. This instrumentation should consist of appropriate gas detecting devices according to 13.6. However, the instrumentation need not be capable of locating the area where liquid cargo leaks through the primary barrier or where liquid cargo is in contact with the secondary barrier.

13.1.3 If the loading and unloading of the ship is performed by means of remotely controlled valves and pumps, all controls and indicators associated with a given cargo tank should be concentrated in one control position.

13.1.4 Instruments should be tested to ensure reliability in the working conditions and recalibrated at regular intervals. Test procedures for instruments and the intervals between recalibration should be approved by the Administration.

### 13.2 Level indicators for cargo tanks

13.2.1 Each cargo tank should be fitted with at least one liquid level gauging device, designed to operate at pressures not less than the MARVS of the cargo tank and at temperatures within the cargo operating temperature range. Where only one liquid level gauge is fitted it should be so arranged that any necessary maintenance can be carried out while the cargo tank is in service.

13.2.2 Cargo tank liquid level gauges may be of the following types subject to any special requirement for particular cargoes shown in column "g" in the table of Chapter 19:

- .1 indirect devices, which determine the amount of cargo by means such as weighing or pipe flow meters;
- .2 closed devices, which do not penetrate the cargo tank, such as devices using radioisotopes or ultrasonic devices;
- .3 closed devices, which penetrate the cargo tank, but which form part of a closed system and keep the cargo from being released, such as float type systems, electronic probes, magnetic probes and bubble tube indicators. If a closed gauging device is not mounted directly on the tank it should be provided with a shut-off valve located as close as possible to the tank; and
- .4 restricted devices, which penetrate the tank and when in use permit a small quantity of cargo vapour or liquid to escape to the atmosphere, such as fixed tube and slip tube gauges. When not in use, the devices should be kept completely closed. The design and installation should ensure that no dangerous escape of cargo can take place when opening the device. Such gauging devices should be so designed that the maximum opening does not exceed 1.5 mm diameter or equivalent area, unless the device is provided with an excess flow valve.

13.2.3 Sighting ports with a suitable protective cover and situated above the liquid level with an internal scale may be allowed by the Administration as a secondary means of gauging for cargo tanks having a design vapour pressure not higher than 0.7 bar.

13.2.4 Tubular gauge glasses should not be fitted. Gauge glasses of the robust type as fitted on high-pressure boilers and fitted with excess flow valves may be allowed by the Administration for deck tanks, subject to any provisions of chapter 17.

### 13.3 Overflow control

13.3.1 Except as provided in 13.3.2, each cargo tank should be fitted with a high liquid level alarm operating independently of other liquid level indicators and giving an audible and visual warning when activated. Another sensor operating independently of the high liquid level alarm should automatically actuate a shutoff valve in a manner which will both avoid excessive liquid pressure in the loading line and prevent the tank from becoming liquid full. The emergency shutdown valve referred to in 5.6.4 may be used for this purpose. If another valve is used for this purpose, the same information as referred to in 5.6.4 should be available on board. During loading, whenever the use of these valves may possibly create a potential excess pressure surge in the loading system, the Administration and the port Administration may agree to alternative arrangements such as limiting the loading rate, etc.

13.3.2 A high liquid level alarm and automatic shutoff of cargo tank filling need not be required when the cargo tank:

- .1 is a pressure tank with a volume not more than  $200 \text{ m}^3$ ; or
- .2 is designed to withstand the maximum possible pressure during the loading operation and such pressure is below that of the start-to-discharge pressure of the cargo tank relief valve.

13.3.3 Electrical circuits, if any, of level alarms should be capable of being tested prior to loading.

#### 13.4 Pressure gauges

13.4.1 The vapour space of each cargo tank should be provided with a pressure gauge which should incorporate an indicator in the control position required by 13.1.3. In addition, a high-pressure alarm and, if vacuum protection is required, a low-pressure alarm, should be provided on the navigating bridge. Maximum and minimum allowable pressures should be marked on the indicators. The alarms should be activated before the set pressures are reached. For cargo tanks fitted with pressure relief valves, which can be set at more than one set pressure in accordance with 8.2.6, high-pressure alarms should be provided for each set pressure.

13.4.2 Each cargo pump discharge line and each liquid and vapour cargo manifold should be provided with at least one pressure gauge.

13.4.3 Local-reading manifold pressure gauges should be provided to indicate the pressure between stop valves and hose connections to the shore.

13.4.4 Hold spaces and interbarrier spaces without open connection to the atmosphere should be provided with pressure gauges.

#### 13.5 Temperature indicating devices

13.5.1 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.



13.5.2 When a cargo is carried in a cargo containment system with a secondary barrier at a temperature lower than  $-55^{\circ}\text{C}$ , temperature indicating devices should be provided within the insulation or on the hull structure adjacent to cargo containment systems. The devices should give readings at regular intervals and, where applicable, audible warning of temperatures approaching the lowest for which the hull steel is suitable.

13.5.3 If cargo is to be carried at temperatures lower than  $-55^{\circ}\text{C}$ , the cargo tank boundaries, if appropriate for the design of the cargo containment system, should be fitted with temperature indicating devices as follows:

- .1 A sufficient number of devices to establish that an unsatisfactory temperature gradient does not occur.
- .2 On one tank a number of devices in excess of those required in 13.5.3.1 in order to verify that the initial cool down procedure is satisfactory. These devices may be either temporary or permanent. When a series of similar ships is built, the second and successive ships need not comply with the requirements of this subparagraph.

13.5.4 The number and position of temperature indicating devices should be to the satisfaction of the Administration.

#### 13.6 Gas detection requirements

13.6.1 Gas detection equipment acceptable to the Administration and suitable for the gases to be carried should be provided in accordance with column "f" in the table of chapter 19.

13.6.2 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.

13.6.3 Pipe runs from sampling heads should not be led through gas-safe spaces except as permitted by 13.6.5.

13.6.4 Audible and visual alarms from the gas detection equipment, if required by this section, should be located on the navigating bridge, in the control position required by 13.1.3, and at the gas detector readout location.

13.6.5 Gas detection equipment may be located in the control position required by 13.1.3, on the navigating bridge or at other suitable locations. When such equipment is located in a gas-safe space the following conditions should be met:

- .1 gas-sampling lines should have shutoff valves or an equivalent arrangement to prevent cross-communication with gas-dangerous spaces; and
- .2 exhaust gas from the detector should be discharged to the atmosphere in a safe location.

13.6.6 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.

13.6.7 A permanently installed system of gas detection and audible and visual alarms should be provided for:

- .1 cargo pump rooms;
- .2 cargo compressor rooms;
- .3 motor rooms for cargo handling machinery;
- .4 cargo control rooms unless designated as gas-safe;
- .5 other enclosed spaces in the cargo area where vapour may accumulate including hold spaces and interbarrier spaces for independent tanks other than type C;

- .6 ventilation hoods and gas ducts where required by chapter 16;  
and
- .7 air-locks.

13.6.8 The gas detection equipment should be capable of sampling and analysing from each sampling head location sequentially at intervals not exceeding 30 min, except that in the case of gas detection for the ventilation hoods and gas ducts referred to in 13.6.7.6 sampling should be continuous. Common sampling lines to the detection equipment should not be fitted.

13.6.9 In the case of products which are toxic or both toxic and flammable, the Administration, except when column "h" in the table of chapter 19 refers to 17.9, may authorize the use of portable equipment for detection of toxic products as an alternative to a permanently installed system, if such equipment is used before personnel enter the spaces listed in 13.6.7 and at 30 min intervals while they remain therein.

13.6.10 For the spaces listed in 13.6.7, alarms should be activated for flammable products when the vapour concentration reaches 30% of the lower flammable limit.

13.6.11 In the case of flammable products, where cargo containment systems other than independent tanks are used, hold spaces and inter-barrier spaces should be provided with a permanently installed gas detection system capable of measuring gas concentrations of 0 to 100% by volume. The detection equipment, equipped with audible and visual alarms, should be capable of sampling and detecting from each sampling head location sequentially at intervals not exceeding 30 min. Alarms should be activated when the vapour concentration reaches the equivalent of 30% 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.

13.6.12 In the case of toxic gases, hold spaces and interbarrier 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 h and in any event before personnel enter the space and at 30 min intervals while they remain therein.

13.6.13 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.

13.6.14 A suitable instrument for the measurement of oxygen levels in inert atmospheres should be provided.

## CHAPTER 14 - PERSONNEL PROTECTION

14.1 Protective equipment

Suitable protective equipment including eye protection should be provided for protection of crew members engaged in loading and discharging operations, taking into account the character of the products.

14.2 Safety equipment

14.2.1 Sufficient, but not less than two complete sets of safety equipment in addition to the firemen's outfits required by 11.6.1 each permitting personnel to enter and work in a gas-filled space, should be provided.

14.2.2 One complete set of safety equipment should consist of:

- .1 one self-contained air-breathing apparatus not using stored oxygen, having a capacity of at least 1,200ℓ of free air;
- .2 protective clothing, boots, gloves and tight-fitting goggles;
- .3 steel-cored rescue line with belt; and
- .4 explosion-proof lamp.

14.2.3 An adequate supply of compressed air should be provided and should consist either of:

- .1 one set of fully charged air bottles for each breathing apparatus required by 14.2.1;  
a special air compressor suitable for the supply of high-pressure air of the required purity; and  
a charging manifold capable of dealing with sufficient spare breathing apparatus air bottles for the breathing apparatus required by 14.2.1; or
- .2 fully charged spare air bottles with a total free air capacity of at least 6,000ℓ for each breathing apparatus required by 14.2.1.

14.2.4 Alternatively, the Administration may accept a low-pressure air line system with hose connection suitable for use with the breathing apparatus required by 14.2.1. This system should provide sufficient high-pressure air capacity to supply, through pressure reduction devices, enough low-pressure air to enable two men to work in a gas-dangerous space for at least 1 h without using the air bottles of the breathing apparatus. Means should be provided for recharging the fixed air bottles and the breathing apparatus air bottles from a special air compressor suitable for the supply of high-pressure air of the required purity.

14.2.5 Protective equipment required in 14.1 and safety equipment required in 14.2.1 should be kept in suitable, clearly marked lockers located in readily accessible places.

14.2.6 The compressed air equipment should be inspected at least once a month by a responsible officer and the inspection recorded in the ship's log-book, and inspected and tested by an expert at least once a year.

#### 14.3 First-aid equipment

14.3.1 A stretcher which is suitable for hoisting an injured person from spaces below deck should be kept in a readily accessible location.

14.3.2 Medical first-aid equipment including oxygen resuscitation equipment and antidotes, if available, for products carried should be provided on board.

#### 14.4 Personnel protection requirements for individual products

14.4.1 Provisions of 14.4 are applicable to ships carrying products for which those paragraphs are listed in column "h" in the table of chapter 19.

14.4.2 Respiratory and eye protection suitable for emergency escape purposes should be provided for every person on board subject to the following:

- .1.1 filter type respiratory protection should be accepted, only when one filter is suitable for all designated cargoes that the ship is certified to carry;
- .1.2 self-contained breathing apparatus should normally have a duration of service of at least 15 min;
- .2 emergency escape respiratory protection should not be used for fire-fighting or cargo handling purposes and should be marked to that effect;
- .3 two additional sets of the above respiratory and eye protection should be permanently located in the navigating bridge.

14.4.3 Suitably marked decontamination showers and an eye wash should be available on deck in convenient locations. The showers and eye wash should be operable in all ambient conditions.

14.4.4 In ships of a cargo capacity of 2,000 m<sup>3</sup> and over, two complete sets of safety equipment should be provided in addition to the equipment required by 11.6.1 and 14.2.1. At least three spare charged air bottles should be provided for each self-contained air breathing apparatus required in this paragraph.

14.4.5 Personnel should be protected against the effects of a major cargo release by the provision of a space within the accommodation area designed and equipped to the satisfaction of the Administration.

14.4.6 For certain highly dangerous products, cargo control rooms should be of the gas-safe type only.

## CHAPTER 15 - FILLING LIMITS FOR CARGO TANKS

15.1 General

15.1.1 No cargo tanks should be more than 98% liquid full at the reference temperature, except as permitted by 15.1.3.

15.1.2 The maximum volume to which a cargo tank should be loaded is determined by the following formula:

$$V_L = 0.98 V \frac{\rho_R}{\rho_L}$$

where:

$V_L$  = maximum volume to which the tank may be loaded

$V$  = volume of the tank

$\rho_R$  = relative density of cargo at the reference temperature

$\rho_L$  = relative density of cargo at the loading temperature and pressure.

15.1.3 The Administration may allow a higher filling limit than the limit of 98% specified in 15.1.1 and 15.1.2 at the reference temperature, taking into account the shape of the tank, arrangements of pressure relief valves, accuracy of level and temperature gauging and the difference between the loading temperature and the temperature corresponding to the vapour pressure of the cargo at the set pressure of the pressure relief valves, provided the conditions specified in 8.2.17 are maintained.

15.1.4 For the purpose of this chapter only, "reference temperature" means:

- .1 the temperature corresponding to the vapour pressure of the cargo at the set pressure of the pressure relief valves when no cargo vapour pressure/temperature control as referred to in chapter 7 is provided;



.2 the temperature of the cargo upon termination of loading, during transport, or at unloading, whichever is the greatest, when a cargo vapour pressure/temperature control as referred to in Chapter 7 is provided. If this reference temperature would result in the cargo tank becoming liquid full before the cargo reaches a temperature corresponding to the vapour pressure of the cargo at the set pressure of the relief valves required in 8.2, an additional pressure relief valve complying with 8.3 should be fitted.

15.2 Information to be provided to the master

The maximum allowable tank filling limits for each cargo tank should be indicated for each product which may be carried, for each loading temperature which may be applied and for the applicable maximum reference temperature, on a list to be approved by the Administration. Pressures at which the pressure relief valves, including those valves required by 8.3, have been set should also be stated on the list. A copy of the list should be permanently kept on board by the master.

## CHAPTER 16 - USE OF CARGO AS FUEL

16.1 General

16.1.1 Methane (LNG) is the only cargo whose vapour or boil-off gas may be utilized in main propelling machinery spaces and boiler rooms and in such spaces or rooms may be utilized only in boilers, inert gas generators, and combustion engines.

16.1.2 The provisions of this chapter do not preclude the use of vapour or boil-off gas for other services in other locations, such as cargo reliquefaction and inert gas generation, provided that such other services and locations are specially considered by the Administration.

16.2 Gas fuel supply

16.2.1 Gas fuel lines should not pass through accommodation spaces, service spaces or control stations. Gas lines may pass through or extend into other spaces provided they fulfil one of the following:

- .1 the gas fuel line should be a double wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes should be pressurized with inert gas at a pressure greater than the fuel pressure. Suitable alarms should be provided to indicate a loss of pressure between the pipes; or
- .2 the gas fuel lines should be installed in a mechanically exhaust-ventilated pipe or duct. The air space between the outer and inner walls of piping or ducts should be equipped with mechanical ventilation having a capacity of at least 30 air changes per hour. The ventilation system should be arranged to maintain a pressure less than the atmospheric pressure. The fan motors should be placed outside the ventilated pipe or duct. The ventilation outlet should be placed in a position where no flammable gas-air mixture may be ignited.

The ventilation inlet should be so arranged that gas or gas-air mixture will not be drawn into the system. The ventilation should always be in operation when there is gas in the supply pipeline. Continuous gas detection should be provided to indicate leaks and to shut down the gas fuel supply to the machinery space in accordance with 16.2.9. The exhaust fan for this duct should be so arranged that the gas fuel supply to the machinery space will be cut off if the required air flow is not established and maintained.

16.2.2 If a gas leak occurs, the gas fuel supply should not be operated until the leak has been found and repaired. Instructions to this effect should be placed in a prominent position in the machinery space.

16.2.3 The double wall piping system or the ventilated duct provided for the gas fuel lines should terminate at the ventilation hood or casing required by 16.2.4.

16.2.4 A ventilation hood or casing should be provided for the areas occupied by flanges, valves, etc., and for the gas fuel piping, which is not enclosed in the double wall piping system or ventilated duct, at gas utilization units, such as boilers, diesel engines and gas turbines. If this ventilation hood or casing is not served by the exhaust ventilation fan serving a duct as specified in 16.2.1.2, then it should be equipped with an exhaust ventilation system and continuous gas detection should be provided to indicate leaks and to shut down the gas fuel supply to the machinery space in accordance with 16.2.9. The exhaust fan should be so arranged that the gas fuel supply to the machinery space will be cut off if the exhaust ventilation is not functioning so as to produce the required air flow. The hood or casing should be installed or mounted to permit the ventilating air to sweep across the gas utilization unit and be exhausted at the top of the hood or casing.

16.2.5 Make-up air for the required ventilation air system and air discharges from the ventilation system should be taken from and led to a safe location.

16.2.6 Each gas utilization unit should be provided with a set of three automatic valves. Two of these valves should be in series in the gas fuel pipe to the consuming equipment. The other valve should be in a pipe that vents, to a safe location in the open air, that portion of the gas fuel piping that is between the two valves in series. These valves should be so arranged that failure of necessary forced draft, loss of flame on boiler burners, abnormal pressure in the gas fuel supply line, or failure of the valve control actuating medium will cause the two gas fuel valves which are in series to close automatically and cause the vent valve to open automatically. Alternatively, the function of one of the valves in series and of the valve in the vent line can be incorporated into one valve body so arranged that when one of the above conditions occurs, flow to the gas utilization unit will be blocked and the vent opened.

16.2.7 A master gas fuel valve that can be closed from within the machinery space should be provided outside the machinery space. The valve should be so arranged as to close automatically if leakage of gas is detected, or loss of ventilation for the duct or casing or loss of pressurization of the double wall gas fuel piping occurs.

16.2.8 Provision should be made for inerting and gas-freeing that portion of the gas fuel piping system located in the machinery space.

16.2.9 Gas detection systems provided in accordance with the requirements of 16.2.1 and 16.2.4 should alarm at 30% of the lower flammability limit and shut down the gas fuel supply to the machinery space before the gas concentration reaches 60% of the lower flammability limit.

16.2.10 All details of the gas fuel system should be submitted to the Administration for approval.

## CHAPTER 17 - SPECIAL REQUIREMENTS

17.1 General

The provisions of this chapter are applicable where reference is made in column "h" in the table of chapter 19. These are requirements additional to the general requirements of the Code.

17.2 Materials of construction

Materials which may be exposed to cargo during normal operations should be resistant to the corrosive action of the gases. In addition, the following materials of construction for cargo tanks, and associated pipelines, valves, fittings and other items of equipment should not be used for certain products as specified in column "h" in the table of chapter 19:

- .1 mercury, copper and copper-bearing alloys, and zinc;
- .2 copper, silver, mercury, magnesium and other acetylide-forming metals;
- .3 aluminium and aluminium-bearing alloys;
- .4 copper, copper alloys, zinc and galvanized steel;
- .5 aluminium, copper and alloys of either;
- .6 copper and copper-bearing alloys with greater than 1% copper.

17.3 Independent tanks

17.3.1 Products should be carried in independent tanks only.

17.3.2 Products should be carried in type C independent tanks and the provisions of 7.1.3 apply. The design pressure of the cargo tank should take into account any padding pressure or vapour discharge unloading pressure.

#### 17.4 Refrigeration systems

17.4.1 Only the indirect system described in 7.2.4.2 should be used.

17.4.2 For a ship engaged in the carriage of products which readily form dangerous peroxides, recondensed cargo should not be allowed to form stagnant pockets of uninhibited liquid. This may be achieved either by:

- .1 using the indirect system described in 7.2.4.2 with the condenser inside the cargo tank; or
- .2 using the direct system or combined system described in 7.2.4.1 and .3 respectively, or the indirect system described in 7.2.4.2 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.

17.4.3 If the ship is to carry consecutively products as specified in 17.4.2 with a ballast passage between, all uninhibited liquid should be removed prior to the ballast voyage. If a second cargo is to be carried between such consecutive cargoes, the reliquefaction system should be thoroughly drained and purged before loading the second cargo. Purging should be carried out using either inert gas or vapour from the second cargo, if compatible. Practical steps should be taken to ensure that polymers or peroxides do not accumulate in the cargo system.

#### 17.5 Deck cargo piping

One hundred per cent radiography of all butt welded joints in cargo piping exceeding 75 mm in diameter is required.

#### 17.6 Exclusion of air from vapour spaces

Air should be removed from the cargo tanks and associated piping before loading and then subsequently excluded by:

- .1 introducing inert gas to maintain a positive pressure. Storage or production capacity of the inert gas should be sufficient to meet normal operating requirements and relief valve leakage. The oxygen content of inert gas should at no time be greater than 0.2% by volume; or
- .2 control of cargo temperatures such that a positive pressure is maintained at all times.

#### 17.7 Moisture control

For gases which are non-flammable and may become corrosive or react dangerously with water, moisture control should be provided to ensure that cargo tanks are dry before loading and that during discharge, dry air or cargo vapour is introduced to prevent negative pressures. For the purposes of this paragraph, dry air is air which has a dew point of  $-45^{\circ}\text{C}$  or below at atmospheric pressure.

#### 17.8 Inhibition

Care should be taken to ensure that the cargo is sufficiently inhibited to prevent polymerization at all times during the voyage. Ships should be provided with a certificate from the manufacturer stating:

- .1 name and amount of inhibitor added;
- .2 date inhibitor was added and the normally expected duration of its effectiveness;
- .3 any temperature limitations affecting the inhibitor;
- .4 the action to be taken should the length of the voyage exceed the effective lifetime of the inhibitors.

#### 17.9 Permanently installed toxic gas detectors

17.9.1 Gas sampling lines should not be led into or through gas-safe spaces. Alarms referred to in 13.6.7 should be activated when the vapour concentration reaches the threshold limiting value.

17.9.2 The alternative of using portable equipment in accordance with 13.6.9 should not be permitted.

17.10 Flame screens on vent outlets

Cargo tank vent outlets should be provided with readily renewable and effective flame screens or safety heads of an approved type when carrying a cargo referenced to this section. Due attention should be paid in the design of flame screens and vent heads to the possibility of the blockage of these devices by the freezing of cargo vapour or by icing up in adverse weather conditions. Ordinary protection screens should be fitted after removal of the flame screens.

17.11 Maximum allowable quantity of cargo per tank

When carrying a cargo referenced to this section, the quantity of the cargo should not exceed 3,000 m<sup>3</sup> in any one tank.

17.12 Submerged electric cargo pumps

The vapour space of cargo tanks equipped with submerged electric motor pumps should be inerted to a positive pressure prior to loading, during carriage and during unloading of flammable liquids.

17.13 Ammonia

Because high concentrations of ammonia in confined spaces can be flammable, the provisions of chapter 10 for flammable products should be applied except in zones on the open deck. Liquid ammonia should never be sprayed into a tank containing air as there is a risk of creating a static electrical charge which could cause ignition. To minimize the risk of stress corrosion cracking occurring when ammonia is carried at a temperature above -20°C (vapour pressure 1.9 bar), the oxygen content of the vapour space in pressure vessels and in pipelines made of carbon-manganese steel (and other steels which require special consideration) should be reduced to the minimum practicable before liquid ammonia is introduced. The condensate system of tanks operating at -33°C may be affected unless they have been thermally stress relieved.



#### 17.14 Chlorine

##### 17.14.1 Cargo containment system

17.14.1.1 The capacity of each tank should not exceed 600 m<sup>3</sup> and the total capacity of all cargo tanks should not exceed 1,200 m<sup>3</sup>.

17.14.1.2 The tank design vapour pressure should not be less than 13.5 bar (see also 7.1.3 and 17.3.2).

17.14.1.3 Parts of tanks protruding above the upper deck should be provided with protection against thermal radiation taking into account total engulfment by fire.

17.14.1.4 Each tank should be provided with two pressure relief valves. A bursting disc of appropriate material should be installed between the tank and the pressure relief valves. The rupture pressure of the bursting disc should be 1 bar lower than the opening pressure of the pressure relief valve, which should be set at the design vapour pressure of the tank but not less than 13.5 bar gauge. The space between the bursting disc and the relief valve should be connected through an excess flow valve to a pressure gauge and a gas detection system. Provision should be made to keep this space at or near the atmospheric pressure during normal operation.

17.14.1.5 Outlets from pressure relief valves should be arranged in such a way as to minimize the hazards on board the ship as well as to the environment. Leakage from the relief valves should be led through the absorption plant to reduce the gas concentration as far as possible. The relief valve exhaust line should be arranged at the forward end of the ship to discharge outboard at deck level with an arrangement to select either port or starboard side, with a mechanical interlock to ensure that one line is always open.

17.14.1.6 The Administration and the port Administration may require that chlorine is carried in refrigerated state at a specified maximum pressure.

#### 17.14.2 Cargo piping systems

17.14.2.1 Cargo discharge should be performed by means of compressed chlorine vapour from shore, dry air or another acceptable gas or fully submerged pumps. The pressure in the vapour space of the tank during discharging should not exceed 10.5 bar gauge. Cargo discharge compressors on board ships should not be accepted by the Administration.

17.14.2.2 The design pressure of the cargo piping system should be not less than 21 bar gauge. The internal diameter of the cargo pipes should not exceed 100 mm. Only pipe bends should be accepted for compensation of pipeline thermal movement. The use of flanged joints should be restricted to a minimum, and when used the flanges should be of the welding neck type with tongue and groove.

17.14.2.3 Relief valves of the cargo piping system should discharge to the absorption plant (see also 8.2.16).

#### 17.14.3 Materials

17.14.3.1 The cargo tanks and cargo piping systems are to be made of steel suitable for the cargo and for a temperature of  $-40^{\circ}\text{C}$ , even if a higher transport temperature is intended to be used.

17.14.3.2 The tanks should be thermally stress relieved. Mechanical stress relief should not be accepted as an equivalent.

#### 17.14.4 Instrumentation - safety devices

17.14.4.1 The ship should be provided with a chlorine absorbing plant with connections to the cargo piping system and the cargo tanks. The absorbing plant should be capable of neutralizing at least 2% of the total cargo capacity at a reasonable absorption rate.

17.14.4.2 During the gas-freeing of cargo tanks, vapours should not be discharged to the atmosphere.

17.14.4.3 A gas detecting system should be provided capable of monitoring chlorine concentrations of at least 1 ppm by volume. Suction points should be located:

- .1 near the bottom of the cargo hold spaces;

- .2 in the pipes from the safety relief valves;
- .3 at the outlet from the gas absorbing plant;
- .4 at the inlet to the ventilation systems for the accommodation, service and machinery spaces and control stations;
- .5 on deck at the forward end, in the middle and at the after end of the cargo area. (Only required to be used during cargo handling and gas-freeing operations.)

The gas detection system should be provided with an audible and visual alarm with a set point of 5 ppm.

17.14.4.4 Each cargo tank should be fitted with a high-pressure alarm giving an audible alarm at a pressure equal to 10.5 bar gauge.

#### 17.14.5 Personnel protection

In addition to the requirements given in chapter 14 the following requirements should be met:

- .1 The enclosed space required by 14.4.5 should be easily and quickly accessible from the open deck and from accommodation spaces and should be capable of being rapidly closed gastight. Access to this space from the deck and from the remainder of the accommodation spaces should be by means of an air-lock. The space should be so designed as to accommodate the entire crew of the ship and be provided with a source of uncontaminated air for a period of not less than 4 h. One of the decontamination showers required by 14.4.3 should be located near the air-lock to the space.
- .2 A compressor and the necessary equipment for filling the air bottles should be provided.
- .3 One set of oxygen therapy equipment should be carried in the space referred to in 17.14.5.1.

#### 17.14.6 Filling limits for cargo tanks

17.14.6.1 The requirements of 15.1.4.2 do not apply when it is intended to carry chlorine.

17.14.6.2 The chlorine content of the gas in the vapour space of the cargo tank after loading should be greater than 80% by volume.

#### 17.15 Diethyl ether and vinyl ethyl ether

17.15.1 The cargo should be discharged only by deepwell pumps or by hydraulically operated submerged pumps. These pumps should be of a type designed to avoid liquid pressure against the shaft gland.

17.15.2 Inert gas displacement may be used for discharging cargo from type C independent tanks provided the cargo system is designed for the expected pressure.

#### 17.16 Ethylene oxide

17.16.1 For the carriage of ethylene oxide the requirements of 17.20 apply, with the additions and modifications as given in this section.

17.16.2 Deck tanks should not be used for the carriage of ethylene oxide.

17.16.3 Stainless steels types 416 and 442 as well as cast iron should not be used in ethylene oxide cargo containment and piping systems.

17.16.4 Before loading, tanks should be thoroughly and effectively cleaned to remove all traces of previous cargoes from tanks and associated pipework, except where the immediate prior cargo has been ethylene oxide, propylene oxide or mixtures of these products. Particular care should be taken in the case of ammonia in tanks made of steel other than stainless steel.

17.16.5 Ethylene oxide should be discharged only by deepwell pumps or inert gas displacement. The arrangement of pumps should comply with 17.20.6.3.

17.16.6 Ethylene oxide should be carried refrigerated only and maintained at temperatures of less than 30°C.

17.16.7 Pressure relief valves should be set at a pressure of not less than 5.5 bar gauge. The maximum set pressure should be specially approved by the Administration.

17.16.8 The protective padding of nitrogen gas as required by 17.20.15 should be such that the nitrogen concentration in the vapour space of the cargo tank will at no time be less than 45% by volume.

17.16.9 Before loading and at all times when the cargo tank contains ethylene oxide liquid or vapour, the cargo tank should be inerted with nitrogen.

17.16.10 The water spray system required by paragraph 17.20.17 and that required by 11.3 should operate automatically in a fire involving the cargo containment system.

17.16.11 A jettisoning arrangement should be provided to allow the emergency discharge of ethylene oxide in the event of uncontrollable self-reaction.

17.17 Isopropylamine and monoethylamine

Separate piping systems should be provided as defined in 1.3.32.

17.18 Methyl acetylene-propadiene mixtures

17.18.1 Methyl acetylene-propadiene mixtures should be suitably stabilized for transport. Additionally, upper limits of temperature and pressure during the refrigeration should be specified for the mixtures.

17.18.2 Examples of acceptable, stabilized compositions are:

.1 Composition 1

.1.1 maximum methyl acetylene to propadiene molar ratio of 3 to 1;

- .1.2 maximum combined concentration of methyl acetylene and propadiene of 65 mol per cent;
  - .1.3 minimum combined concentration of propane, butane, and isobutane of 24 mol per cent, of which at least one third (on a molar basis) must be butanes and one third propane; and
  - .1.4 maximum combined concentration of propylene and butadiene of 10 mol per cent.
- .2 Composition 2
- .2.1 maximum methyl acetylene and propadiene combined concentration of 30 mol per cent;
  - .2.2 maximum methyl acetylene concentration of 20 mol per cent;
  - .2.3 maximum propadiene concentration of 20 mol per cent;
  - .2.4 maximum propylene concentration of 45 mol per cent;
  - .2.5 maximum butadiene and butylenes combined concentration of 2 mol per cent;
  - .2.6 minimum saturated  $C_4$  hydrocarbon concentration of 4 mol per cent; and
  - .2.7 minimum propane concentration of 25 mol per cent.

17.18.3 Other compositions may be accepted provided the stability of the mixture is demonstrated to the satisfaction of the Administration.

17.18.4 A ship carrying methyl acetylene-propadiene mixtures should preferably have an indirect refrigeration system as specified in 7.2.4.2. Alternatively, a ship not provided with indirect refrigeration may utilize direct vapour compression refrigeration subject to pressure and temperature limitations depending on the composition. For the example compositions given in 17.18.2, the following features should be provided:

- .1 A vapour compressor that does not raise the temperature and pressure of the vapour above 60°C and 17.5 bar gauge during its operation, and that does not allow vapour to stagnate in the compressor while it continues to run.
- .2 Discharge piping from each compressor stage or each cylinder in the same stage of a reciprocating compressor should have:
  - .2.1 two temperature-actuated shutdown switches set to operate at 60°C or less;
  - .2.2 a pressure-actuated shutdown switch set to operate at 17.5 bar gauge or less; and
  - .2.3 a safety relief valve set to relieve at 18.0 bar gauge or less.
- .3 The relief valve required by 17.18.4.2.3 should vent to a mast meeting the requirements of 8.2.9, 8.2.10, 8.2.13 and 8.2.14 and should not relieve into the compressor suction line.
- .4 An alarm that sounds in the cargo control position and in the navigating bridge when a high-pressure switch, or a high-temperature switch operates.

17.18.5 The piping system, including the cargo refrigeration system, for tanks to be loaded with methyl acetylene-propadiene mixtures should be either independent (as defined in 1.3.20) or separate (as defined in 1.3.32) from piping and refrigeration systems for other tanks. This segregation applies to all liquid and vapour vent lines and any other possible connections, such as common inert gas supply lines.

#### 17.19 Nitrogen

Materials of construction and ancillary equipment such as insulation should be resistant to the effects of high oxygen concentrations caused by condensation and enrichment at the low temperatures attained in parts of the cargo system. Due consideration should be given to ventilation in such areas where condensation might occur to avoid the stratification of oxygen-enriched atmosphere.

17.20 Propylene oxide and mixtures of ethylene oxide-propylene oxide with ethylene oxide content of not more than 30% by weight

17.20.1 Products transported under the provisions of this section should be acetylene-free.

17.20.2.1 Unless cargo tanks are properly cleaned, these products should not be carried in tanks which have contained as one of the three previous cargoes any product known to catalyse polymerization, such as:

- .1 anhydrous ammonia and ammonia solutions;
- .2 amines and amine solutions;
- .3 oxidizing substances (e.g. chlorine).

17.20.2.2 Before loading, tanks should be thoroughly and effectively cleaned to remove all traces of previous cargoes from tanks and associated pipework, except where the immediate prior cargo has been propylene oxide or ethylene oxide-propylene oxide mixtures. Particular care should be taken in the case of ammonia in tanks made of steel other than stainless steel.

17.20.2.3 In all cases, the effectiveness of cleaning procedures for tanks and associated pipework should be checked by suitable testing or inspection to ascertain that no traces of acidic or alkaline materials remain that might create a hazardous situation in the presence of these products.

17.20.2.4 Tanks should be entered and inspected prior to each initial loading of these products to ensure freedom from contamination, heavy rust deposits and any visible structural defects. When cargo tanks are in continuous service for these products, such inspections should be performed at intervals of not more than 2 years.

17.20.2.5 Tanks for the carriage of these products should be of steel or stainless steel construction.

17.20.2.6 Tanks which have contained these products may be used for other cargoes after thorough cleaning of tanks and associated pipework systems by washing or purging.



17.20.3.1 All valves, flanges, fittings and accessory equipment should be of a type suitable for use with these products and should be constructed of steel or stainless steel or other material acceptable to the Administration. The chemical composition of all material used should be submitted to the Administration for approval prior to fabrication. Discs or disc faces, seats and other wearing parts of valves should be made of stainless steel containing not less than 11% chromium.

17.20.3.2 Gaskets should be constructed of materials which do not react with, dissolve in, or lower the autoignition temperature of these products and which are fire-resistant and possess adequate mechanical behaviour. The surface presented to the cargo should be polytetrafluoroethylene (PTFE) or materials giving a similar degree of safety by their inertness. Spirally-wound stainless steel with a filler of PTFE or similar fluorinated polymer may be accepted by the Administration.

17.20.3.3 Insulation and packing if used should be of a material which does not react with, dissolve in, or lower the autoignition temperature of these products.

17.20.3.4 The following materials are generally found unsatisfactory for gaskets, packing and similar uses in containment systems for these products and would require testing before being approved by the Administration:

- .1 Neoprene or natural rubber if it comes into contact with the products;
- .2 Asbestos or binders used with asbestos;
- .3 Materials containing oxides of magnesium, such as mineral wools.

17.20.4 Filling and discharge piping should extend to within 100 mm of the bottom of the tank or any sump pit.

17.20.5.1 The products should be loaded and discharged in such a manner that venting of the tanks to atmosphere does not occur. If vapour return to shore is used during tank loading, the vapour return system connected to a containment system for the product should be independent of all other containment systems.

17.20.5.2 During discharging operations, the pressure in the cargo tank should be maintained above 0.07 bar gauge.

17.20.5.3 The cargo should be discharged only by deepwell pumps, hydraulically operated submerged pumps, or inert gas displacement. Each cargo pump should be arranged to ensure that the product does not heat significantly if the discharge line from the pump is shut off or otherwise blocked.

17.20.6 Tanks carrying these products should be vented independently of tanks carrying other products. Facilities should be provided for sampling the tank contents without opening the tank to atmosphere.

17.20.7 Cargo hoses used for transfer of these products should be marked "FOR ALKYLENE OXIDE TRANSFER ONLY".

17.20.8 Hold spaces should be monitored for these products. Hold spaces surrounding type A and B independent tanks should also be inerted and monitored for oxygen. The oxygen content of these spaces should be maintained below 2%. Portable sampling equipment is satisfactory.

17.20.9 Prior to disconnecting shore-lines, the pressure in liquid and vapour lines should be relieved through suitable valves installed at the loading header. Liquid and vapour from these lines should not be discharged to atmosphere.

17.20.10 Tanks should be designed for the maximum pressure expected to be encountered during loading, carriage or unloading of cargo.

17.20.11 Tanks for the carriage of propylene oxide with a design vapour pressure of less than 0.6 bar and tanks for the carriage of ethylene oxide-propylene oxide mixtures with a design vapour pressure of less than 1.2 bar should have a cooling system to maintain the cargo below the reference temperature. For reference temperature see 15.1.4.1.

17.20.12 Pressure relief valve settings should not be less than 0.2 bar gauge and for type C independent cargo tanks not greater than 7.0 bar gauge for the carriage of propylene oxide and not greater than 5.3 bar gauge for the carriage of ethylene oxide-propylene oxide mixtures.

17.20.13.1 The piping system for tanks to be loaded with these products should be completely separate from piping systems for all other tanks, including empty tanks, and from all cargo compressors. If the piping system for the tanks to be loaded with the product is not independent as defined in 1.3.20 the required piping separation should be accomplished by the removal of spool pieces, valves, or other pipe sections and the installation of blank flanges at these locations. The required separation applies to all liquid and vapour piping, liquid and vapour vent lines and any other possible connections such as common inert gas supply lines.

17.20.13.2 The products should be transported only in accordance with cargo handling plans that have been approved by the Administration. Each intended loading arrangement should be shown on a separate cargo handling plan. Cargo handling plans should show the entire cargo piping system and the locations for installation of blank flanges needed to meet the above piping separation requirements. A copy of each approved cargo handling plan should be kept on board the ship. The International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk should be endorsed to include reference to the approved cargo handling plans.

17.20.13.3 Before loading the product, certification verifying that the required piping separation has been achieved should be obtained from a responsible person acceptable to the port Administration and carried on board the ship. Each connection between a blank flange and pipeline flange should be fitted with a wire and seal by the responsible person to ensure that inadvertent removal of the blank flange is impossible.

17.20.14 The maximum allowable tank filling limits for each cargo tank should be indicated for each loading temperature which may be applied and for the applicable maximum reference temperature, on a list to be approved by the Administration. A copy of the list should be permanently kept on board by the master.

17.20.15 The cargo should be carried under a suitable protective padding of nitrogen gas. An automatic nitrogen make-up system should be installed to prevent the tank pressure falling below 0.07 bar gauge in the event of product temperature fall due to ambient conditions or malfunctioning of refrigeration system. Sufficient nitrogen should be available on board to satisfy the demand of the automatic pressure control. Nitrogen of commercially pure quality (99.9% by volume) should be used for padding. A battery of nitrogen bottles connected to the cargo tanks through a pressure reduction valve satisfies the intention of the expression "automatic" in this context.

17.20.16 The cargo tank vapour space should be tested prior to and after loading to ensure that the oxygen content is 2% by volume or less.

17.20.17 A water spray system of sufficient capacity should be provided to blanket effectively the area surrounding the loading manifold, the exposed deck piping associated with product handling and the tank domes. The arrangement of piping and nozzles should be such as to give a uniform distribution rate of 10  $\ell/m^2$  per minute. The water spray system should be capable of both local and remote manual operation and the arrangement should ensure that any spilled cargo is washed away. Additionally, a water hose with pressure to the nozzle, when atmospheric temperatures permit, should be connected ready for immediate use during loading and unloading operations.

17.21 Vinyl chloride

In cases where polymerization of vinyl chloride is prevented by addition of an inhibitor, 17.8 is applicable. In cases where no or insufficient inhibitor has been added, any inert gas used for the purposes of 17.6 should contain not more oxygen than 0.1%. Before loading is started, inert gas samples from the tanks and piping should be analysed. When vinyl chloride is carried, a positive pressure should always be maintained in the tanks, also during ballast voyages between successive carriages.

## CHAPTER 18 - OPERATING REQUIREMENTS

18.1 Cargo information

18.1.1 Information should be on board and available to all concerned, giving the necessary data for the safe carriage of cargo. Such information should include for each product carried:

- .1 a full description of the physical and chemical properties necessary for the safe containment of the cargo;
- .2 action to be taken in the event of spills or leaks;
- .3 counter-measures against accidental personal contact;
- .4 fire-fighting procedures and fire-fighting media;
- .5 procedures for cargo transfer, gas-freeing, ballasting, tank cleaning and changing cargoes;
- .6 special equipment needed for the safe handling of the particular cargo;
- .7 minimum inner hull steel temperatures; and
- .8 emergency procedures.

18.1.2 Products required to be inhibited should be refused if the certificate required by 17.8 is not supplied.

18.1.3 A copy of this Code or national regulations incorporating the provisions of this Code should be on board every ship covered by this Code.

18.2 Compatibility

18.2.1 The master should ascertain that the quantity and character of each product to be loaded are within the limits indicated in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk provided for in 1.5 and in the Loading and Stability Information booklet provided for in 2.2.5 and that products are listed in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk if so required under section 3 of the Certificate.

18.2.2 Care should be taken to avoid dangerous chemical reactions if cargoes are mixed. This is of particular significance in respect of:

- .1 tank cleaning procedures required between successive cargoes in the same tank; and
- .2 simultaneous carriage of cargoes which react when mixed. This should be permitted only if the complete cargo systems including, but not limited to, cargo pipework, tanks, vent systems and refrigeration systems are separated as defined in 1.3.32.

### 18.3 Personnel training\*

18.3.1 Personnel involved in cargo operations should be adequately trained in handling procedures.

18.3.2 All personnel should be adequately trained in the use of protective equipment provided on board and have basic training in the procedures, appropriate to their duties, necessary under emergency conditions.

18.3.3 Officers should be trained in emergency procedures to deal with conditions of leakage, spillage or fire involving the cargo and a sufficient number of them should be instructed and trained in essential first aid for the cargoes carried.

### 18.4 Entry into spaces

18.4.1 Personnel should not enter cargo tanks, hold spaces, void spaces, cargo handling spaces or other enclosed spaces where gas may accumulate, unless:

---

\* Reference is made to the provisions of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, and in particular to the "Mandatory minimum requirements for the training and qualifications of masters, officers and ratings of liquefied gas tankers" - regulation V/3, chapter V of the Annex to that Convention and to resolution 12 of the International Conference on Training and Certification of Seafarers, 1978.

- .1 the gas content of the atmosphere in such space is determined by means of fixed or portable equipment to ensure oxygen sufficiency and the absence of toxic atmosphere; or
- .2 personnel wear breathing apparatus and other necessary protective equipment and the entire operation is under the close supervision of a responsible officer.

18.4.2 Personnel entering any space designated as gas-dangerous on a ship carrying flammable products should not introduce any potential source of ignition into the space unless it has been certified gas-free and is maintained in that condition.

18.4.3.1 For internal insulation tanks, special fire precautions should be taken in the event of hot work carried out in the vicinity of the tanks. For this purpose, gas absorbing and de-absorbing characteristics of the insulation material should be taken into account.

18.4.3.2 For internal insulation tanks, repairs should be carried out in accordance with the procedures provided for in paragraph 4.4.7.6.

#### 18.5 Carriage of cargo at low temperature

18.5.1 When carrying cargoes at low temperatures:

- .1 if provided, the heating arrangements associated with cargo containment systems should be operated in such a manner as to ensure that the temperature does not fall below that for which the material of the hull structure is designed;
- .2 loading should be carried out in such a manner as to ensure that unsatisfactory temperature gradients do not occur in any cargo tank, piping, or other ancillary equipment; and
- .3 when cooling down tanks from temperatures at or near ambient, the cool-down procedure laid down for that particular tank, piping and ancillary equipment should be followed closely.



#### 18.6 Protective equipment

Personnel should be made aware of the hazards associated with the cargo being handled and should be instructed to act with care and use the appropriate protective equipment as mentioned in 14.1 during cargo handling.

#### 18.7 Systems and controls

Cargo emergency shutdown and alarm systems involved in cargo transfer should be tested and checked before cargo handling operations begin. Essential cargo handling controls should also be tested and checked prior to transfer operations.

#### 18.8 Cargo transfer operations

18.8.1 Transfer operations including emergency procedures should be discussed between ship personnel and the persons responsible at the shore facility prior to commencement and communications maintained throughout the transfer operations.

18.8.2 The closing time of the valve referred to in 13.3.1 (i.e. time from shutdown signal initiation to complete valve closure) should not be greater than:

$$\frac{3600 U}{LR} \quad (\text{s})$$

where: U = ullage volume at operating signal level (m<sup>3</sup>)

LR = maximum loading rate agreed between ship and shore facility (m<sup>3</sup>/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.

#### 18.9 Additional operating requirements

Additional operating requirements will be found in the following paragraphs of the Code:

3.8.4, 3.8.5, 7.1.1.5, 8.2.5, 8.2.7, 9.4.2, 12.1.1, 12.1.10, 13.1.4, 14.2.5, 14.2.6, 14.3.1, 15.1, 15.2, 16.2.2, 17.4.2, 17.6, 17.7, 17.12, 17.13, 17.14, 17.15, 17.16, 17.17, 17.18, 17.20.

## CHAPTER 19 - 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)	<p>F - Flammable vapour detection</p> <p>T - Toxic vapour detection</p> <p>O - Oxygen analyser</p> <p>F+T - Flammable and toxic vapour detection</p>
Gauging - types permitted (column g)	<p>I - Indirect or closed, as described in 13.2.2.1 and .2</p> <p>C - Indirect, or closed, as described in 13.2.2.1, .2 and .3</p> <p>R - Indirect, closed or restricted, as described in 13.2.2.1, .2, .3 and .4</p>
Refrigerant gases	<p>Non-toxic and non-flammable gases such as:</p> <p>dichlorodifluoromethane (1028)</p> <p>dichloromonofluoromethane (1029)</p> <p>dichlorotetrafluoroethane (1958)</p> <p>monochlorodifluoromethane (1018)</p> <p>monochlorotetrafluoroethane (1021)</p> <p>monochlorotrifluoromethane (1022)</p>

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.

a Product name	b IM number	c Bally type	d Independent tank type required	e Control of vapour cargo tanks	f Vapour detection	g Casting	h Special requirements
Isoprene*	1218	2C/ 2PC	-	-	F	R	14.4.3, 17.8, 17.10, 17.12
Isopropylamine*	1221	2C/ 2PC	-	-	F + I	C	14.4.2, 14.4.3, 17.2.4, 17.10, 17.11, 17.12, 17.17
Methane (LNG)	1972	2C	-	-	F	C	
Methyl acetylene-propadiene mixtures	1060	2C/ 2PC	-	-	F	R	17.18
Methyl bromide	1062	1C	Yes	-	F + I	C	14.4, 17.2.3, 17.3.2, 17.4.1, 17.5, 17.9
Methyl chloride	1063	2C/ 2PC	-	-	F + I	C	17.2.3
Monomethylamine*	1036	2C/ 2PC	-	-	F + I	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	3C	-	-	O	C	17.19
Propane	1976	2C/ 2PC	-	-	F	R	
Propylene	1077	2C/ 2PC	-	-	F	R	
Propylene oxide*	1280	2C/ 2PC	-	Inert	F + I	C	14.4.3, 17.3.1, 17.4.1, 17.6.1, 17.10, 17.11, 17.20
Refrigerant gases (see notes)	-	3C	-	-	-	R	
Sulphur dioxide	1079	1C	Yes	Dry	T	C	14.4, 17.3.2, 17.4.1, 17.5, 17.7, 17.9
Vinyl chloride	1086	2C/ 2PC	-	-	F + I	C	14.4.2, 14.4.3, 17.2.2, 17.2.3, 17.3.1, 17.6, 17.21
Vinyl ethyl ether*	1302	2C/ 2PC	-	Inert	F + I	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	2C/ 2PC	-	Inert	F + I	R	14.4.2, 14.4.3, 17.2.3, 17.6.1, 17.8, 17.10, 17.11

\* This cargo is covered also by the IBC Code.

a	b	c	d	e	f	g	h
Product name	IM number	Stow type	Independent tank type D required	Control of vapour space within cargo tanks	Vapour detection	Gas/dmg	Special requirements
Isoprene*	1218	2C/ 2PC	-	-	F	R	14.4.3, 17.8, 17.10, 17.12
Isopropylamine*	1221	2C/ 2PC	-	-	F + I	C	14.4.2, 14.4.3, 17.2.4, 17.10, 17.11, 17.12, 17.17
Methane (LNG)	1972	2C	-	-	F	C	
Methyl acetylene-propadiene mixtures	1060	2C/ 2PC	-	-	F	R	17.18
Methyl bromide	1062	1C	Yes	-	F + I	C	14.4, 17.2.3, 17.3.2, 17.4.1, 17.5, 17.9
Methyl chloride	1063	2C/ 2PC	-	-	F + I	C	17.2.3
Monomethylamine*	1036	2C/ 2PC	-	-	F + I	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	3C	-	-	O	C	17.19
Propane	1976	2C/ 2PC	-	-	F	R	
Propylene	1077	2C/ 2PC	-	-	F	R	
Propylene oxide*	1280	2C/ 2PC	-	Inert	F + I	C	14.4.3, 17.3.1, 17.4.1, 17.6.1, 17.10, 17.11, 17.20
Refrigerant gases (see notes)	-	3C	-	-	-	R	
Sulphur dioxide	1079	1C	Yes	Dry	T	C	14.4, 17.3.2, 17.4.1, 17.5, 17.7, 17.9
Vinyl chloride	1086	2C/ 2PC	-	-	F + I	C	14.4.2, 14.4.3, 17.2.2, 17.2.3, 17.3.1, 17.6, 17.21
Vinyl ethyl ether*	1302	2C/ 2PC	-	Inert	F + I	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	2C/ 2PC	-	Inert	F + I	R	14.4.2, 14.4.3, 17.2.3, 17.6.1, 17.8, 17.10, 17.11

\* This cargo is covered also by the IBC Code.

Appendix

MODEL FORM OF INTERNATIONAL CERTIFICATE OF FITNESS FOR  
THE CARRIAGE OF LIQUEFIED GASES IN BULK

INTERNATIONAL CERTIFICATE OF FITNESS FOR THE CARRIAGE OF  
LIQUEFIED GASES IN BULK

(Official seal)

Issued under the provisions of the  
INTERNATIONAL CODE FOR THE CONSTRUCTION AND  
EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK  
(resolution MSC.5(48))

under the authority of the Government of

.....  
(full official designation of country)

by .....  
(full official designation of the competent person or  
organization authorized by the Administration)

Name of ship	Distinctive number or letters	Port of registry	Cargo capacity (m <sup>3</sup> )	Ship type (section 2.1.1/ of the Code) <sup>1/</sup>

Date on which keel was laid or on which the 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:  
.....  
.....

The ship is exempted from compliance with the following provisions of the Code:  
.....  
.....

The Certificate should be drawn up in the official language of the issuing country. If the language used is neither English nor French, the text should include a translation into one of these languages.

THIS IS TO CERTIFY:

- 1 .1 That the ship has been surveyed in accordance with the provisions of section 1.5 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.

2 That the following design criteria have been used:

- .1 ambient air temperature .....<sup>oC</sup><sub>2/</sub>
- .2 ambient water temperature .....<sup>oC</sup><sub>2/</sub>
- .3

Tank type and number	Stress factors <sup>3/</sup>				Materials <sup>3/</sup>	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 .....<sup>oC</sup><sub>4/</sub>

3 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:<sup>5/</sup>

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.	

4 That in accordance with sections 1.4/2.8.2\* the provisions of the Code are modified in respect of the ship in the following manner:

5 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;

\*.2 in accordance with the loading limitations appended to this Certificate.

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.\*\*

\* Delete as appropriate.

\*\* Instead of being incorporated in the Certificate, this text may be appended to the Certificate if duly signed and stamped.

This Certificate is valid until .....

Issued at .....  
(place of issue of Certificate)

..... 19..  
(date of issue)

.....  
(signature of authorized  
official issuing the  
Certificate)

(seal or stamp of issuing  
Authority, as appropriate)

Notes on completion of certificate:

- 1/ "Ship type": Any entry under this column must be related to all relevant recommendations, e.g. an entry "type 2G" should mean type 2G in all respects prescribed by the Code.
- 2/ Paragraphs 2.1 and 2.2: The ambient temperatures accepted or required by the Administration for the purposes of 4.8.1 of the Code to be inserted.
- 3/ Paragraph 2.3: Stress factors and materials as accepted or required by the Administration for the purposes of 4.5.1.4 and 4.5.1.6 of the Code to be inserted.
- 4/ Paragraph 2.4: Temperature accepted by the Administration for the purposes of 4.5.1.7 to be inserted.
- 5/ Paragraph 3: Only products listed in chapter 19 of the Code or which have been evaluated by the Administration in accordance with paragraph 1.1.6 of the Code should be listed. In respect of the latter "new" products, any special requirements provisionally prescribed should be noted.

ENDORSEMENT FOR MANDATORY ANNUAL SURVEYS

THIS IS TO CERTIFY that at a mandatory annual survey required by 1.5.2.1.4 of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, the ship was found to comply with the relevant provisions of the Code.

Signed: .....  
(signature of authorized  
official)

Place: .....

Date: .....

(seal or stamp of the Authority, as appropriate)



Signed: .....  
(signature of authorized  
official)

Place: .....

Date: .....

(seal or stamp of the Authority, as appropriate)

Signed: .....  
(signature of authorized  
official)

Place: .....

Date: .....

(seal or stamp of the Authority, as appropriate)

Signed: .....  
(signature of authorized  
official)

Place: .....

Date: .....

(seal or stamp of the Authority, as appropriate)

NOTE: An intermediate survey may take the place of a mandatory annual survey where the relevant provisions of 1.5.2.1.3 and 1.5.2.1.4 are complied with.

ENDORSEMENT FOR INTERMEDIATE SURVEYS

THIS IS TO CERTIFY that at an intermediate survey required by 1.5.2.1.3 of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, the ship was found to comply with the relevant provisions of the Code.

Signed: .....  
(signature of authorized official)

Place: .....

Date: .....

(seal or stamp of the Authority, as appropriate)

Signed: .....  
(signature of authorized official)

Place: .....

Date: .....

(seal or stamp of the Authority, as appropriate)

ATTACHMENT 1 TO THE INTERNATIONAL  
 CERTIFICATE OF FITNESS FOR THE CARRIAGE  
 OF LIQUEFIED GASES IN BULK

Continued list of products to those specified in section 3, and their conditions of carriage.

Products	Conditions of carriage (tank numbers, etc.)

DATE .....  
 (AS FOR CERTIFICATE)

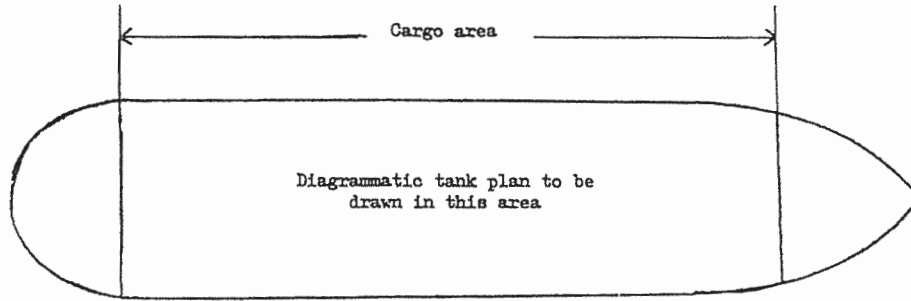
.....  
 SIGNATURE OF OFFICIAL  
 ISSUING THE CERTIFICATE  
 AND/OR SEAL OR ISSUING  
 AUTHORITY

ATTACHMENT 2 TO THE INTERNATIONAL  
CERTIFICATE OF FITNESS FOR THE CARRIAGE  
OF LIQUEFIED GASES IN BULK

TANK PLAN (specimen)

NAME OF SHIP: .....

DISTINCTIVE NUMBER OR LETTERS: .....



DATE .....  
(AS FOR CERTIFICATE)

.....  
SIGNATURE OF OFFICIAL  
ISSUING THE CERTIFICATE  
AND/OR SEAL OR ISSUING  
AUTHORITY

二零一五年七月二十三日於行政長官辦公室

Gabinete do Chefe do Executivo, aos 23 de Julho de 2015. —

辦公室主任 柯嵐

A Chefe do Gabinete, *O Lam*.



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