技術研究分野에 있어서의 船級協會의 活動

金 喆 俊*

1. 緖 論

船舶은 生命財產을 委托하는 重要機關임으로 國家로서도 그 安全性을 確認保證할 責任이 있으므로 船舶의 構造設備와 保存에 대하여 精密하게 檢査監督을 하지 않으면 아니된다. 이를 위하여서 마련된 것이 船舶安全法과 關係法規이며 船舶의 構造 設備 工作 等 全般에 걸친 最低基準과 檢査에 관한 節次, 準備, 基準, 時期 等에 대하여 詳細하게 規程을 定하고 있으며 이 安全法에 의하여 施行되는 檢査가 政府의 檢査이다.

또 船舶은 國境이 없는 海上을 航行하기 때문에 國際性을 지니고 있어서 이러한 安全取締의 基準은 各國間에 統一性을 가지게 하는 것이 바람직하여 國際會議가 開催되어 1930年에 國際滿載吃水線條約이 1948年에 國際安全條約이 各各 締結되어 規制되어왔다. 그러든 것이 第2次大戰後의 海運의 急進的인 發展과 새로운 形態의 船舶 設備가 出現하게 됨으로서 國際會議는 UN機關으로서 再發足하게 되어 政府間海事諮問機關(Inter-Governmental Maritime Consultative Organization) 略稱 IMCO로 불리우게 되었고 國際安全條約은 1960年에 國際滿載吃水線條約은 1966年에 全面改正이 되여 現在通用되고 있으며 各條約國은 國際航海에 從事하는 船舶에 대하여 條約에 의한 取締를 할 수 있도록 되었다.

한편 船舶은 잘統括된 大財產이고 그 運航에는 相當한 危險이 隨伴됨으로 保險對象으로서 最適의 目的物이라 할 수 있고 保險없이는 하루도 움직일 수 없는 處地에 놓이게 되었다. 이와같이 商船이 經濟的인 活動을 함에 있어서는 海上保險이 不可缺의 要件으로 되었고 또 그 保險金額은 다른 어느 것과도 比較가 되지 않을 程度로 高額이 支拂되고 있다. 따라서 船主는 自己의 船舶이 技術的으로 優秀하고 安全性이 높으며 乘組員이나 貨物을 安全하게 運搬할 수 있는 船舶이라는 것을 海上保險業者로부터 認定을 받아서 될 수 있는 限低額의 保險料를 支拂하면서 船舶을 運航하게 할 必要가 있고 保險業者로서는 船舶의 現狀을 確實하게 把握하여 事故發生이 적은 安全性을 갖추고 있는 船舶을 保險으로 받아드리도록 하여야만 保險料支給이 적어지게되므로 그 現狀把握이 必要하게 된 것이다. 이와같은 必要性을 充足시키기 위하여 第3者的인 公平한 立場에서 船舶의 安全性을 證明하여 주는 技術團體로서 誕生한 것이 船級協會이고 그 目的을 위하여 行하는 檢査를 船級檢査라고 하고 있다.

船舶檢査의 至上使命은 모두 船舶의 安全한 運航에 있으므로 檢査의 執行手段은 大略 同一하지만 政府의 責任은 生命財產의 安全確保에 있고 保險者의 目的은 財產의 確保에 있으므로 兩者間에는 얼마간의 差異點이 있는 것은 當然하지만 技術的 行爲에 對하여서는 特히 나누어 생각할 必要는 없다.

따라서 各國에서는 各各 實力이 있는 船級協會를 認定하여 이에 國家的 權限을 移讓하여 船級取得 또는 船級維持로서 政府檢査合格으로 看做하여 船級協會가 行하는 檢査範圍에 屬하는 限 政府檢査를 省略하고 있다. 이 權限移讓의 範圍나 具體的인 方法은 國家에 따라서 若干의 差異가 있는 것은 勿論이다.

이와 같이 安全性 確認이라는 重責을 擔當하고 있는 船級協會의 現況과 技術向上에 있어서의 寄與를 어떻게 하고 있는가를 以下에 記述하여 보기로 한다.

2. 各國 船級協會의 現況

가장 일찌기 船級協會로서 設立된 것은 英國의 Lloyd's Register of Shipping(LR)이며 船級協會의 先祖라고 알려져 있고 船級協會의 起源을 더듬어 보려고 하는 때에는 이 Lloyd 船級協會에 言及을 하지 않을 수 없게 되어 있다. Lloyd 船級協會는 1760年에 設立되여 200餘年의 長久한 歷史를 지니고 있으며 그뒤를 이어서 列强海運國에서 여러 船級協會들이 設立되게 되었다. 即 1928年에 불란서의 Bureau Veritas(BV) 1861年 伊太利의 Registro Italiano Navale(RI) 1862年 美國의 American Bureau of Shipping(ABS) 1964年 놀웨이의 Det Norske Veritas(NV) 1889年 獨逸의 Germanischer Lloyd(GL) 1899年 日本의 Nippon Kaiji Kyokai(NK) 等이 設立되었으며 現在 七大船級協會로서 君臨하고 있다.

이 以外에 蘇聯(RS) 그리스(HR) 東獨(DSRK) 中

* 正會員：韓國船級協會

國(CR) 印尼(BKI) Poland, Yugoslavia, Czechoslovakia 等에도 船級協會가 設立되어 있다. 이들 船級協會는 設立後 日淺하거나 共產圈內에 있어서 그 登錄船腹量, 技術, 經驗, 活動規模等 모든 面에 있어서 앞서의 七大船級協會와 對比하여 훨씬 뒤떨어져 있다.

우리 나라에는 1960年에 韓國船級協會가 設立되어 活動하고 있으며 前述한 七大船級協會와 業務代行協定을 締結 認定을 받고 있다.

各船級協會의 成長過程은 時代에 따른 社會的 要求의 差異 各國의 特殊事情等으로 여러가지 形態를 取하고 있으며 그 說明은 여기에서는 紙面關係로 省略하기로 한다.

各國船級協會의 概況 (噸數 : 萬噸)

名稱	國名	略稱	設立年度	本部所在地	自國保有噸數(1973. 6)	登錄噸數
Lloyd's Register of Shipping	英國	LR	1760	London	3016.0	8802.6(1973. 6)
American Bureau of Shipping	美國	ABS	1862	New York	1491.2	6801.7(1972.12)
Det Norske Veritas	놀웨이	NV	1864	Oslo	2362.1	8090.4(1972.12)
Nippon Kaiij Kyokai	日本	NK	1899	Tokyo	3678.5	3785.2(1973. 6)
Bureau Veritas	佛國	BV	1828	Paris	828.9	1790.0(1971.12)
Germanischer Lloyd	獨逸	GL	1889	Hamburg	791.5	1194.8(1972.12)
Registro Italiano Navale	伊太利	RI	1861	Genoa	886.7	
Register of Shipping of USSR	蘇聯	RS	1932	Leningrad	1739.7	
Hellenic Register of Shipping	그리스	HR	1919	Piraeus	1929.5	
China Corporation Register of Shipping	中國	CR	1954	臺北	146.7	
Biro Klassifikash Indonesia	印尼	BKI	1969	Jakalta	66.9	
Korean Register of Shipping	韓國	KR	1960	Seoul	110.4	

船級協會는 어느 나라 것이나 그 設立目的을 海上에 있어서의 人命財產을 保護하고 海運造船振興에 이바지하는 것으로 하고 있으며 그 目的達成을 위하여 (1)船級의 登錄, 船舶의 檢査, 滿載吃水線의 指定 (2)造船材料 船用品 및 船用品材料의 試驗 및 檢査 (3)船舶 및 各種機器의 圖面審議 및 製作監督 (4)海運 및 船舶에 關한 統計調査 研究 및 情報蒐集과 (5)船級協會 目的達成을 위한 其他 海事關係業務를 行하고 있다.

또한 船級協會는 技術面에서 認定을 받는바 되어 類似業務에 屬하는 陸上의 構造物, 原動機, 機械等 製品에 對한 檢査業務까지도 併行하여 施行하고 있는 船級協會가 大部分이다. 앞서 言及한 七 大船級協會에서 보면 過去 ABS와 NK를 除外하고는 모두가 陸上施設에 對한 檢査業務를 施行하여 왔으며 最近에 이르러 ABS도 ABS Worldwide Technical Service, Inc.를 設立하여 大大的인 事業을 벌리기에 이르렀으며 BV에서는 航空機에 對한 登錄檢査業務까지도 施行하고 있어 그 活動舞臺는 廣範圍한 것으로 되어 있다.

또한 앞서 言及한 國際安全條約과 國際滿載吃水線條約에는 政府가 檢査를 行하는 것으로 되어 있지만 政府는 그 權限을 適當하다고 認定하는 機關에 委任할 수가 있게 되어 있어서 各國船級協會는 各國으로부터 그 權限을 委任받아 이 條約에 依한 檢査業務와 證書發行業務를 行하고 있다.

또 七大船級協會間에는 船級協會會議(Conference of Classification Societies)라는 것이 있어서 相互間에 連絡을 取하여 特히 共通의 技術的 諸問題에 對하여 恒常協議가 되어 왔으며 이것이 發展되어 1968年에 强力한 船級協會의 聯合體로서 IACS(International Association of Classification Societies)로 發足 IMCO의 諮問機關으로 登場하게 되었으며 IMCO에 있어서의 强力한 作用을 할 수 있게 되었다. IACS의 活動業務로서는 (1)IMCO에 있어서의 討議에 參加 (2)ISO 其他의 國際的機關과의 關係維持 (3)國際條約의 統一解釋 (4)船級構造規則의 統一等을 當面된 課題로 하고 있다.

實際의 技術的討議를 위하여서 作業部會를 두고 있으며 現在活動하고 있는 作業部會로서 다음의 10個部會가 있다.

名稱	幹事協會
Working Party on Load Lines	Norway NV
〃 〃 on Strength of Ships	獨逸 GL
〃 〃 on Mooring and Anchoring	蘇聯 RS
〃 〃 on Fire Protection/Tanker Safety	英國 LR
〃 〃 on Engines	포랜드 PRS
〃 〃 on Pipes and Pressure Vessels	日本 NK
〃 〃 on Gas Tankers	프랑스 BV
〃 〃 on Containers	美國 ABS
Correspondence Group on Electricity	美國 ABS
〃 〃 on Propellers	놀웨이 NV

따라서 船級協會로서 國際的인 地位를 確保하려면

이 IACS 機構에의 加入이 必要하게 되었으며 現在 IACS member로서는 七大船級協會以外에 蘇聯 폴랜드 유고슬라비아의 船級協會가 加入되어 10個船級協會로 되어 있다.

3. 技術研究面에서의 船級協會의 活動

船級協會는 各種業務를 行하고 있지만 이 業務中에서 가장 重要한 것은 船舶에 船級을 賦與하여 登錄하고 Register book을 發行하는 일이다. 이 때문에 船舶이 船級에 對하여 定한 條件을 滿足하는지 어떤지를 檢査하는 것으로 되며, 一般으로 이 條件에 適合하고 있으면 그 船級은 充分히 安全하다고 생각하게 된다. 이와같이 船級의 登錄은 重大한 意義를 갖는 것이므로 이 條件을 定하는 構造檢査規則은 愼重을 期할 必要가 있고 各船級協會는 모두 關係方面의 權威者를 모은 技術委員會를 가지고 있으며 여기에서 審議承認한 規則을 公表하고 있다.

各國船級協會가 갖는 各各의 規則은 船舶이 오랜 歷史를 지니고 있는 것이라는 事實만으로 생각하드라도 根本的으로는 그다지 差異가 있다고는 생각할 수가 없지만 近代의 特色인 工業上의 飛躍的인 進步는 當然히 造船界에도 波及되어 特히 速力의 增加, 各種의 近代化, 船舶의 大型化, 自動化, 專用化等 未經驗의 領域으로 擴大되어 가고 있는 最近에 있어서는 오랜 歷史 위에 生긴 規則이라고 하는 것만으로는 對處할 수 없게 되어 가고 있음은 말할 것도 없다. 그러므로 常時 規則의 改正, 補完等은 各船級協會 共通의 問題로 되어 있어서 間斷없는 作業이 繼續되고 있으며 이것에는 確實한 뒷받침이 必要하게 되는 것은 當然한 일이다. 그러면 이러한 뒷받침은 어디에서 行하는가라는 問題가 일어나게 된다. 各나라에는 各各大學이 있고 研究所가 있어서 이들에게 그때그때 研究를 依賴하면 一見解決이 될것 같기도 하지만 이들 機關은 제 各己 所定의 研究課題를 지니고 있기 때문에 特히 興味가 一致하는 경우를 除外하고는 各國 모두 研究組織의 改革이라도 일어나지 않는限 一般으로 期待할 수가 없게 되어 있다. 그래서 이 問題에 即應하여 最短期間에 優先研究를 行할 수 있는 直屬의 研究機關을 必要로 하게 되어 世界的인 傾向으로서 어느 나라의 船級協會를 莫論하고 獨自的인 研究機關을 設置하기에 이르렀으며, 現在 間斷없는 研究事業이 繼續되어 檢査의 基調를 이루는 船級規則의 改正 補完을 이룩하여 나가고 있는 것이다. 이들 研究事業은 理論的研究와 實測研究의 2個部門으로 大略區分을 할 수가 있고 理論的 結果를 解析 및 實船計測과 對比하여가면서 그 結論을 내리고 있는 것이 普通이다.

이러한 研究結果는 造船技術向上面에도 크게 寄與하고 있으며 最近의 國際會議에 있어서의 狀況을 보더라도 그 成果가 얼마나 크다는 것을 可히 짐작할 수가 있는 것이다.

1970年 日本東京에서 開催된 第4回國際船體構造會議의 實況을 살펴보면 Standing Committee 11名中 3名이, 12個 Committee 103名中 22名이, 參加者 122名中 22名을 船級協會 member가 차지하고 있는 것을 보더라도 構造分野에 있어서의 船級協會의 位置를 알 수가 있을 것이다.

1973年 亦是 日本東京에서 開催된 ICCAS(International Conference on Computer Application in the Automation of Shipyard Operation and Ship Design)의 實況을 보면 Session V Structural Analysis and Design에 있어서 提出된 論文12件中에서 船級協會 member가 提出한 것이 6件으로서 半數를 차지하고 있어 船體構造와 Computer 導入面에서도 壓倒的인 地位를 차지하고 있음을 알 수가 있다. 이 會議에 提出된 論文總數는 54個이고 그中 構造關係에서 6件의 論文이 船級協會 member가 提出하고 있으며 Committee member 50名中에 3名이, 參加者 362名中 16名이 各各 船級協會 member로 되어 있다.

또한 1973年 日本東京에서 開催된 ISME(The International Symposium on Marine Engineering)의 實況을 보면 論文總數 91件中에서 8件이 船級協會 member에 依하여 提出되었고 Discussion member 66名中 9名이, 參加者外國人 148名中 10名이, 日本人 409名中 19名이 各各 船級協會 member로 되어 있는 것으로 보더라도 Marine Engineering 部門에 있어서도 船體構造部門에 못지 않게 重要한 比重을 차지하고 있음을 엿볼 수가 있다.

各船級協會의 研究部門은 各己特有의 研究課題를 갖고 理論과 實的計測을 併行하여 進展을 거듭하고 있으며 그 一端을 ISSC 第4次會議에 報告된 各船級協會의 研究活動狀況을 紹介하면 다음과 같다.

Bureau Veritas

1. Loads on Hull Girder

(1) Theoretical studies relating to pitching and heaving motion of ships in a seaway and the forces imposed on the structure. Program written to compute motion and forces for any power spectral density function (long-crested or short-crested waves). Comparison of computational results with model measurements published by several authors.

(2) Constitution of measurements on thirty ships of the maximum longitudinal bending stress experimenced during each voyage, using B.V. extensometers (in Collaboration with Institut-de Recherches de la Construction Navale)

2. Load Carrying Ability

Theoretical and experimental analysis of strains and stresses due to torsion imposed on open ships. A computer program has been written which takes account of all closed cells existing in the section and of deck transverse strips or caissons between hatches. Strain measurements are being made on plexiglass models with a varied number of closed cells and deck transverse strips.

Stresses and Deflections in Main Hull structure and Superstructure: Measurement of strains, in still water, in bottom transverses of an empty wing tank whilst filling the adjacent centre tank. Photoelastic analysis on an altuglass model of a bottom transverse. Analysis of the some transverse by the finite element method.

Stiffened Plate Panels, shells and Corrugated Plates: Theoretical and experimental study of the buckling of stiffened plates the web of the girder being subjected to both direct and shear loads. Comparison of buckling and vibration modes under varied loads.

Major Discontinuities including Hatch Openings, Brackets and Web Perforations: Theoretical and experimental determination of the collapse load of common triangular brackets.

3. Vibration

Theoretical and full-scale research on hull vibration with particular emphasis on engine and propeller excited vibration and to the vibration of tanker superstructures.

4. Design Philosophy and Design Procedure including Plastic Design.

Plastic analysis as applied to the design of ship structures. Application to scantling regulations for transverse framing of tankers.

5. Numerical Methods

Verification of the scantlings of the primary and secondary structure of the tank section of large tankers by the use of computer programs and finite element methods.

6. Miscellaneous Researches

Propeller Blades and shafting:

Theoretical computationai and practical study of shafting alignment problems.

Registro Italiano Navale

1. Loads on Hull Girder

A Computer program has been written for the calculation of motions and induced forces on ships in a confused sea and the program has been used to carry out a large number of systematic calculations for tankers and bulk carriers. From this work a formula has been evolved for the calculation of the wave bending moment as a function of characteristic parameters of the ship and the sea. In addition a simple method has been derived for obtaining the distribution of the wave bending moment over the length of the ship.

Detailed and systematic investigations are now being made into the following:

(a) The determination of absolute and relative motions, and the Velocities and accelerations due to waves, for different types of ships.

(b) The effect on the above parameters of untraditional hull shapes (large-bulbs, V-type sections and twin hulls)

(c) The determination of local dynamic loads induced by the waves on the ship and their equivalent static loads.

2. Load Carrying Ability

Theoretical determination of torsional stresses in ships with large deck openings making due allowance for the changing transverse hull sections.

Stresses and Deflections in Main Hull Structure and Superstructure:

Strain measurements are to be made on a 225,000 ton deadweight tanker in order to verify the results obtained from a three dimensional analysis of a part of the ship's structure idealised as a framework of inter-connected line members.

Stiffened Plate Panels, Shells and Corrugated plates:

A method is being formulated for the calculation of the minimum plate width to be included in the assessment of the torsional stability of unsymmetrical longitudinal stiffeners,

Blerch's theory for the buckling of panels subje-

cted to combined shear and side thrust is being developed to cover different boundary conditions. Experiment work on full-scale models will be carried out to verify the developed theories.

3. Numerical Methods

Application of finite element methods to the stress analysis of structures for which beam theory fails e.g. wash bulkheads and brackets. The results will be checked by measurements on ships.

Lloyd's Register of shipping

1. Loads on Hull Girder.

(1) Estimation of dynamic structural loads due to ship motions in a seaway

Statistical analysis of bending moment data obtained from ship models leading to improved equations for estimating bending moments in irregular waves.

(2) Full Scale Statistical

Statistical recording of wave-induced loading on ships' hull in service.

2. Load Carrying Ability

Tests are continuing on models of "open ships" to obtain additional knowledge of the influence of torsional boxes and transverse members between hatch openings on the torsional rigidity of the hull. In addition, theoretical analysis are being made based on finite element techniques.

Stresses and Deflections in Main Hull Structure and Superstructure:

Strain and deflection measurements have been made on board a bulk carrier and systematic model tests and theoretical studies have been carried out in an attempt to ascertain the degree of correlation which can be obtained between the measured and predicted behaviour of both the hull in general and the local structre. Investigations are continuing to obtain further knowledge on the behaviour of bulk carrier structures.

Full scale measurments have been made on a container ship in order to obtain data which can be related to results of model tests and analytical studies.

3. Slamming and Wave Impact

Analytical studies and full-scale measurements are being made of the stresses in a ships hull due to whipping and wave excited vibration.

4. Design Philosophy and Design Procedure incluing Plastic Design.

The Society is a member of a National Committee which is studying the design and construction of very large tankers. The society is carrying out analysis on proposed structures for a 400,000 ton and a 1,000,000 ton dead weight tanker.

5. Numerical Methods

Development of semi-automatic data generating program systems for use in conjunction with beam and finite element analysis programs. A Semi-automatic data generation program is being finalised which, with the aid of "D-MAC" equipment, produces the complete general geometry of a 2-dimensional structure.

Germanischer Lloyd.

1. Loads on Hull Girder

Dependence of the long-term distribution of bending stresses, induced by vertical and horizontal wave bending monents, on the main characteristics of the ship.

2. Load Carrying Ability

Computation and measurement of longitudinal and transverse deformations and associated stress distributions in tankers. Development of computation methods for torsional stsesses of computation methods for torsional stresses of non-cylindrical, thin-walled bodies composed of open and closed cells.

3. Slamming and Wave Impact

Computation of pressures induced by water on decks and superstructures of ships in a seaway including the affects of acceleration and distribution of water on deck

4. Vibration

Development of a computer program for forced vibrations of the hull and structural elements on the basis of systems of discrete mass discs.

In vestigations on the problem of effective damping of hull vibrations by study forced vibrations measured on models and actual ships. Investigation on the dynamical behaviour of the engine-double bottom system.

Det Norske Veritas

1. Load Carrying Ability

Major Discontinuities including Hatch Openings, Brackets and web perforations:

Structural evaluation of girder systems with openings for longitudinals and various stiffener arrangements. Buckling behaviour and stress evaluation for details e.g. notch contours longitudinal-stiffener connection, longitudinal-lug connection, etc. Experiments in the laboratory and stress analysis by means of finite element techniques.

2. Materials

Steels including Brittle Fracture and Corrosion

The influence of Si, Mn and C on the corrosion in the heat affected zone of unprotected weldments exposed to running sea water. Experiments are carried out in two specially built corrosion tanks with specimens of both industrial steels and laboratory produced steels.

The development of requirements for brittle fracture testing of weldments in vessels carrying liquefied gases (down to −60°C). Emphasis is placed on static and dynamic C.O.D-testing methods. It is planned at a later stage to compare these tests with realistic ones viz, wide plate test and experimental vessel.

3. Vibration

Vibration studies of three parallel submerged girders. Experimental studies include effects of girder spacing, size of flange and various cut-outs in the girder webs, The theoretical part involves finite element application to determine added mass and the interaction between structure and fluid.

4. Numerical Methods

Development of general purpose structural programs based on the Sub-structure concept. These programs will comprise regular linear and non-linear stress analysis, buckling and vibration analysis.

Systematic studies on the accuracy of frame-work and finite element techniques. Comparison with various full-scale measurments made on large tankers.

Nippon Kaiji Kyokai

1. Loads on Hull Girder

Full Scale Statistical:

Stress measurements on Ships

2. Load Carrying Ability

A study of the ultimate strength of girders

3. Fatigue

Investigations into the fatigue strength of hold frames in way of the tank side bracket.

The general study of fatigue crack propagation

4. Miscellaneous Researches

A study of the strength of cargo containers.

China Corporation Registers of Shipping

1. Load Carrying Ability

Major Discontinuities including Hatch Openings, Brackets and web perforations:

Stress analysis of a rectangular plate with various openings on the compression side under pure bending. Theoretical analysis includes:

(a) General equations of buckling

(b) Specific equations for different types of opening including stress concentrations.

Complementary photo-elastic experiments are being carried out to confirm the theoretical predictions.

各國의 船級協會가 造船技術面에서 크게 貢獻하고 있는 狀況을 紹介하는 뜻에서 Computer Program의 開發狀況 및 技術圖誌의 發刊現況을 살펴보면 다음과 같다.

(1) Computer Program 開發狀況

Lloyd's Register of shipping-Computer Frograms

Mathematical routines

LR 16 Solution of linear equations

LR 17 Polynomial curve fitting

LR 34 Harmonic analysis

LR 36 Three-in-one curve fitting

LR 210 Multiple linear regression

Torsional vibration and crankshaft stresses

LR 25 Combined bending and torsional stress in crankshafts

LR 31 Harmonic analysis of engine torque

LR 39 Forced torsional vibrations of a crankshaft system with internal and external damping

LR 41 Crankshaft harmonic torque synthesis

LR 60 Torsional vibration characteristics of unbranched systems

LR 66 Torsional vibrations of multi-branch systems

LR 67 Rule-size diameter of oil engine crankshafts

LR 111 Torque ratios for oil engine crankshafts

Whirling frequencies of shafting

LR 84 Whirling frequencies of propeller shafting

Shaffing alignment

LR 30 Shafting alignment

Stresses in pressure vessels and components

LR 20 Box-type heat exchanger tube plate stresses

LR 22 Checking of flanges in accordance with BS 1500

LR 58 Stresses in weld-neck flanges

LR 61 Stresses in loose type flanges

LR 62 Stresses in a pair of weld-neck flanges having a tube plate clamped between them

LR 80 Approval of pressure vessels in accordance with section Ⅷ of the ASME pressure vessel code

LR 113 Determination of stresses in cylindrical pressure vessels supported on saddles

LR 221 Stresses due to local loads and moments on cylindrical pressure vessels

Metallurgical

LR 98 Proof or yield stress properties of steel products at elevated temperatures

Freeboard

LR 37 Steamer freeboard (1930 Load Line Convention)

LR 43 Tanker freeboard (1930 Load Line Convention)

LR 124 Freeboards for all types of ships (1966 Load Line Convention)

LR 209 Tonnage mark

LR 220 Flooding of ships and stability in damaged condition

Shipweight distribution and longitudinal strength

LR 76 Longitudinal strength (hull shear force and bending moment distribution)

LR 109 Weight distribution, fore and after body LCGs', and longitudinal radius of gyration

Hull vibration

LR 57 Hull vibration frequencies and profiles

Scantling approval

LR 100 Tanker scantlings to Lloyd's Register Rules

LR 109 Modulus of tanker midship section

Grillages

LR 114 5×8 grillage analysis

Properties of sections

LR 51 Properties of plate/rolled section combinations

LR 78 Properties of built-up "T" sections

LR 94 Girder scantlings to Lloyd's Register-rules

Cargo Handling Gear

LR 54 Union purchase forces

LR 68 Strength of tubular derrick booms

LR 77 Strength of bipod masts

Statistical sea state and ship response

LR 64 Ship response in irregular head seas

LR 74 Wave bending moment (statistical)

LR 85 Long-term distribution of ship bending moment

LR 87 Moments of energy spectra

Drilling rigs

LR 123 Wave forces on drilling rigs

Strain analysis

LR 4 Evaluation of stresses from strain gauge readings

Kort nozzles

LR 3 Strength of kort nozzles

Det Norske Veritas-Computer Services

PROGRAM LIBRARY (as of April 1969)

NV 001 Harmonic analysis

NV 002 Harmonic analysis and synthesis

NV 003 Solution of linear equations with symmetric matrix of coefficients

NV 005 Solution of linear equations

NV 007 Tabulation of arbitrary functions

BV 008 Solution of linear equations with many zero-coefficients

NV 009 Solution of large numbers of linear equations with symmetric matrix of coefficients

NV 100 Regression analysis

NV 200 Calculation of hydrostatic data. Input description

NV 203 Linking program between programs for fairing of lines and programs for hydrostatic calculation

NV 205 Control of hull data

NV 206 Displacement sheet calculation

NV 208 Bonjean table calculation

NV 210 Stability

NV 215 Floodable length calculation

NV 216 Damaged stability calculation

NV 220 Launching calculation
NV 230 Calculation of freeboard (1930 convention)
NV 231 Calculation of freeboard (1966 convention)
NV 240 Trim tables I
NV 241 Trim tables II
NV 250 Sounding tables for conical and cylindrical tanks
NV 251 Ullage tables for regular tanks
NV 260 Hydrostatic calculation of still water bending moment and shear force
NV 261 As NV 260, but based on Bonjean values as input data
NV 282 Fairing as lines
NV 285 Drawing program for lines fairing programs
NV 300 Finite element, structure analysis
NV 301 Finite element program for 3-dimensional membrane structures
NV 305 Finite element program for plane membrane structures
NV 306 Analysis of three-dimensional frames
NV 307 Analysis of grillage systems. General
NV 308 Analysis of pipe systems
NV 309 Finite element structural analysis
NV 312 Analysis of plane frames with in-plane loading. General
NV 316 Gas or vapour flow in pipes
NV 317 Outflow from tanks. Emptying time
NV 318 Grillage drawing program for NV 307
NV 320 Stress analysis of simple supported cylindrical tanks under various loading conditions.
NV 321 Buckling of one-bay multi-story frames having lateral supports
NV 322 Stresses in joints
NV 325 Barge saddle reactions in grounded condition
NV 351 Calculation of area, moment of inertia and section modulus for a ship section
NV 352 Approximate calculation of still water shear forces and bending moments
NV 355 Calculation of area, moment of inertia and section modulus
NV 360 Geometrical characteristics of I-profiles
NV 361 Buckling strength of sections made of yield strength controlled steel, according to rules
NV 362 Buckling strength of sections made of yield strength controlled steel, according to rules
NV 362 Buckling strength of sections made of yield strength controlled steel, according to rules. Control program
NV 363 Tabular data for I-beams
NV 364 Acceptable still water shear force along the hull of oil tankers, according to rules
NV 365 Acceptable still water shear force for bulk carriers, according to rules
NV 366 Longitudinals in tankers, according to Rules
NV 367 Longitudinals in dry cargo ships, according to rules
NV 370 Flow distribution in networks by matrix analysis
NV 375 Torsional analysis of ships with wide hatch openings
NV 400 Plate vibration
NV 401 Ship motions and dynamic wave bending monent
NV 402 Uncoupled bending vibration of cantilever beams
NV 403 Short and long term distribution of wave induced motions and loads
NV 409 Shock response of spring-suspended platform having 3 degrees of freedom
NV 410 Calculation of transfer functions for wave induced ships motions and loads
NV 411 Stability and flexibility characteristics of helical springs
NV 412 Wave refraction
NV 413 Transfer functions for stresses in structures that are simultaneously exposed to different types of wave loads
NV 414 Statistical analysis of wave height data from weather ships
NV 415 Fitting of the first three approximations of the Edgeworth series to classed data
NV 450 Vibration of panels I (simply supported)
NV 451 Vibration of panels II (elastically supported)
NV 480 Ship hull vibration
NV 500 Calculation of forced torsional vibrations in straight marine shaft systems
NV 501 Whirling of propeller shaft systems (Jasper's formula)
NV 503 Holzer tabulation of torsional vibrations in straight shaft systems
NV 504 Shaft alignment. Straight shaft systems composed of rotational bodies

NV 505 Whirling frequencies of shaft systems

NV 506 Holzer table. Simple version

NV 511 Crankshafts, Bearing reactions. Angular deflections at bearings

NV 515 Torsional vibrations of branched shaft systems: natural frequencies, rel. moment tables and phase vector sums

NV 516 Secondary torsional resonance in crankshaft systems of multi-cylinder engines

NV 517 Holzer tabulation of axial vibrations in straight marine shaft systems

NV 518 Natural frequencies in torsional and axial vibration in a system of several branches coupled to an elastic ring

NV 520 Stresses from gas-and mass forces and torsional vibrations in diesel engine shaft system

NV 522 Maximum torque and torque-variation in diesel engines

NV 524 Mass forces and mass moments, guide pressure analysis, bedplate moments and bearing reactions in diesel engines

NV 525 Calculation of phase vector sums from Holzer tables

NV 526 Approximate estimation of dynamic propeller forces (based upon volume mean wake and propeller free running diagram)

NV 527 Analysis of measured rotating thrust torque-and bending vectors in a shaft system

NV 528 Anlaysis of measured thrust-, torgue-and bending vectors registered during propulsion tests in regular waves

NV 529 NACA 16 (a=0,8, modified) representation of the propeller blade

NV 530 Calculation of stationary temperature fields in axial symmetric bodies

NV 531 Theoretical calculation of hydrodynamic loading on the marine propeller

NV 533 A vortex flow theory applied to marine propeller problems (modified method of Guilloton)

NV 534 Keyless bore propeller, axial pull up distances and material stresses

NV 535 Finite element analysis of axial symmetric bodies including thermal stresses, yielding and creep

NV 600 Principal stresses from rosette gauges. Dynamic measurements

NV 601 Energy spectrum of irregular waves

NV 602 Photoelasticity. Principal stresses on free surface

NV 603 Stresses from rosette gauges. Dynamic measurements

NV 604 One-dimensional transient heat flow

NV 605 One-dimensional heat transfer

NV 606 Thermodynamic analysis of the pressure time diagram of internal combustion engines

NV 607 Analysis of coordinates from curves lifted by means of D-MAC pencil follower

NV 850 Midship section analysis of oil tankers, accoding to Rules

NV 860 Midship section analysis of bulk/OBO carriers, according to Rules

NV 870 Calculation of cantilevers and web frames, according te Rules

NV 900 Time for cooling non-precooled live cargo

Bureau Veritas

Computer Program Library

1972

M 1150 Freeboard calculation, 1966 Convention

M 1160 Lines drawing

M 1161 Calculation of hydrostatic curves

M 1162 Calculation of curve of righting levers

M 1163 Calculation of flooded stability IMCO-66

M 1165 Calculation of flooded stability SOLAS-60

M 1166 Calculation of floodable lengths

M 1167 Calculation of still water shear forces and bending moments

M 1169 Stability calculation for Hopper dredgers

M 1170 Tonnage calculations

M 1180 Calculation of capacities and sounding tables

M 1181 Geometrical properties of beams

M 1200 Description of the ship

M 1201 Calculation of shear forces and bending moments

M 1202 Forces and moment in static waves

M 1203 Movement of a ship in regular waves

M 204A Short term statistics concerning the movement of the ship

M 1204B Long term statistics concerning the movement of the ship

M 142 Dynamic deflection of a ship in waves
M 1209 Statistical analysis of the distribution of fixed weights
M 1210 Definition of a cross-section
M 1211 Calculation of sthe ection modulus according to the Rules
M 1212 Calculation of shear stresses
M 1213 Calculation of the shear stresses
M 1218 Standardized steel sections
M 1220 Automatic data generation for the general programs for strength of materials
M 1250 Calculation of masts
M 20A Approximate calculation of bending moments in still water
M 20B Verification according to the Rules of the scantlings of cargo ships
M 20C Verification according to the Rules of the scantlings of bulk carriers
M 20D Verification according to the Rules of the scantlings of rudders
M 201 Geometrical properties of box beams
M 202 Reduction of a plate structure to an equivalent pin-jointed structure
M 203 Geometrical properties of beams which represent double hulls
M 120 Automatic data generation for the finite element calculation of a transverse frame of a tanker
M 3001 Analysis of statically indeteraminate beam structures
M 3002 General program for the analysis of statically indeterminate structures
M 3003 General program for static and dynamic analysis of statically indeterminate structues
M 3004 Calculation of statically indeterminate structures by the finite element method
M 3005 Matrix calculation of complex structures
M 3006 Calculation of critical buckling loads by the finite element method
M 3007 Piping calculations
M 3008 Line-plot of the structures analysis by the programs M3001 or M3002
M 3009 Calculation of the principal stresses resulting from strain gauge measurements
M 3011 Torsional vibrations of a branched shafting system
M 3012 Lateral vibrations of a tail shaft supported by rigid bearings
M 3013 Lateral vibrations of a tail shaft supported by elastic bearings
M 3014 Whirling of a tail shaft supported by rigid bearings
M 3015 Whirling of a tail shaft supported by elastic bearings
M 3016 Whirling of a tail shaft taking account of gyroscopic effect in gearing
M 3017 Axial vibrations of a tail shaft
M 3018 Static analysis of shafting
M 3019 Lateral vibrations of the ship considered as a beam

Germanischer Lloyd's Electronic Computer

Ⅰ. Strength investigations
1. Longitudinal strength
2. 2- and 3-dimensional structures, considering shear deformations
3. Torsional strength of "open" ships
4. Shear stress distribution in open and multiple closed cross sections
5. Grillage structures, considering shear, bending and torsion
6. Moments of inertia and section moduli of composite cross sections
7. Warping and torsional rigidities of ship's cross sections

Ⅱ. Vibration calculations
1. Free shear and bending vibrations of hulls
2. Determination of effective bending and shear rigidities for ship vibrations
3. Determination of hydrodynamical masses for 2-dimensional flow, according to Lewis
4. Determination of reduction factors according to Kruppa/Csupor, for 3-dimensional flow

Ⅲ. Hydrostatical calculations
1. Hydrostatic curves and cross-curves of stability
2. Ullage and sounding tables
3. Flooding and damage stability investigations, taking into account a wide range of problems
4. Calculations of floodable lengths.

Ⅵ. Hydrodynamical investigations
1. Ship's motions in regular waves and resultant loads

2. Maximum amplitudes of motions, accelerations, bending moments, etc. to be expected of ships in an irregular seaway with given probability.

V. Freeboard

1. Computation of freeboards according to the Regulations of the International Load Line Convention, 1966.

VI. Marine engineering problems

1. Elastic deflection line of statically indeterminate shaftings
2. Dimensioning of crankshafts of various designs.

Nippon kaiji kyokai-Computer Programs

1. Longitudinal strength of ships due to bending moment and shearing force
2. Stabitity of ships
3. Natural frequency of torsional vibration by Holzer method
4. Strength of gears required by our Rules
5. Analysis of principal st ress for:
   a) the measured results of two and tree directionla9 strains on an aally symmetric body
   (the results of strain measurement on the crank shaft fillet.
6. Spectrum analysis for vibratory phenomena.
7. Bending and torsional stress concentration factor on the crank shaft fillet by Arai's formula.
8. Bending and torsional stress on the fillets of multi-throw crank shaft.
9. Axial spring constants of crank shaft by Arai and Guglielmotti's formula.
10. Exciting force vector for the vibration.
11. Synthesis of theoretical calculated stress and vibratory one.

(2) 技術圖誌 發刊現況

Publications issued by Lloyd's Register of shipping

1. Lloy's register book
2. Register of yachts
3. List of national authorities and sail numbers of racing yachts
4. The flag booklet
5. Yacht rules
6. Register of American yachts
7. Rules and regulations for the construction and classification of steel ships
8. Rules for steel trawlers
9. Rules for inland waterways vessels
10. Rules for floating docks
11. Rules for mobile offshore units
12. Geometric properties of rolled sections and built girders
13. Freight container certification scheme
14. Approved electrodes for welding in hull construction
15. List of approved fuses
16. List of type tested circuit-breakers
17. Cargo handling gear code
18. Provisional rules for the application of glass reinforced plastics to fishing craft
19. Guidance notes and requirements for the classification of air cushion vehicles
20. List of type approved control and electrical equipment

Publications Issued by Det Norske Veritas

1. Register of ships
2. Rules for the construction and classification of steel ships (Norwegian and English edition)
3. Rules for the construction and classification of steel ships with length less than 90 meters(Norwegian and English edition)
4. Rules for the building and classification of wooden vessels (Norwegian)
5. Principles for classification of offshore drilling platforms
6. Rules for the construction and certification of boats of glass reinforced plastics (Norwegian)
7. Rules for the construction and classification of freight containers
8. Tentative rules for the construction and classification of vessels of glass reinforced plastics (Norwegian)
9. Tentative rules for the construction and classification of light craft with length less than 90 meters made of steel or aluminium alloy (Norwegian and English edition)
10. Separate editions of the rules
11. List of type approved products and approved manufacturers

12. Statistical publications
13. Statistical tables showing addition and deduction of Norwegian, Swedish and Danish vessels of 100 tons gross and above during the years 1940—1945.
14. Norwegian marine insurance plan of 1964
Report of the committee of 1964 regarding the Norwegian marine insurance plan
15. Norwegian insurance plan for the carriage of goods of 1967. Report of the committee of 1964 regarding the Norwegian insurance plan for the carriage of goods of 1967.
16. Det Norske Veritas' technical publications.

American Bureau of Shipping Publications

1. Record of the American Bureau of Shipping.
2. Rules for building and classing steel vessels (English, Spanish, Portuguese Greek and German Edition)
3. Rules for building and classing steel vessels for service on rivers and intracoastal waterways (English and Spanish edition)
4. Rules for building and classing offshore mobile drilling units
5. Rules for building and classing steel barges for offshore service
6. Rules for building and classing bulk carriers for service on the Great Lakes
7. Guide for the classification of nuclear ships
8. Requirements for the certification of the construction and survey of cargo gear on merchant vessels
9. Requirements for the certification of the construction and survey of self-unloading cargo gear on Great Lakes vessels
10. Guide for the certification of cargo containers
11. Guides for the classification of manned submersibles
12. Approved welding electrodes, wire flux and wire-gas combinations
13. Rules for the approval of electrodes for manual arc welding in hull construction
14. Rules for the approval of wire-flux combinations for submerged arc welding
15. Provisional rules for the approval of wire-gas comb inations for gas metal are welding
16. Guidance manual for making bronze propeller repairs
17. Provisional rules for the approval of filler metals for welding higher strength steels
18. Requirements for radiographic inspection of hull welds
19. Guide for inert gas installation on vessels carrying oil in bulk
20. Other publications
    (a) Shear force and bending moment calculations
    (b) Marine propeller shaft casualties
    (c) Irroestigation of tailshaft assemblies
    (d) An investigation on peening
    (e) Ultrasonic inspection procedures in commercial shipbuilding
    (f) Surveyor
    (g) Annual report

Publications Issued by Registro Italiano Navale

1. Register book
2. Rules for construction and classification of ships (Italian & English edition)
3. List of shipowners and their ships
4. Tariffs
5. Rules for construction and classification of steel fishing vessels (Italian & English edition)
6. Rules for construction and classification of wood fishing vessels (Italian & English edition)
7. Rules for the construction and classification of hydrofoils (Italian & English edition)
8. Rules for the construction of steel yachts (Italian & English edition)
9. Rules for the construction of wood yachts (Italian & English edition)
10. Provisional rules for the construction of ships intended for inland navigation and of tow-barges intended for sea-going service (Italian & English edition)
11. Tonnage measurement of ships according Italian rules
12. Rules for homologation and testing of containers (Italian & English edition)
13. Guide for the classification of hovercrafts (air-cushion vehicles) (Italian & English edition)
14. Guide for the construction of automation and remote control systems and special rules for ships having unattended engine rooms

15. Guide for the classification of nuclear ships (Italian & English edition)
16. Rules for building and classification of yachts of the international 5.5meters rating class
17. Provisional rules for the construction of pleasure-boats built with glass-reinforced plastics (Italian & English edition)
18. Rules for the construction testing of life-saving appliances
19. Apparatus devices and materials of approved type
20. Collection of circulars having technical character
21. Rules for the construction and classification of ships or platforms for drilling (Italian & English edition)
22. Compulsory testings (Italian & English edition)
23. Rules for the construction of dredgers and hopper barges (Italian & English edition)
24. Rules for tankers intended for transport of liquid chemicals (Italian & English edition)
25. Guide for issuing "Superior Quality Certificates" to pleasure ships or boats
26. Tables of the various equipments that a ship must have
27. Tables of normal and reduced powers of national and foreign D.C. motors approved by the M.M.M. at the July 10th, 1970
28. New international rules for prevention of collisions at sea
29. Tables of life-saving signals for life boats and liferafts
30. Tables of life-saving signals for bridge
31. Annual subscription to the technical pamphlets
32. Annual subscription to the Notices

Publication by Germanischer Lloyd

1. Register of ships
2. Surveyors and agents to Germanischer Lloyd
3. Rules for the classification and construction of seagoing steel ships, inland steel ships and refrigerating installations
4. Recommendations for condition surveys and regulations for repair of containers in use
5. Tariffs of fees for the calculation of fees for seagoing ships, inland vessels, yachts, boats and small ships and for containers
6. Regulations for the checking of position lanterns
7. Rules for the construction and classification of steel yachts
8. Construction rules for ifeboats and service boats made of glass-fibre reinforced plastic material
9. Regulations for the determination of the push-up length of ship propellers by means of the oil-hydraulic pressure method
10. Rules for acceptance and testing of plywood used in the construction of aircrafts
11. Regulations for the testing of fiittings constructed in series
12. Regulations for medium tension electrical plants aboard seagoing ships
13. Regulations for the stowage and lashing of containers aboard ships
14. Rules for the construction of wood sailing yachts
15. Regulations for the construction and examination of cargo handling appliances
16. Rules for the construction and testing of lowering appliances for lifeboats
17. Regulations for the acceptance and testing of plywood used in boat building

Publications Issued by Bureau Veritas

1. Register maritime (Marine register)
2. Rules and regulations for the construction and classification of steel vessels (French, English, Spanish)
3. Recommendations concerning the characteristics construction and testing of windlass on sea-going ships
4. Homologation of mass production internal combustion engines
5. Inspection of the machining hobbing and assembly of reduction gearing
6. Automated ships. technical granting conditions of special marks
7. Additional provisions for fire protections for granting mark SF to cargo ships
8. Containers for the carriage of perishable goods
9. Ships for carriage in bulk of dangerous liquids
10. Recommendations designed to limit the effects of vibration on board ships
11. Glass-reinforced polyester hulls

12. Containers homologation and inspection
13. Classification of offshore platforms
14. Freeboard of dredgers fitted with bottom dump doors
15. Containers : surveys in service
16. General technical conditions for nuclear ships
17. Technical conditions for reactor pressure vessels of nuclear ships
18. Repair docks receiving ships over 200,000 dwt
19. Inspections at works for classification of ships
20. Classification of marine air cushion vehicles
21. Rules and regulations for the construction and classification of inland navigation boats (French, English Dutch edition)
22. Rules and regulations for the construction and classification of wooden fishing vessels (French, English Spanish edition)
23. Rules for the construction of ship's life-boats service and emergency boats (French, English edition)
24. Register of Inland waterways vessels

Publications Issued by Nippon Kaiji Kyokai

1. Register of ships (English edition)
2. Rules and regulations for the construction and classification of ships (Jap. & Eng. edition)
3. Rules for the construction and certification of freight containers (Jap. & Eng. edition)
4. Rules for material testing machines (Japanese edition)
5. Provisional rules for gas turbines with detailed rules (Jap. & Eng. edition)
6. Provisional rules for the construction of pontoon-type cargo barges (Jap. edition)
7. Provisional rules on torsional vibration of shaftings and explanatory notes (Jap. & Eng. edition)
8. Provisional guide for the classification of nuclear ships (Jap. & Eng. edition)
9. Guidance for LNG carriers (Japanese and English edition)
10. Record of Japanese ships (Japanese edition)
11. Directory (English edition)
12. Annual report (English edition)
13. New shipbuildings in Japan (English edition)
14. Transactions of Nippon Kaiji Kyokai (Japanese edition)
15. NK Overseas (English edition)

4. 맺는말

以上 船級協會의 現況과 造船技術研究分野에 있어서의 船級協會의 活動狀況을 略述한 바 各船級協會는 各自의 基本業務인 船舶登錄과 檢査의 基調를 이루는 鋼船規則의 改正補完을 보다 近代的인 技術을 바탕으로 施行하기 위하여 獨自的인 研究機構를 마련하여 間斷없는 技術研究業務를 繼續하고 있으며 그 研究結果는 鋼船規則의 改正補完에만 活用되고 있는 것이 아니라 造船技術開發에도 크게 寄與하고 있음을 알 수가 있으며 船舶構造解析分野에 있어서는 理論, 實船計測 等 各部門에서 各船級協會 모두가 거의 獨占的인 領域을 차지하고 있다는 것을 말하여 주고 있다.

따라서 船級協會로서 國際活動을 營爲하려며는 技術研究開發分野에 있어서도 相當한 地位와 認定을 받지 않고서는 列强과 列을 같이하여 船級協會로서 行勢를 할 수 없는 環境에 놓여져 있다고 하겠다.

끝으로 우리나라에 있어서도 設立後 日淺하기는 하나 船級協會가 設立되어 있고 七大船級協會와 業務代理協定을 締結하여 그 面貌를 갖추어가고 있기는 하지만 아직도 그 聯合體인 IACS에는 加入이 되어 있지 못하므로 早速한 發展이 要望되고 있으며 多幸히 西獨技術援助資金을 얻어 檢査技術開發을 위한 研究機構가 設立되어 가고 있기는 하지만 아직도 前途遼遠한 바이고 船級協會의 member로서가 아니고 造船關聯者의 立場에서 보다 더 積極的인 支援이 必要하다는 것을 添言하면서 끝맺음을 하고저 한다.