Product Oriented Material Management

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in cooperation with

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FOREWORD

"In Japan, we have to control material because we cannot control people." So says a senior manager in one of the world's most effective shipbuilding firms much to the surprise of managers elsewhere who had accepted the myth of a certain something about Japanese culture that produces better workers. Devoid of this excuse, some traditionalists persist, "If we had the supplier/subcontractor infrastructure that supports the Japanese shipyards, we too would be effective." What is not understood, is that Japanese shipbuilding managers worked to create much of their infrastructure and continue to work to sustain it. To them, all material matters, including the systems of their suppliers/subcontractors, are integral parts of their shipbuilding systems.

Since 1980, some U.S. shipyard managers made significant progress in applying modern zone-oriented. i.e., product-oriented, manufacturing methods. The terms "Hull Block Construction Method," "Zone Outfitting Method" and "Zone Painting Method" now have meaning in a number of shipyards even for conversion and overhaul work and for building end products other than ships. Earlier publications stressed dependence of such methods on integrating production engineering and design along product lines. This publication emphasizes dependence on a way of thinking about material matters that transcends traditional boundaries in order to integrate just-in-time procurement with specific build strategies. Benefits are manifest in fewer disruptions caused by late deliveries, less surplus, less requirement for warehousing and lower material prices.

Traditionalists discount the notion of just-in-time and strive for material deliveries as early as possible because some customers, particularly for naval ships, provide substantial amounts of material and/or make progress payments when shipbuilder furnished materials are received. The result is that for some ships, financing costs are already equivalent to labor costs and for naval ships, financing costs to governments are extraordinary. Traditional material management, not being product oriented, cannot be adequately integrated with zone-oriented design and production activities.

The descriptions herein are based on developments by Ishikawajima-Harima Heavy Industries (IHI) of Japan which regards material procurement as an essential function of a total production process and design engineers integrating with production engineers as the nucleus around which other shipyard departments, material suppliers and subcontractors, provide services.

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The material on which the contents are based was compiled by a team for which overall management was provided by Y. Ichinose, President of IHI Marine Technology. Inc., New York City. M. Kasama, Senior Manager of IHI International, Tokyo, was the Project Manager and was directly assisted by D. Kumaki, I HI International Procurement Division. Y. Mikami, Director, IHI International, acted as an advisor to the Project Manager. A. Hashimoto, Senior Manager, IHI Tokyo Shipyard, and Y. Okayama, Senior Manager, IHI International, also acted as advisors. Editing and some supplemental writing was performed by L.D. Chirillo assisted by R.D. Chirillo.

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This publication is an end product of one of the many projects managed and cost shared by Todd for the National Shipbuilding Research Program. The Program is a cooperative effort by the Maritime Administration's Office of Advanced Ship Development, the U.S. Navy and the U.S. shipbuilding industry. The objective, described by Panel SP-2 of the Ship Production Committee of the Society of Naval Architects and Marine Engineers, is to improve productivity.

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1.0 INTRODUCTION

1.1 Background and Objectives

In the most effective shipyards, the material cost for building a commercial ship is now 60 to 70% of the total cost, depending upon complexity and sophistication of the ship's structure and systems. Ironically, material costs are proportionally greater for very productive shipbuilders as their labor costs are relatively low. Thus, as further reductions in labor man-hours become more and more difficult, productive shipbuilders apply greater emphasis on material management as a means to stay competitive.

Processes employed by traditionalists leading to delivery of materials to production sites, consume more time than is necessary and are inefficient. As a consequence, traditional shipbuilders suffer a great deal in material management. Major problems observed are:

- preparation of purchase order specifications (POS) is too slow,
- vendors require relatively long durations for bidding,
- vendor furnished information (VFI) is either late or insufficient to support timely design development,
- relatively long lead times are required for material deliveries,
- promised delivery dates are not reliable enough, and
- insufficient use of standards requires extraordinary dependence on POS preparation.

Traditional shipbuilders need more time between contract award and ship delivery, more time for design, more margins in stock quantity or storage time, etc. all of which increase a ship's cost.

Further, traditionalists more frequently encounter disruptions in planned work due to late material arrivals. The adverse impacts of such disruptions on an immediate shipbuilding project are generally recognized. More seriously, such disruptions force shipbuilders to react to circumstances and cost returns do not reflect normal performance of work. Without knowledge of how work processes normally perform, production control becomes ineffectual and achieving a constantly improving shipbuilding system, as with statistical control methods, is impossible.

In Japan, one major shipbuilding firm routinely orders about 70% of the total material for a ship when only 30% of the design is complete. Normally, all long-lead time machinery and equipment are ordered within a couple of weeks after contract award. Engineering starts immediately as virtually all VFI, most pre-approved, are on hand even before purchase orders are issued. As a consequence, virtually all materials are delivered per schedules to designated sites. Such deliveries are crucial for reducing contract-to-delivery time, reducing required storage area, achieving normal performance of work, etc. All can only be realized by a well organized material management system.

In the U.S., shipbuilders started in 1980 to gradually shift from traditional system-oriented to modern zone-oriented, i.e., product-oriented, shipbuilding methods patterned after those applied by the most effective shipbuilders in Japan. As of early 1985, a few U.S. shipbuilders began to adopt product organizations as adopted by some other U.S. industries and the Japanese shipbuilding industry during the two decades encompassing 1950 to 1970. [1]

[1] Richard P. Rumelt, Strategy, Structure and Economic Performance, Division of Research, Harvard Business School, Boston, 1974, p. 66.

As compared to a functional organization, in a product organization people identify with all aspects of their particular product. For example in a hull construction department, shops separately address parts fabrication, sub-block assembly, block assembly and hull erection. Similarly, in an outfitting department separate shops address fabrication work for producing pipe pieces and assembly work for machinery spaces, assembly work for accommodation spaces, assembly work for weapons spaces, etc. Where most effective, budgeting and planning of all resources, especially material, is on a profit basis as each such organization is operated more like a separate business. A product manager works to achieve coordination across functions instead of being parochially focused on one function. [2]

For such transitions from functional to product organizations, material management is a stumbling block unless it too becomes product oriented. Thus, the primary objective of this publication is to provide guidance for all who participate in material management, i.e., top managers and people involved in planning including design and scheduling as well as those immediately involved in procurement, material control, warehousing, etc. The need for top managers to comprehend the importance of material management and provide a viable system and organization to assure smooth implementation, is vital.

Material management as used in this publication means the activities including material planning, schedule control, contracting for procurement, expediting, warehousing, palletizing, distribution of pallets to production sites, cost control and feedback to coat centers.

1.2 Approach

In order to identify material management problems experienced by U.S. shipbuilders, the researchers:

- o distributed questionnaires to selected shipbuilders and suppliers of machinery and equipment, and
- o to further develop information so received, made visits to several shipyards.

Thus, this publication which is based upon the material management system for zone-oriented, integrated hull construction, outfitting and painting as performed by Ishikawajima-Harima Heavy Industries Co., Ltd. (IHI) of Japan, also reflects some opinions and comments from questionnaire returns and visits with U.S. shipbuilders.

1.3 Questionnaires and Answers

Questionnaires were employed. Their objective was to compile and statistically analyze information on the natures or substances of troubles, quantitatively and qualitatively. They were distributed to thirteen shipyards and forty suppliers of whom only three shipyards and twelve supplers responded. Three additional responses were received as a consequence of researchers visits to shipyards.

The number of responses do not constitute a solid and reliable baais for statistical analysis. Therefore the results, Appendices A, B, C and D, are not exactly representative. However, they do give some indication of what seems to be the problems. As expected, problems raised by the shipyards provide interesting contradictions to those identified by suppliers.

1.4 The Importance of Material Management

Material management for a specific shipbuilding project is a process that actually begins as part of pre-contract negotiation of technical matters. It impacts on contract drawings and specifications. Functional, transition and work-instruction designers participate very actively and the process continues through delivery of material to production sites. Thus, material procurement is only part of material management and for product-oriented shipbuilding systems, purchasing people must maintain close ties with design and production people to an unprecedented degree. [3]

To facilitate such concert of effort, the moat effective shipbuilders assigned their purchasing department to production control managers. Thus, in each of their shipyards, man-hour and material budgeting, scheduling and material control including purchasing and delivery of materials to production sites, are all coordinated by a production control manager who reports directly to the top manager.

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[2] Richard L. Daft, Organization Theory and Design, West Publishing Co., N.Y., 1983, p. 231.

[3] See “Pre-Contract Negotiation of Technical Matters - December 1984”, National Shipbuilding Research Program (NSRP).

As mentioned at the outset, the cost of material accounts for 60 to 70% of a ship's total cost. Needless to say, material is the most significant cost factor. Also, many shipyard functionaries do not realize that material costs include costs due to redundant stock, excessive storage time and lost production man-hours caused by late VFI and material deliveries which forces a shipyard to quote higher prices and become less competitive. Thus, material management responsibilities include reducing related costs as well as cost per item when purchasing.

In order to achieve such reductions, support from design and production is essential. Designers must provide accurate specifications and quantities of materials required, timely enough to permit buyers to negotiate and conclude contracts with vendors within lead times needed for deliveries. Production people must provide exact dates that materials are required at production sites so that comprehensive procurement schedules which minimize related costs can be devised.

Obviously, material management is not as easy as it may seem. As shipbuilders increase productivity, financing costs approach labor costs. Thus shipbuilders have to rely more on minimizing the duration between contract award and ship delivery while insuring that expensive materials do not arrive any earlier than is necessary as means for competing with other increasingly effective shipyards.

Requiring just-in-time material deliveries creates greater need for precise control of a procurement schedule on a daily basis. Material management assumes more responsibility because materials delivered early increase financing costs and a single item that does not conform with a specification or is delivered late, can seriously disrupt a production schedule. Without exaggeration, in a modern shipbuilding system the material manager having control of schedules imposed on vendore, has to be involved in design and production scheduling so that all may be carefully integrated.

Material management is also difficult because the lowest overall costs are not achieved by always buying from lowest bidders. As mentioned before, maintaining minimum stock and/or storage time also lowers costs. Disregarding certain concerns in favor of low bids, e.g., delivery dependability, quality, performance and reliability, and after-sales service, could be disastrous. [4]

Another significant material management responsibility is to make effective use of available funds by considering all influences on a ship's net cost. For example, efficient material managers consider:

- make or buy, i.e., procuring raw materials and using other shipyard resources to manufacture products in-house as compared to buying completed products from vendors or subcontractors.
- speculative buying anticipating price fluctuations such as for non-ferrous metal products,
- adjustments in payment terms to vendors based on fund income flow, market interest rates, etc., and
- balance of cash inflow and outflow to avoid deficits in cash flow.

Obviously, material management per se, not just purchasing, plays an important role in controlling material costs. Close collaboration of material managers with design, production control, production and financing managers is essential in order to consolidate the various requirements which must be incorporated in purchase orders to vendors and subcontractors. Beyond a shadow of a doubt, material management includes leadership for establishing a procurement policy which benefits the entire company and dismisses easy procedures devised to provide convenience merely for purchasing.

[4] W. Edwards Deming, a foremost advocate of statistical control methods and known as the father of productivity in Japan, advises that for productivity purposes, traditional manufacturers must learn to deal with a significantly fewer number of suppliers.

People assigned to material management, especially those directly involved in purchasing and/or subcontracting to outside sources, need patience and faith as well as ability because their duties are many fold, e.g., coordination of different requirements, investigations of market prices, vendors' quality and states of affairs and negotiations with inside and outside personnel. These activities are quite time consuming and, above all, involve transactions of huge amounts of money which significantly affect a ship's cost.

In order to alleviate such burdens, particularly on procurement staffs, seeking solutions by improvements in material management systems is far more effective than relying on improvements in functionaries, such as that gained through long experience. For example, in order to reduce time requirements, a procurement system could be simplified by adopting vendors' catalog products that are pre-approved and employed as standards. In addition, improvements in material management systems are obtained by computerizing repetitive work, data storage, scheduling and control, etc. Also, costs are "pre-controlled" by allocating and suballocating budgets to individual shipyard organizations so that they can evaluate and self-control their material requirements based upon feedback from purchasing.

Material management's final responsibility is to palletize the materials required for each work package and deliver the material so grouped to a specific work site on a designated date. This may seem rather unique as most traditional shipyards assign such processing to the various production shops. Having all facets of material handling under one control is far more effective as work packages require materials from various sources, inside and outside the shipyard. Warehousing people are inherently better qualified to collect, palletize and distribute materials.

As recapitulation, the responsibilities of material management are much broader and more significant than traditionalists imagine. Material management of the highest order of efficiency is an absolute requirement for constantly self-improving, flexible shipbuilding systems that feature integrated, zone-oriented hull construction, outfitting and painting.

2.0 PRODUCT-ORIENTED MATERIAL MANAGEMENT AND PERIPHERAL SYSTEMS

2.1 Features of Modern Shipbuilding

Modern society is often depicted as "high tech" or "information oriented". As compared to pre-World War II social environments, many different products having different specifications and configurations now impose significant manufacturing challenges. Impressive progress in management methods and facilities have made it possible to meet such demand.

Computer-aided design and manufacturing (CAD/CAM) and robots represent the trend in many modern industries. Even though shipbuilders are successfully introducing such methodologies for design and production, shipbuilding remains inherently labor intensive relative to other endeavors. Total application of such technologies requires huge investments, addressing an entire production system, that private shipyards cannot justify. Consequently, investments are generally limited to specific areas that can provide maximum returns with great dependence on vendors and subcontractors. Naturally, focus in-house is on areas which can maintain a high rate of operation so that investments will pay off in relatively short periods of time. Typical such work is hull part and pipe piece fabrication and assembly on-unit, on-block and on-board.

The best way to maintain high operation rates in-house is to increase work volume within a given period which, in ship production, means being very selective concerning in-house work and shortening construction periods by rationalizing production processes.

Shortening construction periods provides numerous advantages beyond savings in amortizing investments. There are also reductions in finance costs, costs for maintenance of ships' machinery, paint systems, etc., and in mooring costs at outfitting piers. Further, shortening construction periods requires relatively longer preparation time for design, material definition and material procurement and also contributes to reduction of the time required between contract award and delivery. The latter enhances sales opportunities and is already an essential factor for competition. [1]

The best and most economical solution for a shipyard to meet such demand is to break down an envisioned end product into interim products, i.e., parts and tiers of subassemblies, which are contrived to facilitate creation of larger assemblies and which are assigned for manufacture to the most specialized and cost-effective producers, in house or elsewhere. Such advanced shipbuilding is said to be product (interim product) oriented and is primarily an assembly process.

[1] "A consortium of Japanese shipyards looks the likely favorite to gain a lucretive $350 million order for six containerships from U.S.-based Sea-Land Services . . . . The three-yard line-up from Japan looks fsvorite for several reasons. One is the punishing delivery schedule called for by the major U.S. private operator." Lloyd's List, December 28, 1984.

2.2 Outline of Product-Oriented Material Management

2.2.1 Relationship Between Product Oriented Material Management and Product-Oriented Production System

Material management must necessarily be completely integrated wherever product-oriented production is being implemented. In other words, the objective of product-oriented material management is to procure materials for work packages each of which defines work to be accomplished to create a specific portion of an envisioned end product (zone), with a specific facility such as a process lane (problem area) during a specific division of the work process (stage). Thus, a product-oriented material management system is designed to just-in-time deliver materials required for work packages which reflect both design and production attributes and which impose a common build strategy on design, material procurement and production. [2]

Product-oriented production in shipbuilding is a methodology based upon a product work breakdown structure (PWBS) which conforms with the concept of Group Technology (GT). The purpose of GT, also called Family Manufacturing, is to produce different products required in varying quantities, such as parts and subassemblies needed to build ships, in a manner so organized to achieve production-line benefits. GT requires coordinated sales, design, material procurement and production far beyond that achieved by traditionalists. [3]

Unlike system orientation, product orientation requires:

- contract design to be part of the shipbuilding process so that contract drawings and specifications address the building process as well as the end product, [4]
- designers and those who perform material definition to regroup information conceived by system to facilitate design, into information organized by zone to facilitate production, [5] and
- division of work per a PWBS.

PWBS first divides the shipbuilding process into three different types of work, hull construction, outfitting and painting, because they impose inherently different problems. Each is then subdivided into fabrication and assembly work. AISO, PWBS classifies contemplated interim products in accordance with the resources they require, i.e., material, manpower, facilities and expenses. Finally, PWBS classifies interim products (parts and subassemblies) by characterizations of both a ship design and a manufacturing process which are called product aspects. The product aspects system and zone are means for dividing a ship design into manageable work parcels. Area (problem area) and stage are means for dividing the design, material procurement and production efforts.

The product aspect system, is retained because some work in a zone-oriented shipyard is more effectively performed by system, e.g., identifying all material requirements and procuring long-lead materials using system diagrammatics and in production, virtually all testing. Optimum progress of all work classified by zone/area/stage, requires integration of hull construction, outfitting and painting which, in turn, requires timely purchasing and punctual delivery of different materials in varying quantities. Such material management is essential to achieve smooth operation of the various process flows (production lines) that GT enables shipbuilders to exploit.

Effective material management requires full support from design so that all necessary technical information and requirements are prepared in time for procurement processing. Time is most crucial in product-oriented manufacturing systems. Design, material management and production functionaries become highly interdependent and must constantly communicate with each other for productivity purposes.

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[2] "Materials" includes all raw and/or fabricated items such as pipe and machinery respectively.

[3] See the National Shipbuilding Research Program (NSRP) publications "Product Work Breakdown Structure - Revised December 1982" and "Pipe Piece Family Manufacturing - March 1982".

[4] See the NSRP publication "Pre-Contract Negotiation of Technical Matters - December 1984".

[5] See the NSRP publications "Integrated Hull Construction, Outfitting and Painting - May 1983" and "Design for Zone Outfitting - September 1983".

2.2.2 Functions of Product-Oriented Material Managernent

The major functions of material management are: material planning, procurement, and distribution.

In addition, material management includee a control function which constitutes one of the specialized subsystems for a shipbuilding process. As for the product-oriented production concept, management and control are unique features of the product-oriented material management concept.

Ž Material planning is a function which:

- identifies required materials and associates them with contemplated work packages,
- prepares requisitions,
- performs value engineering, and
- participates in planning and control of overall material planning, budgets, schedules and inventories.

Ž Procurement is a function which:

- purchases from outside and inside sources,
- performs value engineering,
- makes payments, and
- participates in planning and control of budgets, schedules and inventories.

• Distribution is a function which:

- receives and stores material.
- does field expediting,
- palletizes and issues materials,
- transports materials to work sites, and
- participates in planning and control of schedules.

The principle and subordinate functions of product-oriented material management are shown in Figure 2-1.

FUNCTIONS	PLAN/SEE	DO
Material Planning	Ž General material Planning • Budget control • Schedule control • Value Engineering • Inventory control	Ž Ship's material Planning • Requisition making for purchasing
Procurement	• Budget control • Schedule control . Value Engineering . Inventory control	• Purchasing • Outside manufacturing • Inside manufacturing Ž Payment
Distribution	• Schedule control	Ž Receipt and keeping Ž Field expediting Ž Palletizing/issue Ž Transportation

FIGURE 2-1: Functions of Product-Oriented Material Management.

2.3 Outline of Material Planning

Material planning is actually the first stage of requisitioning, i.e., it is preparation for procurement. In general, material planning identifies material required (types, quality), quantities, delivery times, delivery sites, and establishes a standard material procurement plan for each ship (job) number. The design and production departments have major roles in such activity.

Material planning is, broadly speaking, the backbone of a product-oriented material management system as it establishes basic policies for material selection, such as material grouping (classification), standardization, application, etc. These policies are most important in pursuing product-oriented concepts as any misdirection will seriously affect development of an effective material management system.

2.3.1 Analysis of Material Classification

If interim products are relatively simple, material planning, which identifies a work breakdown and specific material lists per zone/area/stage, can be accomplished quite easily and early enough to allow ample time for procurement, palletizing and delivery to work sites per the production schedule. However, shipbuilding involves many complex interim products and relatively short durations between contract awards and ship deliveries. Following the same material planning procedures as for relatively simple end products is impractical.

The solution employs a material classification scheme, devised by analyzing the nature of items to be procured, which alleviates the initial design workload without negative affect on timely deliveries to production. Materials are classified so that designers involved in material planning (identification of function, quality and quantity) work in accordance with a priority sequence which first addresses imminent requirements and defers material planning for zone/area/stage work packages that are not required by production until later. In other words, material planning is sequenced to anticipate the build strategy which will be employed in production. Time allowed for design, particularly during crucial early design phases, is more wisely employed.

The scheme categorizes materials as: allocated, stock, and allocated stock. The material planning process is categorized to correspond.

The objective of such categorizations is to focus on the extent that quantity accuracy, specification comprehension and other technical information are required in order to place an order.

2.3.2 Material Control Classifications

As described in the foregoing, materials are categorized as allocated, stock and allocated stock.

Allocated materials (A), sometimes called direct materials, are those which are ordered for a specific requirement in a specific ship (main engine, steering engine, etc.) and which require utmost attention from design, purchasing and production planning functionaries.

Stock materials (S), sometimes called running-stock or bin materials, are automatically replenished when stock levels reach predetermined quantities which trigger reorders. The triggering quantities and the amounts reordered are based upon past supply/demand records. S materials do not require material planning during design and production engineering. Examples are nuts, bolts, pipe flanges, etc.

Allocated stock materials (AS), are stock materials which are defined as a consequence of material planning during design engineering. The concepts for A and S materials are combined so that as specific needs are defined, AS materials are ordered periodically with both quantity and delivery-time margins determined by experience. This approach maintains a sufficient stock for known and contingent requirements pending reorders in response to further material definition. Stock for each AS item is controlled by periodically monitoring available supply, new requisitions, pending deliveries and pending issues for all building projects underway. The quantity margin is carefully adjusted during each periodic review so that no surplus remains after the last requirement is fulfilled. Examples of AS materials are large valves, expansion joints, etc., which are mostly standard materials and relatively expensive compared to S materials. [6]

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[6] The concept for AS material is also referred to as the “Fixed Time Review System” or “Net Requirements” as described in Chapter 4 - Inventory and Management Control, H.B. Maynard’s Industrial Engineering Handbook.

2.3.3 Material Standardization

Obviously, standardization of design, procurement and production are effective means to reduce costs, improve quality, shorten lead times for purchasing and enhance producibility. Standardization is a prerequisite for effective product-oriented material management. Also, the use of vendors' catalog items as shipyard standards, with preapproved functional performances and costs, saves critical design time, expedites purchasing and permits efficient use of stock material.

Standards require the selection of good quality materials to insure that they are acceptable to owners. Vendor catalog items that are declared to be shipyard standards must be constantly compared to new products. The use of available products as standards should be a basic policy. In-house design and production of products is almost always significantly more expensive.

There should be two or three vendor's catalog items in a shipyard's standards file for each functional requirement. This insures competition for obtaining the beat prices and delivery commitments. Note should be made that the two or three vendors' products declared as standards for the same requirement, must be functionally equivalent and do not have to be, nor can they be expected to be, physically identical.

Sometimes, there is only one vendor's product that can qualify as a shipyard standard for a specific function. For such cases, buyers should employ long-term contract agreements, perhaps even including escalation clauses, as means to avoid unfavorable terms when procurement is imminent.

2.3.4 Determination of "Make" or "Buy"

The trend in modern, constantly self-developing shipbuilding systems is to only collect and assemble components which meet functional and quality requirements. In other words, the trend is to provide more value added in planning, including design, as means to enhance productivity by speeding up assembly work. Thus with few exceptions, e.g., parts for hull structure and pipe pieces required in vast quantities, subcontracting for the manufacturing of components from outside Bources is almost always far more productive than manufacturing them in-house. Instead of spending significant capital resources to manufacture numerous components in-house, investing more in design, production engineering and procurement functions to efficiently purchase such components, is better business sense.

2.3.5 Role of Designers in Material Planning

A major objective is to develop a design featuring parts and subassemblies which facilitate assembly in accordance with a product-oriented build strategy devised by production engineers. Thus, any proposal for minimizing costs after the design effort is likely to be very limited.

The role of designers in material procurement is especially significant as material costs, for the most part, are directly related to the material specifications they prepare. In preparing such specifications, designers analyze owners' requirements and establish needed functional performances, quality levels and quantities. Accordingly, designers must maintain awareness of their affect on material costs when they participate in material planning. Starting in basic design, i.e., as part of pre-contract negotiation of technical matters before contract award, value engineering should be routine in all design phases.

The tendency of some ship designers to pursue highly technical or sophisticated features only because they are a matter of personal interest has to be resisted. They must be focused on developing a design which is producible as well as compatible with state-of-the-art modern technology.

2.4 Value Engineering

2.4.1 Value Engineering in Design

Value engineering (VE), synonymous with value analysis or value improvement, was first applied mainly in purchasing to evaluate the qualitative value of existing products. Later, VE was expanded to design and elsewhere for evaluating new products.

By examining a ship as a whole during basic design, it is possible to employ VE for devising the most cost effective, production-oriented methods without sacrificing any owner specified functional requirements. Extending the same VE approach to functional and work-instruction design stages, makes possible considerable savings in both material and production costs.

Design is the only function in a shipyard organization that can evaluate the value of a product from both technological and economical aspects. Thus, design plays the most important part in reducing a ship's cost.

2.4.2 Value Engineering in Material Procurement

Almost always, material costs account for the major portion of a ship's cost. Therefore, particularly for shipyards which have perfected zone-oriented, integrated hull construction, outfitting and painting harmonized by statistical control methods, the greatest cost reduction opportunities which remain are associated with material management.

Simply demanding price cuts from vendors without some sort of compensation, is illogical. Instead, buyers should apply VE measures which would detect vendor proposals that are priced attractively, but which could be reduced further in cost by eliminating vendor work for features or levels of quality which exceed a POS.

Another way for buyers to achieve the same objective is to-encourage vendors to propose their normally produced products insofar as they satisfy POS requirements. This gives vendors the opportunity to quote their most competitive prices.

2.4.3 Value Engineering in Other Areas

VE can be effectively applied in areas, other than design and material procurement, such as material distribution and production. For example, an analysis to determine whether to assemble a certain group of fittings on-unit, on-block or on-board, would have to take into account costs for transportation of completed assemblies versus transporting separate fittings. The former, usually more productive, may require temporary reinforcement while the latter does not.

Figure 2-2 shows typically, that initial or basic designers have most affect on a ship's cost, about 60%, while at the same time the cost of their efforts accounts for no more than 3% of incurred direct costs. The same figure shows that all design phases combined with material procurement activity affects 85% of a ship's cost while such efforts account for approximately 10% of incurred direct costs. Obviously, the efforts of design engineers are the most significant and decisive.

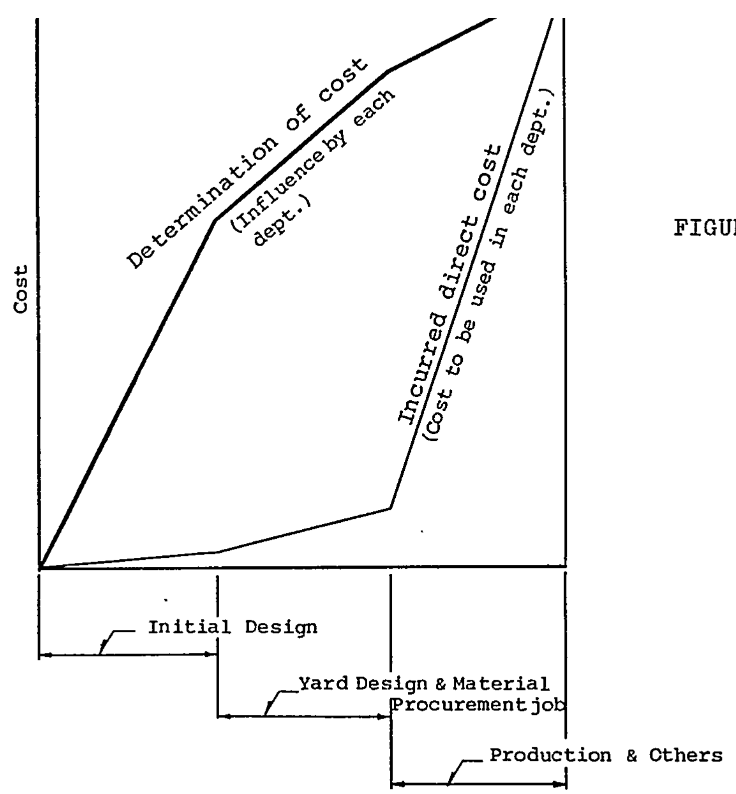


FIGURE 2-2: Responsibility for Determination of Cost vs. Incurred Cost.

2.5 Profit Control in Procurement

The objective of material procurement to acquire material in time and within an assigned budget is generally understood. Most buyers believe they have fulfilled their responsibilities when that objective has been achieved. However, from a modern manager's viewpoint each procurement activity is a cost center and an assigned budget is a yardstick to determine the amount of profit generated by each such activity. Profits so identified are controlled by management.

Another way to lower procurement costs is for management to assign target prices. However, this approach creates emotional problems between management and buying staffs when the targets are too severe and also among the buying staffs who try to outdo each other. Letting the buying staffs set their own price targets and relying more on VE is preferable as it provides more incentive. A suggested material budget/profit control sheet is shown in Figure 2-3.

Such budgets are established in order to attain two objectives, control of material quantities and control of material costs. The former is applied in design and production for the purpose of regulating actual expenditures as compared to preplanned quantities or weights. The latter is applied in material procurement for regulating actual prices as compared to budgeted prices.

The format used to control budgeted material amounts during basic design is called the Basic Material List (BML) from which a Material Budget Control List, complete with pricing, is developed. A typical such list is shown in Figure 2-4.

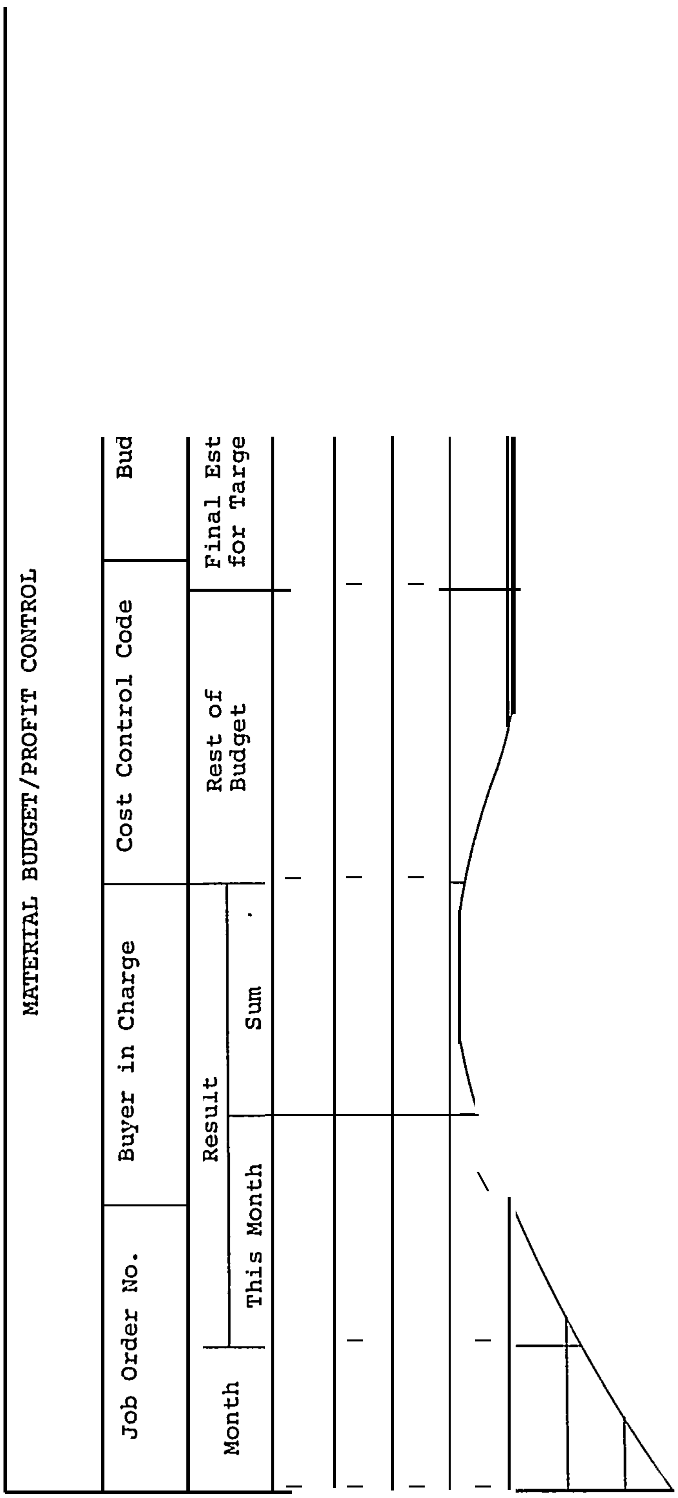


FIGURE 2-3: Material Budget/Profit Control Sheet per Buyer.

MATERIAL BUDGET CONTROL LIST P. (12/30)

Name			Particulars	Q'ty	Net Weight	Gross Weight	@	Price	Remarks
Accommodation	STD Material	2801 Steel							
		2807 Galv.Steel Plate							
		" Steel Wire							
		2808 Insulator							
		" "							
		2809 Miscellaneous							
		" "							
		Sum							
		2821 Window							
		" "							
		" "							
		" "							
		" "							
		2822 Side Scuttle							
		" "							
		" Outer Cover							
		Clear View Screen							

FIGURE 2-4: Example of a Material Budget Control List.

3.0 SUBCONTRACTING FOR MANUFACTURE OF FITTINGS

3.1 Separating Manufacture of Fittings from Shipyard Process Lanes

Most items required for outfitting are made of steel. Traditional shipyards, because they have resources for producing steel hull parts and assemblies continue to manufacture many fittings even though they are not best suited to do so. Other than pipe pieces, fittings are required in a wide variety with insufficient quantities of most types to effectively employ GT. Another exception applies to very large outfit-intensive ships, such as aircraft carriers, which have sufficient requirements for effective family manufacturing of ventilation-duct pieces, pipe supports, etc.

A manufacturing system for a wide mix of products required in varying but small quantities, is necessarily different from one which can exploit GT. Design, material management, production and production control approaches are different. Thus, attempting to manufacture most fittings on process lanes dedicated for hull-block construction and pipe piece family manufacturing, is illogical. The consequences are decreased productivity in all manufacturing processes.

The best way to avoid such losses is to separate the manufacture of the various fittins from a shipyard's main process flows production lines) for hull block construction and pipe-piece family manufacture by assigning such fitting manufacture to a separate production organization or subcontractor. As independent entities they can apply independent cost structures and control procedures. Also, they could solicit orders from other sources so that they, particularly subcontractors, could organize process flows per GT logic. As fittings for different customers would be mixed during their manufacture for the enhancement of productivity, space and other resources would be required to palletize fittings in accordance with each customer's instructions.

Even when such fittings are manufactured by an independent organization within a shipyard, they should be accepted by the warehouse people assigned to receivals just as if the fittings were arriving from outside. For expediting or handling purposes, fittings manufactured within the shipyard could be routed directly to an assembly shop as part of a designated pallet. However, their receipt by the warehouse and custody transfer to the assembly shop should be just as official as if they were fittings received from outside.

Because of peculiarities in the context of GT, there should be general recognition that the manufacture of fittings, except for pipe pieces, do not normally fit into a shipyard's production lines. In order to achieve zone oriented, integrated hull construction, outfitting and painting, harmonized and made constantly self-developing through statistical control methods, there can be no extraneous influences such as job-shop manufacture of certain fittings.

3.2 Use of Subcontractors

3.2.1 Definitions

Subcontract is sometimes used as a synonym for purchase order as both identify an arrangement between a shipbuilder and a supplier of materials or labor as that between a contractor (master) and subcontractor (subordinate) respectively. However, in shipbuilding there is general acceptance that subcontracting, as used in this publication, is different from purchasing as follows:

- Purchasing means buying mill products (steel plate, structural beams, pipe, etc.) or products that typical shipyards cannot conceivably produce (engines, pumps, valves, etc.). Subcontracting means buying labor services (man-hours) for manufacturing work (ladders, walkways, tanks, etc.) that a shipyard conceivably could produce but elects to defer to an outside source for economic or workload reasons.

- Purchasing also means buying a product for which design is controlled by its manufacturer. Subcontracting also means that a shipbuilder is fully responsible for engineering and for providing subcontractors with manufacturing drawings. Subcontractors are only responsible for manufacturing, workmanship and on-time deliveries.

3.2.2 Motives for Subcontracting

As each shipyard's circumstances are different, e.g., geographical locations and labor agreements, motives for subcontracting differ. The main motives for subcontracting are:

- Cost Reduction - Lower costs result when employing a subcontractor who has extraordinary expertise (galvanizing, plastic coating, assembling a boiler, etc.) or has low overhead due to a small business structure relative to that of a shipyard.

- Work Force Modulation - Some shipyards which cannot lay off employees such as due to long-term labor contracts, choose to maintain a minimum work force commensurate with lowest operating levels. When workloads increase, compensation is effected by subcontracting for labor accordingly.

- Management Policy - Another important motive for subcontracting, the most fundamental, results from top management policy for operating a shipyard. One management policy, still applied in some shipyards, is to manufacture all fittings in-house as means for increasing profit by increasing the shipyard's total output. The approach is based upon the theory that profit can be increased by increasing in-house capital expenditures rather than spending money on outside sources. However this policy is difficult to maintain where labor wages and productivity and versatility of crafts cannot be sufficiently controlled.

A different top management policy, preferred by the most effective shipbuilders and now dominating the industry, maximizes profits by minimizing operating resources. This preferred approach is characterized by more investment in functions before production, e.g. production engineering, design and material management including subcontracting, and by highly efficient in-house production which is predominantly assembly work.

Whatever the motive, the overriding objective of subcontracting should be to free shipyard management and labor to concentrate on constant development of zone oriented, integrated hull construction, outfitting and painting on process flows that are organized in accordance with GT. The in-house manufacture of extraneous fittings requiring a job-shop approach, is a significant impediment.

3.2.3 In-House vs. Subcontractor Manufacturing

As shipyards differ from each other in many characteristics, there are no common rules for determining make or buy, i.e., manufacture in-house or by a subcontractor. However, discounting materials that are normally available from suppliers, the following three classifications offer some guidance:

- Always manufacture in-house:
  - products of different designs required in varying quantities but none-the-less large enough total quantities for effective manufacture by the application of GT, e.g., structural parts, subassemblies and assemblies and pipe pieces,
  - products of such sizes and/or weights for which transportation from outside is not practical;

- Sometimes perform in-house and sometimes assign to a subcontractor:
  - work normally assigned to a subcontractor who is already loaded to capacity and assignment to an alternate subcontractor is not practical,
  - manufacture of products required in quantities which exceed the shipyard's capacity,
  - manufacture of products normally assigned to a subcontractor whose reliability becomes uncertain,
  - work of such nature that sharing of inherent risks is prudent;

Ž always assign to a subcontractor:

- specialized work for which the shipyard does not have facilities or technology (even when such subcontractors cause quality or delivery problems, subcontracting to them but with increased shipbuilder surveillance is advisable),
- some work on a regular basis when there is to be continued dependence on subcontractors to absorb fluctuating portions of the shipyard's workload.

4.0 BASIC POLICY FOR TRANSACTIONS WITH SUPPLIERS

Generally, buyers' markets almost always exist. Obviously, amiable relationships cannot be maintained if buyers employ such advantage to force acceptance of price cuts or other stringent contractural penalties without compensating sellers. A proper transaction always involves bargaining with each side trying to get a good deal. Although responsible to obtain the cheapest price, a buyer should also address how a vendor can compensate. A shipyard's purchasing agent must consider give and take as a basic Policy in order to maintain good long-term relationships with suppliers.

Effective material management requires:

- Providing vendors with sufficient lead time to make their design, material and production preparations. In case required delivery times or quantities are not yet finalized and a shipyard places an order based on an estimated total quantity and estimated amounts needed by certain dates, as for AS materials and in effect a mill reservation, the buyer should ensure that the supplier clearly understands beforehand that the initial order is to allow the supplier to make timely preparations. And, as the ship's detail design is developed, the shipyard will issue purchase order amendments which will exactly define quantities and delivery dates. Further, the shipyard should insure that the initial purchase order contains estimates that permit subsequent revisions which almost always grant a little more time for the supplier to perform. Also, the shipyard should apply high priority effort to finalize such initial purchase orders before deadlines required by vendors.

- Selection of standard products or designs in lieu of custom produced products to avoid disturbances to suppliers' process flows, to minimize lead times, and to enhance reliability of vendor performances.

° Employing long-term agreements for future business. Both parties benefit from an agreement to purchase certain quantities at fixed prices during a specified period. Such agreements enable:

-shipyard pre-approval of vendors' catalog products,

-vendor pre-assessment of a shipyard's non-technical terms and conditions,

-pre-approval of vendor drawings,

-routine exchanges of information (e.g., concerning design changes, product performances and production lead times) which help shipyard design and production people to update their files,

-expeditious issuing of requests for proposals which are brief, often one sheet, and models of clarity,

-expeditious issuing of purchase orders which are also brief, often one sheet, and models of clarity,

°committing to large volume orders, Such as for AS materials, instead of buying piece by piece.

4.1 Lead Time for Vendors

Generally traditional shipbuilders tend to squeeze vendors' production periods to compensate for delays caused by in-house production engineering, design and purchasing processes. Although forcing a vendor to make up lost time is sometimes possible, usually the consequence is confusion in a vendor's production schedule, increased vendor production costs and even degradation in product quality. Of course when such problems are encountered, those shipbuilders who have very limited outlook focus only on the the vendor's obligation to meet a contractural delivery date and quality specified without remembering that the vendor was coerced into cutting production time. Eventually, this kind of one-sided sacrifice causes vendors to insist on protection from such situations as a condition for acceptance of future purchase orders. Buyers then encounter tougher negotiation problems.

In order to avoid such conflicts, purchasing agents must constantly maintain awareness of the normal lead time required for and the time needed to conclude a transaction for each product. Such information should be the basis for precise schedules for shipyard preparation of purchase order specifications and drawings and production required dates so that the lead times needed for normal operations of vendors' production facilities can be preserved. In order to achieve smooth interaction of all prerequisite processes, a standard system is advisable for producing technical information required for procurement. *In* other words, establishing circumstances which stimulates the consciousness of designers for timely preparation of purchase order specifications and drawings, while simultaneously providing the best known and most accurate information, is very important for maintaining needed material quality.

4.2 Adoption of Vendors' Design Standards and Standard Products

With some exceptions, fittings for ships are also manufactured for larger non-marine markets. Thus, many products which are regularly available in non-marine markets that are modified for marine use, are less costly and more quickly obtainable than products that are developed for marine use only.

Of course, marine usage means reliability during continuous and long-term operation in a cruel and harsh environment which entails rough wave motions, saline and moist atmospheres, strong winds and other undesireable conditions. The special specification requirements for withstanding such environmental conditions have to be carefully written.

Usually, shipbuilders know much more about marine environments and their affects than fitting manufacturers. Therefore, shipyard engineers should help manufacturers to modify their standard designs in order to meet marine requirements. The resulting product would be less costly and more quickly available than a product of new design which does not lend itself to a manufacturer's normal practices.

4.3 Determining Quantity and Quality

Obviously, costs are minimized when available stocks of materials are minimized but are yet sufficient to assure smooth production process flows that are not interrupted by material shortages. A general definition of "adequate" is somewhat difficult because quantity margins are often needed as a consequence of a number of different influences. Such margins may be intended to simultaneously compensate for design changes, damage, losses, etc. Thus, margins should be determined by statistical analysis of pertinent experiences in order to avoid over purchasing.

Some shipyard people having only parochial concerns, tend to order total quantities for delivery at one time regardless of how material issues to production are scheduled. The consequences are requirements for more storage space and the usual increased costs that are associated with large inventories that could be prevented by prudent scheduling for near just-in-time procurement combined with the use of margins as for AS materials.

Quality also greatly influences material costs. Product quality is, predominantly, determined during design. Sometimes, quality so specified exceeds that which a client agreed to and the result is a material budget deficit. On the other hand, quality less than a client’s requirement, perhaps due to a vague POS, also causes cost increases particularly if not discovered before a vendor's product arrives at a shipyard. Using statistical methods to identify specific quality levels required and requiring each vendor to submit statistical evidence of quality as part of a bid for a purchase order, are extremely effective means for achieving the exact quality desired.

Senselessness in any aspect of material planning, particularly during design, usually imposes a heavy toll on purchasing costs. Needless to say, for each material item the responsibility of designers is to value engineer and determine quantity and quality which insure attainment of functional requirements and which conform with a client's specifically stated needs.

The responsibility of material controllers is to assign material classifications and to determine needed quantity nargins per As material types based on past experiences. The responsibility of buyers is to order materials at the right time to assure phased receivals per production schedules.

The common objective of everyone involved in material management regarding quantity and quality, is to minimize costs associated with implementation of material management systems, storage, financing, excess quality, design misjudgements or errors, etc.

4.4 Speculation Buys

Prices for certain materials are quite unstable depending upon market demand and pose the question of speculation buying if rises in market prices are predicted. Such tactics are useful for raw materials or products that are common for building ships of whatever type and size. Quantities of S materials, for example, could then be consumed in relatively short periods. However, raw materials or products which are usually ordered and allocated per specific ship contracts, if not versatile enough, may end up as dead stock. Therefore, speculation buying of materials should be avoided unless there are great assurances for their use in future projects.

5.0 MAJOR FUNCTIONS OF MATERIAL MANAGEMENT

As defined at the outset, material management is different from material procurement because it includes material planning, control, storage and distribution functions in addition to procurement. Material planning, procurement and distribution are the major functions with supporting functions as shown previously in Figure 2-1.

5.1 Material Planning

Material planning is a requisition function which includes definition by designers and the activation and control of procurement activities for purchasing and receiving.

5.1.1 Duties of Designers

Material planning drastically affects a ship's performance and production costs as well as productivity of the shipbuilding process. Basic designers satisfy functional and quality requirements for each ship and provide a material plan (specifications, quantities and other necessary technical information) which conform with a production strategy and material budget (quantity wise and cost wise). Designers provide the necessary wherewithal for procurement sufficiently in advance to permit orderly implementation of procurement procedures and sufficient lead times for vendors to produce and deliver materials per shipyard production schedules.

As the design phases following basic design are implemented, designers provide more specific requirements for procurement and production in various material lists developed with the support of production control and material control people. Basic information generated by designers for such lists includes:

- hull number, i.e., the ship for which material will be used,
- ship system for which material will be used, i.e. codes needed for estimating and cost control by system,
- where and when material will be required for work, i.e., the pallet code designating which work package the material belongs to (as the pallet code identifies zone/area/stage it satisfies the need for cost control by process flow and if necessary by work stage within a process flow),
- material name, quality, type, class or standard, size, etc., i.e., description expressed as a symbolized material code,
- material piece code (number) to identify its location on a drawing and/or on a material list for a work package (pallet),
- required quantity,
- classification of material so as to indicate purchase for a specific ship (A) or stock material (AS and S).

The fitting material lists for which designers are responsible are linked to stages of design development as shown in Figure 5-1 and consist of:

o MLS - List of material per ship's system. Such lists show the first definition of all *material* by designers and are compared by management to the Basic Material List (BML) in order to determine material savings (profits) that should be credited to functional designers. Also, material lists by system are used in conjunction with material ordering zones in order to quickly obtain material delivery dates in accordance with a hypothetical production schedule.

0 MLF - Material list of fittings required for a pallet, i.e., work package classified by zone/area/stage. MLF are prepared by the people who perform work instruction design and are compared by management to the BML, as revised after the functional design phase, in order to determine material savings (profits) that should be credited to work instruction designers. As the collection of ❑ material on an MLF represents a fixed amount of assembly work classified by zone/area/stage, the abbreviation "MLF" the word "pallet" and the term "work package" are used interchangeably for outfitting work.

o MLP - Material list required to fabricate a pipe piece. Preparation of MLP is regarded as a later phase of work instruction design. A completed pipe piece appears as a distinct fitting on an MLF. Thus, the MLF and MLP are said to be structured material lists that reflect how work is organized.

o MLC - Material list required to fabricate a component other than a pipe piece, i.e., ladder, pipe support, vent-duct section, etc. *In all* other respects, MLC are the same as MLP. Through work, the various materials on MLP and MLC become pipe pieces and components other than pipe pieces, i.e., interim products. which are needed for pallets (MLF) for outfitting on-unit, on-block or on-board.

While material lists so organized identify purposes and allocations of materials, they do not identify required material specifications or other technical information, unless standard materials are used which can be identified by a simple code or name useful for retrieving information from a data bank. Non-standard materials require purchase order specifications (POS) and items to be produced by a subcontractor require fabrication drawings. A drawing/POS list and issuance schedule are necessary to control such preparations.

Design & Mat.	Prepa-ration	Kind of Material		
Stage	List	Completed component	Component to be fabricated	Pipe Piece
Early functional design	MLS (for system)	Machinery & fittings	parts Raw mat.	Parts Raw mat.
Later functional design	(for system)	Machinery & fittings	Fittings	
Working instruction & detail design	MLF (for working zone)	Machinery & fittings	Fittings	Pipe Piece
	MLC & MLP (for fabricating)	-	(Mat. list for fabrication : MLC)	(Mat. list for fabrication : MLP)

FIGURE 5-1: Developing and Updating Material Lists.

In order to rationalize and simplify material planning, three major points may be derived from the foregoing and are key elements for effective material planning and rapid start up of procurement activities:

- o Promote Materials Standardization - Register raw materials, hull parts, fittings, machinery, etc. available in the marketplace as shipyard standards so that each can be identified for procurement by a code.

- o Promote Standardization of Fabrication Drawings - Standardize fabrication (manufacturing) drawings for materials which are not available in the marketplace, which can be used in many type and size ships and which are normally assigned to a subcontractor for manufacture. Standardization enables each such item to be identified for procurement by a code.

- o Maximize the Number of and Fully Exploit Purchase Order Specifications (POS) for Items that Must be Custom Manufactured - Early development of POS for non-standard materials before award of a shipbuilding contract, is very effective. When proposed POS are used to clarify uncertainties about non-standard materials during negotiations with a ship owner before contract award, procurement for such custom materials enjoys rapid start up. The most effective shipbuilders who do so, are able to issue immediately after award of a shipbuilding contract, 50-60% of needed POS accounting for 60-70% of the non-standard material costs.

5.1.2 Budget Control

Obviously, a ship cannot be completed if material planning by designers results in material shortages. If, as a safeguard from shortages, too much of a margin is applied the losses associated with surplus material could also be disastrous. Similarly, if designers are permitted to specify material quality which exceeds requirements of the shipbuilding contract specifications, losses will occur.

To avoid such overruns or budgetary deficits, designers should be assigned material cost budgets to guide their material planning activities within budget limits. Figure 2-4 is a sample Budget Control List which is, in fact, a Basic Material List developed earlier by basic designers for pricing by estimators as bases for predicting a ship’s contract price. The Budget Control List is used, not only as basic data for design but also, as the budget to be exercised for ship production.

5.2 Procurement

Procurement functions can be identified as:

- o purchasing,
- o subcontracting,
- o in-house fabricating,
- o inventory control,
- o material schedule control,
- o profit control, and
- o value engineering.

All but one are generally known or discussed elsewhere in this publication. Material schedule control justifies more description.

5.2.1 Schedule Control for Material Procurement

The major scheduling problem in material procurement is associated with finished products per manufacturers' designs that are not stocked by suppliers, i.e., pumps, large valves, switchboards, etc. In contrast, in-house manufacturing can be strictly self-controlled and production by subcontractors, usually short-term work, is relatively easy for a shipyard to manage.

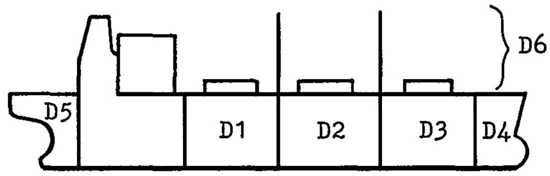
In purchasing, key factors for schedule control are the lead times needed by vendors and the delivery dates required for the shipyard's production effort. Definite material delivery dates are determined from the shipyard's production schedules. However, they are first expressed as preliminary dates, roughly determined from a master schedule and, as more detailed monthly and weekly schedules evolve, the dates by which materials are definitely required are finalized. Therefore, for long lead-time materials which must be ordered soon after award of a shipbuilding contract, delivery dates are preliminarily determined from a hypothetical production schedule.

Ship No. 1234

Keel Laying: 3/ 2/81

Launching: 6/26/81

Delivery: 10/27/81



Zone	Delivery	Requirements	Remarks
D1	12/11/80	For on-block outfitting	
D2	12/11/80	" " "	
D3	12/11/80	" " "	
D4	3/10/81	For on-unit & on-block outfitting	
D5	1/14/81	" " " " "	
D6	2/ 6/81	" " " " "	

FIGURE 5-2: Material Procurement Schedule per Material Ordering Zone.

The assumed schedule is prepared by first dividing a contract design into large zones by specialties, i.e., deck, accomodation, machinery, and electrical. For warship construction, additional specialties would apply as appropriate, e.g., weapons, electronics and nuclear. In the most *effective* shipyards. the specialties exactly match the way both design and production people are organized, i.e., not by traditional systems *or* crafts but, instead, by multidisciplined zone-oriented groups each of which is very expert in addressing both ship operating and shipbuilding problems inherent in one specialty. This grouping of people to match problem categories, is an aspect of GT. [1]

Abilities to achieve a common strategy for material planning and production is greatly enhanced. Within each specialty designers make big subdivisions, 3 to 7 depending on specialty and ship size, each of which is sequenced to reflect the planned build strategy. See Figure 5-2. By roughly arranging system diagrammatics, designers associate material required with particular subdivisions which are called "material ordering zones". All materials for the various systems that pass through a material ordering zone are preliminarily scheduled for delivery by using the date for each zone's earliest required material item.

Dates for starting purchasing activity are then determined by applying *required* lead times in advance of scheduled material ordering zones, i.e., the hypothetical production schedule. The usage of material ordering zones significantly contributes to timely placement of orders and receipt of long-lead time materials and, equally important, converts the material planning strategy soon after contract award to the same zone-oriented strategy that is to be employed in work-instruction design and in production for outfitting on-unit, on-block and on-board.

As both the build strategy and design are refined through continued interaction of production engineers and designers organized by the same specialty, a more elaborate production plan and schedule are produced. More definitive material requirements evolve in smaller increments which exactly match requirements for work packages per zone/area/stage, i.e., pallets.

[1] Recognizing the futility of attempting product (zone) orientation with traditional craft (system) organizations in both design and production, the most effective Japanese shipbuilders changed their organizations in the early 1960s. At that time, they had to overcome the objections of traditionalists. Shipbuilders elsewhere who are, in the 1980s, adopting product-oriented shipbuilding methods and organizations because significant productivity improvement is essential for survival, are encountering the same objections from traditionalists.

As the delivery date assigned when ordering each long-lead time item was the date for the earliest-required material item within its material ordering zone, and since actual deliveries are to be made in smaller lots, the impact of schedule refinement almost always allows more time. Further, as estimated quantities are sometimes specified in original purchase orders, the impact of design refinement may require adjustments in quantities required.

Final material delivery dates are assigned’ as the shipyard's production schedule is refined. Eventually, detail schedules for material manufacturing, inspection, shipping, etc., are fixed to suit the vendor's and shipyard's schedules.

Each buyer should insure before releasing a purchase order based on estimated quantities and/or a hypothetical production schedule, as described in the foregoing, that the vendor fully understands how the shipyard's material management system permits quick material ordering with intention to later issue purchase order amendments for refining both quantities required and delivery dates.

The only thing new about the approach described in the foregoing, is its application for procurement of fittings. Traditionally, shipbuilders everywhere use the same concept to place mill orders for approximate tonnages of structural steel to be delivered at approximate rates. As a hull design develops, refined instructions are issued.

5.3 Distribution

The distribution function includes:

- o receipt of all materials regardless of whether they were purchased, manufactured by subcontractors or fabricated in-house,
- o palletizing, and
- o delivery of palleted materials to specific production sites at scheduled times.

In the shipyards that are most advanced in zone orientation, outfit materials are grouped per zone/area/stage regardless of their types and the systems they represent. Ideally, each such grouping is planned as a work package which requires two workers for one workweek. The material so grouped is an MLF, i.e., a materal list of fittings per zone/area/stage or, in other words, a pallet. Thus, MLF is the axis around which all distribution functions revolve. The distribution functions are:

- o receipt and storage of materials,
- o field inspection,
- o Palletizing/issuing, and
- o transportation.

Materials manufactured in-house such as parts, subassemblies and assemblies for hull structure which are produced on subordinate process flows just-in-time to immediately support larger process flows, are excluded from the distribution function because the supervisor responsible for a flow lane is also assigned responsibility to transfer flow-lane end products to the input of the next process flow. Large quantities of pipe pieces which are produced in-house, are also excluded because they are just as efficiently controlled and palletized as part of pipe-shop operations." [2]

5.3.1 Receipt and Storage

Receipt and storage of materials, recording inventories, exercising issue control, etc., are the major duties of a warehouse organization. However, materials required for ships vary in size and weight tremendously, e.g., from huge diesel engines weighing several hundred tons and shafts that exceed ten meters in length to tiny nuts and bolts. Consequently, different receipt and storage systems are required depending upon material features in order to minimize need for warehouse resources.

[2] “Coating and palletizing are manufacturing stages just as much as welding and bending ....In the interest of overall shipbuilding productivity, pipe shop output is groups of coated pipe pieces, regardless of size and systems, which are required to support outfit assembly work packages organized by zone/problem area/stage.” Pipe Piece Family Manufacturing - March 1982, NSRP, pp. 29-30.

The major expense in warehousing is storage costs. When suppliers deliver materials to production sites at the exact times needed, such as in response to the near perfectly implemented just-in-time buying system used by Toyota Motors in Japan, warehouse costs become almost nil. However, applying the same system to the same degree is not possible with less precisely controlled ship production schedules. However, the philosophy has caught on in shipbuilding and more just-in-time deliveries are being effected.

Judicious use of AS material classifications significatly reduces both quantities of materials to be stowed and the durations in storage. And, huge items, such as main engines, boilers and ships service generators, are already being regularly delivered by suppliers at their required installation sites within reach of cranes for landing on board immediately. Shipyard storage, transportation, interest, etc. costs, cumulatively substantial expenses, are eliminated or significantly reduced.

5.3.2 Instructions, Expediting, etc. for On-Site Deliveries

Normally, material delivery schedules are controlled by people responsible for purchasing. However, as scheduled times approach for deliveries of materials directly to designated work sites, transfer of delivery and receival control to a material expediter on site is far more effective for both the shipyard and supplier. Field expeditors then insure availability of space, cranes, etc. and give instructions regarding final delivery locations, dates and times directly to the suppliers. Usually, the expediters who are responsible for ensuring delivery of pallets to the same production sites, are assigned responsiblities for such final coordination with suppliers.

Transfer of material delivery schedule control as described in the foregoing, enhances delivery services to production. In case of a delay just before scheduled delivery of something, people on site immediately involved in receival and production preparations, are among the first informed and can take immediate countermeasures to minimize disturbance to production flow.

5.3.3 Palletizing, Issuing and Transporting

The objective of material management is to deliver required materials to production sites by work packages in accordance with a pre-established production strategy and schedule. Material management for hull construction is rather straight forward because relatively few material types and work processes are involved. In contrast, outfit work packages are associated with many different kinds of material and processes so that they require especially experienced people for determining work package sizes.

For ideal control of production, work packages classified by zone/area/stage are each sized to define an amount of work that can be performed by a small group of workers in a relatively short period. Such work packages are called "pallets".

The word "pallet" is not used literally as it means all materials required for a work package regardless of the numbers of literal pallets, containers and/or separate shipments required.

As a work instruction drawing for a particular zone/area/stage implies a fixed amount of work, and since materials listed on an associated MLF imply the *same amount* of work, the word "pallet" has the same significance for design, material procurement and production. Thus, "pallet"l is the informational link from start of design activities to completion of production activities.

Through design and production engineering interaction, pallets are roughly envisioned at the start of contract design and are finally definitized during a pallet meeting attended primarily by design and production people. The pallets so conceived and sequenced per production required dates, then constitute a pall&t list. In other words a pallet list is a strategic plan which coordinates diverse tactical operations in design, material procurement and production. [3]

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[3] G. Grimsley, the outfit plenning supervisor in Avondale Shipyards, Inc. described a pallet list as a sequence of boxes, each representing a zone/area/stage. Anytime managers wented to, they could lift the lid of a specific box in order to see how design was progressing. Later they could lift the lid of the same box to see how material marshalling was coming along. Afterwards they could again lift the lid of same box and monitor the production effort. Because of this great visibility, shipbuilders are able to accurately predict the affects of change orders.

For building a typical merchant ship, the pallet meeting is held about three months before the first pallet is needed for production. Intentionally, production is well underway while significant pallet preparations by design and material people have yet to be completed. Thus, an important production control function is to monitor all activities and to make the usually required scheduling adjustments to insure that pallet preparations always match production progress. Such coordination is vital even for the foremost shipbuilders in the world who advise, "In Japan we have to control material because we cannot control peoplel" [4]

Thus, the most effective shipbuilders regard material control, specifically including material procurement, as an essential production control function. For this reason, shipyards in which material procurement is separated from production control, cannot achieve the full potential of zone oriented, integrated structural, outfitting and painting work. [5]

Although pipe pieces are listed on each MLF, as noted earlier their palletization in a pipe shop is advisable. Thus, portions of a pallet could be dispatched to a shipyard work site from different sources, e.g., pipe pieces from the pipe shop, a large machine directly from a vendor, and other materials from a shipyard warehouse.

Among outfitting materials, there are a number of large and/or heavy items each of which counts as a work package by itself or may be divided into several work packages. For example, assembling, aligning, connecting, starting and testing a main propulsion diesel. Such exceptions do not require an MLF and are controlled independently for just-in-time deliveries directly to production sites.

The composition of pallets and their relationships to other material lists are shown in Figure 5-3.

5.4 Field Expeditor Assignments

In each IHI shipyard the field expeditors described in Part 5.3.2, formerly assigned to the discontinued Warehouse Section, are now assigned to the material control organization which reports to the Production Control Department. Thus, material receiving, storing and delivery to production sites as well as actual control, i.e., scheduling, of field work is more integrated than ever before. Responsibilities are typically divided as follows:

Ž Material Delivery Control Group

issue requisitions

control delivery dates

receival and inspection of material purchased from vendors

• Material Handling Group

receival and inspection of fittings manufactured by subcontractors and storage of all materials less hull structural steel which is controlled directly by the Hull Construction Department

- palletizing

Ž Stock and Owner-Furnished Material Control Group

control of S material

-receival/issuance of owner- and government-furnished material

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[4] Y. Mikami, General Manager, IHI International, to L.D. Chirillo, June 1980.

[5] Starting in 1982 and with noteworthy progress, some naval shipyards are applying product-oriented work packages for both ship alteration and overhaul work. However, they are significantly constrained as they must procure most materials from naval supply organizations which are not part of naval shipyard organizations. Until that problem is overcome, they will not be able to implement material control as an aspect of production control and develop an effective material management system.

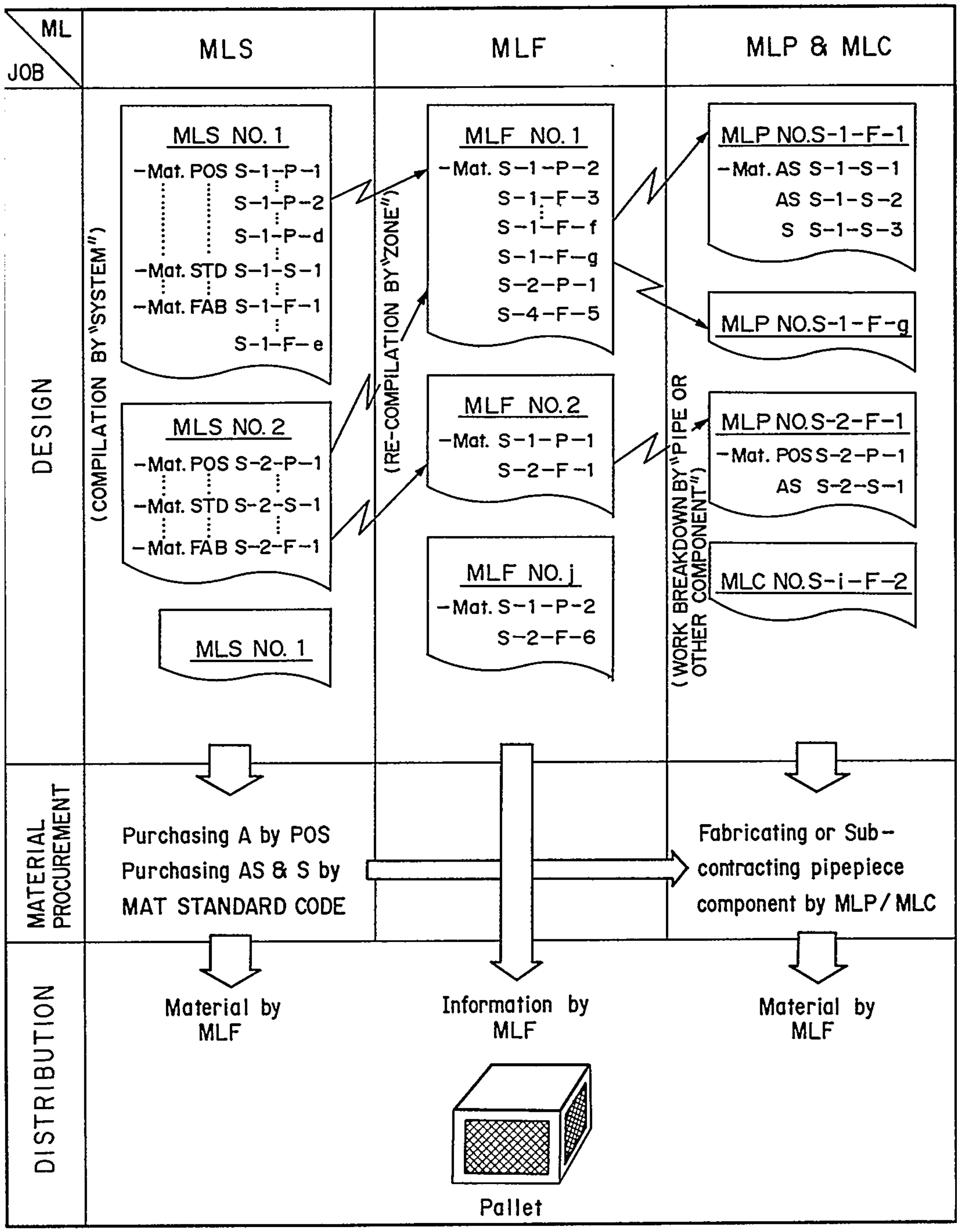


FIGURE 5-3: The Composition of Pallets.

6.0 MATERIAL CLASSIFICATION FROM, THE MATERIAL MANAGEMENT VIEWPOINT

In order to produce something, a manufacturer will:

- break down the envisioned end product into interim products and then devise the most rational process flows and schedules to suit, or will
- first devise a rational process flow and schedule, and afterwards break down the product to suit.

Similar thinking is applicable for control of materials. Materials are broken down into categories considering the best ways to control scheduling of material planning, purchasing and issuing.

'The purpose for organizing work by process flows each of which is subdivided into work stages, is to obtain sharply focused parameters for use in controlling work. Ideally, the same parameters would be usable for material control. Although not perfect for both purposes, a common concept contributes to rationalizing material control as well as improving productivity.

6.1 Breakdown for Comprehensive Production and Material Planning

Managers must first determine what materials should be purchased, fabricated in-house and assigned to subcontractors for fabrication. Simultaneously, they must consider how all such materials are to be assembled in order to create increasingly larger subassemblies and assemblies taking into account available resources, e.g., facilities, workforce size, and technical capabilities. Thus, make-or-buy determination is a basic breakdown for production, material and financial planning.

6.2 Material Breakdown for Designing

For design work which relates to material planning, a material breakdown which is also useful for obtaining key parameters for each design phase *is* necessary. Anticipating zone-oriented construction, the design effort is usually divided into basic, functional and, following a shift to information grouped by zone, work instruction design.

During basic design, preliminary material information is developed such as: basic categories, quality, quantities, weights, etc. of raw materials, machinery and equipment needed to fulfill a ship's specification requirements.

During functional design such information is refined as planning progresses for each functional system of the ship. Finally, after a transition to information grouped by zone, material is further defined and finalized during work instruction design, i.e., the process for preparing working plans in accordance with a product work breakdown which conforms with production control requirements.

The material breakdown used in design engineering, basically product oriented, is further categorized to suit planning for *purchasing,* namely, into materials which require and which do not require POS. Material which do not require POS are further classified into those which require or which do not require shipyard prepared manufacturing drawings and material lists. Based upon the material breakdown so achieved, supplementary categorizations are made to facilitate design-schedule control and material planning (e.g., standard or non-standard, long-lead time or short-lead time, etc.). Such categorizations are convenient for design administration and operation.

6.3 Breakdown for Purchasing Control

The primary duty of buyers is to purchase required materials for timely deliveries as dictated by production schedules. Of major concern are the total lead time required for each material item and classification by lead time. Basic such classifications are long-lead time and short-lead time.

Some other breakdowns which facilitate buying work address:

- the nature of purchasing (e.g., materials for which a simple purchase order is sufficient and materials from subcontractors who require shipyard engineering assistance and/or guidance),
- the type of material (raw material, machinery, etc.), and
- special categorizations of material based on percentages of total material costs and material planning required.

6.4 Material Breakdown for Production

At first, production people need to know for a particular project, which materials are to be manufactured in-house and which are to be manufactured by subcontractors so that they may establish their production strategy and schedules.

For fittings, a breakdown based upon production's need for precise delivery times is also important. For example, shipments of large items, such as a main engine or boiler, directly to installation sites must be precisely controlled. Similar precise delivery needs may also apply to materials which are first received at a warehouse for palletizing. For whatever reason, availability of work space, vulnerability to weather, etc., production must receive certain items at precise times. Thus, special transportation arrangements are necessary. Other pallets are delivered to production sites by regular transportation services several days before scheduled work starts.

In addition, in order to facilitate replacing material lost or damaged during production, materials are also categorized as:

- those which can or cannot be replenished from other pallets, and
- those which do or do not need spare quantities at work sites.

6.5 Consolidation of Material Classifications

As shown in Figure 6-l, each shipyard function could justify a peculiar material breakdown to facilitate control during material planning and processing. By analysis of the various preferences, key elements are identified which are the basis for a common breakdown for all functions. In other words, the key elements permit use of common classification such as A, S and AS which are defined in Part 2.3.2.

BREAKDOWN CRITERIA			Type of Products.	Specification for procurement	Standardization	Material definition timing (lead time)	Necessity of mfr's technical information	Procurement method	Precision of delivery time	Quality control	Unit price	Quantity required	Grade of common use	Necessity of allowance
CONSOLIDATED MATERIAL CLASSIFICATION FOR GENERAL PURPOSE	Non-inventory	A	Finished component	P.O.S	Non-standard standard of mrf.	To be early (long lead time)	Mfg.dwg. & tech.inf.		Exactly controlled grade	Inspection during mfg. Q.C report by mfr.	Very high High	A little	Non	No
	Inventory	AS	Raw material	Material list for Purchase	Standard of the yard	On progress of design (medium lead time)	Technical information No special request	Purchase	Medium grade (with a little permissible tolerance)		Not so cheap	Relatively much	Relatively common	Yes
		S	Parts				on order			Inspection at reception	Cheap Very cheap	Much Very much	Very common	Yes
	Non-inventory	A	Interim Products (outfittings, etc.)	Drawing	Non-standard	At later period of design	(on the yard's hands)	Subcontracting self-fabrication			Not so cheap High Very high	Relatively much A little	Non	No
Planning/work concerned with each criterion			YARD OPERATION PLANNING			DESIGN		MATERIAL PROCUREMENT		PRODUCTION				

FIGURE 6-1: Material Breakdown.

BREAKDOWN CRITERIA		Type of Products	Specification for procurement	Standardization	Material definition timing (lead time)	Necessity of mfr's technical information	Procurement method	Precision of delivery time	Quality control	Unit price	Quantity required	Grade of common use	Necessity of allowance
CONSOLIDATED MATERIAL CLASSIFICATION FOR GENERAL PURPOSE — Non-inventory	A	Finished component	P.O.S	Non-standard standard of mrf.	To be early (long lead time)	Mfg.dwg. & tech.inf.		Exactly controlled grade	Inspection during mfg. Q.C report by	Very high High	A little	Non	No
Inventory	AS	Raw material	Material list for Purchase	Standard of the yard	On progress of design (medium lead time)	Technical information No special request	Purchase	Medium grade (with a little permissible tolerance)	mfr.	Not so cheap	Relatively much	Relatively common	Yes
Inventory	S	Parts			At later period of design	on order			Inspection at reception	Cheap Very cheap	Much Very much	Very common	Yes
Non-inventory	A	Interim Products (outfittings, etc.)	Drawing	Non-standard		(on the yard's hands)	Subcontracting self-fabrication			Not so cheap High Very high	Relatively much A little	Non	No
Planning/work concerned with each criterion		YARD OPERATION PLANNING			DESIGN		MATERIAL PROCUREMENT		PRODUCTION				

FIGURE 6-1: Material Breakdown.

7.0 PROCUREMENT TECHNIQUES BY MATERIAL CLASSIFICATION

As noted previously, designers play the key role in achieving the objectives of product-oriented material management. Therefore, allowing ample time for each design section to concentrate on material planning while functioning as a material cost center, is advisable. Each buying section should also function as a material cost center. This means timely preparation of POS and other technical information by designers so that buyers will have enough time for their negotiating activities before the start of lead times needed by vendors.

There is no doubt. Ample time for market research and price negotiations enhances product-oriented material management. This is particularly so for materials which are very costly, technically quite sophisticated, required in large quantities, etc.

Most very costly materials are discussed during pre-contract negotiations with an owner and are defined in the contract specifications so that they can be ordered immediately after contract award. However, some require specifications and quantity determinations that are dependent upon post-contract design development. As such materials impose significant time problems for both design and purchasing, mutually acceptable solutions should be devised.

Depending upon the type of material, possible solutions include:

- ordering material with reservations concerning certain features which require further design development and resolving the reservations in accordance with schedules that are acceptable to vendors,
- changing the priority order for preparing POS which may require changes in a design section's material planning process and may require a request to change the build strategy, and
- allocating the maximum amount of available time for design with just barely enough time allocated for purchasing before the deadline calculated from required lead time.

Of course, establishing all material specifications and quantities during pre-contract negotiations with a customer is preferable. However, due to the complexity of ships and as most are custom ordered, specification of all materials before contract award is not a reasonable goal. However, shipbuilders can make significant inroads by having design and material standards available for an owner's consideration during pre-contract negotiations.

7.1 Purchasing and/or Subcontracting for Allocated Materials

All A materials are ordered per POS and/or manufacturing drawings including their material lists. As shown in Figure 7-1, a major portion of material costs for a typical ship is determined by relatively few POS. The figure also shows that A materials can be readily categorized—into three groups:

- Category 1 - A material group requiring few POS which accounts for a major portion of total material cost. Per Figure 7-1, 20-25% of the POS account for about 65% of total material cost.
- Category 2 - A material group which accounts for a considerable percentage of total material cost and for which many POS are required. Per Figure 7-1, about 20% of total material cost is determined by POS other than those for Category 1.
- Category 3 - A material group which mainly requires fabrication drawings. Although numerous drawings are required, this group accounts for only a small percentage of total material cost. Per Figure 7-1, the number of drawings required is more than 50% of the total number of POS and drawings combined while representing only a few percent of total cost.

7.1.1 Category 1 Material Group

The materials in Category 1 include:

- those having a high unit cost (main engine, boiler, pumps, etc.),
- those which are custom designed for a specific end use (shafting, castings, automation, etc.)
- those which are purchased in large quantities usually for more than one end use (steel plate and shapes, etc.), and
- those which are obtained from vendors and subcontractors who have special purchasing agreements.

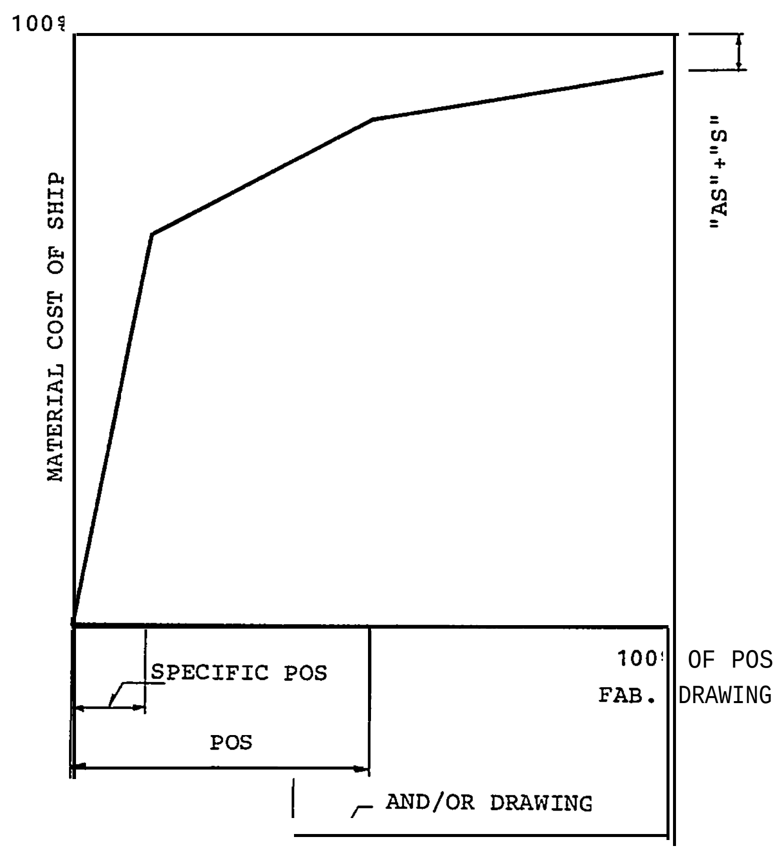


FIGURE 7-1: Procure Item vs. Material Cost Trend.

Category 1 materials usually require long-lead times. Thus, their specifications and delivery times should be determined during basic design. Design engineers should issue required POS immediately after a ship construction contract becomes effective and purchasing activities should start much earlier than the deadlines for allowing lead times needed by suppliers. The elements for estimating required lead times are illustrated in Figure 7-2.

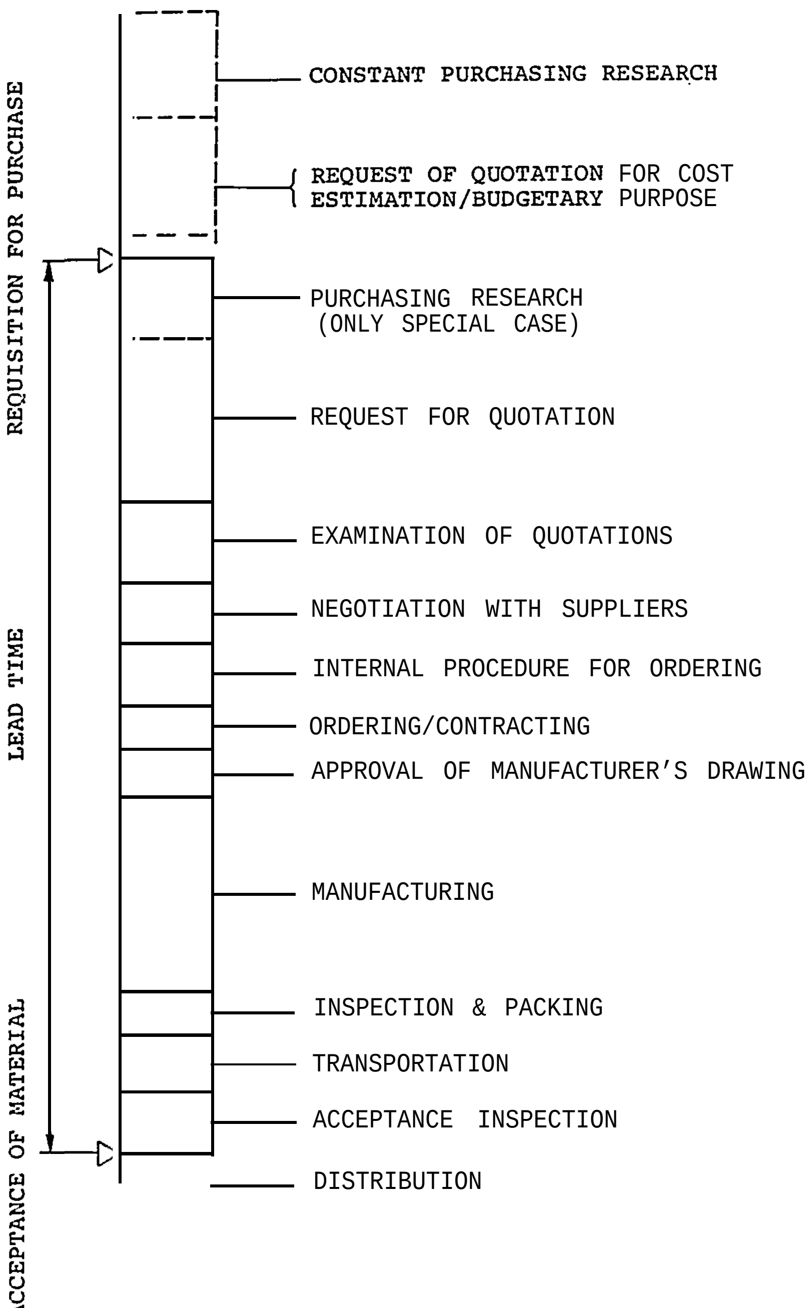


FIGURE 7-2: Elements of Lead Time.

7.1.2 Category 2 Material Group

Category 2 materials have less priority and require shorter lead times compared with Category 1 materials. However, issuing their POS as early as possible after contract award is desirable. Regardless of such early issues, the required POS should be listed in the drawing/POS list, published by basic design immediately after contract award. Then, purchasing people can start planning their procurement activities before POS are completed.

Generally, appreciable design definition must *occur* before grades, sizes and quantities of Category 2 materials can be determined. Also, some POS cannot be completed until basic concepts for manufacturing plans have been determined. As the lead times required for Category 2 materials are not so long, allocating sufficient time for engineering is not usually a problem.

7.I.3 Category 3 Material Group

Category 3 materials are mostly fittings, such as doors, ladders, etc., which subcontractors can efficiently produce per shipyard manufacturing drawings. POS are not usually required.

Traditional U.S. shipbuilders manufacture many such fittings in-house. From an economical viewpoint, having such fitting manufactured by specialized subcontractors is almost always much more effective.

For procedural purposes, Category 3 material ordering per manufacturing drawings should be regarded as similar to ordering per POS as for Category 2 materials. Thus, manufacturing drawings for Category 3 materials should be included in the drawing/POS list initially published by basic designers after contract award and revised and reissued at the start of detail design. The revised drawing/POS list and its schedule enable purchasing people to better plan, schedule and control procurement activities.

Most Category 3 materials can be standardized in order to facilitate procurement per standard manufacturing drawings. For each requirement the only supplementary information needed would address size, quantity and weight. The value of standard drawings for assuring schedule adherence by designers and buyers cannot be overstated. Of course, usage of non-standard Category 3 materials requires engineers to prepare specific manufacturing drawings. In either case, necessary information and drawings must be issued to meet. a procurement schedule based on required lead times.

Estimating costs and production planning for Category 3 materials can be readily and accurately performed from past records per *given* material names, sizes and weights.

7.2 Procuring Allocated Stock Materials

The average number of items categorized as allocated stock materials AS by shipyards is about 1,500. The number differs between shipyards due to geographical locations, available financing, designers' material planning capabilities, company policy regarding inventory control, etc. AS classification designates material that requires sophisticated control.

A materials, for example, are ordered for a specific use in a specific end product. From a material-control standpoint, they impose no particular problems. Even something as complicated as a main engine, which could involve several shipments for attachments such as a turbo charger, pumps, and control system, constitutes “one set” for receipt, issue and payment. Although individual control of such components is needed in production, no special material controls are required elsewhere.

In contrast, AS materials, by definition, involve repetitive procurements with margins in both quantities required and delivery times so as to maintain minimum stocks while making issues for various end USES in more than one end product. "One set” of data per item, as for A materials, is inadequate.

Even if certain AS materials, valves for example, were of the same type but dissimilar in size or of dissimilar types but destined for the same system, they could not be grouped as “one set” for the purpose of simplifying material control. Each kind of AS material is unique.

From another viewpoint, control of an A material item can be partially shifted to the supplier by including all attachments, such as a diesel turbocharger, in one POS. This cannot be done for AS materials, because they cannot be ordered and delivered with other related materials. Thus, AS must be directly controlled by a shipyard separately per item for receipt, inspection, storage, etc.

An AS material item is associated with commonality in usage, i.e., during palletization it could be assigned for installation in any one of several systems in any one of several end products. They are usually employed as interconnections between A materials. Thus, while AS materials only account for a small portion of total material cost, their end uses from a production viewpoint. and their large variety, makes AS materials most difficult to control from a material-management viewpoint.

In any complex industrial endeavor, particularly for building and overhaul of ships, to say that productivity is very dependent upon the skill with which As materials are managed, is not exaggerating. Therefore, AS material-management methods must be devised with great care in order to achieve the most effective and coordinated contributions from design, purchasing and production functionaries.

7.2.1 Material Planning for Allocated Stock

- Materials Categorized as Allocated Stock

As a first step, materials which are proposed for AS categorization should be acknowleged as such by all concerned, particularly people representing design, purchasing, warehousing and production. Each material name, size, grade, etc., must be identified, listed and distributed to all.

As AS q aterials are commonly used in different systems of different end products, many should be registered as shipyard standards. Such standards presented during a pre-contract negotiation, enhance owner acceptance and benefits for both an owner and shipbuilder. Permanent designation as AS material is not necessary. If demand for a particular item diminishes due to market changes, design advances, etc., switch to A material classification could be justified. Also, if demand for an A item increases enough, switch to AS would be appropriate. Thus, frequent reviews of inventory turnover rates are prudent.

- Preliminary Material Estimates by Designers

Early during functional design, engineers estimate the quantity of each AS material item required per system. As material definition and pallet codes are not precise at this stage, such information is organized as MLS per material ordering zones, noted as "preliminaryll and sent to the AS section in purchasing and to production planning. The degree of accuracy should be just sufficient enough for buyers to plan procurement activities and delivery schedules per the material ordering-zone concept described in Part 5.2.1.

Furnishing such preliminary information enables the AS section to get a head start in material-control planning, e.g., changing AS to A and vice versa, proposing substitutions of similar materials from surplus, etc. Also, the preliminary information, which identifies groups of materials roughly sequenced per a build strategy, is useful input for further production planning.

As more precise quantities and estimates are determined during functional design, MLS are revised concurrently.

o Determination of Final Quantities by Designers

During work instruction design, when pallets are finalized on composite arrangement-and-detail drawings, all fittings are listed on MLF. Some such fittings are available in the marketplace. Others have to be fabricated either in-house or by subcontractors. Thus, final determinations of required materials are dependent upon completion of material lists which accompany manufacturing drawings. In other words, quantities of material items, including AS material, are finally determined when MLF, MLP and MLC are completed.

By definition, materials in the AS category are generally susceptible to quantity revisions made necessary by owners' changes and/or design errors. The carefully calculated and controlled quantity margins, inherent features of AS control, offset such potentially disruptive influences.

conomical Ord. Q'ty			Material Name			Standard No.		
Standard lead time								
Month		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.
Q'ty in Stock								
Q'ty Received								
Purch-asing	Q'ty							
	Requisition No.							
Q'ty to be used	Ship No.							
	" "							
	" "							
	Margin							
	Misc. Use							
	Sub-Total							
Q'ty used	Ship No.							
	" "							
	" "							
	Margin							
	Misc. Use							
	Sub-Total							

FIGURE 7-3: Nishijima Ledger for Control of Allocated Stock Material.

• Preparation of Purchase Orders

Just as the AS concept is between the A and S concepts, the AS ordering procedures are between the A and S ordering procedures. A materials are ordered by simply referencing POS and quantities provided by designers. S material orders are triggered automatically whenever quantities in hand are reduced to certain levels. Whereas, reordering an AS material item is triggered periodically for all projects taking into account:

quantity in hand at period start,

planned issues during period,

planned receipts during period,

quantity in hand at period end, and

an order for new requirements which could include a quantity margin. [1]

Usually each such order is for a standard fitting. Therefore a code number which represents a standard specification or standard drawing suffices for a purchase order description.

o Practical Procedure for Determining Order Quantities

- Work Sheet

Ordering quantity for each AS material item is determined by using a work sheet called a "Nishijima ledger", see Figure 7-3. The ledger provides for indicating the quantity required, the quantity received, available stock, and quantity consumed on a monthly basis and on a hull-number basis. Usually, purchasing people are assigned to determine ordering quantities from such ledgers. [2]

[1] See "Outfit Planning-December 1979" NSRP, 4.4 Leveling and Balancing, and Figure 4-4, p. 41 and "Industrial Engineering Handbook", Third Edition, McGraw-Hill Book Company, Chapter 4, Net Requirements Rule.

[2] Captain R. Nishijima of the Imperial Japanese Navy. Per Dr. H. Shinto, former President of IHI, the ledger has been used in Japan since 1929.

If an objective is to improve the accuracy of daily procurement planning and control, in other words to achieve literal just-in-time-deliveries, the Nishijima ledger could be used in a more fractionalized way, e.g, weekly instead of monthly and by zone or system instead of hull number. However, as AS materials have the character of stock materials in their availability for issue, spending time and effort for precise just-in-time deliveries for heavy construction is usually not worthwhile. The indirect expenses associated with such control efforts are quite costly compared to just the material costs. Thus, a purchasing system has to control material in the most economical way while maintaining required quantities so that material shortages will not jeopardize production.

- Listing Quantities Per Ship

As previously described, early during a design effort (typically, about 6 months before keel laying in an IHI shipyard), estimated material quantities are distributed to purchasing and production in the form of MLS which are subdivided to show how materials are distributed in material ordering zones. Each such estimate is then roughly distributed, by purchasing people, into monthly requirements per a preliminary production schedule.

Definition of material ordering zones so soon after contract award does not mean they have to have an exact relationship to the smaller zones that will ultimately be used to define pallets. Material ordering zones are simply a convenience for early material procurement planning. Material requirements, heretofore grouped only by system per diagrammatics, are regrouped by zones that can be sequenced per a preliminary production schedule.

This approach may seem illogical. If material should eventually be grouped by zone, why not structure material data by zone from the beginning? From a designer's viewpoint, early design stages are necessarily system oriented. From a material control viewpoint, AS material is essentially stock matrial and does not require precise delivery control. Therefore, MIS combined with the material ordering zone concept consitute adequate notice.

Along with development of design details, materials are eventually regrouped into MLF, MLP and MLC which correspond to specific zones that have meaning for conduct of production work. MLP and MLC, as previously described, relate to MLF as structured material lists.

Immediately as MLF, MLP and MLC are produced, sorting, collating and comparisons to total quantities predicted by MLS must be accomplished in order to quickly locate any material requirements not previously identified. As the material purchasing plan is initially based on MLS and refined as MLF, MLP and MLC are developed, and since work is more effectively controlled through control of material not people, the most effective shipbuilders advise that the material sorting, collating and comparing function described in the foregoing, is their most important computer application. Computers applied for design, manufacturing, payroll, etc. are not withstanding.

Margins

In order to cope with design changes and material losses or damage, a quantity margin for each AS material item is estimated from historical data and distributed so as to supplement each month's planned consumption during the production effort.

Miscellaneous

As AS materials are also used for ship repair and for building products other than ships, provision for miscellaneous use is made in the Nishijima ledger shown in Figure 7-3.

Determining a Purchase Order

For each kind of AS material, the quantity to be orderd and a delivery date is determined by purchasing people each month by deducting the stock on hand and the quantities reflected in outstanding orders from previous months from estimated requirements. The final quantity, delivery time and time to issue a purchase order is determined after checking the "economical ordering quantityl" and "standard lead time" which are recorded on each Nishijima ledger. "Economical ordering quantity" means the most economical amount to purchase based on past experience.

- Recording Actual Usage

Actual material usage per month by hull number, by margin and by miscellaneous are summed and recorded on the Nishijima work sheet for each kind of AS material. By reviewing such actual consumption, quantities required for succeeding months are reviewed and adjusted as necessary.

7.2.2 Procurement of Allocated Stock

As most AS materials are treated as standards, the major function for their management is purchasing. The purchasing process is simplified because:

- o increasingly, products available in the open market are being registered as shipyard standards, and
- o more and more, shipyard standard drawings and accompanying material lists are being used to describe items that are to be produced in-house or by subcontractors.

7.3 Purchasing and Subcontracting for Stock Material

S material only accounts for a very small portion of total material cost. However, the number of individual items are usually about twice the number for AS material. Thus, from a makerial management viewpoint, S material cannot be ignored.

7.3.1 Planning for Stock Material

S materials are usually ordered when their stocks are depleted per a fixed-reordering-point or two-bin-control rule. In a shipyard, a computer applied fixed-reordering-point system is most economical because many different kinds of S materials are required.

Planning for S materials imposes very little work on designers.

S materials can be changed to AS or even A materials if changed demand so indicates. Therefore, just as for AS material, having designers inform purchasing of estimated quantities of required S materials, is desireable.

Also, as S materials are usually listed in MLF, MLP and MLC, later determination of precise quantities required is easy to accomplish. However, some shipbuilders believe that it is not worthwhile to expend time and money to precisely control all of the many different kinds of S materials because of their relatively low unit costs. Thus, some shipbuilders provide free access to many S materials. For example, bins of nuts and bolts and racks containing U-bolts, gaskets, etc., are located for the convenience of fitting work on-unit, on-block and on-board.

7.3.2 Procuring Stock Materials

The procurement method for S materials is the same as for AS materials. But, because many different kinds of S materials are required and since they are comparatively cheap, purchasing processes and associated paper work can be simplified, e.g., by:

- o employing long-term contracts to fix unit prices and quantities, and
- o maintaining vendors' stocks on consignment inside shipyards.

7.4 Summary of Procurement Methods for Allocated, Stock and Allocated Stock Materials

Procurement prerequisites for A, S and AS materials are tabularized in Figures 7-4 and 7-5. Figure 7-6 shows purchasing patterns for A, S and AS materials relative to a key-date schedule.

	A		AS		S	
	Pur-chase	Sub-contract	Pur-chase	Sub-contract	Pur-chase	Sub-contract
Requisi-tion	POS	DWG	MLS MLF	MLS MLF & STD DWG	MLF	MLF & STD DWG
Procure-ment	Purchase by ship, by material	Subcont. by ship, by material	Purchase by material in a lot	Subcont. by material in a lot	Purchase by material in a given quantity	Subcont. by material in a given quantity

FIGURE 7-4: Procurement Media.

Mat. control classification	A	AS	S
Material control (allocation)	Ship-by-ship	Ship-by-ship	Fixed reorder point Sys (no allocation)
Procurement request	Ship-by-ship and material-by-material	Material-by-material	Material-by-matarial
Listing up in	MLS	MLS ↕ Screening MLF	MLF MLC MLP
Distribution	Ship-by-ship	Ship-by-ship	Ship-by-ship

FIGURE 7-5: Preparation of Material.

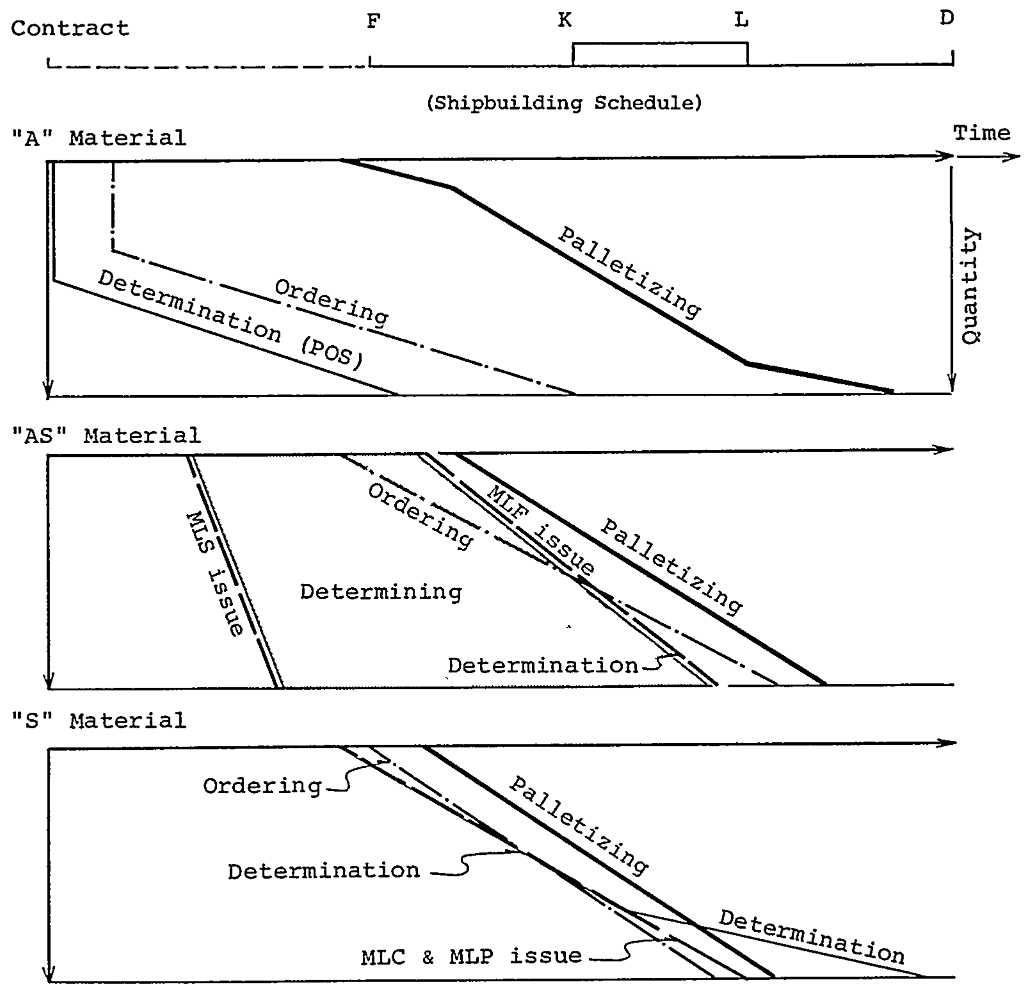


FIGURE 7-6: Purchasing Patterns for Allocated, Allocated Stock and Stock Materials.

8.0 RATIONALIZATION OF PROCUREMENT TECHNIQUES

There are several cost-saving and efficient procurement techniques that are appropriate for shipyards. In order to be effective, all must generally conform with two basic policies. One pertains to contracts with suppliers and subcontractors. The other concerns human resources, specifically, purchasing people. In rationalizing purchasing techniques, measures for conformance with both policies must be skillfully and suitably combined.

8.1 Rationalization of Contracting Procedures

8.1.1 Central vs. Local Procurement

If a company operates several shipyards, developing expertise to procure certain materials through a central procurement office in company headquarters is more economical and advantageous than permitting such expertise to be "spread thin" among several purchasing organizations. This is particulary so for a firm which maintains a basic design capability only in its headquarters.

In addition to its geographical connotation, "central" also means a "center for establishing purchasing strategies and/or activities" for the entire firm. For example, as a vital matter, the central purchasing office must work together with the basic design department:

- o to assist the marketing department in obtaining orders by providing timely information on price and quality of major materials which best suit a marketing objective, and
- o when an order is received, to rapidly issue purchase orders for such materials taking care to achieve scheduled material delivery dates and to keep within monetary budgets,

Materials which should be procured by a headquarters office include:

- o long-lead-time materials,
- o major fittings and raw materials that are clearly defined in a shipbuilding contract,
- o materials needed *in* large quantities that are commonly used by many of a company's shipyards and other industrial divisions,
- o materials for which procurement is biased by political considerations,
- o materials for which the numbers of suppliers are limited, and
- o materials from foreign sources.

The same advice applies to a small company which operates only one shipyard. A small group of procurement specialists who report directly to the general manager and function as a central procurement office, should handle the exceptions described in the foregoing. This approach frees the regular purchasing department to contribute to improving material management systems, to better coordinate with design and production activities and to ideally function as cost centers.

Most A materials are purchased by a central procurement office under the direct supervision of top management. Genrally, S and AS materials are purchased by local purchasing offices which should report to their respective production-control managers.

Local purchasing offices in shipyards should deal mainly with short lead-time materials, i.e., materials that are mostly affected by changes as a detail design progresses. In other words, local procurement offices are mainly preoccupied with materials that are finally defined during the preparation of MLF, MLP and MLC. In addition local procurement offices are better able to maintain the required constant and close relationships with subcontractors.

8.1.2 Long-Term Price Agreement

The objective of long-term price agreements is to stabilize relationships between buyers and sellers for certain periods, typically 6 months or one year. Long-term agreements yield advantages for both buyers and sellers in matters pertaining to prices, deliveries, productivity, etc. Furthermore, such agreements are beneficial to both groups because frequent negotiations associated with multiple procurements are eliminated. Of extreme importance are the shortened lead times that long-term agreements make possible.

There are a number of purchasing methods that, with some modifications and/or devices to satisfy circumstance for each case, are suitable for long-term agreements.

8.1.3 Long-Term Lump Sum Contract

A long-term lump- sum contract is somewhat similar to a long-term price contract. Instead of unit prices, a lump sum applies for a total quantity of a particular material item for a number of ships. Deliveries are made to match the construction schedule of each ship.

8.1.4 Simplified Purchasing Method - Consignment

Consignment requires vendor agreement to maintain a material supply in a shipyard's warehouse. As such materials are issued to production, they are regarded as having been purchased by the shipyard.

8.1.5 Simplified Purchasing Method - Credit

Credit purchasing involves vendor agreement on unit price and to maintain sufficient stock always available for immediate delivery. Orders are placed verbally. When materials are delivered in response to each such order, quantity and total price are entered in a passbook and the grand total transacted per month is paid after a period for which there is mutual agreement.

8.2 Quality and Statistical Control

Inspection upon receipt of materials is carried out in accordance with POS, shipyard manufacturing drawings and a standard protocol for such inspections.

An inspection standard, appropriate for each particular material item, addresses appearance, measurements, operation, overhaul, spare parts, etc., and is referenced in purchase orders. Also, inspections at a manufacturer's plant requiring attendance of shipyard inspectors, or inspections which are to be performed autonomously by a manufacturer, are stipulated in such inspection standards.

Shipbuilders, who require statistical evidence of quality from suppliers before purchase orders are awarded, are more and more allowing autonomous inspection by manufacturers who have reliable statistical quality control systems. Shipbuilders save by not having to dispatch inspectors and by obtaining some price discount which results from elimination of chance that shipyard inspectors will disrupt a manufacturer's operations.

In order to allow autonomous inspection, a shipbuilder should ascertain if the manufacturer:

- routinely employs statistical control methods in production,
- has had transactions with the shipyard in the past,
- is technically reliable,
- is financially and managerially stable,
- has submitted technical information, approval drawings, etc., that can be trusted,
- routinely employs a quality control organization, working standards, inspection standards, etc.

Above all, the assurances that can be had from statistical evidence of quality submitted by a vendor before purchase order award, cannot be over exaggerated. Such evidence, analytically derived, describes whether or not a manufacturer's production systems are performing normally. Should a shipyard POS require abnormal performance, then statistical evidence of normalcy serves as a baseline to evaluate the impact of the extraordinary requirements, even to the extent of analytically deriving the probable number of inspectors required. Shipbuilder/vendor negotiations, proceeding with much more technical knowledge, then produce far more more mutually beneficial decisions than can be reached without statistical evidence.

Maintaining intimate knowledge of suppliers as–described in the foregoing, is obviously impractical if requests for bids for a particular item are not limited. Three requests-for-bids to suppliers, of whom the shipyard has extensive knowledge, reasonably ensure sufficient competition.

Just as in the most effective firms in Japan, managers elsewhere must, for productivity reasons, deal with significantly fewer suppliers.

8.3 Delivery

8.3.1 Determination of Delivery Dates

Materials, for which procurement activity starts immediately after award of a shipbuilding contract, are ordered per a preliminary delivery schedule which is based upon a shipyard's master schedule. As detail design proceeds, an outfitting milestone schedule, monthly schedules, weekly schedules, etc., are established by production. These schedules are the bases for determining delivery dates for large items and the pallets containing smaller fittings.

8.3.2 Delivery Fo11ow-Up

Follow-up on deliveries per initial schedules is performed by the same people who placed the orders, i.e., by buyers in a purchasing office. However, as a scheduled delivery date approaches for a critically needed item, about thirty days before, delivery need is restudied because sometimes adjustments in a delivery date is justified by deviations from supplier and/or shipyard production schedules.

Such adjustments are frequently necessary in shipbuilding. Therefore, instead of using the material ordering section as a channel between suppliers' and a shipyard’s production people, assigning field expediters who normally ensure delivery of materials to production sites, to negotiate final delivery dates with suppliers is more effective. Timely shift of follow-up responsibilities is very important.

If materials are being supplied from a foreign source, follow-up should be shifted from the material ordering people to the field expediters when bills of lading are received.

8.4 Assessments of Suppliers

Assessments of material suppliers are quite essential before transactions take place. Figure 8-1 shows a typical format to facilitate such evaluations. Commensurate with material value and/or criticality, analysis of a vendor's business situation should be made using Appendix E as guidance.

VENDOR SURVEY SHEET

Section in Charge	made out		review		review		review		review	
	Manager	Staff	M	S	M	S	M	S	M	S
Name of Company									Vendor's Code	

OUTLINES

	Address	TEL
Head Office		
Dept. & Person in Charge for Our Company		
"		
"		
"		
Overseas Office		

Large Share-holder	Share (%)	Main Bank	Name of Re-presentative		
			Capital	dollar	dollar
			Established Month Year		Month of settlement
			Member of Business Group:		Listed on market Non

	Division	1982	1983	1984	1985	1986
Total No. of Employees	Business & sales					
	Others					
	Total	Person	P	P	P	P
Average Salary						
Average age						
Average serving years						

Labour union	Yes	No	Upper Organization

Technical cooperation period	Technical cooperation item	Technical cooperation party	Sub-licencing party (Name of Mfg.)
yr/mo. - yr/mo.			

Amount of Our Company's Product handled (fill up year, item, amount)	Transaction started date with us:

FIGURE 8-1(a): Vendor Survey Sheet, Page 1.

BUSINESS TRANSACTIONS

		1979		1980		1981		1982		1983	
Total sales (ordinary profit)		$	% 100	$	% 100	$	% 100	$	% 100	$	% 100
Main customers (to whom sold)	(1) Our Company										
	(2)										
	(3)										
	(4)										
	(5)										
	(6)										

Name of business transacting Manufacturers / Address:	Items (make marks to supplies for our company)	Ratio to own sales amount (%)	Ratio to manufacturers total sales (%)	Ratio of shares hold and yes or no of directors despatched

Other optional opinion on quality, delivery and transaction problems (if required, add additonal sheet)

Ordering department of Our Company							

Vendor's person in charge : Department Name

FIGURE 8-1(b): Vendor Survey Sheet, Page 2.

9.0 SUBCONTRACTING TECHNIQUES

The efficient employment of subcontractors is a key element for successful material management. Subcontracting is, in a sense, a means of temporarily extending a shipyard's production capabilities. Thus, subcontracting procedures are quite different from purchasing activities for raw materials and finished products available in the marketplace. Also, different control techniques are required.

9.1 Contracting Methods

9.1.1 Selection of Subcontractors

Subcontracts for manufacturing are accompanied by drawings which describe what is to be produced. Thus, they indicate work which is to be performed.

In selecting a subcontractor, the first criterion addresses whether candidates have sufficient manufacturing capabilities by themselves and, if not, whether they have management capacity to further subcontract work successfully. The second criterion concerns dependability. Stability in management and administration of financing, production control, human resources, etc., must be evaluated.

The third criterion concerns a subcontractor's geographical location. Sometimes a shipyard may have to provide production know-how or lease tools which could require frequent. dispatch of managers and engineers to a subcontractor's plant. In such cases, engaging subcontractors who are located close to the shipyard can be very effective provided there is willingness to accept shipyard guidance and control. Also, shipyards which procure all materials for work to be performed in-house and outside, usually find advantages in dealing with nearby subcontractors.

9.1.2 Determination of Subcontract Price

A subcontract price is mostly dependent upon work content. Usually, estimated cost is baaed upon manufacturing drawings prepared by the shipyard. A few elements, Such as cost per man-hours and materials, if the shipyard does not supply materials, are determined by market conditions.

Manufacturing costs, naturally, are proportional to the number of man-hours required. Also, the manufacturing sys-tern implemented by subcontracting, inherently splits responsibilities, e.g., drawing preparation and often material marshalling are performed by the shipyard and production processes, facilities and jigs are under the cognizance of the subcontractor. Thus, opportunities for improvements are dependent upon how well shipbuilders and their subcontractors interact. In order to benefit to the maximum extent, each shipyard should limit the number of subcontractors normally dealt with and actively encourage development of subcontractors' works as part of the shipyard’s manufacturing system.

9.2 Quality Control

9.2.1 Inspection Standards

Normally, the main inspection objective is to ascertain quality of a subcontractor'a workmanship in the context of: a manufacturing drawing provided by a shipyard, and production process and quality standards which are published by the shipyard for its own use and/or by some agency in behalf of a shipbuilding industry. Typical such standards are:

- "Shipbuilding Process and Inspection Standards (SPAIS)" issued by IHI,
- "Quality and Inspection Standards for Ships Painting (QISSP)" issued by IHI, and
- "Japanese Quality Standards - Hu1l Part (JSQS) 1982" published by the Research Committee on Steel Shipbuilding, The Society of Naval Architects of Japan. (This publication describes statistically derived accuracies normally achieved by the Japanese shipbuilding industry. A project to so collect, combine and publish structural accuracies normally achieved by U.S. shipbuilders, initiated by the NSRP, started on 1 February 1985.)

Large items, such as castings obtained by subcontract per shipyard manufacturing drawings, should, in addition, be thoroughly checked in accordance with a shipyard's receival inspection standard. Normally, this standard applies for purchases of products that exist in the marketplace.

9.2.2 Inspection Responsibilities

A shipbuilder's in-process inspection at a subcontractor's plant and receival inspection could be eliminated when a subcontractor's quality assurance and production schedule control systems are found to be reliable and if the subcontractor did not have serious related problems in the past. When such qualifications exist, shipbuilder's can accept a subcontractor's self-inspection report and guarantee certificate. Permitting subcontractors to assume such inspection reponsibilities creates incentives from which shipbuilders and subcontractors benefit.

If a subcontractor's quality does not meet the criteria specified, the shipyard must positively and promptly dispatch inspectors to do whatever is necessary to maintain the specified quality. Their main objective is to insure that problems, such as rework or rejection, will not occur after a subcontractor's product arrives in the shipyard. Even though a subcontractor normally assumes rework costs, a shipyard could still suffer from its *own* production schedule slippage, unexpected management, inspection and control expenses, productivity loss due to disruption, etc. Thus, shipbuilder efforts to obtain assurances before a subcontract award and timely technical guidance and assistance to subcontractors afterwards, are often very worthwhile investments.

9.3 Delivery Control

Shipbuilders should assist subcontractors in setting up schedule controls. Thereafter control of delivery schedules should be left to subcontractors, provided shipyards allowed them sufficient time, considering their other workloads, for production, for deliveries, for planning and scheduling, and for making other required preparations.

9.4 Fostering Subcontractors

9.4.1 Fostering Policy

Most traditional shipyards fabricate fittings in-house. From an economical viewpoint, utilizing subcontractors that a shipyard has helped develop, is more effective.

Depending on its geographical location, labor relations, etc., a policy for fostering subcontractors should differ between shipyards. The following characterizes policy generally adopted by shipyards in Japan:

- o in principle, do not invest in a subcontractor's capital,
- o guarantee a certain amount of subcontract work as a base workload,
- o provide technical assistance without charge, and
- o provide managerial guidance until subcontractors are no longer only dependent on shipyard work and/or technology.

9.4.2 Major Points for Fostering

- o Managerial Guidance - If a subcontractor so desires, dispatch shipyard people to act as consultants for resolving magerial problems, such as, in accounting, production control, etc.
- o Technical Guidance - If a subcontractor so desires, dispatch shipyard engineers, foreman, etc. to act as consultants for resolving technical problems.
- o Anticipate Problems - If a subcontractor so desires, periodically, dispatch shipyard people having charge of subcontracting or other appropriate functionaries, to survey for and help resolve problems.

9.5 Evaluations of Subcontractors

Each potential subcontractor should be formally evaluated regarding management and financial status, transaction records, delivery punctuality, etc. Figure 9-1 shows a typical format to facilitate such evaluations. Commensurate with material value and/or criticality, analysis of a subcontractor's business situation should be made using Appendix E as guidance.

Recorded surveys of potential subcontractor's technical capabilities, e.g., facilities, work previously performed, etc., are useful references for planning future subcontracts.

SUBCONTRACTOR SURVEY SHEET

1/2

Section in Charge	made out		review		review		review		review	
	Manager	Staff	M	S	M	S	SM	S	SM	S

Name of Company		Vendor's Code

OUTLINES

	Address	Main product (make marks for us)	TEL
Head Office			
Dept. & Person in Charge for Our Company			
works			
"			
"			
Overseas Office			

Large Share-holder	Share (%)	Main Bank	Name of representative	
			Capital dollar	dollar
			Established Month Year	Month of Settlement
			Member of Business Group:	Listed on Market Non

Main Raw Material and Parts	Main Suppliers	Relying Ratio (%)	Main Raw Material and Parts	Main Suppliers	Relying Ratio (%)

	Division	1979	1980	1981	1982	1983
Total No. of Employees	Engineer					
	Worker					
	Business & sales					
	Others					
	Total					
Average Salary						
Average age						
Average serving years						

Labour union yes no Upper Organization

FIGURE 9-1(a): Subcontractor Survey Sheet, Page 1.

OUTLINE

Qualification	JIS		Others
	Classification society		

Technical cooperation period	Technical cooperation item	Technical cooperation party
Yr/Mo. - Yr/Mo.		

BUSINESS TRANSACTIONS

		1979		1980		1981		1982		1983	
Total sales (ordinary profit)		( )	% 100	( )	% 100	( )	% 100	( )	% 100	( )	% 100
Main Customers	(1) Our Company										
	(2)										
	(3)										
	(4)										
	(5)										
Amount of direct export											
Ratio of sales for each items		%		%		%		%		%	
		%		%		%		%		%	
		%		%		%		%		%	
		%		%		%		%		%	

Agent for Our Company			

Purchased amount of our product (fill-up year, item, amount)	Transaction started date with us: Month Year

Other optional opinion on quality, delivery and transaction problems (If required, add additional paper)

Ordering department of IHI							

Vender's person in charge : Department Name

FIGURE 9-1(b): Subcontractor Survey Sheet, Page 2.

10.0 ORGANIZATION STRUCTURE AND SYSTEM FOR MATERIAL MANAGEMENT

10.1 Organization Structure Outline

As previously described, shipbuilding materials can be grouped into A, S and AS material categories. Using the same divisions for organization of a material management system seems to be natural. However, analysis of the relationships between the material categories and the material management functions, modeled in Figure 10-1, indicates that it would be quite difficult to handle all routine work per A, S and AS categorizations. Structuring an organization by material management functions, i.e., material planning, procurement and distribution, is both practical and more convenient.

Of course, creating an organization that would be ideal for all shipyards is not possible due to their unique circumstances. Thus, the descriptions which follow are typical of Japanese shipyards which have effective material management systems.

10.2 Organization Structure for Simple Operations

Some shipyards have relatively small production outputs and therefore less material volume to manage. Regardless of a shipyard's size, when such volume is small, relatively few people and a simple organization is sufficient. As shown in Figure 10-2, there is no need to apportion procurement responsibilities by central and local as described in Part 8.1.1.

Also, shipyards which specialize in the same type of ship, regardless of its design complexity, do not require a sophisticated organization if the volume of materials to be managed per unit time is small. Therefore, simple organizations should be considered when:

- o there is virtually no need to control many different kinds of material in short time frames, and
- o marketing people do not require active engineering support.

Simple organizations are basically structured-per material management functions. The job descriptions by departments could be:

o Estimating Department

- estimating costs of proposed projects per inquiries
- preparing a working budget for each project for which a contract is received
- analyzing feedback, i.e., actual expenditures for material, man-hours, overhead, etc., and updating parameters used for estimating

o Planning and Scheduling Department

- profit planning
- preparing material and man-hour budgets
- preparing long-term construction plans, milestone schedules by material ordering zones, schedules for deliveries of major fittings, etc.
- reviewing and determining material control classifications, confirming material standards, taking initiative in development of material standards, etc.

o Basic Design Section

- preliminary and basic designing for estimating, including VE
- estimating basic material quantities
- preparing POS for major material items
- promoting standard design features and material standards

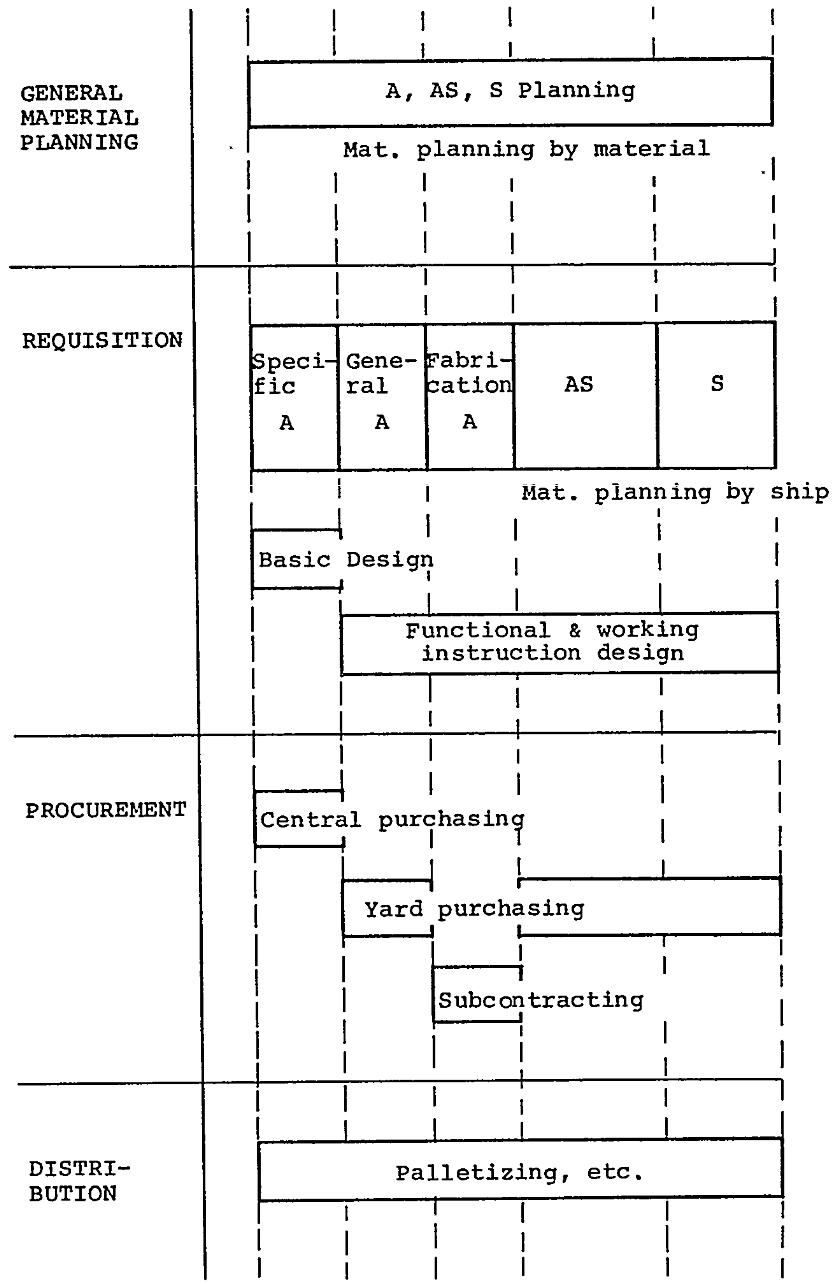


FIGURE 10-1: Relationships Between Material Control Classifications and Procurement Functions.

- o Functional and Work Instruction Design Sections
  - developing functional diagrammatics and work instruction drawings based on VE
  - preparing MLS, MLF, MLP and MLC
  - Preparing POS for materials for which POS were not prepared by basic designers
  - promoting standard design features and materials
- o Procurement Department
  - market research
  - evaluating potential vendors and subcontractors
  - devising and controlling material procurement schedules
  - ordering A materials
  - ordering AS and S materials
  - subcontracting
  - VE during purchasing and subcontracting
  - arranging for shipyard assistance to subcontractors
  - delivery control and expediting
  - planning and control of S and AS inventories
  - recording material receivals and issues
  - palletizing and transporting materials to work sites
  - collecting scrap and surplus materials and promoting their utilization in future projects

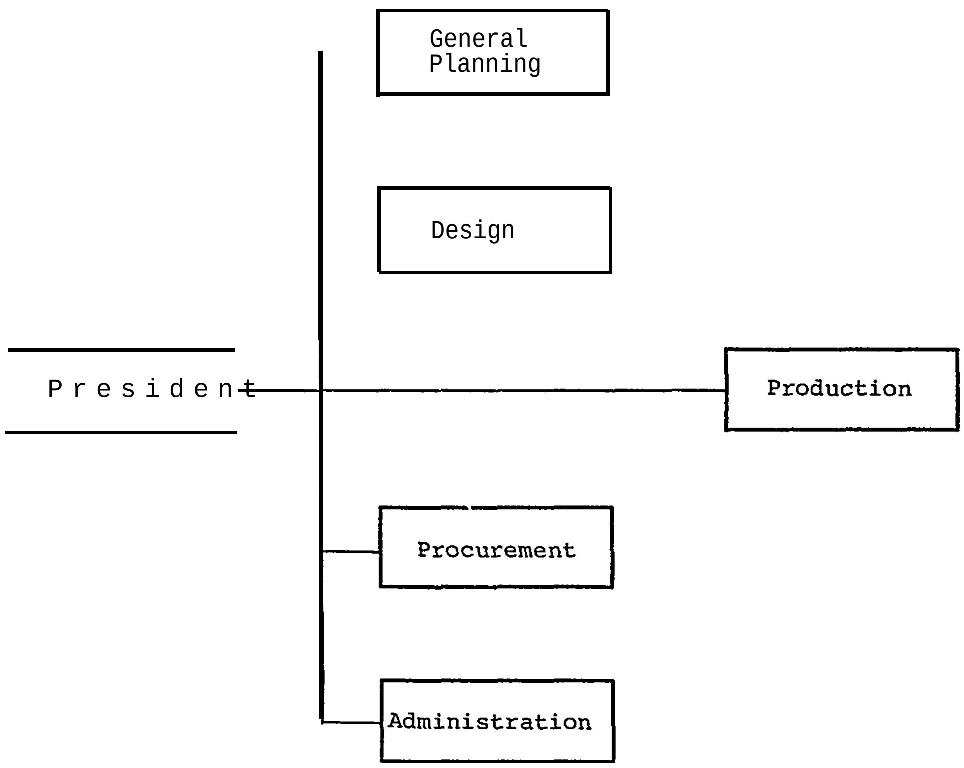


FIGURE 10-2: A Simple Organization When Material Volume is Small.

o *Production Department*

- preparing schedules for acquisition of hull structural steel

  preparing schedules for acquisition of fittings

  material receival inspections

  hull construction, outfitting, painting, etc.

10.3 Organization Structure for Complex Operations

Figure 10-3 shows an organization chart for a firm which operates several shipyards and, by adaptation of the chart, for a firm which operates one yard, both of which have large outputs of mixed and diversified products and large volumes and varieties of materials to control, i.e., challenges *that* require:

o varying quantities of many different kinds of materials, and

o minimizing the durations between contract awards and end-product deliveries.

Especially noteworthy in Figure 10-3 are two organizational features which are absolute requirements for effective material management during implementation of complex building projects:

o Production is not an overbearing monolith. Instead, production responsibilities are divided by inherently different types of work into two departments, i.e., a hull construction department and an outfitting and painting department.

0 The production control department is assigned responsibility to coordinate all industrial operations. This responsibility specifically includes all facets of material *control, so* much so that even the purchasing section reports to the production control department.

The most effective shipbuilders regard these organizational features as absolutely essential for coordinated schedule, material and man-hour control.

Simultaneously undertaking several projects in short time frames increases material procurement and control workloads. For productive operations, work functions must be divided into smaller increments and responsibility for accomplishment of work must be decentralized. Thus the organization structure will need specialists to execute work and an increased control function to support and regulate such work. As a result work volume per unit time is more dense and the quality of work is enhanced.

Job descriptions for the greater organizational division and specialization could be:

o Estimating Department

- same as in Part 10.2

0 Basic Design Department

  same as for Basic Design Section in Part 10.2

0 Functional and Work Instruction Design Sections

- same *as* in Part 10.2

0 Central Purchasing Department

  marketing/purchasing research, purchasing and delivery control of materials identified in Part 8.1.1, i.e., materials for which exceptional purchasing activities are required (although very seldom, AS and S materials may also be inclued)

o Production Control Department

  integrated planning and scheduling for control of an entire shipyard works

- planning and control of material ordering and material stocks

o General Control Section

- planning, control and adjustment of the profit plan, operations plans, etc. including man-hour allocations and scheduling

  consolidated material planning including material control

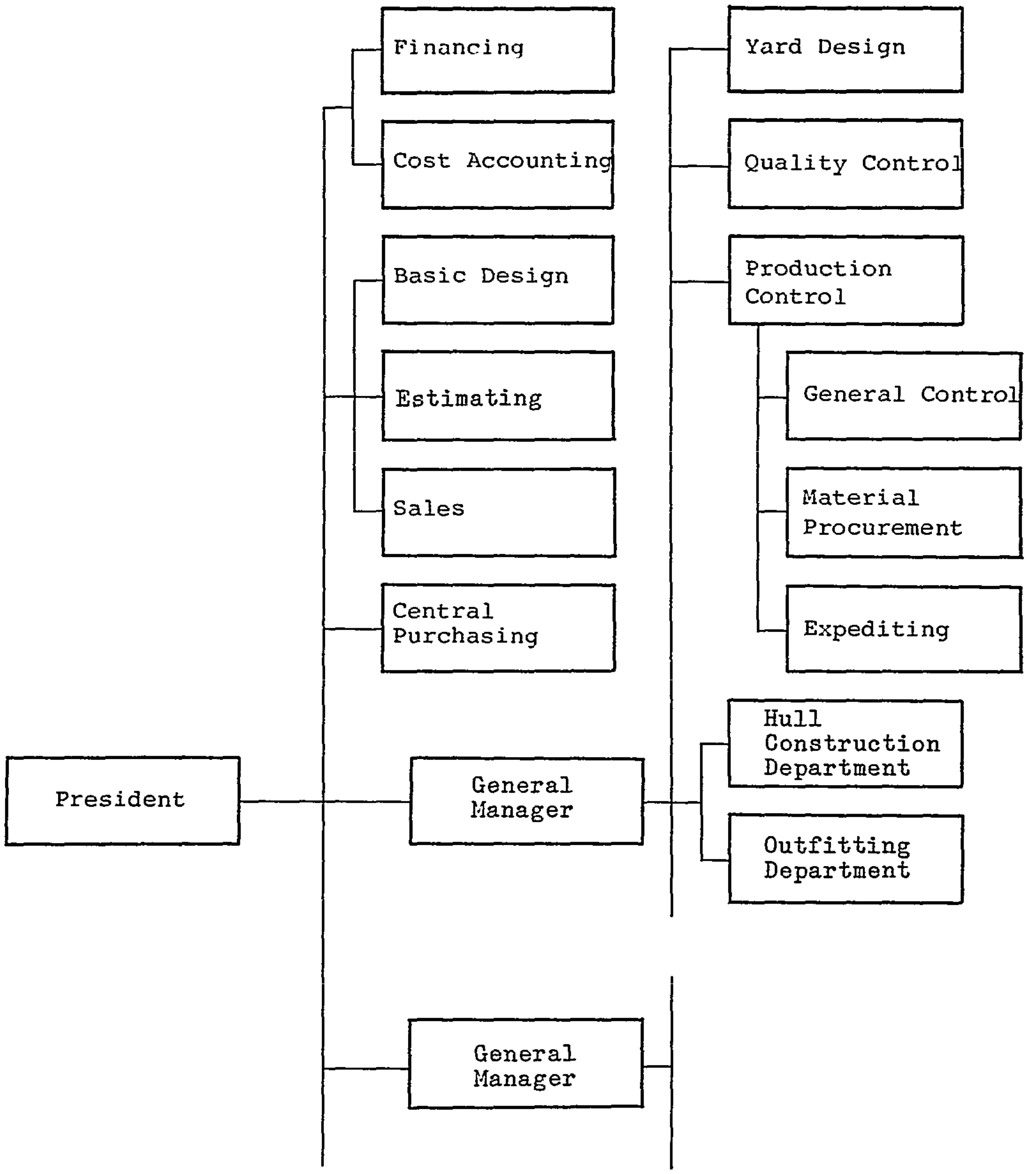


FIGURE 10-3: An Organization for a Company Which Operates Two or More Shipyards and When Material Volume is Large.

o Purchasing Section

market research

evaluating potential vendors and subcontractors

- devising a procurement plan and controlling material procure-merit schedules

ordering materials not already ordered by the Central Purchasing Department i.e., certain A materials (Categories 2 and 3) and principally AS and S materials (basically Categories 1 and 2)

subcontracting

- VE during purchasing and subcontracting

arranging for shipyard assistance to subcontractors

- delivery control

o Expediting Section

- planning and control of S and AS inventories

- field expediting, i.e., taking delivery control from the Purchasing Section in special circumstances as described in Part 8.3.2

recording material receivals and issues

- palletizing and transporting materials to work sites

collecting scrap and surplus materials and promoting their utilization in future projects

o Quality Control Department

- developing quality control standards

implementing receival inspections for both purchased and subcontracted materials

implementing in-process inspections, final inspections, etc.

o Hull Construction Department

- preparing mid-term and short-term schedules for acquisition of hull structural steel

implementing statistical control of accuracy

- hull construction work, i.e, fabrication, assembly, erection, etc.

0 Outfitting and Painting Department

preparing mid-term and short-term schedules, i.e., pallet assembly dates, for acquisition of fittings and paint

manufacturing, painting and palletizing pipe pieces

outfitting and painting on-unit, on-block and on-board

10.4 Comments on Organization

10.4.1 Team Work

Questionnaire responses indicate that procurement people tend to blame designers for hampering procurement activities due to slowness in design contributions for material planning. On the other hand, designers blame purchasing people for not being able to obtain VFI soon enough.

Procurement activity is made up of several specialized jobs, e.g., material planning, requisitioning, purchasing, etc. Purchasing people are sometimes exposed to favors from vendors who so strive to obtain orders. While all such efforts may not be illegal, all affect material management and thus can be expected to have adverse impact on material costs and productivity. Therefore, a procurement activity must have a supervisory function to guard against such fraud. Decentralization of responsibility and authority for procurement is also an effective preventative.

Although each purchase seems to be just a transaction between two firms, each represented by an individual charged with getting the best deal, it is a relatively complex affair from a shipbuilder’s viewpoint. The shipowner’s and regulators’ requirements must be met in accordance with ship construction schedules, but not at any cost. At the same time a shipbuilder’s best interest is served by cultivating long-term relationships with relatively few, just enough for competition, suppliers as compared to very frequently entering into first-time agreements.

Although purchasing personnel should have special qualifications, the most important prerequisite is a consistent shipyard purchasing policy. Without such consistency, the activities of purchasing personnel and of the designers who support purchasing, degenerate into reactions to late POS, insufficient vendor proposals, untimely VFI, etc. Such information exchanges need a supportive network and good team spirit.

A good system for procurement activities is essential, but a basic element for operating the system effectively is good human relationships. In other words the various functionaries involved must have knowledge of the system and display willingness to contribute as team members. Individuals pursuing selfish or parochial interests could achieve impressive records of apparent performance with little real performance insofar as overall material management is of concern. Establishing team spirit is a top management responsibility. There must be initiative to create an atmosphere which encourages people to talk with and help each other. Department and middle managers, as examples, should take the lead to communicate and cooperate with each other.

VE meetings are effective means to foster team spirit.

10.4.2 Organization for Value Engineering

Only recently is VE being recognized as prerequisite for reducing material costs through applications during designing, purchasing, subcontracting, etc. VE is most effective when work is highly organized. Implementation of VE need not be based on a fixed organizational structure. Resilience in application such as with a task force or ad hoc committee is also effective. VE proposals are needed from as many individuals as possible representing all areas of material management. The responsibility to submit proposals should not be left to a few VE specialists.

For example, a VE task force for basic design should, in addition to basic designers, have representatives from functional and work instruction design, production, etc. Very often, good ideas are discovered by people who are not directly involved in the work being considered.

Similarly, a VE task force for purchasing or subcontracting should include representatives from engineering and production. Sometimes, a shipyard VE team could beneficially include people from vendors' and subcontractors' plants.

10.4.3 Organization for Palletizing

As mentioned before, palletizing pipe pieces should be regarded as the last stage of pipe-piece production. However, delivery of pipe pallets to production sites should be done by the warehouse organization which controls palletizing of fittings other than pipe pieces. Usually, the warehouse responsible for receiving and storing A, S and AS materials is the most appropriate organization to have charge of the major palletizing and transporting effort.

10.5 Structure of Product-Oriented Material Management System

The material management system which has been described thus far is illustrated in Figure 10-4 which is a flow chart showing only major activities of the system, i.e., secondary in-house clerical activities, such as monthly payment plans, are not addressed. Although the chart is based upon an organization for simple operations as shown in Figure 10-2, it can be expanded for complex operations by simply modifying allotments of work.

That is, Figure 10-4 shows work processes (horizontal axis) versus organization function (vertical axis). Allotment of work involves dividing both into smaller increments so that the work scope for subdivided function becomes definitive and specialized enough to correspond with the organization structure for complex operations as indicated by Figure 10-3. For example, if "Procurement" as shown in Figure 10-4 is divided into central and local activities, responsibilities for "P/O for A Material" and "Specific Material/Long-Lead Time A Material" becomes the work of central and other responsibilities remain with local.

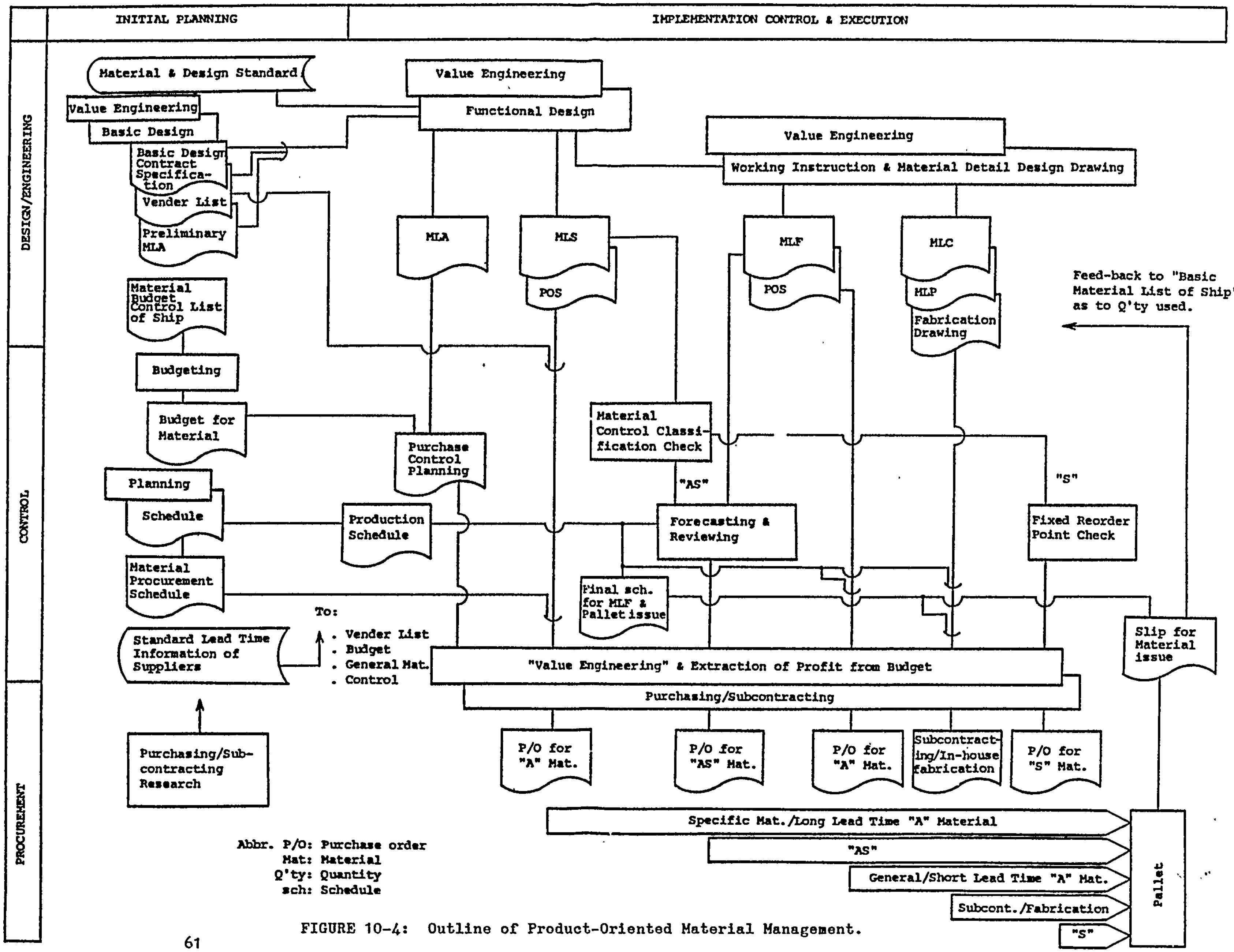
Many routine procurement tasks, such as, preparation of vouchers and checks, are best handled by automated data processing (ADP). There are two basic approaches. One is to simply have ADP assume routine clerical work. The other is to computerize an entire material management system. The latter approach has many merits, such as minimizing human error, labor saving, easy retrieval of management/control data, etc., and is dependent upon the following prerequisites:

- clear delineation of in-house material procurement systems,
- stabilization of production processes, i.e., little dispersion in labor man-hour expenditures,
- extensive standardization of design features and materials,
- clear definition and effective application of a concept for material control classification, e.g., A, S and AS,
- clear definition and standardization of lead times,
- effective palletizing, which involves clear definition and predetermination of unit volume of material issue, issuing schedule, etc.

Regarding the latter item, unit volume of material issue is associated with unit work volume which corresponds to a package consisting of enough work for two people for one week. In practice there are deviations because work volume cannot be so neatly divided. The final output of product-oriented material management is a group of material which constitutes a "pallet" as represented by an MLF. Therefore, the unit volume for palletizing should be preplanned accordingly.

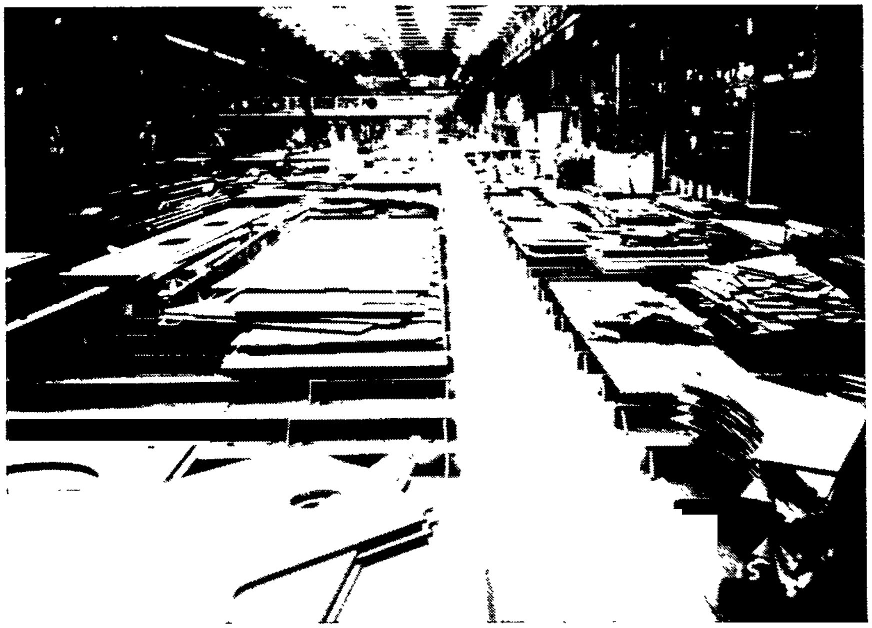
Further, when planning the application of ADP to material management, the following should be anticipated:

- the design workload will increase, especially if a CAD system does not exist or is not fully operational,
- not much benefit should be expected for certain materials, e.g., information regarding the relatively few A materials sometimes requires special input/output rules so that manual processing is just as effective but poses the inconvenience of having two systems,
- educating personnel for coding and input jobs without unacceptable degree of human error takes time especially when data is voluminous.



Abbr. P/O: Purchase order
Mat: Material
Q'ty: Quantity
sch: Schedule

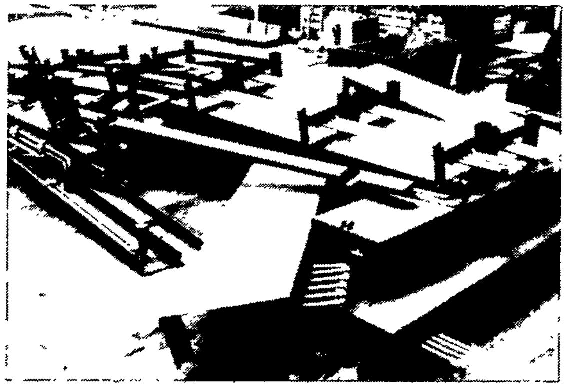
FIGURE 10-4: Outline of Product-Oriented Material Management.



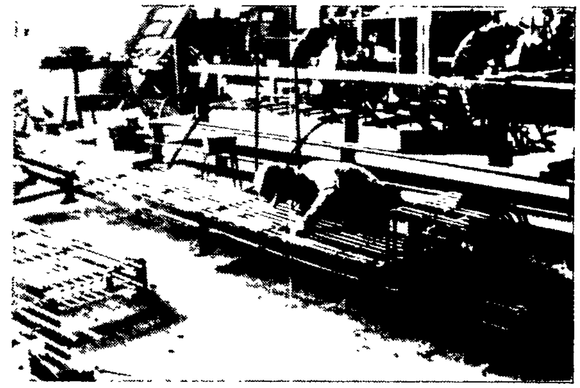
A

B

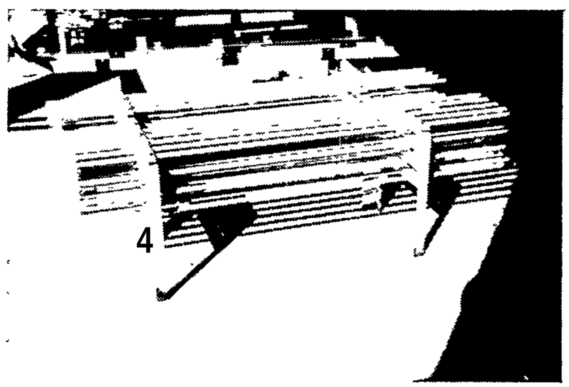
FIGURE 11-1: Effective shipbuilders perform in-house only work which by nature and volume can be implemented in accordance with the most scientific concepts, e.g., Group Technology and Statistical Control. This enables them to apply product organizations and operate and monitor each shop as a separate business. Thus, fabrication work in-house is normally limited to producing hull parts as needed for a block (A) and pipe pieces as needed for pallets (B). Assembly work in-house is normally associated only with performing sub-block assembly, block assembly and hull erection per the Hull Block Construction Method and outfitting on-unit, on-block and on-board per the Zone Outfitting Method. Virtually all other fabrication and assembly work is assigned to subcontractors and is performed per shipyards's standard manufacturing drawings.



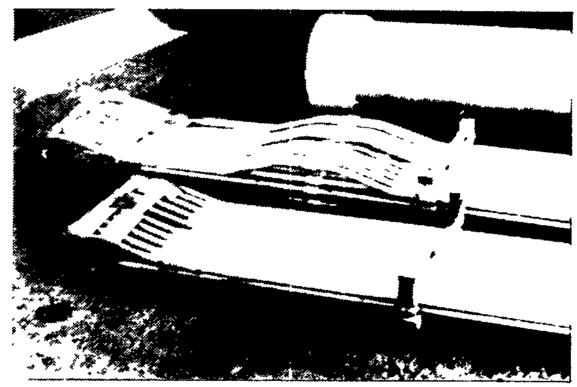
A



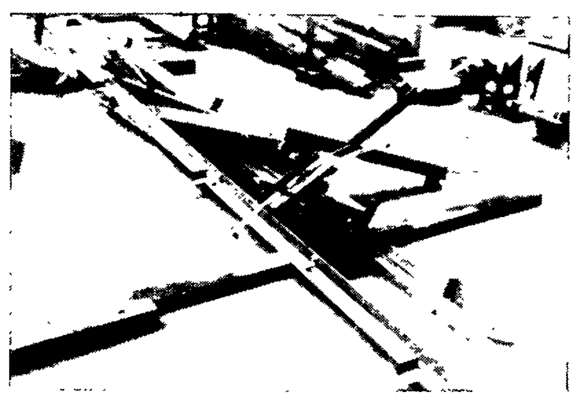
B



C“

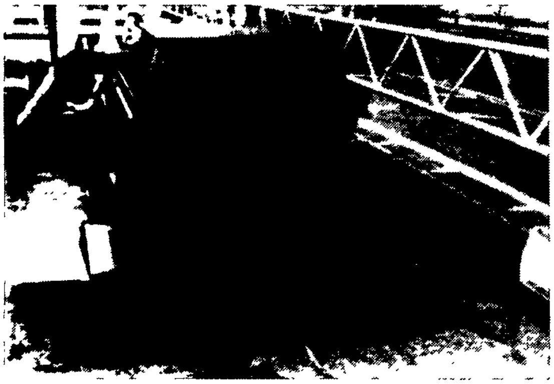


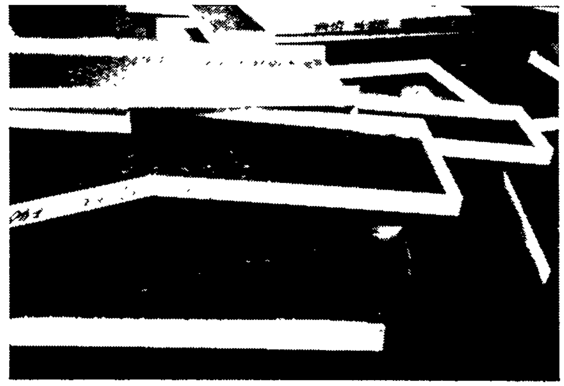
D



E

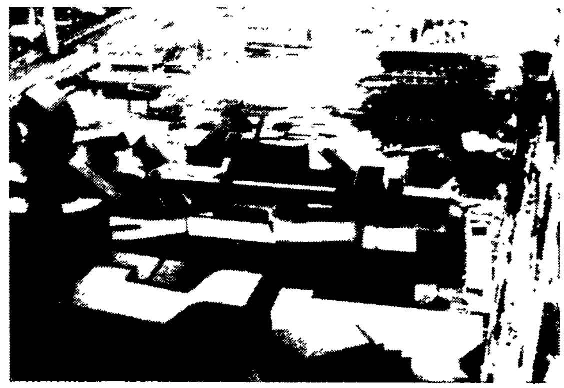
FIGURE 11-2: Typical items which are more effectively produced by subcontractors per shipyards' standard drawings include: tubing assemblies such as for pneumatic or hydraulic systems (A, B, C & D), and small diameter tubing for gages attached to angle irons that are to be used for walkways (E). When such items are susceptible to damage during shipment, subcontractors are permitted to do final assembly work within the shipyards.



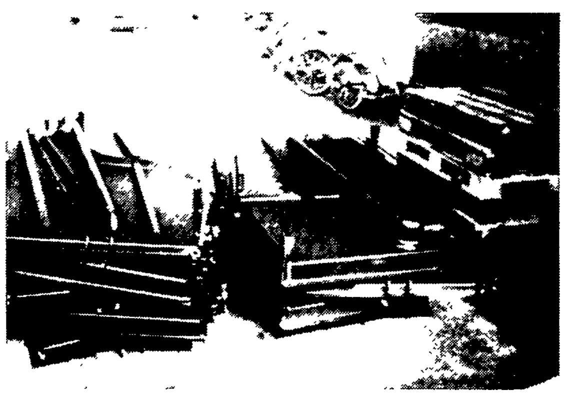


B

C



D



E

FIGURE 11-3: Additional items that are more effectively produced by subcontractors per shipyards' standard drawings include foundations (A), walkway sections (B), pipe supports complete with U-bolts (C), ventilation duct pieces (D) and pans for shower stalls (E). Just as marking, cutting, bending, fitting and welding, the responsibilities assigned to subcontractors include painting and palletizing.

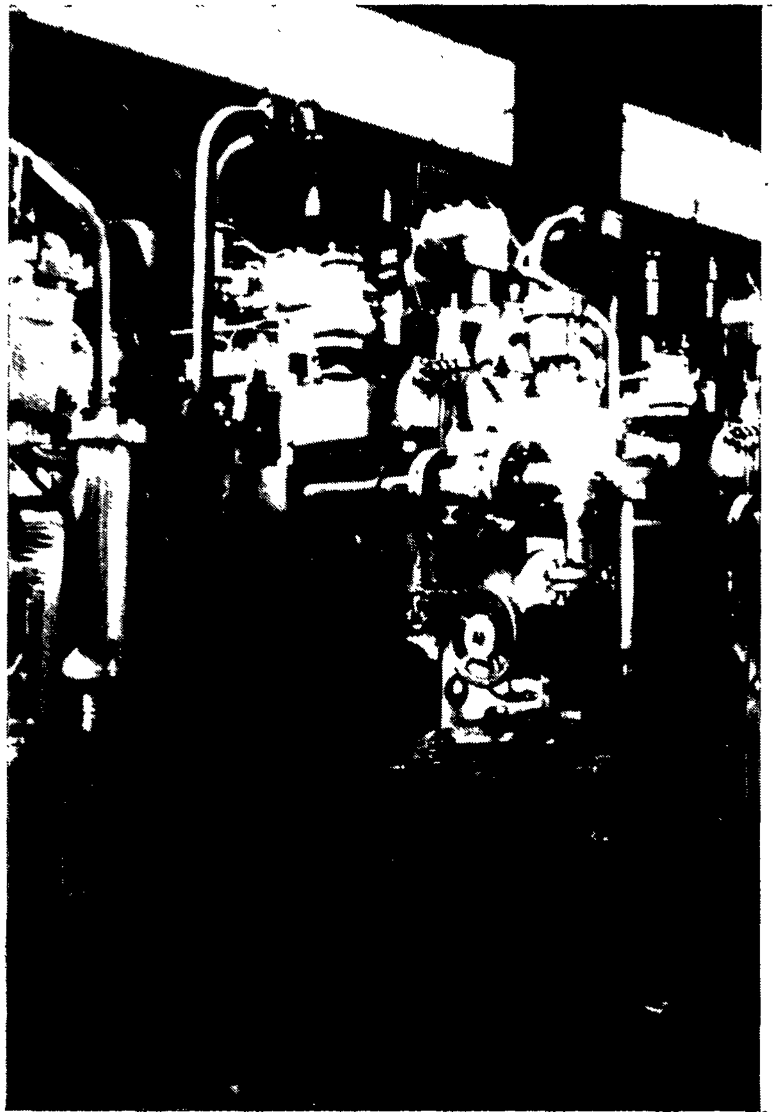
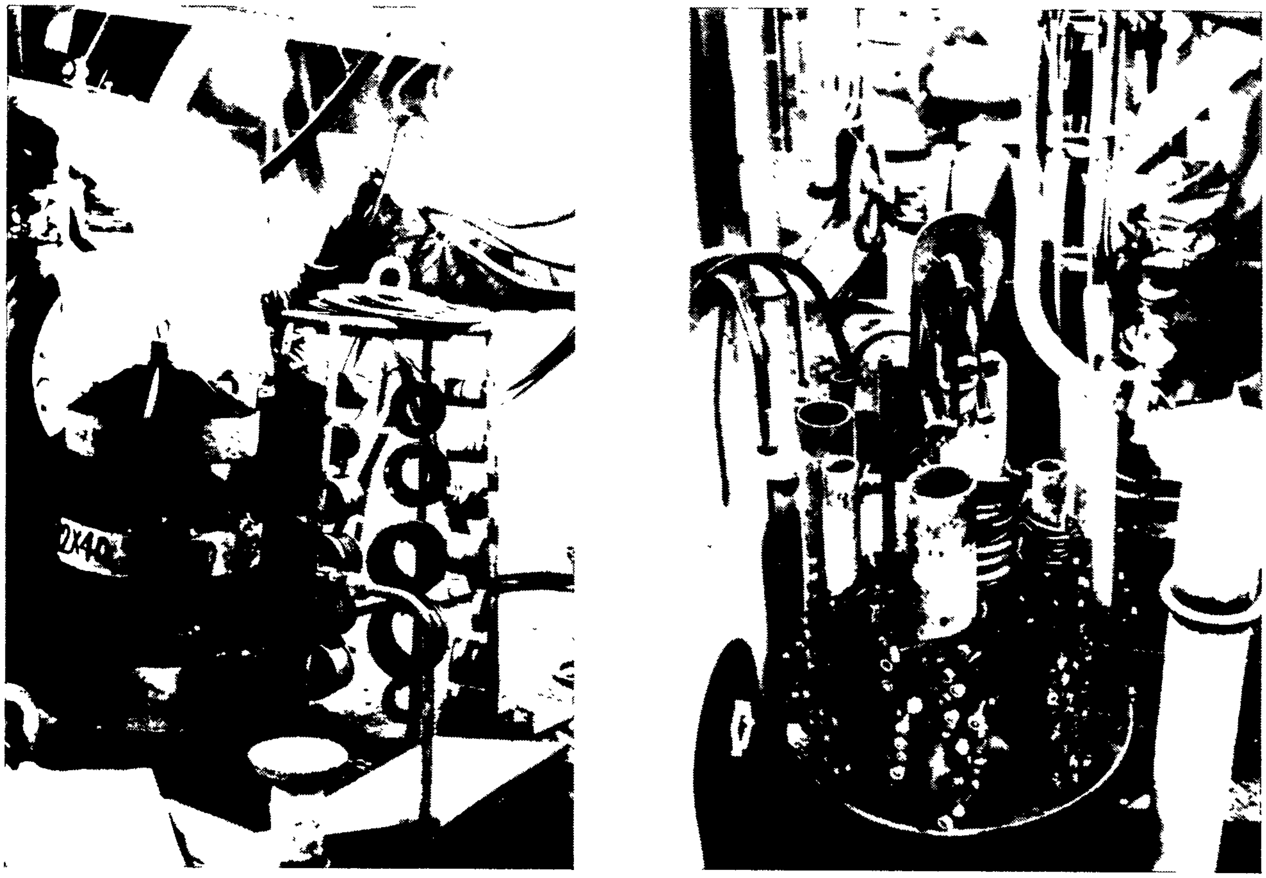


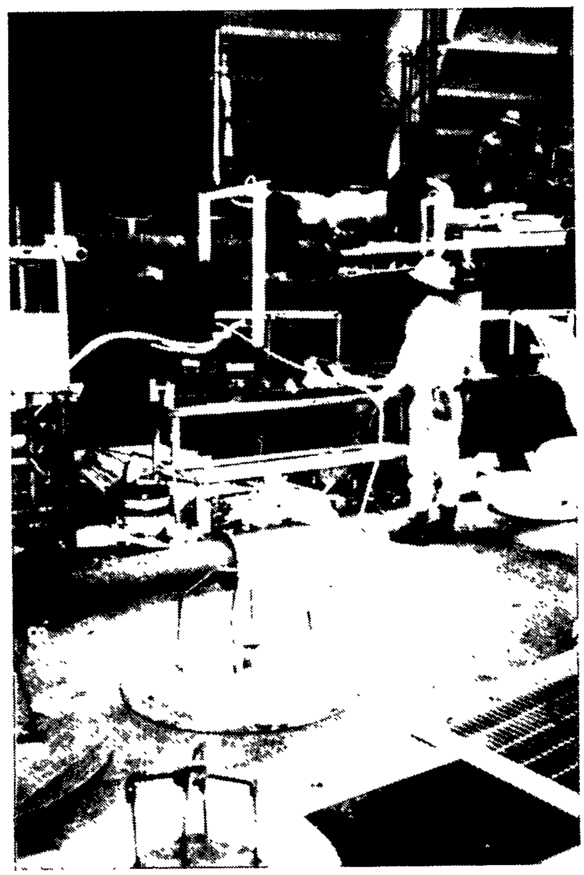
FIGURE 11-4: Shipbuilders who register supplier catalog items as shipyard standards can readily assign to subcontractors, assembly work for which shipyards cannot exploit Group Technology. As shown, per a shipyard standard drawing the subcontracted work included mounting each diesel generator on a foundation, attaching some pipe pieces and pipe fittings which may be shipyard furnished, and painting. In order to maintain competition, two other manufacturers' functionally equivalent diesel generators are also registered as shipyard standards and are incorporated in similar standard drawings. The use of such standards minimizes shipyard vendor-drawing approval workloads, shortens delivery times, simplifies purchasing activities, enhances quality and permits great systematization of material management while obtaining competitive prices. Assemblies, as shown, are typical of those for which shipyard buyers would transfer delivery control to field expeditors. Thus subcontractors effect deliveries 'exactly when field expeditors schedule crane availabilities for landing on-block or on-board per production schedules.



A B

FIGURE 11-5: Some shipbuilders make certain Stock materials readily available for assembly work, particularly on-board as shown, for nuts and bolts and gaskets (A) and for U-bolts (B).

A



B

FIGURE 11-6: Shipbuilders who have mastered integrated hull construction, outfitting and painting at first associate cable lengths with specific blocks. That is, a cable length is regarded as a fitting equivalent to a pipe piece designated for on-block outfitting. Cable suppliers deliver cables cut to length, coiled and palletized (A) per shipyards' instructions. Cables are pulled on-block when blocks are upside down (B). Cables ends are then coded or looped and temporarily secured (C). After block turnover and before landing in a building dock, low from the ground staging permits worker access for aligning and fixing cables to their supports (D). After blocks are erected, only the cable ends are pulled into other regions by more difficult conventional methods.

C

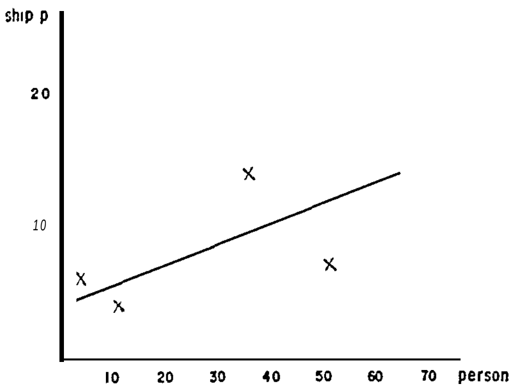
D

FIGURE 11-6 (Continued): Cable which is purchased cut to prescribed lengths and palletized, is classified as Allocated material. If a shipyard elects to cut and palletize in-house, an appropropriate procurement classification could be Stock or Allocated Stock depending upon cable values and quantities required. Conceivably, all three classifications could be used for electric cable at at the same time. Pulling precut electric-cable lengths on-block during the upside-down stage, is a good example of control of work through control of material. Man-hours per lineal feet of cable pulled and lineal feet of cable pulled per unit time become very accurate productivity and progress indicators. Simultaneously, people are working smarter not harder and productivity is enhanced.

APPENDIX A

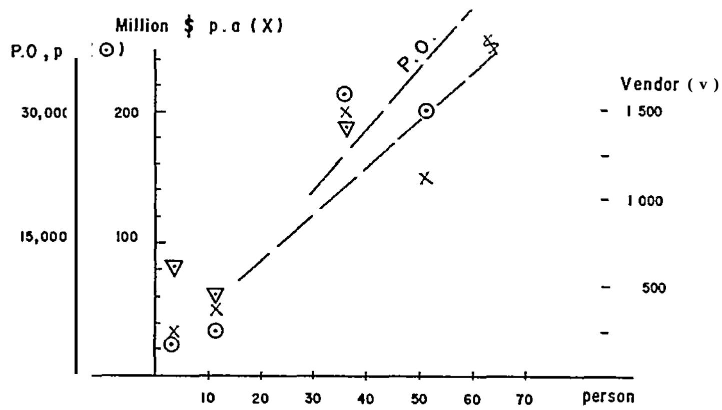
ANALYSIS OF MATERIAL PROCUREMENT PROBLEMS EXPERIENCED IN U.S. SHIPYARDS

(A) Shipyard Activity vs. Personnel Engaged in Procurement



COMMENT: The few answers obtained indicate a rough relationship between the number of building and repair/conversion orders received vs. the nunber of people engaged in purchasing. Repair/conversion was assumed to require 1/10 the people required for building.

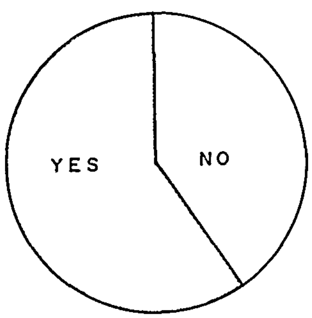
(B) Procurement Activity vs. Personnel Engaged in Procurement



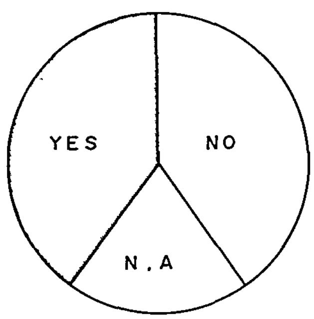
COMMENT: Roughly, the number of purchase orders issued per person per year is estimated to be 700. The total value ordered per person per year is estimated to be $4,000,000.

(C) Procurement Policy

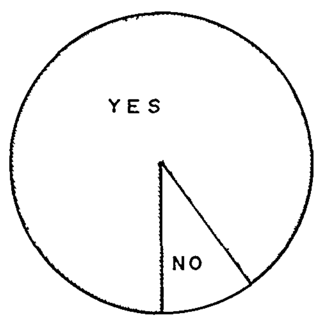
(1) Do You always prepare a budget for materials prior to procurement?



(2) Should a vendor always be selected through open bid?

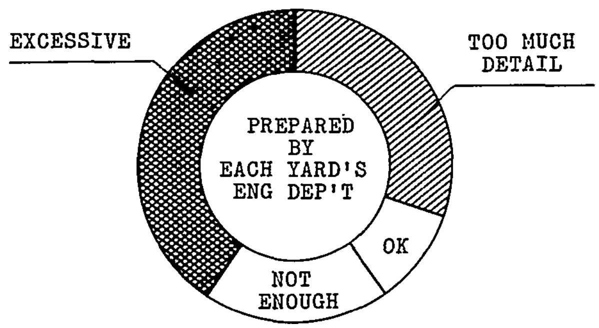


(3) Do you have any designated vendors with whom you have long-term contract agreement on procurement of materials?



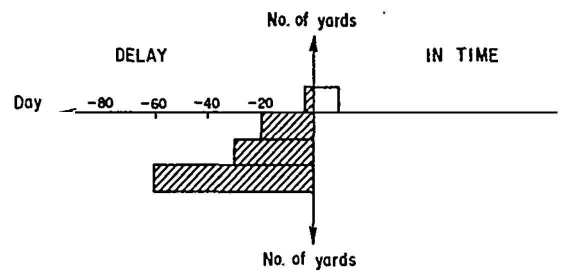
COMMENT: These results show that open bidding is widely practiced, apparently based on strong belief that cheaper prices are always in a shipyard's best interest. The affect of open bidding in driving down prices is not denied. However, the combination of effective material budget and procurement systems would limit the number of bids solicited to just enough of the best qualified suppliers to insure competition. This preferred approach would make shipyards more effective by improving productivity of both their material procurement and production activities.

(D) Preparation of Purchase Order Specifications (POS)



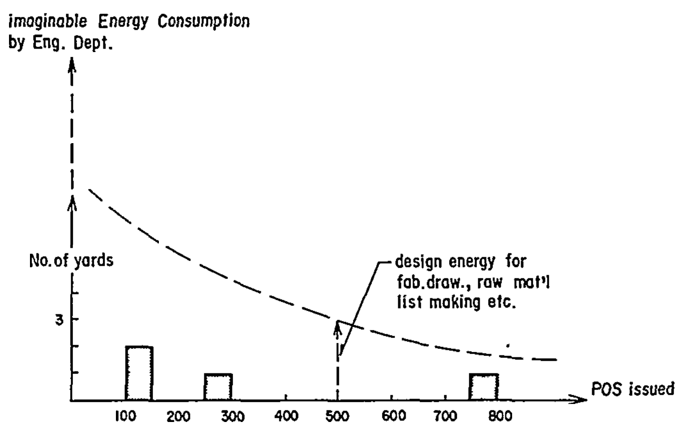
POS Preparation & Content

COMMENT: The majority believed that POS are either excessive or too detailed. However, the results of the inquiry concerning quality, Part (I) herein, indicate that while POS are believed to be excessive and too detailed, material continues to be disqualified because POS are misunderstood by vendors. Instead of focusing on details in POS, for certain needs, sending shipyard personnel to vendors' firms to explain POS would probably be more cost effective.



Timing of Pos

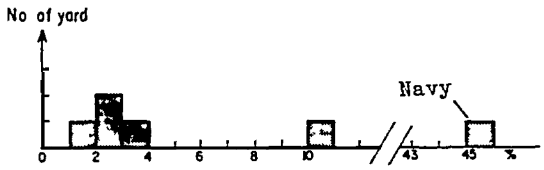
COMMENT: The responses to questions regarding the timeliness of POS indicated that, generally, delays in material deliveries are mainly attributed to delays in engineering.



Average Number of POS Issued Per Ship vs. Imaginable Design Energy

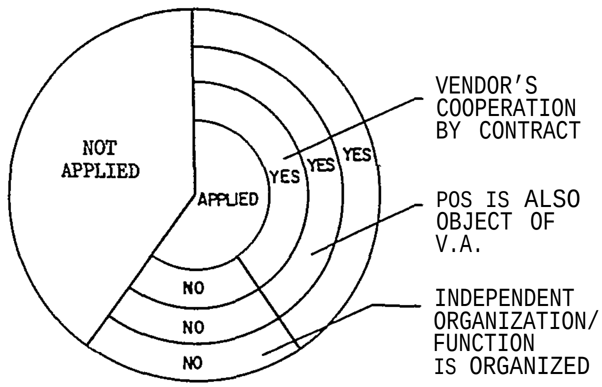
COMMENT: With only one exception, a shipyard which issues a large number of POS relative to others, too much energy is being consumed in preparing fabrication drawings and material lists, i.e., the productivity of engineering is very low.

(E) Owner Designated Manufacturer's (in connection with POS)



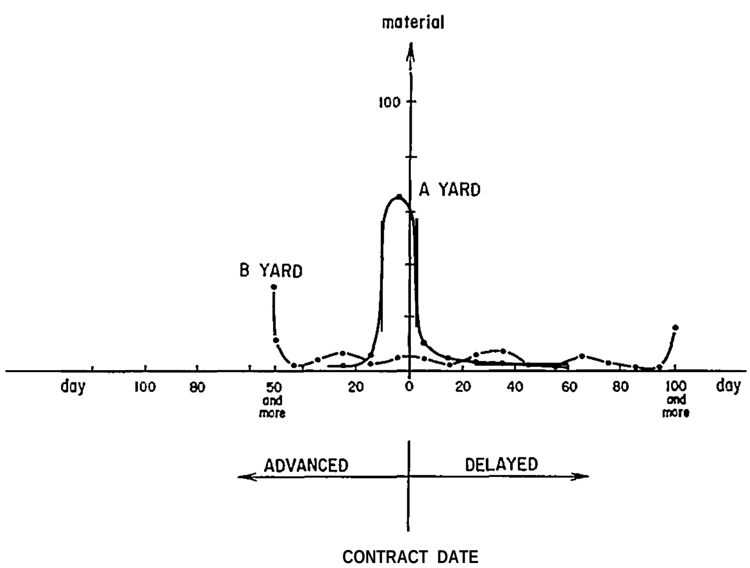
COMMENT: Apart from special cases, e.g., building naval ships, shipbuilders have much freedom to select manufacturers.

(F) Value Analysis/Value Engineering for Material Procurement



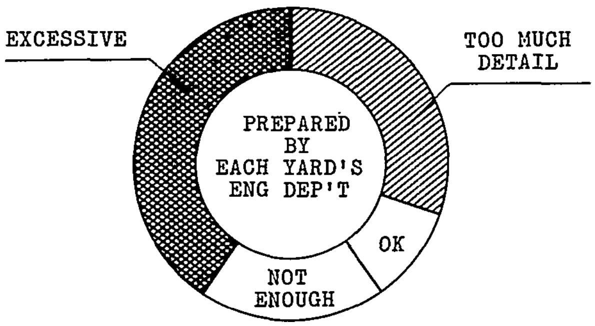
COMMENT: VE is applied by more than half the shipyards. About 40% are especially active.

(G) Delivery Deviation from Contracted Dates



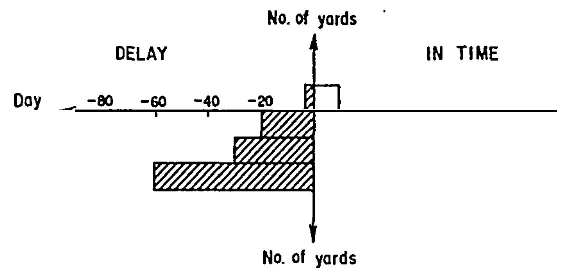
COMMENT: Only two companies responded to the pertinent inquiry. Interestingly, the results that they are obtaining are very different. Yard A shows an ideal distriibution. Yard B should study causes for "advanced" deliveries and causes for delays **and** should determine if some of the former could be applied to the latter in order to obtain a distribution more like that for yard A.

(D) Preparation of Purchase Order Specifications (POS)



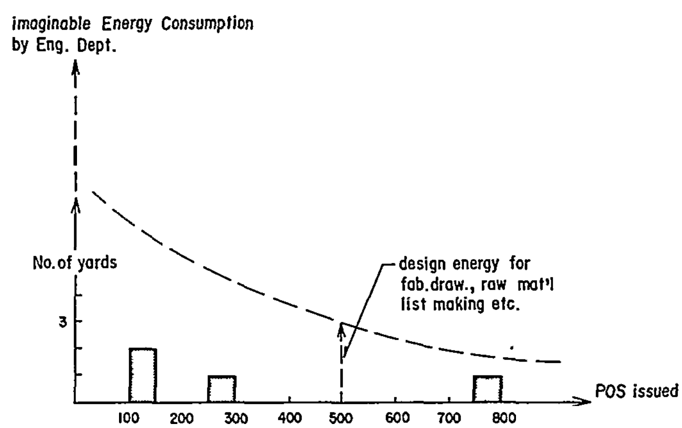
POS Preparation & Content

COMMENT: The majority believed that POS are either excessive or too detailed. However, the results of the inquiry concerning quality, Part (I) herein, indicate that while POS are believed to be excessive and too detailed, material continues to be disqualified because POS are misunderstood by vendors. Instead of focusing on details in POS, for certain needs, sending shipyard personnel to vendors' firms to explain POS would probably be more cost effective.



Timing of Pos

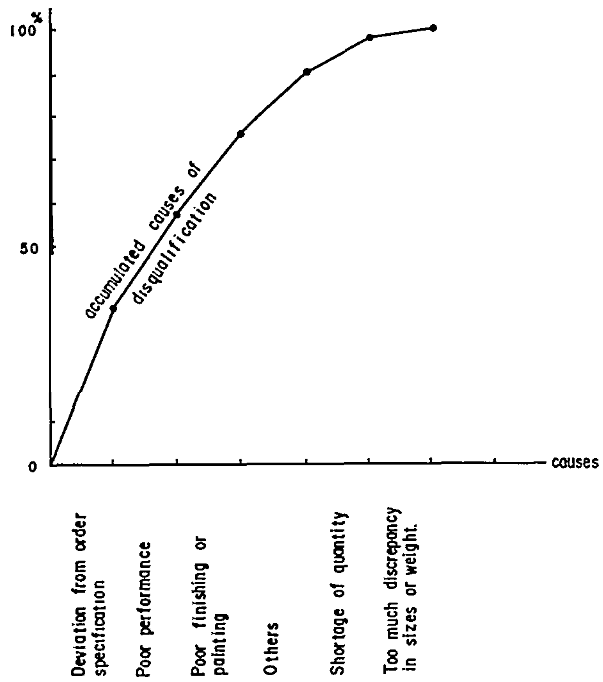
COMMENT: The responses to questions regarding the timeliness of POS indicated that, generally, delays in material deliveries are mainly attributed to delays in engineering.



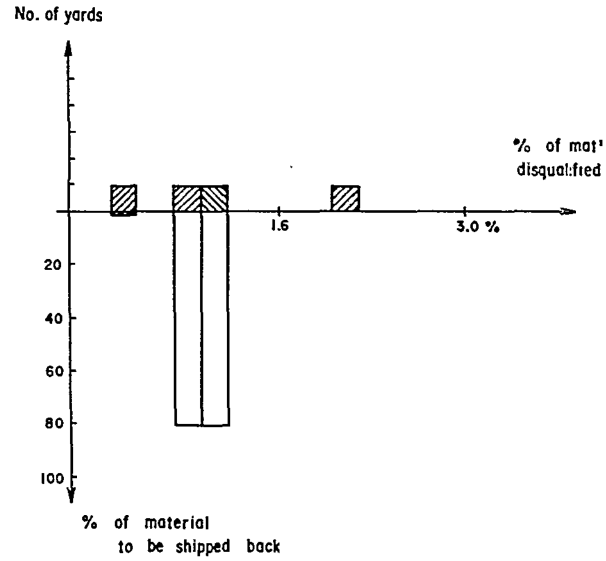
Average Number of POS Issued Per Ship vs. Imaginable Design Energy

COMMENT: With only one exception, *a* shipyard which issues a large number of POS relative to others, too much energy is being consumed in preparing fabrication drawings and material *lists,* i.e., the productivity of engineering is very low.

(I) Quality Control (Receiving Check)



Causes of Disqualification

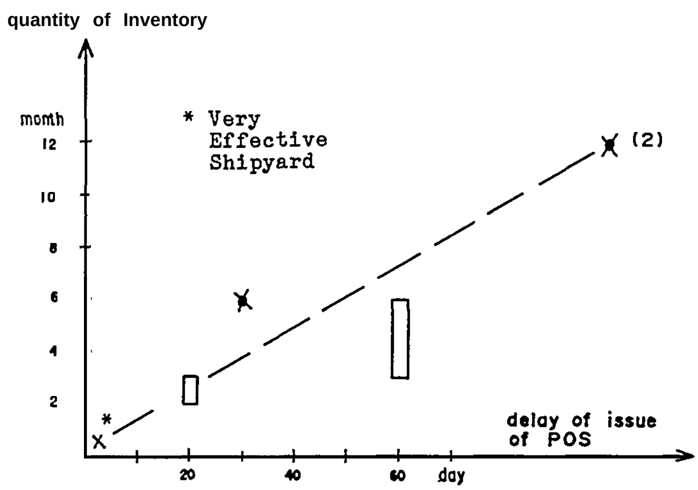


Disqualified Material

COMMENT: This distribution is inconsistent with shipyard replies for Part (D). Probably, the inconsistency is due to different interpretations of POS by shipyards and venders, or carelessness by some vendors. To prevent-such disqualifications the measures noted in Part (D) are reiterated.

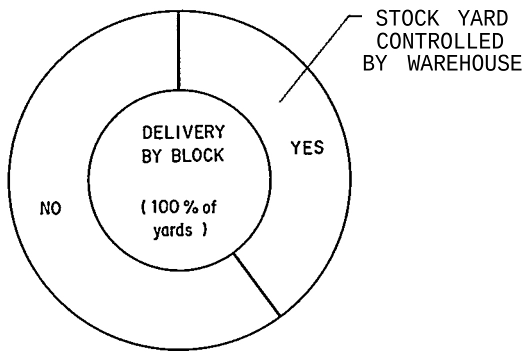
COMMENT: Shipyards which are shipping back disqualified materials should adopt inspection at the concerned vendors' shops in order to avoid deleterious affects on production schedules.

(J) Inventory in Warehouse

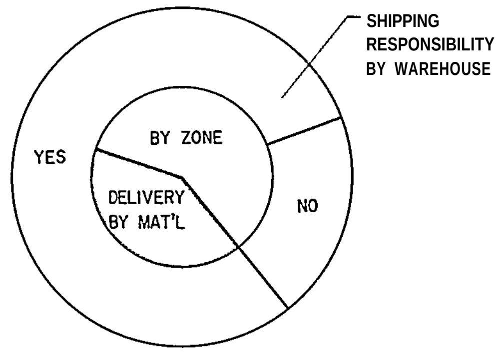


COMMENT: Due to the lack of answers, detecting a trend is difficult. However, the few results as plotted indicate that shipyards which issue POS late, tend to have larger stocks in inventory. Means to minimize inventory are: close review of usage trende, greater emphasia on direct purchase and realistic required dates, relating order dates to minimum lead times required for deliveries and use of meter purchase agreements.

(K) Warehouse Responsibility for Delivering Material



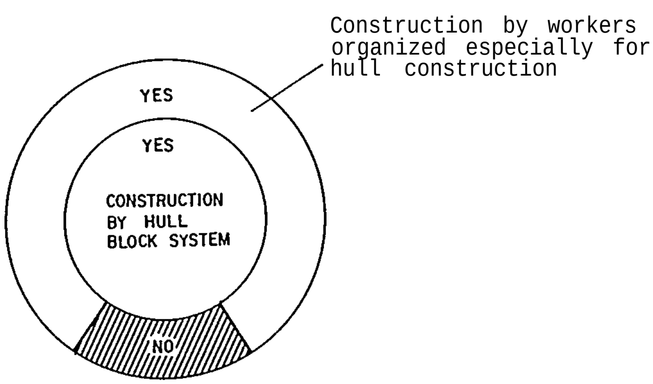
Delivery of Hull Steel



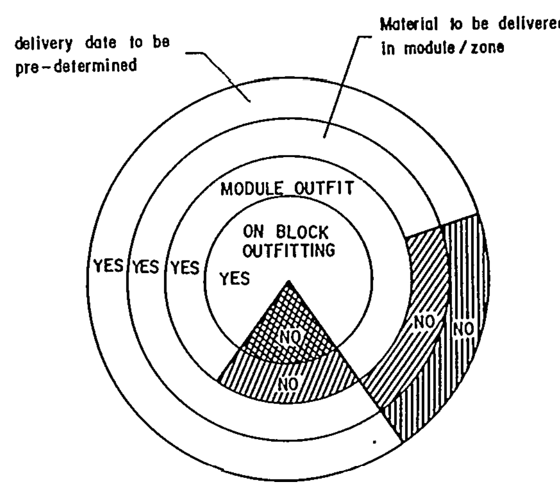
Delivery of Fittings

COMMENT: All shipyards which responded are applying the hull block construction and zone outfitting methods. The difference in control of steel stock is probably due to the layout of facilities or to tradition. The difference in control of fittings is probably due to sending materials through an intermediate collection area as compared to sending them directly to production sites. The best efficiency is obtained when the warehouse is part of the production control organization in order to facilitate direct deliveries to production sites in a manner that enhances production.

(L) Construction of Ship



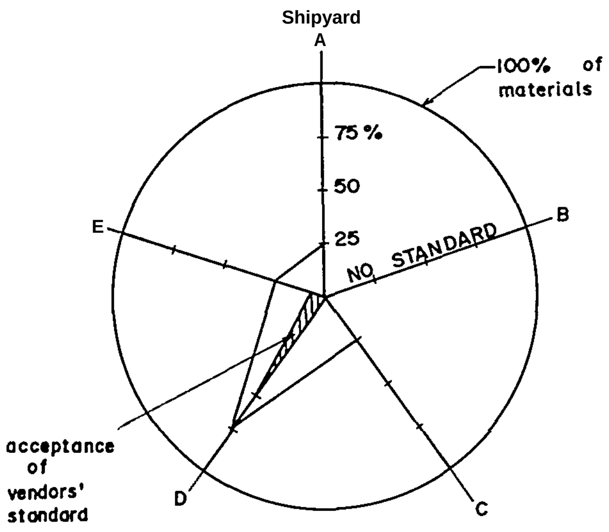
Hull Construction &
Arrangement of Workers



Outfitting

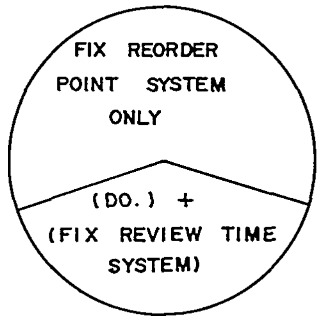
COMMENT: There seems to be no problem in hull construction. As all shipyards advised they are employing the zone outfitting method, they appear to be *not* fully utilizing the concept or have not yet correlated zone outfitting with material handling.

(M) **Material Control**



Standardization of Materials

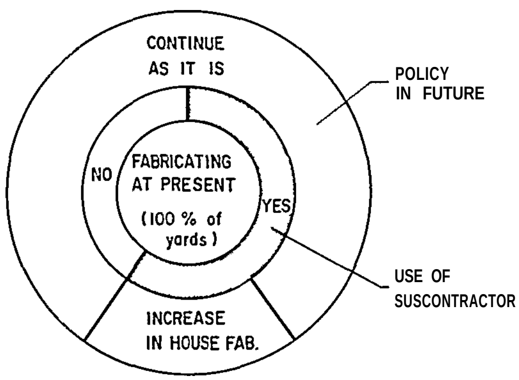
COMMENT: Although a few shipyards are making greater efforts toward standardization, most lack sufficient enough zeal. More standardization effort is required in order to effectively rationalize engineering and material procurement work. In particular, more effort should be applied to certifying vendor catalog items as shipyard standards.



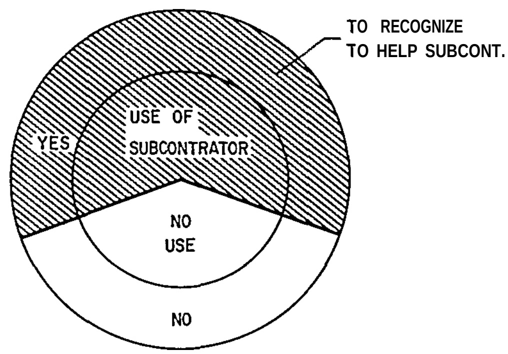
Inventory Control System

COMMENT: For other than allocated (direct) material, quite a few shipyards, almost half, are employing both the Fixed Reorder Point System (for Stock materials) and the more sophisticated Fixed Time Review System (for Allocated Stock materials). Therefore, by further integrating all aspects of material management with production control and employing the Nishijima Ledger as described in the basic text, there are great opportunities to improve productivity through enhanced material control.

(N) Policy for In-house Manufacture of Fittings



Present Condition and
Future Policy for Fabrication



Subcontracting for
Manufacture of Fittings

COMMENT: There is insufficient exploitation of subcontractors. Generally, there is no intention to assign more of the manufacture of fittings to outside sources and only 40% of the shipyards realize the necessity to foster subcontractors. Excuses given are: the yards already have facilities, the trade unions will oppose subcontracting, and subcontracting is more costly. According to the "Distribution and Numbers of Suppliers for Each Production Field", also appended herein, there are many fitting manufacturers and/or subcontractors in many areas of the U.S. In order to become as effective as the world's leading shipyards, managers have to greatly increase their exploitation of subcontractors by first rationalizing their production systems and then addressing real and apparent obstacles.

(0) Problems in Procuring Meterials, Free Comments

(The comments are arranged to contrast the views of shipyards and vendors. Asterisks indicate the numbers of times comments were repeated.)

By Vendors re Shipyards

*** delayed return of approval
** drawings

* POS not detailed enough

** Yards' delivery schedules are too severe or inflexible

* Yards' inspectors do not observe predetermined inspection schedules

* Yards backcharge for problems outside vendors' warranty obligations

By Shipyards re Shipyards

*** slow engineering response to vendors' drawings

* insufficient description in POS

** need to expand standardization

* need to use more commercially available materials

* excessive unplanned material needs

* engineering changes to original POS

* need *to* identify materials earlier

* need to firm specifications at bid stage so that POS can be issued on contract award

* period between contract award and start of construction is too short

* design, material and production efforts are not in the same sequence

* materials lost and damaged by production

By Shipyards Re Vendors

*** vendors fail to keep delivery schedules

** vendor drawing submittal are slow

By Shipyards for owners and Regulators

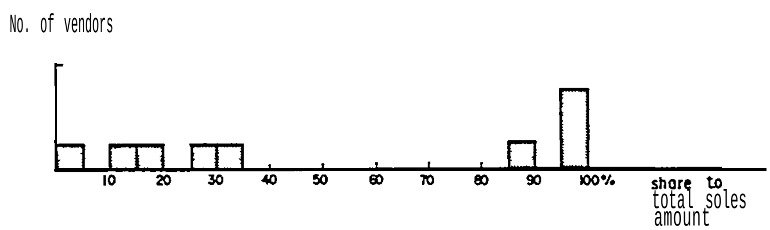
* owner demends after contract award often disrupt procurement schedules and/or material budgets

* regulators slow in approving drawings

APPENDIX B

ANALYSIS OF VENDORS' PROBLEMS WITH U.S. SHIPYARDS

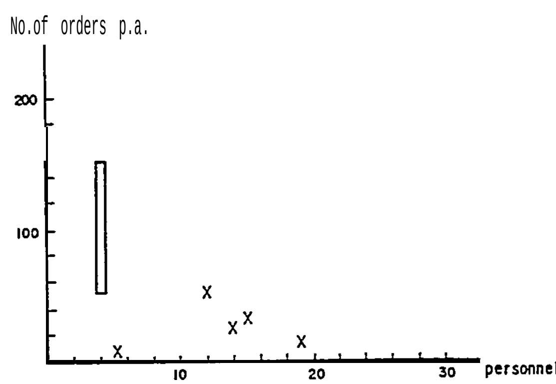
(A) Vendor Activity



Shipbuilding Sales vs. Total Sales

COMMENT: Vendors who replied represent various fields of endeavor. The number of responses was not sufficient to be truly representative. Collectively, the responses yield some hint of the problems that vendors encounter. The vendors who responded have either a very high or very low dependency on the shipbuilding industry. Few have intermediate dependency. However, the answers received do not seem to be biased by dependency.

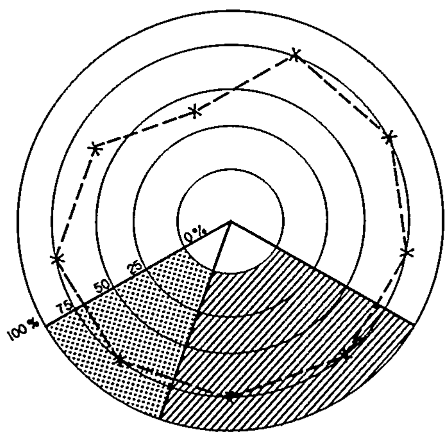
(B) Sales Activity



Sales People vs. Number of Orders Received from Shipyards per Year

COMMENT: Products by the responding vendors have unit prices that range from very expensive so as to require appreciable marketing, to very cheap. This mixture suggests that there is little bias in the answers received.

(c) Grade of POS Issued by Shipyards



Grade for detail:

How many POS are sufficient enough for efficient cost estimating?

25% and less

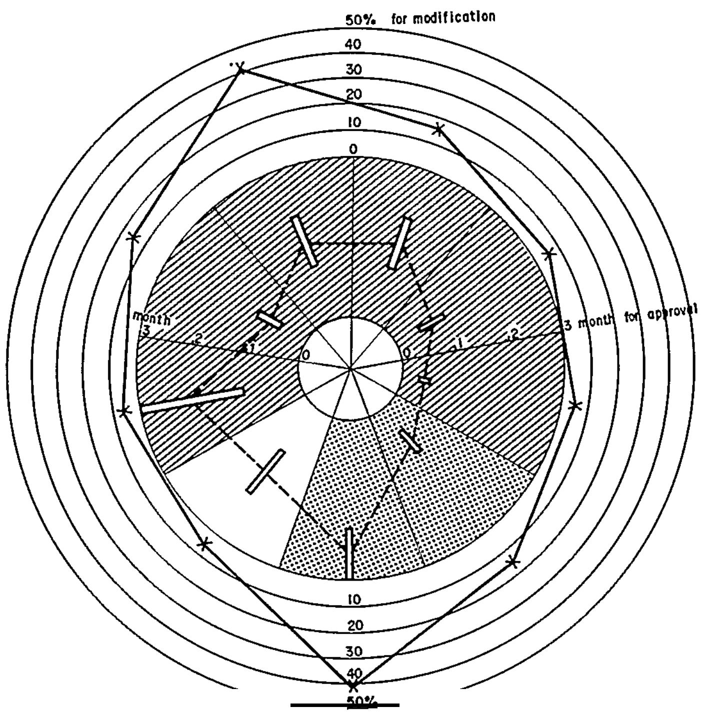
25 ~ 50%

50 ~ 75%

75% and more

Grade for intention (shown by dashed line):

How many POS are judged to be applicable to your products?



Cases of price renegotiation:

50 ~ 75 %

25 ~ 50

25 or less

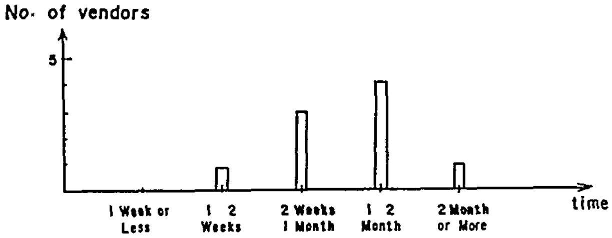
Nil

Periods for drawing approvals (dashed line):

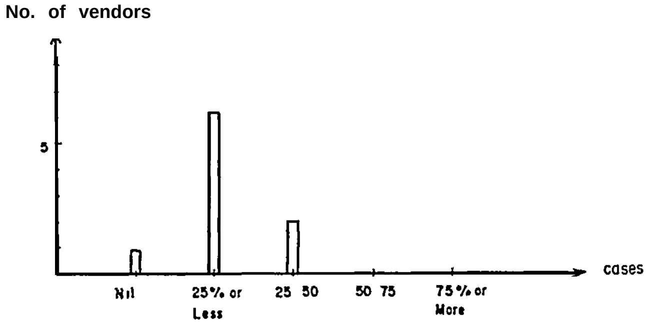
Cases of modification during manufacturing (solid line):

COMMENT: Shipyards' POS, it seems, are technically satisfactory to vendors and the selection of vendors by shipyards seems to be reasonable.

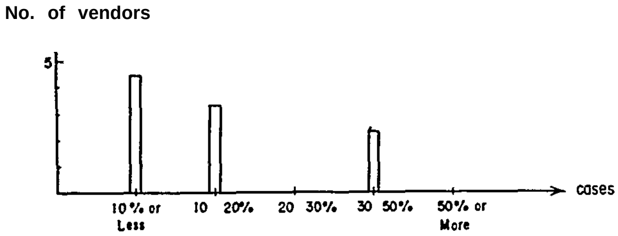
(D) Approval Drawings



Time Required for Shipyards to Approve Drawings



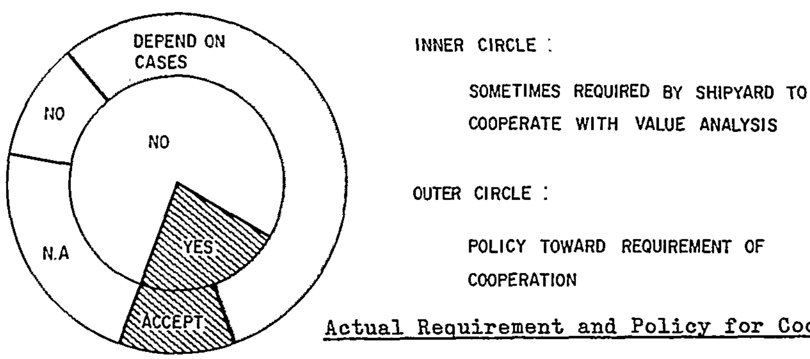
Cases when Price is Renegotiated Due to Shipyards Comments



Cases when Shipyards Require Modifications as Products are Being Manufactured

COMNENT: Shipyards seem to require an average of about two months for approval of vendor drawings. This coincides with shipyard replies. From a material management viewpoint, two months is too long. Quite a few vendors consider renegotiations are necessary after receiving approval drawings and there seems to be some cases where design changes are required by shipyards after vendors manufacturing processes begin. This means that POS were issued without sufficient studies of performance and/or owners requirements. At the same time, shipyard purchasing people think that shipyard engineers produce POS that are too detailed. Therefore, the significance and role of POS should be reevaluated. A policy should be issued concerning important matters to be included, supplemented by other necessary guidance.

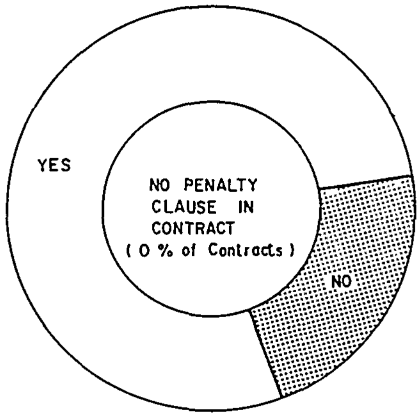
(E) Cooperation or Value Engineering/Value Analysis



Actual Requirement and Policy for Cooperation

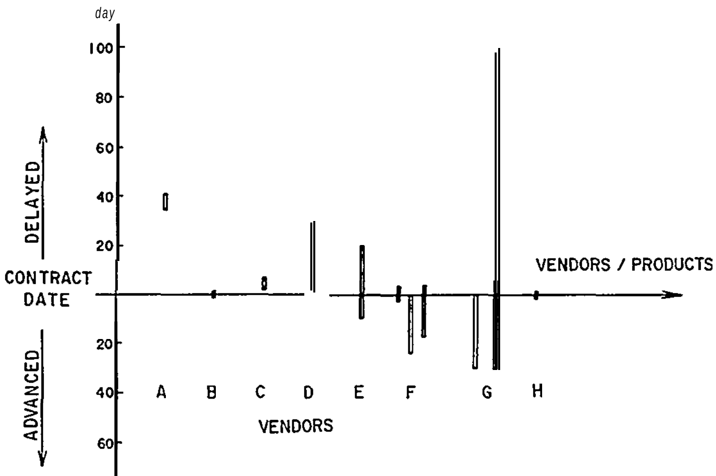
COMMENT: More than half of the vendors who responded indicated willingness to cooperate with shipyards for VE/VA.

(F) Delivery Control

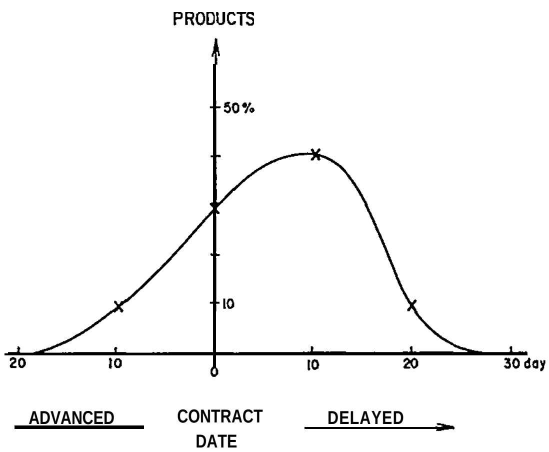


Contract Clause and Effort to Keep Contract Delivery Dates

"YES" refers to those who make special effort to adjust their schedules-or to assign extra employees. "NO" refers to those who do not.



Delivery Date Variation Record in 1982

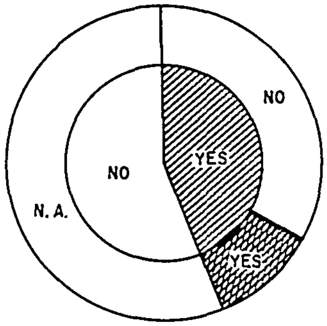


Typical Delivery Date Record

COMMENT: Most vendors try to observe contract delivery dates whether or not penalty clauses exist. Regardless of their efforts, records show that there are still considerable delays due to vendor management problems. Probably, in many cases, sales people have disregarded their own firms' production requirements for meeting shipyard delivery dates. Therefore, shipyards must consider sufficient lead time based on inquiries into vendors' production schedules. Comments which *were* volunteered by vendors include:

- o We try to deliver as needed by shipyards in a *manner* that minimizes handling and storage problems.
- o Deliveries to shipyards *are* often delayed-because our material suppliers do not meet their promised deliveries.
- o Ship construction schedules usually *require* performance; that-exceed our capabilities.
- o Our policy is to meet required delivery dates.

(G) Quality Control

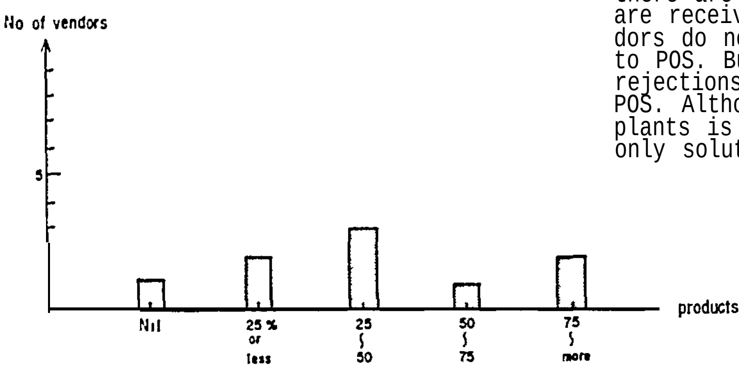


INNER CIRCLE: PROBLEMS POINTED OUT BY SHIPYARD INSPECTORS

OUTER CIRCLE: PROBLEMS RELATING TO POS

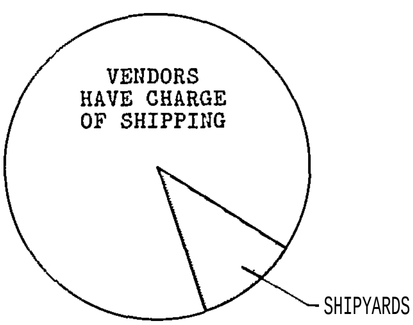
Problems in Quality Control

COMMENT: Most vendors advise that they shop test products without shipyard inspectors in attendance. This coincides with answers from shipyards. Yet, there are quite a few rejections after products are received in shipyards. The answers from vendors do not indicate that rejections are related to POS. But, the answers from shipyards attribute rejections to vendors' lack of understanding of POS. Although omitting inspections at vendors' plants is desireable, such inspections may be the only solution if rejections occur repeatedly.

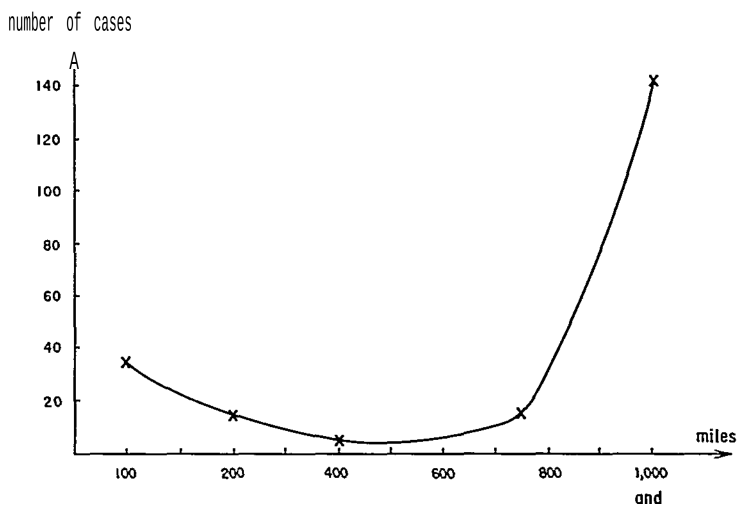


Products Shipped with Only Inspection by Vendor

(H) Shipping



Responsibility for Shipping to Shipyards

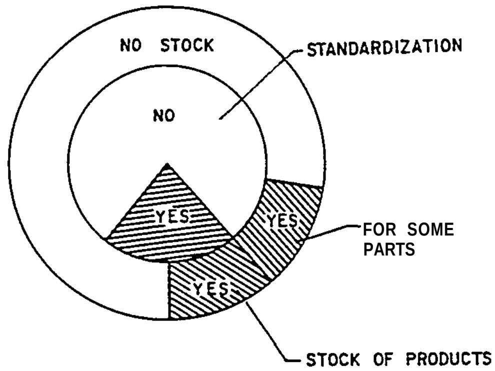


Approximate Shipping Distance

(I) Service Work at Shipyards

COMMENT: There appear to be no problems in this area. When asked, "When required, do you send your service people to shipyards for installation or running tests of your products?, 100% replied "Yes". When asked, "Is it normal for you to finish your services within the periods designated by shipyards?, 100% replied "Yes".

(J) Standardization



Standardization and Stocks of Products

COMMENT: In general, many vendors lack standard products. This fact has been, and still is, a headache for shipyard managers as many times it is more important to have timely arrival of vendor furnished information (VFI) than it is to have the actual product. Also, custom products require longer lead times and in many instances prevent reduction of the period between award of a shipbuilding contract and ship delivery. Adoption of standard products, particularly adoption of vendors regular catalog products as shipyard standards, should be accelerated.

(K) Miscellaneous Questions

When asked about policy *re* sales to shipyards, 100% of the vendors advise that they would like to increase sales to shipyards.

When asked to identify vendor/shipbuilder problems that could be resolved or diminished through discussion:

approximately 10% advised POS are not detailed enough,
" 60% noted delays in return of approval drawings,
" 10% felt that shipyard inspectors do not observe predetermined inspection schedules,
" 20% said that shipyards delivery schedules are too strict or too inflexible.

No vendors thought that shipyards would be reluctant to accept vendor standards.

When asked about the merits of dealing with shipyards:

approximately 10% advised that-profits were higher than with other customers,
10% felt that shipyards offered attractive payment terms,
" 30% thought it gave them high credibility,
" 40% said that shipyards provided good workloads,
" 40% advised that it was opportunity to diversify.

APPENDIX C

MATERIAL LEAD TIME

Insufficient data was submitted in response to questions concerning scheduled and actual milestones, e.g., POS issue, PO issue, receipt of vendors' approval drawings, etc. through actual delivery to a shipyard production site, to justify anything more than some brief statements.

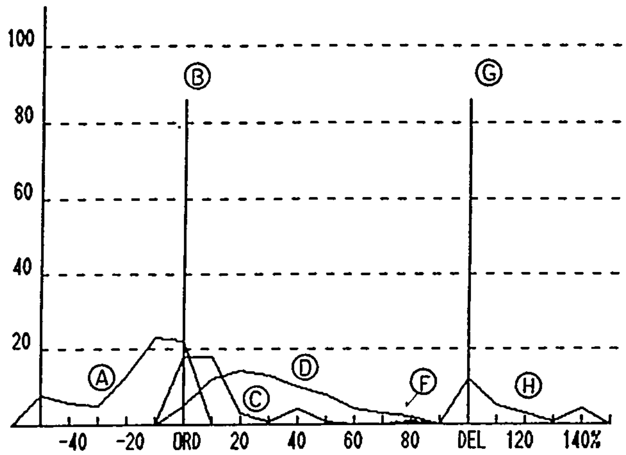
Comparison of the few answers from both shipyards and vendors indicate that material deliveries are usually affected by some technical requirements, e.g., material type, quality, and capacity, and by market factors such as a vendors' backlogs.

In some cases, shipyards and vendors' inputs coincided. For example, vendors' lead times for a main boiler were approximately 12 months, for an auxiliary boiler approximately 11 months and for a waste-heat boiler approximately 10 months, while shipyards reported 9 months minimum and 18 months maximum for an average of 14 months.

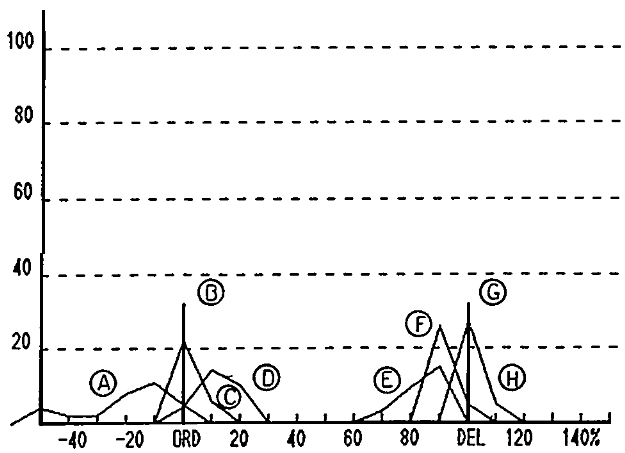
However, for deck machinery there were great differences. Vendors reported 5-6 months lead time and the shipyards reported an average of 17 months for steering gears and 12 months minimum for windlasses. The vendors' lead times for generator sets at 9 months differ significantly from the shipyards reported average of 14 months (10 months minimum and 18 months maximum).

Compared to experiences in Japan, lead times in the U.S. are long, e.g.:

	U.S.	In Japan
Average lead time	20.5 months	6.4 months
Submittal date of plans for approval after issue of PO	2.5 months	15 days
Return of approval plans after their receipt	2.5 months	35 days



ACCUMULATED RECORDS OF ALL U.S. SHIPYARDS



RECORD OF VERY EFFECTIVE SHIPYARD IN JAPAN

A - Issue POS
B - Issue PO
C - Receipt of Mfg's Drawing for Approval
D - Approval of Mfg's Drawing

E – Inspection at Mfg's Shop
F – Shipment
G – Receipt at Shipyard
H – Issue t0 Shop

These plots show the elapsed time in percentages of milestones against the total period from material ordered (ORD) to delivery (DEL) and by depicting the accumulated number of cases as a curve. Thus, the time for material ordering and/or material delivery includes all of the items used in this graph.

From these graphs it can be seen that plots of the times of receipt of manufacturers' approval drawings and the times for approval of manufacturers drawings, do not show peaks as is usually the case for the most effective yards in Japan. This is another indication of longer lead times, more change orders during production, etc., in U.S. yards.

APPENDIX D

DISTRIBUTION OF MATERIAL MANUFACTURERS IN THE U.S.

	AL	AR	AZ	CA	CO	CT	DE	FL	GA	IA	IL	IN	KS	KY	LA	MA
Prim. mat.	1			1	1	1					2	1				
Cast. & forging									2							
Paint, Corrosion cent				9		1	1		2		2			2	2	1
Rig. & fitting				2		1		2		1	5	1	1			1
Outfitting & fab. prod.				6	1	1	1	3	1		3	1			4	5
Deck machinery				1			1								6	2
Living quarter equip.				7		1		3			5				3	
Life saving, signal	1			4				2			1				1	
Piping, pipe fitting, etc	3			9		2	3				2	1		1		1
Insulation				4	1	2			2		1				1	
Main eng.				2		1		1								
Boiler				4		3					1		1		1	
Shaft & prop.								1			3					1
Aux math.		1		14		6	1	2		2	14	4	2		3	7
Gen. and motor						2					1					
Lighting				2												2
Nav. & comm. equip.				9				1	1		2		1		2	7
Elect. eq. and ace.				2	1	5		1			3	1				4
Control sys. & equip.			1	16	1	5		5		1	12		1	1	6	9
Aux. mat				5		1				1	2			2		2
Total	5	1	1	97	5	32	7	21	8	5	59	9	6	6	29	42

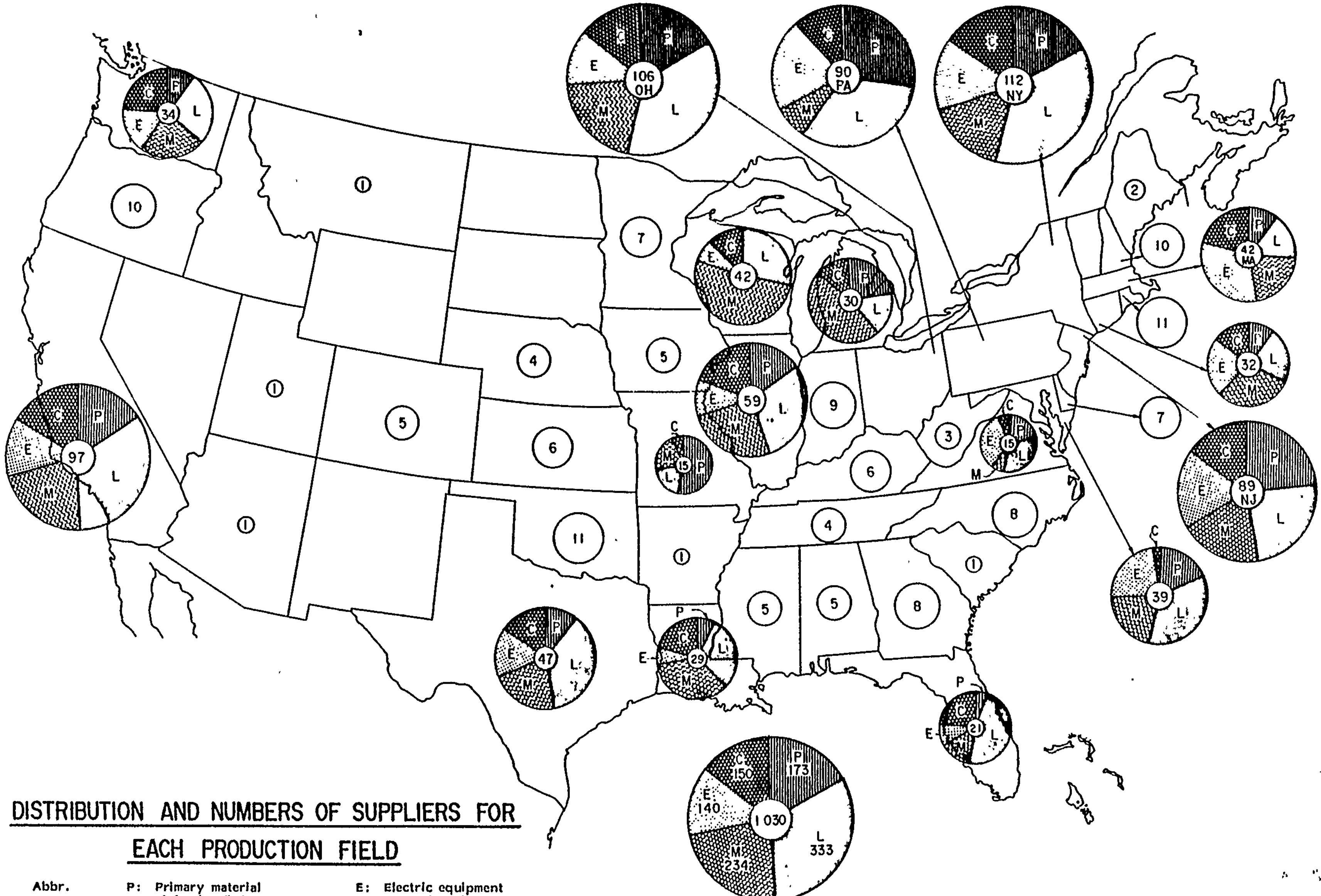
Numbers and Types of Manufacturers - Alabama to Massachusetts

	MD	ME	MI	MN	MO	MS	MT	NC	NE	NH	NJ	NY	OH	OK	OR	PA
Prim. mat.	2		1		1						1	3	1			7
Cast. & forging											1	3	1			5
Paint, corrosion cent	5				7						8	6	7			3
Rig. & fitting					2			3			2	9	2			5
Outfitting & fab. prod.	6		1	1	1	3				2	6	12	10		5	10
Deck machinery	2		5	1	2	1		1	1		2	4	6	1		9
Living quarter equip.	5							1		1	5	8	11	2	1	4
Life saving, signal	1			1							3	1	2			1
Piping, pipe fitting, etc	2		4	2				1	1		4	8	14	3	1	7
Insulation								1			1	3				4
Main eng.												0	1			2
Boiler			2								1	3	2	1		2
Shaft & prop.			2									1				1
Aux math.	6		7	2	1		1				14	11	13	1	1	6
Gen. and motor											1	1	1			0
Lighting											3	1	2			3
Nav. & comm. equip.	8								2	4	4	8	2			3
Elect. eq. and ace.	1	1				1					9	7	7	1		
Control sys. & equip.	1	1	4		1					1	14	17	15	2	1	10
Aux. mat			4					1		2	10	6	9		1	8
Total	39	2	30	7	15	5	1	8	4	10	89	112	106	11	10	90

Numbers and Types of Manufacturers - Maryland to Pennsylvania

	RI	SC	TN	TX	UT	VA	WA	WI	WV
Prim. mat.	2			1		2			1
Cast. & forging									
Paint, corrosion cont			1	2			1		
Rig. & fitting			1	2			1		
Outfitting & fab. prod.	2		1	4		2	4	4	
Deck machinery				3			4	7	
Living quarter equip.	1			5		2	1	3	
Life saving, signal				1			2		
Piping, pipe fitting, etc	1			5		1		5	
Insulation							1		
Main eng.									
Boiler							1	1	
Shaft & prop.						1	2		1
Aux mach.	1			7		1	3	14	
Gen. and motor								1	
Lighting				3		1		2	
Nav. & comm. equip.	2			3		4	6		
Elect. eq. and acc.				1					
Control sys. & equip.	1	1		8		1	8	5	1
Aux. mat	1		1	2	1				
Total	11	1	4	47	1	15	34	42	3

Numbers and Types of Manufacturers - Rhode Island to West Virginia

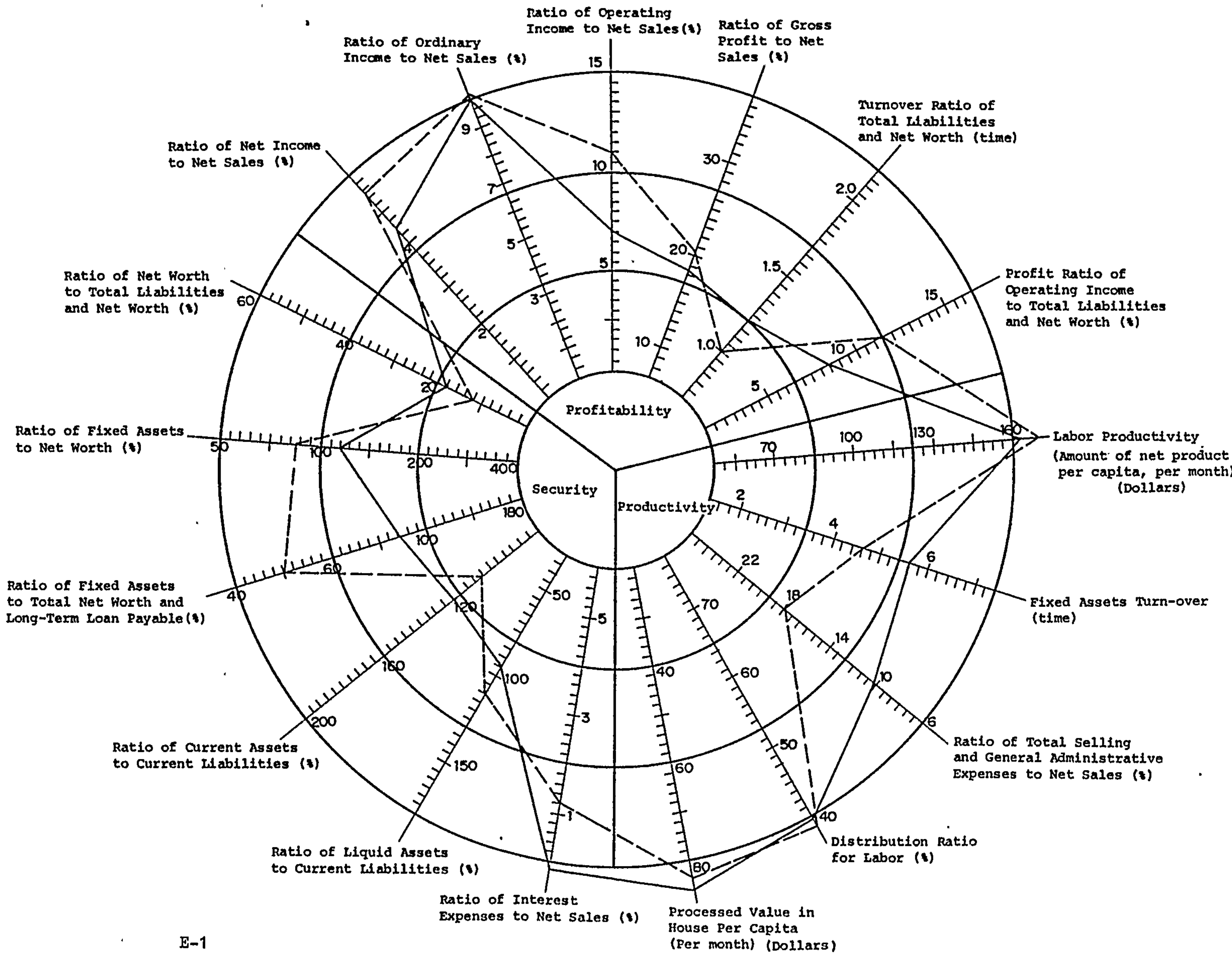


DISTRIBUTION AND NUMBERS OF SUPPLIERS FOR EACH PRODUCTION FIELD

Abbr.

- P: Primary material
- L: Living/outfitting
- M: Machinery
- E: Electric equipment
- C: Control equipment

GRAND TOTAL : 41 STATES



Ratio of Operating Income to Net Sales (%)
Ratio of Gross Profit to Net Sales (%)
Ratio of Ordinary Income to Net Sales (%)
Turnover Ratio of Total Liabilities and Net Worth (time)
Ratio of Net Income to Net Sales (%)
Profit Ratio of Operating Income to Total Liabilities and Net Worth (%)
Ratio of Net Worth to Total Liabilities and Net Worth (%)
Profitability
Ratio of Fixed Assets to Net Worth (%)
Labor Productivity (Amount of net product per capita, per month) (Dollars)
Security
Productivity
Ratio of Fixed Assets to Total Net Worth and Long-Term Loan Payable (%)
Fixed Assets Turn-over (time)
Ratio of Current Assets to Current Liabilities (%)
Ratio of Total Selling and General Administrative Expenses to Net Sales (%)
Ratio of Liquid Assets to Current Liabilities (%)
Distribution Ratio for Labor (%)
Ratio of Interest Expenses to Net Sales (%)
Processed Value in House Per Capita (Per month) (Dollars)

E-1

Balance Sheet

(Dollars)

		Account Titles	Code	As of (A)	%	As of (B)	%	(B) - (A)	$(\frac{B}{A})$(%)
Assets	Current Assets	Cash and Deposits							
		Notes Receivable-Trade							
		Accounts Receivable-Trade							
		Accounts Receivable-Non Trade							
		Finished Goods							
		Raw Materials • Supplies							
		Works in Process							
		Loans							
		Advance Payments							
		Securities							
		Prepaid Expenses							
		Other Current Assets							
		Less-Allowance for Coubtful Accounts							
	Total Current Assets								
	Fixed Assets	Buildings and Structures							
		Machinery and Equipment							
		Cars and Other Land Delivery Equipment							
		Tools, Furniture and Fixture							
		Other Tangible Fixed Assets							
		Land							
		Construction in Process							
		Intangible Fixed Assets							
		Investments, etc.							
	Total Fixed Assets								
	Deferred Assets								
Total Assets					100		100		
Liabilities and Share Holders' Equity	Current Liabilities	Notes Payable-Trade							
		Accounts Payable-Trade							
		Accounts Payable-Other							
		Short-Term Loans Repayable							
		Current Instalments of Long-Term Debt							
		Advances Received							
		Reserve for Bonus							
		Reserve for Taxes							
		Accrued Expenses							
		Deposits Received							
		Other Current Liabilities							
	Total Current Liabilities								
	Fixed Liabilities	Long-Term Loans Repayable							
		Reserve for Retirement Allowances							
		Other Fixed Liabilities							
	Total Fixed Liabilities								
	Specific Reserves								
	Share Holders' Equity	Capital Stock							
		Legal Surplus							
		Retained Earnings							
		Retained Earnings Brought Forward							
		Unappropriated Retained Earnings							
	Total Share Holders' Equity								
	Total Liabilities and Share Holders' Equity				100		100		
Note Receivable Discount									
Accumulated Depreciation									

Income Statement

(Dollars)

		Accounts Titles	Code	Year ended (A)	%	Year ended (B)	%	(B) - (A)	$(\frac{B}{A})$ (%)
Operating Income	Sales	Net Sales							
		Total Sales			100		100		
	Cost of Sales	Finished Goods Inventory at Begining							
		Cost of Goods Purchased							
		Cost of Products Mfd for the Period							
		Finished Goods Inventory at End							
		Total Cost of Sales							
		Gross Profit on Sales							
	Selling and General Administrative Expenses	Directors' Salaries							
		Employees' Salaries and Allowances							
		Welfare Expenses							
		Retirement Allowances							
		Stationary and Supplies							
		Depreciation Expenses							
		Rent and Repair Expenses							
		Insurance							
		Light and Power							
		Taxes and Public Dues							
		Selling Freight							
		Traveling Expenses, Carfare and Postage							
		Entertainment							
		Advertizing Expenses							
		Commission							
		Other Expenses							
		Total Sell. and Gen. Admin. Expenses							
		Operating Income							
Non-Operating Income		Interest and Discounts Earned							
		Dividends Earned							
		Other Revenues							
		Total Non-Operating Revenues							
		Interest and Discount Expenses							
		Other Expenses							
		Total Non-Operating Expenses							
		Ordinary Income							
Extraordinary Income		Profits on Disposal of Fixed Assets							
		Reversal of Specific Reserves							
		Others							
		Total Extraordinary Profits							
		Losses on Disposal of Fixed Assets							
		Provision of Specific Reserves							
		Others							
		Total Extraordinary Losses							
		Net Income Before Taxes							
		Provision of Reserve for Taxes							
		Net Income							
		Retained Earnings Brought Forward							
		Unappropriated Retained Earnings							

Statement for Manufacturing Cost

(Dollars)

			Account Titles	Code	Year Ended (A)	%	Year Ended (B)	%	(B) - (A)	$(\frac{B}{A})$ (%)
Manufacturing Cost	Direct Cost	Material Cost	Inventory at Begin. of the Period							
			Purchase for the Period							
			Inventory at End of Period							
			Total of Material Cost							
			Sub-Contracting							
			Labor Cost							
			Total Direct Cost							
	Indirect Cost		Indirect Material Cost							
			Indirect Labor Cost							
		Factory Expenses	Welfare Expenses							
			Depreciation Expenses							
			Rent and Repair Expenses							
			Insurance							
			Light and Power							
			Traveling Expenses, Carfare and Postage							
			Taxes and Public Dues							
			Retirement Allowances							
			Other Expenses							
			Total Factory Expenses							
			Total Indirect Cost							
			Gross Manufacturing Cost			100		100		
			Works in Process Inventory at Begin.							
			Works in Process Inventory at End							
			Cost of Products Manufactured							

Statement of Appropriations

(Dollars)

	Account Titles	Code	Year Ended (A)	%	Year Ended (B)	%	(B) - (A)	$(\frac{B}{A})$ (%)
Unappro-priated	Retained Earnings Brought Forward							
	Net Income							
Appropriations	Legal Retained Earnings							
	Voluntary Reserve							
	Dividends							
	Directors' Bonuses							
	Retained Earnings Carried Forward							

Number of Directors and Employees

(Persons)

		Items	Code	Year Ended (A)	%	Year Ended (B)	%	(B) - (A)	$(\frac{B}{A})$ (%)
		Directors							
Employees		Clerk							
		Sales							
		Designer, Engineer							
	Factory	Indirect Labor							
		Direct Labor							
		Temporary							
		Odd-Jobber							
		Total							

Business-Index Analysis Table

	Items	Formula		Year ended	Year ended	Tendency	Standard
Profitability	Profit Ratio of OP.I to T.L. & N.W.	$\frac{\text{(OP.I)}}{\text{(T.L. \& N.W.)}} \times 100$	%				
	Turnover Ratio of T.L. and N.W.	$\frac{\text{(N.S.)}}{\text{(T.L. \& N.W.)}}$	time				
	Ratio of G.P. to N.S.	$\frac{\text{(G.P.)}}{\text{(N.S.)}} \times 100$	%				
	Ratio of OP.I to N.S.	$\frac{\text{(OP.I.)}}{\text{(N.S.)}} \times 100$	%				
	Ratio of Ord.I. to N.S.	$\frac{\text{(Ord.I)}}{\text{(N.S.)}} \times 100$	%				
	Ratio of N.I to N.S.	$\frac{\text{(N.I.)}}{\text{(N.S.)}} \times 100$	%				
Security	Ratio of N.W. to T.L. and N.W.	$\frac{\text{(N.W.)}}{\text{(T.L. \& N.W.)}} \times 100$	%				
	Ratio of F.A. to N.W.	$\frac{\text{(F.A.)}}{\text{(N.W.)}} \times 100$	%				
	Ratio of F.A. to T.N.W. & L.T.L.P.	$\frac{\text{(F.A.)}}{\text{(T.N.W)+(L.T.L.P)}} \times 100$	%				
	Ratio of C.A. to C.L.	$\frac{\text{(C.A.)}}{\text{(C.L.)}} \times 100$	%				
	Ratio of L.A. to C.L.	$\frac{\text{(L.A.)}}{\text{(C.L.)}} \times 100$	%				
	Ratio of I.E to N.S.	$\frac{\text{(I.E.)}}{\text{(N.S.)}} \times 100$	%				
	Ratio of L.P. to T.L. and N.W.	$\frac{\text{(L.P.)}}{\text{(T.L. \& N.W.)}} \times 100$	%				
Productivity	P.V. in House per Capita per Month	$\frac{\text{(P.V.)}}{\text{(No. of Employees)}} \div 12$	$				
	Distribution Ratio for Labor	$\frac{\text{(P.E.)}}{\text{(P.V.)}} \times 100$	%				
	Ratio of T.S. & G.A.E. Expenses to N.S.	$\frac{\text{(T.S. \& G.A.E.)}}{\text{(N.S.)}} \times 100$	%				
	Fixed Assets Turnover	$\frac{\text{(N.S.)}}{\text{(F.A.)}}$	time				
	Labor Productivity (per month)	$\frac{\text{(N.P.)}}{\text{(No. of Employees)}} \div 12$	$				
	Efficiency of Investment on Equipment(Machinery)	$\frac{\text{(P.V.)}}{\text{(Amount of Equip.)}}$	time				
Rate of Growth	Ratio of N.S.I.	$\frac{\text{(N.S.I.)}}{\text{(N.S. of Previous Period)}} \times 100$	%				
	Ratio of T.L. & N.W.I.	$\frac{\text{(T.L. \& N.W.I)}}{\text{(T.L. \& N.W. of Previous Period)}} \times 100$	%				
Others	Average Personnel Expenses per Capita per Month	$\frac{\text{(P.E.)}}{\text{(No. of Employees)}} \div 12$	$				
	Amount of Equip. per Capita	$\frac{\text{(Amount of Equip.)}}{\text{(No. of Employees)}}$	$				

NOTE: Legend for abbreviations is on Page E-6.

Items	Code	Year Ended (A)	Year Ended (B)	(B) - (A)	$(\frac{B}{A})$ (%)
Nat Sales					
Amount of Net Product					
Processed Value in House					

LEGEND: L.A. = liquid assets = cash end deposits + notes receivable-trade + accoonts receivable-trade

I.E. = interest expenses = interest and discount expenses - interest and discount earned

L.P. = loan payable = short-term loan payable + long-term loan payable

N.P. = amount of net product = net sales - finished goods and work in-process inventory at the beginning of the period + inventory at the end of the period

P .V. = net product - cost of goods purchased - direct and indirect material cost - consumables and energy cost - subcontracting cost

P.E. = personnel expenses = employee salaries and allowances + direct and indirect labor cost + welfare expenses + retirement and allowances

N.S. I. = net sales increase = net sales - net sales of previous period

T.L. & N.W.I. = Total liabilities and net worth increase = total liabilities and net worth - (T.L. & N.W.I.) of previous period

OP.I. = operating income

N.W. = net worth

C.L. = current assets

G.P. = gross profit

F.A. = fixed, assets

C.L. = current liabilities

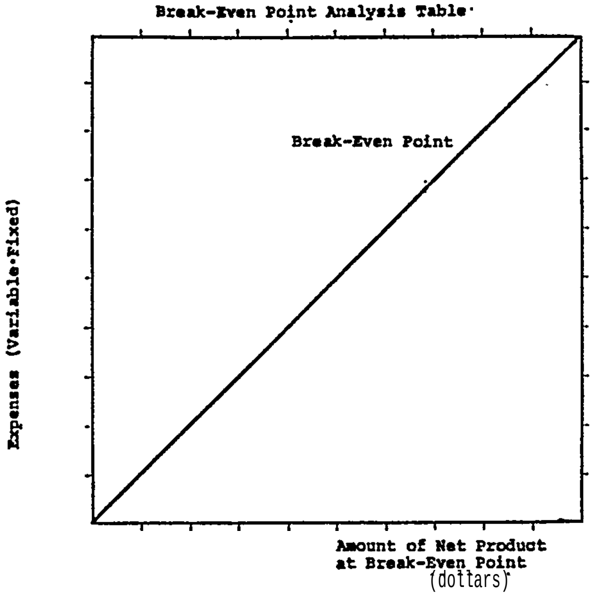
Ord.I. = ordinary income

N.I. . net income

L. T.L.P. = long-term loan payable

T.S. & G.A.E. . total selling and general administrative expenses

Break-Even Point Analysis Table



Items		Year Ended (A)	Year Ended (B)	(B) - (A)	$(\frac{B}{A})$ (%)
S : Amount of Net Product (Net Sales ± Inventory)	$				
V : Variable Expenses [(N.P) - (P.V)]	$				
F : Fixed Expenses [(P.V) - Ordinary Income]	$				
G : (P.V)	$				
Ratio of Variable Expenses to (N.P) (V/S x 100)	%				
Ratio of Fixed Expenses to (N.P) (F/S x 100)	%				
g : Ratio of (P.V) to (N.P) (G/S x 100)	%				
A : (N.P) at Break-Even Point (F/g x 100)	$				
a : Ratio of Break-Even Point (A/S x 100)	%				
Ratio of Operation's Security (100 - a)	%				

VENDOR SURVEY SHEET

Section in Charge	made out		review		review		review		review	
	Manager	Staff	M	S	M	S	M	S	M	S
Name of Company									Vendor's Code	

OUTLINES

		TEL
Address		
Head Office		
Dept. & Person in Charge for Our Company		
"		
"		
"		
Overseas Office		

Large Share-holder	Share (%)	Main Bank	Name of Re-presentative		
			Capital	dollar	dollar
			Established	Month Year	Month of settlement
			Member of Business Group:		Listed on market Non

	Division	1982	1983	1984	1985	1986
Total No. of Employees	Business & sales					
	Others					
	Total	Person	P	P	P	P
Average Salary						
Average age						
Average serving years						

Labour union	Yes	No	Upper organization

Technical cooperation period yr/mo. - yr/mo.	Technical cooperation item	Technical cooperation party	Sub-licensing party (Name of Mfr.)

Amount of Our Company's Product handled (fill up year, item, amount)

Transaction started date with us:

FIGURE 6-1(a): Vendor Survey Sheet, Page 1.

BUSINESS TRANSACTIONS

		1979		1980		1981		1982		1983	
Total sales (ordinary profit)		$	% 100	$	% 100	$	% 100	$	% 100	$	% 100
Main customers (to whom sold)	(1) Our Company										
	(2)										
	(3)										
	(4)										
	(5)										
	(6)										

Name of business transacting Manufacturers Address:	Items (make marks to supplies for our company)	Ratio to own sales amount (%)	Ratio to manufacturers total sales (%)	Ratio of shares hold and yes or no of directors despatched

Other optional opinion on quality, delivery and transaction problems (if required, add additonal sheet)

Ordering department of Our Company							

Vendor's person in charge : Department Name

FIGURE 8-1(b): Vendor Survey Sheet, Page 2.

SUBCONTRACTOR SURVEY SHEET

Section in Charge	made out		review		review		review		review	
	Manager	Staff	M	S	M	S	SM	S	SM	S

Name of Company		Vendor's Code

OUTLINES

	Address	Main product (make marks for us)	TEL
Head Office			
Dept. & Person in Charge for Our Company			
works			
"			
"			
Overseas Office			

Large Share-holder	Share (%)	Main Bank	Name of representative	
			Capital dollar	dollar
			Established Month Year	Month of Settlement
			Member of Business Group:	Listed on Market Non

Main Raw Material and Parts	Main Suppliers	Relying Ratio (%)	Main Raw Material and Parts	Main Suppliers	Relying Ratio (%)

Total No. of Employees	Division	1979	1980	1981	1982	1983
	Engineer					
	Worker					
	Business & sales					
	Others					
	Total					
Average Salary						
Average age						
Average serving years						

Labour union yes no Upper Organization

FIGURE 9-1(a): Subcontractor Survey Sheet, Page 1.

OUTLINE	Qualification	JIS		Others
		Classification society		
	Technical cooperation period	Technical cooperation item	Technical cooperation party	
	Yr/Mo. - Yr/Mo.			

BUSINESS TRANSACTIONS		1979		1980		1981		1982		1983	
Total sales (ordinary profit)		( )	% 100	( )	% 100	( )	% 100	( )	% 100	( )	% 100
Main Customers	(1) Our Company										
	(2)										
	(3)										
	(4)										
	(5)										
Amount of direct export											
Ratio of sales for each items		%		%		%		%		%	
		%		%		%		%		%	
		%		%		%		%		%	
		%		%		%		%		%	

Agent for Our Company			

Purchased amount of our product (fill-up year, item, amount)

Transaction started date with us: Month Year

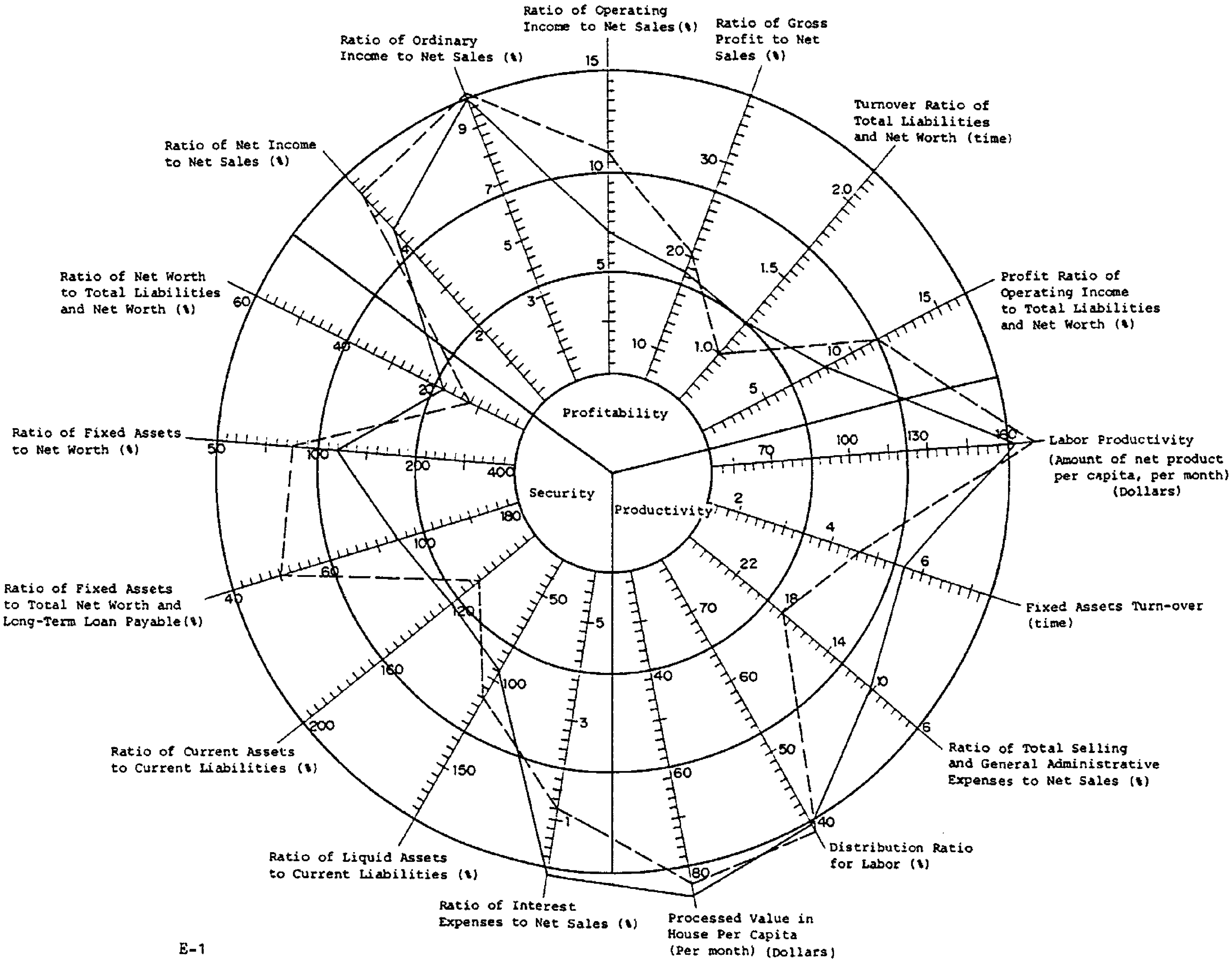
Other optional opinion on quality, delivery and transaction problems (If required, add additional paper)

Ordering department of IHI							

Vender's person in charge : Department Name

FIGURE 9-1(b): Subcontractor Survey Sheet, Page 2.

Business Situation Judgement Chart



Balance Sheet

(Dollars)

		Account Titles	Code	As of (A)	%	As of (B)	%	(B) - (A)	$(\frac{B}{A})$(%)
Assets	Current Assets	Cash and Deposits							
		Notes Receivable-Trade							
		Accounts Receivable-Trade							
		Accounts Receivable-Non Trade							
		Finished Goods							
		Raw Materials · Supplies							
		Works in Process							
		Loans							
		Advance Payments							
		Securities							
		Prepaid Expenses							
		Other Current Assets							
		Less-Allowance for Coubtful Accounts							
	Total Current Assets								
	Fixed Assets	Buildings and Structures							
		Machinery and Equipment							
		Cars and Other Land Delivery Equipment							
		Tools, Furniture and Fixture							
		Other Tangible Fixed Assets							
		Land							
		Construction in Process							
		Intangible Fixed Assets							
		Investments, etc.							
	Total Fixed Assets								
	Deferred Assets								
Total Assets					100		100		
Liabilities and Share Holders' Equity	Current Liabilities	Notes Payable-Trade							
		Accounts Payable-Trade							
		Accounts Payable-Other							
		Short-Term Loans Repayable							
		Current Instalments of Long-Term Debt							
		Advances Received							
		Reserve for Bonus							
		Reserve for Taxes							
		Accrued Expenses							
		Deposits Received							
		Other Current Liabilities							
	Total Current Liabilities								
	Fixed Liabilities	Long-Term Loans Repayable							
		Reserve for Retirement Allowances							
		Other Fixed Liabilities							
	Total Fixed Liabilities								
	Specific Reserves								
	Share Holders' Equity	Capital Stock							
		Legal Surplus							
		Retained Earnings							
		Retained Earnings Brought Forward							
		Unappropriated Retained Earnings							
	Total Share Holders' Equity								
	Total Liabilities and Share Holders' Equity				100		100		
Note Receivable Discount									
Accumulated Depreciation									

Income Statement

(Dollars)

Section	Group	Accounts Titles	Code	Year ended (A)	%	Year ended (B)	%	(B) - (A)	$(\frac{B}{A})$ (%)
Operating Income	Sales	Net Sales							
		Total Sales			100		100		
	Cost of Sales	Finished Goods Inventory at Begining							
		Cost of Goods Purchased							
		Cost of Products Mfd for the Period							
		Finished Goods Inventory at End							
		Total Cost of Sales							
		Gross Profit on Sales							
	Selling and General Administrative Expenses	Directors' Salaries							
		Employees' Salaries and Allowances							
		Welfare Expenses							
		Retirement Allowances							
		Stationary and Supplies							
		Depreciation Expenses							
		Rent and Repair Expenses							
		Insurance							
		Light and Power							
		Taxes and Public Dues							
		Selling Freight							
		Traveling Expenses, Carfare and Postage							
		Entertainment							
		Advertizing Expenses							
		Commission							
		Other Expenses							
		Total Sell. and Gen. Admin. Expenses							
		Operating Income							
Non-Operating Income		Interest and Discounts Earned							
		Dividends Earned							
		Other Revenues							
		Total Non-Operating Revenues							
		Interest and Discount Expenses							
		Other Expenses							
		Total Non-Operating Expenses							
		Ordinary Income							
Extraordinary Income		Profits on Disposal of Fixed Assets							
		Reversal of Specific Reserves							
		Others							
		Total Extraordinary Profits							
		Losses on Disposal of Fixed Assets							
		Provision of Specific Reserves							
		Others							
		Total Extraordinary Losses							
		Net Income Before Taxes							
		Provision of Reserve for Taxes							
		Net Income							
		Retained Earnings Brought Forward							
		Unappropriated Retained Earnings							

Statement for Manufacturing Cost

(Dollars)

Account Titles				Code	Year Ended (A)	%	Year Ended (B)	%	(B) - (A)	(B/A) (%)
Manufacturing Cost	Direct Cost	Material Cost	Inventory at Begin. of the Period							
			Purchase for the Period							
			Inventory at End of Period							
		Total of Material Cost								
		Sub-Contracting								
		Labor Cost								
	Total Direct Cost									
	Indirect Cost	Indirect Material Cost								
		Indirect Labor Cost								
		Factory Expenses	Welfare Expenses							
			Depreciation Expenses							
			Rent and Repair Expenses							
			Insurance							
			Light and Power							
			Traveling Expenses, Carfare and Postage							
			Taxes and Public Dues							
			Retirement Allowances							
			Other Expenses							
		Total Factory Expenses								
	Total Indirect Cost									
Gross Manufacturing Cost						100		100		
Works in Process Inventory at Begin.										
Works in Process Inventory at End										
Cost of Products Manufactured										

Statement of Appropriations

(Dollars)

Account Titles		Code	Year Ended (A)	%	Year Ended (B)	%	(B) - (A)	(B/A) (%)
Unappro-priated	Retained Earnings Brought Forward							
	Net Income							
Appropriations	Legal Retained Earnings							
	Voluntary Reserve							
	Dividends							
	Directors' Bonuses							
	Retained Earnings Carried Forward							

Number of Directors and Employees

(Persons)

Items			Code	Year Ended (A)	%	Year Ended (B)	%	(B) - (A)	(B/A) (%)
Directors									
Employees	Clerk								
	Sales								
	Designer, Engineer								
	Factory	Indirect Labor							
		Direct Labor							
		Temporary							
		Odd-Jobber							
Total									

Business-Index Analysis Table

	Items	Formula		Year ended	Year ended	Tendency	Standard
Profitability	Profit Ratio of OP.I to T.L. & N.W.	$\frac{(OP.I)}{(T.L. \& N.W.)} \times 100$	%				
	Turnover Ratio of T.L. and N.W.	$\frac{(N.S.)}{(T.L. \& N.W.)}$	time				
	Ratio of G.P. to N.S.	$\frac{(G.P.)}{(N.S.)} \times 100$	%				
	Ratio of OP.I to N.S.	$\frac{(OP.I.)}{(N.S.)} \times 100$	%				
	Ratio of Ord.I. to N.S.	$\frac{(Ord.I)}{(N.S.)} \times 100$	%				
	Ratio of N.I to N.S.	$\frac{(N.I.)}{(N.S.)} \times 100$	%				
Security	Ratio of N.W. to T.L. and N.W.	$\frac{(N.W.)}{(T.L. \& N.W.)} \times 100$	%				
	Ratio of F.A. to N.W.	$\frac{(F.A.)}{(N.W.)} \times 100$	%				
	Ratio of F.A. to T.N.W. & L.T.L.P.	$\frac{(F.A.)}{(T.N.W)+(L.T.L.P)} \times 100$	%				
	Ratio of C.A. to C.L.	$\frac{(C.A.)}{(C.L.)} \times 100$	%				
	Ratio of L.A. to C.L.	$\frac{(L.A.)}{(C.L.)} \times 100$	%				
	Ratio of I.E to N.S.	$\frac{(I.E.)}{(N.S.)} \times 100$	%				
	Ratio of L.P. to T.L. and N.W.	$\frac{(L.P.)}{(T.L. \& N.W.)} \times 100$	%				
Productivity	P.V. in House per Capita per Month	$\frac{(P.V.)}{(No.\ of\ Employees)} \div 12$	$				
	Distribution Ratio for Labor	$\frac{(P.E.)}{(P.V.)} \times 100$	%				
	Ratio of T.S. & G.A.E. Expenses to N.S.	$\frac{(T.S. \& G.A.E.)}{(N.S.)} \times 100$	%				
	Fixed Assets Turnover	$\frac{(N.S.)}{(F.A.)}$	time				
	Labor Productivity (per month)	$\frac{(N.P.)}{(No.\ of\ Employees)} \div 12$	$				
	Efficiency of Investment on Equipment(Machinery)	$\frac{(P.V.)}{(Amount\ of\ Equip.)}$	time				
Rate of Growth	Ratio of N.S.I.	$\frac{(N.S.I.)}{(N.S.\ of\ Previous\ Period)} \times 100$	%				
	Ratio of T.L. & N.W.I.	$\frac{(T.L. \& N.W.I)}{(T.L. \& N.W.\ of\ Previous\ Period)} \times 100$	%				
Others	Average Personnel Expenses per Capita per Month	$\frac{(P.E.)}{(No.\ of\ Employees)} \div 12$	$				
	Amount of Equip. per Capita	$\frac{(Amount\ of\ Equip.)}{(No.\ of\ Employees)}$	$				

NOTE: Legend for abbreviations is on Page E-6.

Items	Code	Year Ended (A)	Year Ended (B)	(B) - (A)	$(\frac{B}{A})$ (%)
Net Sales					
Amount of Net Product					
Processed Value in House					

LEGEND: L.A. = liquid assets = cash and deposits + notes receivable-trade + accounts receivable-trade

I.F. = interest expenses = interest and discount expenses - interest and discount earned

L.P. = loan payable = short-term loan payable + long-term loan payable

N.P. = amount of net product = net sales - finished goods and work in-process inventory at the beginning of the period + inventory at the end of the period

P.V. = net product - cost of goods purchased - direct and indirect material cost - consumables and energy cost - subcontracting cost

P.E. = personnel expenses = employee salaries and allowances + direct and indirect labor cost + welfare expenses + retirement and allowances

N.S.I. = net sales increase = net sales - net sales of previous period

T.L. & N.W.I. = Total liabilities and net worth increase = total liabilities and net worth - (T.L. & N.W.I.) of previous period

OP.I. = operating income

N.W. = net worth

C.L. = current assets

G.P. = gross profit

F.A. = fixed assets

C.L. = current liabilities

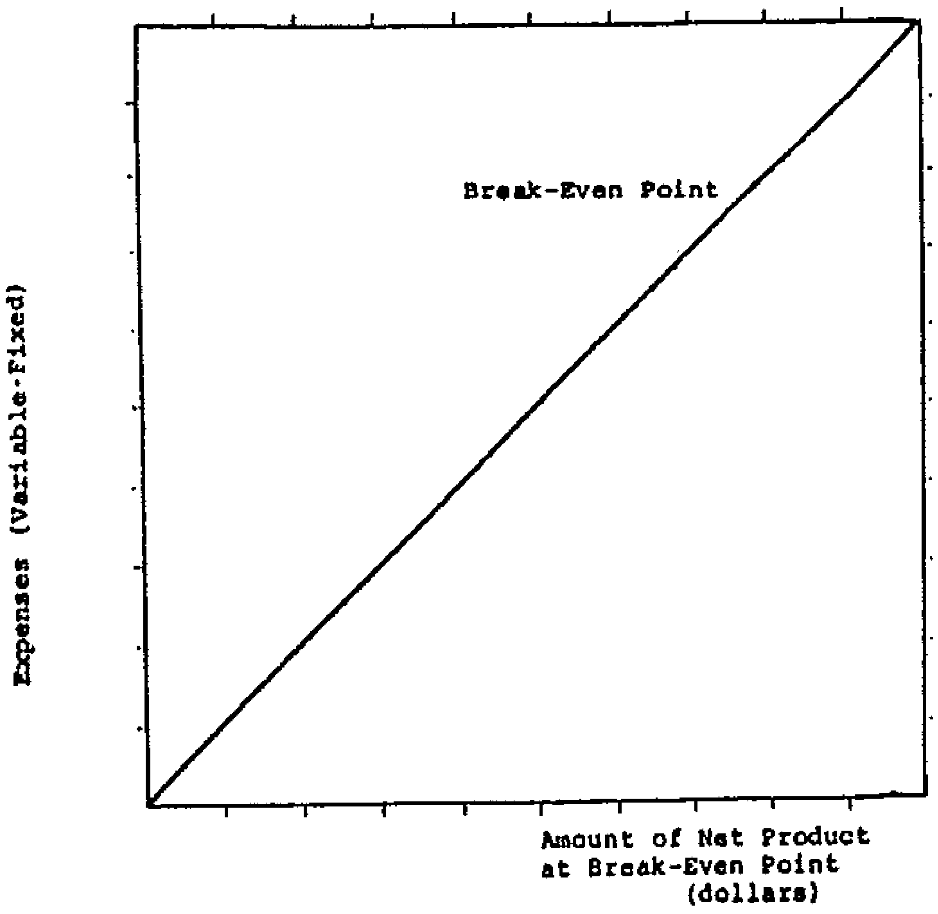
Ord.I. = ordinary income

N.I. = net income

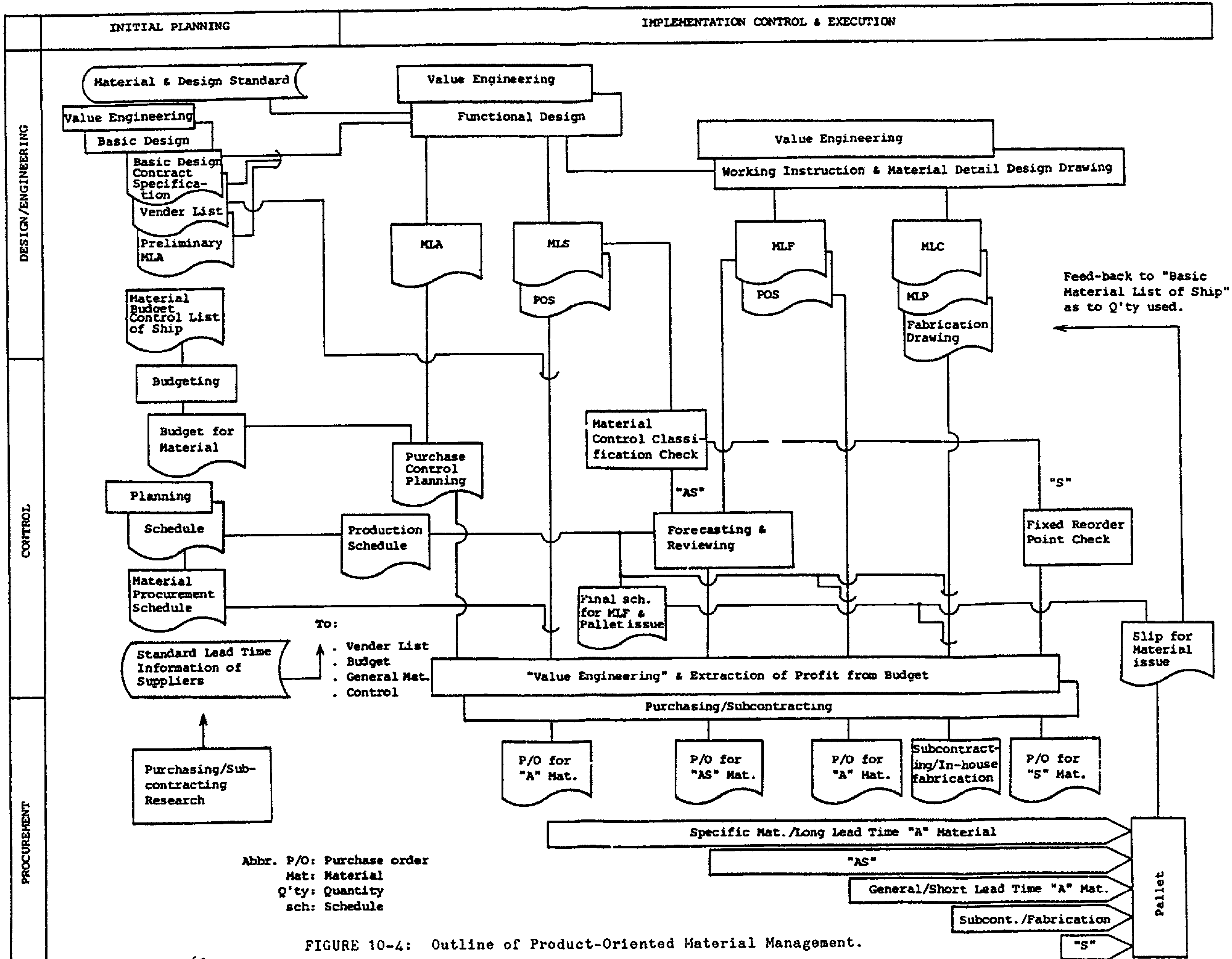
L.T.L.P. = long-term loan payable

T.S. & G.A.E. = total selling and general administrative expenses

Break-Even Point Analysis Table



Items		Year Ended (A)	Year Ended (B)	(B) - (A)	$(\frac{B}{A})$ (%)
S : Amount of Net Product (Net Sales ± Inventory)	$				
V : Variable Expenses [(N.P) - (P.V)]	$				
F : Fixed Expenses [(P.V) - Ordinary Income]	$				
G : (P.V)	$				
Ratio of Variable Expenses to (N.P) (V/S x 100)	%				
Ratio of Fixed Expenses to (N.P) (F/S x 100)	%				
g : Ratio of (P.V) to (N.P) (G/S x 100)	%				
A : (N.P) at Break-Even Point (F/g x 100)	$				
a : Ratio of Break-Even Point (A/S x 100)	%				
Ratio of Operation's Security (100 - a)	%				



Abbr. P/O: Purchase order
Mat: Material
Q'ty: Quantity
sch: Schedule

FIGURE 10-4: Outline of Product-Oriented Material Management.