# SHIPBUILDING INDUSTRIAL/PRODUCTION ENGINEERING WORKSHOP

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PROCEEDINGS FOR

SHIPBUILDING INDUSTRIAL/PRODUCTION

ENGINEERING WORKSHOP

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# SECTION I

## SHIP PRODUCIBILITY
## RESEARCH PROGRAM

## 1.1 <u>History of the Ship Producibility Research Program</u>

Following enactment of the Merchant Marine Act, 1970, the National Shipbuilding Research Program was established by the Maritime Administration. Provisions of this legislation charged the Secretary of Commerce with the responsibility to "collaborate with . . . . shipbuilders in developing plans for the economical construction of vessels" (Section 212(c)). The shipbuilding industry direction for the program is provided by the Ship Producibility Program under Bath Iron Works. This program is responsible for the cooperative industry program to develop improved technical information and procedures for use by U.S. shipyards in reducing the cost and time for building ships. Recently this directive has been made more specific by the Ship Production Committee asking Bath Iron Works to:

* assist U.S. shipyards in the development and implementation of an improved <u>industrial engineering</u> capability
* assist U.S. shipyards in formulating national <u>standards</u> for shipbuilding

To initiate the cooperative industry program in <u>industrial engineering</u> the Maritime Administration, in conjunction with Bath Iron Works, held a three-day planning workshop with the representatives of 23 U.S. shipyards in Atlanta, Georgia, on February 21 through February 24, 1978. The AIIE assisted in the preparation for and conduct of this workshop.

The following is a report of this initial program planning workshop in which the problems to be addressed by the program were identified, some preliminary projects for cooperative development were specified, and the industry organization for directing and monitoring the program was established.

## 1.2 Workshop Purpose and Approach

The purpose of the workshop was to bring together a representative mix of industry experts to ascertain the degree of common problems within the industry and to make recommendations as to what cooperative action might be taken to resolve these problems. Four discussion groups were formed to establish the state-of-the-art in their respective areas, identify economic problems, and recommend action; and thus improve industry's ability to reduce cost and reduce construction time. These groups were:

Production Planning, Scheduling and Control

Methods and Standards

Facility Planning and Engineering

Quality Control/Quality Assurance

# SECTION II

## WORKSHOP PANEL REPORTS

## 2.1 Panel I, Production Planning, Scheduling and Control

Chairman:

Ben Martino, Chief, Industrial Engineering
& General Hull Superintendent
Livingston Shipbuilding Company

Resource Panel Members;

Philip Dilloway, Associate Professor
of Industrial & Management Engineering
University of Bridgeport

Johnny R. Meyers, Director-Resource Development
American Airlines, Inc.

### 2.1.1 Panel Objective

The purpose of this panel is to assess the state-of-the-art of production planning, scheduling, and control practices in the shipbuilding industry, and to define and describe those areas wherein the development of improved practices would be of benefit to the industry.

### 2.1.2 Proposed Workshop Sessions (Used as a guide)

Session 1. Assess the state-of-the-art production control practices and techniques used in the shipbuilding industry.

Session 2. Review and analyze the basic methods and practices used in controlling and coordinating the processing and production operations within the shop areas.

Session 3. Review and analyze the basic methods and practices used in controlling and coordinating the processing and construction activities within the yard areas of the shipbuilding industry.

Session 4. Review and analyze the compatibility of both shop and yard production control and scheduling practices to assure proper integration of the total shipbuilding process.

2.1.3 Panel I Discussion Items

A wide range of discussion-items was covered by each of the groups composing Panel I. With the objective statement in mind, the participants proceeded to share their thoughts with regard to current practice and to those concerns that seemed to hamper the effectiveness of a production planning and control system.

A number of these discussion items encompassed a broad impact area within the industry where production planning, scheduling and control was only one affected area. Other items were quite narrowly discussed with focus on production planning and control. These discussion items, many in the form of questions, are reported for information and further discussion purposes.

1. The U.S. shipyard would find it valuable to have a procedures manual for production planning and control. Such a manual should contain useful general information and outline accepted procedures, but be designed in such a way that the individual shipyard could include data and sections specific to their operations.

2. All shipyards should have systems available which could

be used to monitor progress and assist in shop control. The emphasis should be on systems that are easy to understand by knowledgeable shipbuilders as well as inexpensive to implement, operate, and maintain.

3. Standard test, inspection and acceptance procedures should be developed which are acceptable to the American Bureau of Shipping, the Coast Guard, the Navy, and the Maritime Administration. The intent would be to minimize redundancy of these functions and to minimize production interruptions and delays.

4. Shipyards should have better data and methods of analysis in making management decisions relative to the use of overtime for schedule recovery. Particular attention should be given to determining, in advance, the effects on absentee rate, general morale, and work quality.

5. The practice of using unrealistic production schedules to force productivity should be investigated to determine the detrimental effects on worker performance and overcrowding of scheduled events in the later stages of construction.

6. Engineering standards for production should be developed , particularly in piping, electrical, machinery, painting, and surface preparation.

7. Investigation should be conducted to assist shipyards in determining optimum levels of pre-outfitting for different ship types. These studies should be conducted relat-

ing the functions done by engineering, production planning and methods engineering, as well as the normal production and service functions.

8. Attempts should be made to provide shipyards with information relative to the production impact of mandatory Federal programs on safety and health, the environment, and hiring practices. The possibility of cost-shared training programs needed to implement these programs should be investigated.

9. Programs which address the means needed to improve work force motivation, worker morale, and workmanship should be investigated for implementation in shipbuilding.

10. There is a great deal more that both the shipbuilder and its customers need to know about the total impact of contract changes. Effort should be made to raise the level of prior understanding of these effects in the interest of improving the contract environment of the parties.

11. The interface between engineering, production planning, and production operations needs to be improved. Problems continue to arise when the management of any of these functions attempts to solve local problems in a unilateral manner without full appreciation of the adverse impact of its' solutions on other functions.

Following discussion, an effort was made to focus upon the identification of research tasks. These are reported in the next section using the specified format of problem area description, objective and end product specification.

2.1.4 Panel I Research Task Descriptions

| Problem Area | Objective | End Product |
|---|---|---|
| Lack of clarity across the industry in the responsibility, authority and interface functions of production planning, scheduling and control | Define and clarify the production control function in the industry | |
| How to structure and implement an effective production planning and control system which minimizes organizational conflict | Survey the industry, to examine and describe the philosophies and organizational structures used and found effective in implementing the functions | A report detailing systems which have been tried revealing strengths and weaknesses with recommendations for an implementable plan |
| Management training needs for upper, middle and supervisory level employees in the industry | Impart management communication skills in dealing with a task-oriented work group | Comprehensive program of seminars, workshops, on-the job training, etc. with industry personnel as instructors |
| Manpower, scheduling and time standards are usually developed from a single parameter for convenience | To develop a series of engineered time standards from a multi-parameter data base | Set of engineered time standards:<br>a. Identify relative weights of the various parameters in the overall standard<br>b. Assessment of accuracy<br>c. Identify particular yard conditions needing further study and improvement |
| Lack of flexibility of current manual undisciplined scheduling analysis systems. Inability to schedule and allocate manpower | Search for the best available, comprehensive approach and develop system for the industry | An improved approach using the best of modern technology |

2.1.4 Panel I Research Task Descriptions (continued)

| Problem Area | Objective | End Product |
|---|---|---|
| Disruption and cost overruns caused by change orders | To review current systems and procedures to determine how changes are handled. To gain insight into the cost and impact of the change in a more timely manner. Include all appropriate costs in change order pricing | Shipbuilding production control procedure description for proper pricing and cost tracking |
| Engineering development and the need for material ordering, manufacturing and construction lead times to be satisfied | Synchronization of engineering design with production plans for material, labor, and facilities schedules | A scheme to provide accurate drawings, and hence other production needs e.g. materials, in a timely manner |
| Pre-outfitting and group technology impact upon cost reduction | To improve engineering design for modular construction and pre-outfitting. To encourage the grouping of like parts into "families" for production | A report detailing the use of such approaches in the industry and incorporating recommendations for further advances |
| Work force morale, motivation and collective bargaining | To use collective bargaining in a creative manner to address those constraints which give rise to lower work force productivity in the shipyards | Report on the guidelines and approaches for labor-management negotiations that would enhance the productivity objectives of the industry. |

## 2.2 Panel II, Methods and Standards

Chairman:

John Harvey, Manager of Industrial Engineering
Bath Iron Works Corporation

Resource Panel Member:

Joel Borden, Joel Borden Associates

### 2.2.1 Panel Objective

The purpose of this panel is to assess the state-of-the-art of methods and standards activities in the shipbuilding industry, and to define and describe those areas in the industry wherein the development of improved methods and standards practices would be of benefit to the industry.

### 2.2.2 Proposed Workshop Sessions (Used as a guide)

Session 1. Assess the state-of-the-art of methods and standards practice in the shipbuilding industry, including methods improvement programs, methods control practices, and the application of work standards to process, production, and construction operations in that industry.

Session 2. Review and analyze common practices in the analysis, improvement, standardization and control of process, production, and construction methods in shop and yard operations of the shipbuilding industry.

Session 3. Review and analyze the development and application of imported or engineered work standards to the process, production and construction operations within the shipbuilding industry.

Session 4. Review and analyze labor productivity in the shipbuilding industry with reference to the application of work standards and waqe incentives. Identification of low labor productivity/high cost areas as candidates for improvement.

### 2.2.3 Panel II Discussion Items

The panelists concentrated upon clarifying their problems in this area. This “problem - centered” approach quickly led to identification of those areas where the problems were common throughout the industry. Therefore, the discussion items for the Work Methods and Standards Panel contain the following concerns:

1. Management has little or nothing upon which to evaluate the benefits of a work measurement and work standards program. Is there a commonly held belief as to how to justify such programs to higher management or an approach that would indicate such programs were not justified? A common justification for presenting the benefits to be derived from a work measurement and work standards program for presentation to all levels of management should be established. This study should include several case studies and be prepared using shipyard terminology.

2. Lack of a recording system for performance which aggregates information beyond the single standard level in a shop. For large yards such a system may require a computer to aid in the storage and analysis of the data for management to use for monitoring and control purposes.

3. Are there common approaches to developing shipbuilding standards? How should a program begin?; what should be its objectives?; what criteria should be used to determine an initial standard - setting location?; how should standards be installed, controlled and recorded? These are all questions that arise in the context of standard development efforts.

4. The volume of data in the standards area for a large shipyard is significant. Can computer systems aid the solution to this problem on a common basis across the industry?

5. Training in IE for management and supervisory personnel might significantly aid the performance of the IE functions by building awareness of the goals, tools and personnel involved in IE work in shipbuilding. Training those responsible for performing IE functions would serve to keep them up-to-date with modern IE technological advances.

6. Basic work measurement systems design is an area of concern at least regarding the state-of-the-art in shipyards. Is there a standard approach and should synthetic

or measured standards be used in the shipyards? This arises as the kind of question in need of a response.

7. Analysis of incentive and measured work systems is needed to evaluate the advantages and disadvantages of each approach with respect to shipyards.

8. A survey of the tools used in work measurement and standard setting for methods analysis would give insight into the state of practice in this area which might indicate the need for refresher training programs or reference document preparation.

9. The organizational level, responsibilities and authority of IE functions in the industry need to be examined with guidelines developed as to effective organizational features for the industry to follow. A recommended organization of a typical IE department, including organizational level and responsibilities, as it would function in a shipyard should be developed.

10. A survey of the tools used and the procedures followed by shipbuilders for methods analysis concentrating on the first phase analysis tools used at the aggregate shipyard level and on the second phase analysis tools used for detailed problem areas needs to be performed.

2.2.4 Panel II Research Task Descriptions

| Problem Area | Objective | End Product |
|---|---|---|
| The organization and coordination of IE functions such as estimating, facilities planning, QC, work measurement. Level of IE functions in the organization | To provide an objective view of the interrelationship between IE functions, many of which are currently being performed under other titles pointing toward a concept as to how the IE functions should be organized and coordinated, nature of authority etc. | Descriptive report with specific recommendations |
| Concurrence on the objectives of a **work** measurement program in terms of goals and approach | To establish a generalized approach toward establishing and implementing a effective standard program | A report which serves as a general guide or procedures manual on how to establish a well-considered work measurement program |
| Understanding on the part of supervisory management of the techniques used and benefits derived from work measurement and method analysis | To improve understanding and rapport between engineering and management with regard to developing and using work methods and work measurement analysis techniques | Training programs |
| Labor costs and time associated with developing and using engineered standards to their greatest potential | To study automated means of controlling, maintaining and using standard data and work measurement standards | Report analyzing current technology capabilities and recommending approaches to follow |
| Effective time reporting and time accountir | To provide all levels of management | An early detection system to minimize |

2.2.4 Panel II Research Task Descriptions (continued)

| Problem Area | Objective | End Product |
|---|---|---|
| systems | with a means for detecting and pin-pointing production difficulties for corrective action | labor losses |
| Developing summary lev els of cost informa-tion, escalating from work measurement data, suitable for use by various levels of man-agement | To establish a building block con cept from a solid base of work meas-urement standards to be used for es-timating and bid-ding new jobs; es-tablishing facili-ty, equipment, too and personnel needs; the basis for capability and capacity analysis | An integrated man-agement system for storing and re-trieving work meas-urement information |
| Understanding the ap-plication of various methods analysis tech-niques to different shipyard operations | To illustrate the application and effectiveness of such methods anal-ysis techniques as Flow Process Charts, Flow Dia-grams, Multiple Activity Chart, Operation Chart an Left and Right Hand Charts | Demonstration pro-ject and training |

## 2.3 Panel III, Facilities Planning and Engineering

Chairman:

Richard Price, Chief Industrial Engineer
Avondale Shipyards

Resource Panel Member:

Harry McCaffrey, Director, Facilities Planning & Design
Dow Chemical Co. U.S.A.

### 2.3.1 Panel Objective

The purpose of this panel is to assess the state-of-the-art of facilities engineering practices in the shipbuilding industry, and to define and describe those areas wherein the development of improved practices would be of benefit to the industry.

### 2.3.2 Proposed Workshop Sessions (Used as a guide)

Session 1. Assess the state-of-the-art of facilities engineering in the shipbuilding industry including methods and practices used in plant and facility location, layout, design' and capacity analysis, equipment and machine location, work center location and departmentalization, materials and work flow control, materials handling equipment, warehousing, work crew facilities and work environment, and systems for maintaining plant and facilities.

Session 2. Review and analyze the basic process and production flow patterns, and the thru-put therefrom for the shop operations of the shipbuilding industry. Consideration to be given to problems in materials handling, materials control, in-process storage, warehousing, facility and machine utilization and other factors affectinq the efficient conduct of operations in the shop. Delineation of major improvements needed in the design layout, equipping, and maintenance of shop facilities.

Session 3. Review and analyze the basic staging patterns, construction sequencing practices, materials flow patterns, and general layout of shipyards and peripheral facilities. Consideration to be qiven to materials and equipment handlinq, crew interference and work delays brouqht about by lack of availability of equipment or materials in ship construction operations. Delineation of major improvements needed in the design, layout, equipping and maintenance of shipyards.

Session 4. Review and analyze the considerations and justifications required for facility renovation and new equipment acquisition in the shipbuilding industry. This is to include consideration of problems in capital formation and requirements for investment pay-back. Delineation of possible improvements or chanqes in the economic analysis and treatment of proposals for facility modification and new equipment acquisition.

### 2.3.3 Panel III Discussion Items

Panelists initially concentrated upon clarifying some of the problems which were currently troubling them. It then became clear that different shipyards defined facilities planning and engineering in different ways by electing a certain organizational placement and function assignment. Consequently, discussion pointed toward developing a working definition of facilities planning as a base step:

> "Facilities planning is that part of the management functions which seeks to implement the objectives of a business plan by the most effective utilization of existing material, labor, and plant resources in the most efficient manner."

Subsequent discussion covered the following list of concerns:

1. The lack of a long-range business plan presented in terms that are most useful for facilities planning purposes;
2. Most shipyards do not have experienced industrial engineering staff assigned to the facilities planning function and, as a consequence, many effective IE techniques and procedures may not be brought to bear on the problem;
3. The documentation of facilities planning procedures for shipyards is not consistent;
4. Advances in material handling technology, layout and location technology and other IE tools do not become known and as a consequence are not used at a sufficiently rapid rate.

Finally, panelists were polled as to their perceptions of facilities engineering capabilities and facilities and equipment problems.

Although not all panelists responded and not all questions received answers, the opinions expressed serve as useful evidence of current capabilities. These results are summarized in the following tables:

| | HAVE CAPABILITY | | OPINION | | |
|---|---|---|---|---|---|
| | Yes | No | Critical | Questionable | No Problem |
| Capacity Analysis Procedures | 3 | 1 | 4 | 1 | |
| Data Bank (Production Times) | 2 | 1 | 2 | 1 | 1 |
| Conceptual and Detailed Layout Techniques | 3 | 1 | 3 | 1 | 1 |
| Cost Analysis Approaches | 3 | 1 | 3 | 1 | 1 |
| Equipment & Facility Evaluation Techniques | 3 | 1 | 3 | 1 | 1 |
| Reliability and Maintainability Predictive Tech. | 1 | 3 | 1 | 4 | |
| Updating Techs. | 2 | 2 | 3 | 2 | |
| Sampling Approach- | 1 | 2 | 1 | 3 | |
| Queueing Analysis | 2 | 2 | 1 | 4 | |
| Simulation or Modeling | 2 | 2 | 4 | 1 | |

PANEL EVALUATION OF FACILITIES ENGINEERING

TECHNICAL CAPABILITIES

| | GENERAL EVALUATION | | IMPACT UPON FAC. PLAN. FUNCTION CRITICALITY | | |
|---|---|---|---|---|---|
| | Accept. | Un-Accept. | Serious | Minor | No Problem |
| **FACILITY** | | | | | |
| Access | 5 | | 2 | 1 | 2 |
| Size | 5 | | 3 | | 2 |
| Material Movement | 3 | | 3 | 2 | |
| Climate | 5 | | | 3 | 1 |
| Environment. Constraints | 5 | | 2 | 1 | 2 |
| Topography/ Config. | 4 | | 1 | 1 | 3 |
| Utilities | 3 | | 1 | 2 | 2 |
| Labor Mkt. | 4 | | 3 | 2 | |
| Layout | 3 | | 2 | 1 | 2 |
| **EQUIPMENT** | | | | | |
| Age/Conditiol | 3 | | 3 | 1 | 1 |
| SOA Suit. | 3 | | | 2 | 1 |
| Capacity | 3 | | 2 | 2 | 1 |
| Maintainabil- i ty | 3 | | 1 | 3 | 1 |
| Energy Usage | 3 | | 3 | 2 | |
| **MGT. & SUP-PORTIVE SYS.** | | | | | |
| Maintenance | 4 | 1 | | 4 | 1 |
| Procurement | 4 | 1 | | 4 | 1 |
| Spares Pol. | 5 | | | 4 | 1 |
| Scheduling | 2 | 3 | 4 | | 1 |
| Qual. Cont. | 3 | 1 | 1 | 2 | 2 |
| Production Standards | 3 | 2 | 2 | 2 | |

PANEL EVALUATION OF FACILITY

AND

EQUIPMENT PROBLEMS

2.3.4 Panel III Research Task Descriptions

| Problem Area | Objective | End Product |
|---|---|---|
| Variation in the organizational pattern of the facilities planning functions across the industry | To establish an industry profile with respect to the facilities planning organization including such items as scope, function, authority and responsibility, organizational level | Definitive and descriptive report of the current industry approaches to the facilities planning and engineering function organization |
| Lack of experienced IE staff assigned to the facilities engineering function | To improve the knowledge and capability of staff toward IE techniques, advanced technology and equipment, and the implementation thereof | An institutionalized training program to disseminate facilities planning design methodology and other advances throughout the shipbuilding industry |
| Documentation of IE facilities planning and engineering approaches in the shipbuilding industry | To develop a comprehensive descriptive procedures manual including at least the folowing: defined step: of the process; methodology to be used; organization of responsibilities and authority; documentation required | Report |
| Capacity analysis with respect to facilities and equipment | To develop a procedure which determines facilitie: constraints within the industry which can be used by each shipyard | A definitive report indicating a procedure for determining capacity constraints and demonstrating its use in a shipyard |

## 2.4 Panel IV, Quality Control/Assurance

Chairman:

Neil M. Doherty, Jr., Senior Program Planner
Bath Iron Works Corporation

Resource Panel Member:

Richard W. Krause, Manager
Quality Control-Range Division
General Electric Company

### 2.4.1 Panel Objective

The purpose of this panel is to assess the state-of-the-art of quality control/assurance practices in the shipbuilding industry, and to define and describe those areas wherein the development of improved practices would be of benefit to the industry.

### 2.4.2 Proposed Workshop Sessions (Used as a guide)

Session 1. Assess the state-of-the-art of quality control/assurance practices and techniques used in the shipbuilding industry to assure compliance to the quality standards required by that industry.

Session 2. Review and analyze the quality control/assurance practices and organizational approaches used in assuring adherence to material, process and product quality standards in the shop areas of the shipbuilding industry.

Session 3. Review and analyze the quality control/assurance practices and organizational approaches used in assuring adherence to material, process and product quality standards within the construction operations of the shipbuilding industry.

Session 4. Review and analyze the compatibility of material process, production, and construction quality standards and practices within both the shop and Yard areas of the shiPbuilding industry to determine areas of possible conflict and to pinpoint areas of excessive cost in the maintenance of such quality standards.

2.4.3 Panel IV Discussion Items

Panel discussion moved in rapid fashion to the issue of the multiple sources of documented quality standards and the considerable variation between these sources of standards. Documented requirements appear in the American Welding Society, American Bureau of Shipping, U.S. Coast Guard, American Society of Mechanical Engineers, Underwriters Laboratories, U.S. Public Health Service, shipbuilder's standards and contract specifications. It was noted that definition of consistent quality objectives is a difficult task in the face of this plethora of standards.

Discussion continued with the following points representing the Panel's focus:

1. A common quality system document for the shipbuilding industry would be desirable. It should serve as an umbrella document enabling shipyards to add their own specific material. Itemization of required and/or desired quality functions, consideration of organizational placement, responsibility and authority assignment for the function should also be included;

2. Additional definition and documentation of standards covering such areas as appearance, structural welds, pipe welds, incoming material and structural fairness would improve quality standard application;

3. Development of common interpretations of quality standards for numerous areas of vessel construction would serve to establish a common quality plane within the industry thereby reducing costs associated with disagreements over specification and compliance;

4. A significant quality problem area is that of vendor selection based upon ability to meet the specifications at the quality level desired in a timely fashion. A contributor to the problem is the small volume involved per lot hence providing little leverage. A solution to the problem should result in reducing delays due to rejects and rework of vendor material;

5. A review of how compliance to standards was accomplished by shipyard panelists produced the results in the following table:

| | SUMMARY |
|---|---|
| 1. DESIGN | |
| a. Drawing Approval<br>b. Production Review | Knowledge of standards was generally good though consideration of manufacturing capability by the designer could be increased. Perhaps a need for a manufacturing review of the design. |
| II. PRODUCTION PLANNING | |
| a. Establish Methods<br>b. Specify Equipment & Operation<br>c. Specify Scheduling<br>d. Specify Sequence of Work | Significant impact on quality compliance is achieved through consideration of quality in the factors listed in the development of a production plan. For example, the quality levels to be achieved in actual production in certain areas depend upon the quality levels established in the template making process. |
| III. PRODUCTION | |
| a. Procurement Inspect | Vendor quality is a problem area. |
| b. Training<br>-Training dept. manuals, licenses<br>-Social responsibility | Where welding-certification and licensing is required the training is performed, otherwise there are major quality training needs for all levels of employees. Legislated employment practices may cause added training needs to maintain workmanship and morale. Perhaps specialized programs are needed. |
| c. Workmanship<br>-Motivation<br>-Improvement programs<br>-Communication | Improvement programs tend to be pointed toward salaried personnel.<br>Work force was not kept well informed of the latest quality requirements and cases were also cited where supervision was unaware as well. |
| d. Craft Inspection Procedures<br>-Documentation<br>-Type of reporting<br>-Placement of responsibility | Generally, the inspections other than on the hull structure are accomplished by the craft performing the work or by a separate testing group. Standards and procedures need to be developed and documented. Also, the responsibility for the defects needs to be properly placed. |
| IV. QUALITY ASSURANCE | |
| a. Staff Inspection | The major function of QA departments is |

SUMMARY

| | |
|---|---|
| b. Inspection Procedures<br>c. Documentation<br>d. Sign-off Forms | the inspection and acceptance of the hull structure. The organizational placement, responsibility and authority for this function need to be examined. Staffing with qualified personnel is important - such people should have the proper personality as well as training. Appendix E represents a partial sample of what is needed for documenting a quality procedure. |

COMPLIANCE TO QUALITY STANDARDS

6. Dimensional control was reviewed as a sub-system to the Compliance to Standards discussion resulting in identification of some problems in assembly/erection with dimensional checks made by crafts using molds, tapes and surveying. There is a need for better methods and procedures to reduce erection time and cost, and in the need to integrate dimensional control between structural and mechanical system elements particularly in modular construction. Appendix E contains a sample procedural document.

7. A review of quality costs and the need to evaluate total quality costs was discussed. There is an apparent lack of evidence of goals in this area where trade-off evaluations between prevention, appraisal and failure correction are being made. A tabulation of Sources of Quality Costs was prepared and a consensus reached that the total quality cost was a significant percent of a firm’s total costs.

| REVIEW OF SOURCES OF QUALITY COSTS |
|---|
| I. Prevention<br>    Design Effort<br>    Vendor Effort<br>    Inspection or QA Effort<br>    Training<br>    Maintenance of Quality Standards<br><br>II. Appraisal<br>    Inspection/Non-destructive Testing<br>    Equipment and Calibration<br>    Record-keeping<br>    System Test<br><br>III. Failure<br>    Rework<br>        Workmanship<br>        Design Error<br>        Vendor Related<br>        Scrap<br>        Guarantees<br><br>Iv. Indirect Costs<br>    Delays<br>    Inventories<br>    Overhead |

Resulting from the discussion, various research tasks were identified. These are reported in the next section in terms of the identified problem area, the objective of the research effort,and the specified end product.

2.4.4 Panel IV, Research Task Descriptions

| Problem Area | Objective | End Product |
|---|---|---|
| Different approaches to an organization for quality across the industry | To develop recommendations for organizational placement, responsibilities and authority of the QC/QA function | Common industry guide document |
| Lack of commonly defined and documented quality standards for appearance, structural welds, pipe welds, incoming material and structural fairness as well as other standards pertaining to the hull structure and areas other than the hull structure | To develop and document common definitions of standards. To develop a common quality plane in the industry | Standards documentation report and procedural guideline |
| Vendor quality performance | To increase attention to quality performance of vendors. To reduce costs due to reject delays and rework | Vendor quality standards and a vendor rating system |
| Work force capability to meet quality performance and management understanding of QC/QA, including dimensional control | To improve training and attention to quality within the shipbuilding industry | Training program capable of performance at both hourly employee level and management level |
| Need for better knowledge of the total quality costs in the shipyard and the industry | To identify sources of quality costs. To develop a procedure for evaluating the total costs due to quality and establishing norms | Report specifying procedures for shipyards to use in determining total costs due to quality and establishing their individual quality goals. |

# SECTION III

## OVERALL
## CONCLUSIONS AND RECOMMENDATIONS

On the basis of the results of the Panel's discussion over the two and one half day period, a number of conclusions and recommendations have been prepared. The conclusions are presented first and the recommendations follow.

## 3.1 Conclusions

The collective efforts of participants in the Workshop through discussions in Panels and smaller groups point toward a number of important conclusions.

1. Despite the wide variation in size and product mix of the firms represented, the problems which are most pressing are common to all.
2. Cooperation and exchange of ideas between shipbuilders and other similar industries is beneficial and of itself. A similar workshop could be held on an annual basis.
3. There is an urgent need to promote the application of industrial engineering technology within the shipbuilding industry.
4. It is significant that there is wide discrepancy between firms with regard to the placement and assignment of duties for professional industrial engineers.
5. There is significant confusion in the industry caused by the overlap of responsibility as reflected in shipbuilding specifications between the U.S. Coast Guard, the Maritime Administration, the American Bureau of Shipping, and

the U.S. Navy.

6. There is a general lack of documented procedures for managers, supervisors, and work force.

7. As compared to other industries, there is a general lack of structured training in all the areas covered by the workshop. This deficiency exists for all levels of shipbuilding personnel.

## 3.2 Recommendations

Study of the Panel recommendations and the overall Workshop conclusions by the Panel Chairmen and resource people resulted in the following overall recommendations:

1. Increased promotion of industrial engineering technology and its application to the shipbuilding industry must take place. Initial studies are required to:

   Define industrial engineering and the functions performed relating to that profession within the industry;

   Identify the goals, organizational pattern, training, background, and staffing intensities of the IE functions;

   Identify the appropriate measures of performance of the IE functions and their applications;

   Determine measures for assessing cost-effectiveness (or cost avoidance) justifications for IE projects;

Identify specific IE functions within Production Planning - Scheduling - Control, Work Methods and Standards, Facilities Planning and Engineering, and Quality Assurance.

2. Training programs in IE technology and its implementation in the industry for members of management, supervisory staff, and the work force should be upgraded and intensified.

3. Better communications between management and unions need to be established with regard to finding solutions to problems of work force morale and motivation and the means to improve the quality of workmanship.

4. Establish a Shipbuilding Industrial Engineering Panel (SP-8) under the Ship Production Committee of the Society of Naval Architects and Marine Engineers to take action on these recommendations and continue the work of this conference with responsibilities to act for the industry in coordinating a cooperative technical program with the Maritime Administration and:

   a. Establish a consensus priority list of problem areas for solution;
   b. Solicit and review proposed IE research projects which address the problem areas;
   c. Provide continuing program guidance and overview;
   d. Publish and disseminate research results to the industry and aid in the understanding of such results;

e. Maintain a flexible and continuing program with built-in redirection capability to address new problems as they arise;

f. Maintain an up-to-date awareness of shipbuilding technology and industrial engineering technology;

g. Schedule annual technical meetings for industrial engineers in shipbuilding;

h. Develop and organize a program of training for shipyard management and industrial engineering.

# APPENDIX A

## WORKSHOP REGISTRATION LIST

REGISTRATION LIST

AIIE Shipbuilding Industrial/Production Engineering Workshop

February 21 - 24, 1978

Atlanta, Georgia

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APPENDIX B

# WORKSHOP AGENDA

## WORKSHOP AGENDA

FIRST DAY (TUESDAY, FEBRUARY 21)

Registration .................................... 4:00-8:00 pm

Reception .................................... 6:00-7:00

Workshop Panel Chairmen and Resource Personnel
Briefing .................................... 8:00

SECOND DAy (wEDNESDAy, FEBRUARy 22)

Registration .................................... 7:30-8:00 am

Workshop Opening Remarks .......................... 8:00-9:30

General Chairman

Mr. Francis X. Munger
Program Manager for Ship Producibility Research Program
Bath Iron Works Corporation

AIIE Representative

Dr. David L. Belden
Executive Director
American Institute of Industrial Engineers, Inc.

MarAd Representative

James Higgins
Deputy Assistant Administrator for Commercial Development
U.S. Department of Commerce, Maritime Administration

Shipyard Representative

Mr. Royce A. Young, Jr.
Vice President of Production
Bath Iron Works Corporation

Break .................................... 9:30-9:45

IE Contributions to Industry Panel . . . . . . . . . . . . . 9:45-12:00

Dr. Marvin E. Mundel, Moderator
M.E. Mundel & Associates

Three Corporate IE Managers will present examples of advanced IE in industry.

Mr. Harry H. Heist, Manager
Industrial Engineering Consulting
General Electric Company

Mr. Andrew N. Costas, Director
Industrial Engineering
United States Steel Corporation

Mr. James P. Bontadelli, Chief
Industrial Engineering Staff
Tennessee Valley Authority

Panel Luncheons . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12:00-1:30 pm

Briefings on planning workshops - objectives, working approach, personnel, schedule, results expected.

First Workshop Session . . . . . . . . . . . . . . . . . . . . . . . . . . . . 1:30-5:30

Reception . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6:00-6:30

Dinner - With Guest Speaker . . . . . . . . . . . . . . . . . . . . . . . . 6:30-8:30

Mr. Joseph H. Kehlbeck, Manager
Purchasing/Major Appliance Business Group
General Electric Company
President, AIIE

Second Workshop Session. . . . . . . . . . . . . . . . . . . . . . . . . . 8:30

THIRD DAY (THURSDAY, FEBRUARY 23)

Workshop Chairmen and Resource Panel Breakfast 7:30-8:30 am

Plenary Session - Chairmen's Interim Report to all Participants. . . . . . 8:30-9:30

Break . . . . . . 9:30-9:45

Third Workshop Session. . . . . . 9:45-12:00

Luncheon - With Guest Speaker. . . . . . 12:00-1:30 pm

Mr. Joji Arai, Manager
Japan Productivity Center

Fourth Workshop Session. . . . . . 1:30-5:30

Reception . . . . . . 6:00-7:00

Dinner . . . . . . 7:00-8:30

Wrap Up Workshop . . . . . . 8:30

FOURTH DAY (FRIDAY, FEBRUARY 24)

Workshop Plenary Session - Panel I and II Reports from Panel Chairmen and Resource Personnel Discussion. . . . . . 8:30-10:00 am

Break . . . . . . 10:00-10:15

Panel III and IV Reports from Panel Chairmen and Resource Personnel Discussion . . . . . 10:15-11:45

Summary and Conclusions by General Chairman. . . 11:45-12:15

Workshop Adjourns . . . . . . 12:15

Workshop Report Preparation . . . . . . 1:15

Workshop Chairmen, Resource Panel and
Technical Secretaries

# APPENDIX C

## REPRINTS OF SELECTED SPEAKER PRESENTATIONS

"Productivity - An International Contest"

Joseph H. Kehlbeck
President, AIIE
Manager - Group Purchasing Operation
Major Appliance Business Group
General Electric Company
Louisville, Kentucky

"Productivity"

Joji Arai
Manager, U.S. Office
Japan Productivity Center
Washington, D.C.

# Productivity– an international contest

IE's around the world are faced with similar demands. How can they measure the scope of their country's problem? Output per employee, trade balances, R & D spending, and capital expenditures are basic yardsticks. Using national productivity centers and other resources of the profession, IE's bear key responsibilities for improvements.

It is important for all of us to recognize the need for productivity and what we can do as industrial engineers to make this a better world in which to live. Every major country is engaged in a productivity battle with all of the other major countries of the world. This battle is going on every day. It is not being fought with cannons, airplanes, and warships; it is being fought in every factory every day as that factory competes in the

**MANUFACTURING OUTPUT PER EMPLOYEE**

| COUNTRY | AVERAGE ANNUAL PERCENT CHANGE 1966-75 | 1970-74 | 1974-75 | 1970-75 | RANK |
|---|---|---|---|---|---|
| UNITED STATES | 2 0 | 2 7 | -0.2 | 1.8 | 8 |
| CANADA | 3.9 | 3.6 | 1.5 | 3.0 | 6 |
| JAPAN | 9.0 | 7.1 | -3.1 | 5.4 | 2 |
| FRANCE | 4.9 | 5.0 | -4.3 | 3.4 | 5 |
| GERMANY | 5.3 | 5.8 | 3.3 | 5.4 | 3 |
| ITALY | 5.8 | 7.6 | -3.0 | 6.0 | 1 |
| SWEDEN | 5.8 | 5.8 | -3.4 | 4.4 | 4 |
| UNITED KINGDOM | 3.3 | 4.4 | -3.1 | 3.0 | 7 |

Souce: U.S. Dept. of L.abor

*Figure I. Percentage change in manufacturing output per employee is one indicator of productivity trends. The U.S. ranked eighth in this field of eight for 1970-75.*

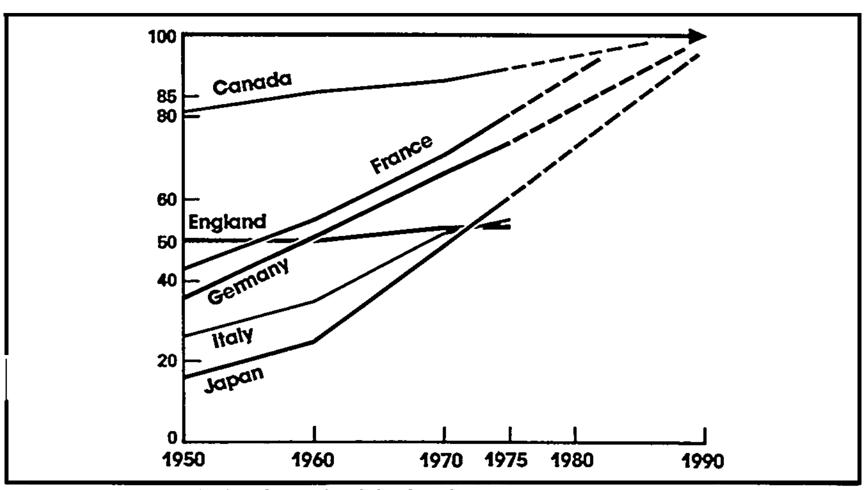


*Figure 2. If the level of U.S. productivity is taken as 100%, the other free world countries are seen to be improving much more rapidly*


JOSEPH H. KEHLBECK
President, AIIE
and, Manager—Group Purchasing Operation,
Major Appliance Business Group
General Electric Co.
Louisville, KY

world market.

The winners in this battle are going to generate jobs, improve their standard of living, and reduce taxes. At the same time, the losers in this all-important battle are going to see high unemployment, become a welfare state similar to what exists in England, and the standard of living will be lower than in other nations throughout the free world.

Since it is my home base, let me discuss fundamental problems with the United States as an illustration. A basic problem today in the U.S. is that the rate of growth of productivity is less than most other major countries of the world. Some may not agree with this statement, but the indicators that support this position are Productivity, International Trade, R & D spending, and Capital Expenditures.

Let's first look at Productivity. Figure 1 shows manufacturing output per employee. As you can see, the United States is number 8 in rank, or the lowest rate of growth in productivity of the eight nations shown. The number one country is Italy, believe it or not, with a 6% increase, followed by Japan and Germany with 5.4%, and then the other major industrial nations, with the United States having the lowest in the average annual percentage of change in the most recent period of time–1970-75.

Another way of looking at the rate of change is to assume the United States is at 100%, and the leader in productivity compared to other nations, Figure 2. As you can see tremendous growth has taken place in countries such as Japan, Italy, and Germany, and at the same time England has plateaued at about 50% of the productivity rate of the United States. Projecting this beyond 1975 you can see that by the year 1990, many of the countries throughout the world, if they keep pace with their present rate of growth, will actually be equal to or exceed the U. S. level of productivity.

Let's look at another indicator: International Trade–something that we read about every day in the papers and the battle that the U. S. continues to lose.

You can see from Figure 3 that in 1973 the U. S. had a favorable $1.4 billion balance of payments. This changed to $5 billion unfavorable in 1974 with the advent of the higher energy costs—which skyrocketed to $25 billion. In 1975, this reversed itself to $11 billion favorable; in 1976 the U. S. was at $5.7 billion unfavorable, and the latest projection for 1977 is a whopping $26 billion unfavorable balance of trade.

**BALANCE OF TRADE**

| | 1973 | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|---|
| FOOD | $5.8 | $7.9 | $9.4 | $8.1 | $5.2 |
| FUEL | -8.3 | -25.5 | -26.6 | -34.6 | -43.9 |
| OTHER | 3 . 9 | 12.6 | 28.3 | 20.8 | 11.5 |
| BALANCE | $1.4 | $ [5.0] | $11.1 | $ [5.7] | $(26.2) |

*Figure 3. Balance of trade figures for the U.S. indicate a precipitous turn to the negative from 1973 to 1977, obviously an unfavorable development.*

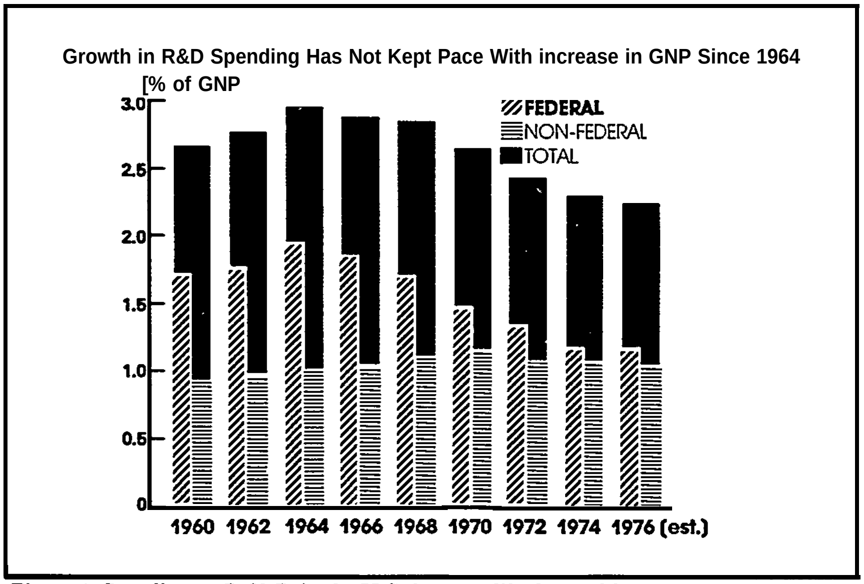


*Figure 4. Spending on R & D in the U.S. has steadily dropped in recent years as a percent of Gross National Product due to Federal cutbacks.*

The latest forecast for the balance of trade over the next few years indicates that this $26.2 billion in 1977 will increase to $28 billion in 1978, and level off at $24 billion in 1979.. . A very unfavorable condition.

The third symptom is Research. Let's look at the dollars being spent for research and development in the United States. The growth in R&D spending has not kept pace with the increase in GNP. since 1964. Federal spending has decreased appreciably in R&D, as you can see by Figure 4. Due to this lack of funding by the United States, the total amount spent on R&D has substantially decreased over this period. This is a deplorable condition when you recognize that many of the real advances in consumer products have come about as spin-offs of federal spending in the aerospace industry.

To further support my contention

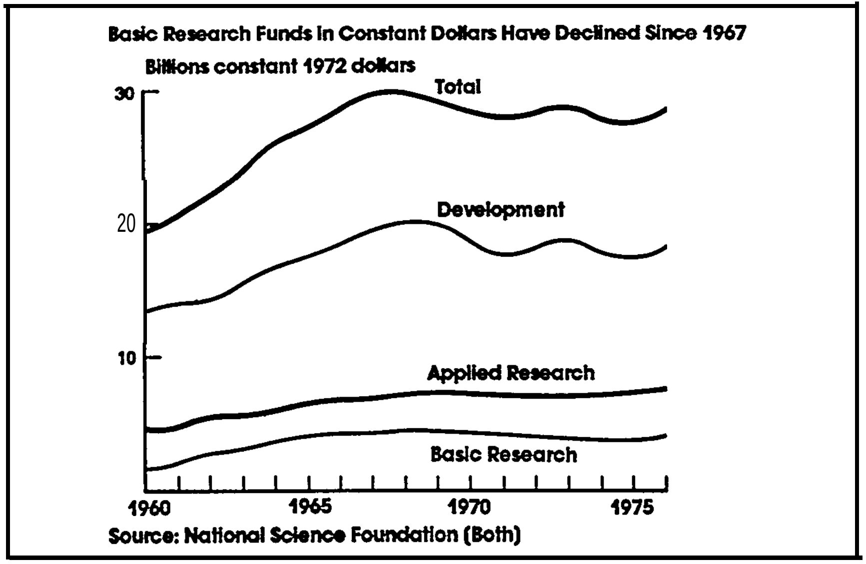


*Figure 5. Expenditures for basic research in the U.S. in terms of constant dollars can be seen to have been declining for about a decade.*

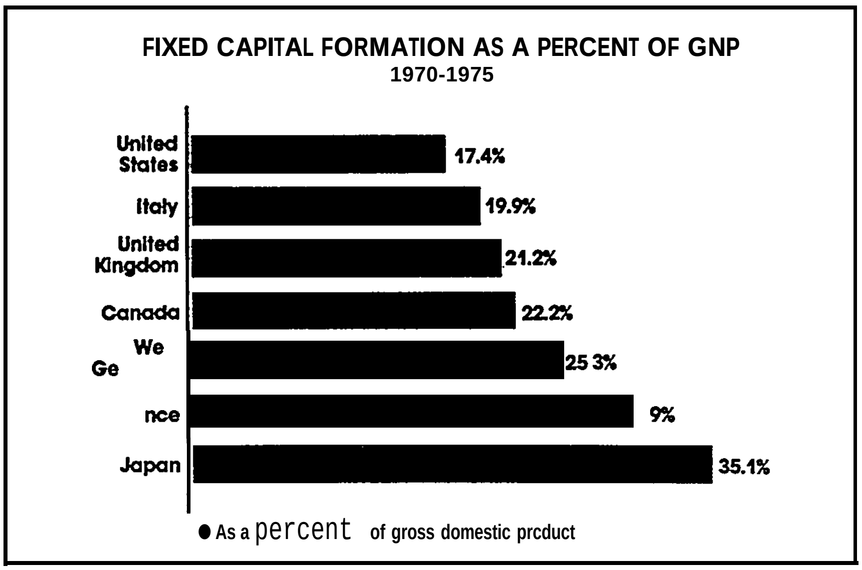


*Figure 6. In fixed capital formation as a percent of Gross National Product the U.S ranked at the bottom of this field of seven.*

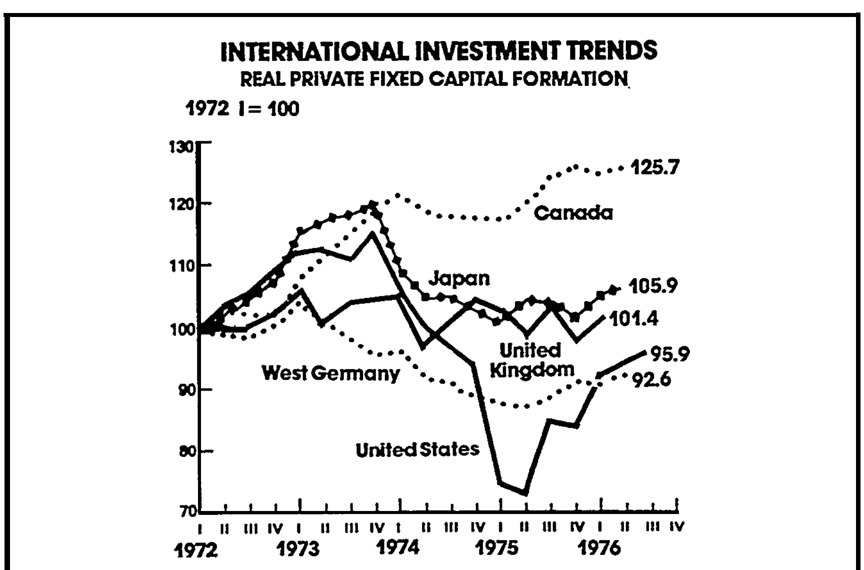


*Figure 7. Comparison fixed capital formation to the rate of Ist quarter 1972 shows the U.S. vying with West Germany for last place.*

that the U. S. is in trouble when it comes to basic research, the trend chart in Figure 5 shows research funds in constant dollars. It shows U. S. total dollars in R&D have declined since 1967 with most of it in the area of development. The U. S. is still spending dollars in applied research and basic research, but has drastically cut back in the area of development where research is put to work to help mankind.

The fourth symptom is Capital Expenditures. Figure 6 shows that the dollars that the U. S. is spending on fixed capital formation as a percent of Gross National Product is the least of any of its maior competitom in this economic battle. The U. S. is running at 17.4%. Japan is more than double the amount of U. S. investment as percent of Gross National Product.

I recently had the opportunity to talk with a number of Japanese industrialists. In our conversation it became apparent tome that they are spending large sums of money on very sophisticated equipment designed to drastically reduce labor and improve productivity.

Figure 7 is a busy chart which shows that the United States is not doing as well as its competitors in this economic battle when it comes to investment trends. The U. S. peaked late in 1973, dropped drastically in 1974 and 1975, and has never really recovered. West Germany is the only nation not doing as well as the U. S. Canada has continued to invest and is now 25.71% over the base of 1972; Japan is at 5.9% over 1972, and the United Kingdom, which everyone considers one of the least productive nations in the world, is at 1.4%. This chart supports my view that the U. S. has major problems in the lack of capital investment in new plants and equipment.

The indicators we have rapidly reviewed-productivity measurements, international trade, R&D spending, capital investment—identify the key problem areas which contribute to the declining rate of

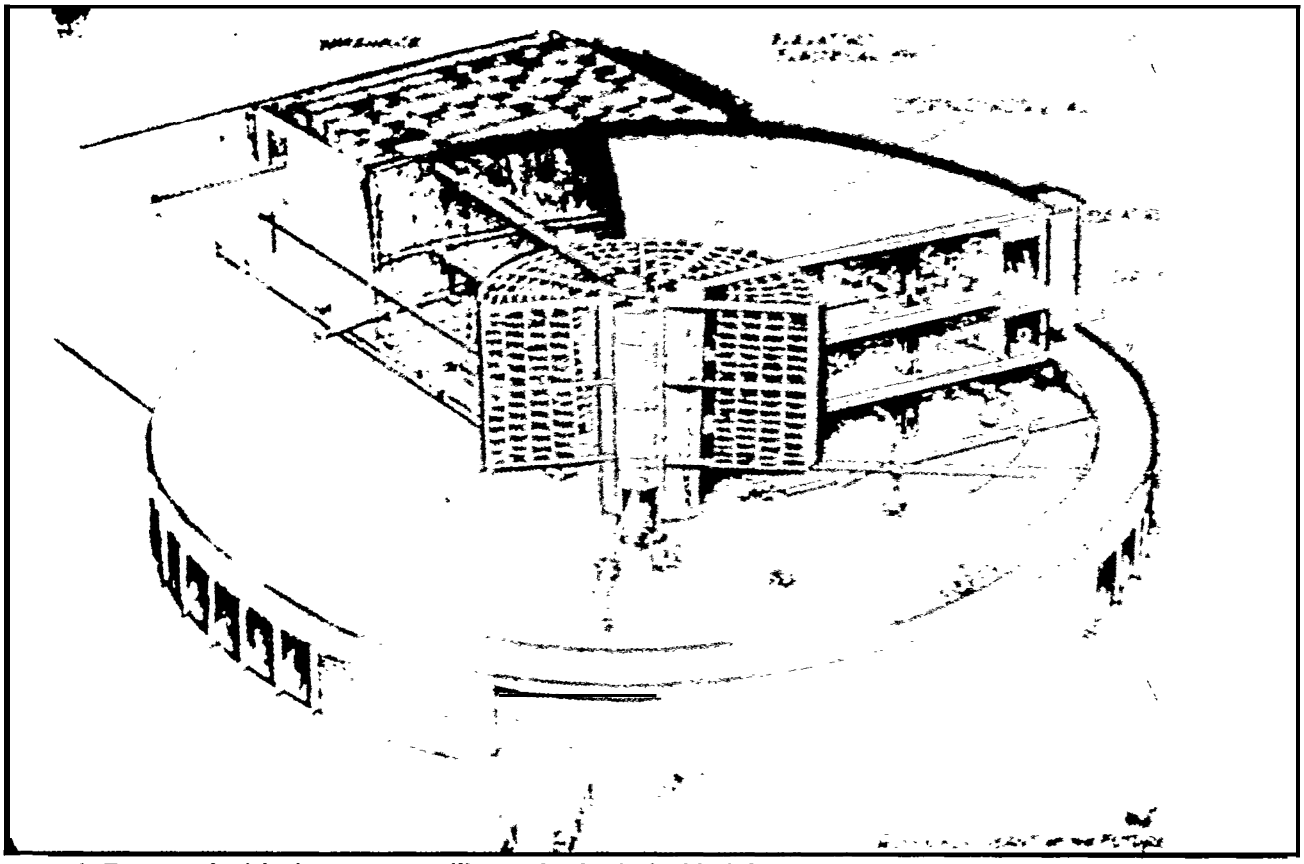

*Figure 8. Future productivity improvements will very often be obtained by bold new concepts and investments such as this idea for an automated assembly plant on the drawing boards in Japan.*

productivity in the United States. The industrial engineers in the U. S. have the responsibility to turn this around. They need to improve productivity in the United States, and through the efforts of every engineer in the U. S., they have the capability if they will all apply their energy to this national problem.

In the business world you need to know all you *can about* your competitor. This same process needs to apply to one nation as compared to other nations. A nation needs to know its competitors' strategy. What are their natural resources? Do they have the necessary raw materials, manpower, plant and equipment? Do they have technical strength to develop new materials and processes or are they followers? And last but not least, what are their national policies toward improving productivity?—supportive—restrictive?

To answer these questions we industrial engineers need to see for ourselves what our competitors are doing. We can't learn unless we travel. Too often U. S. businessmen sit at home believing the U. S. has all the know-how and travel is a waste of money. While they sit at home their competitors in this economic battle travel throughout the world to pick up the latest know-how and technological advances to incorporate in their business.

An example of what you would see if you visited Japan is the sketch of a highly automated unmanned plant shown in Figure 8. It's on the drawing boards and will be completed in the early 1980's. Seeing something like this would have a major impact on your thinking. Especially when you recognize that this plant with its minimum amount of labor, is going to compete with you on the home front. Wouldn't it be a shocker?

One way for U. S. industrial engineers to know what's going on in the world is to work with and support the National Center for Productivity located in Washington, D. C. If they are not familiar with this organization, I would suggest that they become very familiar with it in the. immediate future. They can contact the Center by writing to the National Center for Productivity and Quality of Working Life in Washington, D. C. It's a small federal agency dedicated to improving productivity in the United States. Every industrial engineer in the U. S. should be on the Center's mailing list.

Industrial engineers should also be knowledgeable of the European Association of National Productivity Centers, which is located in Brussels. It has a very active program to make the European Common Market competitive throughout the world. I might add that I recently attended a meeting in which the Executive Director of the European Common Market participated and he had difficulty understanding the union-management adversary relationship in the United States.

The Asian Productivity Organization consists of sixteen Asian nations working together to improve productivity so they can compete in the world market. This group hires U. S. consultants to bring U. S. know-how to the Asian world.

My purpose in mentioning these centers to U. S. engineers and in particular the U. S. National Center is twofold-one, that they should utilize the services of the National Center for Productivity and Quality of Working Life, and two, that the U.S. Center needs their support or it may not survive. The present U. S. administration has shown absolutely no interest in being involved with improving productivity.

The importance of productivity has to be recognized by the federal government and elected U. S. representatives. The U. S. has many laws which substantially add to the cost of doing business with little increase in productivity–to name a few-EPA, OSHA, EEOC, etc. All of these contribute to the cost of producing goods in the U. S. Many competitors of the U. S. in this economic battle do not have to bear this kind of an expense to do business. U. S. engineers have the responsibility to make their government aware of the cost impact associated with these programs to improve the standard of living in the U. S. It does not help to improve the standard of living by driving work offshore and increasing unemployment.

To be successful in this economic battle, citizens need to work *as* a team to improve productivity. Every citizen of a country-that is labor, government, management, the academic world, engineers, and economists—all need to focus on the common goal of improving productivity.

Industrial engineers are achievers. We all are willing to work to achieve certain goals. Most of us are goal oriented.

If we are going to improve productivity in our countries, the first thing we need to do is establish goals—national goals, industry goals, and government goals. For if we do not, we will just continue to wander in the ocean of opportunity and never reach our destination. All of us must develop productivity goals in our own operation and work to achieve these goals.

What is each industrial engineer's responsibility? Certainly it is to implement productivity improvements. Most of *us are* being paid to improve productivity. We also recognize the impact technology has on productivity. This needs to be communicated to those less informed.

U. S. engineers also need to support government and private research and development. The key to long-range success in this economic battle is basic and applied research. U. S. engineers need to convince their elected officials that government funds for research need to be increased to levels comparable to other industrialized nations.

The *Wall Street Journal* had an article "Backing Off Basics" in a recent issue. I would like to quote a statement from this article:

> 'The National Science Foundation says U. S. expenditures for R&D have slipped to about 2% of gross national product from more than 3% in 1965 and currently trail the 2.3% level in West Germany and estimates of more than 3% in the Soviet Union. The federal government adds that the number of patents it granted to foreign inventors in 1975 reached 35% of the total, against only 17% in 1961."

The U. S. needs to disseminate technological information. When new ideas come up, they need to be made available to U. S. industry so it can compete in the world market. Certainly U. S. engineers need to support the Productivity Center concept. A clearing house for disseminating information is essential to U. S. success. They also need to foster management, labor, and government understanding on the need for productivity goals. Unless U. S. citizens all work together to achieve this common goal, the U. S. will not be successful.

Last, but not least, U. S. engineers need to support capital investment through tax incentive. They must make it worthwhile to become capital intensive. Today the U. S. is not spending adequate amounts of money on new plants and equipment. Japanese friends and economic enemies are walking by the U. S. . . . or should I say running by the U. S. . . . every day of the year. I recently heard a steel executive in the U. S. state that he was running facilities forty to fifty years old and trying to compete with the Japanese who recently obsoleted a 19-year old facility. The United States has a serious problem. Its productivity rate is not going in the right direction. It's coming to a screeching halt. I am confident the industrial engineers of the U. S. can turn this around. IE

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# PRODUCTIVITY

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Japan Productivity Center

Lately it has become a favorite pastime for American intellectuals to either vociferously criticize Japan for building an 8.5 billion dollar trade surplus against the United States, thereby depriving employment opportunities to hard working Americans, or on the other hand to admire the Japanese for unabashedly pursuing technological innovations and working hard while everyone else sleeps.

The ubiquitous Japanese are to be found at the four corners of the earth peddling products labeled “Made in Japan”. Charles de Gaulle once called Mr. Ikeda, then Prime Minister of Japan, “A Transistor Salesman”.

Japanese are pictured as little yellow men with thick glasses and protruding teeth; they are considered inscrutable and cunning. It is thought that the “Made in Japan” products that are peddled are manufactured in a dark crowded plant by laborers who work for cheap wages. Another picture is that of an oriental who is clad in a Saint Laurent designed western suit with the ever present thin pocket calculator, pushing buttons in his office that activate computer-assisted manufacturing in the plant below - a plant that produces video-tape recorders, facsimile transmitters and quartz watches.

Neither description is correct. Just as depicting a typical American as being six feet tall, blond, congenial and prodigal is not accurate.

Japanese are people who live on the far side of the Pacific on an archipelago, the land area of which when put together is about the size of California. The entire space available for human habitation is about 1/25 of the United States. Worse yet, only about 14% of the land is flat and suitable for agriculture, industry and human habitation. It is an unusual nation in that for the past two thousand years, it has never been invaded by foreign forces except for a brief period when it was placed under occupation of the American Armed Forces after World War II.

In other parts of Asia as well as in Europe, wars were the most effective means of crossing cultures which resulted in the emergence of new and hybrid societies and cultures. However, Japan stubbornly maintained its insularism. Somehow without benefit of being conquired, the people in Japan developed the unusual propensity to absorb other cultures and assimilate them into their own.

Our own phonetic spelling was developed from characters inherited from China and Korea. We imported Buddhism which originated in India through China. After Commodore Perry's black ship opened our ports, we arduously pursued western technology, political ideas, and the structure of government, and we created a hybrid form of a modern industrial society, the surface being that of a western civilization but underneath having a peculiarly Japanese hybrid philosophy and culture.

Japan is a nation without natural resources. She depends upon overseas supplies for 90% of her energy and raw material needs. The long list of dependency ratios of natural resources starts with 100% reliance on foreign supplies of aluminum, nickel, and 88% of iron ore. On the energy side, the list starts with 100% uranium, 99.7% crude oil and 78.5% coal. Thirty percent of our food supply comes from foreign sources.

Yet, Japan is now the third most productive nation in the world. Her gross national product is more than five times that of all Southeast Asia, about the same as that of France and Great Britain put together, two thirds that of the Soviet Union and a third that of the United States. Japan produces half of the world's merchant ships, about a third of the world's radios and television sets, and a sixth of all its crude steel, pig iron and synthetic fiber.

Japanese workers earn higher wages than their counterparts in Great Britain, France and Italy. Surprisingly, while no American ever says "Cheap British, French or Italian Labor", the expression "Cheap Japanese Labor" is almost an inherent adjective when speaking about Japanese and their products. Though Japan is the second largest economy in the free world, the biggest overseas trade partner of the United States, she remains a mysterious nation with an inscrutable people.

Actually Japanese are not too different from Americans, though our way of identifying a problem and the process for solving it may be a bit different. When it comes to problems, most of them are almost identical to those that you face. High cost of material and labor, controversy between environmentalists and industrialists, unemployment, bankruptcy, unreasonable labor unions, stubborn management, whimsical young workers, ridiculous government interference. Sound familiar - these are problems facing Japanese corporations today.

As for our shipbuilding industry and their problems,, let me cite some articles from recent publications:

"Business failures are sending shudders through Japan's vast shipyards. Sixteen Japanese shipbuilders had gone bankrupt by the end of November 1977, compared with four in 1974, one in 1975 and six in 1976 ......... Another jolt to the Japanese: the surge of shipbuilding plus highly competitive pricing by other Asian nations and the Communist countries. . . . . . . . .They undercut some of the giants of Japanese industry: Mitsubishi Heavy Industries, Ishikawajima-Harima Heavy Industries and Hitachi Shipbuilding & Engineering ." (U.S. NEWS & WORLD REPORT, January 23, 1978)

"The world's shipbuilders received total orders of 1332 ships (cargo ships over 1,000 DWT), a 27% decline from 1827 ships in 1976. Of this total 47% market share in tonnage went to Japan." (FINANCIAL TIMES OF LONDON, January 18, 1978)

"The orders placed in Japanese shipyards in 1976 drastically declined from 33,790,000 tons in the peak year of 1973 to 8,412,000 tons. A spokesman for the Ministry of Transport indicated that 1) the prolonged surplus of carrier space is making ship owners hesitant to place orders for new ships; 2) the surge of the value of the yen is another retarding factor; 3) stiff competition is forcing prices down resulting in shipyards refusal to accept orders for prices below costs. He further expressed the view that the total orders for 1977 may not exceed 6 million tons." (ANNOUNCEMENT OF MINISTRY OF TRANSPORT, January 16, 1978)

As compared with the average productivity of all industries that increased from 100 in 1975 to 131.2 by the third quarter of 1977, our shipbuilding industry's productivity declined to 83.1 from 100.

Though the industry is currently in terrible shape, historical observation shows that Japan annually launched about 14,000,000 tons of ships from 1970 through 1976. This amount is far above Sweden's production of 2.2 million tons. Sweden being the next largest shipbuilder.

There are many reasons why Japan's shipbuilding industry grew at such a rapid pace in the past two decades. Even though Japan is only 1/25 the size of the United States, her coast line is 26,505 kilometers long which is about the same as that of the United States. Many deep inlets protected from ocean waves afforded suitable locations for shipyards. Later these locations with planned landfill made it possible to lay out new and more efficient yards. The average 2,000 hours of sunshine per year plus a mean temperature of 14-15 degrees Celsius gave Japan a natural advantage over European countries.

Many other factors contributed to the growth of the industry. The first and most important factor is capital investment. In the shipbuilding industry the per employee capital investment reached $20,000 in 1975 - up from $7,000 per employee in 1970. The level of investment in plant and equipment was about the same as the average of all industries, which was 29% of real output between 1962 and 1972. This is twice the 13.6 of the U.S. and considerably higher than the average of 17% of European countries during the same period.

The second important factor is technological innovation. The introduction of EPM, NC Gas Cutters, CAD and CAM systems, as well as the block building method and new welding technology increased the industry's productivity dramatically.

We are attempting to increase our productivity in areas other than the shipbuilding industry and thus become competitive in the international market through heavy investment in research and development with emphasis on high-value-added products which use less raw materials and energies.

During 1977 government and private industry spent about 8 billion dollars on research and development. Of this 8 billion dollar investment, 75% represents private efforts. This trend is much different from the American situation where 75% of research and development expenditures are made by the government. Some experts estimate that by 1980 the Japanese government and industry will be spending more money than their American counterparts on non-military research programs.

Heavy emphasis is placed on the development of high speed and large scale computers, peripheral equipment, medical electronics, and communications equipment. A serious attempt is also being made to develop a series of sophisticated sensor/computer/machine interaction devices with practical industrial application through the joint efforts of a score of leading high technology companies with the enthusiastic encouragement of the government.

In June 1976 the Ministry of International Trade and Industry completed the basic design of an unmanned manufacturing plant with floor space of approximately 250,000 square feet. It is expected that the plant will be located underground and will produce machine tools with some 2,000 different parts. This prototype plant is expected to be completed by 1983 and will be operated by ten persons rather than the 750 workers normally required for this type of operation. Already in many plants throughout Japan, numerical and computer controlled machines and robots are used extensively.

No one would deny IBM its technological leadership and the superiority of its marketing strategy - particularly with its having 75% of the world market. Although the Japanese would in no way be considered a serious challenge to U.S. computer manufacturers, the eightfold increase of the import of Japanese computers and related equipment to 71 million dollars between 1975 and 1976 might be an indication of the serious attempt on the part of Japan to develop its technology in this area.

Over the last five years the Japanese government has spent 214 million dollars to help manufacturers develop a system that would compete with IBM's Series 370 as well as another 112 million to devise vastly improved computer circuits in the next four years.

The recent announcement by IBM of the introduction of its 3033 series processor was followed by the introduction of similar systems by Fujitsu, the Japanese computer manufacturer.

You might have noted i.n a recent article in the WALL STREET JOURNAL that the once bluest of blue-chip corporations, Xerox, is now seriously competing with Japanese manufacturers in the area of low quantity copying machines rather than with other American manufacturers.

The third factor is the economy of scale. In an attempt to meet the demand of shipowners for building ever larger tankers and dry cargo carriers, Japanese increased docks of over 60,000 ton capacity from 21 in 1962 to 57 in 1976, and particularly those docks with a capacity of over 90,000 GT from 13 in 1962 to 35 in 1976.

The increased dock capacity and introduction of new technology enabled a yard to launch the 484,377 DW ton Nishomaru in 1975.

In the steel industry which is closely related to shipbuilding, 51.4% of Japan's 72 blast furnaces have large inner volumes of more than 2,000 cubic meters compared with 2.6% of 192 of the U.S. furnaces. The result has been a tremendous reduction in cost and an increase in productivity as expressed in terms of man hours per ton of steel. As compared with 25.5 hours in 1964, it was down to 9.2 hours in 1974. The U.S. mills which were nearly twice as productive as the Japanese a decade ago have gone from 13.1 hours in 1964 to 9.8 hours in 1974. Not much need be said in the area of economy of scale because it was Americans who taught us the tremendous benefit of it.

The fourth factor is the increased knowledge and skill of the workforce.

As in the United States, the intellectual level of workers has contributed substantially toward enabling management to pursue technological innovations. While in this country about 48% of high school graduates go on to college, in Japan 42% do. Although this is lower than in the United States, the Japanese figure is higher than that of European countries. In the shipbuilding industry especially, an average of 800 technical high school graduates and 700 college graduates, who had majored in shipbuilding engineering, were available each year.

The relatively high academic level of workers enabled Japanese companies to pursue the fruits of technological innovations. In this same category I would like to discuss the highly controversial characteristics of the Japanese worker.

In New York City for example, it has been noted that 75% of the passengers on the last commuter train of the evening of the Long Island railroad are Japanese. It is estimated that about 20,000 Japanese businessmen work in Manhattan, and usually they are the last ones to leave the office buildings long after the American employees have gone. Why do they work so long and hard?

One of the reasons many scholars give is the loyalty of the Japanese worker to his company. In this country loyalty is toward a person, be it friend, associate or boss. In Japan the loyalty is to the company rather than an individual.

The life pattern of a Japanese is centered around the company he works for, not just during working hours but even after that five o'clock whistle. He tends to closely associate himself with his superiors, colleagues and subordinates on and off the job. Professor Yoshino of U.C.L.A. described this Japanese propensity in the following way: "Ones welfare and prosperity were most closely tied to those of the group. The individual was identified with a collectivity to such an extent that whatever one did was almost immediately and totally reflected on the collectivity. Thus, a collectivity had real power to sanction or reject the conduct and behavior of each individual member."

Another reason is that even though Japanese now earn more than their Italian, French and British counterparts, their wage and salary level is still lower than that of their American, German and Scandinavian counterparts. While their salaries and wages are moderate, the lack of raw materials, energy and food which have to be imported result in high prices for essential items for living. American tourists are shocked to discover that Kobe beef costs $25.00 a pound, and a lunch that would cost $5.00 in the U.S. would be $15.00 in Japan. Electricity, gas, water, gasoline and other energy products costs twice as much as in the U.S. Worse yet, to buy a house that would cost $100,000 in a Washington suburb, in Japan you would pay more than $300,000 for one on the outskirts of Tokyo.

Our meager social security system is also a contributing factor. Per capita social security payments amount to barely a half of what an American gets. Pensions received are about 1/8 of the American counterpart. To prepare for that rainy day and old age, Japanese save over 20% of their income. To lead a moderately comfortable life in Japan, one must work very hard.

As for the skill of the work force, under our lifetime employment system which guarantees job security until you reach 55, the company through the years molds the man into a shape which best suits their needs through the rotational program. Every third or fourth year, workers will be transferred from one department to another. One day you might be working as a personnel specialist; the next day you have been transferred to the sales department.

In this country a company hires a man to fill a position. The position is there before the man applies. His qualifications must be such that he will be able to perform the function as required by the position. In Japan, because of the prevalent lifetime employment system, a man is hired for his personality, aptitudes and academic accomplishments on graduating from school. The important qualification is a man's ability to cooperate with his fellow workers and coordinate his efforts to accomplish an objective as a member of a team. It is more important for a Japanese company to select a man with a good personality rather than a man with superior knowledge in a particular field.

Under this system, it would be unusual to find a corporation headed by an executive who had graduated from a school on an academic level such as the Harvard Business School. Rather than placing emphasis on the expertise and ability of a man, Japanese corporate management highly values the merits of a seasoned man with a good personality and experience in many aspects of corporate life.

Naturally when you have a corporate structure such as this, management depends upon the team work of men rather than the knowledge and skill of a limited number of brilliant executives. This type of system creates unique decision making processes based upon collectivity.

In the United States managers make decisions and order subordinates to implement them. Initiative comes from the top, and the finely defined scope of the duties of subordinates dictates that they obey orders. Managers must be resourceful and creative for the future of the corporation is dependent upon their decisiveness. For this reason American companies consider recruiting and training of company managers to be the most important aspect for their survival and expansion. In Japan, on the contrary, rarely do decisions come from senior managers as they would in the case of U.S. corporations. It is the responsibility of middle managers to identify problems and formulate tentative solutions. Before presenting the proposals to the senior manager, he must review them with other departments and make composite plans based on a consensus. This gives middle managers greater responsibility and a high degree of sense of participation in final decisions, thus making them the most enthusiastic players on management's team.

Obviously this is a time consuming process. In the United States a problem requiring immediate action in a rapidly changing business environment may be made by a manager in a matter of minutes; in Japan a similar decision would require weeks and sometimes months before it was resolved.

Although it takes time before a decision is reached in the Japanese system, once it is made it can be implemented with relative ease as the consensus is already there. On the other hand, the quickly made decision of the American boss may run into difficulty in the implementation of the decision. Perhaps a happy medium would bring about the best result.

Another factor that contributed to the increased knowledge and skill of our work forces is the "Quality Control Circle Movement in Japan". The introduction of the statistical quality control concept through a series of lectures and consultations with outstanding quality control specialists such as Drs. Juran and Deming in the 1950's led the Japanese to mold their own version of the quality control program within the framework of their culture.

The QC Circle can be defined as a group of workers and shop foremen who voluntarily meet to solve job-oriented quality and productivity problems. The first group was formed in 1962, and now there are about 600,000 circles with a membership of six million workers. In most major manufacturing companies approximately 852 of the workers are active in the circle movement. Usually at a meeting of a Circle **50%** of the time is spent on topics related to quality control and improvement; 40% is spent on productivity and cost discussions; 10% on other pertinent topics.

A group is made up of the shop foreman and the workers under his supervision, ranging in numbers from 4 to 5 men to 25 to 30 men. Workers are taught how to collect data; how to draw histograms, cause and effect diagrams, Pereto diagrams, control charts, Scatter diagrams, how to prepare Binomial Probability Paper and select samples, and how to analyze the cause of defects. Through a series of brain-storming sessions, they attempt to solve problems that arise at their working stations. In many manufacturing operations, this movement not only drastically reduced the defect ratio of the products but completely eliminated inspection crews.

There are literally tens of thousands of cases reported in which the worker's voluntary programs resulted in a drastic increase in productivity and a decrease in the production of defective parts and products.

The basic theme emphasized in the movement is that the system must aim for the development of workers, and it should never be used by management as a means for exploiting workers. There must be motivation so the workers will enthusiastically participate in the program. The system has worked so well in Japan that now several U.S. companies including Lockheed Space & Missile and Boeing Company are implementing QC Circle programs.

Under the category of systems improvement we can include the micro and macro level of systems. I hardly consider myself qualified to discuss the importance of systems improvement with such experts in the area as you gentlemen.

Therefore, I would like to take up the subject of systems improvement on macro level. Although Japan is under a democratic rule and upholds the principles of capitalism and free economy, her people are also aware of the limits of her ability and power due to the scarcity of natural resources and virtual non-existence of a military force for even her own defense. The well-planned and coordinated economic policy was necessary to set the nation back on its own two feet at the end of the war. The land reform which under normal democratic rule would have taken years to accomplish was performed almost overnight through the decree of the Supreme Commander of Allied Powers resulting in increased productivity in the agricultural sector. It also freed a large segment of the agricultural population to move into the manufacturing sector.

The economic planning agency was established to set a course for the growth of the nation. As compared to 30 odd economists which make up the President's Council of Economic Advisors, our Agency is staffed with 300 economists and statisticians. Under the government's policy during the 1950's priority was placed on the reconstruction of textiles, steel, electrical equipment, fertilizers, and machinery industries. During the 1960's automobiles, shipbuilding, and electronic industries were added to the list.

The percentage of net national product accounted for by the primary industries declined from 22.7 in 1955 to 7.5 in 1970, and their work force from 38% of the entire labor force to 16%. In 1955 textiles and sundry goods represented 55% of the total export volume, while steel, machinery, and chemicals accounts for only 37%. In 1975 the share of textile and sundry goods declined to 21% and that of machinery and chemicals increased to 75%.

From 1962 to 1972 Japanese production of pig or alloy iron rose from 18 million tons yearly to **75** million tons; in the same period, French production from **14** to **19** million, Chinese from 15 to 28 million and West Germany from 24 to 32 million. As for automobiles, our output rose from 250,000 cars and 2% of the world's production in 1962 to 7.1 million cars and 19% of the world's production in 1973.

In pursuit of attaining the desired economic growth for its survival, the legislative and executive branches coordinated their programs and policies so that the government would not constitute a retardant to economic growth; unlike the United States where upholding the rules of democracy and free competition sometimes results in policies and programs that adversely affect some sectors of society, such as strict enforcement of Antitrust laws and regulations, Occupational Safety and Health Act, Equal Employment Opportunity Act. While in this country, the government will try to break up IBM and AT&T knowing their excellence in technology and their contribution to American society far outweighs the evils of monopoly. In Japan the merger of Yawata Steel, the largest company, with Tokai Steel, the second largest, received the blessing of the government, and resulted in the creation of Nippon Steel Company.

The technology transfer takes place at varied speeds in different societies. Even though the Japanese and Germans were increasing investments in research and development, new intentions in the United States far surpass them. While Americans suffer from the “not-invented-here” syndrome, Japanese unabashedly used foreign technology to produce goods. The invention of the transistor by Bell Laboratory greatly benefited the Japanese electronic industry, and the development of the basic oxygen furnace in Europe helped the Japanese foster the growth of its steel industry.

Recently Scandinavian countries are planning to set aside a certain percentage of labor’s share of profit for investment in plant and equipment. In Japan the natural cycle of labor’s investment with deposits of over 20% of workers’ income at financial institutions helped the growth of companies, as the debt-financing has been the most prevalent mode of expansion in our country.

There is actually no preplanned and structured Japan Inc. as is so popularly believed by many in this country. It is true that Japanese business and industry are more accommodating than their American counterparts when the government asks them to pursue certain policies to attain a desired national goal. When the Japanese government enacted the world’s most stringent pollution control law setting forth emission standards for automobiles, the Japanese automobile manufacturers immediately started to develop new types of engines and catalytic converters rather than storming to Parliament to complain that they were unable to comply. Or - when the government suggested that computer manufacturers should form three groups of companies and coordinate their research and development programs in each group so that they would be able to retain the capability to compete in the international market with foreign manufacturers the industry was most obliging.

These national goals were rather faithfully observed by major industries due primarily to the following reasons:

1. When Japan entered the industrial revolution, it was government not industry that created modern plants. As our social and political system was created through the government’s initiative rather than the people’s, even 100 years after the western political system and principles were introduced and the American style democratic society was structured some 35 years ago, the majority of people still believe that the function of government is to issue edicts.

2. Debt-financed Japanese companies are more vulnerable to the whims of financial institutions than their American counterparts. The Ministry of Finance, being the regulatory agency of the financial institutions, can discreetly let the borrower know what programs the government wants them to pursue.

3. Lacking natural resources, energy and capital, the effective allocation of the needed but limited resources, energy and capital has to be determined by some central organization rather than through the free market principle. This duty was entrusted to the government.

4. The government of Japan is run by bureaucrats. Because of the unique function of government, the cream of the graduates of the finest schools tend to choose government careers over business. When these officials, who are good planners and administrators, retire, industry welcomes them into the upper hierarchy of management.

There are many other reasons I could cite, but this unique environment created the image of so-called Japan, Inc. in the eyes of foreigners. There is a loosely-knit tie between government and industry, but I do not believe it can be called a well-structured system.

These traditional, as well as the newly created systems, worked very well in the booming economy of the 50's and 60's. The oil crisis, followed by the world wide recession has, and is seriously and adversely affecting the operations of Japanese business and industry.

Expansion-oriented Japanese management, which had been hiring at about 10% above the labor requirement based upon the linear forecasting of market trends, suddenly found themselves with an excessive labor force.

Under the life-time employment system, which for the past thirty years played such an important role in creating harmonious labor-management relations, the essential climate for increasing productivity for expansion, management found that they were unable to lay off or discharge employees as their American counterparts had.

Lacking adequate social security, pension and other welfare programs, as are available in the United States and European countries, Japanese business cannot afford to give its corporate management the prerogatives exercised by their American counterparts, for that would destroy the very foundation of their industrial society and create great chaos. Whether they like it or not, and until they are pushed to the verge of bankruptcy, Japanese corporations will have to either keep borrowing, use their reserves, or sell off assets in order to retain their work force.

Over the course of thirty years of employment, an average Japanese employee triples his salary with accelerated raises. Thus a Japanese company pays four times more in salary to a worker with thirty years seniority over a newly hired man with the same job classification. In order to offset the rising labor cost of older employees as well as to prepare for eventual expansion, Japanese companies continue hiring younger people.

Because of this long existing system, Japanese businessmen consider labor costs as a fixed cost rather than a variable cost that fluctuates depending upon the market's demand as in the United States.

Some economists reason that Japan's tremendous increase in productivity in the last two decades was actually accomplished through the process of rejuvenation of the labor force. Unfortunately for Japan, however, the future demographic picture is gloomy. Now that the shift of the younger population from agriculture to mining and manufacturing has been virtually completed, and more young people are staying longer in academic institutions, Japanese corporations will not be able to depend upon the abundant supply of young workers, who had been their primary source for reducing labor costs and increasing productivity.

The unprecedented economic and demographic hardship placed upon corporate management will undoubtedly force many managers to reexamine their employment system and long range policies.

On the side of the workers, there are many social and economic reasons why hard working and enthusiastic workers may not be continuously so motivated.

A recent attitude survey of Japanese industrial workers showed that close to **60%** of them were dissatisfied with their work. This result was interesting because a similar survey conducted in this country showed that more than 60% of the industrial force was satisfied with their work.

Although job security remains an important factor in an employee's sense of obligation and esprit-de-corps, the demographic shift and the rapidly changing social and business environment will bring about the restructuring of the corporate organization and its behavior.

In spite of the fact that Japan exports less than 10% of her GNP, a surge in export trade has always acted as a trigger in stimulating the domestic consumption enabling her to enjoy rapid growth.

In the stable world economy we no longer can expect the export trade to have this triqqer effect on the domestic economy and contribute toward the rise in consumer confidence. We cannot keep repeating the cycle of concentrating our efforts on a limited number of products with highly competitive potentials in the world market and then enter orderly marketing agreements when such strategies result in a rise of protectionism in the other countries.

Government and business are now coordinating their policies and actions so that we will be able to produce higher value-added products of high technology content per unit of energy and raw material.

Japan is a nation of paradoxes.

We need to analyze the experiences of other industrial nations and re-examine our past performances and mistakes so that we may develop policies and programs with a long range view.

APPENDIX D

# COMMERCIAL SHIPBUILDING INSPECTION AND DIMENSIONAL CONTROL GUIDELINES

## SECTION A

## INSPECTION GUIDELINES

### TABLE OF CONTENTS

# REFERENCES

1. Non-Destructive Test Methods (Hull Structure)
2. Non-Destructive Testing of Structural Welding
3. Ultrasonic Inspection of Hull Butts & Corner Welds
4. Ultrasonic Equipment Qualification Procedure
5. Certification of Ultrasonic Test Personnel
6. Inspection and Control of Ultrasonic Test Standards and Accessories
7. Ulixasonic Inspection of Tee Welds (Through Member)
8. Ultrasonic Inspection of Tee Welds (Root Member)
9. Ultrasonic Inspection of Steel Plate for Laminar Defects
10. Ultrasonic Inspection of Full Penetration Tee and Corner Welds
11. Ultrasonic Thickness Measurement
12. Certification of Non-Destructive Testing Personnel
13. Welding Procedures
14. U.S. Coast Guard Rules and Regulations
15. American Bureau of Shipping Rules for Building and Classing Steel Vessels
16. Construction Standards for Piping Systems, Commercial Shipbuilding
17. Dimensional Control Guidelines

## I. PURPOSE

This booklet provides an interpretation of the present rules and requi.rements of the Classification Societies. These guidelines are subject to the user’s judgement and interpretation of acceptable shipbuilding practices.

II. LINEAR RESPONSIBILITY CHART

| FUNCTION | EV Operations | Program Manage[illegible] | T[illegible]nical Manager | Materials Manager | Prod. Control Manager | Prod. Mgr. Fabri-[illegible]tion & Assembly | Quality Assurance Mgr. - CH. Insp. | [illegible]ading-[illegible]man |
|---|---|---|---|---|---|---|---|---|
| 1 Establish quality assurance guidelines | 4 | 5 | 3 | | 3 | 5 | 1 2 | |
| 2 Determine special regulatory body requirements | | 2 | 2 | | 3 | 3 | 1 2 | |
| 3 Establish in hard owner/regulatory body liason | | 1 2 | 2 | | - | - | 1 2 | |
| 4 Maintain quality control interface with customer and regulatory body | 5 | 5 | 3 | 3 | 3 | 4 | 1 2 | |
| 5 Inspect work for owner acceptance | 4 5 | 4 | | | 4 | 3 | 1 2 | |
| 6 Feedback support activities deficiencies as directed by project guidelines | 4 | 5 | 4 | 4 | 4 | 1 2 | 1 2 | |
| 7 In-process quality control | | | | | | 4 | 3 | 1 2 |

LEGEND

1 Responsible for (decision)

2 Does work

3 Provides support

4 Is informed

5 Is consulted

## III . PROCEDURE

A. In-Process Control

1. In-process control of quality is the responsibility of the applicable leadingman under the direction of his immediate supervisor.

B. Inspection Procedures

1. Inspection Points

a. Units will be assembled complete structurally and presented for inspection to the Production Inspectors. Inspection points shall be as follows: (Inspection record shall be by Form 221) .

| No. | Item | Completion | In-Process |
|---|---|---|---|
| 1. | Void Areas | | x |
| 2. | Structural Unit Assembly | x | |
| 3. | Sand Blast | | x |
| 4. | Structural Erection | x | |
| 5. | Compartment Pick Up | | x |
| 6. | Compartment Paint | x | |

NOTE : All areas to be released for coatings shall have pre-inspection by the Inspectors prior to release for owner's representative inspection.

2. Inspection Points (Owner & Regulatory Bodies)

a. In-process inspections by the owner and regulatory bodies is a contractual obligation. The Builder's working process interference will be minimized. Errors, omissions and unsatisfactory workmanship shall be brought to the attention of the Chief Inspector.

b. "In-Process" work inspections will be arranged by the Production Inspectors to inspect work which is under active construction. Notification for such inspections will, as a minimum, be verbal and given 1/2 hour in advance. "In-Process" inspections will be conducted on items as given in Paragraph B.1.a above. In cases where the owner or regulary bodies cannot be contacted, the Chief Inspector will carry out the necessary inspection and provide the owner with written verification as to the acceptability of such areas.

c. Inspections which require participation of owners and regulatory bodies will be arranged by the Production Inspectors. Form 221 below will indicate time and type of inspection to be performed.

d. Inspection notices, Form 221, will be provided in duplicate to concerned interests. On completion of inspection; remarks and comments will be noted on form. Concerned interests will be notified when remarks and comments have been satisfied. Remarks and comments shall be crossed out on the form after final acceptance by the owner.

e. All major structural voids shall be inspected by regulatory bodies and owners prior to closure.

C. Inspection Process

1. Non-conformances observed during any inspection are to be marked using a non-grease type chalk.

2. Inspection cards will be prepared, process and recorded by the Inspectors foreach unit.

   a. Sub-Assembly
   b. Panel Assembly
   c. Main Assembly
   d. Pre-Outfit

3. Sign-off Inspection cards, Form No. E-639, are provided for fitting, welding and outfitting sign-off. After production sign-off is accomplished (signifies unit is ready for formal inspection) the card is turned over to the Production Inspectors for sign-off under the inspection column.

4. Sign-off by inspection is the authorization to ship unit/sub-unit to its next destination.

5. At completion of inspection and sign-off by owners of Form 221, Notification of Inspection, a copy of sign-off Inspection Form No. E-639 will be forwarded to the owners.

6. Production Inspectors will inform the owner and regulatory bodies of regular inspection on Form 221, Notification of Inspection, each working day by 1500 the day prior to intended inspections, giving the time of inspection and location.

7. Notification of inspections which are to be held on Saturday or Sunday will be delivered to the owners and regulatory bodies by 1400 hours Friday.

8. In the event an inspection is to be canceled or the time changed, the concerned interests will be promptly notified.

9. Conformance to applicable drawinqs are to be strictly adhered to. Problems that arise as a result of drawing errors or faulty workmanship are to be brought to the attention of the Inspectors who will consult with the owner and regulatory bodies for a satisfactory resolution.

D. Inspection Locations

1. Assembly Areas.
   Structure
   Production Inspectors/Owners and regulatory bodies as required.

2. Sandblast/Paint Building or location as designated.
   Surface Prep/Coating
   Production Inspectors Coatings Dept./Owner and Paint Representative as required.

3. Ways and Water

   a. Structure, (Erection seams & butts prior to release for paint preparation, shall be inspected by owners & regulatory bodies. Notification shall be by Form 221).
      Production Inspectors/Owners and regulatory bodies as required.

   b. Final coating inspection as applicable.
      Production Inspectors, Coatings Dept.

HULL ________ UNIT ________ **LOCATION** ____________________

DRAWING NO. ____________________ **DESCRIPTION** ____________________

____________________

TYPE OF INSPECT. ____________________

| | FITTING | | WELDING | | PREO. | | INSPECT | |
|---|---|---|---|---|---|---|---|---|
| | Date | Sign | Date | Sign | Date | Sign | Date | Sign |
| **Receiving (Plate Yard)** | | | | | | | | |
| **Preservation Process** | | | | | | | | |
| **Layout and Burn** (Fabrication) | | | | | | | | |
| Sub-Assy or Forming | | | | | | | | |
| Sub-Assembly | | | | | | | | |
| Panel Assembly | | | | | | | | |
| **Main Assembly** | | | | | | | | |
| **Preoutfitting** | | | | | | | | |
| **Erection** | | | | | | | | |

**Special Instructions:** ____________________

____________________

NOTE: **Sign-Off by Inspection is authorization to ship.**

E-639 8/76

Form E-639

D-A-8a

Form F221

F221

COMMERCIAL SHIPBUILDING
NOTIFICATION OF INSPECTION

Hull ..........................

Date ..........................

To Local Representatives of:

☐ Maritime Administration
☐ Owner

☐ American Bureau of Shipping
☐ United States Coast Guard

Check one:

☐ The following test has actually been performed by the Contractor and meets all specification requirements. If the regulatory body inspection officer desires to witness this test, a retest will be performed on ..........................

☐ The following test will start on .......................... .
The Contractor is reasonably sure that the test will meet all specification requirements.

Released by ..........................................
(Authorized Signature)

..........................................
Inspection (Sign) Dept. Date.

Type of Test ..........................................

For (Sign if present): Date

MARAD ..........................................

OWNER ..........................................

ABS ..........................................

USCG ..........................................

## IV. MATERIAL

### A. Surface Conditions

1. All plates and shapes must meet surface conditions of ABS rules. Special considerations shall be given to avoid scars and imperfections on longitudinal and transverse strength structure as indicated below. Notches shall be avoided.

   a. Longitudinal plates and shapes in midships 3/5 length.
   b. Main deck plating, tank top plating.
   c. Shell plating.
   d. Box girders.
   e. Longitudinals and all deck stringer plates.
   f. Transverse web frames.
   g. Longitudinal and transverse bulkheads and attachments.
   h. Pillars.
   i. All deck cutouts.

2. Repairs to scars and imperfections of members included in Paragraph A-1 above, must be made by grinding, gouging, chipping or welding depending on magnitude of imperfection outlined as follows:

   a. In general, minor scars may be repaired by grinding.

   b. Scars which exceed 3/32” in depth and 1“ in length shall be repaired by chipping, grinding and welding.

   c. Repair welds which are generally low in profile (3/32”) need not be ground.

   d. Special requirements repair welds which are generally low in profile (3/32”) need not be ground in interior locations if appearance is not a factor. Fabrication and assembly of welded butts and seams on unstiffened side of metal bulkheads, interior and exterior, on superstructure and in passageways shall be ground smooth where exposed to view.

3. Scars in non-strength areas shall not require repair or treatment.

4. Lifting pads that are in evidence in F.O. IB tanks and deep tanks shall be removed by cutting neat over top of weld, slag removed, and surfaced suitable for coating. The same shall apply in areas that are covered with joiner panels or sheathing.

5. Sharp edges shall be ground only where they represent a personnel hazard in a traffic area.

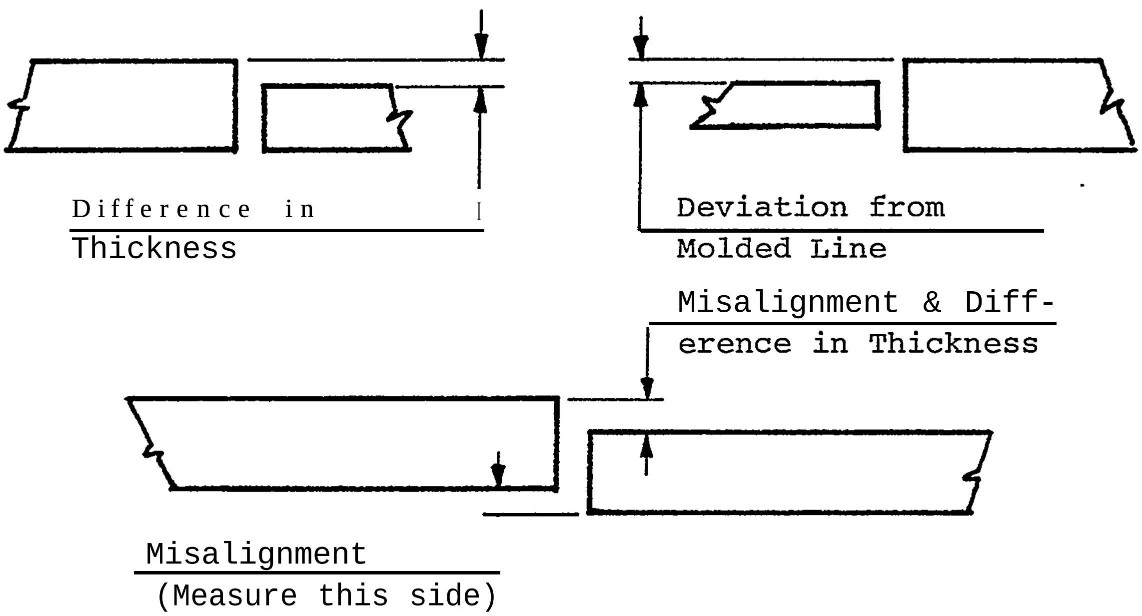
B. Material Handling

1. All crafts shall exercise care in material handling to prevent damage. Where damage is evident, repairs shall be performed before shipping to the next designated work area.

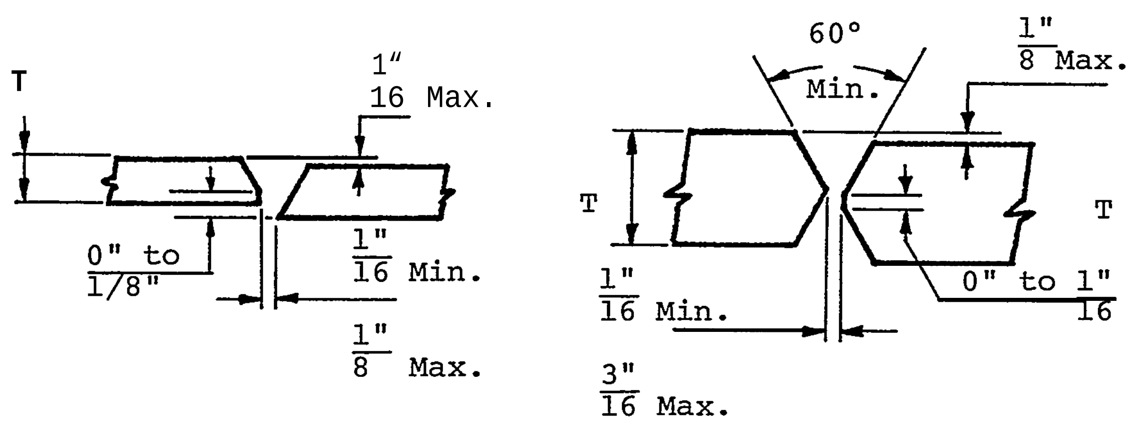
## V. FITTING

### A. Alignment and Fit-up

1. Alignment measurement -




2. Alignment and fit-up of butts -



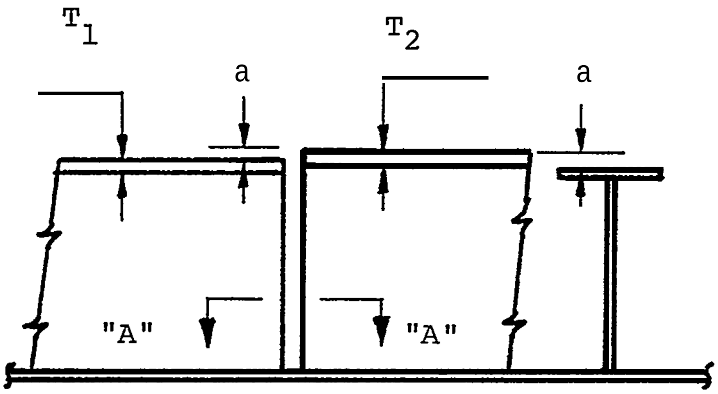

T = 1/4" to 3/8"

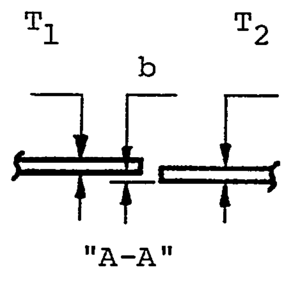
T = 3/8" and above

V. <u>FITTING</u>

A. Alignment and Fit-up (continued)

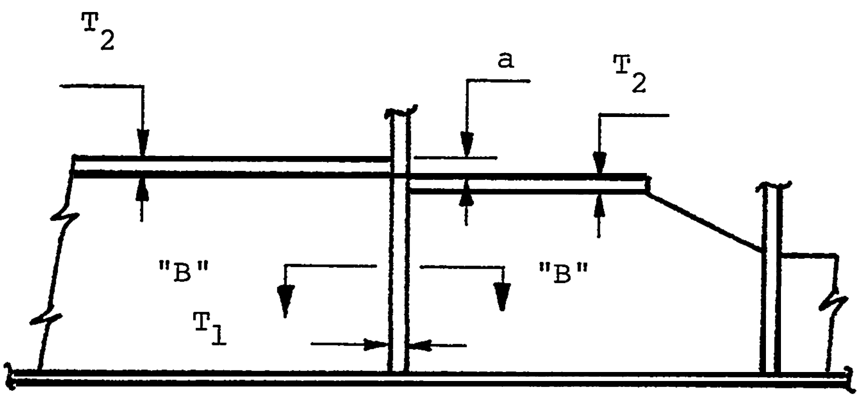
3. Fit-up of webs, flanges and face plates -



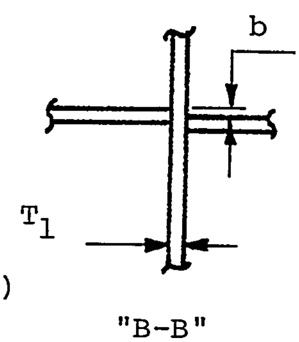




Maximum Allowable
$a = 1/2\ T_2$ (Thinner Member)

Maximum Allowable
$b = 1/2\ T_2$ (Thinner Member)




Maximum Allowable $a = 1/2\ T_2$ (Thinner Member)




Max. Allowable
$b = 1/2\ T_1$

4. When misalignment exceeds the tolerances shown or additional weld reinforcement is needed for additional strength - these conditions will be inspected and resolved on a case basis by the Inspectors prior to welding.

   No misalignment or minimal misalignment is the <u>objective</u> during fabrication and erection.

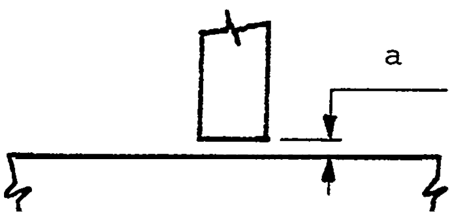
V. FITTING

B. Faying Surfaces

1. Clearance between faying surfaces of lap joints and permanent installed backing bar butt joints shall not exceed 1/16″ except as specified on plans. (Does not apply to riveted buck bolted joints) .

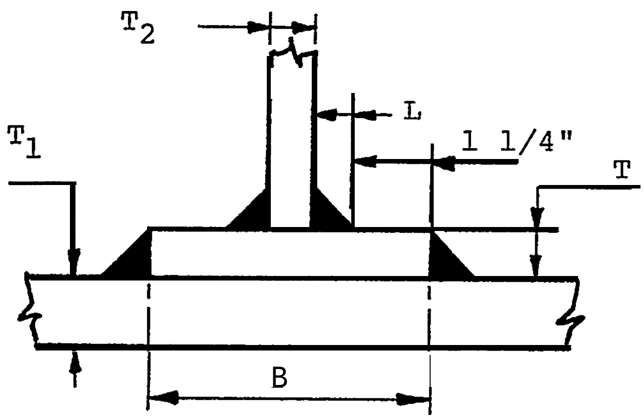
C. Fillet Gap

1. When liners and inserts are used and not shown on drawings, owners concurrence is required.




a **1/16″** acceptable.

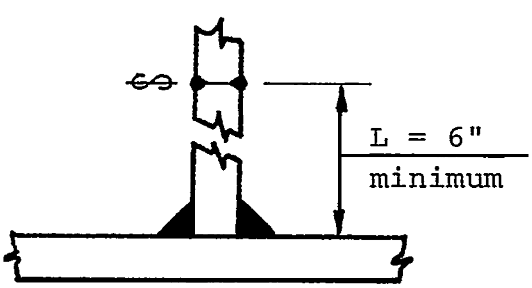
**1/16″** a **3/16″** increase fillet leg by “a”.




Gaps in excess of 3/16″ which require full penetration weld must be approved on a case basis after consulting interested parties

$T_1$ T $T_2$

B – $T_2$ + 2(L + 1 1/4″)



D. Plate Edge Build-Up

1. Plate edge build-up where permitted will be in strict accordance with ABS rule requirements and with concurrence of owners and regulatory bodies. Build-up to be with type of filler metal specified by the welding procedure.

2. Where plate edge build-up is employed for a fix, the joint is to be fully prepared and inspected prior to release for final production welding. To comply with ABS rules, arc strikes are to be avoided.

E. Fit-Up Resolution

1. Inspector's and owners inspection and resolution is required if structure make-up clearance exceeds plate thickness. Once fit-up permission is obtained, work must be performed without deviation.

## VI. WELDING

A. Welding materials shall be dispersed with utmost care. Only those electrodes which are compatible with designated materials shall be used in accordance with applicable welding procedure. Substitution of welding material is not permitted without prior approval of the Welding Engineer.

B. Errors resulting from use of improper welding materials or procedure is cause for rejection of related work.

C. Positive relation shall be established between parent metals and filler weld metals on all “in-process” work. Only approved electrodes will be used for tack or block welding.

D. Welds shall be free of cracks or crack-like indications or linear indications.

E. The height of reinforcement of a butt weld or seam shall be kept to a minimum in the following areas:

1. Exterior shell.
2. Exposed areas of weather decks.
3. Exterior sides of deck houses.
4. On decks that have a covering; weld reinforcement should be 1/16” not to exceed 3/32”.

F. Size of welds shall be uniform to required size and checked with a weld gauge.

G. Fillet welds for structure

1. Undercut, at the edge of a weld, which is 1/32” (0.8MM) or 10% of the base metal thickness (whichever is less) shall be permitted. Although the intent of welding procedure (Ref. 13) is to have no undercut on the underwater body, ABS Rule 30.5.8 applies.

2. For base metal thickness of 1/2” (13MM) or greater, undercut up to 1/16” (1.5MM) is acceptable, provided the total length of undercut exceeding 1/32” (0.8MM) does not exceed 15% of the entire joint length, or 12 inches (305MM) in any continuous 36 inches (915MM) of weld, or 2 (two) intermittent welds in any series of 8 (eight) intermittent welds.

H. Welding Porosity

1. Visible welding porosity shall not be acceptable at oil tight or water tight boundaries. In other areas porosity shall be acceptable provided there are no indications greater than 3/32" diameter, with no more than (2) indications in any 6" length of weld. Excessive porosity on other than oil tight and water tight boundaries may be corrected by filling with fortified epoxy compound prior to coating.

2. Elongated gas holes less than 1/2" length and 1/16" in width are acceptable in non-water tight and non-structural attachment fillet welds. Should a general porous condition exist in any area, the condition shall be corrected.

I. Overlap

1. Overlap at weld edges shall be repaired by welding or grinding to create a smoothly faired weld edge.

J. Snipes

1. Ballast tanks, water tanks, bilge areas and weather deck areas shall be completely seal welded. Snipes required for drainage shall be sized suitably to effect complete seal welding.

2. Special Requirement - All welds up to 6" above decks in washdown areas and 6" above floor plates in lower engine room must be continuous.

K. Welding Quality

1. Supervisors shall inspect back gouging prior to authorizing back welding.

2. Members to be welded shall be inspected for acceptable fit up prior to commencement of welding, faults shall be corrected prior to production welding.

3. Approved sequence welding as outlined in approved welding procedure shall be strictly adhered to.

4. Rejectable welding shall be promptly dealt with as necessary to produce a finished product which meets applicable rules.

5. Records of weldor qualifications for hull welding shall be maintained and be available for concerned parties.

6. Special Requirements - Supervisors shall check "Tee" joint fitting for any additional weld required to close excessive gap or unmatched bevel.

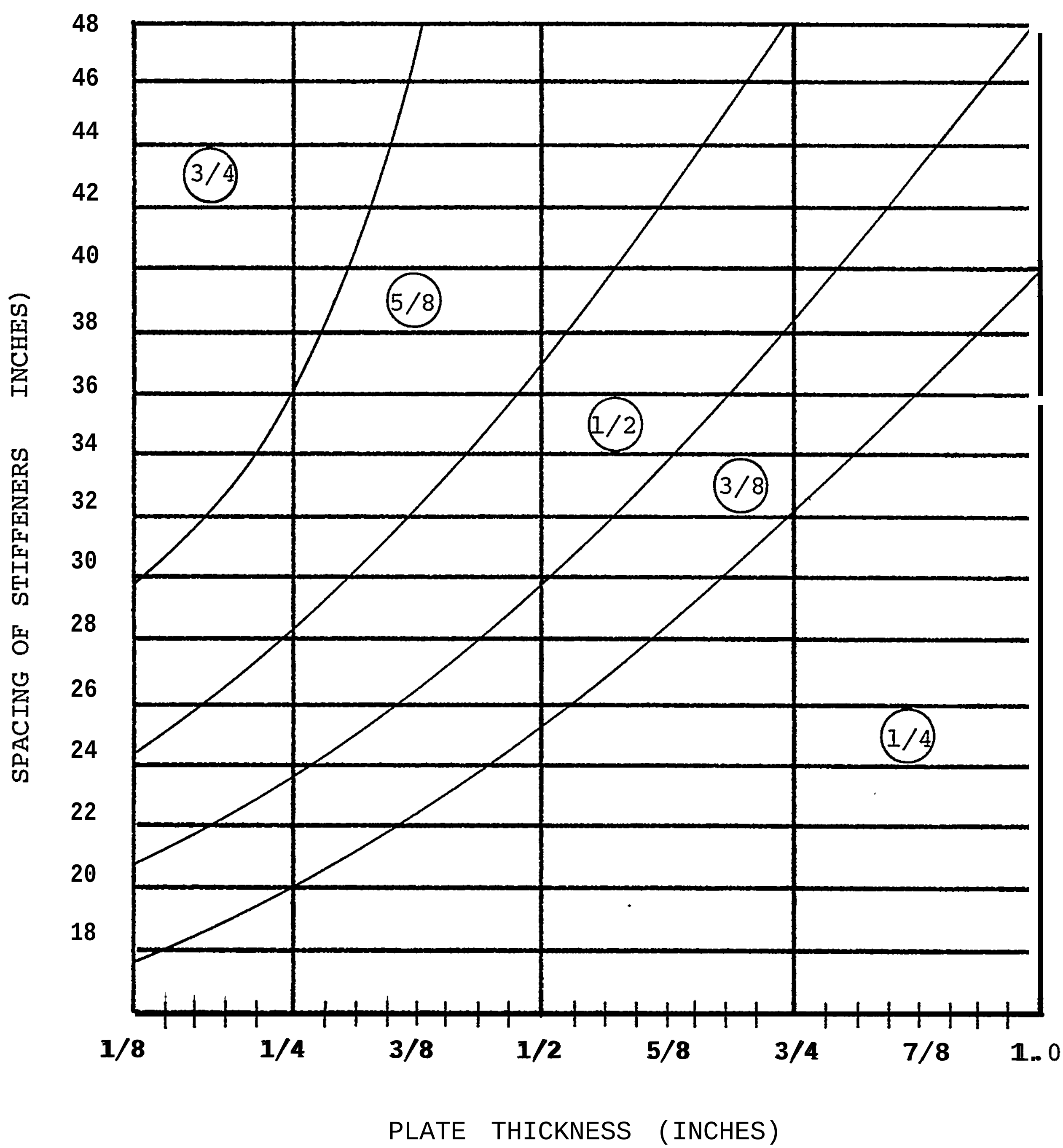
L. Weld Spatter

1. Removal of well-bonded weld spatter shall not be required.

2. Special Requirements - All weld spatter shall be removed except where permitted by owner. (Check with Inspectors for permitted areas such as behind joiner panels, inner bottom F.O. tanks, etc.).

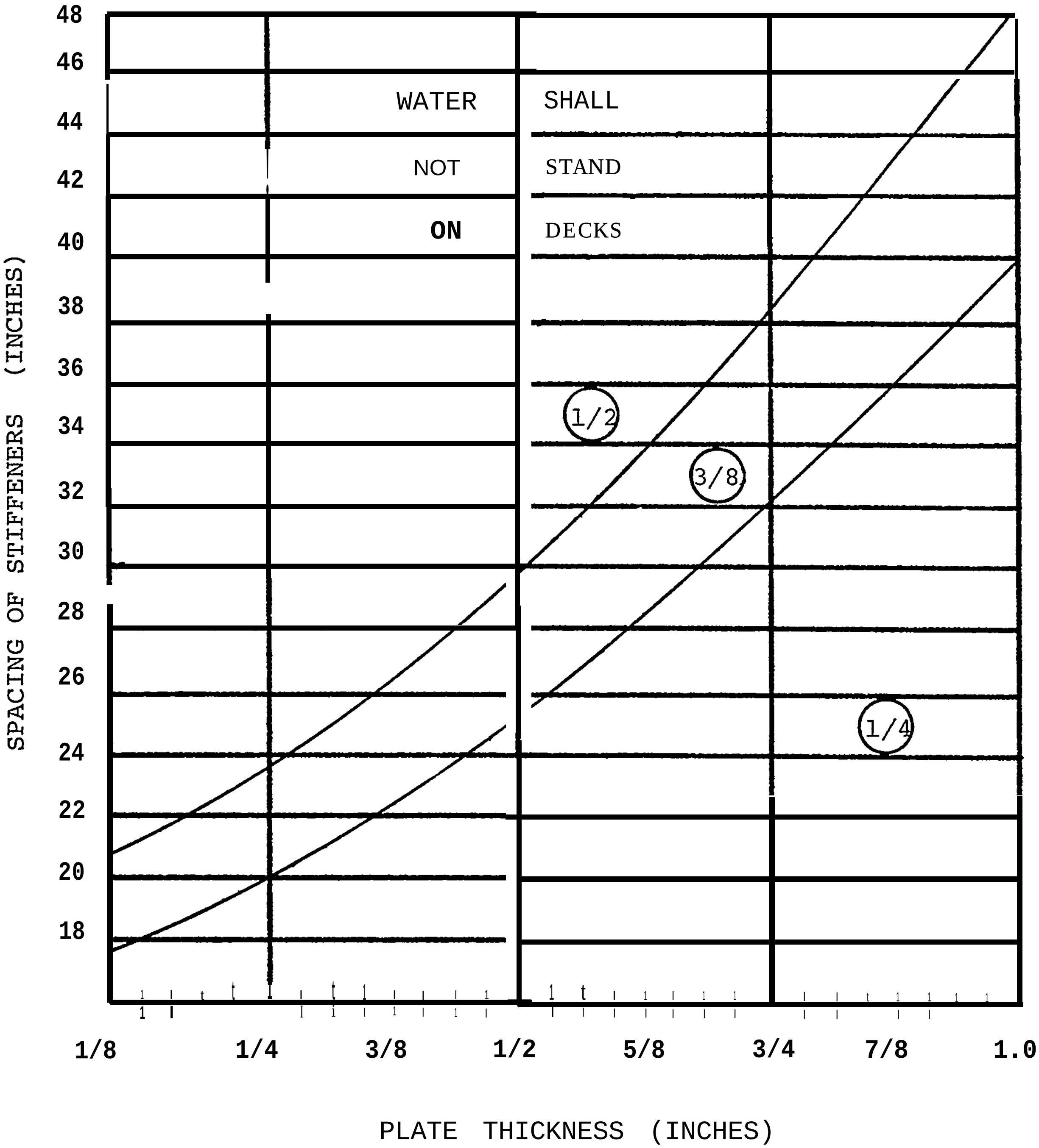
VII. FAIRNESS

A. Fairness of all welded structure shall conform to this chart.



VII . FAIRNESS

A. Fairness of all welded structure shall conform to this chart.




SPECIAL OWNERS REQUIREMENTS

B. Structures not in conformance with the Fairness Chart shall be straightened by approved methods to meet fairness criteria.

1. Where heating and shrinking is employed for straightening, excessive temperatures are to be avoided.

   1400°F - Max. Med. Carbon Steel (Dull Red Color)

   1250°F - Max. HTS - AH, DH and EH

2. Minor damages incurred to plate edges, etc., which require straightening by local heating shall not be quenched.

3. Visible deformities shall be dealt with as required prior to assembly.

4. Straightening by the use of heat shall not normally be employed on stringer and sheer strake plating within 3/5 midship length or on any area of A-517F (T-1) steel. If a situation a-arises where straightening is required, approval shall be in strict accordance with ABS Rules, Section 30.5.7.

5. In general, straightening of HTS by use of heat shall be kept to a minimum.

6. Areas covered by joiner panels or sheathing and where structural strength will not be impaired, shall not require fairing.

## VIII. SAND BLASTING AND PAINTING

A. Surface Preparation

1. Cleaning and blasting requirements shall be in accordance with the ship's specifications, as stated in the approved paint schedule.

B. Paint Application

1. In-process inspections may include mixing of coatings.

2. Care shall be taken to observe that all units coated prior to erection and before air test shall have all oil and/or water tight boundaries taped over far and near with no more than one (1) coat of pre-erection primer having been applied to the area.

3. Production Inspectors will inspect all work and notify owners when ready for their inspections.

4. Where possible, all rework will be completed prior to application of the second coat.

IX. PIPING SYSTEM

A. Welded parts of inside of the fabricated pipes (except butt welded joints with backing rings or sleeves) shall be finished to suit the purpose of each piping system in accordance with the following classes:

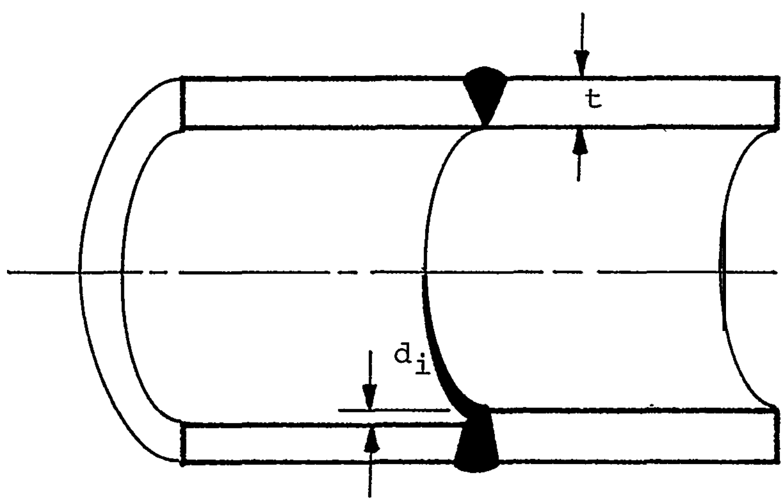
1. Class I

   Welding beads on inside of pipe shall be finished by grinding. Weld spatter and slag shall be removed.

2. Class II

   Weld spatter and slag shall be removed and weld bead cleaned with a wire brush.

B. For Class II Piping System; tolerance of pipe diameters at butt joints between pipes and connecting pipes, elbows or T pieces shall be as follows:

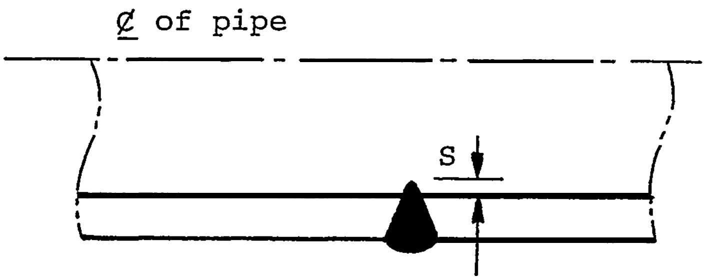



$t$ = thickness of pipe wall

$d_i$ = tolerance of out dia. between pipes and/or pipes & pieces

| nom. pipe dia. | $d_i$ in. |
|---|---|
| **8"** and below | $\frac{t}{8}$ or 1/8″ whichever smaller |
| above **8"** | $\frac{t}{8}$ or 3/16" whichever smaller |

C. Allowable limit of welding beads protruding inside the surface of the pipe shall be as follows:




| Pipe Class | Allowable Limit (s) In. |
| --- | --- |
| I | 1/16" |
| II | 1/8 " |

D. Testing

1. Testing shall be carried out in accordance with the test memoranda published for the subject system.

## X. DIMENSIONAL CONTROL INSPECTION

A. Dimensional Control Inspection shall be conducted in accordance with the guidelines set forth in the Dimensional Control Guidelines Booklet for Commercial Ship.

SECTION B

DIMENSIONAL CONTROL GUIDELINES

TABLE OF CONTENTS

1. REFERENCES

1.1 Hull Structural Procedure

1.2 Commercial Shipbuilding Inspection Guidelines

1.3 Book of Mold Loft Offsets

A. PURPOSE

This section provides the shipbuilders with the present rules and requirements of the Classification Societies. These Guidelines are subject to the user's judgement and interpretation of acceptable shipbuilding practices.

## 2. GENERAL NOTES

### 2.1 Responsibility

2.1.1 Fabrication and Shipfitters shall accomplish all work in general accordance with these guidelines; shall be aware of and take corrective action for unsatisfactory items; and shall accomplish all initial layout and dimensional checks.

2.1.2 Fabrication -

The Production Inspectors shall perform and document, as necessary, the dimensional control checks.

2.1.3 Assemblys -

The Surveyors and Shipfitters shall perform and document, as necessary, the dimensional control checks. Final dimensional check of a unit prior to release for erection shall be performed by the Surveyors and Production Inspectors.

2.1.4 Erection on the Ways -

The Surveyors assisted by the "Erection" Shipfitters and Production Inspectors shall properly align the unit being erected and perform, as found necessary, dimensional control checks.

2.2 Critical Dimensions and Master Reference Lines are as follows:

| | | |
|---|---|---|
| Width | -- | Center or Master Buttock |
| Length | -- | Master Frames |
| Height | -- | Master Waterlines |

**2.2.1** Location of master reference line from neat end of unit.

**2.2.2** Location of major longitudinal and transverse bulkheads, deck, stringers, girders at periphery of units or sub-assembly.

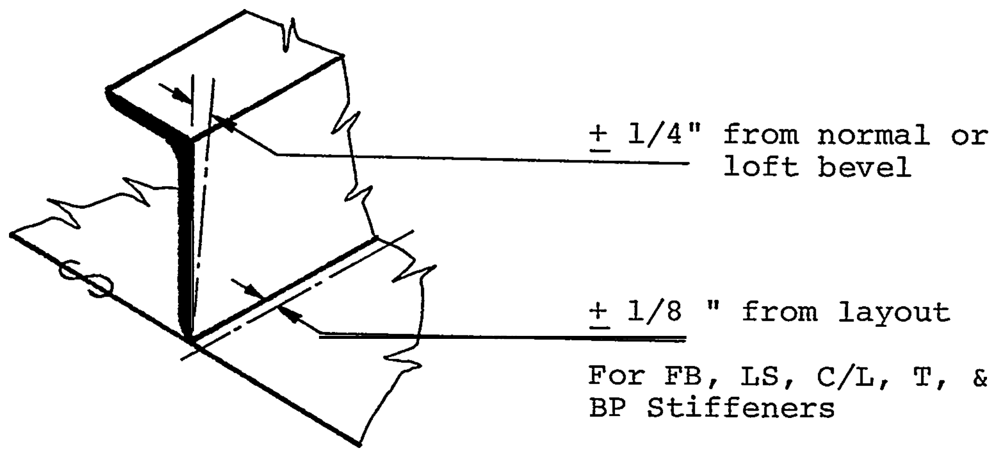
**2.2.3** Location of floors, girders, bulkheads, etc., within the sub-assembly or unit that back-up major structure or engine foundations on adjacent units.

2.2.4 All critical dimensions and master reference lines to be used will be circled on mold loft cards, assembly sketches or lifted from book of offsets.

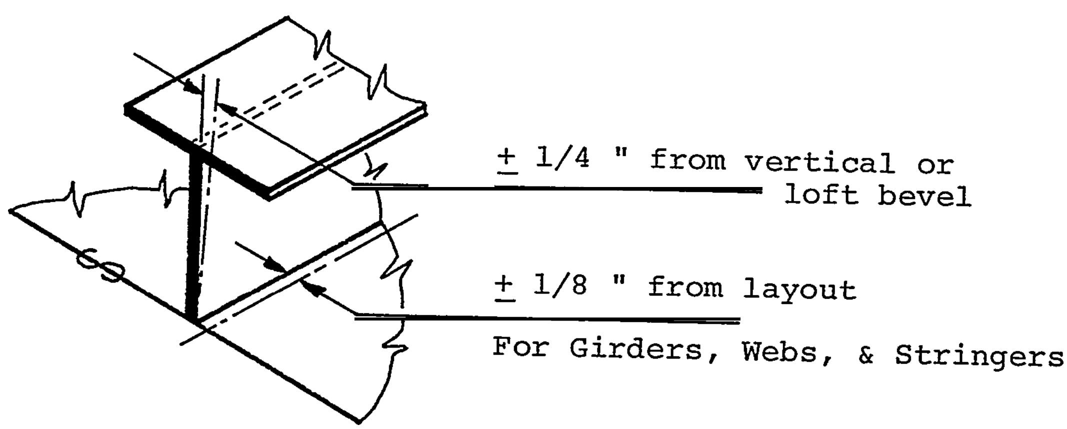
2.3 All master references (¢, master buttock, master frames and master waterlines) shall be clearly center punched, outlined and identified on the structure with a contrasting paint or marking pen. Incorrect master references shall be painted out once new ones have been established.

2.4 All structure shall be held to the mold loft layout on the periphery of the unit as follows: (Except curved shell layout which should be checked again in accordance with item **4.4).**

(A)




(B)

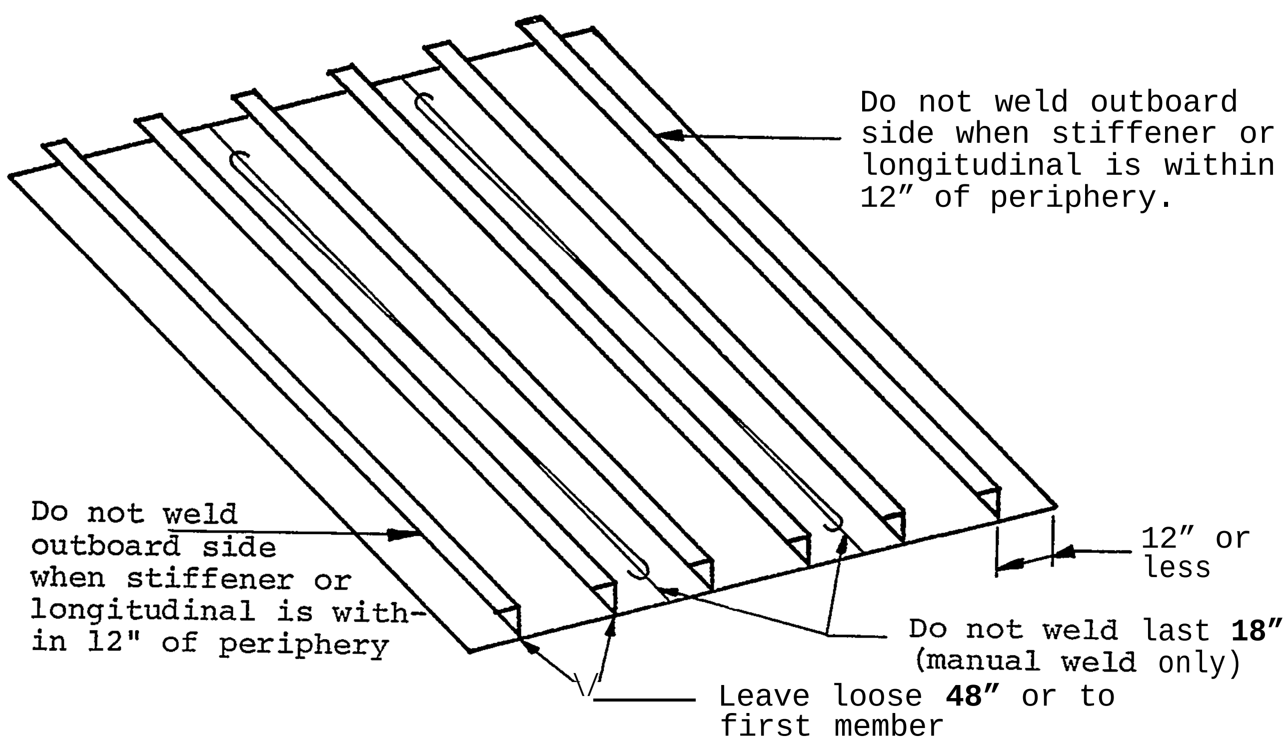


2.5 All measuring tapes used by layout personnel shall be checked bi-monthly.

2.6 Where provided, tolerances shown on detail drawings and Hull Structural Procedures shall supercede tolerances in these guidelines.

2.7 For Containerships, and Bulk Cargo Ships care should be taken in the assembly and the erection of units in way of the cargo holds to build the longitudinal dimensions to the positive tolerances rather than negative tolerances in order to ensure a cargo hold length longer rather than shorter than that shown on the plan.

2.8 Outboard weld of the outboard stiffeners and longitudinal and last 18″ of deck and bulkhead seams shall be left unwelded where applicable:



3. FABRICATION

3.1 Flame planer to be checked monthly for squareness.

3.2 All F.B. and shape fabrication shall be accomplished to + 1/8".

3.3 All flame planer plates shall be checked after burning to + 1/16”, to the loft sketch.

3.4 Burning machine output shall be checked once a shift for width, length, and diagonal. Rectangular plates shall be held to + 1/8”. Mirror image plates are to be checked for same dimensional sizes.

3.5 Where specified by loft templates in accordance with Reference 1.1 (Hull Structural Procedure) Section 4, the burning of container guide brackets and jig plates shall be checked and held to specified tolerance.

3.6 The following check shall be made at sub-assembly:

3.6.1 All assemblies built to loft sketches shall be checked and overall dimensions held to + 1/4".

3.6.2 The transverse deck beams after assembly for cutouts, chocks and face plate bevels. After welding straighten, if necessary, to hold ± 1/2" of camber.

3.7 All shaped shell plates shall be checked for back set and twist after forming to mold loft common base templates.

3.8 A random dimensional check at the time of layout or after cutting and fitting of the following material or sub-assemblies shall be conducted by Inspectors on a non-scheduled basis.

3.8.1 Bars and shapes such as deck longitudinal, bulkhead stiffeners, shell stringers, etc.

3.8.2 Web frames; deck, bulkhead, and shell plates. Mirror image plates are to be checked for same dimensional size.

3.8.3 Sub-assemblies and complex sub-assemblies (masts, rudder, major foundations, etc.) .

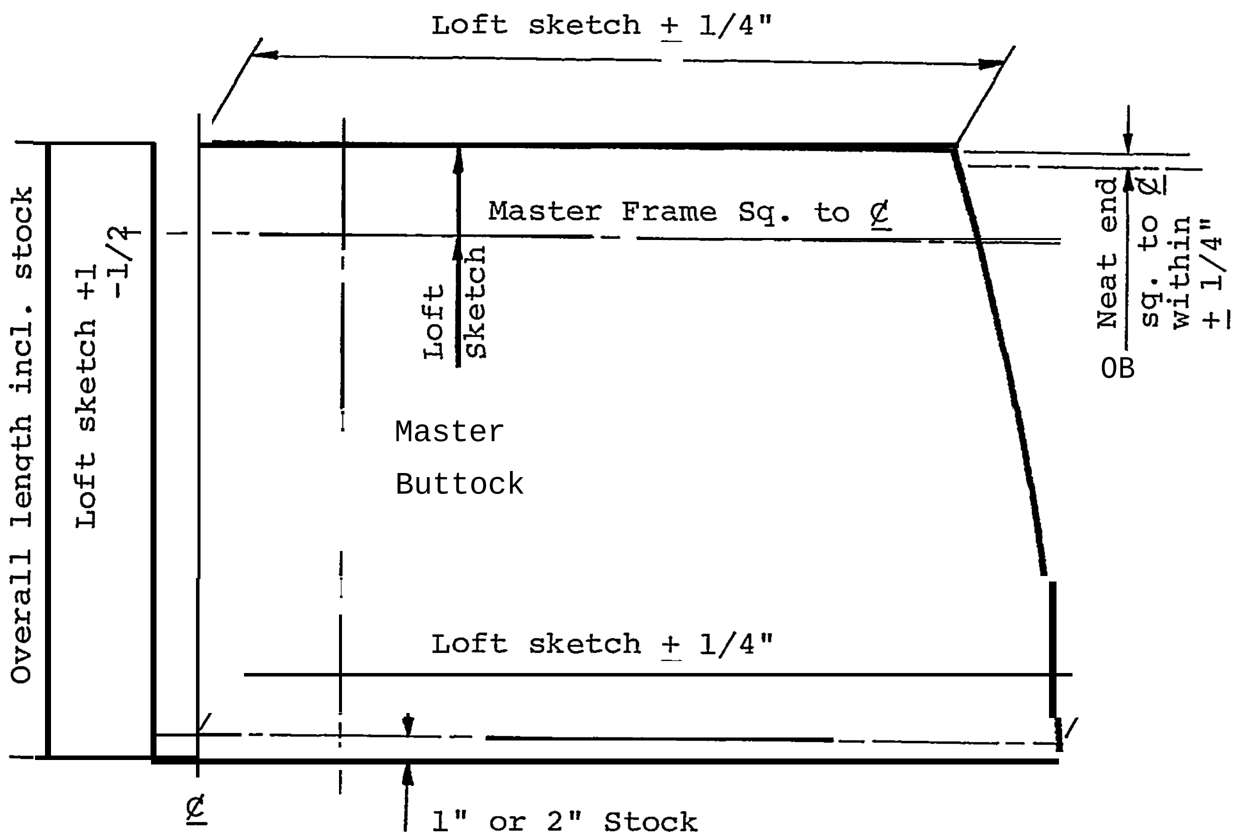
**3.9** The critical dimensions, as designated, shall be checked against the appropriate loft card, burning machine, flame planer, or loft BM sketches. These shall be signed and dated at the time of the check.

**3.9.1** If an item is found not to be within tolerance, but usable, a marked copy of the sketch, with comments, shall be forwarded to the next assembly work area supervisor for information.

3.10 A log shall be maintained by the Production Inspectors at fabrication for all dimensional control checks performed.

## 4. SUB-ASSEMBLIES

**4.1** Deck and Bulkhead Sub-Assemblies.




4.1.1 Master reference lines (℄, master buttock, master frame, master waterlines) shall be established at time of laydown and checked after complete welding. The IB seam should be recut to hold half widths to + 1/4".

4.1.2 The neat end should be recut if out of square from ℄ in excess of + 1/4".

**4.1.3** The stock end should be recut if extra stock exceeds by more than 1" the extra stock requirements shown on the lofting information.

**4.1.4** The layout for grids should include all bulkheads, webs, etc.

4.1.5 The OB edge should be recut only if recutting the IB seam will not hold half widths to + 1/4" and the neat end square to the ℄ after complete welding.

4.2 Innerbottom Assemblies -

Innerbottom assemblies to be handled similar to decks. (See deck sub-assembly sketch, item 4.]).

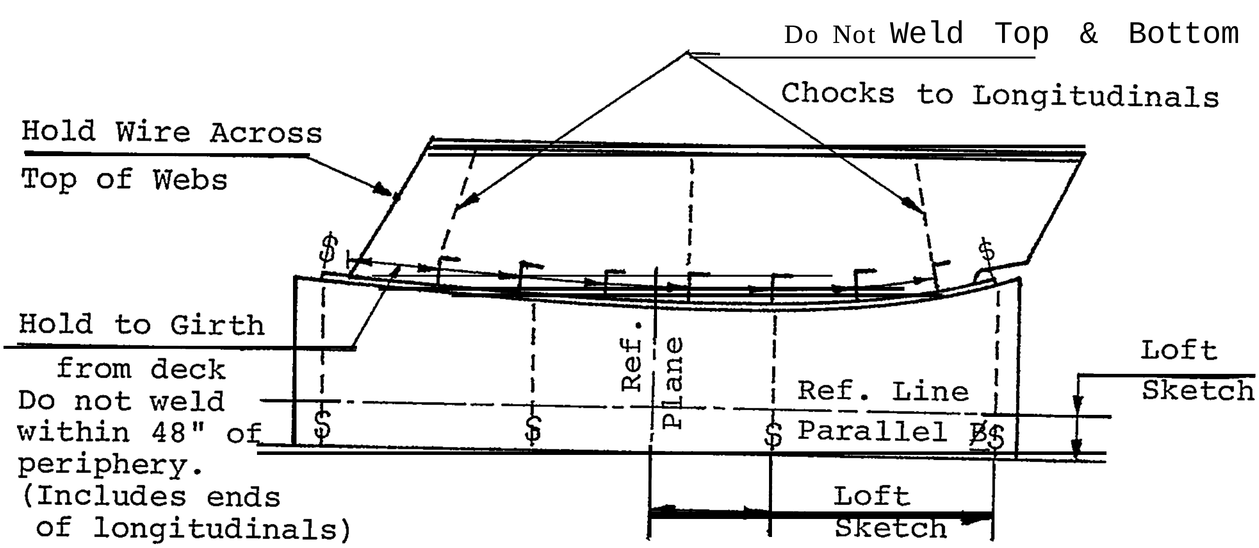
4.2.1 Critical outboard structure as identified on loft assembly sketch shall be held to ± 1/8" to align with wing tank structure.

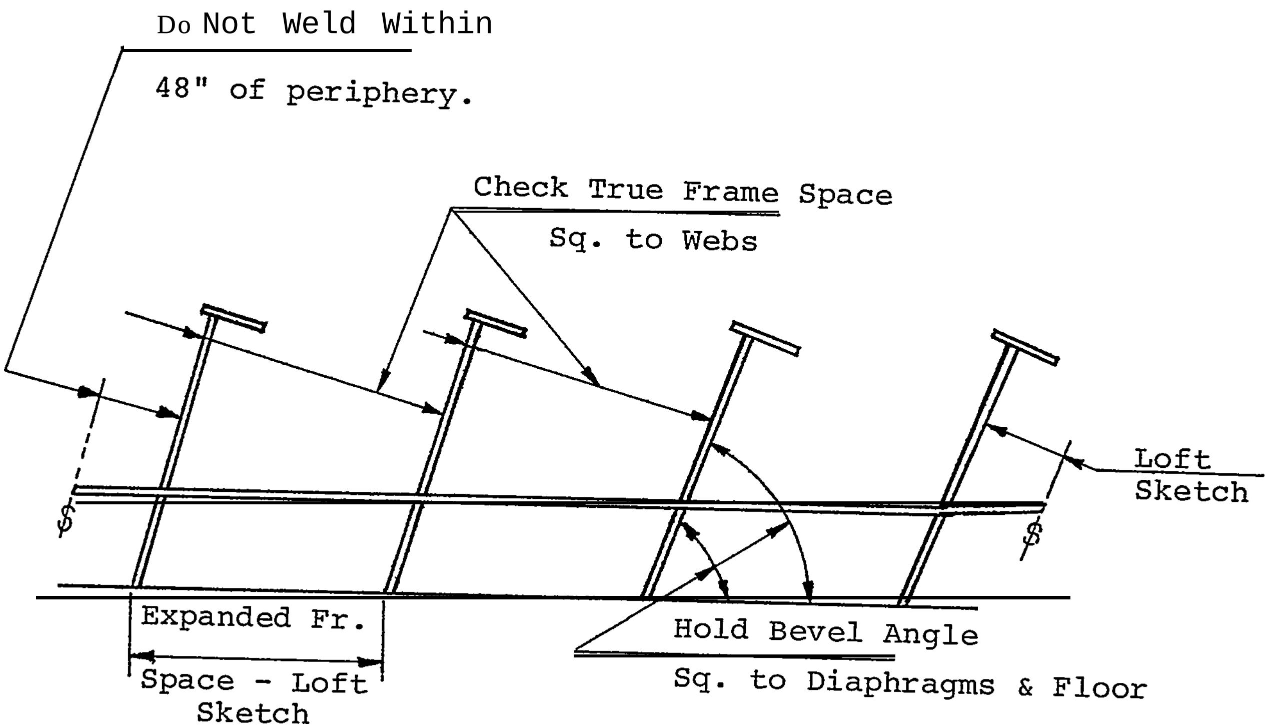
**4.3** Miscellaneous Panel Assembly -

**4.3.1** Miscellaneous panels shall be requested and checked to loft dimensions prior to layout. After welding, neat edges shall be recut when they exceed loft dimensions by 1/4" and stock edges shall be recut when they exceed loft dimensions by 1".

**4.4** Shell Assemblies -

Prior to setting diaphragms, layout all seam and web frame locations on platen or floor; during assembly check the following:






4.4.1 Upper and lower seams to loft layout.

4.4.2 Fore/aft butts to loft sketch - recut neat end if out more than 1/4".

4.4.3 Web frame (and any other transverse frame) locations to loft layout using bevel angle held square to diaphragms and floor - hold all webs (or transverse frames to the bevel angle.

4.4.4 Hold wire across top of webs to hold deck cuts in plane.

4.4.5 True frame spacing square to web plating.

4.4.6 Layout fore/aft ends using girth tapes from deck - hold all longitudinal normal except as noted on the plan.

4.4.7 Do not weld the top and bottom chocks on web frames to longitudinal. (For longitudinally framed shell).

4.4.8 Longitudinal shell stringers shall be checked for their proper angle to the base plane in accordance with loft assembly sketch.

**4.5** Container Guide Sub-Assembly -

The container guide sub-assemblies will be assembled in jigs as outlined in Reference 1.1, Section. 4 (Hull Structural Procedure) .

4.5.1 The assembly jigs shall be substantially braced and shall be checked and repaired if damaged.

4.5.2 All structure shall be properly aligned and restrained during assembly to minimize distortion.

4.5.3 After welding, all double guide cell assemblies shall be checked with a checking template. There shall be no twisting and spacing shall not exceed + 1/16” from design.

4.5.4 After the welding of the outboard truss, assembly is complete and all restraint released; the container guides shall be checked as follows:

a. Guide cells are within tolerance to checking templates.

b. Guide angles are flat to + 1/8” to a mean plane which is normal to the inboard edge of the assembly.

4.6 General Provisions -

4.6.1 Mock Set-Up -

The Shipfitters, assisted by the Surveyors, shall set up mocks with centerline, frame and work lines. Mock in “Rough Set” state shall be checked by Surveyors and the frame lines, centerline, height of mocks on posts or base line on mock plates established.

4.6.2 All sub-assemblies and sub-units shall have critical dimensions and master reference lines checked by the Surveyors assisted by the Shipfitters during assembly and at completion.

4.6.3 The critical dimensions, as designated, shall be checked against the appropriate loft sketch. A copy of the loft sketch shall have actual critical dimensions recorded and shall be signed, dated and filed for reference in the Surveyors office.

a. If an assembly or sub-unit is found not to be within tolerance, but usable, a marked copy of the sketch, with comments shall be forwarded to the next assembly work area supervisor for information.

5. ASSEMBLIES

**5.1** General Notes

5.1.1 Units must be assembled in a level condition. Errors resulting from major framing intersections (Ȼ, longitudinal and transverse bulkhead, deck/shell web intersections, etc.) being out of level can be as serious as failure to hold members plumb or check half widths. Level plates or shims shall be used to adjust for plate thickness variations in excess of 1/4”, and weights or pulling gear shall be used to hold the major framing intersections within a unit to ± 1/4" from a mean plane.

In heavily restrained units such as inner-bottoms where it is not possible to hold + 1/4”, a mean condition is to be established and the corners of the units shall be restrained with welded braces or steamboat ratchets.

5.1.2 Units are to be assembled on substantial and rigid mocks. Diaphragm and post mocks are to be repaired and additional members added if necessary to support major framing intersections. Where steel horses are used they shall be positioned to support framing intersections and leveled with level plates prior to unit assembly.

5.1.3 Mock Set-Up -

The Ship fitters, assisted by the Surveyors, shall set up mocks with centerline, frame and work lines. Mock in “Rough Set” state shall be checked by Surveyors and the frame lines, centerline, height of mocks on posts or base line on mock plates established.

5.1.4 With the unit level on the mock, the Surveyor shall reverse critical reference lines )Ȼ, master buttock and master frame) to the top of the unit for erection.

5.1.5 In fitting shell assemblies, the fore/aft position of the first web from the neat end should be taken at its mid-height in order to split any error in web location between assembly and erection.

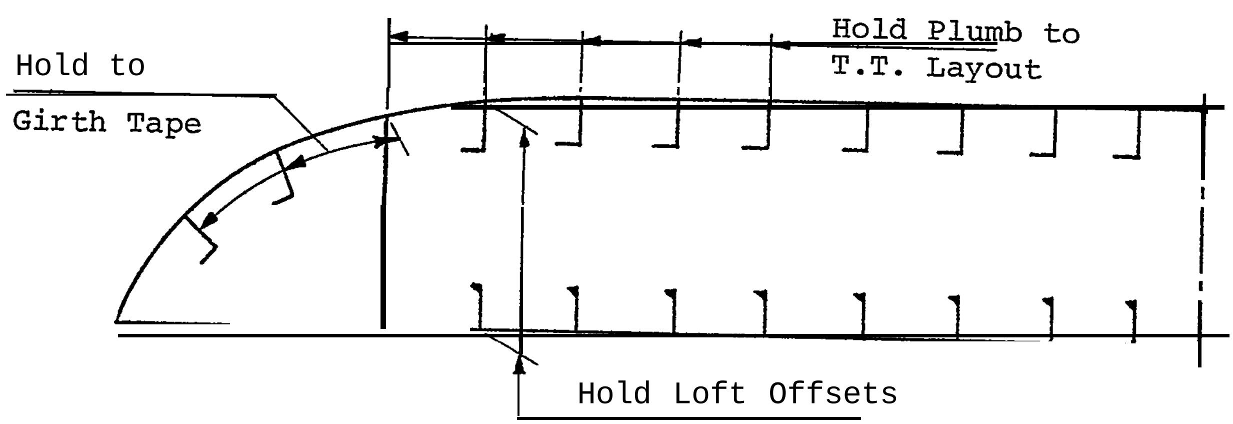
5.1.6 Bulkheads shall be held to the layout to ± 1/8" and shall be held plumb at intersections to ± 1/4" in their height.

**5.2** Innerbottom Units

5.2.1 ℄ and P/S midship innerbottom assemblies shall be leveled using ℄ and the outboard girder. Forward and aft innerbottom assemblies having no outboard girders shall be leveled using the tank top outboard.

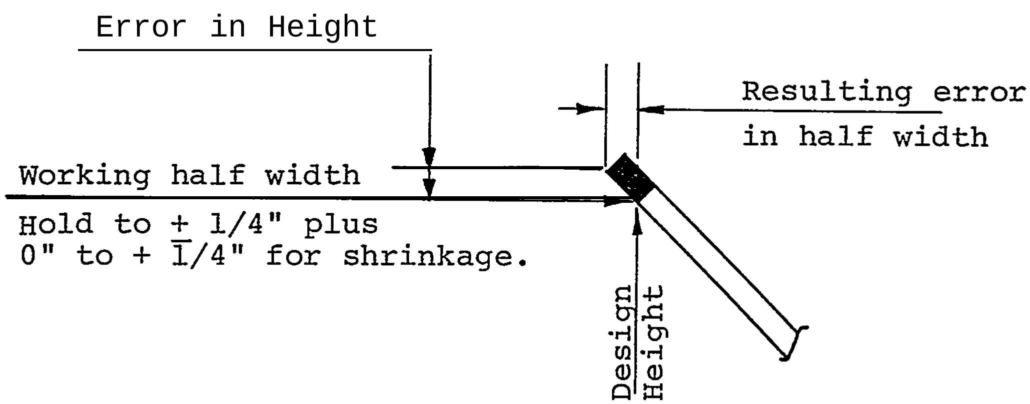
5.2.2 In fitting shell hold plate girders and shell longitudinal inboard plumb to the tank top layout. The longitudinal outboard of the outboard girder and all other longitudinal shown on loft sketches as being normal shall be laid out with girth tapes prior to fitting.

**5.2.3** On longitudinally framed units check height of every 2nd longitudinal from the tank top to loft offsets and temporarily brace if necessary prior to shell installation.



5.3 Deck/Shell Assemblies

5.3.1 Shell assemblies shall be set to loft offsets using a buttock established by the Surveyors. Care must be taken to measure half widths from a neat cut line established by checking heights from the deck as, in severely shaped areas, errors in height can result in approximately equal errors in half widths as shown below:




Half widths shall be held to ± 1/4" with an additional 0 to + 1/4" added for shrinkage depending upon the shape and experience.

5.3.2 Wing tank assemblies shall be set to the longitudinal bulkhead in lieu of the shell plating due to the possible errors outlined above. The lower edge of the bulkhead shall be held to ± 1/4".

5.4 Wing Tank Units

5.4.1 Wing tanks not built in special mocks shall be built on level mocks adjusted for plate thickness variations in excess of 1/4". Care must be taken in setting webs to bevel agnle if mock base is not parallel to ₵.

5.4.2 Prior to setting up mock diaphragms, layout the periphery of the longitudinal bulkhead, knuckles in longitudinal bulkhead, upper and lower shell seams, and transverse webs on the assembly floor or platen. During assembly check the following:

a. Upper and lower seams and knuckle location for longitudinal bulkhead.

b. Upper and lower shell seams.

co Fore/aft butts to loft sketch - recut neat end if out more than 1/4”.

d. Web frame (and any transverse frame) locations to loft layout using bevel angle held square to diaphragms and floor - hold all webs (or transverse frames) to bevel angle.

e. Layout longitudinal bulkhead to loft assembly sketch.

**5.4.3** Hold transverse webs and floors to layout and plumb to ± 1/4".

**5.4.4** Hold plate stringers to layout and check angle in erection plane to that shown on assembly sketch to ± 1/4".

**5.4.5** Use girth tapes to layout and check shell stringer locations.

**5.4.6** Shipfitters shall reverse master references (master frame, waterlines, etc.) prior to moving from the mock.

**5.4.7** Units shall be welded to the maximum extent practicable and in all cases block tacked on the overhead side prior to moving or turning. After moving and turning for welding, no welding is to be done if there are broken tacks until the unit is returned to a level condition.

**5.4.8** When dealing with wing tanks with open webs and struts hold half breadths between longitudinal bulkhead and the shell to + 1/4".

5.5 Box Girder Units

5.5.1 Where a mock is required by the assembly procedure to assist in holding the unit flat and square, it shall be checked prior to each assembly.

5.5.2 Where the shell is fitted piecemeal, layout the fore/aft ends using girth tapes from the decks. Hold all longitudinals normal or parallel to the decks as noted on the plan.

5.5.3 After assembly and prior to welding, the flatness of the assembly deck or plane shall be checked, as well as the width, heights and diagonals at each end of the loft assembly sketch.

5.5.4 Where two (2) units or assemblies are joined prior to erection, care should be taken to insure that both units are straight and without twist. This shall be monitored during welding and weld sequencing shall be used to control or correct deviations.

**5.6** Side Shell Units

See Section 4.4 and Paragraphs 5.4.3, 5.4.4, 5.4.5, 5.4.6, and 5.4.7.

5.7 Container Guide Installation (Bulkheads and Webs)

5.7.1 Structural fitting and major welding shall be complete prior to container guide installation.

5.7.2 The unit shall be securely restrained to a level mock and all container support webs checked and level prior to container guide installation.

5.7.3 After guide installation is complete, they shall be checked as follows:

a. Guide cells are within tolerance to checking templates and at design distance off ¢.

b. Guide angles are flat to + 1/8" to a mean plane and that plane—is parallel to the plane of the bulkhead.

5.8 Container Guide Truss Assembly.

The container guide truss will be assembled in a jig as outlined in Reference 1.1, Section 4 (Hull Structural Procedure) .

5.8.1 The assembly jig shall be substantially braced and shall be checked and repaired if damaged.

5.8.2 All structure shall be properly aligned and restrained during assembly to minimize distortion.

5.8.3 After welding is completed and all restraint released, the container guides shall be checked as follows:

a. Guide cells are within tolerance to checking templates and at design distance off g.

b. Guide angles are flat to + 1/8" to a mean plane and the forward and—aft planes are 3'-8" apart and parallel.

**5.9** Special Units

**5.9.1** Complex "3-D" units shall be built in general accordance with the guidelines outlined for similar units. Particular attention should be paid to holding major structure (deck, bulkhead, shell wing tanks, stringers, etc.) to proper heights, half widths and fore/aft position at the erection planes. Critical dimensions shall be checked to loft assembly sketches.

**5.10** General Provision

5.10.1 All units shall have critical dimensions and master reference lines checked by the Surveyors assisted by the Shipfitters during assembly.

5.10.2 Upon completion of unit assembly and prior to release of the unit for blast, paint and erection, a final dimensional check shall be performed by Surveyors and the Production Inspectors.

5.10.3 The critical dimensions, as designated, shall be checked against the appropriate loft sketch. A copy of the loft sketch or unit sketch shall have actual critical dimensions recorded and shall be signed, dated and filed for reference in the Surveyors Office.

a. If a unit is found not to be within tolerance, but usable, marked copy of the sketch, with comments shall be forwarded to the next Erection Supervisor for information.

## 6. ERECTION ON THE WAYS

6.1 The critical dimensions and master reference lines established in the Assembly Area shall be used for regulation and aligning units on the ways. Under no circumstances should the shell half widths be used as this includes the error resulting from plate burning, welding and trimming.

**6.1.1** The Surveyors shall establish the master ℄ on each deck as fitting and welding progresses to hold it.

**6.1.2** During the initial erection and welding of the innerbottom, the keel condition and the tank top at ℄, outboard girder and an inboard girder at about **1/4** breadth shall be checked by the Surveyors and plotted weekly.

**6.1.3** Care must be taken to hold deck to deck heights in erecting units in order to insure alignment with multi-level units forward or aft.

**6.1.4** Care must be taken in erection of main transverse bulkheads, longitudinal box girders, transverse bolted box girders and hatch coaming to maintain the design height and a level plane.

**6.1.5** At no time will more than 1" of stock be removed without approval of the Erection Supervisor.

**6.1.6** The deck or tank top conditions below cargo doors shall be monitored during erection. Units containing cargo doors shall be regulated in accordance with the following procedure:

a. Molded line of deck above to bottom of sill of each door at inboard and outboard corner shall be verified to be correct.

b. If (a) is correct, unit shall be regulated to achieve proper deck height at door. (Assembly Area is to take extra care at installation) .

c. If (a) is not correct within reasonable tolerance, 3/16”; the door shall be regulated within tolerance.

d. Unit shall be scribed to meet (b) or (c) as applicable.

e. Seams under door sill to be ground flush and sill to be shimmed as necessary to provide positive contact with deck. Welding to be completed on bottom sill only after unit is welded to deck and door coaming is welded to bulkhead.

6.2 Container Guide Units (Erection)

6.2.1 The length of each main cargo hold between bulkheads must be held to ± 1" in order to insure proper installation of the container guide system.

6.2.2 Care must be taken during the erection of the units in way of cargo holds to hold the pre-outfitted container guides flat to + 1/8".

6.2.3 Care must be taken in the erection of the guide truss assemblies or intermediate webs to hold the height (the top of the guides are neat) and the design distance across the centerline butt.

6.2.4 All container guide units shall be erected so as to maintain the tolerances specified in Reference 1.1, Section 4 (Hull Structural Procedure) .

6.3 The Surveyors, assisted by the “erection” Shipfitters and Production Inspectors, shall align the unit being erected on the ways with previously set unit, utilizing master reference lines and critical dimensions established in the assembly area and record necessary data on designated loft assembly sketch. The scribe cut dimension as agreed upon shall be used by “Erection” Shipfitters to insure proper alignment of the unit.

6.3.1 Critical dimensions for each erected unit shall be recorded, signed and dated on designated loft assembly sketch and filed in the Surveyors Office.

6.3.2 A copy of the final critical dimensions, scribe cut dimensions of each erected unit as well as the deviations from molded hull form shall be forwarded to the Ship Superintendent.